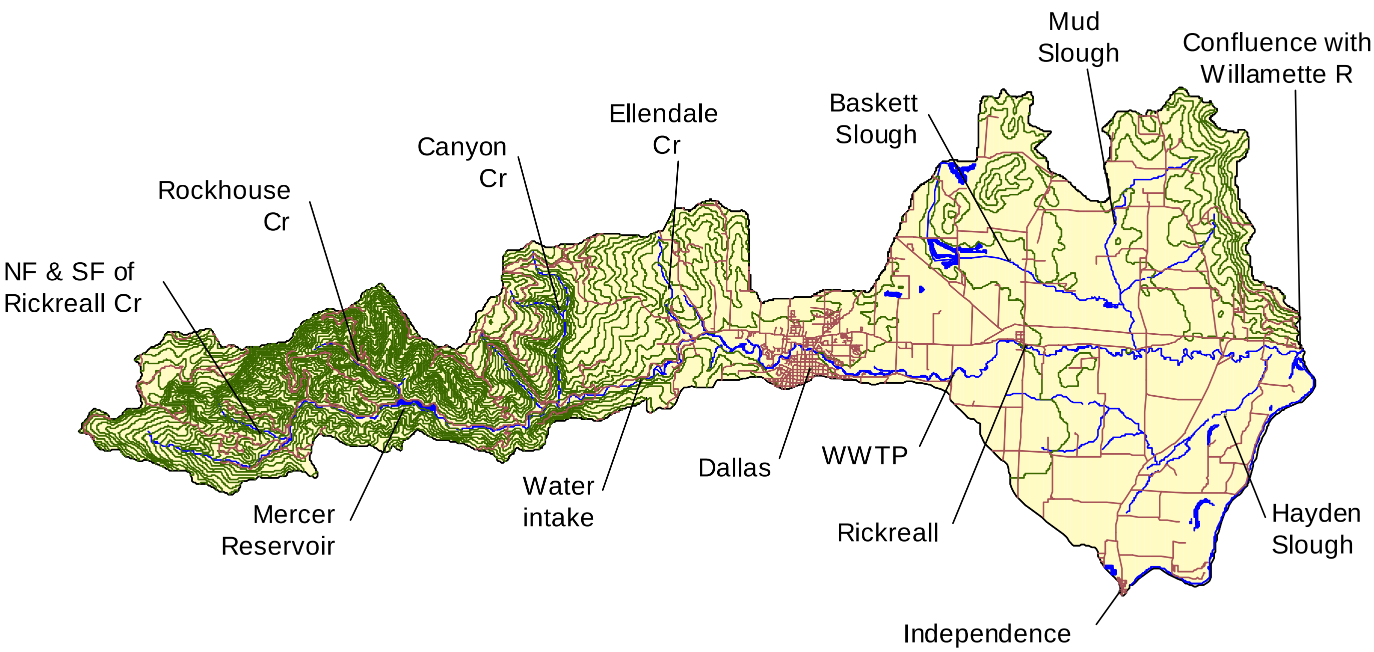
Rickreall Watershed Assessment



Rickreall Watershed Council
289 E. Ellendale, #504
Dallas, OR

January 25, 2001

Rickreall Watershed Assessment

Prepared for

The Rickreall Watershed Council

January 25, 2001

By

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DOCUMENT SUMMARY

This document is the product of an assessment of watershed condition for the Rickreall Creek watershed. The assessment used available information to describe current conditions and to project trends over time. This assessment was requested by the Rickreall Creek Watershed Council for their use as they develop strategies for protection and restoration of the watershed and as they consider further assessments to better understand their watershed.

The assessment examined a wide range of issues including land use history, water quality, water quantity, aquatic and terrestrial habitats, soil conditions, and social and economic conditions. The assessment followed the guidance provided by the Oregon Watershed Assessment Manual (Watershed Professionals Network 1999) or built upon the procedures described in the manual. In other instances, procedures were based on discussions and direction from the technical steering committee of the Rickreall Watershed Council. The purpose of the assessment was not to collect new data, but rather synthesize existing data sets and studies pertaining to the Rickreall Creek watershed to provide a picture of the watershed at this point in time.

Information and data was gathered from a variety of sources. These sources included libraries at Oregon State University and the City of Dallas, Polk County Historical Society, government files, aerial photos, GIS layers, unpublished reports and data sets from the City of Dallas and Polk County, published literature, theses and dissertations, and from consultations with technical specialists, and residents with background knowledge of the basin. The Internet proved to be a good source of electronic data from government sites. Two analysts visited the watershed on four trips. Visited areas included both the upper and lower watershed areas. In the upper watershed, visits were made to the reservoir, the 1987-burn area, Rickreall Creek at major tributary junctions, the South Fork of Rickreall, and the ridgetops above Rockhouse Creek. In the lower watershed, trips included driving over a majority of the roads, a canoe float on a two-mile section of the Rickreall below the community of Rickreall and visits to the water treatment and wastewater treatment plants. These gathered data sets, reports, visits, and discussions were the basis to construct a synthesis of the current picture of watershed health through an assembly of figures, GIS maps, photographs, and tables that comprise this document.

In the remainder of this document, the Rickreall Creek Watershed is described in terms of chapters on: 1) watershed characterization, 2) history of human use, 3) water quality, 4) water quantity, 5) aquatic and terrestrial resources, 6) soils, and 7) social and economic considerations.

The following is a statement of general findings and watershed condition. Each statement is followed by a recommendation for consideration or action. This list should not be considered as a final statement but rather a start of a discussion that the readers of this document may carry on—particularly those that live in the watershed. They need to decide about what they think is important about this watershed.

Highly diverse physical character of the watershed creates many observable patterns. This relatively small watershed, due to its shape and location, has a wide diversity in almost all elements of watershed structure. For example lower portion of the watershed has an elevation gain of 200 feet from the Willamette River to the city of Dallas, but rises over 3,000 feet west of Dallas to the top of the watershed. This contrast in geomorphology creates different climate, soils, vegetation and land use patterns. The highly diverse physical nature of the watershed creates much of the land use patterns also. RECOMMENDATION: Recognize the sources of diversity and patterns in the Rickreall. This will clue one into subtle workings of the watershed and help to identify areas that are critical to the "good things" and "important functions" of the watershed. It will help to identify good things to protect and bad things to fix.

The watershed provides many important services to its residents. These services include a flow of waters used for drinking, agricultural irrigation, commercial uses, and recreational uses. The watershed is more than the stream. Its services include the productive soils that provide harvests for agriculture and timber, functioning waste disposal, and natural habitat for wildlife. Rickreall Creek may not be fully recognized by many citizens for its many positive contributions. Such an attitude can be a greater limitation for stream recovery than the physical and functional constraints to the stream. The bad news is that the positive elements of the watershed could shift toward a worse condition if a community overlooks the intangibles of stream and watershed condition. RECOMMENDATION: Consider developing education and information outreach to the public about important services and unique aspects of Rickreall Creek. Help to develop a sense of pride in the creek and watershed. Also attempt to describe a vision statement for the desired future condition of the watershed. Be as specific as possible.

Rickreall Creek falls to very low flows during the summer and is overallocated for stream withdrawals. Projections for Dallas indicate that a water shortage may be expected by 2010. The relatively low amount of snowpack in the Coast Range combined with the lack of rain during the summer months accounts for the low flows in Rickreall Creek. Indeed, it was the lower flowing streams on the west side of the Willamette Valley that appears to have encouraged the development of historic travel routes on that side of the Willamette River. The travel routes, or more specifically the fords, were likely important in Dallas being sited at some distance from the Willamette River. This location created the subsequent need for more water than the Rickreall could naturally supply during summer low flows. Mercer Reservoir has solved the problem by augmenting the summer flow of Rickreall Creek. However as a result of sediment filling into the reservoir and growth of the city, a new source of summer water will need to be secured in the future. The City has a number of alternatives currently under study. The most favorable from an economic standpoint is construction of a second dam and reservoir in Rickreall Creek. This year the Rickreall was designated along with the Upper Willamette River as critical habitat for endangered winter steelhead. The full ramifications of such as listing remain to be seen. RECOMMENDATION: The Council should consider ways to become proactive in the decision-process of securing water supply for city of Dallas and users downstream. Help to prioritize issues of importance such as cost in dollars, safety to community, intangible costs to the environment, and benefits to the entire community. Consideration of alternatives and their risks should be explicitly discussed.

Measures of stream condition of the stream suggests that there have been some negative affects the lower portion; but the stream is in relatively good condition higher up in the watershed. Measures of good function include a returning steelhead run, apparently healthy cutthroat population in the upper portion, and no known disappearance of fish species. The steelhead are different genetically from other native steelhead in the Santiam system. However, there is not good reason to believe that native steelhead did not use Rickreall Creek, though probably at lower numbers than rivers on the east side of the Willamette River. The naturally reproducing steelhead now in the stream are likely the result of mixing of introduced and native steelhead. Conditions for fluvial and resident cutthroat trout appear favorable in some sections of the lower Rickreall below Dallas. However, high summer temperatures, low flow, lack of large woody debris, the naturally entrenched channel are likely limitations. As a result, this section may deserve some attention for restoration. The stream condition downstream of the reservoir also shows several differences when compared to sections above the reservoir. In the reach below the reservoir, there are lower amounts of gravel and sand, area of pools is lower, and the stream is wider. This is the section with the most sensitive fish populations—larger resident cutthroat trout and juvenile steelhead occur here. RECOMMENDATION: Perform stream habitat and fish surveys (electroshocking or snorkel surveys) to determine abundance, distributions, and use of habitat. High priority areas for focus restoration work would be Rickreall Creek in the lower portion and the section between the reservoir and Dallas. Tributaries such as lower part of Baskett Slough, Ellendale Creek, and Forester Creek might be examined during high flows to see how they function as important refuges and spawning areas. Purpose of surveys would be to assess stream use by cutthroat and steelhead as well as rare non-game species (Oregon Chub, sandroller stickleback, and lamprey). An assessment of fish in the stream will allow citizens a way to appraise their stream and begin to develop a sense of its condition and will help to develop the sense of pride.

The conditions of the upper watershed appears to be relatively good as measured by the response to the 1987 fire, current road condition, slope failures, and stream condition. However, there are few older aged stands that may provide refuge for old-growth associated species. Large areas near the reservoir are in 20-year old stands as a result of the fire and riparian forests are of younger ages and have fewer streamside conifers. Rickreall Creek appears to have somewhat lower summer flows and higher winter flows than the nearby Little Luckiamute River. The summer flows are enhanced by reservoir released. High winter flows may be related to the large areas of young stands in the rain-on-snow zone. There appears to be a high density of roads, but for the most part, they appeared to be in good condition. Some culverts on tributaries below the reservoir appeared to be fish barriers at low flows and may also be barriers at high flow. RECOMMENDATIONS: Engage landowners in the upper watershed to discuss with the council their management plans and specific issues that they face. Begin discussions regarding the positive and negative consequences of opening the watershed to greater public access.

Alteration of historic habitat conditions is pervasive with development and occurs in the Rickreall as throughout the Willamette Valley. As many as eight vertebrate species have locally disappeared from the Willamette Valley in the last 200 years (grizzly bear, lynx, wolf, white-tailed deer, California condor, black-crowned night heron and yellow-billed cuckcoo, and spotted frog). While there probably hasn't been an area anywhere where species have not disappeared following rapid changes in settlement or development, the situation in the Willamette Valley should be viewed more as the "tip of the iceberg." Christmas bird counts indicate declines in several species including the Oregon state bird, the meadowlark. Several other additional species in the watershed will face mounting pressures from landuse changes. Conservation and management of habitat is the best way to help stop species loss. The historic landscape vegetation patterns of the Willamette Valley had been established by periodic burning by indigenous people that had occupied the area for at least several thousand years. This disturbance pattern was likely important for the "baseline" or historic condition of a number of watershed elements such as vegetation communities and the abundance and distribution of animals. Cessation of burning and introduction of agriculture resulted in decline of several vegetation types such as prairies, oak savannas, and wetlands. These habitats are being replaced with other habitats such as croplands, pastures, second-growth conifer forest, roadsides, rural homesites, and urban communities. These changes in habitat are a non-intentional result of a need to develop and respond to a regional economy beyond the boundaries of the Rickreall watershed. The habitat in the Willamette Valley may be still considered relatively intact. Development in many instances can proceed along with habitat preservation. RECOMMENDATION: Become aware of critical habitat. Attempt to assess loss of habitat. Assess species changes. Consider low budget monitoring programs such as a Christmas bird count or road surveys. Engage ODFW non-game specialists to talk to the Council. Encourage County and agriculture oriented agencies and groups to consider adopting policies and practices that help to prevent loss of habitat in rural areas. Wetland, prairie, and oak savanna restoration projects may be attempted. Work with City of Dallas regarding plans to acquire and develop a greenway along Rickreall Creek. Consider working with streamside landowner regarding easements for a greenway. High priority areas would be where people have easy access to the creek such as the area between Dallas and Rickreall.

Chapter 1 : WATERSHED CHARACTERIZATION

Character of Westslope Watersheds

The Rickreall is one of a group of five major watersheds that drain the west side of the Willamette River basin. These “west-side” watersheds are quite different from the “east-side” watersheds of the Willamette Basin with respect to geology, climate, valley forms, and even in settlement history and current land use. The west-side watersheds are underlain by large amounts of older geological formations of a sedimentary origin, whereas east-side watersheds have significant amounts of volcanic formations. Accordingly, west-side stream valleys tend to be mature, with more downcutting and larger amounts of fine sediment than east-side valleys. West-side streams have greater variation in seasonal flow volumes as a result of little to no snow pack development. High winter streamflows alternate with very low flows during dry summer months. Summer stream temperatures are higher in west-side streams. Compared to the more evenly sloped east-side streams, the west-side streams tend to be very steep in the headwaters and are very flat in the lower portions. With softer bedrock, fish-barrier falls are less frequent on west-side streams and the upper extent of fish use is typically limited by increasing gradient. As significant areas of west-side watersheds lie within the floor of the Willamette Valley, the lower valleys tend to be wide, of low gradient, and the stream channels tend to entrench into their floodplains. These difference in stream character leads to differences in fish assemblages. Spring chinook are not thought to have spawned in these streams and steelhead use was much lower than that of eastside streams. Even human settlement patterns were influenced by the more accessible, flatter ground of the western slopes, which were preferred travel routes by early settlers into the valley. Compared to east-side watersheds, west-side watersheds have greater amounts of private land ownership, higher population density, and greater portions of land are in agricultural use.

Character of the Rickreall

As a watershed, the Rickreall at 98 square miles is relatively small compared to major drainages to the Willamette River, but it is as diverse as many larger watersheds. This high diversity in a relatively small area is due to the narrow and long shape of the watershed that stretches from the Willamette River up to the crest of the Coast Range, a distance of over 25 miles with an elevation change of 3,500-feet (Map 1-1 shows the watershed location within Polk County).

The City of Dallas is located nearly in the center of the watershed and marks the transition between the “upper” portion and “lower” portion of the watershed. Dallas is located at what is referred to as River Mile 16 (River Miles represent the distance along the stream starting at the mouth of Rickreall, which is River Mile 0). Above Dallas, the north-south width of the watershed is no more than four miles and as narrow as two miles. The elevation ranges from 300 feet above sea level in Dallas to nearly 3,600 feet at the top of Laurel Mountain, the highest point in the watershed. As a result of this relatively rapid change in elevation, headwater tributaries are steep in somewhat narrow valleys, and have cool water flowing over cobbles and boulders that support native trout and other cool-water aquatic species.

At about the center of the upper watershed, at River Mile 26, Rickreall Creek is impounded by an earthen dam. This dam creates Mercer Reservoir, a 60-acre municipal water supply for the city of Dallas. Downstream of Mercer Reservoir, summer flow in Rickreall Creek increase as a result of release water from the reservoir and additional flow from several large tributaries. Approximately half of the increased summer flow released from Mercer Reservoir is diverted from the natural channel at River Mile 20 and travels through the municipal water system of the City of Dallas. The remaining water in the creek continues on and also flows through Dallas and on into the eastern or lower portion of the watershed.

The eastern or lower portion of the watershed is much flatter and the watershed widens to ten miles as it spreads out onto the broad Willamette Valley floor. Rickreall Creek regains some of its diverted flow at River Mile 9 where the municipal wastewater treatment plant has its outfall. Below here to the confluence with the Willamette River, Rickreall Creek receives little additional summer contributions from tributaries. The stream decreases in energy due to the reduced gradient and it begins to meander, flow more slowly, and warms in temperature. The channel is relatively entrenched or constrained between high banks or terraces where it has cut down into floodplain deposits. Cold-water fish give way to warm water species and forests give way to open landscapes now in agriculture. This variation across the landscape from west to east is evident nearly in every aspect of the watershed—such as the geology and soils, climate, vegetation, landscape morphology, human settlement patterns, and land use.

Distinct Areas within the Watershed

From a land-use perspective, the Rickreall Creek Watershed may be considered as having three distinct areas: an upland forest area in the west, an urban area in the middle, and a valley agriculture area in the east. These contrasting land uses are readily evident in Map 1-2, a composite aerial photo of the watershed. Each area has its own set of conservation issues and demands that are being made on them by the landowners and the public.

The upland forest was originally mature conifer forests intermixed with younger forests created by natural disturbances such as fire and windstorms. The hill slopes are relatively steep, even for the Coast Range, due to the larger amounts of basalt geology, which resists weathering, compared to the sandstone sedimentary common to other areas of the Coast Range. The upland forest area is now largely in private industrial forest ownerships with lesser amounts in federal. There are relatively few private holdings. The vegetation today is a mix of second growth forests with scattered recently harvested units and almost no old-growth stands. Several areas of natural grass balds occur on the south-facing slopes near the ridge tops as shown in Photo 1-1.

Photo 1-1: The upper watershed is a mix of recently harvested stands and second growth forests. Some grassy balds exist on south facing slopes as in this foreground. This view is towards the southwest from the mouth of Rockhouse Cave, above Rockhouse Creek. Mercer Reservoir lies off to the left of the photo; the farthest horizon is Fanno Ridge beyond the southern boundary of Rickreall watershed.

Photo 1-2: Lower Rickreall Creek at Villwoks Dam, a concrete ford over the stream at River Mile 7.5. The lower section of the Rickreall is characterized by a channel of low gradient that is somewhat entrenched. The riparian zones are narrow but well developed with mature hardwoods. Land-use along this section is agriculture beyond the riparian zone.

The middle, urban area of the watershed lies at the base of the steep topography of the Coast Range. Here the landscape is much flatter, but still rolling. The population density increases and the landscape takes on a rural-residential and then an urban character in the city of Dallas. The creek itself provides for recreation at riverside parks, a source of water withdrawals for domestic and industrial uses, and a transport for discharges of stormwater runoff and wastewater effluent.

The valley agricultural area begins downstream of the Dallas urban area. Here the landscape becomes mixture of rural residential, small farms, and forest parcels and eventually takes on an agricultural character. Along Rickreall Creek the land is a mix of diverse land uses including private homes, light industry, farmlands, and the small community of Rickreall. The valley area was originally a mix of forests, open prairies, and seasonal wetlands. The flat landscape was formed by a series of catastrophic Pleistocene floods that occurred in the Columbia River and back-washed fine sediment up into the Willamette Basin. Small tributaries that originate in the valley area are normally seasonal or nearly stagnant in summer, tend to flow over sand and silt sediments, and are characterized by wetland areas and hardwood-dominated riparian zones. Many of these tributaries and associated wetlands have been channelized or tiled. The mainstem and the remnant valley streams support a greater variety of warm-water fishes such as speckled dace, redside shiners, sculpins, suckers, brook lampreys, along with other likely introduced species of fish. There is important habitat for some of the less common, native species such as Oregon chub, sand rollers, or stickleback. Also fish use the smaller tributaries for refuge during winter floods. These small tributaries are often in close proximity to human development and can be affected by road crossings, drainage or irrigation projects (Photo 1-2).

Ownership, Population, and Roads

Land ownership in the watershed falls into different patterns in each area. The upper watershed, above the former community of Ellendale, is mainly industrial forestlands with a smaller amount of public lands. From Ellendale downstream, the watershed is mostly private ownerships (Map 1-3). Major, corporate or public landholders include Boise Cascade, the Bureau of Land Management (BLM), Willamette Industries, and the Fish and Wildlife Service (Basket Slough National Wildlife Refuge). Information on the acreage of individual private landholders was not available for this analysis but is available through the Polk County tax assessor’s office. Private ownership appears to be diverse of types. Some larger landholders include Dalton’s rock quarry located in the Ellendale area, a large dairy just east of Rickreall, and some of farms in the lower watershed. Some light industries are also located in the lower watershed, as are the communities of Rickreall, Eola, and the city of Independence. The urban zone around Dallas is a typical mix of businesses, residences, and light industries, and includes Willamette Industries, Inc. (wood products) and Tyco Industries (electronics).

The population density of the watershed shows development has been concentrated in the Dallas urban area and also downstream along Rickreall Creek (Map 1-4). The pattern likely reflects a shift from rural and farm-associated holdings to non-farm residences and developments as more people seek rural settings for homesites. This shift has been slowed by state land-use laws that are effective at controlling growth into lands zoned for agriculture and forestry and also by local Dallas City ordinances that allow only 129 building permits for new residences to be issued annually.

Roads are shown in Map 1-3. Dallas shows a network of streets. The lower watershed shows the main highways, smaller paved roads and a series of gravel roads. The upper watershed shows a network of gravel roads that largely serve the management of the timberlands. Not all of the road system is shown for the watershed. Other maps of the upper watershed indicate that Map 1-3 shows approximately half the existing roads. Roads not shown are smaller spur roads.

Geology and Landforms

The highest peaks on the western divide are mafic igneous intrusive rocks of gabbro and diorite that cut through the sedimentary rocks of the Yamhill Formation. However, most of the upper watershed are steeply sloping Siletz River volcanics (Map 6-1). Moving downstream toward the foothills, the creeks cut through sedimentary rocks of the Yamhill Formation, which also rim the southern divide between the Rickreall and the Little Luckiamute. Beginning just above Dallas the creek enters the old alluvial and lacustrine terraces of the Willamette Valley floor mixed with Rickreall deposits from upstream. The drainage divide that separates Rickreall from Ash Creek to the south is barely perceptible on the nearly level terraces. In the east part of the watershed, the terrace escarpment above the Willamette bottomlands is closely followed by Highway 51 which passes north out of Independence. Rickreall Creek enters the modern floodplain of the Willamette River just to the east of the Highway 51 bridge. In the far northeast, the watershed divide is formed by the Eola Hills, which are sedimentary layers capped by Grande Rhonde basalt and Columbia River basalt.

The rocks of the northern Coast Range, which includes the upland areas of the Rickreall watershed, have at their core the Eocene Siletz River basalts, which are thick pillow basalts extruded from the sea floor. These volcanic rocks were part of an ancient island chain that collided with the North American Continent. A basin formed between these seamounts and the continent and it filled with sediments. The silts, sands, muds and volcanic debris of the Yamhill Formation were deposited over the Siletz River Basalts in the shallow Eocene sea. These deposits were in turn covered over with the sedimentary deposits of the Nestucca and Spencer Formations. This sea floor was then uplifted as the Coast Range.

The lacustrine and alluvial deposits of the Willamette Valley terraces and floodplains are Quaternary-aged, and include old valley alluvium, sediments from repeated Missoula Flood events during the late Pleistocene, and recent floodplain deposits. Floodplains and terraces rise stepwise from the Willamette

River and its tributaries towards the foothills. These stepwise deposits correlate with geomorphic surfaces with distinctive morphologies and soils (Baldwin 1976).

The relief of the watershed and the longitudinal profile of Rickreall Creek up through the South Fork are shown in Map 1-5. Most of the eastern portion is generally of low elevation (120 to 250 feet) and flat to rolling. The Eola Hills fringe the northeast edges of the watershed and rise to 1000-feet elevations. The watershed slowly and gradually rises in elevation towards the west until just past Dallas. Above Dallas, the streams have cut steeper valleys into the Coast Range. The ridges rise to 3600 feet at Laurel Mountain, Riley Peak and several other unnamed prominences along the ridges. Rickreall Creek channel climbs slowly and continuously and then increases in its rate of climb into the headwaters of the South Fork. Had the profile been performed on the headwaters of Rickreall Creek proper in the northwest portion of the watershed, it may have shown a steep rise to Silver Falls then a flattening above.

Climate and Hydrology

Mean annual precipitation over the watershed ranges from 40 inches per year at lower elevations to greater than 100 inches per year at the highest elevations (Figure 1-1). Over the season, precipitation peaks in November through January and falls to very low amounts in July and August. There is large variation in annual precipitation at high elevations. It is noteworthy that the rainfall gage at Laurel Mountain recorded the highest annual rainfall for the State of Oregon in 1996 at 206 inches (see http://www.ocs.orst.edu/whatsnew.html).

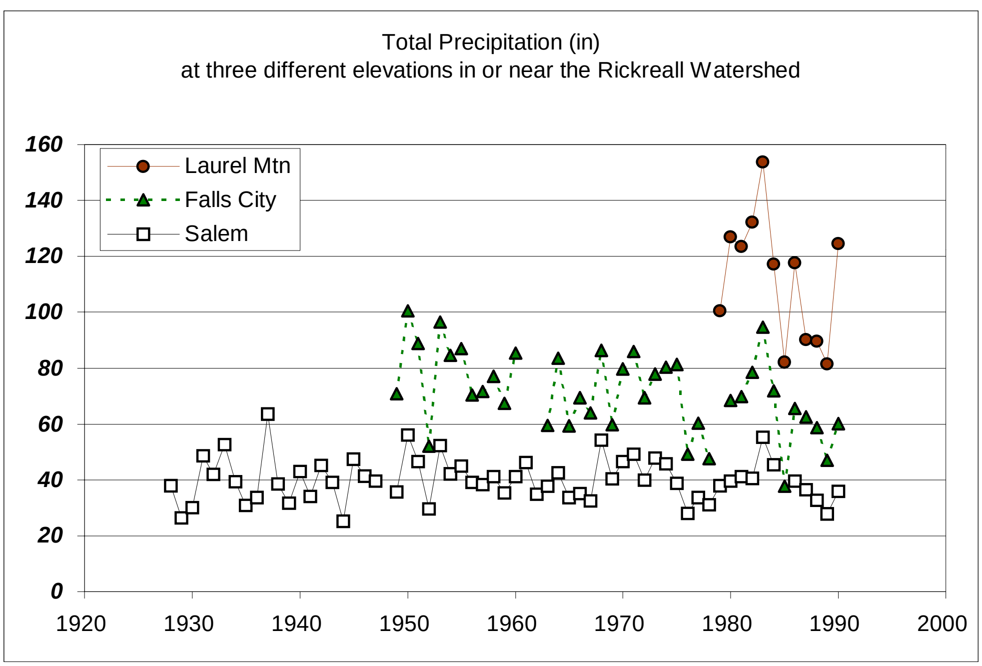
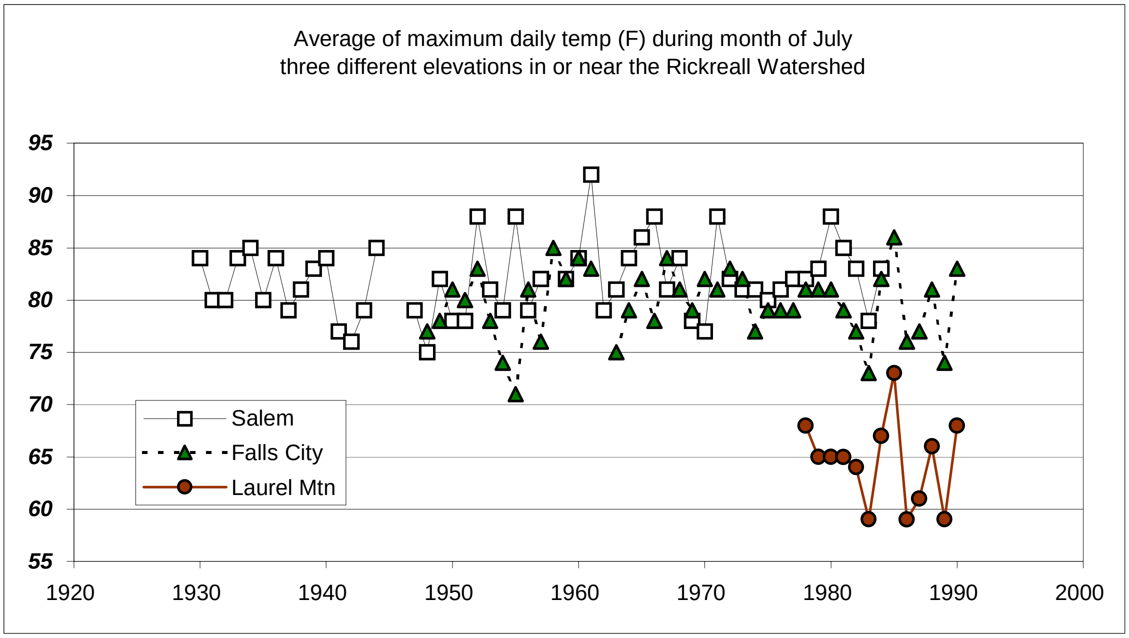


Figure 1-1 Precipitation patterns in Rickreall watershed show both greater amounts and greater year-to-year variability over time at higher elevations.



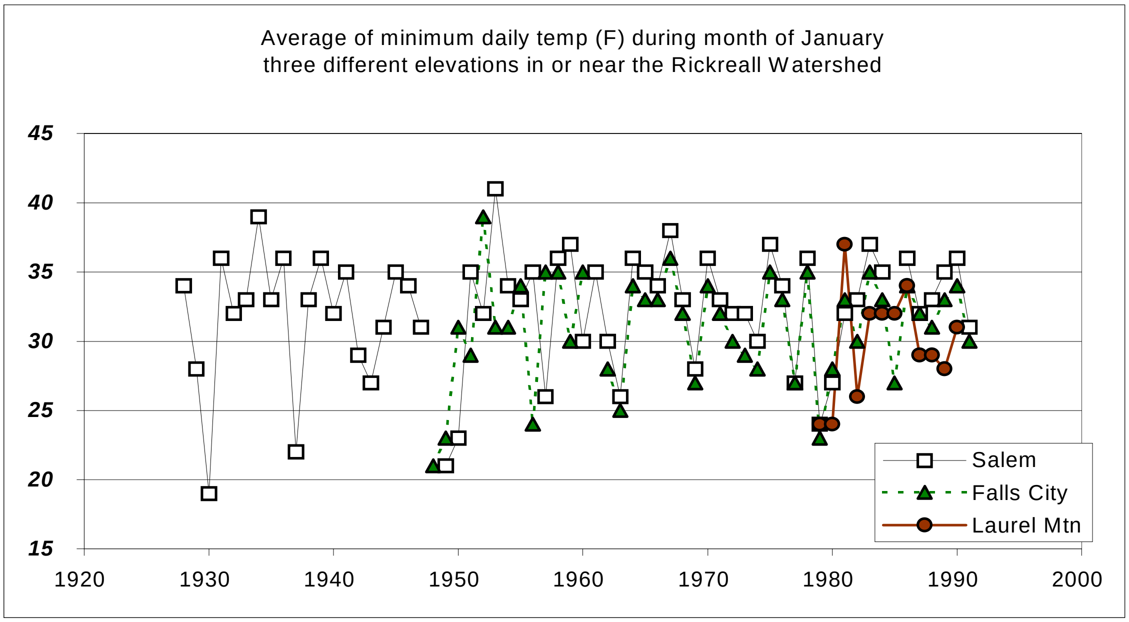
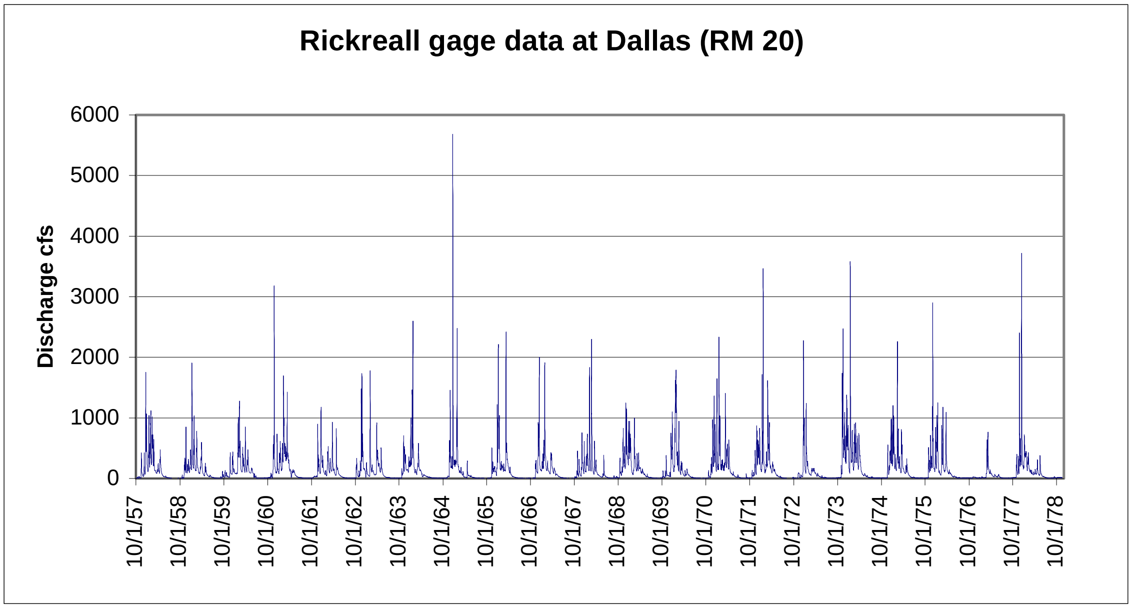


Figure 1-2: Mean maximum daily air temperatures during the month of July (top) and mean minimum daily temperatures during January (bottom) in the Rickreall watershed. There is a strong elevational effect for mean July maximum temperatures but not for mean January

Summer daily high temperature data also show a trend with elevation for these same sites. Maximum daily temperatures in July average 85 F in Salem and average 65 F at Laurel Mountain. Minimum daily temperatures in January average just above freezing in Salem and average slightly below freezing at Laurel Mountain. These winter daily minimum temperatures show little variation with elevation (Figure 1-2). More pronounced is the year-to-year variation in January minimum temperatures. For example in Salem, the means of daily minimum temperatures during January have varied from a low of 19 F (1930) to a high of 41 F (1953).

Stream discharge records are available for five stations in the Rickreall Creek watershed, however only two have records of over one year. These data are available via the Internet from the USGS webpage (http://waterdata.usgs.gov/nwis-w/OR/).

Data from these two stations provide a description of the stream flow from two points in the watershed (Figure 1-3). The Rickreall Creek discharge suggests a drainage area that is relatively large and steep, with high peak flows in the winter and an extended period of baseflow into the spring. Analysis of the discharge averaged by month over the period of record shows discharge peaking in January, while precipitation peaks in December (c.f. annual hydrograph, Figure 4-2 in Chapter 4). This lag between precipitation and discharge peaks results from a combination of saturated soils during the winter season and contribution from snowmelt. These factors delay the runoff peak and extend high flows into February. The period of low flow, primarily from July through October, reflect lack of precipitation and baseflow is largely groundwater discharge. This low flow discharge is important for its effects on water quality, agricultural use, and fish populations.



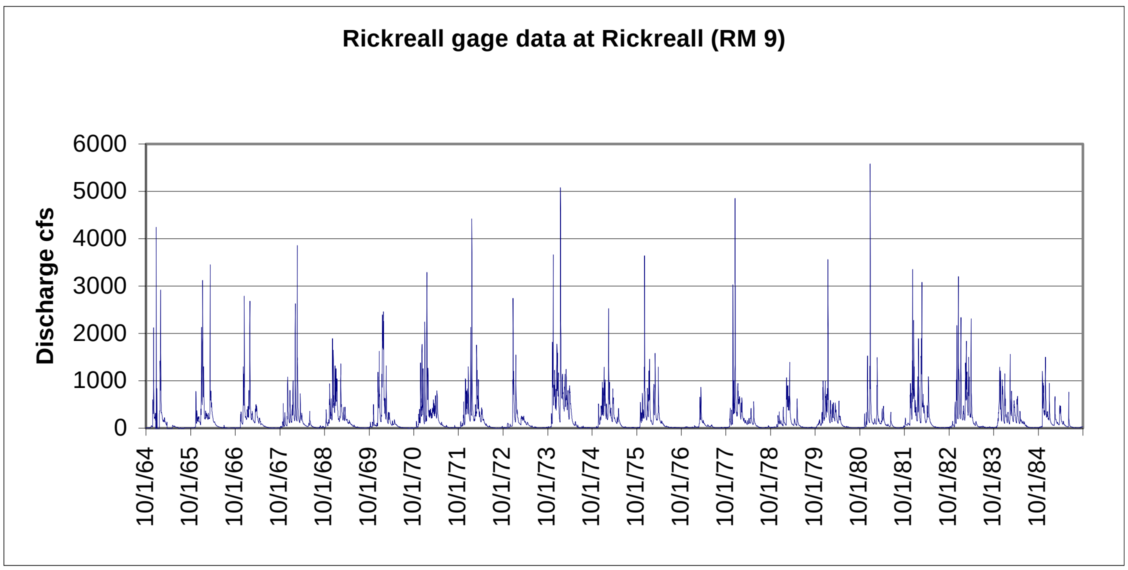
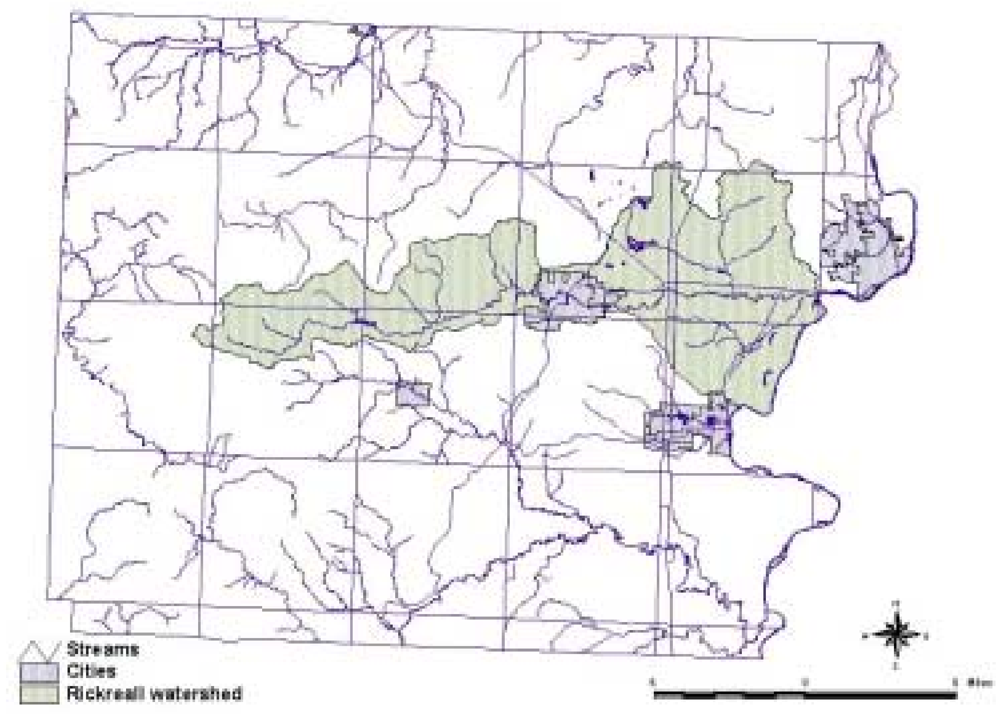
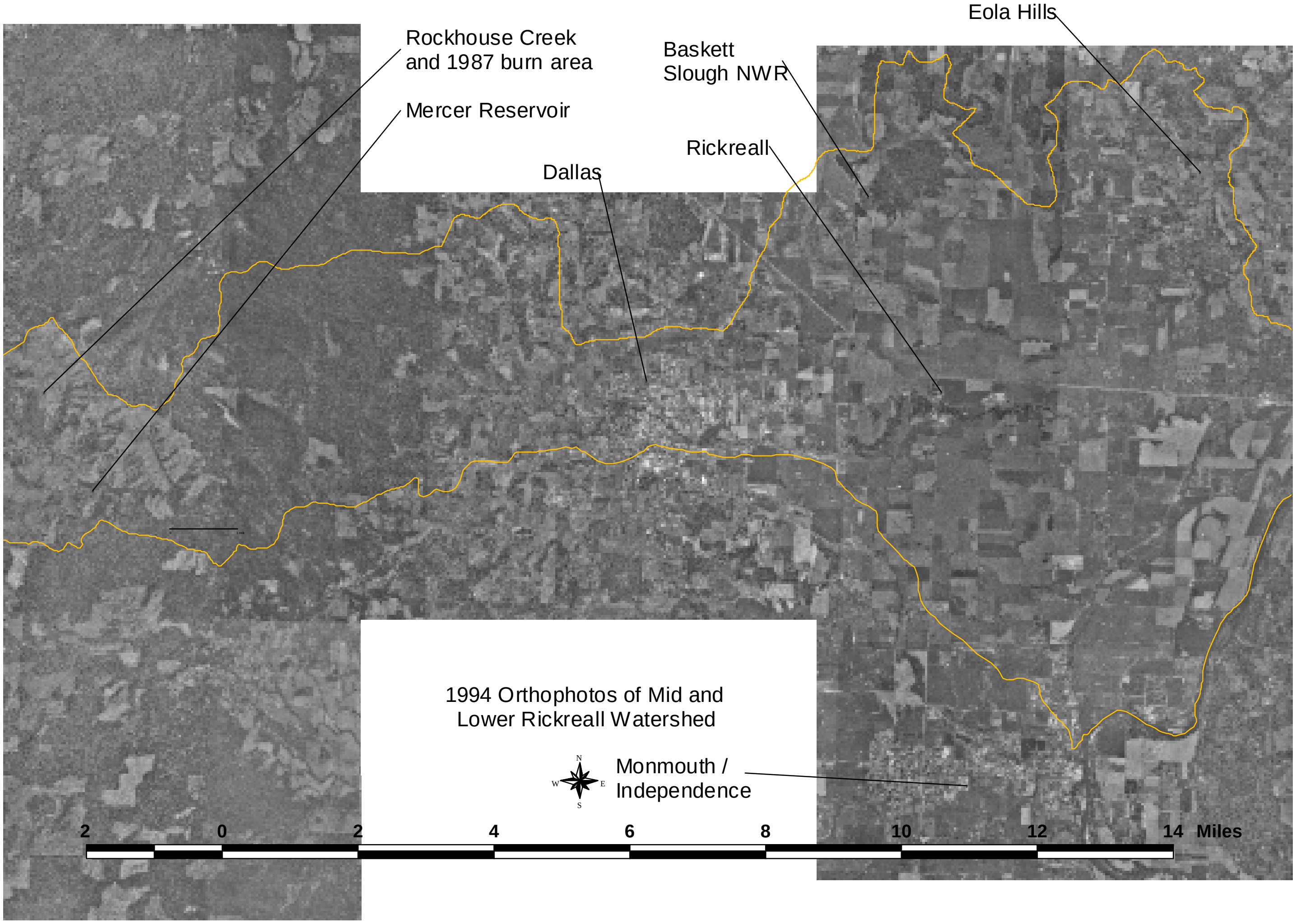


Figure 1-3: Rickreall stream discharge at USGS Dallas gaging station located just below the municipal water intake (top) and at USGS Rickreall gaging station located just above the Highway 99 bridge in Rickreall (bottom). The Rickreall station did not record the flood flow of 1964.

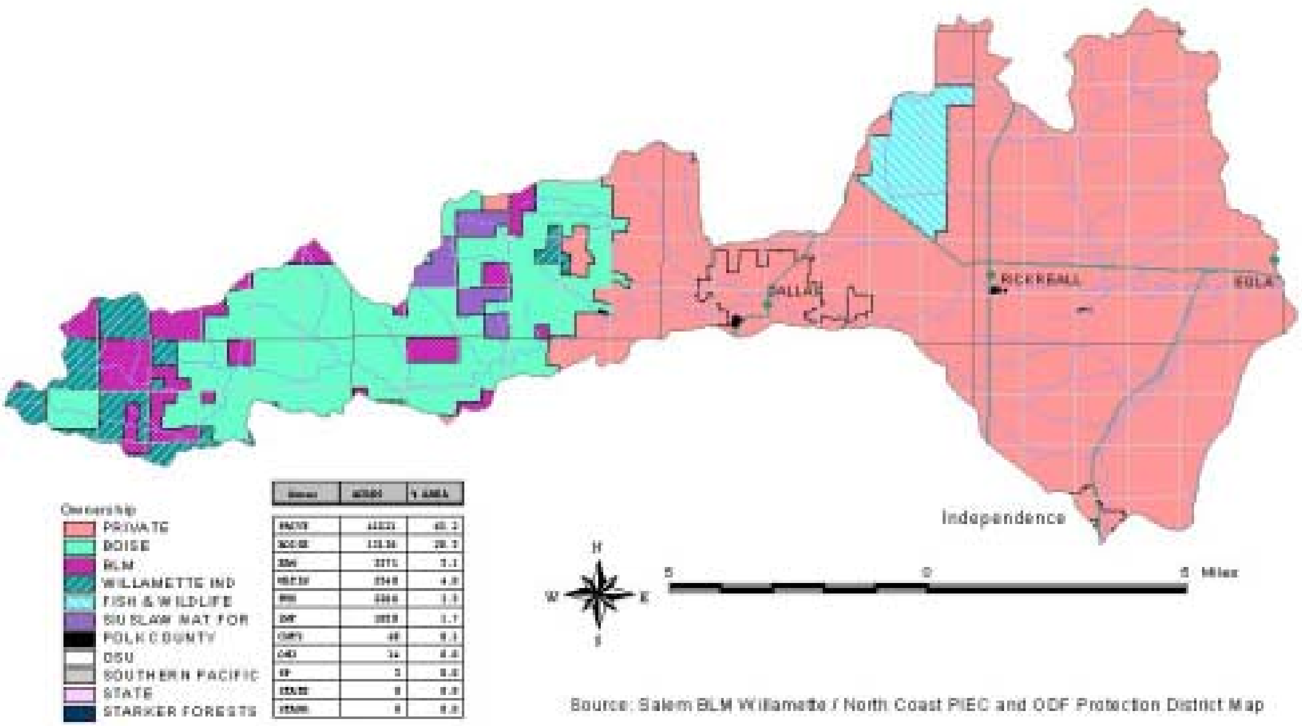
Map 1-1: Location of the Rickreall watershed in Polk County.



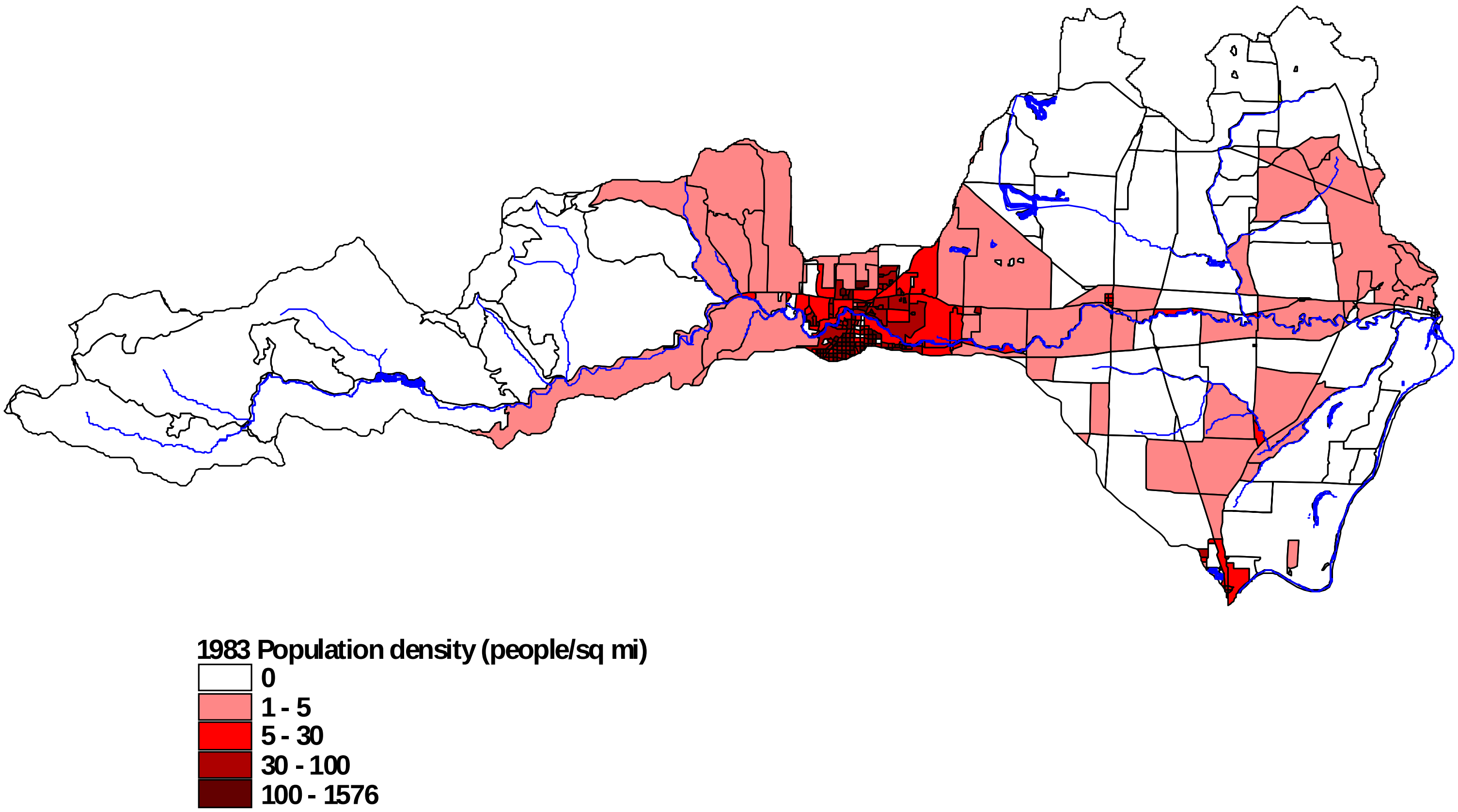
Map 1-2: 1994 orthophoto of the watershed showing landuse patterns.



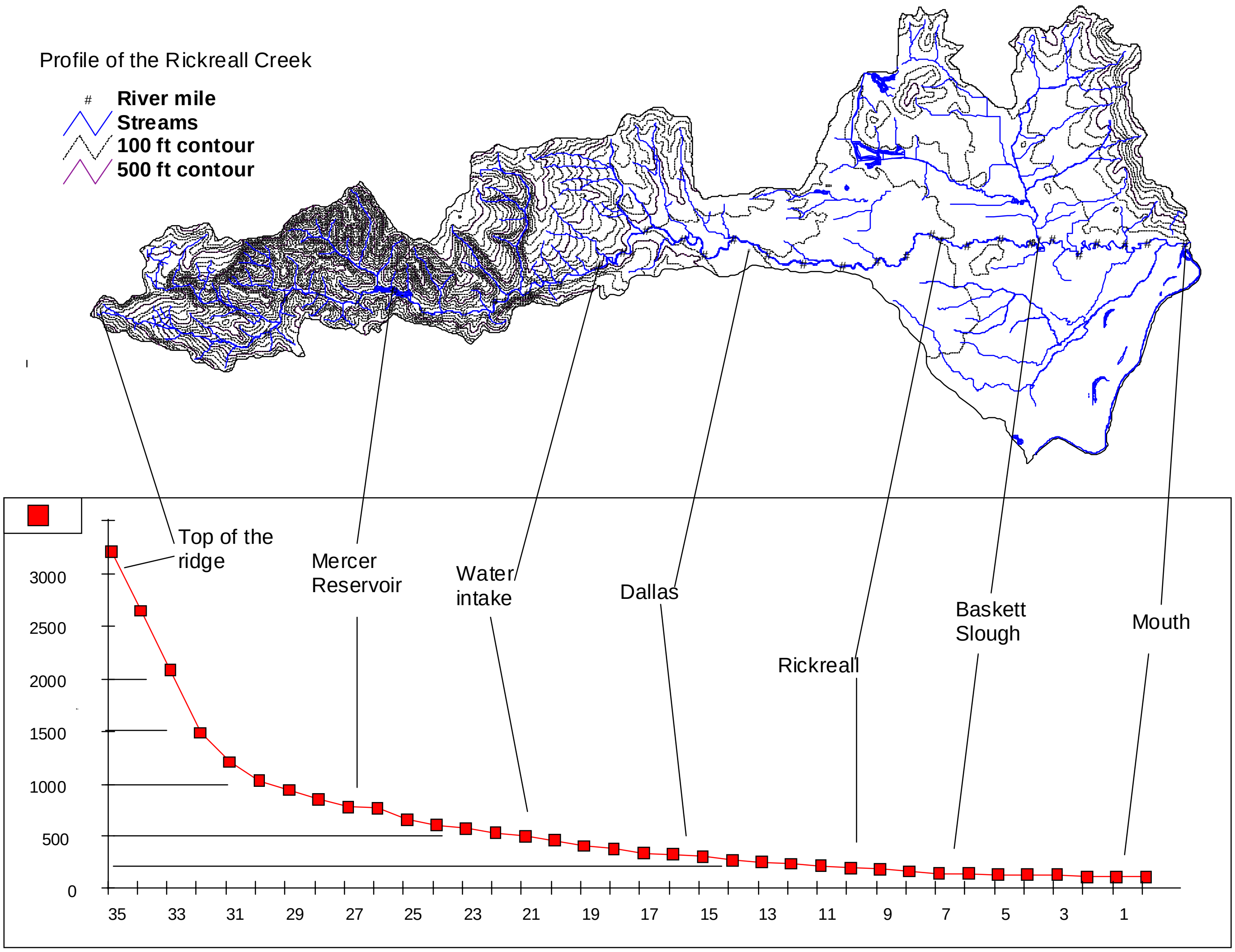
Map 1-3: Land ownership and main roads in Rickreall watershed. Shown are public lands and industrial forest ownership; private ownership in the lower watershed is not broken out by owner here. Roads shown are main roads; additional spur roads exist in upper and lower watersheds. Not all streets in Dallas are shown.



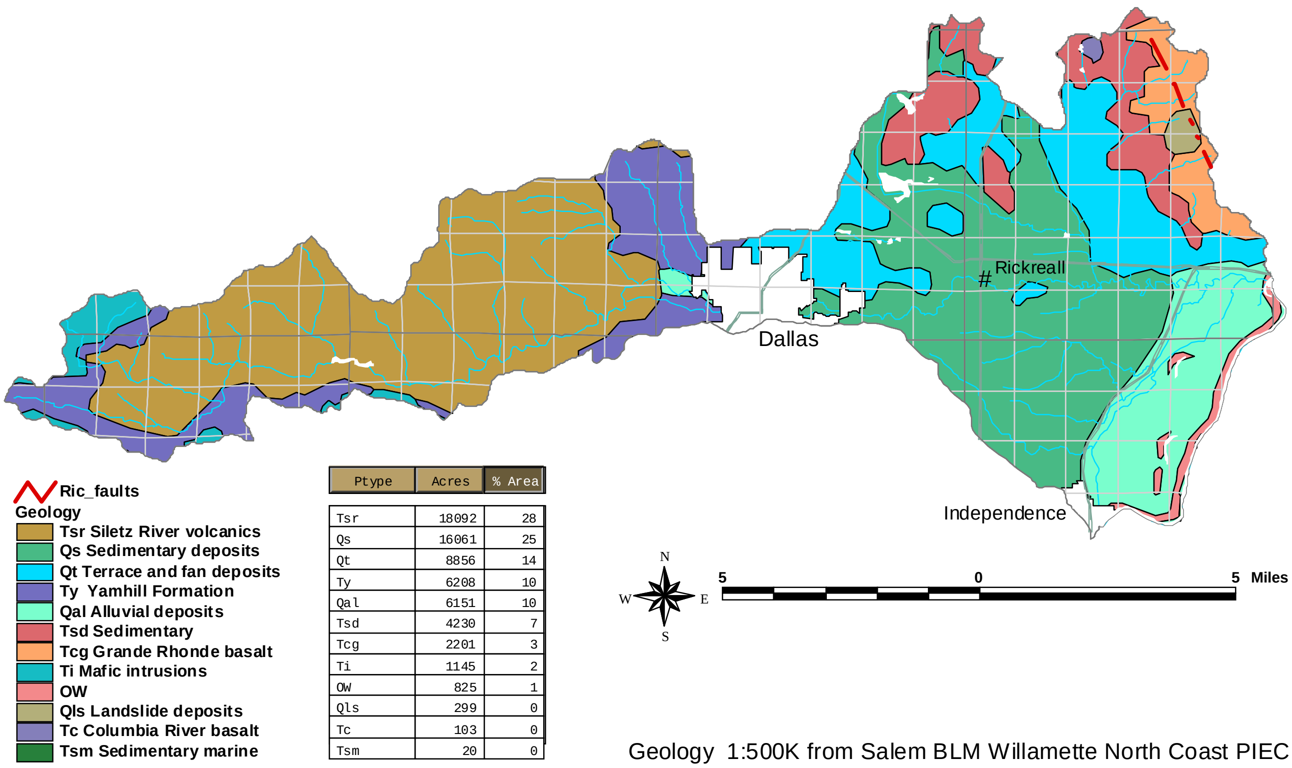
Map 1-4: Most of the population of the Rickreall watershed lives in and around the city of Dallas (population of about12,000). Smaller centers of population occur in Independence, Rickreall, and Eola. Lightly populated areas occur along the transportation routes. Portions of the lower watershed and most of the upper watershed are unpopulated.



Map 1-5: Stream profile of Rickreall Creek. Shown are River Mile locations and locations of features in the watershed. The graph shows elevations of Rickreall Creek as a function of River Mile measured along the creek length upstream from the mouth.



Map 1-6 Geology.



Ptype	Acres	% Area
Tsr	18092	28
Qs	16061	25
Qt	8856	14
Ty	6208	10
Qal	6151	10
Tsd	4230	7
Tcg	2201	3
Ti	1145	2
OW	825	1
Qls	299	0
Tc	103	0
Tsm	20	0

Geology 1:500K from Salem BLM Willamette North Coast PIEC

Chapter 2 : HISTORICAL CONDITIONS

The historical record is summarized here to provide insights into what the area looked like at the time of Euro-American exploration and settlement and to gain an understanding of how human uses have modified the watershed through time.

For the purpose of this analysis, the history of the Rickreall Creek watershed is divided into three periods: the Kalapuyan landscape, the American pioneers, and the transition to modern times (Table 2-1). Watershed conditions during each of these historical periods are described based on evidence from written and verbal first-hand accounts of explorers and watershed residents, resource inventories, maps, drawings, and photographs.

Table 2-1: Periods of social and institutional changes in the Rickreall Creek watershed.

pre-Columbian–1845	Kalapuyan landscape
1846–1879	American pioneers
1880–1940	Transition to modern times

These historical periods set the context for the current conditions in the Rickreall watershed. By World War II, many of the land use activities and other trends were established.

The Kalapuyan Landscape: pre-Columbian–1845

The indigenous people in the Rickreall Creek watershed and surrounding area at the time of Euro-American contact called themselves the Kalapuya. It is thought that the Kalapuya lived in the Willamette Valley prior to Euro-American contact for several thousand years. Technologies such as roasting of filberts and camas used by these people are thought to be at least 9000 years old (Minor and Toepel 1991, Reckendorf and Parsons 1966). At the time of the Lewis and Clark expedition in 1805-1806, at least six nations of Native Americans, estimated at 10,000-12,000 individuals total, lived in the valley (Boyd 1986). By 1841, only 400 or so Kalapuya survived in the Willamette Valley, with much of the population before this period decimated by waves of small pox in 1782 and malaria in 1830. The first recorded history of the Kalapuya was on October 4, 1826. In the approximate area of Berry Creek, in southern Polk County, the McLeod expedition noted a group of Kalapuya digging roots (Davies 1961). One of the few known sketches of a Kalapuyan and the landscape at the time of Euro-American arrival is shown in Figure 2-1.

Evidence shows that the Kalapuya practiced active resource management through the periodic setting of fires (Boyd 1986). The use of fire for vegetation management has been termed "pyroculture" (Gilsen 1989). This process involved periodic broadcast burning over large areas of the landscape to control unwanted plants, including Douglas-fir and possibly poison oak, to the advantage of desired plants, including oak, camas and huckleberries (Boyd 1986; Minore 1972; Gilsen 1989). The widespread use of this practice is evidenced by patterns of plants that exist today and by thousands of prehistoric artifacts used to process food, medicine, and dyes (Aikens 1975, Collins 1951).   The fire management was responsible for the landscape and vegetation encountered by the early explorers. In 1834, Hudson Bay Company chief trader John Work, following the route of the McLeod expedition, noted extensive broadcast burning in the Willamette Valley (Scott 1923). Vaughn (1890 p. 64) stated: “At that time there was not a brush or tree to be seen on all those hills, for the Indians kept it burned over every spring, but when the whites came, they stopped the fires for it destroyed the grass and then the young spruces sprang up and grew as we now see them.”

Figure 2-1: Sketch of a Kalapuya man near a Marys River tributary, 1841 (Wilkes 1845). Drawn by A. A. Agate. The drawing shows a more open landscape.

The arrival of Euro-Americans proved to be a disaster for the Native American inhabitants of the Willamette Valley. Decimated by disease, their resource base being co-opted, and in cultural conflict with their new neighbors, the Kalapuya, Umpqua, and Takelma were removed by the United States government to the Grand Ronde Reservation near the present town of Willamina in 1855. Anthropological information on these people was gathered late and was piecemeal (see Zenk 1976, cited in Boyd 1986). A project is currently underway to collect databases of literature, documents, and data describing the Native American cultures of the Grand Ronde Tribes. As many as 9,000 documents, many unpublished have been collected. A database is to be available on laser fiche (June Olson, pers. comm. Cultural Resources, Grand Ronde Tribes 503-879-2249).

There exists numerous written accounts from early explorers and settlers that provide a glimpse of what the Willamette Valley and in specific instances, what the lower Rickreall Creek landscape looked like. These comments refer to open oak savannas, rich grassland prairies, wetlands, and trees along meandering streams. The upper watershed area was composed of coniferous forests which were yet unexploited.

The following are a series of narratives from the journals of James Clyman, an early frontiersman who came to the Willamette Valley about 1845 and eventually lead a group of pioneers south to California. Spelling and punctuation are uncorrected.

On the geography of the Yamhill Valley area:

> *...This vally is here not short of Fifty miles wide and perhaps one Hundred and Fifty in length   numerous Brooks and rivulets meander their way in various directions through the vally from the neighbouring mountains on either side of the Willhamet and when necessary can easily be converted into the means of driveing all kinds of mchineery that can be found useful for a greate manufactureing communety.*

On the local Government and land claims:

> *The Laws of Iowa have been adopted and a number of acts or Laws passed by the provisional Legislature of oregon   The claim Laws allow every man 640 acres the claiman must build a cabbin on his claim within two months after his haveing taken possession and must be a resident by himself or by Tenant   his claim must be square or oblong the [lines] running North and South and East and West if the nature of the country permit*

On the animals of Oregon and Willamette Valley:

> *The seal is common on the coasts and in the bays and Rivers   greate Quantities and greate verieties of water fowl is found in all parts of the The open country during the rainy season such as the Swan the crane goose Brant and innumerable Quantities of Ducks with the wood cock and Snipe...*
>
> *The animals are Panthers several kins of wolves   The Black the yallow grey and spotted all large and traublesome killing hogs cattle and even in some instances horses and mules   The small Prarie wolf is likewise numerous   I saw no foxes   The Wild [cat?] is not numerous   plenty of Elk are found in the mountains and deer in all*

the Thickets waterfowl is plenty Beyond all conception in the rainy season all the Lowlands being litterly covered the[y] all move to the north and east during the months of April and May The Land Fowl are the Firr gous the Pheasant and Quail as likewise the medow lark which are found in greate abundanc on the open lands ... the Red brast wood pickers a sparrow are also seen The condor The Buzzard the Raven and crow with several speces of Hawks most of which are Plenty the Hawks feed mostly on mice and moles both of which are numerous

several Kinds of squirrels are seen all of which Burrow in the earth and lie torpid in the rainy season some lay up seed to lie on the other come out verry lean being nothing but skin and bone

The quantity [of water] that pours from these mountains on either side in to the Wilhamet vally is truly astonishing every 8 or 10 miles Brings you to a river and brooks innumerable...

Comments Clyman made while passing through the Rickreall watershed, likely near the future location of Dallas, in 1845:

May 25: It rained all night and the morning looked dark and Disagreeable five of us packed up and started for the california rendavous about noon in commenced raining and rained all afternoon made 15 miles and encamped on the Applegate settlement on the South branches of the yam hill I could not admire the Applegate selection although the soil is good But a portion of the country is a complete mudhole and the settlement is inconveniently situated The hills as usual as beautiful and picturesque and in many places covered Belly deep to our horses in clover

May 26: A disagreeable rainy night left our encampment passed over a beautiful undulating country near the Killamook mountains [Coast Range] make about four miles and encamped on La Creole [Rickreall Creek] a handsome clear running stream with fine rich prarie intervales on either side some settlements have commenced to be made on this creek during the last winter and a mill is now in building a few miles above our camp This La Creole or Rockreole is finely adapted for Hydraulic purposes as well as for agricultureal timber is however in many places rather scarce

The following are some selected narratives of other early visitors regarding the Willamette Valley landscape:

1841 (Late Summer): The country in the southern part of the Willamette Valley, stretches out into wild prairie-ground, gradually rising in the distance into low undulating hills, which are destitute of trees, except scattered oaks; these look more like orchards of fruit trees, planted by the hand of man, than groves of natural growth, and serve to relieve the eye from the yellow and scorched hue of the plains. The meandering of the streams may be readily followed by the growth of trees on their banks as far as the eye can see. (Wilkes, 1845).

Between the Lucky-mate [Luckiamute] and Mouse [Marys] River there is a range of hills, as between other streams; but at one place a spur of the Coast Range approaches within ten miles of the Willamette; from this issue many small streams which run down it, and through the fine plains to the Lucky-mate [Luckiamute] upon the one side, and into Mouse [Marys] River on the other. This is a beautiful region; from the bottom can be seen, at different points, seven snow-covered peaks of the Cascade Range. The Cascade is within view for a great distance, to the north and south; which, together with the beautiful scenery in the valley, renders it a picturesque place. Thrifty groves of fir and oak are to be seen in every direction; the

> *earth is carpeted with a covering of luxuriant grass, and fertilized by streams of clear running rivulets, some of which sink down and others pursue their course above ground to the river. Between the forks of Mouse River approaches a part of the Cascade [Coast range], but it leaves a valley up each branch about one mile in width, the soil of which is rich and good prairie for several miles above the junction. The mountain sides are covered heavily with timber. Thus these beautiful valleys offer great inducements to those who wish to have claims of good land, with fine grounds for pasturage and timber close at hand. There are no claims made as yet above the forks, These streams furnish good mill sites for each of the first six miles, and are well filled with trout. (Palmer 1845).*

George Emmon's journal speaks of a view in 1841 from what is probably the Eola Hills looking south into the Rickreall watershed:

> *8/7/41...the Yamhills [Eola Hills]...are a little singular being the only hills of any magnitude that rise from the great Walamat Valley—in an extent of Prairie from 60 to [1]00 miles either way...from the top of these at an alt. of about 1000 feet—had a grand panorama view. ...prairie to the south as far as the view extends—the streams being easily traced by a border of trees that grew up on either bank...white oak scattered about in all directions. (Boyd 1986).*

It appears that at the time of early Euro-American settlement, most of the low elevation Willamette Valley area was open grasslands with scattered concentrations of oaks in hilly areas, an environment which might be best termed "oak savanna" (Habeck 1961, cited in Boyd 1986).

The vegetation has been described by Boyd (1986) as a series of microenvironments that included

1) Native grasslands with oak (*Quercus garryanna*) dispersed in concentrations free of underbrush—originally called "oak openings" by the early land surveyors. Their occurrence and makeup depended on the availability of water. These have been the severely altered by introduced exotics and the cessation of burning.
2) Marshy areas or wetlands that occurred in low lying areas such as around shallow lakes (that were later drained) or in small drainages to rivers called "swells." These were important areas for the camas (*Comas quash*), wapiti (*Sagittarius latifolia*), a wild onion (*Allium* spp.)—important food sources to Kalapuya.
3) Deciduous forests composed chiefly of ash (*Fraxinus latifolia*) and alder (*Alnus rubra*) formed in the narrow corridors along the waterways. The winter villages of the Kalapuya are thought to have been located in this zone.
4) Dense conifer forests dominated by Douglas-fir (*Pseudotsuga menziesii*) were found at higher elevations of the surrounding mountains.

At the time of Euro-American settlement, grizzly bears, white-tailed deer, California condors, lamprey eels, Willamette chub, wolverines, cougar, wolves, elk are thought to have inhabited the watersheds on the west side of the Willamette River (Storm 1941). David Douglas performed the first technical descriptions of plant species in the Pacific Northwest. His journal includes descriptions of his travels with the McLeod expedition through the Willamette

Valley during September 1826 (Douglas 1959). There (pp. 213-200), he describes the landscape as undulating with scattered oaks and pines, that large portions of the grass had been burned, that small streams were common and at times were located in deep ravines that were difficult to cross, and that deer were easily shot daily for meals. He notes herds of elk, and several encounters with grizzly bears and describes an incident where one member of the party was attacked by a grizzly and escaped by climbing a tree. This attack probably occurred somewhere near the lower Rickreall watershed.

American Pioneers: 1846–1879

An important element that determined the relatively early settlement of Polk County was that the west side tributaries to the Willamette River were easier to ford and therefore provided the best travel routes south into the valley. Early settlers came into the Willamette Valley from Fort Vancouver (near present day Portland) along the California Trail or Hudson's Bay trapper trail. The historic trail is thought to be along or near present day Perrydale Road to the cemetery then along the Kings Valley highway (from video recording of presentation by Arlie Holt to the Rickreall Watershed Council, November 17, 1997). The fords over the rivers were apparently carefully located to provide safe crossing and not randomly situated. The ford over the Rickreall may have been one of the reasons that the present city of Dallas is located fifteen miles from the Willamette River. Location along the Willamette River would have been the obvious strategic transportation location. However, Dallas has also benefited from its central location in the county—being on the edge of both agriculture and timber areas. Being so far up into the watershed, the continued existence of Dallas is linked to the flows of Rickreall Creek and arguably, also, to nearby Ash Creek.

The southern Willamette Valley, with its open prairies, good soil and abundant water, was an attractive area for settlement. Settlement appears to have occurred rapidly beginning as early as 1844 in the Dallas area. Polk County was created from Yamhill District in 1845 and in 1850, Dallas (originally called Cynthian) was established as the county seat. Various small industries soon sprang up. The first mill to be established in Polk County was a gristmill at Ellendale Creek in the late 1840s. It is notable that, as there were no other grist mills south of here, wheat was packed by mules to the mill from as far away as Sutter's Mill in California. Other mills were soon established nearby. At Ellendale, a sawmill was established in1854, a woolen mill in 1865, and this was followed by a whisky distillery. A second gristmill was moved to the community of Rickreall from Falls City in 1865. A diversion dam was built near the upper end of Dallas' city park in 1857 and was used to supply a millrace until 1930. Mills and industry were established in Dallas and included a second woolen mill in 1896, additional sawmills in the 1890's, and a flourmill that operated until the 1920's. It is notable that the Muir and McDonald Tannery which was established in Dallas on Rickreall Creek in 1863 is still in operation today. Many of these mills had small dams in the creek and also contributed to the growth of the Dallas and to the settlement of the county. Population growth since 1910 is shown in

Settlement history was obtained from A. Holt and R. Marsh, pers. comm. and from an unpublished report prepared by Boatwright Engineering.)

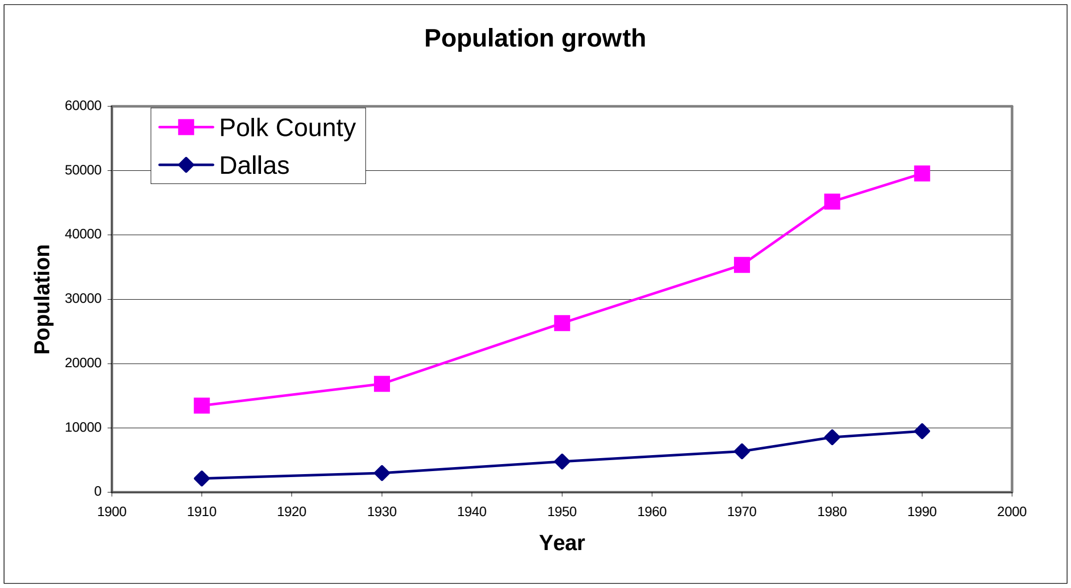


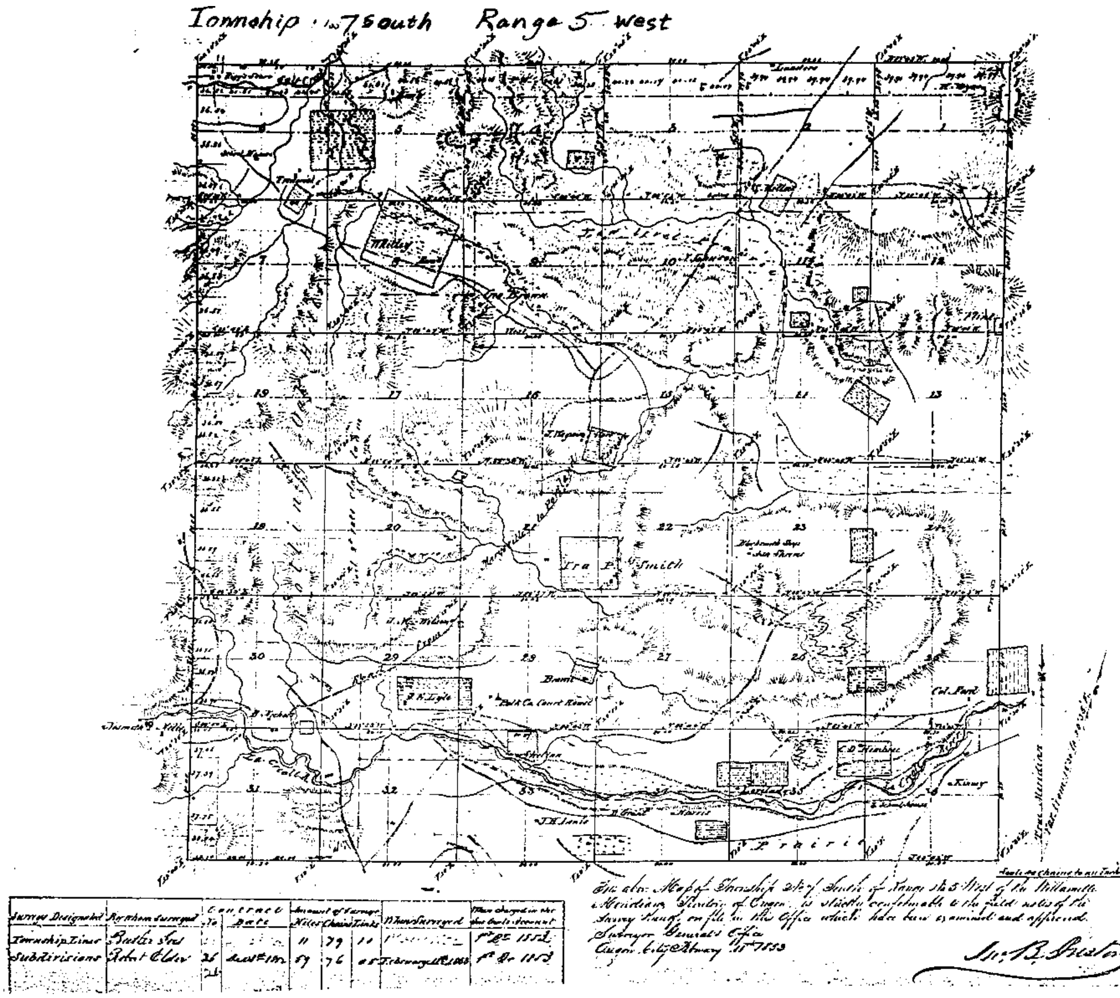
Figure 2-2: Historic population growth of Polk County and Dallas.

The General Land Office of the United States surveyed the landbase of much of the western United States during the 1850's (typically available at the County Offices or at the BLM offices in Salem and Eugene). These surveys provide an excellent historical record of the landscape at the time of settlement. The surveyors' notes contain information about a number of historical features, which can be used to reconstruct roads and homesteads, vegetation patterns, stream channels and other features. A copy of the 1853 GLO survey for a portion of the lower Rickreall Creek watershed including Dallas, Township 7 South, Range 5 West, is shown in Figure 2-3. This map shows the Polk County courthouse on the north side of Rickreall Creek, the main road from Marysville (now Corvallis) to Portland, and a scattering of land claims with names of claimants. The site of the Marysville-Portland road corresponds nearly to what is mapped as a ford on the USGS 7.5 minute Dallas map. This ford is located about one mile upstream of the current bridges in Dallas and may be the original ford of the California Trail. Also visible on the 1853 GLO map are hills, drainages, prairies, wetlands, and shallow lakes. The historic vegetation thought to exist in 1851 is portrayed in a GIS layer created the by the Oregon Natural Heritage Program (ONHP) and the Oregon Department of Fish and Wildlife (ODFW) and is shown Chapter 5 (Map 5-3).

Transition to Modern Times: 1880–1940

Logging activities were moving into the upper watershed following the settlement period of the county and began to increase by the turn of the century. By 1890, logging occurred at least up to River Mile 26 (present day Mercer Reservoir). The creek was used to float logs to mills first in Ellendale then in Dallas and as a result, was classed as "navigable waters" (Farnell 1979). The first sawmill was built near present day Ellendale about the mid-1850's later mills were built in Dallas near the turn of the century. Smaller logs were floated downstream to the Ellendale mill using water of winter freshets for a period of at least 45 years. At least three splashdams were built along Rickreall Creek above River Mile 26 to aid the log drives of larger logs to the Dallas mills. (Dallas resident, Gary Johnson 623-2105 reportedly has copies of photographs taken of the splashdams in 1896. Copies are also reproduced in Farnell 1979.) Logs were driven down from the headwaters of Rickreall Creek and from Laurel Creek for at least a decade. A local journal, the *Pacific Coast Wood and Iron*, reported that as many as 5 million board feet of logs were in the river in February of 1901. In January of 1906, one company had reportedly drove 6 million board feet of timber in the Rickreall. By this time, railroads were beginning to be used to transport logs through Falls City to mills in Dallas and the practice of using splashdams was ended in Oregon soon afterwards by lawsuit.

Figure 2-3: General Land Office Survey map created in 1853 of Township 7 South, Range 5 West shows La Creole (Rickreall) Creek near bottom, Polk County courthouse in Sec. 28, and Marysville to Portland Road (diagonally). Also shown are prairies, wetlands, and land claims.



By the 1890's, railroads replaced the Willamette River as the major means of transportation of goods in and out of the county. Up to this time, significant amounts of wheat were exported by river at the site of Lincoln. Railroads were never built up into the upper Rickreall watershed. Instead the railroad was built through Falls City and up through Black Rock and along the ridgetop of the Rickreall watershed. This decision may have kept the upper Rickreall somewhat isolated and may have postponed some of the logging there until the development of roads. While trails existed and there was logging in the watershed, the first road was not built until the 1940's.

Grains, cattle, and sheep were among the more important agricultural industries following settlement in the county. Italian prunes and hops were introduced in 1890 and were widely planted. Prunes declined after World War I when European orchards increased their supply to the European market. Hops declined after World War II. Since then, agriculture shifted first toward grains and then more recently to grass seed with greater diversification into specialty crops such as nursery products and Christmas trees. Though figures are not available, large areas of the lower watershed are thought to have been tiled and drained. More recently there has been a shift back towards re-establishing wetland areas.

The Rickreall Creek watershed has been an important source of water to Dallas since settlement. A combined private and municipal water supply organization was established in 1903 and was purchased by the city in 1931. The first water system was an 8" diameter pipe with gravity flow over a distance of 7 miles (R. Marsh, pers. comm.). Water was obtained from Rockhouse Creek and then other sources were established in Canyon Creek and Applegate Creek. The water fed a reservoir downstream. In 1940 the city built a pumping station and in 1959 Mercer Reservoir was constructed. In 1972 the reservoir capacity was doubled by adding a lift to the reservoir.

Water pollution was recognized as an issue in the Willamette Basin by the 1930's, with most of the sources listed as domestic sewage and discharge of domestic wastes. Public opinion and policy, however, were not focused on water quality issues: "Because the rivers of the Valley are not largely used for municipal water supply and because evidence of befoulment are not widely forced upon the senses, the public is tolerant toward stream pollution." (Willamette Valley Project 1936, p. 109). Wastewater treatment facilities were first constructed for Dallas in 1969 and upgraded in 1998.

By the late 1930's the pattern of land uses in the Rickreall Creek watershed was becoming similar to the present situation. Dallas was a growing urban center with a large sawmill and other industries. Large and small farms occupied most of Polk County, primarily the lower portion of Rickreall watershed. Aerial photographs provide a useful way to view vegetation patterns and land use activities over time. A series of four aerial photographs spanning the period from 1936 to 1994 (Figures 2-4 a through d) show Rickreall Creek at the community of Rickreall. The photos show subtle, but gradual, changes. Over the 60 years, there is a shift away from row crops to grass seed, development of additional roads, and the establishment of the dairy. There is a small area of loss of riparian area to agriculture, channelization of a small stream, and some evidence of recent bedload movement in the stream in 1970.

Figure 2-4 a-c Aerial photos of Rickreall watershed at community of Rickreall. Figure 2-4a top in 1936 and 2-4b bottom in 1955. Most of the land appears to have been brought under cultivation by 1936. Agriculture was shifting away from hops and prunes by 1936 and towards grains by 1955. A small stream near the lower right of 1936 photo is no longer visible by 1955 and may have been tiled. Other stream channels and riparian zones appear largely unchanged.

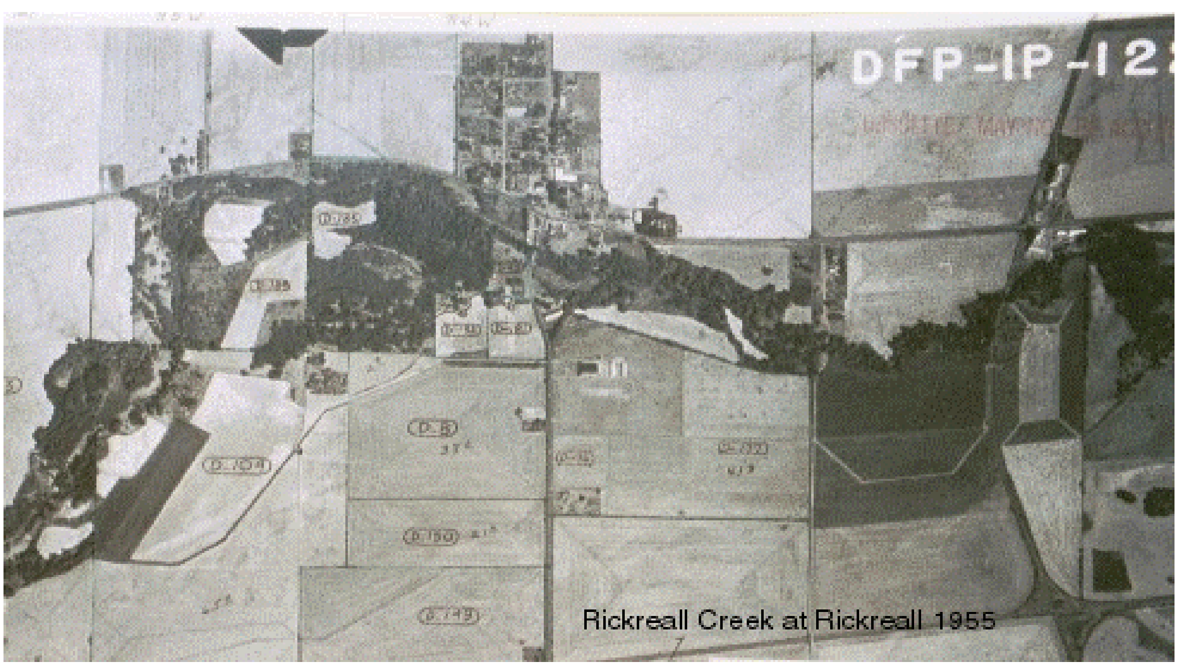


Figure 2-4c top and 2-4d bottom: Aerial photos of Rickreall watershed at community of Rickreall, 1970 and 1994. By 1970, the riparian zone west of Rickreall (left) shows some loss to agriculture and the streambed shows recent bedload deposits (white areas). By 1994, there is a greater shift toward grass seed crops, development of the dairy on far right and additional roads in upper left. The gravel bars visible in the 1970 photo are vegetated by 1994.

Summary

By the 1940's, the landscape features of the Rickreall Creek watershed had changed significantly. Lands that were historically grass prairies, oak savannas, wetlands, and riparian forests had been developed into farmlands, and, to a lesser extent, other land uses. The end of the Kalapuyan practice of using fire to control vegetation resulted in natural succession of areas that were once grasslands and open oak woodlands into conifer forests. Shifts in animal populations and distributions occurred. Human population within the watershed had increased, with people concentrated in Dallas, Rickreall, and along the creek. Riparian stream habitat and wetlands were likely reduced by encroachment by agriculture.

Chapter 3 : WATER QUALITY

Beneficial Uses and Standards

The Clean Water Act of 1972 guides much of the activities of monitoring and controlling water quality of surface water and groundwater (see Appendix 3-1 for background on the Act). As part of the protection process of waters, the Act requires that the various states designate "beneficial uses" for their water bodies. Based on these designated beneficial uses, standards and criteria for protection are then derived. States use different systems to designate beneficial uses. In Oregon, beneficial uses are broadly designated for large watershed areas (Oregon Administrative Rules 340.41). Designated beneficial uses that apply to Rickreall Creek are listed below (Table 3-1). It should be noted that broad designations sometimes do not adequately describe all portions of a water body. For example, Rickreall was originally designated as "salmonid spawning," but this designation on the lower portion was changed to "anadromous fish passage" in 1995. This change was a critical step that helped to facilitate the discharge permit process for the City of Dallas waste-water treatment plant as the spawning designation required that more stringent water quality standards be met.

Table 3-1: Oregon designated beneficial uses for Rickreall Creek (Oregon Administrative Rules 340.41).
Aesthetic Quality
Anadromous Fish Passage
Boating
Fishing
Industrial Water Supply
Irrigation
Livestock Watering
Private Domestic Water Supply
Public Domestic Water Supply
Resident Fish and Aquatic Life
Salmonid Fish Rearing
Salmonid Fish Spawning
Water Contact Recreation
Wildlife and Hunting

Water quality standards are numerical values typically expressed as the concentration of a constituent that protects the most sensitive designated beneficial uses. Criteria describe how a standard is to be applied (e.g., that 10 % of samples cannot exceed the standard value). Common water quality standards, criteria, and data from Rickreall Creek are summarized in Table 3-2. As an aid to readers, an explanation of water quality parameters and units of measurement are presented in Table 1 of Appendix 3-2.

Table 3-2: Water quality summary for Rickreall Creek.

Water Quality Parameter	Beneficial Uses Affected	State Water Quality Standard	Water Quality Limited Criteria	Issue of Concern for Rickreall Creek?
Flow modification	Resident fish and aquatic life Salmonid spawning and rearing	Creation of conditions that cause detrimental changes in the resident biological community	Data that shows the aquatic community to be 60% or less of the expected reference community (score data). Documented flow conditions that impair other beneficial uses	Permitted withdrawals may exceed natural streamflow during summer. See Chapter 4
Dissolved oxygen	Resident fish and aquatic life Salmonid spawning and rearing	Cold water aquatic resource: 8.0 mg/L Cool water aquatic resource: 6.5 mg/L Warm water aquatic resource 5.5 mg/L minimum	Greater than 10 % of the samples exceed the standard and a minimum of at least 2 exceedences of the standard for a season	Low DO levels (< 6 mg/L) commonly measured at River Mile 2.2 prior to 1972. Moderate DO levels (5.7 to 6.6 mg/L) measured at River Mile 8.2 in 1989 and 1992. See Table 3-3.
Temperature	Resident fish and aquatic life Salmonid spawning and rearing	64ºF (18ºC) 7 day moving average of daily maximum unless; 55ºF (13ºC) during times in waters that support anadromous fish spawning	7 day moving average exceeds standard	Temperatures occasionally exceed 64 F during summer at River Miles 2.2, 8.2 and 16.7. See Tables 3-3 through 3-5..
Turbidity	Resident fish and aquatic life Water supply Aesthetics	No more than 10% increase over background	Systematic or persistent increase of > 10% in turbidity	No data reviewed.
pH	Resident fish and aquatic life Water contact recreation	6.5 to 8.5	> 10 % samples exceed standard and at least 2 exceedences for season of interest	pH measures range from 6.7 to 7.8 (all within range) for years 1957 through 1992 at River Miles 2.2, 8.2 and 16.7. See Table 3-4.
Bacteria	Water contact recreation	126 *E. coli* /100mL, 30 d. log mean, minimum of 5 samples 406 *E. coli*/100mL, single sample	200 Fecal coliform/100 ml, geometric mean 400 Fecal coliform/100 ml in > 10 % samples and at least 2 exceedences for season of interest	Fecal coliform commonly exceeds standard at River Miles 2.2 and 8.2. Less than 50 MPN/100 ml at River Mile 16.7. See Table 3-4.
Sediment ation	Resident fish and aquatic life Salmonid spawning and rearing	Formation of bottom or sludge deposits deleterious to fish, aquatic life, public health, recreation, or industry.	Documentation that sedimentation is significant limitation to fish or other aquatic life	Some evidence of cobble embeddedness in lower section. See Chapter 5.
Total dissolved gas	*Resident fish and aquatic life	*Concentration of total dissolved gas not to exceed 110% of saturation *liberation of dissolved gas not to cause objectionable odors or be deleterious to uses of such waters	> 10 % samples exceed standard and at least 2 exceedences for season of interest or survey that identifies impairment of beneficial use	No data reviewed.

Table 3-2 Cont.				
Water Quality Parameter	**Beneficial Uses Affected**	**Water Quality Standard or Criteria**	**Water Quality Limited Criteria**	**Issue of Concern for Rickreall Creek?**
Chlorophyll a	Water contact recreation Aesthetics Fishing Water supply Livestock watering	Natural lakes which thermally stratify 10 ug/L Natural lakes which do not thermally stratify, reservoirs, rivers and estuaries 15 ug/L	3 month average exceeds standard	Concentrations at Highway 51 (River Mile 1) ranged from 1 to 6 ug/L.. Upstream of WWTP range from 1 to 3 ug/L. Maximum expected concentration is 20 ug/L. See Tables 3-3 and 3-4.
Aquatic weeds or algae	Water contact recreation Aesthetics Fishing	Development of fungi or other growths having deleterious effect on stream bottoms, fish, other aquatic life, health, recreation or industry	Macrophytes documented as abundant, invasive non-natives Periphyton (attached algae) or phytoplankton (floating algae) documented as causing other exceedence of other standards or impairing beneficial use	Some evidence of abundant periphyton at River Mile 6 (above Morrow Rd) observed by analysts during a canoe survey of River Miles 8 to 5 during June, 2000.
Biological criteria	Resident fish and aquatic life	Waters shall be of sufficient quality to support aquatic species without detrimental changes in resident biological communities	Data on aquatic community status shows impaired condition	Some evidence of shifts of macroinvertebrate communities in lower section. See chapter 5.
Habitat modification	Resident fish and aquatic life Salmonid spawning and rearing	Creation of conditions that are deleterious to fish or other aquatic life are not allowed	Documentation that habitat conditions are a significant limitation to fish or other aquatic life	Mercer reservoir has no fish passage and is trapping sediment. However existing data does not document an effect on fish. See Chapter 5.
Toxics	Resident fish and aquatic life	Full criteria listed in Oregon Administrative Rules 340-41-445(2)(p)(B) Table 20. Copper 18 up/L acute; 12 ug/L chronic.	Exceeds standard 10% of the time and for at least two values Found in sediments or tissue in concentrations that exceed standards or screening values	High copper concentrations (200 to 300 ug/L) occur in Rickreall Creek from discharges from Dallas WWTP. Copper concentrations are to be brought to standards by Phase III of plant upgrade (by 2008).
Total dissolved solids	All beneficial uses	Guide concentration Willamette River and tributaries 100.0 mg/L	Not to exceed guide concentration	Elevated concentrations of dissolved solids (200 to 300 ug/L) occur downstream of Dallas WWTP. Phase III is not expected to achieve standards. However no significant impairment to beneficial uses is anticipated.

Rickreall Creek and the 303(d) List

Section 303(d) of the Clean Water Act requires each state to develop a list of waters that do not meet state standards for water quality (see Appendix 3-3 about the 303(d) list). Rickreall Creek was originally placed on the list for: 1) flow modification and 2) temperature (summer) from the mouth of the river to Mercer Reservoir and 3) dissolved oxygen. In 1994 the Department of Environmental Quality 1994 Water Quality Assessment Report indicated that the beneficial uses of Rickreall Creek were not entirely supported by instream water quality. The report stated that low dissolved oxygen, chlorine toxicity, and high temperature affected aquatic life. The determination was made based on the ambient water quality standards in effect at the time and the salmonid spawning, incubation and rearing designation by Oregon Department of Fish and Wildlife. As a result of the change in designated beneficial use and the design of a Total Maximum Daily Load (TMDL, see Appendix 3-4 for explanation) for dissolved oxygen, Rickreall Creek was removed from the 303(d) list for dissolved oxygen. The most recent (1998) 303(d) list includes Rickreall Creek for flow modification and temperature. The beneficial uses that are affected by these parameters are resident fish and aquatic life, and salmonid spawning and rearing. Appendix 3-5 provides greater details about the listing criteria for these two parameters of concern.

City of Dallas Wasterwater Treatment Plant (WWTP)

The City of Dallas has a municipal wastewater treatment plant at River Mile 9.2 that discharges to surface water. Operation of a new facility began in June 1999 and the facility was fully operational after this major upgrade in September 1999. The prior wastewater treatment plant had been operating at that same site since 1969. Before that, another plant or treatment facility is reported to have been operating since 1950 at River Mile 14 (K. Carter, City of Dallas). The current wastewater treatment facility discharges treated effluent to Rickreall Creek under a National Pollution Discharge Elimination System (NPDES) permit issued by the Department of Environmental Quality (DEQ).

The WWTP is in the process of being upgraded in three phases. The plant is allowed to operate under interim limits, which are based on what the treatment plant and collection system is actually capable of achieving with good operation. Based on the approved Facility Plan and variances, an NPDES permit was issued by DEQ in January of 1998. This permit outlines the phased implementation of facility improvements recommended, and defines effluent limits for each phase. The permit also required that a temperature management plan be submitted to DEQ and specified temperature-monitoring requirements as part of the permit. The three phases are described briefly here and can be found in detail in CH2M Hill (1996).

Phase I is the new WWTP, completed in 1999. Phase I provides significant reductions in oxygen demanding pollutants, elimination of chlorine, and includes an expansion of treatment capacity so that the risk of raw sewage overflows is greatly diminished. This will significantly improve the effluent quality, however, water quality based limits such as those for certain heavy metals that are not expected to be met will be addressed in later Phases Il and III.

In Phase II, to be operational in 2005, some industrial discharges will be segregated from the domestic wastewater system and transported to a dedicated industrial treatment facility, covered by a separate permit. This will result in significant reductions in copper and ammonia loading on the WWTP.

In Phase III, to be complete and operational by 2008, effluent filters will be installed to bring the discharge into compliance with all permit limits, and should result in compliance with all water quality based standards with the possible exception of copper.

Other Industrial Dischargers

Major industries in the watershed are Willamette Industries and Tyco Printed Circuit Group (formerly Praegitzer Industries). Willamette Industries processes timber; Tyco manufactures printed-circuit boards. Currently, neither industry foresees significant increases in their flows to the wastewater collection system. Indeed, Willamette Industries closed its plywood portion of the mill this year. Because of the large volume of industrial flow from the two major industries, which adds little biological oxygen demand and total suspended solids, wastewater entering the sewage treatment plant is dilute. (DEQ, 1993—Rickreall Creek Water Quality Report, Total Maximum Daily Load Program)

DEQ staff stated that they have concerns about the metals, particularly copper, passing through the WWTP from Tyco. There is a pilot effort underway (part of Phase II WWTP facility upgrade) which will segregate industrial wastewater from municipal wastewater. This pilot involves discharge water from Tyco being put into a lagoon and land applied to a poplar tree plantation. DEQ has approved the City's industrial pretreatment program. A permit has been issued for this activity by the City to Tyco. The plantation is tile drained which creates another concern; which is the flushing of higher than desirable levels of total dissolved solids. It is not know if this will become a water quality concern. See (CH2MHill, 1998) for a more detailed review of the industrial effluent poplar tree reuse system.

Copper, while it is not highly leachable from soils, may be an issue for runoff from the pilot poplar site. Safeguards to reduce site runoff and soil erosion in the pilot study and the operational site will be critical to the project success. Currently all of the industrial wastewater is still being discharged to the WWTP. These discharges might be in violation of the copper criteria in Rickreall Creek. (DEQ, 2000, personal communication)

Stormwater Management

Stormwater is runoff that accumulates in and flows through natural and/or human-made storage and conveyance systems during and immediately following a storm event. This water can carry pollutants to creeks, lakes, wetlands, coastal waters, and groundwater, and can impair water quality. Proper management of stormwater can help prevent impaired water bodies, degraded animal habitats, polluted drinking water, increased flooding, and hydrologic changes to streams, lakes, wetlands and rivers. (American Public Works Association, 1999)

The Environmental Protection Agency (EPA) began a program to address pollution from storm water in 1990. Storm water dischargers from municipal, industrial, and construction sites are being brought into a permitting program by phases that are being introduced over a fifteen-year period.

The City of Dallas has already implemented much of what is typically in a storm water program but not in a formalized manner (K. Carter, City of Dallas).

Water Quality of Rickreall Creek Watershed

Historical conditions

The Bureau of Land Management, in preparing a watershed analysis of their lands in the vicinity of Rickreall Creek (BLM 1998), attempted to describe historic water quality conditions. Their description is summarized in the following two paragraphs.

The lowlands along the Rickreall, Luckiamute and Mill Creek main stems had an overall tendency (due to the low gradients and unconfined settings) toward lower stream velocities, greater sediment storage, and a high amount of wetland habitats. Relatively high water tables all year round and the long-term maintenance of a shaded stream canopy likely maintained stable stream temperatures with little annual and diurnal variation.

Upstream, in higher gradient, higher energy streams, water quality was less buffered from variations in response to disturbance events, and annual and diurnal climatic influences. Stream temperatures may have been in the high 60's F in small channels whose riparian shade had been removed by fire. Pulses of sediment and leachable nutrients (phosphorus, nitrate, etc) entered the channel during winter storms and when fires increased their availability. During stable periods, nutrient concentrations were likely low and often were a major limiting factor in the abundance of aquatic plant and animal life. Higher stream velocities and channel roughness generally kept the waters well oxygenated, and the influence of vegetation and aquatic animals on water chemistry was probably small when compared to the lowlands.

Current water quality qata

Water quality data reviewed for Rickreall Creek were taken from a compilation of 60 pages of data reproduced in a CH2M Hill, Technical Memorandum dated December 1995 (provided by K. Carter, City of Dallas). Most of the data originated from DEQ from the STORET database; some is modeled values produced by CH2MHill. Data spans the years 1957 to 1995 and were summarized by months, though data has not been collected in a regular manner. Water quality data are available for 12 locations from Rickreall Creek river-mile 0.1 to river-mile 23. In most cases, the data appear to be grab samples, but in more recent years, (1989) there was some continuous monitoring. The most recent data available for this assessment were from 1995.

Sample data have been selected to provide a general representation of water quality data that are available on the 60-page compilation. Some years and river reaches are better represented in the data than others are. Tables 3-3 through 3-5 are a group of three sites on the mainstem of Rickreall Creek downstream from Dallas. These were sites with the greatest coverage of years, and also represented three widely dispersed sites. Table 3-6 presents data from Rickreall above the City of Dallas. Table 3-7 shows modeled results of expected water quality for tributary systems below the City of Dallas. CH2M Hill is used as a consultant for water planning for the City and used a water quality model and data from Nevada and Idaho to estimate nutrient, conductivity and bacteria data for Hayden Slough, Basket Slough and the nonpoint sources between Highways 99 and 51(NPS-Area). They used their best guess to estimate BOD_5, Temperature and DO data for the NPS-Area.

Table 3-3: Nine years of low flow water quality data collected on Rickreall Creek at River Mile 2.2 (Highway 51 Bridge).

Year	Month	Fecal Coliform MPN/100ml	BOD_5 mg/L	NH_3-N mg/L	OPO_4 mg/L	D.O. % sat.	D.O. mg/L	Temp F	pH
1957	July-Sept	--	1.1-3.1	-	--	55-73	5.1-6.7	66-68	6.7-7.0
1958	July-Sept	--	2.6-12.0	-	--	54-85	5.5-7.4	59-73	7.0
1965	Aug	--	2.3	-	--	65	6.1	59	7.1
1969	Sept	450	0.7-2.0	0.13	--	59	6.0	60	7.0
1970	Aug	450	0.8-1.0	0.07	--	--	--	--	--
1971	Aug	60-230	0.7-0.9	0.17	--	63	6.0	65	7.0
1972	Sept	2400	--	0.16	--	27	2.8	59	6.7-6.9
1989	Oct	25-93	1.3-1.4	0.03	0.15-0.29	81	7.9-8.6	51-58	7.4-7.5
1992	Oct	22-33	1.1-1.4	0.04	0.10-.011	70	7.4	55-57	7.3-7.4

Table 3-4: Seven years of low flow water quality data collected on Rickreall Creek at River Mile 8.2 (Highway 99W).

Year	Month	Fecal Coliform MPN/100ml	BOD_5 mg/L	NH_3-N mg/L	OPO_4 mg/L	D.O. % sat.	D.O. mg/L	Temp F	pH
196	Oct	--	1.1	0.12	--	79	8.4	55	7.1
1967	Aug	--	1.2-6.9	0.33	--	70	6.2-7.0	61-70	6.8-6.9
1971	Sept	23-620	0.8	--	--	89	7.0	60	7.0
1973	Aug	--	--	--	--	--	--	68	--
1975	Sept	60	2.8	--	--	100	9.7	63	7.2
1989	Oct	>1200	3.8	0.08	0.46	54-91	5.7-9.6	53-57	7.0-7.4
1992	Oct	>1200	0.9	0.03	0.36-.042	62-65	6.6-7.3	50-55	7.2-7.3

Table 3-5: Four years of low flow water quality data collected on Rickreall Creek at River Mile 16.7 (Levens Street, in Dallas).

Year	Mont h	Fecal Coliform MPN/100ml	BOD_5 mg/L	NH_3-N mg/L	OPO_4 mg/L	D.O. % sat.	D.O. mg/L	Temp F	pH
1973	Aug	--	--	--	--	--	9.8	67	--
1975	Sept	45	0.02	0.02	--	105	10.5	61	7.5
1989	Oct	<3	0.04	0.04	0.01	--	11.6	50	7.8
1992	Oct	49	0.03	0.03	0.01	96	10.5	53	7.6

Table 3-6: Water quality for Rickreall Creek at various River Miles during three years from 1973, 1989 and 1992.

	Data by River Mile									
River Mile:	**23.3**	**16.7**	**15.0**	**11.7**	**10.3**	**8.2**	**6.5**	**5**	**2.2**	**0.8**
1973 (Aug 13)										
D.O. (mg/L)	9.7	9.8	9.9	9.3	--	6.7	--	6.6	--	6.5
Temp (F)	71	67	66	71.6	--	68	--	66	--	66
pH	--	--	--	--	--	--	--	--	--	--
Ec (umhos/cm)	--	--	--	--	--	--	--	--	--	--
1989 (Oct 18)										
D.O. (mg/L)	--	11.6	9.9	9.1-10.6	--	6.8-9.0	9.1	--	7.9	--
Temp (F)	--	50	52.7	51-53	--	53-58	54	--	52	--
pH	--	7.8	7.4	7.2-7.5	--	7.1-7.3	7.5	--	7.4	--
Ec (umhos/cm)	--	117	214	201-222	152-163*	228	257	229	213-259	--
1992 (Oct. 5)										
D.O. (mg/L)	--	10.5	--	--	10.3	6.6	--	8.8	7.3	--
Temp (F)	--	53	--	--	53	55	--	57	57	--
pH	--	7.6	--	--	7.5	7.2	--	7.4	7.4	--
Ec (umhos/cm)	--	214	--	--	235-236	329-350	--	357	357-361	--

Diurnal range of data values obtained by sampling at 15- minute intervals over 24-hour period.

Table 3-7: Modeled water quality data for upper Rickreall Creek mainstem, two lower section tributaries, and the NPS area.

Season	**flow cfs**	**Temp F**	**DO mg/L**	**BOD mg/L**	**NH4-N mg/L**	**NO2+ NO3-N mg/L**	**Org-N mg/L**	**OPO4 mg/L**	**chloro phyll-a mg/L**	**TDS mg/L**	**fecal coliform #/100 mL**	**Turbidity NTU**
Rickreall mainstem upstream of Dallas												
Spring	81	54	10.7	1	0.04	0.04	0.18	0.01	1	102	20	4
Summer	6	64	9.5	1	0.05	0.04	0.17	0.01	1	102	20	1
Fall	15	54	10.8	1	0.03	0.03	0.20	0.01	1	102	20	1
Winter	485	45	12.0	1	0.03	0.03	0.20	0.01	1	65	20	4
Baskett Slough and Hayden Creek (modeled results were the same)												
Spring	4.0	56	8.3	1.2	0.06	0.2	1.0	0.15	5.0	150	2,000	6.2
Summer	0.3	63	5.0	7.0	0.12	0.2	1.9	0.05	10.0	300	2,000	3.1
Fall	0.8	56	8.3	1.2	0.06	1.0	1.0	0.15	15.0	300	2,000	3.1
Winter	24.0	50	9.0	1.2	0.06	0.2	1.0	0.15	1.0	300	2,000	6.2
Non-point source area to Rickreall Creek between Highways 99 and 51												
Spring	2.0	58	5.0	7.9	2.0	2.2	1.0	0.3	1.0	300	5,000	6.2
Summer	0.2	63	5.0	7.9	2.0	2.2	1.0	0.3	5.0	300	5,000	3.1
Fall	0.6	57	5.0	7.9	2.0	1.0	1.0	0.3	1.0	300	5,000	3.1
Winter	19	50	9.0	7.9	2.0	2.2	1.0	0.3	1.0	300	5,000	6.2

Following are discussions of the key water quality parameters.

Aquatic weeds and algae

No historical aquatic weeds or algae data found for Rickreall Creek Watershed. Attached and floating filamentous green algae were observed in June 2000 at River Mile 6 (just upstream of the Morrow Road crossing) by the watershed analysts. Algae production is somewhat high in the lower watershed due to the physical characteristics of the stream (K.Carter, City of Dallas). There were no such widespread alga growths upstream from the WWTP on the same days.

Fecal coliform bacteria

The single sample standard was regularly exceeded from River Mile 8.2 (Highway 99 bridge) and points downstream from 1969 to 1992 sample dates. This standard was not exceeded at river mile 16.7 (Levens Street) in the three years of available data for that location. A CH2MHill report attributed the increases in fecal coliform to local NPS-Area and agricultural drains (CH2M Hill, 1995). High bacteria concentrations were the most commonly exceeded standard in small streams in the Willamette Valley and most high values occurred during high stream flows (Anderson et al. 1997). Past sewage overflows from the WWTP, failing septic systems, and urban runoff could also have contributed to these high fecal coliform numbers in Rickreall. But as a result of system upgrades, there has not been a sanitary sewer overflow since 1999 (K. Carter, City of Dallas).

Conductivity

Historical data show significant increases in conductivity downstream of River Mile 8.2 (Highway 99W). Conductivity data for the low flow selected low flow periods in October of years 1989 and 1992 show increasing conductivity from upstream to downstream sample sites. The lowest values (117 umhos/cm in 1989 and 214 umhos/cm in 1992) in both years were from the farthest upstream sample location (river mile 16.7) and the values increase at River Mile 8.2 and down stream (220 to 360 umhos/cm). Increases in conductivity indicate greater concentrations of dissolved ions and possible sources to the stream.

Copper

Existing background copper concentrations in Rickreall Creek have been measured at concentrations ranging from 4u/L to 8 u/L. These “background” concentrations already approach the standard of 12 mg/L (City of Dallas, July 1996)

Although chronic and acute concentrations of copper have been established by DEQ (Table 3-2), it has been demonstrated that site specific conditions may modify copper toxicity to the extent that less stringent standards could be applied based on site specific modifiers (DOB’s et al 1994). The City of Dallas (1996) report documents evidence of aquatic life that has been collected near the mixing zone within 200 feet of the WWTP outfall, where copper concentrations range from 200u/L to 300u/L. The report proposes that these findings of aquatic life show that initial concentrations of copper are being diluted or environmental conditions are mitigating copper toxicity to some extent. Bioassay results suggest that copper is largely unavailable, because copper is adsorbing onto organic matter in the effluent. However it is reasonable to assume that some copper will partition back to the dissolved phase upon interaction with the receiving water and may then become available to fish and aquatic organisms. (CH2MHill, 1996)

It is likely that Rickreall Creek regularly violates the instream standards for copper downstream from the Dallas discharge during periods of low dilution. However, copper concentrations are expected to decrease substantially when Phase II of the WWTP upgrade is completed when industrial effluent will be separated and used for poplar tree irrigation, thereby reducing copper concentrations in the WWTP effluent to approximately 20-50 u/L during 7Q10flow (City of Dallas, 1996). These concentrations are expected to decrease even more in Phase III when some industrial contributions are removed after Phase II of the Dallas sewage treatment plant improvements but may also not comply with the standard until after completion of Phase III. (DEQ, 1997)

Dissolved oxygen

Water quality data for dissolved oxygen for Rickreall Creek show high levels for the entire creek during high flow periods (Tables 3-3 through 3-5). Data, by river mile, also show Rickreall Creek typically maintains DO levels of 9 mg/L and above in sections upstream of approximately river mile 11.7, even during low flow periods (Table 3-6).

Lower levels of dissolved oxygen tend to occur in the lower river during the summer low-flow period of July and August. The data for river mile 2.2 and river mile 8.2 show several periods when at low flow DO levels were reported below the 6.0 mg/L. This is less than the cool water standard listed in Table 3-2 (see Appendix 3-5 for greater detail on the standards). Diurnal fluctuations in DO can be seen in the range of data in Table 3-4 from October, 1989 when DO levels fluctuated from 5.7 to 9.6 mg/l over the course of a 24 hours (15-minute sample intervals).

A TMDL (see Appendix 3-4 for background) was established for biological oxygen demand (BOD) in 1995 and therefore Rickreall Creek is no longer on 303(d) list for Dissolved Oxygen. The way the Clean Water Act is written, Rickreall Creek will maintain its status as "water quality limited" for dissolved oxygen as long as it does not meet the State standard. Instream concentrations periodically drop below the 6.5 mg/L standard during the summer. However, the waste load allocations assigned to Dallas in the December 1993 TMDL are not applicable due to new instream dissolved oxygen standards and the change in salmonid classification. Dissolved oxygen levels are improved since the Phase I improvements to the Dallas sewage treatment plant but will not consistently comply with the instream standard until after Phase III is complete and operational (DEQ, 1997).

Flow Modification

Rickreall Creek is on the 303(d) list for flow modification from the mouth to Mercer Reservoir. See Water Quantity Chapter 4 for water quantity issues.

Macroinvertebrate survey data

Macroinvertebrate bioassessments were performed at three sites on Rickreall Creek in 1995 (data provided by K. Carter, City of Dallas). Site 1 was 150 m upstream of the WWTP. Sites 2 and 3 were downstream, Site 2 was 2000 m downstream of the WWTP and Site 3 was at Greenwood Road, 5 miles downstream of the WWTP. The macroinvertebrate communities were different at each site sampled. Taxa and relative abundance for the three sites are given in Appendix 3-6. Site 2, downstream of the WWTP, had "reduced fauna that was heavily dominated by Chironomids." This indicated poor water quality. See Appendix 3-6 for complete bioassessment data, which compares two downstream sites to the upstream site (Tables 1-4). The results indicate that the two downstream sites were moderately impaired. The increase in Ephemeroptera-Plecoptera -Trichoptera at the Greenwood Road Site 3 indicates some recovery of water quality from the Site 2, located 2000 m downstream from the WWTP. Similar habitat scores at the three sites indicate that the differences in abundance and in pollution-tolerant taxa are related to differences in water quality at the three sites (DEQ, 1989).

Ammonia

Water quality criteria for ammonia are dependent on water temperature and pH. Historical data for Rickreall Creek do not show any levels above the standards (standards for ammonia presented in Appendix 3-5). The new City of Dallas Wastewater Treatment Plant is designed to meet both acute and chronic water quality criteria. Chemical and organic waste spills are potential sources of acute concentrations of ammonia. Safeguards against spills and emergency spill plans are critical elements to prevent fish kills from toxic ammonia levels.

Nitrate

The historical data do not show any instances where Rickreall Creek water exceeded the 10-mg/L “evaluation indicator” (benchmark used when there is no established standard). The WWTP exceeded this amount in several of the effluent samples in the historical data set, however the concentrations were only as high as 15 and 18 mg/L and would have been diluted in the outfall mixing zone to less than 10 mg/L.

Phosphorus (total P)

Historical data for Rickreall Creek shows this indicator value is frequently exceeded below River Mile 8.2. From River Mile 8.2 to the mouth total phosphorus (TP) concentrations exceeded the evaluation indicator concentration in about 75 % percent of the samples, while none of the samples exceeded this indicator value from River Mile 11.7 (Fir Villa Road) and upstream. WWTP effluent data from 1989 showed TP values from 0.1 to 6.9 mg/l. There was a letter from DEQ on these high TP levels in December 1993 and it was suggested that the values in the data were being expressed as phosphate rather than as elemental-P. This caused the results for TP to look about three times higher than they were. Using this correction, the WWTP effluent data for years 1988, 1989, 1992 and 1993 are consistently in the range of 1 to 2 mg/l TP.

pH

Water quality data indicate that pH values are within the standards, see Tables 3-3 to 3.5.

Sediment

Upper watershed has high sediment delivery events. See Chapter 6 for discussion.

Temperature

The temperature standard is violated in Rickreall Creek most summers (May through October) from the mouth to Mercer Reservoir. Because of the water quality limited status, the WWTP discharge is not allowed to cause a measurable increase (0.25 degrees F) in the stream temperature outside of the mixing zone because of the low levels of dilution available (DEQ, 1997).

Temperature continues to increase downstream and generally exceeds the proposed DEQ standard of 64 degrees F for several weeks throughout the summer. Measured temperatures in the stream system during the 1995 July-August period averaged nearly 66 degrees F just upstream of the WWTP and more than 68 degrees F at Highway 51 (CH2MHill, 1995) It is not clear to what extent temperature has changed compared to reference conditions of the creek.

Total dissolved solids

Rickreall Creek routinely exceeds the total dissolved solids (TDS) guideline both upstream and downstream of the WWTP outfall. While the guideline is 100 mg/l TDS, the creek ranges from 70 mg/l to 130 mg/L TDS upstream from the discharge (DEQ, 1997).

According to the City of Dallas, (1996) TDS modeling results indicate that after implementation of Phase III of the WWTP upgrade, in-stream concentrations are expected to exceed the 100 mg/L guideline at times. Based on stream water quality sampling, upstream levels of TDS typically exceed the TDS guideline. Because the TDS criteria are a guideline and not a standard, stream specific conditions typically dictate the acceptable TDC concentration to be used. After implementation of Phase III-WWTP upgrade, TDS concentrations of 130 to 250 mg/L are not expected to cause a significant impact to downstream aquatic resources. This argument is made because current background concentrations typically exceed the established guideline, and they concluded that acceptable levels of TDS could be higher for Rickreall Creek. In addition, although TDS levels are expected to range from 230mg/L to 360 mg/L during Phases I and II of the WWTP upgrade, no short-term significant impacts at these current levels and no apparent significant impacts have been identified in Rickreall Creek. (City of Dallas, 1996 and CH2MHill (1996a).

CH2MHill (1996a) reports that the WWTP effluent contribution to the TDS and the exceedance of the TDS guideline would not adversely impact beneficial aquatic resources in Rickreall Creek. They reach this conclusion because current and anticipated TDS concentrations are two orders of magnitude lower than levels reported to cause adverse effects for most aquatic species, 10,000 mg/L (citing EPA, 1987). Furthermore, current and anticipated TDS levels in Rickreall Creek will remain lower than the EPA drinking water standard of 500 mg/L.

Toxics

Poly-aromatic hydrocarbons (PAHs) Semi- and Volatile-Organics (Sediment) Data were cited from the USGS, Willamette Basin. DEQ cites the Willamette River Basin Water Quality Study Phase I and II (DEQ 1998-303(d) List Rationale) as a basis for consideration of listing Rickreall Creek for several toxic substances. These included Anthracene, Bis(2Ethylhexl)phthalate, Floranthene, Phenol and Pyrene, which were found in sediments, but at values below guidelines and guidance values. No beneficial use impairment evaluations are available that show a toxicity problem. Other toxic substances were found that had no well established guidelines available for evaluating risks nor for evaluating whether beneficial uses are impaired (Azobenzene, Butylbenzylpthalate, Di-n-butylphthalate, P-cresol, and Phenanthrene are in this latter group). The 1998 listing status for these chemicals is OK.

Pesticides

According to DEQ rationale pesticides detected in water include Atrazine, Cycloate, Desethylatrzine, Hexizone, Metolachlor, Prometon and Simizine. These were found in the course of the Willamette Basin Study Phase I and II. These pesticides either do not have established standards or were in concentrations below standards, criteria or guidance levels. No pesticides were detected in the sediment in that study.

Metals (Sediment)

Copper, Antimony Chromium, Manganese, Nickel, and Zinc were found in elevated levels in sediments when compared to various guidelines or guidance values, however sediment toxicity does not correlate well with sediment contaminant concentration and is dependent on local conditions. No data on beneficial impairment (bioassays) is available. Therefore there is no justification for a listing of metals in sediment.

Turbidity

No data found for Rickreall Creek Watershed but see the modeled values in Table 3-7. Standards allow not more than a ten- percent cumulative increases in background turbidity as a result of any activity (see Appendix 3-5).

Groundwater Quality

Studies done by the United States Geological Survey show that the quality of the groundwater in the area of the watershed varies widely. Water from shallow depths in the consolidated rocks generally is of good quality. However, water in the consolidated rocks contains increasing concentrations of dissolved mineral solids with increasing depth in the rocks and commonly is too mineralized for most uses. Unconsolidated deposits generally contain water suitable for most uses, but in localized areas the water may contain high concentrations of iron or manganese or dissolved solids and may require treatment for some uses.

A report by Gonthier (1983) found that the major groundwater related problems in the area were low well yield and poor-quality groundwater. These problems commonly occur together in individual wells and they occur most frequently in wells drilled into consolidated rocks. The consolidated rocks consist chiefly of low-permeability formations that generally contain water with increasing concentrations of dissolved materials with depth below the land surface. Commonly, several wells are drilled into the consolidated rocks before an adequate domestic water supply is obtained. (Gonthier 1983)

Sodium contamination (salt water) is common in many wells in Polk County. The sodium is from marine deposits and generally occurs in deeper wells. Gonthier (1983) noted that salt water is more likely in valleys near streams than in upland sites. Bernert (1994) reported that nitrate is an important parameter in groundwater contamination in Polk County. High nitrate values typically are observed in lowland valleys and tend to be associated with intensive agricultural landuse. Areas with elevated nitrate might also be likely to expect elevated concentrations of the more mobile pesticides. (Bernert 1994)

Evidence gathered in a 1993-1995 study conducted in Willamette Basin indicates that there is concern of nitrate contamination of shallow wells developed in alluvium agricultural areas (Hinkle 1997). The domestic wells sampled in that study were all less than 80 feet deep and were developed in alluvium. Nitrate concentrations ranged from less than 0.05 to 26.0 mg N L^{-1}. Nine percent of wells sampled exceeded the 10-mg N L^{-1} standard. (Hinkle 1997).

Thirteen different pesticides were detected in the 1993-1995 study of shallow groundwater, but concentrations were low with only 1 detection exceeding USEPA standards (Hinkle 1997). Atriazine was the most frequently detected pesticide.

Bonn and Hinkle (1995). did an analysis of water quality data for groundwater of the Willamette Basin, Oregon, (1980-90). The data set consisted of information from DEQ (123 wells in agricultural areas) and the Oregon Department of Human Resources Health Division (ODH, 312 public water supply wells). They found that elevated NO3-N concentrations generally were associated with shallow wells; NO3-N concentrations exhibited a weak inverse relation with depth. The greatest NO3-N concentrations occurred in wells sampled by DEQ in a study that targeted shallow wells in agricultural areas. The MCL (standard) for NO3-N was exceeded at 26 of 123 DEQ wells. The DEQ data, however, were not significantly different from a comparable subset of the ODH data (shallow wells completed in basin-fill and alluvial aquifer and identified as agricultural land use) (Bonn and Hinkle 1995).

While these data are not specific to the Rickreall Creek Watershed the trends shown for the Willamette Basin provide important information as to the status of groundwater quality in the region.

Contamination of Groundwater

Groundwater contamination does not appear to be a major or widespread problem in the watershed, but local occurrences have been reported. Pollution of groundwater will occur if facilities for the disposal of wastes or for application of other degrading substances are poorly designed, operated and maintained for the type of soil conditions existing at a disposal site or if the potential pollutants are handled carelessly. Gonthier, (1983) found that the risk of pollution is higher in the sand and gravel and the younger alluvium because of their high porosity and permeability and shallow depth. Locally, groundwater from sand and gravel aquifers contains concentrations of iron and manganese that may be excessive for some types of uses (Gonthier 1983).

The Rickreall Community Water Association routinely monitors for constituents in drinking water supplies. The water source is from four wells located along Highway 51 north of Independence, Oregon. The monitoring results in their 1999 Annual Drinking Water Quality Report show no detections of 75 contaminants. The only contaminant present was Nitrate (as nitrogen), which was present at a level of 12.6mg/l in one of the wells, which is 2.6mg/l above the maximum contaminant level, the highest level of a contaminant that is allowed in drinking water. (Rickreall Community Water Association, 1999)

Potential groundwater problems from nonpoint sources of pollution are discussed in Chapter 6. Some potential sources include:

- Solid and hazardous waste
- Superfund sites
- Underground storage site tanks
- Reported spill sites
- Land application of municipal and industrial wastes
- Land application of septage/sludge
- Failing septic systems

Well construction, wellhead protection and groundwater testing are proactive management tools that can be used to help protect groundwater quality. Improperly constructed drinking water wells—those wells not constructed to state standards or with poor seals— can act as a conduit for contaminants to enter aquifers from both point and nonpoint sources. Properly constructed and maintained wells can help prevent the introduction of contaminants into aquifers.

Potable groundwater is viewed as a critical priority for Oregon’s continued economic viability. It may be useful to the Watershed Council to evaluate the potential benefits of creating a local wellhead protection program, which would be administered with assistance from DEQ, but implemented locally. By working together, local and state governments can implement custom designed local Wellhead Protection Programs to protect local groundwater resources. See DEQ (1992) for more details.

The Rickreall Creek Watershed Council could conduct a groundwater education and outreach program, including providing rural watershed residents and landowners with well water testing. Offering free or subsidized water testing for parameters such as nitrates and bacteria can be good way to start a dialogue with landowners about the watershed.

Water Quantity and its Relationship to Water Quality

For a detailed discussion of water quantity/flow issues in the watershed see Chapter 4. It is important to view water quality and water quantity in an integrated way in both the assessment as well as in management practices that may stem from this assessment. Estimates of water quantity are necessary for evaluation of water quality impacts as well as estimating critical flow processes such as flood and drought frequency.

Water quantity is of critical concern in Polk County because of the variable, but generally low, groundwater availability and low stream flow during the summer period. Lack of water in some cases has limited the industrial and residential growth in the county. Low stream discharge also poses a problem regarding discharge of sewage effluent. Streamflow can be such that a significant portion of stream discharge in late summer can be comprised of sewage effluent.

Rickreall Creek Water Quality Summary

Key water quality issues of ongoing concern in Rickreall Creek include two parameters for which it has been placed on the 303(d) list; temperature and flow modification. Two other parameters, that are not included in the listing, but which warrant continued attention, include metals, particularly copper and dissolved oxygen. Copper should be largely addressed in Phase II and III of the Dallas Wastewater Treatment Plant upgrade, but Phase III will not be operational until 2008. Also there has been some opposition to the on land application system from private citizens. Dissolved oxygen is being managed under an approved TMDL .

The water quality data for lower Rickreall Creek indicate a trend towards more eutrophic stream conditions (i.e., enriched with nutrients that enhance algae and aquatic plant growth). These conditions can create some moderate impairment of beneficial uses. A lack of early historical stream data makes it difficult to say what were the reference stream conditions, how much change has taken place and how long conditions have been impaired. The lower reach likely has been affected in the past by the combined effects of runoff from agricultural areas, effluent from the WWTP, failing private onsite sewage systems, stormwater from urban areas, and even log drives and natural stream bank erosion. Evidence of impairment includes total phosphorus levels that were greater than indicator concentration, fecal coliform bacteria that consistently exceeded standards over the period of water quality data and excessive growths of filamentous algae. Limited bioassessment data further support this characterization; available macroinvertebrate sampling data show some evidence of impaired water quality downstream of the WWTP with recovery further downstream near Greenwood.

Total dissolved solids concentrations are elevated in the lower creek but also in reaches above the WWTP.

The recent construction of a new WWTP and the full implementation of the final phases of the wastewater treatment facility should help improve water quality in the lower Rickreall. The new plant has eliminated chlorine additions, provides significant reductions in oxygen demanding pollutants and greatly reduced the risk of raw sewage overflows. The City of Dallas is also involved in improving the quality of urban runoff with programs such as street sweeping. Dallas will play an even larger role by developing a stormwater management plan by 2005. The agricultural community and other rural landowners are currently in the planning stages for the Senate Bill 1010, Agricultural Water Quality Management Plan, and will have a large responsibility in improving water quality in the lower Rickreall and especially in the agricultural tributaries.

The middle reach of the creek between the WWTP and the Mercer Dam generally has good water quality. Exceptions include temperature and TDS, which sometimes exceed standards in this reach. The City of Dallas is actively acquiring easements and ownership of riparian lands immediately adjacent to Rickreall Creek within the City limits and is using riparian revegetation to help mitigate temperatures as part of a larger temperature management plan.

There was no water quality data found for the upper extents of Rickreall Creek above Mercer Reservoir. The City of Dallas began collecting temperature data for several tributary streams this year. Those data should prove useful in future watershed assessments. There have been recent instances of severe sedimentation reported in the upper watershed following the Rockhouse Creek fire and the February 1996 storms, these are discussed in Chapter 6. The health of the upper watershed depends on following the best management practices of the Forest Practices Act, largely aimed at controlling sediment and stream temperatures. There are a number of potential nonpoint sources in both rural and urban areas that have not adequately been evaluated for their impacts on water quality, including urban stormwater, agricultural drainage systems, private onsite wastewater systems, highway runoff, and forest roads.

Potable groundwater is a priority for healthy watersheds and continued economic viability in the area. While the City of Dallas currently gets its water from Rickreall Creek, many rural residents and communities like Rickreall and Independence depend on groundwater. The major groundwater issues in the area are low yielding wells, and a number of wells yield poor-quality groundwater. Sodium contamination (salt water) occurs in some wells that draw from Coast Range rock aquifers. There is nitrate contamination of some wells developed in valley alluvium aquifers. These aquifers occur under high intensity irrigated agricultural lands and this highlights the importance of protecting groundwater from agricultural chemicals. Proper well construction, wellhead protection and groundwater testing are proactive measures to help protect groundwater quality. The watershed council can work cooperatively with landowners and residents and with local and state governments to promote and implement a wellhead protection program and conduct groundwater education and outreach activities that include voluntary well-water testing programs.

The Rickreall Creek Watershed could benefit from a systematic, long-term monitoring program to evaluate of water quality trends over time. An important consideration for future assessment efforts will be development of a monitoring program for water quality and quantity throughout the watershed. Because of natural variation in flow and water quality characteristics, these efforts will be most valuable if they can be maintained for periods spanning more than a single water year. In the future, the Watershed Council could advocate for gathering water quality data where there are current gaps. Future efforts could address natural versus anthropogenic effects on water quality in the watershed. Other projects could be designed around particular smaller drainages and could attempt to quantify nonpoint impacts in subwatersheds such as Basket and Hayden Slough. The Watershed Council could work cooperatively with the City of Dallas, large forest landowners and BLM and USFS to monitor streams in the headwaters.

Chapter 4 : WATER QUANTITY

Hydrologic Data

Rickreall Creek has multiple years of stream flow data at two gage locations—Dallas and Rickreall. Collectively the two stations have data for the years 1958 to 1985. The station at Dallas is actually upstream of the city of Dallas and below the original water intake of Dallas at River Mile 20. The station at Rickreall is just above the Highway 99 bridge and about a mile below the wastewater outfall (refer to Map 1-6 for relative locations). Both stations are below the Mercer Reservoir, which was built in 1959.

Average annual discharge (measured rate of streamflow) is shown in Figure 4-1. The data are in cubic feet per second (cfs). I cfs translates into about 7.5 gallons per second, 450 gallons per minute (gpm) or 0.65 million gallons per day (MGD). These data averaged by "water years" that begin in October of the year indicated and end in September of the next year (at the start of the rainy season in Oregon). Finally these data are annual average discharges (total cubic feet of flow past that point in a water year divided by total seconds in a year). Therefore they are more representative of the winter high flows when most of the water flows in streams in Oregon and do not reflect annual drought years very well.

Average annual discharge was uniform for the years 1958 through 1972 and then became more variable for 1973 to 1985. Low discharges occurred in 1973, followed by a year of high discharge in 1974. Both stations track each other well; Rickreall seems to respond in greater magnitude to high water years. Rickreall has consistently higher discharge not because of the Dallas water system, but rather that the Rickreall Creek drains about a 50 % larger watershed area (43 square miles) at the Rickreall gage than at the Dallas gage (28 square miles). Ellendale Creek and several unnamed streams contribute flow to Rickreall between the two gages. Additional sources of increased flow would be from groundwater, small-unmapped seeps and streams, and even some amounts of storm water runoff from the urbanized area of Dallas.

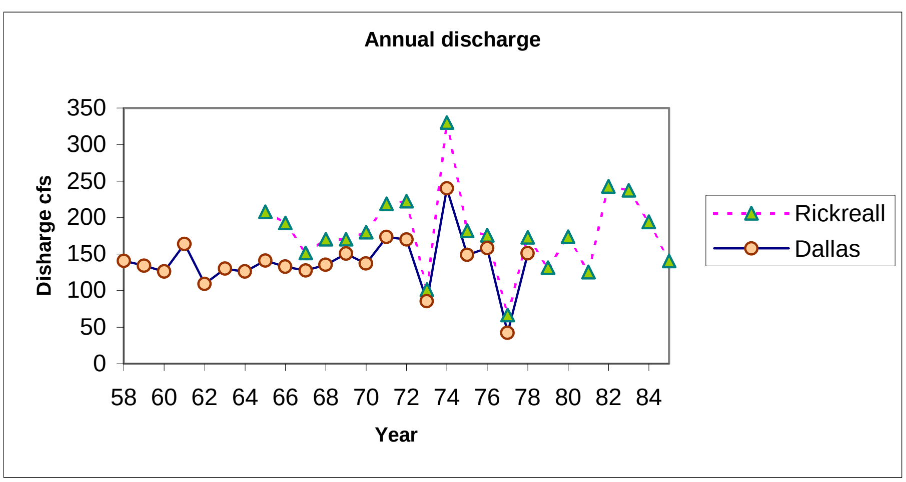
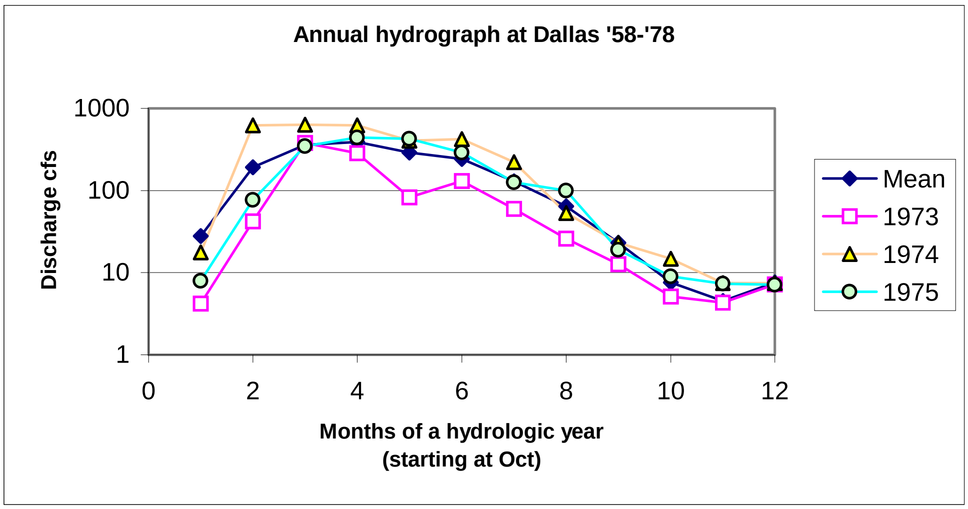


Figure 4-1: Stream discharge for Rickreall Creek at two gaging stations.

Average monthly flow for these same gages is shown in Figure 4-2. Also superimposed on the long-term mean are three individual years with high year to year variation (e.g., years 1973-1975). All these hydrographs show the characteristic pattern of stream flow with flow increasing in October, reaching a peak in January and declining slowly to their lowest flows in August and September. Winter mean flows for January can be 100-fold higher than mean flows in August-September. Therefore these discharge data are graphed on a log scale. This means that the vertical dimension of the graph was "compressed" progressively more at higher flows so that both the low flow high flow patterns are still discernable. This is a common graphing procedure used when data span ranges over several orders of magnitude. Note also that the difference between years in Figure 4-1 is evident in the variation in the winter flows and also the summer flows. That is, 1973 was a "dry" year throughout, suggesting that low winter rains result in low summer flows.



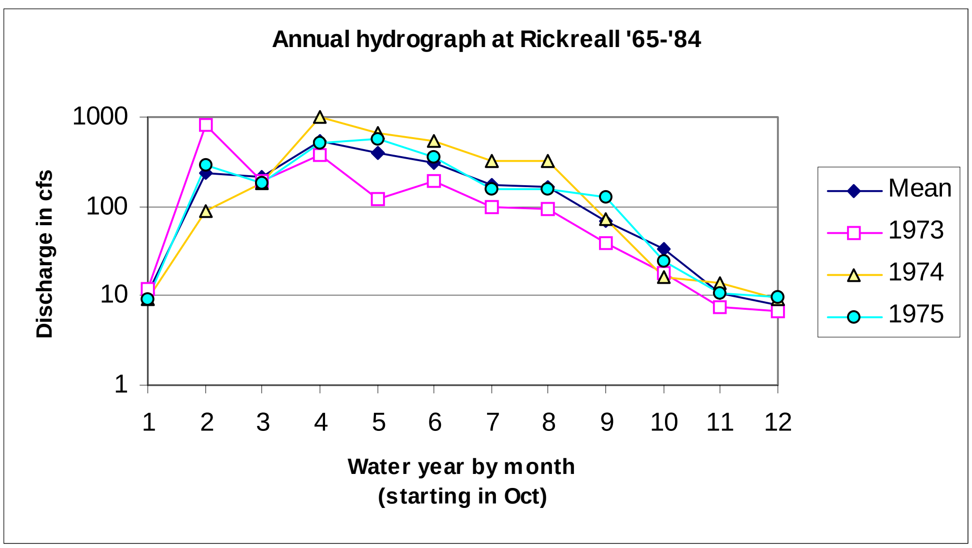


Figure 4-2: Annual hydrographs averaged by months for two gaging stations on Rickreall Creek

The City of Dallas collects flow data from various points about the watershed. The City also records the amount withdrawn from Rickreall and the amounts discharged to Rickreall. This data together with the USGS stream flow data can be used to construct a typical water budget during a low flow August day (Figure 4-3).

The flow volumes used in Figure 4-3 were those measured by the City of Dallas for low flow conditions in 1998 and 1999 at the following locations: above the reservoir, just below the reservoir, in Applegate and Canyon Creeks, withdrawals at the municipal intake (raw data provided by K. Carter, City of Dallas), and releases at the wastewater treatment plant (WWTP) (data from the City of Dallas 1996). The Dallas and Rickreall gage data are shown in Figure 4-4 and show the typical low flow volumes over the period of record. Ellendale Creek was estimated based on it having a 30 % larger drainage area than Canyon Creek. Using these numbers the remaining flows were constructed to balance the budget.

One unusual result was that the Dallas intake averages 5.9 cfs during the months of July through September for 1998 through 2000, but the WWTP outfall is considerably less at about 2.6 cfs (Table 1 in Dallas 1996 reported 2.5 cfs WWTP outfall in 1995 and projected 2.6 cfs for 2000). Therefore 3.4 cfs had to be accounted for. It was assumed that losses from the City's water stream may be explained by leakage from pipes, evaporation from the treatment ponds, lawn watering, and outdoor water use that diverts water into the storm drain system and back to the creek. Therefore 1.7 cfs was assumed to be lost to evaporation and 1.7 cfs was assumed to be diverted back to the creek.

Two other assumptions that were made to balance the budget were 1.5 cfs of "other withdrawals" occurs between the City's intake and its outfall; and withdrawals from Rickreall Creek between the outfall and the Rickreall gage are balanced by additions back to the creek.

Withdrawals of 1.5 cfs are surprisingly large and may likely be an overestimate. However, the 1.5-cfs estimate is being driven by the 1.7-cfs diversion from the City's system back to the creek. If one assumes a greater proportion of the City's loss is evaporated (or enters into soil storage and possibly diverted to Ash Creek), then the withdrawals would be proportionately reduced. Perhaps the other withdrawals may be more on the order of 0.5 cfs. As Map 4-1 indicates that there is close to 100 permitted diversions between the City's intake and the WWTP outfall and withdrawals of 0.5 cfs may be reasonable. This would be equivalent to 20 withdrawals at a rate of 11.3 gallons per minute operating continuously.

The data in Figure 4-3 must be considered as approximations and are based on the assumption that the low flow data for the instream gages measured during 1958 through 1985 are still representative of the flows in 1998 and 1999. It may be of interest for the Council to investigate these numbers more closely and perhaps examine some of the City's data. For example, it may be of interest to look at the metered data for their various classes of users and determine use by domestic, commercial, and industrial. The budget could be refined to include City water that goes to the Ellendale area and is not returned to the City's waste stream.

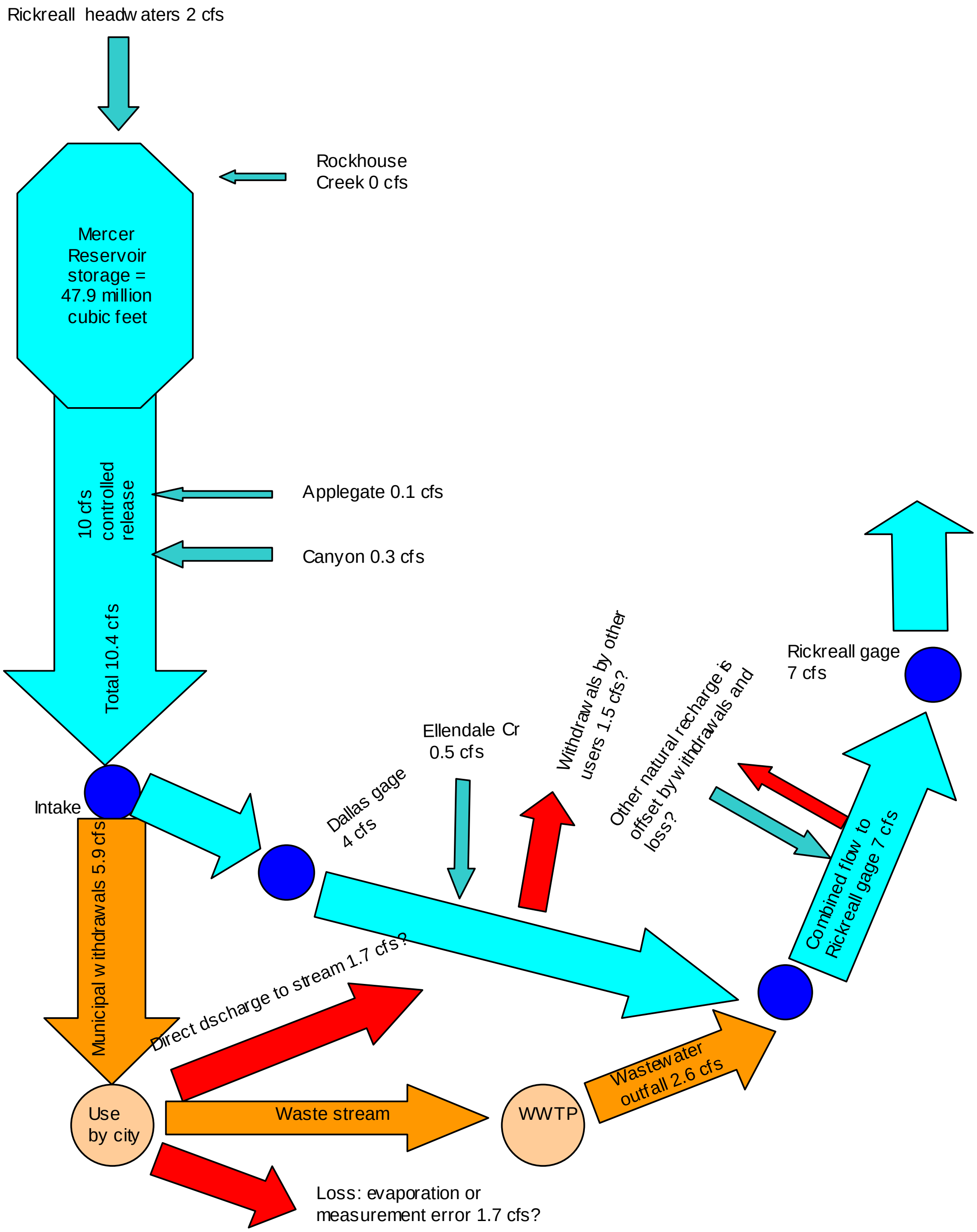


Figure 4-3: Water budget of Rickreall Creek at August low flow showing alterations to flow by city of Dallas. Red arrows and question marks indicate assumptions used to balance the budget.

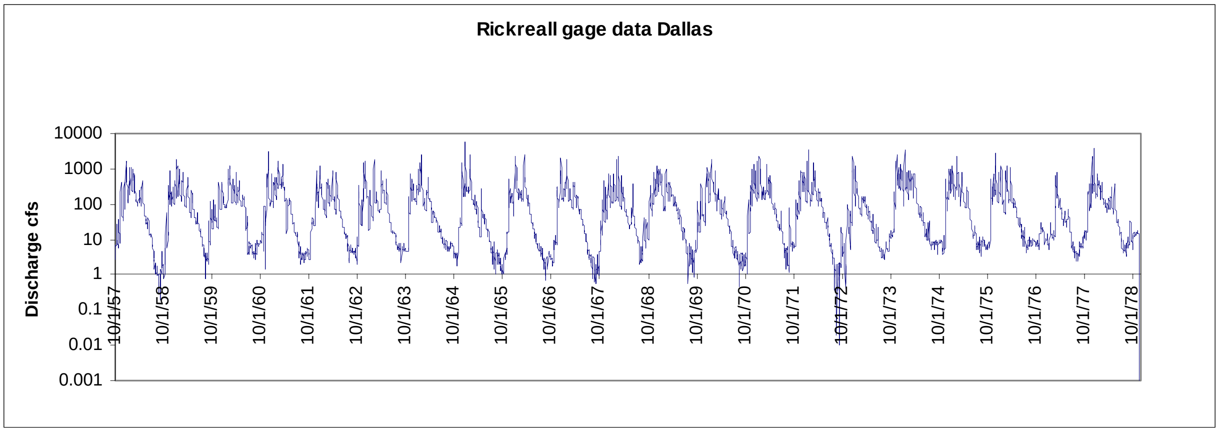
Patterns of Low and High Flow Discharges for Rickreall Creek

Daily discharge data for the Dallas and Rickreall gages are shown in Figure 4-4. Annual low flows at Dallas typically dropped to 3 cfs or less. In 8 of the 21 years, flow declined to less than 1 cfs; in 1972 no flow was recorded for a short period. Annual low flows at Rickreall were slightly higher and typically were 5 cfs. There were two years, 1969 and 1972, at Rickreall with low flows of 1 cfs or less. (One cubic foot per second is equal to about 7.5 gallons per second or would be a stream 3 feet across, four inches deep and flowing at 1 foot per second.) These flows appear to be relatively low for a drainage area of similar size and clearly must reflect the significant withdrawals of water from the stream. For example, the Little Luckiamute River near Falls City with a smaller drainage area than that above Dallas, rarely fell below 8 cfs during its record of low flows for the period 1965 through 1971.

Peak flows are evident on Figure 4-4 but may be more easily viewed in Figure 1-3 (Chapter 1) where data are plotted on a linear scale as opposed to a log scale. Peak flows for the Dallas gage typically exceed 1000 cfs each year and commonly reach 2000 cfs. (A stage-rating table is not available for Rickreall Creek, but by eye, the 1000-cfs level likely represents an approximate bankfull discharge when the flow rises above the lowest floodplain.) The highest flows exceeded 5600 cfs in 1964. Peak flows at the Rickreall gage are approximately 50 % higher than peak flows at the Dallas gage.

Comparisons of peak flows may also be made to the Little Luckiamute River at Falls City. As peak flows have been suggested to increase as a function of the square root of basin area (Viessman et al. 1972), the 20 % smaller Little Luckiamute might be expected to have only about 10 % smaller peak flows that those at Dallas for the same period of record. Little Luckiamute peak flow in 1964 was 3570 cfs and during the years 1965 to 1971 peak flows ranged from 1200 to 2100 cfs. These data are about 25 to 60 % lower than the gage at Dallas. These data suggest that, at least compared to the Little Luckiamute, that the peak flows in the Rickreall are somewhat high. Even the 310 square mile Marys River watershed had 1964 peak flows of 11,000 cfs and a range between 3000 and 7000 cfs for the period between 1965 and 1971; these are in line with the Little Luckiamute data.

The reservoir is not managed to affect peak flows. Given the volume of peak flows, withdrawals by the City and other users should not significantly decrease peak flows. The reservoir fills in a matter of days once fall rains start and withdrawals are less than 5 cfs and would not show up in peak flow volumes. A more likely explanation for higher peak flows would examine shape of the basin and other factors to see if water is routed more quickly to the channel. Channel precipitation will cause higher peak flows. The surface area of the reservoir will act to route rainfall immediately downstream where vegetation and soil would act to retain rainfall. However, one inch of rain falling in 24 hours onto the 60 acres of the reservoir would produce only 3 additional cfs.



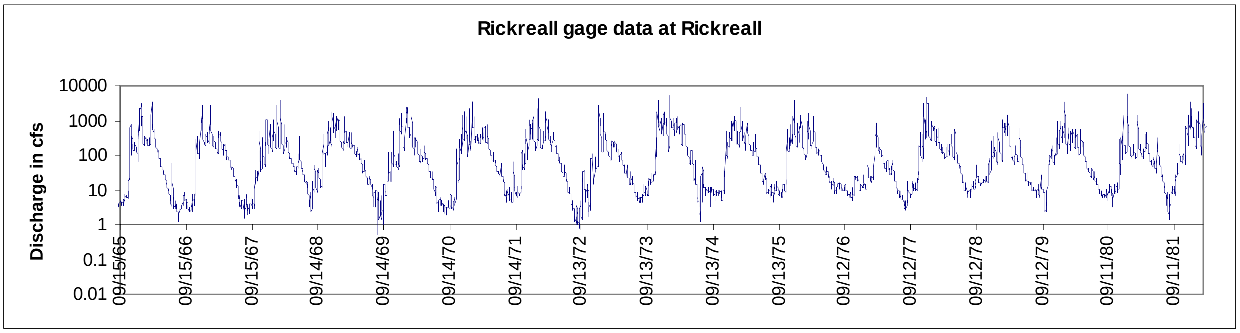


Figure 4-4: Daily discharge data for Rickreall Creek at two USGS gage stations. Dallas is at River Mile 20 and drains approximately 29 square miles; Rickreall is at River Mile 9 and drains approximately 43 square miles. Data are log scale to show low flow discharges over time.

High peak flows may simply be a function of the natural character of storm events and rainfall patterns in the basin. The upper watershed is bounded by high ridges and Laurel Mountain holds the state record for the highest rainfall in a 24-hr period.

One must also consider forestry activities in the basin as a possible factor for high peak flows in the Rickreall. High densities of roads can route water more quickly to stream channels (Jones and Grant 1996). Road density appears to be high in the upper basin. Also if relatively high proportions of the basin (e.g., >25 %) are in younger stands (i.e., not yet closed canopy, younger than 20 years) high peak flows can result. This is particularly true if there are rain-on-snow events. Rain-on-snow events may occur anywhere snow accumulates before a warmer rainstorm causes the snow to melt. This zone is approximately between 1500 feet to 4000 feet in Oregon. Referring to the minimum temperature data in January in Figure 1-2 (Chapter 1), one can see that average minimum temperatures in January in the upper basin are right near the freezing point, indicating that the rain-on-snow events could occur as high as Laurel Mountain. Aerial photos and a visit to the watershed suggest that a significant portion of the upper watershed is composed of young stands as a result of both forest harvests and the fire of 1987. Therefore, high peak flows may be expected until the canopy begins to reach hydrologic maturity (e.g., closed canopies in at about twenty years of age).

While the fire cannot be the explanation for high peak flows prior to 1987, it could very well be contributing to any increases in peak flows after 1987. This fire was quite hot; 40 % of the watershed area above the reservoir was burned with 27 % of the area sustained a complete burn to mineral soil (Hale 1988). Fires can increase runoff by removing the vegetation and creating rills in slopes. Very hot fires can also cause soils to become hydrophobic and decrease the rate of infiltration and thereby greatly increase runoff volumes. Unfortunately there is no gage data after 1981 by which to examine trends of increased flows following the fire.

Surface Water Withdrawals

The number of permitted users of surface and groundwater in the watershed number in the hundreds. Point of diversion and point of use data from the WRD are shown in Map 4-1. It has been estimated that 1700 acres of land are irrigated in the lower watershed (White 1998). The point of use in Map 4-1 indicates that over 7000 acres are included in point of use permits. The earliest permits of water use in the watershed go back to the mid 1800’s. Rickreall Creek is currently over-appropriated during the summer and no new water withdrawal permits are being issued for summer use.

According to OAR 690-400-11, the definition of over-appropriated is as follows:

1) *the quantity of surface water available during a specified period (portion of the year) is not sufficient to meet the expected demands from all water rights at least 80 % of the time during that period: or*

2) *the appropriation of ground water resources by all water rights exceeds the average annual recharge to a ground water source over the period of record or results in the depletion of already over-appropriated surface waters.*

Based on this definition, and an analysis of water availability at 80 % exceedance probability, the Oregon Water Resources Commission (WRC) made a policy decision to restrict the issuance of new water use permits for Rickreall Creek and its tributaries so as not to contribute further to the condition of over-appropriation present in the basin. In 1992, the WRC in essence closed the basin to further appropriation of surface water between May 1 and October 31 of each year. This was done to protect senior water rights from being affected by the water use of junior appropriators and reduce the likelihood for increased regulation of users during the low-flow period (cf. OAR 690-502-100(3) and the Willamette Basin Report).

A water availability report was run according to the guidelines of the Oregon Watershed Assessment Manual (Watershed Professionals Network 1999). These reports are the process in which a stream is determined to be over-allocated with respect to permitted water withdrawals diversions or uses. The reports were run through a web site of the Water Resources Department (http://www.wrd.state.or.us).

Figure 4-5 shows expected flows at the mouth of Rickreall Creek assuming 50 % or 80 % of natural flows might exceed this amount. Also shown are the combined permitted withdrawals for all uses. The permitted withdrawals exceed the predicted flow of the stream during the low flow period of July through September. Because not all water rights are exercised to their maximum all the time, the amount actually being withdrawn for use is less than that shown in the graph. On the other hand, many streams in Oregon, including Rickreall have non-permitted withdrawals. These are not quantified here. These results deserve further attention as these and the hydrography discussion above suggest that the stream flows may go low in summer and impact aquatic resources. Certainly the additional releases from Mercer Reservoir (i.e., the draw down of the reservoir) ameliorate the natural low flows. However any uncontrolled withdrawals exacerbate the problem. The watershed council might want to inventory diversions and permitted uses to help define a better low flow budget for the stream. This data combined with actual stream discharge measures would help to assess potential impacts to aquatic resources.

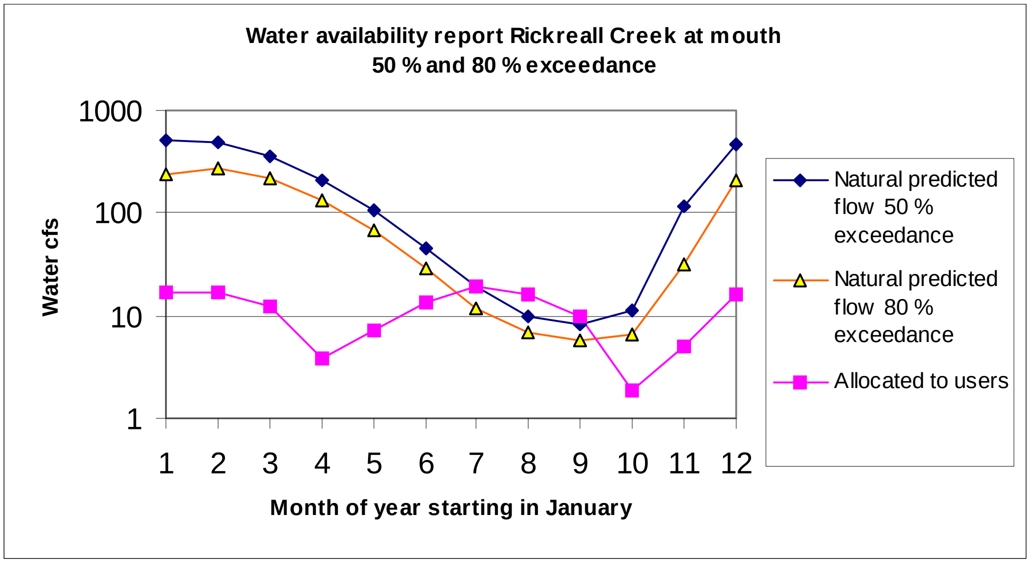


Figure 4-5: Water availability report for Rickreall Creek showing the projected stream flows by month and that allocated to water users. There were no instream rights for Rickreall Creek at the mouth. Where the combined allocation exceeds instream flow during the summer months, the stream is over-allocated. (Data from Water Resources Department).

Table 4-1 shows the permitted uses of surface water in the watershed. The City of Dallas' water treatment plant withdraws nearly 4 million gallons per day during July and August. There are no instream water rights established for Rickreall Creek at the mouth, but there is a 5 cfs year-round instream water right at River Mile 19.1. The date of the right is 6/22/64. Rickreall Creek is not listed in Table 11 of Weavers et al. (1992) as having a high priority for obtaining additional instream water rights.

Table 4-1: Water rights[1] for Rickreall Watershed in cubic feet per second (Water Resources Department 1992)

Agriculture	Industry	Municipal	Domestic	Recreation	Miscellaneous	Total rights of record
42.8	0.2	15.3	1.5	0.1	0.8	60.7

[1]A water right is the amount of water legally allotted to users, not necessarily the amount actually used.

Mercer Reservoir and other Reservoirs

The Rickreall watershed has six reservoirs that are licensed and monitored by the Water Resources Department. There are smaller reservoirs and ponds that also exist and are visible on the USGS 7.5 minute map and on the 1994 orthophotos. Basic data on the six reservoirs are given in Table 4-2 and the reservoir locations are show on Map 4-2.

Table 4-2: Reservoirs in Rickreall watershed monitored by Water Resources Department (Shulters 1974; Willamette / North Coast PIEC 2000).

# on Map 4-2	Name	Year built	Use	Area acres	Drainage area mi^2	Max. depth ft	Owner
1	Mercer Reservoir	1958	storage / diversion	60	18	60	City of Dallas
2	Ediger Reservoir	1957	private rec. / irrigation	10	0.9	15	private
3	Morgan Bros. Res.	1968	irrigation / storage	35	0.6	10	Baskett Slough NWR
4	Marx Res. 2	n.d.	private rec. / irrigation	6	0.4	15	private
5	Marx Res. 1	1964	maintain reservoir 2	8	0.2	n.d.	private
6	Stevens	n.d.	n.d.	3	0.7	n.d.	private

Mercer Reservoir is created by an earthen dam. It is 460 feet long by 79 feet high with a concrete spillway. The dam was built in 1958 then elevated in 1973 to increase the water storage capacity from 1200 acre-feet to 1550 acre-feet. (One acre-foot is the volume of water that covers an acre to a depth of one foot.) The dam is owned and operated by the City of Dallas, but the land at and above the reservoir is owned by Boise Cascade, Willamette Industries and BLM. There is no fish passage and Rickreall Creek above Dallas is considered to be steelhead habitat by ODFW and entire Rickreall is included as part of the Upper Willamette critical habitat designation of the National Marine Fisheries Service (Federal Register 2000). Dam is considered to be in non-compliance for fish passage (S. Mamoyac, pers. comm.).

The operating procedure by the City is to fill the reservoir in the fall. Excess water passes the spillway until July. At that time, the City begins drawing down the reservoir to maintain stream flows of 10 cfs to allow for sufficient flow at the municipal water intake downstream and for additional water to continue past the intake. Releases are based on weather forecasts. City has instituted elements of conservation such as education and an increasing block rate pay rate structure where greater use pays higher rates (Shea 1998).

Access into the upper watershed was open to the public until 1986 when the decision was made to limit public access. Vandalism and erosion were cited as the reasons for gating the road to the upper watershed near Ellendale. Non-motorized use is still allowed and the gate is opened for the public vehicles during deer hunting season.

Increased water demand with growth of the city and decreased storage volume in the reservoir from sediment filling is a problem the City is must solve. In the fall of 1987 a forest fire burned 5,000 acres of the watershed with 3,300 acres burned of all vegetation. It was estimated that as much as 100 acre-feet of sediment would fill the reservoir that winter (Miles 1989). The burn area was quickly seeded with annual grass and sediment retention barriers were installed. Ten acre-feet of sediment eventually entered the reservoir as a result of the fire. It has been estimated that between 10 and 25 acre-feet is also the annual storage loss to sediment (D. Shea 1998, CH2MHill 1999). The 1996 floods caused 70 acre-feet of loss (Shea 1998). Storage volume of the reservoir in 1998 was estimated to be 1100 acre-feet (CH2MHill 1999). Given the projected rates of growth of the city, and the rate of sedimentation, the city will begin to fall short of needed capacity about 2010.

Plans to secure more water include the installation of flashboards at the spillway to gain additional height. This is considered a temporary solution that would add 170 acre-feet of storage and would allow more time to reach a long-term solution. Several proposals have been put forward. These include dredging the reservoir, raising the current dam height, building a second dam either in Rickreall or in Mill Creek, creating off-stream storage ponds, and obtaining water from the Willamette River as part of a regional water district. Currently, construction of a second dam on the Rickreall is projected to be the most economical option (CH2MHill 1999). But these analyses have been based largely upon analyses of structural supply costs (e.g., costs/savings of conservation or intangible costs such as costs to stream condition have not been formally considered yet). Construction would need to start about 2010. Major issues to be resolved would be overcoming a regulatory climate that is averse to building of new dams. Specifically a new dam would need to address impacts to stream above Dallas where steelhead spawning and rearing occurs.

The issues of water supplies for the city and the other users appears to be a high-profile issue and one that the watershed council needs to monitor and perhaps become involved in education, outreach, and planning process.

Lakes

There are two lakes greater than10 acres in size the Rickreall watershed (Table 4-3 and see Map 4-2. Both of these lakes are abandoned channels of the Willamette River. At least two smaller lakes also are visible on the 1994 orthophotos in the same vicinity. Boyle Lakes appear to be an old wetland that has been drained or is seasonal.

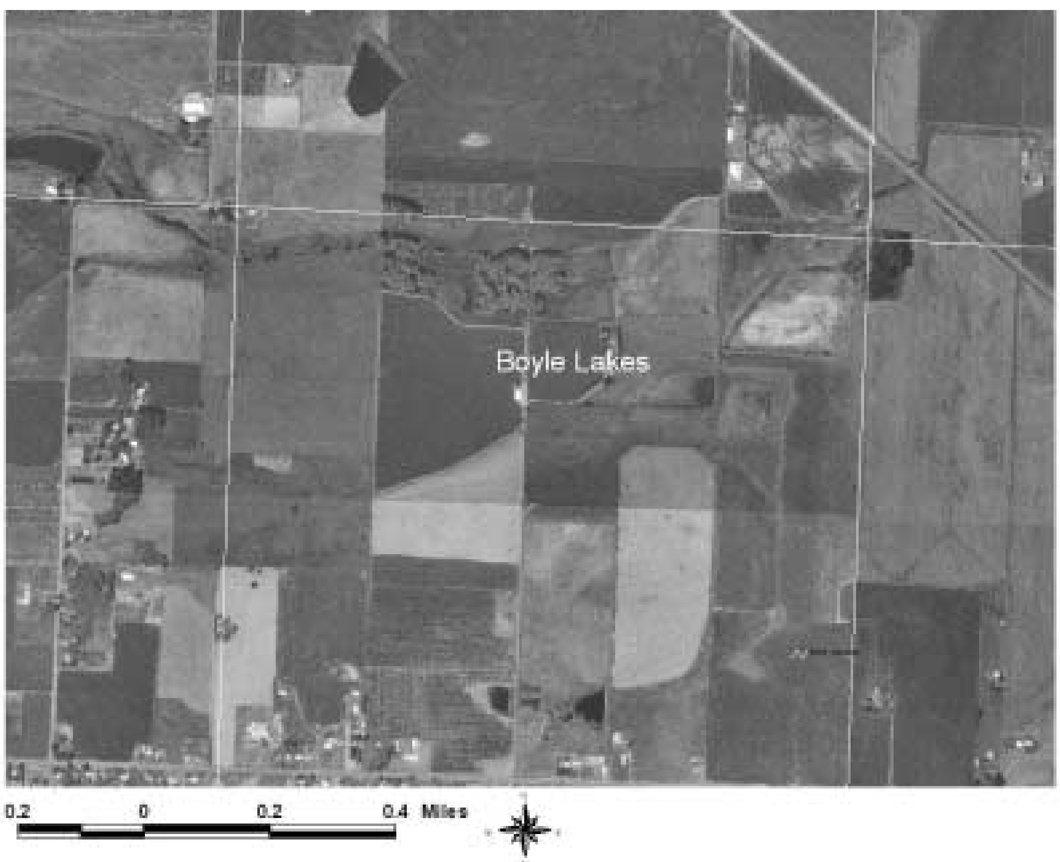
Table 4-3: Lakes in the Rickreall watershed.

Lake	Area acres	Use	Max. depth ft	comments
Hayden	15	private rec. / irrigation	10	flooded by Willamette R.
Humbug	20	private rec. / irrigation	8	flooded by Willamette R.
Boyle Lakes	10	n.d.	n.d.	may be drained or seasonal

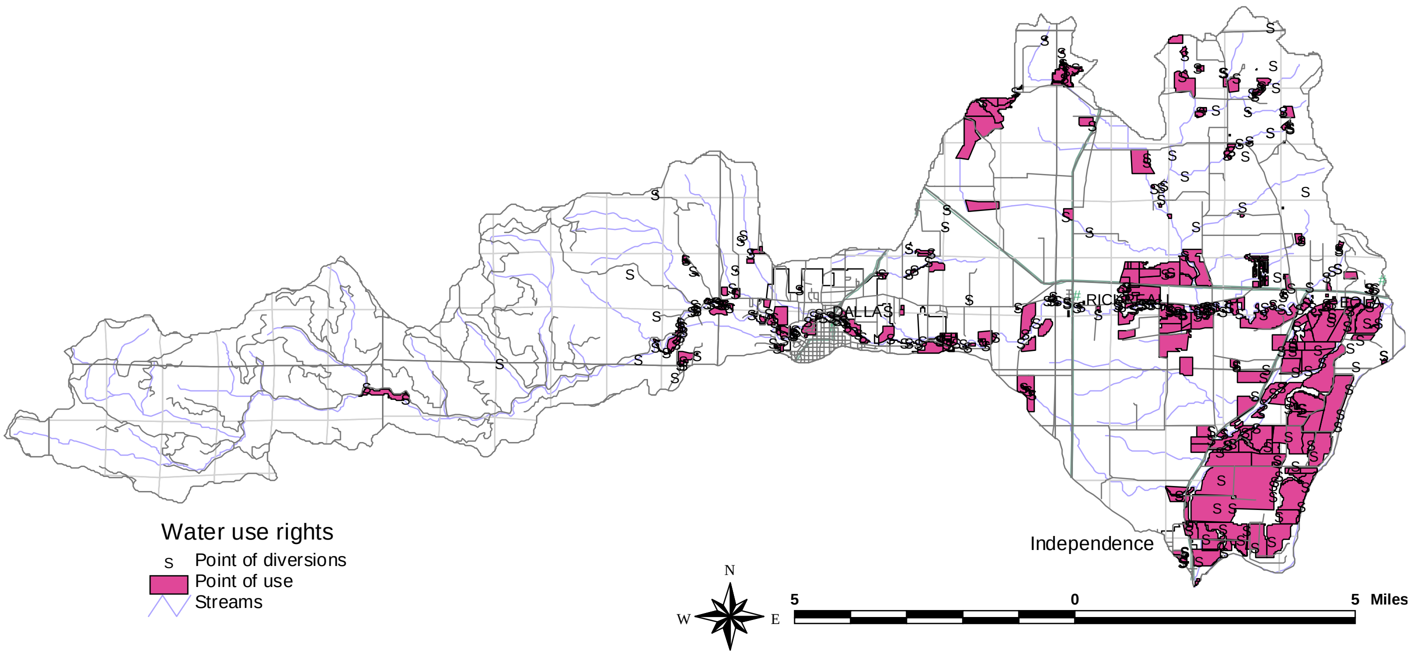
Wetlands

Wetlands occur in several locations in the Rickreall watershed. The Oregon Natural Heritage Program mapped natural wetlands in the Willamette Valley (Map 4-2).   These wetlands lie in areas along the Willamette River on the lowest terrace and along the floodplain of the Rickreall Creek downstream of Dallas. Additional wetlands have been created in the northeast portion of the watershed on lands owned by Mark Knaupp and in the Baskett Slough National Wildlife Refuge. The USGS 7.5 minute map shows additional wetlands in an unnamed drainage just east of Ellendale Creek. The Boyle Lakes area may be considered a wetlands as the 1851 GLO map indicates that a wetland occurred in that vicinity (Map 5-3).   According to the 1994 orthophotos, this wetland appears to be seasonal at best or has been drained.

Figure 4-6: Former wetland area called Boyle Lakes on 7.5 minute USGS map appears to be drained on 1994 orthophotos. This area appears to be a wetland on the 1851 vegetation map (Map 5-3 in Chapter 5).

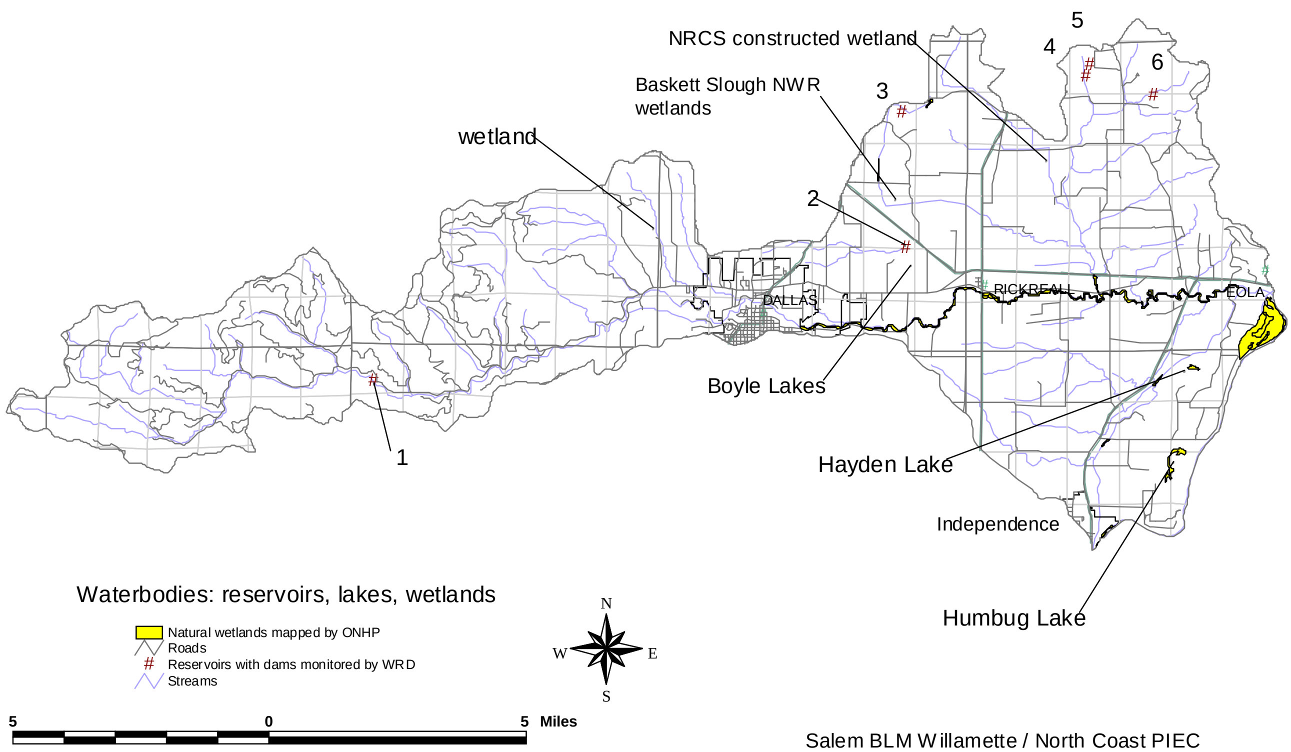


Map 4-1: Water use in Rickreall watershed as permitted by the Oregon Water Resources Department. Points of diversion are locations were water is taken per the permit. Points of use are the areas where water is used.



Source: Salem BLM Willamette / North Coast PIEC WRD

Map 4-2: Water bodies in Rickreall watershed. Numbered circles refer to reservoirs that have dams that are monitored by Oregon Water Resources Department. Numbers refer to data in Table 4-2. Wetlands are those mapped by Oregon Natural Heritage Program (in yellow) plus other added wetlands (from USGS 7.5-minute map, 1994 orthophotos, or from field visits).



Chapter 5 : AQUATIC AND TERRESTRIAL RESOURCES

Fish Diversity and Sensitive Species

The Rickreall Creek watershed is home to 13 native and at least 12 introduced fish species (Table 5-1).

Table 5-1: Fish species thought to occur in the Rickreall Creek and its tributaries

Native species:		Introduced species:	
Common name	**Scientific name**	**Common name**	**Scientific name**
cutthroat trout	*Oncorhynchus clarki*	Coho salmon [1]	*Oncorhynchus kisutch*
Steelhead	*O. mykiss*	Brown trout [1]	*Salmo trutta*
Chinook salmon [1]	*O. tshawytscha*	Warmouth sunfish [1]	*Lepomis gulosus*
Pacific lamprey [1]	*Lampetra tridentata*	Bluegill sunfish [1]	*L. macrochirus*
western brook lamprey	*L. richardsoni*	Pumpkinseed [1]	*L. gibbosus*
speckled dace	*Rhinichthys osculus*	Brown bullhead [1]	*Ameiurus nebullosus*
northern pike minnow	*Ptychocheilus oregonensis*	Mosquitofish [1]	*Gambusia affinis*
largescale sucker	*Catostomus macrocheilus*	Yellow perch [1]	*Perca flavescens*
redside shiner	*Richardsonius balteatus*	Smallmouth bass	*Micropterus dolomieu*
reticulate sculpin	*Cottus perplexus*	Largemouth bass	*M. salmoides*
torrent sculpin	*C. rhotheus*	White crappie [1]	*Pomoxis annularis*
sandroller [1]	*Percopsis transmontana*	Black crappie [1]	*P. nigromaculatus*
Oregon chub [1]	*Oregonichthys crameri*		

[1] Thought to occur infrequently.

Data from Table 4 of Altman et. al. 1997 with additions from various sources. Pacific lamprey and northern pike minnow reported by C. Hazel, pers. com.; brook lamprey electroshocked by author during site visit; Oregon chub listed as occurring in Baskett Slough NWR according to BLM GIS layer.

It should be pointed out that fish surveys in the Rickreall watershed have been conducted only on a limited basis and surveys were typically designed to find cutthroat and steelhead. Surveys that have been conducted include several ODFW electrofishing surveys in the mainstem and tributaries conducted since 1980. Gill netting of Mercer Reservoir during 1970s, Oregon Department of Forestry (ODF) upper extent fish use surveys in several of the tributaries, downstream migrant trapping at ViIlwok's Dam (concrete ford at River Mile 8). These data are available from ODFW (S. Mamoyac, Corvallis Office) and all summaries or field data sets (except for Villwok's Dam data) are on file at the Rickreall Watershed Council Office.

Seven fish species are discussed below because they are considered "sensitive" in that either they face some known level of challenge to their continued population levels or the existing information on the condition of their population is limited and there is reason for concern for health of the species (Table 5-2).

Table 5-2: Fish species in the Rickreall Creek watershed with some level of sensitive status.

Common Name	Fed. status	Notes:
winter steelhead	LT	Known to be introduced and now reproducing naturally. Presumed likely to have occurred as native fish at low numbers. Current population is likely a mix of the original native and introduced fish.
cutthroat trout	--	Fluvial cutthroat, a variety that travels to larger rivers, is a stock of concern to ODFW due to suspected low populations.
spring chinook	LT	Juveniles observed in west side basins by ODFW. Not thought to have supported spawning runs, but see discussion below.
coho	--	Introduced to the Upper Willamette and therefore not considered to be part of natural range.
Oregon chub	LE	Reportedly in Baskett Slough NWR according to BLM records.
Pacific lamprey	SoC	Amocytes, a juvenile stage, were observed in Rickreall Creek (C. Hazel pers. comm.)
sandroller	--	Stock of concern to ODFW due to suspected low populations.

SoC=Species of Concern, C=Candidate Species, LT=Listed Threatened, LE=Listed Endangered

Winter Steelhead

In March 1999, winter steelhead were listed as “Threatened” under the Federal Endangered Species Act (ESA) in the Upper Willamette River. Designations of critical habitat were made February 16, 2000 by the National Marine Fisheries Service (NMFS). The Upper Willamette was designated as part of the critical habitat for winter steelhead. Rickreall Creek is considered part of the Upper Willamette hydrologic unit code and therefore is also part of the critical habitat (Federal Register 2000; see also www.nwr.noaa.gov). A designation of critical habitat provides Federal agencies with a clear indication as to when consultation under section 7 of the Endangered Species Act (ESA) is required.

There remains some discussion about whether steelhead were originally native to the west-side drainages of the Willamette River (S. Mamoyac, K. Jones, ODFW Corvallis, pers. comm.). The uncertainty about the original range of the steelhead is due to the complex life history of this species, lack of definitive survey data, and widespread stocking of non-native steelhead. It is likely that this uncertainty will never be resolved completely.

Historically, Willamette Falls at Oregon City was a selective migration barrier, which was passable during high flows, to anadromous salmonids. Native winter steelhead, which entered the Willamette system later than Coastal steelhead, (Howell et al. 1985), were able to negotiate Willamette Falls (Collins 1968), as were spring chinook salmon. While no further obstacles blocked steelhead from accessing the west slopes of the Willamette, the species prefers higher-gradient eastslope streams flowing from the western Cascades. Small numbers of native winter steelhead are thought to have used Coast Range drainages of the Willamette (Wevers et al. 1992). Occasional reports of steelhead in the west sub-basins were made prior to the recent ODFW stocking programs (Dimick and Merryfield 1945; Willis et al. 1960 cited in Wevers et al. 1992). “Wanderers” also may have appeared in the west-side streams (K. Jones ODFW, Corvallis, pers. comm., Federal Register Vol. 63 No. 46, Tuesday, March 10, 1998 pp.

800). Fish ladders were added at Willamette Falls as early as 1885 to facilitate the passage of fish species, with major improvements to these ladders in 1971 (Bennett 1987; PGE 1994; Cited from Fed. Reg. Vol. 63, No. 46. Tuesday, March 10, 1998 pp. 1800). Fish ladders allowed the successful introduction to the Willamette Basin of Skamania stock summer steelhead and early migrating Big Creek stock winter steelhead, as well as coho salmon.

Steelhead were stocked throughout the Willamette Basin, including the Rickreall Creek. ODFW released adult winter steelhead to the Rickreall Creek basin in 1969 and again in 1971. These releases consisted of approximately 200 adult fish per year of Big Creek hatchery stock. In 1982, 24,600 steelhead fry from Eagle Creek stock were released to Canyon, Skid, and Applegate Creeks. From 1984 through 1990, fry from Big Creek stock were released to Rickreall, Canyon, Applegate and Skid Creeks (Wevers et al. 1992).

Naturally reproducing steelhead have been documented in the Rickreall watershed. A downstream weir trap, operated at the concrete ford at River Mile 8 (also referred to as Villwoks Dam), caught juvenile steelhead thought to be smolts over a two-year period during the mid-1970's (S. Mamoyac, pers. comm., data on file at ODFW offices in Corvallis). In electrofishing surveys in Rickreall Creek below Dallas performed on several occasions from February of 1988 to June 1990 both adult cutthroat and adult unclipped steelhead were shocked as were *O. mykiss* juveniles (thought to be steelhead and not resident rainbow trout), (S. Mamoyac, pers. comm.). The term "unclipped" refers to the lack of a clip to the adipose fin. Such a clip is often used to mark hatchery juvenile fish before they are released into streams. Therefore an unclipped fish is good indication that it is a wild or naturally spawned fish. As recently as 1999, steelhead juveniles have been electroshocked in the mainstem (River Mile 19 and River Mile 23) and in Canyon Creek (raw data forms provided by S. Mamoyac ODFW fisheries biologist, Corvallis).

Allozyme analysis was performed on 34 juvenile steelhead taken from Canyon Creek during September, 1997. Sampling was part of a larger project to determine genetic origins of steelhead. The data were requested by the National Marine Fisheries Service's (NMFS) biological review team during their determinations of critical habitat for winter steelhead. These analyses showed clustering of allozymes from steelhead in the Santiam watershed which were thought to typify historic native steelhead to the Willamette basin. The allozymes from the west slope streams (Rickreall and Yamhill) did not cluster with the Santiam group but appeared to be more similar to stocks outside the basin such as lower Columbia stocks (D. Teel, NMFS, Manchester WA, pers. comm.).

Teel cautions that genetic testing on populations is not an unequivocal process; that there is some variation within populations, and one doesn't know what a native fish should cluster like. Also that a fish has become naturally reproducing is important. The issue of native versus stocked origins is more important for ESA considerations. The ODFW still appears to value the steelhead in Rickreall Creek as it lists Rickreall Creek as providing spawning and rearing habitat for steelhead on its website.

Resident rainbow trout—non-anadromous rainbows--are not thought to be native to the westslope drainages of the Willamette River. Releases of Roaring River hatchery rainbow trout have been made in these drainages since the 1920's to provide a sport fishery. While there is no evidence of natural production of rainbow trout from hatchery releases (Wevers et al. 1992), stocked rainbow possibly may have resulted in a small number of returning steelhead (C. Bond, pers. comm.). For *O. mykiss* to be considered resident rainbow in the Rickreall, they would need to be found isolated above the reservoir and there are no documented captures of rainbow trout above the reservoir.

Cutthroat Trout

While four life-history types occur in the coastal cutthroat trout (resident, fluvial, adfluvial, and anadromous), only two of these types occur naturally in the west slope streams of the Willamette River. Resident cutthroat are those that live the entire year in a single pool or set of pools, are widespread, and are the dominant trout in the headwater streams of western Oregon (Hooton 1997). Indeed, abundant cutthroat trout were observed in several tributaries (Rockhouse Creek, Canyon Creek, and Skid Creek) by the watershed analysts during field visits this summer. Larger, fluvial cutthroat complete in-river migrations between small spawning tributaries and main river sections such as the Willamette. Populations of fluvial cutthroat in the Rickreall Creek may have been larger in the recent past, as this is the case with other west side rivers, such as the Marys River. Adfluvial cutthroat trout are those that migrate between stream and lakes. These likely occur now in the Rickreall since the construction of Mercer Reservoir.

Several surveys have documented cutthroat trout throughout the watershed.   The ODFW performed gill net surveys every odd year for a 10-year period in Mercer Reservoir. The nets were set for 16 to 24 hours at a point just opposite the mouth of Rockhouse Creek or just west of the mouth. The data shows relatively abundant cutthroat trout in Mercer Reservoir (Table 5-3). The average length varied between 8 and 10 inches, the largest trout caught was 13 inches. Two large mouth bass were also caught during the surveys.

Table 5-3: Gill netting data from Mercer Reservoir.			
date	**# nets**	**# cutthroat caught**	**mean length in.**
4/9/81	2	89	8.1
4/19/83	1	27	8.5
4/9/85	1	38	9.6
4/15/87	1	18	9.6
4/19/89	1	40	10.4
4/10/91	1	41	9.6

As part of the Oregon Department of Forestry (ODF) stream protection rules, fish use must be determined in streams before forestry operations near the stream can be allowed. The far upper reaches of about seven tributaries have also been surveyed. In nearly five cases of these upper extent surveys in the Rickreall basin, the surveys were performed on planned forestry operation that were located above the upper extent of fish use and therefore no fish were found. In the two surveys that found fish, the surveys established that fish use ends at least a 1/4 mile downstream of Silver Falls on the North Fork of Rickreall, and that fish use ends at a 5-10' waterfall in the west portion of section 7 on the South Fork of Rickreall Creek. Also these surveys established that no fish occur above Silver Falls. The remaining surveyed streams that held no fish were very small and located in steep headwaters.

It was not surprising that no fish were found in such habitat. Generally, most streams that are not separated from downstream reaches by an impassible barrier can be expected to support cutthroat, at least in the spring of the year, in reaches with gradients up to 15 % and in water with depths of 1 foot. In some cases, fish will even be found upstream of impassable barriers if the habitat is adequate. In nearly all cases, cutthroat trout will be the fish found highest in the basin.

Only small portions of the headwater stream have been covered in these surveys. Indeed the distribution of cutthroat in the Coast range is poorly documented by surveys to date. But the ODF program of stream protection and fish surveys will continue to slowly map these streams for fish use. Because cutthroat are the dominant resident fish in headwater streams in the Coast Range, they are a good indicator of stream health and watershed condition. A better understanding of the status of cutthroat trout in the upper Rickreall watershed above the reservoir would provide a useful gauge of the watershed, both at the time of the surveys and through time with continuing surveys. Upper extent presence-absence surveys are fairly easy to perform and cost about $150 per stream to perform. The role of the reservoir and the effect of the 1987 fires would be of interest in influencing fish use of streams.

Cutthroat trout appear to be secure in the mainstem Rickreall below the reservoir. ODFW electroshocking surveys for steelhead found abundant cutthroat numbers. During a field visit by the assessment team, many adult cutthroat were spotted in the vicinity of Applegate and Skid Creeks. Some of the larger fish were nearly 12 inches in length. Smaller cutthroat were observed in the tributaries. The habitat looked reasonably good according to the criteria in Table 5-2; however large woody debris appeared to be quite low (Photo 5-1).

The status of cutthroat trout in the lower Rickreall below Dallas is unclear. The habitat looks reasonably good to support cutthroat (see Photo 1-2, Chapter 1). Electrofishing surveys by the ODFW produced cutthroat in some instances but not in others. This suggests that cutthroat use the stream seasonally, exist in selected areas, or exist at low densities.

Table 5-4: General considerations for cutthroat trout habitat requirements.
Oriented towards pools versus riffles, and use cover such as woody debris (jams and logs) and overhanging banks.
Adults prefer intermediate stream velocities (1 ft/sec or slower) and deeper water.
Fry use slower water and are often associated with complex lateral habitats.
Juveniles may be outcompeted by juvenile steelhead or coho in areas that lack sufficient cover.
An optimum temperature for juveniles is 60°F; the ability to swim is lost at 82°F.
Juveniles have been known to remain in a single pool for several years or to make significant migrations within a basin.
Frequently attain large size in beaver ponds, larger pools or reservoirs.

http://www.orst.edu/Dept/ODFW/conference/cuthab.html. March 1999.

Photo 5-1: Rickreall Creek at Applegate Creek has low wood but cutthroat numbers appeared to be relative abundant.

Chinook Salmon

Spring chinook historically were able to negotiate Willamette Falls during high flows (Collins 1968) and are a native anadromous fish to the upper Willamette River. Spring Chinook in the upper Willamette were listed as “Threatened” under the ESA in March 1999. A decline in the abundance of these fish is attributed to reduced habitat coverage and quality, and suspected over-harvesting of native fish for a large hatchery program.

Carl Bond, retired fisheries professor from Oregon State University reports that his major professor, Roland Dimick, lived in the area in the 1920’s and would have known if there were salmon in the Rickreall Creek. According to Bond, it was Dimick’s opinion that chinook had never used the Rickreall Creek or other westslope drainages. Chinook, juveniles have been observed in the lower mainstem of the Mary River (S. Mamoyac, Corvallis ODFW, and M. Wade, Springfield ODFW, pers. comm.). It is possible that the Rickreall Creek provides over-wintering and rearing habitat for juvenile chinook spawned in the mainstem of the Willamette or other tributaries. The ODFW considers the lower Rickreall to about the community of Rickreall as providing rearing and migration habitat on its website. Winter surveys may be of interest to the Rickreall watershed council to determine whether juvenile chinook use the lower Rickreall or possibly Baskett Slough.

Coho Salmon

Coho salmon are not native to the Willamette River above Willamette Falls. However, they have been in the basin for almost 80 years as a result of introductions that started in the1920’s (Wevers et al. 1992). In 1958, ODFW began a larger stocking program, introducing Toutle, Cowlitz or other hatchery-origin coho into several Rickreall Creek tributaries over a 30-year period. The stocking program failed to establish a major fishery in the Rickreall or elsewhere in the Upper Willamette. But the ODFW still lists Rickreall and Canyon Creeks as providing potential spawning and rearing habitat. Indeed there are anecdotal reports of coho. One report relates a fisherman who caught a coho in the last five years. A second report is of an experience angler that sighted coho adults over spawning redds in the mainstem near Pioneer Road (G. Nelson, pers. comm.).

Oregon chub

Oregon chub are listed as occurring in Baskett Slough NWR on BLM GIS data layers. Oregon chub was listed as endangered under the ESA by the US Fish and Wildlife Service in 1993. The Oregon chub occurs only in the Willamette and Umpqua basins, and the Umpqua Oregon chub is taxonomically distinct from Willamette populations (Markle et al. 1991). The preferred habitat of the Oregon chub is quiet water such as sloughs and overflow ponds at low elevations in the Willamette Valley (Dimick and Merryfield 1945). Much of the historic range of these fishes has disappeared in the Willamette River and its tributaries as a result of the construction of flood control dams, channelization of the river and channel cleaning for the purpose of navigation (Sheerer 1998). In addition to the loss of habitat, introduced species may inhibit the establishment of new populations of chub, which colonize during high-flow events. Non-native fish are present at approximately half of the known population sites of Oregon chub.

Currently twenty-four populations are known to exist, with four of these being newly established from transplants performed by ODFW. One of the oldest known populations exists in Gray Creek, a tributary of Muddy Creek in the Finley National Wildlife Refuge in the Marys River watershed. This population is considered stable, at 450-600 individuals. ODFW has an ongoing investigation into Oregon chub abundance and distribution (Sheerer, pers. comm.). The US Fish and Wildlife Service has produced a Recovery Plan for the Oregon Chub that outlines the goals and objective for management for the recovery of this unique species. The Rickreall Watershed Council may wish to look for other potential areas where the chub may exist.

Pacific lamprey

Lamprey are listed throughout the Columbia River system as a candidate species by NMFS (BLM 1997). Habitat loss from hydropower projects and declines in populations of salmonids are thought to contribute to their decline. These fish, which are anadromous, parasitize salmonids in their ocean phase and are unable to negotiate fish ladders and other obstacles. Between 1943 and 1949, the Willamette River supported a commercial fishery on these fish with an average annual harvest of 233,179 pounds (Wydoski et al. 1979). There is additional information on this species and other anadromous fish on the StreamNet website: (*http://www.streamnet.org/ff/lifehistory/anad_table.html*). (The space following “anad” is actually an underline symbol “_”.)

Sand rollers

Sand rollers (also known as trout perch) have been listed as a “stock of concern” by ODFW due to suspected low populations. They are native only to the lower Columbia River and its tributaries, including the Willamette River. Little is known about this species, though they are thought to hide in daylight hours among large submerged objects and feed at night over sandy substrates. Sand rollers were been documented as occurring at River Mile 8.5 of the Rickreall back in 1954 by OSU personnel (Wevers et al. 1992). Because of their secretive nature, sand roller populations may be underestimated. Sand rollers and Oregon chub are considered the two most endemic fish species of the western Cascades/ Willamette River basin region, with little to no occurrence in other regions (Hughes et al. 1987). Most of the introduced warm water species listed in Table 5-1 would occur in the lower mainstem of the Rickreall Creek and may prey upon and compete with sandrollers. Much of the historic habitat of sandrollers has been lost to the draining of wetlands and channelization (Dunette 1997).

ODFW Survey Data Sets for Rickreall Watershed

The ODFW has been performing stream habitat surveys over the state of Oregon since 1990. These surveys have also been supported financially by the Oregon Forestry Industry Council. This information is collected during the summer months by ODFW stream survey crews. The methods have been most recently described by Moore et al.

(1997). The field data focuses on channel and valley morphology (stream and reach data), riparian characteristics and condition (reach data), and instream habitat (habitat unit data).

The survey data is compiled into a comprehensive database that is used in fish management and planning activities. The data is available in ArcInfo on the Internet. The “reach” data set for Rickreall watershed generalizes the habitat units that were surveyed by ODFW. The reach data gives an overview of the conditions within the reach or section of stream. Another data set maintained by ODFW and available to the public is the “habitat” data set. The habitat data set includes all of the unit data for the entire survey. The reach data set shown here is a summarization of the habitat data set. Approximately 1/3 of the reach data set is shown here. The most pertinent data was selected for the summary table.

The ODFW surveys concentrated on the upper portions of Rickreall Creek and included Rockhouse Creek and two smaller tributaries. The surveys were generally above Rickreall River Mile 20, although a 435-m section was included at the mouth and is also referred to as Reach 1. Note also that the mainstem of Rickreall Creek according to the ODFW surveys (and the USGS map) is different from what the GIS layers from Polk County and therefore the most of the maps in this document. The ODFW and USGS consider the main stem to be what some maps refer to as the North Fork, while the Polk County GIS layers indicate the mainstem as the South Fork. Where confusion may exist, we will refer to forks as North or South, respectively.

Table 5-5 summarizes the ODFW surveys. Some general patterns are evident in the data with respect to the reservoir. However, it should be noted that the reaches below the reservoir are generally of lower gradient than those above the reservoir. Gradient is a strong controlling element of channel condition. Some of the differences among reaches are a result of differences in gradient. These must be kept in mind when comparing these data.

1. Significant lengths of the channel of Rickreall are constrained by terraces or valley side slopes (c.f. valley types or channel types). Less constraint in valley types were recorded in reaches 2, 5 and 6. These observations agree with the channel habitat typing of this assessment, where most of the channel was classed as confined except those below and above the reservoir.
2. The stream and channel is at least twice as wide below the reservoir (c.f., wet widths, active channel widths, or terrace widths). Active channel widths are much greater below the reservoir
3. Land use and riparian conditions indicates that greater amounts of forest harvesting activity was occurring above the reservoir. The reaches above the reservoir had either young trees, second growth trees, or in timber harvest conditions. Also, these upper reaches had greater proportion of the riparian vegetation in smaller trees and greater amounts in pure hardwood stands. There were also fewer numbers of large conifers (e.g., conifers > 20 “ dbh).
4. Pool area was generally high (e.g., > 30 %) in most reaches. Low pool area tended to occur in reaches of highest gradient or smallest tributaries. Figure 5-1 shows the strong trend of gradient in the pattern of pool area among reaches. The three

reaches above the reservoir in the mainstem of Rickreall have a tendency toward greater pool area than the three reaches below the reservoir, despite being of slightly higher gradient.

5. The most significant pattern is one of higher fine substrate sizes in the sediment of reaches above the reservoir compared to reaches below the reservoir (e.g., sand or gravel in total habitats and in riffles). Reservoirs tend to trap sediment that would normally be processed downstream. Reservoirs also modify flows downstream by reducing both high and low flow extremes. Flood flows are the way in which streams introduce gravels and distribute them downstream. It is unlikely that Mercer Reservoir affects gravel content by modified high flows as high flows are allowed to pass over the dam. More likely, the reservoir is acting to trap gravels that would normally move downstream from headwater areas. Measurements to 1990 indicate that the reservoir has trapped 350+ acre-ft of sediment since it was constructed in 1960 (CH2M Hill, 1995). One acre foot of sediment, if spread over the active channel for eight miles below the reservoir, would be 1-foot deep.
6. Woody debris is quite low in lower Rickreall Creek. Volumes increase above the Summary of Survey of Lower Rickreall by CH2M Hill reservoir as gradients increase. This is an expected trend. However, it is likely the reservoir is trapping pieces of woody debris.

Table 5-5: ODFW Stream Reach Summaries for Rickreall Watershed: grouped by location with respect to Mercer Reservoir. Reaches below the reservoir are shown in gray; those above the reservoir are shown in white.

Stream	Reach	Surv_ date	Gradient	Length	land	land	Rip	Rip	Pool	Valley	Valley	Channel	Wet	Act ch
									area	width indx	type	type	width	width
		m/d/y	%	m	use1	use2	veg1	veg2	%				m	m
RICKREALL mouth	1	Aug-93	1	435	YT		M30	S	37	8.6	CT	CA	6.7	13.8
RICKREALL	1	Aug-93	1	17452	YT		M30	S	37	8.6	CT	CA	6.7	13.8
RICKREALL	2	Aug-93	0.9	1618	ST	LT	M30		46.7	1	MV	CH	7	11
RICKREALL	3	Sep-93	0.9	7097	LT	YT	M30	S	29.9	5.3	CT	CA	8	15.3
RICKREALL	4	Sep-93	1.4	8085	LT	YT	M30	S	24.3	1	OV	CH	10.3	17.2
RICKREALL	5			6648										
Mean			1.0	6889					35.0	4.9			7.7	14.2
RICKREALL	6	Aug-93	1.9	15944	YT		D15	D3	49.8	1.4	OV	CH	7.3	9.2
RICKREALL	7	Aug-93	11.1	15543	TH	LT	D15	D3	34.2	1.3	MV	CH	3.9	6.4
RICKREALL	8	Aug-93	2.3	3470	ST	ST	M15	M3	58.2	10.5	CT	TC	3.3	3.2
RICKREALL TRIB	1	Aug-93	20.7	1468	ST		C15	C3	19.3	1.5	SV	CH	2	2.1
ROCKHOUSE	1	Jul-93	3.3	10211	YT		D15		47.6	19.5	CT	TC	3.1	4.2
ROCKHOUSE	2	Aug-93	8.2	1528	YT	ST	M15		12.6	3	MT	US	1.8	1.9
ROCKHOUSE	3	Aug-93	22.8	754	TH	ST	D3		1.2	1	MV	CH	1.5	1.7
ROCKHOUSE TRIB	1	Aug-93	6.7	2707	ST	TH	D30		18.1	20	CT	TC	2.4	5.7
ROCKHOUSE TRIB	2	Aug-93	8.4	1173	ST		D30		4.4	6	MT	US	1.2	1.5
Mean			9.5	5866					27.3	7.1			2.9	4.0

Table continued	Reach	Terrace width m	Act ch ht m	Terrace ht m	Sand total %	Gravel total %	Sand riffles %	Gravel riffles %	Bedrock %	Shade %	Bank erosion %	LWD vol m3/100 m	Max temp C	Conifer > 20" #/1000 m
RICKREALL mouth	1	21	0.8	2.6	7	15	7	16	0	71	0	7.6	20	84.5
RICKREALL	1	21	0.8	2.6	7	15	7	16	0	71	0	7.6	20	84.5
RICKREALL	2	0	0.8	0	0	14	0	10	0	75	0	0.8	17	0
RICKREALL	3	21	0.7	1.6	3	16	0	14	0	81	0	5.4	13	60.3
RICKREALL	4	0	0.6	0	3	11	0	10	0	83	0	6	17	30.2
RICKREALL	5													
Mean		12.6	0.7	1.4	4.0	14.2	2.8	13.2	0.0	76.2	0.0	5.5	17.4	51.9
RICKREALL	6	18	0.6	6.5	14	21	8	25	0	63	0.1	10.3	19.4	12
RICKREALL	7	10.5	0.3	2.1	13	15	11	21	0	82	0.3	26.5	12.8	42.2
RICKREALL	8	5.9	0.3	0.7	48	37	36	40	0	63	1	24	9.4	0
RICKREALL TRIB	1	4.8	0.2	0.8	15	22	15	29	0	81	0	53.6	11.7	0
ROCKHOUSE	1	5.9	0.3	0.6	22	35	18	39	0	72	4	13.9	13.3	18.1
ROCKHOUSE	2	2.4	0.2	0.6	16	37	12	36	0	88	4.7	17.2	16.7	0
ROCKHOUSE	3	3	0.3	0.6	22	39	10	35	0	98	0	32.3	14.4	0
ROCKHOUSE TRIB	1	6	0.3	0.8	20	33	20	31	0	83	0	24.9	17.8	0
ROCKHOUSE TRIB	2	2	0.2	0.7	15	32	19	32	0	78	0	61.1	13.3	0
Mean		6.5	0.3	1.5	20.6	30.1	16.6	32.0	0.0	78.7	1.1	29.3	14.3	8.0

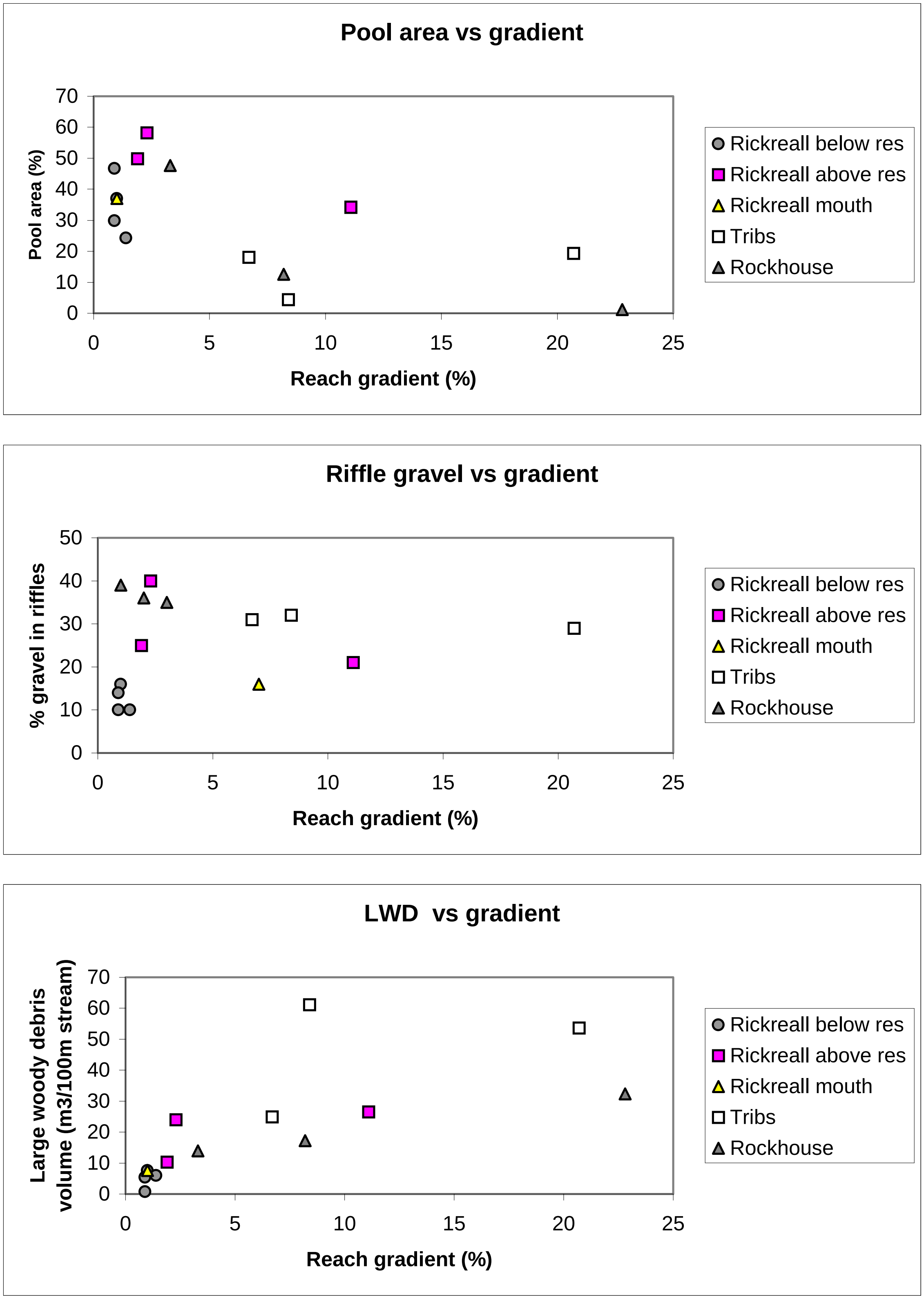


Figure 5-1: ODFW survey reach summaries versus reach gradient in Rickreall Creek.

Survey of Lower Rickreall Creek by CH2MHill

In October 1995, CH2MHill performed a foot survey of stream morphological characteristics of the Rickreall Creek from the mouth upstream to the wastewater treatment plant at River Mile 10 (CH2MHill 1996). The survey was performed by an experienced fisheries biologist. The surveyor summarized the stream condition as follows:

1. Lack of adequate spawning gravels was judged to be one of the two most limiting factors for effecting the fisheries resource in the lower Rickreall. Substrates contained high percentages of silt and organics due mostly to the low channel gradient. Spawning gravels were present but embedded up to 60 % in areas. Embeddedness decreased to 10 % in riffles located near the top of the survey. Spawning habitat appeared to be more suited for cutthroat than anadromous fish.
2. The other limiting factor to fish in the lower Rickreall is lacking off-channel habitat that provides refuge from high flows. Much of the channel was entrenched into the floodplain with high banks and few side channels. Pool habitat was abundant throughout with many pools being in excess of 3 feet deep and some up to 10 feet deep. The habitat was characterized as providing good summer rearing for juvenile salmonids and good passage for adult salmonids. Riffle habitat was very limited and primarily found above River Mile 8.
3. Low basal flows were listed as a third important limiting factor to fish in the lower Rickreall by concentrating pollutants and decreasing dissolved oxygen and raising temperatures. Water quality was reported to be degraded due to agricultural non-point pollution. Degraded quality included low dissolved oxygen, increased nutrients, chemical contamination, and increased water temperatures. [Note that these observations are likely the result of the surveyor's literature review and not measurements he made.]
4. Riparian zones were characterized as adequate for providing shade, litter, and bank stability. Recruitment potential for large woody debris was characterized as limited due to lack of large streamside conifers.
5. Surveyor thought the stream showed signs of "flashy" flow events and described an episode of a rapid streamflow rise to an estimated 65 cfs following a 0.5 inch rainfall. Discharge at the mouth at the start of the survey was estimated to be 34 cfs.
6. The lower 2.1-mile section of stream from the mouth to the bridge at Independence Highway was characterized as high having a degree of channel entrenchment with high banks. This area was judged to provide poor spawning but good summer rearing habitat. Few off channel refuge areas limit winter habitat and overhead cover was lacking.
7. The next, 2.6-mile, section from Independence Highway to the Greenwood Road was similar to the first section being characterized as highly entrenched with up to 40-foot banks supporting deciduous riparian vegetation. Fish habitat was similar to the prior section.
8. The third section was 3.5-miles from Greenwood Road to Highway 99 in Rickreall. Here several changes in stream condition were noted. Gravel was noted as beginning to increasing in diameter to egg sized, gravel embeddedness decreased,

and habitat diversity increased. Entrenchment was decreased and riparian zones appeared to be narrower (10 to 40 feet wide). The surveyor noted that flow went through a culvert under the concrete ford at River Mile 8. The conditions of high stream velocity through the culvert appeared to create a fish passage barrier.

9. The fourth section from Highway 99 to Bowersville Road and the wastewater treatment plant was 2.2 miles. Here still more channel widening was noted and banks were lower. Gravel bars were noted as providing off-channel habitat. Habitat diversity increased. Summer rearing habitat was reduced but still present. Gravels and cobbles were more common and embeddedness was reduced. Aquatic invertebrates increased due to greater abundance of riffle habitat, though species diversity remained low. Large woody debris was lacking here as in all downstream sections.

Channel Habitat Types

Channel habitat typing was performed on streams that are mapped on the USGS 7.5 minute topography map using the procedures outlined in the Oregon Watershed Assessment Manual (Watershed Professionals Network 1999) as a guide (Map 5-1). A summary of channel types is shown in Figure 5-2.

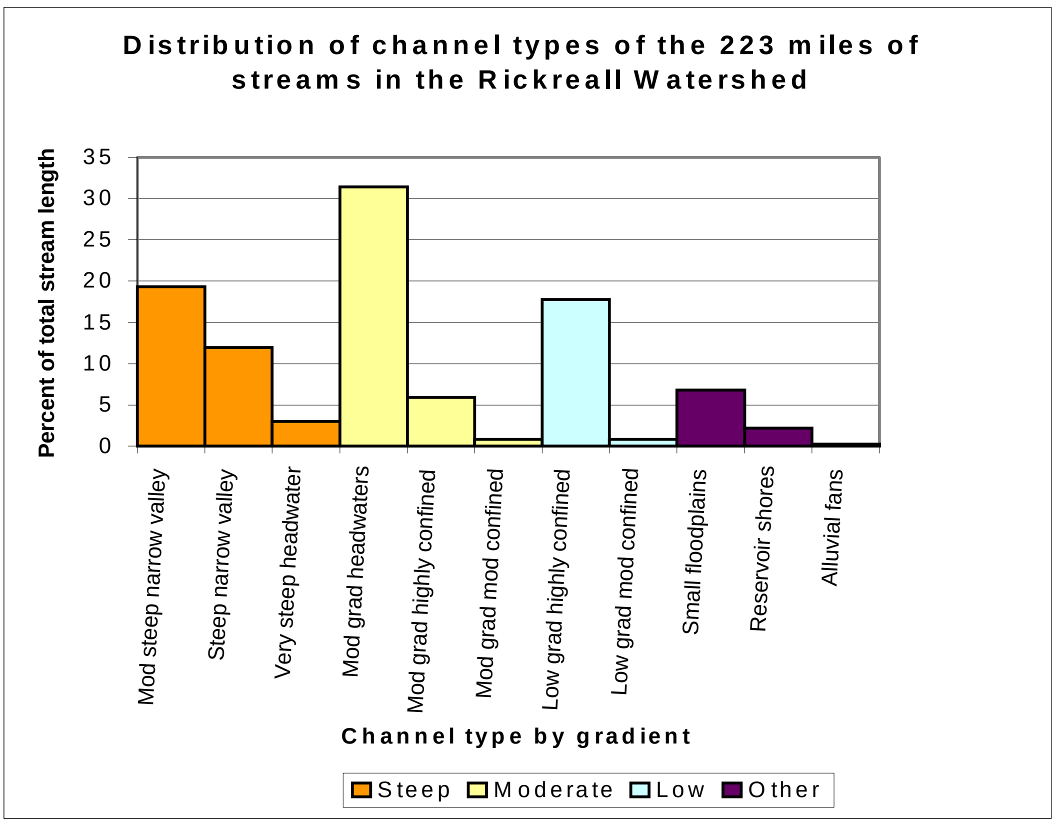
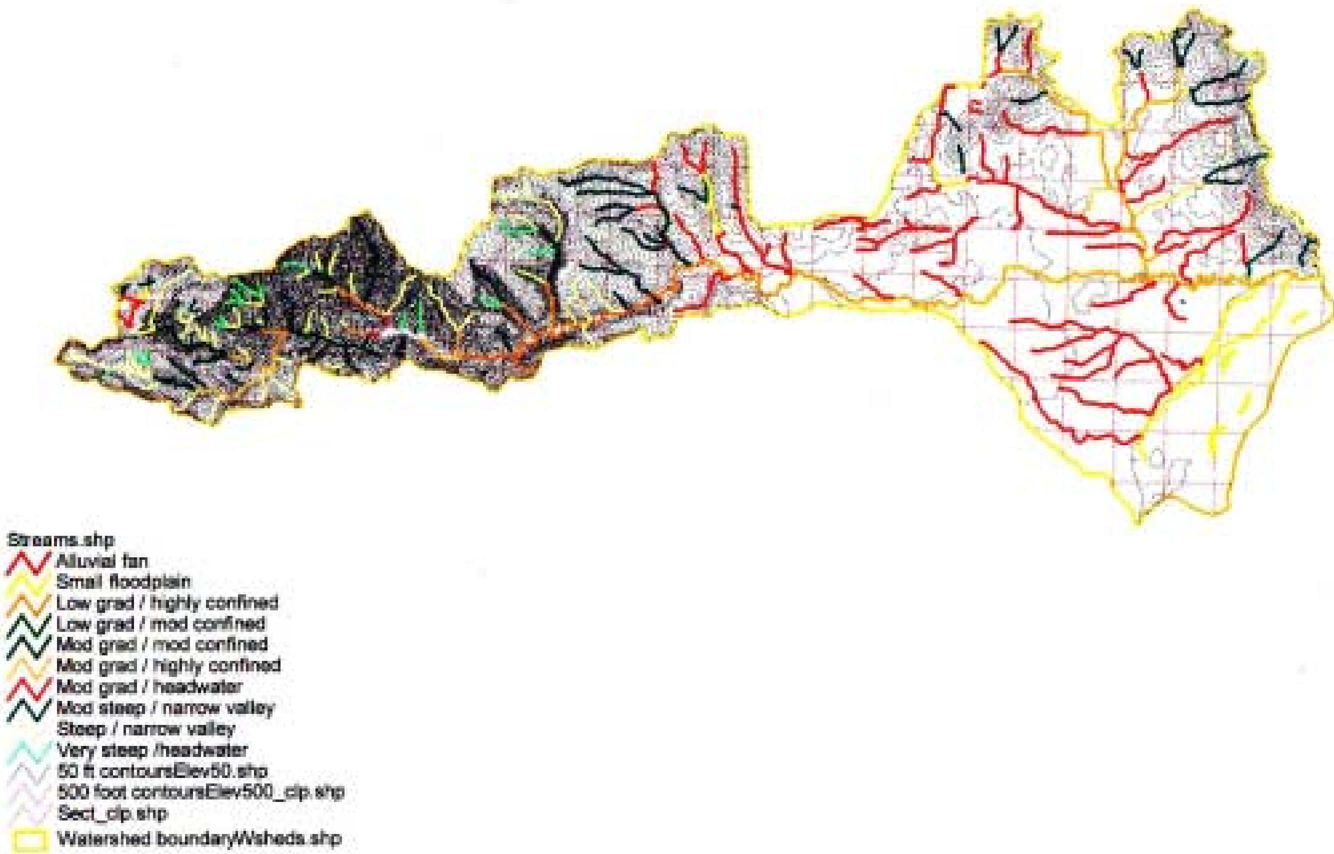


Figure 5-2: Channel habitat typing summary of streams in the Rickreall watershed. Greater miles of high gradient streams is mainly a function of a greater stream network in the headwaters of a stream system. Note that confined streams dominate

5-1: Channel habitat types. See also Figure 5-2.



Culverts and Fish Barriers

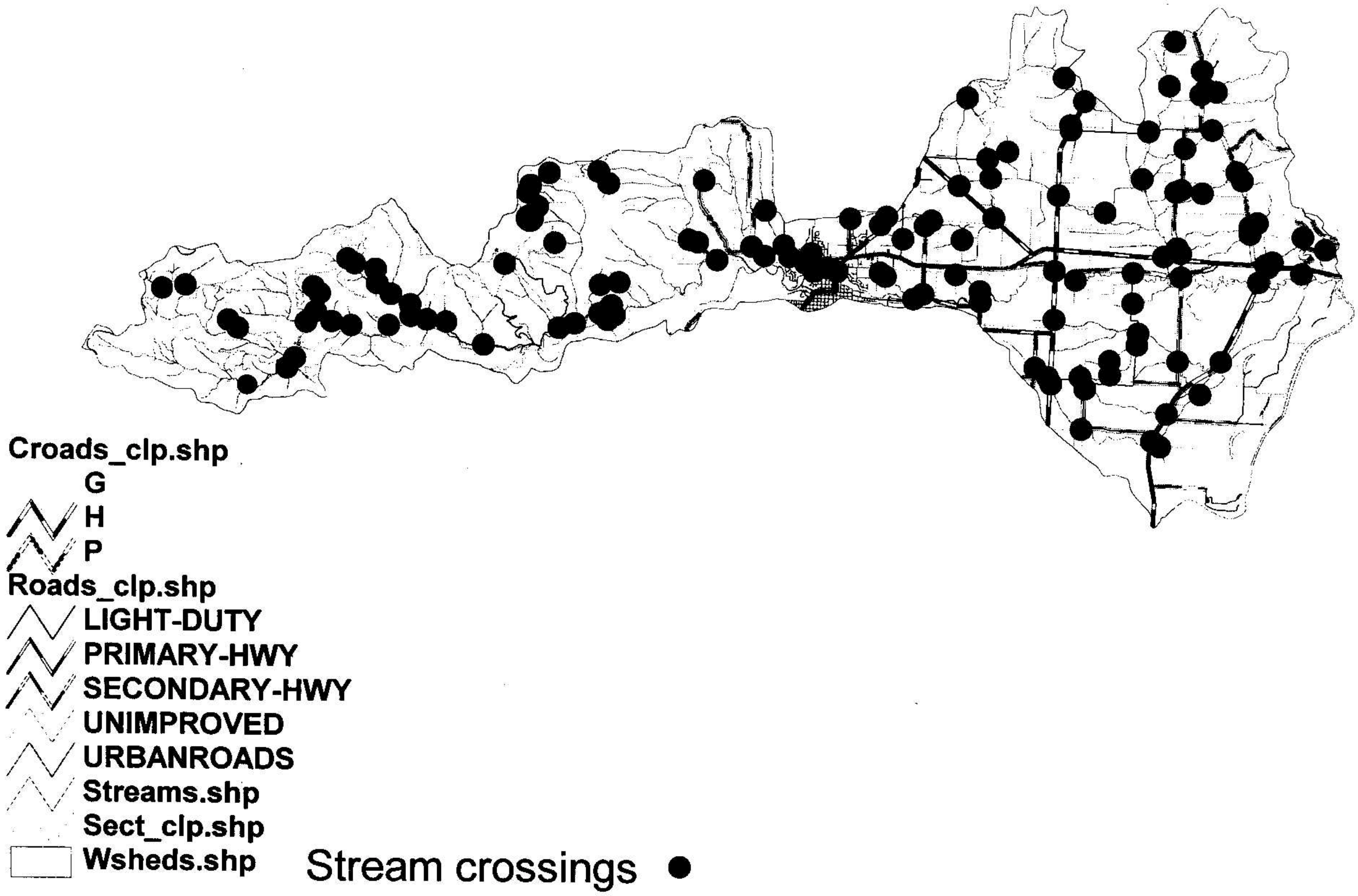
Road crossings of stream are shown in Map 5-2. Crossings of larger streams are accomplished by bridges, but most crossings use culverts. Culverts can pose problems for stream systems in two ways. First, they can block fish movement and effectively isolate populations or prevent access to upstream areas during migrations by fish. Secondly, culverts can initiate road failures if they are undersized or become blocked during high stream flows. Most of the problem culverts are those that were installed years ago without regard to stream and fish needs.

Today these problem culverts are relatively easy to identify and sometimes the fixes are inexpensive. As a result, a number of culvert surveys have been initiated. Most of the work to date has been on public lands and roads.

Two state agencies, ODF and ODFW, are surveying culverts for fish passage problems. In 1998 ODF surveyed all roads on state lands in Polk County for culverts**.** Some adjacent private lands were also included in the surveys. The survey was part of a three-county survey that covered some 300 miles of road. The purposes of the surveys were to identify all structures, map their location, and describe their conditions. Standard data were collected according to guidelines set by the Forest Practices Section of ODF. Typical data include diameter, drop of outfall, pool below, gradient, road condition, and ditch conditions. Among the early findings was a realization that a large number of culverts exist on the landscape, with many of these blocking upstream habitat. ODFW's inventories of state and county public roads (except urban areas) include an examination of culverts for fish passage. These surveys also uncovered problems, which will be prioritized for repairs and restoration (G. Galovich, ODFW, Corvallis, pers. comm.).

Developing a program to survey culverts on remaining private lands may be a project for the watershed council. However many of the culverts providing access to headwater streams are likely on the industrial forest lands. Both Willamette Industries and Boise Cascade have public commitments to road and culvert programs, largely through their endorsement of the Sustainable Forestry Initiative (see http://www.afandpa.org/forestry/forestry.html). The Sustainable Forestry Initiative program is a standard of environmental principles and performance measures that integrates the forestry activities with the protection of wildlife, plants, soil and water quality and a wide range of other conservation goals. Both companies have contracted Pricewaterhouse Coopers to perform third-party certification assuring that they are being managed sustainably. (For more information see these companies websites: www.wii.com and www.boisecascade.com.

Map 5-2: Stream crossings by roads. There are likely additional crossings as not all roads are on the GIS layers.



Other Fish Passage Obstructions

The Mercer Reservoir is non-fish passable. ODFW estimates that there are 11 miles of inaccessible steelhead habitat above the reservoir. The reservoir also prohibits cutthroat trout from migrating longer distances along the Rickreall. The reservoir isolates the population above from those below.

The concrete ford at River Mile 7.5 (Villwok's dam, see Photo 1-2 in Chapter 1) may create some fish passage problems. The CH2MHill survey of 1995 noted that the concrete ford was not fish passable as the water was passing beneath through an undersized culvert. This year, during a visit by the analysts, the ford was passing water over the top and fish passage appeared to be possible.

Several of the culverts over tributaries downstream of the reservoir did not look passable during low flow; however the test is passability during high flows or when fish are more likely to be moving up or down stream.

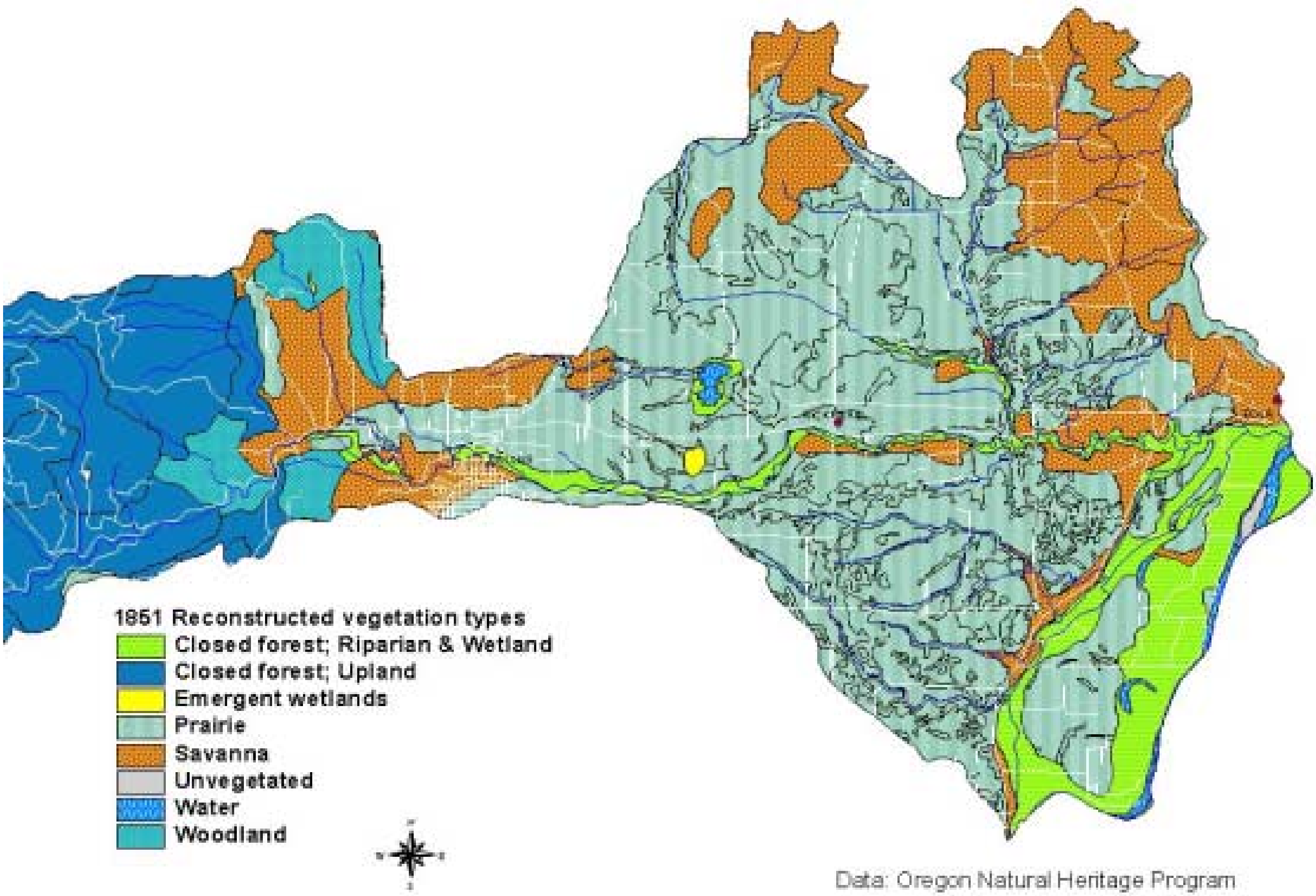
Riparian Zones and Wetlands

Historical records such as journal entries of explorers and settlers indicate that much of the riparian forests and wetlands that originally existed along valley bottoms of larger rivers were cleared for homesteads beginning about 1840 (Storm 1941, see also Chapter 2). Development of the valley bottom appears to have occurred rapidly between 1840 and 1880. Some sense of change in riparian vegetation along the lower Rickreall can be gained by comparing the 1851 historic vegetation map (Map 5-3) with the current 1997 vegetation map (Map 5-4). The 1851 map suggests that the original riparian zones were wider than those of today, but were still narrow. The riparian forests along the lower Rickreall are typically less than 100 feet wide, while those on the 1851 vegetation map appear to be several hundred feet wide. Greater change in riparian vegetation appears to have occurred in the floodplain area along the Willamette River. Most of the lower floodplain appears to have been closed forests covering several square miles. Today, these areas are mostly in croplands and orchards. It is of note that the area just south of the mouth of the Rickreall appears to still be in riparian forests and may represent an important remnant of the original riparian forests (Figure 5-4).

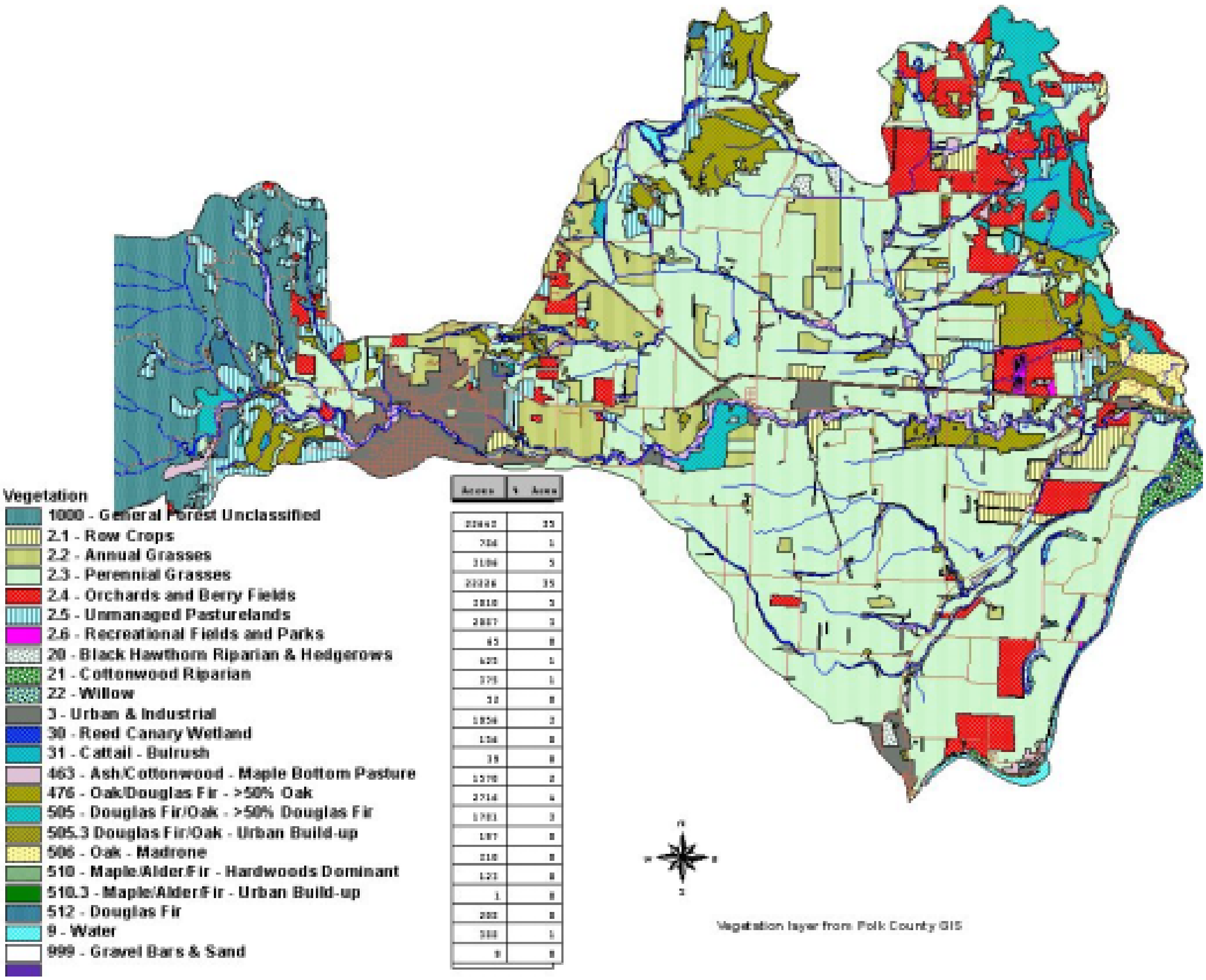
Channelization of headwater, tributary streams likely occurred before the 1930's in the lower Rickreall watershed. In addition, much of the loss of riparian zones likely had occurred by this time. An examination of aerial photos taken in 1936 reveals that much of the Rickreall Creek drainage had been developed for agricultural use. Comparison of the 1936 photos to those taken in 1955, 1970, and 1994 show that small (probably less than 5%) amount of riparian habitat was lost (Photos 2-4a through 2-4d).

A more comprehensive map of current riparian vegetation may be available through the Coastal Landscape Analysis and Modeling Study (CLAMS). CLAMS uses satellite imagery and modeling to develop vegetation layers (Map has been requested). The CLAMS project promises to be a useful source of information and possibly analysis tools for watershed groups in the Coast Range. More information is available on the CLAMS website (http:/www.fsl.orst.edu/clams).

Map 5-3: Vegetation types in 1851. Reconstructed from the GLO land surveys. Most of the prairie, the closed riparian forest, and the wetlands have been converted to crop lands (see next map).



Map 5-4: Current vegetation in the lower watershed. Total watershed is 35 % "general forests" (upper watershed), 35 % perennial grass, 14 % other crops/pastures, 12% woodlands, 3 % urban, 1 % water.



Current wetlands are shown in Map (4-2). Again, comparison of the 1851 vegetation map with the current maps and orthophotos can provide an insight into the current status of wetlands. The 1851 map indicates that wetlands existed between Dallas and Rickreall (Map 5-3). These wetlands correspond to the area labeled Boyle Lakes on Map 4-2 and Figure 4-6 (see Chapter 4). Map 5-3 and the orthophotos indicate that most of these wetland have been drained or converted to agriculture. The 7.5 minute USGS map indicated that some element of wetlands occurred there.

Figure 5-3: Remnant riparian forests along the Willamette River appear in the 1994 orthophoto. The forest can be seen along the inside of the sweeping bend in the river. This area likely was not converted to agriculture because of its wet soils and frequency of flooding.

The Oregon Natural Heritage Program performed a wetlands inventory in the Willamette Valley. Their report is available at www.sscgis.state.or.us/data/ sources.html. Their findings include the following summaries:

> "Most [wetland] sites inventoried in the Willamette Valley are dominated by non-native species. The most common invasive species in bottomland and wetland habitats are reed canary grass (*Phalaris arundinacea*), roughstalk bluegrass (*Poa trivialis*), Himalayan blackberry (*Rubus discolor*), nipplewort (*Lapsana communis*), English ivy (*Hedera helix*) and bittersweet nightshade (*Solanum dulcamara*). These species are very difficult to keep out of native areas and extremely difficult to control once they have invaded an area."
>
> "Throughout the Willamette Valley, riparian zones and wetlands are actively being developed [i.e., filled or drained]. This was observed numerous times during the course of this project. Section 404 (wetland fill permit) violations appear to be commonplace. Privately owned wetlands and riparian areas throughout the Valley deserve increased protection from degradation and development."
>
> "Wetlands found on sites with high quality remnants have been included in a conservation priority list. The most important sites on private land are the Calapooia River, Muddy Creek, North Santiam River, Luckiamute River, Kingston Prairie, the Mission Bottoms area, and the Bull Run Creek fragment. Private lands along many other rivers and creeks are also worthy of protection. Public lands in the Willamette Valley need to be protected from degradation. Restoration activities could be attempted at non-native dominated areas on public lands, although protecting native habitat should clearly take precedence over restoration. Small emergent wetland sites are scattered throughout the Willamette Valley, both in and between the priority wetlands. These sites should be a focus of protection along with the forested riparian zones. Hydrological threats to these areas also need to be addressed. Large native emergent wetlands were not found outside of public lands."

Sensitive Species other than Fish

A complete species list of all animals thought to occur at the time of Euro-American arrival has been compiled by Hulse et al. (1997) for the in the Muddy Creek sub-basin of the nearby Marys River watershed. This list included 234 total amphibian, reptile, mammal and bird species. This list is probably representative for the Rickreall Creek Watershed, because the Muddy Creek drainage has both a valley floor and upland habitats similar to the Rickreall watershed. Eight vertebrate species are listed as extirpated from the Muddy Creek sub-basin: grizzly bear, California condor, lynx, gray wolf, white-tailed deer, yellow-billed cuckoo, black-crowned night heron, and spotted frog (Hulse et al. 1997).

The Oregon Natural Heritage Program (ONHP) has assembled a list of sensitive species in Polk County (http//:www.hertitage.tnc.org). Approximately 90 of these species of plants and animals are thought to occur or at least have potential habitat in the Rickreall Creek Watershed (Appendix 5). The ONHP list includes species listed by one or more of the following: federal agencies including the US Fish and Wildlife Service and NMFS; state agencies including ODFW and the Oregon Department of Agriculture; and nonprofit and educational organizations such as Native Plant Society of Oregon, Oregon State University's Oregon Flora Project (OSU), and the ONHP. Species that are not listed on federal or state lists, but are listed by another group are also included in the table. For many of these listed species there is not enough data to determine the status of their populations.

Biodiversity

Biodiversity indices developed by the Hulse project for the Muddy Creek drainage of the Marys River basin near Corvallis, Oregon suggests that overall biodiversity has declined prior to Euro-American settlement (Hulse et al 1997). The researchers attribute the decline to a general pattern of land use change and loss of habitat. Given the projected population increases for the Muddy Creek area, which may be extrapolated to other areas of the Rickreall Creek Watershed, biodiversity is projected to continue to decline. Stabilization at current levels can only be achieved via a reduction in human population growth or change in land use allocations (Hulse et al. 1997).

Chapter 6 : SOIL QUALITY AND LAND HEALTH

Soil quality is important through its influence on hydrology, sediment characteristics, nutrient dynamics, slope stability, vegetative cover and land use. Many inherent soil qualities, such as degree of soil development, soil depth, slope and soil texture, are the result of the soil-forming factors -- of parent material and relief changed over time by organisms and climate. Other soil qualities are more dynamic and tend to be strongly influenced by land use and management, and these include soil infiltration capacity, soil organic matter, and nutrient content and soil tilth. This chapter assesses the relationships of soil qualities, land use and management, and the impacts on watershed health and water quality.

Soil Groups

The diverse soil types of the Rickreall Creek Watershed are grouped here, for the purpose of watershed assessment, into 8 broad groups based on soil hazards for erosion, soil wetness and flooding (Map 6-1). These soils are listed and each group is described in Appendix 6). At 800-1000 feet above sea level a climatic soil classification break occurs (>60 in. precipitation per year), with udic moisture regime soils above this elevation and xeric moisture regime below. The soils that formed in the valley are less leached and have a higher base saturation than the soils of the foothills and mountains. This characteristic is due in part to less rainfall at lower elevations and the length of time that the soils have been exposed to weathering (Knezevich 1982.)

The Polk County Soil Survey (Knezevich 1982) is the original source of spatial information and interpretations about local soils. Polk County digitized these soil survey maps into a Geographic Information System (GIS). An update of the soil survey was completed using GIS-functionality to correct slope designations with a high-resolution (10 m pixel) digital elevation model. Some of the soil delineations were given more field checking (e.g. Bellpine soils) as part of that update. That project was a cooperative one involving Polk County GIS shop and NRCS soil scientist. The soil coverage created in that project and interpretations were used to create new soil coverage for the watershed analysis. The model used here to group soils is in the Appendix 6. Watershed and reflect the capability class of soils for general land uses.

Soil Erosion and Delivery to Streams

In reference condition, soils in the Rickreall Creek Watershed were covered by lush vegetation year round and experienced low rates of soil erosion. Soil loss rate was probably similar to that measured under established grass crops (0.01-0.11 tons per acre per year). Disturbances such as fire and landslides temporarily denuded vegetation causing localized erosion. Historians have recorded the practice of burning the valley floor and foothills by the Kalapuyas

(see Chapter: History). Frequent, low intensity prairie and savanna fires probably did not cause a large amount of soil erosion. Periodic fires that burned in the Coast Range forests may have been more intensive, leaving soils exposed to severe erosion. Fire history reconstruction for the Oregon Coast Range indicates an average fire interval of about 230 years under the current climate (Long et al. 1998). (Cite Agee Reference too)

Soil erosion is a natural process that often is accelerated by human activities. Accelerated soil erosion on cropland, forest roads, and construction sites is a potential source of sediment pollution to surface waters. Where moderate to severe erosion occurs, the productive capacity and value of land can decrease over time. Sediments can fill natural depressions and drainages, road ditches, and pools in creeks, destroying fish and wildlife habitat and shortening the life of reservoirs and wetlands. Sediment from forested uplands can decrease the storage capacity of the Mercer Reservoir and can result in expensive dredging operations.

Clay-sized sediments eroded from uplands and stream banks may have nutrients and pesticides bound to them and are a major source of non-point pollution. The concentrations of numerous pesticides are positively correlated with the concentration of suspended sediment in runoff in small streams in the Willamette Basin (Anderson et al. 1997) Fine textured sediments can remain suspended and cause turbidity that negatively affects many beneficial uses.

Forest Uplands

Forest Practices Impacts on the Forested Uplands of the Watershed

Logging in the Oregon Coast Range is challenging where slopes are steep, soils are sometimes shallow or moderately deep, and soils are loose and easily compacted by ground-based yarding. Constructing roads into the forest requires crossing numerous streams and potentially unstable slopes. Heavy winter rains can produce significant runoff and subsurface flow that can result in drainage problems and road fill failures.

Over time logging practices have evolved to reduce impacts of forest management activities such as road construction and site preparation following harvests. Timber harvest practices have changed to reduce ground disturbance and to minimize impact to watersheds and streams. However, much of this watershed was logged before the current Oregon Forest Practices Act rules were adopted and as a result some of the forested uplands were adversely impacted during harvests.

Soil Compaction and Displacement in the Forested Uplands

Soil compaction, puddling and rutting can be caused by methods and machinery used in forestry and road construction. Such soil disturbances can decrease the soil infiltration capacity and trigger increased runoff and sediment yield. Ground skidding logs can disturb significant areas of the harvested stands (Froehlich 1984). Johnson and Beschta (1980) report that new skid trails have about 50% lower infiltration capacity than undisturbed forest soils for soils of the Coast Range. Lower infiltration capacity can trigger increased runoff and soil loss if precipitation intensities exceed infiltration rate.

The BLM (1998) watershed analysis that included the Rickreall Creek Watershed forested uplands sections concludes that soil compaction and /or displacement have resulted from timber harvesting by ground-based yarding equipment, mechanical site preparation, and slash burning. Ground based logging using crawler tractors was used on a majority of the area in 1940's to the 1960's and resulted in extensive areas of disturbed, compacted and displaced soils. In their analysis, BLM reports only 313 acres out of almost 26, 000 acres (1%) of BLM lands in the analysis area that have compacted soils from past logging practices and no other specific data is presented. This is a low assessment of percent compacted ground following timber harvest, compared to other studies in the Coast Range (cited in the preceding paragraph).

The BLM (1998) analysis states that surface disturbance associated with forest practices in the watershed has resulted in greater soil erosion by water, dry raveling and debris avalanche landslide. The report states that, in shallow soils, areas that were once forested have reverted to brush, following logging. This is due largely to the difficulty of establishing trees in shallow soil areas. Accelerated erosion reduces the acreage of productive forestland, reduces the return rate of debris avalanches in headwall areas and eventually most of the eroded material enters streams.

Mass Erosion in the Forested Uplands

Reference Conditions

Under reference conditions mass erosion is the dominant erosion process in the steep forested headwater portion of the watershed. A study of an undisturbed Coast Range forest reported an average of 14 small slides per square kilometer, with 8% of small streams (USFS Class III and IV) impacted by channel scour and deposition (Ketcheson and Froehlich 1978). The majority of the measured slides were on slopes greater than 80%. Concave headwalls with over-thickened colluvial deposits are responsible for a large portion of mass movements in the Coast Range that reach stream channels. Other high-risk landslide areas include steep, deeply incised channels and lower portions of long rectilinear slopes (Ketcheson and Froehlich 1978). Headwall failures are usually associated with high intensity rain falling on saturated soil. These slides deliver coarse material for stream substrate and large woody debris that provide complexity to stream habitat, but can also can adversely affect fish habitat and water quality with excessive fine sediments.

Mass Erosion: Historical and Current Conditions

Accelerated mass wasting from uplands has not been adequately quantified in the watershed. The expected amount of sediment that has or will be delivered to Rickreall Creek and its tributaries, and ultimately to Mercer Reservoir, via mass erosion has not been well established. The relative contributions and interactions of natural and landuse-induced mass erosion are similarly not well quantified for this watershed.

While past forest harvesting and roads may have increased mass erosion rates above historic conditions, current forest practices attempt to minimize mass erosion. Efforts are underway to identify areas of high risk of mass erosion. An example of this is a GIS-based digital terrain model, developed by Siuslaw National Forest, which rates risk of mass erosion based on slope steepness and configuration (K Bennett, USFS, pers. comm.). Likewise models that integrate factors of the climate and the terrain are being used predict when debris avalanches and other landslides will occur based on rainfall intensity patterns (DOGAMI 2000).

Most landslides in the watershed originate on slopes with gradients greater than 60% (BLM 1998), represented by Soil Group H and shaded Gray on the Soil Map (Map 6-1). Slope hazards and landslide slide tracks in the watershed have been described by the BLM watershed analysis (BLM 1998). These data were derived from interpretation of aerial photographs from five years, dating back to 1956. In the overall forested uplands of the analysis area, slide rates were on average one per 495 acres, but on slopes greater than 60% there was an average of one slide per 23 acres of land.

Slides on public and private land are proportional to the area in each type of ownership. Slides were primarily associated with roads and clearcuts. Past logging practices are implicated as a root cause since 56 percent of the slides measured occurred prior to 1956. However, large storms can function as major triggers of landslides, for example, for the slides counted between 1956 and 1996, 37 percent of the slides occurred during the 1996 peak storm event and originated from roads and recently logged areas. From this information it can be concluded that extreme weather events that trigger landslides will continue to test the adequacy of the Oregon Forest Practices Act in the future.

Controversy persists about the impact of forest harvesting and roads on the frequency and magnitude of landslides. Ketcheson and Froehlich (1978) reported slightly fewer small debris slides in clearcut forest blocks than in undisturbed forest. However the slides in clearcut areas traveled 1.7 times farther and impacted more small streams with channel scour and deposition than slides in undisturbed forest. Swanson et al. (1977) reported a nearly twofold increase in slides following harvesting over all lands and a four-fold increase following harvesting on the most slide-prone ground.

Debris avalanches are a major process in upper watersheds and a primary source of sediment there. It is useful to make some assumptions based on best available information. Given the uncertainties of rock structure and weather, management strategies that focus on carefully managing the steeper parts of the watershed (slopes greater than 60%) should over the long run be effective in reducing sediment delivery from mass erosion.

Fire and Flood in the Watershed

Two recent events demonstrated the profound force and uncertainty of nature in the Rickreall Creek Watershed. A wildfire in 1987 burned 5000 acres and was followed in February 1996 by a severe set of storms that left much of the Pacific Northwest with severe erosion on mountain slopes and flooded river valleys. This one-two-punch resulted in serious erosion in the watershed that was focused in the Rockhouse Creek subwatershed right above the Mercer Reservoir. These two events called for emergency reponses and suggest an ongoing need for emergency readiness as a watershed management strategy. Perhaps a Fire and Flood Emergency Response Team should be created and coordinated by the watershed council.

Rockhouse Creek Fire 1987

In October 1987, a wildfire burned 5000 acres in the Coast Range west of Dallas, including 2500 acres in the Rockhouse Creek and Rickreall Creek watersheds. The fire burned young forest cover over roughly half of the acreage of the Mercer Reservoir watershed, the water supply for the City of Dallas. A force of 1200 firefighters battled the blaze for 8 days. Miles of fire line were dug by hand and with bulldozers. With 40% of Rockhouse Creek watershed burned and much of it severely burned the winter rainy season was about to start. The watershed and the reservoir were in a precarious position, setup for severe soil erosion and sedimentation of the reservoir. This watershed is very steep with long slopes and soil depth ranging from shallow to deep.

An emergency watershed protection plan was quickly developed that called for aerial seeding of bare soils and the construction of 19 sediment dams constructed of large bales on 7 waterways, and the construction of a rock sediment retention dam at the mouth of Rockhouse Creek. The City of Dallas obtained funds from USDA-SCS Emergency Water Protection to implement the plan. Without these measures the estimates of erosion were 80 to 100 tons of soil per acre. An estimated 100 acre-feet or more of sediment would reach the reservoir the first winter and another 16 acre feet would enter the Rickreall creek below the dam. At the estimated dredging cost of $10,000 to $15,000 per acre-foot of sediment, the cost to remove the sediment from the reservoir would be over $1 million.

Debris Flows in February Storms 1996

The storms of February 1996 tested both the integrity of the watershed's forested slopes, and the land use practiced upon them. Several studies recorded observations of the effects of these storms on watersheds. The NRCS Geomorphologist, Jenine Castro, made a report of numerous debris flows in Rockhouse Creek subwatershed following these storm events (Memo from J. Castro to City of Dallas, April 5, 1996). This watershed had been largely cut over and replanted, and then it was severely burned in the 1987 wildfire.

Castro characterized the debris flows as carrying a "tremendous amount of sediment into Mercer Reservoir; much of the sediment was deposited in and along the tributary channels." She estimated 90% of the debris flows originated from roads. These roads lacked waterbars and were very steep and captured streamflow during the event. She mentions a large (8-10 acre) landslide that is contributing sediment to the reservoir but did not visit the slide and did not give its exact location.

Castro predicted that many more such flows would occur in the next ten years that would reduce the capacity of the Mercer Reservoir and increase turbidity. Practices recommended as short term fixes included installation of filter fabric to trap sediments, inspection of road crossings, construction of additional sediment basins and stabilization of the large landslide. Ken Hale, NRCS Dallas, commented on a large unstable area above the Reservoir, but was unsure of its location. J. Castro made a similar claim but had not actually seen it. This area needs to be identified.

The long-term approach includes mapping slopes that have high risk of failure and subsequent sediment delivery. Unnecessary roads should be obliterated and other roads made more stable by outsloping and waterbarring. Crossings and culverts must be sized for longer return period storms. Watershed revegetation was deemed "extremely important" and it was suggested that a revegetation plan be developed along with private landowners.

Recent dredging in the Reservoir at the mouth of Rockhouse Creek removed 50,000 cubic yards, required 2000 truckloads to be hauled and cost $125,000.00. (Compare this to cost of erosion control after fire)

Reports of1996-Storm Effects on Slides

Aerial reconnaissance of the Oregon Coast Range that included the Upper Siletz River Watershed just west of Rickreall Creek following the 1996 storms was used to observe landslides and evaluate the associated landuses (Weaver and Hagans 1996). In the Northern Coast Range portion of that survey, most slides (71%) were in recent clearcuts and only 6% were in uncut areas, while roads were only associated with 15% of observed slides. In the Upper Siletz Watershed 63% were associated with new clearcuts, 10% were in uncut areas and 36% originated at roads. The most common geomorphic position associated with slides in the Upper Siletz was steep swales that were often the headwaters to stream channels that begin just down slope.

An Oregon Department of Forestry (ODF) landslide survey following the severe storms of winter 1995-1996 supports the above findings for stands harvested 0 to 9 years ago, but not for stands aged 10 to 100 years (Dent et al. 1998). The ODF survey was conducted on forestland where state forest practices had been followed. Landslides from these severe storm events were most frequent on very steep slopes (greater than 65%). Most of the sites harvested and reforested from 0 to 9 years experienced increased landslide frequency and mass erosion amounts compared to undisturbed forest sites (>100 years old). However, stands that were harvested and reforested in the past 10 to 30, and 30 to 100 years experienced fewer slides and less mass erosion than the undisturbed older forests over 100 years old (K. Mills, ODF, pers. comm.)

Forest Roads

Roads can increase surface erosion, mass wasting, and stream sedimentation. Road density (miles per square mile) has been used as a meter to compare the potential impacts of roads on different watersheds. One problem with interpreting road density information is that usually more information is needed about road conditions, size, traffic and road location in the landscape in order to make an evaluation of road impacts on the watershed. This additional information is often more difficult to obtain and to interpret.

Road densities on forested lands in the BLM megawatershed analysis were 4.1 miles of road per square mile on the average and road density was similar for public and private forest ownership.   These road densities are similar to numbers reported for the Willamette Basin (Table 6-2). A gap in the data is for the privately controlled roads on private lands. An effort to obtain this data for the Rickreall Creek Watershed Assessment was unsuccessful.

Table 6-1: Road Status in Rickreall Creek, Mill Creek, Lukiamute River, and Rowell Creek Megawatershed. (BLM 1998)

Road Status	Surfacing			Total Miles	Total Miles	Road Density
	Black Top	Rock	Natural (Dirt)		%	miles/ mile^2
Total in Analysis Area	5	876	33	914	100	4.1
BLM-Controlled on BLM	5	111.8	16.2	133	14.6	3.1
BLM on Private	0	8.6	0.8	9.4	1	N/A
NonInventoried Privately Controlled in Private	0	N/A	N/A	749.7	82	4.2
Privately Controlled on BLM	0	20.5	1.4	21.9	2.4	N/A
BLM Roads Closed	0	N/A	N/A	19.8	2.2	0.5

Table 6-2: Road Densities for the Willamette Basin (Hulse et al, 1998).

Road Description	Road Density(miles / sq. mile)
All roads	3.8
BLM roads	3.7
USFS roads	4.8

Road construction has historically been one of the greatest contributors to cumulative effects to hydrologic processes on forested uplands (BLM 1998). Proper designs now include locating roads away from streams and erosive sites and planning to minimize the extent, width, and period of use. Guidelines are available to help locate roads and landings in relation to streams (ODF 1994; Trimble and Sartz 1957). Once constructed, roads must also be properly operated and maintained. Recommendations for reducing road impacts include managing wet weather traffic, decommissioning certain roads, minimizing disruption of natural drainages, upgrading culverts, placing rock on unsurfaced roads, and maintaining ditches and culverts (BLM 1998).

Road inspections are a critical part of road management that can identify potential problems such as plugged culverts, rutting and sedimentation. Regardless of public or private ownership, most land managers with large forest holdings conduct road inspections and inventories.

A forest road inventory done by the BLM (BLM 1998) identified some key facts about the condition of the roads on the megawatershed that includes the forested uplands of Rickreall Creek Watershed. Many culverts have rusted and are in at greater risk of failing, and other culverts are undersized for the 100-year return period storm event. Old log structures commonly used as crossings in the early days of tractor logging are "in various stages of collapse". The report does not identify any specific locations where this occurs. Some roads need to be covered with rock to help cut down on sedimentation. The road surface and general road condition is most critical near stream crossings and priority should be placed on inspecting the road segments that have the highest potential to contribute sediment to the creek.

In Oregon, the timber industry has made a commitment to remove or rehabilitate high hazard roads as part of the agreement for the Oregon Plan for Salmon and Watersheds. However, none of the requested road information was provided by private forest landowners on their roads. This remains an information gap that is needed to evaluate the potential impact of forested roads on Rickreall Creek and on the Mercer Reservoir.

Updated information from comprehensive road inventory conducted on state lands was made available in 1999 and will be integrated into ODF’s GIS (R. Nall, pers. comm.). Road information is available from Siuslaw National Forest in their GIS “road coverage” (K. Bennett, USFS, pers. comm.). Roads in agricultural and urban areas can have potential impacts on water quality also, especially in lowland streams. Further assessment of roads in the watershed is needed.

Agricultural Areas

Soil Erosion and Runoff

Under normal rainfall conditions, soil erosion in the Willamette Valley ranges from slight to severe depending on slope steepness, slope configuration, soil erodibility, and crop management practices (Table 6-3). Several agricultural practices leave the soil exposed during the winter rainy season and have been implicated in triggering severe soil erosion on sloping land such as Soil Groups B and C (Map 6-1).

The potential for severe soil erosion events on agricultural land in the watershed is documented in the historical accounts from the winters of 1949 (USDA-SCS 1949), 1956 (Torbitt and Sternes 1956), and 1964-1965 (Baum and Keiser 1965). The highest rates of soil loss have been the result of episodic intense rainfall during conditions of low infiltration capacity. During these storms, infiltration was limited by saturation of the soil, snow cover and frozen ground and sealing of soil surfaces by raindrop impact on unprotected cropland.

Practices contributing to high erosion include: fall-plowed cropland not seeded and without sufficient crop residues; fall-conventionally-seeded small grains, legumes, and grasses; and clean-tilled orchards and Christmas tree farms without cover crops (Young et al. 1980; USDA SCS 1949; Bela 1979).

Perennial grass crops provide good soil cover and are conservative of nutrients, with the possible exception of the year of crop establishment. Yet, cropped fields that receive intermittent concentrated flood flows may experience moderate rill erosion even with established grass crops.

Christmas tree farms, orchards and vineyards require winter cover crops or some other form of crop residue to adequately protect soils. No-tillage planting, cover crops, and grassed waterways are currently underutilized practices that could effectively reduce sediment concentrations in runoff.

Some lands that receive flood flows such as Soil Groups D and E (Map 6-1) are subject to slight or moderate erosion from overflow waters when left bare during winter. Cropping with annual crops such as corn and small grains pose erosion hazards if fields are left bare during winter months.

Table 6-3: Soil loss from field investigations, small watershed studies, Universal Soil Loss Equation, and Cesium-137 records for soils of the Willamette Valley.

Soil loss by land cover type (T ac^{-1} yr^{-1})		Weather	Study type	Reference
10 30 – 100	Average Fall-seeded and no cover crops	Hard rain on partly frozen and snow covered ground	Field inspection after storm	USDA-SCS (1949)
0.14 14.0	Grass established Fall planted (nearly bare)	Normal winter rainfall	Small watershed (2 yr.)	Simmons (1981)
0.7 - 2.0 1.6 - 4.6 2.9 - 8.6 4.8 - 14.1	Pasture/Hay Orchard (cover crop) Winter wheat fall-seeded up- and-down Row crop up- and-down	Normal weather modeled by USLE	USLE estimates for local conditions	Marion County SWCD (1982)
0.01 - 0.1 0.05 - 0.5	Grass Winter Wheat	Normal winter rainfall	Standard erosion plots (2 yr.)	Istock and Harward (1980)
0.2 - 4.0	Fall-seeded small grains and grass	Normal winter rainfall	Small watershed (2 yr.)	Istock and Lowery (1980)
1 – 12	Combined crops	Long term soil loss rate 1945-1979	Cesium-137 record	Brown and Kling (1980)

Factors Influencing Soil Erosion and Sediment Delivery

Decreased infiltration capacity of the soil, soil compaction, and the presence of impervious surfaces contribute in various ways to overland flow and subsequent soil erosion. These factors are discussed as they relate to the soil erosion processes of sediment detachment and transport. Though these processes and conditions occur naturally, human activities can increase their impact on watersheds.

Infiltration capacity of a soil is dynamic and decreases with increasing soil moisture content and formation of a seal on the soil surface (Farrel and Larson 1972.) At the end of the summer dry season, the upper soil profile is dry and the soil is often cracked. Infiltration capacity is high under such conditions. However, with the onset of the winter rainy season, soil profiles wet-up and cracks close. By early winter soils often become saturated, and where left bare, the soil surface can develop a seal as a result of raindrops breaking down soil aggregates and repacking the silt particles into a thin skin. Occasionally soils freeze or are covered with snow and this also may lower the infiltration capacity (Lowery et al. 1980.)

Overland flow or runoff begins when precipitation exceeds infiltration capacity of the soil. Where vegetation, forest litter or crop residues protect soils, there is generally little surface runoff in the Willamette Valley. Where soils are bare and surface seals have formed, detached silt and clay soil particles can be carried off in thin sheet flow and in small rills, and the amount of sediment transported in runoff can be large. Runoff also occurs where subsurface water moves downslope over impermeable sub-soil layers or bedrock and then comes to the surface on lower slopes. This condition occurs extensively in the Willamette Valley and often is expressed in the occurrence of side-hill seeps. Where these lands are farmed and remain bare in the winter, significant erosion can occur. Subsurface drainage such as tiling and ditching has been used to reduce runoff in such conditions, but this can have the side effects of reducing base flow of streams in some cases (Lowery et al. 1982). In late winter and spring, infiltration capacity increases again as plants grow, soils drain and surface seals crack. In addition to increasing erosive cutting action, increased runoff and erosion can alter stream flows and increase stream bank erosion.

Soil compaction, puddling, and rutting can be caused by farm machinery operating on wet and plastic soils. Soil compaction can reduce the infiltration capacity and soil productivity. Puddling and rutting destroy soil structure and can concentrate runoff and cause severe soil erosion and subsequent sediment delivery to surface waters.

Little information is available that relates upslope soil loss or streambank erosion amounts to sediment delivery to the Rickreall Creek and its tributaries.

Streambank Erosion

The streambank of Rickreall Creek is overall fairly well protected with vegetation and supports a healthy, narrow riparian forest. Active streambank erosion is evident over short stretches of the creek and tributary streams that have had bank vegetation denuded. High flows saturate soils and can undercut the toes of banks. Unprotected stream banks slough or cave in large slabs, delivering nutrient-rich soil directly into the stream. Productive streamside land is lost as a result. Quantitative information on the amount of sediment eroded from stream banks is insufficient to make an accurate assessment of the problem. A stream bank inventory and monitoring of bank erosion is needed to answer the question of the importance of bank erosion in the watershed.

The USDA-NRCS office in Dallas maintains records of much of the stream bank work that has occurred in the Rickreall Creek. Privacy issues make it difficult to obtain this information and it has not been adequately summarized. Perhaps a cooperative arrangement could be reached between NRCS and the watershed council to determine a way to release summary information about past stream bank work that would protect the privacy of streambank landowners.

The City of Dallas is purchasing riparian lands along the creek that pass through the city and they are maintaining woody vegetation as part of a temperature management plan. Temperature management plans that maintain streambank vegetation provide multiple benefits of streamside trees, shade, habitat, visual and noise reducing screens and bank structural support.

While current forest practices require riparian buffers, there are no similar rules for riparian buffers associated with pastures, cropland and urban land. Land use practices that can accelerate stream bank erosion include:

- Livestock grazing on banks and with access to creek
- Clean tilling or mowing to the edge of a channel
- Streamside recreation
- Land uses in the watershed that decrease the infiltration capacity of the land and storage of runoff, including increasing the amount of impervious surfaces
- Development on the banks that destroy riparian vegetation
- Chemical overspray and drift
- Reduction of these negative impacts could be addressed well with a streambank information and education program.
- Practices that protect banks and that reduce bank erosion include:
- Revegetation of creek banks
- Soil bioengineering erosion control
- Leaving creekside buffers
- Fencing livestock away from creeks
- Improving soil quality in watershed to reducing flooding.

These practices are well suited to cost share programs and volunteer watershed work days for the Watershed Council, and community and student groups.

Fertilizers and Pesticides

Historical and Current Conditions

Early agriculture relied on crop rotations with legumes and forages and several other crops to maintain nutrients. Tillage, crop rotations and cover crops were used to control weeds. Fertilizer use gained acceptance and wider use following World War I and the trend continued to increase.

Fertilizer and pesticides are widely used on farms, forest plantations, residential lawns, golf courses, and highway rights-of-way. Nutrients can enter surface water attached to sediment or dissolved in runoff and also dissolved in subsurface flow. Nitrate and pesticides leached from through the soil can contaminate groundwater resources as well.

Fertilizer

Grass seed crops in western Oregon receive between 125 and 256 lbs. of nitrogen per acre per year (Horneck and Hart 1988). Young et al. (1999) estimated that the amount of nitrogen applied annually to grass seed fields could be reduced by an average of 30% and growers could still optimize crop and economic returns.

A major research project is underway to determine long term impacts of grass seed production on water quality (Griffith et al. 1997, Horwath et al. 1998). Work has focused on poorly drained soils such as Group E (Soil Map 6-1), which are well suited to perennial ryegrass crops and they have substantial subsurface flow above clayey subsoil. Between crop uptake and denitrification in the poorly drained riparian soils, shallow-groundwater NO_3-N is reduced to low levels, even when fertilized with nitrates up to 170 lbs. of nitrogen per acre per year. In another study, Young et al. (1999) found that using nitrogen fertilizers at recommended rates (90 to 100 lbs. of nitrogen per acre) would result in a low potential for leaching of NO_3-N on fine-textured soils where grass seed crops are grown.

Because there have been few measurements of nutrient losses from uplands and the subsequent concentrations in surface water, nutrient and chemical transport and their impacts on water quality are not adequately known for the watershed.

Nitrate concentrations in runoff and shallow wells frequently exceeded 10 mg per liter from three of six agricultural watersheds in the southern Willamette Valley (Simmons 1981). Nitrate losses are highest when runoff events occur shortly after fertilizer applications, and even then amount to less than 4% of total applied fertilizer. Simmons (1981) reported total phosphorus (TP) losses of 0.36 to 20.9 kg per hectare, and dissolved inorganic phosphorus runoff concentrations 0.1 to 5.1 mg per liter. These are environmentally significant concentrations of P since 0.05 mg P L^{-1} can cause algae growth in surface waters.

Pesticides

Pesticide applications have been poorly tracked in the past, but pesticide transport and impact in the watershed are beginning to be scrutinized. In 1999 Oregon Legislature passed House Bill 3602, which tracks pesticide use throughout the state including agriculture, forestry, industrial and urban users. The program is due to be operational in 2002 and can provide valuable information on pesticide use within the watershed since watershed location is one of the pieces of information tracked. This program should provide information to future watershed assessments.

Anderson et al. (1997) collected data to characterize the distribution of dissolved pesticide concentrations in small streams throughout the Willamette Basin. They reported that a total of 36 pesticides were detected, with five herbicides including Atrazine and Diuron detected frequently. Pesticide concentrations for all those tested were usually less than 1.0 ug per liter, however an unusually high number of concentrations were in the range 1-90 ug per liter. One problem in interpreting these data is that aquatic life toxicity criteria have only been established for three of the detected chemicals. Anderson et al. (1997) published several tables on pesticide properties and commonly applied rates for the Willamette Valley.

Significant correlation exists between land use and pesticide detection in surface water of the Willamette Valley (Anderson et al. 1997). The amount of forested land in a watershed was negatively associated with pesticide occurrence. In predominantly agricultural watersheds, the instream concentrations of a few pesticides that were applied to a wide variety of crops were significantly correlated with estimates of the amount used.

A pilot study measured herbicide movement in runoff and in shallow subsurface flow to streams from grass seed fields in poorly drained Dayton silt loam soils. The application rates for the herbicide Diuron varied from 1.8 lb active ingredient (a.i.) per acre for perennial ryegrass seed crops up to 10 lb a.i. per acre for treatment of rights-of-way and field borders. Diuron was detected at instream concentrations of 1 to 12 ug L^{-1}, suggesting that no environmentally significant residues of Diuron are likely in aquatic systems next to grass seed fields, though further research is needed (Jenkins et al. 1994). Yet, concentrations of diuron in the Willamette Valley as high as 5-10 mg per liter were measured in very small ponded areas, where the herbicide had drained following application. That is a thousand-fold higher concentration than the ug per liter instream levels discussed earlier. Recent studies suggest that these levels of this pesticide could have potentially adverse effects on aquatic species (Schuytema and Nebeker 1998). Such relationships require further study.

Livestock and Watersheds

Livestock issues include management of confined animal feeding operations (CAFOs) and livestock grazing in the riparian zones of streams. The problem associated with animal facilities result from runoff, facility wastewater and manure. Water-quality parameters that can be directly impacted by livestock include fecal coliform levels, nutrients, habitat modification, sedimentation, and water temperatures. Grazing and livestock access can deteriorate stream bank vegetation and increase bank failures. Overgrazed pastures are potential sediment source areas. Livestock can have significant impacts on riparian zones. Excluding animals from these areas with fencing and providing off-stream watering helps to alleviate impacts. Such practices as manure management, filter strips and riparian planting are available to be cost shared up to 75% (USDA-EQIP Program). [Statistics on CAFOs permitted in the watershed by the Oregon Department of Agriculture (ODA, Chuck Harmon, pers. comm.). Inventories are needed to determine impacts of livestock on creeks and riparian areas.

Rickreall Dairy

The Rickreall Dairy is the only commercial dairy in the Rickreall Creek Watershed. The dairy operator was interviewed as part of this watershed assessment and we inventoried control measures that the dairy has taken to meet its pollution control responsibilities. The dairy has 3200 cattle including 1500 heifers and is located adjacent to and north of the creek just east of Rickreall in the town Derry. The dairy has a water right to the creek and uses creek water to clean the barn and to irrigate crops.

The dairy has a confined animal feeding operation permit (CAFO) from the Oregon Department of Agriculture. There has been considerable investment in manure and liquid wastewater handing systems at the dairy. Liquid wastewater from barn cleaning and milkhouse waste are stored in a large lagoon and nutrient rich slurry is irrigated on the adjacent cropland. The lagoon is required as winter nutrient slurry storage, since they can not fertigate in the rainy season (October 1 to April1). The waste storage lagoon may reduce the nutrient, pathogen and organic loading to surface waters.

Monitoring wells were installed to monitor groundwater quality next to the lagoon. In addition to not winter applying nutrients, the permit requires that the cropland treated not have more than 55 pounds nitrate-N in the upper four foot soil profile going into winter rainy season. This is a conservative amount of N compared to typical grass seed operations in the Willamette Valley (See nutrient section). Soil tests of the five-foot soil profile in fall of 1999 had measured N-levels above this amount and the diary was served notice by ODA. Originally the permit was approved with 295 acres of land available for irrigation with slurry from the lagoon. Summer of 2000, the dairy purchased an additional 330 acres available for fertigation.

The soils that the dairy is applying the nutrient slurry to are poorly drained and clayey soils Cove and Bashaw. These soils are nearly level to slightly depressional and have very slowly permeable clay subsoils and substratum. Recent research in the Willamette Valley on similar soils revealed an aquaclude between shallow subsurface water and deeper aquifers (D'Amore et al. 2000). Given the hydrologic conditions of this soil there is not a large risk of nitrate leaching to groundwater. Additionally similarly clayey poorly drained soils in Willamette Valley grass seed cropland have been shown to be efficient at denitrification. Based on the site hydrology and the potential for ponding and overflow on these soils future monitoring should probably be directed at N losses through shallow subsurface flows and N and P and bacteria losses through winter runoff. Mass balance should be done to make sure that soils are not receiving excessive N or P.

The Dairy employs a wide range of nutrient conservation practices. Manure solids are placed on a concrete pad and covered. Silage is made in covered piles on concrete as well. Manure piles are windrow composted on site and sold as a composted cow manure soil amendment. Raingutters were installed on the barn and the runoff water from the roof and the concrete run north into the cropland and away from the Rickreall Creek.

Details of CAFO includes a list of practices and improvements, wastewater holding ponds and covered manure piles, recycled water and an automatic barn cleaning system. Winter application of manure is prohibited. The amount of N applied to the soil is monitored as well with soil tests.

Water Quality for Livestock Watering

The dairy is located downstream from the City of Dallas Wastewater Treatment Plant, and uses groundwater from Rickreall's municipal wells to water their cattle, even though they own rights to use creek water for this purpose they have concerns about water contamination, particularly bacteria. Past releases of raw sewage from the plant were given by the operator as the reason for this concern. However, the dairy has not tested water from the creek to confirm this. When asked about the quality of the creek water before and after the new WWTP, dairy operator commented that the creek used to smell badly in summer but does not smell any more (L. Kazemier, pers. comm).

The operator pointed out large growths of filamentous algae that currently occur below the WWTP but not upstream the WWTP. The men at the dairy had to clear the intake screen in the creek twice a day, when it clogged with algae. Observations of the creek on that day confirmed the dense growths of algae that were floating and attached, and in some places algae covered the creeks gravel bottom from bank to bank. There were no such growths observed on that day in the creek at the bridge immediately upstream from the WWTP.

SB1010 Agricultural Water Quality Management Area Plan

Oregon's Senate Bill 1010 (SB-1010) requires the reduction of non-point source pollution from agriculture. As part of the response to this law the Oregon Department of Agriculture along with local Soil and Water Conservation Districts are developing plans to enhance the water quality from agricultural lands. A Local Advisory Committee is currently being selected for the Agricultural Water Quality Management Area Plan for the area that includes Rickreall Creek, Ash Creek, Luckiamute River and Marys River. Candidates for the committee will be selected from a wide variety of agricultural operations. A similar plan has already been developed for the Yamhill River Subbasin.

The water quality management area plans outline education strategies to inform landowners and farmers about agricultural water quality issues and to encourage them to use best management practices. Senate Bill 1010 also mandates that the plan contain a description of measures required to prevent and control water pollution from agricultural activities in the planning area. The list of "prevention and control measures" will in turn become administrative rules and form the basis for plan enforcement. A main emphasis of SB-1010 is to encourage producers to develop Voluntary Conservation Plans, which outline management strategies for addressing nonpoint source pollution. The Department of Agriculture has designated the Benton Soil and Water Conservation District (Benton SWCD) as its Local Management Agency for the development and implementation of the plan. Benton SWCD will work cooperatively with the Polk SWCD, USDA Natural Resources Conservation Service, USDA Farm Service Agency, and Extension Service to provide technical, financial and educational assistance. The plan for the area to the North, Yamhill Subbasin Plan, identifies important general categories of factors affecting water quality, these are:

- Erosion prevention and sediment control
- Irrigation
- Livestock waste

- Nutrients
- Pesticides chemigated irrigation water
- Road, staging areas and farmsteads
- Streamside areas

Sections of the Yamhill County plan may not go far enough in protecting soil and water resources. For instance in the Yamhill Subbasin Plan a grower can have soil loss at two times the tolerable soil loss rate and still be in compliance with the plan. The Rickreall Creek Watershed Council can have input into the plan that is to be developed for Rickreall Creek. The plan development and implementation if successful can improve the water quality of the lower reaches of Rickreall Creek and groundwater resources under the watershed. Issues likely to be addressed in the plan includes those listed above and agricultural drainage water quality, pesticide and nitrate contamination of groundwater, land application of waste waters, soil quality management, treatment of roadsides and ditches, wetland restoration and others.

Rural Roads

Ditch clearing may have positive and negative effects on watershed condition. Routine ditch clearing can trigger significant erosion in the ditch and increase sediment delivery to streams. However, periodic road ditch clearing by excavators is needed to keep ditches and culverts functional. During ditch clearing protective vegetation is removed with accumulated sediment and there is a potential to undercut stable cutslopes and initiate bank sloughing. Bare ditch bottoms with loosened soil are susceptible to erosive cutting and can yield significant amounts of sediment until stabilized or vegetation reestablishes.

Complimentary practices such as relief culverts, rock checks and channel liners need to be used with ditch cleaning in places where ditches erode. Soil conservation in agriculture and best management practices in forestland are preventive measures that serve to reduce the frequency of ditch cleanings because they reduce the amount of sediment that is transported to road ditches.

Roadside ditches that are contributing sediment have not been inventoried so there is no data on this.

Failing On-Site Sewage Systems

In the course of discussions with watershed council members over the past six months it is commonly asserted that failing onsite sewage systems are contributing to the nonpoint source contaminant loads to Rickreall Creek.

On-site sewage disposal systems, septic systems, provide sewage disposal and treatment for individual properties that cannot hook up to a sanitary sewer. Areas outside of Dallas City limits use on-site systems for treatment of wastewater. Most of the systems in the watershed are conventional systems with a septic tank and a drain-field. A variety of alternative systems are available for sites where soil conditions are unsuitable to a conventional system. These alternatives use pressurized distribution lines and sand filtering to help overcome the natural limitations of some soils. Technical and maintenance intensity and cost generally increase with the use of alternative systems. Prior to the approval of these alternative systems much of the area in the watershed had soils with severe limitations for conventional on-site sewage systems. Poorly drained soils with clayey subsoils (such as Cove, Bashaw, Dayton and others) were generally denied the use of a conventional system since they are wet soils and have slowly permeable subsoils. Prior to 1980 the overall approval rate for on-site systems was 70 percent. Since the alternative systems have been authorized the overall approval rate in Polk County is 99 percent. The County reports that it has record of only one on-site system that has failed, for systems installed under the rules that have been in effect since 1974. According to Polk County there are no single areas with enough malfunctions to consider a community system. They are not aware of any direct sewage discharges and maintain that all systems installed since 1974 should not be creating nonpoint contamination. (On-site Waste review comments provided by Gene Clemens, Director of Community Development, Polk County). It was not reported how many on-site systems were installed before 1974.

Rock Quarries and Gravel Mining

Dalton Rock, who stated the quarry in 1993 right along Rickreall Creek, runs a rock quarry in the basalt rocks. The crushed rock is a valuable resource that can reduce sedimentation on forest roads. The quarry supplies rock throughout the central Willamette Valley for road rock and asphalt making. Dalton Rock has received numerous environmental awards for its operations and reclamation work. They use sedimentation ponds and other techniques for controlling sediment and erosion on the site. Currently the operation is expanding its production area within a 122-acre permit boundary. (Source Dalton Rock)

Zoning Districts by Natural Subdivisions of the Watershed

This section is intended to provide general information and would need to be much more detailed to adequately address all the intricacies of the zoning rules and the zones.

Zoning districts in the watershed closely follow natural subdivisions of the watershed (see Map 7-1). These subdivisions discussed in the introduction are based on associated geology, topography, climate, soils, stream classification, vegetation and predominant landuse activities. Several of the zones have as one of their stated purposes the conservation and protection of watersheds, soils and other natural resources including fish and wildlife habitat. Zoning can be an effective tool in the overall watershed management. Effective zoning is an expression of the natural character of the land and of the values of the citizens with a clear vision and realistic goals.

The Timber Conservation Zoning District is predominantly located in the steeper forested uplands of the Coast Range and Foothills. One of the purposes of the zone is to conserve, protect and encourage forest management for timber production and harvesting, protect associated natural resources including watersheds, soil, fish and wildlife habitat and provide for compatible recreational uses. The timber conservation zoning district is defined and described in Chapter 177, Polk County Code, which explicitly states in 177.010(B) of the purpose of the zone "Conserve and protect watersheds soil, fish and wildlife habitats and other such uses associated with forests,

The Farm/Forest Zoning District closely approximates the Foothills Subdivision where mixed agricultural and forestry landuses occur. The purpose of the Farm/Forest Zone is to provide for the full range of agricultural and forest uses, while providing for the maximum property tax benefits (e.g. farm use assessment, timber tax treatment, open space deferral etc.) available and conformity with Farm/Forest objectives. There are isolated lands within the zone that have no actual or potential use for agriculture or forest purposes. Other non- natural resource uses must not be adverse to the accepted agricultural and forest practices. Some of the uses that may be established under these rules include: forest operations, farm use, road widening, single family dwelling, cemetery, solid waste disposal site and others. In this zone new non-resource dwellings are limited to certain soils (with capability class IV -VIII) and there is a 40-acre lot size limit for creation of new parcels (Draft Review Comments, Gene Clemens Polk County Director of Community Development). In keeping with the diverse character of this zone the land use varies from intensive to extensive, and this zone was adopted to deal with a myriad of potential uses while primarily favoring farm and forest uses. (Chapter 138, Polk County Code)

The Exclusive Farm Use Zoning District includes the natural subdivisions of the Willamette Valley including the terraces, floodplains and also includes the lower margins of the foothills where intensive agriculture is the main landuse. The purpose and intent of the Exclusive Farm Use Zoning District (EFU) is to conserve agricultural lands, and this is done by establishing clear standards for the use and development of designated agricultural lands. The EFU is applied to lands defined as "agricultural lands" by Oregon Administrative Rule (OAR) 660-33-020(1). This is intended to provide primarily for agricultural uses on lands classified as prime farmland, capability class I and II soils and other important agricultural soils that are capability class III and IV. Resource uses permitted in this zone are listed in Chapter 136, Polk County Code.

The AR-5, Acreage Residential-Five Acre Zone is intended to be a buffer area between farm zones and higher density urban and urbanizing areas to reduce conflicts between residential use and normal farming practices. Another strategic use of the zone is to provide for orderly growth of the urban areas so the community will be able to afford the service to and within new urban areas, including the costs of maintenance of utilities, roads and protective and social services. The zone is intended to provide for efficient redivision of acreage subdivisions and promote pre-planning of future important streets. This zone accommodates people who want to live in the country as hobby farmers, horse, goat, and llama enthusiasts or in order to have a rural lifestyle with a large garden and orchard. Part of the stated purpose of the zone includes not adversely affecting fish and wildlife resources and habitat areas, natural areas and scenic areas. Permitted and conditional uses are provided in Chapter 128.500, Polk County Code.

Conversion of Land to Urban and Residential Development

Urban and suburban development has occurred primarily on land that had soils t that also had high potential agricultural productivity. The City of Dallas sits on Abiqua, Salkum, McAlpin, Suver, and Dupee soils. Some of the Abiqua soils in the city occasionally flood along Rickreall Creek. The town of Rickreall was built mainly on Malabon and Salkum soils.

Urban development in Dallas and other areas might cause severe soil compaction and increase runoff. Planting grass on construction sites during winter protects bare soil from splash erosion. Precautions such as seeding with grass and then mulching the bare ground or hydro-seeding can significantly reduce soil losses from construction sites. Fabric fencing (silt fence) and straw bales can help slow runoff and trap sediments.

Impervious surfaces include roofs, driveways, parking lots and rock quarries convert precipitation directly into surface runoff and short-circuit natural hydrologic storage that moderates flows. Rainwater is shunted from infiltration and soil storage, and base flow declines because water is hurried out of the watershed as runoff (Ferguson 1994). Stream erosion and elevated sediment levels can follow the increased flows. Benefits of baseflow such as instream flows and aquifer recharge can decline in urbanizing sub-basins as the area of impervious surface increases.

Map 6-1 shows the High value Farmland Soils Map overlay with zoning. Further analysis is needed to determine the impacts that past development has had on the productive soil base. Soil information should be used to plan for future development in order to protect soils with the highest natural productivity potential for agriculture and forestry uses.

Wetland, Riparian and Watershed Restoration

Soil maps and GIS soil coverage can be used to conserve and restore wetlands and riparian areas. The soil survey contains several interpretative tables that are useful for such purposes. There are tables for water management interpretations (Knezevich, 1982) evaluates soil types for suitability for pond reservoir areas, embankments, dikes and levees, drainage, and irrigation. Another set of tables provides a rating of soils for wetland plants, shallow water areas and wetland wildlife. It is important to realize that for small restoration projects (of a few acres or less) the soil survey map might be too small a scale (1:20,000) and should be enhanced by site specific soil investigations. Some wetland and riparian restoration efforts go awry or fail when soil characteristics are ignored or when workers rely on the small-scale county soil map. Onsite soil and geomorphic investigations can help guide restoration of hydrology and vegetation to better assure project success.

Summary

Polk County soils were classified for the purpose of watershed analysis. Soils were grouped by major associated landuse, capability class, slope, productivity, hydric soils and flood frequency. From this classification a new soils GIS coverage was created that helps the reader to see the soil as more of a functional part of the landscape of the watershed. From this map generalizations can be made about areas that are more prone to soil erosion, areas that flood, areas that are potentially suitable to wetland restoration. In forested uplands the steeper soils most like to have slides can be identified.

In the forested uplands, mass erosion has been the dominant process for sediment delivery. Erosion events follow disturbances such as the Rock House Creek Fire. Forest practices and existing networks of forest roads are tested by such events and by particularly wet winters such as 1996, when numerous slides occurred in the watershed and many roads failed. More data on roads in particular are needed to evaluate the impacts to the upper watershed. Accelerated mass wasting from uplands can be a major source of stream sediment in the watershed, and practices and remedial action is needed to reduce sediment load to reservoir.

The potential for large soil loss events has been documented here. Care must be exercised to protect soil from water erosion. This is achieved with winter cover and with drainage tile in areas where side-hill seeps occur in agricultural fields.

Fertilizers and Pesticides from agriculture are not well quantified and their impacts on water quality in the watershed have not been well characterized. Recent research has shown that there is substantial denitrification in riparian areas with poorly drained soils adjacent to grass seed farms. In the future, more landscape process research should continue in the Willamette Valley. New pesticide reporting laws that go into effect in 2002 might contribute useful information in future assessments about pesticides used in the watershed and their fates.

Data are sparse or inadequate for sediment delivery, stream bank erosion, forested-upland debris avalanche, road condition and inventory. These all need to be inventoried. This is time consuming and expensive data.

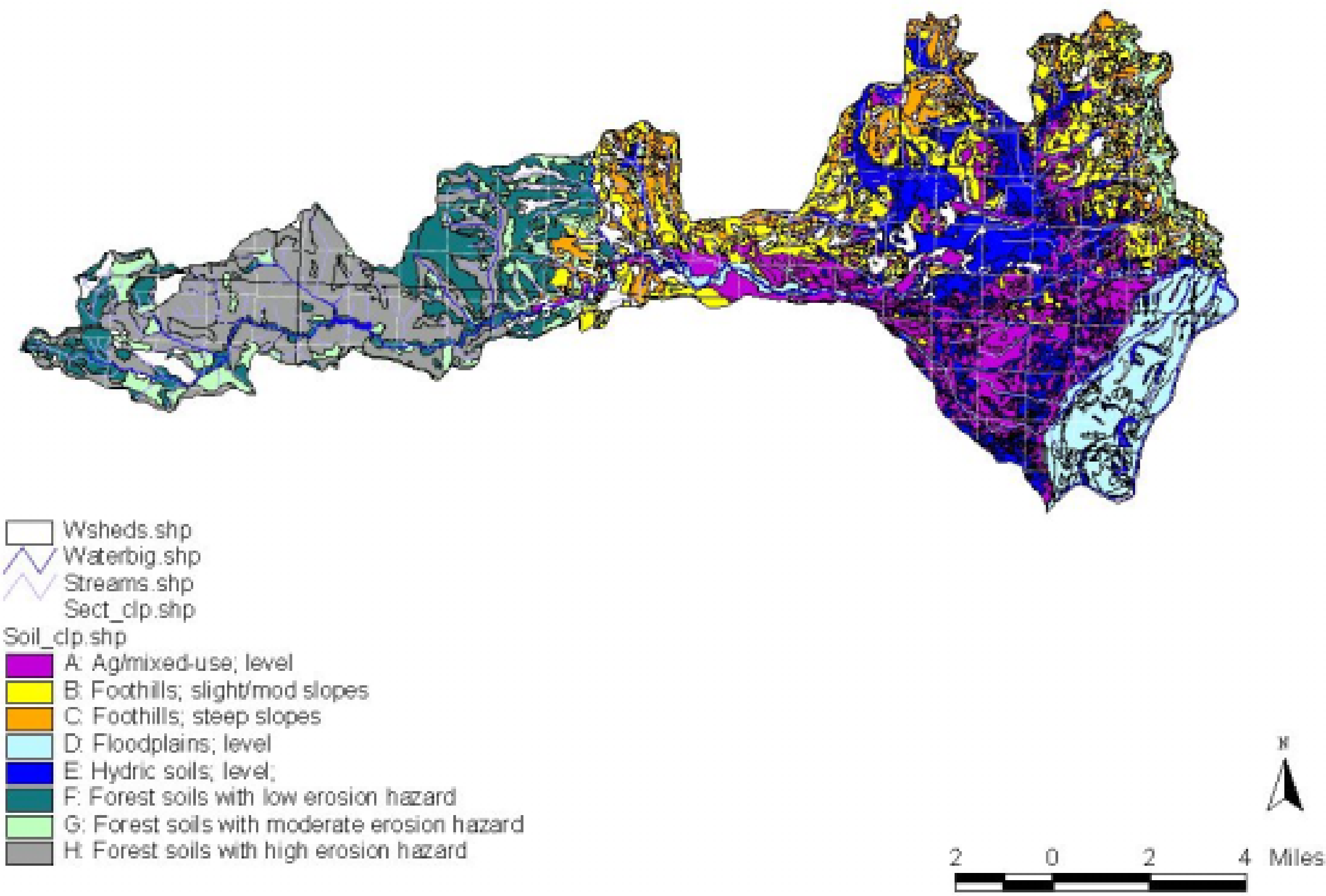
Productive soils have been converted to urban and residential landuse. Locally impervious surfaces convert precipitation directly into surface runoff and short-circuit natural hydrologic storage. Zoning laws are in place to help protect the natural resource value of agricultural and forest lands, and at the same time offers residential areas a buffer from farming and logging practices.

A large dairy and a rock quarry located on Rickreall Creek are discussed to highlight examples of some of the potential nonpoint is source issues in the watershed and to point to the amount of effort that already goes into practices to protect the watershed and Rickreall Creek.

Soil data and interpretations can help people who are trying to restore wetlands and riparian areas. GIS capabilities will provide tools to better use this information. There is a need for more use of the available soil interpretation information in planning. In cases where small projects are being planned, the 1:20,000 soil map

and GIS coverage made from it, may not be of fine enough resolution and onsite investigations should be used instead.

Map 6-1: Soil groups of the Rickreall watershed. The soil series in each soil group are given in Appendix 6. The patterns of soils reflect the vegetation layers in Maps 5-3 and 5-4.



Chapter 7 : ECONOMICS AND DEMOGRAPHICS

The majority of economic data available from state and federal agencies is aggregated at the county level. The assumption used in the analysis is that the trends for Polk County reflect trends for the Rickreall Watershed. While 100 % of the Rickreall Watershed is in Polk County, only 12 % of Polk County lies within the watershed (Map 1-1). Judging by the location of the watershed and that it crosses a mix of landuse types and populations, it is assumed that the mix of land uses and social profiles for watershed are reasonably represented by the Polk County data.

Ninety percent of the Rickreall watershed is in private ownership. The largest block of public lands is the Baskett Slough National Wildlife Refuge (ca. 6000 acres). Most of the remaining public lands are in the upper watershed (Map 1-3). There are scattered smaller public holdings such as the city park and city facilities, a county park and fairgrounds at Rickreall and school grounds.

The land use by area is primarily agriculture, followed by forestry with lesser areas in urban, rural residential, and light industry. A landuse map is not available at this time, but one can get a good idea of the mix of landuses by viewing the watershed composite orthophotos (Map 1-2), population density (Map 1-4), vegetation layer (5-4), and zoning map (Map 7-1). There are clear differences between the upper and lower portions of the watershed. The upper portion is nearly all forest in large holdings. The lower portion is a more diverse mix of large and small private holdings, mix of zoning types, and mix of population densities.

The distribution of taxlots by size class provides an indication of private ownership patterns. The sizes of the taxlots are a good representation of the density of multiple small private holdings. An exception is where a single entity owns multiple taxlots—in which case one would over estimate the area in small holdings (see the Baskett Slough area). But since there is a large area in very small taxlots, it is reasonable to assume these represent actual individual ownerships and not large farms. The taxlot size map indicates that nearly 40 % of the lower watershed is in hundreds of small holdings. These holdings are concentrated in and near the communities (e.g., Dallas, Rickreall, Eola, and Independence) and scattered along the main highways.

The remaining area in the lower watershed is in large taxlots and is mostly agricultural fields of over 100 acres (see aerial photos and vegetation map). Over 50 % of the vegetation of lower watershed is classed as perennial grass seed production (Map 5-4). Another 20 % is classed as other agriculture and orchards. Lawns, driveways, roads, and rooftops are not broken out in the vegetation classes, but it is likely that a large portion of the “other agriculture and orchards” vegetation class are in rural residential land use.

Economic Characteristics of Polk County

The forested lands of Polk County have provided a widely fluctuating timber harvest over time (Figure 7-1). The total harvests appear to show an increasing trend over time with harvests in 1998 totaling about 110 million board feet (MMBF)). Peak harvest years occurred in 1963 and 1988 (160 MMBF each year) and the low harvest was in

1967 (65 MMBF). The harvest volumes during the mid-1970s to mid-1980s may reflect a recession economy.

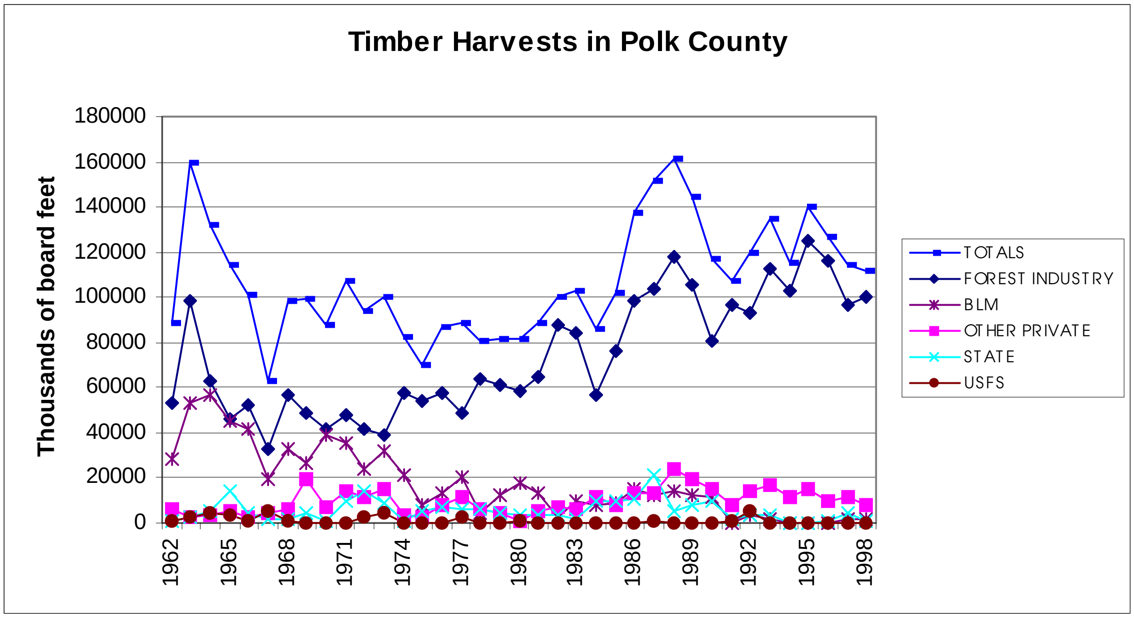


Figure 7-1: Timber harvests in Polk County.

The harvest levels of different ownership types have changed over time. Forest industry harvests have risen significantly in the County, while all other ownerships have either declined or remained steady. A comparison of public and private timber harvests over time shows that public harvests provided nearly half the timber up to the early 1970's, but now private harvests provide almost all of the timber supply in Polk County.

Probably a larger component of the rural economy is agriculture. Total gross income from farm sales has increased steadily from 1976 to 1999, while the number of harvested acres has remained fairly steady (Figure 7-2). Part of the growth in income over time is due to inflation, but part is due to a shift to more valuable crops. Sales of livestock and products have increased only slightly over time, while the large increase in total farm sales has been driven mainly by an increase in crop sales. Crops now make up nearly 90 % of all county farm sales.

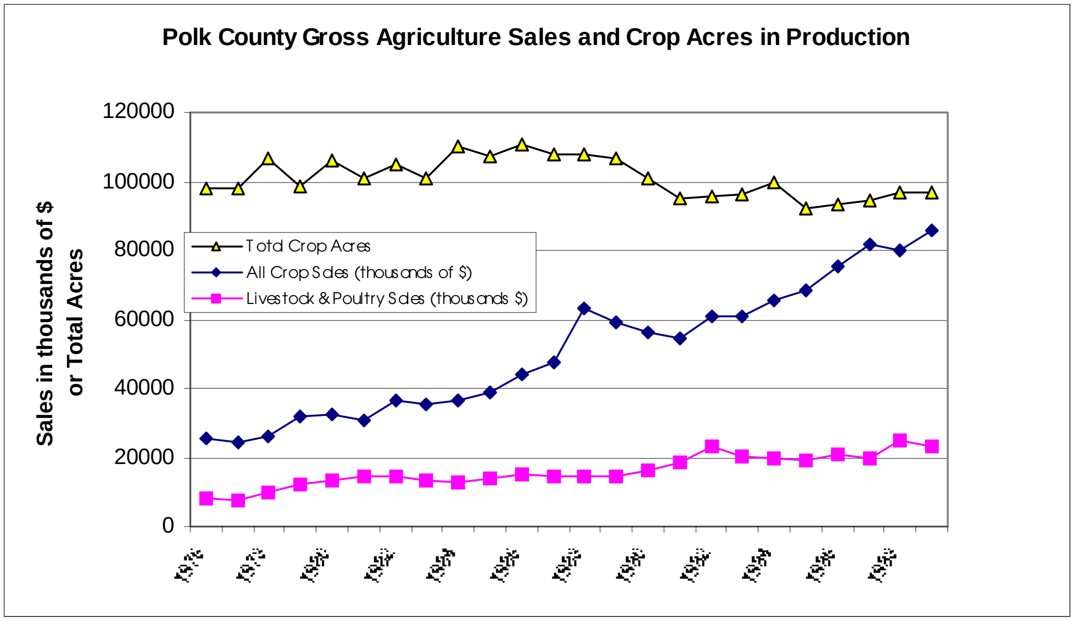


Figure 7-2: Polk County agriculture sales and harvested acres over time.

In the mid-1970's to the 80's grains produced the greatest value in crop sales. Since the mid-1980's, specialty products and grass and legume seeds have generated the greatest dollar value of gross sales in Polk County (Figure 7-3, see also Table 7-1). Grass and legume seeds now make up 44 % of all crop sales, while specialty products comprise 26 %. Specialty products in Polk County in 1999 consisted of 42 % forest farm sales, 32 % Christmas trees, and 19 % nursery (see Table 7-2 for breakdowns).

There has been a shift in acres of crop types over time (Figure 7-4). The acreage in crops has shifted continually away from grain in the mid-1970s to be replaced by grass seed and legume seed production today. The proportional acreage in grass and legume seeds has risen from 20 % in 1976 to 65 % in 1999. Despite the growth in dollar sales of specialty products, the harvested acreage of these products is only listed at 580 acres, this is because no acres are counted for farm forest sales or nursery (see Table 7-2).

Dairy is the only commodity that has remained in the top five agricultural value products from Polk County over the last 25 years (Table 7-1).

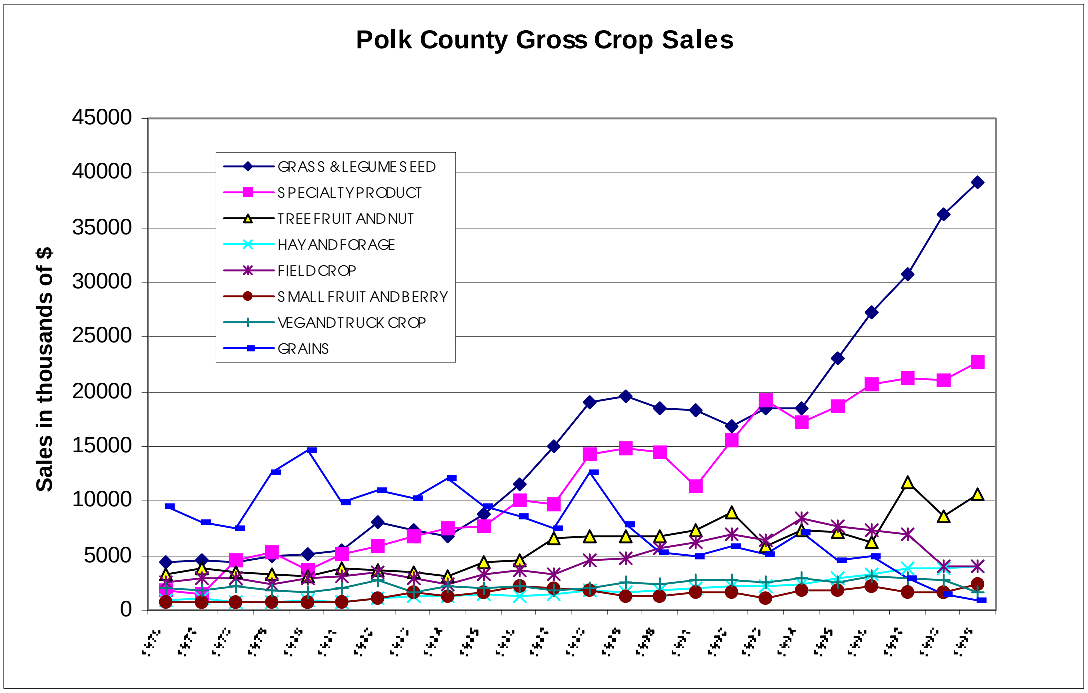


Figure 7-3: Polk County crop sales over time by crop type.

Table 7-1 Top five agricultural commodities in Polk County in 1999 and 1976.

Item	Sales in 1999
Tall fescue	$19,082,000
Dairy	14,204,000
Perennial ryegrass	11,484,000
Christmas trees	9,614,000
Nursery crops	7,348,000
Item	Sales in 1976
Wheat	$8,178,000
Dairy	2,884,000
Annual ryegrass	2,015,000
Sweet cherries	1,762,000
Cattle	1,672,000

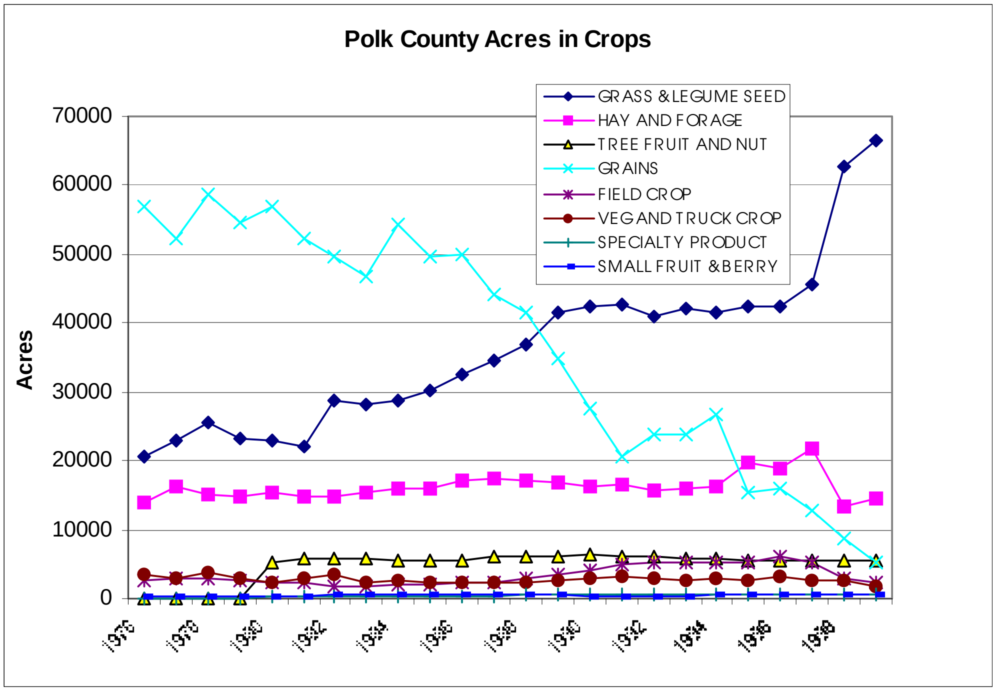


Figure 7-4: Polk County acres in crops over time.

Table 7-2: Total agriculture report for Polk County 1999.

County Report for Polk County in 1999	HARVEST /UNIT	YIELD /UNIT	PROD. /UNIT	PRICE /UNIT	VALUE PROD.(000)	PCT SOLD	VALUE SALES(000)	HARVEST UOM	YIELD UOM	PROD. UOM	PRICE UOM
WHEAT	3500	68	238000	$3.29	$784	98	$768	ACRES	BU/A	BU	$/BU
BARLEY	300	58	17300	$1.62	$28	82	$23	ACRES	BU/A	BU	$/BU
OATS	1300	99	128700	$1.35	$174	80	$139	ACRES	BU/A	BU	$/BU
1000 - GRAINS TOTALS	5100				$986		$930				
ALFALFA HAY	1000	5	5000	$100.00	$500	25	$125	ACRES	T/A	TONS	$/T
OTHER HAY	10000	2	20000	$75.00	$1,500	20	$300	ACRES	T/A	TONS	$/T
HAY SILAGE	2000	32	64000	$14.00	$896	25	$224	ACRES	T/A	TONS	$/T
SILAGE CORN	1500	28	42000	$27.00	$1,134	50	$567	ACRES	T/A	TONS	$/T
GRASS AND GRAIN STRAW	0	0	76000	$40.00	$3,040	95	$2,888	ACRES	T/A	TONS	$/T
2000 - HAY & FORAGE TOTALS	14500				$7,070		$4,104				
CRIMSON CLOVER	200	600	120	$60.00	$72	60	$43	ACRES	LBS/A	000 LBS	$/CWT
RED CLOVER	3500	400	1400	$55.00	$770	100	$770	ACRES	LBS/A	000 LBS	$/CWT
HAIRY VETCH	330	380	124	$75.00	$93	100	$93	ACRES	LBS/A	000 LBS	$/CWT
CHEWINGS FESCUE	70	800	56	$80.00	$45	100	$45	ACRES	LBS/A	000 LBS	$/CWT
TALL FESCUE	29000	1400	40600	$47.00	$19,082	100	$19,082	ACRES	LBS/A	000 LBS	$/CWT
ANNUAL RYEGRASS	14000	2000	28000	$20.00	$5,600	100	$5,600	ACRES	LBS/A	000 LBS	$/CWT
PERENNIAL RYEGRASS	14500	1440	20880	$55.00	$11,484	100	$11,484	ACRES	LBS/A	000 LBS	$/CWT
ORCHARDGRASS	4300	920	3978	$44.00	$1,750	100	$1,750	ACRES	LBS/A	000 LBS	$/CWT
COMMON VETCH	165	700	116	$20.00	$23	100	$23	ACRES	LBS/A	000 LBS	$/CWT
ARROWLEAF CLOVER	350	700	245	$65.00	$159	100	$159	ACRES	LBS/A	000 LBS	$/CWT
OTHER MISC. GRASS SEED & LEGUMES	100	0	0	$0.00	$35	100	$35	ACRES			
3000 - GRASS & LEGUMES TOTALS	66515				$39,113		$39,084				

Table 7-2 cont.	HARVEST	YIELD	PROD.	PRICE	VALUE	PCT	VALUE	HARVEST	YIELD	PROD.	PRICE
County Report for Polk County in 1999	/UNIT	/UNIT	/UNIT	/UNIT	PROD.(000)	SOLD	SALES(000)	UOM	UOM	UOM	UOM
PEPPERMINT FOR OIL	415	57	23847	$14.47	$345	100	$345	ACRES	LBS/A	LBS	$/LB
HOPS	830	1730	1436	$2.04	$2,930	100	$2,930	ACRES	LBS/A	000 LBS	$/LB
SUGARBEET FOR SEED	90	2770	249	$0.58	$144	100	$144	ACRES	LBS/A	000 LBS	$/LB
RADISH SEED	50	1400	70	$60.00	$42	100	$42	ACRES	LBS/A	000 LBS	$/CWT
VEG AND FLOWER SEED	130	0	0	$0.00	$240	100	$240	ACRES			
MISC. FIELD CROPS	900	0	0	$0.00	$295	100	$295	ACRES		TONS	
4000 - FIELD CROPS TOTALS	2415				$3,996		$3,996				
APPLES	140	220	30800	$15.50	$477	100	$477	ACRES	BX/A	BX	$/BX
SWEET CHERRIES	1120	4	4700	$770.00	$3,619	100	$3,619	ACRES	T/A	TONS	$/T
TART CHERRIES	500	2	1100	$450.00	$495	100	$495	ACRES	T/A	TONS	$/T
PEACHES	20	150	3000	$25.00	$75	100	$75	ACRES	BX/A	BX	$/BX
BARTLETT PEARS	10	9	90	$420.00	$38	100	$38	ACRES	T/A	TONS	$/T
ASIAN PEARS	10	2	20	$800.00	$16	100	$16	ACRES	T/A	TONS	$/T
PRUNES AND PLUMS	485	4	2130	$240.00	$511	100	$511	ACRES	T/A	TONS	$/T
WINE GRAPES	1120	2	2800	$1,220.00	$3,416	100	$3,416	ACRES	T/A	TONS	$/T
HAZELNUTS	2200	2080	2290	$0.44	$2,015	100	$2,015	ACRES	LBS/A	TONS	$/LB
WALNUTS	30	1100	15	$0.85	$26	100	$26	ACRES	LBS/A	TONS	$/LB
5000 - TREE FRUIT & NUTS TOTALS	5635				$10,688		$10,688				
STRAWBERRIES	40	4.6	368	$52.72	$194	100	$194	ACRES	T/A	000 LBS	CTS/LB
RED RASPBERRIES	80	4862.5	389	$69.41	$270	100	$270	ACRES	LBS/A	000 LBS	CTS/LB
BLACK RASPBERRIES	25	2320	58	$194.83	$113	100	$113	ACRES	LBS/A	000 LBS	CTS/LB
EVERGREEN BLACKBERRIES	85	8200	697	$54.38	$379	100	$379	ACRES	LBS/A	000 LBS	CTS/LB
MARION AND OTHER BLACKBERRIES	180	6527.8	1175	$75.57	$888	100	$888	ACRES	LBS/A	000 LBS	CTS/LB
BOYSENBERRIES	25	5520	138	$65.22	$90	100	$90	ACRES	LBS/A	000 LBS	CTS/LB
BLUEBERRIES	60	8883.3	533	$79.92	$426	100	$426	ACRES	LBS/A	000 LBS	CTS/LB
GOOSEBERRIES	20	4250	85	$62.00	$53	100	$53	ACRES	LBS/A	000 LBS	CTS/LB
6000 - SMALL FRUIT & BERRIES TOTALS	515				$2,413		$2,413				
DRY STORAGE ONIONS	35	330	12	$5.00	$60	100	$60	ACRES	CWT/A	000 CWT	$/CWT
SWEET CORN FRESH	50	170	8500	$14.00	$119	100	$119	ACRES	CWT/A	CWT	$/CWT
SNAP BEANS PROCESSED	389	5	2183	$150.30	$328	100	$328	ACRES	T/A	TONS	$/T
SWEET CORN PROCESSED	918	5	6707	$75.10	$504	100	$504	ACRES	T/A	TONS	$/T
CABBAGE	15	20	300	$120.00	$36	100	$36	ACRES	T/A	TONS	$/T
TOMATOES	12	300	3600	$36.20	$130	100	$130	ACRES	CWT/A	CWT	$/CWT
SQUASH AND PUMPKINS	20	25	460	$120.00	$55	100	$55	ACRES	T/A	TONS	$/T
OTHER MISC. VEG. & TRUCK CROPS	110	0	0	$0.00	$320	100	$320	ACRES			
GARLIC	75	5	300	$400.00	$120	100	$120	ACRES	T/A	TONS	$/T
7000 - VEG & TRUCK CROPS TOTALS	1624				$1,672		$1,672				
NURSERY CROPS	0	0	0	$0.00	$7,348	100	$7,348	ACRES			
GREENHOUSE CROPS	0	0	0	$0.00	$794	100	$794	ACRES			
MISC. SPECIALTY CROPS	0	0	0	$0.00	$465	100	$465	ACRES			
FARM FOREST PRODUCTS	0	0	7700	$575.00	$4,428	100	$4,428	ACRES		000 BF	$/000BF

CHRISTMAS TREES	580	0	754	$12.75	$9,614	100	$9,614	ACRES	TREE/A	1000S	$/TREE
Table 7-2 cont.	HARVEST	YIELD	PROD.	PRICE	VALUE	PCT	VALUE	HARVEST	YIELD	PROD.	PRICE
County Report for Polk County in 1999	/UNIT	/UNIT	/UNIT	/UNIT	PROD.(000)	SOLD	SALES(000)	UOM	UOM	UOM	UOM
FEE HUNTING AND RECREATION	0	0	0	$0.00	$65	100	$65	PEOPLE		$/REC.	
8000 - SPECIALTY PRODUCTS TOTALS	580				$22,714		$22,714				
BEEF COWS	4300	0	0	$0.00	$0	0	$0	NO. HEAD		HD MKTD	
CATTLE	16900	0	0	$0.00	$2,644	100	$2,644	NO. HEAD		HD MKTD	
HOGS AND PIGS	1025	2	2100	$100.00	$210	100	$210	NO. HEAD		HD MKTD	
SHEEP AND LAMBS	11950	0	0	$0.00	$649	100	$649	NO. HEAD		HD MKTD	
EWES	5600	0	0	$0.00	$0	0	$0	NO. HEAD			
DAIRY PRODUCTS	5600	176	986000	$14.70	$14,494	98	$14,204	NO. HEAD	CWT/COW	CWT	$/CWT
FARM CHICKENS	5350	0	4200	$1.19	$5	100	$5	NO. HEAD		HD MKTD	$/HEAD
BROILERS	0	0	2360000	$1.97	$4,649	100	$4,649	NO. HEAD		HD MKTD	$/HEAD
CHICKEN EGGS	4800	20	96	$87.00	$84	92	$77	NO. HEAD	DOZ/HD	000 DOZ	CTS/DOZ
WOOL	9944	6	60000	$13.00	$8	15	$1	NO. HEAD	LBS/HD	LBS	CTS/LB
HONEY AND BEESWAX	720	0	0	$0.00	$17	100	$17	NO. HEAD		LBS	CTS/LB
HORSES AND MULES	3100	0	0	$0.00	$410	100	$410	NO. HEAD			
MISC. POULTRY AND OTHER PRODUCTS	0	0	0	$0.00	$325	100	$325	NO. HEAD			
RABBITS	725	0	18500	$4.25	$79	100	$79	NO. HEAD		HEAD	$/HEAD
9000 - LIVESTOCK & POULTRY TOTALS	70014				$23,574		$23,270				

UOM = Unit of Measure

Population Projections

Population growth in Dallas and Polk County are shown in Figure 7-5.

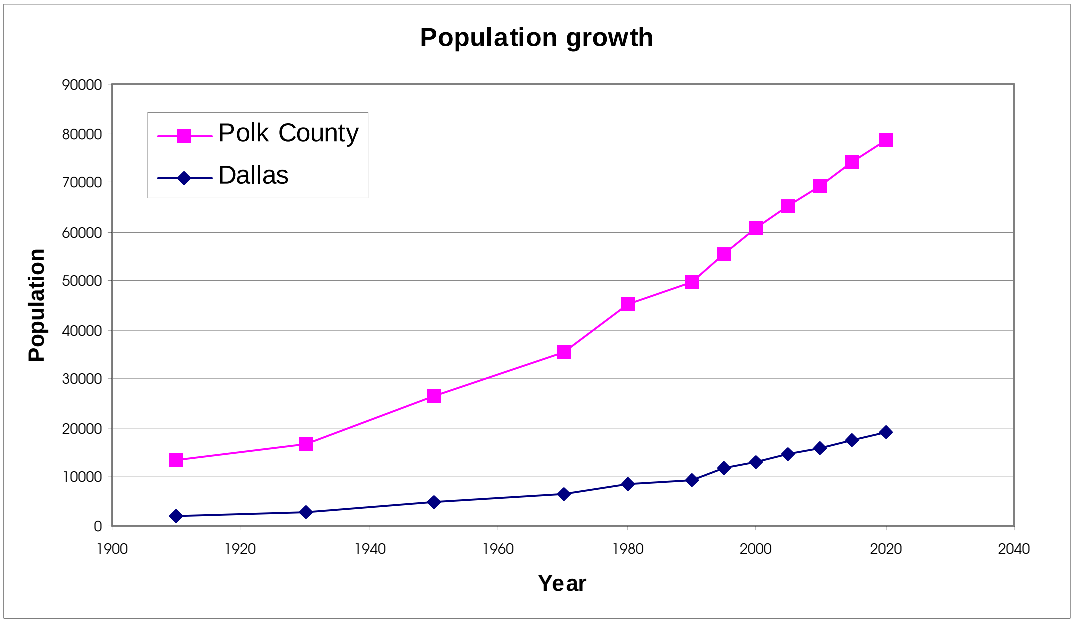


Figure 7-5: Population projection for Polk County and Dallas.

A study conducted by a regional research consortium called the Pacific Northwest Ecosystem Research Consortium (Hulse et al. 1997) has implications for the Rickreall. This study focused on the Muddy Creek sub-basin in the southeastern part of the Marys River Watershed. The Muddy Creek sub-basin is similar to the Rickreall. The Muddy Creek watershed was chosen as a prototype for the larger Willamette River basin project because previous analyses showed that, between 1970 and 1990, land use change in the basin was greatest at the periphery of major metropolitan areas. The authors noted that the Muddy Creek sub-basin is near a metro area (Corvallis) that is likely to experience strong development pressure within the next 20-30 years.

The Hulse report estimated that 88% of the Muddy Creek sub-basin is privately owned. Most is zoned for Exclusive Farm Use (42% of the watershed), Forest Conservation (35%) or Secondary Forest uses (11%). Approximately 12% of the watershed is in public ownership. Despite this, the watershed is projected to experience significant growth in residential development over the next 15 years. The Benton County Development Department projects 1000 new people (or 400 households) in the sub-basin by the year 2015. Combining this information with population projections from PSU led to a baseline projection (called the “Plan Trend Future” in the report) of 1,118 new people or 475 new dwellings by 2025. The research team bounded this baseline projection with alternative growth scenarios, ranging from a high development scenario of 1,250 new households by 2025 (a doubling of the 1990 resident population of the watershed) to a high conservation scenario of only 125 new households over 1990 levels.

The research team then estimated the impact of the scenarios on biodiversity and water quality. They concluded that the high development future would put twice as many species per year at risk of losing >50 % of their habitat over the next 30 years compared to the last 150 years. They recommended seeking a land use/land cover pattern that is more conservative than the Plan Trend Future. In terms of water quality, they concluded that under the Plan Trend Future, water quality would degrade by the year 2025. A future that tends toward the high conservation scenario is necessary to maintain water quality at 1990 levels.

Further information about development pressures in the Rickreall watershed would require more time and resources. The Polk County Development Department can compile data on building permits over time, by location, and could at least approximate the watershed boundaries. In addition, the Polk County Assessor's Office has data on every tax lot in the County. Records could be analyzed to find dates of lot subdivision, as well as the year any house was built. From this analysis, a database of land and housing development over time could be constructed.

Recreational Resources and Use in the Rickreall Watershed

The predominance of private land in the watershed results in relatively few developed recreation areas. Polk County has one park – Nesmith – next to the fairgrounds near Rickreall. The city has several parks and an arboretum. In addition to the parks, the Baskett Slough National Wildlife Refuge allows recreational use. Refuge offers hiking trails and abundant wildlife viewing opportunities.

Access to the private road into the upper watershed is allowed. Motorized use is prohibited without a permit except during hunting seasons. Private lands in the watershed offer opportunities for waterfowl, big game, and small game hunting.

Summary and Conclusions

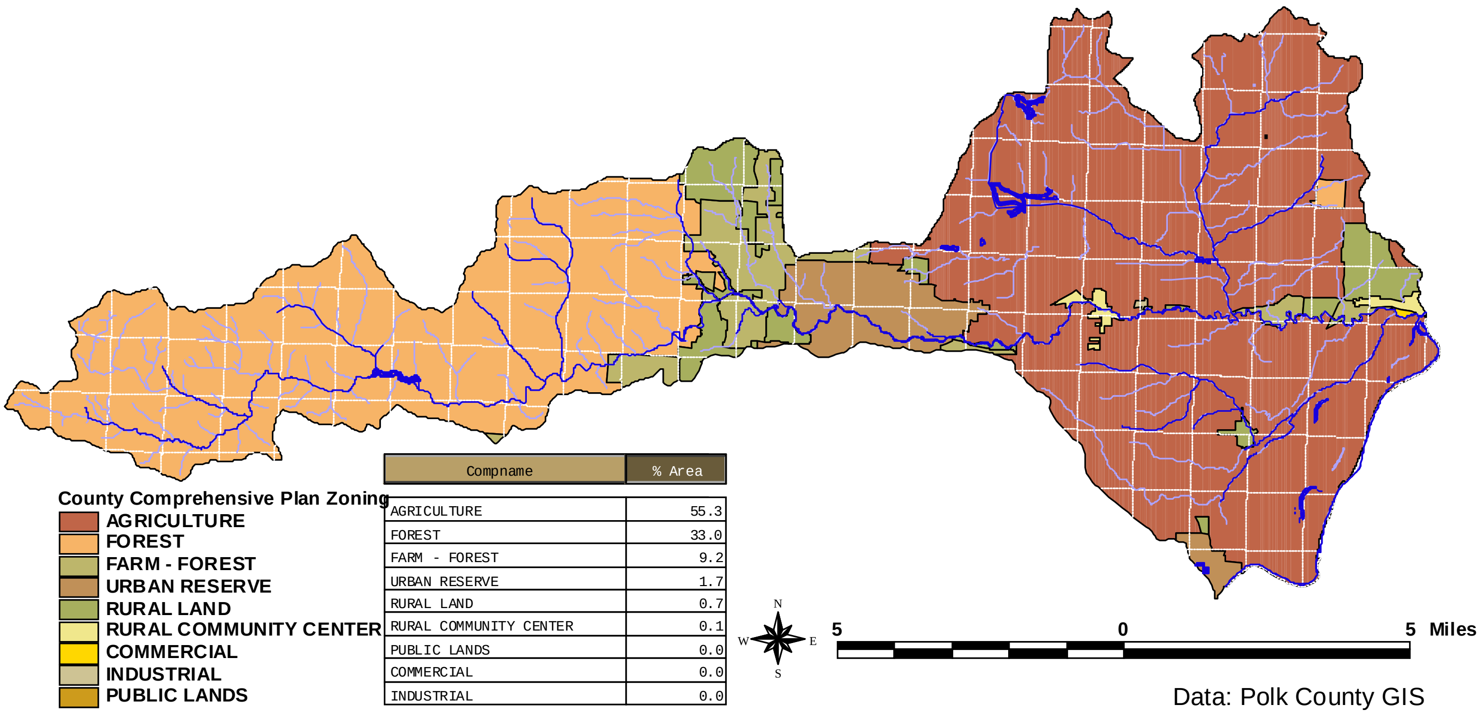
Much of the data used to describe socioeconomic conditions is only available at the county level. Therefore, some caution must be used when interpreting the results for the Rickreall watershed. The data on agricultural sales and acreage, as well as the data on timber harvest, primarily describe rural parts of Polk County. If we assume that the portion of Polk County that is in the Rickreall has a similar distribution of agricultural and forest lands as the part of the county outside of the watershed, then the trends shown in these statistics should be fairly representative of the watershed. The data show that the number of acres in agriculture has been holding fairly steady over time, while the value of agricultural output has been rising. Agricultural landowners have increased the amount of acreage in grass seeds, while decreasing the acreage in grains. Further investigation should look at the differences in farming practices (e.g., pesticide applications) for grass seed and grains and assess the implications for water quality.

Timber harvest levels have fluctuated widely over time in Polk County. Today's levels are lower than the long-term average for the County. Most of the public lands in the watershed are being managed under the Northwest Forest Plan, and very little harvest has come from those lands in recent years. An increase in harvest from private lands has resulted, and further investigation should look at the differences in harvest practices of private and public owners.

Changes in the economic structure of the county will also have implications for the watershed. As Dallas has grown in both population and economic opportunities, new residents have created a demand for rural residential housing. In addition, more residents of the watershed may have found work in Corvallis, Salem, or Portland, leading to more commuting out of the watershed. Further investigation should document the number of new dwellings that have been built in the watershed over time. These data are available from the Polk County Development Department by special request. Further analysis should also look at the impact on water supply as more residences are built.

Finally, few data on recreation use within the watershed exist. Current use does not appear to have major impacts on water quality, and the water resources of the watershed are not a major recreational attraction. As population continues to grow, however, recreational use should be monitored.

Map 7-1: Polk County comprehensive plan zoning



Compname	% Area
AGRICULTURE	55.3
FOREST	33.0
FARM - FOREST	9.2
URBAN RESERVE	1.7
RURAL LAND	0.7
RURAL COMMUNITY CENTER	0.1
PUBLIC LANDS	0.0
COMMERCIAL	0.0
INDUSTRIAL	0.0

Data: Polk County GIS

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Beschta RL, SJ O'Leary, RE Edwards, KD Knoop. 1981. Sediment and organic matter transport in Oregon Coast Range streams. Water Resources Research Institute. V. 70 Oregon State University. Corvallis, Oregon. Valley Library. [Research in two Oregon Coast Range streams, Flynn creek and Oak Creek measured bedload transport, particulate organic matter transport, total suspended solids concentration and turbidity during storm runoff. Both creeks drain forest lands of predominantly mature Douglas fir. The study shows relationships between flow and total suspended solids during storm runoff events. Total suspended solids is the most important factor affecting turbidity of Oregon Coast Range Streams. However relationships between these two parameters varied between storms and between drainages; therefore the authors conclude that predictive relationships must be developed on a watershed by watershed basis. Results also demonstrated that turbidities (hence total suspended solids concentrations) quickly return to less than 30 ntu (nephlomatic turbidity units) following runoff peak. Oak Creek had turbidities less than 30 ntu within 24 hours for 96% of the storms measured. The years-sampled represent relatively frequent, but small to moderate runoff events. References includes 49 citations.]

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APPENDIX 3-1: Clean Water Act and Other Regulations

Clean Water Act Background

In 1972, Congress enacted the first comprehensive national clean water legislation in response to growing public health concern for serious and widespread water pollution. The Clean Water Act (CWA) is the primary federal law that protects the health of our nation's waters, including lakes, rivers and coastal areas. Like most other federal environmental laws, CWA enforcement is shared by the U.S. Environmental Protection Agency (EPA) and the states, with states having primary responsibility. In Oregon the state agency with the primary responsibility is the Oregon Department of Environmental Quality (DEQ).

Over the last 25 years, the quality of rivers, lakes and bays nationally has improved dramatically as a result of the cooperative efforts by federal, state and local governments and communities to implement the public health and pollution control programs established by the Clean Water Act. The Clean Water Act has two fundamental national goals: 1) to eliminate the discharge of pollutants into the nation's waters, and 2) to achieve water quality levels that are "fishable and swimmable".

To achieve its objectives, the CWA provides that all discharges into the nation's rivers are unlawful, unless specifically authorized by a permit. Thus, industrial and municipal dischargers must obtain permits from EPA under the Act's National Pollutant Discharge Elimination System (NPDES) program (authorized in section 402 of the Act). A NPDES permit requires the discharger (source) to attain technology-based effluent limits. Permits specify the control technology applicable to each pollutant, the effluent limitations a discharger must meet, and the deadline for compliance. Sources are required to maintain records and to carry out effluent monitoring activities. Permits are issued for 5-year periods and must be renewed thereafter to allow continued discharge. For more general background on the provisions of the Clean Water Act see CRS Issue Brief for Congress (1999).

The Clean Water Act of 1972 was intended to clean up our rivers, streams and groundwater and to protect the multitude of benefical uses of our nation waters. The Act has used technology-based limits to clean up point source discharges. Point sources have been controlled through permit oversight, which have worked to ensure that industries and municipalities have not exceeded standards. Over the years there has been a shift from the major point sources that were addressed first to an increasing emphasis on nonpoint source pollution. Nonpoint sources are addressed primarily through the voluntary implementation of Best Management Practices (BMP's) by cities, farmers, forest industries and individual citizens.

The Clean Water Act has resulted in considerable progress in cleaning up point source water pollution. Currently, the number one source of pollution affecting U.S. waterways is nonpoint source, or runoff pollution. Examples of common nonpoint source pollutants include:sediment;pesticides and nutrients running off farm fields, forest lands and urban lawns;oil, grease, heavy metals, and other toxic materials carried from streets highways, rooftops and parking lots into storm sewers;farm animal waste from barnyards and pet waste from urban areas; andsoil washed away from logging and construction sites.

Nonpoint sources of pollution are not subject to CWA permits or other regulatory requirements under federal law. They are covered by state programs for the management of runoff under section 319 of the Clean Water Act. Both point and nonpoint sources of water pollution can impact the “beneficial uses” of waterbodies, as described in the next section.

Regulatory Management Tools

The Clean Water Act activates a variety of tools for regulatory oversight of waterbodies. These include:

303(d) list,

Total Maximum Daily Loads (TMDL),

National pollution Discharge Elimination System (NPDES) permits,

Best Management Practices (BMP's) to address nonpoint source pollution.

The state of Oregon uses other tools to address water quality and to complement Federal tools including:

Senate Bill 1010,

Oregon Forest Practices Act and the

Oregon Groundwater Act.

Major Legislation Relating to Groundwater Protection

Federal

Safe Drinking Water Act (SDWA)

Provides a system of national standards and treatment technologies for public drinking water.

Clean Water Act (CWA) Sec. 106 Groundwater Protection Strategy—40 CFR, Part 130

Provides planning funds to assist state in developing a comprehensive groundwater protection program.

Resource Conservation and Hazardous Waste Recovery Act (RCRA)

Regulates nonhazardous waste facilities such as municipal landfills.

Regulates hazardous material generated from industrial waste, which can contaminate groundwater.

Provides for the regulation of underground storage tanks (UST).

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

Superfund Program

State

Oregon Groundwater Act (1989)

APPENDIX 3-2: Water Quality Measurements

Table A3-2-1: Summary / explanation of selected water quality parameters.

Parameter	Brief description	Abbreviations	Units of measurement
Dissolved Oxygen	Amount of oxygen dissolved in water	DO	milligrams/Liter (mg/L)
Temperature	Temperature of water	T	Degrees F (or C)
Turbidity	Scattering of light in water due to particulate matter; low light transmission is high turbidity	Turb	Nephelometric Turbidity Unit (NTU)
Total suspended Solids	Total concentration of particles suspended in the water column	TSS	mg/L
Total dissolved solids	Total concentration of dissolved ions in water	TDS	mg/L
Conductivity	Ability of the water to carry an electrical current; inverse of resistance to electric current; linearly correlated to TDS.	Cond Ec	micromhos/cm (umohs/cm) or microSiemens/cm (uS/cm)
PH	Hydrogen ion activity showing acidic, neutral or basic water	pH	pH units:[-log(Hydrogen ion oncentration)]
Alkalinity	Capacity of water to neutralize acid	Alk	mg/L(as calcium carbonate)
Hardness	Total concentration of calcium and magnesium ions in water		mg/L (as calcium carbonate)
Total phosphorus	Concentration of all forms of phosphorus	P, TP	mg/L
Phosphate	Biologically available form of phosphorus	OPO_4	mg/L orthophosphate ion (PO_4)
Total nitrogen	Concentration of all forms of nitrogen	N, TKN	mg/L
Nitrate	Biologically available form of nitrogen	NO_3	mg/L nitrate (NO_3)
Ammonium	Biologically available form of nitrogen	NH_4	mg/L ammonium (NH_4)
Sulfate	Concentration of sulfate	SO_4	mg/L
Chloride	Concentration of natural ionic form of chloride (not chlorine)	Cl	mg/L chloride
Magnesium	Concentration of magnesium ion	Mg	mg/L
Sodium	Concentration of sodium ion	Na	mg/L
Potassium	Concentration of potassium	K	mg/L
Bacteria	Concentration of bacteria of interest such as *Escherichia coli* or fecal coliform	E. Coli	counts/100 milliliters (ml) or Maximum probable number/100 ml
Biochemical oxygen demand	Amount of oxygen required by bacteria while decomposing organic matter	BOD	mg/L

APPENDIX 3-3: Section 303(d) of the Federal Clean Water Act

The 1972 Federal Clean Water Act in Section 303(d) requires each state to develop a list of waters that do not meet state standards for water quality. The list provides a way to identify problems and develop and implement plans to protect beneficial uses while achieving federal and state water quality standards.

The list identifies areas of water quality problems, but does not specify the causes of those problems. Water quality problems that are considered include parameters such as nutrients, bacteria, toxic contaminants, turbidity and temperature. For these waters that do not meet standards, states are required to establish TMDL's, which are discussed in a later in this chapter.

The Oregon Department of Environmental Quality (DEQ) determines which waters should be placed on the 303(d) list using existing scientific data and best professional judgment. DEQ first presents a draft list for public comment. After comments are reviewed and considered, a final list is developed and sent to U.S. Environmental Protection Agency (EPA) for approval. The final list is accompanied by a list of priorities that target resources for correcting water quality problems. DEQ must submit an updated list to the Environmental Protection Agency (EPA) every two years.

A stream, river, lake or estuary may be removed from the list if there is evidence that: 1) it is meeting water quality standards; 2) it is violating water quality standards due only to natural conditions (meaning that there is no human-caused influence); 3) its Total Maximum Daily Load (TMDL) has been approved; or 4) it was placed on the list in error. (ODEQ, **http://waterquality.deq.state.or.us/wq/303dlist/303dfactsheet.htm)**.

For example, the State Standard sets the temperature at 64°F statewide unless there is habitat for cold-water fish spawning or bull trout, which require standards of 55°F and 50°F, respectively. If a stream or river violates temperature standards, DEQ would require that responsible parties or management agencies develop a water temperature management plan to address the problem. If temperatures still do not meet water quality standards after an approved temperature management plan has been implemented and if DEQ determines that all feasible steps have been taken to address the problem, then the temperature actually attained will become the standard for that water.

APPENDIX 3-4: TMDLs, Storm Water

Total Maximum Daily Loads (TMDL's)

The EPA requires state's to develop TMDL's for waters that do not meet standards for water quality. A TMDL is a strategy for bringing a waterbody back into compliance with water quality standards—for improving water quality to the point where recognized beneficial uses of water are fully supported. A full TMDL development process determines the pollutants or stressors causing water quality impairments, identifies maximum permissible loading capacities for the waterbody in question, and then, for each relevant pollutant, assigns load allocations (Total Maximum Daily Loads) to each of the different sources, point and nonpoint, in the watershed.

TMDL Planning and Management in the Rickreall Creek Watershed

Rickreall Creek was removed from the 303(d) list in 1994 for the dissolved oxygen parameter, after a TMDL after USEPA approved a TMDL for biological oxygen demand (BOD) in 1994 (**http://waterquality.deq.state.or.us/wq/TMDLs/approvedTMDLs.htm**).

At the time of development of this TMDL, nonpoint sources were not being conjunctively addressed with point sources via the TMDL process. More recent modifications to the TMDL process have resulted in a point source—nonpoint source approach that is on schedule to be undertaken in the Rickreall Creek Watershed in the year 2003. (DEQ Personal Communication, Mark Hamlin, 2000) See below for a timeline of events regarding TMDL planning in the Rickreall Creek watershed. (DEQ, 1997)

Storm Water Program

EPA issued Phase I of the Municipal Stormwater Permit Program in 1990. This program targets stormwater discharge from medium and large municipal storm sewer systems as well as stormwater discharges from industrial activities, including discharges from construction activities disturbing five acres or more. Phase I of the Municipal Stormwater Permit Program (MSPP), (not to be confused with previously discussed Phase I of the WWTP facility plan) requires that all owners/operators of small municipal storm sewer systems reduce discharge of pollutants from a regulated system to the "maximum extent practicable" to protect water quality. (Federal Register Vol. 63, No 6, p.1574)

Phase II-MSPP addresses stormwater discharges from activities exempt under Phase I:

construction activities disturbing less than five acres

light industrial activities

"donut holes"—small municipal storm sewer systems located in a larger community regulated under Phase I.

Phase II -MSPP Addresses stormwater discharges from:

small municipal storm sewer systems in urbanized areas (serving a population of less than 100,000)

construction activities that disturb between one and five acres

By 2005, the City of Dallas is to have addressed stormwater management issues and developed a management plan for urban nonpoint sources associated with the urban area of Dallas (DEQ, 2000). At that time, the City of Dallas will need to ensure that it has regulations or ordinances in place that satisfy the proposed Phase II minimum control measures for:

construction site stormwater runoff

post-construction stormwater management in new development and redevelopment

illicit discharge detection and elimination

pollution prevention/good housekeeping for municipal operations

(American Public Works Association, 1999)

APPENDIX 3-5: Description of Water Quality Standards

Bacteria (*Esherichia coli*) or Water Contact Recreation (Fecal Coliform)

BENEFICIAL USES AFFECTED: Water Contact Recreation

STANDARDS or CRITERIA: OAR 340-41-(basin)(2)(e and

Standards applicable to all basins:

(e) Bacteria standards:

(A) Numeric criteria: Organisms of the coliform group commonly associated with fecal sources (MPN or equivalent membrane filtration using a representative number of samples) shall not exceed the criteria described in subparagraphs (i):

(i) Freshwaters and Estuarine Waters other than shellfish growing waters:

(I) A 30-day log mean of 126 *E. coli* organisms per 100 ml, based on a minimum of five (5) samples;

(II) No single sample shall exceed 406 *E. coli* organisms per 100 ml;

(f) Bacterial pollution or other conditions deleterious to waters used for domestic purposes, livestock watering, irrigation, bathing or shellfish propagation, or otherwise injurious to public health shall not be allowed.

Freshwaters and Estuarine Waters other than shellfish growing waters: A log mean of 200 fecal coliform per 100 milliliters based on a minimum of five samples in a 30 day period with no more than ten percent of the samples in the 30 day period exceeding 400 per 100 ml].

WATER QUALITY LIMITED CRITERIA: A 30-day log mean of 126 *E coli* organisms per 100 ml or more than 10% of the and a minimum of at least two exceedences exceed samples exceed 406 *E coli* organisms per 100 ml or, if *E coli* data are not available, the geometric mean of fecal coliform bacteria exceeds 200 per 100 milliliters or more than 10 percent of the samples and a minimum of at least two exceedences exceed 400 per 100 milliliters for the season of interest;

TIME PERIOD:

Summer: June 1 through September 30 (period of highest use for water contact recreation);

Fall-Winter-Spring (FWS): October 1 to May 31

Conductivity

Standard: There is no standard for conductivity but it can be used to interpret water quality information.

Conductivity or specific conductance is a measure of water's ability to conduct an electrical current, and it depends on temperature and concentrations of dissolved substances such as salts. Surface waters in the Willamette Valley and Coast Range are typically 150 mhos /cm or less. Domestic and industrial wastewater, storm water, irrigation return water and other agricultural runoff can have higher conductivity the receiving stream. Ground water base flow can typically has higher conductivity than the creek. (WQMTGB, 1999)

Copper

Standard: For freshwater organisms, EPA has established an acute copper concentration of 18 ug/L and 12 ug/L as a chronic concentration (EPA, 1986)

Dissolved Oxygen

BENEFICIAL USES AFFECTED: Resident Fish and Aquatic Life, Salmonid Spawning & Rearing

STANDARDS or CRITERIA: OAR 340-41-(basin)(2)(a)

Dissolved Oxygen concentration shall not be less than the following:

Standards applicable to all basins (adopted 1/11/96, effective 7/1/96)

During times and in waters that support salmonid spawning until fry emergence from the gravels:

Dissolved Oxygen shall not be less than 11 mg/l; unless intergravel dissolved oxygen is greater than 8.0 mg/l (as a spatial median minimum), then DO criteria is 9.0; or

where conditions of barometric pressure, altitude and naturally occurring temperatures preclude attainment of the 11 or 9 mg/l standard, then dissolved oxygen levels shall not be less than 95% saturation.

Spatial median minimum intergravel dissolved oxygen concentration shall not fall below 6.0 mg/l.

For waters identified as providing cold-water aquatic resources, the dissolved oxygen shall not fall below 8.0 mg/l (unless it is diurnal monitoring data that can be used to estimate the 7-day minimum, then the minimum shall not fall below 6.5) or where conditions of barometric pressure, altitude and naturally occurring temperatures preclude attainment of the 8.0 mg/l standard, then dissolved oxygen levels shall not be less than 90% saturation.

For waters identified as providing cool-water aquatic resources, the dissolved oxygen shall not be less than 6.5 mg/l.

For waters identified as providing warm-water aquatic resources, the dissolved oxygen shall not be less than 5.5 mg/l.

WATER QUALITY LIMITED CRITERIA: Greater than 10 percent of the samples exceed the appropriate standard and a minimum of at least two exceedences of the standard for a season of interest.

TIME PERIOD:

Rearing: as identified by ODFW Staff; Spawning through fry emergence: as identified by ODFW Staff

Flow Modification

BENEFICIAL USES AFFECTED: Resident Fish & Aquatic Life, Salmonid Fish Spawning & Rearing

STANDARDS or CRITERIA: OAR 340-41-(basin)(2)(i)

The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish shall not be allowed.

-or-

OAR 340-41-027

Standards applicable to all basins:

Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.

WATER QUALITY LIMITED CRITERIA: Documented flow conditions that are a significant limitation to fish or other aquatic life as indicated by the following information:

Beneficial uses are impaired. This documentation can consist of data on aquatic community status that show aquatic communities (primarily macroinvertebrates) which are 60% or less of the expected reference community for both multimetric scores and multivariate model scores are considered impaired. Streams with either multimetric scores or multivariate scores between 61% and 75% of expected reference communities are considered as streams of concern. Streams greater than 75% of expected reference communities using either multimetric or multivariate models are considered unimpaired. -or-

Where monitoring methods determined a Biotic Condition Index, Index of Biotic Integrity, or similar metric rating of poor or a significant departure from reference conditions utilizing a suggested EPA biomonitoring protocol or other technique acceptable to DEQ. -or-

Fishery data on escapement, redd counts, population survey, etc. that show fish species have declined due to water quality conditions; and an established or applied for Instream Water Right, and documentation that flows are not frequently being met such as through statistical summaries of stream flow based on actual flow measurements, and identification of human contribution to the reduction of instream flows below acceptable level indicated (e.g. evidence of water rights and diversions above or in the segment.

TIME PERIOD:

Annual

Macroinvertebrate Life (Biological Criteria)

BENEFICIAL USES AFFECTED: Resident Fish and Aquatic Life

STANDARDS or CRITERIA: OAR 340-41-027

Standards applicable to all basins:

Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.

"*Aquatic species*" means any plants or animals which live at least part of their life cycle in waters of the State.

"*Biological Criteria*": means numerical values or narrative expressions that describe the biological integrity of aquatic communities inhabiting waters of a given designated aquatic life use.

"*Resident Biological Community*" means aquatic life expected to exist in a particular habitat where water quality standards for a specific ecoregion, basin, or water body are met. This shall be established by accepted biomonitoring techniques.

"*Without Detrimental Changes in the Resident Biological Community*" means no loss of ecological integrity when compared to natural conditions at an appropriate reference site or region.

"*Ecological Integrity*" means the summation of chemical, physical and biological integrity capable of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region.

"*Appropriate Reference Site or Region*" means a site on the same water body, or within the same basin or ecoregion that has similar habitat conditions, and represents the water quality and biological community attainable within the areas of concern.

WATER QUALITY LIMITED CRITERIA[1]: Aquatic communities (primarily macroinvertebrates) which are 60% or less of the expected reference community for both multimetric scores and multivariate model scores are considered impaired. Streams with either multimetric scores or multivariate scores between 61% and 75% of expected reference communities are considered as streams of concern. Streams greater than 75% of expected reference communities using either multimetric or multivariate models are considered unimpaired. -or-

Where monitoring methods determined a Biotic Condition Index, Index of Biotic Integrity, or similar metric rating of poor or a significant departure from reference conditions utilizing a suggested EPA biomonitoring protocol or other technique acceptable to DEQ.

TIME PERIOD:

Annual

Nutrients

BENEFICIAL USES AFFECTED: Aesthetics or use identified under related parameters

WATER QUALITY LIMITED CRITERIA: Greater than 10 percent of the samples exceed standard and a minimum of at least two exceedences of the standard or criteria used in draft TMDLs for a season of interest;

TIME PERIOD:

June through September or as specified under the specific standard above

Ammonia

Evaluation Indicator for Ammonia (no standard established)

Table 3-9 Critical Values for Total Ammonia Concentrations mg/l [1] Where Salmonids are Present

	Acute Criterion			Chronic Criterion		
PH	15 C	20 C	25 C	15 C	20 C	25 C
6.5	30	29	20	2.8	1.76	1.23
7.5	14.9	14.6	10.2	2.6	1.78	1.25
8.0	6.9	6.8	4.8	1.57	1.10	0.78
9.0	0.86	0.91	0.72	0.195	0.148	0.12
[1] Values from Ambient H_20 Quality Criteria						

Total Nitrogen

Evaluation Indicator: 0.30 mg/l (no standard established)

Nitrate

Evaluation Indicator: (Drinking H20) 10 mg/l (no standard established)

Drinking water standard for nitrate is intended to protect babies from infant methemoglobinemia (blue baby syndrome) and protect livestock such as cattle where higher rates of calf abortion are related to high nitrate concentrations in water.

Total Phosphorus

Evaluation Indicator: 0.05 mg/l (no standard established)

The indicator value is the concentration that has been shown to lead to accelerated eutrophication in lakes.

pH

BENEFICIAL USES AFFECTED: Resident Fish & Aquatic Life, Water Contact Recreation

STANDARDS or CRITERIA: OAR 340-41-(basin)(2)(d)

Summary: pH shall not fall outside the following ranges for the waters in Willamette Basin: 6.5 to 8.5;

* when 25% of the measurements taken between June and September are greater than pH 8.7, the Department shall determine whether the value higher than 8.7 are anthropogenic or natural in origin

WATER QUALITY LIMITED CRITERIA: Greater than 10 percent of the samples exceed standard and a minimum of at least two exceedences of the standard for a season of interest;

TIME PERIOD:

Summer: June 1 through September 30;

Fall-Winter-Spring (FWS): October 1 to May 31;

The pH of the stream water is a measure of how acidic or basic the water is. This parameter can affect the production and survival of fish and emergence and survival of aquatic insects. The solubility and toxicity of certain water pollutants like heavy metals and ammonia varies with the water pH. Excessive plant growth can alter the water pH. Photosynthesis and respiration produce slight variability in diurnal and seasonal pH values (WQMTGB, 1999).

Sedimentation

BENEFICIAL USES AFFECTED: Resident Fish & Aquatic Life, Salmonid Fish Spawning & Rearing

STANDARDS or CRITERIA: OAR 340-41-(basin)(2)(j)_The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry shall not be allowed.

WATER QUALITY LIMITED CRITERIA: Documented that sedimentation is a significant limitation to fish or other aquatic life as indicated by the following information:

Beneficial uses are impaired. This documentation can consist of data on aquatic community status that show aquatic communities (primarily macroinvertebrates) are impaired. -or-

Fishery data on escapement, redd counts, population survey, etc. that show fish species have declined due to water quality conditions; and documentation through a watershed analysis or other published report which summarizes the data and utilizes standard protocols, criteria and benchmarks. Measurements of cobble embeddedness or percent fines are considered under sedimentation. Documentation should indicate that there are conditions that are deleterious to fish or other aquatic life.

TIME PERIOD:

Annual

Temperature

BENEFICIAL USES AFFECTED: Resident Fish & Aquatic Life, Salmonid Fish Spawning & Rearing

STANDARDS or CRITERIA: OAR 340-41-(basin)(2)(b)

Seven (7) day moving average of the daily maximum shall not exceed the following values unless specifically allowed under a DEQ approved basin surface water temperature management plan:

64° F (17.8° C);

55° F (12.8° C) during times and in waters that support salmon spawning, egg incubation and fry emergence from the egg and from the gravels;

[except when the air temperature during the warmest seven-day period of the year exceeds the 90th percentile of the 7-day average daily maximum air temperature calculated in a yearly series over the historic record]

WATER QUALITY LIMITED CRITERIA: Rolling seven (7) day average of the daily maximum exceeds the appropriate standard listed above. In the cases where data were not collected in a manner to calculate the rolling seven (7) day average of the daily maximum, greater than 25 percent (and a minimum of at least two exceedences) of the samples exceed the appropriate standard based on multi-year monitoring programs that collect representative samples on separate days for the season of concern (typically summer) and time of day of concern (typically mid to late afternoon).

TIME PERIOD:

Rearing: June 1 through September 30

Total Dissolved Solids (TDS)

Guideline: 100 mg/l TDS

Toxics

BENEFICIAL USES AFFECTED: Resident Fish and Aquatic Life, Drinking Water

STANDARDS or CRITERIA: OAR 340-41-(basin)(2)(p)

Standards applicable to all basins:

OAR 340-41-445(2)(p)(A): Toxic substances shall not be introduced above natural background levels in the waters of the state in amounts, concentrations, or combinations which may be harmful, may chemically change to harmful forms in the environment, or may accumulate in sediments or bioaccumulate in aquatic life or wildlife to levels that adversely affect public health, safety, or welfare; aquatic life; wildlife; or other designated beneficial uses;

OAR 340-41-445(2)(p)(B): Levels of toxic substances shall not exceed the criteria listed in Table 20 which were based on criteria established by EPA and published in Quality Criteria for Water (1986), unless otherwise noted;

OAR 340-41-445(2)(p)(C): . . . Where no published EPA criteria exist for a toxic substance, public health advisories and other published scientific literature may be considered and used, if appropriate, to set guidance values.

WATER QUALITY LIMITED CRITERIA [1]: Water Quality Standards Violations:

The water quality standard listed in Table 20 (see OAR 340-41) for the chemical is violated more than 10% of the time and for a minimum of two values.*

Other Evidence of Impairment of Beneficial Uses:

A fish or shellfish consumption advisory or recommendation issued by the Health Division specifically refers to this chemical.

The chemical has been found to cause a biological impairment via a field test of significance such as a bioassay. The field test must involve comparison to a reference condition.

TIME PERIOD: Annual

Turbidity

BENEFICIAL USES AFFECTED: Resident Fish and Aquatic Life, Water Supply, Aesthetics

STANDARDS or CRITERIA: OAR 340-41-(basin)(2)(c)

No more than ten percent cumulative increase in natural stream turbidities shall be allowed, as measured relative to a control point immediately upstream of the turbidity causing activities.

WATER QUALITY LIMITED CRITERIA: A systematic or persistent increase (of greater than 10%) in turbidity due to an operational activity that occurs on a persistent basis (e.g. dam release or irrigation return, etc).

TIME PERIOD:

Annual

APPENDIX 3-6: Bioassessment of Aquatic Macroinvertebrates

Appendix 3-6 **Bioassessment Data**

Table 1

6

Rickreall Creek @ Fir Villa Rd.

Genus	Species	ABUND	%
Oligochaeta		1	0.92
TOTAL: MISC. TAXA		1	0.92
Baetis	bicaudatus	2	1.83
Baetis	tricaudatus	8	7.34
seudocloeon		4	3.67
ithrogena		50	45.87
TOTAL: EPHEMEROPTERA		64	58.72
Calineuria	californica	3	2.75
TOTAL: PLECOPTERA		3	2.75
Rhyacophila		1	0.92
Cheumatopsyche		22	20.18
TOTAL: TRICOPTERA		23	21.10
Optioservus		1	0.92
TOTAL: COLEOPTERA		1	0.92
Tanytarsini		17	15.60
TOTAL: CHIRONOMIDAE		17	15.60
TOTAL: ALL DIPTERA		17	15.60
AND TOTAL		109	100.00

Rickreall Creek 2000 m d/s Dallas STP

Genus	Species	ABUND	%
Hyallela	azteca	7	12.28
Asellus		1	1.75
TOTAL: MISC. TAXA		8	14.04
Coenagrionidae		1	1.75
TOTAL: ODONATA		1	1.75
Rhithrogena		2	3.51
TOTAL: EPHEMEROPTERA		2	3.51
Malenka		1	1.75
TOTAL: PLECOPTERA		1	1.75
Cheumatopsyche		1	1.75
TOTAL: TRICOPTERA		1	1.75
Hemerodromia		1	1.75
TOTAL: MISC. DIPTERA		1	1.75
Chironomidae		3	5.26
Orthocladiinae		40	70.18
TOTAL: CHIRONOMIDAE		43	75.44
TOTAL: ALL DIPTERA		44	77.19
GRAND TOTAL		57	100.00

Rickreall Creek @ Greenwood Rd.

Genus	Species	ABUND	%
Fluminicola		1	0.58
Juga		21	12.21
TOTAL: MISC. TAXA		22	12.79
Baetis	bicaudatus	4	2.33
Baetis	tricaudatus	21	12.21
Heptagenia		1	0.58
Tricorythidae		1	0.58
TOTAL: EPHEMEROPTERA		27	15.70
Pteronarcys	californica	10	5.81
Capniidae		2	1.16
Calineuria	californica	2	1.16
Isoperla		6	3.49
TOTAL: PLECOPTERA		20	11.63
Glossosoma		1	0.58
Cheumatopsyche		11	6.40
TOTAL: TRICOPTERA		12	6.98
Simuliidae		16	9.30
TOTAL: MISC. DIPTERA		16	9.30
Tanytarsini		75	43.60
TOTAL: CHIRONOMIDAE		75	43.60
TOTAL: ALL DIPTERA		91	52.91
GRAND TOTAL		172	100.00

Table 2

Bioassessment Results Rickreall Cr.
October 1989

Metrics	Metric Value Station 1	2	C	% Comparison Station 1	2	C
Taxa Richness	9	14	10	90	140	100
HBI	6.035	7.355	3.385	56	46	100
Scrapers/Filt. Collect.	2	0.111	2.31	87	5	100
EPT/Chiron. Abundance	0.09	0.79	5.29	2	15	100
% Contrib. Dom. Taxon	99.98	97.67	100	100	98	100
EPT Index	3	10	7	43	143	100
Community Loss Index	0.89	0.36	0	1	0	0

Metrics	Bioassessment Score Station 1	2	C
Taxa Richness	6	6	6
HBI	2	0	6
Scrapers/Filt. Collect.	6	0	6
EPT/Chiron. Abundance	0	0	6
% Contrib. Dom. Taxon	0	0	0
EPT Index	0	6	6
Community Loss Index	4	6	6
Biometric Score	18	18	36
% of Control	50	50	100
Biological Cond.	Mod.	Mod.	

	Habitat Assessment Score Station 1	2	C
Habitat Score	37	38	41
% of Control	90	93	100
Assessment Category	Compar.	Compar.	

Stations

1 - Rickreall Cr. 2000yds d/s Dallas STP
2 - Rickreall Cr. @ Greenwood Rd.
C - Rickreall Cr. @ Fir Villa Rd. (Control site)

Table 3

Metric Descriptions

Taxa Richness - This equals the total number of taxa (genera and/or species) identified from each site. Taxa richness generally increase with increasing water quality.

HBI - The Hilsenhoff Biotic Index (HBI) ranges from 0 to 10, increasing as water quality decreases. It is based on the pollution tolerance and relative abundance of each taxon at a sample site. The index was developed by W.L. Hilsenhoff (1987) as a means of detecting organic pollution.

Ratio of Scrapers/Filt. Collectors - The ratio of invertebrate feeding groups, in this case scrapers and filtering collectors, provides insight into the nature of potential water quality changes. Predominance of one feeding type may indicate an unbalanced community responding to an overabundance of a particular food source.

Ratio of EPT & Chironomidae Abundances - This metric compares the abundance of Ephemeroptera, Plecoptera and Trichoptera (EPT) relative to Chironomid (midge) abundance. Chironomids tend to become increasingly abundant in response to increased organic enrichment or heavy metal concentrations.

% Contribution of Dominant Taxon - The percent contribution of the ten numerically dominant taxa to the total number of organisms is an indication of the community balance and health. A community dominated by relatively few species indicates environmental stress.

EPT Index - The EPT index is the total number of distinct taxa within the orders Ephemeroptera, Plecoptera and Trichoptera. The EPT Index generally increases with increasing water quality.

Community Loss Index - This index is a measure of the loss of benthic species between a reference or control station and a study site. The index ranges from 0 to infinity and increases as the dissimilarity between sites increases.

Appendix 3-7 Temperature Management Plan for the Rickreall Creek Watershed and ODFW Correspondence regarding Salmonid Producing Water Quality Standard for Rickreall Creek Watershed.

Temperature Management Plan for the Rickreall Creek

Temperature deserves special attention in the water quality screening process because Rickreall Creek is 303(d)-listed for temperature in the summer from the mouth to Mercer Reservoir. Waters are considered to be temperature limited if the stream temperature exceeds 64°F for a moving seven-day average.

The city of Dallas received an exception to the DEQ in-stream temperature standard as part of their latest NPDES Permit Application. Based on "cool water" water quality criteria established for Rickreall creek, if ambient water temperatures reach 64 degrees F there can be no measurable increase in temperature because of a WWTP effluent discharge. However, the city found that water quality data and model results for Rickreall above the WWTP show that in-stream water temperatures often exceed 64 degrees F ranging between 64 and 70 degrees F in the summer (June through September) even under natural conditions.

According to the city, although temperature model results and temperature mass balance calculations indicate that the WWTP discharge will initially increase in-stream temperature immediately downstream of the WWTP, they maintain that the effluent will actually reduce the increase in water temperature further downstream than would be the case under natural conditions without the WWTP discharge. They therefore conclude that these are not a negative impact on in-stream temperature and aquatic resources based on implementation of the facility plan. In actuality, there appears to be an overall environmental benefit to in-stream temperature in addition to maintaining downstream flows and aquatic habitat during critical low flow periods because of the WWTP discharge. Salmonid species known to utilize Rickreall Creek, resident and anadromous, are not known to utilize areas downstream of the WWTP during the summer when temperatures typically exceed water quality criteria. ODFW sampling has documented cutthroat trout slightly upstream of the WWTP during the fall and winter but not in the summer likely because they either move further upstream or downstream into the Willamette River during the summer (ODFW, pers comm.., 1996) In personal conversation with DEQ staff (September 2000), it was stated that DEQ relied on the professional judgment of the ODFW fish manager who found that the lower river downstream of the WWTP does not have suitable habitat such as side channels or large woody debris, hence the non-presence of fish. This raises questions such as, are fish not present because they have to be elsewhere to survice due to high temperatures?

In summary, the exception to the temperature standard is based on the lack of fish use and the rationale that the in-stream temperature is improved downstream of the WWTP during the summer because the increased flow from the WWTP discharge reduces water residence time and also reduces the surface to volume ratio of the water column, both of which reduce the potential effects of solar radiation exposure.

APPENDIX 5: Sensitive species (other than fish) in the Willamette Valley.

The Federal rank lists species in order of perceived peril as: 1) Listed Endangered (LE), 2) Listed Threatened (LT), 3) Proposed Endangered (PE), 4) Proposed Threatened (PT), 5) Species of Concern (SoC), and 6) Candidates for listing (C). Eight species in Table A5-1 are either Listed Endangered or Listed Threatened. The bald eagle is being considered for removal from the federal threatened list, and the gray wolf probably has been extirpated from the watershed. The six remaining federally listed species include:peregrine falcon and Kincaid's lupine, Northern spotted owl, marbled murrelet, Aleutian goose, and dotted water-flax seed. Two species are proposed for federal endangered listing: Fender's blue butterfly and Willamette daisy, while one is proposed for a threatened listing: three-colored monkey flower.

The state system is similar to the federal system in regards to threatened and endangered ranks, but replaces "Candidates" and "Species of Concern" with four "Sensitive Species" rankings. These include "Critical" (SC), for species with listing pending; "Vulnerable" (SV), for species where listing is not thought to be imminent and may be avoided with action; "Peripheral" (SP), for species that are naturally rare or whose Oregon populations are on the edge of their ranges; and "Undetermined" (SU), for species whose status is unclear from lack of information. The state Endangered Species Act is more limited in scope than the federal ESA and only actively applies to lands owned or managed by the state. Criteria for state listing of a species extends to populations that are 1) actively undergoing or are in imminent danger of habitat deterioration, 2) being over-utilized or where over-utilization is likely to occur, or 3) not being protected adequately by existing programs. "Sensitive" status is given to any species that might qualify as "Endangered" or "Threatened" in the future. Other species included in the tables with no federal or state status are listed by another group and generally indicate species that may be f concern or about which not enough information is known.

Table A5-1: Sensitive species that potentially occur or formerly occurred in the Rickreall Creek Watershed (Oregon Natural Heritage Program).
Status abbreviations: **LE** = Fed. Listed Endangered, **PE** = Fed. Proposed Endangered, **LT** = Fed. Listed Threatened, **PT** = Fed. Proposed Threatened, **C** = Fed. Candidate Species, **SoC** = Fed. Species of Concern, **SC** = State Sensitive Critical, **SV** = State Sensitive Vulnerable, **SP** = State Sensitive Peripheral, **SU** = State Sensitive, Undetermined status. Those species with no listed status are proposed by Oregon Natural Heritage Program or the Nature Conservancy as species that merit attention.

Common name	Scientific name	Fed. status	State status
REPTILES			
Northwestern pond turtle	Clemmys marmorata marmorata	SoC	SC
painted turtle	Chrysemys picta	-	SC
sharptail snake	Contia tenuis	-	SV
AMPHIBIANS			
Oregon spotted frog	Rana pretiosa	C	SC
southern seep salamander	Rhyacotriton variegates	SoC	SV
tailed frog	Ascaphus truei	SoC	SV
Northern red-legged frog	Rana aurora aurora	SoC	SV/SU
Clouded salamander	Aneides ferreus	-	SV

Table A5-1 (cont.)			
BIRDS			
peregrine falcon	*Falco peregrinus*	LE	LE
bald eagle	*Haleaeatus leucophalus*	LT	LT
northern spotted owl	*Strix occidentalis caurina*	LT	LT
marbled murrelet	*Brachyramphus marmoratus*	LT	LT
Aleutian Canada goose (wintering)	*Branta canadensis leucopareia*	LT	LE
northern goshawk	*Accipiter gentiles*	SoC	SC
little willow flycatcher	*Empidonax traillii brewsteri*	SoC	SV
northern pygmy owl	*Glaucidium gnoma*	-	SC
burrowing owl	*Athene cunicularia*	-	SC
western meadowlark	*Sturnella neglecta*	-	SC
Oregon vesper sparrow	*Pooecetes gramineus affinis*	-	SC
purple martin	*Progne subis*	-	SC
common nighthawk	*Chordeiles minor*	-	SC
streaked horned lark	*Eremophila alpestris strigata*	-	SC
yellow-breasted chat	*Icteria virens*	-	SC
Lewis' Woodpecker	*Melanerpes lewis*	-	SC
pileated Woodpecker	*Dryocopus pileatus*	-	SV
western bluebird	*Sialia mexicana*	-	SV
white-tailed kite	*Elanus leucurus*	-	-
dusky Canada goose (wintering)	*Branta canadensis occidentalis*	-	-
acorn woodpecker	*Melanerpes formicivorus*	-	-
MAMMALS			
gray wolf	*Canis lupus*	LE	LE
Canada lynx	*Lynx canadensis*	C	-
white-footed vole	*Arborimus albipes*	SoC	SU
Pacific western big-eared bat	*Corynorhinus townsendii*	SoC	SC
fringed myotis	*Myotis thysanodes*	-	SV
American marten	*Martes americana*	-	SV
long-eared myotis	*Myotis evotis*	-	SU
silver-haired bat	*Lasionycteris noctivagans*	-	SU
Western gray squirrel	*Sciurus griseus*	-	SU

Table A5-1 (cont.)

INSECTS

Common name	Scientific name	Fed status	State status
Fender's blue butterfly	*Icaricia icarioides fenderi*	PE	-
Fender's rhyacophilan caddisfly	*Rhyacophila fenderi*	SoC	-
Haddock's rhyacophilan caddisfly	*Rhyacophila haddocki*	SoC	-
Roth's blind ground beetle	*Pterostichus rothi*	SoC	-
Vertree's ceraclean caddisfly	*Ceraclea vertreesi*	SoC	-
Siskiyou chloealtis grasshopper	*Chloealtis aspasma*	SoC	-
montane bog dragonfly	*Tanypteryx hageni*	-	-
Mary's Peak ice cricket	*Grylloblatta spp.*	-	-
American acetropis grass bug	*Acetropis americana*	-	-
stink bug	*Dendrocoris arizonensis*	-	-
foliaceous lace bug	*Derephysia foliacea*	-	-
Heidemann's nabid (bug)	*Hoplistoscelis heidemanni*	-	-
Martin's water-measurer	*Hydrometra martini*	-	-
marsh ground beetle	*Acupalpus punctulatus*	-	-
potentilla root borer beetle	*Chrysobothris potentillae*	-	-
Corvallis diving beetle	*Hydroporus corvallis*	-	-
Taylor's checkerspot butterfly	*Euphydryas editha taylori*	-	-
Mulsant's small water strider	*Mesovelia mulsanti*	-	-
true fir pinalitus (bug)	*Pinalitus solivagus*	-	-
Douglas-fir platylygus (bug)	*Platylygus pseudotsugae*	-	-
Alsea ochrotrichian micro caddisfly	*Ochrotrichia alsea*	-	-
Willamette callippe fritillary butterfly	*Speyeria callippe spp.*	-	-
valley silverspot butterfly	*Speyeria zerene bremneri*	-	-

Table A5-1 (cont.)			
VASCULAR PLANTS			
Kincaid's lupine	Lupinus sulphureus	LE	LE
dotted water-flax seed	*Spirodela punctata*	LT	LT
Willamette daisy	*Erigeron decumbens*	PE	LE
three-colored monkeyflower	*Mimulus tricolor*	PT	LT
peacock larkspur	Delphinium pavonaceum	SoC	LE
Willamette Valley larkspur	*Delphinium oreganum*	SoC	LE
white-topped aster	Aster curtus	SoC	LT
tall bugbane	*Cimicifuga elata*	SoC	C
shaggy horkelia	*Horkelia congesta*	SoC	C
loose-flowered bluegrass	*Poa laxiflora*	SoC	C
Nelson's sidalcea	*Sidalcea nelsoniana*	-	C
whorled marsh-pennywort	*Hydrocotyle verticillata*	-	-
dwarf isopyrum	*Isopyrum stipitatum*	-	-
thin-leaved peavine	*Lathyrus holochlorus*	-	-
small-flowered lipocarpha	*Lipocarpha micrantha*	-	-
Bradshaw's lomatium	*Lomatium bradshawii*	-	-
Howell's montia	*Montia howellii*	-	-
meadow sidalcea	*Sidalcea campestris*	-	-
humped bladderwort	*Utricularia gibba*	-	-
narrow-leaved milkweed	Asclepias fascicularis*	-	-
dotted water-meal	Wolffia borealis	-	-
showy milkweeed	Asclepias speciosa*	-	-
Wahoo	Euonymus occidentalis	-	-
indian rhubarb	Peltiphyllum peltatum	-	-
Timwort	Cicendia quadrangularis	-	-
Mountain lady-slipper	Cypripedium montanum	-	-
adder's tongue	Ophioglossum pusillum	-	-
upland yellow violet	Viola nuttalli praemorsa	-	-
Columbia water-meal	Wolffia columbiana	-	-

LE = Listed Endangered PE = Proposed Endangered C = Candidate Species

LT = Listed Threatened PT = Proposed Threatened SoC = Species of Concern

Additional State Sensitive Rankings: SC = sensitive critical, S V = sensitive vulnerable, SP = sensiteve peripheral, SU = sensitive, undetermined status.

*Corvallis Chapter Native Plant Society of Oregon, Species of Concern

Special Plants and Fungi

There are four lists currently used by the Natural Heritage Council to rank special plants and fungi (Table A5-2). List 1 consisting of the taxa which are endangered or threatened throughout their range or are presumed extinct. List 2 contains species that are threatened, endangered or possibly extirpated from Oregon, but are stable or more common elsewhere. List 3 is a review list for species that need more information to determine their status. All fungi in the survey are new and are placed on the review list by the Oregon Natural Heritage Program. List 4 contains taxa of concern that are not currently threatened or endangered.

Table A5-2: Sensitive Special plants and fungi (source: ONHP).

Lichens	Mosses	***Fungi***		Liverworts
List 1: Sulcaria badia	List 2: Micromitrium tenerum Physcomitrella patens	*List 3:* Otidea leporina Phaeocollybia radicata Ramaria gracilis Rhizopogon brunneiniger Rhizopogon exiguus Rhizopogon subcinnamomeus Rhizopogon subradicatus Sarcosoma latahense	*List 3:* Bondarzewia mesenterica Elaphomyces decipiens Gymnomyces monosporus *Helvella elastica* Helvella maculata Leptonia occident Leucogaster citrinus Martellia idahoensis	List 1: Sphaerocarpos hians
List 3: Bryoria subcana Usnea hesperina	List 3: Physcomitrium immersum			

APPENDIX 6: Soil Groups for Rickreall Watershed

Agricultural and Mixed Land Use Soils of the Main Valley Floor and Foothills

Table A6-1. Soil Group A (PURPLE) Main valley floor terraces, Level to nearly level with few limitations, diverse agriculture and urban uses. Capability classes I and Is and IIw.

Map Unit	Series	Type	Slope class	Capability Class
1A	Abiqua	Silty clay loam	0-3	I
3	Amity	Silt loam	0-3	II w
12A	Briedwell	Silt loam	0-3	IIs
18	Coburg	Silty clay loam	0-3	IIw
45	Malabon	Silty clay loam	0-3	II s
48A	McAlpin	Silty clay loam	0-3	II w
65B	Santiam	Silt loam	0-3	IIw
75A	Willamette	Silt loam	0-3	I
77A	Woodburn	Silt loam	0-3	II w

Table A6-2. Soil Group B (YELLOW) Gently to strongly sloping soils of the terraces and foothills; Slight to moderate erosion hazard; Capability classes IIe and IIIe.

Map Unit	Series	Type	Slope class	Capability Class
1B	Abiqua	Silty clay loam	3-5	II e
8C	Bellpine	Silty clay loam	3-12	II e
8D	Bellpine	Silty clay loam	12-20	III e
12C	Briedwell	Silt loam	3-12	IIIe
15C	Chehulpum	Silt loam	3-12	Vis
26C	Dixonville	Silty clay loam	3-12	II e
26D	Dixonville	Silty clay loam	12-20	III e
27C	Dupee	Silt loam	3-12	III e
29C	Hazellair	Silt loam	3-12	III e
30C	Helmick	Silt loam	3-12	IIIe
31C	Helvetia	Silt loam	0-12	IIIe
35C	Jory	Silt loam	2-12	II e
35D	Jory	Silt loam	12-20	III e
36C	Jory	Silty clay loam	2-12	IIe
36D	Jory	Silty clay loam	12-20	IIIe
48B	McAlpin	Silty clay loam	3-6	IIe
52C	Nekia	Silty clay loam	2-12	IIe
52D	Nekia	Silty clay loam	12-20	IIIe
56C	Philomath	Silty clay	3-12	VI e
61C	Ritner	GR Silty clay loam	3-12	Ivs
64B	Salkum	Silty clay loam	2-6	IIe
64C	Salkum	Silty clay loam	6-12	IIe
65C	Santiam	Silt loam	6-15	IIe
65D	Santiam	Silt loam	15-20	IIIe
67C	Steiwer	Silt loam	3-12	IIIe
68C	Suver	Silty clay loam	3-12	IIIe
74C	Willakenzie	Silty clay loam	2-12	IIIe
74D	Willakenzie	Silty clay loam	12-20	IIIe
75C	Willamette	Silt loam	3-12	II e
75D	Willamette	Silt loam	12-20	IIIe
77C	Woodburn	Silt loam	3-12	IIe
77D	Woodburn	Silt loam	12-20	III e

Table A6-3. Soil Group C (ORANGE) Steeply sloping soils of old terraces and foothills; high hazard of erosion; Capability classes IVe and VIe.				
Map Unit	**Series**	**Type**	**Slope class**	**Capability Class**
8E	Bellpine	Silty clay loam	20-30	IV e
12D	Briedwell	Gravelly loam	7-20	IV e
15E	Chehulpum	Silt loam	12-40	VIIs
16E	Chehulpum-Steiwer complex	Silt loam	12-40	VIIs
27D	Dupee	Silty clay loam	3-12	IVe
29D	Hazellair	Silt loam	12-20	IV e
30D	Helmick	Silt loam	12-20	IVe
30E	Helmick	Silt loam	20-50	VIe
31	Helvetia	Silt loam	12-20	IVe
35E	Jory	Silt loam	20-30	IV e
36E	Jory	Silty clay loam	2-30	IV e
52E	Nekia	Silty clay loam	20-30	IVe
56E	Philomath	Silty clay	12-45	VI e
60C	Rickreall	Silty clay loam	3-12	VIe
60D	Rickreall	Silty clay loam	12-20	VIe
60E	Rickreall	Silty clay loam	20-50	VIIe
60F	Rickreall	Silty clay loam	50-75	VIIe
61D	Ritner	GR Silty clay loam	12-30	VIs
67D	Steiwer	Silty clay loam	12-20	IVe
67E	Steiwer	Silt loam	20-50	VIe
68D	Suver	Silty clay loam	12-20	IVe
68E	Suver	Silty clay loam	20-30	IVe
74E	Willakenzie	Silty clay loam	20-30	IVe
76C	Witzel	Very stony loam	3-12	Vis
78	Xerochrepts and Haploxerolls		Steep	VIe

Table A6-4. Soil Group D (LIGHT BLUE) Level and nearly level soils of the floodplains that are occasionally flooded, usually support diverse agriculture, and have slight to moderate risk of erosion from floodwater; Capability classes IIw, IIs, and IVw.					
Map Unit	**Series**	**Type**	**Flood Hazard**	**Slope class**	**Capability Class**
2	Abiqua		Occasional	0-3	Iiw
13	Camas	Gr. sandy loam	Common	0-3	IV w
14	Chahalis	Silty clay loam	Common	0-3	II w
17	Cloquato	Silt loam	Common	0-3	II w
46	Malabon,	Silty clay loam	Occasional		Iiw
49	McBee	Silty clay loam	Occasional	0-3	II w
53	Newberg	Silty clay loam	Common	0-3	II w
54	Newberg	Loam	Common	0-3	II w
58	Pilchuck	f. sandy loam	Common	0-3	IV w
62	Riverwash	Gravel, Cobbles, Sand	Frequent	0-5	VIIIw
79	Xerofluvents	Loamy	Frequent	0-5	Viw

Table A6-5. Soil Group E (DARK BLUE) Hydric soils. Poorly drained soils of broad flat terraces and depressions, and floodplains of tributary streams. Grass seed farming and other agricultural crops that can withstand seasonally wet soils. Some areas are artificially drained. Includes important and potential wetlands and riparian areas.				
Map Unit	**Series**	**Type**	**Slope class**	**Capability Class**
6A	Bashaw	Silty clay loam	0-3	IV w
6C	Bashaw	Silty clay	3-12	IVw
7	Bashaw	Clay	0-3	IV w
11	Brenner	Silt loam	0-3	III w
20	Concord	Silt loam	0-3	III w
21	Cove	Silty clay loam	0-2	IVw
22	Cove	Thick surface	0-3	IIIw
25	Dayton	Silt loam	0-3	IV w
28	Grande Rhonde*	Silty Clay Loam	0-2	IIIw
33	Holcomb*	Silt loam	0-3	IIIw
72	Waldo	Silty clay loam	0-3	III w
73	Wapato	Sitly clay loam	0-3	III w

*Wetness limitations but Not Listed as Hydric

Forested and Mixed Land Use Soils of the Coast Range and Foothills

Table A6-6. Soil Group F (DARK GREEN) High productivity forestland with low erosion risk for forest management. Marginal to high-risk agriculture practiced in places. Very strongly sloping (3-30 percent). Some soils have high risk of slumping.			
Map Unit	**Series**	**Type**	**Slope class**
4D	Apt	Silty clay loam	3-25
5D	Astoria	Silt loam	5-30
9D	Blachly	Silty clay loam	3-30
10D	Bohannon	Gravelly loam	3-25
23D	Cruiser	Gravelly loam, bedrock substratum	3-25
24D	Cumley	Silty clay loam	2-20
32D	Hembre	Gravelly Silt loam	3-25
34D	Honeygrove	Silty clay loam	3-25
37D	Jory	Silty clay loam	2-30
38E	Kilchis	Stony loam	3-30
40D	Kilowan	Gr. Silty clay loam	3-25
41D	Klickitat	Gravelly Clay loam	3-30
42B	Knappa	Silt loam	0-7
43D	Luckiamute	Very stony loam	3-30
44D	Lurnick	Gravelly loam	3-30
47D	Marty	Gravelly loam	3-25
50D	McDuff	Silty clay loam	3-25
55D	Peavine	Silty clay loam	3-30
66D	Slickrock	Gravelly loam	3-25
69D	Trask	Shaly loam	3-30
70D	Valsetz	Stony loam	3-30
80D	Yellowstone	Stony loam	3-30

Table A6-7. Soil Group G (LIGHT GREEN) High productivity forestland with High erosion risk for forest management. Very strongly sloping (25-50 percent). Some soils have high risk of slumping.

Map Unit	Series	Type	Slope class
4E	Apt	Silty clay loam	25-50
5E	Astoria	Silt loam	30-60
8F	Bellpine	Silty clay loam	30-50
9E	Blachly	Silty clay loam	30-50
10E	Bohannon	Gravelly loam	25-50
23E	Cruiser	Gravelly loam, bedrock substratum	25-50
32E	Hembre	Gravelly Silt loam	25-50
34E	Honeygrove	Silty clay loam	25-50
37E	Jory	Silty clay loam	30-50
40E	Kilowan	Gr Silty clay loam	30-50
41E	Klickitat	Gravelly clay loam	30-50
44E	Lurnick	Gravelly loam	30-50
47E	Marty	Gravelly loam	25-60
50E	McDuff	Silty clay loam	25-50
52E	Nekia	Silty clay loam	30-50
52F	Nekia	Silty clay loam	30-50
55E	Peavine	Silty clay loam	30-60
61E	Ritner	Gr. Silty clay loam	30-60
66E	Slickrock	Gravelly loam	25-50
70E	Valsetz	Stony loam	35-50

Table A6-8. Soil Group H (GRAY) Low or Moderate Productivity Forest Land and High erosion risk for forest management. Very steeply sloping (>50 percent and > 60 % by unit).

Map Unit	Series	Type	Slope class
8G	Bellpine	Silty clay loam	50-75
10F	Bonhannon	Gravelly loam	50-75
23F	Cruiser	Gravelly loam, bedrock substratum	50-75
32F	Hembre	Gravelly Silt loam	50-70
34F	Honeygrove	Silty clay loam	50-75
38F	Kilchis	Stony loam	60-90
39F	Klickitat-Kilchis Complex		60-90
40F	Kilowan	Silty clay loam	50-75
41F	Klickitat	Gravelly clay loam	50-75
43F	Luckiamute	Very stony loam	30-75
44F	Lurnick	Gravelly loam	50-75
50E	McDuff	Silty clay loam	50-75
51D	Mulkey	Loam	5-25
55F	Peavine	Silty clay loam	60-75
59	Pits	--	--
63	Rock Outcrop	--	30-90
69F	Trask	Shaly loam	30-90
70F	Valsetz	Stony loam	50-75
71F	Valsetz-Yellowstone Complex	Stony loam	50-90
80F	Yellowstone	Stony loam	30-90

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GLOSSARY

Short definitions are given for some of the terms used in this document. In many cases, definitions are given in the text. The readers are also directed to the appendixes; in particular water quality parameters are described in Appendix 3.x.

100-yr storm	A statistical statement that the storm was so big, one wouldn't expect it for another 100 years.
303 (d) list	List of waters in the state that do not meet standards for water quality.
Alluvial	Deposits created by moving water. Typically soil deposits.
Anadromous	Fish that spawn in fresh water and live in salt water. Resident fish stay in a local area of the stream all year long.
Aquifer	Area of the ground that has an amount of water saturated in the soils and cracks of the bedrock. `
Biodiversity	Measure of numbers of different species and/or habitats within an area.
BLM	U.S. Bureau of Land Management
Board feet	Measure of lumber or timber. One board foot is equivalent to a 12" x 12" board that is 1 " thick.
CAFO	Confined animal feeding operation. CAFOs are often dairies.
CFS	Cubic feet per second.
Channel	The river bed and banks that contains the water of a stream or river.
Colluvial	Deposits created by slides, erosion from hillslopes.
Constrained	A channel that has steep and high banks with little opportunity for the flood water to enter a floodplain.
Dam	The material or structure that impounds or holds back a stream or river.
DEQ	Oregon Department of Environmental Quality
Embeddedness	The degree to which cobble or gravel sized substrate is buried by sand or finer particles. Embeddedness inhibits macroinvertebrates and fry (young fish).
Erosion	The detachment of soil particles and their subsequent movement. The wearing away of a soil profile (the structure and layering).
Euro-American	Person of European decent that has become a U.S. citizen--in contrast to Native American.
Extirpated	Locally extinct or died off.
Fish barrier	Some obstruction in the stream that stops fish from swimming up or down. Can be a falls, culvert, of shallow water, or dam. Barriers can be seasonal.

Fluvial	Of flowing water.
Gage	Variant of gauge. A measuring device such as a graduated rod to derive stream discharge or a graduated collector to measure rainfall.
Geomorphology	Physical form of the landscape
Gill net	A net that is set out to catch fish. It stretches when a fish tries to swim through the holes and tightens behind their gills, trapping them.
GIS	Geographic Information System--a computer aided way to make maps using various data sets. These maps can easily be measured by the computer too.
GLO surveys	Land surveys to establish section lines during the mid 1800's. These surveys also recorded vegetation types
Gradient	The steepeness of a stream channel or hillslope.
Headwall	The steepest portion of a valley usually at the head or start of a stream.
Hydrograph	Plot of stream flow volumes over time.
Hydrology	The study of flowing water. Or the information about flow in a stream.
Low flow	Low flows in a stream such as during late summer.
macroinvertebrates	Relatively large sized invertebrates (lacking a backbone)--typically insects.
Mass wasting	The event of large amounts of soil and bedrock moving suddenly as a landslide or slump.
Naturally reproducing	Term for fish that may not have been native (there before Euro-American settlement) but currently reproduces on it own as a native fish.
OAR	Oregon Administrative Rules. The state law.
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Game.
Off-channel habitat	Slow water areas along the edges of stream or side channels and beaver ponds that offer refuge for young fish and shelter during floods.
Old-growth	Stand of trees, conifers, that have characteristics of large and old-aged trees. Typically over 200 years old.
ONHP	Oregon Natural Heritage Program.
Orthophoto	Aerial photo that has been digitized (made into tiny dots) and reformatted (stretched) so as to remove distortions on the corners of the photo. Orthophotos are flat projects just like a map. Aerial photos project slightly curved.
Over-allocated	The condition where the sum of all the permitted withdrawals from a stream are greater than what has been deemed should stay in the channel as an instream right.
Peak flow	Flood flows in a stream.

Perennial	Grows without needed replanting for several years. Most agriculture crops are annuals.
Pools and riffles	Areas of a stream: pools are deeper and slower water, riffles are shallow and fast flowing--they create turbulence on the surface.
Reservoir	The impoundment or lake that is created by a dam.
Riparian	Of rivers or stream side.
Savanna	A mixture of grasslands and scattered trees.
SB 1010	Senate Bill # 10-10. A law passed in Oregon to begin to reduce non-point source pollution to stream. (Not from a single point such as a pipe, but from a dispersed area such as a road, field or construction site.
Sediment	Mineral matter that is transported by waters. Can be clay sized (very small) to boulder sized.
Spring chinook	Chinook salmon that enter the river to spawn in late winter or spring. Salmon in the Willamette are spring chinook. Most salmon on the coast are fall chinook.
Steelhead	Ocean traveling rainbow trout that comes back to its stream of origin to spawn.
Substrate	The mineral particles on the bottom of a steam. Can be sand up to bedrock.
Water right	The amount of water a permittee is allowed to withdraw during a time period.
Watershed	Area of land that is drained by a stream or river--a basin.
Wetland	Any shallow, permanently or seasonally wet area. Usually still or slow moving waters. Includes the soils and vegetation.
Withdrawals	Removal of water from a water body.
Woody debris	Larger logs-typicall counted during stream surveys. Woody debris is good for fish habitat.
WWTP	Waste water treatment plant or sewage treatment plant.