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LOWER MOLALLA RIVER AND MILK CREEK WATERSHED ASSESSMENT

MICHAEL B. COLE

RICHARD J. BLAHA

AND

MATTHEW P. KILLIAN

PREPARED FOR

MOLALLA RIVERWATCH
MOLALLA, OR

PREPARED BY

ABR, INC.
FOREST GROVE, OREGON

LOWER MOLALLA RIVER AND MILK CREEK

WATERSHED ASSESSMENT

FINAL REPORT

Prepared for

Molalla RiverWatch
P.O. Box 867
Molalla, Oregon 97038-0867

Prepared by

Michael B. Cole
Richard J. Blaha
and
Matthew P. Killian

ABR, Inc.—Environmental Research & Services
P.O. Box 249
Forest Grove, Oregon 97116

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WATERSHED ASSESSMENT

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Molalla RiverWatch, Inc. (MRW) members Kay Patteson, Bill Taylor, Marilyn Bloch, Damon Schrosk and two Molalla High School students assisted with temperature gauge deployment, and field data collection. The MRW staff and members also provided project planning, coordination, reports and administration. Marilyn Bloch extensively researched and has written much of the information for the Historical Conditions Chapter.

Private property owners Joe Gymkowski and Melissa Gentry, Si Matson, and Milk Creek Tree Farm owner Blair Patterson allowed access through their properties to the Molalla River and Milk Creek. Combined with public access sites on land owned by Clackamas County, this allowed for temperature gauge deployment and field studies to be done at sites spaced from the headwaters to the mouth of both the Molalla River and Milk Creek.

ABR, Inc. – Environmental Research & Services team, Michael B. Cole, Richard J. Blaha, Matthew P. Killian, Jena Lemke, and Adam P. Harris conducted field data collection, complied GIS mapping and analysis, researched and has written and prepared this watershed assessment for Molalla RiverWatch, Inc.

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Written and researched by Michael B. Cole

Historical Conditions
Written and researched by Marilyn Bloch, Molalla RiverWatch

Ellen Thronson
May Oblack
Peggy Sigler
Monte Graham
Kay Patteson
John Haxton
Jena Lemke

Channel Habitat Types
Written and researched by Michael B. Cole and Richard J. Blaha

Hydrology and Water Use
Written and researched by Matthew P. Killian and Michael B. Cole

Jena Lemke, ABR, Inc.

Riparian and Wetlands
Written and researched by Richard J. Blaha and Michael B. Cole

Sediment Sources
Written and researched by Matthew P. Killian and Michael B. Cole

Channel Modification
Written and researched by Richard J. Blaha

Water Quality
Written and researched by Michael B Cole

Jena Lemke, ABR, Inc.

Fish and Fish Habitat
Written and Researched by Michael B. Cole and Adam P. Harris

Mark Mouser, Clackamas County
Dick Caldwell, ODFW
Andy Talabere, ODFW
Kirk Schroeder, ODFW

Watershed Condition Summary
Written by Michael B. Cole

GIS Mapping and Analysis
Richard J. Blaha and Matthew P. Killian

Editing and Formatting
Michael B. Cole

CHAPTER ONE: INTRODUCTION

PURPOSE AND SCOPE

The purpose of this watershed assessment is to inventory and characterize watershed conditions of the lower Molalla River & Milk Creek (LMR&MC) watershed and to provide recommendations to address the issues of water quality, fisheries and fish habitat, and watershed hydrology. The assessment is intended to identify alterations to fish habitat, water quality, and hydrology, and to understand how human activities have affected watershed conditions and functions. With these objectives in mind, this assessment was performed by gathering, synthesizing, analyzing, and interpreting existing data, and supplementing existing data sets with new data collected during the assessment. This assessment was performed following the guidelines of the Oregon Watershed Enhancement Board (OWEB) watershed assessment manual (WPN 1999).

Importantly, a watershed assessment of this scale and using these methods does not prescribe site-specific solutions for improving or restoring desirable watershed conditions or functions, but instead is intended to provide resource managers with the information needed to develop more specific action plans and monitoring strategies to improve watershed conditions.

METHODS

ASSESSMENT GUIDELINES

This assessment was performed using the Oregon Watershed Assessment Manual (WPN 1999). The manual provides background information, a framework and methods, and resources for conducting watershed assessments in Oregon. When sufficient data existed, analyses of watershed conditions and functioning were performed using the methods described in the manual.

MAPPING

Maps for this assessment were produced using ArcView 3.2a and ArcView 8.1 (ESRI, Redlands, CA). This software is used to view, create, and analyze Geographical Information Systems (GIS) data. GIS data and maps used in this assessment are available from ABR, Inc., and Molalla RiverWatch, Inc.

PHOTODOCUMENTATION

Watershed conditions at the time of the assessment were documented with photographs during site visits for ground truthing and collection of new data. Owing to the amount of memory required for the photographs, a separate document with the complete set of assessment documents, named the *LMR&MC Watershed Assessment Appendix of Photographs*, accompanies this report.

WATERSHED OVERVIEW

LOCATION AND SETTING

The Molalla River watershed occurs in northwest Oregon, flowing northeast out of the foothills of the Cascade Mountains and through the Willamette River valley, where it empties into the Willamette River approximately 2 miles east of the City of Wilsonville. The assessment area comprises two fifth-field watersheds, the Molalla River and Milk Creek watersheds (Hydrologic Unit Codes 170900902 & 170900903), both occurring entirely within Clackamas County (Figure 1.1). This assessment area of the lower watershed includes the mainstem Molalla River from river mile (RM) 0 upriver to RM 26.4 and all tributaries below the North Fork of the Molalla River, including Milk Creek and its tributaries. The lower Molalla River & Milk Creek (LMR&MC) watershed encompasses approximately 101,007 acres; including 65,791 acres in Milk Creek and 35,216 acres draining into the mainstem Molalla River.

Eight subwatersheds occur within the assessment area; two of these, the lower Molalla River and the Molalla River/Willamette River subwatersheds occur within the Lower Molalla River fifth-field watershed. Six of these, lower Milk Creek, middle Milk Creek, upper Milk Creek, Milk Creek headwaters, Canyon Creek, and Woodcock Creek occur in the Milk Creek fifth-field watershed (Figure 1.2).

ECOREGIONS AND VEGETATION

The LMR&MC watershed occurs within two of Oregon's ten major physiographic provinces: the

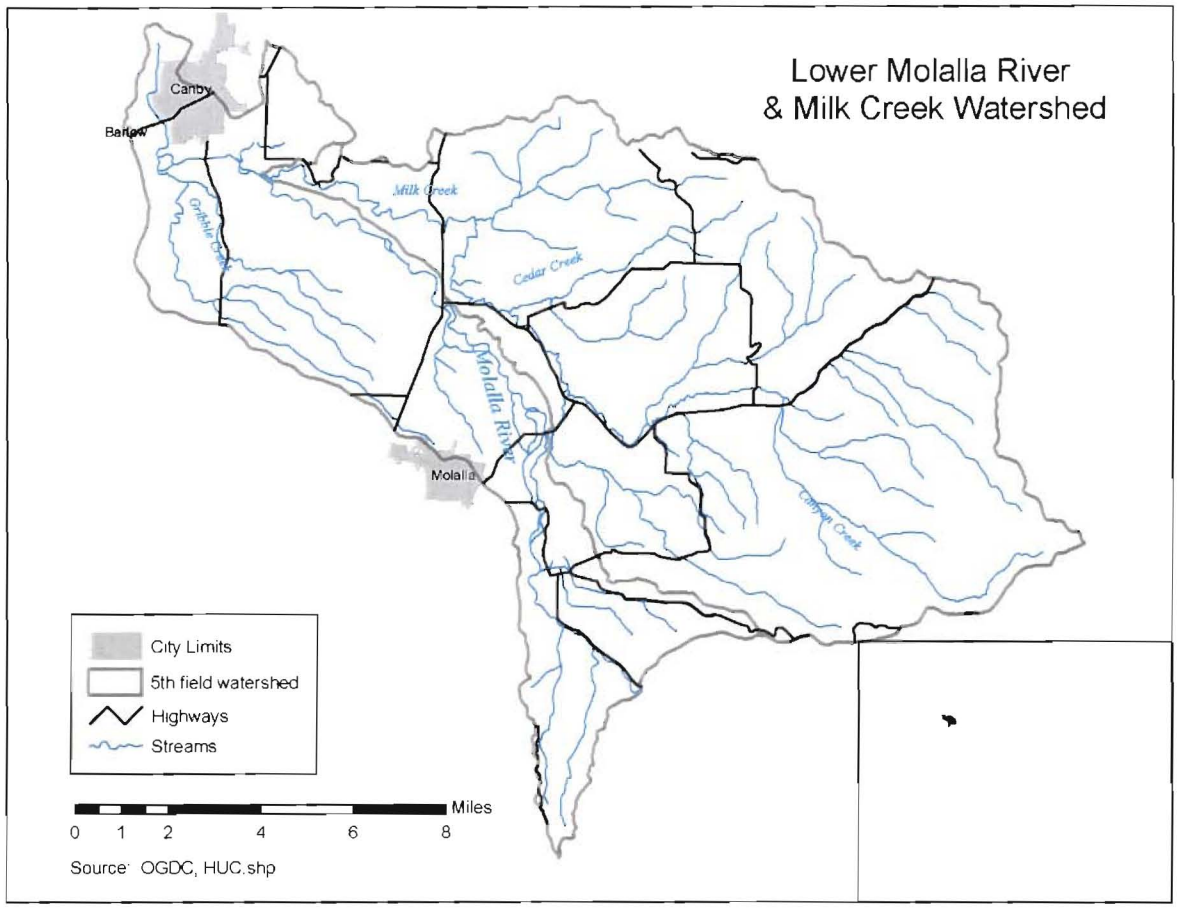

Figure 1.1. Fifth field watersheds occurring within the lower Molalla River and Milk Creek watershed assessment study area.

Willamette Valley province and the Western Oregon Cascades province. These larger geographic areas are subdivided into ecoregions based on uniform climate, geology, physiography, vegetation, soils, land use, wildlife, and hydrology. Each ecoregion has characteristic disturbance regimes that shape the form and function of watersheds in the region. Therefore, the identification of ecoregions within a watershed context can assist in determining how the watershed responds to physical alterations. The LMR&MC watershed includes portions of five ecoregions: Prairie Terraces, Valley Foothills, Western Cascades Lowlands and Valleys, Western Cascades Montane Highlands, and the Willamette River & Tributaries Gallery Forest (Figure 1.3).

The Willamette River & Tributaries Gallery Forest ecoregion comprises the riparian and floodplain corridors along the Willamette River and its major tributaries, including the lower Molalla River. These floodplains are bordered either by Missoula flood deposits or by rock outcrops (WPN 1999). Current streamside vegetation is highly variable, but often scarce or dominated by invasive species. Potential streamside vegetation in this ecoregion includes black cottonwood, Oregon ash, western Hawthorne, bigleaf maple, and shrubs including willow, dogwood, hazelnut, and snowberry. Within the LMR&MC watershed, this ecoregion occurs only along the mainstem Molalla River and its floodplain immediately east of the City of Molalla.

The Prairie Terraces ecoregion is the dominant ecoregion occurring on the Willamette River valley floor. The ecoregion is underlain by fluvial deposits from the Missoula floods; streams

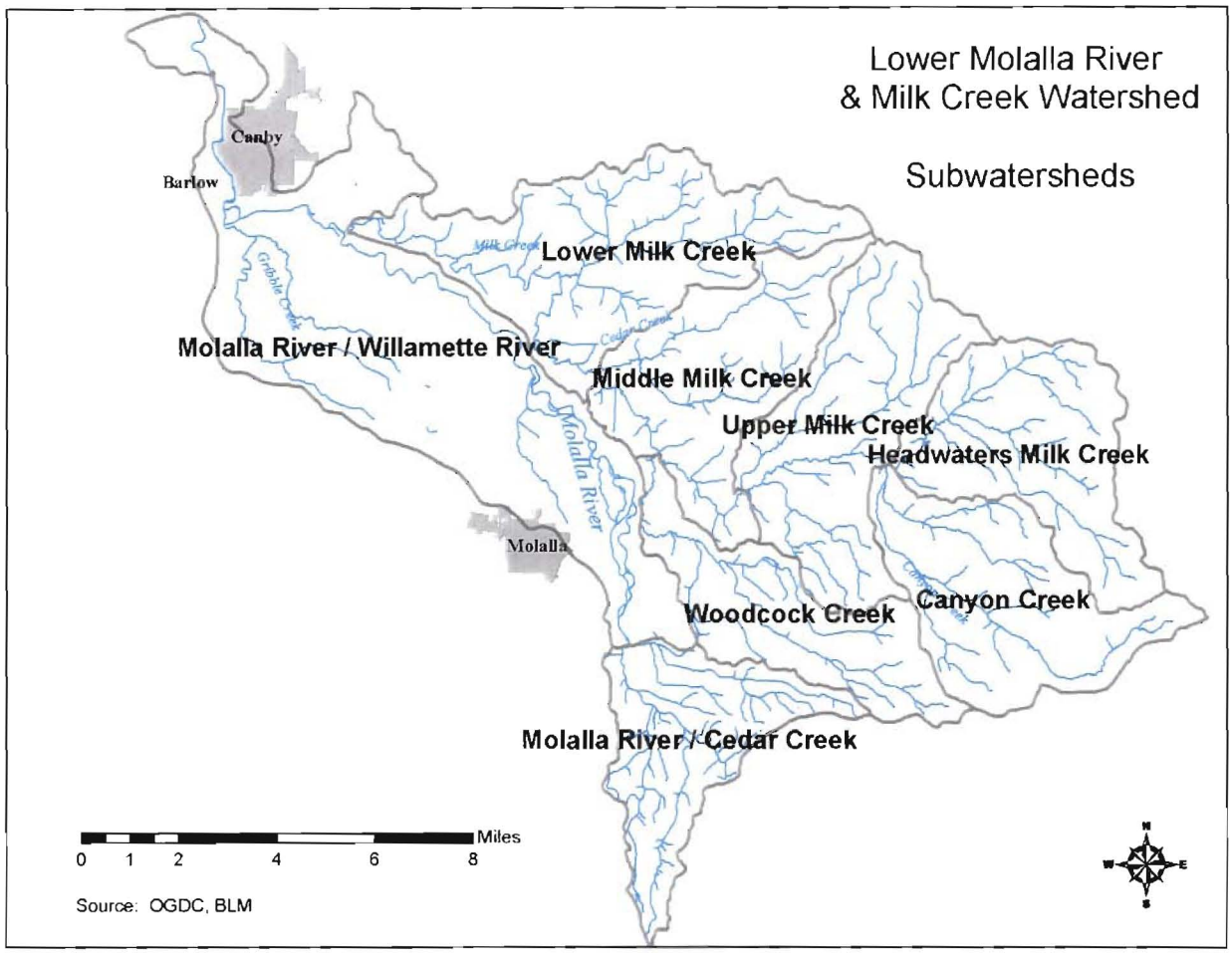

Figure 1.2. Subwatersheds occurring within the lower Molalla River and Milk Creek watershed assessment study area.

are very low gradient, often less than 1–1.5% slope, and are often deeply entrenched within clay banks (WPN 1999). Current upland vegetation is highly variable, including croplands, forested riparian areas, oak savanna, and prairies. Periodic burning by Native Americans historically maintained Oak savanna and prairie ecosystems through much of this ecoregion. The suppression of periodic low intensity fires from the ecoregion has led to replacement of oak savannas and prairies with oak and Douglas fir forests (WPN 1999). Within the LMR&MC watershed, the Prairie Terraces ecoregion occurs on the lower-elevation west side of the watershed, adjacent to the lower Molalla River floodplain through the Gribble Creek drainage.

The Valley Foothills ecoregion is the most extensive in the LMR&MC watershed. This ecoregion encompasses the foothills bordering the Willamette River valley and is characterized by rolling hills. Streams occurring within this ecoregion tend be moderate gradient, and watersheds within the ecoregion tend to have moderate stream densities (WPN 1999). Current upland vegetation is highly mixed, including pastureland, coniferous and deciduous forest, vineyards, and orchards. Natural upland vegetative communities were comprised primarily of Oregon white oak, Douglas fir, and western red cedar. Historically, dense forests of these species occurred within this ecoregion (WPN 1999). Within the LMR&MC assessment area, most of the middle

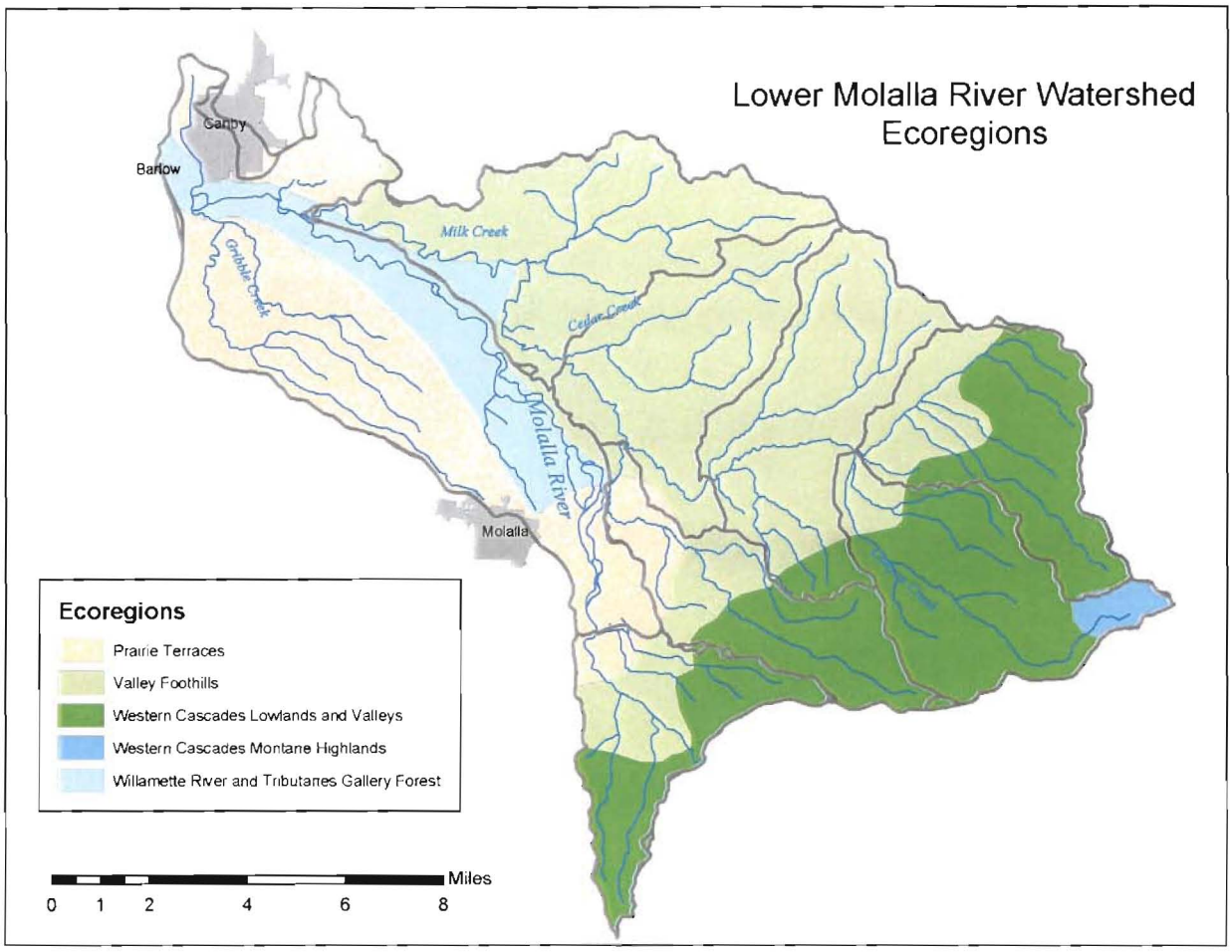

Figure 1.3. Ecoregions occurring within the lower Molalla River and milk Creek watershed assessment study area.

and lower Milk Creek watershed occurs in this ecoregion.

The Western Cascades Lowlands and Valleys ecoregion occurs between the Western Cascades Montane Highlands to the east and Valley Foothills to the west. Lava flows dominate the geology of the ecoregion, where streams typically flow through steep-sided canyons (WPN 1999). Streams range from low to high gradient and watersheds typically have a moderately high stream density. Upland vegetation includes Douglas fir, western hemlock, western red cedar, vine maple, and red alder forests (WPN 1999). This ecoregion occurs in the southeast portion of the LMR&MC watershed and encompasses the upper and headwater portions of the Milk Creek watershed.

The Western Cascades Montane Highlands ecoregion consists of high-elevation (3000-6000 ft) areas within the western Cascade Mountains north of the Umpqua River. Lava flows again dominate the geology of the region and the topography consists primarily of steep, glaciated, dissected mountains with moderate- to high-gradient streams (WPN 1999). Upland vegetative communities are dominated by Pacific silver fir, western hemlock, Douglas fir, mountain hemlock, noble fir, and white fir. Only a small portion of this ecoregion extends into the LMR&MC assessment area, occurring in the higher-elevation headwaters of Canyon Creek.

Two major vegetational zones occur within the LMR&MC watershed and correspond closely with the aforementioned ecoregions (Figure 1.4).

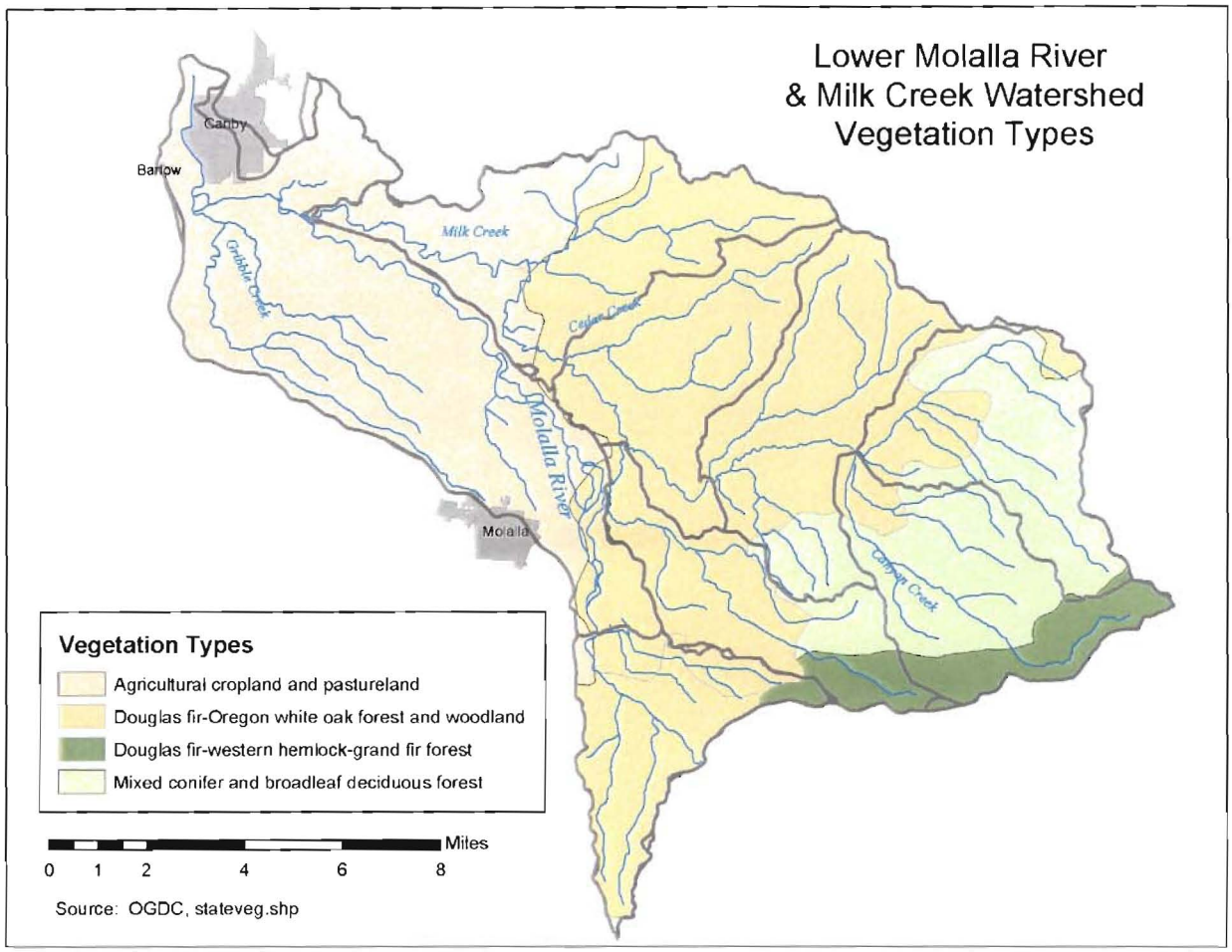

Figure 1.4. Major vegetation zones occurring within the lower Molalla River and Milk Creek watershed assessment study area.

The northwest portion of the watershed, occurring in the lowland Willamette valley and terraces occurs within the Willamette Valley zone. This vegetational zone includes oak woodlands, grasslands, conifer forests dominated by Douglas fir (Franklin and Dyrness 1988). The south and eastern portion of the watershed occurs within the *Tsuga heterophylla* zone, the most extensive vegetation zone in western Oregon. This zone is characterized by dominance by Douglas fir-dominated forests in a subclimax state and by western hemlock as the dominant climax species (Franklin and Dyrness 1988).

LAND USE AND OWNERSHIP

Land use in the watershed ranges from forestry to urban and industrial development. Dominant land uses are agriculture and forestry. Most of the watershed is privately owned, with small, scattered BLM inholdings (Figure 1.5). Owing to their dominance within the watershed, forestry and agricultural activities have likely had the largest effect on water quality, hydrology, and fish populations within the watershed. Agricultural activities such as clean-tilling of the soil, disruption and removal of riparian vegetation, and stream channelization are known to affect both water quality and hydrology (Wevers et al. 1992). Stream channelization on agricultural lands has occurred throughout the lower Molalla River

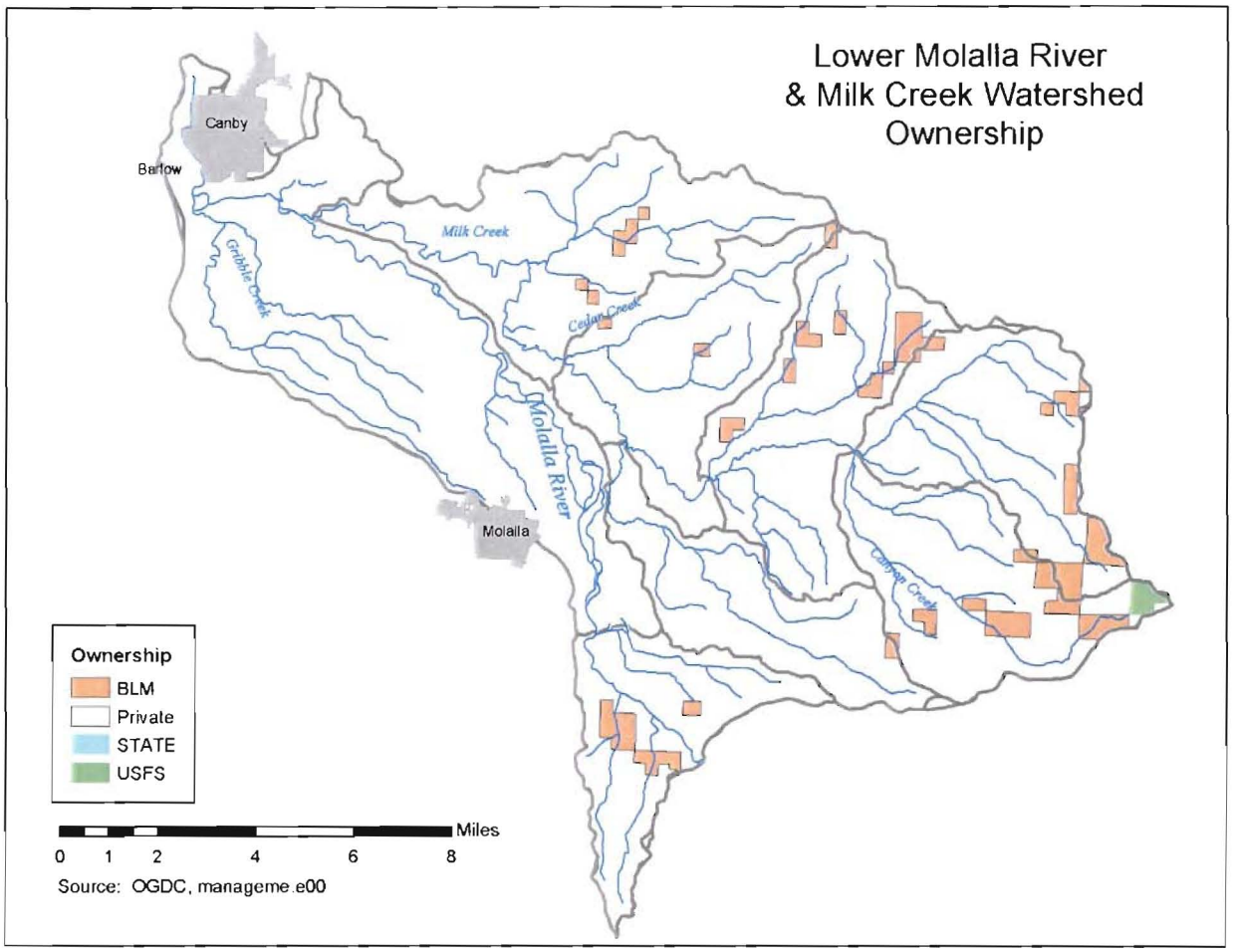

Figure 1.5. Land ownership wihin the lower Molalla River and Milk Creek watershed assessment study area.

system and associated tributaries (Wevers et al. 1992).

Only two small urban areas occur within the watershed, Canby and Molalla. Most of the city of Canby occurs within the watershed boundaries, while Molalla primarily occurs within the neighboring Pudding River watershed.

MINING

Gravel mining has occurred in the lower 20 miles of the Molalla River. Wevers et al. (1992) reported three active mining sites in 1992 and suggested that mining activity may have been broadening the river channel, creating shallow riffles that can impede upstream migrations of fall chinook. At present, two mining operations are active along the lower mainstem Molalla River.

GEOLOGY AND SOILS

The geology of the watershed consists of both sedimentary and igneous rocks and deposits (Figure 1.6). The lower end of the watershed, represented largely by low-elevation valley floors and adjacent lowland terraces, is dominated by alluvial and lacustrine deposits. Much of the geology of the lower watershed is dominated by Missoula flood deposits. During the last ice age, Missoula flood waters covered the Willamette Valley floor to a depth of 400 feet with sediment-laden water. Deposition of these sediments resulted on the present-day geology and soils of the Willamette Valley.

Conversely, geology of the upper portions of the LMR&MC watershed is dominated by igneous rocks resulting from lava flows from the Cascade Mountains.

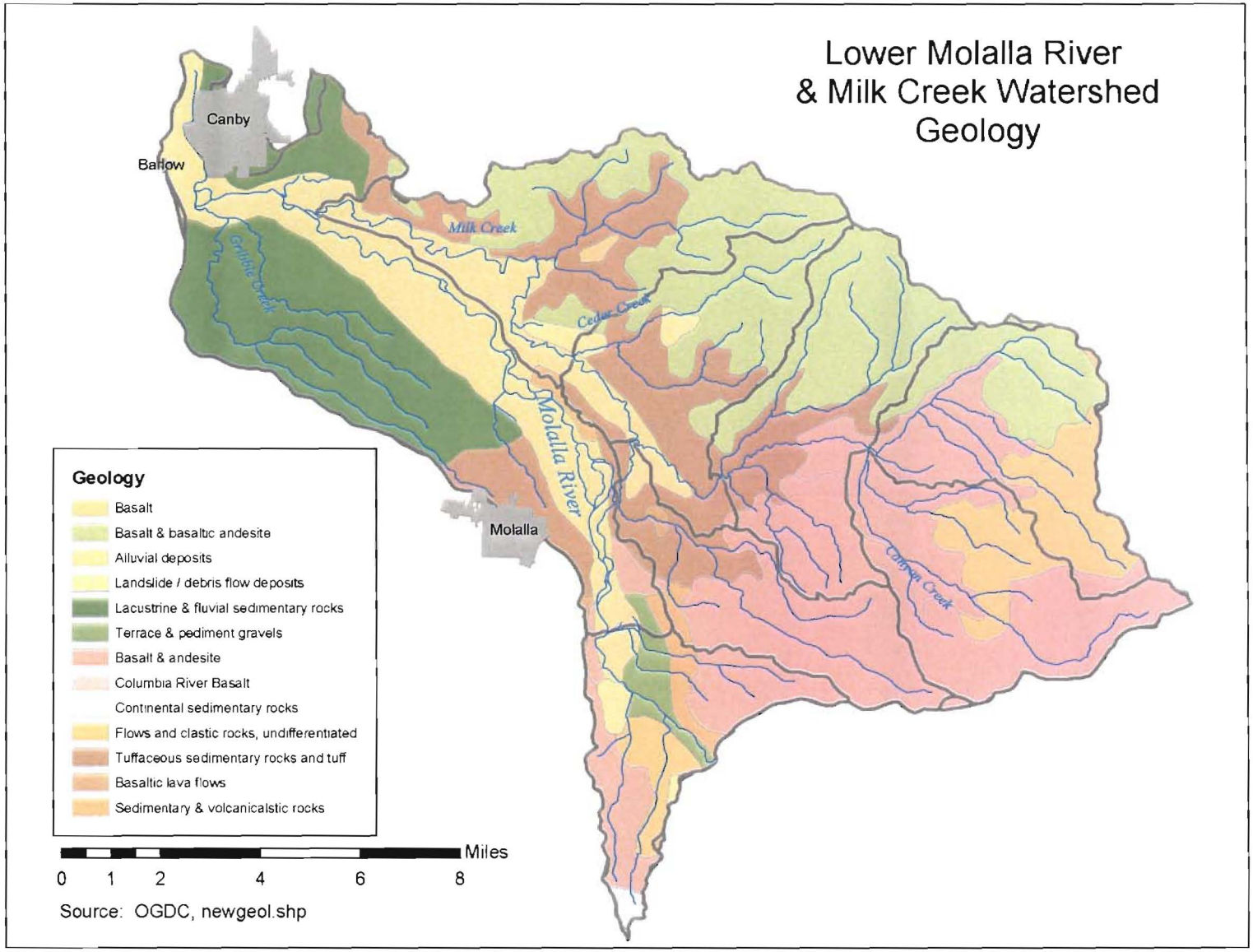

Figure 1.6. Geology of the lower Molalla River and Milk Creek watershed, Oregon.

Soils within the watershed are generally deep and range widely between silty clay and fine sandy loams in the lowlands to silty clay or very cobbly loams as elevation increases in the Cascade highlands. Soils in river floodplains formed largely in Willamette Valley alluvium (water transported materials).

CLIMATE

Oregon is divided into nine climate zones based on similar climatic conditions, including temperature and precipitation. The lower Molalla River & Milk Creek watershed occurs in Zone 2, the Willamette Valley climatic zone, representing the state's largest climatic division (Oregon Climate Service 2003). This region is characterized by cool, wet winters and warm, dry summers. Mild temperatures predominate throughout the year. Precipitation primarily occurs as winter rainfall, with the amount of precipitation increasing with elevation. In general, ecoregions occurring in lower elevations within the LMR&MC watershed receive an average of 40 to 50 inches of rainfall per year, while those occurring in higher elevations receive as much as 60 to 90 or more inches per year.

The City of the Molalla receives an average of 44.8 inches of rainfall per year, with most precipitation occurring between November and March (Western Regional Climate Center 2003). High temperatures in Molalla average 48.4 and 77.9 F, and low temperatures average 34.2 and 50.2 F in the winter and summer, respectively (Western Regional Climate Center 2003). Little snowfall occurs on the valley floor; however, some snowpack does develop in the headwaters of the Molalla River at higher elevations and contributes to flows in the watershed (Wevers et al. 1992).

HYDROLOGIC REGIME

Flows in the Molalla River and its tributaries closely follow seasonal rainfall patterns. Flow rates increase substantially with the onset of the rainy season in October and November and generally remain high through April. As summer progresses, flows rapidly drop, often reaching their lowest in August or September. Total annual river discharge at the gage station in the city of Canby is 3.6 billion cubic feet. Maximum discharge recorded on the Molalla River occurred during the 1964 floods when discharge peaked on the river near Canby at 43,600 cfs on December 22.

References to Chapter One

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Wevers, M. J., D. Nemeth, and J. Haxton. 1992. Molalla and Pudding Subbasin Fish Management Plan. Oregon Department of Fish and Wildlife, Corvallis, Oregon. 108 pp.

CHAPTER TWO: HISTORICAL CONDITIONS

HISTORICAL SETTING

Before westward migrations by Europeans, the upper elevations of the Molalla watershed were densely forested with ancient stands of Douglas fir, western hemlock, and western red cedar. Open areas at higher elevations provided browse for elk and deer and, seasonally, mountain huckleberries. The lower reaches of the river and tributaries, termed the "Molalla Prairie" by travelers, was "skirted with beautiful prairie bottoms two to eight miles in length and from one to two miles wide,... (which) alternate with groves of fir" (Palmer 1949). In 1845 the Molalla prairie was described as forested foothills containing fir, oak, cedar, maple, alder, dogwood, vine maple and grassy prairies (www.Molalla.net/community/first.htm). Ezra Fisher, a traveling minister in 1849, described the land as "rolling country interspersed with forests of fir and open lands generally set thick with ferns and scattering grass. Soil generally good, but settlements few." (Fisher 1849) The native peoples frequently burned over the prairies, keeping them clear of trees to attract deer and elk and allow food plants to grow.

NATIVE AMERICANS

The Molalas were the primary native inhabitants of the Molalla River drainage, with frequent visits from the Klamaths and perhaps the Kalapuyas at the mouth of the river. Accounts by early explorers and anthropologists provide the little information that is known about the Molalas. The northern branch of the Molalas lived along the length of the Molalla River and its tributaries. (Chapman 1996a) A group living near the present city of Molalla were the Mukanti band. In winter, the Mukanti lived in rectangular, semi-subterranean houses with hides and mats and a firepit for cooking and warmth, and in summer, in portable pole shelters with grass thatching or hide covers. (Chapman 1996a) The Molalas intermarried and traded with the Klamaths to the south, the Chinookans in the Columbia River region to the north and the Kalapuyas to the west (Chapman 1996, Zenk) and possibly the Clackamas (at Willamette Falls to the north).

Historical accounts of the food sources for the Molalas provide information about the vegetation and wildlife of the time. The Molalas were hunters and gatherers and traded for some of their goods. Deer and elk were the most important game, used for clothing as well as food. They also hunted bear and smaller animals such as coyotes, bobcats, beaver, cougars, and otter; as well as birds such as eagles, pheasant, hawks, woodpeckers, which were used for food, fur, skins, and feathers. The Molalas used the bow and arrow, snares, deadfalls and pitfalls, as well as trained dogs and, from the 1820's on, a few horses (Chapman 1996a, Emmert 2003, Zenk and Rigsby).

Food sources available only seasonally to the Molala included fish, roots, seeds, nuts and berries. They fished for salmon, steelhead, and trout with harpoons and stationary basketry traps used with weirs. Fish were dried and cached for the off seasons. The moist prairies along the lower river supported camas, the roots of which were dug, baked in pit ovens, dried and mixed with hazelnuts, and stored in woven bags. The dry prairies provided wild onions, "a type of water tuber, like potatoes" (Emmert 2003), blackberries, salal berries, raspberries. Higher elevations in late summer supported tarweed seeds and huckleberries. The berries were dried on wooden frames, and stored for the winter (Chapman 1996a, Emmert 2003, Baar 1979).

Hemlock provided poles for housing and sweat lodges. Cedar bark was used for walls and roofs, along with hides. The Molalas constructed baskets, bags, and mats from grasses and reeds and used yew wood, oak, and vine maple for bows (Baar 1979, Emmert 2003). In 1851, after about 5 years of increasing occupation by European-American settlers, an estimated 120 Molalas lived in this area (Chapman 1996a).

Old-timers remember an old long house (native dwelling) and sweat lodge (spiritual structure) at river mile 24 in the early twentieth century (Ellen Thronson and Mya Oblack, personal communication). Pioneer accounts mention a native river crossing of the Molala-Klamath trail at river mile 22, near the Crown Zellerbach log pond built later on Dickey Prairie (Chapman 1996a).

PRESENCE AND ABUNDANCE OF FISH AND FISH HABITAT

The few accounts available indicate that the fish on the Molalla before Euro-American settlement were abundant and a substantial source of food for the Molalas. General Joel Palmer on his visit to the Molalla in 1845-46 described the river: "Up river are valuable mill sites, the water clear, and well stocked with fish." A description of the Indian fishery at Willamette Falls in 1841 by Charles Wilkes gives a hint of the state of fish abundance upriver on the Molalla: "I never saw so many fish collected together before; and the Indians are constantly employed in taking them" (Beckham). Ethnologist Stephen Dow Beckham says that salmon, sturgeon, lamprey and trout were abundant in the Clackamas homeland (the Willamette and the Clackamas rivers), (Beckham) and this account probably could describe the nearby Molalla drainage, as well.

THE FIRST EURO-AMERICANS

The first European-American visitor to the Molalla River may have been the Methodist minister Jason Lee on his way up the Willamette in 1837 (Engle 1927). James Baker settled near Canby with his native wife and three sons in 1838 (Peggy Sigler, Canby Depot museum director, personal communication). Early settlers, William and James Russell, visited in the present Mulino-Molalla area as early as 1840 (Chapman 1996a). A gravestone on the North Fork of the Molalla, inscribed with "Simon McGraw, 1795-1843", indicates the presence of Euro-Americans, most likely trappers and explorers, before 1843.

The first settlements were on the river, William Vaughan in 1844, on the west side, near the present Vaughan Road, and John Dickey in 1846, on the east side, with others following soon after (Chapman 1996a). Soon, however, settlers began taking land claims a few miles from the river on a major road from Salem to Oregon City, which had been a Molala trail. From 1845 to 1847, four provisional land claims were taken at the site of the present city of Molalla. By 1860 there were 75 heads of household in the Molalla area (Chapman 1996a).

The Molalas at first drove off the European-American settlers, but gradually the two peoples became acquainted and lived near each other (Baar 1979, Chapman1996a). In 1855, the Molalas and other indigenous peoples were ordered to live on reservations, primarily the Grand Ronde, Siletz, and Klamath. Some native individuals did not live on any reservation, while others returned from reservation life to the Molalla area (Chapman 1996).

ROADS

The Euro-American settlers used some of the traditional trails of the Molala and other native peoples, including present day Oregon Highways 99, 213, and 211. The first four donation land claims in the present city of Molalla were at the crossroads of two Indian trails (Oregon City Enterprise 1936).

There were early river crossings near the present towns of Canby and Liberal, including crossings of Milk Creek at present day Mulino, of the Molalla at Feyrer Park, across the North Fork, and near Trout Creek. There were early bridges just upriver of present-day Feyrer Park (1847) (Chapman 1996d), Wright's Bridge (1866), near Liberal (Chelson 1875), Good's Bridge (1868) at river mile 6 (Weekly Enterprise 1868), the Southern Pacific railroad bridge at river mile 3.5, and Knight's Bridge at river mile 2.5 (1877—the second bridge at the site) (Canby Depot Museum bridge file).

Later bridges were built at present-day Oregon Highway 99E (1901) (Canby Depot Museum bridge file) and near present day Meadowbrook (1913-1914— the first steel bridge on the Molalla) (*Bulletin*, Mar. 28, 1973). A covered bridge was built at Trout Creek in 1928 (Canby Depot Museum bridge file). A logging road, the Molalla Forest Road, was built in 1943-1944 as a cooperative venture of Ostrander Railway and Timber Company and Weyerhaeuser Timber Company between the Willamette River and the upper Molalla River with bridges near river miles 10 and 22.2. (Chapman 1995)

The railroad came to Canby in 1871. In 1913 a spur line was built from Canby to Molalla (Chapman 1995). In 1915 an electric railroad line was extended from Oregon City to Molalla and

eventually went south to Mt. Angel and Silverton (Chapman 1995).

DIKES

Beginning in 1938, the Army Corps of Engineers built reinforcing structures along the Molalla. Stone reinforcements were placed at river miles 2.9 (left), 4.8 (l), 7.0 (l), 8.2 (l), 8.5 (l), 9.0 (l), 9.5 (l), 10.4 (l), 11.3 (l), and 12.3 (l). Stone and levee protections were built at river mile 10 (r), the Milk Creek confluence, in 1954. In 1957 a stone and levee structure was built at river mile 14.4 (l). A stone reinforcement went in at river mile 21.0 (l). In 1967 a class III structure (riprap, rocks sized 800 # down to 25 #) was built at Island Park, river mile 5.4 (r) in 1965. In 1970 a class III structure was put in at river mile 13.9 (l). In 1973 a class III structure was put in at Shady Dell, river mile 20.2. In 1975 a class III reinforcement was laid at river mile 5.1 (l). In 1981 a class III structure went in at Good's Bridge, 6.0 (l). In 1982, a class III repair was laid at 7.4 (l). There were two other projects, at river mile 18.5 and 21.0, no date.

After the 1996 flood, the National Resources Conservation Service carried out 15 projects on the mainstem Molalla River and Milk Creek from May 1996 through July 1998. One project was located at Knights bridge at the Christian Camp, river mile 2.5. Four projects occurred off of Alder Creek Lane, river miles 6.5 to 10, one near river mile 11, one slightly upstream of Wagon Wheel Park, near river mile 15, one off Marshall Road, at about mile 15.5. There were four projects on Milk Creek, two just downstream of Marshall Road and two just upstream. On the upper river mainstem, two repairs were located on either side of Upper Forest Road Bridge, one near Dickey Prairie store (RM 22.2) and one at the Allen place at the Cedar Creek confluence (RM 24.0). Four projects occurred along Dickey Prairie Rd. up to Glen Avon Bridge. One location had a dike built entirely around it (up to the road on either side, on the right bank). The Arrowhead Golf Course repaired an Army Corps revetment during this time at river mile 14 +(l) (Monte Graham, NRCS project manager, Marion County Soil and Water Conservation Service, personal communication).

LOGGING

E. S. Collins dug a mill pond for a logging operation on Dickey Prairie in 1914 for his father's company, Ostrander Railway and Timber Company (Chapman 1995). Early logging companies often used the Molalla River and Milk Creek to transport their timber to market, particularly shorter lumber such as railroad ties, sometimes using splash dams, flumes, and log ponds (Hardy 1967, Chapman 1995). Others used plank roads to haul logs (Chapman 1995). By the 1920's, the logging industry was booming in the area. The Eastern-Western Logging Company bought 40 million feet of timber southeast of Molalla and set up a logging camp in 1924. By 1927 they had built a railroad south from Molalla, a spur of the Willamette Valley Southern line (*Molalla Pioneer*, May 1924). Eastern-Western logged 100 million board feet a year (Flint 1995b) and shipped the logs to their mill in Portland. In 1929 a forest fire swept through Eastern and Western timberlands and lead the company to perform cleanup logging until 1937 (Chapman 1995).

Between 1941 and 1945, an estimated 300-600 log trucks passed through Molalla daily (Chapman 1995, Flint 1995b). The Molalla Forest Road, built in 1944 by two big timber companies, Ostrander and Weyerhaeuser, relieved the pressure on the roads. At the time, it was the longest private roadway in the West (Chapman 1995).

After World War II, logging became a major industry in the Molalla watershed. Crown Zellerbach, (which had bought out Ostrander), Weyerhaeuser, and Pope and Talbot were the largest commercial logging companies. All had large headquarters on the river. Numerous local logging companies also operated, most sending their logs to the big mills, but some milling their own timber.

Some of the logging practices were destructive to the land. Logs were skidded across the Molalla River, and some fish-bearing streams were even used as skidroads. (Flint 1995a) Tome Wallace of Northwest Steelheaders in a Jan. 20, 1976 article in the *Molalla Pioneer,* and local logger Gene Lais described tractors dragging logs across spawning beds. Splash dams were used—earthen dams put across a stream and then

breached when full—to flood logs downstream. Streams were filled with logs and slash, preventing fish from moving upstream. Later loggers were required to remove all debris from streams.

Clearcutting riparian zones to the water's edge occurred on private timberlands. Jess Pope, sportswriter of the *Molalla Pioneer* in the 1970's, noted the many fishing holes ruined by logging practices, and related that local loggers condemned clear-cutting to the river's edge. (*Molalla Pioneer*, Jan. 20, 1976)

Two main lumber mills remain in Molalla. William James and Bob Avison started Avison Mill in 1946. It is now operated by Floragon Forest Products. RSG Forest Products mill started as Kappler Lumber Company in 1945, was bought by Publisher's Paper in 1963, by Smurfit in 1985, and by RSG in 1987 (Bellman & Chapman 1995).

Presently the Bureau of Land Management, Weyerhaeuser Company, Longview Fibre, Port Blakely and small private owners have holdings in the Molalla watershed.

AGRICULTURE

Wheat was the most common crop in the early days of settlement, being a medium of exchange as well as a food crop. Early settlers hunted deer, ducks, and geese, fished for salmon at Willamette Falls and trout in the river and creeks. Potatoes, turnips, carrots, beets and cabbages and apple trees were farmed. They raised sheep, cows, pigs and chickens and gathered huckleberries and filberts (Chapman 1996a). To clear the land, the settlers cut down the trees or burned them and planted crops in the ashes. Later, farm production for sale included chickens, turkeys, eggs, sheep, goats, cattle, horses, teasel, honey, dried prunes, and flax. (*Oregon City Courier Herald*, New Year Number, 1902) Rails, shakes and timbers were early cottage industries (*The Clackamas County Inventor*)

An early irrigation system was installed on Carl Feyrer's farm near present day Feyrer Park in 1932 (*Oregon City Enterprise*, Aug. 12, 1932)

URBANIZATION

The earliest known post office named Molalla was at present day Liberal. Discontinued in 1851, the post office was later re-established in 1868 and moved to Molalla in 1872 (Molalla Pioneer 1973). The Canby area's first school was established in 1852 (Case). The first school building in the Molalla area was built the same year the first doctor arrived, in 1856; the first store opened in 1859 (Molalla Pioneer 1920). Canby's post office started in 1871. The first school in the Mulino area was held in the Grange hall, built in 1876. (*The Bulletin*, Vol. II, No. 15, Apr. 11, 1973) The first hotel in the Molalla area was at Wilhoit Springs, built in 1884 (*Everything's Fine-o in Mulino*, Nov. 1991). A water system and a bank were started in Molalla in 1891.

The Colton area was starting to be settled in the 1890's. The city of Canby was incorporated in 1893, Barlow by 1910, and Molalla in 1913. The town site at Liberal was platted in 1913 (Chapman, Judith, unpublished manuscript).

The population of Euro-American settlers near the Molalla was 75 heads of household in the Molalla area and probably similar in the Canby area in 1860. The 2000 census shows 18,577 in the cities of Canby, Molalla and Barlow, increasing almost 50% from the 1990 figure. This does not include the populations of unincorporated areas (*Oregon Blue Book*).

GRAZING

William Vaughan, the first permanent settler in the Molalla area, took his cattle to Pine Creek and Bear Creek for summer pasture (Hardy 1967). "Other settlers ran cattle in the upper Molalla River area until the timber companies moved in" (Chapman 1996b).

Recent livestock statistics for the county as a whole give an idea of the extent of grazing activity on the Molalla River. The 2002-2003 survey by the Oregon Department of Agriculture shows a Clackamas County population of 34,700 livestock animals (cattle and calves, sheep and lambs, and pigs). Added to this is a 1997 figure of 6,077 horses in the county from the most recently released US Department of Commerce Census of Agriculture. The Molalla River basin is estimated to represent a quarter to a third of those figures.

MINING

GOLD AND QUARTZ

In 1860 William Sprague, hired by Oregon City Inc. Mining Company, discovered gold in placer deposits worth $695 per ton and surface diggings worth $3-$5 per day on the Molalla, possibly at Lost Coffee Creek. In 1862 Robert and Howard Ogle found gold on what is now Ogle Creek. By the mid 1880's claims were dotting the Molalla River. Four mining companies were established on the Molalla in 1903, the largest being the Ogle Mt. Mining Company. The mine was heavily worked from 1903 to 1910. Cyanide and sulfuric acid were used to extract the gold and quartz. The mine operated day and night with shifts of 15 men. The mine closed in 1915; some modest amount of mining followed before being sold to Weyerhaeuser in 1953 for the timber (Hemphill 1973) Approximately 25 mining claims are current on the upper Molalla and some dredging is being done to work the claims (Dennis Stafford, personal communication).

GRAVEL

There were at least two historical gravel mining operations on the Molalla and two which are presently active. Molalla Sand and Gravel was near river mile 12, just down river from Oregon Highway 213. Another gravel mine operated at river mile 21, active until 1999 (Kay Patteson, personal communication). At about river mile 4.5, there are two active gravel mining operations: Parker Northwest, on both sides of the river and Rinker Materials, formerly Pacific Rock Products, on the left bank.

WATER USE AND DIVERSIONS

WATER SYSTEMS

An 8-inch well was first dug for city water in Molalla in 1918. In 1921, a river water supply was built. The primary supply was a Trout Creek concrete intake dam, 7 ½ miles southeast of Molalla. (Sanborn, 1915 map).

ELECTRIC POWER

In 1903 the Molalla Power Company built a 6600 volt, 3 phase hydroelectric plant on the Molalla, ½ mile above the highway bridge at Canby. In 1908 the Canby Canal Company began excavation of a canal for an irrigation project. There was conflict between the two for use of the river. In 1914 Molalla Power, which became Molalla Electric Company, gained the title and Canby Canal Company was disbanded. In 1920 the hydroelectric plant was dismantled and the company bought power from Portland Railway, Light and Power at Hubbard. Molalla Electric was then operated as a wholly owned subsidiary of PGE. The property was merged with PGE's in 1938 (Judith S. Chapman files).

MILLS

Early mills were Richard Howard's mill (1848) at Mulino, John Cutting's mill at present Oregon Highway 211, and Gabriel Trullinger's 3 mills on present Union Mills Road (beginning in 1854), all on Milk Creek, and Maxwell Ramsby's mill (early 1850's) on the Molalla near the present intersection of Wright Road and Oregon Highway 211. (Chapman 1995) The Howard mill had a dam with headgates on Milk Creek; a large canal was used as a millrace to channel water from the creek. (Engle 1973) Other sawmills came in the latter part of the century. Wales Russell and sons and G. Strong and C. Stewart had a sawmill at Wright's Bridge at present Liberal; (Hardy 1979) Bill Austin's mill was 1 ½ miles south of Maple Grove; Seth Austin's water-powered mill was at the later Weyerhaeuser Co. site, drawing water from the North Fork, Fred Shafer's Woodcock Creek mill, which was later moved to the mouth of Woodcock Creek, Fred Noon's mill, near Fred Shafer's , which had a flume down to the Molalla, and Fred Mortenson's mill near the North Fork, all mainly cut railroad ties and then floated them down the river to Canby. Amos Lais had a sawmill a mile downriver from the North Fork confluence (Chapman 1995). In 1906 the Hult Lumber Company bought a sawmill on Milk Creek at present Hult Road in Colton. (http://www.hevanet.com/sundvall/colton/coltinfo)

SIGNIFICANT DISTURBANCE EVENTS

FLOODS AND STORMS

- The "Great Freshet" of 1853 in January destroyed Dr. McLoughlin's sawmill (Nelson 1960).
- In 1855-1856, there was snow on the ground for more than a month and an ensuing flood that lasted for six weeks. All of Gladstone and the main street of Oregon City were under water (Bulletin 1974).
- In 1861 snow started in December and fell all winter, accumulating to 12-to-15 feet and a flood rose 55 feet on the Willamette (Bulletin 1974).
- January 10, 1875, the Columbia River froze over. (Chelson 1875).
- In 1881 there was a statewide flood (Nelson 1960) .
- The February 6, 1890 flood was 2 feet higher than the 1861 flood (Bulletin 1974).
- Flooding occurred in 1901, (Army Corps of Engineers1970) 1909, Dec. 20, 1917, ("Flood of the Molalla") Jan. 10, 1923, (Army Corps of Engineers, op. cit.; clipping Oregon City Public Library files) Mar. 31, 1931, (Army Corps of Engineers, no date) Nov. 23, 1942, (ibid.) 1943, (Army Corps of Engineers, 1970) Jan. 7, 1948, (Army Corps of Engineers, no date; Oregon City Enterprise, 1948, Oregon City Public Library files; www.nws.noaa.gov) Feb. 18, 1949, (Army Corps of Engineers, no date) Nov. 23, 1953, (ibid.) Dec. 22, 1955, (Army Corps of Engineers, no date; Army Corps of Engineers, 1970) Nov. 24, 1960, (Army Corps of Engineers, no date; www.nws.noaa.gov) and Feb. 11, 1961, (www.nws.noaa.gov).
- A large flood event occurred on Jan. 22 (www.nws.noaa.gov).
- Torrential rainstorms in December and January of 1964–1965 were followed by significant flooding on Dec. 22, 1964 (www.nws.noaa.gov; Army Corps of Engineers, no date) and on Jan. 28, 1965, the latter when the peak at Portland was within inches of peak stage during the spring flood of 1948 (www.wrh.noaa/portland/history.htm #top 1; Army Corps of Engineers, no date; Army Corps of Engineers, 1970).
- Floods occurred on Jan. 21, 1972, (www.nws.noaa.gov), Jan. 15, 1974, (www.nws.noaa.gov) Feb. 7, 1996, (www.nws.noaa.gov) and Nov. 10, 1996. (www.nws.noaa.gov)

HISTORICAL CONDITIONS TIMELINE

Before 1837 Native American peoples, the Molala and perhaps, at the mouth of the river, the Kalapuya, inhabit the area with visits from the Klamath

1837—Jason Lee visits on his tour of the Willamette Valley

1838's—James Baker settles in Canby area with native wife and family

1840—William and James Russell visit the Mulino-Molalla area

1844—William Vaughan settles along the left bank of the river

1840's—Vaughan grazes cattle upriver at Pine and Bear Creeks

1845–1847—our provisional land claims are taken at the site of the present city of Molalla

1846—John Dickey trades with the Molalas for land on the right bank of the river

1847—Bridge is built linking Dickey Prairie with the tiny settlement at Molalla

1848—Richard Howard builds the first sawmill in the area, on Milk Creek, at present hamlet of Mulino

1851—Earliest post office in Molalla area, at Liberal, is discontinued, re-started in 1868

1855—Native Americans are moved onto reservations, Molalas mainly at Grand Ronde and Siletz; severe storm and flood

1856—First Molalla school building is built and first doctor arrives

1858—First threshing machine arrives

1859—First store opens in Molalla

1860—Census records 75 heads of household in the Molalla area; William Sprague of Oregon City Mining company discovers gold on the upper Molalla

1861—Severe winter and flood

1869–1870—First church opens in Molalla

1871—Canby area's first post office opens

1872—Post office opens in Molalla

1875—Severe winter (Columbia River freezes over)

1876—First grade school opens at Mulino Grange Hall

1880—First informal library opens in Canby

1881—Statewide flood

1884—First church is built in Canby; first area hotel is built at Wilhoit Springs

1890—Flood two feet higher than 1861 flood; population of Canby and Molalla areas reaches 1,369

1890s—Colton is beginning to be settled

1891—Water system and bank are established in Molalla and Canby's newspaper, *The Three Sisters*, is started

1893—City of Canby incorporates

1900—Public library is started in Molalla, the oldest continuous library in the county

1901—Flood

1903—Telephone service is started in Molalla; Ogle Mt. mine begins operations on Ogle Creek; supports a population of 100 men and women 1908- 1910; closes down in 1915

1908—Flood

1910—City of Barlow has become incorporated;

1913—City of Molalla is incorporated; Molalla Pioneer newspaper is established; railroad comes to town and celebration spawns annual Buckeroo rodeo and fair

1916—Clay mine is established S.E. of Molalla

1917—Flood; Ostrander Railway and Timber Company sets up logging operation on Dickey Prairie

1920's—Logging industry is booming; Eastern-Western Logging Company sets up camp in 1924, and builds a railroad spur in 1927. Operates until 1937

1923—Flood

1929—Forest fire sweeps through Eastern-Western timber lands

1931—Flood

1941–1945—Estimated 300–600 log trucks pass through Molalla daily

1942—Flood

1943—Flood

1944—Molalla Forest Road is finished to transport logs from upriver to the log dumps at Canby, the longest private roadway in the West

1945–1946—Kappler Lumber Company builds a mill at Liberal, now owned and operated by RSG; Avison Lumber Mill is built by William James and Bob Avison, now owned and operated by Floragon

Late 1940's—Logging becomes a major industry; Crown Zellerbach, Weyerhaeuser, and Pope and Talbot are the largest logging companies

1948—Flood

1949—Flood

1953—Flood

1960—Flood

1961—Flood

1962—Violent windstorm on Columbus Day

1964–1965—Rainstorm and floods

1972—Flood

1974—Flood

1996—Floods

1997—U.S. Dept of Commerce reports 6077 horses raised in Clackamas County; a quarter to a third of which are estimated to be in the Molalla watershed

2002–2003—Oregon Dept. of Agriculture shows a population of 34,700 livestock animals (cattle and calves, sheep and lambs, and pigs) in Clackamas County

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CHAPTER THREE: CHANNEL HABITAT TYPES

INTRODUCTION

Rivers and streams are dynamic systems that are shaped by a number of physical, hydrologic, and biological factors. A river or stream is considered stable when it consistently transports its sediment load associated with local scour and deposition (Rosgen 1996). In other words, when a river is stable, an equilibrium occurs between rates of erosion and deposition (Leopold 1994). When scouring processes produce degradation, or when excessive sediment deposition results in aggradation, the river channel is said to be unstable. Land uses such as agricultural practices, timber harvest, and urbanization can cause channel instability by increasing sediment loads and altering local hydrology; which in turn can alter channel form through degradative or aggradative processes, such as streambed scour or sediment deposition.

Channels vary in their sensitivity to these land-use impacts, depending in part on their geomorphic characteristics, including channel gradient, channel size, and channel confinement or constraint. Classification of river segments according to these geomorphic characteristics can help determine their relative sensitivity to disturbance and their responsiveness to restoration efforts, and, therefore, can help focus restoration efforts on stream reaches or segments that will most likely respond to restoration efforts.

Several stream classification systems that group streams according to geomorphic characteristics currently exist (Rosgen 1994, Montgomery and Buffington 1996). The Oregon Watershed Assessment Manual presents a system developed from these existing systems and designed specifically for grouping Oregon rivers and streams according to their sensitivity to disturbance and, therefore, their responsiveness to restoration efforts. This stream classification system— Channel Habitat Typing (CHT)—allows streams throughout the state to be classified based on similar geomorphologic characteristics, including stream size, channel gradient, and channel side-slope constraint. Appendix 3.1 lists the characteristics of each type of CHT identified in the watershed.

METHODS

USGS topographic maps (1:24,000 scale) were used as base maps for channel habitat typing. Channel typing was performed following OWEB protocols (WPN 1999). Stream segments were classified by channel gradient and confinement. Channel gradient classes included <1%, 1–2%, 2–4%, 4–8%, 8–16%, and >16%. Channels were classified as Confined, Moderately Confined, and Unconfined, by examination of topographic maps and aerial photographs. Channel habitat type units generally were a minimum of 1000 feet in length; however, exceptions were made when channels exhibited unusual characteristics. Table 3.1 summarizes CHT coding, nomenclature, and attributes of the various CHTs in the OWEB protocol. Field validation of channel habitat typing throughout the watershed occurred in fall 2003. CHTs were digitized and lengths measured using ArcView 3.2a

RESULTS

The upper reaches of drainage networks within the watershed consist primarily of constrained channels of moderate-to-steep gradient classes, including Very Steep Headwater channels (VH), Steep Narrow Valley channels (SV), and Moderately Steep Narrow Valley channels (MV) (Figures 3.1 and 3.2). Proceeding downstream through the mid reaches of tributary networks in the watershed, channels become less constrained and gradients are low to moderate (LM, MM). The lower reaches of many tributary drainages, as well as most of the mainstems of the Molalla River and Milk Creek, consist of unconstrained, low gradient systems on floodplains (FP1, FP2, FP3).

A total of 257.5 miles of streams were assigned CHTs throughout the watershed (see Table 3.2). Among all stream reaches within the watershed, 41% (105.6 miles) are CHTs considered to be highly sensitive to disturbance. More than half of the total watershed channel length classified as highly sensitive to disturbance was classified as FP1 or FP2, indicating that large floodplain channels occurring in the lowland areas of the

Table 3.1. Summary of Channel Habitat Types (CHT) (source: WPN 1999)

Code	CHT Name	Gradient	Channel Confinement	Size
ES	Small Estuary	<1%	Unconfined to moderately confined	Small to medium
EL	Large Estuary	<1%	Unconfined to moderately confined	Large
FP1	Low Gradient Large Floodplain	<1%	Unconfined	Large
FP2	Low Gradient Medium Floodplain	<2%	Unconfined	Medium to large
FP3	Low Gradient Small Floodplain	<2%	Unconfined	Small to medium
AF	Alluvial Fan	1-5%	Variable	Small to medium
LM	Low Gradient Moderately Confined	<2%	Moderately confined	Variable
LC	Low Gradient Confined	<2%	Confined	Variable
MM	Moderate Gradient Moderately Confined	2-4%	Moderately confined	Variable
MC	Moderate Gradient Confined	2-4%	Confined	Variable
MH	Moderate Gradient Headwater	1-6%	Confined	Small
MV	Moderately Steep Narrow Valley	3-10%	Confined	Small to medium
BC	Bedrock Canyon	1->20%	Confined	Variable
SV	Steep Narrow Valley	8-16%	Confined	Small
VH	Very Steep Headwater	>16%	Confined	Small

Table 3.2. Miles of stream, by Channel Habitat Type (CHT), occurring in the lower Molalla River and Milk Creek watershed, Oregon. Channel habitat types are grouped by their sensitivity to disturbance.

Subwatershed	FP1	FP2	FP3	MM	LM	**HIGH**	MC	MH	LC	MV	**MOD**	SV	VH
Canyon Creek	0.0	0.0	0.0	3.1	0.3		0.0	1.5	0.0	10.2		7.2	6.5
Headwaters Milk Ck	0.0	0.0	0.0	0.0	0.0		6.6	3.4	0.0	9.9		2.9	4.4
Lower Milk Cree	11.3	1.7	0.0	2.8	2.5		6.6	7.5	1.4	6.4		0.0	0.0
Middle Milk Ck	2.5	4.6	1.1	0.6	2.9		1.6	6.1	0.4	6.0		0.5	0.0
Molalla R/Cedar Ck	4.1	0.0	0.0	7.4	0.5		1.5	7.1	0.0	14.8		2.0	0.0
Molalla/Willamette	20.7	4.5	14.3	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
Upper Milk Ck	0.0	6.2	0.0	2.0	4.7		6.6	0.3	0.6	11.9		0.9	0.0
Woodcock Ck	1.8	0.0	0.0	6.2	0.0		0.0	3.2	2.2	10.2		1.4	0.3
TOTAL MILES	**40.4**	**17.0**	**15.4**	**22.1**	**10.9**	**105.6**	**23.0**	**29.0**	**4.7**	**69.3**	**126.0**	**14.8**	**11.1**
% TOTAL	16%	7%	6%	9%	4%	**41%**	9%	11%	2%	27%	**49%**	6%	4%
Sensitivity	High	High	High	High	High		Med	Med	Med	Med		Low	Low

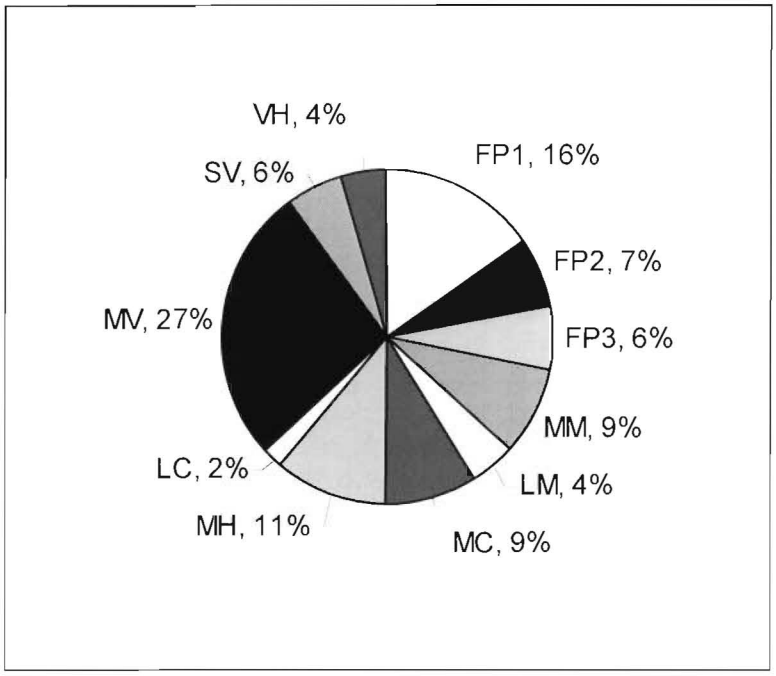

Figure 3.1 Relative frequencies of stream Channel Habitat Types (CHTs) occurring in the lower Molalla River and Milk Creek watershed, Oregon.

watershed represent a large proportion of the most sensitive channels occurring in the watershed.

Moderately sensitive channels represented 49% (126.0 miles) of the total watershed channel length. These channels typically occurred midway through tributary drainage networks, where gradients begin to flatten from steeper headwater areas and channels become less (moderately) constrained. Finally, channels with low sensitivity to disturbance represented only 10.0% (25.9 miles) of the total stream length in the watershed. These channels occurred exclusively in steep, confined headwater areas and are generally less responsive to restoration efforts than are highly or moderately sensitive channels.

DISCUSSION

Channel responsiveness to changes in discharge or sediment loads resulting from disturbance or restoration efforts is largely a function of channel confinement and gradient. Of the CHTs occurring in the watershed, the most responsive CHTs to restoration and enhancement are LM and MM, and to a lesser extent FP1, FP2 and FP3, representing more than 41% of the total stream length in the watershed and presenting significant opportunities for habitat improvement. LM and MM channels are regarded as particularly well-suited for restoration activities because the presence of confining land-form features can improve the accuracy of predicting channel responses to activities intended to affect channel form. An additional 49% of watershed stream miles are classified as moderately responsive to restoration efforts and should also be considered for stream restoration efforts, as well.

Assignment of low sensitivity to SV and VH type streams in the watershed should not dissuade restoration efforts in these areas, as all CHTs will benefit from the restoration of riparian vegetation. Restoration efforts in these areas would likely primarily focus on improvement of riparian conditions to help maintain cool water temperatures and supplies of wood and other organic material to downstream reaches. Vegetation near streams helps to absorb stream energy, stabilize streambanks, and reduce sediment loading and stream temperatures. The woody debris input from vegetated banks creates and

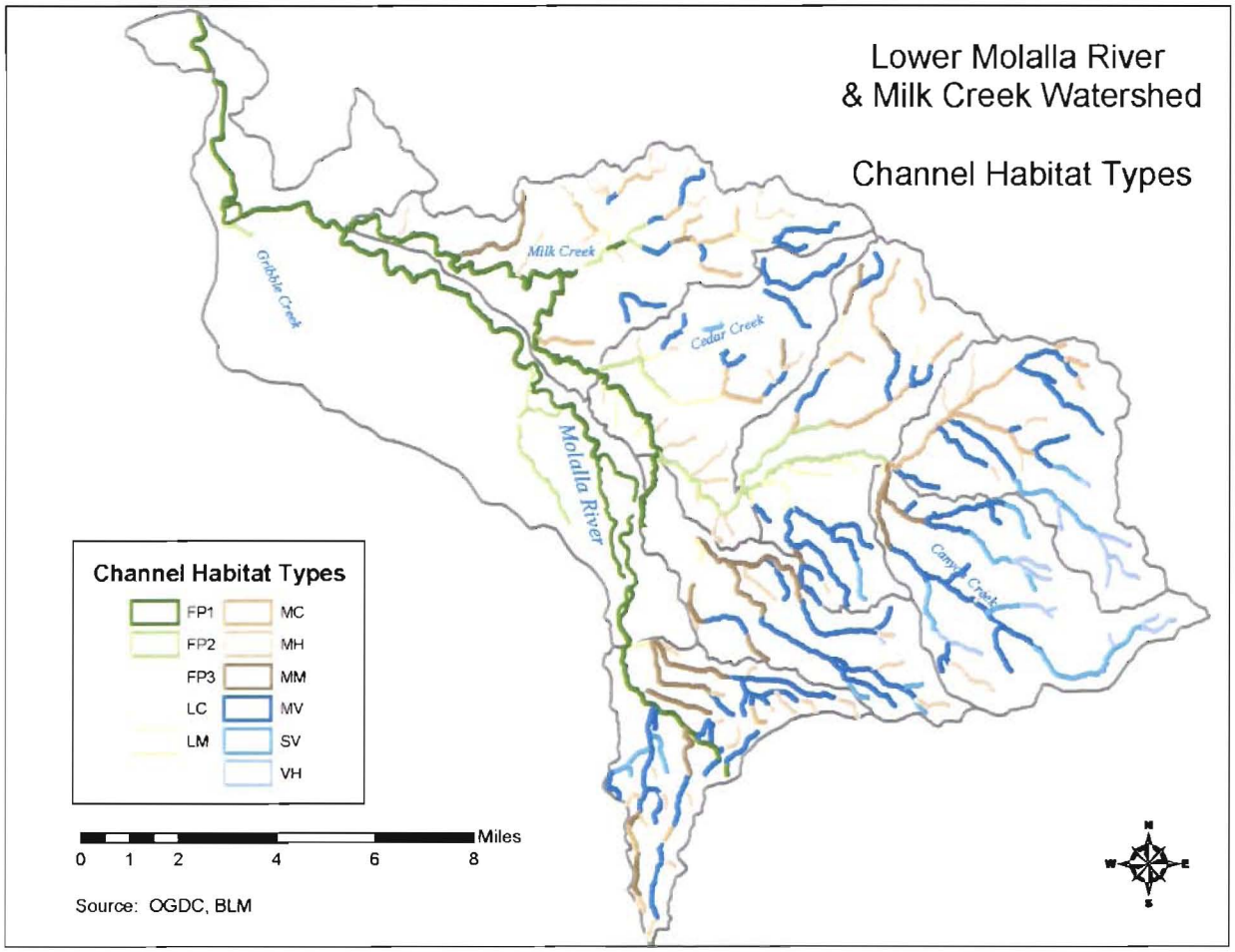

Figure 3.2. Channel Habitat Types (CHTs) occurring in the lower Molalla River and Milk Creek watershed, Oregon.

maintains habitat for young salmonids and other aquatic life by trapping sediment, forming pools, and providing cover. Additionally, leaf litter and insects falling into the stream provide important food sources for stream life.

Depending upon riparian cover, agriculture and forestry practices, and stream discharge, bottomland channels that are designated LM (Low gradient – Moderately confined) or FP1, FP2 or FP3 (Flood Plain-Large, -Medium, or -Small) can downcut during high flows and become incised. Such events can create severely confined channels that prevent future high-water events from dissipating energy on the floodplain; rather, the energy will further downcut the channel, producing more channel instability and a lower water table. Restoration efforts along these channel types that are incised should focus, at least in part, on reestablishing hydrologic connectivity between the stream channel and floodplain.

DATA GAPS AND RECOMMENDATIONS

Some Channel Habitat Types were field-checked for accuracy; however, private land access and time constraints prevented a comprehensive check of all of the designations. Because the CHTs were classified according to topographic conditions, some of the stream reaches could have been misclassified as moderately confined or unconfined, rather than confined. More ground-truthing of these areas is required. Future work should expand on the current designations to

ensure accuracy, as well as to monitor channels for further entrenchment.

Although channel habitat typing provides one source of information used in identifying restoration opportunities, we suggest that more intensive field-based surveys be performed to examine stream channel conditions to both produce baseline information and to better quantify channel conditions in various areas of the watershed for restoration prioritization.

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LOW GRADIENT MEDIUM FLOODPLAIN CHANNEL - FP2

FP2 channels are main-stem streams in broad valley bottoms with well-established floodplains. Alluvial fans, dissected foot slopes, and hill slope and lowland landforms may directly abut FP2 floodplains. Channels are often sinuous, with extensive gravel bars, multiple channels, and terraces. These channels are generally associated with extensive and complex riparian areas that may include such features as sloughs, side-channels, wetlands, beaver-pond complexes, and small groundwater-fed tributary channels.

Sediment deposition is prevalent, with fine-sediment storage evident in pools and point bars, and on floodplains. Bank erosion and bank-building processes are continuous, resulting in a dynamic and diverse channel morphology. Streambanks are composed of fine alluvium and are susceptible to accelerated bank erosion with the removal or disturbance of stream-bank vegetation and root mats. Channel gradient is low, and high stream flows are not commonly contained within the active channel banks, resulting in relatively low stream power.

CHANNEL ATTRIBUTES

Stream gradient: =2%
Valley shape: Broad, flat, or gentle landforms
Channel pattern: Single to multiple channels, sinuous
Channel confinement: Unconfined
Oregon stream size: Large to medium
Position in drainage: Middle to lower end of drainage basin
Dominant substrate: Sand to cobble

CHANNEL RESPONSIVENESS

Floodplain channels can be among the most responsive in the basin. The limited influence of confining terrain features and fine substrate allows the stream to move both laterally and vertically. Although often considered low -energy systems, these channels can mobilize large mounts of sediment during high flows. This flow often results in channel migration and new channel formation.

Large Woody Debris: High

Because of the high sedimentation rates, only large debris pieces or accumulations of smaller pieces are likely to impact overall channel conditions. The role of wood, as well as the amount and distribution of pieces, is variable over time, as high flows and stream power regularly change conditions. Single pieces are likely to be associated with pools in side-channels and localized sediment depositions. Accumulations of wood are often responsible for the creation of mid-channel bars and side-channel development.

Fine Sediment: Moderate

Increases in the supply of fines may cause temporary storage and pool filling, but moderate to high flows will mobilize the majority of the sediment. Deposition may be more permanent in smaller side-channels, and pool filling and minor shifts in side-channel location could occur.

Coarse Sediment: High

Floodplain channels are generally depositional areas for coarse sediment. When the supply of coarse sediment surpasses the transport capabilities of the stream, the channel is particularly vulnerable to widening, lateral movement, side-channel development, and braiding. Overall aquatic habitat complexity is reduced, as pools are filled and obstructions, such as large boulders or bedrock outcrops, are buried.

Peak Flows: Low to Moderate

These floodplain channels are usually capable of transporting high flows with a minimum of alteration to the primary physical characteristics of the channel. Flows tend to spread out across the valley rather than cause streambed scour. Localized bank erosion is expected as new channels are developed, especially if the sediment supply has been increased.

RIPARIAN ENHANCEMENT OPPORTUNITIES

Due to the unstable nature of these channels, the success of many enhancement efforts is questionable. Opportunities for enhancement do occur, however, especially in channels where lateral movement is slow. Lateral channel migration is common, and efforts to restrict this natural pattern will often result in undesirable alteration of channel conditions downstream. Side-channels may be candidates for efforts that improve shade and bank stability.

LOW GRADIENT SMALL FLOODPLAIN CHANNEL - FP3

FP3 streams are located in valley bottoms and flat lowlands. They frequently lie adjacent to the toe of foot slopes or hill slopes within the valley bottom of larger channels, where they are typically fed by high-gradient streams. They may be directly downstream of a small alluvial fan and contain wetlands. FP3 channels may dissect the larger floodplain. These channels are often the most likely CHT to support beavers, if they are in the basin. Beavers can dramatically alter channel characteristics such as width, depth, form, and most aquatic habitat features. These channels can be associated with a large floodplain complex and may be influenced by flooding of adjacent main-stem streams. Sediment routed from upstream high- and moderate-gradient channels is temporarily stored in these channels and on the adjacent floodplain.

CHANNEL ATTRIBUTES

Stream gradient: =2%

Valley shape: Broad

Channel pattern: Single to multiple channels

Channel confinement: Moderate to unconfined

Oregon stream size: Small to medium

Position in drainage: Variable

Dominant substrate: Sand to small cobble

CHANNEL RESPONSIVENESS

Floodplain channels can be among the most responsive in the basin. The limited influence of confining terrain features and fine substrate allows the stream to move both laterally and vertically. Although often considered to be low-energy systems, these channels can mobilize large amounts of sediment during high flows. This flow often results in channel migration and new channel formation.

Large Woody Debris: High

In forested basins, these channels are likely to have relatively high wood counts. Those located at the foot of high-gradient channels or along the margin of a large, floodplain channel are especially subject to wood availability. Wood can readily affect channel pattern, location, and dimension. Wood is likely to be a major channel roughness element, often associated with pools or spawning gravel distribution.

Fine Sediment: Moderate to High

The location of these channels often dictates a high sediment input to the stream. These channels are sediment deposition zones, with side-channels particularly vulnerable to **aggradation** and shifting. If a large and persistent source of sediment is available, pool filling and channel migration could result.

Coarse Sediment: High

Floodplain channels are generally depositional areas for coarse sediment. When the supply of coarse sediment surpasses the transport capabilities of the stream, the channel is particularly vulnerable to widening, lateral movement, side-channel development, and braiding. Overall aquatic habitat complexity is reduced as pools are filled and obstructions such as large boulders or bedrock outcrops are buried.

Peak Flows: Low

Floodplain channels are usually capable of transporting high flows with a minimum of alteration to the primary physical characteristics of the channel. Flows tend to spread out across the valley rather than cause streambed scour. Localized bank erosion is expected as new channels are developed.

RIPARIAN ENHANCEMENT OPPORTUNITIES

Floodplain channels are, by their nature, prone to lateral migration, channel shifting, and braiding. While they are often the site of projects aimed at channel containment (e.g., diking, filling), it should be remembered that floodplain channels can exist in a dynamic equilibrium between stream energy and sediment supply. As such, the active nature of the channel should be respected, with restoration efforts carefully planned. The limited power of these streams offers a better chance for success of channel enhancement activities than the larger floodplain channels. While the lateral movement of the channel will limit the success of many efforts, localized activities to provide bank stability or habitat development can be successful.

LOW GRADIENT MODERATELY CONFINED CHANNEL - LM

These channels consist of low-gradient reaches that display variable confinement by low terraces or hill slopes. A narrow floodplain approximately two to four times the width of the active channel is common, although it may not run continuously along the channel. Often low terraces accessible by flood flows occupy one or both sides of the channel. The channels tend to be of medium to large size, with substrate varying from bedrock to gravel and sand. They tend to be slightly to moderately sinuous, and will occasionally possess islands and side-channels. Because of the difficulty in assessing the degree of confinement and the height of stream-bank terraces from maps or air photos, these channels are often misidentified as LC channels unless field-checked.

CHANNEL ATTRIBUTES

Stream gradient: <2%

Valley shape: Broad, generally much wider than channel

Channel pattern: Single with occasional multiple channels

Channel confinement: Variable

Oregon stream size: Variable, usually medium to large

Position in drainage: Variable, often main-stem and lower end of main tributaries

Dominant substrate: Fine gravel to bedrock

CHANNEL RESPONSIVENESS

The unique combination of an active floodplain and hillslope or terrace controls acts to produce channels that can be among the most responsive in the basin. Multiple roughness elements are common, with bedrock, large boulders, or wood generating a variety of aquatic habitat within the stream network.

Large Woody Debris: Moderate to High

In forested basins, wood alone or in combination with other elements is associated with pool formation and maintenance, bar formation, and, occasionally, side-channel development. These channels may have relatively low woody debris numbers due to past management activities.

Fine Sediment: Moderate to High

The location of these channels often dictates a high sediment input to the stream. These channels can be sediment deposition zones for larger particles, although a significant portion of the fine sediment may be transported, particularly in bedrock channels. Increases in fine-sediment supply will likely result in filling of margin pools and bed-fining of side-channels and low-velocity areas. Decreases in sediment supply may induce scour in non-bedrock channels or localized bank erosion.

Coarse Sediment: Moderate to High

These channels are depositional areas for coarse sediment. When the supply of coarse sediment surpasses the transport capabilities of the stream, pools are filled, and the influence of large boulders, wood, and bedrock control structures is lessened. If significant amounts of large sediment are added, the channel is particularly vulnerable to widening, lateral movement, side-channel development, and localized scour.

Peak Flows: Moderate

These channels are capable of passing most high flows without adjustments to the overall dimensions of the channel. Development of point or **medial bars** is likely in basins with high sediment loads, as is side-channel development. Localized bed or bank scour is possible on bends in the main channel.

RIPARIAN ENHANCEMENT OPPORTUNITIES

Like floodplain channels, these channels can be among the most responsive of channel types. Unlike floodplain channels, however, the presence of confining landform features often improves the accuracy of predicting channel response to activities that may affect channel form. Additionally, these controls help limit the destruction of enhancement efforts common to floodplain channels. Because of this, LM channels are often good candidates for enhancement efforts. In forested basins, habitat diversity can often be enhanced by the addition of roughness elements such as wood or boulders. Pool frequency and depth may increase, and side-channel development may result from these efforts. Channels of this type in non-forested basins are often responsive to bank stabilization efforts such as riparian planting and fencing. Beavers are often present in the smaller streams of this channel type, and fish habitat in some channels may benefit from beaver introduction through side-channel and scour pool development. Introduction of beavers, however, may have significant implications for overall channel form and function, and should be thoroughly evaluated by land managers as well as biologists as a possible enhancement activity.

LOW GRADIENT CONFINED CHANNEL - LC

LC channels are incised or contained within adjacent, gentle landforms or incised in volcanic flows or uplifted coastal landforms. Lateral channel migration is controlled by frequent bedrock outcrops, high terraces, or hill slopes along streambanks. They may be bound on one bank by hill slopes and lowlands on the other, and may have a narrow floodplain in places, particularly on the inside of meander bends. Stream-bank terraces are often present, but they are generally above the current floodplain. The channels are often stable, with those confined by hill slopes or bedrock less

likely to display bank erosion or scour than those confined by alluvial terraces. High-flow events are well contained by the upper banks. High flows in these well-contained channels tend to move all but the most stable wood accumulations downstream or push debris to the channel margins. Streambanks can be susceptible to landslides in areas where steep hill slopes of weathered bedrock, glacial till, or volcanic-ash parent materials abut the channel.

CAUTION: Some degree of caution should be exercised in evaluating channels that have downcut into alluvial material set in a wide, flat valley. If the streambanks are high enough to allow a floodplain width less than two times the bankfull width, then the stream meets the definition of confined. However, some streams meeting this definition may have recently downcut, effectively reducing floodplain width as the channel deepens. It is beyond the scope of this manual to deal with technical issues, such as rate of channel incision. The analyst, however, should note channels that display evidence of recent downcutting, low channel banks, and evidence of abandoned floodplain. For whatever reason, these channels may be transitioning from LM to LC channels, and should receive additional scrutiny before assigning the proper CHT.

CHANNEL ATTRIBUTES

Stream gradient: <2%

Valley shape: Low- to moderate-gradient hill slopes with limited floodplain

Channel pattern: Single channel, variable sinuosity

Channel confinement: Confined by hill slopes or high terraces

Oregon stream size: Variable, usually medium to large

Position in drainage: Variable, generally mid to lower in the larger drainage basin

Dominant substrate: Boulder, cobble, bedrock with pockets of sand/gravel/cobble

CHANNEL RESPONSIVENESS

The presence of confining terraces or hill slopes and control elements, such as bedrock, limit the type and magnitude of channel response to changes in input factors. Adjustment of channel features is usually localized and of a modest magnitude.

Large Woody Debris: Low to Moderate

In larger forested basins, wood numbers are often low in this channel type. This limited debris may be in part due to land management activities, but these channels usually display sufficient energy to route wood downstream. Also, limited lateral movement of the channel reduces the recruitment of wood from bank erosion. Wood is often present in jams or as large, single pieces capable of withstanding high-energy flows. Even in streams of this channel type that are smaller and display less energy, wood may be routed or retained above the elevation of the bankfull channel, where it has limited impact on aquatic habitat.

Fine Sediment: Low

The confining nature of the landforms that define this channel type tends to focus enough stream energy to route most introduced fine sediment downstream. In basins with high background sediment levels, such as sand and siltstone-bedded channels in the Coast Range, supply may approach or surpass transport capacity, resulting in pool filling and bed fining.

Coarse Sediment: Moderate

These channels can be depositional areas for coarse sediment. When the supply of coarse sediment surpasses the transport capabilities of the stream, pools are filled, and the influence of large boulders, wood, and bedrock control structures is lessened. If significant amounts of large sediment

are added, the channel is particularly vulnerable to widening, lateral movement, side-channel development, or scour.

Peak Flows: Low to Moderate

These channels have limited floodplain, and are capable of passing most high flows without adjustments to the overall dimensions of the channel. Development of point or medial bars is likely in basins with high sediment loads. Localized bed or bank scour is possible on bends in the main channel.

RIPARIAN ENHANCEMENT OPPORTUNITIES

These channels are not highly responsive, and in-channel enhancements may not yield intended results. In basins where water-temperature problems exist, the confined nature of these channels lends itself to establishment of riparian vegetation. In non-forested land, these channels may be deeply incised and prone to bank erosion from livestock. As such, these channels may benefit from livestock access control measures.

MODERATE GRADIENT MODERATELY CONFINED CHANNEL - MM

This group includes channels with variable controls on channel confinement. Alternating valley terraces and/or adjacent mountain-slope, foot-slope, and hill-slope landforms limit channel migration and floodplain development. Similar to the LM channels, a narrow floodplain is usually present, and may alternate from bank to bank. Bedrock steps with cascades may be present.

CHANNEL ATTRIBUTES

Stream gradient: Generally 2-4%

Valley shape: Narrow valley with floodplain or narrow terrace development

Channel pattern: Usually single channel, low to moderate sinuosity

Channel confinement: Variable

Oregon stream size: Variable, usually medium to large

Position in drainage: Mid to lower portion of drainage basins

Dominant substrate: Gravel to small boulder

CHANNEL RESPONSIVENESS

The unique combination of a narrow floodplain and hill-slope or terrace controls acts to produce channels that are often the most responsive in the basin. The combination of higher gradients and the presence of a floodplain set the stage for a dynamic channel system. Multiple roughness elements such as bedrock, large boulders, or wood may be common, resulting in a variety of aquatic habitats within the stream network.

Large Woody Debris: High

In forested basins, wood alone or in combination with other elements is associated with pool formation and maintenance, bar formation and gravel sorting, and, occasionally, side-channel development. LWD may be the primary factor responsible for forming pools in forested systems. Due to the moderate gradient, smaller pieces are transported downstream or form jams. A change in the wood supply would likely have significant impact on pool condition, sediment movement, bar development, and, possibly, side-channel condition.

Fine Sediment: Moderate

The location of these channels often dictates a high sediment input to the stream. These channels can be sediment deposition zones for larger particles, although the moderate gradient produces enough energy to route most of the fine sediment downstream. Increases in fine-sediment supply

will likely result in filling of margin pool and bed fining of side-channels and low-velocity areas. Decreases in sediment supply may induce scour in non-bedrock channels or localized bank erosion

Coarse Sediment: Moderate to High

Unless the channel is quite large, these channels may be temporary storage areas for coarse sediment. When the supply of coarse sediment surpasses the transport capabilities of the stream, pools are filled, and the influence of large boulders, wood, and bedrock control structures is lessened. If significant amounts of large sediment are added, the channel is particularly vulnerable to widening, lateral movement, side-channel development, or scour. Steeper channels within this CHT would likely transport a greater portion of the load and not be as responsive as lower-gradient reaches.

Peak Flows: Moderate

These channels have limited floodplain, and are capable of passing most high flows without adjustments to the overall dimensions of the channel. The higher energy induced by steeper gradients can result in development of point or medial bars in basins with high sediment loads, as well as side-channel development. Localized bed or bank scour is possible on bends in the main channel.

RIPARIAN ENHANCEMENT OPPORTUNITIES

Like floodplain channels, these channels are among the most responsive of channel types. Unlike floodplain channels, however, the presence of confining landform features improves the accuracy of predicting channel response to activities that may affect channel form. Additionally, these controls help limit the destruction of enhancement efforts, a common problem in floodplain channels. The slightly higher gradients impart more uncertainty as to the outcome of enhancement efforts when compared to LM channels. MM channels, however, are often good candidates for enhancement efforts. In forested basins, habitat diversity can often be enhanced by the addition of roughness elements, such as wood or boulders. Pool frequency and depth may increase, as well as side-channel development, as the result of these efforts. Channels of this type in nonforested basins are often responsive to bank stabilization efforts such as riparian planting and fencing. Beavers are often present in the smaller streams of this channel type, and fish habitat in some channels may benefit from beaver introduction which promotes side-channel and scour-pool development. Introduction of beavers, however, may have significant implications for overall channel form and function, and should be thoroughly evaluated by land managers as well as biologists as a possible enhancement activity.

MODERATE GRADIENT CONFINED CHANNEL - MC

MC streams flow through narrow valleys with little river terrace development, or are deeply incised into valley floors. Hill slopes and mountain slopes composing the valley walls may lie directly adjacent to the channel. Bedrock steps, short falls, cascades, and boulder runs may be present; these are usually sediment transport systems. Moderate gradients, well-contained flows, and large particle substrate indicate high stream energy. Landslides along channel side slopes may be a major sediment contributor in unstable basins.

CHANNEL ATTRIBUTES

Stream gradient: 2-4%, may vary between 2 to 6%

Valley shape: Gentle to narrow V-shaped valley, little to no floodplain

development

Channel pattern: Single, relatively straight or conforms to hill-slope control

Channel confinement: Confined

Oregon stream size: Variable

Position in drainage: Middle to lower

Dominant substrate: Coarse gravel to bedrock

CHANNEL RESPONSIVENESS

The presence of confining terraces or hill slopes and control elements, such as bedrock substrates, limits the type and magnitude of channel response to changes in input factors. Adjustment of channel features is usually localized and of a modest magnitude.

Large Woody Debris: Low

In larger forested basins, wood numbers are often low in this channel type. This lack of debris may be, in part, due to past land management activities, but these channels usually display sufficient energy to route wood downstream. Also, limited lateral movement of the channel reduces the recruitment of wood from bank erosion. Wood is often present in jams or as large, single pieces capable of withstanding high-energy flows. Even in streams of this channel type that are smaller and display less energy, wood may be routed or retained above the elevation of the bankfull channel, where it has limited impact on aquatic habitat.

Fine Sediment: Low

The confining nature of the landforms and the moderate gradient combine to produce enough stream energy to route most introduced fine sediment downstream. Localized pool filling and bed fining may occur if a large and persistent source exists.

Coarse Sediment: Moderate

These channels can be both a transport or deposition area for coarse sediment. When the supply of coarse sediment surpasses the transport capabilities of the stream, pools are filled, and the influence of large boulders, wood, and bedrock control structures is lessened. If significant amounts of large sediment are added, the channel is particularly vulnerable to widening, limited lateral movement, or scour.

Peak Flows: Moderate

These channels have limited floodplain, and are capable of passing most high flows without adjustments to the overall dimensions of the channel. Development of point or medial bars is likely in basins with high sediment loads. Localized bed or bank scour is possible on bends in the main channel.

RIPARIAN ENHANCEMENT OPPORTUNITIES

These channels are not highly responsive, and in-channel enhancements may not yield intended results. Although channels are subject to relatively high energy, they are often stable. In basins where water-temperature problems exist, the stable banks generally found in these channels lend themselves to establishment of riparian vegetation. In non-forested land, these channels may be deeply incised and prone to bank erosion from livestock. As such, these channels may benefit from livestock access control measures.

MODERATE GRADIENT HEADWATER CHANNEL - MH

These moderate-gradient headwater channels are common to plateaus in Columbia River basalts, young volcanic surfaces, or broad drainage divides. They may be sites of headwater beaver ponds. These channels are similar to LC channels, but occur exclusively in headwater regions. They are potentially above the **anadromous fish** zone. These gentle-to-moderate headwater streams generally have low streamflow volumes and, therefore, low stream power. The confined

channels provide limited sediment storage in low-gradient reaches. Channels have a small upslope drainage area and limited sediment supply. Sediment sources are limited to upland surface erosion.

CHANNEL ATTRIBUTES

Stream gradient: 1-6%

Valley shape: Open, gentle V-shape valley

Channel pattern: Low sinuosity to straight

Channel confinement: Confined

Oregon stream size: Small

Position in drainage: Upper, headwater

Dominant substrate: Sand to cobble, bedrock; boulders may be present from erosion of surrounding slopes and soils

CHANNEL RESPONSIVENESS

The low stream power and presence of confining terraces or hill slopes and control elements, such as bedrock substrates, limit the type and magnitude of channel response to changes in input factors. Adjustment of channel features is usually localized and of a moderate magnitude.

Large Woody Debris: Moderate

Wood numbers and influence is quite variable in these channels. While the low stream energy may limit the magnitude of response associated with wood, wood numbers can be high and wood may be the dominant roughness element. In these cases, wood is critical for pool and cover habitat formation and maintenance.

Fine Sediment: Moderate

The confining nature of the landforms that define this channel type tends to focus enough stream energy to route much of the introduced fine sediment downstream. Localized pool filling and bed fining can occur in lower-gradient reaches.

Coarse Sediment: Moderate to High

The low energy in these small channels is incapable of transporting larger sediment. Increases in the sediment load can easily overwhelm the channel and result in widening, lateral movement, or scour. In some basins, the location of these channels makes them vulnerable to inputs of sediment and wood from slides.

Peak Flows: Moderate

These channels have limited floodplain, and are capable of passing most high flows without adjustments to the overall dimensions of the channel. Localized bed or bank scour is possible on bends in the main channel.

RIPARIAN ENHANCEMENT OPPORTUNITIES

These channels are moderately responsive. In basins where water-temperature problems exist, the stable banks generally found in these channels lend themselves to establishment of riparian vegetation. In non-forested land, these channels may be deeply incised and prone to bank erosion from livestock. As such, these channels may benefit from livestock access control measures.

MODERATELY STEEP NARROW VALLEY CHANNEL - MV

MV channels are moderately steep and confined by adjacent moderate to steep hill slopes. High flows are generally contained within the channel banks. A narrow floodplain, one channel

width or narrower, may develop locally. MV channels efficiently transport both coarse bedload and fine sediment. Bedrock steps, boulder cascades, and chutes may be common features. The large amount of bedrock and boulders create stable streambanks; however, steep side slopes may be unstable. Large woody debris is found commonly in jams that trap sediment in locally low-gradient steps.

CHANNEL ATTRIBUTES

Stream gradient: 4-8%, may vary between 3 to 10%

Valley shape: Narrow, V-shaped valley

Channel pattern: Single channel, relatively straight similar to valley

Channel confinement: Confined

Oregon stream size: Small to medium

Position in drainage: Mid to upper

Dominant substrate: Small cobble to bedrock

CHANNEL RESPONSIVENESS

The gradient and presence of confining terraces or hill slopes and control elements, such as bedrock substrates, limit the type and magnitude of channel response to changes in input factors. Adjustment of channel features is localized and of a minor magnitude.

Large Woody Debris: Moderate

In larger forested basins, wood numbers are often high in this channel type. Wood is present in jams or as single pieces capable of withstanding high-energy flows. Large woody debris may be the primary element responsible for pool formation and development. In bedrock systems, wood has less influence, and is often transported downstream.

Fine Sediment: Low

The confining nature of the landforms and the higher gradients combine to produce enough stream energy to route most introduced fine sediment downstream. Filling of lateral pools and lower energy areas may result from increases in the sediment supply.

Coarse Sediment: Moderate

These channels are usually transport reaches for coarse sediment, although lower-energy sections can retain sediment and adjust channel dimensions. When the supply of coarse sediment surpasses the transport capabilities of the stream, pools are filled, and the influence of large boulders, wood, and bedrock control structures is lessened.

Peak Flows: Moderate

These channels have limited floodplain, and are capable of passing most high flows without adjustments to the overall dimensions of the channel. Development of point or medial bars is likely in basins with high sediment loads. Localized bed or bank scour is possible on bends in the main channel.

RIPARIAN ENHANCEMENT OPPORTUNITIES

These channels are not highly responsive, and in-channel enhancements may not yield intended results. Although channels are subject to relatively high energy, they are often stable. In basins where water-temperature problems exist, the stable banks generally found in these channels lend themselves to establishment of riparian vegetation. In non-forested land, these channels may be deeply incised and prone to bank erosion from livestock. As such, these channels may benefit from livestock access control measures.

STEEP NARROW VALLEY CHANNEL - SV
VERY STEEP HEADWATER – VH

These two channel types are very similar, except that VH channels are steeper. Because of this similarity, they are discussed together. SV channels are situated in a constricted valley bottom bounded by steep mountain or hill slopes. Vertical steps of boulder and wood with scour pools, cascades, and falls are common. VH channels are found in the headwaters of most drainages or side slopes to larger streams, and commonly extend to ridge-tops and summits. These steep channels may be shallowly or deeply incised into the steep, mountain or hill slope. Channel gradient may be variable due to falls and cascades.

CHANNEL ATTRIBUTES

Stream gradient: SV 8-16%, VH >16%

Valley shape: Steep, narrow V-shaped valley

Channel pattern: Single, straight

Channel confinement: Tightly confined

Oregon stream size: Small, small-medium transition

Position in drainage: Middle upper to upper

Dominant substrate: Large cobble to bedrock

CHANNEL RESPONSIVENESS

The gradient and presence of confining terraces or hill slopes and control elements, such as bedrock substrates, limit the type and magnitude of channel response to changes in input factors. Adjustment of channel features is localized and of a minor magnitude. These channels are also considered source channels supplying sediment and wood to downstream reaches, sometimes via landslides.

Large Woody Debris: Moderate

In larger forested basins, wood numbers are often high in these channel types. Large woody debris may be the primary element responsible for pool formation and development. In bedrock systems, wood has less influence, and is often transported downstream.

Fine Sediment: Low

The confining nature of the landforms and the higher gradients combine to produce enough stream energy to route most introduced fine sediment downstream. Filling of lateral pools and lower energy areas may result from increases in the sediment supply.

Coarse Sediment: Low to Moderate

These channels are usually transport reaches for coarse sediment, although lower-energy sections can retain sediment and adjust channel dimensions. When the supply of coarse sediment surpasses the transport capabilities of the stream, pools are filled, and the influence of large boulders, wood, and bedrock control structures is lessened. Minor channel widening or scour can occur.

Peak Flows: Low

These channels have limited floodplain, and are capable of passing most high flows without adjustments to the overall dimensions of the channel. Localized bed or bank scour is possible.

RIPARIAN ENHANCEMENT OPPORTUNITIES

These channels are not highly responsive, and in-channel enhancements may not yield intended results. Although channels are subject to relatively high energy, they are often stable. In basins where water-temperature problems exist, the stable banks generally found in these channels lend themselves to establishment of riparian vegetation. This may also serve as a recruitment effort for LWD in the basin.

CHAPTER FOUR: HYDROLOGY AND WATER USE

INTRODUCTION

Understanding how land and water uses can alter natural hydrologic processes requires a basic understanding of how water moves through a watershed. The hydrologic cycle describes the cyclical movement of water from the atmosphere through the watershed and back again by way of condensation, precipitation, infiltration, evaporation, evapotranspiration and runoff. In the atmosphere, water vapor condenses to form clouds, which in turn produce precipitation in the form of rain, sleet, snow, or hail depending on climate. Precipitation, upon reaching the land surface, can infiltrate the soil, evaporate, or flow into surface waters as runoff. The amount of water that infiltrates the soil is related to topography, vegetation type, soil type, the rate of precipitation and the degree to which the soil is already saturated. Surface runoff primarily occurs when soils are saturated, covered by impervious surfaces, or when rates of precipitation exceed the rates of infiltration for a given soil type. Water is returned to the atmosphere through the evaporation of surface water and evapotranspiration through vegetation. Evapotranspiration is a combination of the evaporation and transpiration processes, whereby vegetation draws water in through roots and releases excess from leaves.

Human activities, including forestry practices, agriculture, grazing, irrigation, urban development, and road building can significantly alter these hydrologic processes. Effects of these activities on watershed hydrology can include changes in the timing and quantity of streams flows, resulting in increased peak flows, reduced ground water recharge, and altered timing and quantities of water yields. Changes in water quantity can consequently alter water quality and aquatic communities. The degree of hydrologic alteration is largely affected by the location, extent, and type of land use activity.

The purpose of this component of the assessment is to evaluate the potential impacts of land and water-use practices on the hydrology of the Lower Molalla River & Milk Creek watershed. The Watershed Assessment Manual includes screening-level assessments of each of the major land-use types occurring in the LMR&MC watershed to determine which land-use types are potentially altering hydrologic processes. An in-depth analysis beyond the scope of this project would be necessary to determine which specific activities were responsible for any hydrologic changes that have occurred.

HYDROLOGIC CHARACTERIZATION

CLIMATE AND TOPOGRAPHY

The Lower Molalla River watershed is approximately 127 square miles in area, located within the eastern portion of the Willamette River basin extending through the Prairie terraces and Willamette valley foothills into the western portion of the Cascade lowlands ecoregions. The climate is characterized by cool wet winters and warm dry summers with year-round mild temperatures. Precipitation in the watershed increases with elevation, which ranges from approximately 56 feet above sea level at the lower end of the Molalla River mainstem to approximately 4,230 feet in the Canyon creek subwatershed.

PRECIPITATION

Mean annual precipitation in the LMR&MC watershed ranges from less than 45 inches to greater than 70 inches per year (Table 4.1). Peak precipitation occurs between November and January (Oregon Water Resources Department 1986), while June through September tend be the driest months (BLM/USFS 1999). Precipitation in the watershed falls primarily as rain with 75% of precipitation falling between October and March. Annual precipitation in the form of rainfall averages 47 inches per year, with the highest monthly precipitation typically occurring in December or January. Snow accumulations are minimal with an annual average of 1.69 inches (Western Regional Climate Center 2003).

DISCHARGE AND PEAK FLOW GENERATING PROCESSES

Only one gauging station is currently in operation in the watershed, located on the upstream side of Goods Bridge on the left bank at river mile 6.01. The gauge is operated and maintained by the

Table 4.1. General watershed characteristics of the lower Molalla River and Milk Creek watershed, Oregon.

	Subwatershed	Subwatershed area (mi^2)	Mean elevation (feet)	Minimum elevation (feet)	Maximum elevation (feet)	Mean annual precipitation (inches)
1	Canyon Creek	16.9	1880.8	600.6	4230.6	68.0
2	Headwaters Milk Creek	15.9	1377.6	600.6	3590.4	64.0
3	Lower Milk Creek	22.0	521.4	125.4	1494.9	48.5
4	Middle Milk Creek	15.9	633.4	240.9	1603.8	50.0
5	Molalla River/Cedar Creek	12.9	1001.0	405.9	1930.5	57.8
6	Molalla R./Willamette R.	42.8	235.6	56.1	693.0	46.1
7	Upper Milk Creek	18.4	861.4	392.7	1600.5	54.1
8	Woodcock Creek	12.8	1023.3	300.3	2296.8	56.8
Total Watershed		157.6				

USGS. Streamflow data have been collected from this station between August 1928 and September 1959, October 1963 and September 1978 and October 2000 to present, resulting in nearly 50 years of streamflow data. In the Lower Molalla River watershed, discharge tends to be highest during the winter months, coinciding with the highest levels of precipitation. Mean monthly discharge on the lower Molalla River is highest in December and January, with average flows of 2,276 and 2,392 cfs, respectively (Figure 4.1). Lowest discharges generally occur between July and September, with average discharges during these months ranging between 100 and 200 cfs. (USGS data 2003). The mean daily flows recorded by this gauge illustrate the large seasonal variability in flows. Annual peak flows in the lower Molalla River further illustrate the fluctuations in discharge that can occur in the watershed (Figure 4.2).

Annual peak flows, defined as the maximum instantaneous rate of discharge occurring during the year (WPN 1999), typically occur between November and March in the Lower Molalla River watershed. Ninety-seven percent of the LMR&MC watershed occurs below 2,300 feet above sea level placing it within the rain dominated peak-flow-generating zone. As such, this hydrologic analysis assesses the potential effect of forest conditions on watershed hydrology using rain events as the primary hydrologic, or peak flow generating, process.

Rain-on-snow events can and do occur in the watershed, and can be a large contributing factor exemplified by the flood events of 1964 and 1996. Watershed characteristics upstream of the assessment area also greatly influence the peak flow events in the Lower Molalla River and need to be considered when characterizing the hydrology of the assessment area. Flood frequency analyses were performed and peak flow estimates were made on the Lower Molalla watershed and in the upper Molalla watershed using USGS streamflow data to determine peak flood discharge estimates up to the equivalence of a 500-year event. A 500-year event is defined as discharge expected to occur once every 500 years or a discharge event with a 0.2% probability of occurring in any given year.

Rain-on-snow events are more likely to occur in the upper Molalla River watershed (not included in this assessment) owing to higher elevations. The large size of the upper watershed and the fact that rain-on-snow events dominate peak flows in

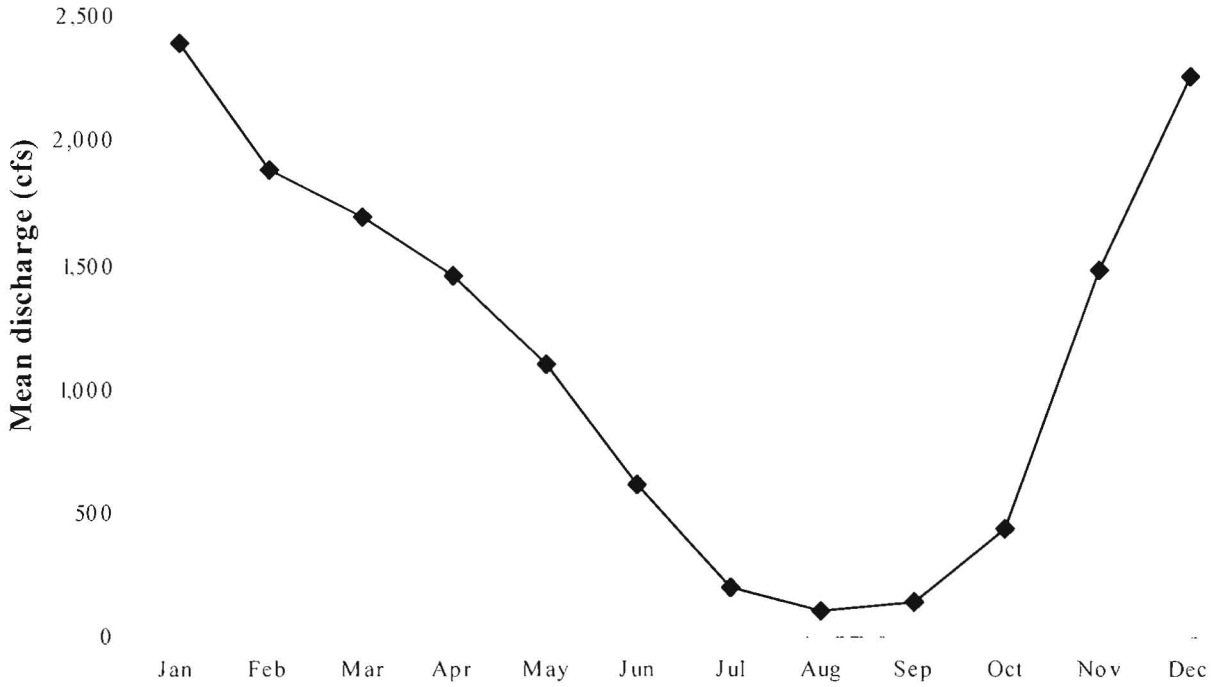

Figure 4.1. Mean monthly streamflow of the Molalla River near Canby, Oregon (USGS Station 14200000) based on daily streamflow data (1929–1959, 1964–1978, and 2000–2001).

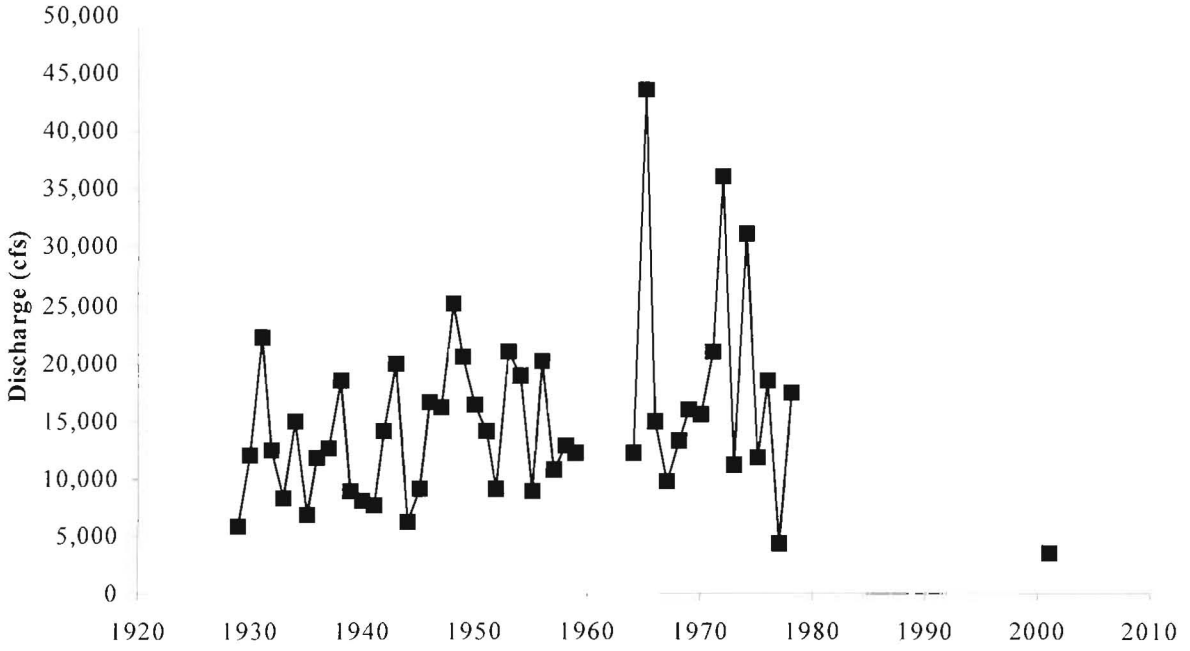

Figure 4.2. Peak streamflow of the Molalla River near Canby

the upper watershed largely influence the peak flows recorded at the Lower Molalla streamflow gauge. Flood frequency analyses were also performed on the Upper Molalla watershed and the Milk creek watershed to determine the influence of the two watersheds on peak downstream flood events occurring in the Lower Molalla watershed. This flood frequency analysis reveals an average peak flow input of 77% from the upper portions of the watershed during peak flow events. While the Lower Molalla exists nearly entirely in the rain-generated peak flow zone, downstream peak flows and flooding, particularly in the Lower Molalla/ Willamette subwatershed, can and does occur more often as a result of the upper watershed's characteristics where rain on snow events are more likely to occur.

HYDROLOGIC ASSESSMENT

LAND USE

Land Use in the lower Molalla River & Milk Creek watershed includes rural residential (45%), agriculture (25%), and commercial forestry (19%) with only a small area(1%) zoned as urban (Table 4.2). Much of the watershed (48%) consists of rural residential property including small family farms. Lands devoted to agriculture occur primarily along the mainstem Molalla river subwatershed and adjacent areas with some croplands occurring in the lower reaches of tributaries, particularly in the Lower Milk creek subwatershed. Croplands in the watershed are primarily used for grass seed production, small Christmas tree farms and nurseries, and some smaller areas for hay and pasture. Croplands in the watershed are predominantly irrigated. Land use dedicated to forestry exists in the upper portions of the watershed and primarily occurs in the Canyon Creek, Milk Creek headwaters, Upper Milk Creek and Woodcock Creek subwatersheds. Portions of the towns of Canby and Molalla are the only zoned urban areas within the watershed assessment boundaries.

POTENTIAL FORESTRY IMPACTS

Forest practices, such as the removal and disturbance of timber and other vegetation, as well as associated road building, influence quantities and rates of runoff, evapotranspiration, and infiltration. This alteration can lead to changes in peak and low flows, as well as surface and

Table 4.2. Land-use practices in the lower Molalla River and Milk Creek watershed, Oregon.

			Forestry		Agriculture and/or range		Urban		Rural Res	
	Subwatershed	Area (acres)	Acres	%	Acres	%	Acres	%	Acres	%
1	Canyon Creek	10812.9	7231.9	67%	0.0	0.0%	0	0%	3580.9	33.1
2	Headwaters Milk Creek	10199.5	3339.5	33%	0.0	0.0%	0	0%	6860.0	67.3
3	Lower Milk Creek	14075.5	611.8	4%	1903.7	13.5%	0	0%	11560.1	82.1
4	Middle Milk Creek	10210.1	885.4	9%	73.1	0.7%	0	0%	9251.6	90.6
5	Molalla River	27388.6	106.9	0%	22920.2	83.7%	959.0	4%	3402.6	12.4
6	Molalla R/Cedar Creek	8234.1	1612.0	20%	282.1	3.4%	0	0%	6340.0	77.0
7	Upper Milk Creek	11753.1	2243.8	19%	244.0	2.1%	0	0%	9265.3	78.8
8	Woodcock Creek	8213.3	3167.5	39%	155.5	1.9%	0	0%	4890.2	59.5
Total watershed		**100865.7**	19198.8	19%	25578.6	25.4%	959.0	1%	55150.7	55%

ground-water yield within a watershed (WPN 1999).

Forestry impacts are evaluated by first determining what peak-flow-generating processes occur in each subwatershed (WPN 1999). If more than 75% of any subwatershed occurred in the rain-on-snow category, the analysis is continued to examine the potential effects of current forest conditions on watershed hydrology. Rain-on-snow events are the primary peak-flow generating process at intermediate elevations greater than 2,300 feet in the Cascades Mountains lowlands and valleys ecoregion (WPN 1999, Appendix A). The area above this elevation was calculated for each subwatershed to determine what proportion of each subwatershed occurred in this peak-flow category. Canyon creek and the Headwaters of Milk creek are the only subwatersheds containing areas at these elevations and far less than 75% of the area in each of these two subwatersheds occurred in this zone. As a result, no further analysis was performed and we concluded that forestry activities pose a low risk of increasing peak flows in the watershed.

POTENTIAL AGRICULTURAL IMPACTS

Agricultural practices often result in long-term alteration of natural landscape conditions and can potentially impact watershed hydrology. Removal of vegetation for crop production can decrease rates of infiltration and increase runoff rates, resulting in an increase in peak flows. Leveling the landscape for field drainage can eliminate wetlands and topographic features such as depressions, these landscape features are critical for maintaining watershed hydrology throughout the course of the year. Removing these features can increase peak flows during the wetter seasons by reducing runoff retention during peak precipitation events. Removal of these features also decreases low flows during the drier seasons by eliminating inputs to ground and surface water storage which are critical to maintaining base flows. The extent of these impacts on watershed hydrology is dependent on several factors including the type of vegetation removed, the soil types affected, and the type of agriculture treatment practiced (WPN 1999).

The Oregon Watershed Assessment Manual provides a screening-level assessment of agricultural and rangeland uses on hydrology by examining cover types, treatment practices, and hydrologic soil groups to determine where the highest risks for increases in peak flows occur within the watershed. Some combinations of these three variables are more likely to reduce infiltration rates, increase runoff, and increase peak-flows. Agricultural land comprises over 25% of the total Lower Molalla River and Milk Creek watershed area, with most of the acreage occurring in the Molalla River subwatershed. Therefore, this screening-level assessment was first performed in this subwatershed using GIS land use coverages and examination of aerial photos.

To start, hydrologic soil groups occurring within agricultural areas in the subwatershed were identified using the Natural Resources Conservation Service (NRCS) soil survey maps. Agricultural lands within subwatersheds were delineated by hydrologic soil group and the area within each soil group was calculated. Each hydrologic soil group within each subwatershed was then evaluated to determine current and historic agricultural cover types. The hydrologic condition of each cover type and treatment practice was then determined using tables provided in the Assessment Manual (WPN 1999). Runoff curve numbers were then selected for combination of soil group, hydrologic condition, and cover type. This process resulted in a current condition rating for each cover type within each soil group located in each subwatershed. This process was then repeated using the historic cover type of that ecoregion. Runoff depth values were generated by determining the 24-hour, 2-year precipitation amount for each ecoregion and hydrologic condition; these values were assigned to current and historic conditions of each cover type. The change in runoff values between historic and current cover types was then averaged by soil group and then for the entire subwatershed. Using NRCS ratings for western Oregon watersheds provided in the Assessment Manual, the risk of potential peak flow enhancement was determined by this overall change in runoff values.

Across the three hydrologic soil types occurring in the Molalla River subwatershed,

agriculture currently poses a low risk of increasing peak flows (Table 4.3). Because agriculture is far more prevalent in this subwatershed than in others, no further analyses of potential impacts of agricultural lands on hydrology was performed.

POTENTIAL FOREST AND RURAL ROAD IMPACTS

Road surfaces, whether paved or compacted fill, are generally impervious to water infiltration. Reduced infiltration of precipitation on the road surface increases surface runoff. Roadways constructed along waterways can restrict lateral channel movement and produce incised channels that are disconnected from their floodplain. As urban areas are scarce in the LMR&MC watershed, roadways are primarily forest or rural roads.

A total of 765.3 miles of roads occur in the watershed, averaging 4.8 miles of road per square mile. Forest roads account for 208.5 miles of roads while rural roads account for 556.8 road miles within the watershed. Using an average road width of 0.0047 miles for forest roads and 0.0066 miles for rural roads the roaded area for each land use type (forest or rural) was calculated by subwatershed to assess the potential impact on peak-flow enhancement. Among subwatersheds, Cedar Creek poses the highest potential risk to peak-flow enhancement with a rural roaded area equaling 9.4% of the total rural land use area of the subwatershed (Table 4.4) and 58.8% of forested areas within the subwatershed (Table 4.5). Watershed wide, roads occupy 3.3% of the total forested land, while rural roads occupy 2.9% of the total rural land use area. At these densities, the watershed-wide risk for peak flow enhancement from road runoff is low (WPN 1999). However, sediment-laden runoff likely occurs from these roads, and waterways that are near these road systems are more likely to be detrimentally affected by runoff. In the basin, 142.3 miles of roadways are within 200 feet of the Lower Molalla and its tributaries.

POTENTIAL URBAN AND RURAL RESIDENTIAL ROAD IMPACTS

Total impervious surface area of a watershed exceeding 10% can result in an altered hydrologic regime and degradation of physical habitat (May et al. 1997 and Schueler 1994). The Oregon Watershed Assessment Manual provides a screening level risk assessment of potential hydrologic impacts of urban development of a watershed by using a surrogate variable, total road densities, to approximate the total area of impervious surfaces. The Assessment Manual assigns levels of potential risk of hydrologic impacts by examining total road densities. Subwatersheds with a total road density greater than 5.5% would be expected to have total impervious areas of greater than 10% and be assigned a high probability of peak-flow enhancement. Subwatersheds with total road densities ranging between 4.2 and 5.5 mi/mi^2 would be expected to have total impervious areas between 5 and 10% and a corresponding assignment of moderate risk of peak-flow enhancement. Watershed wide, total road densities are 4.41 mi/mi^2, resulting in assignment of moderate potential of impervious surfaces altering watershed hydrology (Table 4.6). Among subwatersheds, the headwaters of Milk Creek and lower Milk Creek pose the highest risk of potential impacts with road densities of 6.6 and 4.3 mi/mi^2 respectively (Table 4.6).

WATER USE CHARACTERIZATION

WATER RIGHTS

The Oregon Water Code, enacted on February 24, 1909, governs the use of the State's waters. This water code established four general principles to govern water use:

- Water belongs to the public.
- Any right to use it is assigned by the State through a permitting system.
- Water use under that permit system follows the "prior appropriation doctrine," i.e., older water uses get priority over newer water uses.
- Permits may be issued only for beneficial use without waste.

—Bastasch (1998)

The Oregon Water Resources Department is responsible for executing the State's laws on water

Table 4.3. Average change in runoff values for each dominant hydrologic soil group (HSG) occurring in agricultural lands in the Molalla River subwatershed. Because the overall change in runoff from background is less than 0.5 inches, agricultural practices in the subwatershed pose a low relative risk for peak flow enhancement.

HSG	% Agland	Runoff value change from background (in)
B	26.9%	0.30
C	44.7%	0.35
D	20.4%	0.27
Overall		**0.29**

Table 4.4. Mileage and area of rural roads, and risk of peak flow enhancement posed by these roads, occurring in subwatersheds of the lower Molalla River and Milk Creek watershed.

Subwatershed	Acres	Rural Acres	Rural Area (mi)	Rural Roads (mi)	Rural Road Area (mi^2)	% Roaded Area	Incr. Peak Flow Risk
Canyon Creek	10810.12	3580.94	5.60	22.67	0.15	2.7%	Low
Headwaters Milk Creek	10197.15	6860.04	10.72	105.12	0.69	**6.5%**	**Moderate**
Lower Milk Creek	14072.62	13463.76	21.04	93.88	0.62	2.9%	Low
Middle Milk Creek	10207.75	9324.68	14.57	53.64	0.35	2.4%	Low
Molalla R/Cedar Creek	8231.76	6622.09	10.35	147.11	0.97	**9.4%**	**High**
Molalla R/Willamette	27382.53	26322.72	41.13	51.55	0.34	0.8%	Low
Upper Milk Creek	11750.34	9509.25	14.86	58.90	0.39	2.6%	Low
Woodcock Creek	8211.13	5045.77	7.88	23.92	0.16	2.0%	Low

Table 4.5. Mileage and area of forest roads and risk of peak flow enhancement posed by these roads occurring in subwatersheds of the lower Molalla River and Milk Creek watershed.

Subwatershed	Acres	Forested Acres	Forested Area (mi)	Forest Roads (mi)	Forest Road Area (mi^2)	% Roaded Area	Incr. Peak Flow Risk
Canyon Creek	10810.12	7231.94	11.30	81.43	0.38	3.4%	Low
Headwaters Milk Creek	10197.15	3339.48	5.22	29.37	0.14	2.6%	Low
Lower Milk Creek	14072.62	611.77	0.96	7.50	0.04	3.7%	Low
Middle Milk Creek	10207.75	885.39	1.38	9.21	0.04	3.1%	Low
Molalla R/Cedar Creek	8231.76	106.88	0.17	20.88	0.10	58.8%	**High**
Molalla R/Willamette	27382.53	1612.02	2.52	1.38	0.01	0.3%	Low
Upper Milk Creek	11750.34	2243.80	3.51	21.14	0.10	2.8%	Low
Woodcock Creek	8211.13	3167.52	4.95	37.60	0.18	3.6%	Low

Table 4.6. Potential risk for peak flow enhancement resulting from urban and rural road densities in subwatersheds of the lower Molalla River and Milk Creek watershed, Oregon.

Subwatershed	Urban/Rural Area (mi^2)	Urban/Rural Roads (mi)	Road Densities ($mi./mi.^2$)	Incr Peak Flow Risk
Canyon Creek	5.6	22.67	1.3	Low
Headwaters Milk Cr	10.7	105.12	6.6	**High**
Lower Milk Creek	21.0	93.88	4.3	**Moderate**
Middle Milk Creek	14.6	53.64	3.4	Low
Molalla River	11.8	147.11	3.4	Low
Molalla R/Cedar Cr	41.1	51.55	4.0	Low
Upper Milk Creek	14.9	58.90	3.2	Low
Woodcock Creek	7.9	23.92	1.9	Low
Total	**126.1**	**556.78**	**4.4**	**Moderate**

supply and use established in this code. To obtain a water right, an application must be submitted to this agency. The OWRD evaluates the request and, if appropriate, grants a provisional permit for water use to the applicant. When the State confirms water use is in accordance with the permit, a fully certified water right certificate will be granted to the applicant. Water use is appropriated at a certain rate of withdrawal, usually measured in cubic feet per second (cfs). Additionally, restrictions on the total amount of water withdrawn, and the months for which the water right is valid, are established. There are 2,336 water rights in the lower Molalla River, Milk Creek, Pudding River watershed (WRD data, 2004).

Instream water rights are filed by ODFW, DEQ or Oregon State Parks Department and held in trust for the people of Oregon by the OWRD for instream "public uses" such as recreation, navigation, pollution abatement or conservation. Unlike irrigation or other "consumptive-use" water rights, these water rights seek to ensure that a certain amount of flow is maintained in the stream; however, like "consumptive-use" water rights, they are subject to regulation by priority date under the prior appropriation doctrine. Instream water rights have been filed with OWRD for each Water Availability Basin (WAB) occurring within the LMR&MC watershed (Table 4.7). Two of these rights have been granted, the Molalla River WAB and the Molalla River above Milk Creek WAB, both for the protection of anadromous and resident fish habitat (Figure 4.3).

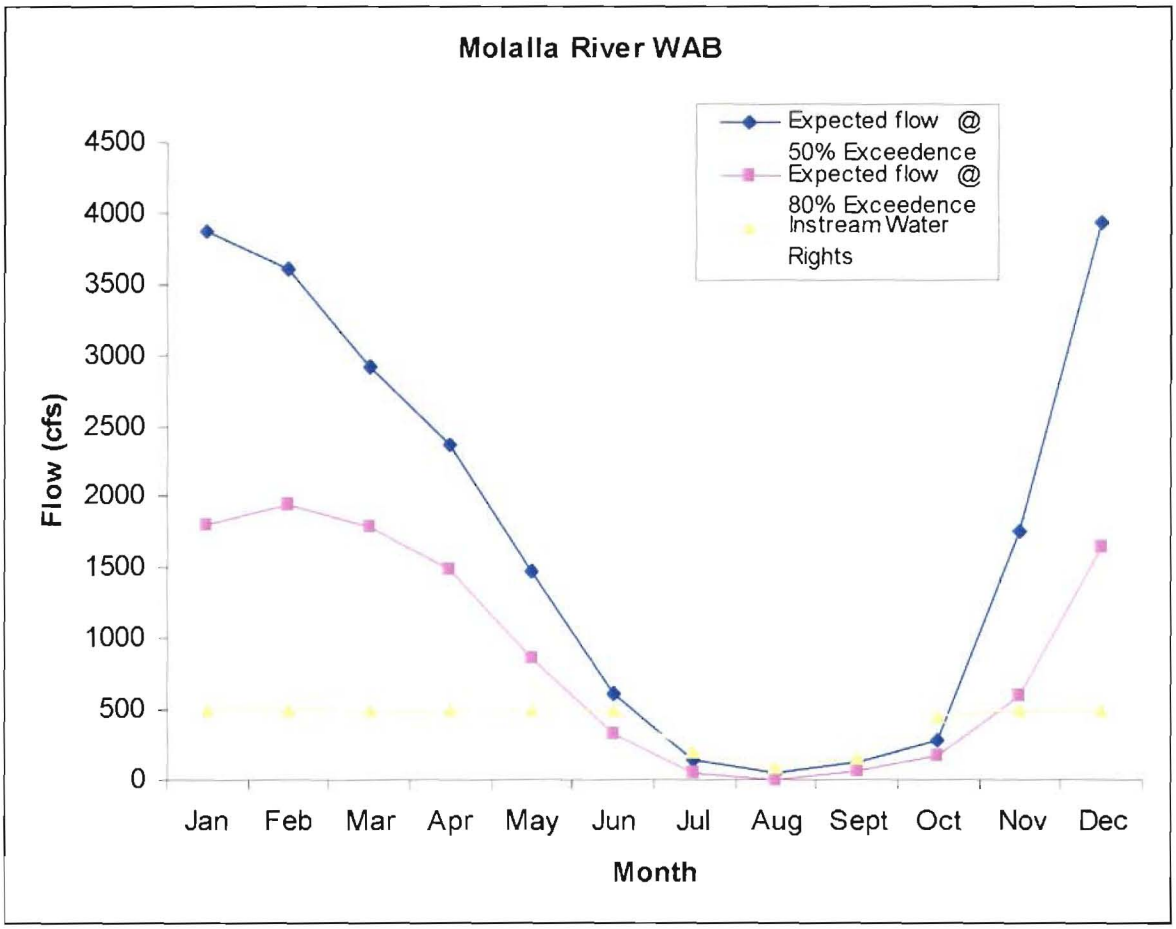

Figure 4.3. Expected streamflows after subtracting consumptive uses from 50% and 80% exceedence flow levels in comparison to instream flow requirements for the Molalla River WAB. When expected flows are less than instream flows, insufficient water is available to support both instream rights and consumptive uses.

Table 4.7. Instream Water Rights (ISWR) for the lower Molalla River and Milk Creek watershed.

Water availability basin	Application	Certificate	Legal Description	Purpose
Molalla	69796A	62322	In Molalla River and its tributaries from the confluence of Milk Creek to the mouth of the Molalla River	Anadromous and resident fish habitat
Molalla above Gribble Creek	135A			
Molalla above Milk Creek	70747A	72587	Molalla River from Dickey Creek river mile 22.3 downstream to Milk Creek river mile 8.0	Anadromous and resident fish habitat
Milk Creek	131A			

CONSUMPTIVE WATER USE

Consumptive water uses, or uses which draw water out of the stream, are summarized and reported by the OWRD through the Water Availability Reporting System (WARS). Irrigation, municipal, industrial, domestic, agricultural, and storage uses were reported by this system for the LMR&MC watershed (Table 4.8). Consumptive use by percent of streamflow (at the 50% exceedence level; i.e., the flow at which half of the monthly flows exceed this value, or the median flow) is highest in the summer months of July, August, and September, when streamflow in the watershed tends to be lowest (Table 4.9). When this use is greater than 10%, the greatest opportunity for flow restoration through conservation measure exists. Using this criterion, flow restoration opportunities are greatest in the Molalla and Milk Creek WAB's where consumptive uses and storage range from 32.0 to 86.0% at the 50% exceedence level during the summer months of July through September.

WATER USE ASSESSMENT

WATER AVAILABILITY

The lower Molalla River and Milk Creek watershed has been divided into four water availability basins (WABs). WABs are designated by the Oregon Water Resources Department for water availability modeling purposes. Within the LMR&MC watershed, these basins include the Molalla River WAB (010400), the Molalla River above Gribble Creek WAB (010420), the Molalla River above Milk Creek WAB (010422), and the Milk Creek WAB (010421). Water availability is calculated for each WAB by the Oregon Water Resources Department by subtracting the estimated consumptive use of existing water rights from the natural streamflow. These calculations are made for both 50% and 80% exceedence flow levels. The 50% exceedence flow is the flow at which half of the annual flows exceed this value, or the median flow. This flow value is used as an upper limit in developing in-stream water rights for protection of aquatic species and other in-stream beneficial uses (WPN 1999). The 80% exceedence level represents the stream flow that is in the channel 80% of the time over a 30-year period, in order to include both wet and dry periods in the calculation. OWRD uses the 80% exceedence flow to determine whether new water rights can be issued in a WAB (WPN 1999); water rights are issued only when water is available at the 80% exceedence level.

Expected stream flow at the 50% and 80% exceedence levels (after subtracting consumptive uses and storage) and instream water rights for each WAB are presented in Figures 4.3, 4.4, 4.5, and 4.6. When expected streamflows are less than instream water rights flows, insufficient water is available for both consumptive uses and instream

Table 4.8. Annual consumptive water use and storage (50% exceedence level) by water availability basin in the lower Molalla River and Milk Creek watershed, Oregon.

WAB	Irrigation	Municipal	Industrial	Domestic	Agriculture	Storage	Total
Molalla	65.31	11.92	17.52	7.44	2.44	2.66	107.35
Molalla abv Gribble	65.31	11.92	17.52	7.44	2.44	2.66	107.35
Molalla abv Milk	33.16	9	11.52	0.6	1.24	0.38	55.89
Milk	33.19	3	6	6.96	1.44	1.89	52.57

Table 4.9. Monthly water consumption as a percent of the 50% exceedence level for water availability basins (WABs) in the lower Molalla River and Milk Creek watershed, Oregon.

	Monthly Water Consumption (% of stream flow)											
WAB	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Molalla River	1.7	1.7	1.6	1.9	4.5	14.2	54.4	76.2	35.0	6.6	2.1	1.6
Molalla abv Gribble	0.3	0.3	0.3	0.3	1.1	3.9	15.9	23.6	9.6	1.9	0.4	0.2
Molalla abv Milk	0.2	0.2	0.2	0.2	0.6	2.2	9.2	14.2	6.0	1.1	0.2	0.1
Milk Creek	0.7	0.8	0.8	1.0	3.9	12.7	56.9	86.4	32.0	6.7	1.3	0.7

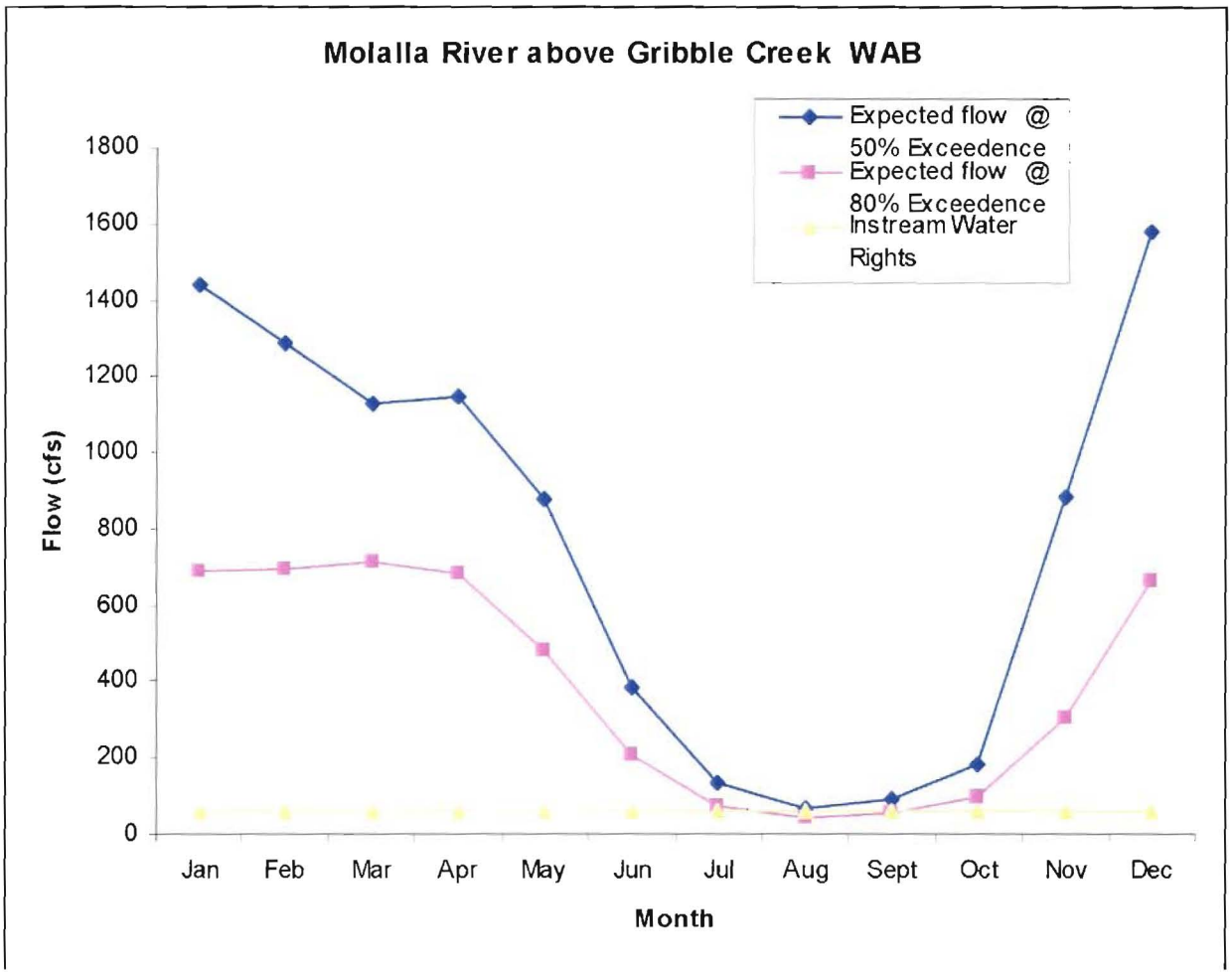

Figure 4.4. Expected streamflows after subtracting consumptive uses from 50% and 80% exceedence flow levels in comparison to instream flow requirements for the Molalla River above Gribble Creek WAB. When expected flows are less than instream flows, insufficient water is available to support both instream rights and consumptive uses.

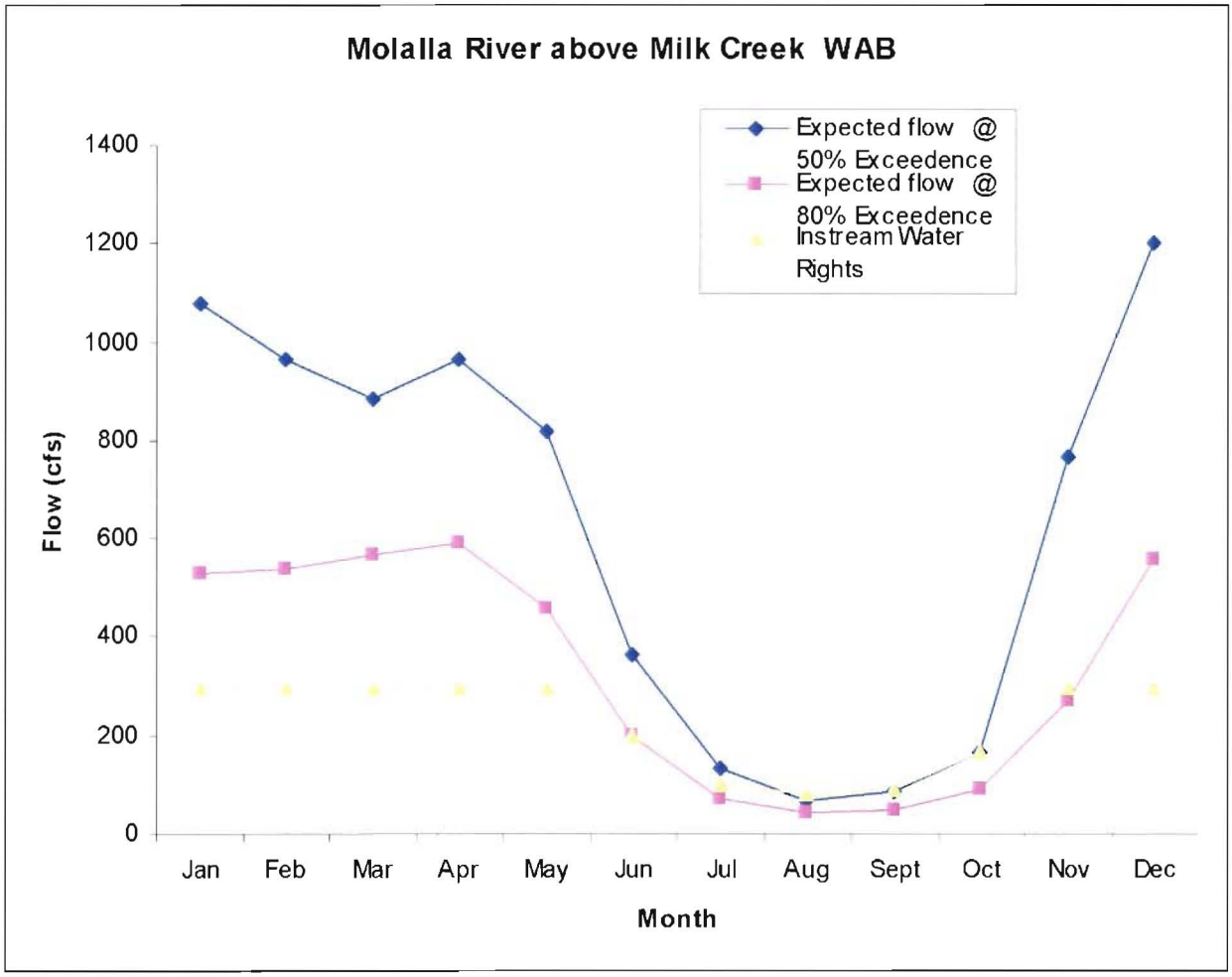

Figure 4.5. Expected streamflows after subtracting consumptive uses from 50% and 80% exceedence flow levels in comparison to instream flow requirements for the Molalla River above Milk Creek WAB. When expected flows are less than instream flows, insufficient water is available to support both instream rights and consumptive uses.

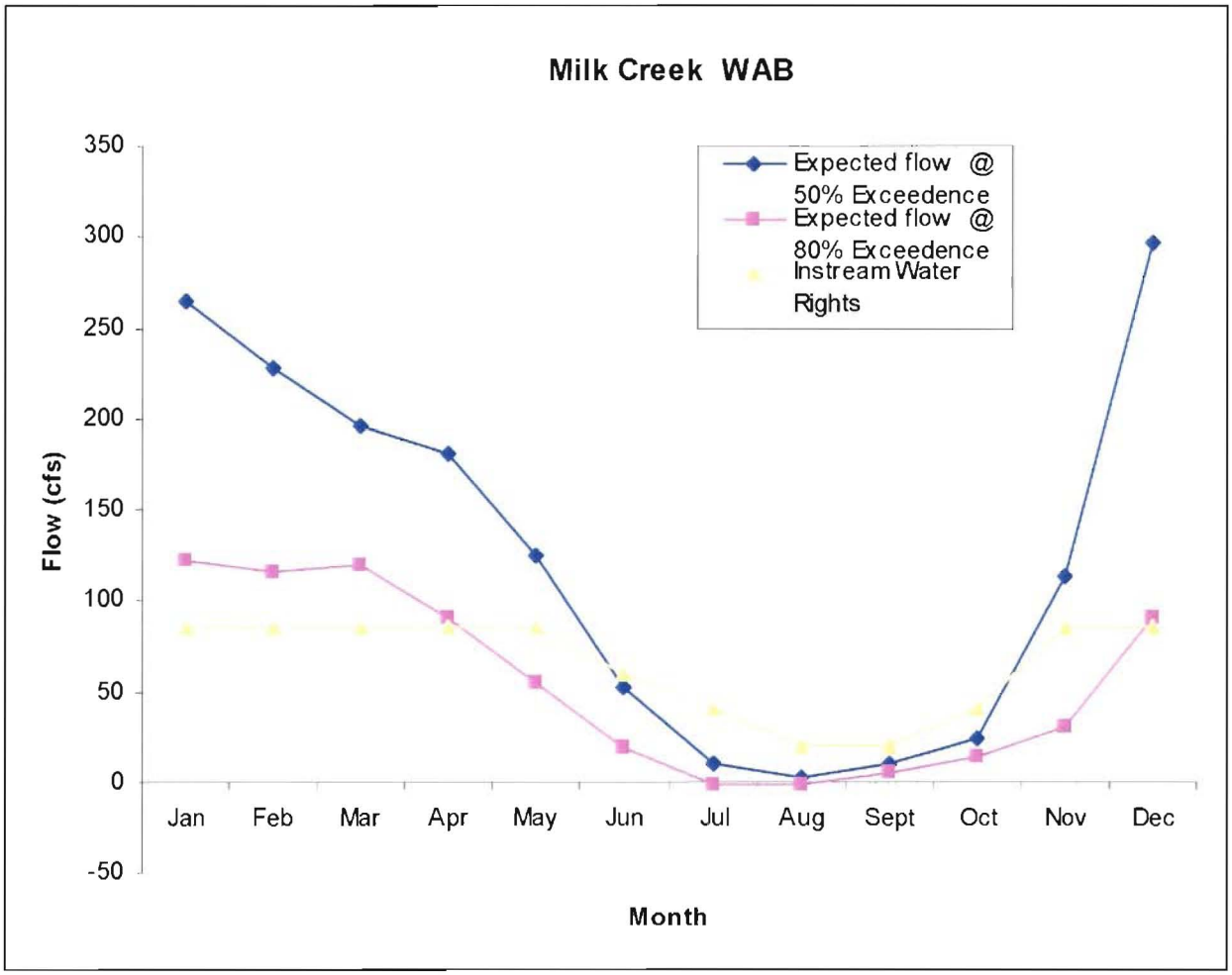

Figure 4.6. Expected streamflows after subtracting consumptive uses from 50% and 80% exceedence flow levels in comparison to instream flow requirements for the Milk Creek WAB. When expected flows are less than instream flows, insufficient water is available to support both instream rights and consumptive uses.

Table 4.10. Flow restoration priorities of water availability basins (WABs) occurring in the lower Molalla River and Milk Creek watershed, Oregon.

	Flow Restoration Priority		
WAB	**Priority**	**Opportunity**	**Need**
Molalla	Not a priority	Good	Moderate
Molalla above Gribble	Not a priority	Poor	Low
Molalla above Milk	Not a priority	Poor	Moderate
Milk	Current Resources Priority	Good	Highest

rights. In the Molalla River WAB, water availability is negative during July through October at 50% exceedence flows and during June through October at 80% exceedence flows (Figure 4.3). Water availability is negative in August and September at 80% exceedence flows in the Molalla above Gribble Creek WAB (Figure 4.4). In the Molalla above Milk Creek WAB, water availability is negative from August until October at 50% exceedence flows and from June through November at 80% exceedence flows. Milk Creek water availability is negative from June through October at 50% exceedence flows and is negative from May through November at 80% exceedence flows.

Because not all water rights are used to their maximum allowable extent at all times, these figures likely overestimate the amount of water being withdrawn at any given time. Nonetheless, the calculations indicate that water quantities can become too low to support beneficial uses if consumptive uses occur to the extent that current water rights allow.

FLOW-RESTORATION PRIORITY AREAS

The Oregon Plan for Salmon and Watersheds establishes streamflow restoration priorities for the recovery of salmonids by WAB (Oregon Water Resources Department 2003b). WABs are ranked by flow restoration needs and opportunities, and are assigned a priority. Streams can be a current resources priority, a priority, not a priority, or remain unprioritized. Need rankings range from 0 to 4, either being unranked, low, moderate, high, or highest, while opportunity rankings are also based on a 0 to 4 rating for being unranked, poor, fair, good, or very good. Table 4.10 summarizes the rankings and priorities for streamflow restoration for the WABs in the LMR&MC watershed. The Milk Creek WAB has been designated as the only priority basin within the upper LMR&MC watershed with a high need and good opportunity for streamflow restoration. August consumptive use in the Milk Creek watershed is 86% of the natural stream flow at 50% exceedence flows and is 118% of natural flow and 80% exceedence, indicating that significant potential for flow restoration through conservation measures, increased efficiency of use, and/or best management practices exists in this WAB.

References to Chapter Four

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