CHAPTER 2 – WATERSHED OVERVIEW

A landscape forged by fire and sculpted by ice, with a climate cold in winter and hot in summer, the Okanogan River Basin in north central Washington State lies in the rain shadow of the North Cascades. Geology, climate, and topography combine to create a semi-arid region whose residents depend upon snowmelt to replenish the aquifers and streams that provide water for this thirsty land and its inhabitants.

WATERSHED DESCRIPTION[1]

The Okanogan River Watershed is a sub-watershed of the Columbia River Watershed located in north central Washington State. This plan primarily focuses on the watershed lying within the boundaries of State of Washington Water Resources Inventory Area 49 (WRIA 49) but also includes portions within the State outside of this administrative boundary that are directly or closely linked hydrologically to the watershed. The Pasayten and Ashnola Rivers in northwestern Okanogan County, which drain approximately 300 square miles into the Okanogan River Watershed, are not included in WRIA 49, but are considered in this plan. The significant portion of the geographic watershed that lies within British Columbia, Canada, will only be covered minimally within this plan due to the fact they are outside of the jurisdiction of our planning efforts. Additionally, the area identified as the East WRIA area has been included in this plan (Appendices).

The Okanogan River originates in British Columbia and flows through four lakes (Okanogan, Skaha, Vaseaux, and Osoyoos) before crossing into the State of Washington. The Okanogan watershed encompasses about 2,600 square miles (1.65 million acres) in the State of Washington, and 6,300 square miles within British Columbia (Ecology 1995). The Similkameen River, eighty percent of which lies within Canada with two principle drainages, the Pasayten and Ashnola arising in the Pasayten Wilderness in north central Washington, provides 75% of the average flows to the Okanogan River Basin. The Okanogan River is considered the northernmost geologic dividing line between the Cascade and Rocky Mountain Ranges. The river runs through a mountainous region bounded on the east and west by high forested ridgelines that are steep and rugged with several peaks 7,000 to 8,000 feet above sea level. Lateral ridges that divide the watershed into numerous smaller

[1] Further details can be obtained by reading the Level 1 Technical Assessment (ENRIX, September 2006) and the Okanogan Watershed Water Quality Management Plan (Okanogan Conservation District, updated June 2005), both available for review at the Okanogan Conservation District office.

sub-watersheds extend toward the valley floor and taper to more gently sloped hills at lower elevations. Within Washington State, the Okanogan River runs primarily north to south approximately 79 miles (ENTRIX, Inc. and Golder 2001) from Lake Osoyoos to its confluence with the Columbia River (Columbia River mile 533.5). The Okanogan River floodplain, averaging about one mile wide, descends from 912 feet at the Canadian border to approximately 779 feet at the confluence.

During the last glaciation, more than 10,000 years ago, the Okanogan Lobe of the Cordilleran ice sheet covered much of the Okanogan Basin and rerouted ancestral streams. The retreating glacier left behind thick deposits of unconsolidated silt, sand, gravel, and cobbles as valley fill and terraces along the tributary streams and the mainstem Okanogan River. These glacial deposits are estimated at more than 500 feet thick in certain areas (Ecology, 1995).

The unconsolidated glacial deposits provide the primary water storage in the Okanogan basin. The fractured bedrock contains only very low yield aquifers (Ecology 1974). However, a least one well driller has reported that there are isolated locations of large quantities of water in bedrock.

CLIMATE AND HYDROLOGY

Rainfall/snowmelt provides the primary form of recharge for the aquifers. Groundwater and surface water interact throughout the watershed (Ecology 1995). Irrigation infiltration is an artificial recharge where irrigation is common practice (e.g., Pogue Flats and the Duck Lake Groundwater Management Area)

The climate of the Okanogan River valley is semiarid in the lower valleys and subhumid in the mountains. Cool winter precipitation and dry, hot summer conditions characterize the climate of the Okanogan River Watershed. The climate is influenced considerably by the barrier to marine air that the Cascade Mountain Range provides. Other factors that influence the climate of the region are the mountain and valley formations.

Precipitation in the watershed ranges from more than 60 inches in the upper elevations of the Pasayten and Ashnola sub-watersheds to approximately 8 inches at the confluence of the Okanogan and Columbia Rivers. Winter season snowfall varies from 30 to 70 inches. Snow can be expected after the first of November and remains on the ground from the first of December until March or April. Snow accumulates to a depth of about 10 to 20 inches in the valley, and up to 40 inches at higher elevations.

The hydrology of the Okanogan River Watershed is characterized by high springtime run-off due to spring rains and melting snowpack, with low summer and early fall flows due to nearly absent precipitation and diminishing snowpack. Irrigation practices may have subsequently reduced summer flows.

There are numerous other important tributaries that drain directly into the Okanogan River. Some of the more significant and larger tributaries draining from the west are Johnson, Salmon, Loup Loup, and Chiliwist Creeks. Dams impound Salmon Creek in Conconully Lake and Conconully Reservoir for irrigation. Important tributaries from the east include Tonasket, Antoine, Siwash, Bonaparte, Tunk, Omak, and Nine Mile Creeks.

Significant trends in wet or dry periods have been observed over the past 100 years, and the effects of these trends on water availability need to be considered in watershed planning. For example, the long-term mean annual precipitation at Omak is 11.8 inches, but during a 23-year period from 1917 through 1939, mean annual precipitation averaged 9.6 inches (or 2.2 inches below average per year). For a four-year period within that same time period (1928 to 1931), mean annual precipitation averaged only 6.9 inches. These long-term dry periods have a significant effect on cumulative water storage. In general, shallow (e.g., < 50 ft below ground surface) groundwater levels and groundwater storage are somewhat related to the rise and fall of cumulative departure from average precipitation (CDAP). When CDAP is increasing, more water is available to recharge groundwater, so water tables rise (i.e., assuming no well withdrawals); similarly, water tables decline when CDAP decreases. For example, CDAP decreased about 50 inches over the 23-year period noted above, indicating reduced recharge over this time period, which probably resulted in low water tables (although no data were available to support this inference).

LAND USE INFLUENCES

Both human activities and naturally occurring events favorably and adversely affect the environment and hydrology of the Okanogan River Watershed. Seemingly irrelevant activities can have impacts, direct and indirect, on water quantity, water quality, habitat, natural and artificial means of water storage, and instream flows. For example, forest regeneration can alter species composition.

Forest lands comprise approximately 47% of the Okanogan River basin. Influenced by soil type, elevation, precipitation, and aspect, forests lie in a mosaic across the landscape interspersed with non-forested areas of shrub-steppe.

Forest resources are managed by managing timber and other vegetation. Wood and other products are grown and harvested. Range forage is grazed. Fuels can be managed to reduce wildfire risk. Plantings, specifically designed harvest, and placement of debris or habitat structures may enhance habitat value. The amount and arrangement of forest cover influences water infiltration and runoff.

Our understanding of forests grows through continuing efforts in research, monitoring, and societal discussions. Watershed research continues in areas such as water movement and storage within timber canopy and soils, effects of harvest on snow pack, melt, and runoff, and water quality effects due to roads, harvest, fire and fire suppression, grazing, recreation, and watershed processes such as erosion, hydrology, and riparian function.

The Okanogan-Wenatchee National Forest is implementing a "Dry Forest Strategy" for managing of dry forest vegetation on the portions of the Wenatchee and Okanogan National Forests that support dry forest plant communities (Strategy for Management of Dry Forest Vegetation, Okanogan and Wenatchee National Forests, April 2000). The objective of the Strategy is to provide a framework for management of dense, dry forest vegetation. The framework is intended to identify management objectives appropriate to maintain, protect, and enhance the health of dry forest environments. Further, it is meant to illustrate vegetation and fuel treatments potentially appropriate under various dry forest conditions. This Strategy is adaptive in nature. Refinements and modifications to the Strategy are anticipated as management objectives are met and new information becomes available through research and monitoring.

Hydrology may be altered, increasing peak flows and changing overall water yield and timing of runoff. Timber harvest and roads contribute to these changes (Washington Forest Practices Board, 1997). Operations can cause more dramatic changes in certain portions of a drainage than in other areas, such as in small headwater subbasins with southerly aspects than in other areas. Increases in water yield may provide benefits to water users. Increasing frequency or severity of peak flows can cause fish habitat degradation and increase stream channel instability. Woody debris recruitment to streams may be reduced when timber harvest or road and skid trail locations occur within riparian areas. Large woody debris is an important component of stream channel structure, fish habitat, and instream nutrient processes (Washington Forest Practices Board, 1997).

The native plant communities of the open shrub steppe lands in the Okanogan Watershed have been classified by the Natural Resources Conservation Service (NRCS) into ecological sites. An ecological site is typified by a characteristic hydrology, particularly infiltration and runoff, which has developed over time. The development of the hydrology is influenced by the development of the soil and plant community.

Cropland is defined as that land that is suited to or used for crops. Land devoted to row crops, close grown field crops, orchards, rotation hay and pasture, improved hayland, and summer fallow [NRCS (Natural Resource Conservation Service) Field Office Technical Guide, National Agronomy Manual].

Wheat is the primary cereal grain grown in Okanogan County as well as in the Okanogan River basin (Washington Agricultural Statistics, 1998). Other cereal grains may include spring wheat (variety: Penewawa), spring barley (beardless varieties), and spring oats (Monida or Magnum). These grains are usually minor, in extent, but may be seeded due to certain crop rotations, weather conditions, grain markets and, to some extent, requirements of certain government programs.

Non-irrigated grass hay or grass/legume hay is found in areas that have a high water table, usually located along small creeks in the upland areas and mountain meadows. Most of these sites are harvested once each year (one cutting) or even less frequently. The decision to hay these fields is based on favorable moisture and growing conditions. Total acreage used for non-irrigated hay production in the basin is 20,936. The majority of the hay is raised by livestock operators who use the hay for their own livestock feed. If surplus hay is available, it is sold as a cash crop. Many farmers, who raise hay as part of their rotation, sell to livestock operators. During some years, the hay crop is insufficient to feed the basin’s herd and Columbia basin hay is then brought into the Okanogan River basin to meet livestock needs.

Some truck crops (vegetables and fruit) are grown on a limited basis. These types of crops are usually grown in areas of the Okanogan River valley where there is deep soil, ample water available through irrigation and warm evenings providing the needed “degree days” to raise vegetables. Tomatoes, hot peppers, and sweet corn are examples of these types of vegetables.

There are nine irrigation districts, reclamation districts, or canal companies operating in the Okanogan Watershed. These nine irrigation water providers comprise the bulk of irrigation water delivery from surface water sources to approximately 24,710 acres (Okanogan Conservation District, 1989). The Washington State Department of Ecology’s (DOE) 1995 Initial Watershed Assessment, WRIA 49, Okanogan River Watershed notes that 98 percent of the surface water rights issued in the Okanogan Watershed are for irrigation use. There are 790 surface "paper" water right permit holders for 155,052 acre feet per year, over an area of 57,939 acres (Final WRIA 49 Level 1 Technical Assessment, Appendix A-1.2b).

There are about 80,668 acres of land water-righted for irrigation in WRIA 49, according to the Ecology WRATS/GWIS database. As discussed previously, it is undocumented – and unlikely – that all water rights are fully employed. The County Assessor's parcel database designates a total of 55,321 acres for an agricultural use of some sort. This value would agree reasonably well with the County Assessor's data. The 1999 Okanogan Limiting Factor Analysis (LFA) identified a total of 101,930 acres of crop land in the Okanogan Basin, of which 50 percent (about 51,000 acres) was estimated to be irrigated. Of this, approximately 13,281 acres are irrigated hayland. Most of this is alfalfa that is grown for about seven years then the fields are rotated to small grain for two years of cleanup, and are then planted back to alfalfa. Small grain clean-up crops are typically spring wheat, spring barley, rye, and oats grown for forage hay. There are several hundred acres of irrigated corn grown for silage. Other irrigated forages grown in the watershed are Sudan grass and triticale.

The amount of farmed acres has been decreasing during the last several decades. Many factors have contributed to the decline. Some factors include: continuous suppressed grain prices in the last 25 years (recent grain prices are higher, somewhat overcoming this factor); greater transportation costs because Okanogan County fields are further from markets which puts the Okanogan County farmers in a less than competitive position to the central Washington and Palouse area farmers; yields are typically lower than most areas in the inland northwest. Many fields are small and irregularly shaped. When these small, irregularly shaped fields are farmed with large modern equipment designed to be used on large, regularly shaped fields, efficiency decreases and cost of production rises. The economics of raising grain in Okanogan County do not allow for many full time farmers. It takes approximately 4,000 acres planted in dryland grain to support a family. The infrastructure associated with grain production is not in Okanogan County. Today, the majority of the dryland cropland is leased to farmers from Douglas County. The dry cropland area near Molson is farmed by local farmers; however, grain production is usually a part of a diversified farm operation, which may also include raising hay, cattle, and forest products.

In many cases, terraces above the Okanogan River were developed into orchards between the mid-1970s and the mid-1990s. Within the last decade, however, this trend has reversed and orchards are being converted to residential housing or subdivided into small rural farms.

WATER QUANTITY

Water use is described in terms of the amount of both surface and ground water used. The major uses of water in WRIA 49 are for agricultural and municipal and domestic purposes. Water may be taken for use either from exempt wells (exempt from the requirement to obtain a water right certificate), or from a water right stating the purpose, place of use, and amount of water that may be used (including any seasonal or other restrictions on the timing of use) (Final WRIA 49 Level 1 Technical Assessment, page 3-11).

State water well data suggest that there may be about 3,300 exempt wells in the WRIA 49. As is true of many other regions, there has been an increasing trend to drill wells, with the number of new wells per year multiplying by a factor of three through the 1960s and 1970s. In the 1980s and 1990s the numbers of new wells continued to double, flattening off in the 2000-2005 period at 142 new wells per year. These data may reflect an increase in WRIA 49 land development in more remote areas, far from public water service (Final WRIA 49 Level 1 Technical Assessment, pages 3-12 & 3-13).

There are 8,040 total connections (residential and non-residential) reported to be served by public water systems in WRIA 49, most of which are residential. The average annual residential use in the City of Omak is about 470 gallons per household per day and Okanogan's approximately 430 gallons per household per day.2 In the City of Okanogan the summer use is approximately 722 gallons per household per day and winter use is 156 gallons per household per day. Summer use is approximately 80 percent of the yearly use while winter use is 20 percent in the City of Okanogan. In the city of Omak, the summer month's use is 980 gallons per day per household while winter usage is 264 gallons per day per household.

There are a total of 25 WRIA 49 water rights with "CI" (Commercial and Industrial) purposes. These are almost entirely served by ground water and have appropriated 8,529 gpm and 11,101 AFY of water. These represent 4.5 percent of instantaneous ground water rights and 10.8 percent of annual water rights in WRIA 49.

Based upon a rough estimate by ENTRIX that half of WRIA 49 water rights are not in current use, it appears that while there may be over-appropriation of both surface and ground water in some basins, it is doubtful that there is overuse.

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[2] Ray Clements, City of Okanogan Public Works Director and Chad Short, City of Omak, Assistant Public Works Director; personal communication with Bob Clark, Okanogan Conservation District, March 20, 2009.

Looking at the total incorporated demand, demand in unincorporated areas, and total WRIA 49 demand, projected growth figures demonstrate that: (1) most demand growth is driven by growth in residential demand, and (2) most of that demand growth occurs in unincorporated areas.

Farmland conversion is occurring and less land is irrigated now than in the past. This trend is expected to continue, and would offset the decrease with growth in domestic and municipal water demand in the Okanogan River Basin.

In round numbers, the projected growth of water demand in WRIA 49 by 2026 (not including offsetting reduction in agricultural water use) is roughly 2,000 MGY. This is equivalent to approximately 6,500 AFY, or continuous pumping of 4,000 gpm, or continuous diversion of 9 cfs. This is not a great deal of water, particularly framed as an increase in demand over 20 years.

All of the six largest Group A water systems in the WRIA (Brewster, Okanogan, Omak, Oroville, Riverside, and Tonasket) currently have surplus pumping capacity and surplus source capacity to meet existing demand. Existing instantaneous water rights are also more than sufficient to meet current demand, but not all of the water systems may have sufficient water rights to meet water demand on an annual basis. Both Brewster and Riverside appear to be fully using their existing water rights to meet current needs, and appear to have no margin left to serve new growth.

Looking at instantaneous water rights with growth projected to 2026, both Omak and Tonasket have a large surplus; Oroville's water rights are more than adequate; and Okanogan has an adequate margin. Riverside (433 gpm) and Brewster (45 gpm) would require additional water rights to serve growth.

On an annual basis, all the municipal water systems except Omak would need additional water rights by 2026. Deficits range from 78 AFY (Tonasket) to 887 AFY (Brewster). Detailed data for all the water systems, including these projections, are contained in Appendix A 3.2 of the Level 1 Technical Assessment.

WATER QUALITY

Water quality data collected from the mainstem Okanogan River and each of its tributaries were examined and compared against existing Class A and Class AA water quality numeric criteria recognized in the State of Washington. Other relevant biological or physical metrics were used in cases where no specific criteria have been made. The water quality data were obtained from the CCT, the OCD, and DOE. Data collected by OCD for the Okanogan Water Quality Management Plan (OCD 1999, revised 2005) over the past five years have produced baseline water quality measurements in most of the major tributaries in the Okanogan basin from which to gauge conditions.

Principal findings of the conventional water quality parameters from the Okanogan River and its tributaries include temperature, dissolved oxygen, pH, turbidity, fecal coliform, metals, and organic pollutants.

Class A temperature standards were exceeded in the Okanogan mainstem and in multiple monitoring stations in Omak, Tunk, Salmon Creek, and Wannacut creeks, and at the lower Sinlahekin, Bonaparte, Antoine, and middle Tonasket creek monitoring stations. This essentially basin-wide finding is not new. The potential to enhance riparian cover in tributary systems to provide shade and lower temperatures could be explored through additional habitat analysis. There are areas where temperature is not regularly noted as a problem and these tributaries include Chiliwist, Tallant, Johnson, Siwash and Loup Loup creeks. These areas probably experience cooler temperatures due to being heavily forested.

Dissolved oxygen did not meet water quality criteria in more than 10 percent of samples analyzed in lower Tunk Creek, Salmon Creek, Johnson Creek, Bonaparte Creek, Antoine Creek, Tonasket Creek, and Ninemile Creek. A large number of tributary systems that failed to meet Class A dissolved oxygen criteria could be problematic, as oxygen deficits severely limit the functional value of aquatic systems to support aquatic life.

The Okanogan mainstem and tributaries are almost uniformly alkaline (well above neutral readings of 7). The degree to which pH is affected by land use activities is unknown, but could be explored in subsequent analyses.

Turbidity increases with total suspended solid (TSS) loads and is an optical measure of light penetration or light refraction, depending on the method of measurement. Factors that contribute to TSS include suspended sediment, suspended organic matter, and dissolved organic matter. The precise relationship between turbidity and TSS is generally basin specific, and depends on the source geology and organic matter in a system. In the Okanogan basin, turbidity regularly exceeds 50 nephelometric turbidity units (NTU) in the mainstem and in a variety of tributaries but no basin-wide background turbidity has been established therefore the data should be considered qualitative and preliminary. In general, the impact of turbidity on aquatic life generally depends on the duration and frequency of events where it is measurable above background levels. Without a site-specific analysis of turbidity effects on biological resources in the basin, identifying additional systems that may be affected is speculative. Establishing the relationship between TSS and turbidity for a "model system" within the watershed (e.g., Omak or Bonaparte Creek) could provide data to develop a relationship further that could be applied to many other tributaries in the Okanogan basin with similar geology. This could yield a powerful tool by which to predict sedimentation loads entering the mainstem Okanogan from simple turbidity measurements.

Fecal coliform exceeded water quality criteria relatively often in the mainstem and in some tributaries (e.g., Bonaparte & lower Sinlahekin Creek). Exceedances may arise from multiple sources, and are likely most easily addressed at the tributary scale. Many tributaries have not been sampled for this parameter, so identifying sources will require more sampling. However, sampling in the mainstem in particular exhibited seasonal trends, with counts highest between May and October. This seasonal pattern may reflect greater direct contact with the water by livestock and wildlife during the late spring to early fall months.

Collectively, the results of the metals sampling conducted by DOE and the OCD do not suggest there are basin-wide issues with metal contamination with the exception of Tunk Creek, where copper and lead were detected above metal criteria. However, sampling has not been conducted in many tributary basins, including some with a mining legacy.

Dichlorodiphenyltrichloroethane (DDT) and related compounds (DDE, DDD, etc.,) and PCBs appear to remain a problem in some isolated areas. However, current evidence does not suggest these persistent organic pollutants, for which Total Maximum Daily Limit (TMDL) studies have been conducted, are a problem basin-wide.

WATER STORAGE

There were two previous studies of potential water storage opportunities identified, one in the Salmon Creek area and the other on the Similkameen River. The Salmon Creek study was completed in 1998-1999 and provided a "fatal flaw" level of screening considering the timing and amount of water potentially available at each storage site, the cost and timeframe to develop storage at the site, engineering feasibility, regulatory requirements, and environmental costs and benefits. This study was completed for a Joint Committee comprised of the Colville Confederated Tribes (CCT) and Okanogan Irrigation District (OID). It was particularly sensitive to environmental conflicts, because environmental restoration (of Salmon Creek) was the goal of the project. This study considered aquifer storage and recovery (ASR), and several specific surface sites, as well as a new reregulating reservoir for

OID. Brown Lake and a high dam at Salmon Lake were considered the most feasible among the surface storage sites. Data for evaluating groundwater storage (ASR) were quite limited, but was considered capable of producing a firm yield of 800 acre-feet per year at a cost of approximately $2.5 million.

Storage opportunities on the Similkameen River have been studied historically by the Army Corps of Engineers and the Oroville-Tonasket Irrigation District (OTID), and have been more recently considered by the Okanogan PUD. Storage using flashboards at Enloe Dam was submitted to DOE by the WRIA 49 Planning Unit but was not funded by Ecology; reason given was that the Planning Unit had not completed its Watershed Plan.

OTID and its predecessor (West Okanogan Valley Irrigation District) studied and obtained rights to storage at Palmer Lake. There was opposition to raising the water level of Palmer Lake to store water, especially after residential septic systems have placed near the shoreline. Ultimately, the OTID exchanged its Palmer Lake storage right for a foot of storage water in Lake Osoyoos to help the District provide water to its irrigators during drought years.

In 1948, the Corps issued a study of major storage and hydropower opportunities on the Columbia River and its tributaries. A high dam at Shanker's Bend was included in that study, but was not constructed (although most, if not all, of the other projects were). The site was studied in the 1950's, 1970's and 1980's. The site appears to offer potentially regional storage benefits, providing hydroelectric generation, water storage, and flood control, as well as potential improvements to fish habitat in the Okanogan. Various configurations of the project have entailed as much as 1.6 million acre-feet of flood storage, 84 megawatts of electric power generation, and 162,000 acre-feet of usable water storage. The Shanker's Bend project is being considered again by DOE and the Okanogan PUD.

INSTREAM FLOWS

WRIA 49 is comprised of numerous drainage basins. The Similkameen River is considered a major tributary to the Okanogan River. Its flow is, on average, actually more than 4.4 times the flow of the Okanogan where the two rivers join south Oroville. About 90 percent of the Similkameen River drainage is from Canada. Only 10 percent of the drainage is within Washington from Sinlahekin Creek and its primary tributary Toats Coulee Creek, as well as from other streams (Paysaten and Ashnola). Sinlahekin Creek drains into Palmer Lake, which empties into the Similkameen River through Palmer Creek. There are numerous other important tributaries that drain directly into the Okanogan River and some of the more significant and larger ones draining from the west are Johnson, Salmon, Loup Loup, and Chiliwist Creeks. Dams impound Salmon Creek in Conconully Lake and Conconully Reservoir for irrigation. Important tributaries from the east include Tonasket, Antoine, Siwash, Bonaparte, Tunk, and Omak Creeks.

There are several data sets with long-term continuous records, short-term continuous records, individual point data from throughout the year, or only very short-term seasonal data regarding flow that have been collected from DOE, OCD, CCT, BOR and the USGS. For those tributary streams for which data are available, the estimated mean annual flows per square mile are highest in the Sinlahekin Creek (~448 ac-ft/sq mi), Similkameen River (~433 to 478 ac-ft/sq mi), and North Fork Salmon Creek (~460 to 491 ac-ft/sq mi) and lowest in the Bonaparte Creek (~21 to 37 ac-ft/sq mi) and Tunk Creek (~21 to 52 ac-ft/sq mi). Peak discharges typically occur during the 4-month period from April through July, reflecting primarily snowmelt or snow on rain events, when streams contribute about 70-80 percent of their average annual discharge. Low flows generally occur from August (Johnson Creek) to October (Okanogan River) depending on the stream, but prior to the beginning of autumn rainy periods. In some cases, the streamflow hydrographs are influenced by upstream diversions or regulation (e.g., Whitestone Creek). Some smaller streams freeze up during winter and have no flow until the spring flaw.

HABITAT

Quantitative data characterizing habitat types, using standardized repeatable methods, exist for only a limited number of sites in the Okanogan basin. In recent years, great progress has been made in characterizing certain elements of habitat (i.e., water quantity, water quality) and these data are described in greater detail in other sections of this document. Other important elements of habitat such as stream bed configuration, substrate characteristics, bank characteristics, hydraulic properties, channel geometry, etc. remain uncharacterized throughout the basin.

An Aquatic Habitat Assessment conducted by ENTIRX provides a comprehensive representation of the type, proportion, and distribution of channel types, and thus habitats, in the Okanogan basin. The structure and variability of stream channel habitat is predominantly a function of channel slope (gradient), which is largely determined by topography (Montgomery 1999). Therefore, it was possible to broadly classify the types of stream habitat that might occur at a given location using maps of the stream channel location and widely available elevation models that portray basin topography. These methods are described in greater detail in Appendix E of the Level 1 Technical Assessment.

A second objective of the Assessment was to summarize newly acquired information on site specific locations and provide an assessment of the relative quality of the habitat.

Approximately 99 percent of the mainstem Okanogan and Similkameen River can be classified as low-gradient valley or pool-riffle reaches (Attachment 2 — Map Atlas, Gradient and Channel Characteristics, Level 1 Technical Assessment). These gently sloping stream channels are punctuated at intervals by relatively high gradient reaches. Cascades are the next most abundant reach type. More than half of the pool riffle reaches are located in the Similkameen River (eleven miles). The mainstem Okanogan and Similkameen Rivers, within the United States, are heavily utilized by steelhead trout for spawning. Of the spawning that occurs in the mainsteam rivers, redd densities are highest near the confluence of the Similkameen and Okanogan Rivers. While spawning occurs throughout the mainstem Okanogan, redds appear to be concentrated in areas immediately downstream of mainstem-tributary confluences (e.g., Omak Creek, Tunk Creek, and Bonaparte Creek). The role that tributaries may play in maintaining mainstem spawning habitat, either through transport and deposition of sediment or altered hydraulic properties is a topic that merits further investigation. Fine sediments comprised a relatively large proportion of the substrate types at all of the mainstem study locations (Figure 6.2-1, Level 1 Technical Assessment). This is typical of large low-gradient rivers.

Wood loading was ranked as poor for all mainstem study reaches (Table 6.2-1, Level 1 Technical Assessment). However, it should be noted that while the evaluation criteria used in this assessment have been applied to Eastern Washington streams, as originally used in the Okanogan LFA (ENTRIX and Golder 2001) they were originally developed for small streams (<15 m in width) in western Washington. However, the evaluation criteria do not consider ecoregional differences in riparian stand density or in potential tree size, both of which are important factors in determining whether wood pieces delivered to the stream influence channel morphology. As such, the criteria may be overly conservative and suggest that "poor" conditions exist in circumstances where wood loading is appropriate. The structure of eastside riparian forests under natural conditions have not been systematically characterized in the same manner as riparian forests in western Washington (Collins and Montgomery 2002, Collins et. al. 2003) and is an information gap that could be addressed in future studies. Another information gap for eastern Washington streams in the role of wood in larger low-gradient streams. Contrary to conventional wisdom, large wood pieces can, and do, affect channel morphology through the formation of floodplain islands, wood jams and rafts, and channel avulsion (Fetherston 1995, Abbe and Montgomery 2003) and thus play a critical role in structuring aquatic habitats.

The percentage of surface area comprised of pool habitat at the mainstem study reaches sampled ranged between 42 and 100 percent (Table 6.2-2, Level 1 Technical Assessment). One of the sites ranked as "fair" is intensively used for spawning by steelhead trout (Colville Tribe 2005). Seven of the study reaches lacked riffles altogether.