CHAPTER 9. CHANNEL CHARACTERISTICS

This chapter will summarize background information about stream energy, channel morphology, channel classification, pools, riffles and related topics. The background information provides a common understanding of streams, but is not overly specific to the Lower Sprague-Lower Williamson watershed assessment area. At this time, limited data are available on channel characteristics within the assessment area, particularly at a large scale. Many site-specific assessments of channel characteristics have been conducted at different stream reaches within the system, but no comprehensive study of the channel characteristics within the assessment area has been located.

STREAM ENERGY

General features of stream and river systems reflect the long-term constraints of geology, landform and climate and the resultant vegetation patterns. During landscape evolution, stream characteristics such as drainage density, stream order, and the longitudinal channel profile develop from the interaction of runoff and stream sediment transport processes.

Channels undergo many subtle and not easily detected changes from season to season, and from year to year. A riffle may scour during the high flow and immediately backfill as flow decreases and, to the casual observer, no change has occurred. Channel changes are a part of the natural equilibrium in stream dynamics. Recognizing that channels are constantly changing, both the immediate and long-term effects of changes need to be considered. Knowledge of stream dynamics and energy dissipation is fundamental for understanding how channels change.

Channels are formed in 1.5-year return interval runoff events. The floodplains are also built during these events. The interaction between channel change, migration and floodplain development are important to understand in order to evaluate management practices and restoration activities.

Precipitation that falls on a catchment is forced by gravity along a downward path toward the ocean, and a certain amount of potential energy will be dissipated in transit. The water's initial elevation above sea level determines the total amount of potential energy available to do work. Once the water heads downstream, the potential energy is converted to kinetic energy. Some kinetic energy is utilized for sediment transport, bed scour and bank erosion, but more than 95 percent is ultimately consumed as heat loss during turbulent mixing within the main flow, as well as along channel margins (Morisawa 1968).

At a given location along a stream, the availability of energy to do work depends upon the time-rate loss of potential energy (Bagnold 1966) or total stream power. Unit stream power can be defined as the time-rate loss of potential energy per unit mass of water. In this equation, the energy slope of flowing water is often assumed to be approximated by channel gradient. The unit stream power concept is important because it provides a basis for understanding the erosive capability of flowing water in open channel systems. Channels that are steep, straight, with hydraulically "smooth" banks and beds, uniform in cross-section, and of large hydraulic radius will be associated with relatively high unit stream powers. However, the unit stream power of the channel sections can be reduced in several ways.

A stream channel that changes from being relatively deep and narrow to being shallower and wider (i.e., increase in width-to-depth ratio) may experience a concurrent loss of pools, which often provide important in-stream habitat for fish. Because bed shear stress would be increased in a wide, shallow cross-section, such channels would have relatively high potential for bedload transport and bank erosion, and would generally be characterized as unstable. Channels with these types of cross-sections occur naturally but can also be the result of increased sediment loads, increased peak flows, decreased riparian vegetation (particularly woody species), mechanical damage to streambanks (by heavy equipment, livestock or grazing, or ice flows), or some combination of these factors. More detailed discussions of stream hydraulics and sediment transport can be found in Leopold et al. 1964, Bagnold 1966, Morisawa 1968, Dunne and Leopold 1978, and Richards 1982.

CHANNEL MORPHOLOGY

Methods to characterize small stream channel morphology generally use some expression of width and depth. However, channels are not uniform in their cross-sectional shape and any width-to-depth measurement is only a relative index to the actual channel shape. Channel morphology is related to a large number of interacting variables, so the expected width or depth of a particular stream reach cannot easily be predicted. In general, width usually increases faster than depth downstream. The width-to-depth ratio could be used as a dimensionless index of channel morphology and would be useful for comparing upstream and downstream reaches. Due to the complex nature of the interactions in the stream channel, however, comparisons of width-to-depth ratios should be made only for streams of equal order or drainage area. Different flows also provide different channel characteristics, as is illustrated in the differences between the effects of 5-year, 10-year, 25-year and 100-year runoff events.

Any attempt to characterize stream channel morphology must recognize its three-dimensional aspects. Even though average widths and depths can generally index the amount and quality of in-stream habitat (Beschta and Platts 1986), longitudinal variability in width and depth is also important. One stream may express a uniform depth and width and have insignificant amounts of fish-rearing habitat. Yet, in another segment of the same stream with essentially the same average width and depth, but formed so that there are shallow riffle sections that are interspersed with deep pools and overhanging banks, there may be relatively abundant rearing habitat. The patterns of variations in width, depth and channel morphology are not entirely random, but are often grouped so as to provide a hierarchical structure to a stream system (Frissel et al. 1985). Even though alluvial channels do not have fixed spacing of pools and riffles, nearly 90 percent of the pool-riffle sequences may consist of channel reaches 3 to 9 widths in length. Where bed and bank characteristics are controlled by large roughness elements, the expected size and spacing of morphological features may be more variable.

Schumm's (1977) complex response concept identifies several expected changes in channel morphology by stream systems undergoing changes in flow or sediment availability. Increased high flows tend to increase channel width and depth. Increased sediment availability and transport tend to increase width, steepen gradient by decreasing sinuosity and decrease depth. If a channel is undergoing widening, it may be responding to increases in flow, increases in sediment availability, some other factor (such as loss of streamside vegetation), or a combination of all of these.

Pools

Pools are a major stream habitat for most fish. Salmonids often require back water or dammed pools with water moving at low velocities to survive harsh winter conditions. Elser (1968) and Lewis (1969) demonstrated that deep, slow velocity pools with large amounts of overhanging cover support the highest and most stable fish populations. Platts (1974) found that high-quality pools also supported the highest fish biomass. In the South Fork Salmon River drainage of Idaho, where Platts conducted this research, pool quality was an important factor that accounted for explained variation in total fish numbers. High-quality pools alone, however, do not make the fishery. Pools of all shapes, sizes and qualities are needed. Young-of-the-year need shallow, low-quality pools that other fish will not use. Increased growth allows them to eventually compete, without undue predation, in the higher-quality pools, which have better food supplies and winter rearing habitat.

Pools generally result from localized scour during moderate to high flows. The fact that a pool has formed indicates that the location is one of intense turbulence and energy dissipation during high flows. In many instances, subtle changes in channel dimensions or roughness may be sufficient to initiate pool formation and maintain pools over time (Keller and Melhorn 1973). The narrowing of channel banks can cause a converging of flow lines and acceleration of water; the gain is kinetic energy ultimately dissipated as turbulence along the bottom of a downstream pool. Although pools may form in this manner along straight reaches of a stream, they are more commonly formed at bends, where flows are deflected by channel banks, turbulence is intense, and the bed is erodible. Pools can also be formed by large roughness elements. For instance, water flowing over a log partially or wholly buried in the bed, boulders, or bedrock outcrop may create a pool immediately downstream. The size, frequency, distribution and quality of pools in a stream depend upon the mechanisms of formation and other characteristics, such as size of channel substrates, erodibility of banks, size of obstruction and depth of flow.

Riffles

Riffles, which are seen during periods of low flow when substantial portions of the channel bed may become exposed or have relatively shallow water flowing over it, are remnant channel features formed at higher flows. Riffles are major storage locations of bed material. In a meandering stream, riffles are ideally located between successive pools at the inflection point of the thalweg (the line following the lowest points of the riverbed). Their form represents a balance between the frequency and magnitude of flows, sediment transport, and other channel characteristics such as obstructions, bank erosion or deposition. Keller and Melhorn's (1973) description of diverging flows may be an important mechanism of riffle formation, though other mechanisms undoubtedly exist. As water moves out of a highly turbulent pool during high flow, it encounters a lower effective slope, hence reduced stream power, and may deposit coarse bedload sediment in transport. As the water continues to pass over the riffle, it accelerates until again expending most of its kinetic energy, as turbulence, at the next pool. Side channel dumps of sediment also form riffles.

THEORY AND FIELD METHODS

The ability of scientists and resources managers to provide for the most efficient channel form should be based on specific conditions of the fluvial system. There are few generalizations drawn from scientific studies of channel form that can be useful in practical problems of river restoration or maintenance. Width is the morphologic parameter most easily altered by the river. If the river is deprived of some of its natural discharge, and sometimes at natural flow levels, it will narrow its channel. Bank erosion usually will follow unusual or unnatural alteration in sediment supply or a change in water sediment relation. An alteration in channel gradient (slope) is the most disruptive to the natural equilibrium. An increase in gradient is the main reason that channel straightening or channelization is so destructive to river systems. Also, river curves provide an essential source of hydraulic resistance necessary for equilibrium.

To develop maintenance and restoration objectives, a procedure might include the following steps: inspect the channel upstream and downstream of the reach exhibiting problems; inspect nearby or similar valleys that appear more natural; and choose a reach of natural river that appears to represent the condition of the problem channel before it was disturbed or disrupted.

It is important to consider the principal morphological features of the river channel that must be retained or restored. First, the slope or gradient of the channel must be the same as it is in the natural or undisturbed reach of the river. The deviation from this natural slope, as with drop structures or grade control, is the clearest reason that the channel may be making additional adjustments.

The second consideration is channel width. The width must represent the bank full dimension such that when the normal bank full discharge is exceeded, the water will overflow onto a floodplain of much greater width. Thus both width and depth at bank full discharge must be considered, and an overflow area provided for greater discharges.

If river curves that are present in the undisturbed reaches have been eliminated or importantly changed in the disturbed area, they must be reinstalled by physically constructing them. The layout of curves is the principal way the desired gradient is maintained or restored. No natural channel is straight, so the restoration of curves of appropriate size and shape is a main element in river restoration. The bed elevation should vary, in that pools occur in the curved reach and shallower zone in the crossovers.

The dimensions of width, depth, meander length, radius of curvature, slope and other features have been published for many regions in the United States. These dimensions can be used when evaluating channel morphology as a way to roughly check those same dimensions measured in undisturbed reaches of the river being studied.

By observing a river, it should be obvious that a grade control structure flattens the channel gradient upstream for only a short distance and puts an unnatural anomaly into the fluvial system. Such an anomaly will be attacked by the flow and, given time, will be eliminated. An unnatural anomaly will ultimately be destroyed by undercutting, by lateral erosion of the abutments, by scour hole erosion at the toe, or by some combination of these processes.

If a reach of channel is suffering unusual bank erosion, downcutting of the bed, aggradation, change of channel pattern or other evidence of disequilibrium, a realistic approach to amelioration of these problems should be based on restoring the natural combination of dimension and form characteristics of similar channels in quasi-equilibrium. These characteristics include appropriate values of width, gradient, pool and riffle sequence, length, radius, amplitude of curves and meanders, and hydraulic roughness.

CHANNEL CLASSIFICATION

Stream channel characteristics such as width, depth or number of pools in a section of stream are determined by many factors, including topography, geology, hydrology and climate. Additionally, vegetation conditions and the history of disturbance, such as floods, fires, landslides, road construction, channel modification, or livestock and timber management practices may influence stream channel conditions. High in the watershed, slopes are steep, and the rapid stream flows readily erode sediment, gravel and rocks from the banks and bed. Lower in the watershed, streams often meander across the valley bottoms and may divide into multiple channels. These features may provide stream channel characteristics that respond predictably to natural and human-caused modifications and may be classified into channel habitat types (CHTs). Clasifying current CHTs in the watershed helps to: (1) evaluate basin-wide stream channel conditions, (2) understand how land use activities may have affected the channel form, and (3) predict how different channels may respond to particular restoration efforts (WPN 1999). Ultimately, changes in watershed processes will affect channel form and produce changes in habitat for fish and other organisms.

Channel responses to changes in ecosystem processes are strongly influenced by channel confinement and gradient (Naiman and Bilby 1998). Classifying stream channels in the watershed may help identify which stream segments are most affected by disturbances, and which segments are most likely to respond favorably to restoration activities. As an example, more confined, higher gradient streams provide little response to restoration efforts.

In-channel structures and activities associated with human activities such as ditching and streambank stabilization (for example with riprap) and flood control can adversely affect aquatic organisms and their associated habitats by changing the physical character of the stream channel. These changes can ultimately alter community composition of in-stream aquatic biota.

Identification of channel modification activities can help in determining the likely effect of human-caused channel disturbances on channel morphology, aquatic habitat and hydrologic functioning.

Unfortunately, not much data exist regarding the specific locations of channel modifications and historical channel disturbances. Information presented in this section is based on existing relevant data, but many sources of channel modification are undocumented.

The key questions addressed in this section are:

1. What are the channel habitat types?
2. What are the changes in watershed conditions?
3. What are the major modifications to channel morphology?

Designation of Channel Habitat Types

CHT categories, listed below, are based on stream geomorphic structure, including stream gradient, channel size and channel pattern. In "Applied River Morphology," Rosgen (1996) defined these CHT categories. Topography in the Lower Sprague-Lower Williamson subbasin is characterized by moderate to steep gradient uplands that move quickly into low gradient lowlands. Low gradient streams with extensive floodplains tend to be especially sensitive to the effects of watershed disturbance (see Figures 9-1 and 9-2).

Type Aa+ Channels

Rosgen Type Aa+ channels are confined, very steep gradient streams (greater than 10 percent) found in the headwaters of the stream network. During high flows, the stream may appear as a torrent or waterfall. Type Aa+ channels typically have a step/pool morphology with chutes, debris flows and waterfalls.

Type A Channels

Type A channels are similar to Type Aa+ channels but are found on slightly less steep gradients. These channels have similar landform characteristics and gradients ranging from 4 percent to 10 percent. Type A channels are often small streams high in the stream network, although sections of Type A channels may be found along larger streams as well.

Type B Channels

The B channel designation includes streams having moderately steep to gently sloped channels, with low rates of aggradation and stream bank erosion. Type B channels are moderately entrenched.

Type C Channels

Type C channels are low gradient, with generally less than 2 percent slope. They are frequently found in valleys formed by alluvial deposits. Type C channels characteristically meander across the valley floor and form point-bars on inner bends.

Type D Channels

Type D channels are shallow, wide and braided, with active bank erosion. They are low gradient and often include multiple channel systems.

Type DA Channels

Type DA channels are low gradient, multiple channel systems, which are generally stable and deep relative to channel width.

Type E Channels

Type E stream segments are characterized by a gentle gradient, similar to Type C, but Type E streams are narrower and deeper than Type C streams, and are more stable.

F Channels

Type F streams are entrenched, meandering streams that are not stable, and are continually eroding, depositing sediment and gradually re-establishing a functional floodplain. In the absence of severe disturbance to the stream system, Type F streams may transition to Type E as they become stable.

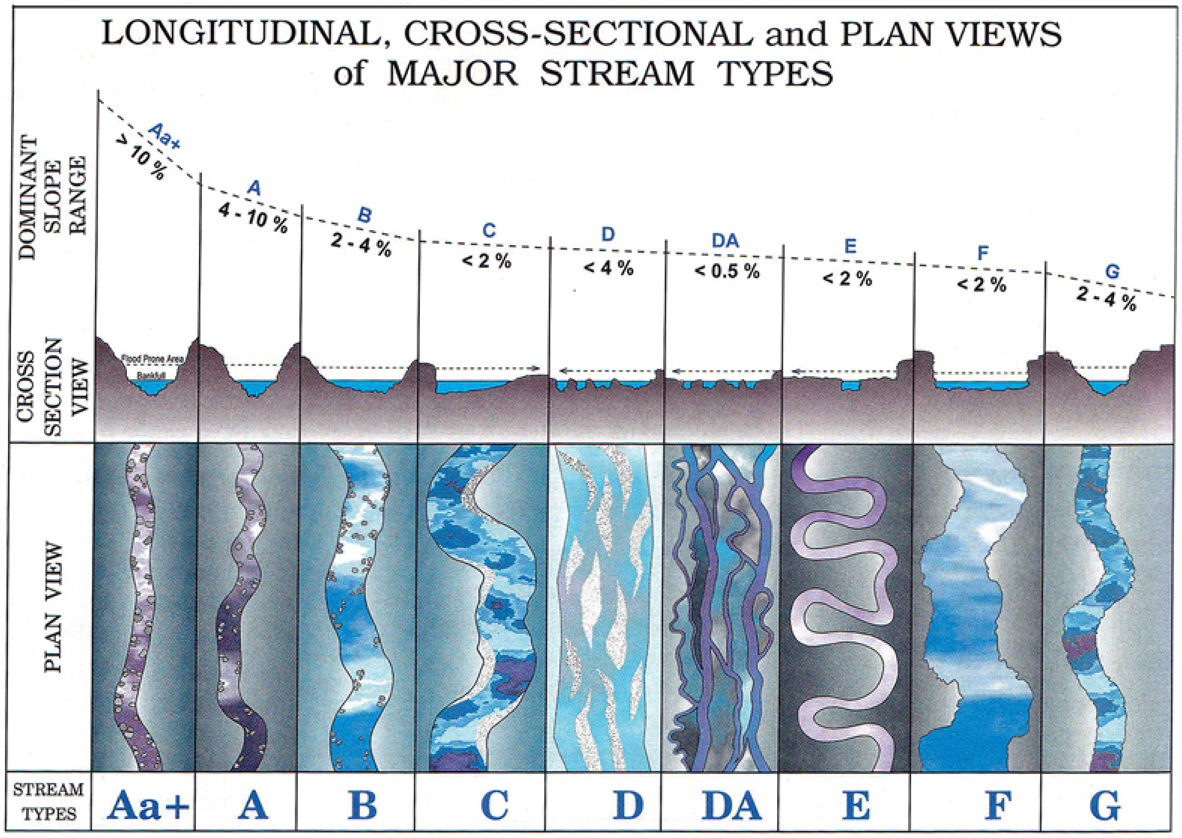


Figure 9-1 Rosgen Channel Classes
(Data Source: Rosgen 1996)

Table 9-1 Rosgen channel type descriptions for the Lower Sprague-Lower Williamson subbasin
(Data Sources: Rosgen 1996, WPN 1999)

Rosgen Channel Type	Comparable OWEB Stream Type(s)	General Description	Entrenchment Ratio	Width-to-Depth Ratio	Sinuosity	Slope (%)	Landform/Soils/Features
Aa+	VH SV	Very steep, deeply entrenched, debris transport streams.	< 1.4	< 12	1.0 to 1.1	>0.10	Very high relief. Erosional, bedrock, or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with deep scour pools; waterfalls.
A	SV BC MV MH	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder-dominated channel.	< 1.4	< 12	1.0 to 1.2	0.04 to 0.10	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step/pool bed morphology.
B	MH MM	Moderately entrenched, moderate gradient, riffle-dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 to 2.2	> 12	> 1.2	0.02 to 0.039	Moderate relief, colluvial deposition and/or residual soils. Moderate entrenchment and width-to-depth ratio. Narrow, gently sloping valleys. Rapids predominate, with occasional pools.
C	LM FP1 FP3	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains.	> 2.2	> 12	> 1.4	< 0.02	Broad valleys with terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channel. Riffle-pool bed morphology.
D	AF FP2	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	N/A	> 40	n/a	< 0.04	Broad valleys with alluvial and colluvial fans. Glacial debris and depositional features. Active lateral adjustment, with abundance of sediment supply.

Table 9-1. Continued.

Rosgen Channel Type	Comparable OWEB Stream Type(s)	General Description	Entrenchment Ratio	Width-to-Depth Ratio	Sinuosity	Slope (%)	Landform/Soils/Features
DA	LM LC	Multiple channels that are narrow and deep, with expansive, well-vegetated floodplain and associated wetlands. Very gentle relief with highly variable sinuosities. Stable streambanks.	> 4.0	< 40	Variable	< 0.005	Broad, low gradient valleys with fine alluvium and/or lacustrine soils. Multiple channels controlled geologically, creating fine deposition with well-vegetated bars that are laterally stable and broad wetland floodplains.
E	FP1	Low gradient, meandering riffle/pool stream with low width-to-depth ratio and little deposition. Very efficient and stable. High meander width ratio.	> 2.2	< 12	> 1.5	< 0.02	Broad valley/meadows. Alluvial materials with floodplain. Highly sinuous with stable, well-vegetated banks. Riffle/pool morphology with very low width-to-depth ratio.
F	LC	Entrenched meandering riffle/pool channel on low gradients with high width-to-depth ratio.	< 1.4	> 12	> 1.4	< 0.02	Entrenched in highly weathered material. Gentle gradients, with a high width-to-depth ratio. Meandering, laterally unstable with high bank erosion rates. Riffle-pool morphology.

Modifications to Stream Channel Conditions

Reservoirs

A reservoir is considered to be "a constructed basin formed to contain water or other liquids" (USGS 1999b). Modifications to the stream channel in the form of dams and reservoirs can affect not only the impoundment area, but also downstream channel morphology, water quality, and fish habitat and passage. Several reservoirs exist in the Lower Sprague-Lower Williamson subbasin (Table 9-1). The reservoirs listed in Table 9-1 are mapped reservoirs. Use of mapped reservoirs only probably underestimates the number of reservoirs within the subbasin, because many smaller irrigation reservoirs and holding ponds are not large enough to be mapped at this scale.

The Sprague River and Williamson River watersheds have the least number of mapped reservoirs of the watersheds in the assessment area, with one and two reservoirs respectively. The Sprague River watershed reservoir is relatively small (0.06 acres), whereas the Williamson River watershed reservoirs are larger (0.34 and 0.59 acres).

The North Sprague River watershed exhibits seven mapped reservoirs, ranging in size from 0.05 acres to 0.59 acres. The West Sprague River watershed has eight mapped reservoirs. This watershed exhibits the largest mapped reservoir within the subbasin, the Long Prairie Reservoir (2.22 acres).

Table 9-2 Reservoir distribution in the Lower Sprague-Lower Williamson subbasin (Data Source: USGS 2007)

Watershed Name	Reservoir Name	Area (m^2)	Area (acres)
North Sprague River	Grade Reservoir	271.5	0.07
	John Smith Reservoir	804.0	0.20
	Junction Reservoir	440.0	0.11
	Pothole Reservoir	352.5	0.09
	S Grade Reservoir	319.0	0.08
	Unnamed Reservoir	2,368.0	0.59
	Wigwam Reservoir	194.5	0.05
Sprague River	Unnamed Reservoir	248.0	0.06
West Sprague River	Borrow Reservoir	590.0	0.15
	Lone Pine Reservoir	434.0	0.11
	Long Prairie Reservoir	8,990.0	2.22
	Long Reservoir	259.5	0.06
	Mahogany Ridge Reservoir	469.0	0.12
	Prairie Reservoir	440.5	0.11
	Quarry Reservoir	579.5	0.14
	Rocky Hole Reservoir	900.5	0.22
Williamson River	Hilltop Reservoir	1,378.0	0.34
	Lobert Draw Reservoir	2,376.5	0.59

Splash Dams and Stream Cleaning

Splash dams, which are small dams made of logs and shrubbery piled in the stream channel to hold back and divert water, have been used throughout the watershed. The history of stream cleaning, which is the removal of debris, vegetation and sediment from the stream channel, is somewhat unclear. It is certain that this practice has been used on both public and private lands in the Lower Sprague-Lower Williamson subbasin. Logs were transported only in the lower reaches of the Sprague and Williamson rivers, as flows were too low in other areas.

Stream Widening and Incisement

There are stream channels throughout the Lower Sprague-Lower Williamson subbasin that have experienced substantial channel modification associated with erosion activities related to gullying, stream incisement and channel widening. Such changes to the channel morphology have been caused or exacerbated by a variety of human activities in past decades and in past centuries. These activities have included over-grazing, beaver trapping, removal of riparian vegetation, land clearing, wildfires and loss of wetlands. Data are not available, however, with which to specify the locations or severity of such changes. Nevertheless, the impacts on stream structure and function are important. In particular, such changes to the channel morphology are often associated with increased sedimentation of spawning gravels, increased water temperature and diminished riparian function.

Channel Engineering and Stream Straightening

During the first half of the twentieth century, many reaches of the Lower Sprague and Lower Williamson rivers were straightened, diked and channelized. The majority of this work was conducted by the U.S. Army Corps of Engineers to control flooding and maximize use of the land for agricultural production. These impacts on the stream channel are still visible today in many of the valley reaches.

Ditches and Canals

Map 9-1 shows the locations of the mapped ditches and canals within the Lower Sprague-Lower Williamson subbasin. There are many more miles of ditches that supply irrigation water and drain flood waters, but these ditches are not mapped on Map 9-1, because they are too small to show up at this scale.

Ditches and canals were prevalent in the Williamson River Delta Preserve, owned and managed by The Nature Conservancy. This canal system historically drained the agricultural fields in spring and early summer and supplied irrigation water during the late summer and fall. The delta area was excluded from Upper Klamath Lake and Agency Lake by an extensive dike system around the perimeter of the delta. The dikes were breached in the fall of 2007, so the delta area is now hydraulically reconnected to the lakes. The dikes and canal system no longer control water levels within the delta area.

Dam

The Lower Sprague-Lower Williamson subbasin exhibited one major dam, the Chiloquin Dam. The Chiloquin Dam was located just south of the town of Chiloquin on the Sprague River about a mile above the Sprague River's confluence with the Williamson River, and about 15 miles above Upper Klamath Lake. The dam was constructed in 1917 as a control structure for the point of diversion of the United States Indian Irrigation Service project for Modoc Point. When the Klamath Indian Reservation was terminated in 1954, the dam, its canal and the Modoc Point irrigation project were transferred to the Modoc Point Irrigation District (MPID). There are approximately 5,000 acres under irrigation in the MPID. MPID and a number of Klamath tribal members who have irrigated land in the Modoc Point have filed claims in the Klamath Basin Adjudication (OWRD 2004).

The Chiloquin Dam obstructed fish passage both up and down the Sprague River, effectively preventing migration of trout and the endangered sucker fish from Upper Klamath Lake to the Sprague River. The National Research Council of the National Academy of Sciences stated in its 2003 Report on the Klamath River Basin that "removal of Chiloquin Dam has high priority and should be pursued aggressively." The National Academy of Sciences report notes that "…Chiloquin Dam may have eliminated more than 95% of the historical spawning habitat in the Sprague River" (OWRD 2004).

During the summer of 2008, the Chiloquin Dam was removed. MPID has secured a new diversion point downstream just east of Highway 97 and has developed a pumping station at the new point of diversion.

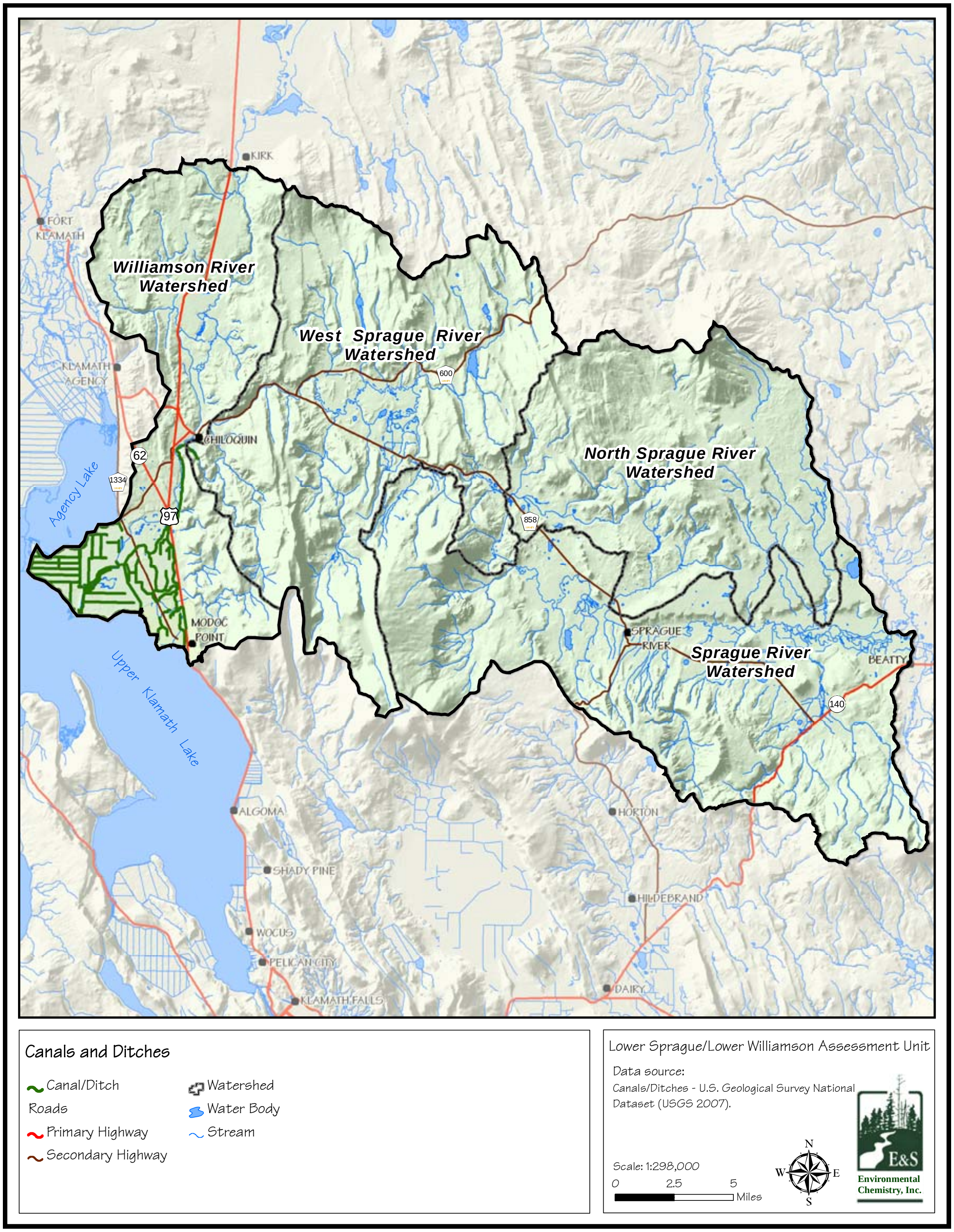
DATA, METHODS AND LIMITATIONS

The purpose of the Watershed Assessment is to present a broad overview of conditions at the scale of the watershed and subwatershed. The information in this chapter was gathered from already existing data acquired from public agencies and Rosgen (1996). The information used in this Assessment is expected to be reliable for the types of analyses and at the spatial scales presented. However, the completeness and accuracy of the data are determined by each individual data source. Source citations are included with each display item. Caution should be used when planning on-the-ground projects. Use of the data at spatial scales significantly different from the source information may result in errors or inaccuracies.

The U.S. Geological Survey (USGS) created the National Hydrography Dataset (NHD) in cooperation with the U.S. Environmental Protection Agency (EPA). It is a combination of USGS digital line graph (DLG) hydrography files and EPA Reach File 3 (RF3). The NHD provides both DLG and RF3 data in a flexible and refined format. The NHD is based on 1:100:000-scale data. However, higher resolution data are continuously being incorporated into this format (USGS 1999a). Therefore, the accuracy of this data is sufficient at a watershed scale, but not at a farm or ranch planning scale.

DATA GAPS

At this time, limited data are available on channel characteristics within the assessment area, particularly at a large scale. Many site-specific assessments of channel characteristics have been conducted at different stream reaches within the assessment area, but no comprehensive study of the channel characteristics within the assessment area has been located.



Map 9-1 Location of known (mapped) ditches and canals within the Lower Sprague-Lower Williamson subbasin

(Data Source: USGS 2007)

Data methods/limitations: National Hydrology Dataset (NHD) streamlines classified as "Canal/Ditch" are shown on this map. A "Canal" or "Ditch" is considered "an artificial open waterway constructed to transport water, to irrigate or drain land, to connect two or more bodies of water, or to serve as a waterway for watercraft" (USGS 1999b).

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