RECLAMATION
Managing Water in the West

Winthrop Area (W2)
Assessment of Geomorphic and Ecologic Indicators
Methow River, Methow Subbasin

Okanogan County, Washington

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Boise, Idaho

December 2011

Cover Photo: View – Methow Subbasin, Washington – Bureau of Reclamation

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EXECUTIVE SUMMARY

The Bureau of Reclamation (Reclamation) and Bonneville Power Administration contribute to the implementation of salmonid habitat improvement projects in the Methow subbasin to help meet commitments contained in the *2010 Supplemental Federal Columbia River Power System (FCRPS) Biological Opinion* (BiOp) (NOAA Fisheries 2010). The BiOp includes a Reasonable and Prudent Alternative (RPA), or a suite of actions, to protect listed salmon and steelhead across their life cycle. Habitat improvement projects in various Columbia River tributaries are one aspect of this RPA. Reclamation provides technical assistance to States, Tribes, Federal agencies, and other local partners for identification, design, and construction of stream habitat improvement projects that primarily address streamflow, access, entrainment, and channel complexity limiting factors. Reclamation's contributions to habitat improvement are all meant to be within the framework of the FCRPS RPA or related commitments.

This assessment provides scientific information on the geomorphology and habitat condition in the "W2 Reach" (Wolf Creek to Winthrop section) of the Middle Methow River between river mile (RM) 55 and 50. This information can be used to identify potential habitat improvement projects, to inform future monitoring of fish habitat improvement projects, and evaluate how these projects are addressing key limiting factors to protect and improve survival of salmon and steelhead listed under the Endangered Species Act (ESA). The ESA-listed species of concern found in the Middle Methow River include Upper Columbia River (UCR) spring Chinook salmon (*Oncorhynchus tshawytscha*), UCR steelhead (*Oncorhynchus mykiss*), and Columbia River bull trout (*Salvelinus confluentus*). An additional species of concern that is not ESA-listed at this time is the Pacific lamprey (*Entosphenus tridentatus*).

This report documents physical features and analyzes riverine processes that may affect the overall health of the system at the reach scale. Two valley segments were identified in the assessment area based on hydrologic considerations. These valley segments are referred to as the Upper W2 and Lower W2, and are divided at the confluence of the Chewuch River. This division was necessary because flow inputs from the Chewuch River account for about 30 percent of the Methow River's flow in the Lower Middle Methow. The Upper W2 was further divided into two channel segments based on geologic valley confinement. The upstream section was moderately confined and is referred to as Channel Segment M8; and the downstream section was unconfined and is referred to as Channel Segment M7. No divisions were needed for the Lower W2 as the valley segment was geologically confined and the channel segment is referred to as Channel Segment M6.

Channel Segments M8 and M6 have not been significantly impacted by anthropogenic disturbances except for modifications to the vegetation structure and composition due to clearing and thinning for development. However, Channel Segment M7 has been negatively impacted by anthropogenic disturbances that have disconnected channel-floodplain interactions. Historic channel paths and floodplain areas (about 21 percent) have been disconnected by elevated road grades; a reinforced levee; and fill material placements. Impacts to physical processes resulting from artificially disconnecting the floodplain may include (1) a slight increase in streampower and sediment transport capacity and can result in a reduction of gravel and wood retention that would have contributed to formation of diverse habitats; and (2) isolation of historic channel paths and floodplain areas resulting in decreased biotic inputs and energy transfer (i.e., food web), riparian vegetation health maintenance, and ecological connectivity. In addition, bank protection (riprap) has been placed along the levee and several sections of streambank to protect developed areas and infrastructure. This bank protection has artificially restricted lateral channel migration processes and floodplain reworking and may have modified geomorphic channel processes, and sediment and wood recruitment by the channel.

The overall cumulative effects of anthropogenic disturbances have negative impacts on the physical and ecological processes that create and maintain aquatic habitat complexity, quality, and variability. These disturbances have modified the physical and ecological processes by (a) artificially disconnecting the floodplain, (b) restricting lateral channel migration, and (c) clearing and altering riparian vegetation structure and composition.

OVERVIEW

The Bureau of Reclamation (Reclamation) and Bonneville Power Administration contribute to the implementation of salmonid habitat improvement projects in the Methow subbasin to help meet commitments contained in the *2010 Supplemental Federal Columbia River Power System (FCRPS) Biological Opinion* (BiOp) (NOAA Fisheries 2010). The BiOp includes a Reasonable and Prudent Alternative (RPA), or a suite of actions, to protect listed salmon and steelhead across their life cycle. Habitat improvement projects in various Columbia River tributaries are one aspect of this RPA. Reclamation provides technical assistance to States, Tribes, Federal agencies, and other local partners for identification, design, and construction of stream habitat improvement projects that primarily address streamflow, access, entrainment, and channel complexity limiting factors. Reclamation's contributions to habitat improvement are all meant to be within the framework of the FCRPS RPA or related commitments.

INTRODUCTION

The Middle Methow River was divided into two subwatersheds based on hydrologic conditions (UCSRB 2007). Upstream of the Chewuch River confluence near RM 51.3 to the headwaters, the Methow River is referred to as the Upper Middle Methow. Downstream of the Chewuch River confluence to Texas Creek near RM 28, the Methow River is referred to as the Middle Methow.

This geomorphic and ecologic indicators assessment provides scientific information on the geomorphology and habitat condition for the "Wolf Creek to Winthrop" or W2 Reach between river miles (RM) 55 and 50 of the Middle Methow River in the State of Washington. The valley segment from RM 55 to 51.3 is referred to as the Upper W2 and the segment from RM 51.3 to 50 is the Lower W2. The data presented in this assessment can be used to help identify potential habitat improvement projects, and to help future monitoring of fish habitat improvement projects and evaluate how these projects are addressing key limiting factors to protect and improve survival of salmon and steelhead listed under the Endangered Species Act (ESA).

The species of concern found in the Middle Methow River include Upper Columbia River (UCR) spring Chinook salmon (*Oncorhynchus tshawytscha*), UCR steelhead (*Oncorhynchus mykiss*), and Columbia River bull trout (*Salvelinus confluentus*) that are included in the ESA Threatened and Endangered list (UCSRB 2007) and the Pacific lamprey (*Entosphenus tridentatus*). The Methow River is a major spawning area for UCR spring Chinook salmon and UCR steelhead, important for Pacific lamprey spawning and rearing, and it is an important migration corridor for UCR spring Chinook salmon, UCR steelhead, CR bull trout, and Pacific lamprey.

At the watershed scale, several factors that are affecting the species of concern in the Middle Methow watershed were identified in the Limiting Factors Analysis (Andonaegui 2000) and the *Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan* (UCSRB 2007), referred to as the *Recovery Plan*. The hydrology, geology, sediment inputs and routing, vegetation structure, and anthropogenic disturbances that affect the riverine processes in the Methow subbasin were described by Reclamation in a Geomorphic Assessment (Reclamation 2008a). To describe anthropogenic affects to riparian and floodplain-channel interactions, two Reach Assessments have been completed: the Big Valley Reach between RM 62.4 to 55 (Reclamation 2008b) and the Middle Methow Reach between RM 50 to 41 (Reclamation 2010).

The focus of this assessment is to document riverine conditions on the W2 Reach from RM 55 to 50. Anthropogenic disturbances may be negatively impacting dynamic riverine processes and may reduce listed species productivity and abundance. The analysis was based on the riparian and channel-floodplain processes as recommended by Beechie et al. (2010), and the method used was an evaluation of reach-based ecosystem indicators (REI) which provides an understanding of how geomorphic and ecologic processes are currently functioning. Results and summaries are presented at the reach and channel segment scales to capture localized impacts and trends. The discussion of results and summarization of interpretations are provided at the reach scale.

Purpose of Assessment

This assessment refines the scientific understanding of geomorphic and ecologic processes occurring on the W2 Reach of the Middle Methow River. Several causal factors have been identified at the watershed scale that were believed to be limiting for ESA-listed fish species. The primary limiting factors are identified in the *Recovery Plan*. Limiting factors are the "condition that limits the ability of habitat to fully sustain populations of salmon" (State of Washington 1998 Engrossed Substitute House Bill 77RCW). These factors included water quantity and quality, channel stability, habitat diversity and quantity, and fine sediment that could be affecting abundance, productivity, spatial structure, and diversity of the species.

The causal conditions of the factors that are limiting to ESA-listed fish species included (1) surface water withdrawals and vegetation clearing adjacent to the active channel that reduces stream shading and lead to negative impacts to water quantity and quality; (2) levees that disconnect side channels and off-channel habitat; (3) residential development that affects channel-floodplain interactions necessary to maintain appropriate riparian and floodplain processes; (4) reduced wood recruitment due to the loss of riparian vegetation and reduced wood retention in natural accumulation areas such as side channels and abandoned channels; and (5) high road densities in the watershed that may negatively impact the effective drainage network and increase fine sediment inputs to streams.

Assessment Methods

At the reach scale, physical habitat dynamics are primarily a function of sediment and water inputs that drive channel shape, sediment transport and storage characteristics, and formation of hydraulic features such as pools and riffles (Beechie et al. 2010). To understand how the riverine ecosystem dynamics are functioning, riparian processes and channel-floodplain interactions were analyzed using a matrix of REI. The REI was based on the “Matrix of Diagnostics/Pathways and Indicators” (USFWS 1998). Thresholds used to determine the condition of each indicator rating were vetted through a group of scientists working in the Upper Columbia Basin in order to accurately capture conditions observed east of the Cascade Range. A condition rating was determined for each indicator based on REI criteria, geomorphic constraints, and professional judgment.

The W2 assessment area REI is provided in Appendix A of this report. The objectives of the REI analysis were to identify root causes of degradation and the driving processes that create and maintain habitat conditions. For example, vegetation composition and structure on the floodplain influences the delivery of wood to the channel, bank reinforcement, nutrient cycling, and thermal regimes. In addition, an appropriately functioning floodplain influences water quality, hyporheic interactions, and terrestrial connectivity.

Methow River Watershed

The Methow River is the primary drainage in the Methow subbasin located along the eastern side of the Cascade Range. The river drains about 1,800 square miles and has a dendritic drainage pattern with a drainage density of about 2.62 which is a measure of the amount of stream network necessary to drain the basin. Basin relief is about 8,000 feet with a maximum elevation of about 8,844 feet at Tower Mountain along the Northern Cascade Crest and a minimum elevation of about 800 feet at the confluence with the Columbia River near RM 524 (Table 1). Annual precipitation ranges from over 80 inches along the Northern Cascade Crest to about 10 inches near the town of Pateros (Richardson 1976). The hydrology is a snowmelt dominated system with runoff occurring between April and June with periodic rain-on-snow events occurring from October through November.

Table 1. Methow Subbasin Characteristics

Methow Subbasin Area	Elevation Range	Drainage Density	Hydrologic Unit Code	Strahler Stream Order	Stream Classification	Land Ownership
1,208,746 acres (WRIA 48)	~8,800’-800’	2.62*	170200080605	6	Class AA and Class A	89% public 11% private

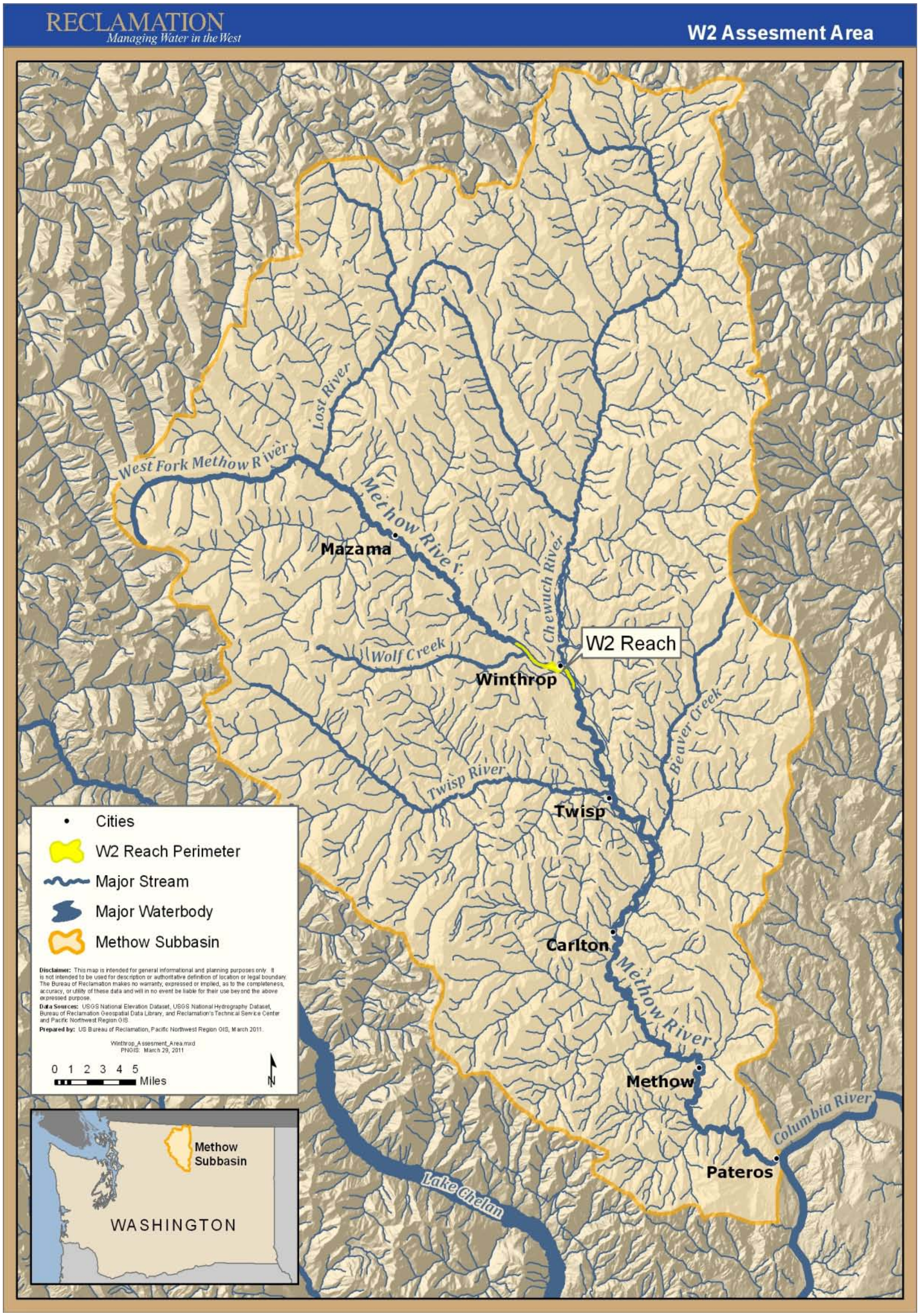

Figure 1. Methow watershed and W2 assessment area location map

The State of Washington Department of Ecology (WDOE) rates the water quality as Class AA, extraordinary, for the Upper Middle Methow (WDOE website). Water quality in the Middle Methow was rated as Class A, excellent, by the WDOE.

Table 2. Middle Methow River subwatershed divisions

Subwatershed	Location
Upper Middle Methow	Headwaters to Chewuch River confluence
Middle Methow	Chewuch River confluence to Texas Creek

Primary limiting factors and management objectives for the Middle Methow River subwatersheds are summarized from the *Recovery Plan* and *Biological Strategy* and provided in Table 3.

Table 3. Limiting factors and management objectives by subwatershed

Subwatershed	Limiting Factors	Management Objectives
Upper Middle Methow River	Habitat quantity and diversity	Increase habitat diversity and quantity
	Water quantity	Increase instream flows
Middle Methow River	Habitat diversity and quantity	Improve riparian habitat conditions
	Excessive artificial channel stability	Increase off-channel habitat
		Increase habitat diversity
	Water quantity	Increase instream flows

REGIONAL SETTING

The Methow subbasin is within the Northern Cascade Mountains section of the Cascade-Sierra Mountains physiographic province. The ecoregion is within the eastern Cascades Section of the Cascade Mixed Forest-Coniferous Forest-Alpine Meadow Province (Bailey classification), and the Okanogan Valley (Omernik classification).

The geology of the Methow subbasin is comprised of three geologic terranes (1) North Cascades crystalline core, (2) Methow terrane, and (3) Okanogan-Shuswap terrane (Tennyson and Cole 1987). The Methow terrane is a structural basin (Barksdale 1948) that is bounded by the Fraser-Yalokum fault system (Tennyson and Cole 1987). The Fraser-Yalokum fault system juxtaposes the Methow terrane against the Okanogan-Shuswap terrane to the east and the North Cascades crystalline core to the west (Tennyson and Cole 1987). Refer to Reclamation (2008a) Appendix C for a more detailed discussion.

Bedrock in the assessment area is predominantly Jurassic age metamorphic rocks derived from volcanic and sedimentary deposits, and to a lesser degree, Cretaceous age intrusive igneous rocks (Figure 2). Quaternary age sedimentary deposits that mantle the bedrock include glacial and alluvial valley fill deposits comprised of boulders, cobbles, gravel, sand, and silt.

The Methow subbasin has been sculpted by alpine and continental glaciers. In the assessment area, alpine and continental glaciers have eroded a broad U-shaped valley. Alpine glaciers were more erosive than the continental glaciers and deeply eroded the valley leaving behind steep valley walls and glacial deposits. The continental glaciers that advanced from the north filled the valley with ice, but were less effective at scouring the valley floors and valley walls. Associated with these continental glaciers were copious amounts of glacial sediments deposited on the valley floors and walls as terraces and glacial outwash plains.

The glacial history of the valley strongly affects the groundwater aquifer and the stream's baseflow (Konrad et al. 2003). In the upper section of the Middle Methow valley, the alpine glaciers eroded a deep glacial trough from about the Early Winters Creek confluence (RM 69) to about Weeman Bridge (RM 61). This trough has filled with alluvium and serves as an extensive groundwater aquifer. Surface water along the Methow River seasonally runs in the subsurface in this area when the elevation of the groundwater table is lowered. Downstream of Weeman Bridge to the end of this assessment area, down valley groundwater flows are impeded by bedrock, forcing the flows back to the surface which increases baseflows in the Methow River. For further discussion, refer to Reclamation (2008a) Appendix D.

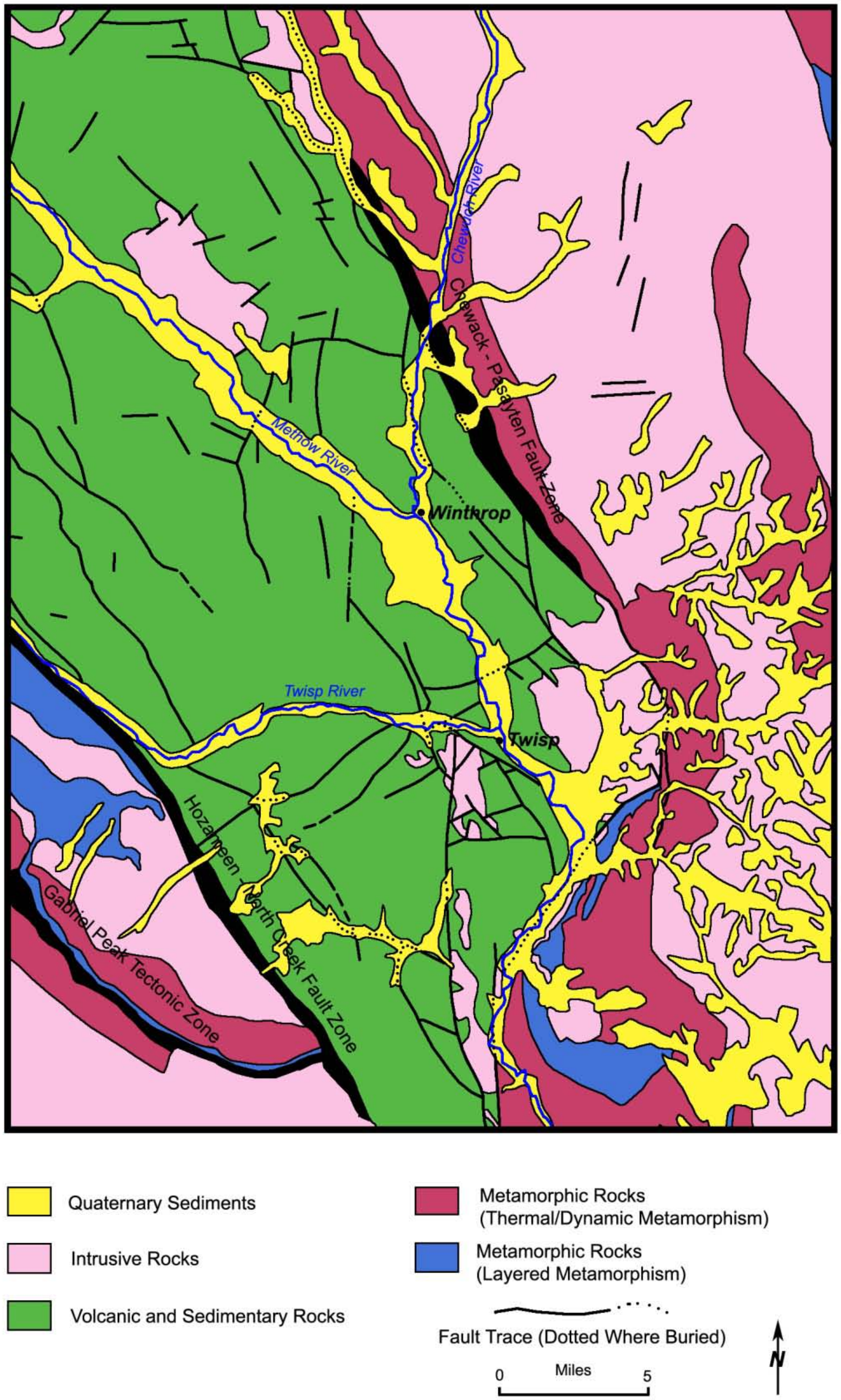

Figure 2. Generalized geologic map modified from Stoffel et al. (1991)

WATERSHED CONDITIONS

About 89 percent of the watershed is publically owned with the remaining 11 percent in private ownership. Public lands are managed as non-designated recreational forest and designated Wilderness Area. Private land uses include agriculture, and residential and commercial developments.

Many areas of the watershed were **At Risk** or **Unacceptable** (Table 4) based on thresholds contained in the U. S. Fish and Wildlife Service Matrix of Diagnostics/Pathways and Indicators (USFWS 1998).

Watershed road density for the Methow subbasin was 1.11 mi/mi^2 and the road density in the Upper Middle Methow watershed was about 1.55 mi/mi^2. Higher road densities negatively impact the routing of overland flows due to road embankments that re-direct or pond overland flows. The road density has probably had a relatively “minor” affect on the effective drainage network in the Upper Middle Methow. Based on the REI criteria (Appendix A), the watershed road density and effective drainage network indicator is **At Risk**.

Primary watershed disturbances are generally related to wildland fires and Euro-American settlement. There have been about 400 fires recorded in the Upper Methow watershed caused predominantly by lightning strikes (MVRD 1996). In general, severe fires have burned in the Upper Methow watershed every 100 to 300 years and fire frequency has not changed significantly since the 1920s. Recent fires in the watershed include the Tripod Fire (2006), Farewell Fire (2003), Needles Creek Fire (2003), Thirtymile Fire (2001), Whiteface Fire (1994), and Quartz Mountain Fire (2004). About 70 percent of the Chewuch watershed has been burned with varying intensities by the Thirtymile, Farewell, and Tripod fires.

Euro-American settlement occurred in the late nineteenth century and established an economy based on agriculture, forestry, and mining. There has since been a demographic shift to an economy driven by tourism, recreation, and general goods and services industries. This shift has resulted in conversion of some agricultural lands to residential and commercial development.

Overall, the watershed disturbance indicator is **At Risk** primarily due to the following: (1) valley bottom development may cause long-term disruption of channel-floodplain interactions and negatively affect aquatic/terrestrial habitat diversity and connectivity, and (2) historically, fires were relatively short-term but frequent environmental disturbances, but now due to fire suppression efforts, combustible fuels have accumulated throughout the watershed which may have changed fire severity and recurrence intervals.

Hydrologically, the Methow River is a snowmelt dominated system that is characterized by spring snowmelt runoff high flows with low summer and winter flows. Rain-on-snow events can occur between November and February, but generally do not result in major increases in river flows in the Methow River as compared to other river basins in the Pacific Northwest.

Burton (1997) found that forestry practices can result in changes in flow discharge, duration, and timing. There have been a number of historic timber harvests in the watershed and still occur on Forest Service lands in the Upper Middle watershed. However, current forestry practices have changed to only allow partial cuts and thinning, and utilization of the existing road network for access.

In addition, agricultural land use practices can change watershed controls such as the rates of precipitation interception, soil infiltration and evapotranspiration. Surface water diversions for agriculture production also reduce instream flows which results in less available aquatic habitat and fish passage barriers. The cumulative effect of these alterations may have multiple impacts on the watershed hydrologic regime and instream flows. Several channel segments along the Methow River and its tributaries have been listed by the WDOE as Category 4C waterbodies for insufficient instream flows that negatively impact aquatic habitat. The primary reasons for these listings are due to irrigation diversions. Based on current understanding, the flow/hydrology indicator is **At Risk** due to anthropogenic impacts that may have changed the watershed's hydrologic regime and agriculture practices that result in reduction of instream flows.

Water quality for the Upper Middle Methow above the town of Winthrop, and for the Chewuch River is classified as Class AA, extraordinary waters. The Middle Methow below the town of Winthrop is classified as Class A, excellent waters (WDOE website). The Methow River "naturally" dewaters between the town of Mazama and Weeman Bridge in late summer and fall which is most likely due to the geology (depth of alluvial valley fill). Several stream segments along the Methow River and its tributaries are listed as Category 4C waterbodies for insufficient instream flows primarily due to irrigation diversions. There are also other channel segments and tributaries that are listed as Category 5 (impaired by warm water temperatures) and Category 2 (impaired by low levels of chemical contamination) waterbodies (WDOE website). Water quality and quantity is At Risk based on impairments identified by the WDOE.

Habitat access has been impeded by diversion dams and insufficient instream flows due to surface water diversions. Diversions on the Methow River include the following: (1) Foghorn Diversion Dam near RM 53 may inhibit juvenile fish passage at some biologically significant flows; (2) Barkley Diversion Dam near RM 49.6, a "push-up" dam that is manipulated annually in late July or August, is an entrainment hazard for many fish including juvenile steelhead/rainbow trout, juvenile spring Chinook salmon, cutthroat trout, Pacific lamprey and some adult bull trout that reside in the diversion delivery channel upstream of the fish screen during irrigation season and are lost when the ditch is turned off in the fall (Reclamation 2010); and (3) the Methow Valley Irrigation District's east diversion near RM 46 has been mostly removed and is no longer a hazard to fish. Due to the presence of mainstem fish passage barriers, habitat access is considered **At Risk**.

A summary of watershed condition specific and general indicators are presented in Table 4.

Table 4. Summary of condition ratings for the watershed indicators

Spatial Scale	General Indicator	Specific Indicator	Specific Indicator Condition	General Indicator Condition
Watershed Condition	Watershed Road Density and Effective Drainage Network	Watershed Road Density	At Risk	At Risk
		Effective Drainage Network	At Risk	
	Disturbance Regime	Disturbance Regime	At Risk	At Risk
	Flow/Hydrology	Flow	At Risk	At Risk
		Hydrology	At Risk	
	Water Quality	Water Quality	At Risk	At Risk
	Habitat Access	Mainstem Physical Barriers	At Risk	At Risk

REACH CHARACTERIZATION

The objective of this section is to provide context for the physical and ecological processes occurring at the reach scale. The reach scale processes include channel-floodplain interactions and riparian processes (Beechie et al. 2010). Controlling these processes are (1) geologic controls that provide valley constraints that restrict the channel's ability to laterally migrate across the valley floor, (2) active channel and floodplain interactions, and (3) channel gradient that influences streampower and sediment transport capacity. Changes to the reach scale processes could adversely impact habitat quantity and quality, channel complexity and variability, and energy transfer that sustain ESA-listed species.

Surficial Geology

The surficial geology of the W2 assessment area was described based on aerial photograph and topographic interpretations, field observations, and geologic mapping completed by Stoffel et al. (1991) and Waitt (1972). Bedrock in the assessment area was comprised predominantly of metamorphic rocks of the Methow terrane, and upstream of the assessment area the bedrock contained igneous intrusive rocks of the North Cascades crystalline core.

The surficial deposits were predominantly glacial and alluvial deposits derived from metamorphic and igneous bedrock scoured in the headwaters and then transported by glaciers and the river to the W2 assessment area. These metamorphic and igneous stones are hard and resistant to chemical and mechanical weathering. The glaciers deposited gravels and cobbles as ice-marginal terrace gravels (kame terraces) along the valley walls; as glacial outwash plains along the valley floor; and as glacial drift (undifferentiated glacial deposits). Recent alluvial deposits are primarily derived from the reworking of glacial deposits by the Methow River to form lower floodplain terraces and the active channel deposits; and by tributaries along the valley walls that deposit alluvial fans on the valley floor. A summary of geologic deposits is contained in Table 5, and a surficial geologic map of the W2 assessment area is provided in Figure 3.

Table 5. Surficial geologic map units and descriptions

Geologic Unit	Geologic Deposits	Description
F	Fill	Elevated embankments and graded surfaces that are within the Low Surface (Qs) unit that may affect floodplain processes. Elevated embankments and graded surfaces were not mapped in the other geologic units.
Qs	Low Surface	Alluvium comprised predominantly of gravels and cobbles with sand, silt and boulders. Generally derived from the reworking of floodplain and glacial deposits along the active channel. Some areas included in this unit have been mechanically disturbed by anthropogenic activities.
Qht	Quaternary high terrace	Alluvium comprised predominantly of gravels and cobbles with sand and silt. These surfaces are relatively higher (ranging from about 4 to 8 feet) than the Qs unit and are sometimes flooded along the margins adjacent to the active channel.
Qaf	Quaternary alluvial fan	Alluvial fans comprised of gravel, cobbles, boulders, sand and silt are present along the valley margins and contribute sediment and wood to the system where the river is in contact with the fans.
Qkt	Quaternary kame terrace	Alluvium comprised predominantly of gravel, cobbles, sand and silt, deposited by ice marginal glacial processes. Terrace deposited during the Pleistocene epoch by continental glaciations.
Qgd	Quaternary glacial drift	Glacial deposits (undifferentiated) comprised predominantly of cobbles, gravel, boulders, sand and silt, generally related to glacially constructed landforms (i.e., moraines and outwash plains). Material deposited during the Pleistocene epoch primarily by continental glaciations.
Jvs	Jurassic bedrock	Metamorphic sedimentary and volcanic rocks of the Methow tectonic terrane.

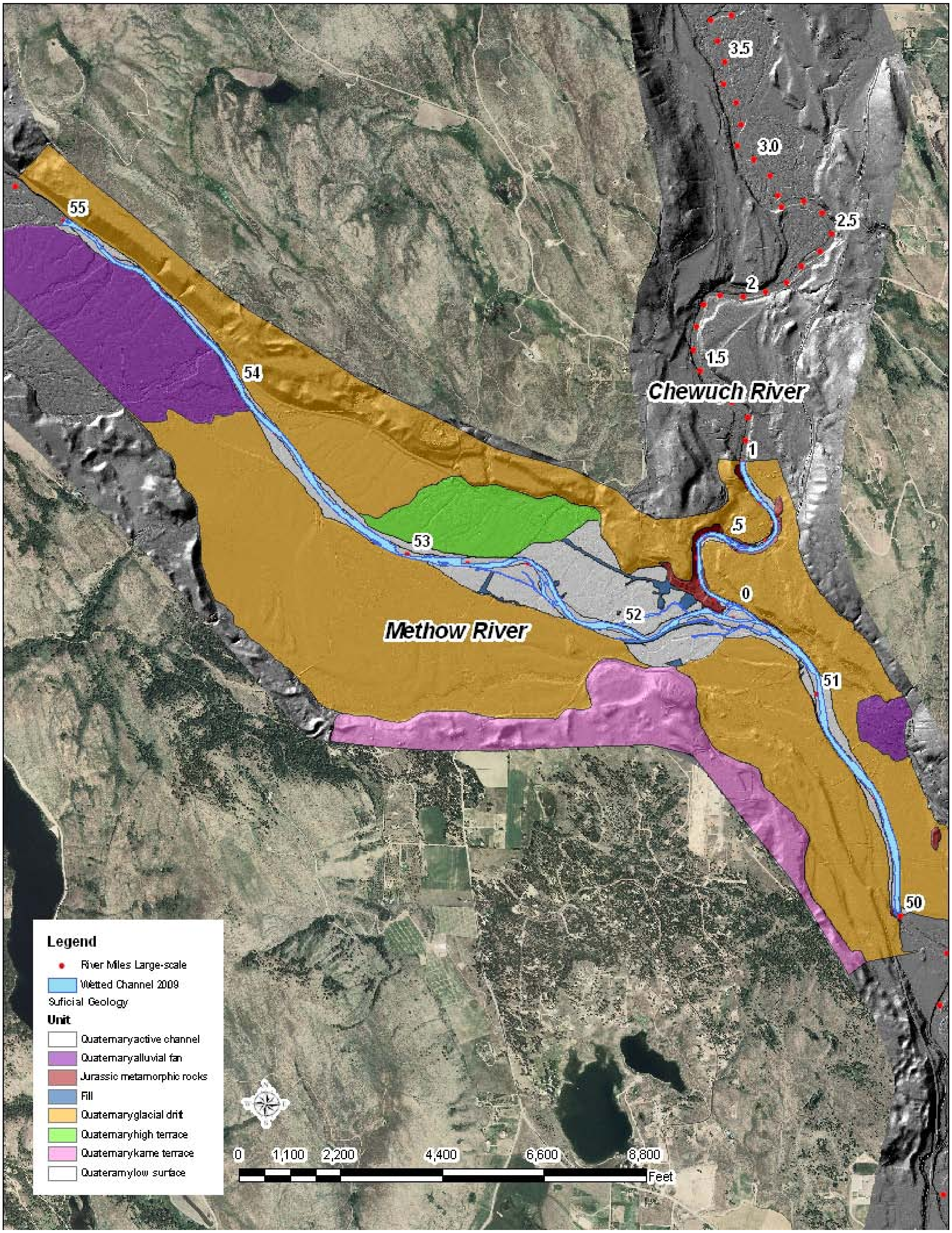

Figure 3. Surficial geologic map of the W2 assessment area

Geologic Valley Confinement

Geologic valley confinements were based on the surficial geologic mapping. Average valley widths were measured between valley walls to define the average valley bottom widths. The average constrained valley widths were measured between the geologic controls that constrain channel migration across the valley floor (i.e. alluvial fans, glacial deposits). Average channel widths were measured between the terrace/channel slope break that were relatively well defined on the 2006 light detection and ranging (LiDAR) hillshade elevation model. All measurements were made using geographical information system (GIS) technology. Valley confinement was determined using the ratio between average channel width and average constrained valley width. Unconfined valley segments have a ratio greater than 4:1; moderately confined segments were between 4:1 and 2:1; and confined segments had less than 2:1 (Hillman 2006).

The W2 assessment area is in an alluvial valley type (Montgomery and Buffington 1998). The valley bottom-type is classified as a glaciated U-shaped trough (U1) (Naiman et al. 1992) with an average valley bottom width of 1,386 feet and an average valley bottom gradient of about 0.4 percent. Valley confinement was determined using the ratio between the average channel width and the constrained valley bottom width (Table 6). Valley confinement was predominantly moderately confined with an unconfined segment between RM 52.9 and 51.3 (Figure 4).

Table 6. Valley segment characteristics

River Miles	Average Constrained Valley Bottom Width (CVBW)[1]	Average Channel Width (CW)	Ratio (CW: CVBW)	Valley Confinement[2]	Geologic Valley Constraints
RM 55-52.9	289 feet	131 feet	2.2:1	Moderately Confined	Alluvial Fan, Glacial Drift and High Terrace
RM 52.9-51.3	1,452 feet	173 feet	8.4:1	Unconfined	Glacial Drift, Kame Terrace, High Terrace and Bedrock
RM 51.3-50	318 feet	156 feet	2.0:1	Moderately Confined	Glacial Drift

[1]Oregon Department of Fish and Wildlife (2010)
[2]Hillman (2006)

Channel characteristics are based on Montgomery and Buffington (1998) classifications for channel reaches and bed-form types. Channel reach classifications applicable to the W2 assessment include: (1) free-formed alluvial channel reaches which “exhibit a variety of bed morphologies and roughness configurations that vary with slope and position within the channel network”, and bed-form morphology that includes plane-bed and pool-riffle along with transitional morphologies; and (2) forced alluvial channel reaches that have “external flow obstructions, such as LWD [large woody debris] and bedrock outcrops, [that] force local flow convergence, divergence, and sediment impoundment that respectively form pools, bars, and steps" and plane-bed type bed-form morphology is generally rare. Channel type classifications are based on Rosgen (1996) and include a broad-level classification of the channel (Level I).

Channel segment characteristics include the following: (1) channel segment RM 55 to 52.9 is a free-formed alluvial channel with a plane-bed type bed-form and the channel is an A-type channel; (2) channel segment RM 52.9 to 51.3 is a forced alluvial channel with bedrock and large wood as the forcing agents and has a plane-bed to pool-riffle type bed-form and the channel is a C-type channel; and (3) channel segment RM 51.3 to 50 is a free-formed alluvial channel with a plane-bed type bed-form and the channel is a A-type channel. Channel segment characteristics are summarized in Table 7.

Table 7. Channel segment characteristics

River Miles	Valley Confinement[1]	Channel Reach Type[2]	Bed-form Type[2]	Channel Type[3]
RM 55-52.9	Moderately confined	Free-formed alluvial channel	Plane-bed	A-type
RM 52.9-51.3	Unconfined	Forced alluvial channel	Plane-bed to pool-riffle	C-type
RM 51.3-50	Moderately confined	Free-formed alluvial channel	Plane-bed	A-type

[1]Hillman (2006)
[2]Montgomery and Buffington (1998)
[3]Rosgen (1996)

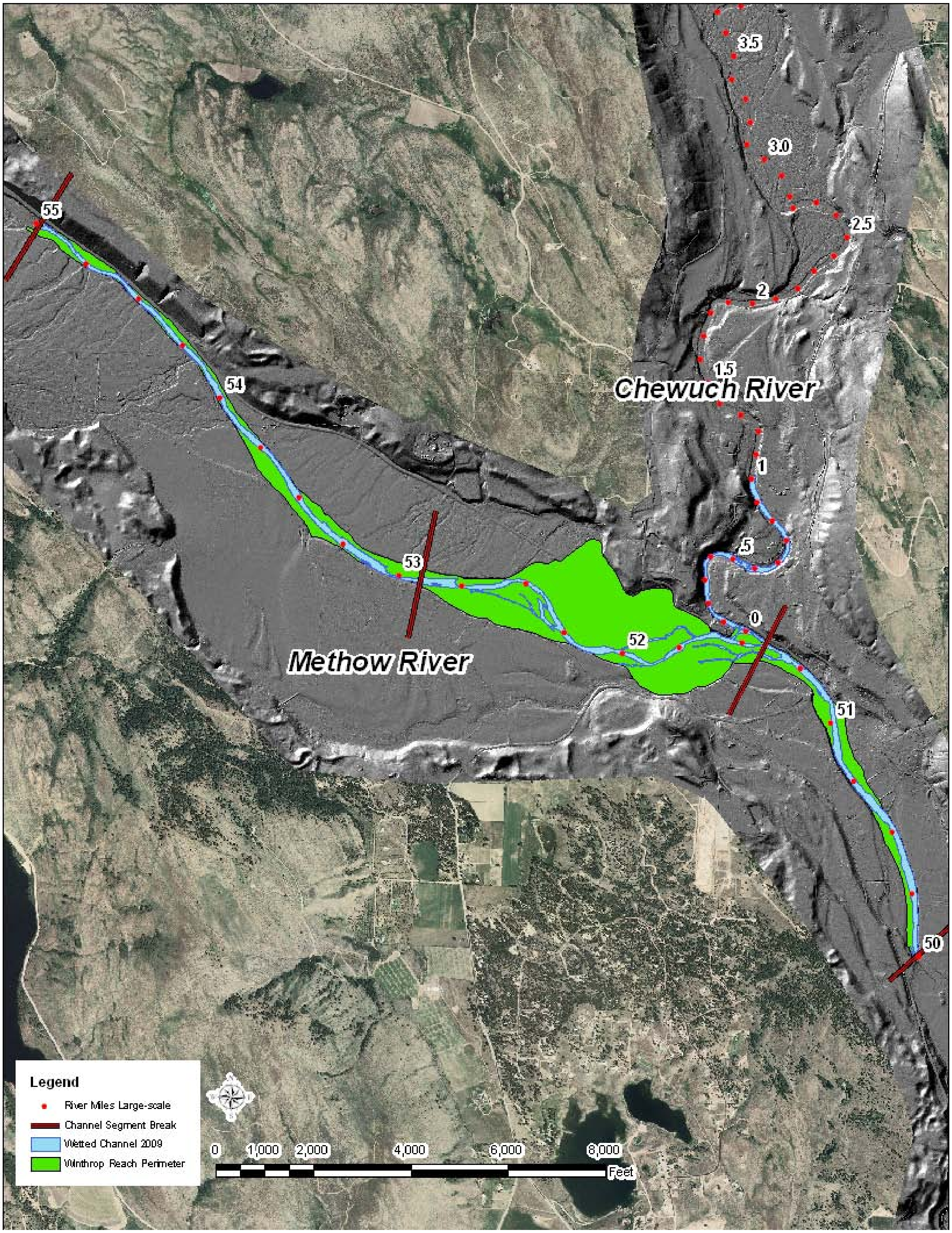

Figure 4. Winthrop (W2) assessment area geomorphic channel segment delineations

Active Channel and Floodplain Designations

Geomorphic channel segments were identified based on valley confinement, geologic controls, and topography. These channel segments were further subdivided into active channel and floodplain areas in order to describe localized channel controls, variability, and connectivity. The active channel is the area that is inundated and impacted by channel forming flows. Floodplain areas are where the river goes out-of-bank in greater than channel-forming flows and flows over higher surfaces (i.e. terraces). In general, floodplain areas that are immediately adjacent to the active channel are more frequently flooded. The flood effects are reduced as flows are dispersed away from the channel over a larger cross sectional area.

Areas where active channel and floodplain interactions occur unimpeded by any elevated topographic features are hydraulically “connected”. Conversely, areas where these interactions are impeded are referred to as hydraulically “disconnected”. In general, the disconnected areas in this assessment are associated with anthropogenic disturbances that have created elevated topographic features (i.e., levees or road grades) that hydraulically disconnect active channel and floodplain interactions. Table 8 summarizes the connectivity by geomorphic channel segment and Figure 5 provides a visual reference of the overall connectivity within the reach.

Table 8. Summary of active channel and floodplain connectivity by geomorphic channel segments

Geomorphic Channel Segment	Total Acreage	Connected Acreage	Disconnected Acreage (Percent)
Segment M8	69 acres	69 acres	0 acres (0%)
Segment M7	221.5 acres	161.8 acres	59.7 acres (27%)
Segment M6	40.7 acres	40.7 acres	0 acres (0%)
Totals	331.2 acres	271.5 acres	59.7 acres (18%)

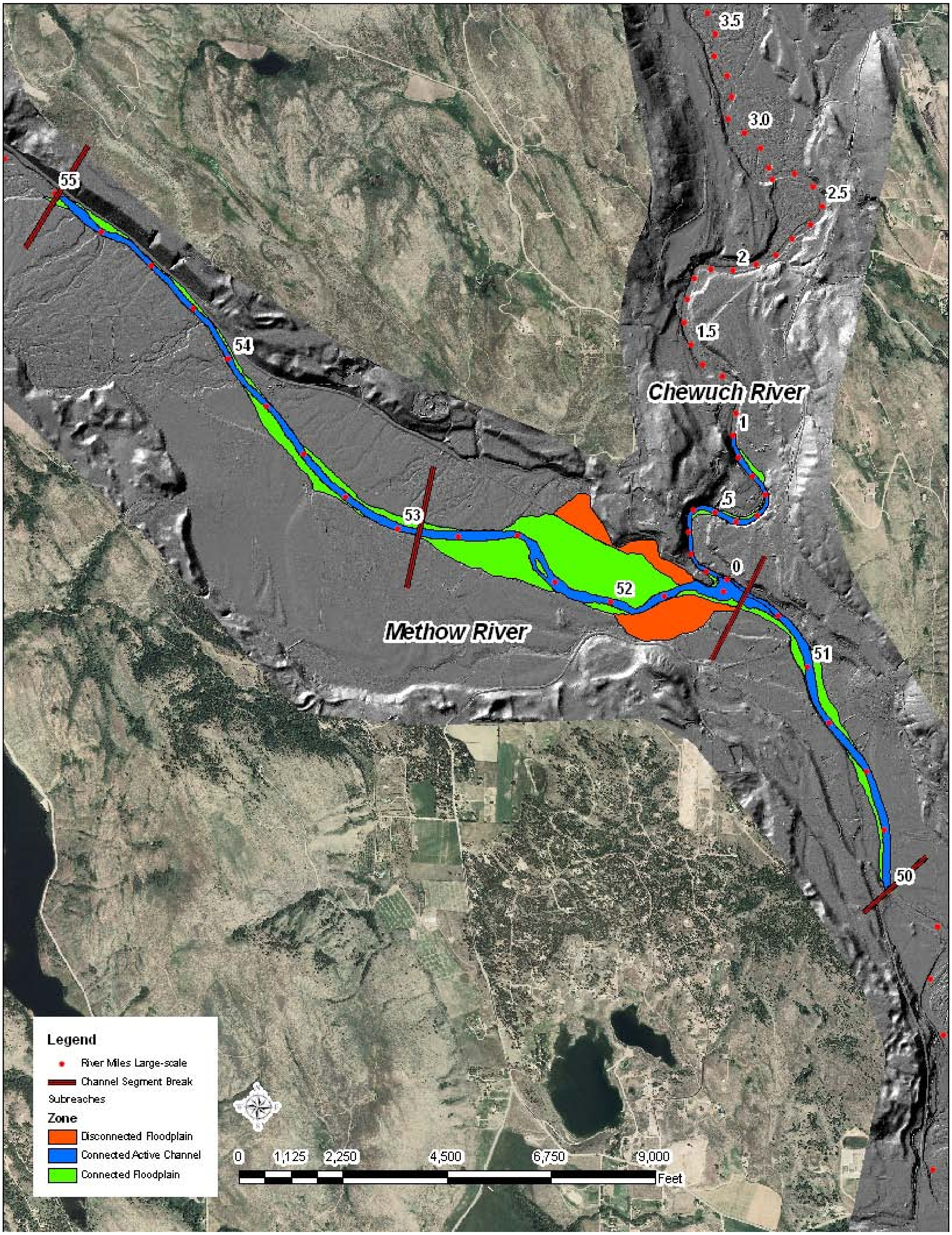

Figure 5. Hydraulic connectivity between the active channel and floodplain areas in the W2 Reach

Channel Gradient Determinations

A longitudinal channel profile was generated using the 2006 LiDAR data collected during the Geomorphic Assessment (Reclamation 2008a). The LiDAR used does not penetrate the water, but does capture hydraulic controls along the channel alignment (i.e. riffles and rapids). The surface water channel profile was generated to determine the channel gradient from about RM 60 to 50. This report uses the results from this analysis (Figure 6), and based on the raw survey data, calculated the channel gradients for each of the geomorphic channel segments.

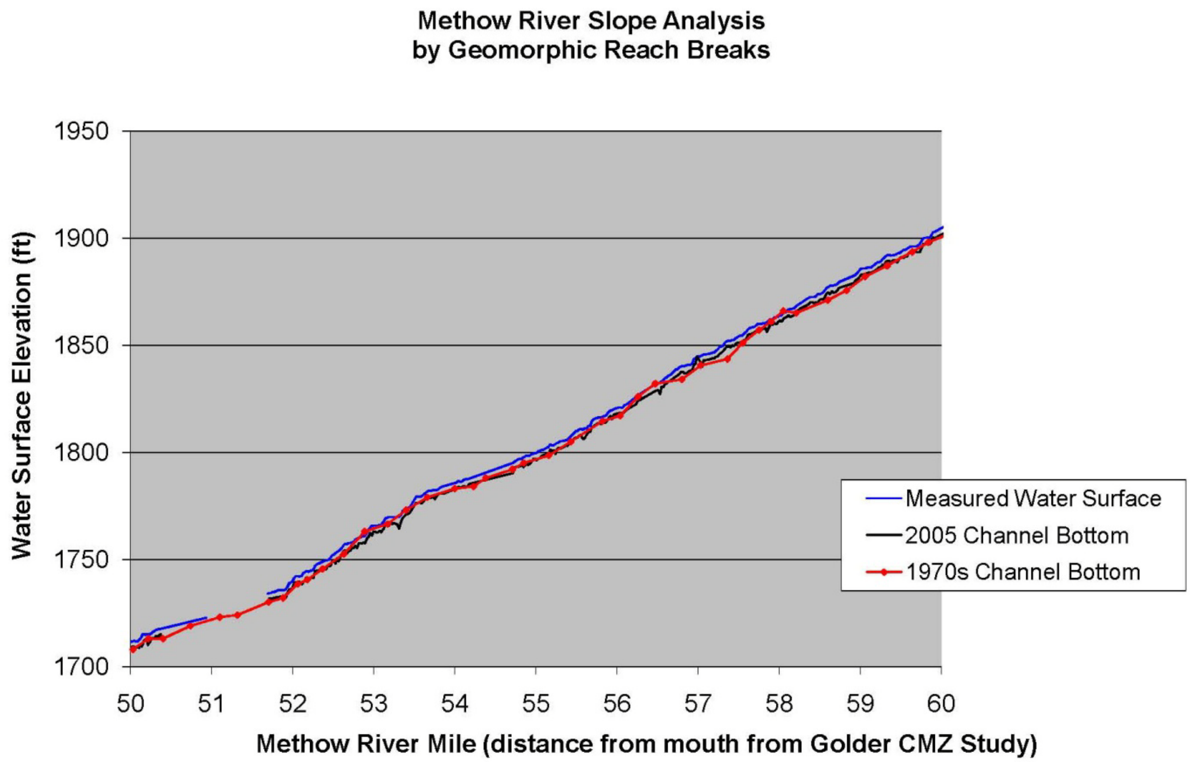

Figure 6. W2 assessment area longitudinal channel profile (2006) from Reclamation (2008a)

The raw data was analyzed using river miles at the endpoints of the 2009 channel alignment (Reclamation 2008a) and the average channel slope was calculated for each channel segment. The average channel slopes ranged between 0.4 percent and 0.3 percent for all channel segments (Table 9).

Table 9. Channel planform calculations based on 2006 LiDAR and 2009 aerial photographs

Geomorphic Channel Segment	River Miles	Valley Confinement	Elevation Change	Channel Distance (2009)	Avg. Channel Slope (percent)	Sinuosity
Segment M8	RM 55.0-52.9	Moderately Confined	1796-1757 feet	10,981 feet	0.4%	1.01
Segment M7	RM 52.9-51.3	Unconfined	1757-1729 feet	8,045 feet	0.3%	1.12
Segment M6	RM 51.3-50.0	Moderately Confined	1729-1710 feet	7,502 feet	0.3%	1.02

Fish Usage

The fish species of interest using the W2 Reach are (1) spring and summer Chinook salmon; (2) steelhead; (3) bull trout; (4) coho salmon; and (5) Pacific lamprey. Table 10 provides a summary of how each of these species utilize the reach. Intuitively, this reach may also be providing all fish species thermal refugia during low flow periods in late summer and early spring. Groundwater upwelling caused by bedrock forcing subsurface flows to the surface provides cooler water in the late summer and warmer water in the early spring within the wetted channel and in some off-channel areas.

Table 10. Summary of fish species of interest and fish usage in the W2 Reach (Reclamation 2008a)

Fish Species of Interest	Fish Usage in W2 Reach
Spring and summer Chinook salmon	Migratory corridor to reach major spawning areas in upper watersheds; and also for adult holding, spawning, rearing, foraging, and potentially winter refugia
Steelhead	Migratory corridor to reach major spawning areas in upper watersheds; and also for adult holding, spawning, rearing, foraging, and potentially winter refugia
Bull trout	Migratory corridor to reach major spawning areas in upper watersheds; and also for foraging and rearing
Coho salmon	Adult holding, spawning, and juvenile rearing; note, naturally spawning coho are increasing as a result of the Yakama Nations reintroduction effort
Pacific Lamprey	Adult holding, spawning, and juvenile rearing

REACH SCALE PHYSICAL INDICATORS

In this report, landscape processes were briefly discussed in the Regional Setting section and watershed-scale processes were summarized in the Watershed Characterization section. At the reach scale, physical habitat dynamics are primarily a function of sediment and water inputs that drive channel shape, sediment characteristics, and formation of habitat features such as pools and riffles (Beechie et al. 2010). To understand how the riverine ecosystem dynamics are functioning, riparian processes and channel-floodplain interactions were analyzed using a matrix of reach-based ecosystem indicators (REI). The condition rating determined for each indicator is based on REI criteria, geomorphic constraints, and professional judgment. Condition ratings of the indicators help identify watershed-scale systemic problems, reach-scale channel and floodplain functional problems, and evaluation of processes that benefit the riverine ecosystem. The REI for the W2 assessment area is provided in Appendix A and the following section discusses the condition rating of each specific and general indicator.

Reach-based Ecosystem Indicators Summary

The condition of the reach-based ecosystem specific indicators informs how the general indicators (or pathways) are functioning. General indicators are used to evaluate riverine dynamics. Based on thresholds listed in the REI (Appendix A), conditions for general indicators are as follows:

- Water Quality and Quantity are **Adequate** based on the following:
  - Water temperature at the WDOE's monitoring station 48A150 on the Methow River at Winthrop had a Water Quality Index score of 83. Scores of 80 and greater indicate water quality met WDOE expectations and is of "good" quality (WDOE 2008). Based on WDOE determination, water temperature is **Adequate**.
  - Turbidity at long-term water monitoring station (48A130) along the Methow River near Twisp, received a Water Quality Index score of 81 and met or exceeded expectations (WDOE 2008) and is **Adequate**.
  - Overall water quality at the Winthrop short-term monitoring station (48A150) and Twisp long-term monitoring station (48A140) met or exceeded expectations and was of lowest concern. The chemical contamination/nutrients general indicator is **Adequate**.
- Habitat Access is **At Risk** because Foghorn Diversion Dam, a potential main channel physical barrier, near RM 53 may impede upstream and/or downstream juvenile fish passage at some biologically significant flows (Figure 7).

Figure 7. View to the northwest looking upstream at Foghorn Diversion Dam. W2 Assessment Area – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

- Habitat Quantity is **At Risk** due to the following:
    - Dominant substrate was determined to be cobble-to-boulder sized materials (averaged about 72 percent). Fine sediment in spawning areas and embeddedness of cobbles in rearing areas were appropriate. Based on the REI criteria, gravel substrate in spawning areas was appropriate for the channel type, fine sediment was less than 12 percent, and there was no cobble embeddedness which is adequate. The overall dominant substrate indicator is **Adequate**.
    - Instream wood does not meet the "desired levels of wood per mile" (greater than 20 pieces of large wood per mile). This is most likely a natural condition in the moderately confined and confined channel segments. However, in the unconfined channel segment, some of the channel/floodplain interactions have been partly disconnected. Medium-to-large trees available for long-term recruitment by the channel are insufficient in the unconfined channel segment and there was some reduction in the confined segments as well, due to anthropogenic disturbances. The instream wood indicator is **At Risk**.
    - The pool frequency criteria for a channel width of greater than 100 feet is one pool every 5 to 7 channel widths in pool-riffle type channels with average slopes of less than 0.2 percent. Pools should exhibit good fish cover, cool water, minor reduction in pool volume by fine sediment, and many large pools with depths greater than about 3 feet. These criteria are not applicable to Channel Segments

M8 and M6. These channel segments are predominantly free-formed, plane-bed, straight, high gradient channels that will not develop or maintain significant numbers of discreet pools. Channel segment M7 which is a forced alluvial channel probably had a higher percentage of instream wood available to contribute to pool formation prior to anthropogenic disturbances (partial floodplain disconnection and in-stream wood removal). The pool frequency criteria are partially applicable to this segment in that it is an alluvial, plane-bed to pool-riffle type channel. The overall channel gradient is still quite steep and the channel planform is relatively straight, with the channel type a combination of plane-bed and pool-riffle. This combination indicates that the natural pool spacing is somewhat more (fewer pools) than the suggested 5 to 7 channel widths for a pool-riffle system with less than 0.2 percent slope. Application of the 5 to 7 channel width pool spacing standard would indicate 4.4 to 6.1 pools per mile. About 3.2 pools per mile were mapped in Channel Segment M7 with average maximum pool depths of 4.6 feet and residual pool depths of 3.2 feet. This combination indicates that the pool frequency, spacing, and quality are within the expected variability for the channel type. Based on the natural channel types and characteristics, pool frequency per mile, complexity, and cover are **Adequate** for the W2 Reach as a whole.

  - Off-channel habitat was prevalent in the unconfined channel segment (M7). Segments M6 and M8 had little off-channel habitat. Off-channel habitat is generally minimal in moderately confined channel segments due to lack of floodplain area for off-channel habitat to exist in. In Channel Segment M7, anthropogenic disturbances have disconnected parts of the floodplain that have historic channel paths. For this reason, off-channel habitat is **At Risk**.

- Channel Condition and Dynamics was **At Risk** due to the following:

  - Floodplain connectivity was appropriate in the moderately confined and confined segments, but anthropogenic disturbances have disconnected about 27 percent of the floodplain in the unconfined segment. Elevated road embankments, a levee, and fill material have reduced hydraulic connectivity between historic channel paths and floodplain. The reduction in floodplain connectivity from historic levels meets the REI criteria for **At Risk**.

  - Artificial bank stability has not impacted lateral channel migration in the moderately confined and confined channel segments. However, bank armoring to protect infrastructure and developed areas has restricted lateral channel migration in the unconfined channel segment. There has not been a detectible change in channel geometry, but lateral channel migration rates have most likely been reduced from historic rates. The bank stability indicator is **At Risk**.

- Vertical channel stability does not appear to be an issue as there are several bedrock outcrops that were observed adjacent to the channel and some in the channel. The locations of these outcrops suggest bedrock is fairly shallow beneath the overlying alluvium, and that the bedrock controls the reach-scale channel grade. No measurable channel incision or aggradation was detected during the Geomorphic Assessment (Reclamation 2008a). Vertical channel stability is **Adequate** for the reach.

- Riparian/Upland Vegetation was **At Risk** due to the following:
  - Floodplain vegetation structure has been negatively impacted from anthropogenic disturbances. About 33 percent of the vegetation has been cleared or thinned for commercial, residential and agriculture development, and the supporting infrastructure. Less than 80 percent of the species structure and composition were considered consistent with the potential native riparian community. The vegetation structure is **At Risk**.
  - Vegetation disturbance along the 30-meter buffer zone adjacent to the active channel has been cleared and thinned for commercial, residential, and agriculture development. About 34 percent of the buffer has been impacted by anthropogenic disturbances. The vegetation disturbance has negatively impacted wood recruitment potential to the channel, channel boundary roughness, and terrestrial connectivity (i.e. aquatic insect life stages). Vegetation along the buffer zone is **At Risk**.
  - Vegetation canopy cover was not directly measured. The vegetative structure along a 10-meter buffer zone adjacent to the active channel was evaluated as a surrogate to direct densitometer measurements. About 15 percent of the buffer zone had been cleared or thinned for development. However, about 84 percent of the buffer zone was in a shrub-to-large trees condition that was considered **Adequate** for channel shading, bank reinforcement, and fish cover.

Table 11 contains the summary of condition ratings for each of the specific and general indicators contained in the REI.

Table 11. REI condition ratings for indicators

Spatial Scale	General Indicator	Specific Indicator	Specific Indicator Condition	General Indicator Condition
Reach Characteristics	Water Quality and Quantity	Water Temperature	Adequate	Adequate
		Turbidity	Adequate	
		Chemical Contamination/Nutrients	Adequate	
	Habitat Access	Main Channel Physical Barriers	At Risk	At Risk
	Habitat Quality	Channel Substrate	Adequate	At Risk
		Turbidity	Adequate	
		Substrate Embeddedness	Adequate	
		Fine Sediment	Adequate	
		Instream Wood	At Risk	
		Pools	Adequate	
		Off-channel Habitat	At Risk	
	Channel Condition and Dynamics	Floodplain Connectivity	At Risk	At Risk
		Bank Stability/Channel Migration	At Risk	
		Vertical Channel Stability	Adequate	
	Riparian/Upland Vegetation	Vegetation Structure	At Risk	At Risk
		Vegetation Disturbance	At Risk	
		Vegetation Canopy Cover	Adequate	

UPPER W2 SECTION

Channel Segment Characterization

Geomorphic channel segments were identified based on geologic valley constrictions. The channel segment divisions (breaks) are located within the geologic constrictions and where the channel was moderately confined. Subreaches were delineated based on interpretations from aerial photographs, 2006 LiDAR hillshade elevation model, topographic maps, and field observations. The objective was to identify areas where channel-floodplain interactions have been impacted by anthropogenic disturbances. Where necessary to quantify the areas where anthropogenic disturbances disconnected the channel-floodplain interactions, the subreaches were divided into smaller areas or "parcels", and subreaches with these parcel subdivisions are referred to as subreach complexes. Subreach complexes may include both connected and disconnected areas due to anthropogenic disturbances. The objective of these parcel subdivisions is to understand the physical connectivity of the channel-floodplain interactions and vegetative processes. These interactions contribute to creation and maintenance of appropriate channel morphology, habitat structure, thermal regime, water chemistry, species assemblage, and connectivity between physical and biotic processes (Beechie et al. 2010).

The floodplain vegetation was evaluated using ArcGIS analysis. Vegetation was previously mapped during the Geomorphic Assessment (Reclamation 2008a). The focus of this analysis was to determine vegetation structure and disturbances within the floodplain areas, along a 30-meter buffer zone, and along a 10-meter buffer zone. This analysis provides insight on the health, structure, and composition of riparian vegetation, terrestrial connectivity, organic inputs to the stream, and stream shading.

Channel units were mapped in the field based on observed physical characteristics and then each unit was redrawn on rectified aerial photographs (2009) in ArcGIS. "Channel units" are hydraulic features and should not be confused with "habitat units" that are a measure of habitat type and quantity available at low flows. For example, the habitat assessment includes the long pool tail-out in the "glide-pools" as pool habitat even though this area of the pool is functioning as a run hydraulically. For the channel unit mapping, the pools (area of pool scour) and runs are spatially defined and mapped separately as geomorphic channel units.

The Upper W2 valley segment was divided into two channel segments based on geologic valley confinement. Channel Segment M8 is located between RM 55 and 52.9 along a moderately confined valley segment. Channel Segment M7 is located between RM 52.9 and 51.3 along an unconfined valley segment. A summary of the channel segments is provided in Table 12 and a location map is provided in Figure 8.

Table 12. Upper Middle Methow channel segment delineations

Channel Segment	River Mile	Valley Confinement	Area
Segment M8	RM 55-52.9	Moderately Confined	69.0 acres
Segment M7	RM 52.9-51.3	Unconfined	221.5 acres

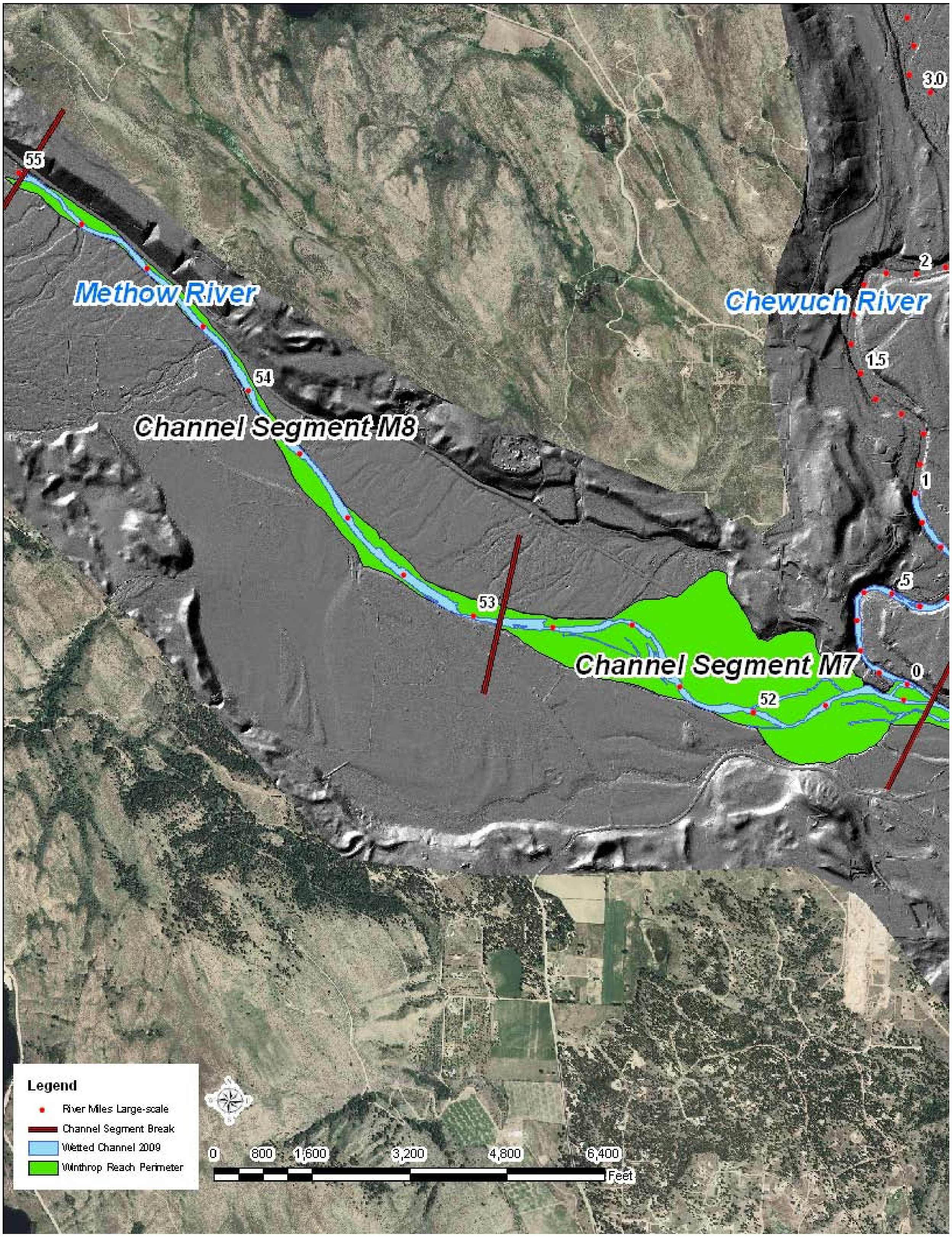

Figure 8. Upper W2 Channel Segment delineations

Channel Segment M8

Channel Morphology

Channel Segment M8 is located between about RM 55 and 52.9, and contains a total area of 69 acres which includes the active channel and floodplain. The channel is within a moderately confined valley segment between the Wolf Creek alluvial fan and glacial deposits. Average channel slope is steep at 0.4 percent and the channel is a free-formed channel with a plane-bed that is naturally entrenched (A- to F-type channel based on Rosgen 1996). Channel sinuosity is very low at 1.01. Bankfull width is about 110 feet with a width-to-depth ratio of 35.2 and entrenchment ratio of 1.3 (USFS 2006a; this study). Channel morphology metrics are provided in Table 13.

Table 13. Summary of channel morphology metrics

Channel Segment	River Miles	Morphology	Metric
Segment M8	RM 55.0-52.9	Valley Confinement	Moderately Confined
		Average Channel Slope	0.4%
		Channel Sinuosity	1.01
		Bankfull Width	111 feet
		Bankfull Depth	3.15 feet
		Width/Depth Ratio	35.2
		Rosgen Channel Classification	A-F
		Entrenchment Ratio	1.3

Lateral Channel Migration

This segment is a steep, straight, moderately confined, plane-bed system. Lateral channel migration is naturally low and is restricted by the Wolf Creek alluvial fan to the south and glacial deposits to the north (Figure 9). Near RM 54.15 bedrock crops out along river left which locally restricts lateral channel migration (Table 14).

Figure 9. View is to the southeast looking downstream along Channel Segment M8. W2 Assessment Area – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009

Table 14. Channel Segment M8 bedrock channel controls

River Mile	Bedrock Location	Description
RM 54.15	River left	Restricts lateral channel migration

The valley length is about 10,860 feet as measured near the midpoint between geologic restrictions. Channel lengths have fluctuated between about 10,940 feet and 10,984 feet, based on analysis of aerial photographs from 1945 to 2009 (Table 15), and a channel sinuosity of 1.01 has remained consistent. Channel alignments were retraced for years 1945 through 2004 from Reclamation (2008a) and from 2009 aerial photography (Figure 10).

Table 15. Channel Segment M8 channel sinuosity

Year	Valley Length	Channel Length	Sinuosity
1945	10,860 feet	10,984 feet	1.01
1954	10,860 feet	10,943 feet	1.01
1964	10,860 feet	10,937 feet	1.01
1974	10,860 feet	10,942 feet	1.01
1985	10,860 feet	10,940 feet	1.01
2004	10,860 feet	10,981 feet	1.01
2009	10,860 feet	10,981 feet	1.01

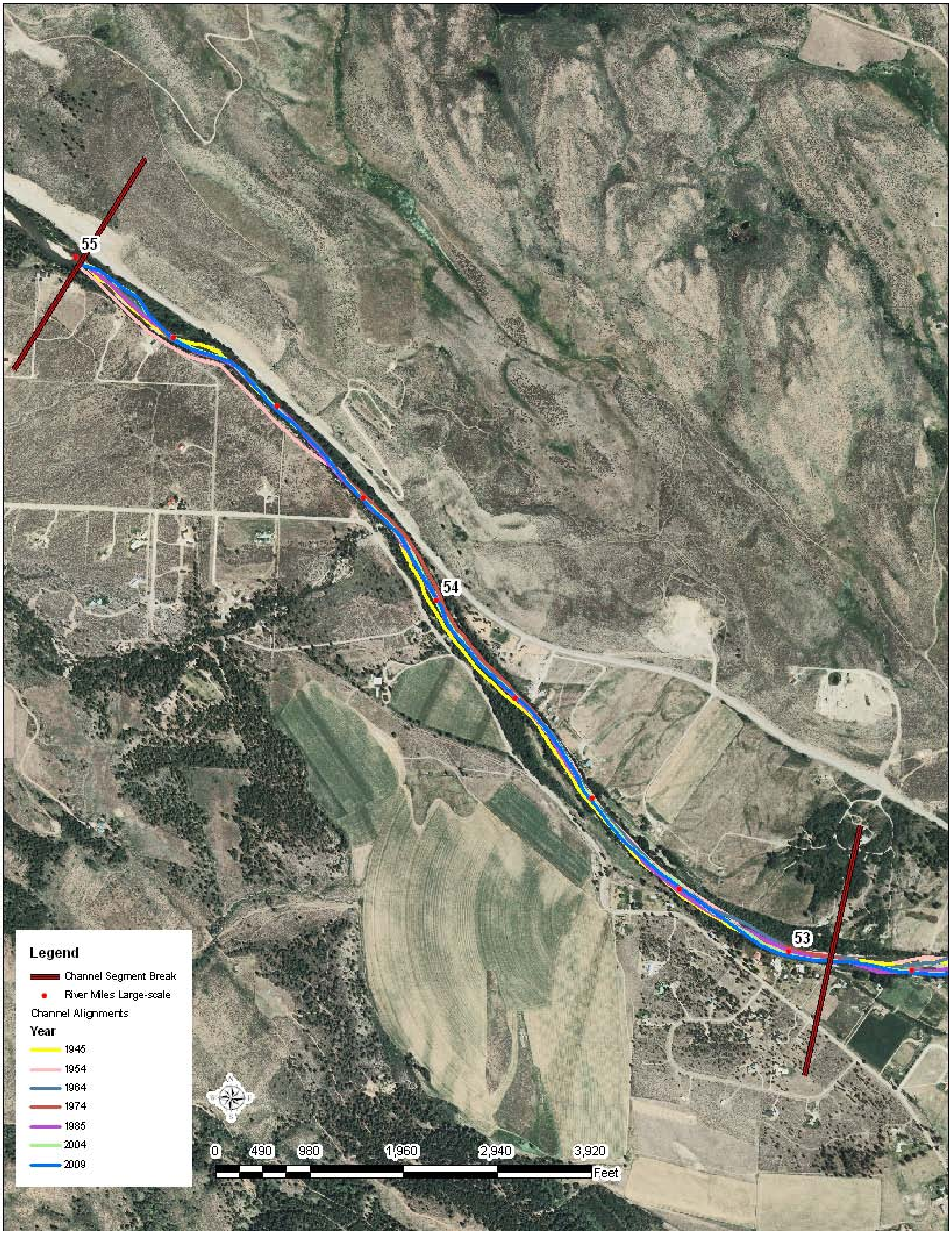

Figure 10. Channel Segment M8: Historical channel alignments

Hydraulic Connectivity

This channel segment is geomorphically and hydraulically moderately confined with narrow strips of floodplain along the channel. The active channel and floodplain areas were divided into subreaches based on lateral and longitudinal geomorphic controls. No anthropogenic features were observed that disrupted connectivity between active channel and floodplain. Based on channel morphology, streamflows, and field observations, this channel segment's active channel and floodplain interactions are hydraulically connected and functioning appropriately for this system. A summary of the subreaches and their connectivity are provided in Table 16 and a location map is provided in Figure 11.

Table 16. Summary of channel and floodplain conntectivity by subreaches

Channel Segment	River Miles	Subreach	Total Acres	Connected Acres	Disconnected Acres (Percent)
Segment M8	RM 55.0-52.9	M8-IZ-1	35.1 acres	35.1 acres	0 acres (0%)
		M8-OZ-1	1.3 acres	1.3 acres	0 acres (0%)
		M8-OZ-2	3.1 acres	3.1 acres	0 acres (0%)
		M8-OZ-3	5.2 acres	5.2 acres	0 acres (0%)
		M8-OZ-4	13.9 acres	13.9 acres	0 acres (0%)
		M8-OZ-5	10.4 acres	10.4 acres	0 acres (0%)
Total			69.0 acres	69.0 acres	0 acres (0%)

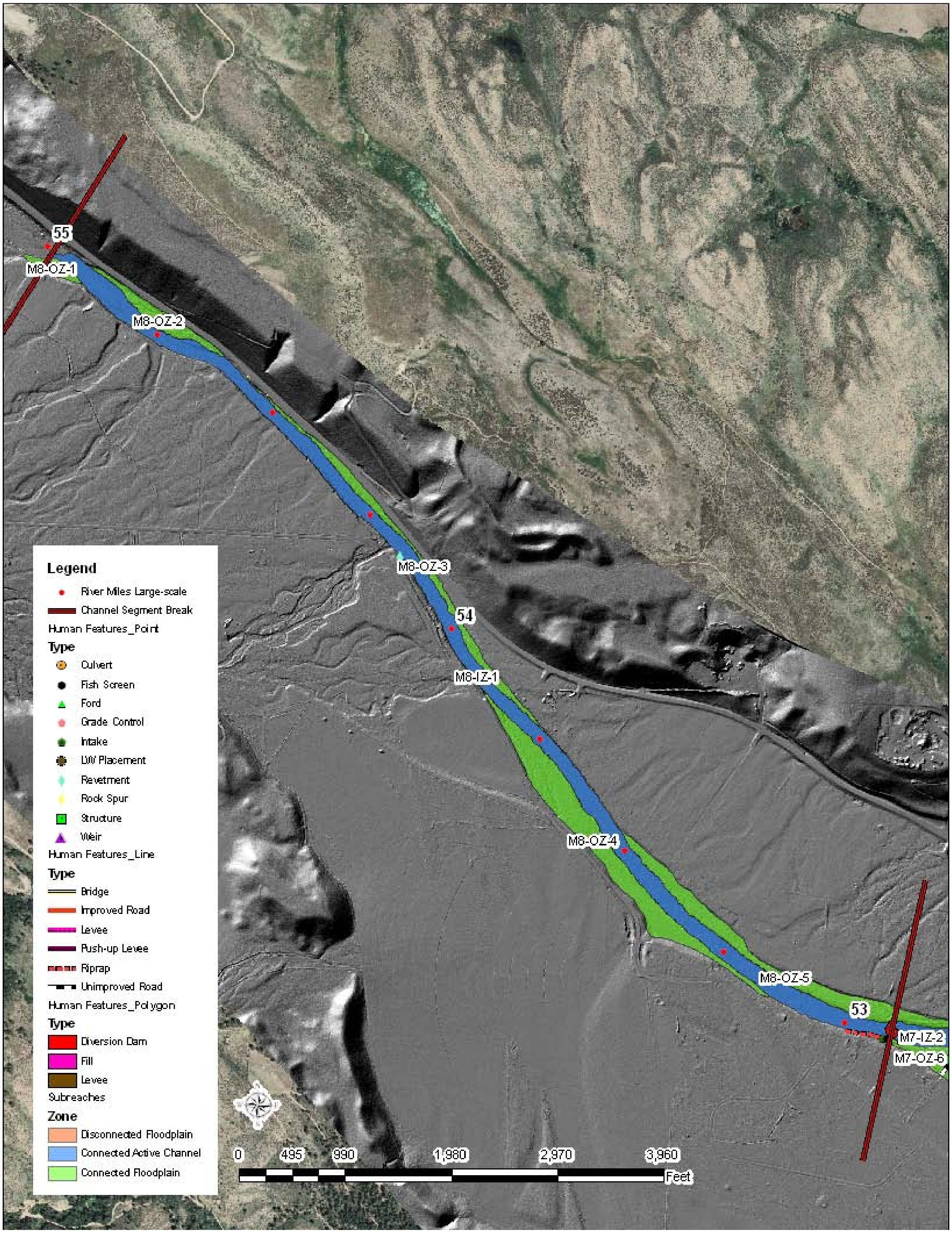

Figure 11. Channel Segment M8: Active channel and floodplain connectivity and anthropogenic features

Vegetation Structure

Analysis of riparian vegetation within the floodplain provides an indication of riparian health and land-use disturbances. In Channel Segment M8, about 20 percent (8.48 acres) of the riparian vegetation has been disturbed by infrastructure, and agriculture and residential development (Table 17). Conversely, about 80 percent (30.23 acres) of the vegetation remains undisturbed. Greater than 70 percent of the vegetation is in a medium-to-large tree condition with black cottonwoods comprising about 63 percent of the species composition (Figure 12).

Table 17. Summary of floodplain vegetation composition metrics

Channel Segment	Map Unit	Classification	Area	Percentage
Segment M8	10	Agricultural Areas (Current and Fallow)	4.70 acres	11%
	6	Bars with Forbs or No Vegetation	3.35 acres	8%
	2	Black Cottonwood	26.45 acres	63%
	1	Quaking Aspen	1.74 acres	4%
	14	Road	0.57 acres	1%
	11	Residential Areas	3.21 acres	8%
	7a	Shrub Steppe	0.16 acres	<1%
	8a	Upland Forest	2.04 acres	5%
Total		**42.22 acres**		**100%**

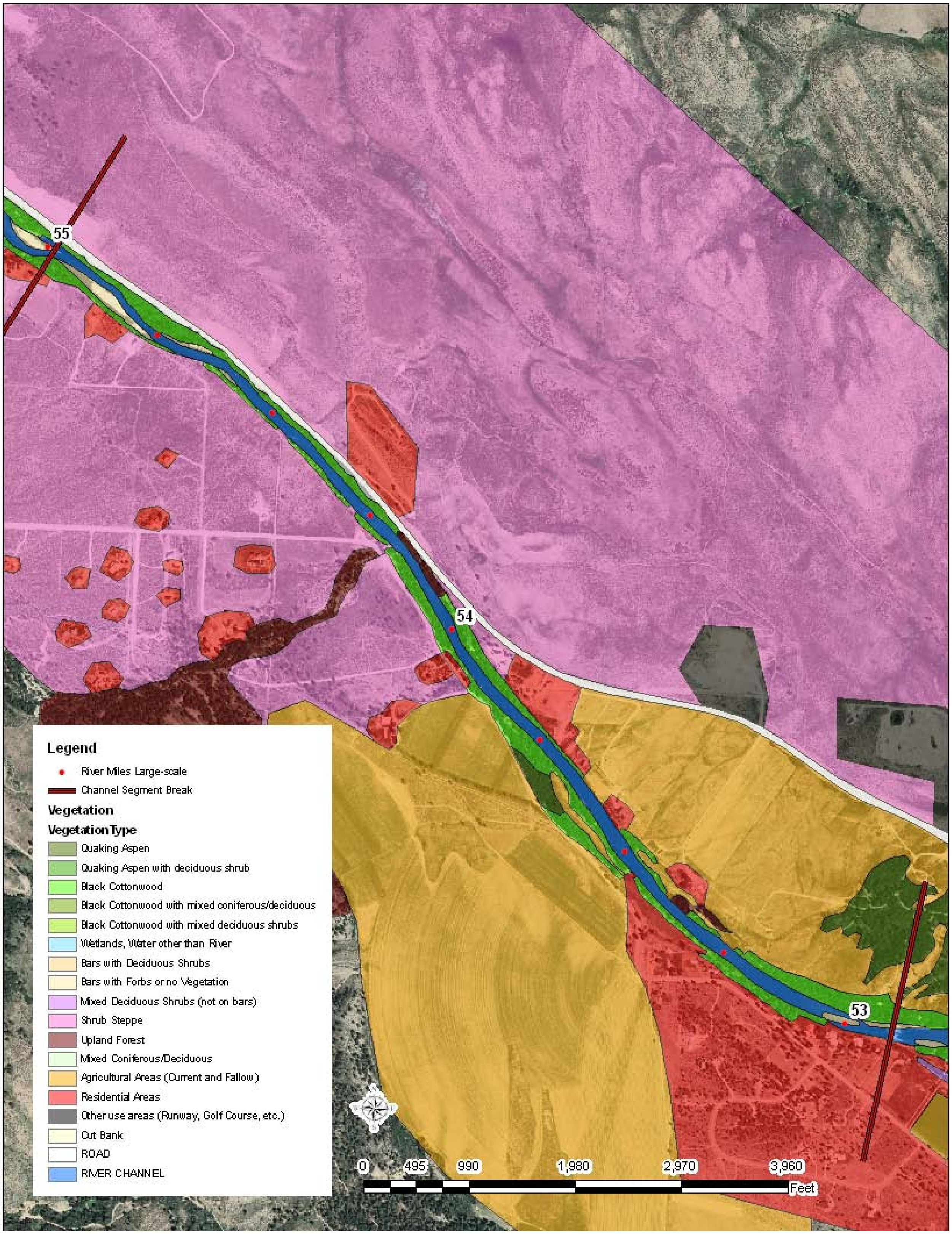

Figure 12. Channel Segment M8: Vegetation structure

Aquatic Habitat

Channel unit area (in acres) was evaluated to determine the percent of each unit present within the wetted channel. Run and riffle channel units were dominant which would be expected for a steep, straight, plane-bed, moderately confined channel (Table 18 and Figure 13).

Table 18. Channel Segment M8: Channel unit percentage

Rapid	Riffle	Run	Pool	Side Channel
4 percent	28 percent	65 percent	3 percent	<1percent

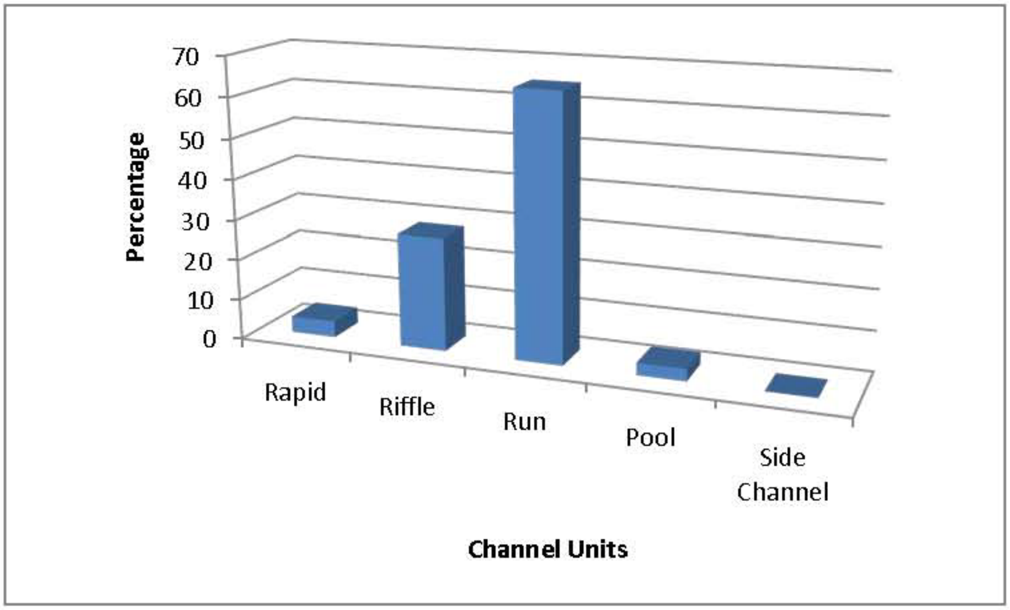

Figure 13. Channel Segment M8: Chart of channel unit percentages

The channel segment is essentially straight with a sinuosity of 1.01, and meanders were of such low amplitude that they do not sufficiently focus flows at the meander apex to form lateral scour pools (Figure 14). Pool formation in steep, straight, plane-bed, cobble based streams is typically very limited.

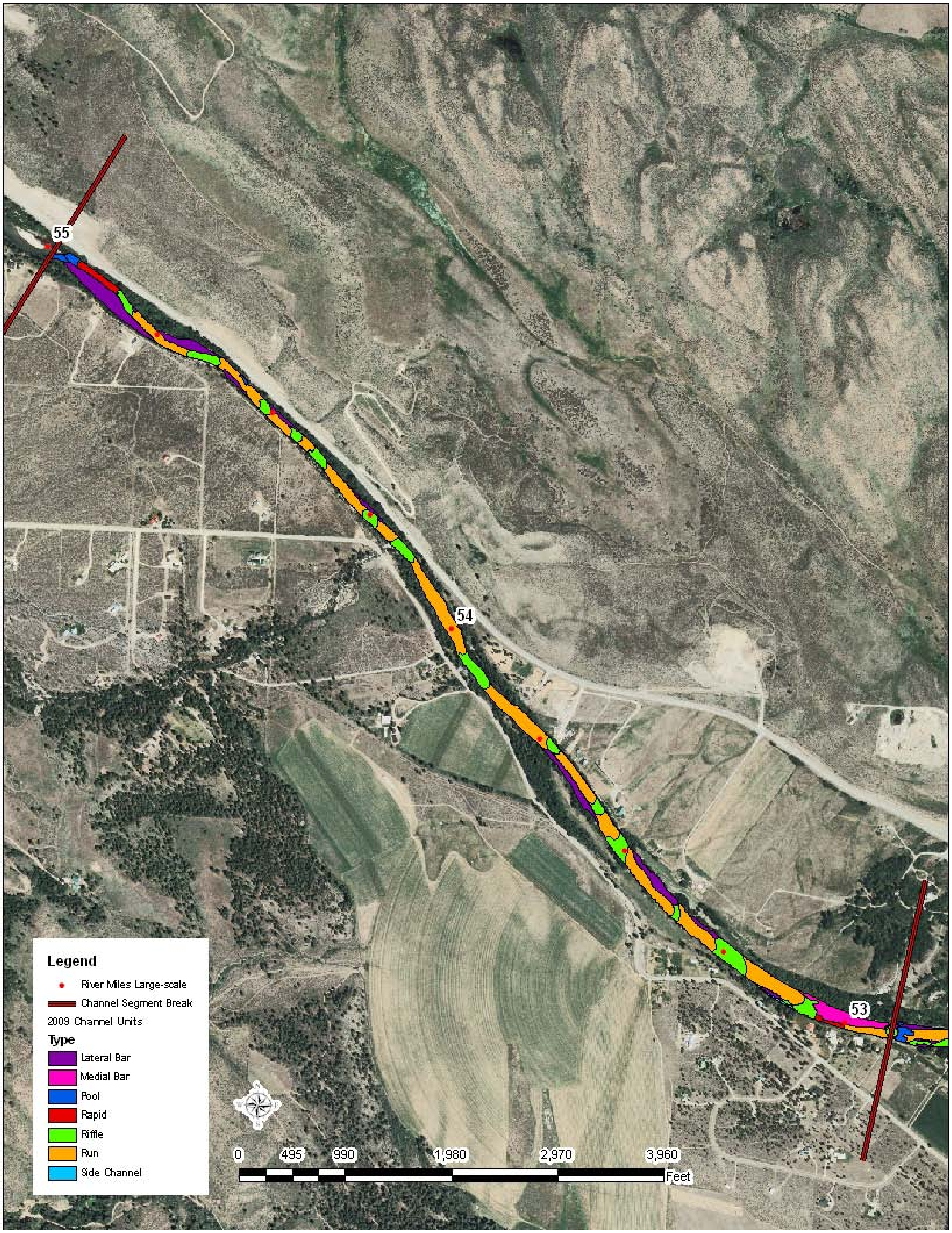

Figure 14. Channel Segment M8: Visual representation of channel units

As part of this assessment, side channels were mapped as a separate channel unit and given a unique identifier (SC_53.1R_GB as an example is a side channel at RM 53.1 on river right and is a gravel bar-type side channel). Gravel bar-type side channels are part of the active channel and are associated with unvegetated bars and channel braids that are persistent but not well established; floodplain-type (FP) side channels are established channels associated with vegetated islands and floodplain areas outside the active channel. One side channel was mapped in this segment totaling about 0.14 acres (Table 19).

Table 19. Channel Segment M8: Side channel identifier, type, and acreage

Channel Segment	River Miles	Side Channel	Side Channel Type	Acres
Segment M8		SC_53.1R_GB	Gravel Bar	0.14
Total Acres by Side Channel Type;	**Floodplain Type:**	0 Acres (0%)		
	Gravel Bar Type:	0.14 Acres (100%)		
Total Side Channel Acres:	**0.14 Acres**			

During the Stream Inventory Surveys (USFS 2006b and USFS 2008), observed larger wood sizes were scarce with only 3.7 pieces of large (at least 12 inches diameter with a length of at least 35 feet) wood per mile. In this channel segment, wood is not expected to deposit or remain in the channel due to channel characteristics (straight, steep, plane-bed, and confined).

Summary

This channel segment contains a total area of 69 acres of active channel and floodplain areas that are hydraulically connected. The channel is a moderately confined, free-formed alluvial channel that is steep, straight, and has a plane-bed bed-form. Channel sinuosity (1.01) has remained essentially consistent based on channel planform analysis from 1945 to 2009.

The floodplain vegetation structure and composition appear appropriate for a moderately confined system with some minor anthropogenic disturbances. About 20 percent of the riparian vegetation has been disturbed due to infrastructure, and agriculture and residential development. More than 80 percent of the riparian vegetation remains undisturbed and more than 70 percent was in a medium-to-large trees condition.

Aquatic habitat was comprised predominantly of run and riffle channel units that would be expected for this system. Channel confinement, type, planform, and gradient maintained the stream's competence to transport wood and sediment downstream. Some wood was stored along the channel margins, but its location only interacted with the channel during channel forming flows and did not directly contribute to pool or side channel formation.

Channel Segment M7

Channel Morphology

Channel Segment M7 is located between about RM 52.9 and 51.3, and contains a total area of 221.5 acres which includes the active channel and floodplain. The channel is within an unconfined valley segment with a broad floodplain that is bounded between glacial deposits with some bedrock controls. The valley segment has been partly artificially confined by a levee, elevated road grades, fill placements and leveling, and bank protection related to floodplain development and infrastructure. Average channel slope is moderately steep at 0.3 percent and the channel is a forced alluvial channel with a plane-bed to pool-riffle bed-form that has a defined floodplain with a relatively straight meander pattern (C-type channel based on Rosgen [1996]). Channel sinuosity is low at 1.12 with a bankfull width of about 160 feet, width-to-depth ratio of 52.3 and entrenchment ratio of 4.0 (USFS 2008). Channel morphology metrics are provided in Table 20.

Table 20. Channel Segment M7 summary of channel morphology

Channel Segment	River Miles	Morphology	Metric
Segment M7	RM 52.9-51.3	Valley Confinement	Unconfined Confined
		Average Channel Slope	0.3%
		Channel Sinuosity	1.15
		Bankfull Width	157 feet
		Bankfull Depth	---
		Width/Depth Ratio	52.3
		Rosgen Channel Classification	C
		Entrenchment Ratio	4.0

Lateral Channel Migration

Channel Segment M7 is in an unconfined valley section and is a plane-bed to pool/riffle type system. The floodplain has glacial deposits and some bedrock outcrops along the margins. This stream section has been partly artificially confined by a levee and elevated road grades that disrupt channel and floodplain interactions and several areas along the streambank have been armored with riprap that restricts lateral channel migration. Local restrictions on lateral and vertical channel migration also occur where bedrock crops out along and within the channel (Table 21 and Figure 15).

Table 21. Channel Segment M7 Methow bedrock channel controls

River Mile	Bedrock Location	Description
RM 52.65	River right	Restricts lateral channel migration
RM 51.6	River left and in-channel	Restricts lateral and vertical channel migration

Figure 15. View is to the northeast looking downstream at a bedrock outcrop along river left near RM 51.6. W2 Assessment Area – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009

Valley length in this section was about 7,170 feet as measured near the midpoint between geologic restrictions. Channel lengths have fluctuated between about 7,858 feet and 8,136 feet based on analysis of aerial photographs from 1945 to 2009 (Table 22). Channel sinuosity has ranged between 1.10 and 1.13 for this time period. Historically, the channel was able to migrate slightly farther northward in the downstream part of the section based on old channel paths visible on the 2006 LiDAR hillshade elevation model. The channel may have had slightly more sinuosity with slightly higher amplitude meanders prior to anthropogenic disturbances that occurred before 1945, however, the sinuosity has remained nearly constant and is likely consistent with the channel form and type (Figure 16).

Table 22. Channel Segment M7 channel sinuosity

Year	Valley Length	Channel Length	Sinuosity
1945	7,170 feet	8,022 feet	1.12
1954	7,170 feet	7,858 feet	1.10
1964	7,170 feet	8,032 feet	1.12
1974	7,170 feet	8,136 feet	1.13
1985	7,170 feet	7,970 feet	1.11
2004	7,170 feet	7,954 feet	1.11
2009	7,170 feet	8,045 feet	1.12

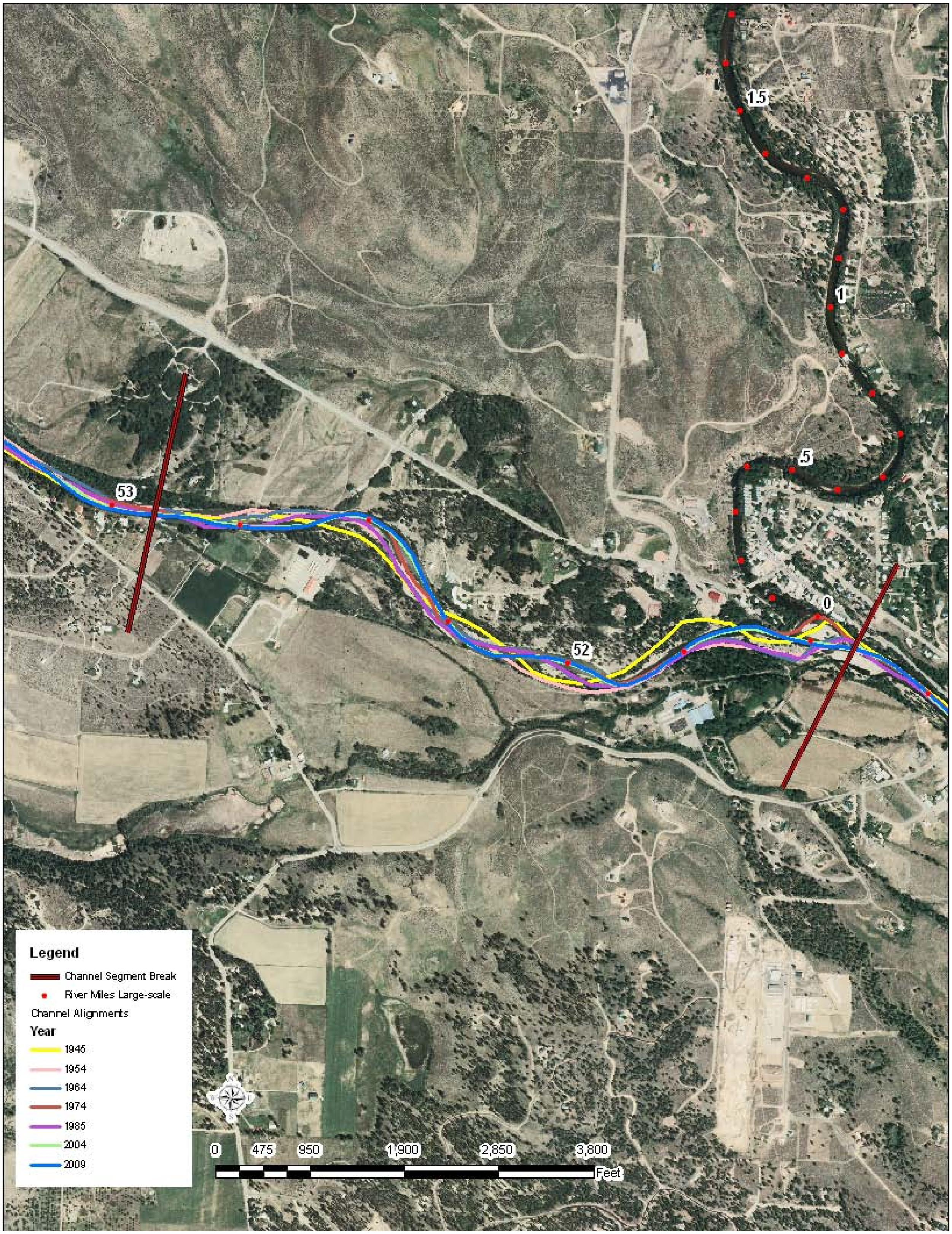

Figure 16. Channel Segment M7: Historical channel alignments

Hydraulic Connectivity

This channel segment is located in a geologically and hydraulically unconfined valley segment that has been partly artificially confined by anthropogenic disturbances that disrupt channel-floodplain interactions. In order to delineate the areas (and calculate acreage) where channel-floodplain interactions are either connected or disconnected, some subreaches had to be subdivided into smaller units, referred to as parcels. The subreaches that were subdivided are referred to as subreach complexes.

The most significant anthropogenic impacts were from a levee constructed to protect a fish hatchery; fill used as foundation material for buildings and common areas (Figure 17); and elevated road grades. These disruptions between active channel and floodplain processes are significant, but are not considered severe based on the REI criteria because over 70 percent of the channel segment remains hydraulically connected (Table 23).

Figure 17. View is to the south looking at fill and ground leveling for development of floodplain. W2 Assessment Area – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009

Table 23. Channel Segment M7 summary of channel and floodplain connectivity by subreach

Channel Segment	River Miles	Subreach	Total Acres	Connected Acres	Disconnected Acres (Percent)
Segment M7	RM 52.9-51.3	M7-IZ-2	38.9 acres	38.9 acres	0 acres (0%)
		M7-OZ-6	33.8 acres	33.8 acres	0 acres (0%)
		M7-OZ-7 Complex	102.7 acres	76.0 acres	26.7 acres (26%)
		M7-OZ-8	0.9 acres	0.9 acres	0 acres (0%)
		M7-OZ-9 Complex	44.9 acres	11.9 acres	33.0 acres (73%)
		M7-OZ-10	0.3 acres	0.3 acres	0 acres (0%)
Total			221.5 acres	161.8 acres	59.7 acres (27%)

Approximately 1,900 linear feet of levee in M7-DOZ-9b protects the fish hatchery along river right and disconnects about 33 acres of floodplain (Figure 18). In M7-DOZ-7b, about 1,380 feet of elevated road grades and 8.1 acres of fill material disconnect the floodplain, and other roads in M7-OZ-7a disrupt flood flows across flood prone areas (Table 24). Figure 19 shows the locations of connected and disconnected areas and their associated anthropogenic disturbances.

Figure 18. View to the northeast looking downstream along the hatchery levee on river right. W2 Assessment Area – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009

Table 24. Channel Segment M7: Anthropogenic features and metrics

Channel Segment	Subreach/Parcel	Feature Type	Metric
Segment M7	M7-OZ-7a	Elevated Road Grades	1,380 feet
		Fill	1.7 acres
	M7-DOZ-7b	Elevated Road Grades	1,540 feet
		Fill	8.1 acres
	M7-DOZ-9b	Levee	1,900 feet
		Fill	0.7 acres

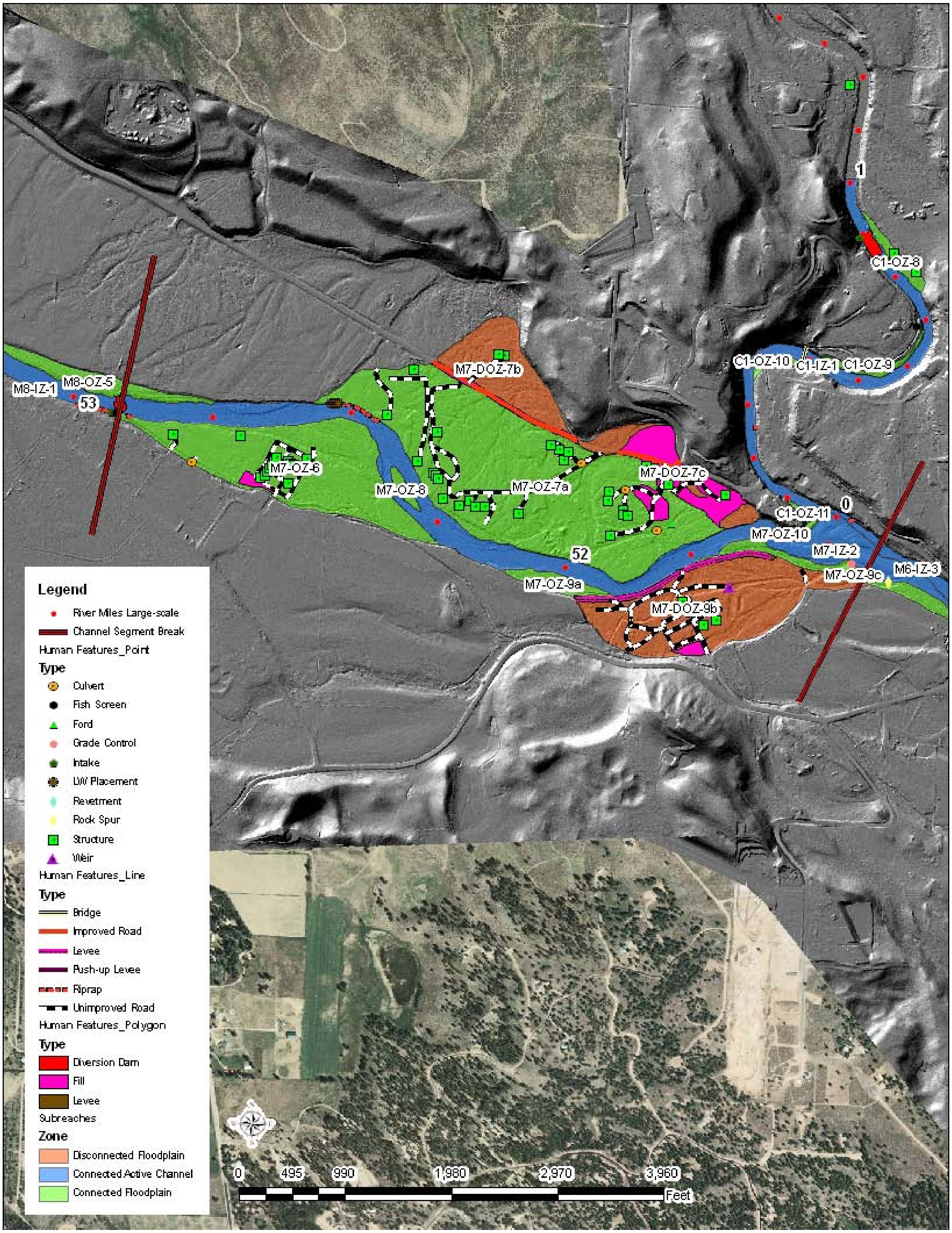

Figure 19. Channel Segment M7: Active channel and floodplain connectivity and anthropogenic features

Vegetation Structure

Anthropogenic disturbances in this channel segment have changed the vegetation structure and composition. About 35 percent (67.85 acres) of the riparian vegetation has been disturbed by infrastructure, and agriculture and residential development (Table 25). Black cottonwoods, black cottonwoods mixed with coniferous/deciduous, and mixed coniferous/deciduous trees comprised about 44 percent (85.05 acres) of the species composition (Figure 20).

Table 25. Summary of floodplain vegetation composition metrics

Segment M7	10	Agricultural Areas (Current and Fallow)	19.68 acres	10%
	5	Bars with Deciduous Shrubs	8.18 acres	4%
	6	Bars with Forbs or No Vegetation	4.13 acres	2%
	2	Black Cottonwood	15.96 acres	8%
	2a	Black Cottonwood with Mixed Coniferous/Deciduous	21.01 acres	11%
	9	Mixed Coniferous/Deciduous	48.08 acres	25%
	7	Mixed Deciduous Shrubs (Not on Bars)	9.97 acres	5%
	1	Quaking Aspen	12.02 acres	6%
	14	Road	3.18 acres	2%
	11	Residential Areas	44.99 acres	25%
	7a	Shrub Steppe	3.98 acres	2%
Total		**191.18 acres**		**100%**

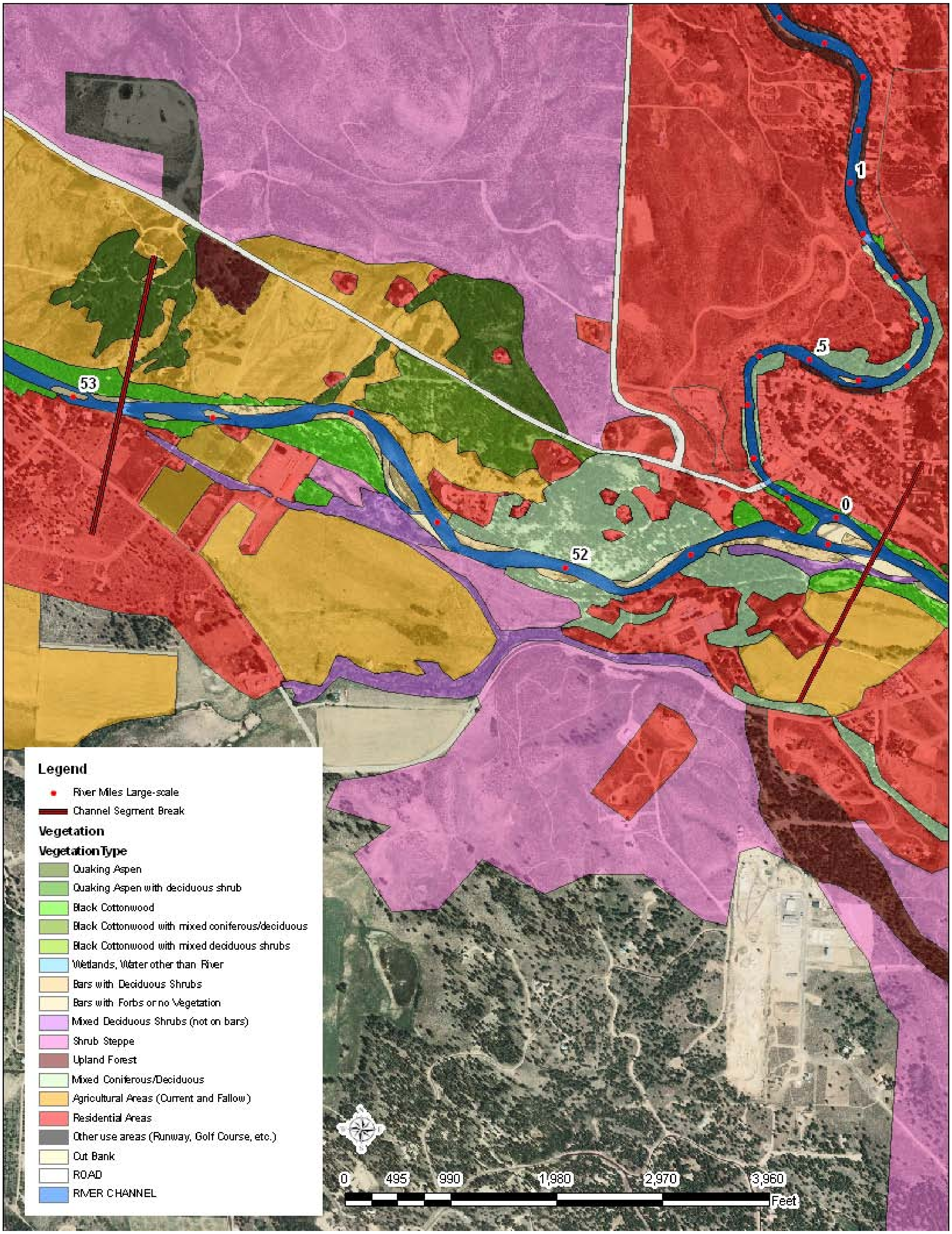

Figure 20. Channel Segment M7: Vegetation structure

Aquatic Habitat

Channel unit area (in acres) was evaluated to determine the percent of each unit present within the wetted channel. This channel segment has predominantly runs and riffles along the mainstem with a relatively small percentage of pools (Table 26 and Figure 21). This is within the natural range for a moderately steep, straight, plane-bed to pool-riffle type channel such as Channel Segment M7. Prior to anthropogenic disturbances, this channel segment likely contained more instream wood that could have contributed to pool formation and provided appropriate cover. Reduction in instream wood (likely from removal of instream wood) has removed a forcing agent that typically contributes to pool formation in pool-riffle type channels and may have resulted in slightly fewer pools in this section (Figure 22).

Table 26. Channel Segment M7: Channel unit percentages

Rapid	Riffle	Run	Pool	Side Channel
5 percent	23 percent	40 percent	7 percent	25 percent

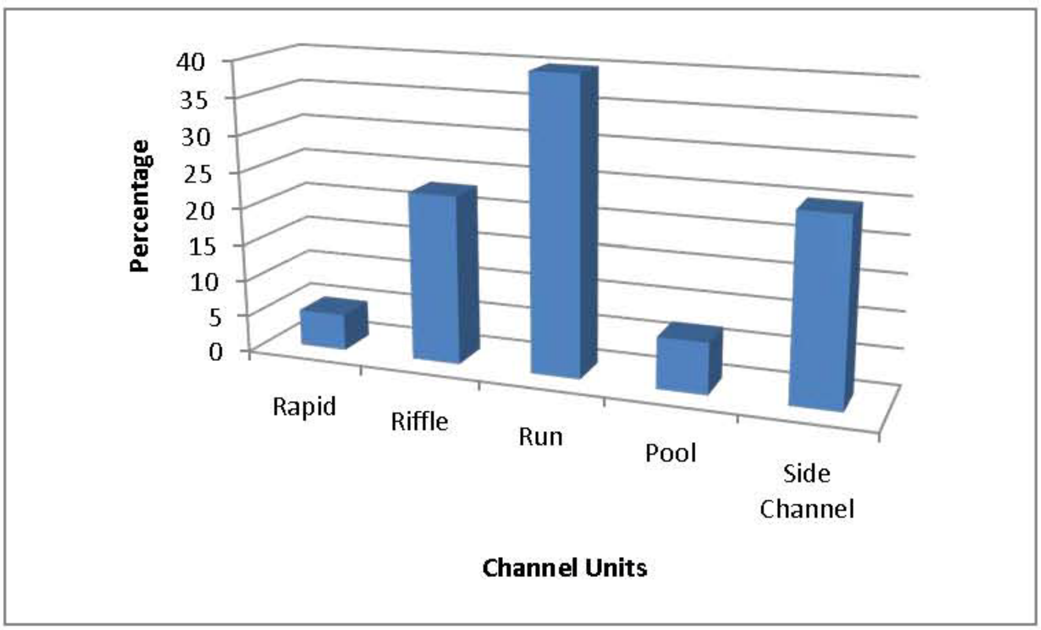

Figure 21. Channel Segment M7: Chart of channel unit percentages

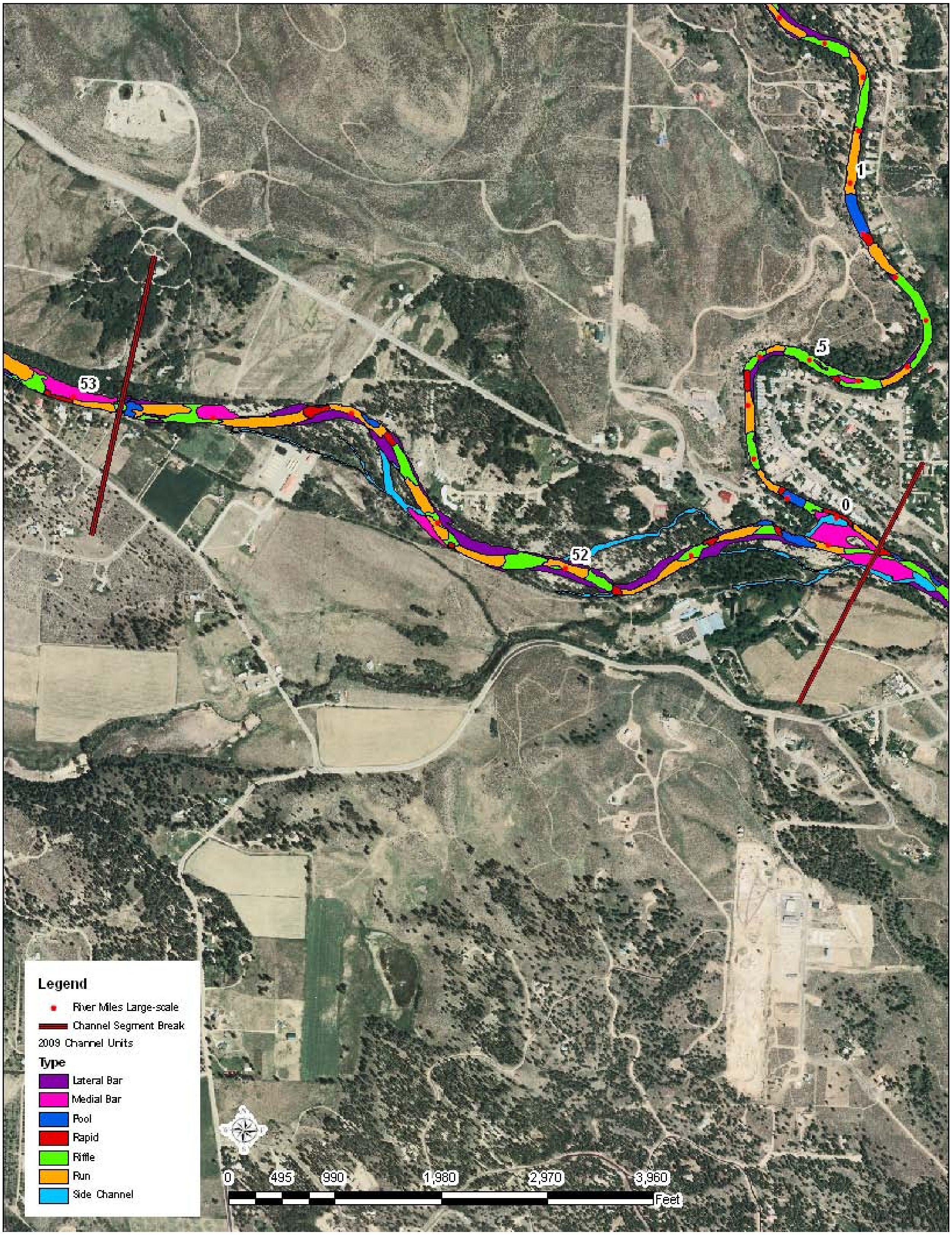

Figure 22. Channel Segment M7: Visual representation of channel units

As part of this assessment, side channels were mapped as a separate channel unit and provide the primary off-channel habitat in the section. Side channels were relatively numerous and were generally associated with wood accumulated high on gravel bars and the floodplain. Eight side channels were mapped totaling about 6.15 acres. About 90 percent of the side channels were classified as floodplain-type side channels which typically provide complex micro-habitat and ecological function. One of these side channels that was mapped as a floodplain-type side channel (SC_51.70R_FP/ART) was a constructed outfall channel from the fish hatchery that provided spawning and rearing habitat (Figure 23). The remaining side channels were classified as gravel bar-type side channels which generally provide spawning and rearing habitat (Table 27).

Figure 23. Salmon spawning along the hatchery outfall channel. W2 Assessment Area – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009

Table 27. Channel Segment M7: Side channel identifiers, types, and acreage

Segment M7		SC_52.70R_FP	Floodplain	0.66
		SC_52.40R_FP	Floodplain	1.13
		SC_52.35R_GB	Gravel Bar	0.05
		SC_52.05R_FP	Floodplain	0.23
		SC_52.00L_FP	Floodplain	1.37
		SC_51.70R_FP	Floodplain	1.63
		SC_51.70R_FP/ART	Floodplain/Artificial	0.52
		SC_51.55L_GB	Gravel Bar	0.56
Total Acres by Side Channel Type:	**Floodplain Type:**	**5.54 Acres (90%)**		
	Gravel Bar Type:	**0.61 Acres (10%)**		
Total Side Channel Acres:	**6.15 Acres**			

Summary

This channel segment is in an unconfined section that contains a total area of 221.5 acres of active channel and floodplain. The floodplain has been partly artificially confined by a levee, elevated road grades, and fill placements. The channel is a forced alluvial channel with a plane-bed to pool-riffle bed-form and a moderately steep channel slope of about 0.3 percent. This channel segment has a well defined floodplain and relatively straight meander pattern (C-type channel based on Rosgen [1996]). Channel sinuosity was predominantly 1.12 with a bankfull width of about 160 feet, width-to-depth ratio of 52.3 and entrenchment ratio of 4.0 (USFS 2008).

Anthropogenic disturbances have changed the vegetation structure and composition. About 35 percent (67.85 acres) of the vegetation has been disturbed by infrastructure, and agriculture and residential development with negative impacts to the vegetation structure. Black cottonwoods; black cottonwoods mixed with coniferous/deciduous; and mixed coniferous/deciduous trees comprise a majority of the tree species at about 44 percent.

The predominant channel units were runs and riffles along the mainstem with a relatively small percentage of pools. Very minor reduction in wood retention and likely removal of instream wood may have contributed to slightly reduced pool formation in Channel Segment M7.

Off-channel habitat was provided primarily by about 6.15 acres of side channel area. Wood accumulations on the floodplain appear to contribute to side channel formation and evolution. An artificial side channel, the hatchery outfall channel, provides cool off-channel habitat and accounted for about 8 percent (0.52 acres) of off-channel habitat.

LOWER W2 SECTION

Channel Segment Characterization

The Middle Methow valley segment was delineated based on geologic valley confinement and on hydrology based on flow inputs from the Chewuch River. One channel segment was identified within the valley segment, Channel Segment M6. The channel segment is located between RM 51.3 and 50.0 along the confined valley segment and covers about 40.7 acres of active channel and floodplain. A summary of the channel segment is provided in Table 28 and a location map is provided in Figure 24.

Table 28. Lower Middle Methow channel segment delineations

Channel Segment	River Mile	Valley Confinement	Area
Segment M6	RM 51.3	Confined	40.7 acres

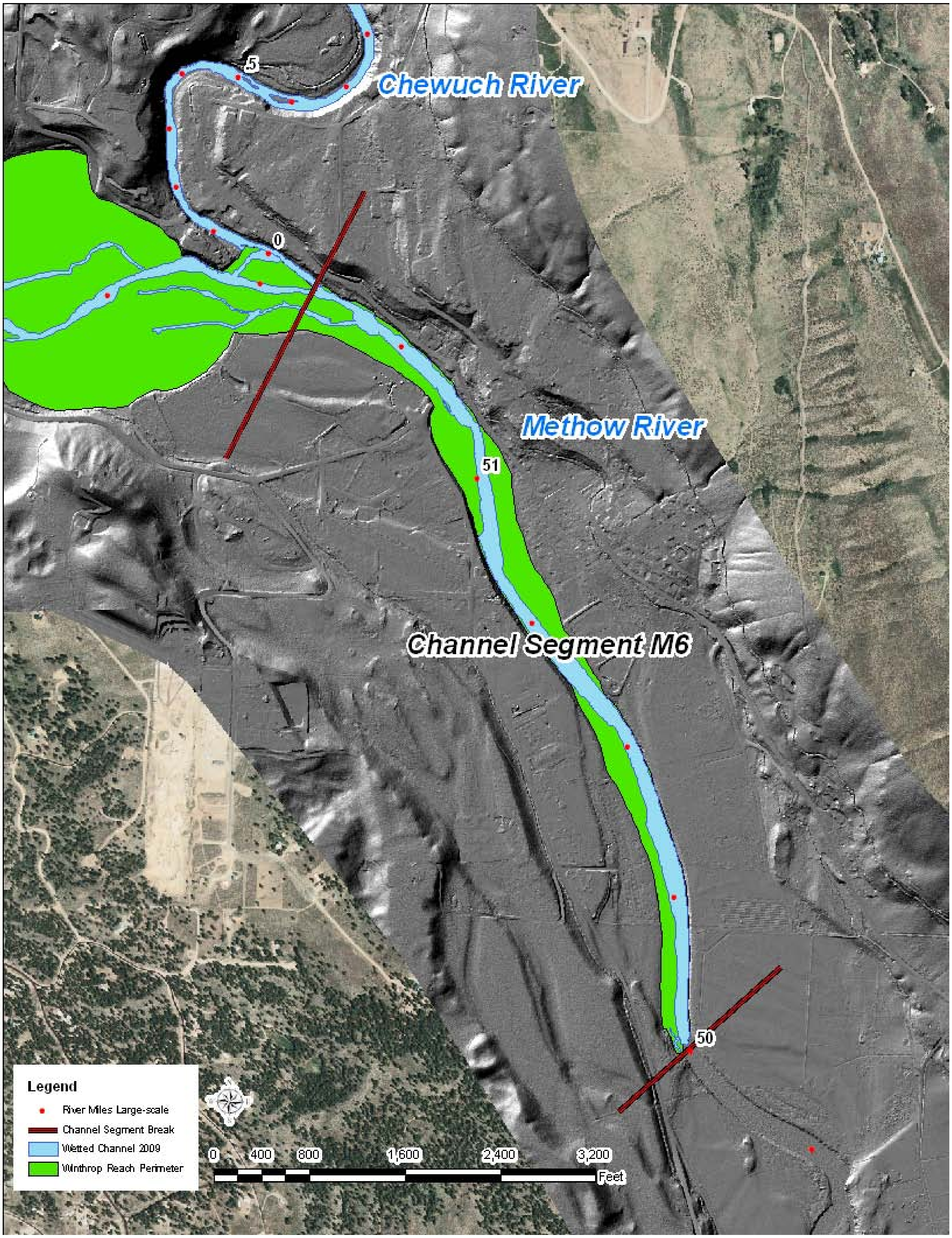

Figure 24. Lower W2 Channel Segment delineation

Channel Segment M6

Channel Morphology

Channel Segment M6 is located between RM 51.3 and 50, and contains a total area of 40.7 acres. The channel is within a confined valley segment between the Twin Lakes kame terrace, glacial deposits (undifferentiated), and bedrock. Average channel slope is moderately steep at 0.3 percent and the channel is a plane-bed system that is naturally entrenched (A- to F-type channel based on Rosgen [1996]). Channel sinuosity is very low at 1.02 with a bankfull width of about 176 feet, width-to-depth ratio of 60.3 (USFS 2008; this study). Channel morphology metrics are provided in Table 29.

Table 29. Channel Segment M6 summary of channel morphology

Channel Segment	River Miles	Morphology	Metric
Segment M6	RM 51.4-50	Valley Confinement	Confined
		Average Channel Slope	0.3%
		Channel Sinuosity	1.02
		Bankfull Width	176 feet
		Bankfull Depth	---
		Width/Depth Ratio	60.3
		Rosgen Channel Classification	F
		Entrenchment Ratio	1.23

Lateral Channel Migration

Lateral channel migration is restricted by glacial deposits and bedrock. Bedrock crops out along river left near RM 51.3 and 51.15, and along river right near RM 50 which locally restricts lateral channel migration (Table 30).

Table 30. Channel Segment M6 bedrock channel controls

River Mile	Bedrock Location	Description
RM 51.3	River left	Restricts lateral channel migration
RM 51.15	River left	Restricts lateral channel migration
RM 50.0	River right	Restricts lateral channel migration

The valley length was about 7,337 feet as measured near the midpoint between geologic restrictions. Channel lengths have fluctuated between about 7,455 feet and 7,508 feet based on analysis of aerial photographs from 1945 to 2009 (Table 31), and a channel sinuosity of 1.02 has remained consistent. Channel alignments were retraced for years 1945 through 2004 from Reclamation (2008a) and from 2009 aerial photography (Figure 25).

Table 31. Channel Segment M6 channel sinuosity

Year	Valley Length	Channel Length	Sinuosity
1945	7,337 feet	7,508 feet	1.02
1954	7,337 feet	7,493 feet	1.02
1964	7,337 feet	7,489 feet	1.02
1974	7,337 feet	7,474 feet	1.02
1985	7,337 feet	7,455 feet	1.02
2004	7,337 feet	7,461 feet	1.02
2009	7,337 feet	7,502 feet	1.02

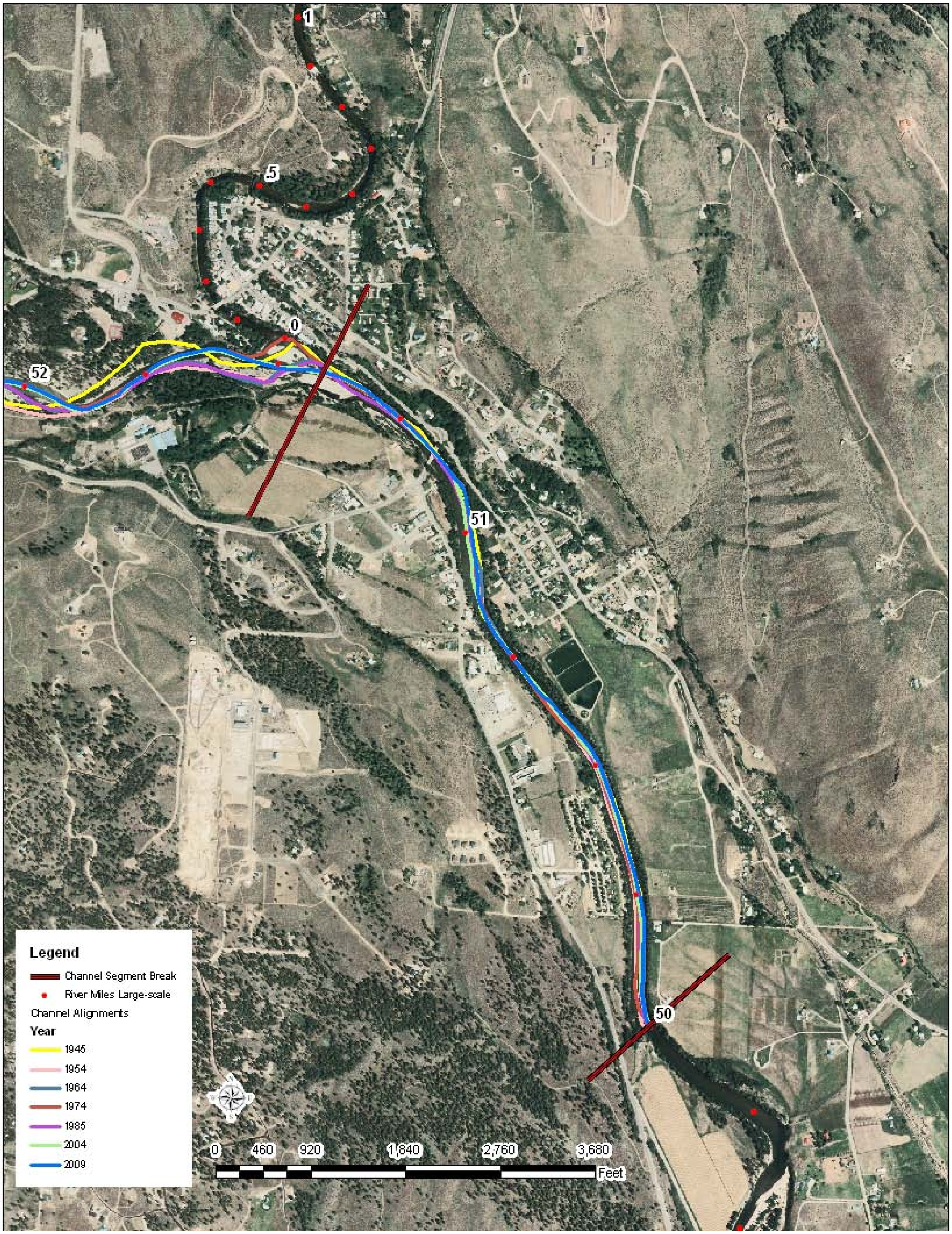

Figure 25. Channel Segment M6: Historical channel alignments

Hydraulic Connectivity

This channel segment is geomorphically and hydraulically confined with narrow strips of floodplain along the channel (Figure 26). The active channel and floodplain areas were divided into subreaches based on lateral and longitudinal geomorphic controls. There are anthropogenic features that disrupt flood flows, but no features were observed that disconnected hydraulic connectivity between active channel and floodplain. Based on channel morphology, streamflows, and field observations, this channel segment's active channel and floodplain interactions are hydraulically connected with few anthropogenic disruptions. A summary of the subreaches and their connectivity are provided in Table 32 and a location map is provided in Figure 27.

Figure 26. View to the southeast looking downstream at the thin strip of vegetation along the floodplain. W2 Assessment Area – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 11, 2009

Table 32. Channel Segment M6 channel and floodplain connectivity by subreach

Channel Segment	River Miles	Subreach	Total Acres	Connected Acres	Disconnected Acres (Percent)
Segment M6	RM 51.3-50.0	M6-IZ-3	26.1 acres	26.1 acres	0 acres (0%)
		M6-OZ-11	8.3 acres	8.3 acres	0 acres (0%)
		M6-OZ-12	6.3 acres	6.3 acres	0 acres (0%)
Total			40.7 acres	40.7 acres	0 acres (0%)

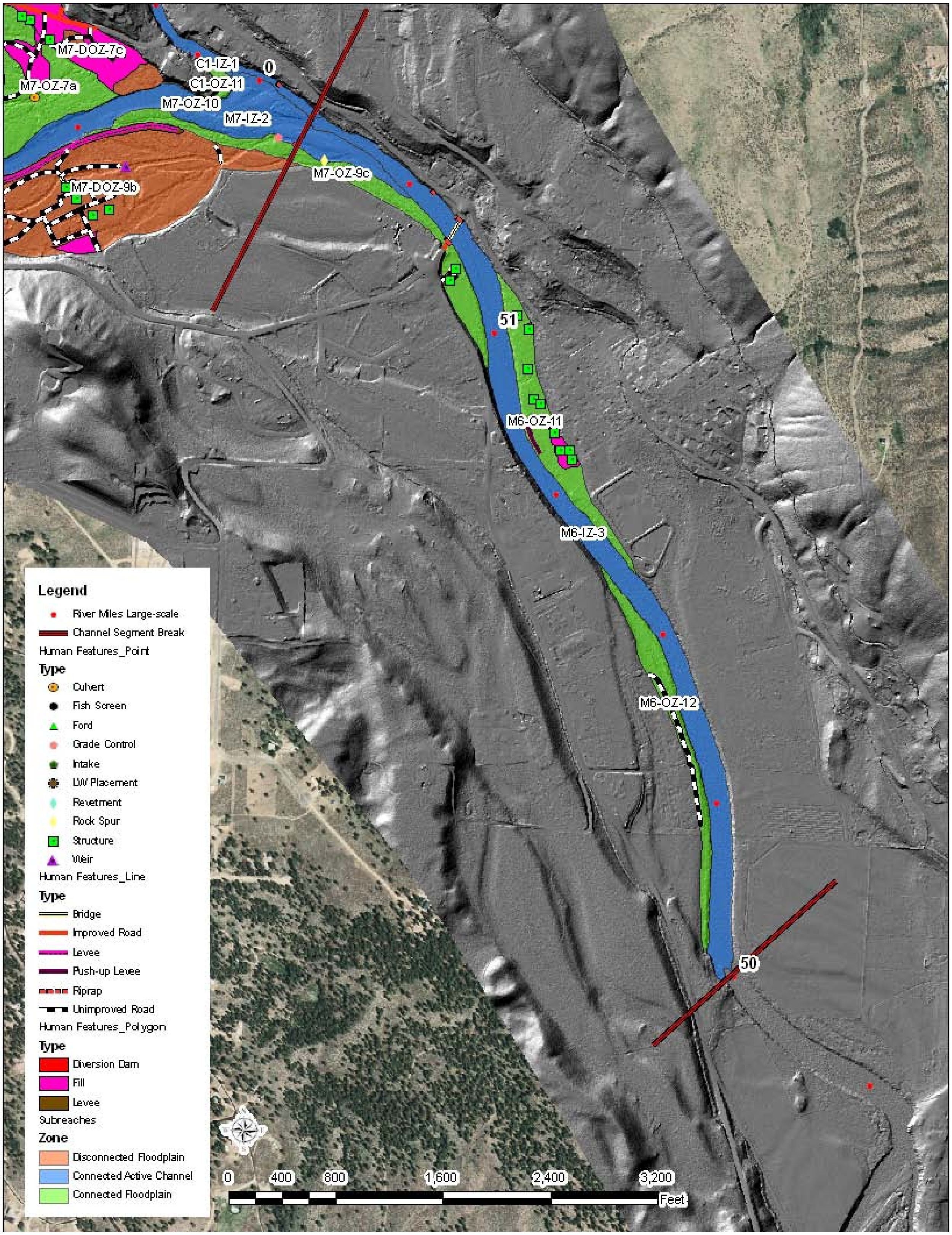

Figure 27. Channel Segment M6: Active channel and floodplain connectivity and anthropogenic features

Vegetation Structure

This channel segment is confined and has narrow strips of floodplain accessible to the active channel. About 38 percent (7.97 acres) of the vegetation has been disturbed for residential and agriculture development (Table 33). The remaining vegetation was comprised predominantly of black cottonwood stands that cover about 61 percent (12.93 acres) of the floodplain and are in a predominantly medium-to-large trees condition (Figure 28).

Table 33. Summary of floodplain vegetation composition metrics

Channel Segment	Map Unit	Classification	Area	Percentage
Segment M6	10	Agricultural Areas (Current and Fallow)	0.31 acres	2%
	6	Bars with Forbs or No Vegetation	0.11 acres	1%
	2	Black Cottonwood	12.93 acres	61%
	7	Mixed Deciduous Shrubs (Not on Bars)	0.05 acres	<1%
	11	Residential Areas	7.66 acres	36%
Total		**21.06 acres**		**100%**

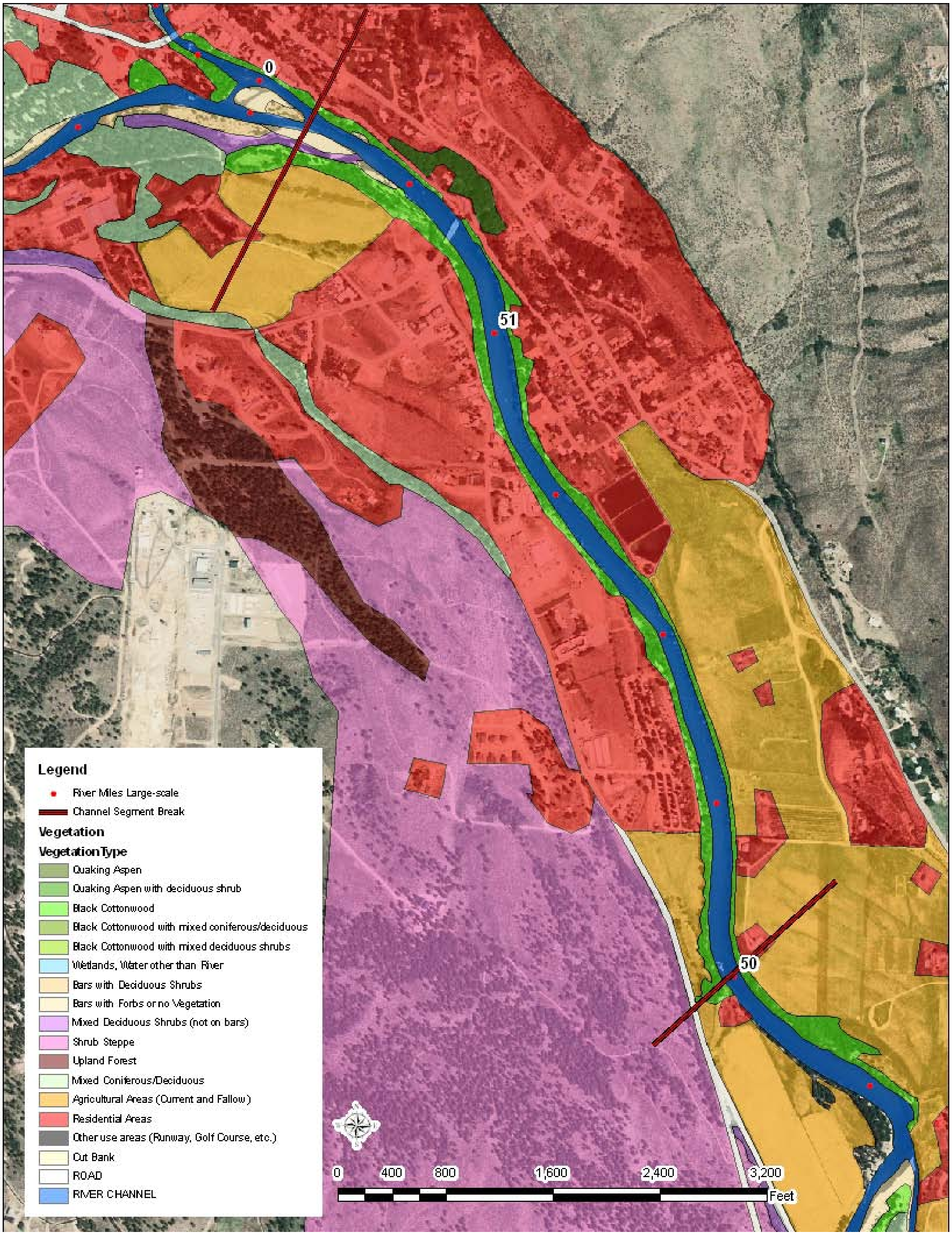

Figure 28. Channel Segment M6: Vegetation structure

Aquatic Habitat

Channel unit area (in acres) was evaluated to determine the percent of each unit present within the wetted channel (Table 34). Run and riffle channel units were dominant which would be expected for a moderately steep, straight, confined plane-bed type channel (Figure 29).

Table 34. Channel Segment M6: Channel unit percentages

Rapid	Riffle	Run	Pool	Side Channel
2 percent	25 percent	69 percent	4 percent	<1 percent

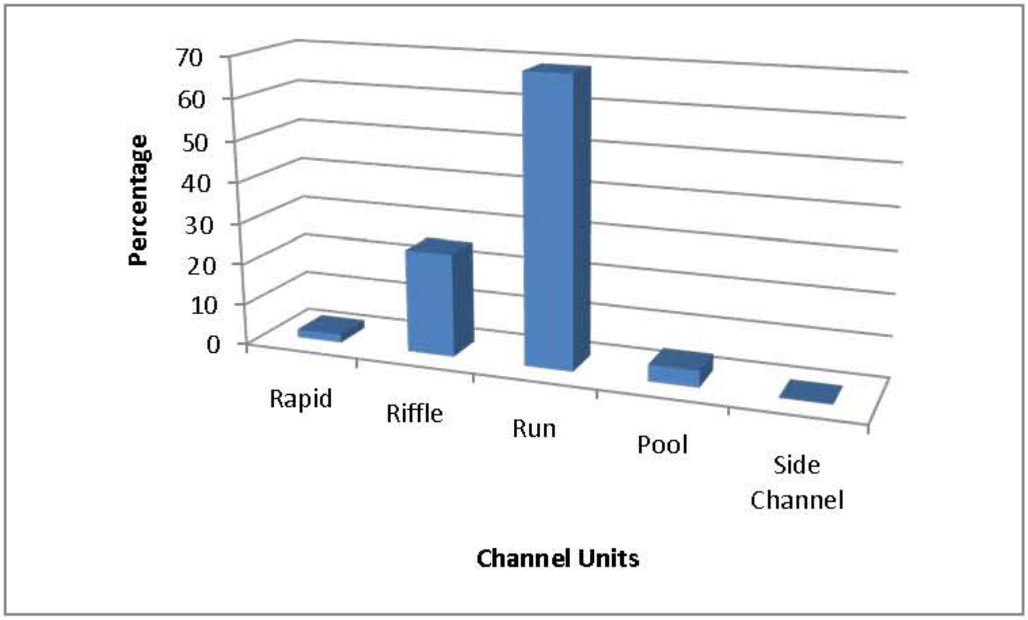

Figure 29. Channel Segment M6: Chart of channel unit percentages

The channel segment is essentially straight with a sinuosity of 1.02, and meanders were of low amplitude that does not sufficiently focus flows at the meander apex to form lateral scour pools. Where the channel comes into contact with bedrock, shear stresses are sufficient to maintain large pools (Figure 30). Pool formation in straight, plane-bed, cobble-based streams is typically very limited.

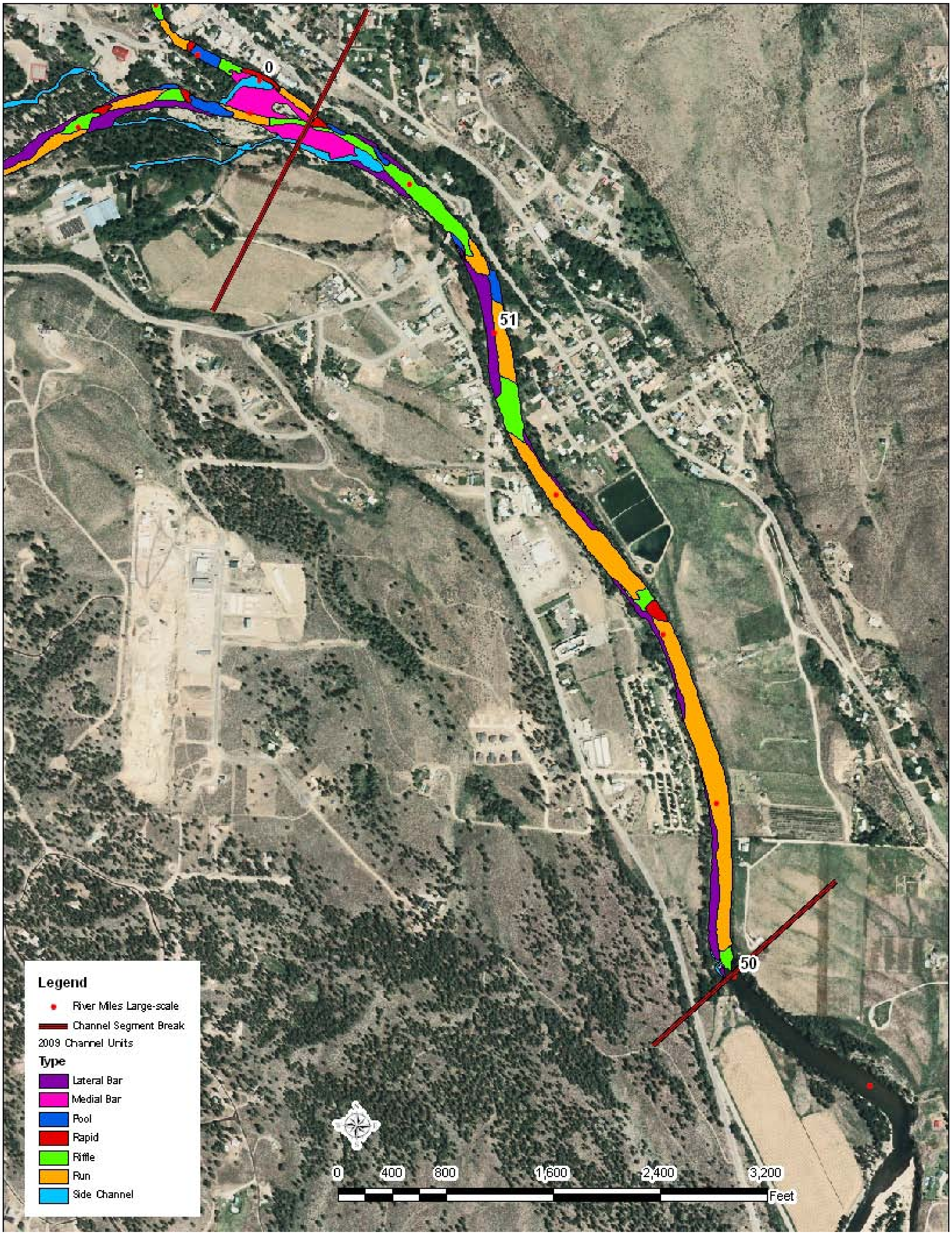

Figure 30. Channel Segment M6: Visual representation of channel units

As part of this assessment, side channels were mapped as separate channel units. Only two gravel bar-type side channels were observed in this segment totaling 0.12 acres (Table 35). One side channel (SC_50.05R_GB) was associated with a bedrock outcrop (Figure 31). Gravel was deposited upstream of the outcrop where the side channel formed and where the bedrock was in contact with the channel a deep lateral scour pool had developed. Because these are only side channels at the lowest part of the hydrograph, neither provides the habitat benefits commonly associated with "side channels." At moderate and high flows, these "side channels" are slight topographic features in the bed of the main channel and do not provide significant high-water refugia, juvenile rearing, or adult holding.

Table 35. Channel Segment M6: Side channel identifier, type, and acreage

Channel Segment	River Miles	Side Channel	Side Channel Type	Acres
Segment M6		SC_51.12R_GB	Gravel Bar	0.03
		SC_50.05R_GB	Gravel Bar	0.09
Total Acres by Side Channel Type:	**Floodplain Type:**	**0 Acres (0%)**		
	Gravel Bar Type:	**0.12 Acres (100%)**		
Total Side Channel Acres:	**0.12 Acres**			

Figure 31. View to the south looking downstream at low flow gravel bar-type side channel along river right and bedrock outcrop. W2 Assessment Area – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 11, 2009

Larger wood observed during the Stream Inventory Survey (USFS 2008) was scarce with only 5.7 pieces of large wood per mile. Most of the wood was located along the channel margins. This is due to the confined condition of this channel segment and the moderately steep channel slope which results in a higher energy/higher transport capacity channel capable of transporting woody debris.

Summary

This channel segment contains a total area of 40.7 acres of active channel and floodplain areas that are hydraulically connected. The channel is a confined to moderately confined, free-formed alluvial channel with a plane-bed bed-form that is moderately steep, and essentially straight. Channel sinuosity (1.02) has remained essentially consistent based on channel planform analysis from 1945 to 2009.

The floodplain vegetation is adjacent to the channel as narrow vegetative stands within a narrow floodplain. About 38 percent (7.97 acres) has been disturbed for residential and agriculture development. Black cottonwood stands in a medium-to-large trees condition comprise 61 percent (12.93 acres) of the vegetation species.

Aquatic habitat was comprised predominantly of run and riffle channel units that would be expected for this system. The channel is essentially straight (sinuosity of 1.01) with low amplitude meanders. Pool development is predominantly associated with bedrock outcrops that forced channel bed scour.

Wood is relatively scarce in this segment (5.7 pieces per mile) primarily due to natural channel characteristics and past channel clearing practices. Some wood was stored along the channel margins, but its location only interacted with the channel during channel forming flows and did not directly contribute to pool or side channel formation.

CONCLUSIONS

The purpose of this assessment is to provide scientific information on the geomorphology and habitat condition of the W2 Reach of the Middle Methow River between RM 55 and 50. The Methow River is a tributary to the Columbia River in the State of Washington. This report documents physical features and analyzes riverine processes that may affect the overall health of the system at the reach scale.

In the moderately confined sections (Channel Segments M8 and M6) of the stream, anthropogenic disturbances have no significant impacts on floodplain connectivity, lateral channel migration, or channel condition. However, anthropogenic disturbances that have occurred in the unconfined section (Channel Segment M7) of the stream have partly disconnected channel-floodplain interactions. Elevated road grades, a reinforced levee, and fill material used for development have disconnected about 18 percent (59.7 acres) of historic channel paths and floodplain areas. Impacts on physical processes in this section are (1) a slight increase in streampower and sediment transport capacity, which may have resulted in a reduction of gravel and wood retention that would contribute to formation of diverse habitat types; and (2) isolation of historic channel paths and floodplain areas that are hydraulically disconnected from the active channel and may result in slightly increased streampower during floods, and decreased energy transfer (i.e. food web, leaf litter), riparian vegetation health, and ecological connectivity.

Bank protection (riprap) has been placed along the levee and several sections of streambank to protect developed areas and infrastructure. The bank protection artificially restricts lateral channel migration and floodplain reworking and results in negative impacts to geomorphic channel processes and, sediment and wood recruitment.

The overall cumulative effects of anthropogenic disturbances in the unconfined stream section (Channel Segment M7) have negatively impacted the physical and ecological processes necessary to create and maintain aquatic habitat complexity, quality, and variability. These disturbances have modified the physical and ecological processes by (a) artificially disconnecting the floodplain, (b) restricting lateral channel migration, and (c) clearing and altering riparian vegetation structure and composition.

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GLOSSARY

Term	Definition
action	Proposed protection and/or rehabilitation strategy to improve selected physical and ecological processes that may be limiting the productivity, abundance, spatial structure or diversity of the focal species. Examples include removing or modifying passage barriers to reconnect isolated habitat (i.e. tributaries), planting appropriate vegetation to reestablish or improve the riparian corridor along a stream that reconnects channel-floodplain processes, placement of large wood to improve habitat complexity, cover and increase biomass that reconnects isolated habitat units.
alluvial fan	An outspread, gently sloping mass of alluvium deposited by a stream, esp. in an arid or semiarid region where a stream issues from a narrow canyon onto a plain or valley floor. Viewed from above, it has the shape of an open fan, the apex being at the valley mouth.
alluvium	A general term for detrital deposits made by streams on river beds, floodplains, and alluvial fans; esp. a deposit of silt or silty caly laid down during time of flood. The term applies to stream deposits of recent time. It does not include subaqueous sediments of seas and lakes.
anthropogenic	Caused by human activities.
bedrock	The solid rock that underlies gravel, soil or other superficial material and is generally resistant to fluvial erosion over a span of several decades, but may erode over longer time periods.
canopy cover (of a stream)	Vegetation projecting over a stream, including crown cover (generally more than 1 meter [3.3 feet] above the water surface) and overhang cover (less than 1 meter [3.3 feet] above the water).
channel forming flow	Sometimes referred to as the effective flow or ordinary high water flow and often as the bankfull flow or discharge. For most streams, the channel forming flow is the flow that has a recurrence intermal of approximately 1.5 years in the annual flood series. Most channel forming discharges range between 1.0 and 1.8. In some areas it could be lower or higher than this range. It is the flow that transports the most sediment for the least amount of energy, mobilizes and redistributes the annually transient bedload, and maintains long-term channel form.
channel morphology	The physical dimension, shape, form, pattern, profile and structure of a stream channel.
channel planform	The two-dimensional longitundinal pattern of a river channel as viewed on the ground surface, aerial photograph or map.
channel stability	The ability of a stream, over time and under the present climatic conditions, to transport the sediment and flows produced by its watershed in such a manner that the stream maintains its dimension, pattern and profile without either raising or lowering the elevation of the streambed.

Term	Definition
channel units	Morphologically distinct areas within a channel segment that are on the order of at least one to many channel widths in length and are defined by distinct hydraulic and geomorphic conditions within the channel (i.e. pools, riffles, and runs). Channel unit locations and overall geometry are somewhat stage dependent as well as transient over time, and observers may yield inconsistent classifications. To minimize the inconsistencies, channel units are interpreted in the field based on the fluvial processes that created them during channel forming flows, then mapped in a geographic information system (GIS) to provide geospatial reference.
control	A natural or human feature that restrains a streams ability to move laterally and/or vertically.
degradation	Transition from a higher to lower level or quality. A general lowering of the earth's surface by erosion or transportation in running waters. Also refers to the quality (or loss) of functional elements within an ecosystem.
diversity	Genetic and phenotypic (life history traits, behavior, and morphology) variation within a population. Also refers to the relative abundance and connectivity of different types of physical conditions or habitat.
ecosystem	An ecologic system, composed of organisms and their environment. It is the result of interaction between biological, geochemical and geophysical systems.
floodplain	that portion of a river valley, adjacent to the channel, which is built of sediments deposited during the present regimen of the stream and is covered with water when the river overflows its banks at flood stages.
fluvial	Produced by the action of a river or stream. Also used to refer to something relating to or inhabiting a river or stream. Fish that migrate between rivers and streams are labeled "fluvial".
fluvial process	A process related to the movement of flowing water that shape the surface of the earth through the erosion, transport, and deposition of sediment, soil particles, and organic debris.
general indicator	Reach, valley segment, watershed, and basin scale indicators (i.e., water quality) that are used to define or refine potential environmental deficiencies caused by natural or anthropogenic impacts that negatively affect a life stage(s) of the species of concern (i.e., limiting factor). Sometimes referred to as pathways.
geomorphic reach	An area containing the active channel and its floodplain bounded by vertical and/or lateral geologic controls, such as alluvial fans or bedrock outcrops, and frequently separated from other reaches by abrupt changes in channel slope and valley confinement. Within a geomorphic reach, similar fluvial processes govern channel planform and geometry resulting from streamflow and sediment transport.

Term	Definition
geomorphology	The science that treats the general configuraion of the earth's surface; specif. the study of the classification, description, nature, origin and development of landforms and their relationships to underlying structures, and the history of geologic changes as as recorded by these surface changes.
GIS	Geographical information system. An organized collection of computer hardware, software, and geographic data designed to capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.
habitat unit	A channel-wide segment of a stream which has a distinct set of characteristics. Habitat units and channel units are used interchangeably in the literature, however, habitat units are identified and measured during low-flows and sometimes include several channel units. For example, "pool habitat" is measured from the head of the pool scour to the crest of the pool tailout, which technically includes the following "channel units", pool, run, and riffle.
indicator	A variable used to forecast the value or change in the value of another variable; for example, using temperature, turbidity, and chemical contaminents or nutrients to measure water quality.
limiting factor	Any factor in the environment that limits a population from achieving complete viability with respect to any Viable Salmonid Population (VSP) parameter.
parcel	A smaller unit within a subreach that has differing impacts on physical and/or ecological processes than an adjacent unit, and the need to sequence or prioritize potential rehabilitation actions within the context of the subreach and reach.
reach-based ecosystem indicators (REI)	Qualitative and/or quantifiable physical and/or biological indicators that are referenced to watershed characteristics and reach characteristics.
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
riparian area	An area adjacent to a stream, wetland, or other body of water that is transitional between terrestrial and aquatic ecosystems. Riparian areas usually have distinctive soils and vegetation community/composition resulting from interaction with the water body and adjacent soils.
riprap	Materials (typically large angular rocks) that are placed along a river bank to prevent or slow erosion.
river mile (RM)	Miles measured in the upstream direction beginning from the mouth of a river or its confluence with the next downstream river.
side channel	A distinct channel with its own defined banks that is not part of the main channel, but appears to convey water perennially or seasonally/ephemerally. May also be referred to as a secondary channel.

Term	Definition
spawning and rearing habitat	Stream reaches and the associated watershed areas that provide all habitat components necessary for adult spawning and juvenile rearing for a local salmonid population. Spawning and rearing habitat generally supports multiple year classes of juveniles of resident and migratory fish, and may also support subadults and adults from local populations.
subbasin	A subbasin represents the drainage area upslope of any point along a channel network (Montgomery and Bolton 2003). Downstream boundaries of subbasins are typically defined in this assessment at the location of a confluence between a tributary and mainstem channel. An example would be the Middle Fork John Day River subbasin.
subreach	Distinct areas comprised of the floodplain and off-channel and active-channel areas. They are delineated by lateral and vertical controls with respect to position and elevation based on the presence/absence of inner or outer riparian zones.
subreach complex	A subreach that has been subdivided, or parceled, into smaller areas due to complicated anthropogenic impacts and the need to sequence implementation actions.
terrace	A relatively stable, planar surface formed when the river abandons its floodplain. It often parallels the river channel, but is high enough above the channel that it rarely, if ever, is covered by over-bank river water and sediment. The deposits underlying the terrace surface are primarily alluvial, either channel or overbank deposits, or both. Because a terrace represents a former floodplain, it may be used to interpret the history of the river.
tributary	A stream feeding, joining, or flowing into a larger stream or lake (Neuendorf et al. 2005).
valley segment	An area of river within a watershed sometimes referred to as a subwatershed that is comprised of smaller geomorphic reaches. Within a valley segment, multiple floodplain types exist and may range between wide, highly complex floodplains with frequently accessed side channels to narrow and minimally complex floodplains with no side channels. Typical scales of a valley segment are on the order of a few to tens of miles in longitudinal length.
vertical channel migration	Movement of a stream channel in a vertical direction; the filling and raising or the removal or erosion of streambed material that changes the elevation of the overall streambed over an entire reach or subreach.
viable salmonid population	An independent population of Pacific salmon or steelhead trout that has a negligible risk of extinction over a 100-year time frame. Viability at the independent population scale is evaluated based on the parameters of abundance, productivity, spatial structure, and diversity (ICBTRT 2007).

Term	Definition
watershed	The area of land from which rainfall and/or snow melt drains into a stream or other water body. Watersheds are also sometimes referred to as drainage basins. Ridges of higher ground form the boundaries between watersheds. At these boundaries, rain falling on one side flows toward the low point of one watershed, while rain falling on the other side of the boundary flows toward the low point of a different watershed.

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APPENDICES

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APPENDIX A

Reach-based Ecosystem Indicators

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Appendix A

Reach-based Ecosystem Indicators (REI)

Version 1.1

The reach-based ecosystem indicators table has been compiled from literature review, data contained in the *Methow Subbasin Geomorphic Assessment, Okanogan County, Washington* (Reclamation, 2008a), *Geomorphology and Hydraulic Modeling for the Middle Methow River from Winthrop to Twisp* (Reclamation, 2010a), *Methow River Habitat Assessment Stream Survey of the Big Valley Reach* (USFS 2006 in Reclamation 2008b), *Middle Methow River Habitat Assessment River Mile 40.3 to 52.4* (USFS 2009 in Reclamation 2010b), and from new data collected for this assessment. The ranges of criteria presented here are not absolute and should be adjusted to each unique subbasin as data become available.

General Regional Characteristics

At the regional spatial scale, characteristics described include the following information ecoregion, drainage basin, valley segments, and channel segments. This information informs planners and evaluators on the regional setting where the assessment occurred. These regional characteristics are recommended in the *Monitoring Strategy* (Hillman 2006).

Watershed Characteristics

At the watershed/subwatershed spatial scales, several reach-based ecosystem indicators are evaluated as general indicators to inform planners and evaluators on the how the geomorphic and ecologic processes are functioning. At this scale, an overall condition is evaluated to determine if deficiencies at the reach-scale are symptomatic of a larger (watershed scale) problem that should be addressed to reduce impact to the sustainability and effectiveness of planned habitat actions.

Reach Characteristics

Physical Variables

At the reach spatial scale, individual reach-based ecosystem indicators are evaluated to inform planners and evaluators on the condition status of indicators that are responsive to reach scale impacts. The condition status assigned is Adequate for those that meet or exceed criteria and At Risk or Unacceptable for those that could use improvement. These reach-based ecosystem indicators are typically the focus for the implementation of habitat actions.

GENERAL REGIONAL CHARACTERISTICS

REGIONAL SETTING

Ecoregion	**Bailey Classification**	Domain - Humid Temperate Domain	Province – Cascade Mixed Forest-Coniferous Forest-Alpine Meadow Province	Section – Eastern Cascades Section
	Omernik Classification	Okanogan Valley	N/A	N/A
	Physiography	Division – Pacific Mountain System	Province – Cascade-Sierra Mountains	Section – Northern Cascade Mountains
	Geology	Geologic District 134	Lithology – Alluvium	N/A

Data from Morrison and Smith (2007).

DRAINAGE BASIN CHARACTERISTICS

Geomorphic Features	**Methow Basin Area**	**Basin Relief**	**Drainage Density**	**Hydrologic Unit Code**	**Strahler Stream Order**	**Stream Classification**	**Land Ownership**
	1,208,746 acres (WRIA 48)	~8,500’ - 800’	2.62*	170200080605	6	Class AA (extraordinary) and Class A (excellent)	89% public 11% private

*Drainage density was calculated using the Washington/Oregon Hydrography Frameworks stream network at 1:24,000 and based on the National Hydrography’s Subbasin HUC for the Methow subbasin.

VALLEY SEGMENT CHARACTERISTICS

Valley Characteristics	**Valley Type**		**Valley Bottom Type**	**Valley Bottom Width (Avg.)**	**Valley Bottom Gradient (Avg.)**	**Constrained Valley Bottom Width (Avg.)**[1]			**Channel Width (Avg.)**			**Valley Confinement**[2]		
	Alluvial		Glaciated U-shaped valley *(U2)*	1386 ft	0.40%	RM 55.0-52.9: 289 feet	RM 52.9-51.3: 1,452 feet	RM 51.3-50.0: 318 feet	RM 55.0-52.9: 131 feet	RM 52.9-51.3: 173 feet	RM 51.3-50.0: 156 feet	RM 55.0-52.9: Ratio 2.2: Moderately Confined	RM 52.9-51.3: Ratio 8.4 Unconfined	RM 51.3-50.0: Ratio 2.0 Moderately Confined

[1]Oregon Department of Fish and Wildlife (2010)
[2]Hillman (2006)

CHANNEL SEGMENT CHARACTERISTICS

Channel Characteristics	Channel Reach Type[1]			Bed-form Type[1]			Channel Type[2]			Channel Gradient			Sinuosity		
	RM 55.0-52.9 Free-formed alluvial channel	RM 52.9-51.3 Forced alluvial channel	RM 51.3-50.0 Free-formed alluvial channel	RM 55.0-52.9 Plane-bed	RM 52.9-51.3 Plane-bed to pool riffle	RM 51.3-50.0 Plane-bed	RM 55.0-52.9 (A-type)	RM 52.9-51.3 (C-type)	RM 51.3-50.0 (A-type)	RM 55.0-52.9: 0.4 percent	RM 52.9-51.3: 0.3 percent	RM 51.3-50.0: 0.3 percent	RM 55.0-52.9: 1.01	RM 52.9-51.3: 1.12	RM 51.3-50.0: 1.02

[1]Montgomery and Buffington (1998)
[2]Rosgen (1996)

WATERSHED CHARACTERISTICS

GENERAL INDICATOR: EFFECTIVE DRAINAGE NETWORK AND WATERSHED ROAD DENSITY

Criteria: The following criteria were developed by USFWS (1998).

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Watershed Condition	Effective Drainage Network and Watershed Road Density	Zero or minimum increases in active channel length correlated with human caused disturbance. And Road density <1 miles/miles^2.	Low to moderate increase in active channel length correlated with human caused disturbances. And Road density 1-2.4 miles/miles^2.	Greater than moderate increase in active channel length correlated with human caused disturbances. And Road density >2.4 miles/miles^2.

Narrative:

Road density for the Methow subbasin was 1.11 mi/mi^2 (Table 1) which meets the At Risk criterion. Road density for the Upper Middle Methow River is 1.55 mi/mi^2 and the Lower Middle Methow River is 2.26 mi/mi^2 which meet the At Risk criterion. Higher road densities within the Upper Middle Methow River and Lower Middle Methow River watersheds negatively impact the routing of overland flows due to road embankments that re-direct or pond overland flows. Overall, the effective drainage network and road density general indicators are **At Risk**.

Table 1. Road classifications for the Methow subbabin (Morrison and Smith 2007).

HUC 6 Name	Total Road (miles)	Area of HUC 6 (mi^2)	Road Density (mi/mi^2)	Condition (based on criterion)
Andrews Creek	0.559 mi/mi^2 mi	34.236 mi^2	0.02 mi/mi^2	Adequate
Bear Creek	37.618 mi	16.834 mi^2	2.23 mi/mi^2	At Risk
Benson Creek	88.968 mi	39.738 mi^2	2.24 mi/mi^2	At Risk
Black Canyon Creek	25.942 mi	15.942 mi^2	1.63 mi/mi^2	At Risk
Boulder Creek	22.556 mi	20.460 mi^2	1.10 mi/mi^2	At Risk
Buttermilk Creek	55.488 mi	37.162 mi^2	1.49 mi/mi^2	At Risk
Cedar Creek	2.330 mi	30.807 mi^2	0.08 mi/mi^2	Adequate
Chewuch River/Kay Creek	1.628 mi	33.946 mi^2	0.05 mi/mi^2	Adequate
Chewuch River/Pearrygin Creek	100.736 mi	39.730 mi^2	2.54 mi/mi^2	Unacceptable Risk
Cub Creek	75.559 mi	24.382 mi^2	3.10 mi/mi^2	Unacceptable Risk
Davis Creek	84.966 mi	40.317 mi^2	2.11 mi/mi^2	At Risk
Eagle Creek	1.193 mi	13.440 mi^2	0.09 mi/mi^2	Adequate
Early Winters Creek	28.192 mi	49.626 mi^2	0.57 mi/mi^2	Adequate
Eight Mile Creek	91.913 mi	46.487 mi^2	1.98 mi/mi^2	At Risk
Falls Creek	38.283 mi	26.730 mi^2	1.43 mi/mi^2	At Risk
Goat Creek	68.724 mi	35.977 mi^2	1.91 mi/mi^2	At Risk
Gold Creek	123.360 mi	73.583 mi^2	1.68 mi/mi^2	At Risk
Headwaters Chewuch River	0.00 mi	52.178 mi^2	0.00 mi/mi^2	Adequate
Lake Creek	3.834 mi	53.518 mi^2	0.07 mi/mi^2	Adequate
Libby Creek	76.895 mi	40.209 mi^2	1.91 mi/mi^2	At Risk
Little Bridge Creek	38.711 mi	24.417 mi^2	1.59 mi/mi^2	At Risk
Lower Beaver Creek	84.637 mi	49.811 mi^2	1.70 mi/mi^2	At Risk
Lower Lost River	7.332 mi	66.413 mi^2	0.11 mi/mi^2	Adequate
Lower Middle Methow River	114.45 mi	50.54 mi^2	2.26 mi/mi^2	At Risk
Mainstem Lower Chewuch River	94.815 mi	38.402 mi^2	2.47 mi/mi^2	Unacceptable Risk
Mainstem Lower Methow River	77.603 mi	88.958 mi^2	0.87 mi/mi^2	Adequate
Mainstem Lower Twisp River	88.502 mi	43.965 mi^2	2.01 mi/mi^2	At Risk
Mainstem Upper Chewuch River	10.787 mi	27.660 mi^2	0.39 mi/mi^2	Adequate
Mainstem Upper Twisp River	61.615 mi	63.058 mi^2	0.98 mi/mi^2	Adequate
Methow River/Texas Creek	40.339 mi	31.657 mi^2	1.27 mi/mi^2	At Risk
Mouth of Methow River	38.674 mi	24.734 mi^2	1.56 mi/mi^2	At Risk
North Fork Boulder Creek	74.012 mi	60.533 mi^2	1.22 mi/mi^2	At Risk
Rattlesnake Creek	46.267 mi	38.402 mi^2	1.20 mi/mi^2	At Risk
Robinson Creek	1.150 mi	19.730 mi^2	0.06 mi/mi^2	Adequate
South Creek	0.410 mi	15.799 mi^2	0.03 mi/mi^2	Adequate
South Fork Lost River	0.00 mi	36.147 mi^2	0.00 mi/mi^2	Adequate
Squaw Creek	30.105 mi	33.301 mi^2	0.90 mi/mi^2	Adequate
Twenty Mile Creek	18.231 mi	42.228 mi^2	0.43 mi/mi^2	Adequate
Upper Beaver Creek	144.493 mi	62.614 mi^2	2.31 mi/mi^2	At Risk
Upper Lost River	0.00 mi	65.247 mi^2	0.00 mi/mi^2	Adequate

Upper Middle Methow River	84.606 mi	54.568 mi^2	1.55 mi/mi^2	At Risk
Upper Twisp River	2.169 mi	20.100 mi^2	0.11 mi/mi^2	Adequate
War Creek	3.337 mi	27.402 mi^2	0.12 mi/mi^2	Adequate
West Fork Methow River	4.710 mi	49.772 mi^2	0.09 mi/mi^2	Adequate
Windy Creek	11.868 mi	22.452 mi^2	0.53 mi/mi^2	Adequate
Wolf Creek	10.607 mi	40.363 mi^2	0.26 mi/mi^2	Adequate
Grand Total	**2018.176 mi**	**1823.579 mi^2**	**1.11 mi/mi^2**	**At Risk**

GENERAL INDICATOR: DISTURBANCE REGIME (NATURAL/HUMAN)

Criteria: The following criteria were modified from USFWS (1998).

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Watershed Condition	Disturbance Regime	Environmental disturbance is short lived; predictable hydrograph, high quality habitat and watershed complexity providing refuge and rearing space for all life stages or multiple life-history forms. Natural processes are stable.	Scour events, debris torrents, or catastrophic fires are localized events that occur in several minor parts of the watershed. Resiliency of habitat to recover from environmental disturbances is moderate.	Frequent flood or drought producing highly variable and unpredictable flows, scour events, debris torrents, or high probability of catastrophic fire exists throughout a major part of the watershed. The channel is simplified, providing little hydraulic complexity in the form of pools or side channels. Natural processes are unstable.

Narrative:

About 400 fires have been recorded in the Upper Methow watershed with about 75 percent of them being caused by lightening (MVRD, 1996). In general, severe fires have burned in the Upper Methow watershed every 100 to 300 years and fire frequency has not changed significantly since the 1920s. In the lower elevations of the Methow Valley, fires were historically frequent with an estimated 2- to 18-year return interval between 1700 and 1900 (Ohlson 1996). The riparian forests in the Methow Valley are dominated by broadleaf deciduous trees and shrubs, which intrinsically are not as flammable as coniferous trees. Therefore, valley floor fires were occasionally set by natives; otherwise fires were probably episodic in the riparian forests, occasionally creeping into riparian zones from adjacent forests and grasslands.

Recent fires in the Methow subbasin include the Tripod Fire (2006), Farewell Fire (2003), Needles Creek Fire (2003), Thirtymile Fire (2001), Whiteface Fire (1994), and Quartz Mountain Fire (2004). Three recent fires have burned with varying intensities throughout about 70 percent of the Chewuch River watershed (primary tributary to the Middle Methow River): (1) Thirtymile Fire burned approximately 9,300 acres; (2) Farewell Fire perimeter included approximately 79,000 acres; and (3) Tripod Fire burned approximately 175,000 acres. After an area burns there is generally an increase in soil erosion and mass wasting until soils are re-stabilized by vegetation. Burn areas may also increase water temperatures as the vegetative cover is removed and surface waters are exposed to direct sunlight. Fires are an integral part of the ecosystem. They rejuvenate vegetation, and provide coarse-fine sediment and large woody debris to the fluvial system.

The Methow subbasin was settled by Euro-Americans in the late 19th century with an established economy based on agriculture, forestry, and mining. The basin is now experiencing a demographic shift to tourism, recreation, and general goods and services industries. This shift is resulting in the conversion of agricultural areas to residential and commercial development. Development along the floodplain and adjacent valley bottoms can increase the percentage of cleared and impervious areas that have a cumulative impact on streamflows, vegetation, and overall water quality. In addition, residential and commercial development has been occurring on the floodplain that may have disrupted active channel/floodplain interactions. Levees, push-up dikes, elevated road embankments and fill have been used in several locations (i.e. Lost River development, downstream of Mazama, Winthrop National Fish Hatchery, Winthrop Park area, Twisp Park area, etc.) which disconnect or disrupt flood waters from accessing historic floodplain areas; and lateral channel migration processes have been restricted where bank protection has been used to for reinforcement and to “stabilize” eroding banks.

Fires are a relatively short-term but frequent environmental disturbance with little change from pre-settlement conditions. However, development in the valley bottoms is a longer term disturbance that could have adverse impacts. Overall, the disturbance regime general indicator is **At Risk** due to valley bottom development resulting in the disruption of floodplain processes and restriction of lateral channel migration.

GENERAL INDICATOR: FLOW / HYDROLOGY

Criteria: The following criteria were developed by USFWS (1998).

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Watershed Condition	Flow/hydrology	Magnitude, timing, duration and frequency of peak flows within a watershed are not altered relative to natural conditions of an undisturbed watershed of similar size, geology and geography.	Some evidence of altered magnitude, timing duration and/or frequency of peak flows relative to natural conditions of an undisturbed watershed of similar size, geology and geography.	Pronounced changes in magnitude, timing, duration and/or frequency of peak flows relative to natural conditions of an undisturbed watershed of similar size, geology and geography.

The Methow River is a snowmelt dominated system (Figure 1) that is characterized by a spring snowmelt runoff with low summer and winter flows, except for occasional rain-on-snow events that typically occur in late fall (November and December) and late winter (January and February). Forestry practices in the upper watershed can result in immediate and significant changes in the discharge, duration, and timing of flow events, especially if a dense road network accompanies the operations (Burton 1997). Timber harvests still occur on Forest Service lands, but practices have changed in that only partial cuts and thinning are used to promote forest health, and the existing road network is utilized for access. In addition, agricultural land use changes the watershed controls that determine rates of precipitation interception, infiltration, and evapotranspiration rates; and surface water diversions for agriculture production reduce instream flows. When combined with associated changes in surface roughness, these alterations have multiple impacts on the rainfall-runoff relationship (Skidmore et al. 2009). Much of the valley bottoms have been developed for agricultural and residential uses along the middle and lower portions of the Methow River. Finally, urbanization has converted some areas of the watershed land surfaces to an impermeable condition, reducing infiltration capacity and changing the character of the runoff hydrograph from storm events.

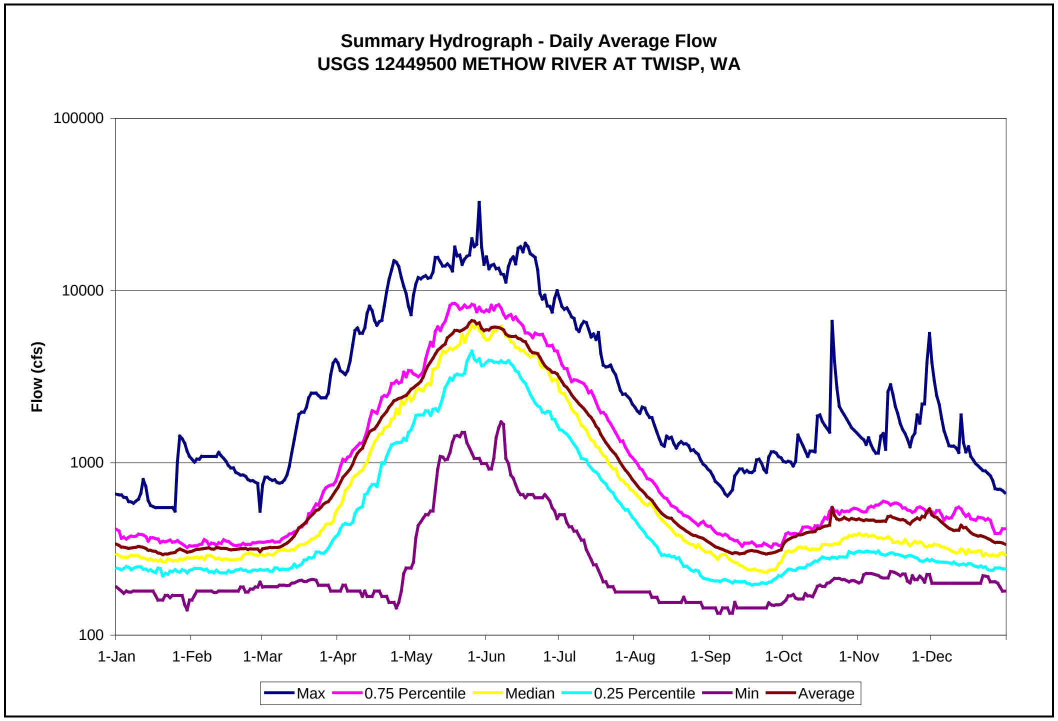


Figure 1. Mean daily flow statistics from long-term monitoring station for Methow River at Twisp, WA (Reclamation 2008a)

Narrative:

Indirect impacts on the flow/hydrology regime may be pervasive and include forest practices, floodplain development, irrigation diversions, urbanization, and the routing of flows caused by higher road densities. In addition, there are several channel segments along the Methow River and its tributaries that are listed by Washington Department of Ecology (WDOE) as Category 4C for insufficient instream flows due primarily to irrigation diversions. Overall, the flow/hydrology general indicator is **At Risk**.

GENERAL INDICATOR: WATER QUANTITY AND QUALITY

Criteria: The following criteria were adapted and modified from the USFWS (1998) and WDOE.

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Water Quality and Quantity	Quantity/Temperature/Chemical Contamination/ Nutrients	Adequate instream flows for habitat, low levels of water quality impairments from landuse sources, no excessive nutrients, no CWA 303d designated reaches. Or, Washington State Department of Ecology standards – 173-201A-200.	Inadequate instream flows for habitat, moderate levels of water quality impairments from landuse sources, some excess nutrients, CWA 303d designated reaches.	Inadequate instream flows for habitat, high levels of water quality impairments from landuse sources, high levels of excess nutrients, CWA 303d designated reaches.

Water quality of the Lower Methow River from the confluence with the Columbia River to the mouth of the Chewuch River is classified as Class A (excellent), and upstream of the Chewuch confluence is classified as Class AA (extraordinary) (WDOE website). From Weeman Bridge (RM 61.1) to Mazama (RM 67.2), the Methow River "naturally" dewaters in late summer and fall, but this may be exacerbated by water use for irrigation (CCPUD, 1998). Dewatering is primarily due to the geology (depth of alluvial valley fill), but only limited studies have been conducted on the surface water and ground water interactions (Konrad, Drost, and Wagner, 2003). Several stream segments along the Methow River and its tributaries are listed as Category 4C for insufficient instream flows due primarily to irrigation diversions (Table 2). Tributaries to the Upper Methow River with stream segments that are listed as Category 4C for insufficient instream flows upstream of the mouth of the Chewuch River include Early Winters Creek and Wolf Creek (Table 3). The Chewuch River, a primary tributary to the Methow River, has a stream segment at RM 1.3 that was listed as Category 4C for insufficient instream flow. The Twisp River, another primary tributary to the Methow River at RM 41.2, has a stream segment at RM 1.8 that is listed as Category 4C for insufficient instream flow. Along the Methow River there are four stream segments at about RM 66.5, RM 59.0, RM 49.0, and RM 31.5 that are listed as Category 4C for instream flow.

Warm water conditions may occur in the Methow River and its tributaries during summer months, and may be exacerbated by decreased instream flows, reduced floodplain connectivity, and removal of riparian vegetation along the streambanks for development. The Chewuch River, a primary tributary, has a stream segment listed as Category 5 for temperature at the Okanogan National Forest boundary near Boulder Creek. The Twisp River has two stream segments listed as Category 2 for temperature near War Creek and near its mouth. Alder Creek (West Fork), which flows into the Methow River downstream of Twisp, was listed as Category 2 for temperature. The Lower Methow River near monitoring station 48A070 (near Pateros) is listed as Category 5 for water temperature.

Other water quality issues include (1) Andrews Creek (East Fork), a tributary to the Chewuch River is listed as Category 2 for Dissolved Oxygen and 4,4'-DDE, (2) the Methow River within the Middle Methow reach assessment area near Bear Creek is listed as Category 5 for 2,3,7,8-TCDD and Category 2 for 2,3,7,8-TCDD TEQ, (3) Alder Creek (West Fork), a tributary to Methow River below Twisp, listed as a Category 2 for pH and Zinc and (4) the Lower Methow River near monitoring station 48A070 (near Pateros) is listed as Category 2 for pH.

Narrative:

The water quality general indicator is **At Risk** based on WDOE's category ratings for water impairments as follows: Category 4C – impaired with a non-pollutant; and Category 5 and 2 listings – impaired by warm water temperatures and low levels of chemical contamination.

Table 2. Methow River, WDOE website (http://apps.ecy.wa.gov/wats08/PrintListing.aspx?).

Listing ID	Parameter	Medium	Township Range Section	Monitoring Station	Location	2008 Category*	2004 Category*	1998 303(d) List?	1996 303(d) List?
3732	Temperature	Water	30.0N-23.0E-28	48A070	Near Pateros	5	5	Y	Y
6215	Instream Flow	Habitat	36.0N-20.0E-31	None	RM 59 (Weeman)	4C	4C	Y	Y
6216	Instream Flow	Habitat	36.0N-19.0E-26	None	RM 66.5 (Chokeberry)	4C	4C	Y	Y
6217	Instream Flow	Habitat	34.0N-21.0E-11	None	RM 49.0 (KOA)	4C	4C	Y	Y
6218	Instream Flow	Habitat	32.0N-22.0E-16	None	RM 31.5 (Walsh)	4C	4C	Y	N
8433	Temperature	Water	30.0N-23.0E-21	None	RM 5.0	2	2	N	Y
11288	Ammonia-N	Water	30.0N-23.0E-28	48A070	Near Pateros	1	1	N	N
11290	pH	Water	30.0N-23.0E-28	48A070	Near Pateros	2	2	N	N
11291	Ammonia-N	Water	33.0N-22.0E-20	48A140	Near Pateros	1	1	N	N
11294	pH	Water	33.0N-22.0E-20	48A140	Near Pateros	2	2	N	N
16838	Fecal Coliform	Water	33.0N-22.0E-20	48A140	Near Pateros	1	1	N	N
16839	Fecal Coliform	Water	30.0N-23.0E-28	48A070	Near Pateros	1	1	N	N
40721	Arsenic	Water	33.0N-22.0E-20	48A140	Near Twisp	1	1	N	N
51562	2,3,7,8-TCDD	Tissue	34.0N-21.0E-13	None	Near Bear Creek	5		N	N
51615	2,3,7,8-TCDD TEQ	Tissue	34.0N-21.0E-13	None	Near Bear Creek	2		N	N
51675	4,4'-DDD	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
51736	4,4'-DDE	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
51796	4,4'-DDT	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
51918	Alpha-BHC	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N

51979	Beta-BHC	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52094	Endosulfan I	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52140	Endosulfan II	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52192	Endosulfan Sulfate	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52252	Endrin	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52312	Endrin Aldehyd	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52372	Gamma-bhc (Lindane)	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52433	Heptachlor	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52494	Heptachlor Epoxide	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52554	Hexachlorobenzene	Tissue	34.0-21.0E-13	None	Near Bear Creek	1		N	N
52615	Mercury	Tissue	34.0-21.0E-13	None	Near Bear Creek	1		N	N
52672	PCB	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N
52735	Total Chlordane	Tissue	34.0N-21.0E-13	None	Near Bear Creek	1		N	N

Table 3. Tributaries to the Methow River, WDOE website (http://apps.ecy.wa.gov/wats08/PrintListing.aspx?)

Tributary	Listing ID	Parameter	Medium	Township Range Section	Monitoring Station	Location	2008 Category*	2004 Category*	1998 303(d) List?	1996 303(d) List?
Early Winters Creek	6214	Instream Flow	Habitat	36.0N-19.0E-28	None	RM 1	4C	4C	Y	Y
Wolf Creek	6220	Instream Flow	Habitat	35.0N-21.0E-32	None	Mouth	4C	4C	Y	Y
Twisp River	6219	Instream Flow	Habitat	33.0N-21.0E-11	None	RM 1.8	4C	4C	Y	Y
	8435	Temperature	Water	33.0N-22.0E-08	None	Mouth	2	2	Y	Y
	39350	Temperature	Water	33.0N-20.0E-18	None	War Creek Campground	2	2	N	N
Alder Creek	17017	Temperature	Water	33.0N-21.0E-24	None	West Fork	2	2	N	N
	17030	pH	Water	33.0N-21.0E-25	None	West Fork	2	2	N	N
	17040	Zinc	Water	33.0N-21.0E-24	None	West Fork	2	2	N	N
Chewuch River	6213	Instream Flow	Habitat	35.0N-21.0E-35	None	RM 1.3	4C	4C	Y	Y
	39349	Temperature	Water	36.0N-21.0E-35	None	Near Okanogan NF Boundary	5	5	N	N
Andrews Creek	8432	Dissolved Oxygen	Water	38.0N-22.0E-06	None	East Fork	2	2	N	N
	8969	4,4'-DDE	Water	38.0N-22.0E-06	None	East Fork	2	2	N	N

*Water quality assessment categories (http://www.ecy.wa.gov/programs/wq/303d/WAAssessmentsCats.html).

- Category 1 – Meets tested standards for clean waters.
- Category 2 – Waters of concern.
- Category 3 – Insufficient data.
- Category 4 – Polluted waters that do not require a TMDL.
    - Category 4a – has a TMDL
    - Category 4b – has a pollution control program.
    - Category 4c – is impaired by a non-pollutant.
- Category 5 – Polluted waters that require a TMDL.

GENERAL INDICATOR: HABITAT ACCESS

Criteria: The following criteria have been modified from USFWS (1998).

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Access	Main Channel Physical Barriers	No manmade barriers present in the mainstem that limit upstream or downstream migration at any flow.	Manmade barriers present in the mainstem that prevent upstream or downstream migration at some flows that are biologically significant.	Manmade barriers present in the mainstem that prevent upstream or downstream migration at multiple or all flows.

Narrative:

Several stream segments along the Methow River and its tributaries are listed as Category 4C for insufficient instream flows due primarily to irrigation diversions. The Methow River main channel diversion dams are Foghorn Dam near RM 53 and Barkley near RM 49. Foghorn Diversion Dam most likely impedes juvenile fish passage at some biologically significant flows. Barkley Diversion Dam is pushed up annually in late July or August. The push-up dam spans about 70 percent of the wetted main channel which may increase the entrainment of fish into the Barkley ditch. Many fish including juvenile steelhead/rainbow trout, juvenile spring Chinook salmon, cutthroat, Pacific lamprey, and some adult bull trout are residing in the Barkley ditch upstream of the fish screen during irrigation season. Despite fish salvage efforts many of these fish are lost when the ditch is turned off in the fall (Reclamation 2010b). The Methow Valley Irrigation District's east diversion dam (RM 46) has been mostly removed and is no longer a hazard to fish. The Fulton Diversion Dam near RM 1 on the Chewuch River has been modified and is no longer a low flow fish passage barrier. The Chewuch Diversion Dam near RM 8 on the Chewuch River most likely prevents upstream migration of juvenile Chinook salmon and steelhead at higher flows. The Methow Valley Irrigation District's west canal diversion on the Twisp River near RM 4 does not appear to be a fish passage barrier but is modified annually. There are some small diversion dams and culverts within the tributaries that may be fish passage barriers, but nearly all of the culverts have been replaced to improve fish passage on U.S. Forest Service (USFS) managed land and many small diversion dams have been modified to improve fish passage on privately owned lands.

Due to manmade barriers on the mainstem Methow River, the main channel physical barriers general indicator is **At Risk**.

REACH CHARACTERISTICS

GENERAL INDICATOR: WATER TEMPERATURE

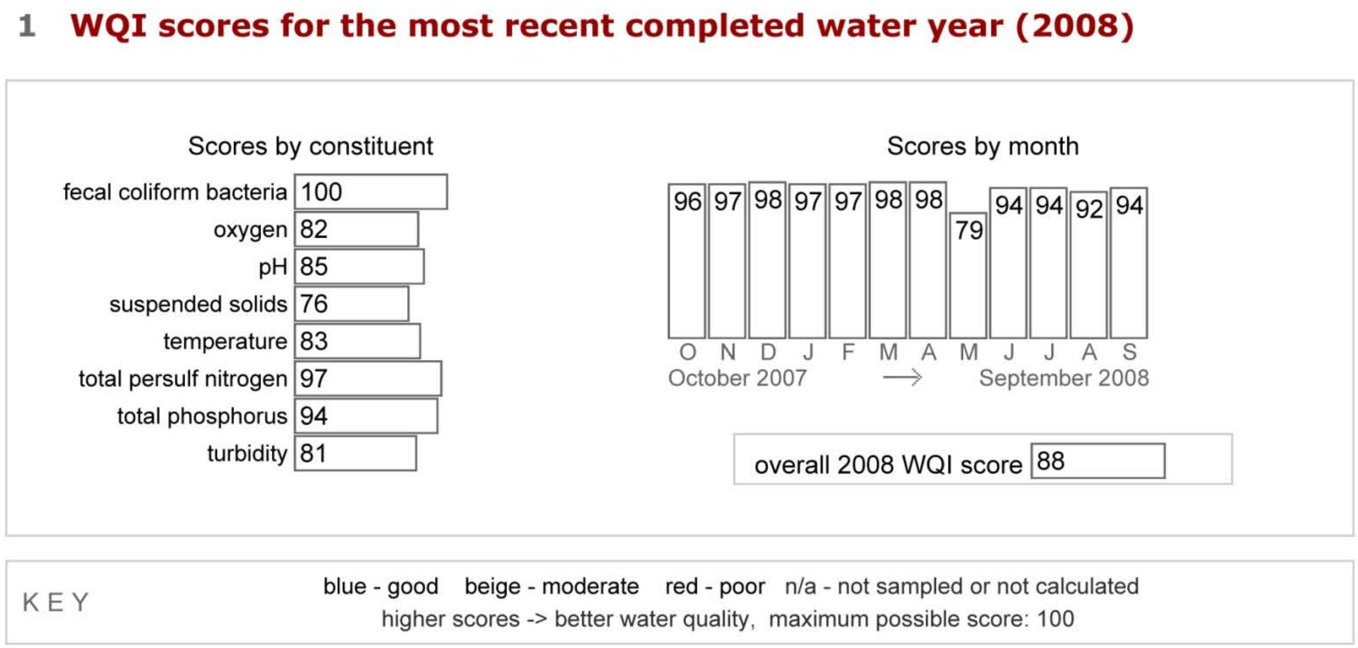
Criteria: The following criteria were developed by Hillman and Giorgi (2002) and USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Water Quality	Water Temperature	MWMT/ MDMT/ 7-DADMax	Bull Trout: Incubation: 2-5°C Rearing: 4-10°C Spawning: 1-9°C Salmon and Steelhead: Spawning: June-Sept 15°C Sept-May 12°C Rearing: 15°C Migration: 15°C Adult holding: 15°C Or, 7-DADMax performance standards (WDOE): Salmon spawning 13°C Core summer salmonid habitat 16°C Salmonid spawning, rearing and migration 17.5°C Salmonid rearing and migration only 17.5°C	MWMT in reach during the following life history stages: Incubation: <2°C or 6°C Rearing: <4°C or 13-15°C Spawning: <4°C or 10°C Temperatures in areas used by adults during the local spawning migration sometimes exceed 15°C. Or 7-DADMax performance standards exceeded by ≤15%	MWMT in reach during the following life history stages: Incubation: <1°C or >6°C Rearing: >15°C Spawning: <4°C or >10°C Temperatures in areas used by adults during the local spawning migration regularly exceed 15°C. Or 7-DADMax performance standards exceeded by >15%

Narrative:

The WDOE determined a Water Quality Index score of 83 for water temperature (Chart 1) at Monitoring Station 48A150 on the Methow River at Winthrop (2008). Scores of 80 and greater indicate water quality met expectations and is “good”. Based on WDOE water quality standards, water temperature in the Winthrop reach is **Adequate**.

Chart 1. WDOE Water Quality Index* scores Station 48A150 (2008) Methow River at Winthrop.



*The Water Quality Index is designed to rate general water quality based on monitoring conducted by Ecology's Freshwater Monitoring Unit. Monitoring results from monthly grab samples have been converted to scores ranging from 1 to 100 following a fairly complex methodology. * In general, scores less than 40 indicate water quality did not meet expectations or was poor. Scores of 40 through 79 indicate moderate quality, and scores of 80 and greater indicate water quality met expectations and is good.

For temperature, pH, fecal coliform bacteria, and dissolved oxygen, the index expresses results relative to levels required to maintain beneficial uses (based on criteria in Washington’s Water Quality Standards, WAC 173-201A). For nutrient and sediment measures, where standards are not specific, results are expressed relative to expected conditions in a given region (http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?).

GENERAL INDICATOR: TURBIDITY

Criteria: The performance standard for this indicator is from Hillman and Giorgi (2002), and Washington State Department of Ecology.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Water Quality	Turbidity	Nephelometric Turbidity Units (NTU)	Performance Standard: Acute <70 NTU Chronic <50 NTU For streams that naturally exceed these standards: Turbidity should not exceed natural baseline levels at the 95% CL. <15% exceedance. Or, Turbidity shall not exceed: 5 NTU over background when the background is 50 NTU or less; or a 10 percent increase in turbidity when the background turbidity is more than 50 NTU (WDOE – 173-201A-200).	15-50% exceedance.	>50% exceedance.

Narrative:

Turbidity is measured in Nephelometric Turbidity Units (NTU) which is a measure of the cloudiness of the water caused by suspended solids. Exceeding a criterion does not necessarily mean the water quality standard has been violated according to the Environmental Protection Agency. Timing (date) of the turbidity exceedences predominantly occur in October through December when there is a good potential for rain-on-snow events; and in July and August when thunderstorms usually occur. The turbidity exceedances are considered to be natural occurrences within the Methow watershed. At water monitoring station 48A150 (Methow River at Winthrop) the Water Quality Index (WQI) for turbidity in 2008 was 81 or in good condition and the overall water quality met or exceeded expectation. At the long-term water monitoring station (48A130) along the Methow River near Twisp, the WQI for turbidity in 2008 was 81 or in good condition and the overall water quality met or exceeded expectation (data available on WDOE's water quality website). Based on this information, the turbidity specific indicator is **Adequate**.

GENERAL INDICATOR: CHEMICAL CONTAMINATION / NUTRIENTS

Criteria: The following criteria were developed by USFWS (1998) and Washington State Department of Ecology.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Water Quality	Chemical Contamination/ Nutrients	Metals/ Pollutants, pH, DO, Nitrogen, Phosphorous	Low levels of chemical contamination from land use sources, no excessive nutrients, no CWA 303d designated reaches. Or, Washington State Department of Ecology standards – 173-201A-200.	Moderate levels of chemical contamination from land use sources, some excess nutrients, one CWA 303d designated reach.	High levels of chemical contamination from land use sources, high levels of excess nutrients, more than one CWA 303d designated reach.

Narrative:

The WDOE determined that the overall water quality at the Winthrop short-term monitoring station (48A150) and Twisp long-term monitoring station (48A140) met or exceeded expectations and was of lowest concern (Table 4). The chemical contamination/nutrients general indicator is **Adequate**.

Table 4. WQI for year 2008 at monitoring stations 48A150 and 48A140 from Washington State Department of Ecolocy website (http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?)

Station 48A150 (2008) Methow River at Winthrop	Parameter	WQI*	Condition
	Fecal coliform bacteria	100	Good
	Oxygen	82	Good
	pH	85	Good
	Suspended solids	76	Moderate
	Temperature	83	Good
	Total persulf nitrogen	97	Good
	Total phosphorus	94	Good
	Turbidity	81	Good
	Overall	**88**	**Good**

Station 48A140 (2008) Methow River at Twisp	Parameter	WQI*	Condition
	Fecal coliform bacteria	98	Good
	Oxygen	93	Good
	pH	81	Good
	Suspended solids	75	Moderate
	Temperature	84	Good
	Total persulf nitrogen	97	Good
	Total phosphorus	95	Good
	Turbidity	81	Good
	Overall	**89**	**Good**

*The Water Quality Index is designed to rate general water quality based on monitoring conducted by Ecology's Freshwater Monitoring Unit. Monitoring results from monthly grab samples have been converted to scores ranging from 1 to 100 following a fairly complex methodology. ***** In general, scores less than 40 indicate water quality did not meet expectations or was poor. Scores of 40 through 79 indicate moderate quality, and scores of 80 and greater indicate water quality met expectations and is good.

For temperature, pH, fecal coliform bacteria, and dissolved oxygen, the index expresses results relative to levels required to maintain beneficial uses (based on criteria in Washington's Water Quality Standards, WAC 173-201A). For nutrient and sediment measures, where standards are not specific, results are expressed relative to expected conditions in a given region (http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?).

GENERAL INDICATOR: MAIN CHANNEL PHYSICAL BARRIERS (NATURAL/HUMAN)

Criteria: The following criteria have been modified from USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Access	Main Channel Physical Barriers	Barriers (Natural/Human)	No manmade barriers present in the mainstem that limit upstream or downstream migration at any flow.	Manmade barriers present in the mainstem that prevent upstream or downstream migration at some flows that are biologically significant.	Manmade barriers present in the mainstem that prevent upstream or downstream migration at multiple or all flows.

Narrative:

There is one irrigation diversion structure at the downstream boundary of the W2 reach (Barkley Diversion Dam) and one within the reach (Foghorn Diversion Dam). The Barkley Diversion Dam near RM 49 is a push-up dam that during low summer flows is constructed to maintain irrigation flows. In addition, the Barkley Diversion Dam creates an entrainment hazard for juvenile salmonids and Pacific lamprey. Foghorn Diversion Dam near RM 53 most likely impedes juvenile fish passage at some biologically significant flows. The main channel physical barriers general indicator is **At Risk**.

GENERAL INDICATOR: CHANNEL SUBSTRATE

Criteria: Performance standards for these criteria are from Hillman and Giorgi (2002).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Quality	Substrate	Dominant Substrate/ Fine Sediment	Gravels or small cobbles make-up >50% of the bed materials in spawning areas. Reach embeddedness in rearing areas <20%. <12% fines (<0.85mm) in spawning gravel or ≤12% surface fines of ≤6mm.	Gravels or small cobbles make-up 30-50% of the bed materials in spawning areas. Reach embeddedness in rearing areas 20-30%. 12-17% fines (<0.85mm) in spawning gravel or 12-20% surface fines of ≤6mm.	Gravels or small cobbles make-up <30% of the bed materials in spawning areas. Reach embeddedness in rearing areas >30%. >17% fines (<0.85mm) in spawning gravel or >20% surface fines of ≤6mm.

In channel segment M8, the Stream Inventory Survey (USFS 2006 and USFS 2009) found that the dominant substrate was comprised predominantly by medium to large cobbles (Table 5). Percentage of fine sediment less than 6 mm in size was considered low. The channel is in a moderately confined section between the Wolf Creek alluvial fan, and glacial terraces that are cored by bedrock. Gravel retention should not be expected due to the physical characteristics of the confined channel which maintain flows with sufficient streampower capable of transporting gravel size materials.

Channel segment M7 had a dominate substrate comprised predominantly of cobble that was too coarse for anadromous fish spawning habitat. Suitable spawning habitat was observed in some runs, pool crests, and in the hatchery outfall (artificial side channel SC_51.70R_ART and floodplain-type side channel SC_51.70R_FP). About 7 percent of the substrate was fine sediment (surface fines) less than 6 mm. Substrate used by juvenile salmonids for rearing were not embedded based on professional judgment (USFS 2009). There has been a reduction in the linkage between active channel and floodplain areas due primarily to elevated road grades and a levee, and lateral channel migration has been restricted where bank protection was placed. Artificial channel and floodplain confinement may have caused localized increases in the river's sediment transport capacity where high flows cannot dissipate stream energy over historic floodplain areas, and the loss of lateral channel migration processes due to bank protection may have promoted bed scour. In addition, historic removal of instream large wood may have decreased channel roughness and the wood's contributions to creating scour pools, and the sorting and retention of spawning size gravels. The cumulative effect of these localized restrictions may have enabled the river to transport more gravel-size materials further downstream to the Chewuch River confluence where flow convergence reduces the Methow River's streampower allowing gravel deposition.

Most of the substrate observed in channel segment M6 was too coarse (cobble-size material) for anadromous fish spawning. There was some spawning habitat observed along runs and riffles (pool tail-out crests) along the lower half of the channel segment, and in the hatchery outfall channel (side channel SC_51.70R_ART and SC_51.70R_FP) that is located entirely within this channel segment. None of the pools were judged to be embedded and about 10 percent of the substrate was comprised of fine sediments less than 6 mm in size (USFS 2009). The channel and floodplain confinement by glacial terraces cored by bedrock limits floodplain interactions, concentrating flows in the channel and maintaining the stream's competence to transport gravel-size materials downstream.

Narrative:

Predominantly cobble-size materials that were considered too coarse for anadromous fish spawning were observed throughout the reach. Fine sediment was not observed to be negatively affecting spawning or rearing areas. Geomorphic processes occurring along channel segments M8 and M6 probably do not support significant quantity of gravel retention due to natural channel confinement and slope. This combination maintains the stream's competence to move larger materials resulting in transport of gravel-sized materials.

Channel segment M7 has localized areas that have artificially disconnected channel/floodplain interactions and lateral channel migration processes due to elevated road embankments, levee, and bank protection. Prior to the anthropogenic disturbances, the river may have (a) dissipated high flows over a larger floodplain area which would reduce streampower, (2) laterally migrated across more floodplain area that would recruit additional sediment and lengthen the channel, and (3) decreased channel roughness due to the historic removal of instream wood thereby reducing its contribution to creating scour pools, and the sorting and retention of spawning size gravels. Gravel-size materials were found to comprise about 22 percent of the substrate, whereas cobbles and boulders comprised 72 percent which would be expected for a free-formed alluvial channel. However, this channel segment may have been a forced alluvial channel that had (and still does have) bedrock forced pool-riffle bedforms, but may be lacking in stable wood forced pool-riffle bedforms.

Based on the REI criteria for dominant substrate, percentage of fine sediment in spawning areas, and embeddedness in rearing areas, the stream is **Adequate** for the dominant substrate indicator. Substrate sizes and percentages for fine sediment and embeddedness were adequate in channel segments M8 and M6. Channel segment M7 has been impacted by anthropogenic disturbances which may have changed the physical processes resulting in localized increases in sediment transport capacity; however, substrate characteristics are still within expected ranges.

Table 5. Summary of channel substrate metrics (USFS 2006 and 2009).

Channel Segment	River Miles	Substrate	Metric
Segment M8	**RM 55.0-54.2**	Percent Surface Fines (<6 mm)	---
		D50	---
		D84	---
		Percent Sand	5%
		Percent Gravel	20%
		Percent Cobble	65%
		Percent Boulder	10%
Segment M7	**RM 54.2-51.4**	Percent Surface Fines (<6 mm)	7%
		D50	127 mm
		D84	247 mm
		Percent Sand	6%
		Percent Gravel	22%
		Percent Cobble	59%
		Percent Boulder	13%
Segment M6	**RM 51.4-50**	Percent Surface Fines (<6 mm)	10%
		D50	108 mm
		D84	238 mm
		Percent Sand	9%
		Percent Gravel	11%
		Percent Cobble	57%
		Percent Boulder	12%

GENERAL INDICATOR: INSTREAM WOOD

Criteria: The following criteria were developed by USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Quality	Instream Wood	Pieces Per Mile at Bankfull	>20 pieces/mile >12" diameter >35 ft length; and adequate sources of woody debris available for both long- and short-term recruitment.	Currently levels are being maintained at minimum levels desired for "adequate", but potential sources for long-term woody debris recruitment is lacking to maintain these minimum values.	Current levels are not at those desired values for "adequate", and potential sources of woody debris for short- and/or long-term recruitment are lacking.

In channel segment M8, the Stream Inventory Surveys (USFS 2006 and 2009) determined that larger wood sizes were scarce with only 3.7 pieces of large (at least 12 inches diameter with a length of at least 35 feet) wood per mile (Table 6). Wood moves through the system similar to sediment, and wood retention would not be expected in this moderately confined channel segment as most of the flow is confined within the streambanks which maintains flows with sufficient streampower capable of transporting woody debris. Wood recruitment potential was considered poor due to natural channel characteristics (straight, moderately confined) through this segment with additional slight impacts from removal of trees for development and infrastructure (Highway 20).

Channel segment M7 has been partly artificially confined by elevated road grades and a levee. Prior to this partial confinement, the stream may have accessed more of its floodplain that would dissipate stream energy and may have provided hydraulic conditions more appropriate for instream wood retention. The Stream Inventory Survey (USFS 2009) observed 9.7 pieces of large wood per mile in this segment. Wood recruitment potential was considered poor due to removal of vegetation along the streambanks for development leaving only a narrow strip of vegetation.

The Stream Inventory Survey (USFS 2009) observed only 5.7 pieces of large wood per mile in channel segment M6. Instream wood would not be expected to be retained in this confined, free-formed alluvial channel that has low sinuosity and relatively uniform bedform (plane-bed) because flows are focused in the channel. Confinement constrains the flows to the channel resulting in sufficient streampower to transport woody debris. Wood recruitment potential was considered poor due to natural channel characteristics (straight channel) and vegetation clearing within the limited floodplain area that has left only a narrow strip of vegetation along the streambanks.

Table 6. Summary of instream wood metrics.

Channel Segment	River Miles	Wood[1]	Metric
Segment M8	**RM 55.0-54.2**	Small Wood Per Mile	8.7
		Medium Wood Per Mile	3.7
		Large Wood Per Mile	0
		Total Medium and Large Wood	3.7
Segment M7	**RM 54.2-51.4**	Small Wood Per Mile	22.7
		Medium Wood Per Mile	8.6
		Large Wood Per Mile	1.1
		Total Medium and Large Wood	9.7
Segment M6	**RM 51.4-50**	Small Wood Per Mile	22.3
		Medium Wood Per Mile	5
		Large Wood Per Mile	0.7
		Total Medium and Large Wood	5.7

[1]Wood dimensions for Eastside Forests (USDA 2006): Small wood has a diameter greater than 6-inches to 12-inches, at a length of 20 feet from the large end; medium wood has a diameter greater than 12-inches to 20-inches, at a length of 35 feet from the large end: and large wood has a diameter greater than 20-inches, at a length of 35 feet from the large end.

Narrative:

Each of the channel segments do not have "desired levels of wood per mile" (greater than 20 pieces of large wood per mile). In the free-formed alluvial channel reaches (channel segments M8 and M6) the lack of wood is most likely a natural condition because the streampower is focused within the channel and there is limited floodplain areas in which the energy can be dissipated that results in the wood being transported downstream. The short, unconfined forced alluvial channel reach (channel segment M7) has localized areas where active channel/floodplain interactions are disconnected, lateral channel migration is restricted, and riparian vegetation has been cleared which decreases channel processes associated with this type of channel reach. Wood recruitment in this channel reach would be primarily through lateral channel migration processes with minimal wood being input from the upstream, confined channel segment (M8).

Wood retention in the moderately confined to confined channel segments (M8 and M6) would not be expected in these free formed channel types and wood recruitment would be minimal due to the straight channels and lack of lateral channel migration (natural condition). Wood retention in unconfined channel segment M7 would be expected to be moderate and twenty pieces of large wood per mile may be unrealistic due to the short length of this channel segment; and wood recruitment would be expected from lateral channel migration that is hindered by localized artificial channel confinement and vegetation clearing. Instream wood per mile and long-term wood recruitment potential may be near natural levels for the confined channel segments (M8 and M6), but may be below natural levels in unconfined channel segment M7. The overall rating for the reach **Adequate** with the caveat that wood levels and recruitment potential in channel segment M7 could be improved.

GENERAL INDICATOR: POOLS

Criteria: The following criteria were adapted from USFWS (1998) and Montgomery and Buffington (1993).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Quality	Pools	Pool Frequency and Quality Large Pools (in adult holding, juvenile rearing, and over-wintering reaches where streams are >3 m in wetted width at base flow)	Pool frequency: Channel width No. pools/mile 0.5 ft 39 5-10 ft 60 10-15 ft 48 15-20 ft 39 20-30 ft 23 30-35 ft 18 35-40 ft 10 40-65 ft 9 65-100 ft 4 For channel widths greater than 100 feet, pool spacing for an alluvial valley type that are moderately confined to unconfined with a channel slope <2% is generally a pool for every 5-7 channel widths (Montgomery and Buffington (1993). Pools have good cover and cool water and only minor reduction of pool volume by fine sediment. Each reach has many large pools >1 m deep with good fish cover.	Pool frequency is similar to values in "functioning adequately", but pools have inadequate cover/temperature, and/or there has been a moderate reduction of pool volume by fine sediment. Reaches have few large pools (>1 m) present with good fish cover.	Pool frequency is considerably lower than values for "functioning adequately", also cover/temperature is inadequate, and there has been a major reduction of pool volume by fine sediment. Reaches have no deep pools (>1 m) with good fish cover.

Stream Inventory Surveys (USFS 2006 and 2008) delineated their habitat reaches primarily based predominantly on important tributary inputs, and not on geomorphic channel confinements used for this assessment. The locations of the habitat reaches are provided in Table 7. Information was extrapolated from the Stream Inventory Surveys based river miles and descriptions, and applied to the geomorphic reaches.

Table 7. Summary of habitat reach locations and geomorphic reach locations.

Habitat Reach Location	Approximate River Miles	Geomorphic Reach Location	River Miles
Big Valley to Wolf Creek[1]	RM 55.0-54.2	Channel Segment M8	RM 55.0-52.9
Wolf Creek to Chewuch River[2]	RM 54.2-51.4	Channel Segment M7	RM 52.9-51.3
Chewuch River to above Barkley Diversion Dam[2]	RM 51.4-50.0	Channel Segment M6	RM 51.3-50.0

[1]USFS 2006
[2]USFS 2009

Channel segment M8 is moderately confined and is a free-formed alluvial channel that has a plane-bed bedform (Montgomery and Buffington 1997). The Rosgen (1996) channel type is an A- to F channel with a slope of about 0.3 percent and bankfull width of 110 feet, width-to-depth ratio of 35.2, and entrenchment ratio of 1.3:1 (USFS 2006 and 2008). During the 2006 Stream Inventory Survey (USFS 2006), about 1.2 pools per mile were observed that had an average maximum pool depth of 3.0 feet. Observers noted that the pools lacked fish cover and complexity, but wood would not me expected to be retained instream in a confined channel section. A summary of pool metrics is provided in Table 8.

Channel segment M7 is unconfined and is a forced alluvial channel that has predominantly a plane-bed to pool-riffle bedform (Montgomery and Buffington, 1997). The Rosgen (1996) channel type is a C-channel with a slope of about 0.3 percent and bankfull width of 160 feet, width-to-depth ratio of 52.3, and entrenchment ratio of >4.0:1 (USFS 2006 and 2009). About 21 percent of the floodplain is artificially disconnected due to a levee and elevated road embankments. Prior to anthropogenic disturbances, this channel segment may have retained more instream wood that would have contributed to pool formation and provided fish cover. During the 2008 Stream Inventory Survey (USFS 2008), about 3.2 pools per mile were observed that had an aveage maximum pool depth of 4.6 feet. Observers noted that the pools lacked fish cover and complexity.

Channel segment M6 is confined and is a free-formed alluvial channel that has a plane-bed bedform (Montgomery and Buffington 1997). The Rosgen (1996) channel type is an A- to F-channel with a slope of about 0.5 percent and bankfull width of 175 feet, width-to-depth ratio of 60.3, and entrenchment ratio of 1.2:1 (USFS 2008). During the 2008 Stream Inventory Survey (USFS 2008), about 4.3 pools per mile were observed that had an average maximum pool depth of 5.1 feet. Observers noted that the pools lacked fish cover and complexity, but wood would not be expected to be retained instream in a confined channel section.

Table 8. Summary of pool metrics

Habitat Reach	Associated Channel Segment	Pools	Metric
Reach 1 (RM55.0-54.2)[1]	**Segment M8**	Pools Per Mile	1.2
		Pools >5 Feet Deep Per Mile	0
		Average Pool Maximum Depth	3 feet
		Average Pool Residual Depth	1.2 feet
		Riffle to Pool Ratio	7-to-1
Reach 5 (RM 54.2-51.4)[2]	**Segment M7**	Pools Per Mile	3.2
		Pools >5 Feet Deep Per Mile	1.1
		Average Pool Maximum Depth	4.6 feet
		Average Pool Residual Depth	3.2 feet
		Riffle to Pool Ratio	---
Reach 4 (RM 51.4-50)[2]	**Segment M6**	Pools Per Mile	4.3
		Pools >5 Feet Deep Per Mile	1.4
		Average Pool Maximum Depth	5.1 feet
		Average Pool Residual Depth	3.4 feet
		Riffle to Pool Ratio	---

[1] USFS 2006
[2] USFS 2009

Narrative:

The pool frequency criteria for a channel width of greater than 100 feet is one pool every 5 to 7 channel widths in pool-riffle type channels with average slopes of less than 0.2 percent. The pools should exhibit good fish cover, cool water, minor reduction in pool volume by fine sediment, and many large pools with depths greater than about 3 feet. These criteria are not applicable to channel segments M8 and M6. These channel segments are moderately confined to confined free-formed alluvial channel segments that are relatively straight, high gradient channels that will not develop or maintain significant numbers of discreet pools. Channel segment M7 probably had a higher percentage of instream wood available to contribute to pool formation prior to anthropogenic disturbances (partial floodplain disconnection and instream wood removal). The pool frequency criteria are partially applicable to this segment in that it is a colluvial to alluvial, plane-bed to pool-riffle type channel. The overall channel gradient is still quite steep and the channel planform is relatively straight with the channel type a combination of plane-bed and pool-riffle. This combination indicates that the natural pool spacing is somewhat less than the suggested 5 to 7 channel widths for a pool-riffle system with less than 0.2 percent slope. Application of the 5 to 7 channel width pool spacing standard would indicate 4.4 to 6.1 pools per mile. About 3.2 pools per mile were mapped in channel segment M7 with average residual pool depths of 3.2 feet. This combination indicates that the pool frequency, spacing, and quality are within the expected variability for the channel type.

Based on the natural channel types and characteristics, pool frequency per mile, complexity, and cover are **Adequate** for the reach as a whole.

GENERAL INDICATOR: OFF-CHANNEL HABITAT

Criteria: The following criteria have been modified from USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Quality	Off-channel Habitat	Connectivity with Main Channel	Reach has many ponds, oxbows, backwaters, and other off-channel areas with cover, and side channels are low energy areas. No manmade barriers present along the mainstem that prevent access to off-channel areas.	Reach has some ponds, oxbows, backwaters, and other off-channel areas with cover, and side channels are generally high energy areas. Manmade barriers present that prevent access to off-channel habitat at some flows that are biologically significant.	Reach has few or no ponds, oxbows, backwaters, and other off-channel areas. Manmade barriers present that prevent access to off-channel habitat at multiple or all flows.

No backwater pools or oxbows were observed in channel segment M8 during the Stream Inventory Survey (USFS 2006 and 2009). During the geomorphic channel unit mapping, one gravel bar-type side channel (SC_53.15R_GB) was observed (Table 9). Off-channel habitat would be expected to be minimal in this moderately confined stream section.

In channel segment M7 there was about 5.54 acres of floodplain-type side channels and 0.61 acres of gravel bar-type side channels. Floodplain-type side channels comprised about 90 percent of the available off-channel habitat. The outfall channel from the State Salmon Hatchery was considered an artificial floodplain-type side channel that connects to a natural side channel at its lower end. Water in the hatchery outfall was cooler than the stream based on thermal infrared imagery and provides spawning and rearing habitat for anadromous fish.

Two gravel bar-type side channels were observed in channel segment M6. Side channels would not be expected to be numerous due to the channel confinement and type. There were limited floodplain areas along the channel and lateral channel migration was nearly nonexistent as would be expected for the channel type.

Table 9. Channel Segment M7 summary of side channels

Channel Segment	River Miles	Side Channel	Side Channel Type	Acres
Segment M8		SC_53.5R_?GB	Gravel Bar	0.14
Total Acres by Side Channel Type;	**Floodplain Type:**	0 Acres (0%)		
	Gravel Bar Type:	0.14 Acres (100%)		
Total Side Channel Acres:	**0.14 Acres**			
Segment M7		SC_52.70R_FP	Floodplain	0.66
		SC_52.40R_FP	Floodplain	1.13
		SC_52.35R_GB	Gravel Bar	0.05
		SC_52.05R_FP	Floodplain	0.23
		SC_52.00L_FP	Floodplain	1.37
		SC_51.70R_FP	Floodplain	1.63
		SC_51.70R_FP/ART	Floodplain/Artificial	0.52
		SC_51.55L_GB	Gravel Bar	0.56
Total Acres by Side Channel Type:	**Floodplain Type:**	**5.54 Acres (90%)**		
	Gravel Bar Type:	**0.61 Acres (10%)**		
Total Side Channel Acres:	**6.15 Acres**			
Segment M6		SC_51.12R_GB	Gravel Bar	0.03
		SC_50.05R_GB	Gravel Bar	0.09

Total Acres by Side Channel Type:	Floodplain Type:	0 Acres (0%)
	Gravel Bar Type:	0.12 Acres (100%)
Total Side Channel Acres:	0.12 Acres	

Narrative:

Off-channel habitat was not prevalent in channel segments M8 and M6 because these are straight, high-gradient, plane-bed type channels in moderately confined and confined stream sections, respectively. Floodplain areas were narrow along the channel margins which naturally limited formation of off-channel habitat. The floodplain along channel segment M7 has been artificially confined by anthropogenic disturbances, but still provides about 6 acres of side channels with cooler water, good cover, and low energy areas. Some of the anthropogenic disturbances have created access barriers to historic channel paths and for this reason off-channel habitat is **At Risk**.

SPECIFIC INDICATOR: FLOODPLAIN CONNECTIVITY

Criteria: The following criteria have been modified from USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Channel Condition	Channel Dynamics	Floodplain Connectivity	Floodplain areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession.	Reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function, riparian vegetation/succession.	Severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetland extent drastically reduced and riparian vegetation/succession altered significantly.

Narrative:

There is a reduced linkage between historic channel paths, floodplains, and riparian areas; overbank flows have been reduced by anthropogenic disturbances; and riparian vegetation structure and composition have been modified due to floodplain development in channel segment M7. The other channel segments (M8 and M6) are hydraulically connected to their floodplains and no anthropogenic disturbances have significantly changed riparian vegetation composition and structure with the exception of a few areas where some riparian vegetation clearing occurred. Anthropogenic disturbances have disconnected channel-floodplain interactions on about 21 percent of the floodplain in channel segment M7, and riparian vegetation composition and structure has been modified. Based on the REI criterion, this reach is **At Risk** for floodplain connectivity.

Table 10. Subreach connectivity by subreach

Channel Segment	River Miles	Subreach	Total Acres	Connected Acres	Disconnected Acres (Percent)
Segment M8	**RM 55.0-52.9**	**M8-IZ-1**	35.1 acres	35.1 acres	0 acres (0%)
		M8-OZ-1	1.3 acres	1.3 acres	0 acres (0%)
		M8-OZ-2	3.1 acres	3.1 acres	0 acres (0%)
		M8-OZ-3	5.2 acres	5.2 acres	0 acres (0%)
		M8-OZ-4	13.9 acres	13.9 acres	0 acres (0%)
		M8-OZ-5	10.4 acres	10.4 acres	0 acres (0%)
Total			**69.0 acres**	**69.0 acres**	**0 acres (0%)**
Segment M7	**RM 52.9-51.3**	**M7-IZ-2**	38.9 acres	38.9 acres	0 acres (0%)
		M7-OZ-6	33.8 acres	33.8 acres	0 acres (0%)
		M7-OZ-7 Complex	102.7 acres	76.0 acres	26.7 acres (26%)
		M7-OZ-8	0.9 acres	0.9 acres	0 acres (0%)
		M7-OZ-9 Complex	44.9 acres	11.9 acres	33.0 acres (73%)
		M7-OZ-10	0.3 acres	0.3 acres	0 acres (0%)
Total			**221.5 acres**	**161.8 acres**	**59.7 acres (21%)**
Segment M6	**RM 51.3-50.0**	**M6-IZ-3**	26.1 acres	26.1 acres	0 acres (0%)
		M6-OZ-11	8.3 acres	8.3 acres	0 acres (0%)
		M6-OZ-12	6.3 acres	6.3 acres	0 acres (0%)
Total			**40.7 acres**	**40.7 acres**	**0 acres (0%)**

SPECIFIC INDICATOR: BANK STABILITY/CHANNEL MIGRATION

Criteria: The criteria for bank stability/channel migration are a relative condition of the specific indicator developed by Reclamation.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Channel Condition	Channel Dynamics	Bank Stability/ Channel Migration	Channel is migrating at or near natural rates.	Limited amount of channel migration is occurring at a faster/slower rate relative to natural rates, but significant change in channel width or planform is not detectable.	Little or no channel migration is occurring because of human actions preventing reworking of the floodplain; or channel migration is occurring at an accelerated rate such that channel width has at least doubled, possibly resulting in a channel planform change, and sediment supply has noticeably increased from bank erosion.

Less than 5 percent of the banks are actively eroding (Table 11) in channel segments M8 and M6 due to natural channel characteristics (confined straight, high-gradient, plane-bed). In channel segment M7, about 16 percent of the banks are actively eroding, which would be less than expected in a “naturally” unconfined stream section. Channel segment M7 has been artificially confined and the streambanks have been protected with a riprap armored levee (about 1,900 feet in length), riprap placed along about 550 feet of streambank to protect structures, and about 60 feet of improved roads that are armored with riprap (Table 12).

Table 11. Summary of bank erosion

Channel Segment	River Miles	Bank Erosion	Metric
Segment M8	RM 55.0-54.2	Linear Length Per Mile	405 feet
		Percent Eroding Banks	5%
Segment M7	RM 54.2-51.4	Linear Length Per Mile	1,720 feet
		Percent Eroding Banks	16%
Segment M6	RM 51.4-50	Linear Length Per Mile	223 feet
		Percent Eroding Banks	2%

Table 12. Summary of anthropogenic features restricting lateral channel migration

Channel Segment	Subreach/Parcel	Feature Type	Metric
Segment M8	**M8-IZ-1**	Revetment	1
		Riprap	355 feet

Segment M7	**M7-IZ-2**	Levee	1,580 feet
		Riprap	550 feet
		Rock Spur	1
	M7-DOZ-9b	Levee	1,900 feet
	M7-OZ-9c	Improved Roads	60 feet

Narrative:

Bank armoring has restricted lateral channel migration in channel segment M7, but not in channel segments M8 or M6. Lateral channel migration is occurring at a slower rate than would naturally be expected to occur in channel segment M7, but was appropriate in channel segments M8 and M6. Based on the REI criterion, channel stability is **At Risk** due to artificial features restricting lateral channel migration in channel segment M7.

SPECIFIC INDICATOR: VERTICAL CHANNEL STABILITY

Criteria: The criteria for bank stability/channel migration are a relative condition of the specific indicator developed by Reclamation.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Channel Condition	Channel Dynamics	Vertical Channel Stability	No measurable or observable trend of aggradation or incision and no visible change in channel planform.	Measurable or observable trend of aggradation or incision that has the potential to, but not yet caused, disconnect the floodplain or a visible change in channel planform (e.g. single thread to braided).	Enough incision that the floodplain and off-channel habitat areas have been disconnected; or, enough aggradation that a visible change in channel planform has occurred (e.g. single thread to braided).

Narrative:

Bedrock was observed adjacent to and in the channel (Table 13) suggesting depth to bedrock is fairly shallow underneath the alluvial deposits. The bedrock controls the grade of the channel and is resistant to fluvial erosion. There was no measurable channel incision or aggradation reported in the Tributary Assessment (Reclamation 2008a), and no observable field indication during this assessment. Vertical channel stability is **Adequate** for the reach based on the REI criterion.

Table 13. Bedrock channel controls

River Mile	Bedrock Location	Description
RM 54.15	River left	Restricts lateral channel migration
RM 52.65	River right	Restricts lateral channel migration
RM 51.6	River left and in-channel	Restricts lateral and vertical channel migration
RM 51.3	River left	Restricts lateral channel migration
RM 51.15	River left	Restricts lateral channel migration
RM 50.0	River right	Restricts lateral channel migration

SPECIFIC INDICATOR: VEGETATION CONDITION (STRUCTURE)

Criteria: The criteria for riparian vegetation structure are a “relative” indication to the functionality of the specific indicator.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Riparian/Upland Vegetation	Vegetation Condition	Vegetation Structure	>80% species composition, seral stage, and structural complexity are consistent with potential native community.	50-80% species composition, seral stage, and structural complexity are consistent with potential native community.	<50% species composition, seral stage, and structural complexity are consistent with potential native community.

Analysis of riparian vegetation within the floodplain provides an indication of riparian health and land-use disturbances. In channel segment M8, about 20 percent (8.48 acres) of the riparian vegetation has been disturbed by infrastructure, and agriculture and residential development (Table 14). Greater than 70 percent (30.23 acres) remain essentially undisturbed and are in a medium-to-large tree condition. Black cottonwoods comprised about 63 percent of the species that are reliant on flood disturbances for rejuvenation and regeneration.

Channel segment M7 has the most anthropogenic disturbances with about 37 percent (67.85 acres) of the floodplain being cleared for commercial and residential development, and associated infrastructure. About 19 percent of the floodplain was comprised of black cottonwoods and a mix of black cottonwoods and coniferous/deciduous species.

The riparian vegetation was essentially comprised of a narrow strip along the channel margins in channel segment M6. About 38 percent (7.97 acres) of the riparian vegetation has been cleared or thinned for agriculture and residential development. The dominant riparian species was comprised of about 61 percent of black cottonwoods.

Narrative:

The floodplain covered about 254 acres in the reach. A total of about 84 acres or 33 percent have been cleared or thinned for commercial, residential, and agricultural development, and supporting infrastructure. Less than 80 percent of the species composition and structure are considered consistent with a potential native riparian community. Based on the REI criterion, the floodplain vegetation structure and composition is **At Risk**.

Table 14. Summary of floodplain vegetation composition metrics

Channel Segment	Map Unit	Classification	Area	Percentage
Segment M8	10	Agricultural Areas (Current and Fallow)	4.70 acres	11%
	6	Bars with Forbs or No Vegetation	3.35 acres	8%
	2	Black Cottonwood	26.45 acres	63%
	1	Quaking Aspen	1.74 acres	4%
	14	Road	0.57 acres	1%
	11	Residential Areas	3.21 acres	8%
	7a	Shrub Steppe	0.16 acres	<1%
	8a	Upland Forest	2.04 acres	5%
Total		**42.22 acres**		**100%**
Segment M7	10	Agricultural Areas (Current and Fallow)	19.68 acres	10%
	5	Bars with Deciduous Shrubs	8.18 acres	4%
	6	Bars with Forbs or No Vegetation	4.13 acres	2%
	2	Black Cottonwood	15.96 acres	8%
	2a	Black Cottonwood with Mixed Coniferous/Deciduous	21.01 acres	11%
	9	Mixed Coniferous/Deciduous	48.08 acres	25%
	7	Mixed Deciduous Shrubs (Not on Bars)	9.97 acres	5%
	1	Quaking Aspen	12.02 acres	6%

	14	Road	3.18 acres	2%
	11	Residential Areas	44.99 acres	25%
	7a	Shrub Steppe	3.98 acres	2%
Total		**191.18 acres**		**100%**
Segment M6	10	Agricultural Areas (Current and Fallow)	0.31 acres	2%
	6	Bars with Forbs or No Vegetation	0.11 acres	1%
	2	Black Cottonwood	12.93 acres	61%
	7	Mixed Deciduous Shrubs (Not on Bars)	0.05 acres	<1%
	11	Residential Areas	7.66 acres	36%
Total		**21.06 acres**		**100%**

SPECIFIC INDICATOR: VEGETATION CONDITION (DISTURBANCE)

Criteria: The criteria for riparian vegetation disturbance are a “relative” indication to the functionality of the specific indicator.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Riparian/Upland Vegetation	Vegetation Condition	Vegetation Disturbance (Natural/Human)	>80% mature trees (medium-large) in the riparian buffer zone (defined as a 30 m belt along each bank) that are available for recruitment by the river via channel migration; <20% disturbance in the floodplain (e.g., agriculture, residential, roads, etc.); <2 mi/mi^2 road density in the floodplain.	50-80% mature trees (medium-large) in the riparian buffer zone (defined as a 30 m belt along each bank) that are available for recruitment by the river via channel migration; 20-50% disturbance in the floodplain (e.g., agriculture, residential, roads, etc.); 2-3 mi/mi^2 road density in the floodplain.	<50% mature trees (medium-large) in the riparian buffer zone (defined as a 30 m belt along each bank) that are available for recruitment by the river via channel migration; >50% disturbance in the floodplain (e.g., agriculture, residential, roads, etc.); >3 mi/mi^2 road density in the floodplain.

The 30-meter buffer zone adjacent to the active channel was analyzed to provide an indication of land-use disturbances, medium-to-large wood recruitment potential via lateral channel migration, and channel boundary conditions. About 32 percent (16.2 acres) of the buffer zone in channel segment M8 have been disturbed predominantly for infrastructure, and some agriculture and residential development (Table 15). Medium-to-large trees comprised about 54 percent (27 acres) of the buffer zone that was available for recruitment by the stream, and provided appropriate channel boundary conditions. In some areas, the channel boundary conditions have been negatively impacted due to vegetation clearing.

Channel segment M7 has about 27 percent (9.81 acres) that have been disturbed for infrastructure, and agriculture and residential development. Based on the vegetation composition, about 53 percent (18.98 acres) of the buffer zone was comprised of medium-to-large trees available for potential recruitment. Channel boundary conditions have been significantly impacted by vegetation clearing for development and infrastructure.

In channel segment M6, about 43 percent (14.92 acres) has been disturbed for agriculture and residential development. The buffer zone was comprised of about 54 percent (18.66 acres) of medium-to-large trees available for potential recruitment. Channel boundary conditions have been negatively impacted due to vegetation clearing for residential and agriculture development.

Narrative:

The 30-meter buffer zone adjacent to the active channel covered about 120.27 acres of the reach. About 34 percent (40.93 acres) of the buffer zone has experienced anthropogenic disturbances from commercial, residential, and agriculture development. Riparian vegetation composition included about 45 percent (53.92 acres) of black cottonwoods and mixed black cottonwoods with coniferous species.

About 55 percent of the buffer zone is in a medium-to-large tree condition comprised predominantly of black cottonwoods or a mix of black cottonwoods with coniferous species. Road density is about 8.3 miles/miles^2 for the whole reach (includes active channel and floodplain areas). The vegetation disturbance for the reach is **At Risk** due to anthropogenic disturbances along the 30-meter buffer zone and high road densities.

Table 15. 30-meter buffer zone composition metrics

Channel Segment	Map Unit	Classification	Area	Percentage
Segment M8	10	Agricultural Areas (Current and Fallow)	4.01 acres	8%
	6	Bars with Forbs or No Vegetation	0.06 acres	<1%
	2	Black Cottonwood	25.80 acres	52%
	14	Road	4.87 acres	10%
	11	Residential Areas	7.32 acres	15%
	7a	Shrub Steppe	6.80 acres	13%
	8a	Upland Forest	1.20 acres	2%
		Total	**50.06 acres**	**100%**
Segment M7	10	Agricultural Areas (Current and Fallow)	4.98 acres	14%
	5	Bars with Deciduous Shrubs	1.14 acres	3%
	6	Bars with Forbs or No Vegetation	0.15 acres	<1%
	2	Black Cottonwood	9.10 acres	25%
	2a	Black Cottonwood with Mixed Coniferous/Deciduous	0.36 acres	1%
	9	Mixed Coniferous/Deciduous	9.52 acres	27%
	7	Mixed Deciduous Shrubs (Not on Bars)	3.59 acres	10%
	1	Quaking Aspen	0.43 acres	1%
	11	Residential Areas	4.83 acres	14%
	7a	Shrub Steppe	1.62 acres	5%
		Total	**35.72 acres**	**100%**
Segment M6	10	Agricultural Areas (Current and Fallow)	5.62 acres	16%
	5	Bars with Deciduous Shrubs	0.03 acres	<1%
	6	Bars with Forbs or No Vegetation	0.31 acres	1%
	2	Black Cottonwood	18.66 acres	54%
	7	Mixed Deciduous Shrubs (Not on Bars)	0.19 acres	1%
	1	Quaking Aspen	0.38 acres	1%
	11	Residential Areas	9.30 acres	27%
		Total	**34.49 acres**	**100%**

SPECIFIC INDICATOR: VEGETATION CONDITION (CANOPY COVER)

Criteria: The criteria for riparian vegetation canopy cover are a "relative" indication to the functionality of the specific indicator.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Riparian/Upland Vegetation	Vegetation Condition	Canopy Cover	Trees and shrubs within one site potential tree height distance have >80% canopy cover that provides thermal shading to the river.	Trees and shrubs within one site potential tree height distance have 50-80% canopy cover that provides thermal shading to the river.	Trees and shrubs within one site potential tree height distance have <50% canopy cover that provides thermal shading to the river.

The 10-meter buffer zone adjacent to the active channel was analyzed to provide an indication of stream shading, organic input, and terrestrial connectivity for aquatic insects. This buffer zone was used as a surrogate for canopy cover because densitometers were not used to actually measure canopy cover. In channel segment M8, about 12 percent (1.99 acres) of the buffer zone had been disturbed predominantly for infrastructure, and some agriculture and residential development (Table 16). The vegetation structure was about 88 percent (14.63 acres) comprised of shrubs to large trees, suggesting sufficient stream shading, organic input, and terrestrial connectivity.

About 22 percent (2.45 acres) of the buffer zone in channel segment M7 had been disturbed for agriculture and residential development. Vegetative structure was about 77 percent (8.76 acres) comprised of shrubs to large trees that indicates a very slight deficit in appropriate cover.

In channel segment M6, about 11 percent (1.23 acres) had been disturbed for agriculture and residential development. About 87 percent of the vegetative structure was in a shrub to large trees condition which provided appropriate cover.

Narrative:

The 10-meter buffer zone adjacent to the active channel covered about 39.06 acres of the reach. About 15 percent (5.67 acres) had been disturbed by agriculture and residential development, and infrastructure. The vegetative structure was about 84 percent (32.99 acres) of the vegetation being in a shrub to large trees condition.

The buffer zone was comprised of greater than 80 percent appropriate vegetative structure with less than 20 percent anthropogenic disturbance. Canopy cover was interpreted to be **Adequate** in providing stream shading, organic inputs, and terrestrial connectivity.

Table 16. 10-meter buffer zone composition metrics

Channel Segment	Map Unit	Classification	Area	Percentage
Segment M8	10	Agricultural Areas (Current and Fallow)	0.70 acres	4%
	6	Bars with Forbs or No Vegetation	0.06 acres	<1%
	2	Black Cottonwood	13.07 acres	78%
	14	Road	0.20 acres	1%
	11	Residential Areas	1.09 acres	7%
	7a	Shrub Steppe	0.91 acres	6%
	8a	Upland Forest	0.65 acres	4%
		Total	**16.68 acres**	**100%**
Segment M7	10	Agricultural Areas (Current and Fallow)	1.38 acres	12%
	5	Bars with Deciduous Shrubs	0.90 acres	8%
	6	Bars with Forbs or No Vegetation	0.15 acres	1%
	2	Black Cottonwood	2.99 acres	26%
	2a	Black Cottonwood with Mixed Coniferous/Deciduous	0.01 acres	<1%
	9	Mixed Coniferous/Deciduous	3.07 acres	27%
	7	Mixed Deciduous Shrubs (Not on Bars)	1.24 acres	11%
	1	Quaking Aspen	0.15 acres	1%
	11	Residential Areas	1.07 acres	10%
	7a	Shrub Steppe	0.40 acres	4%
		Total	**11.36 acres**	**100%**
Segment M6	10	Agricultural Areas (Current and Fallow)	0.71 acres	6%
	6	Bars with Forbs or No Vegetation	0.19 acres	2%
	2	Black Cottonwood	9.51 acres	86%
	7	Mixed Deciduous Shrubs (Not on Bars)	0.09 acres	1%
	11	Residential Areas	0.52 acres	5%
		Total	**11.02 acres**	**100%**

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Skidmore et al. 2009	Skidmore, S., Thorne, C., Cluer, B., Pess, G., Beechie, T., Castro, J., and Shea, C., 2009, Science base and tools for evaluating stream engineering, management, and restoration proposals; prepared for NOAA Fisheries and U.S. Fish and Wildlife Service: Manual available online at www.restorationreview.com.
USFS 2006	U.S. Forest Service. 2006. *Methow River Habitat Assessment Stream Survey of the Big Valley Reach (Wolf Creek to Hancock Springs).* U.S. Department of Agriculture, Pacific Northwest Region, Region 6. October 2006.
USFS 2009	U.S. Forest Service. 2009. *Middle Methow River Habitat Assessment River Mile 40.3 to 52.4 (From 0.9 miles below the confluence with Twisp River to the confluence with Wolf Creek).* U.S. Department of Agriculture, Pacific Northwest Region, Region 6. Revised March 10, 2009.
USFWS 1998	U.S. Fish and Wildlife Service. 1998. “Matrix of physical/environmental pathways and indicators for east-side streams” in Hillman and Giogi, 2002, Appendix C.

APPENDIX B

Photographic Documentation

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Appendix B

WOLF CREEK TO WINTHROP (W2) PHOTOGRAPHIC LOG

Photographic documentation of the Wolf Creek to Winthrop (W2) area was completed during the fall 2009 in support of the document, *Wolf Creek to Winthrop (W2) Assessment of Geomorphic and Ecologic Indicators, Middle Methow River, Methow Subbasin, Okanogan County, Washington*. Photographs were taken in the field and their location and direction were noted on aerial photographs. The photopoints were then mapped using GIS and are provided as Figures 1 through 3. Each photograph was captioned with the direction of the photograph, subject matter, and date, and provided as Photographs 1 through 39 in this appendix.

PHOTOGRAPH LOCATION DOCUMENTATION

Aerial photographs showing photograph locations for the Upper, Middle, and Lower Middle Methow River are provided in Figures 1 through 3.

Figure 1. Photographic locations in the Upper Methow reach between about RM 55 and 53

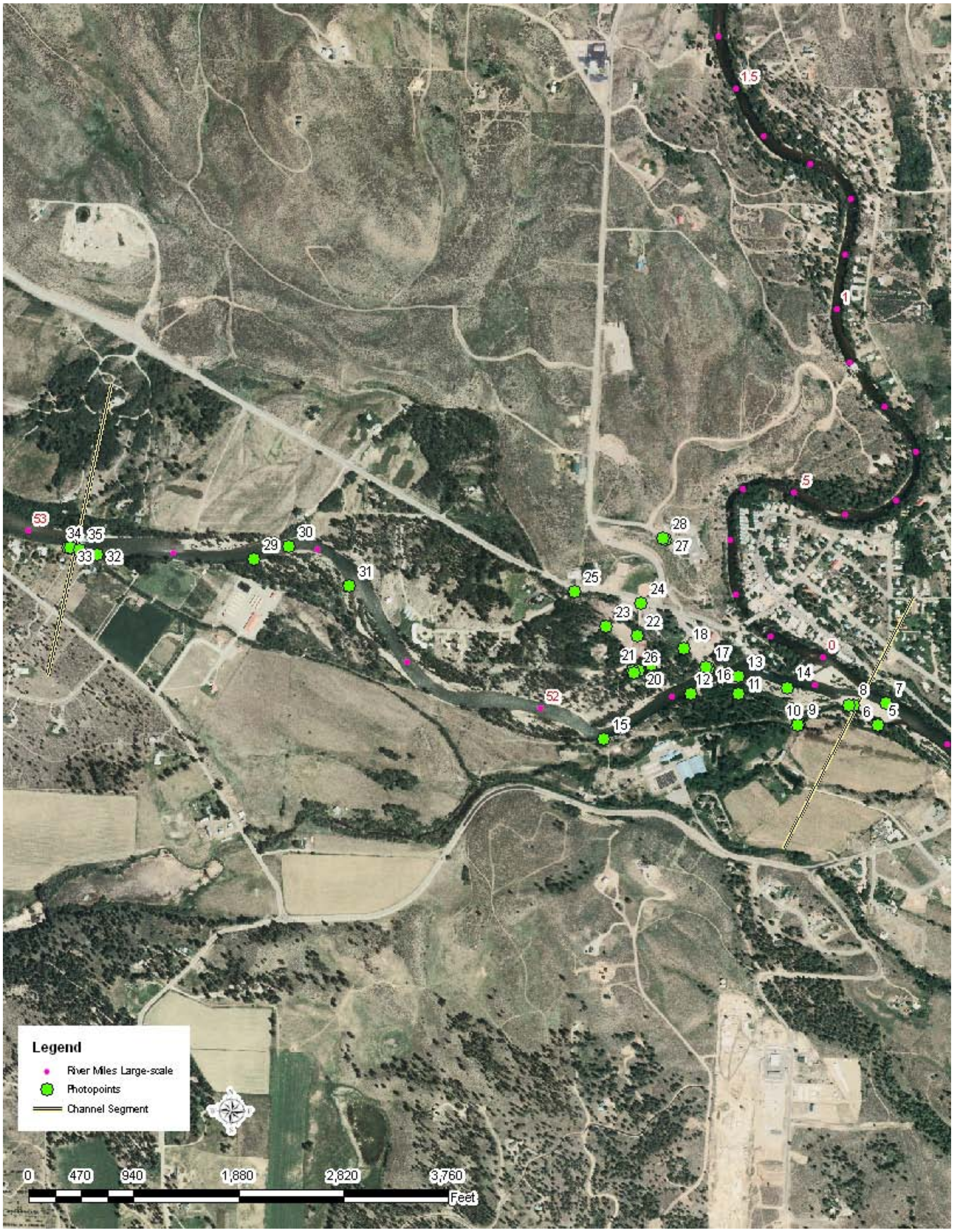

Figure 2. Photographic locations in the Middle Methow reach between about RM 53 and 51.5

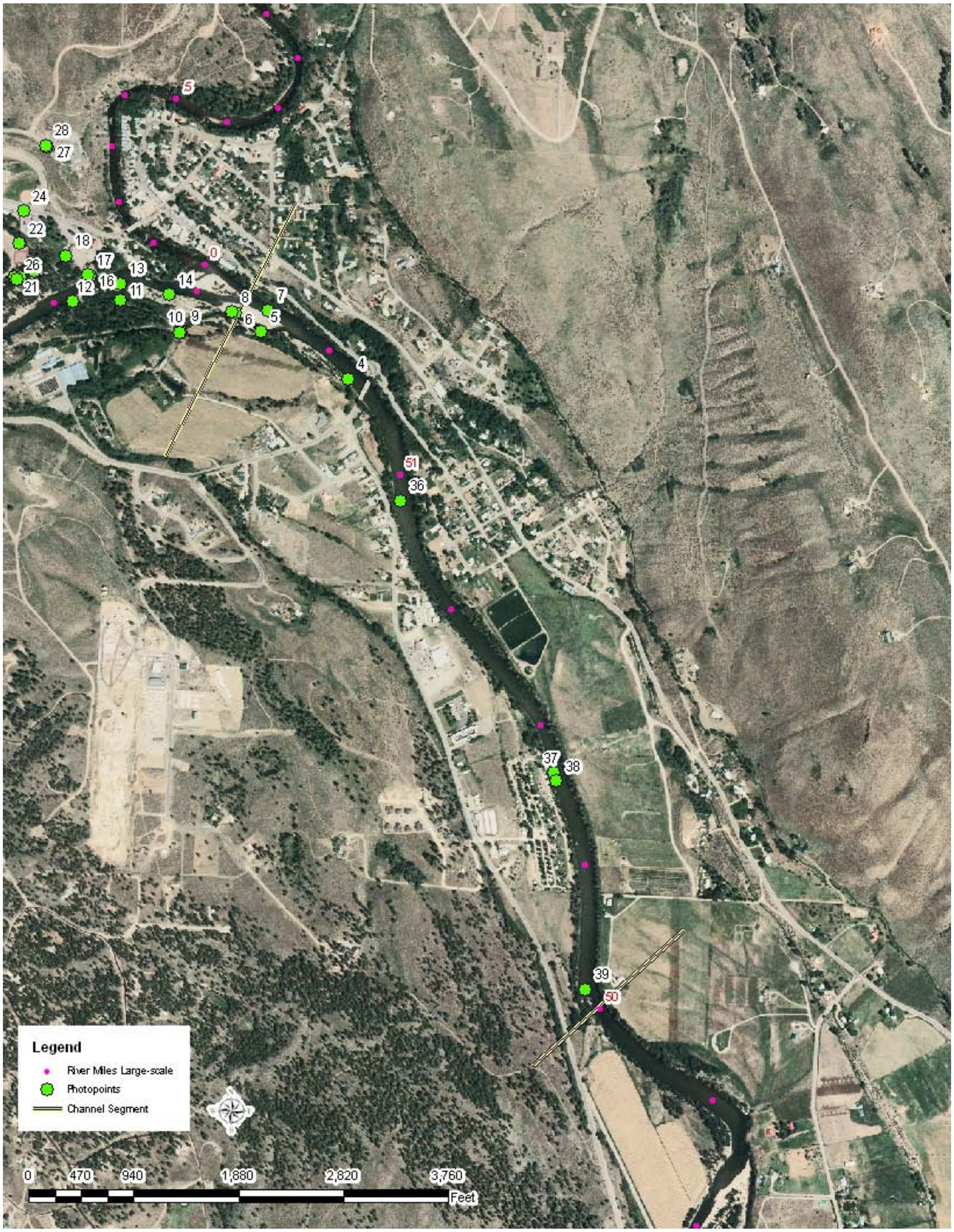

Figure 3. Photographic locations in the Lower Methow reach between about RM 51.5 and 50

PHOTOGRAPHIC DOCUMENTATION

Captioned photographs that correlate to the location maps in the previous section are provided as Photograph No. 1 through Photograph No. 39.

Photograph No. 1. View to the southeast looking downstream at pocket-pool habitat created by large boulders. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009.

Photograph No. 2. View to the northwest looking across the river at the confluence of Wolf Creek. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009.

Photograph No. 3. View to the southeast looking downstream along river right at bank protection at a historic diversion site downstream of Wolf Creek. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009.

Photograph No. 4. View to the southeast looking downstream at the Winthrop Bridge. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009.

Photograph No. 5. View to the east looking downstream at a pool in the Winthrop Hatchery side channel where salmon were holding. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009.

Photograph No. 6. View to the southwest looking at salmon spawning in a run along the Winthrop Hatchery side channel. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009.

Photograph No. 7. View to the northeast looking upstream at the confluence of the Chewuch River. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009.

Photograph No. 8. View to the west looking upstream at foot-bridge along the Winthrop Hatchery side channel. Note riprap along river right and grade-control structure in stream. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009.

Photograph No. 9. View to the west looking at salmon spawning in a run along the Winthrop Hatchery side channel. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009.

Photograph No. 10. View to the west looking at bridge crossing along the Winthrop Hatchery side channel. Note redd and salmon in the lower right corner of photograph. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009.

Photograph No. 11. View to the west looking at the Winthrop Fish Hatchery levee. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009.

Photograph No. 12. View to the east looking downstream at a small-to-medium size wood complex deposited at the head of a developing side channel. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009.

Photograph No. 13. View to the northeast looking downstream at a bedrock outcrop along river left and the developing pool created by lateral scour. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009.

Photograph No. 14. View to the north looking across at a gravel bar type side channel that flows from the Methow River into the Chewuch River. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009.

Photograph No. 15. View to the northeast looking downstream along the Winthrop Fish Hatchery levee along river right. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 20, 2009.

Photograph No. 16. View to the west looking upstream at the tail of a side channel in Winthrop Park. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 17. View to the northeast looking at fill placed in floodplain in Winthrop Park. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 18. View to the west looking at a footbridge placed across a side channel in Winthrop Park. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 19. View to the north looking at a side channel crossing and relative elevation of fill placed in the floodplain in Winthrop Park. Note the sandy flood deposits in side channel. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 20. View to the northwest looking at a culvert and road placed across side channel in Winthrop Park. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 21. View to the west looking at an elevated road embankment placed across floodplain near Winthrop Park. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 22. View to the west looking at fill placed in floodplain near Winthrop Park. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 23. View to the southwest looking at a school building built on fill placed within the floodplain. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 24. View to the northwest looking at a baseball field built on fill placed within the floodplain. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 25. View to the southwest looking at an elevated road embankment placed within the floodplain. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 26. View to the northeast looking downstream along a side channel near Winthrop Park. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 27. View to the south looking at the development that has occurred in the floodplain. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 28. View to the southwest looking at the development that has occurred in the floodplain. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 29. View to the northwest looking downstream at bedrock in the channel. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 30. View to the east looking downstream at riprap placed along river left. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 31. View to the southeast looking downstream at head of side channel along river right. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 32. View to the northwest looking upstream at Foghorn Diversion Dam. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 33. View to the west looking upstream at riprap placed along river right upstream of Foghorn Diversion Dam. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 34. View to the northeast looking downstream at the crest of Foghorn Diversion Dam. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 35. View is to the east looking downstream from Foghorn Diversion Dam at scour pool below the dam where numerous salmon were holding. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 36. View to the south looking downstream at active channel area and riparian vegetation along the channel margin. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 37. View to the north looking upstream at tree recently recruited by the channel. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 38. View to the south looking downstream at active channel and riparian vegetation along the channel margin. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

Photograph No. 39. View to the south looking downstream at bedrock in active channel area that had contributed to the development of a lateral scour pool to the left and side channel to the right. W2 Assessment – Methow Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, August 21, 2009.

APPENDIX C

GIS Databases

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Appendix C

GIS Databases

The Wolf Creek to Winthrop (W2) Reach Geographic Information System (GIS) File Geodatabase was produced in support of the document, *Wolf Creek to Winthrop (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*. More file geodatabases at the tributary and valley segment spatial scales are contained in the *Methow Subbasin Geomorphic Assessment, Okanogan County, Washington (Reclamation 2008a); Big Valley Reach Assessment, Okanogan County, Washington (Reclamation 2008b); Geomorphology and Hydraulic Modeling for the Middle Methow River from Winthrop to Twisp, Technical Report No. SRH-2009-42 (Reclamation 2010a); and the Middle Methow Reach Assessment, Methow River, Okanogan County, Washington (Reclamation 2010b).*

The ***W2_Assessment*** File Geodatabase includes multiple feature classes:

Feature Classes	Description
W2 Reach Perimeter	Perimeter of assessment area (polygon)
Surficial Geology	Surficial geology (polygon)
Valley Bottom Width	Valley bottom width measurements (polyline)
Constrained Width	Constrained valley bottom width (polyline)
Valley Length	Valley length (polyline)
Channel Width	Channel width measurements (polyline)
Channel Length	Channel length (2009) (polyline)
Channel Segment	Channel segment delineations (polyline)
Channel Alignments	Channel alignment delineations (polyline)
Channel Units	Geomorphic channel units (polygon)
Active Channel Area_Upper W2	Active channel; upper W2 area (polygon)
Active Channel Area_Lower W2	Active channel; lower W2 area (polygon)
HCMZ-Upper W2	Historic channel migration zone; upper W2 (polygon)
HCMZ-Lower W2	Historic channel migration zone; lower W2 (polygon)
Features_Polygon	Human features (polygon)
Features_Line	Human features (polyline)
Features_Point	Human features (point)
Subreaches	Subreach delineations (polygon)
Photopoints	Photograph locations (point)

For more information or to request a copy of the ***W2_Assessment*** geodatabase and other pertinent geographic information system data on DVD, contact the GIS Group at the Reclamation's Pacific Northwest Regional Office, 1150 North Curtis Road Suite 100, Boise, Idaho 83706.

W2 Assessment of Geomorphic and Ecologic Indicators, Geodatabase Files

Project Feature Classes

Feature Class – W2 Reach Perimeter
Title – W2 Reach Perimeter: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Perimeter
Abstract – Perimeter of the Wolf Creek to Winthrop (W2) assessment area. The geographic boundaries were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).

Feature Class – Surficial Geology
Title – Surficial Geology: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Surficial Geology
Abstract – The surficial geology map units are described in the Wolf Creek to Winthrop (W2) assessment report. Map units were delineated based on interpretation of geologic and geomorphic features utilizing the hillshade elevation models created from light distancing and ranging (LiDAR) data. Surficial geology was delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).

Feature Class – Valley Bottom Width
Title – Valley Bottom Width: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Valley bottom widths
Abstract – These polylines represent the location of valley bottom width measurements. Valley bottom width is defined as being the area between valley wall to valley wall that control the limits of lateral channel migration. Valley width measurements were delineated using hillshade elevation models developed from light distancing and ranging (LiDAR) data and the surficial geology mapping. Valley bottom widths were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).

Feature Class – Constrained Width
Title – Constrained Width: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Constrained Valley Bottom Widths
Abstract – These polylines represent the location of constrained valley bottom width measurements. Constrained valley bottom width is defined as being the area between geologic or geomorphic constrictions along the valley floor that restrict lateral channel migration (i.e. alluvial fans and glacial deposits). Constrained width measurements were

delineated using hillshade elevation models developed from light distancing and ranging (LiDAR) data and the surficial geology mapping. These measurements were taken at locations that were readily defined based on the hillshade models that appear to be representative of "average" constrained valley widths. Constrained valley bottom widths were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).

Feature Class – Valley Length
Title – Valley Length: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Valley Length
Abstract – These polylines represent the location of the valley length measurements. These valley lengths are defined as the length of the valley as measured along the approximate centerline between the constrained valley bottom widths (not between the valley walls) which is the valley bottom area that is accessible to the stream channel and is more representative when calculating the channel's sinuosity. Valley lengths were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).

Feature Class – Channel Width
Title – Channel Width: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Channel Width
Abstract – These polylines represent the location of channel width measurements. Channel width measurements were delineated using hillshade elevation models developed from light distancing and ranging (LiDAR) data. These channel widths were defined as the measurement between channel bank scarps and do not represent bankfull discharge or the elevation of channel forming flows. These measurements were taken at locations that were readily defined based on the hillshade models that appear to be representative of "average" channel widths. Channel widths were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).

Feature Class – Channel Length
Title – Channel Length: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Channel Length
Abstract – These polylines delineate the "wetted" channel length by geomorphic reach based on 2009 aerial photographs. The channel alignments were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).

Feature Class – Channel Segment
Title – Channel Segment: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Channel Segment

Abstract – Geomorphic channel divisions used to delineate channel segment boundaries. Channel segment divisions were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).

Feature Class – Channel Alignments
Title – Channel Alignments: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Channel Alignments
Abstract – These polylines delineate the "wetted" channel alignments by geomorphic reach based on available aerial photographs. Channel alignments were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).

Feature Class – Channel Units
Title – Channel Units: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Channel Units
Abstract – The polygons show the location and areal extent of channel units within the W2 assessment area on the Methow River. The channel units were mapped remotely and in the field by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho) using paper copies of 1:12,000-scale, color aerial photographs taken in 2006 and LiDAR hillshade elevation model.

Feature Class – Active Channel Area_Upper W2
Title – Active Channel Area: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Active Channel
Abstract – These polygons delineate the active channel area for the upper W2 assessment area that are inundated and impacted by channel forming flows based on aerial photographs, LiDAR hillshade elevation model, and field observations. The active channel areas were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho) using the lower Nason 2009 rectified aerial photographs.

Feature Class – Active Channel Area_Lower W2
Title – Active Channel Area: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Active Channel
Abstract – These polygons delineate the active channel area for the lower W2 assessment area that are inundated and impacted by channel forming flows based on aerial photographs, LiDAR hillshade elevation model, and field observations. The active channel areas were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho) using the lower Nason 2009 rectified aerial photographs.

Feature Class – HCMZ-Upper W2
Title – Historic Channel Migration Zone: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Historic Channel Migration Zone
Abstract – These polygons delineate the extent that lateral channel migration (or historic channel migration zone) has occurred in the upper W2 assessment area based on aerial photographs, LiDAR hillshade elevation model, and field observations. The limits were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).

Feature Class – HCMZ-Lower W2
Title – Historic Channel Migration Zone: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Historic Channel Migration Zone
Abstract – These polygons delineate the extent that lateral channel migration (or historic channel migration zone) has occurred in the lower W2 assessment area based on aerial photographs, LiDAR hillshade elevation model, and field observations. The limits were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).

Feature Class – Features_Polygon
Title – Human (anthropogenic) features: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Anthropogenic Features
Abstract – These polygons delineate the anthropogenic features identified on aerial photographs, LiDAR hillshade elevation model, and field observations. The anthropogenic features were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).

Feature Class – Features_Line
Title – Human (anthropogenic) features: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Anthropogenic Features
Abstract – These polylines delineate the anthropogenic features identified on aerial photographs, LiDAR hillshade elevation model, and field observations. The anthropogenic features were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).

Feature Class – Features_Point
Title – Human (anthropogenic) features: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*
Keywords – Anthropogenic Features

Abstract – These points delineate the anthropogenic features identified on aerial photographs, LiDAR hillshade elevation model, and field observations. The anthropogenic features were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).

Feature Class – Subreaches

Title – Subreaches: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*

Keywords – Subreaches

Abstract – These polygons delineate the subreaches and subreach complexes that are distinct areas comprised of floodplain and active channel areas. They are delineated by lateral and vertical controls and processes with respect to position and elevation. The subreaches were delineated by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).

Feature Class – Photopoints

Title – Photograph Locations: This feature class was created for the *Winthrop Area (W2) Assessment of Geomorphic and Ecologic Indicators, Methow River, Methow Subbasin, Okanogan County, Washington*

Keywords – Photopoints

Abstract – Point locations of photographs taken during the field inventory are noted on the most recent available ortho-photographs and the locations are redrawn in ArcGIS. Photographs are used to visually document baseline conditions and to provide basis for compliance monitoring. Each photograph is captioned and includes the direction of the photograph and the subject matter. The photographs and captions were done by Edward W. Lyon, Jr., L.G. (Reclamation's Pacific Northwest Regional Office, Boise, Idaho).