A GEOMORPHIC ASSESSMENT TO INFORM STRATEGIC STREAM RESTORATION PLANNING IN THE MIDDLE FORK JOHN DAY WATERSHED, OREGON, USA.

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Photo 1 - Partly confined valley, margin-controlled discontinuous floodplain reach type, Middle Fork John Day River

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Photo 2 - Laterally unconfined valley, moderate sinuosity gravel bed reach type, Middle Fork John Day River

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1 - INTRODUCTION

Location

The Middle Fork John Day Watershed is a 2050 km^2 subwatershed of the Columbia River Basin (CRB) located in east-central Oregon (Figure 1). The John Day basin supports wild populations of Chinook salmon and summer steelhead, but numbers of both are significantly reduced relative to historic levels (e.g., Wilson et al., 2004-2005). Rivers of the CRB have been modified by human development since settlement in the early 19th Century. Impacts to anadromous salmonid populations have been most directly measured through physical barriers to upstream migration to the MFJD in the form of hydroelectric dams (located downstream of MFJD on the mainstem Columbia River), and through degradation of local habitat by economic and farming activities within individual watersheds. These include logging, grazing and ranching across alluvial floodplains and adjacent landscapes, and mining of river channels, floodplains and contributing watersheds (NOAA, 2013).

Purpose and Methods

We present a series of maps that depict the results of a full watershed-scale geomorphic analysis. Our geomorphic assessment was based on Brierley and Fryirs (2005) River Styles Framework. The hierarchical scheme of river assessment is “nested” across spatial scales spanning regional, watershed, river reach, geomorphic unit, and habitat or hydraulic unit features. In this project we sought to: (1) classify streams throughout the Middle Fork John Day Watershed; (2) determine their geomorphic conditions; (3) analyze their recovery potential; and (4) conceptualize and create a strategic management plan for river recovery rehabilitation, and in some cases, restoration. The methods for each stage are described in detail in the article that accompanies this atlas. In general, we used remotely-sensed techniques coupled with field verification to accomplish these tasks.

Levels of analysis in the stream network

In this study we mapped variables (stream classification, geomorphic condition, recovery potential, and prioritized management reaches) for (a) the entire watershed, including ephemeral streams (see Plates 4-7); and (b) the perennial network, of which anadromous streams form a subset. The “salmonid extent” is shown on Figure 1 for summer steelhead and Chinook salmon.

Photo 3. Vinegar Creek in the upper Middle Fork Watershed. Anadromous streams in the mainstem and tributaries of the Middle Fork are wadeable during most of the year.

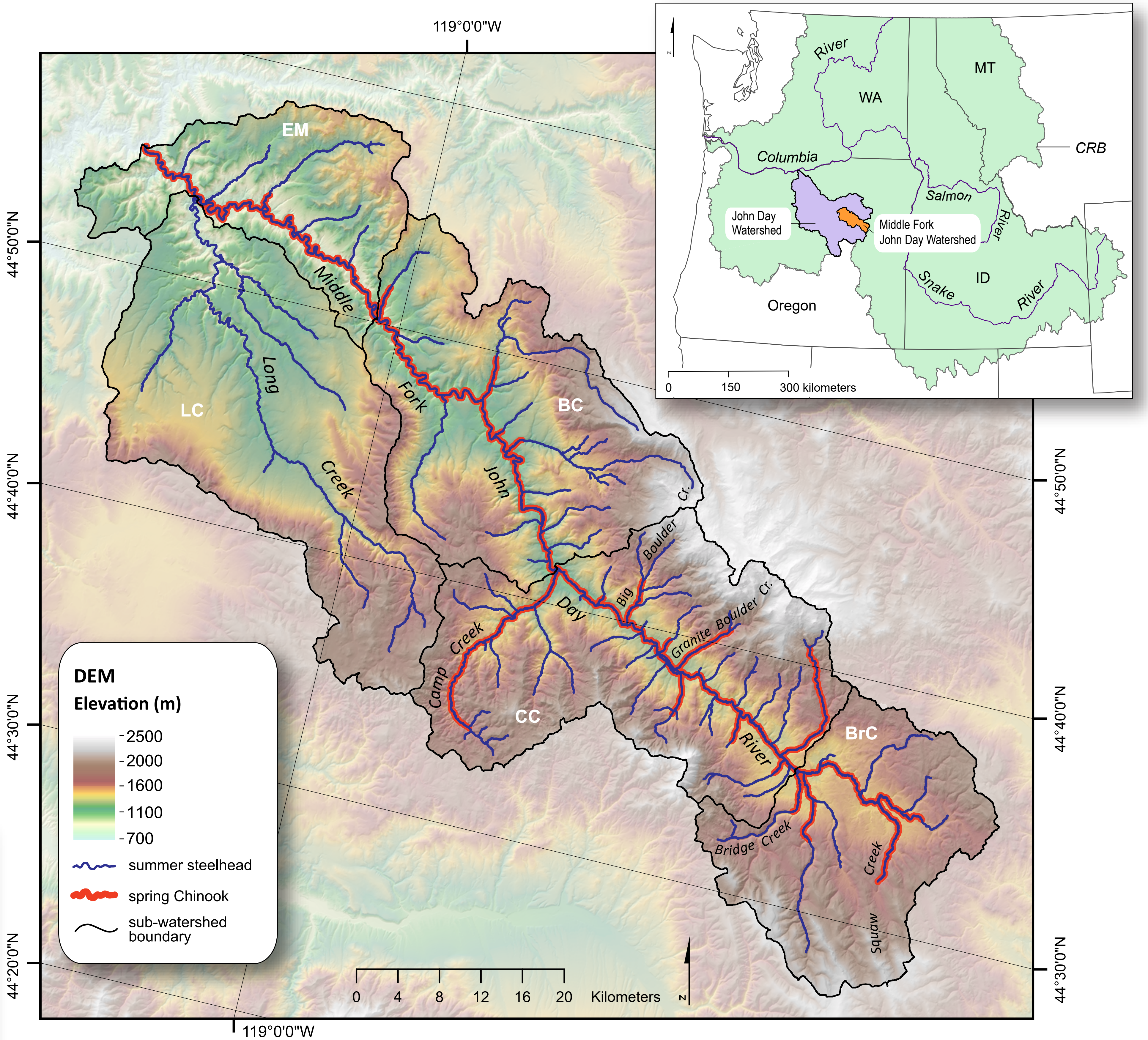


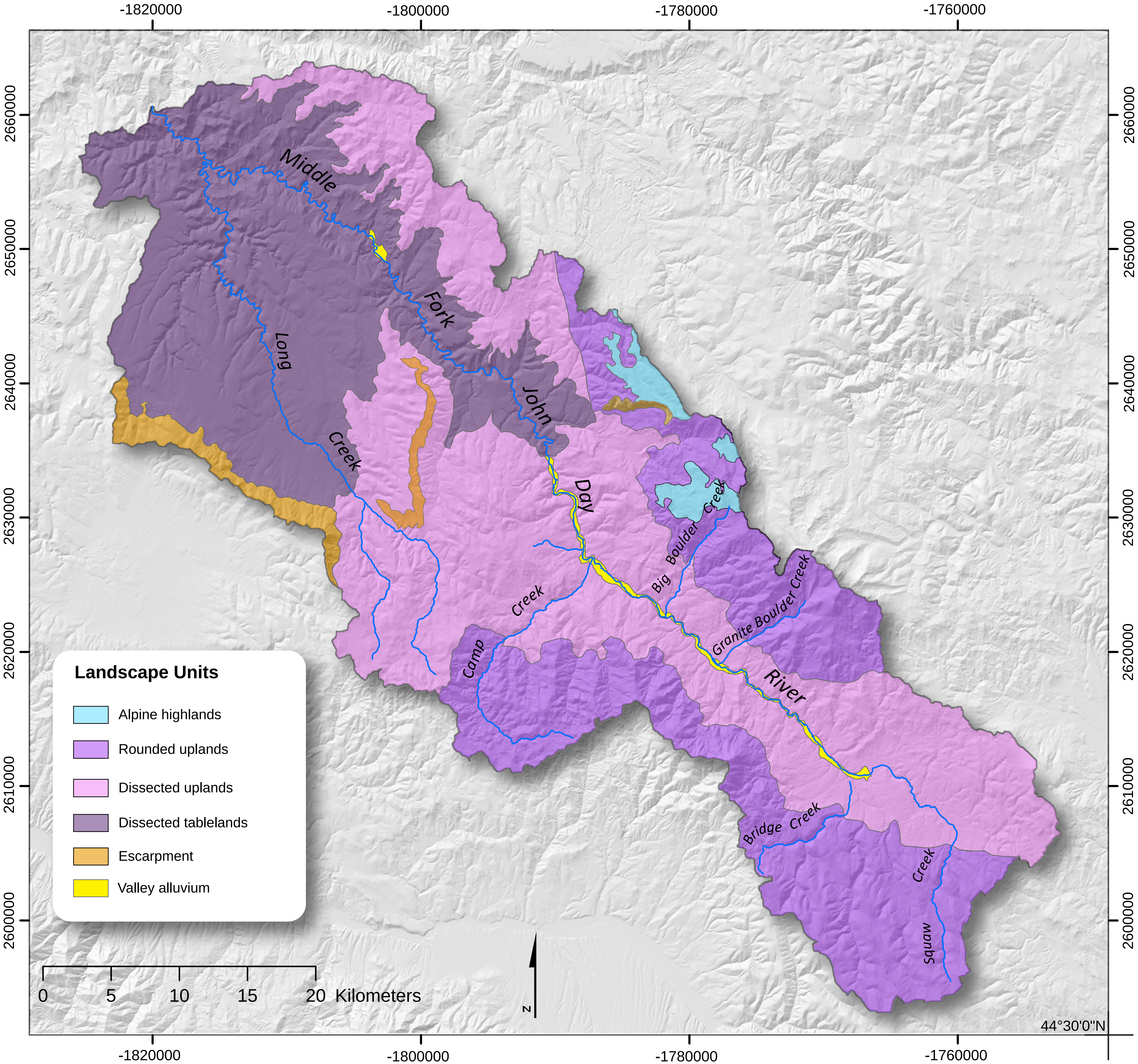
Figure 1. Location of the Middle Fork John Day Watershed in context of the John Day sub basin, within the larger Columbia River Basin. The salmonid extent of the stream network is shown for endangered summer steelhead and at-risk Chinook salmon. Sub-basin boundaries are EM = Eight Mile; LC = Long Creek; CC = Camp Creek; BB = Big Creek, and BrC = Bridge Creek

Data sources:
Digital vector stream network datasets derived from National Hydrography dataset (NHD). Rasters obtained from National Elevation Dataset (NED) (USGS, 2007).

Coordinate system:
North American Datum 1983 UTM Zone 11
GCD_North American -1983
Datum: D_north american 1983
Spheriod: GRS_1980

Fish data was compiled by the StreamNet project, which is administered by the Pacific States Marine Fisheries Commission (PSMFC). Data was provided by Washington Dept. of Fish and Wildlife, Oregon Dept. of Fish and Wildlife, Idaho Dept. of Fish and Game and Montana Fish Wildlife and Parks.

2 - LANDSCAPE UNITS



Landscape units form the core of a regional watershed analysis and combine geologic (local and regional bedrock), geomorphic (landforms, soils), climate, vegetation (ecological life zones, density and distribution) and other factors such as aspect and elevation. Landscape unit maps are used in conjunction with topographic datasets to observe and predict where significant changes are likely to influence river morphology and function (i.e., reach breaks). For example, long reaches of the mainstem Middle Fork John Day River shown on this map comprise unconfined and partly confined channels flowing amid wide valley bottoms filled with Quaternary alluvium. They are underlain by older volcanic or marine bedrock. By contrast, deeply entrenched valleys hosting a relict, antecedent, sinuous planform are underlain by thick sequences of Columbia River basalts forming dissected tablelands with sparse vegetation. The uppermost steep headwaters of tributary valleys host rivers flowing in confined valleys on steep, forested slopes. They are underlain by metavolcanic or granitic bedrock (see Plate 4 for distribution of valley settings and their corresponding reach types).

Alpine highlands: the highest elevation terrain is based on the subalpine/alpine zone. This terrain is mostly at or above timberline, with steep-sided, glacially influenced slopes, peaks, and valleys.

Rounded uplands: form the core of the central river valley and adjacent rounded hills. These are highly dissected, steeply sloping, low mountains and rolling hills traversed by larger streams fed by both snowmelt and spring base flow.

Dissected uplands: drawn from the mélange and mesic forest zones, this landscape unit comprises mid-level mountains and dissected volcanic plateau areas.

Dissected tablelands: this landscape unit consists of low mountains and the highly dissected broad plateau formed by relatively flat-lying Columbia River Basalt. The landscape hosts a variety of grasslands, shrublands, sage, and western juniper woodlands.

Escarpment: bands of bedrock cliff faces, dissected slopes, and colluvial slopes. Upland vegetation consisting of sparse conifer stands, shrubs and grasses.

Valley alluvium: wide valley bottoms afford the accommodation space and low gradient to aggrade fine alluvial sediments. Valleys are flanked by older Quaternary terrace and fan deposits. This landscape unit is expressed in the bottomlands along the main trunk stream in the upper watershed.

Data was informed by Level IV Ecoregions compiled by the Western Ecology Center of the USEPA (Environmental Protection Agency) on the basis of bedrock, soils, climate and vegetation associations (Thorson et al., 2003).

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Data sources:
Digital vector stream network datasets derived from National Hdrography dataset (NHD). Rasters obtained from National Elevation Dataset (NED) (USGS, 2007). Map 2 reproduced from O'Brien & Wheaton (2015).

3 - FIELD MAPS AND BASIN HYDROLOGY - VALIDATING RIVER CHARACTER AND BEHAVIOR

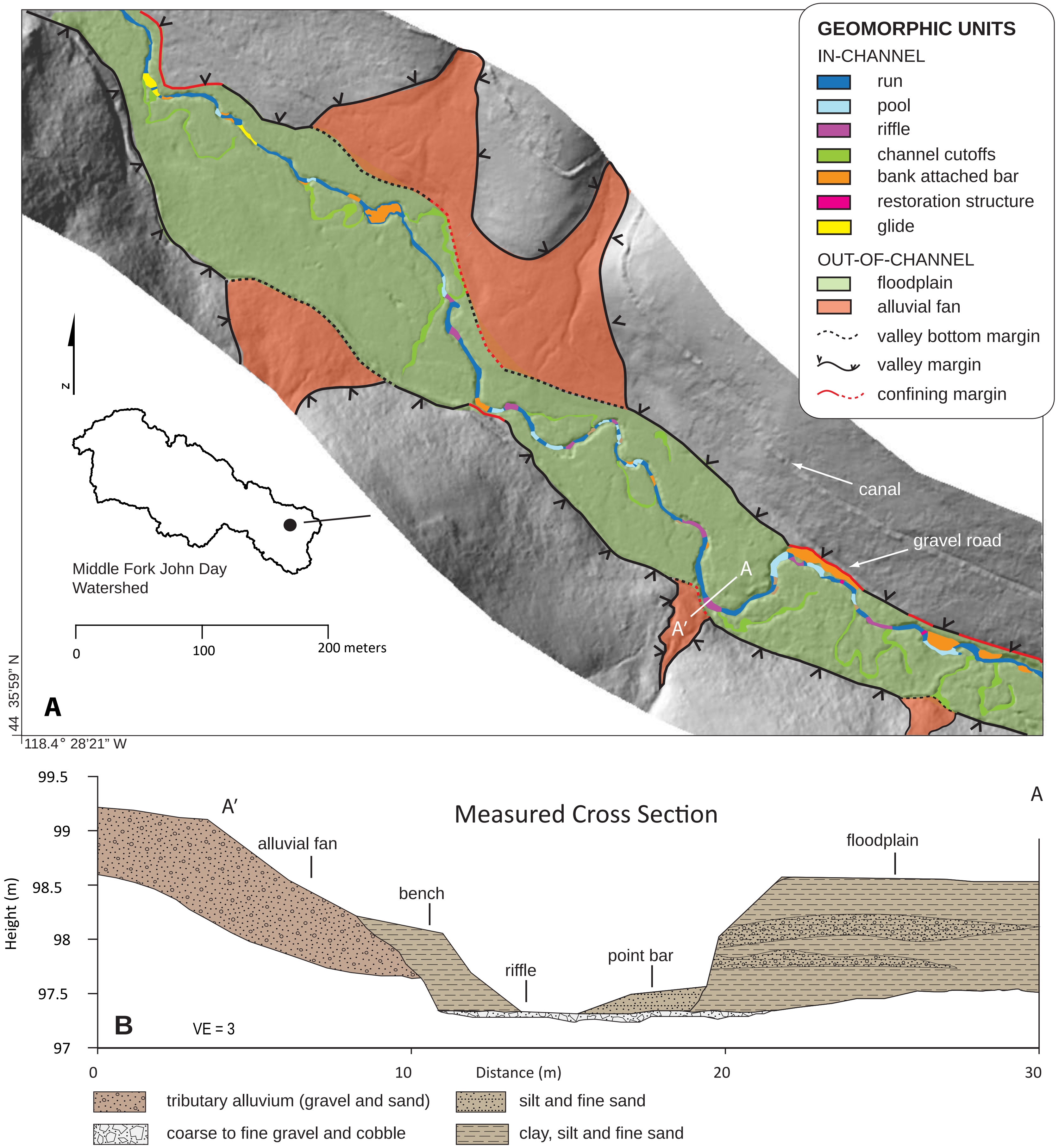


Figure 2. A representative sample of (A) geomorphic field mapping of valley setting and channel position on the valley bottom, combined with mapping of floodplain, valley margin, and in-channel geomorphic units. This is the meandering planform-controlled discontinuous floodplain reach type (River Style) which is found in a partly confined valley setting. An example of (B) measured channel cross section showing broad grain size classes and geomorphic units. This figure represents field mapping and ground validation of stream classifications that are initially identified through desktop work using remotely sensed methods.

Geomorphic field mapping and data collection consisted of visits to representative study sites for each of the reach types (River Styles) determined by our desktop watershed analysis. We validated reconnaissance maps prepared from aerial photographs and LiDAR coverage, surveyed channel cross sections (Figure 2B), mapped in-channel, floodplain and valley margin geomorphic units (Figure 2A), and collected a host of geomorphic information. Among these are valley setting (valley and channel confinement), channel planform and geometry, bed material texture (e.g., grain size data for bed and floodplain), and mapping of geomorphic/hydraulic units. We rendered fifteen site validation maps (for each river class) at a scale of 1:5,000 to 1:10,000 depending on detail required to depict detail of in-stream geomorphic units for each site.

Basin hydrology is a primary driver of river valleys and their channels. The magnitude and frequency of floods shapes channel morphology and the type and distribution of channel and floodplain geomorphic units. The largest flood on record for the Middle Fork John Day River was in May of 2011, with a peak flow of 5430 cfs. This peak flow exceeded the 100 year return period (Figure 3), but three other floods exceeding 4500 cfs, including notable 1965 and 1997 winter rain-on-snow events, have occurred during the period of record. Although flows of this magnitude are rare in the Middle Fork, 10-year floods of ~3000-4000 cfs are more common, and are important for creating and maintaining diverse channel morphology. Also important for maintaining and improving diverse floodplain geomorphic units and riparian habitat is the river's ability to reach and rework its floodplain.

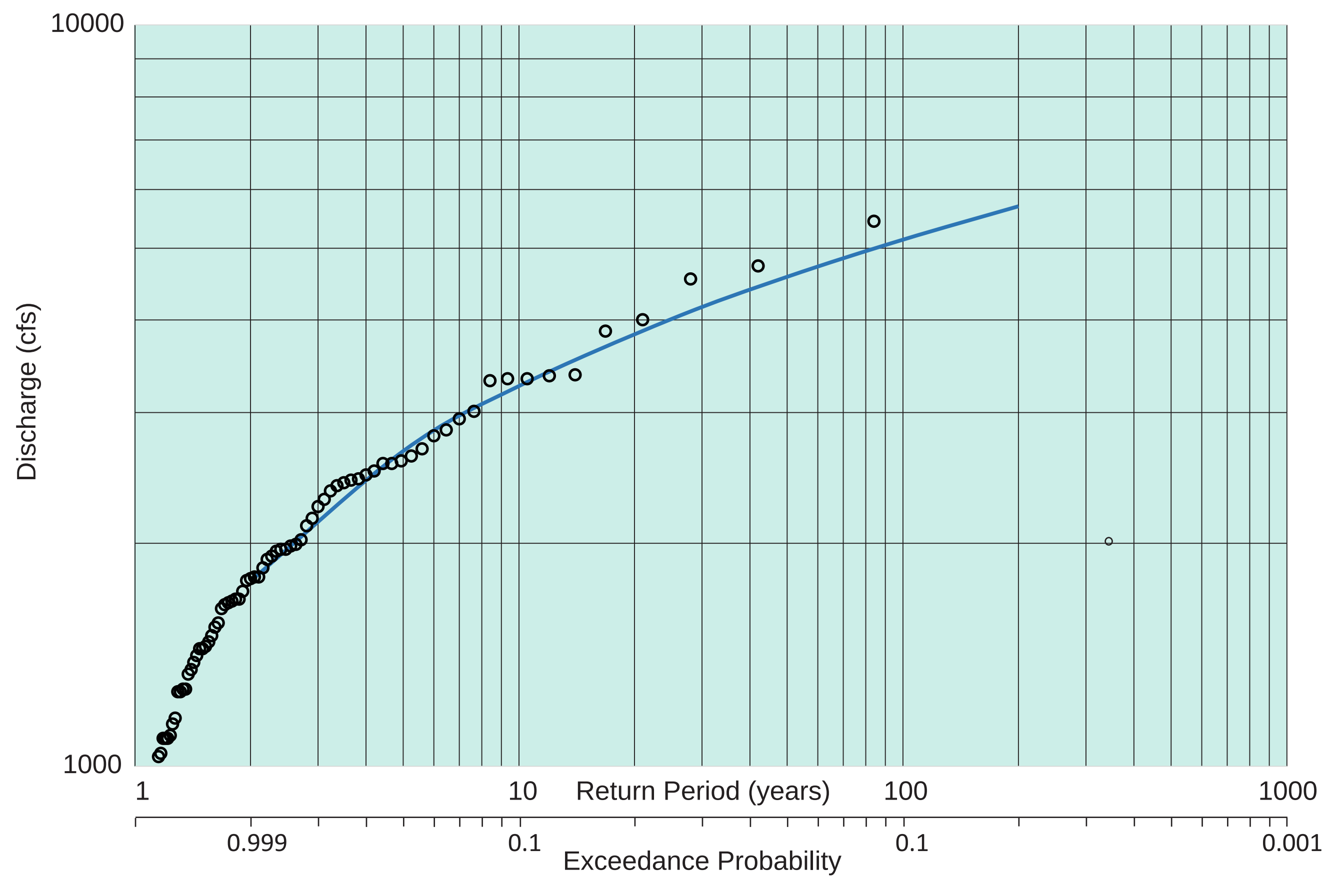
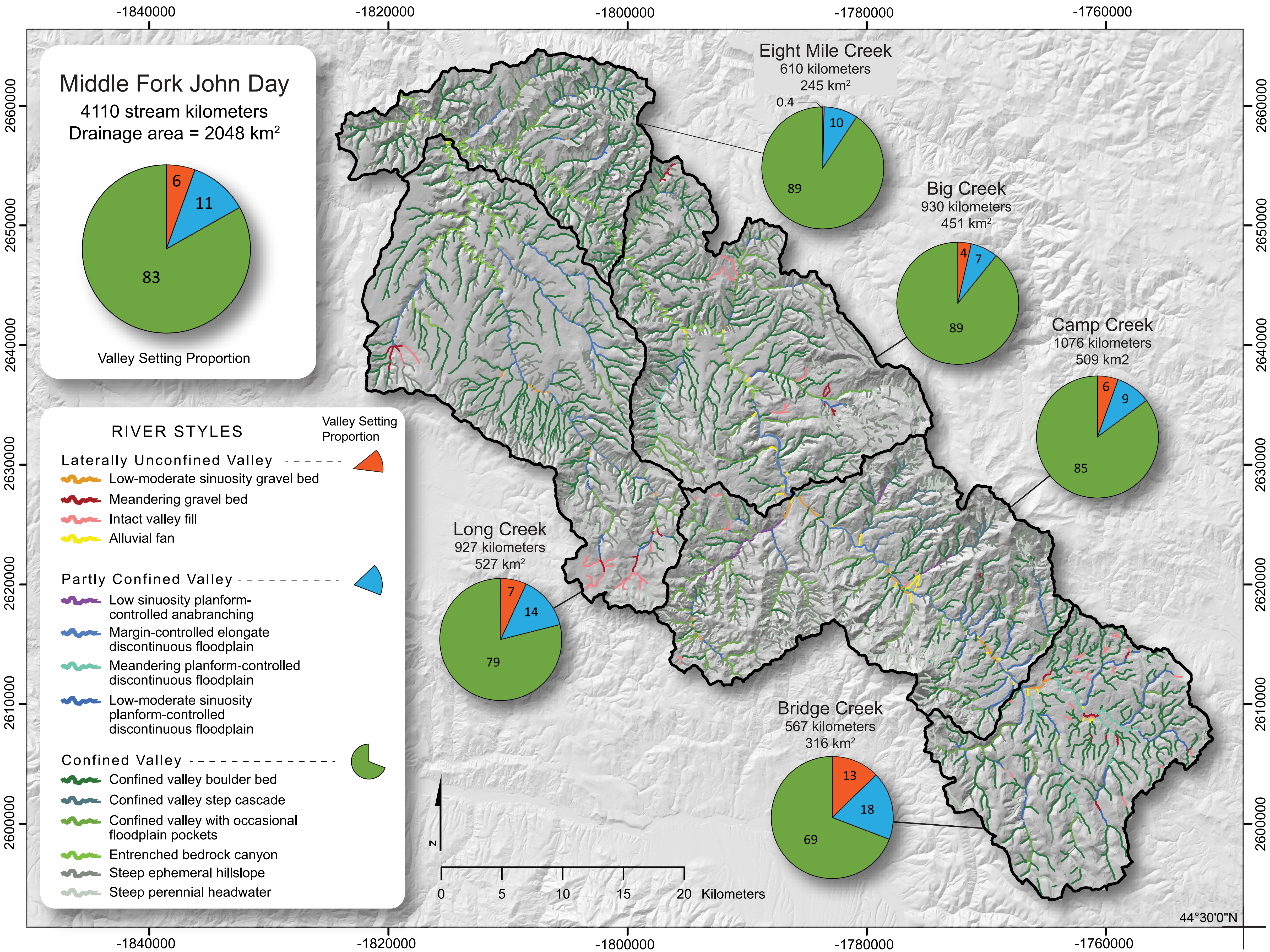


Figure 3. Log-Pearson III flood frequency analysis calculated for 2, 5, 10, 25, 50, 100, and 200 year return periods for peak discharge of the Middle Fork John Day River. Data (circles) are measured peak flows for 83-year period of record (1930-2014), and are plotted with a corresponding exceedance probability (blue line).

4 - STREAM CLASSIFICATION



Stream classification

This map displays the distribution of reach types (River Styles) throughout the ephemeral and perennial stream network. Reach types are delineated by valley setting, and channel and floodplain geomorphic attributes (see accompanying article and O'Brien and Wheaton (2015)), and represent substantial variations that govern controls on river character and behavior. Percent stream length is given in terms of valley setting (channel confinement) in pie charts.

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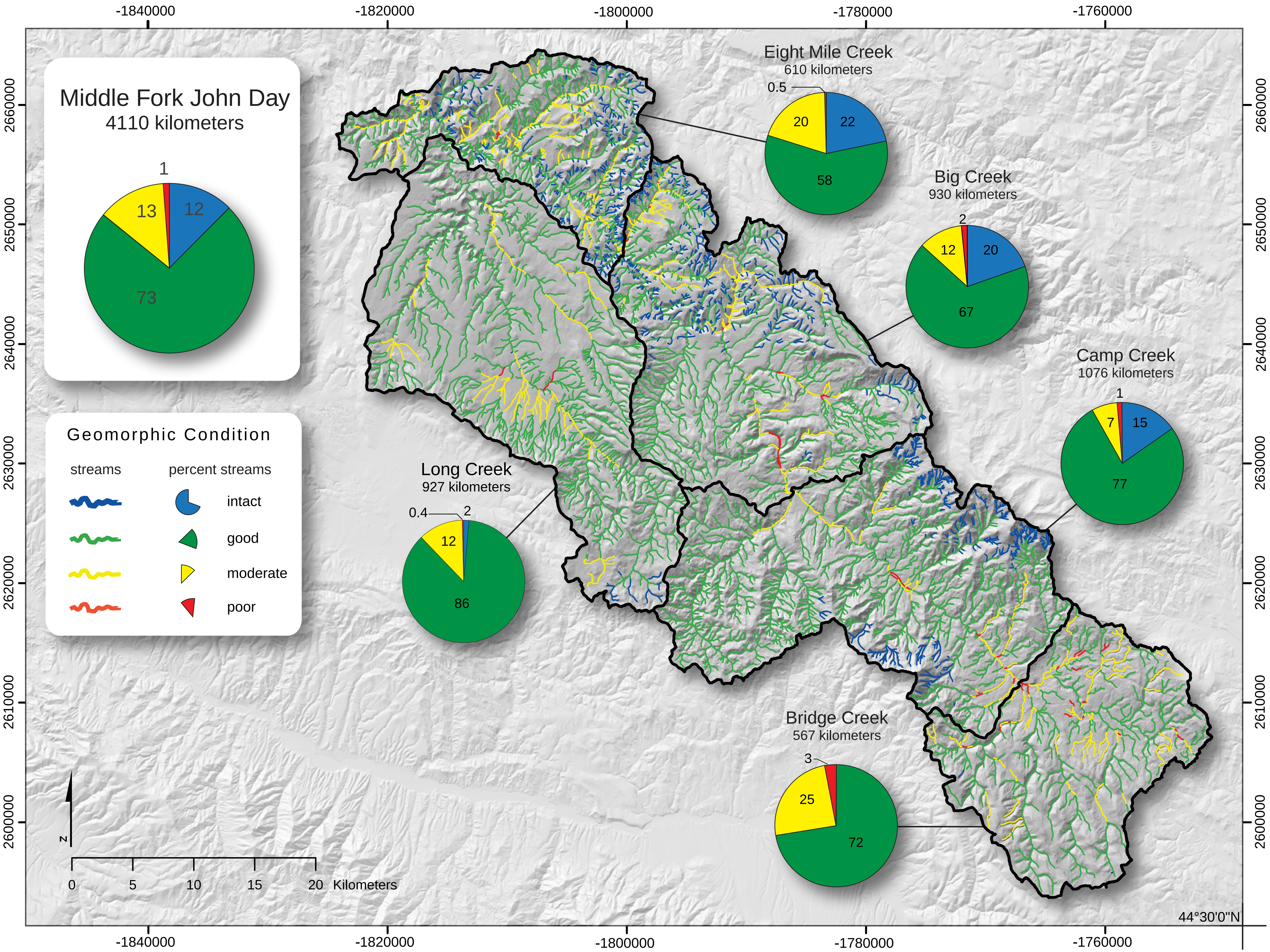
5 - GEOMORPHIC CONDITION



Geomorphic Condition

Assessment of geomorphic condition is based on analysis of river evolution, which is a measure of deviation from the “natural or expected state” of a given stream reach in a particular valley setting. A condition assessment records the effects of limiting factors and pressures imposed by human land use, and is the measure of a river’s capacity for adjustment (the potential to modify its channel position, instream geomorphic units, and floodplain). Separate reaches of the same river style may display physical differences that are understood by comparing each one to a “reference reach”, the most suitable (and often, the most pristine) example found in the watershed. Stream condition is a key ingredient for determining reach recovery potential (see Plate 6), and eventually, the formation of strategic management plans (Plate 7).

Plate 5 shows the distribution of intact, good, moderate and poor geomorphic condition for the entire stream network (perennial and ephemeral streams). Pie charts show the percentage of each class within the five HUC 10 subwatersheds.

Description of geomorphic condition variants

Intact condition: streams reflect near-pristine ecological and geomorphic state, with little or no history of anthropogenic impacts or recent geomorphic inbalance (e.g., disproportionate sediment flux, channel disruption by mass wasting, etc). These areas have healthy riparian, valley bottom and hillslope vegetation, abundant instream wood, secondary channels and wetlands.

Good condition: streams function normally with mild historic or current anthropogenic impacts, particularly to accessible floodplains. These areas have healthy to slightly degraded riparian, valley bottom and hillslope vegetation. Channel, floodplain, and instream geomorphic units adjust dynamically as expected.

Moderate condition: streams show significant impacts or modifications to floodplain, channel course, planform, riparian and instream vegetation, and instream geomorphic units. Wood loading is typically low or depleted.

Poor condition: streams have incurred irreversible geomorphic change, usually by heavy anthropogenic impacts. In the Middle Fork John Day Watershed (and most other watersheds of the Columbia Basin), these include channel bed dredge mining, road building, urbanization, intense farming and grazing, channel redirection and buttressing.

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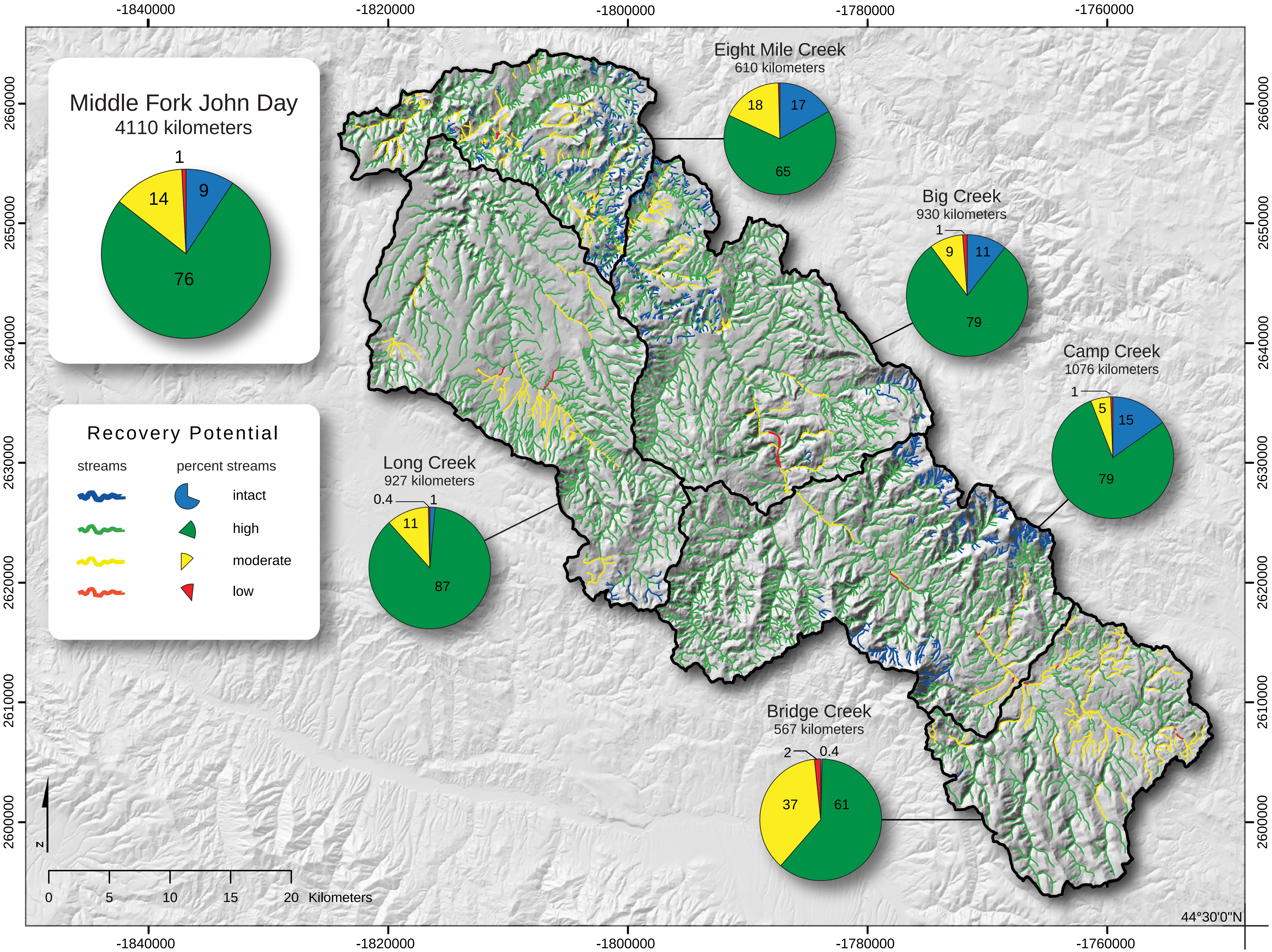
Data sources:
Digital vector stream network datasets derived from National Hydrography dataset (NHD). Rasters obtained from National Elevation Dataset (NED) (USGS, 2007). Maps 5 was modified from O’Brien & Wheaton (2015).

6 - RECOVERY POTENTIAL



Recovery Potential is defined in the River Styles framework as the *capacity for improvement of the geomorphic condition of a reach in the next 50-100 years.*

This is a process of predicting future change by leveraging results of the stream classification and geomorphic condition analyses (Plates 4 and 5). Recovery potential is assessed as whether a particular reach is Intact, requiring restoration to improve; in a degraded state, or possibly poised to become a "created" river style. Position and proximity to intrinsic pressures within the watershed are also considered (see accompanying article). The output from this effort is a watershed scale map that feeds directly to development of a strategic management plan (Plate 7).

Plate 6 shows the distribution of Intact, high, moderate and low recovery potential for the entire stream network (perennial and ephemeral streams). Pie charts show the percentage of each class within the five HUC 10 subwatersheds.

The apparent similarity between recovery potential (this map) and geomorphic condition (Plate 5) lay in the projection of future improvement, and the extent to which recovery or rehabilitation is possible. In the case of the Middle Fork John Day, a high percentage of intact and good condition reaches are already intact, or have the potential to improve. Most reaches in moderate condition are located in areas where current land use pressure is unlikely to ease, giving them less chance of improving (or degrading) over time. Most reaches in poor geomorphic condition will not recover of their own accord, although some have slightly better positioning and outlook for lifting of land uses that have been discontinued.

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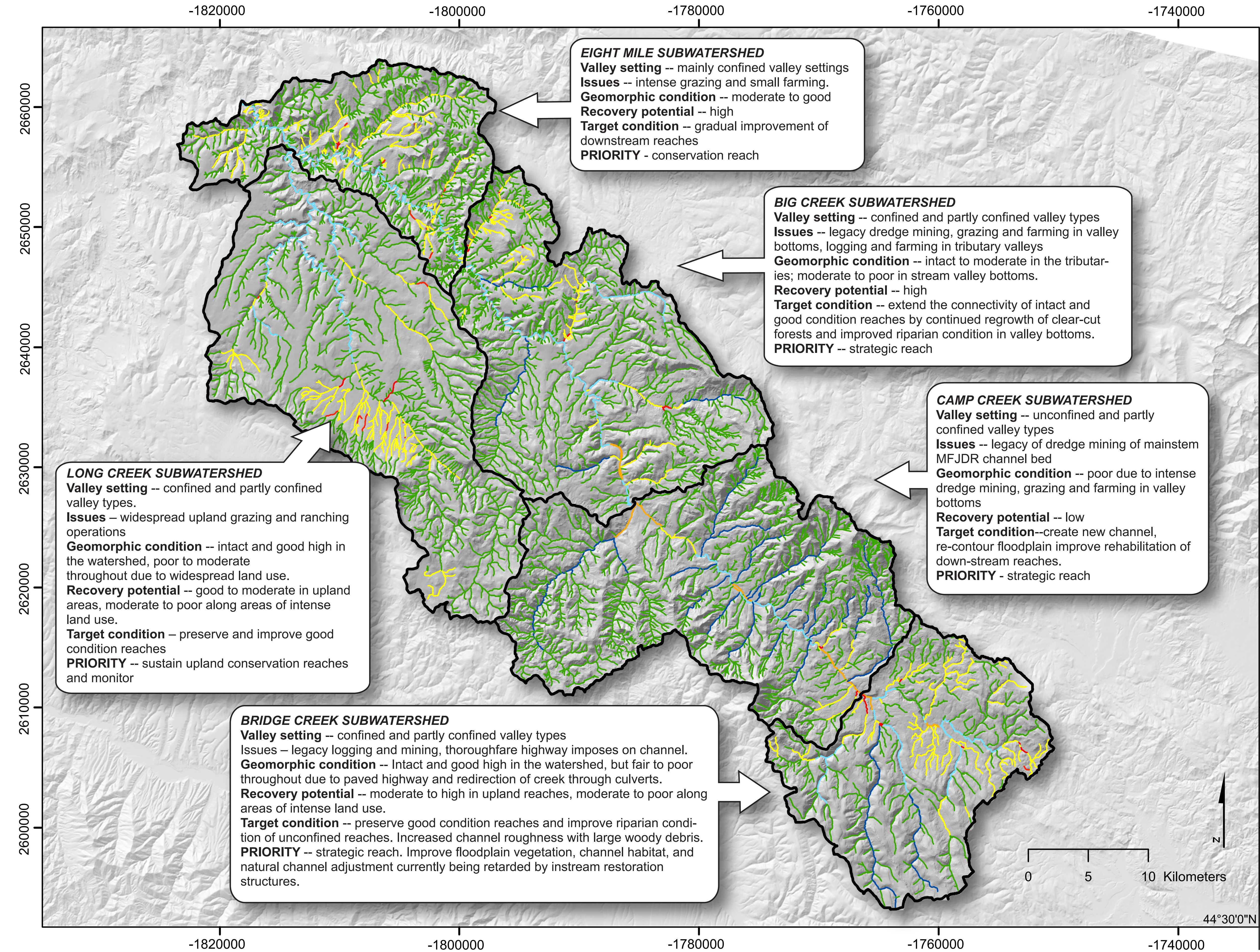
7 - PRIORITIZED MANAGEMENT REACHES



Prioritized management reaches

The stream classification, geomorphic condition and recovery potential assessments (Plates 4-6) form the backbone of the long-term strategic planning for the Middle Fork John Day Watershed. The prioritized management reaches shown here hinge on (a) maintaining the high quality habitat in existing good-condition reaches, (b) restoring connectivity of the mainstem from the lower to upper watershed, and c) increasing habitat quality through bolstering of diverse instream geomorphic units of the upper watershed.

Conservation reach: first priority. Conserve unique, rare, or remnant intact reaches. Preserve remaining habitat and refugia of intact and good-condition reaches.

Strategic reaches: high priority. Regardless of the geomorphic condition, mitigate problem areas that may propagate negative affects to down-stream and high quality reaches.

Connected reaches with high recovery potential: important priority. Maximize the positive effects of intact and good condition reaches—particularly those connected to conservation areas or high quality habitat.

Isolated reaches with high recovery potential: next priority. 'Rescue" or sustain pockets of high quality habitat that are isolated between low-quality or poor condition reaches.

Moderate or poor recovery potential: where resources allow, rehabilitate or redesign at lowest priority.

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