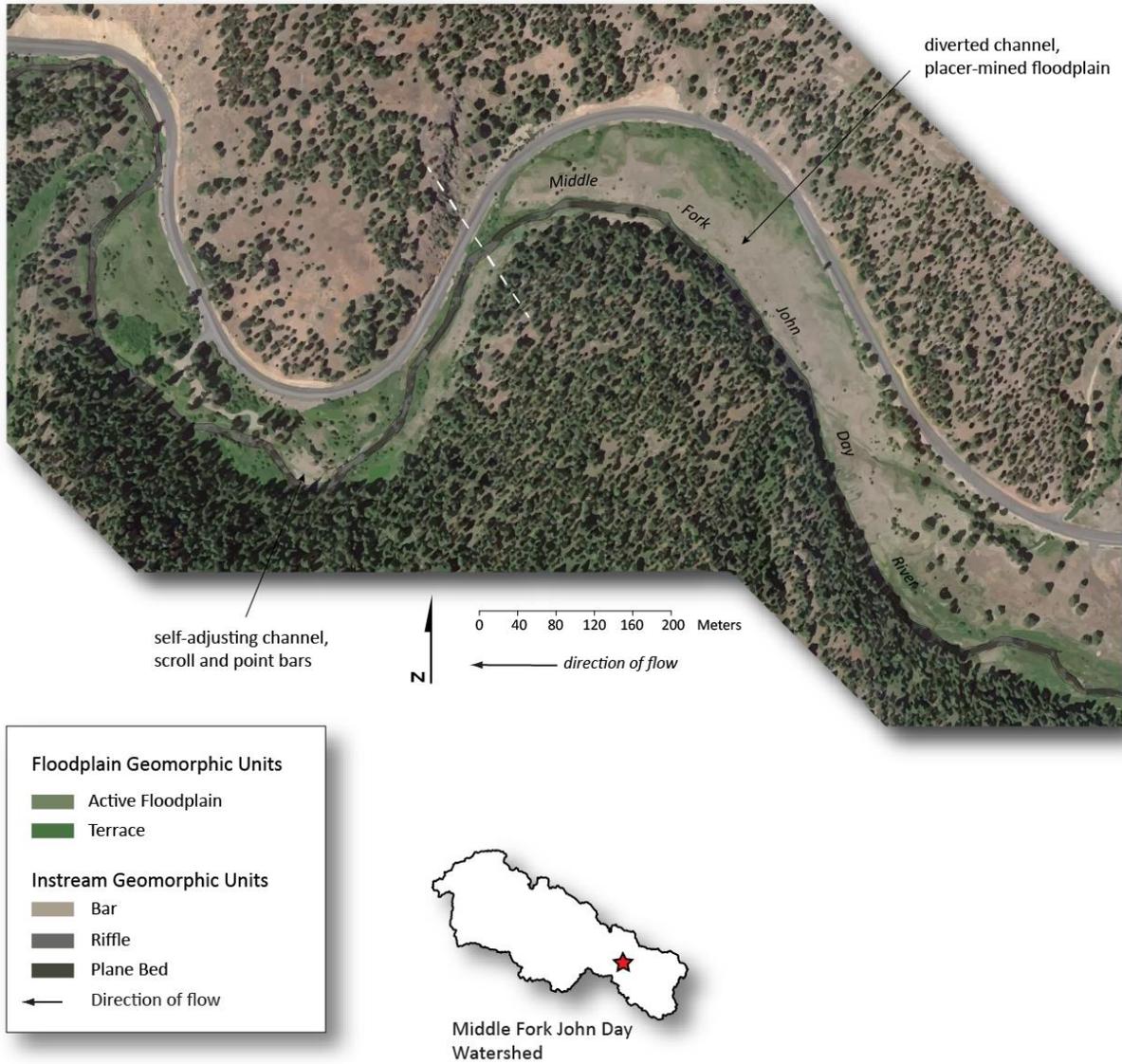


**BEDROCK CONTROLLED ELONGATE DISCONTINUOUS FLOODPLAIN RIVER STYLE**  
 -- Middle Fork John Day Watershed



**Figure A 6. Floodplain and instream geomorphic units associated with the Bedrock-controlled, elongate discontinuous floodplain river style. This figure represents the naturally adjusting variant within the partly confined valley setting.**

## A2.3 PROFORMA – MEANDERING PLANFORM-CONTROLLED DISCONTINUOUS FLOODPLAIN RIVER STYLE

The *Meandering planform-controlled discontinuous floodplain river style* occurs in partly confined valleys, where the channel is sometimes in contact with the valley walls, and at other times meanders freely across the valley floor. Flat-lying floodplain and terrace surfaces are found on the valley floor. The channel is a moderate-to-high sinuosity system with widely-ranging channel beds, from sand to cobbles. Where the channel has capacity to adjust it is actively meandering, and numerous bars (both mid-channel and bank-attached) are present. Pools flank the outside of channel bends, with steeper shallow riffles connecting slower, deeper pools. Floodplains and terraces are composed predominantly of finer material than is found on the streambed. Numerous fallen trees create heterogeneity in this stream type, and where suitable valley-floor vegetation is present, this river style is often marked by abandoned and active beaver dams.

This river style is common to the central and southeastern portions of the watershed, within the Rounded Uplands landscape unit underlain by myriad volcanic rock units. This river style flows within partly confined valleys possessing planform-controlled, discontinuous floodplains (Figure A 7). Channels have medium to high sinuosity and are actively meandering where there is capacity to adjust (where not confined by valley walls or in-channel deposits). Floodplains are vertically aggraded, fine grained and stable, with a uniform surface marked by paleochannels, meander cutoffs, ponds, and discontinuous terrace segments. At this proforma site, subsurface spring flow across the floodplain is significant. Pool-riffle sequences are the dominant geomorphic units, interspersed with runs and glides that are positioned between bends. Cutbanks occur at the base of riffles where they transition to pools along bends, and chute cutoffs are common at bends. Floodplain material is clay, silt and fine sand, whereas bed material is cobble, gravel and sand. Structural elements include channel-spanning and bank-attached woody debris but channel-spanning restoration structures designed to create local pools have been installed along the Middle Fork John Day at this river style's proforma site (Figure 5 and Figure 38). At base flow, the stream is contained within the steep-walled channel and flows innocuously through the pools, riffles and runs. At bankfull flows, significant channel adjustment may occur as cutbanks erode, point bars advance and meanders translate or widen position. At overbank stage floodplain scour and aggradation occurs.

### Subwatersheds in which this river style is Observed

*HUC 10:* Big and Bridge Creeks

*HUC 12:* Slide Creek, Mill Creek, Summit Creek, Squaw Creek, Dry Fork, and Clear Creek

### Details of Analysis

*Representative Reach:* MFJDR, near Bates, Oregon.

*Map Sheets and Air Photographs Used:* 2011 1 m NAIP imagery, photographs and notes from fluvial audit in summer of 2011

*Date of Proforma Draft:* 5 July 2013

*Date of Field Visit:* 13-22 July 2013

*Coordinates:* 383224.75 m E, 4939507.21 m N (UTM 11N NAD 1983)

### River Character

*Valley Setting:* partly confined

*Channel Planform:* meandering with moderate to high sinuosity and numerous meander cutoffs

*Bed Material Texture:* predominantly gravel, with some sand and cobbles

*Channel Geometry:* narrow single thread trapezoidal channel generally ~3 m wide. Cross section contains coarser (gravel/cobble) channel bed, with banks composed of finer (predominantly sand with gravel and mud) deposits

composing contemporary floodplain and terrace/valley fill surfaces found at higher elevations more distal from active channel.

#### Instream Geomorphic Units

*Bank-attached bars and mid-channel bars:* composed of well-sorted and rounded gravels, along with some cobbles deposited on the inside of meander bends and mid-channel around bends. May be sparsely vegetated indicating a degree of stability, but are mainly barren.

*Pool-riffle sequences:* channel consists of pools located on the outside of meander bends, with bank-attached bars (see above) on the inside of bends; straighter, steeper riffles (slightly coarser with small boulders occurring on active channel bed) connect these pools. Sand can generally be found accumulating in the deeper, slower pools. Undercut banks are common in these locations.

*Runs and glides:* meander loops exhibit plane bed sections that connect bends. These are low gradient, somewhat featureless sequences with uniform silt and sand or gravel/cobble substrates.

*Wood Jams:* these accumulations of wood often contain one 'key piece' sourced from the tall ponderosa pines lining the terraces, which fall and span the channel, thus trapping other woody debris as they move downstream. These accumulations of wood often create small pools upstream, with associated deposition of coarser bedload in these areas. Along the Middle Fork Proforma site, several enormous wood jams were large enough to locally decrease the upstream gradient, slowing current and trapping fines.

*Restoration Structures:* along several km of the proforma reach of this river style, large wood jams have forced pools and cross-channel logs have been installed to locally force pools, bars, and cutbanks. Natural wood plays a significant role in channel geomorphic unit assemblages.

#### Floodplain Geomorphic Units

*Contemporary Floodplain Deposits:* continuous deposits of mud and sand across the valley floor, vegetated by trees, small shrubs and grasses. Frequently dissected by paleo channels that do not contain active flow at lower discharges.

*Terraces:* flat-lying abandoned floodplain surfaces located > 1 m above active floodplain and below the steeply-sloped valley margin walls. Marked by smooth surfaces lacking channelization, these areas are colonized by large spruce and pine trees. Composed of similar mud/sand/gravel mixture as contemporary floodplain deposits.

*Alluvial Fans:* smooth-surfaced, fan-shaped landforms that drain small basins and interfinger with floodplain sediments of the trunk valley.

#### Vegetation Associations

*Instream:* largely unvegetated; fallen trees provide local roughness elements which obstruct flow and trap sediment. Grasses sparsely colonize some larger bars. Banks that have collapsed into the channel are densely vegetated by grasses.

*Floodplain:* active floodplain is generally marked by dense colonization by grasses. Terrace surfaces are subtle and rise ~1 m above the active floodplain. The floodplain and hillslopes are well connected; dense conifer forests line both valley walls, and once colonized the floodplain itself before logging operations ensued in recent decades.

#### River Behavior

*Low Flow Stage:* this river style is the result of localized valley widening, generally coupled with a low stream slope (and resultant low stream power) creating a dominantly gravel streambed. Much of the sediment found on the channel bed is sourced locally, the result of reworking floodplain deposits on the valley floor, and high connectivity with steep valley walls. At low flows, the channel is well contained in a single-thread flow path, and the banks are generally stable as they are composed of fine sand, silt and clay. However, some bank erosion and subsequent mass failure is possible even at low-flow stages, given the undercut nature of numerous banks – continuous bank shear by the flow, particularly at the outside of bends, may cause block failures of bank material. The assemblage of

geomorphic units includes pools, bars, runs and riffles; large woody debris, sourced from the tall pines and spruces on terrace surfaces frequently acts to create localized hydraulic heterogeneity, leading to fine-scale sediment deposition and scour.

*Bankfull Stage:* higher flows likely continue the scouring and undercutting of channel banks and cause local avulsions, given the lack of vegetation directly along the channel. The initiation of new bank undercutting may take place at this stage. The largely unvegetated channel bars have low cohesion and may be reworked at bankfull. Sand is likely mobilized from bank sources and deposited in pools or as a veneer on gravel bars.

*Overbank Stage:* at this stage, the high-flow channels crosscutting the active floodplain will be activated, as these areas are generally located ~1 m or less above the active channel, with recent abandoned channels resulting from oxbow cut-offs much closer in elevation to the low-flow channel. Fresh sediment will be deposited on the floodplain, and large-scale channel avulsions are likely, given the numerous abandoned channels visible on the active floodplain coupled with the lack of vegetation in these areas.

### Controls

*Upstream Drainage Area:* 36 km<sup>2</sup>

*Landscape Unit and Position in Watershed:* rounded hills or rounded uplands; generally found in low-slope reaches associated with local valley expansion, generally found in upper watershed

*Process Zone:* Sediment storage zone

*Valley Morphology:* consistently narrow flat valley floor (~50 m wall-to-wall) with highly-vegetated (pine, spruce) steeply-sloping valley walls.

*Valley Slope:* On average, 1%

**MEANDERING PLANFORM-CONTROLLED DISCONTINUOUS FLOODPLAIN  
-Middle Fork John Day River**

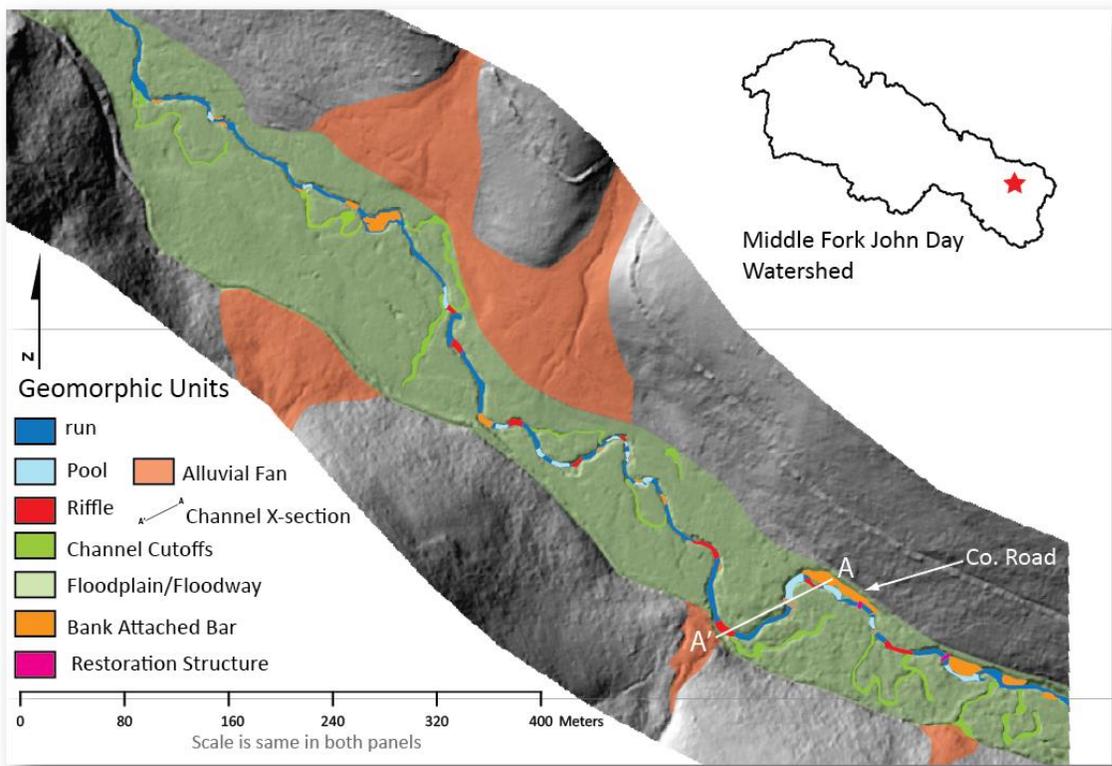
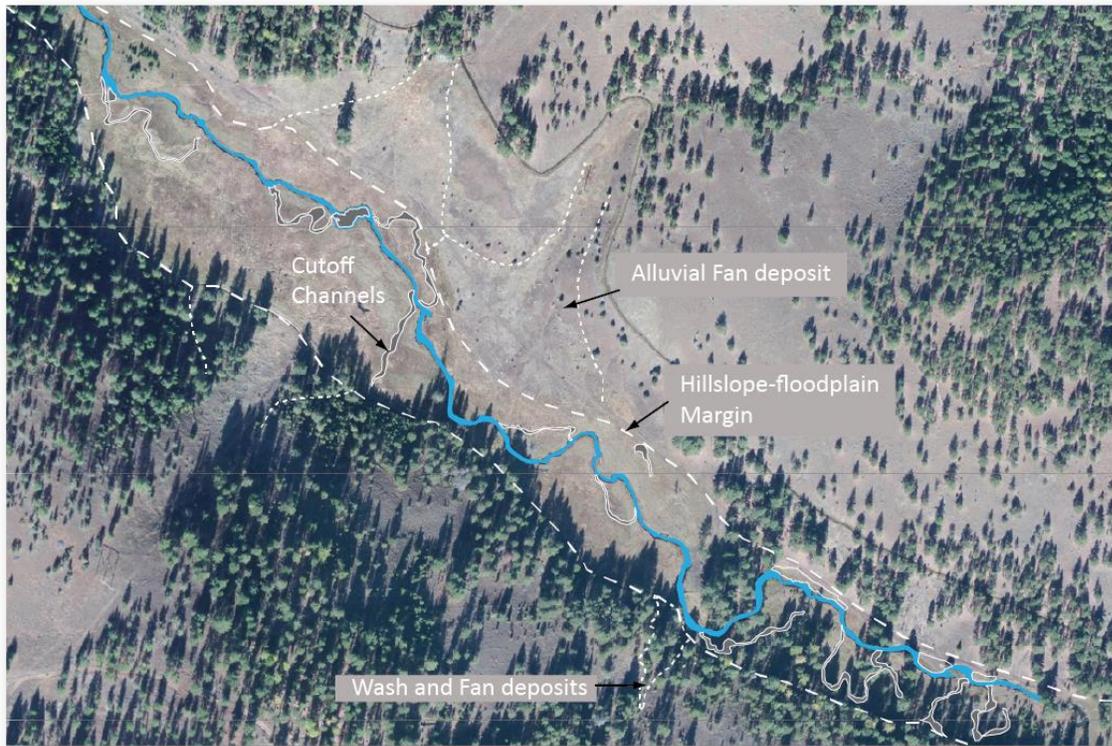


Figure A 7. Floodplain and instream geomorphic units associated with the Meandering planform-controlled discontinuous floodplain River Style.

The *Low sinuosity planform-controlled anabranching river style* describes steep-gradient streams of the central and upper catchment area. These reside in steep walled, partly confined valley settings with ample accommodation space for accumulation of coarse stream bed gravels. The channel planform has a low to moderate sinuosity, planform-controlled single thread, but in areas of local widening exhibits multi-channel anabranches. The substrate is essentially a gravel sheet. Floodplain geomorphic units are diverse, with paleochannels and paleocutbanks marking an undulating surface inset into fine-grained Holocene discontinuous terrace segments. The planform is strongly controlled by alluvial and debris fans along Camp Creek (Figure A 8 and Section B2.3) and in Granite Boulder Creek, the two tributaries of the MFJDR where this river style is observed. Instream geomorphic units are dominated by coarse planar features: riffles, rapids and runs; and by bank attached and mid-channel gravel bars. Wood jams are abundant in the channel, and promote structurally forced bars. The floodplain topography of Camp Creek has been influenced by abundant bouldery debris flows emanating from west-flowing tributaries, and by the presence of a small-gauge railway that allegedly ran up canyon in support of mining operations—piles of gravel and numerous dirt roads are clearly visible in air photos taken circa 1943—giving the floodplain a hummocky or undulating appearance.

### Subwatersheds in which this river style is Observed

*HUC 10:* Bridge and Camp Creeks

*HUC 12:* Granite Boulder, Big Boulder, Upper Camp, and Lower Camp Creeks

### Details of Analysis

*Representative Reach:* Lower Camp Creek

*Map Sheets and Air Photographs Used:* 2011 1 m NAIP imagery, photographs and notes from fieldwork in summer of 2013

*Date of Proforma Draft:* 5 July 2013

*Date of Field Visit:* 11-22 July 2013

*Coordinates:* 354958.37 m E, 4945844.88 m N (UTM 11N NAD 1983)

### River Character

*Valley Setting:* Partly Confined

*Channel Planform:* low to moderate sinuosity with first order anabranch channels

*Bed Material Texture:* coarse gravel, cobble and boulders

*Channel Geometry:* Narrow single thread trapezoidal channel generally ~3 m wide. Cross section contains coarser (gravel/cobble) channel bed, with banks composed of finer (predominantly sand with gravel and mud) deposits composing contemporary floodplain and terrace/valley fill surfaces found at higher elevations more distal from active channel.

### Instream Geomorphic Units

*Bank-attached bars and mid-channel bars:* composed of well sorted and rounded gravels, along with some cobbles deposited on the inside of meander bends and mid-channel around bends. May be sparsely vegetated indicating a degree of stability, but are mainly barren.

*Riffles, runs and steps:* channel consists coarse gravel plane bed features ranging from straighter, steeper riffles and short rapids, to actual boulder steps with associated pools (slightly coarser with small boulders occurring on active channel bed). Sand can generally be found accumulating in the deeper, slower pools.

*Wood Jams:* these accumulations of wood often contain one 'key piece' sourced from the tall ponderosa pines lining the terraces, which fall and span the channel, thus trapping other woody debris as it moves downstream.

These accumulations of wood often create small pools upstream, with associated deposition of coarser bedload in these areas. They are distinguished from beaver dams by the lack of characteristic cuttings and a higher degree of permeability by water and sediment.

*Anabranched channels:* the gravel sheet occupying the valley bottom is partitioned by first-order anabranched sequences (one and two split channels) connected by single thread sections.

*Structural elements:* large wood is a factor in maintaining heterogeneous channel morphology in these perennial streams. These tend to force bars, pools, and cutbanks.

### Floodplain Geomorphic Units

*Contemporary Floodplain Deposits:* continuous deposits of mud and sand across the valley floor, vegetated only by small shrubs and grasses. Frequently dissected by paleo channels, which do not contain active flow at lower discharges.

*Terraces:* flat-lying abandoned floodplain surfaces located >0.5 m above active floodplain and below the steeply sloped valley margin walls. Marked by smooth surfaces lacking channelization, these areas are colonized by large spruce and pine trees. Composed of similar mud/sand/gravel mixture as contemporary floodplain deposits.

### Vegetation Associations

*Instream:* largely unvegetated; fallen trees provide local roughness elements which obstruct flow and trap sediment. Grasses sparsely colonize some larger bars. Banks that have collapsed into the channel are densely vegetated by grasses.

*Floodplain:* active floodplain is generally marked by dense colonization by grasses. Large pines and spruces, and dense grasses distinguish terrace surfaces.

### River Behavior

*Low Flow Stage:* this river style is the result of localized valley widening, generally coupled with a low stream slope (and resultant low stream power) creating a dominantly gravel streambed. Much of the sediment found on the channel bed is sourced locally, the result of reworking floodplain deposits on the valley floor. At low flows, the channel is well contained in a single-thread flow path, and the banks are generally stable as they are often armored by cobbles sourced from the contemporary channel bed. The assemblage of geomorphic units includes pools, bars, and riffles; large woody debris, sourced from the tall pines and spruces on terrace surfaces frequently acts to create localized hydraulic heterogeneity, leading to fine-scale sediment deposition and scour.

*Bankfull Stage:* higher flows likely continue the scouring and undercutting of channel banks (and terrace risers) and cause local avulsions, given the lack of vegetation directly along the channel. The initiation of new bank undercutting may take place at this stage. The largely unvegetated channel bars have low cohesion and may be reworked at bankfull. At this stage, flow may exceed the capacity of the low flow channel and spill over to the additional anabranched channels. Gravel bars forms may be reworked at this stage.

*Overbank Stage:* at this stage, the high-flow channels crosscutting the active floodplain will be activated, as these areas are generally located ~1 m or less above the active channel, with recent abandoned channels resulting from channel cut-offs much closer in elevation to the low-flow channel. Fresh sediment will be deposited on the floodplain, and large-scale channel avulsions are likely, given the numerous abandoned channels visible on the active floodplain coupled with the lack of vegetation in these areas.

### Controls

*Upstream Drainage Area:* 36 km<sup>2</sup>

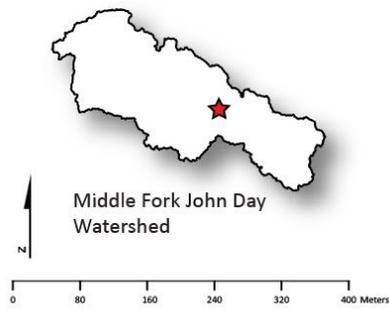
*Landscape Unit and Position in Watershed:* Rounded Hills or Rounded Uplands landscape units; generally found in low-slope reaches associated with local valley expansion, generally found in upper watershed

*Process Zone:* Sediment storage zone

*Valley Morphology:* Consistently narrow flat valley floor (~50 m wall-to-wall) with highly vegetated (pine, spruce) steeply sloping valley walls.

*Valley Slope:* On average, 1%

*LOW SINUOSITY PLANFORM-CONTROLLED ANABRANCHING RIVER STYLE-- Middle Fork John Day Watershed*



**Figure A 8. Geomorphic units associated with the Low sinuosity planform-controlled anabranching River Style.**

### A3.1 ENTRENCHED BEDROCK CANYON RIVER STYLE

The *Entrenched bedrock canyon river style* occurs in confined valleys, where the channel is frequently in direct contact with the steeply sided valley walls. The valley floor is quite narrow, and contains a thin-yet-continuous floodplain surface and more elevated rare terrace surfaces (Figure A 9). The channel is a low sinuosity single thread system, with a course constrained entirely by the valley walls. The channel bed is coarse, consisting primarily of cobbles with some boulders and gravel. In terms of geomorphic units, the channel consist almost entirely of steep water riffles interspersed with slower runs. There is virtually no heterogeneity contributed by roughness elements such as instream vegetation or large woody debris.

In the northwest region of the watershed, the semi-arid Dissected Tablelands landscape unit is underlain by a thick succession of Columbia River Basalt (Figure 21). Through a combination of regional uplift and incision, the northwest-flowing MFJDR and its largest tributary, Long Creek, incised the bedrock landscape as antecedent streams. Thus these streams inherited a relict, large-amplitude, superimposed sinuosity. This river style flows through steep-walled, confined bedrock valleys. Little accommodation space exists in the valley bottoms, yet the channel is hemmed by recurring elongate narrow floodplains. These continuous floodplains are underlain by silt and fine sand, and inset by terraces at channel bends (Section B1.1). The planform is single thread, bedrock-controlled, straight to slightly sinuous within a superimposed meandering outline. The Instream geomorphic units of this river style reflect the greatest channel width and discharge characteristics of the MFJDW. They are dominated by plane bed morphology—riffles, runs and glides punctuated by scattered boulders. Pools are present as well, but are subtle. Instream and bank-attached bars include point bars, streamlined mid-channel bars resembling islands, and longitudinal bars. Structural elements include bank-accumulated woody debris. Bed material is dominated by cobbles with occasional boulders. The MFJDR is a moderate to poor condition variant of this river style because of the presence of the two-lane highway built through the canyon. Thus, the northeast bank has been modified by bank-reinforcing structural elements (mostly large boulders).

#### Subwatersheds in which this river style is observed

*HUC 10:* Big, Eight-Mile, and Long Creeks

*HUC 12:* Bear, Indian, Slide, Granite, Rush, Six Mile, Three Mile, Lower and Middle Long, Basin, Pass, and Pine Creeks.

#### Details of Analysis

*Representative Reach:* MFJDR along County Road 20

*Map Sheets and Air Photographs Used:* 2011 1 m NAIP imagery, aerial photographs from EcoFlight overflights, Google Terrain (USGS 7.5' Quadrangle derived), Google Street View

*Date of Proforma Draft:* 5 July 2013

*Date of Field Visit:* 13-22 July 2013

*Coordinates:* 342482.56 m E, 4963987.28 m N (UTM 11N NAD 1983)

#### River Character

*Valley Setting:* confined

*Channel Planform:* superimposed meandering valley with low sinuosity channel in frequent contact with valley walls.

*Bed Material Texture:* predominantly cobbles with boulders and gravel

*Channel Geometry:* single thread trapezoidal channel generally ~12 m wide. Cross section contains coarser (cobble/boulder/gravel) channel bed, with floodplain and terraces composed mainly of gravels.

### Instream Geomorphic Units

*Riffles:* steep, homogenous sections of channel with a coarse cobble bed including lesser amounts of boulders and gravels.

*Runs:* slightly lower gradient sections of smooth water that contain a finer bed, though it is still predominantly cobbles with boulders and gravel.

*Bars:* composed of the same size fraction as found on the channel bed, these deposits are often found on the inside of meander bends. They are vegetated by grasses in most cases, which have likely grown since the previous year's high flows. There is a lack of larger shrubs or trees on these surfaces.

*Structural elements:* large wood is a factor in maintaining heterogeneous channel morphology in these streams. These tend to force bars, pools, and cutbanks, but are mainly bank-attached features.

### Floodplain Geomorphic Units

*Contemporary Floodplain Deposits:* thin yet continuous veneer of finer gravels deposited by high flows, found <1 m above low-flow channel surface, often narrow width due to steeply sloping valley walls.

*Terraces:* flat-lying abandoned floodplain surfaces located > 1 m above active floodplain and below the steeply sloped valley margin walls. Composed of similar gravels as contemporary floodplain deposits.

### Vegetation Associations

*Instream:* unvegetated, apart from cobble bars that are marked by grasses.

*Floodplain:* active floodplain is generally marked by dense colonization by grasses and willows, while large pines and spruces distinguish terrace surfaces.

### River Behavior

*Low Flow Stage:* this river style results from a steep-sided confined valley that produces imposed-form morphology. The valley sides contribute coarse material in addition to sediment delivered from upstream, causing steep slopes and a riffle-dominated morphology. At low flows, the channel is well contained in a single-thread flow path, and the banks are generally stable as they are often armored by cobbles sourced from the contemporary channel bed. The combination of this armored surface and frequent contact with bedrock mean that little to no bank erosion can occur at low flows.

*Bankfull Stage and Overbank Stage:* given the steeply sided nature of the valley and high degree of confinement seen in this river style, it is impossible for the channel to ever overtop its banks. At extremely high flows, blocks of bedrock or talus may be plucked from the channel banks, and scour of localized floodplain or terrace deposits may be possible, but true avulsion or bank incision is quite limited by the resistant basalt composing the canyon walls. In essence, the channel may only downcut; this is possible but difficult given the coarse channel bed, and thus likely occurs only during extreme events.

### Controls

*Upstream Drainage Area:* 1194 km<sup>2</sup>

*Landscape Unit and Position in Watershed:* Dissected Tablelands, found in lower watershed

*Process Zone:* sediment transport zone (net equilibrium)

*Valley Morphology:* consistently narrow flat valley floor (~50 m wall-to-wall) with sparsely vegetated (sage, juniper) steeply sloping valley walls.

*Valley Slope:* on average, 3%

**ENTRENCHED BEDROCK CANYON RIVER STYLE**  
 -- Middle Fork John Day Watershed

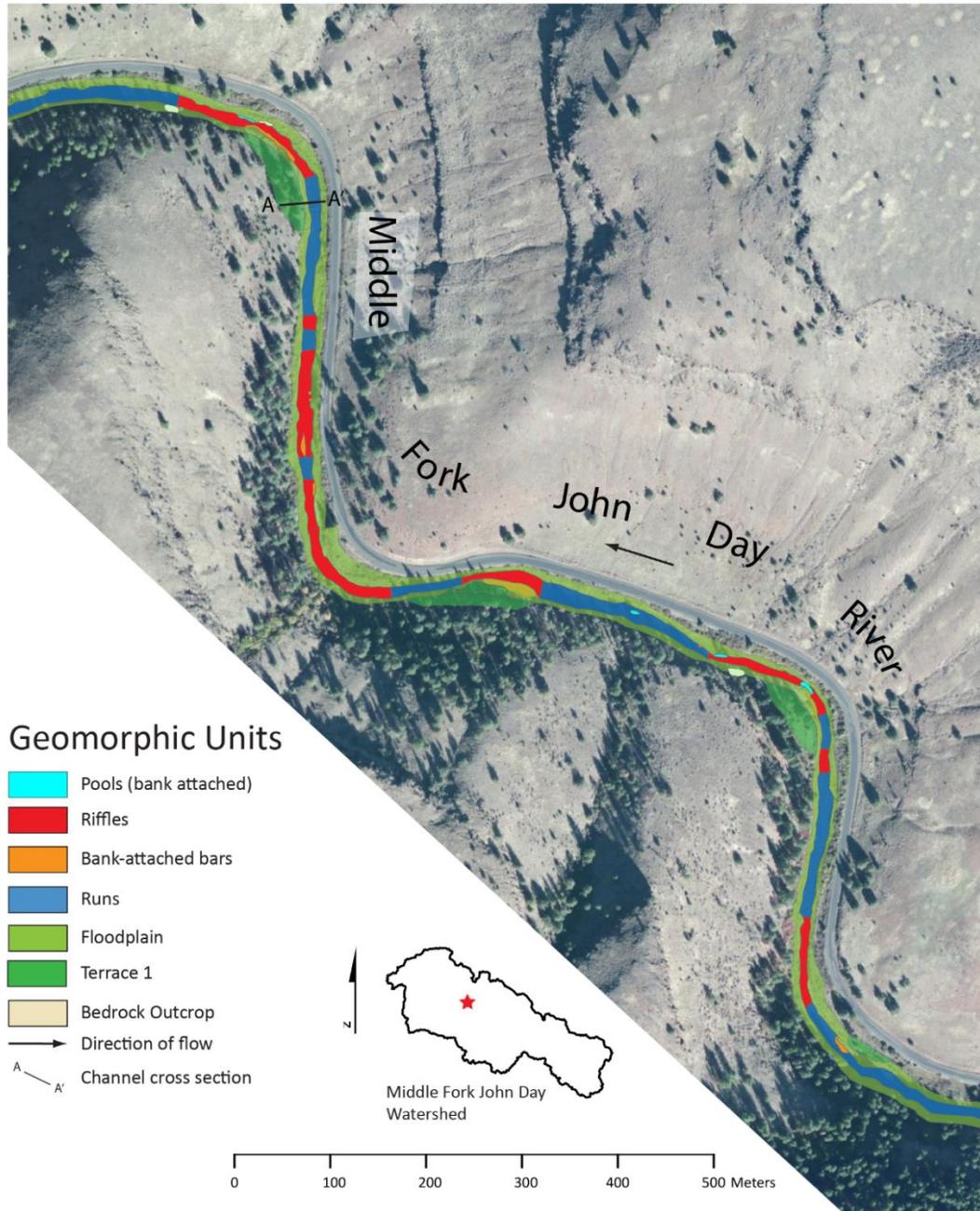


Figure A 9. Geomorphic units associated with the Entrenched bedrock canyon river style.

## A3.2 PROFORMA – CONFINED VALLEY WITH OCCASIONAL FLOODPLAIN POCKETS RIVER STYLE

The *Confined Valley with Occasional Floodplain Pockets river style* occupies narrow tributary valleys with channels that are tightly constrained by steep hillslopes and locally, bedrock cliffs. Occasional, narrow and elongate floodplains are underlain by fine sediments. Occasional terraces bound floodplain segments. This river style is commonly found in steep-walled valleys of forested, dissected uplands, and exhibits a low sinuosity, single-thread, bedrock-controlled planform (Figure A 10 and Section B1.2). These channels receive a regular supply of sediment and wood directly from the valley sides, meaning they are generally coarse (cobble/boulder) bedded systems where the array of geomorphic units includes high-gradient riffles and runs broken by less common forced glides and occasional pools. Typically, locally-sourced large woody debris from the valley sides is responsible for forcing pools and creating flow heterogeneity. Instream geomorphic units include riffles, runs, rapids, and occasional step-pool sequences. Structural elements include instream wood. Bed material is dominantly boulders, cobbles and coarse gravel. At base flow the river is contained within the immediate channel, but is capable of reworking in-channel bars and eroding relatively stable, steep-walled banks. Overbank flows tend to rework woody debris and in-channel geomorphic units, and to vertically aggrade the fine grained floodplain.

### Subwatersheds in which this river style is Observed:

*HUC 10:* Big, Bridge, Camp, Eight-Mile, and Long Creeks (see Figure 39 Figure 40).

### Details of Analysis

*Representative Reach:* Bridge Creek (MFJDR) along U.S.26

*Map Sheets and Air Photographs Used:* 2011 1 m NAIP imagery, Google Terrain (7.5' USGS quadrangle-derived), aerial photographs from EcoFlight overflights, Google Street View

*Date of Proforma Draft:* 16 July 2012

*Date of Field Visit:* 19-28 July 2012

*Coordinates:* US: 377823 E, 4933200 N; DS: 378453 E, 4933810 N (UTM 11 N NAD 1983)

### River Character

*Valley Setting:* confined

*Channel Planform:* low sinuosity with infrequent broken/occasional floodplain pockets

*Bed Material Texture:* coarse; predominantly cobbles with boulders and gravel

*Channel Geometry:* narrow single thread trapezoidal channel generally 2-3 m wide. Cross section contains coarser (cobble/boulder) channel bed with poorly developed floodplain surfaces containing finer gravels and some sand. Terraces and other alluvial features (bars, cut banks) are rare.

### Instream Geomorphic Units

*Riffle/Run/Pool Sequences:* the channel is low sinuosity and largely homogeneous, predominantly containing coarse-bedded (cobble/boulder/gravel) riffles, which are mixed with lower-slope runs created by slight local valley widening or a local input of sediment. Plunge and scour pools are created primarily by large woody debris jams.

*Bedrock Outcrops:* this river style is often found flowing through resistant basalt, and interspersed bedrock outcrops create zones of localized convergent flow and form flatwater sections upstream and plunge pools downstream, both of which serve as local sinks for sediment.

*Active Floodplain Pockets:* found in areas where temporary valley widening permits the deposition of sediment, as well as in eddies behind bedrock outcrops or upstream of valley constrictions where water pools during high flows. Composed of finer gravels and some mud/sand, typically vegetated by small shrubs and grasses. Terraces are not

observed, likely due to the inability of the channel to downcut through resistant lithology and subsequently abandon its floodplain.

*Valley Floor Deposits:* these channels are steep systems that carry little fine sediment and drain steep, resistant terrain. As such, they are largely imposed-form systems that flow over terrain created by bedrock geology and hillslope processes and lack continuous alluvial floodplain deposits or self-formed terrace surfaces. Valley floors are strewn with cobbles and boulders delivered from upslope and/or deposited during extreme high flow events.

*Structural elements:* large wood is a factor in maintaining heterogeneous channel morphology in these perennial streams. When they do flow, discharge and stream power are high, and large wood jams are observed within the channel. These tend to force bars, pools, and cutbanks.

#### Vegetation Associations

*Instream:* largely unvegetated; fallen trees provide local roughness elements which obstruct flow, trap sediment, and create scour/plunge pools.

*Valley Floor/Walls:* grasses, shrubs, and occasional seedlings of larger trees frequently colonize floodplain surfaces. Valley walls are colonized primarily by spruce.

#### River Behavior

*Low Flow Stage:* This river style is the result of a tightly confined valley which contains some areas of local widening, permitting the development of occasional floodplain pockets. It is these pockets, which distinguish this river style from a step/cascade system, even though both styles are steep, coarse systems found in narrow valleys. Sediment enters these streams both from upstream sources and from hillslope processes that deliver coarse talus to the stream from steep, resistant valley walls. This continuous delivery of coarse sediment to the channel requires a high stream slope for transport and reduces the fine sediment load being carried by the stream. At low flows, the channel is confined to a single-thread path and all but the finest end-members of the bed (i.e. sand and fine gravel) will be stable. The banks will also exhibit a high degree of stability, given the mature trees that are established on the steep valley sides, which often extend right to the edge of the channel. Outcrops of bedrock offer an additional degree of erosion resistance. The assemblage of geomorphic units is not well varied, primarily consisting of steeper riffles interspersed by flatter runs, which may be forced by bedrock outcrops, large woody debris, or a locally coarser sediment source which backs up flow. Scour and plunge pools are forced primarily by large woody debris, although they may arise less frequently because of bedrock outcrops and/or talus piles.

*Bankfull Stage:* Flows reaching this stage may inundate the backwater areas created by large woody debris jams and bedrock outcrops; these slow water areas are often the result of local valley widening, and this is where pockets of floodplain occur, as the diminished transport capacity in these areas allows for the deposition of fresh sand and gravel and the building of new floodplains, particularly as high flows recede. These higher flows may scour channel banks, although these areas are resistant due to their coarse composition and high degree of mature vegetation. The high slope of the streams may lead to mobilization of coarser cobbles at this stage, while more stable boulders and large woody debris may trap finer gravels and the limited sand that is carried by these streams.

*Overbank Stage:* At this stage, the narrow valley floor may be inundated and some degree of bank scour may occur, although these channels lack evidence of recent avulsions or migration, implying that these are stable systems. Flow spilling up onto the valley bottom would encounter a significant amount of resistance due to trees (both living and fallen), along with coarse talus material delivered from upslope. As such, even very high flows likely have a limited geomorphic effectiveness, evidenced by the lack of paleo-channels and/or avulsions in this river style. The establishment of arid upland riparian vegetation and soil development implies that overbank stages are rarely reached but for a very limited amount of time (i.e. hours). Overbank flows may scour floodplain pocket deposits and rework these distributing this fine material downstream in new areas of local valley widening, particularly as high flows recede and transport capacity is diminished.

## Controls

*Upstream Drainage Area:* 37 km<sup>2</sup>

*Landscape Unit and Position in Watershed:* steep, confined valleys which connect uplands to alluvial streams in mainstem laterally unconfined valleys; typically found in middle watershed draining rounded hills.

*Process Zone:* isolated floodplain pockets of sediment accumulation, overall sediment transport zone (net equilibrium, mobilizing sediment received from upstream and valley sides)

*Valley Morphology:* very narrow valley bottom (~5 m) which shows local constriction and widening depending on position of bedrock outcrops and mass movement of talus. Nearly all of valley bottom is part of the low-flow channel; otherwise, a V-shaped valley with steeply sloping walls.

*Valley Slope:* On average, 5%

*CONFINED VALLEY WITH OCCASIONAL FLOODPLAIN POCKETS RIVER STYLE*  
*--Middle Fork John Day Watershed*

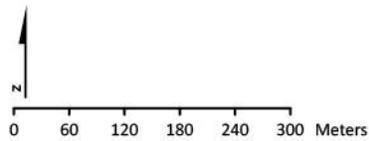
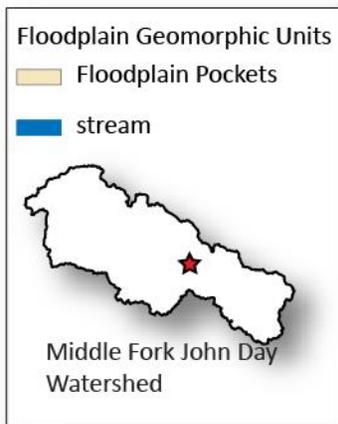


Figure A 10. Geomorphic units associated with the Confined valley with occasional floodplain pockets River Style.

### A3.3 PROFORMA – CONFINED VALLEY STEP-CASCADE RIVER STYLE

The *Confined valley Step-cascade river style* is set within a confined valley and occupies steep, southwest-draining tributary streams associated with dissected uplands and resistant metasedimentary rocks. The planform is straight to slightly sinuous and single thread with occasional secondary channels forced by debris flows and local channel widening (Figure A 11 and Section B1.3). Instream geomorphic units include down-channel oriented boulder berms, step-cascade sequences, pools, rapids, and occasional runs. Bed material is coarse, dominated by boulders, cobbles, and coarse gravel with alternating sections of exposed bedrock scoured by high flows. Base flow is contained within the channel and may locally rework gravels, but has little effect on the configuration of geomorphic units. Bankfull or overbank deposits have the energy to erode and incorporate coarse hillslope material, and rework instream geomorphic units. Large recruitment of wood from hillslopes choke the channel and effectively force changes to bar morphology during high flows.

#### Subwatersheds where this river style is observed

*HUC 10: Camp Creek*

*HUC 12: Big Boulder, Granite Boulder, and Vinegar Creeks*

#### Details of Analysis

*Representative Reach:* upper Granite Boulder Creek.

*Map Sheets and Air Photographs Used:* 2011 NAIP 1 m color aerial photos, Google Terrain Map (USGS 7.5' Quadrangle Derived), 1-m Lidar DEM

*Date of Proforma Draft:* 10 July 2013

*Date of Field Visit:* 15-22 July 2013

*Coordinates:* 373004.26 m E, 4943079.88 m N (UTM 11N NAD 1983)

#### River Character

*Valley Setting:* confined

*Channel Planform:* straight, valley aligned

*Bed Material Texture:* coarse gravel, cobbles and boulders

*Channel Geometry:* single thread channel ~5-8 m wide, with occasional secondary channels. Symmetrical cross section is defined by bedrock channel connected directly to hillslopes.

#### Instream Geomorphic Units

*Steps and pools:* sequences of steps formed by transverse arrangements of boulders, and pools backed up behind them.

*Cascades and rapids:* planar features with high channel roughness comprising boulders and coarse gravel along the straight channel.

*Runs:* these planar features form with stable cobble or gravel substrates, in extended stretches, often terminated by rapids or other bar- or bedrock-controlled changes in gradient.

*Mid-channel bars:* defined by occasional secondary channels within the bedrock walls.

*Structural elements:* large wood jams are a factor in maintaining heterogeneous channel morphology in these perennial streams. Discharge and stream power are high, and LWD is observed within the channel. These tend to force bars, pools, and in places, cutbanks.

#### Hillslope-channel associations

Colluvial slopes dominated by slope wash sediments and coarse gravels that feed the channel.

### Vegetation Associations

*Instream:* unvegetated aside from sparse colonization of several point bars by willow.

*Hillslopes:* generally covered in grasses, shrubs, and some riparian vegetation.

### River Behavior

*Low Flow Stage:* flow is focused in the channel bottom, filling intervening pools and dropping over ledges. Stream bed has high roughness. Stream flows around and amongst boulders.

*Bankfull Stage:* high in the watershed, a bankfull stage capable of covering the channel boulders is uncommon, but would form turbulent rapids and cascades.

*Overbank Stage:* there is no actual "overbank" flow because the banks are essentially the adjoining hillslopes.

### Controls

*Upstream Drainage Area:* 564 km<sup>2</sup>

*Landscape Unit and Position in Watershed:* upper to middle positions of tributary watersheds

*Process Zone:* Sediment production and transport zone

*Valley Morphology:* Confined valley setting, lacking floodplain pockets

*Valley Slope:* On average, 0.6%

CONFINED VALLEY STEP-CASCADE RIVER STYLE - Middle Fork John Day Watershed

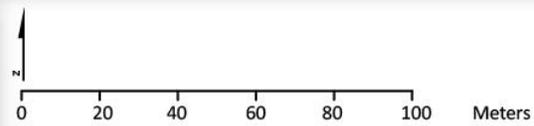
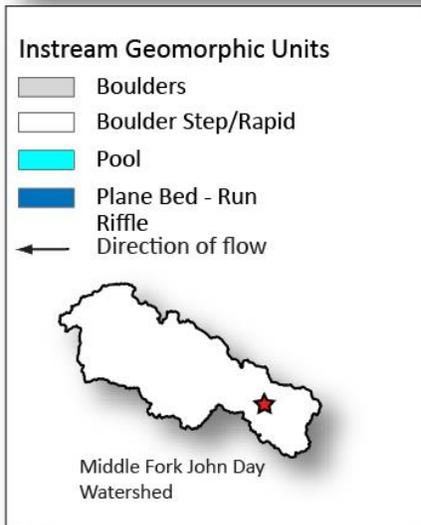


Figure A 11. Geomorphic Units associated with the Confined valley step-cascade river style.

### A3.4 PROFORMA – STEEP EPHEMERAL HILLSLOPE RIVER STYLE

The *steep ephemeral hillslope river style* occurs in small first or 2nd-order basins with steep-walled, confined valleys. An additional hallmark of this river style is the low sinuosity of the channels, which are ephemeral in nature and do not contain surface flow except during spring snowmelt (in highlands) or localized, high-intensity thunderstorms (in lowland headcuts). These basins are marked by a high frequency of mass movement on steep-walled valley sides, and thus channels exhibit a wide range of substrates, influenced by the size of material delivered from upslope. Geomorphic units found in these channels include cascades, riffles, and pools, all of which are forced by larger roughness elements such as woody debris, boulders, and shrubs.

This river style represents 63% of all first-order streams in the watershed. These are steep ephemeral channels that originate from branched head cuts, and collect overland sheetflow and shallow subsurface throughflow from hillslopes into single thread drainages. This river style is strongly associated with semi-arid dissected table lands and uplands in the northeast portion of the watershed (Figure A 12). Channels are completely confined by adjoining hillslopes. The planform is bedrock-controlled and aligned by the valley through which it flows. Bed texture is coarse, with angular material eroded and transported downslope from adjacent hillslopes or is bedrock exposed through scouring overland flow. Instream geomorphic units are step-pool sequences and cascades and plunge pools. Cutbanks tend to form where hillslopes shed sediments rapidly into the channel and are removed by intermittent stream flow.

#### Subwatersheds in which this river style is Observed

*HUC 10:* Big, Bridge, Camp, Eight-Mile, and Long Creeks (see Figure 39 Figure 40).

#### Details of Analysis

*Representative Reach:* unnamed tributary of the MFJDR

*Map Sheets and Air Photographs Used:* 2011 NAIP 1 m color aerial photos, Google Terrain Map (USGS 7.5' Quadrangle Derived), 1-m Lidar DEM

*Date of Proforma Draft:* 4 September 2012

*Date of Field Visit:* 19-28 July 2012

*Coordinates:* 363523.84 m E, 4948720.01 m N (UTM 10N NAD 1983)

#### River Character

*Valley Setting:* confined

*Channel Planform:* straight, aligned by hillslope swales and shallow valleys.

*Bed Material Texture:* sand-to-Boulders, large deal of local variation due to roughness elements

*Channel Geometry:* single thread channel generally ~1 m wide and “v” shaped with thin gravel and boulder bed underlain by bedrock.

#### Instream Geomorphic Units:

*Forced Step-Pool Sequences:* presence of woody debris, vegetation (mainly juniper and pinon pine), and/or boulders delivered from upslope create steps ~1m high, and force plunge and scour pools around these features.

*Hillslopes:* generally sparsely vegetated by grasses with rare sagebrush, often exhibiting scars from mass movement, and very steep (~30-40°), containing a mix of fine sediment to boulders, along with outcrops of bedrock.

### Vegetation Associations

*Instream:* sparsely vegetated by grasses and occasional juniper/pinon pines, which create local roughness elements.

*Hillslopes:* largely vegetated by small grasses with some sagebrush which provides little resistance to downslope movement of material.

### River Behavior

*No Flow Stage:* This river style is the result of rapid sediment evacuation from steep low-order drainages. It appears that the vast majority of sediment is mobilized from these areas as a result of short-duration and high-intensity runoff events such as spring snowmelt and summer thunderstorms. As such, the term 'no flow' applies here to the majority of the year, when the channel is dry. The assemblage of geomorphic units includes steps, plunge/scour pools forced by vegetation, boulders, or large woody debris.

*High Flows:* These channels are imposed form and flow infrequently, and thus there is no 'bankfull' discharge. High flows driven by snowmelt or thunderstorms occur rapidly for short durations, and appear well capable of mobilizing the sediment found on channel beds. In addition, the bed and banks of the channel may be scoured, and vegetation (including shrubs and small trees) which colonize the channel and local hillslopes during periods of no flow may be torn out at these stages. The undercutting of banks may oversteepen the adjacent hillslopes, leading to mass wasting. Channel slope is very high in these small drainages, and as such the planform is very straight even at high flows.

### Controls

*Upstream Drainage Area:* < 1 km<sup>2</sup>

*Landscape Unit and Position in Watershed:* Steeply sloping hillsides in dissected uplands and alpine uplands

*Process Zone:* Sediment evacuation zone

*Valley Morphology:* Narrow, steep-walled, v-shaped valley with no valley floor

*Valley Slope:* On average, 30%

STEEP EPHEMERAL HILLSLOPE RIVER STYLE --Middle Fork John Day River

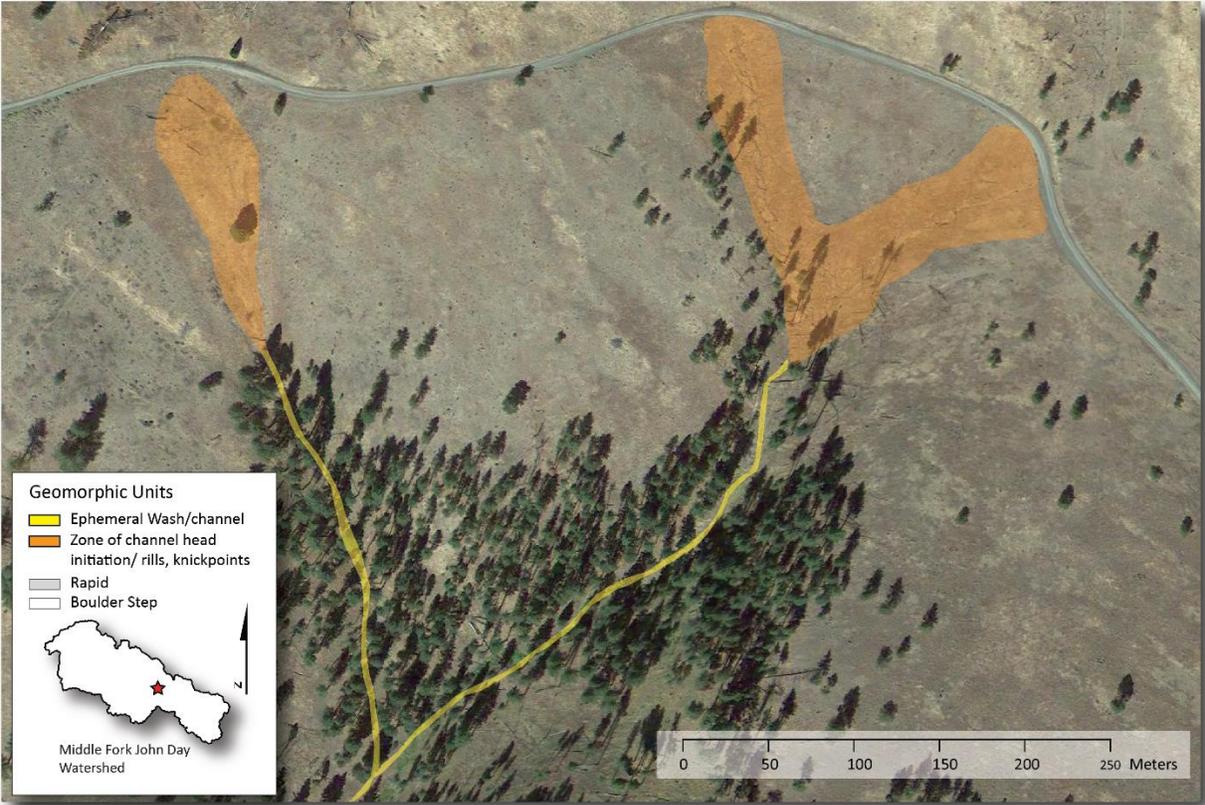


Figure A 12. Geomorphic units associated with the Steep ephemeral hillslope river style.

### A3.5 PROFORMA – CONFINED VALLEY BOULDER BED RIVER STYLE

The *Confined valley boulder bed river style* occurs in small basins (typically 2<sup>nd</sup> or 3<sup>rd</sup>-order) which are intermittent, frequently exhibiting no flow. High runoff occur in these channels following spring snowmelt and/or high intensity summer thunderstorms. These channels are characterized by an abundance of noncohesive sediment with a wide range of size fractions, steep slopes, and flashy, potentially profuse discharges – all of which can lead to a braided/multiple channel planform (typically in the distal watershed). The valleys containing bedrock rivers are typically confined and steep-walled, with bedrock-controlled, valley aligned planforms. These channels are directly connected to hillslopes, leading to a high frequency of mass wasting which sources a wide variety of sediment sizes directly to the channels. Although they typically reside in confined valley settings with little or no actual floodplain, *Confined valley boulder bed rivers* can traverse low angle landscapes and exhibit straight to slightly sinuous planforms with occasional anabranching channels. Yet, they are significantly more diverse in terms of instream geomorphic units than are channels of the steep headwater areas: these include bars, rapids, runs, and cutbanks that occur where the stream bed meanders slightly and intersects imposing hillslopes or debris flow deposits. In general the bedrock streams have steep gradients and beds underlain by a relatively thin veneer of coarse gravel, cobbles and boulders (Figure A 13).

#### Subwatersheds in which this river style is observed:

Confined-valley boulder bed rivers are found in every subcatchment of the MFJDW.

#### Details of Analysis

*Representative Reach:* Jungle Creek, MFJDW

*Map Sheets and Air Photographs Used:* 2011 NAIP 1 m color aerial photos, Google Terrain Map (USGS 7.5' Quadrangle Derived), 1-m Lidar DEM

*Date of Proforma Draft:* 4 July, 2013

*Date of Field Visit:* 12-22 July 2013

*Coordinates:* 356641.47 m E, 4950846.41 m N (UTM 10N NAD 1983)

#### River Character

*Valley Setting:* confined, but planforms vary between straight (no capacity for lateral adjustment), and low sinuosity with some capacity for lateral adjustment (as in a wash setting) or transition to *Alluvial Fan River Style*, with gravel bed and secondary channels.

*Channel Planform:* predominantly straight and valley aligned with a single thread; but transitions to multiple channels converging and diverging around mid-channel bars. Course dictated by presence of alluvial fans, landslides, and bedrock outcrops.

*Bed Material Texture:* sand to boulders, bedrock outcrops, high potential for local variation due to roughness elements.

*Channel Geometry:* multiple symmetrical channels, generally 1-2 m wide with mid-channel bars higher in catchments to 3-4 meters wide down canyon.

#### Instream Geomorphic Units

*Pools/Riffles:* individual channels are primarily steeply sloping, contain coarse sediment and are largely featureless. Rare pools occur in over deepened areas at confluence of channels and/or along outside of meander bends in individual channels.

*Bars:* a variety of bar forms are present, but predominantly include mid-channel bars around which individual channels diverge and converge, and lateral bars which result from the deposition of coarse material along the inside

of meander bends. Bars likely shift after each high flow, as they are sparsely vegetated and loosely cohesive, thus making avulsions common.

*Steps, rapids, and cutbanks:* Jungle Creek is geomorphically diverse, with cutbanks present at nearly every bend; steep, coarse plane beds (rapids), and over-deepened plunge pools.

*Structural elements:* large wood is a factor in maintaining heterogeneous channel morphology in these intermittent streams. When they do flow, discharge and stream power are high, and large wood jams are observed within the channel. These tend to force bars, pools, and cutbanks.

*Hillslopes:* generally sparsely vegetated by grasses with rare sagebrush, often exhibiting scars from mass movement, and very steep (~30-40°), containing a mix of fine sediment to boulders, along with outcrops of bedrock.

#### Vegetation Associations

*Instream:* bars are sparsely vegetated by grasses and small shrubs, and vegetation density appears to increase with the time since the last high flow.

*Hillslopes:* bedrock Rivers traverse diverse landscapes such as open landscapes colonized by grasses and shrubs, and conversely, through conifer forests, typically of the rounded upland landscape unit.

#### River Behavior

*No Flow Stage:* this river style is the result of rapid sediment evacuation from steep low-order drainages accumulating on slightly wider valley bottoms of higher-order drainages. It appears that the vast majority of sediment is mobilized from these areas as a result of short-duration and high-intensity runoff events such as spring snowmelt and summer thunderstorms. As such, the term 'no flow' applies here to the majority of the year, when the channel is dry. The assemblage of geomorphic units includes channels which are mainly composed of riffles with rare pools, and a variety of bar forms which result from an abundance of upslope sediment delivery.

*High Flows:* these channels are imposed form and flow infrequently, and thus there is no 'bankfull' discharge. High flows driven by snowmelt or thunderstorms occur rapidly for short durations, and appear well capable of mobilizing the sediment found on channel beds. In addition, the bed and banks of the channel may be scoured, and vegetation (including shrubs and small trees) which colonize the channel and local hillslopes during periods of no flow may be torn out at these stages. The undercutting of banks may oversteepen the adjacent hillslopes, leading to mass wasting. Between high flows, sediment delivery appears high due to the 'turning on' of individual headcuts and/or mass wasting from hillslopes, both of which source material to the valley floor. This abundance of non-cohesive sediment coupled with a general lack of vegetation likely leads to a multi-channel planform which is reworked during each high flow event.

#### Controls

*Upstream Drainage Area:* 18.5 km<sup>2</sup>

*Landscape Unit and Position in Watershed:* most common in dissected lowlands and similarly arid regions, but found in numerous landscape units where low-order headcuts converge

*Process Zone:* sediment accumulation zone between high flows, sediment transport zone during floods

*Valley Morphology:* narrow, steep-walled, v-shaped valley with channel system covering entire valley floor

*Valley Slope:* On average, 4%

CONFINED VALLEY BOULDER BED RIVER STYLE--Middle Fork John Day Watershed

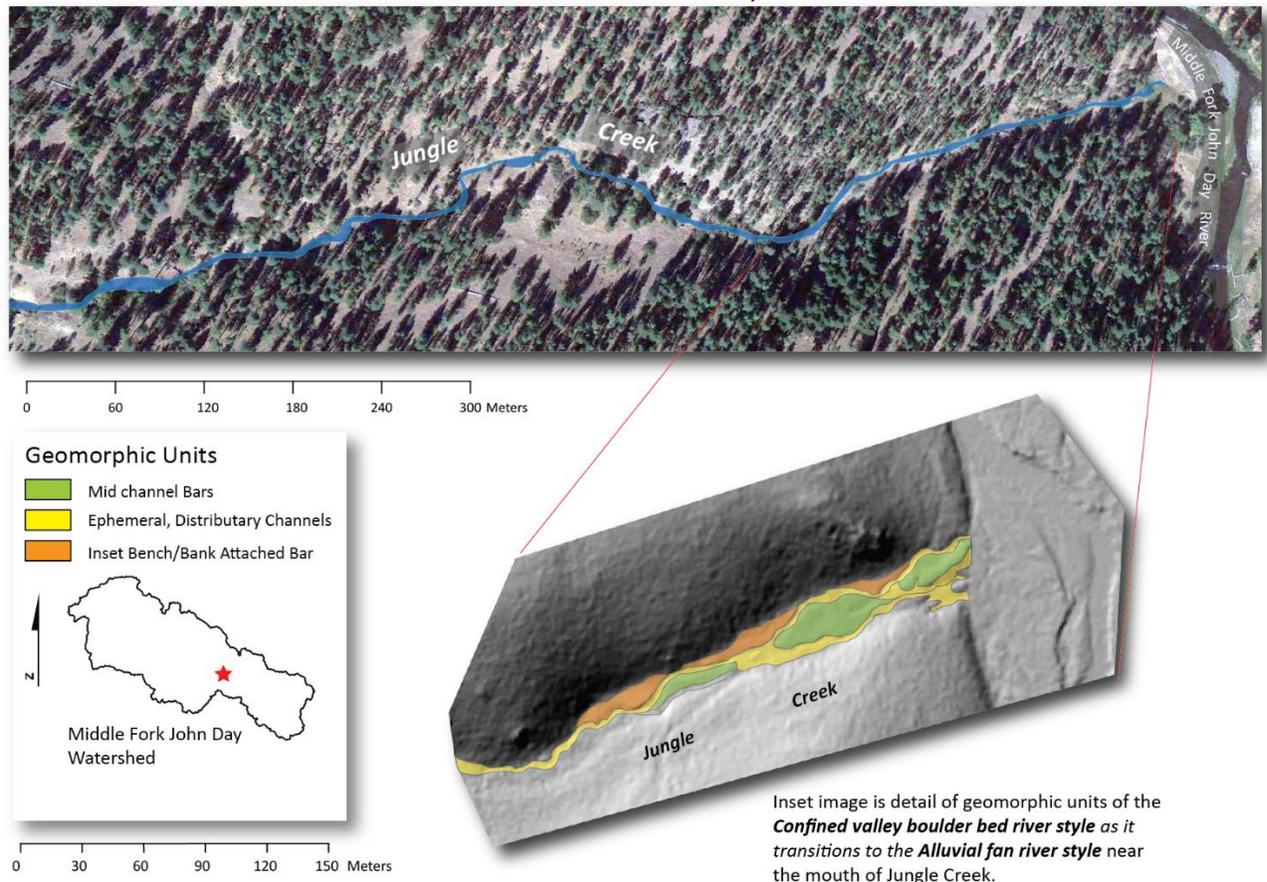


Figure A 13. Geomorphic setting and instream geomorphic units of the Confined valley boulder bed river style.

### A3.6 PROFORMA – STEEP PERENNIAL HEADWATER

The *steep perennial headwater river style* occurs in steep 1st or 2nd-order drainages with confined valleys. The imposed-form stream is in nearly continuous contact with valley walls, which may be composed of coarse talus blocks and/or bedrock surfaces. These channels have no visible floodplain or terrace surfaces, and contain a narrow range of geomorphic units: primarily bedrock or boulder steps, cascades, and forced plunge pools. Large woody debris which falls into the channel has a large influence on substrate dynamics and the distribution of geomorphic units, particularly since this river style frequently occurs in small, steep forested drainages which have recently burned.

First-order streams formed in forested uplands of the central and eastern MFJDW are described by the *steep perennial headwater river style* (**Error! Reference source not found.**). Streams of this river style are mapped as perennial (USGS, 2007) and tend to collect snowmelt, overland and subsurface flow, and commonly, spring flow in their channels. Like other first-order streams in the watershed, they are 100% confined in narrow channels whose planform is bedrock-controlled and aligned in valley junctions. Channel lengths are commonly influenced by coarse, hillslope-sourced mass-wasted deposits, and by dense wood jams. Channels traversing bedrock and coarse deposits are marked by cascades, steps and plunge pools, whereas areas with well-developed soil profiles exhibit a deeper “notched” channel shape obscured by forest vegetation and woody debris.

#### Subwatersheds in which this river style is Observed

Confined-valley steep perennial headwater streams are found in every subcatchment of the MFJDW.

#### Details of Analysis

*Representative Reach:* unnamed tributary of Bridge Creek (MFJDR), adjacent to U.S.Route 26.

*Map Sheets and Air Photographs Used:* 2011 1 m NAIP imagery, 2 m state of Oregon lidar and derived hillshade/slope rasters, Google Terrain (7.5' USGS quadrangle-derived), aerial photographs from EcoFlight overflights, Google Street View

*Date of Proforma Draft:* 16 July 2012

*Date of Field Visit:* 19-28 July 2012

*Coordinates:* 374249.71 m E, 4932276.55 m N (UTM 11N NAD 1983)

#### River Character

*Valley Setting:* confined, steep-walled and very narrow

*Channel Planform:* very low sinuosity with no visible floodplain or terrace surfaces

*Bed Material Texture:* coarse; predominantly boulders and cobbles

*Channel Geometry:* narrow single thread channel generally < 2 m in width. Cross section contains coarse (boulder/cobble) channel bed with poorly-developed floodplain surface mainly composed of bedrock and colluvial hillslope material (cobbles/boulders delivered from upslope).

#### Instream Geomorphic Units

*Riffle-Run Sequences:* The channel is low sinuosity and largely homogeneous, predominantly coarse-bedded (boulder/cobble) steps and cascades, which are forced by coarse sediment and large woody debris jams. These steep sections are interspersed with flat water plunge pools.

*Bedrock Outcrops:* This river style is often found flowing through resistant basalt, and interspersed bedrock outcrops create zones of localized convergent flow and form flat water sections upstream and plunge pools downstream, both of which serve as local sinks for sediment.

*Valley Floor Deposits:* These channels are steep systems that carry little fine sediment and drain steep, resistant terrain. As such, they are largely imposed-form systems, which flow over terrain created by bedrock geology and hillslope processes and lack continuous alluvial floodplain deposits or self-formed terrace surfaces. Valley floors are strewn with cobbles and boulders delivered from upslope and/or deposited during extreme high flow events. Valley walls and bottoms show colonization by large arid tree species, indicating that overbank stage is rarely reached for extended periods of time and deposition of sediment during these periods is limited.

Structural Elements – small, steep channels on forested hillslopes contain woody debris, and channel pathways are overlain and clogged by wood and log jams.

#### *Vegetation Associations:*

*Instream:* largely unvegetated; fallen trees provide local roughness elements which obstruct flow and trap sediment.

*Valley Walls:* colonized by arid upland species including ponderosa pine, indicating a lack of consistent/extended floodplain inundation.

#### River Behavior

*Low Flow Stage:* this river style is the result of coarse sediment being contributed locally by steep-walled valleys. In combination with regular outcroppings of resistant bedrock, this creates a channel form which is largely imposed. This continuous delivery of sediment to the channel via mass wasting requires a high stream slope for transport, and the resistant lithologies being drained means that the supply of fine sediment is limited. At low flows, the channel is well contained in a single-thread flow path, and the banks are stable as they are vegetated by mature upland ponderosa pine and contain large boulders of basalt. There is a narrow range of geomorphic units present, including steps and cascades, along with plunge pools forced by bedrock or large woody debris. Virtually no bank erosion occurs at low flows, given the high degree of bank stability due to armoring by coarse sediment along with the well vegetated banks and valley walls.

*Bankfull Stage:* flows reaching this stage have the potential to cause slight scour of the channel banks, although this may be limited due to their coarse nature and the established valley side/bottom vegetation. It is possible that some of the finer sediment (i.e. cobbles and occasional gravel) on the channel bed may be transported at this stage, but given that these channels are not alluvial systems and are likely not configured to mobilize their bed at regular intervals, it is unlikely that mobilization of  $D_{50}$  occurs at this stage. Stable boulders and large woody debris may trap the small amount of gravel and sand which moves through these systems.

*Overbank Stage:* at this stage, the valley floor may be completely inundated, given its narrow width, and some degree of bank scour may occur, although these channels lack evidence of recent avulsions or migration, implying that these are quite stable systems. Additionally, bedrock outcrops provide a large degree of stability in these systems. The establishment of arid upland riparian vegetation and soil development implies that overbank stages are rarely reached but for a very limited amount of time (i.e. hours). Flows which overtop the bank may be capable of mobilizing some larger particles (up to  $D_{84}$ ), but it is likely that some particles remain immobile in nearly all flows, especially given the presence of downed trees, established upland vegetation, and colluvial talus which may limit the geomorphic effectiveness of any flow.

#### Controls

*Upstream Drainage Area:* 0.15 km<sup>2</sup>

*Landscape Unit and Position in Watershed:* high in the watersheds, generally first or second-order streams draining steep terrain along divides.

*Process Zone:* sediment mobilization zone (net degradation)

*Valley Morphology:* very narrow, V-shaped steeply-sloping valley sides with nearly the entire valley bottom occupied by the stream channel.

*Valley Slope:* On average, 10%

*STEEP PERENNIAL HEADWATER RIVER STYLE*  
*--Middle Fork John Day Watershed*

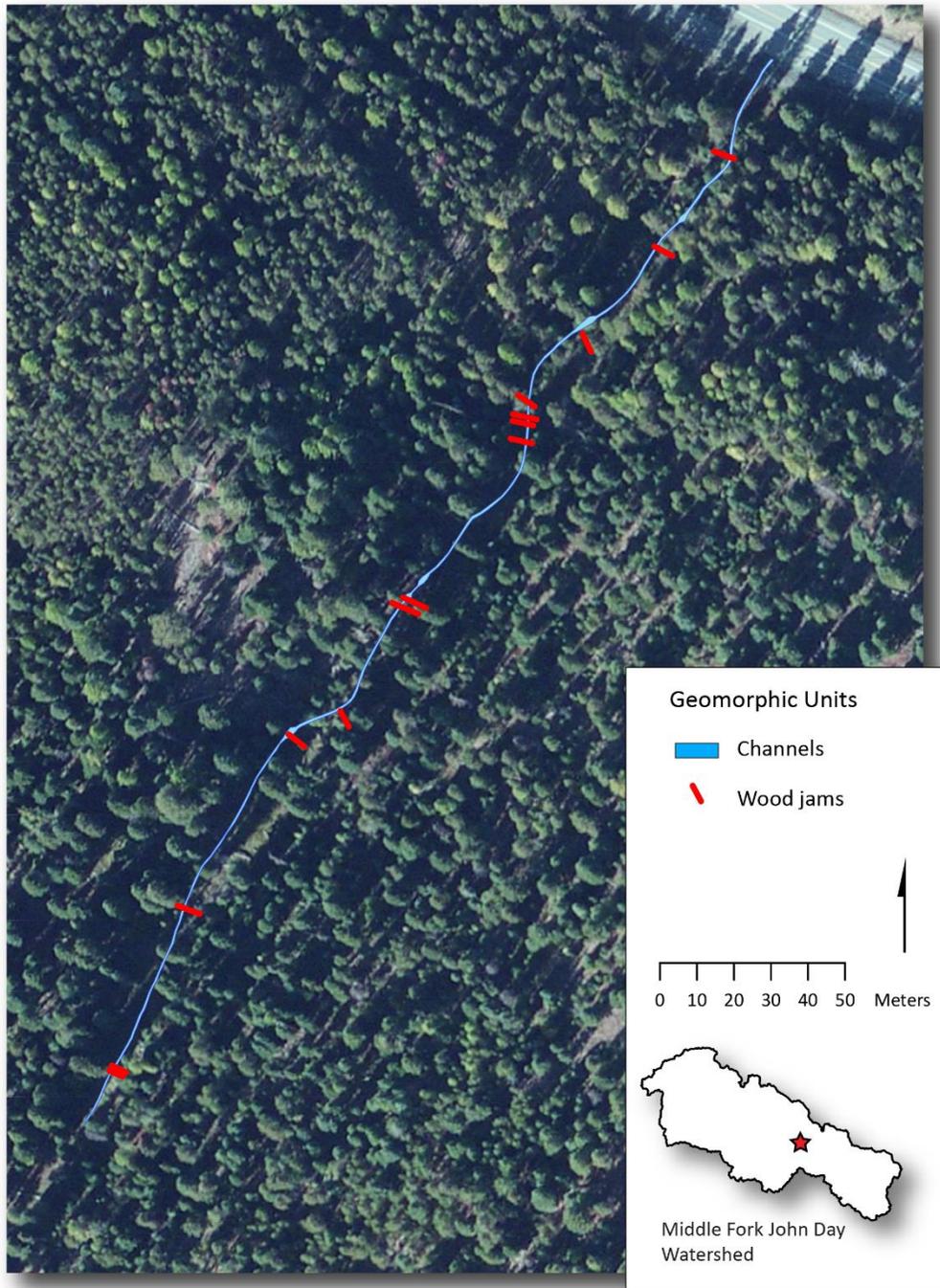


Figure A 14. Geomorphic units associated with the Steep perennial headwaters river style

## 11 APPENDIX B – DATA TABLES AND DIAGRAMS FROM STAGE TWO AND STAGE THREE ANALYSES

Appendix B contains data underlying the geomorphic condition assessment of every river style in the MFJDW that is important to fish. We exclude two river styles representing ephemeral streams (the *Confined valley bedrock river* and *Steep ephemeral hillslope river styles*) and two river styles of uppermost headwater streams in intact geomorphic condition (*Steep perennial headwaters* and *Confined valley step-cascade river styles*). The remaining river styles include criteria and measures for determining geomorphic condition, tables explaining geomorphic condition of each variant, and figures that provide context for each condition variant in terms of valley setting and channel planform. The geomorphic condition data are grouped and presented by common valley setting (confined, partly confined and laterally unconfined settings). At the end are figures that combine geomorphic evolution diagrams, the product of river styles Stage Two, with *trajectory of change* diagrams, the foundation for determining geomorphic recovery potential and the product of river styles Stage Three.

### B1 GEOMORPHIC CONDITION OF RIVER STYLES IN CONFINED VALLEY SETTINGS

#### B1.1 ENTRENCHED BEDROCK CANYON RIVER STYLE

The Entrenched Bedrock Canyon river style occupies the Long, Eight Mile, and Big Creek watersheds that drain semiarid dissected tablelands underlain by the Columbia River Basalt (Figure B 2). Channels flow in confined valleys defined by a superimposed, antecedent planform. The geomorphic evolution of imposed channels—their adjustment capacity—is limited to reworking of bed material and discontinuous floodplain segments, and to aggradation and incision of a veneer of gravel in the confined bedrock valley. Adjustment occurs on a temporal scale of decades to millennia, driven by climate- and weather-induced changes in sediment supply that temporarily aggrade or expunge sediment from channels. Bed form and floodplain reworking may be of interest to resource managers because they reflect short-term changes in geomorphic condition and habitat viability; however, like most confined-valley bedrock streams, the overall effect on geomorphic condition by human land use is limited.

#### EXPLANATION OF GEOMORPHIC CONDITION VARIANTS

Figure B 1 shows two variants of this river style. Panel 1 is located on Long Creek (11T 327764.74 E, 4964141.51 N). Panel 2 is along the Middle Fork John Day River (342971.11 E, 4963772.49 N), and is the reference reach for this river style. Both variants fit the description outlined in Appendix A, but differ by scale of valley depth, channel width, and bed material caliber. Prior to settlement in the early 1800's, the hydraulic diversity of the channels was presumably greater than today, induced by volumes of large wood swept downstream from forested uplands, and perhaps by rich riparian vegetation that colonized short floodplain segments. Panel 2 lies downstream of the small community of Long Creek, where active grazing of every available floodplain segment and adjacent landscape may have affected both LWD recruitment and perhaps, sediment supply. Panel 1 lies downstream of intensely mined and grazed reaches. Although these activities surely affected the balance of wood loading and sediment supply to the channel during the last century, little photographic or anecdotal evidence exists to quantify those changes. Yet we can assume that (a) changes to out-of-channel geomorphic units has been minor; little space exists to accommodate extensive floodplain segments or terrace deposits, and no paleo-deposits exist to suggest there have been large shifts to the sediment balance in these streams; (b) adjustment to instream geomorphic units is limited to reorganization of bars, pools, rapids and runs.

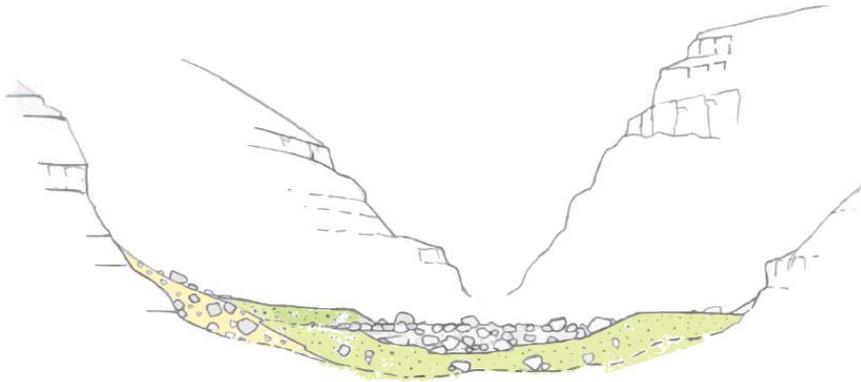
**Table B 1. Criteria and measures used to assess geomorphic condition of variants of the Entrenched Bedrock Canyon river style in confined valley settings (adapted from Tables 10.8 and 10.9 of Brierley and Fryirs, 2005).**

Degrees of Freedom and their Relevant Geoindicators	Questions used to assess geomorphic condition of each reach	Pass Creek	Long Creek	MFJDR
<b>Channel Attributes</b>	<b>3 out of 4 questions must be answered YES For stream to be assessed in GOOD condition</b>			
Size	Channel size dictated by narrow bedrock walls and within coarse bed load deposits	Yes	Yes	Yes
Shape	Is the channel shape consistent	No	Yes	Yes
Bank	Bank erosion defined through lack of distinct fine-grained floodplain deposits?	No	Yes	Yes
Woody Debris Loading	Is there woody debris in the channel or potential for recruitment of woody debris?	No	No	Yes
		X	✓	✓
<b>Channel Planform (3 out of 5)</b>	<b>3 out of 5 questions must be answered YES</b>			
Number of Channels	Are there signs of change such as avulsions or overbank channels forming on the floodplain?	Yes	Yes	Yes
Sinuosity of Channels	Is the channel sinuosity consistent with the sediment load/transport regime and the slope of the channel?	Yes	Yes	Yes
Lateral Stability	Is the lateral stability consistent with the sediment texture and channel slope? Are there signs of degradation such as local widening and atypical in-channel reworking of bed material?	No	Yes	Yes
Geomorphic Unit Assemblage	Are the number, type and pattern of instream geomorphic units appropriate for the sediment regime, slope, bed material and valley setting? Are key units of this river style present (planar riffles and runs, cutbanks, pools, point bars)?	Yes	Yes	Yes
Riparian Vegetation	Are the appropriate types and density of riparian vegetation present on the banks and floodplain?	No	No	Yes
		✓	✓	✓
<b>Bed Character (2 out of 3)</b>	<b>3 out of 4 questions must be answered YES</b>			
Grain Size and Sorting	Is the range of sediment throughout the channel and floodplain organized and distributed appropriately?	Yes	Yes	Yes
Bed Stability	Is the bed vertically stable such that it is not incising or aggrading inappropriately for the channel slope, sediment caliber, and sinuosity?	Yes	Yes	Yes
Sediment Regime	Is the sediment storage and transport function of the reach appropriate for the catchment position (i.e., is it a sediment transfer or accumulation zone?)?	Yes	Yes	Yes
Hydraulic Diversity	Are roughness characteristics and the pattern of hydraulic diversity appropriate for the catchment position?	Yes	Yes	Yes
		✓	✓	✓
<b>geomorphic condition</b>	Total checks and crosses are added for each stream reach	<b>Moderate</b>	<b>Good</b>	<b>Good</b>

**Table B 2. Explanation of geomorphic condition for variants of the Entrenched bedrock canyon river style. “Check” and “x” boxes refer to the same symbols in Table B 1.**

Degree of Freedom	Good Condition - MFJDR and Long Creek	Moderate Condition - MFJDR and Pass Creek
<b>Channel Attributes</b>	<p>The mainstem MFJDR and its tributary Long Creek are relatively remote streams in the lower watershed. Thus, they have incurred little direct pressure from development and land use; the main pressures and limitations come from indirect, downstream affects of flow and sediment flux alteration from upstream land use. Distribution of sediment may have also been altered by intense dredge mining of upstream reaches. Yet, there are few obvious signs of this in the lowermost reaches of either stream. Channels have high width-depth ratios with shallow banks composed of coarse gravel and cobble. Lateral, point, and mid-channel bars are common, and the geomorphic unit assemblage is composed of planar features: plane bed, rapids, and runs. Long creek has a higher overall channel roughness and direct hillslope contribution of coarse colluvium.</p> <p style="text-align: right;"><input checked="" type="checkbox"/></p>	<p>The single thread channel of the lower MFJDR is constrained between bedrock and a county road for roughly half its length. Bank erosion is focused at outside bends and against riprap. The channel is directly connected to hillslopes, but geomorphic units are limited to plane bed features. The limitation of geomorphic condition in Pass Creek is downstream proximity to farmland reducing flow volume, and multiple dirt tracks that traverse and line the channel.</p> <p style="text-align: right;"><input type="checkbox"/></p>
<b>Channel Planform</b>	<p>Channel planforms for all MFW streams that have incised the Columbia River Basalt (northwest watershed) are straight, but follow a super imposed meandering outline - they are incised meanders. Their floodplains are narrow, thin, and discontinuous, and the streams have a low capacity for adjustment. The volume of natural wood in these systems (especially the mainstem) is relatively low.</p> <p style="text-align: right;"><input checked="" type="checkbox"/></p>	<p>These streams have similar channel attributes. The smaller scale tributaries tend to have proportionally fewer and narrower floodplain pockets, but the configuration for all streams of this type are the same.</p> <p style="text-align: right;"><input checked="" type="checkbox"/></p>
<b>Bed Material</b>	<p>Sediment caliber and distribution is relatively uniform - coarse gravel with occasional boulders contributed by closely connected hillslopes.</p> <p style="text-align: right;"><input checked="" type="checkbox"/></p>	<p>These reaches have similar bed material attributes - the smaller scale tributaries tend to have higher channel roughness and coarse gravel plane bed geomorphic units that resemble rapids and runs.</p> <p style="text-align: right;"><input checked="" type="checkbox"/></p>

The Entrenched Bedrock Canyon river style is relatively limited in terms of capacity for channel and floodplain adjustment. Relevant geoidicators tie closely to sediment caliber, bed characteristics and consistency within geomorphic units. Bed stability is also important, with focus on uniform conditions and absent areas of unusual aggradation. Consequently, wood loading is important for these streams to offset a tendency for plane bed geomorphic units to dominate the channel. Yet, wood is scarce in Long Creek because of the presence of a mid-catchment zone of agricultural fields, farms and towns. Wood is likewise scarce along the lowermost reaches of the MFJDR.



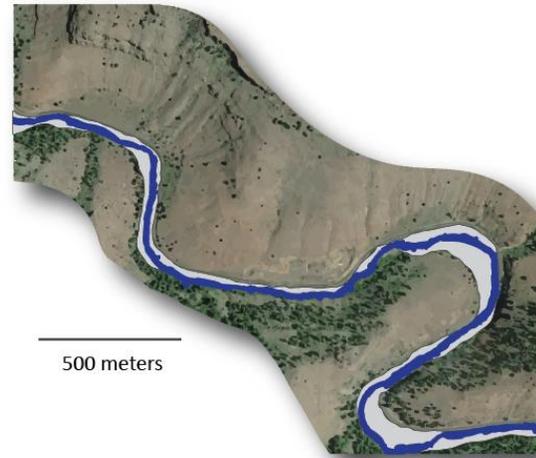
1. Long Creek, lower Middle Fork John Day Watershed (Long Creek HUC 10 subwatershed). Confined valley, short and limited discontinuous floodplain segments, bed material is coarse gravel and cobble with sparse boulders supplied mostly from adjacent steep hillslopes.



1. Upper Long Creek subwatershed. Long Creek flows within a steep-walled, bedrock valley. Valley depth is ~100 m, width is ~15 m at river level. Channel is a superimposed meandering outline (antecedent stream).



2. Middle Fork John Day River. Same details as above, but including mid-channel, bank attached, and point bars. Fine-grained abandoned floodplains (terraces) are located mostly at bends and atop point bars. Road construction has created greater constriction, but channel is distinctly confined and possesses little capacity for adjustment. Bed material is cobble and gravel, and probably reflects the effects of channel disturbances due to mining activities. The effects are unknown, but may represent winnowing of fines over time as upstream channels were effectively overturned and intensively placer mined.



2. Middle Fork John Day River. Channel is a superimposed meandering outline (antecedent stream). Valley depth is ~300 m, width is ~50 m at river level.

Figure B 1. Geomorphic condition variants of the Entrenched bedrock canyon river style. Panel 1 is of Long Creek; Panel 2 shows the Middle Fork John Day River.

TRAJECTORY OF CHANGE DIAGRAM – STAGE THREE

The Entrenched Bedrock Canyon river style comprises the mainstem MFJDR for roughly half its total length (as a single reach) and encompasses nearly all of the lower Long Creek Subwatershed (Figure 39). Its steep-walled, confined valley setting precludes much of the traditional land uses endured by the upper watershed, and yet reflects downstream effects from that land use in the patterns of sediment distribution, wood loading, and effects of placer mining. While the Intact or pre-settlement condition of this river style isn't known with certainty, a reasonable assumption is that the overall health of the lower watershed is tied to management strategies employed in the upper watershed. Plane bed features, relatively low channel roughness, and hydraulic diversity dominate geomorphic units. A healthier, more diverse riparian cover probably existed prior to road building/channel narrowing. With time and attention to problem areas upstream, the condition of this reach will undoubtedly improve in terms of floodplain and channel condition. However, it is in relatively good condition at present and this reach would not benefit from any direct management actions.

In the lower Long Creek Subwatershed there are contrasting conditions of adjacent Long and Pass Creeks, where Pass Creek (11T 329992 E, 4964545 N) is impacted by a road, rampant cattle trailing, and upstream ranch operations. The riparian cover in the channel bottom is somewhat less healthy than Long Creek.

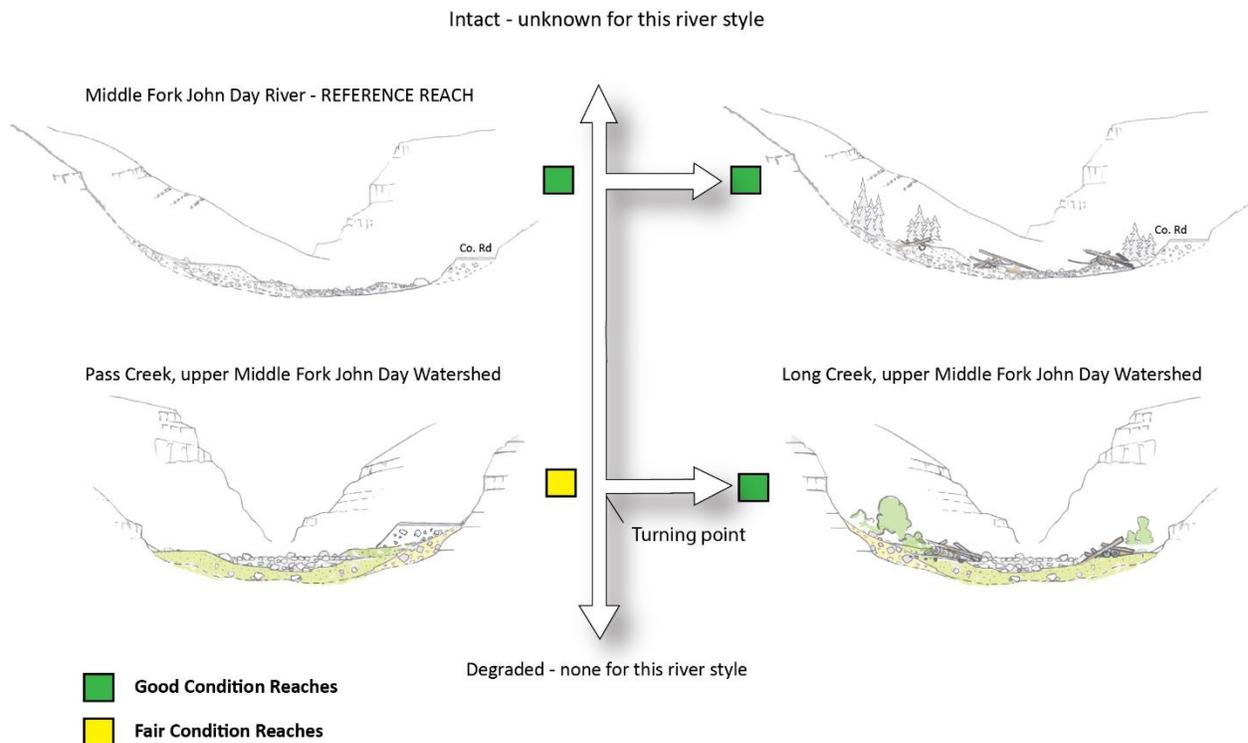


Figure B 2. Trajectory of change diagram for the Entrenched bedrock canyon river style.

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## B1.2 CONFINED VALLEY WITH OCCASIONAL FLOODPLAIN POCKETS RIVER STYLE

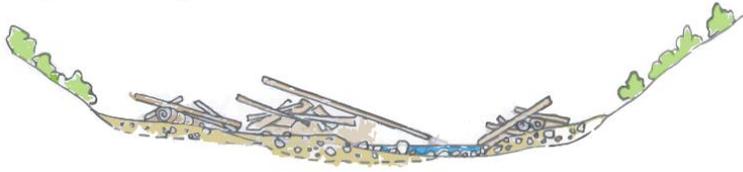
The *Confined valley with occasional floodplain pockets river style* is a “backbone” river style of the MFJDW. It is found in nearly every subwatershed of the MFJDW, occupying an intermediate position between headwater streams and those of partly confined valleys where local expansion leads to more extensive floodplains. Only one reach is observed along the mainstem MFJDR; all others occupy forested tributaries where ample sediment production and transport allows discontinuous floodplains to aggrade, or amid steep basalt uplands with a rich riparian corridor. In general, confined-valley bedrock streams such as these should reflect (a) transfer of sediment from headwaters; (b) higher instream roughness and hydraulic diversity; and (c) a diverse suite of geomorphic units forced by ample instream wood and a healthy riparian cover. This profile is adequately captured in Vinegar Creek, but other variants display local effects traceable to removal of vegetation through fire and logging, low recruitment of natural wood, mining disturbance, and road building.

### EXPLANATION OF GEOMOPRHIC CONDITION VARIANTS

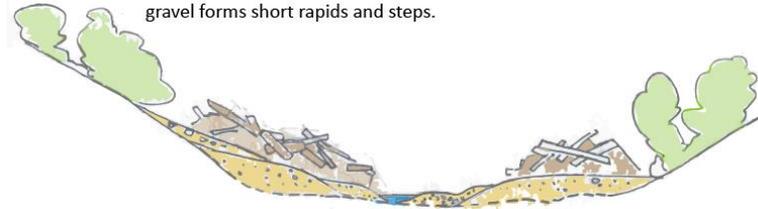
Four variants of this river style were identified (Figure B 3) to exemplify the diversity of forms within this river style. Panel 1 is Indian Creek (1523 m, 11T 355434.63 E, 4967875.48 N), an upper watershed reach amid a burn and clear-cut logged area showing signs of high sediment storage; Panel 2 is Vinegar Creek, the reference reach for this river style, a near-pristine, mid-watershed reach (1386 m, 11T 381126 E, 4942564 N) with abundant LWD and high hydraulic diversity; Panel 3 is Bridge Creek, an important anadromous stream imposed upon by Oregon State Highway 26 (1400 m, 11T 378584 E, 4933650 N); and Panel 4, is Big Creek, a semiarid stream situated downstream of an intensely mined and logged sub watershed (1050 m, 11T 352834 E, 4959767 N).

Many reaches of the *Confined valley with occasional floodplain pockets river style* comprise the main trunk of tributaries where they occur, and tend to have roads built alongside and crossing them (e.g., Bridge Creek and Big Creek). Roads, then, are a key impediment to natural channel form and planform adjustment potential. Logging and natural burn areas are another apparent cause of unusual sediment patterns in some reaches. For example, Upper Indian Creek is denuded of its original forest cover and shows prolific gravel bed accumulation in the confined valley setting. However, ample large wood has accumulated in the channel and is contributing to diversity of bar forms and even a few channel avulsions along that reach.

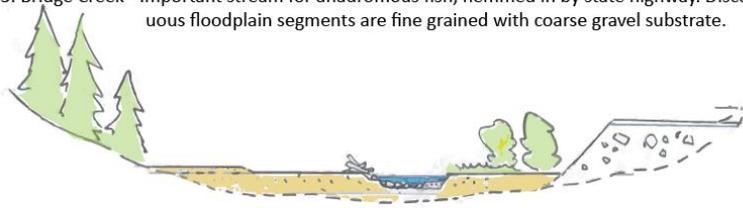
1. Indian Creek - Area of watershed heavily burned and logged. Abundant large wood jams in stream. Cobble and coarse gravel substrate, fine grained floodplain segments small or absent, floodplain consists of gravel bars and sheets.



2. Vinegar Creek - REFERENCE REACH for this river style. Abundant large wood form jams and create high hydraulic diversity and structurally forced bars and pools, hillslope derived coarse gravel forms short rapids and steps.



3. Bridge Creek - Important stream for anadromous fish, hemmed in by state highway. Discontinuous floodplain segments are fine grained with coarse gravel substrate.



4. Big Creek - Discontinuous floodplain segments are fine grained with coarse gravel substrate. Hydraulic diversity is low, channel is relatively featureless with runs and occasional rapids; natural wood is absent, lateral bars common.

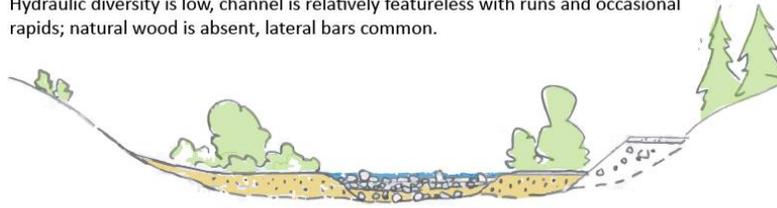


Figure B 3. Geomorphic condition variants of the Confined valley with occasional floodplain pockets river style.

**Table B 3. Criteria and measures used to assess geomorphic condition of variants of the Confined valley with occasional floodplain pockets river style (adapted from Tables 10.8 and 10.9 of Brierley and Fryirs, 2005).**

Degrees of freedom and their relevant geoindicators	Questions to used to assess geomorphic condition of each reach	Indian Creek	Vinegar Creek	Bridge Creek	Big Creek
<b>Channel attributes</b>	<b>3 out of 4 questions must be answered YES For stream to be assessed in GOOD condition</b>				
Size	Is channel size appropriate given the catchment area, the prevailing sediment regime, and the vegetation character? Is the channel functionally connected to floodplain pockets? (i.e., is the channel overwidened, overdeepened, or does it have an appropriate width : depth ratio?)	No	Yes	Yes	Yes
Shape	Is the channel shape consistent with confined valley features (typically symmetrical)?	No	Yes	Yes	Yes
Bank	Is the bank morphology consistent with caliber of sediment? Are banks eroding in the correct places?	Yes	Yes	Yes	Yes
Woody Debris Loading	Is there woody debris in the channel or potential for recruitment of woody debris?	Yes	Yes	No	No
		X	✓	✓	✓
<b>Channel</b>	<b>4 out of 5 questions must be answered YES</b>				
Number of Channels	Is the channel single thread as appropriate for this river style? Are there signs of change such as avulsions or overbank channels forming on the floodplain?	No	Yes	Yes	Yes
Sinuosity of Channels	Is the channel sinuosity consistent with the sediment load/transport regime and the slope of the channel?	Yes	Yes	No	Yes
Lateral Stability	Is the lateral stability consistent with the sediment texture and channel slope? Are there signs of degradation such as local widening and atypical in-channel reworking of bed material?	Yes	Yes	Yes	No
Geomorphic Unit Assemblage	Are the number, type and pattern of instream geomorphic units appropriate for the sediment regime, slope, bed material and valley setting? Are key units of this river style present (planar riffles and runs, cutbanks, pools, point bars)?	Yes	Yes	No	No
Riparian Vegetation	Are the appropriate types and density of riparian vegetation present on the banks and floodplain?	No	Yes	Yes	Yes
		✓	✓	✓	X
<b>Bed character</b>	<b>3 out of 4 questions must be answered YES</b>				
Grain Size and Sorting	Is the range of sediment throughout the channel and floodplain organized and distributed appropriately?	Yes	Yes	Yes	Yes
Bed Stability	Is the bed vertically stable such that it is not incising or aggrading inappropriately for the channel slope, sediment caliber, and sinuosity?	No	Yes	Yes	Yes
Sediment Regime	Is the sediment storage and transport function of the reach appropriate for the catchment position (i.e., is it a sediment transfer or accumulation zone?)?	No	Yes	Yes	Yes
Hydraulic Diversity	Are roughness characteristics and the pattern of hydraulic diversity appropriate for the catchment position?	No	Yes	Yes	No
	Total checks and crosses are added for each stream reach	X	✓	X	X

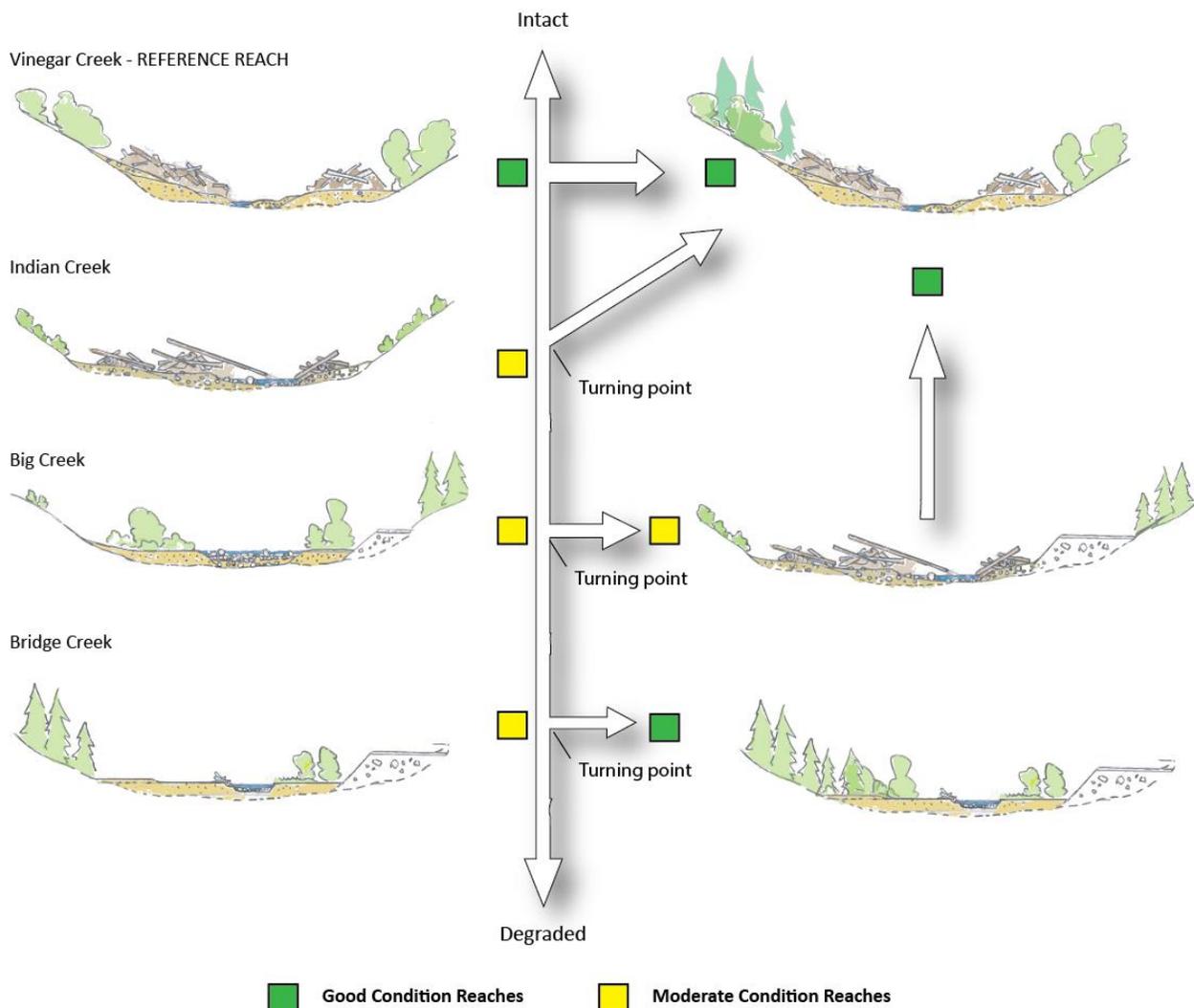
<b>Geomorphic condition</b>		<b>Moderate</b>	<b>Good</b>	<b>Moderate</b>	<b>Moderate</b>
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**Table B 4. Explanation of geomorphic condition for variants of the Confined valley with occasional floodplain pockets River Style. Check and “x” boxes in the table above refer to the same symbols in Table B 3.**

Degree of Freedom	Good Condition - Vinegar Creek	Moderate Condition - Big, Bridge, Indian Creeks
<b>Channel Attributes</b>	<p>Roughly symmetrical cross section within a narrow, discontinuous fine-grained sand to mud floodplain. Bank erosion is focused at outside bends, at contact with hillslopes, and around mid-channel bars capped by fine-grained floodplain material. Channel bed hosts some vegetation, mostly where bars form islands. Intense instream wood loading drives hydraulic and geomorphic diversity. Direct connection to hillslopes provides coarse material for rapids and plane bed features with high roughness.</p> <p style="text-align: right;"><input checked="" type="checkbox"/></p>	<p><i>Bridge and Big Creeks:</i> low-angle cross section within sand and mud floodplain underlain by gravel and cobble extending laterally from the channel. Channel width is consistent with the size and sediment expected from their catchments, but they are hemmed in by roads, which limit the capacity for adjustment. In big creek, the bed load along the study reach (Figure 76, #4) is dominantly cobble, and may have been influenced by clear cut operations. <i>Indian Creek:</i> the channel character of this reach was influenced by natural fire and clear cut operations--riparian vegetation is reduced and sedimentation increased.</p> <p style="text-align: right;"><input type="checkbox"/></p>
<b>Channel Planform</b>	<p>Valley aligned planform confined by bedrock and hillslopes. Channel is well-connected to both hillslope and floodplain. Riparian vegetation is established on thin, narrow floodplain surfaces. Dead wood is abundant as standing and fallen logs and litter. Vegetation and recruitment of woody debris plays a crucial role in channel shape, sinuosity, and formation of diverse geomorphic units that have dominantly planar morphology.</p> <p style="text-align: right;"><input checked="" type="checkbox"/></p>	<p>Irregular, low sinuosity planform, well-connected to discontinuous, fine-grained floodplain pockets and hillslopes. Riparian vegetation is reasonably healthy with scattered woody stands, and rich grass and woody riparian species covers the floodplain. Natural wood has been mostly purged or cleared from some reaches (compared to good condition variant) and not likely to play a strong role in channel shape and sinuosity. Bed is stable. Geomorphic units are not well-developed, mostly planar types.</p> <p style="text-align: right;"><input checked="" type="checkbox"/></p>
<b>Bed Material</b>	<p>Sediment is varied with channel bed composed of coarse gravel and cobble coupled with finer gravel and sand fractions in lower energy settings. Coarse sediment projects beneath thin, narrow marginal discontinuous floodplain segments composed of fine sand, silt and mud. Contribution of hillslope colluvium to channel adds important coarse gravel fraction.</p> <p style="text-align: right;"><input checked="" type="checkbox"/></p>	<p><i>Bridge and Big Creeks:</i> channel bed composed of coarse gravel and cobble; coarse sediment forms planar geomorphic units, with little diversity (pool-riffle sequences and cutbanks ). Distribution of sediments vary between coarse, planar units and over-widened areas with finer gravels forced by road and by bank disturbance. <i>Indian Creek:</i> the reach is choked with gravel sheets and bars, unusual for a high position in a small catchment, as compared to most in the MFJDW.</p> <p style="text-align: right;"><input type="checkbox"/></p>

**TRAJECTORY OF CHANGE DIAGRAM – STAGE THREE**

Reach sensitivity to disturbance increases with distance downstream for this river style. If land use practices remain favorable, the reference reach will continue to evolve and improve its floodplain and channel condition. Conditions in Indian Creek have the potential to improve as the catchment recovers from logging and fire-induced increase in hillslope and upper catchment sedimentation. The high volume of wood may help to coerce gravel sheets and bars into more heterogeneous bed forms and, as riparian cover returns, has the potential to evolve toward a good condition variant. The lower watershed reaches of Big Creek are mostly denuded of instream wood and the stream bed is dominated by plane bed geomorphic units. This may be the result of management practices (logging, grazing and road building), but this reach has not sustained irreversible geomorphic change. Reaches of this variant have the potential to recover along a pathway where heterogeneity can be restored to the channel with the advent of watershed recovery from logging activities and conservation practices. The geomorphic condition of Bridge Creek is permanently constrained by State Highway 26 and directed through numerous culvert crossings. Yet, this reach has a healthy riparian cover and diverse geomorphic units. There is no reason the condition of the stream will degrade further and may even improve with time (Figure B 4).



**Figure B 4. Trajectory of Change diagram for variants of the Confined valley with occasional floodplain pockets River Style.**

### B1.3 CONFINED VALLEY STEP-CASCADE RIVER STYLE

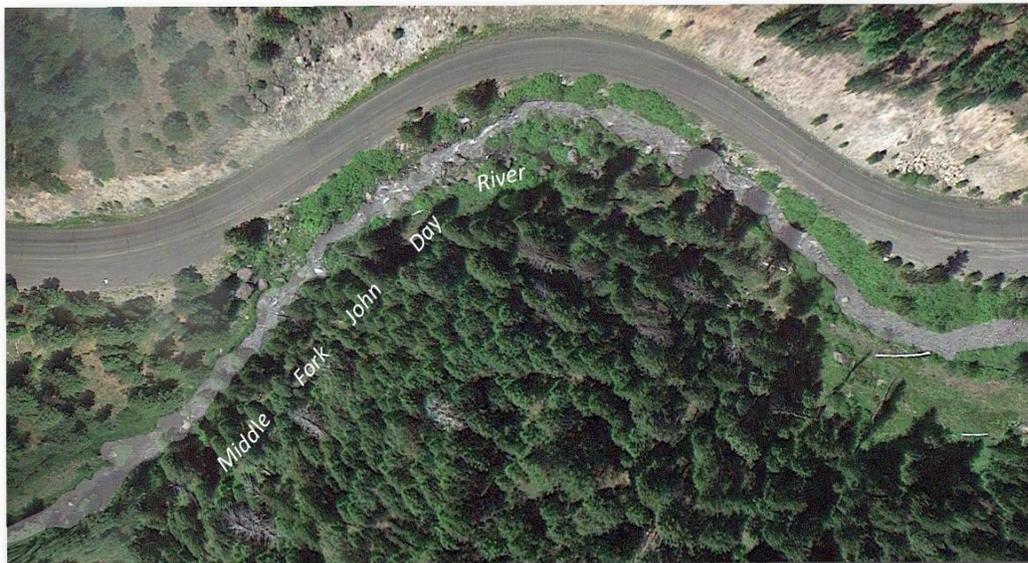
#### EXPLANATION OF GEOMORPHIC CONDITION VARIANTS

We observed two variants of the *Confined valley step-cascade river style* in the MFJDW. The most typical configuration resides in the uppermost reaches of Big Boulder and Granite Boulder Creeks in confined valley settings with ample coarse sediment, vertically stable bed and relatively steep gradient. A second variant formed on the mainstem MFJDR in response to a local mass wasting event (**Error! Reference source not found.**) and is eomorphically atypical of the mainstem.

Reaches of the *Confined valley step-cascade river style* have low adjustment potential and are located higher in tributary valleys, leaving them relatively immune from all but local, direct anthropogenic pressures over time (such as mining or road and culvert construction). A variant along the MFJDR was evidently forced by local bedrock failure, but exacerbated by road construction and further constriction in the confined valley reach (Figure B 5).



1. Granite Boulder Creek: the headwater stream is confined with no floodplain, possesses a step-pool-rapid-cascade sequence of geomorphic units, has coarse boulder and cobble bed material, and a steep gradient. This example is the reference reach and typifies the upper networks of Big Boulder and Granite Boulder Creeks draining southwest to the Middle Fork John Day River. Good condition variant.



2. The moderate condition variant is a short reach of the mainstem Middle Fork John Day River. This is atypical of the mainstem whose coarse bed material and steep gradient was caused by local rock fall/mass wasted deposit from river left, and by constriction/construction resulting from road building.

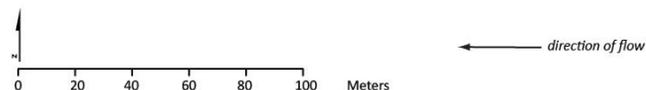


Figure B 5. Geomorphologic condition variants of the Confined valley step-cascade river style. White mask indicates extent of channel.

Table B 5. Criteria and measures used to assess geomorphic condition of variants of the Step-Cascade river style in confined valley settings (adapted from Tables 10.8 and 10.9 of Brierley and Fryirs, 2005).

Degrees of Freedom and their relevant Geoindicators	Questions used to assess geomorphic condition of each reach.	Big/Granite Boulder Creek	Middle Fork John Day
<b>Channel Attributes</b>	<b>2 out of 3 questions must be answered YES For stream to be assessed in GOOD condition</b>		
Size	Is channel size appropriate given the catchment area, the prevailing sediment regime, and the vegetation character?	✓	X
Bank	Is the bank morphology consistent with caliber of sediment? Are banks eroding in the correct places?	✓	X
Woody Debris Loading	Is there woody debris in the channel or potential for recruitment of woody debris?	✓	X
<b>Channel Planform</b>	<b>2 out of 3 questions must be answered YES</b>		
Number of Channels	Is the channel single thread as appropriate for this river style? Are there signs of change such as avulsions or overbank channels forming on the floodplain?	✓	✓
Geomorphic Unit Assemblage	Are the number, type and pattern of instream geomorphic units appropriate for the sediment regime, slope, bed material and valley setting? Are key units of <i>this</i> river style present (steps, pools, rapids, cascades)?	✓	X
Riparian Vegetation	Are the appropriate types and density of riparian vegetation present on the banks?	✓	✓
<b>Bed Character</b>	<b>3 out of 4 questions must be answered YES</b>		
Grain Size and Sorting	Is the range of sediment throughout the channel and floodplain organized and distributed appropriately?	✓	✓
Bed Stability	Is the bed vertically stable such that it is not incising or aggrading inappropriately for the channel slope, sediment caliber, and sinuosity?	✓	✓
Sediment Regime	Is the sediment storage and transport function of the reach appropriate for the catchment? position (i.e., is it a sediment transfer or accumulation zone?)?	✓	X
Hydraulic diversity	Are roughness characteristics and the pattern of hydraulic diversity appropriate for the catchment position?	✓	✓
		✓	X
<b>Geomorphic Condition</b>	Total checks and crosses are added for each stream reach	<b>Good</b>	<b>Moderate</b>

### TRAJECTORY OF CHANGE DIAGRAM – STAGE THREE

The Confined valley step-cascade river style has no distinct variants to speak of in Granite Boulder and Big Boulder Creeks– the catchment position, grain size, gradient and valley setting of all the reaches is consistent between watersheds and are in good geomorphic condition. This river style has very low capacity for adjustment and therefore, low adjustment potential. The isolated, moderate-condition variant found along the MFJDR has little or no capacity for adjustment given its confined valley setting and restriction by the highway.

## B2 GEOMORPHIC CONDITION DATA FOR RIVER STYLES OF PARTLY CONFINED VALLEY SETTINGS

### B2.1 LOW-MODERATE SINUOSITY PLANFORM-CONTROLLED DISCONTINUOUS FLOODPLAIN RIVER STYLE

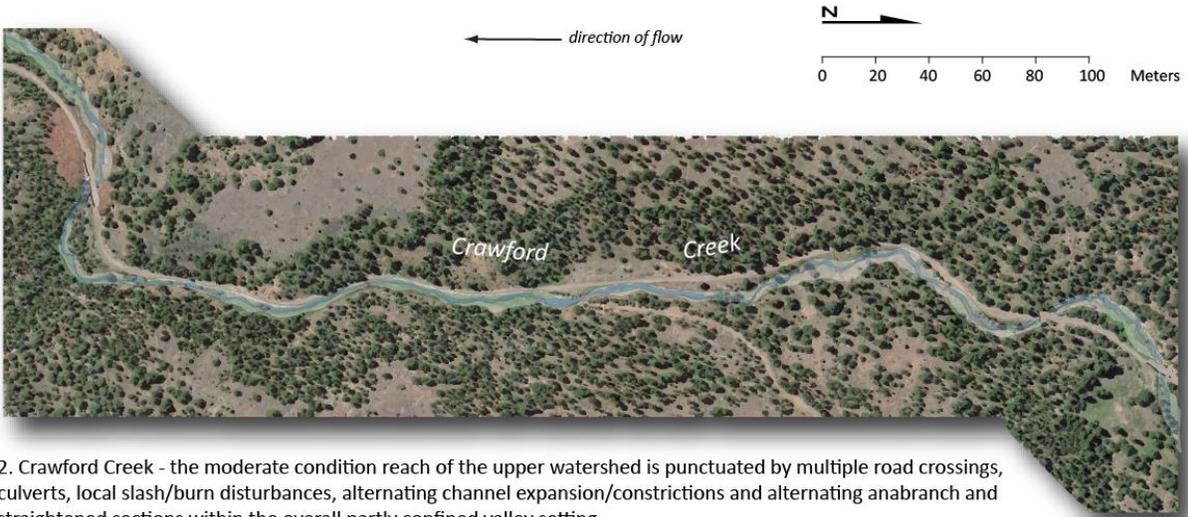
The Meandering PC-Floodplain river style is the most common of all streams flowing in partly confined valley settings, and the second most common river style of any valley setting (18%; Figure 39). Likewise, reaches of this river style are the most diverse in terms of both in-channel and out-of-channel geomorphic units (Figure B 6) and occupy middle- to lower catchment positions of tributaries to the MFJDR, where valley expansion occurs near the confluence with the mainstem. This river style is present throughout the MFJDW and is especially common in the Camp and Bridge Creek HUC 10 watersheds.

#### EXPLANATION OF GEOMORPHIC CONDITION VARIANTS

Two variants of this river style were identified (Figure B 6). The reference reach lay along Vinegar Creek (11T 380730 E, 4944391 N, el. 1424 m asl) with a complex assemblage of fine grained floodplain pockets and pools, riffles, plane bed, islands, cutbanks, and a variety of bar types (point, diagonal, lateral, eddy and compound). Riparian vegetation and both deciduous and coniferous trees that provide ample woody debris to the channel densely colonize the floodplain and valley. The valley hosts a gravel road high above the stream and a small flow diversion that circumvents the reach, but is otherwise near pristine in terms of river character and behavior. A contrasting variant of moderate geomorphic condition is a middle-catchment reach of Crawford Creek (11T 385446 E, 4938725 N, el. 1321 m asl). Here the stream is impacted by a road built astride its floodplain and subjected to repeated culvert and bridge crossings and intersecting gravel tracks. The floodplain vegetation appears healthy, but channel dimensions and patterns of sedimentation vary with areas of local expansion and constriction coincident with disturbances (i.e., roadway and timber slash/burn areas), and contain little woody debris. A brief poor-condition variant is associated with this reach.



1. Vinegar Creek - the good condition, reference reach is consistent with the attributes of mid-catchment, expanded valleys: fine-grained floodplain pockets, moderately sinuous channel with occasional island and anabranch, abundant wood, and diverse suite of geomorphic units. It is unimpeded by all but the most rudimentary dirt tracks and a minor diversion ditch.



2. Crawford Creek - the moderate condition reach of the upper watershed is punctuated by multiple road crossings, culverts, local slash/burn disturbances, alternating channel expansion/constrictions and alternating anabranch and straightened sections within the overall partly confined valley setting.

0 20 40 60 80 100 Meters

**Figure B 6. Geomorphic condition variants for the Low-moderate sinuosity planform-controlled discontinuous floodplain river style. White mask indicates extent of floodplain.**

**Table B 6. Criteria and measures used to assess geomorphic condition of variants of the Low-moderate sinuosity planform-controlled discontinuous floodplain river style in partly confined valley settings (adapted from Tables 10.8 and 10.9 of Brierley and Fryirs, 2005).**

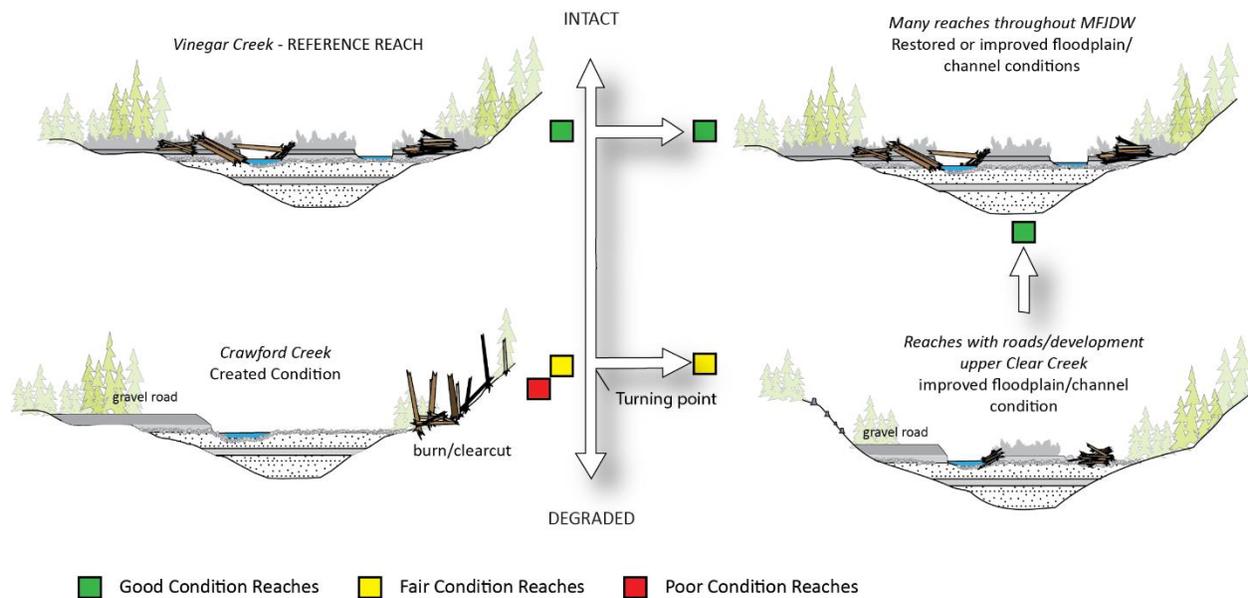
Degrees of freedom and their relevant geoindicators	Questions used to assess geomorphic condition of each reach	Vinegar Creek	Crawford Creek
<b>Channel attributes</b>	<b>3 out of 4 questions must be answered YES For stream to be assessed in GOOD condition</b>		
Size	Is channel size appropriate given the catchment area, the prevailing sediment regime, and the vegetation character? Is the channel functionally connected to floodplain pockets? (i.e., is the channel overwidened, overdeepened, or does it have an appropriate width : depth ratio?)	Yes	Yes
Shape	Is the channel shape consistent with partly confined valley features (typically asymmetrical)?	Yes	No
Bank	Is the bank morphology consistent with caliber of sediment? Are banks eroding in the correct places?	Yes	No
Woody debris loading	Is there woody debris in the channel or potential for recruitment of woody debris?	Yes	No
		✓	X
<b>Channel planform</b>	<b>4 out of 5 questions must be answered YES</b>		
Number of channels	Is the channel appropriate for this river style? Are there signs of change such as avulsions or overbank channels forming on the floodplain?	Yes	No
Sinuosity of channels	Is the channel sinuosity consistent with the sediment load/transport regime and the slope of the channel?	Yes	Yes
Lateral stability	Is the lateral stability consistent with the sediment texture and channel slope? Are there signs of degradation such as local widening and atypical in-channel reworking of bed material?	Yes	Yes
Geomorphic unit assemblage	Are the number, type and pattern of instream geomorphic units appropriate for the sediment regime, slope, bed material and valley setting? Are key units of this river style present (planar riffles and runs, cutbanks, pools, point bars)?	Yes	Yes
Riparian vegetation	Are the appropriate types and density of riparian vegetation present on the banks and floodplain?	Yes	Yes
		✓	✓
<b>Bed character</b>	<b>3 out of 4 questions must be answered YES</b>		
Grain size and sorting	Is the range of sediment throughout the channel and floodplain organized and distributed appropriately?	Yes	No
Bed stability	Is the bed vertically stable such that it is not incising or aggrading inappropriately for the channel slope, sediment caliber, and sinuosity?	Yes	Yes
Sediment regime	Is the sediment storage and transport function of the reach appropriate for the catchment position (i.e., is it a sediment transfer or accumulation zone?)	Yes	Yes
Hydraulic diversity	Are roughness characteristics and the pattern of hydraulic diversity appropriate for the catchment position?	Yes	No
		✓	X
	Total checks and crosses are added for each stream reach	✓	X
<b>Geomorphic condition</b>		<b>Good</b>	<b>Moderate</b>

**Table B 7. Explanation of geomorphic condition for variants of the Meandering Planform-controlled discontinuous floodplain River Style. Check and “x” boxes in the table above refer to the same symbols in Table B 6.**

Degree of Freedom	Good Condition - Vinegar Creek	Moderate Condition - Crawford Creek
<b>Channel Attributes</b>	Roughly symmetrical cross section within a narrow, discontinuous fine-grained sand to mud floodplain. Bank erosion is focused at outside bends, at contact with hillslopes, and around mid-channel bars capped by fine-grained floodplain material. Channel bed hosts some vegetation, mostly where bars form islands. <input checked="" type="checkbox"/>	low-angle cross section within sand and gravel floodplain. Channel shape is inconsistent, as indicated by variable width and depth (very wide with low angle banks, versus narrow and steep-sided, locally) and sediment distribution along the channel. <input type="checkbox"/>
<b>Channel Planform</b>	Irregular, low-sinuosity planform, that is in contact with confining bedrock and hillslopes >80% of actual length. Channel is well-connected to both hillslope and floodplain. Riparian vegetation is established on floodplain surface. Dead wood is abundant as standing and fallen logs and litter. Grass cover is thick on floodplain. Vegetation and recruitment of woody debris plays a crucial role in channel shape, sinuosity, and formation of diverse geomorphic units; i.e., bars, islands and pools. <input checked="" type="checkbox"/>	Irregular, low sinuosity planform, well-connected to discontinuous floodplain pockets and hillslopes, channel cutoffs developed. Riparian vegetation is reasonably healthy with scattered woody stands, and rich grass and woody riparian species covers the floodplain. Natural wood has been mostly purged or cleared from the reach (compared to good condition variant) and not likely to play a strong role in channel shape and sinuosity. Bed is stable. Geomorphic units are not well-developed, mostly planar types. <input checked="" type="checkbox"/>
<b>Bed Material</b>	Sediment is varied with channel bed composed of coarse gravel and cobble coupled with finer gravel and sand fractions in lower energy settings. Coarse sediment projects beneath marginal discontinuous floodplain segments composed of fine sand, silt and mud. <input checked="" type="checkbox"/>	Segregated, bi-modal sediment mix, with channel bed composed of coarse gravel and cobble; coarse sediment forms planar geomorphic units, with little diversity (pool-riffle sequences and cutbanks ). Distribution of sediments vary between coarse, planar units and over-widened areas with finer gravels (forced by road and by bank disturbance). <input type="checkbox"/>

**TRAJECTORY OF CHANGE DIAGRAM— STAGE THREE**

The good condition, reference reach of Vinegar Creek is diverse in terms of both in-channel and out-of-channel geomorphic units. The geomorphic and ecological health of this stream would unlikely improve by any effort other than treatment as a conservation reach and consideration of land use activities focused upstream. The trajectory of change for this and similar good-condition reaches throughout the MFJDW is to evolve within boundary conditions driving and defining this river style. Variants such as lower Crawford Creek have incurred obstructions and disturbances that will prevent it from attaining a recovered condition. However, despite road building, culvert crossings, variable channel dimensions, and timber burn/hillslope damage, this variant has potential to adjust to these disturbances and evolve to a healthy “created” condition. A moderate-condition variant in Clear Creek shares many of these attributes (most notably hillslope/clear cut timber harvest damage and road building) but is quickly evolving to a restored, good-condition variant (Figure B 7).



**Figure B 7. Trajectory of change diagram for variants of the Low-moderate sinuosity planform-controlled discontinuous floodplain river style.**

## B2.2 MEANDERING PLANFORM-CONTROLLED DISCONTINUOUS FLOODPLAIN RIVER STYLE

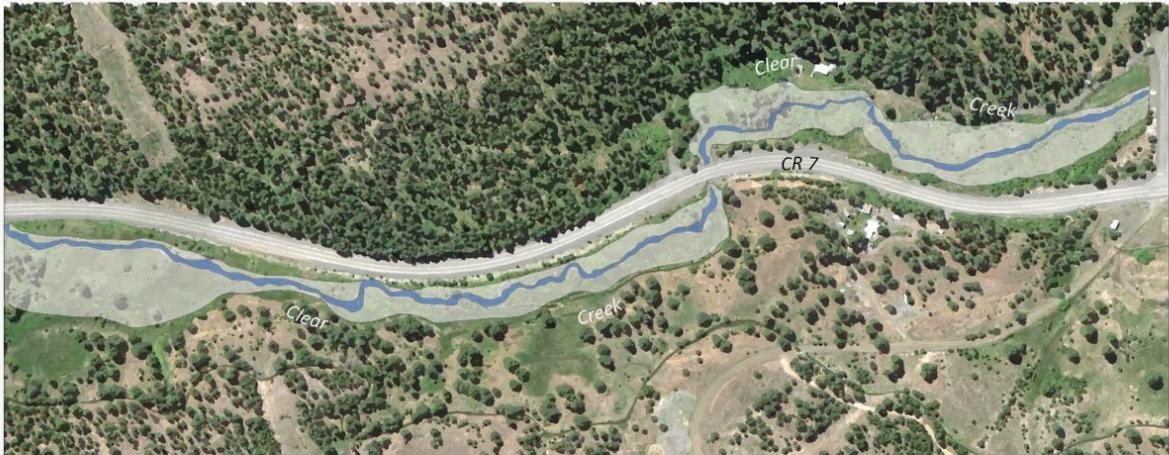
The *Meandering planform-controlled discontinuous floodplain river style* is relatively uncommon in the MFJDW (4% of all river styles in any valley setting) and found almost entirely within the Bridge Creek HUC 10 watershed (Figure 39). Its distinctive assemblage of geomorphic units consists of pool-riffle pairs separated by plane bed sections and point bars and cutbanks punctuated by ample instream wood.

### EXPLANATION OF Geomorphic CONDITION VARIANTS

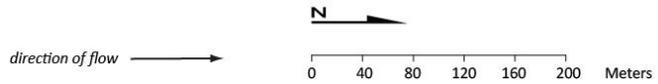
The reference reach and proforma site for this river style (Figure B 7) flows through a near-pristine and isolated stretch of the mainstem MFJDR (11T 383134 E, 4939458 N, el. 1269 m asl). The floodplain is grazed on annual rotation and floodplain logging occurred decades ago, but is occupied by riparian, deciduous and coniferous forest growth with an intact and healthy appearance (and is inhabited by a large herd of Elk). The pool-riffle, plane-bed sequence of geomorphic units are remarkably consistent along the 5 km reach. Channel heterogeneity is increased by several restoration structures (cross-channel logs, forming structurally forced pool-mid channel bar sequences). The channel attributes (width-depth) and bank characteristics are laterally and vertically stable throughout the reach. Figure B 8 also shows a reach of the Meandering planform-controlled discontinuous floodplain river style in moderate geomorphic condition. Simply put, this otherwise healthy reach of lower Clear Creek is hemmed in by County Road 7, which reduces the planform sinuosity and has at least two flow diversions upstream of its transition with the alluvial fan reach (the transition to the *Alluvial fan river style* and the mouth of Clear Creek is shown in Figure B 14). Yet the channel geomorphic units include requisite pools, riffles, plane bed, and a variety of bar forms (point, lateral, and diagonal).



1. The good condition, reference reach of the Meandering planform-controlled discontinuous floodplain river style on the mainstem Middle Fork John Day River, despite a history of logging, annual floodplain grazing, and the presence of a seldom maintained dirt track and a small diversion (visible). The 5 km-long reach is composed of consistently-placed pool-riffle sequences, plane bed sections, abundant structural wood, and a fine-grained floodplain occupied by native vegetation. This segment is among the most pristine along the mainstem Middle Fork John Day.



2. A moderate condition variant of the Meandering planform-controlled discontinuous floodplain river style lies along Clear Creek near its mouth. Two canals draw from this reach that is confined by a highway (OR CR 7) and adjacent developments. Wood is scarce, perhaps by proximity to several road crossings, but geomorphic units are otherwise diverse and characteristic of this river style.



**Figure B 8. Geomorphic condition variants for the Meandering planform-controlled discontinuous floodplain river style. White mask indicates extent of floodplain.**

**Table B 8. Criteria and measures used to assess geomorphic condition of variants of the Meandering planform-controlled discontinuous floodplain river style in partly confined valley settings (adapted from Tables 10.8 and 10.9 of Brierley and Fryirs, 2005).**

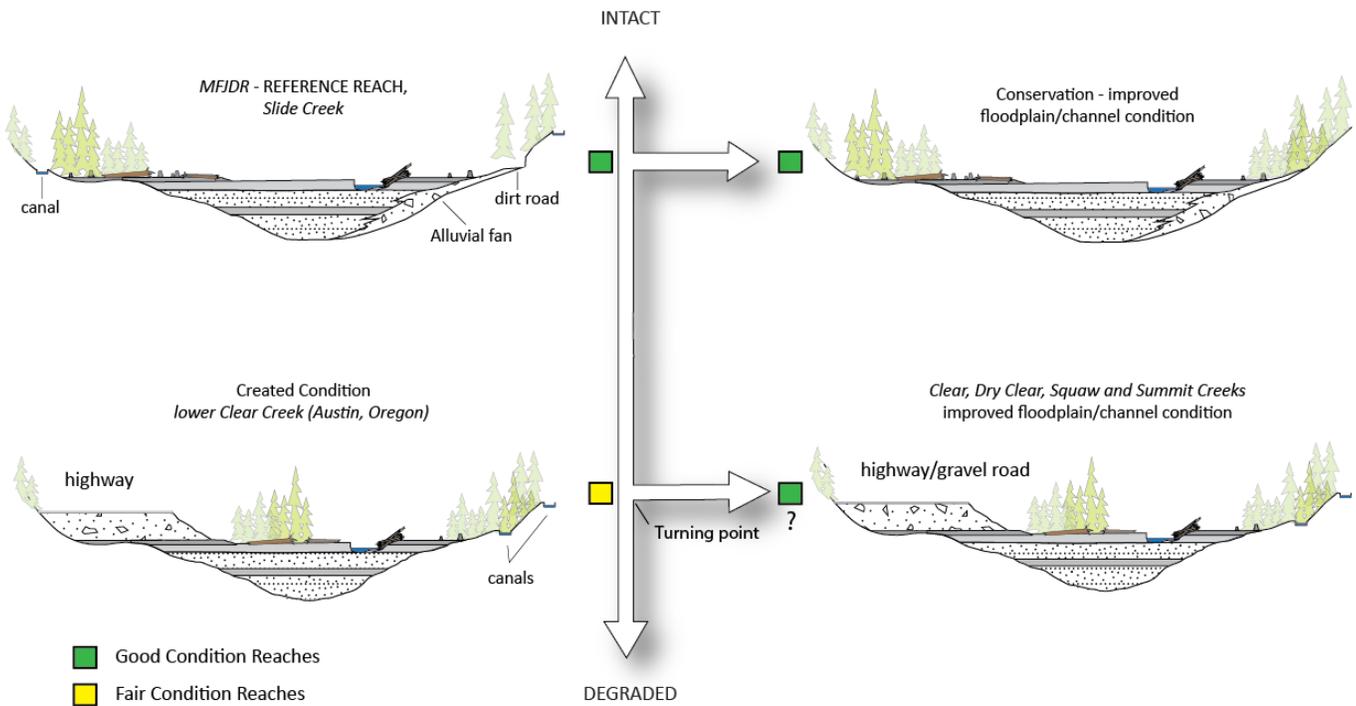
Degrees of Freedom and their relevant Geoindicators	Questions used to assess geomorphic condition of each reach.	MFJDR	Clear Creek
<b>Channel Attributes</b>	<b>3 out of 4 questions must be answered YES For stream to be assessed in GOOD condition</b>		
Size	Is channel size appropriate given the catchment area, the prevailing sediment regime, and the vegetation character? Is the channel functionally connected to floodplain pockets? (i.e., is the channel overwidened, overdeepened, or does it have an appropriate width : depth ratio?)	Yes	No
Shape	Is the channel shape consistent with partly confined valley features (typically asymmetrical)?	Yes	Yes
Bank	Is the bank morphology consistent with caliber of sediment? Are banks eroding and re-depositing in the correct places?	Yes	No
Woody Debris Loading	Is there woody debris in the channel or potential for recruitment of woody debris?	Yes	No
		✓	X
<b>Channel Planform</b>	<b>4 out of 5 questions must be answered YES</b>		
Number of Channels	Is the channel appropriate for this river style? Are there signs of change such as avulsions or overbank channels forming on the floodplain?	Yes	No
Sinuosity of Channels	Is the channel sinuosity consistent with the sediment load/transport regime and the slope of the channel?	Yes	No
Lateral Stability	Is the lateral stability consistent with the sediment texture and channel slope? Are there signs of degradation such as local widening and atypical in-channel reworking of bed material?	Yes	No
Geomorphic Unit Assemblage	Are the number, type and pattern of instream geomorphic units appropriate for the sediment regime, slope, bed material and valley setting? Are key units of this river style present (planar riffles and runs, cutbanks, pools, point bars)?	Yes	Yes
Riparian Vegetation	Are the appropriate types and density of riparian vegetation present on the banks and floodplain?	Yes	Yes
		✓	✓
<b>Bed Character</b>	<b>3 out of 4 questions must be answered YES</b>		
Grain Size and Sorting	Is the range of sediment throughout the channel and floodplain organized and distributed appropriately?	Yes	Yes
Bed Stability	Is the bed vertically stable such that it is not incising or aggrading inappropriately for the channel slope, sediment caliber, and sinuosity?	Yes	Yes
Sediment Regime	Is the sediment storage and transport function of the reach appropriate for the catchment position (i.e., is it a sediment transfer or accumulation zone?)?	Yes	Yes
Hydraulic Diversity	Are roughness characteristics and the pattern of hydraulic diversity appropriate for the catchment position?	Yes	Yes
		✓	✓
		✓	X
<b>Geomorphic Condition</b>	Total ticks and crosses are added for each stream reach	<b>Good</b>	<b>Moderate</b>

**Table B 9. Explanation of Geomorphic condition variants for the Meandering planform-controlled discontinuous floodplain river style. Check and “x” boxes in the table above refer to the same symbols in Table B 8.**

Degree of Freedom	Good Condition - MFJDR	Moderate Condition - Clear Creek
<b>Channel Attributes</b>	Steep-sided asymmetrical cross section within a fine-grained sand to mud floodplain. Bank erosion is focused at meander bends as expected, and is otherwise minimal. Channel bed is free of vegetation. Restoration structures (cross-channel emplaced logs) force plunge pools and structurally-forced eddy bars	Steep-sided cross section within a fine-grained sand to mud floodplain. Bank erosion is correct in pool-riffle sequences, but areas of local straightening, canal diversion, roadway forcing, and culvert containment of the stream have changed sediment distribution throughout the reach and bank characteristics. Channel shape and size are inconsistent in places, as indicated by variable width, a greater abundance of channel margin tussock stands and a few secondary channels.
<b>Channel Planform</b>	Irregular, low to moderate-sinuosity planform, adjustment is gradual on scale of decades. Well-connected to floodplain. Riparian vegetation is established on floodplain surface. Dead wood is abundant as standing and fallen logs and litter. Grass cover is thick on floodplain. Vegetation and wood influences meander development; abundant recruitment of woody debris plays role in channel shape and sinuosity as well as forcing point bars, pool-riffle sequences, and plane-bed features - runs and glides.	Irregular, low sinuosity planform, adjustment is gradual on scale of decades, not years; well-connected to floodplain, channel cutoffs developed. Riparian vegetation is scattered with few woody stands, but rich grass covers the floodplain. Natural wood is much less abundant in these reaches and not likely to play a role in channel shape and sinuosity. Bed is stable. However, in-stream geomorphic units reflect the appropriate assemblage of pool-riffle sequences and planar runs and glides.
<b>Bed Material</b>	Segregated, bi-modal sediment mix, with channel bed composed of coarse gravel and cobble; coarse sediment projects beneath Floodplain composed of fine sand, silt and mud.	Segregated, bi-modal sediment mix, with channel bed composed of coarse gravel and cobble; coarse sediment forms planar geomorphic units, with little diversity (pool-riffle sequences, point and lateral bars, and plane-bed features).

**TRAJECTORY OF CHANGE DIAGRAM – STAGE THREE**

Reaches of the *Meandering planform-controlled discontinuous floodplain river style* fall into two groups: those impacted by roads, canals, and other development; and good condition reaches that traverse the mid-sections of relatively pristine basins. The former group mostly occupy the upper watershed and comprise headwater tributaries of the mainstem (Figure B 9). The Impacted reaches are “created” conditions that will benefit from thoughtful habitat improvement planning, especially in perennial, anadromous reaches such as lower Clear, Dry Clear, Squaw and Summit Creeks. Examples of good condition reaches include the MFJDR upstream of Bates, Slide Creek, and upper Camp Creek. They already occupy areas of less potential disturbance and should be managed as connected conservation reaches.



**Figure B 9. Trajectory of change diagrams for variants of the Meandering planform-controlled discontinuous floodplain river style.**

### B2.3 LOW SINUOSITY PLANFORM-CONTROLLED ANABRANCHING RIVER STYLE

The *Low sinuosity planform-controlled anabranching river style* is observed in Camp, Big Boulder and Granite Boulder Creeks. The character of this river style stems from coarse, abundant sediment available from hillslopes and headwater streams.

#### EXPLANATION OF GEOMORPHIC CONDITION VARIANTS

Two condition variants occur in this river style (Figure B 10 and Table B 10). One is found in the mid to lowermost reaches of Camp Creek where tributary-sourced debris flows and debris fans provide a large volume of coarse gravel and boulders to the stream. Debris fans cause stream-borne sediments to accumulate upstream of bedrock-walled constrictions that in turn lead to formation of channel anabranches. A very different variant occurs high in Big Boulder and Granite Boulder Creeks, where upper reaches are choked with coarse sediment and abundant wood sourced from hillslopes. The sediment storage is observed upslope of a narrow bedrock-controlled constriction; valley expansion downstream marks a transition to the *Alluvial fan river style* and confluence with the mainstem MFJDR.



1. Granite Boulder Creek - the reference reach for the Low sinuosity planform-controlled anabranching river style in good geomorphic condition. Local sediment storage results from high hillslope input and upper catchment sediment production associated with fire and logging history. Dissected floodplain is underlain by coarse boulder and cobble bed material. Profuse wood loading creates structurally forced heterogeneity in geomorphic units. Channels depicted in blue are approximately located due to obscuration by vegetation cover.



2. Camp Creek - the lower watershed is an area of significant coarse sediment storage, wide partly confined floodplain, and common anabranch channels. Debris flows from adjacent hillslopes contribute bouldery material. Wood loading contributes to moderate structural forcing of geomorphic units. Early to mid-century channel placer mining caused major disruption of the channel, but has shown significant recovery over several decades. Moderate geomorphic condition.



0 100 200 Meters

**Figure B 10. Geomorphic condition variants of the Low sinuosity planform-controlled anabranching river style.**

Table B 10. Criteria and measures used to assess geomorphic condition of variants of the Low sinuosity planform-controlled anabranching river style in partly confined valley settings (adapted from Tables 10.8 and 10.9 of Brierley and Fryirs, 2005).

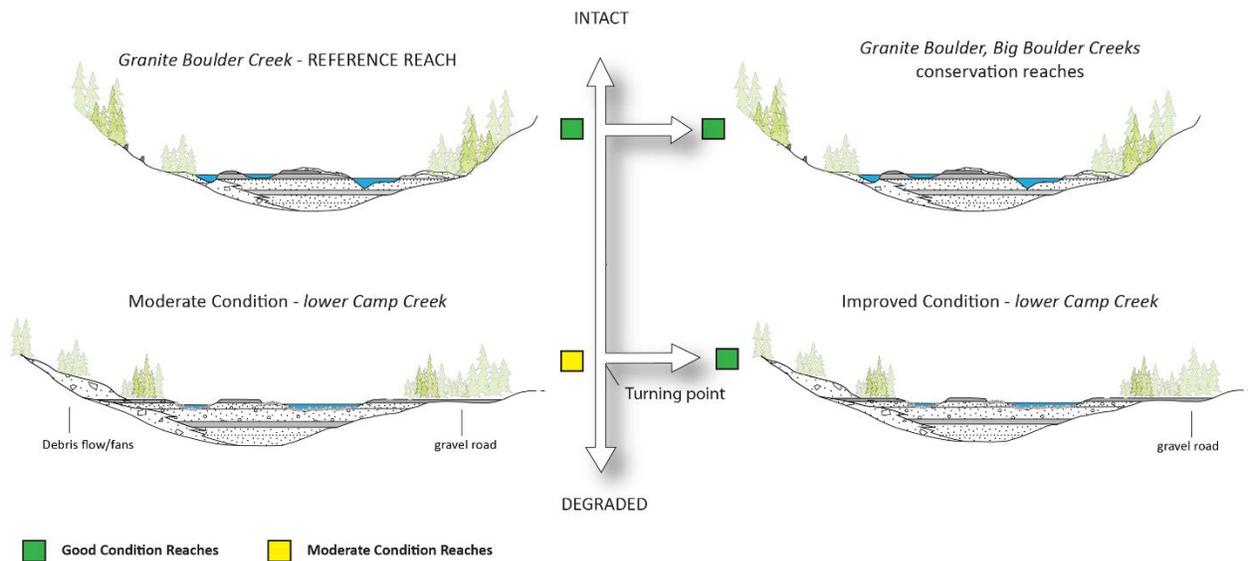
Degrees of Freedom and their relevant Ge indicators	Questions used to assess geomorphic condition of each reach.	Camp Creek	Big Boulder Creek
<b>Channel Attributes</b>	<b>2 out of 3 questions must be answered YES For stream to be assessed in GOOD condition</b>		
Size	Is channel size appropriate given the catchment area, the prevailing sediment regime, and the vegetation character?	Yes	Yes
Bank	Is the bank morphology consistent with caliber of sediment? Are banks eroding in the correct places?	Yes	Yes
Woody Debris Loading	Is there woody debris in the channel or potential for recruitment of woody debris?	Yes	Yes
		✓	✓
<b>Channel Planform (3 out of 5)</b>	<b>2 out of 3 questions must be answered YES</b>		
Number of Channels	Is the channel multi-channel as appropriate for this river style? Are there avulsions and overbank channels forming on the floodplain segments?	Yes	Yes
Geomorphic Unit Assemblage	Are the number, type and pattern of instream geomorphic units appropriate for the sediment regime, slope, bed material and valley setting? Are key units of this river style present (gravel sheets, cutbanks, bars, pools, riffles, and planar GU's)?	Yes	Yes
Riparian Vegetation	Are the appropriate types and density of riparian vegetation present on the banks?	Yes	Yes
		✓	✓
<b>Bed Character (3 out of 4)</b>	<b>3 out of 4 questions must be answered YES</b>		
Grain Size and Sorting	Is the range of sediment throughout the channel and floodplain organized and distributed appropriately?	No	Yes
Bed Stability	Is the bed vertically stable such that it is not incising or aggrading inappropriately for the channel slope, sediment caliber, and sinuosity?	No	Yes
Sediment Regime	Is the sediment storage and transport function of the reach appropriate for the catchment position (i.e., is it a sediment accumulation zone?)?	Yes	X
Hydraulic diversity	Are roughness characteristics and the pattern of hydraulic diversity appropriate for the catchment position?	Yes	Yes
		X	✓
		X	✓
<b>Geomorphic Condition</b>	Total ticks and crosses are added for each stream reach	<b>Moderate</b>	<b>Good</b>

**Table B 11. Explanation of Geomorphic condition variants for the Low sinuosity planform-controlled anabranching river style. Check and “x” boxes in the table above refer to the same symbols in Table B 10.**

Degrees of Freedom	Good Condition - Big Boulder and Granite Boulder Creeks	Moderate Condition - Camp Creek
<b>Channel Attributes</b>	Multiple channels are formed within gravel-boulder sheets. Bank erosion is focused at outside bends, at contact with hillslopes, and around mid-channel gravel bars capped by fine-grained floodplain material. <input checked="" type="checkbox"/>	Multiple channels are formed within gravel-boulder sheets. Bank erosion is focused at outside bends (where fine grained floodplain overtops gravel), at contact with hillslopes, and around mid-channel gravel bars capped by fine-grained floodplain material. Channel bed hosts vegetation, mostly where bars form islands. <input checked="" type="checkbox"/>
<b>Channel Planform</b>	Irregular, low-sinuosity anabranches intercede across a wide gravel valley fill. The primary branch is in contact with confining bedrock and hillslopes >80% of actual length. Channel is well connected to both hillslope and gravel floodplain. Riparian vegetation is well established on floodplain surface. High volumes of dead wood are available as standing and fallen logs and litter. Grass cover is thick on floodplain. Vegetation and recruitment of woody debris plays a crucial role in channel shape, sinuosity, and formation of diverse geomorphic units (i.e., bars, islands and pools). <input checked="" type="checkbox"/>	Irregular, low-sinuosity anabranches intercede across a wide gravel valley fill. The primary branch is in contact with confining bedrock and hillslopes, but also by linear piles of dredge-mined tailings. These legacy mining features have become more subtle and colonized by vegetation since cessation of activities post 1940's, but still exert control on adjustment potential for the stream. Channels are well connected to both hillslope and gravel floodplain. Riparian vegetation is well established on floodplain surface. High volumes of dead wood are available as standing and fallen logs and litter. Grass cover is thick on floodplain. Vegetation and recruitment of woody debris plays a crucial role in channel shape, sinuosity, and formation of diverse geomorphic units (i.e., bars, islands, pool-riffle sequences), and planar features (rapids and runs). <input checked="" type="checkbox"/>
<b>Bed Material</b>	Sediment is varied with channel bed composed of coarse gravel, cobble and boulders coupled with finer gravel and sand fractions in lower energy settings of the channel. Coarse sediment projects beneath narrow, discontinuous floodplain segments composed of fine sand, silt and mud. <input checked="" type="checkbox"/>	Sediment is varied with channel bed composed of coarse gravel, cobble and boulders coupled with finer gravel and sand fractions in lower energy settings of the channel. Coarse sediment projects beneath narrow, discontinuous floodplain segments composed of fine sand, silt and mud. coarse sediment forms planar geomorphic units, including rapids, runs, and pool-riffle sequences. The presence of dredge piles across the valley bottom of Camp Creek has created a hummocky surface that affects channel development and sediment distribution. <input checked="" type="checkbox"/>

**TRAJECTORY OF CHANGE DIAGRAMS – STAGE THREE**

The Gravel Anabranched river style is tied to a history of fire and more recently, clear-cut operations that may have destabilized hillslopes and led to an increase in the frequency of debris flows and overall sediment production to the channel. In any case, local anabranches occur higher in the catchment where sediment accumulation and storage appear over fit for the valley. By contrast, air photos from 1940 (USGS Earth Explorer, <http://earthexplorer.usgs.gov/>) reveal that lower Camp Creek was subject to dredge mining, which may have contributed to unusual patterns of sediment distribution leading to anabranch and multiple channels amid gravel bars. The disruption caused by dredge mining is the basis for assessing the lowermost reaches of Camp Creek in moderate geomorphic condition (Figure B 11).



**Figure B 11. Trajectory of change diagram for two variants of the Low sinuosity planform-controlled anabranching River Style.**

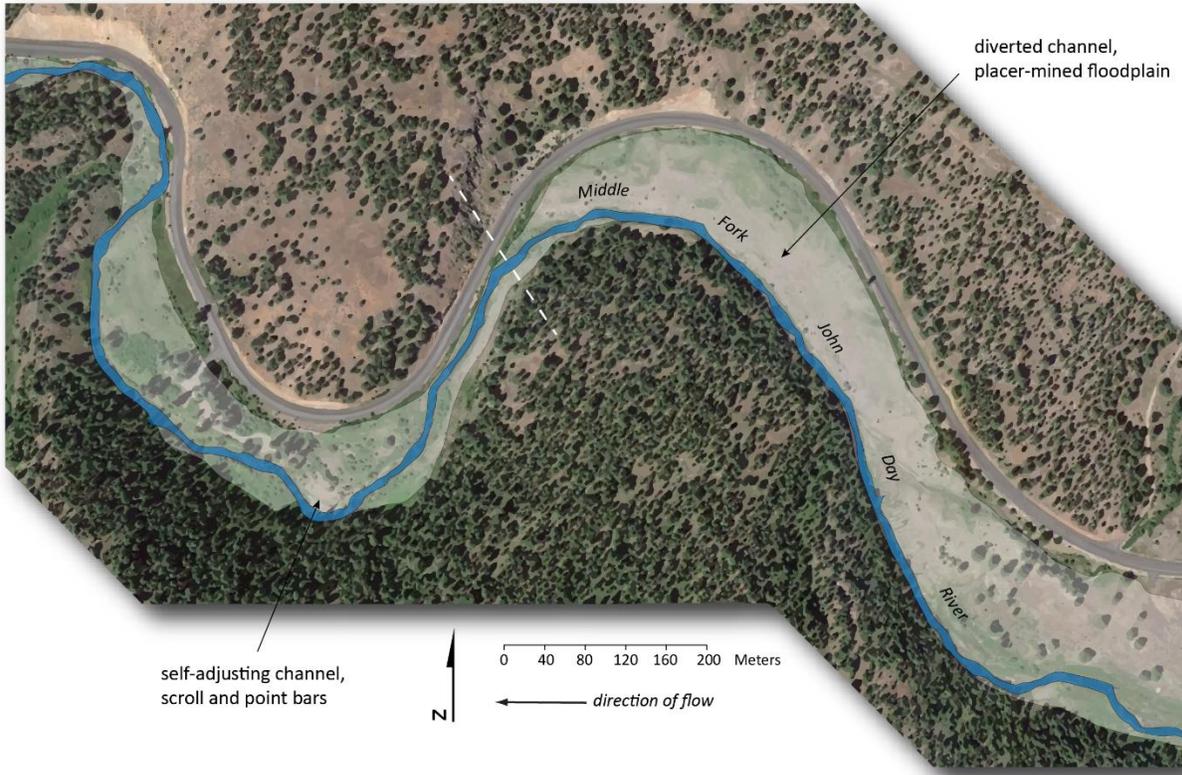
### B2.3 BEDROCK-CONTROLLED ELONGATE DISCONTINUOUS FLOODPLAIN RIVER STYLE

Several reaches of the mainstem MFJDR are characterized by bedrock control of the planform (Figure B 12 and Table B 12). For roughly half of these, the partly confined setting with low sinuosity, bedrock-controlled planform is naturally evolved. Discontinuous floodplain segments are fine-grained, underlain by coarse gravel, and surfaces are densely colonized by grasses, shrubs, deciduous trees and other riparian growth. Instream geomorphic units are generally plane bed runs, riffles, and bars. There is little instream wood to force structural change to bed material configurations. For several other reaches, the channel is partly confined by the left bank or valley wall for kilometers at a time, although the valley itself is wide and unrestrictive. These reaches were created by diverting the channel to free up alluvial floodplain areas for grazing or hayfield production. These diversions significantly changed the function and boundary conditions of the reaches. Straightening and shortening the sinuous planforms causes an increase in gradient and stream power that drives incision. Affected reaches can no longer adjust across their wide floodplains under average high flow conditions (cf.,

Figure 29-Figure 30).

#### EXPLANATION OF Geomorphic CONDITION VARIANTS

The reference reach for this river style is centered on 11T 365307 E, 4947072 N on the Middle Fork John Day River. Significant floodplain restoration efforts have occurred here. The paved county road traverses the valley, but does not significantly reduce the valley width or create greater channel confinement. The moderate-condition variant is shown by the example in Figure B 12, because attributes of both natural/good and modified/moderate geomorphic condition variants are shown side-by-side.



**Figure B 12.** Geomorphic condition of the Bedrock-controlled Discontinuous Floodplain river style. White mask shows floodplain extent. The white dashed line shows approximate downstream limit of channel diversion for mining operations that forced the river to flow along the south bank, where it exists today.

**Table B 12. Criteria and measures used to assess geomorphic condition of variants of the Bedrock-Controlled Elongate Discontinuous Floodplain river style in partly confined valley settings (adapted from Tables 10.8 and 10.9 of Brierley and Fryirs, 2005).**

Degrees of Freedom and their relevant Geoindicators	Questions used to assess geomorphic condition of each reach.	MFJDR	MFJDR, Long Creek
<b>Channel Attributes</b>	<b>3 out of 4 questions must be answered YES For stream to be assessed in GOOD condition</b>		
Size	Is channel size appropriate given the catchment area, the prevailing sediment regime, and the vegetation character? Is the channel functionally connected to floodplain pockets? (i.e., is the channel overwidened, overdeepened, or does it have an appropriate width : depth ratio?)	Yes	Yes
Shape	Is the channel shape consistent with confined valley features (typically symmetrical)?	Yes	No
Bank	Is the bank morphology consistent with caliber of sediment? Are banks eroding in the correct places?	Yes	No
Woody Debris Loading	Is there woody debris in the channel or potential for recruitment of woody debris?	Yes	No
		✓	X
<b>Channel Planform</b>	<b>4 out of 5 questions must be answered YES</b>		
Number of Channels	Is the channel appropriate for this river style? Are there signs of change such as avulsions or overbank channels forming on the floodplain?	Yes	No
Sinuosity of Channels	Is the channel sinuosity consistent with the sediment load/transport regime and the slope of the channel?	Yes	No
Lateral Stability	Is the lateral stability consistent with the sediment texture and channel slope? Are there signs of degradation such as local widening and atypical in-channel reworking of bed material?	Yes	Yes
Geomorphic Unit Assemblage	Are the number, type and pattern of instream geomorphic units appropriate for the sediment regime, slope, bed material and valley setting? Are key units of this river style present (planar riffles and runs, cutbanks, pools, point bars)?	Yes	Yes
Riparian Vegetation	Are the appropriate types and density of riparian vegetation present on the banks and floodplain?	Yes	Yes
		✓	X
<b>Bed Character</b>	<b>3 out of 4 questions must be answered YES</b>		
Grain Size and Sorting	Is the range of sediment throughout the channel and floodplain organized and distributed appropriately?	Yes	Yes
Bed Stability	Is the bed vertically stable such that it is not incising or aggrading inappropriately for the channel slope, sediment caliber, and sinuosity?	Yes	Yes
Sediment Regime	Is the sediment storage and transport function of the reach appropriate for the catchment position (i.e., is it a sediment transfer or accumulation zone?)	Yes	Yes
Hydraulic diversity	Are roughness characteristics and the pattern of hydraulic diversity appropriate for the catchment position?	Yes	Yes
		✓	✓
	Total checks and crosses are added for each stream reach	X	✓
<b>Geomorphic Condition</b>		<b>Good</b>	<b>Moderate</b>

**Table B 13. Explanation of geomorphic condition variants for the Bedrock-controlled discontinuous floodplain river style. Check and “x” boxes in the table above refer to the same symbols in Table B 12.**

Degrees of Freedom	Good Condition - MFJDR	Moderate Condition - MFJDR, Long Creek, Pass Creek
<b>Channel Attributes</b>	<p>Asymmetric cross section within a narrow, discontinuous fine-grained sand to mud floodplain. Bank erosion is focused at outside bends and at contact with hillslopes. Gravel-cobble point bars and scroll bars are capped by a veneer of fine-grained sediments. Channel bed hosts some vegetation, mostly tussock stands eroded from fine-grained sediments comprising banks. The lack of wood loading reduces hydraulic and geomorphic diversity. Direct connection to hillslopes provides coarse material for small ramps, rapids and plane bed features that dominate channel geomorphic units.</p> <p style="text-align: right;"><input checked="" type="checkbox"/></p>	<p><i>MFJDR, Long and Pass Creeks:</i> The engineered variant of this river style hosts a symmetrical, steep-walled channel that has been diverted along a single bank of the MFJDR. These reaches have been artificially straightened, resulting in a decrease in hydraulic and geomorphic diversity and an increase in gradient and corresponding stream power. The channel width is consistent with the width and sediment expected from their catchments, but the affected reaches have been decoupled from their adjacent floodplains and deepened, which limits their capacity for adjustment.</p> <p style="text-align: right;"><input type="checkbox"/></p>
<b>Channel Planform</b>	<p>Low sinuosity, bedrock-controlled planform that scrolls between opposite banks of the mainstem MFJDR. Channel is well connected to both hillslope and floodplain, and healthy riparian vegetation is established on extensive though discontinuous fine-grained floodplain surfaces. Instream wood is scarce, though, as standing and fallen logs and litter recruitment from hillslopes is low and delivery from tributaries is also low through floodplain clearing and generally low discharges. geomorphic units along the mainstem MFJDR are dominantly of planar morphology: plane bed, subtle ramps, runs and small rapids.</p> <p style="text-align: right;"><input checked="" type="checkbox"/></p>	<p>Engineered reaches have straight channels confined along bedrock or hillslopes. Although they are well connected to bedrock and hillslope confining units, they are not well connected to the extensive fine grained floodplains once created by overbank flooding and vertical accretion processes. On-site ranching operations include extensive grazing and some hayfield cultivation that are maintained at the expense of natural adjustment processes for a trunk stream in a wide, alluvial valley. Riparian vegetation is likewise reduced or cleared, reducing the amount of instream wood available for recruitment.</p> <p style="text-align: right;"><input type="checkbox"/></p>
<b>Bed Material</b>	<p>Sediment is varied with channel bed composed of coarse gravel and cobble coupled with finer gravel and sand fractions in lower energy settings. Coarse sediment projects beneath extensive, discontinuous floodplain segments composed of fine sand, silt and mud. Contribution of hillslope colluvium to channel adds important coarse gravel fraction.</p> <p style="text-align: right;"><input checked="" type="checkbox"/></p>	<p><i>MFJDR:</i> channel bed composed of coarse gravel and cobble; coarse sediment forms planar geomorphic units with little diversity. Distribution of sediments varies between coarse, planar units and over-widened areas with finer gravels forced by road and by bank disturbance.</p> <p><i>Long and Pass Creeks:</i> these reaches contain mostly coarse gravel and cobble, but unlike the mainstem, are considerably more diverse in terms of geomorphic units (point, lateral and mid-channel bars, pools and riffles).</p> <p style="text-align: right;"><input checked="" type="checkbox"/></p>

**TRAJECTORY OF CHANGE DIAGRAM – STAGE THREE**

See Figure 48 and discussion in Section 6 for trajectory of change information for the *Bedrock-controlled elongate discontinuous floodplain river style*.

### B3.1 MEANDERING GRAVEL BED RIVER STYLE

The *Meandering gravel bed river style* appears as isolated reaches of tortuous meanders across wide, laterally unconfined valleys. These streams appear under fit for the valleys they cross, and are typically intermittent streams with the exception of a reach located on the mainstem Middle Fork John Day (Figure B 13). These low-gradient streams may be fed by groundwater throughflow and near subsurface flow and are grazed annually. Evidence of paleochannels and abandoned meanders are consistent with a Holocene history of active meandering channels, but in the present day, they appear more as passive meandering channels, with little detectable adjustment in their channel patterns during the last ~80 years (e.g., USGS Earth Explorer, <http://earthexplorer.usgs.gov/>).

#### EXPLANATION OF GEOMORPHIC CONDITION VARIANTS

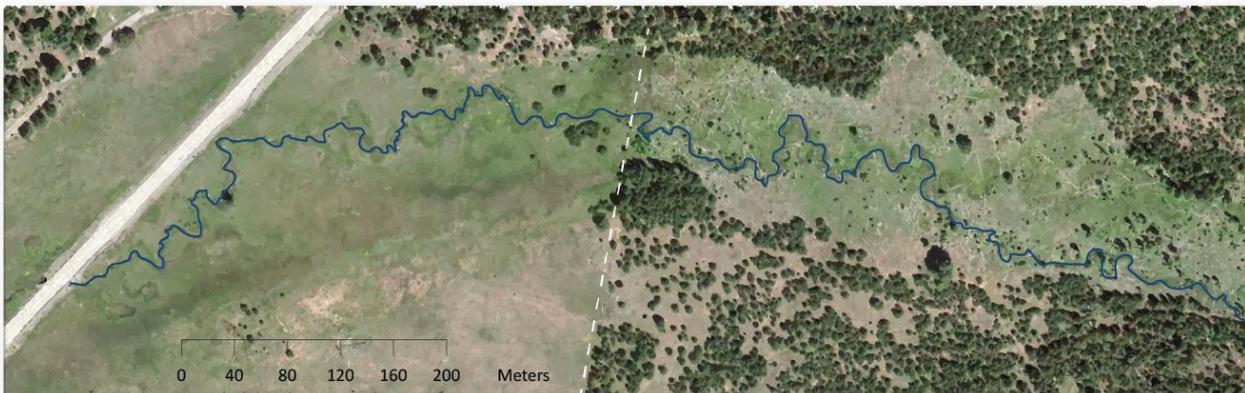
Two variants of the *Meandering gravel bed river style* were identified. The reference reach comprises a reach of Squaw Creek (11T 388631 E, 4936311 N, el. 1324 asl) and represents this river style in good geomorphic condition. This stream is intermittent and usually dry by late summer, but clearly shows contrasting management practices between private and federal ownership (top panel, left and right hand sides, respectively). On the publicly owned side (a) the channel and banks are intact and asymmetrical at bends; (b) in-channel woody debris and larger forest litter (logs) is abundant; and (c) restoration structures have been constructed, adding plunge pools and forced bars to the suite of geomorphic units. Despite being intermittent and not always available for fish, this reach represents the best overall geomorphic condition of this river style in the watershed, and is fenced off to prevent cattle from entering the stream. By contrast, on the private half (a) most floodplain vegetation and woody debris have been removed; (b) channel width is unstable and variable; (c) bank erosion is irregular and in the wrong places; and (d) the stream is hemmed in by highway 20. This reach is in moderate geomorphic condition and has high recovery potential, but is negatively impacted by grazing and clearing practices. To illustrate the moderate condition variant, we use the first 3 km of the MFJDR below the confluence of Squaw and Summit Creeks (11T 385752 E, 4937637 N, 1294 m asl) shown in Figure 57. In this reach the visible impacts are grazing, vegetation clearing from the floodplain, and lack of instream wood. Geomorphic units are dominated by plane bed runs interspersed with pool-riffle sequences, cutbanks, and point bars.

**Table B 14. Criteria and measures used to assess geomorphic condition of variants of the Meandering gravel bed river style in confined valley settings (adapted from Tables 10.8 and 10.9 of Brierley and Fryirs, 2005).**

Degrees of Freedom and their relevant Geoindicators	Questions used to assess geomorphic condition of each reach	Squaw Creek	MFJDR
<b>Channel Attributes</b>	<b>3 out of 4 questions must be answered YES For stream to be assessed in GOOD condition</b>		
Size	Is channel size appropriate given the catchment area, the prevailing sediment regime, and the vegetation character? Is the channel functionally connected to the floodplain? (i.e., is the channel overwidened, overdeepened, or does it have an appropriate width-to-depth ratio?)	Yes	Yes
Shape	Is the channel shape consistent with laterally unconfined valley features (typically asymmetrical)?	Yes	Yes
Bank	Is the bank morphology consistent with caliber of sediment? Are banks eroding in the correct places?	Yes	No
Woody Debris Loading	Is there woody debris in the channel or potential for recruitment of woody debris?	No	Yes
		✓	✓
<b>Channel Planform</b>	<b>3 out of 5 questions must be answered YES</b>		
Number of Channels	Is the channel appropriate for this river style? Are there signs of change such as avulsions or overbank channels forming on the floodplain?	Yes	Yes
Sinuosity of Channels	Is the channel sinuosity consistent with the sediment load/transport regime and the slope of the channel?	Yes	Yes
Lateral Stability	Is the lateral stability consistent with the sediment texture and channel slope? Are there signs of degradation such as local widening and atypical in-channel reworking of bed material?	Yes	No
Geomorphic Unit Assemblage	Are the number, type and pattern of instream geomorphic units appropriate for the sediment regime, slope, bed material and valley setting? Are key units of this river style present (planar riffles and runs, cutbanks, pools)?	Yes	No
Riparian Vegetation	Are the appropriate types and density of riparian vegetation present on the banks and floodplain?	No	No
		✓	X
<b>Bed Character</b>	<b>3 out of 4 questions must be answered YES</b>		
Grain Size and Sorting	Is the range of sediment throughout the channel and floodplain organized and distributed appropriately?	Yes	Yes
Bed Stability	Is the bed vertically stable such that it is not incising or aggrading inappropriately for the channel slope, sediment caliber, and sinuosity?	Yes	Yes
Sediment Regime	Is the sediment storage and transport function of the reach appropriate for the catchment position (i.e., is it a sediment transfer or accumulation zone)?	Yes	Yes
Hydraulic Diversity	Are roughness characteristics and the pattern of hydraulic diversity appropriate for the catchment position?	Yes	Yes
		✓	✓
	Total ticks and crosses are added for each stream reach	✓	X
<b>Geomorphic Condition</b>		<b>Good</b>	<b>Moderate</b>

**Table B 15. Explanation of geomorphic condition variants for the Meandering gravel bed river style. Check and “x” boxes in the table above refer to the same symbols in Table B 14.**

Degrees of Freedom	Good Condition - MFJDR, Squaw Creek	Moderate Condition - Squaw Creek
<b>Channel Attributes</b>	Steep-sided asymmetrical cross section within a fine-grained sand to mud floodplain. Bank erosion is focused at meander bends as expected, and is otherwise minimal. Channel bed is free of vegetation. Restoration structures (cross-channel emplaced logs) force plunge pools and structurally forced eddy bars. <input checked="" type="checkbox"/>	Steep-sided cross section within a fine-grained sand to mud floodplain. Bank erosion is correct for fine-grained floodplain and steep banks. Channel shape and size are inconsistent in places, as indicated by variable width, greater abundance of channel margin tussock stands and trampled banks. <input type="checkbox"/>
<b>Channel Planform</b>	Irregular, moderate to high-sinuosity planform, adjustment is gradual on scale of decades. Well-connected to floodplain. Riparian vegetation is established on floodplain surface. Dead wood is abundant as standing and fallen logs and litter. Grass cover is thick on floodplain. Vegetation and wood influences meander development; abundant recruitment of woody debris plays role in channel shape and sinuosity as well as forcing bars and pools. <input checked="" type="checkbox"/>	Irregular, moderate to high sinuosity planform, adjustment is gradual on scale of decades, not years; well connected to floodplain, channel cutoffs developed. Riparian vegetation is very scattered with few woody stands, but rich grass covers the floodplain. Natural wood has been cleared from the reach and not likely to play a role in channel shape and sinuosity. Bed is stable. Geomorphic units are not well-developed. <input type="checkbox"/>
<b>Bed Material</b>	Segregated, bi-modal sediment mix, with channel bed composed of coarse gravel and cobble; coarse sediment projects beneath floodplain composed of fine sand, silt and mud. <input checked="" type="checkbox"/>	Segregated, bi-modal sediment mix, with channel bed composed of coarse gravel and cobble; coarse sediment forms planar geomorphic units, with little diversity (pool-riffle sequences and cutbanks). <input checked="" type="checkbox"/>



A view of the **Meandering gravel bed river style** on Squaw Creek showing attributes of both good and moderate condition variants. White dotted line shows a fence line with opposing management schemes on either side. At right, the floodplain is littered by a field of full sized logs (i.e., burn fall), providing abundant natural instream wood. Diverse geomorphic units exist here, aided by dozens of installed restoration structures (mostly cross-channel logs). The downstream half (at left) has been cleared of floodplain vegetation and extensively grazed. Symmetrical bank and bed instability (deeper incision, possibly due to compacted floodplain surface).

### TRAJECTORY OF CHANGE DIAGRAM – STAGE THREE

Moderate condition reaches of Squaw Creek and MFJDR may improve over time with little or no restorative intervention, but would benefit from replanting of floodplain riparian vegetation, exclusion of intense grazing, and the addition of instream wood (Figure B 13).

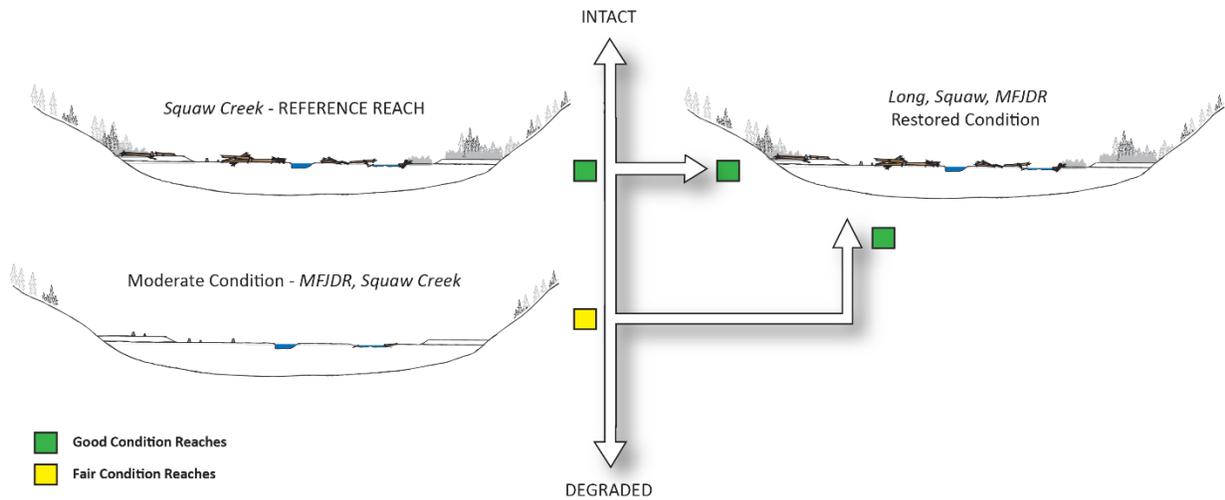


Figure B 13. Trajectory of change diagrams for variants of the Meandering gravel bed river style.

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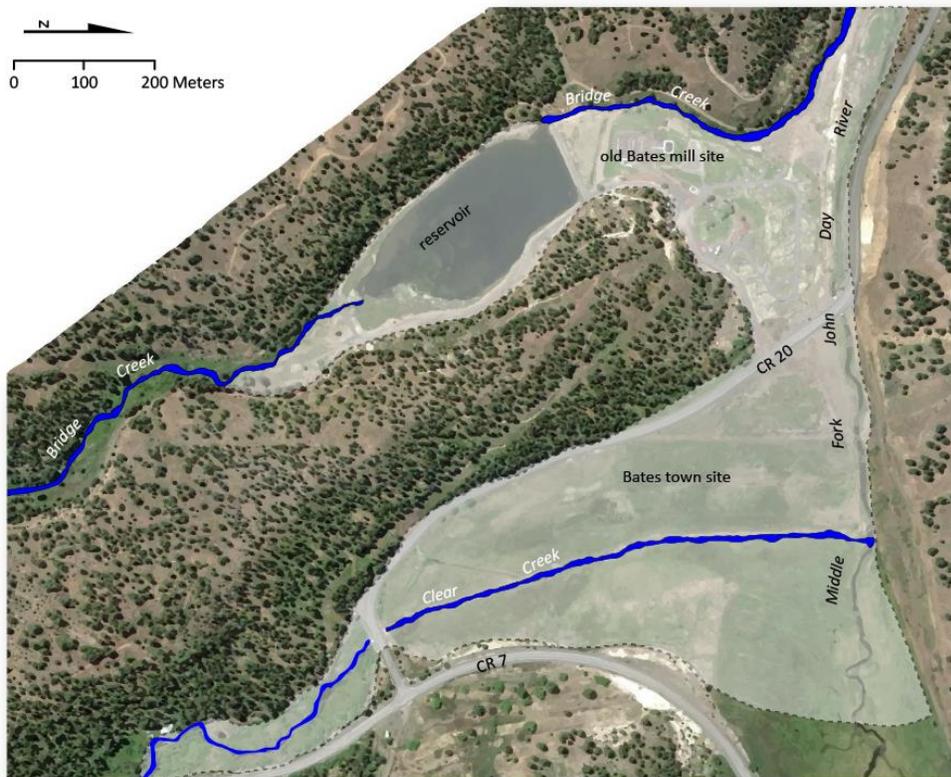
## B3.2 ALLUVIAL FAN RIVER STYLE

### EXPLANATION OF GEOMORPHIC CONDITION VARIANTS

Alluvial fans are widespread in the MFJDW where tributaries meet the mainstem). Two variants are observed in MFJDW: a good condition variety where the geomorphic features typical of alluvial fan settings is intact (reference condition at mouth of Big Boulder Creek 11T 363934E, 4947710N), and a second, poor-condition variant caused by extensive development on fan surfaces (Figure B 14). We use the example of the Bates sawmill and town site at the mouths of Clear and Bridge Creeks (380170E, 4938641N). The *Alluvial Fan river style* is a natural target for development along the mainstem (provides a tributary water source, rich alluvial environment for agriculture in some cases, and a landscape position above the mainstem flood plain). Adjacent, possibly coalesced alluvial fans at the mouths of Clear and Bridge Creeks were the sites of a mill and town complex. The streams have been diverted and straightened to accommodate the development.



1. Big Boulder Creek - although marginally developed, this reach possesses the characteristic features of a **good condition** alluvial fan: distributary and secondary channels contain abundant wood loading, heterogeneous geomorphic units, and large grain size distribution. Decreased gradient and increased accommodation space near the confluence give rise to diverse geomorphic units and multiple channel configurations.



2. Bridge and Clear Creek alluvial fans - adjacent tributary mouths hosted the Bates townsite and Mill in the early century. These **poor-condition** variants have been relegated to a campground and pasture, where single thread channels are straightened or diverted to accommodate developed areas. Distributary channel patterns are absent, floodplains are developed or in pasture, geomorphic units are generally planar, and bed material is heterogeneous.

Figure B 14. Geomorphic condition variants for the Alluvial Fan river style. White mask indicates extent of floodplains.

Table B 16. Criteria and measures used to assess geomorphic condition of variants of the Alluvial fan river style in confined valley settings (adapted from Tables 10.8 and 10.9 of Brierley and Fryirs, 2005).

Degrees of Freedom and their relevant Geoinicators	Questions used to assess geomorphic condition of each reach	Big/Granite Boulder	Clear/Bridge Creeks
<b>Channel Attributes</b>	<b>2 out of 3 questions must be answered YES For stream to be assessed in GOOD condition</b>		
Size	Is channel size appropriate given the catchment area, the prevailing sediment regime, and the vegetation character?	✓	✓
Bank	Is the bank morphology consistent with caliber of sediment? Are banks eroding in the correct places?	✓	X
Woody Debris Loading	Is there woody debris in the channel or potential for recruitment of woody debris?	✓	X
		✓	X
<b>Channel Planform</b>	<b>2 out of 3 questions must be answered YES</b>		
Number of Channels	Are distributary channels present as appropriate for this river style? Are there signs of change such as avulsions or overbank channels forming on the floodplain?	✓	X
Geomorphic Unit Assemblage	Are the number, type and pattern of instream geomorphic units appropriate for the sediment regime, slope, bed material and valley setting? Are key units of this river style present (bars, planar GU's, pools, cutbanks)?	✓	X
Riparian Vegetation	Are the appropriate types and density of riparian vegetation present on the banks (evidence of a dynamically shifting floodplain?)	✓	X
		✓	X
<b>Bed Character</b>	<b>3 out of 4 questions must be answered YES</b>		
Grain Size and Sorting	Is the range of sediment throughout the channel and floodplain organized and distributed appropriately?	✓	X
Bed Stability	Is the bed vertically stable such that it is not incising or aggrading inappropriately for the channel slope, sediment caliber, and sinuosity?	✓	✓
Sediment Regime	Is the sediment storage and transport function of the reach appropriate for the catchment? position (i.e., is it a sediment transfer or accumulation zone?)?	✓	X
Hydraulic Diversity	Are roughness characteristics and the pattern of hydraulic diversity appropriate for the catchment position?	✓	X
		✓	X
	Total checks and crosses added for each reach	✓	X
<b>Geomorphic Condition</b>		<b>Good</b>	<b>Poor</b>

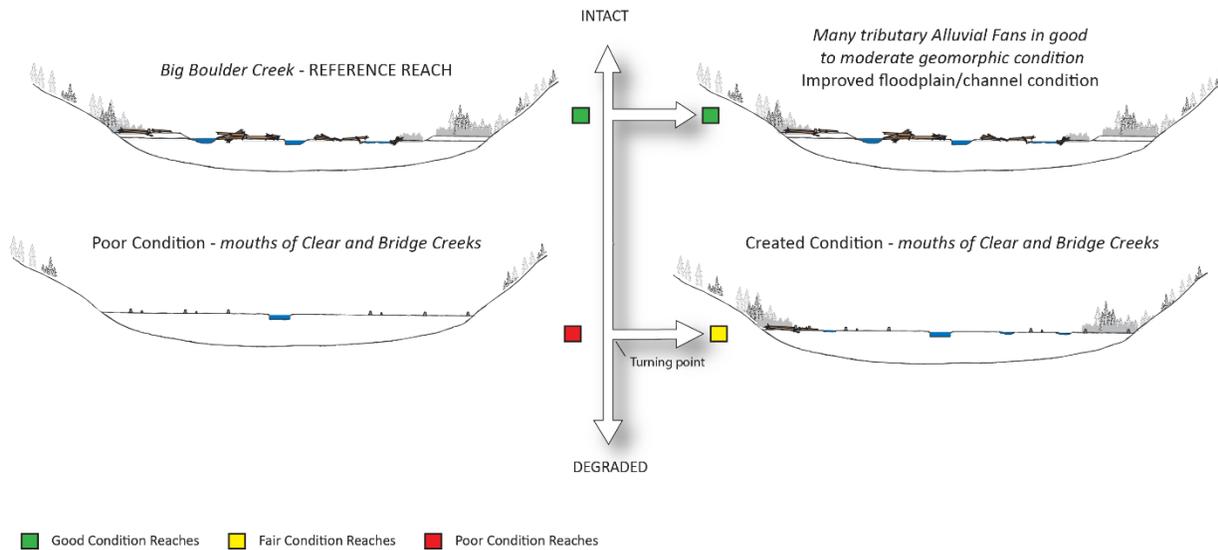
**Table B 17. Explanation of geomorphic condition for variants of the Alluvial Fan River Style. Check and “x” boxes in the table above refer to the same symbols in Table B 16.**

Degree of Freedom	Good Condition - Big Boulder Creek	Poor Condition - Bridge/Clear Creeks
<b>Channel Attributes</b>	<p>Steep-sided, mostly symmetrical cross section within a coarse-grained sand to gravel floodplain. Bank erosion is focused at meander bends and is consistent along straighter sections of the reach. Channel bed is free of vegetation except for some bank erosion resulting in channel margin tussocks. Geomorphic units consist of plane bed features: runs and gentle rapids. A few point, lateral, and mid channel bars form with riffles, but the generally the channel flows within well-defined banks. The creek is single thread, but distributary channels are present as expected for this river style.</p>	<p>Low angle cross section within a fine-grained sand to mud floodplain. Bank erosion is correct in the very few pool-riffle sequences, but areas of local straightening, canal diversion, roadway forcing, and culvert containment of the stream have changed sediment distribution throughout the reach and bank characteristics. The area is heavily grazed, resulting in uniform, subtle bank characteristics. Channel shape and size are generally consistent, but the channel is single-thread, and contains no distributary channels typical of alluvial fan settings.</p>
<b>Channel Planform</b>	<p>Irregular, low -sinuosity planform within narrow, sand and gravel floodplain. Floodplain is overlain by a veneer of fine-grained sediment near mouth. Riparian vegetation is established and healthy. Dead wood is abundant as standing and fallen logs and litter. Grass cover is thick on floodplain. Vegetation and recruitment of woody debris plays a significant role in channel shape and sinuosity as well as forcing point bars, pool-riffle sequences, and plane-bed features - runs and glides.</p>	<p>Irregular, straightened planform that is well-connected to floodplain. The area is used for pasture. Riparian vegetation is absent and pasture grass covers the floodplain. Natural wood is absent in these reaches and has no role in channel shape and sinuosity. Bed is stable. Instream geomorphic units are limited to planar features--runs and a few lateral and point bars.</p>
<b>Bed Material</b>	<p>Segregated, bi-modal sediment mix, with channel bed composed of coarse gravel and cobble; coarse sediment projects beneath Floodplain composed of fine sand, silt and mud.</p>	<p>Channel bed composed of coarse gravel and cobble that forms planar geomorphic units having little diversity.</p>

**TRAJECTORY OF CHANGE DIAGRAM – STAGE THREE**

Variants of the Alluvial Fan river style are distinct in the MFJDW. Those in good or moderate condition are on a trajectory to improve, provided their hosting catchments are managed accordingly. This is especially true if they are receiving restoration treatment, such as the Alluvial Fan surface at the mouth of Granite Boulder Creek.

Moderate to poor condition reaches that suffer from development will not become degraded if they are treated as “Created” conditions. Such an effort was generally successful for the mouths of Bridge and Clear Creeks after the mill and town were removed. Little attention was devoted to restoring the character and behavior of the Alluvial Fan river style at either site, but they represent important transit routes for fish to the upper watersheds.



**Figure B 15. Trajectory of change diagram for the Alluvial fan river style.**