Technical Report No. ENV-2025-076

Chewuch River Design Concepts – River Miles 9.5 to 1

Methow River Sub-Basin, Okanogan County, Washington
Columbia-Pacific Northwest Region

U.S. Department of the Interior

September 2025

Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; honors its trust responsibilities or special commitments to American Indians, Alaska Natives, Native Hawaiians, and affiliated Island Communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Cover Image – A view of the Chewuch River at approximately river mile 2.75 in Okanogan County, Washington (C. Byrne/Bureau of Reclamation).

Technical Report No. ENV-2025-076

Chewuch River Design Concepts – River Miles 9.5 to 1

Methow River Sub-Basin, Okanogan County, Washington
Columbia-Pacific Northwest Region

Prepared by:

Bureau of Reclamation
Technical Service Center
Denver, Colorado

U.S. Department of the Interior September 2025

Technical Report No. ENV-2025-076

Chewuch River Design Concepts – River Miles 9.5 to 1

Methow River Sub-Basin, Okanogan County, Washington
Columbia-Pacific Northwest Region

Prepared by: Colin Byrne, PhD
Hydraulic Engineer, Sedimentation and River Hydraulics Group, 86-68240

Prepared by: Nathan Holste, PE, MS
Hydraulic Engineer, Sedimentation and River Hydraulics Group, 86-68240

Peer Review Certification

This section has been reviewed and is believed to be in accordance with the service agreement and standards of the profession.

Peer reviewed by: D. Nathan Bradley, PhD
Geomorphologist, Sedimentation and River Hydraulics Group, 86-68240

Acknowledgments

This work was completed with important contributions from members of the Methow Salmon Recovery Foundation, Natural Systems Designs, and Wolf Water Resources as well as regional Bureau of Reclamation staff.

Acronyms and Abbreviations

ft	foot/feet
ft^3/s	cubic feet per second
LCRA	Lower Chewuch Reach Assessment
MSRF	Methow Salmon Recovery Foundation
Reclamation	Bureau of Reclamation
RM	River Mile
UCRTT	Upper Columbia Regional Technical Team
U.S.	United States
USGS	U.S. Geological Survey

Contents

Page

Tables

Figures

Appendices

1.0 Introduction

The Bureau of Reclamation's (Reclamation) Technical Service Center was tasked with generating restoration design concepts to complement the Lower Chewuch Reach Assessment (LCRA). The LCRA was largely written by Methow Salmon Recovery Foundation (MSRF). However, Reclamation also supported MSRF by providing hydraulic modeling of the Chewuch River and hydraulic and geomorphic analyses along the river (Byrne and Hurst 2025). The restoration design concepts discussed within this report are the product of discussions with MSRF and other project partners. As discussed within the LCRA and below, the overall goal of the restoration concepts is to improve habitat and assist in the recovery of Bull Trout, Upper Columbia Spring Chinook, and Upper Columbia Summer Steelhead through the enhancement of several river factors that influence the life stages of these species.

1.1 Lower Chewuch River Geomorphic Setting

The Lower Chewuch River is considered here to be the most downstream twenty miles of river from Winthrop upstream to Twentymile Creek (figure 1). The Chewuch River basin at its confluence with the Methow River has a contributing drainage area of 524 square miles and a mean basin elevation of 5290 feet (ft), which drives a predominantly snowmelt driven hydrograph (U.S. Geological Survey 2019). The Chewuch River between River Mile (RM) 20 and 0 can be characterized by stretches of pool-riffle morphology interspersed with stretches of more uniform width and depth. Those river morphologies are created due to the contributing hydrologic and geologic characteristics. River slope often drives changes in river morphology along the Chewuch River. The average slope of the lower 20 miles is 0.0056, but tributaries drive slope breaks and the lower 9 miles have reaches with ranging from 0.004 to 0.018. Valley confinement can also provide geological control on river form with valley walls and tributary fans being common along the Chewuch River. Finally, grain sizes along the river are predominantly in the large gravel to moderately sized cobbles, but downstream from tributaries and in higher stream power locations large cobbles and boulders are present as well.

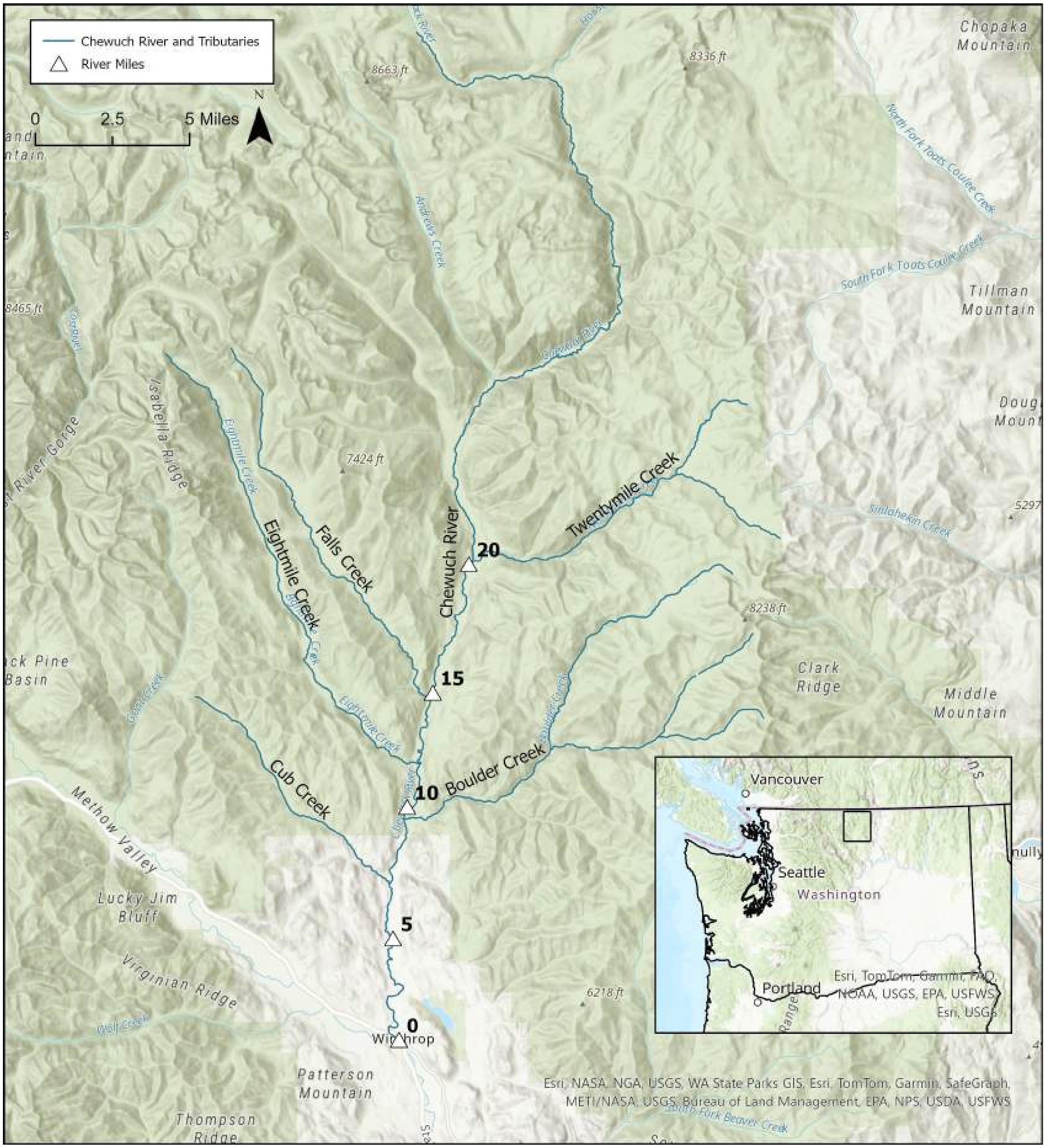


Figure 1.—Overview of the Chewuch River. River Mile 0 is at the confluence with the Methow River and river miles increase in the upstream direction.

1.2 Lower Chewuch River Concept Locations

Restoration design concepts included within this report focus on two sections of river between river mile (RM) 9.5 and RM 1, which is located a mile upstream of the Chewuch River confluence with the Methow River. Above RM 9.5, previous large wood-focused concepts were already developed (Byrne et al. 2024). The two sections of river this report focuses on are from RM 9.5 to 7.5 and RM 5.5 to 1. The section of river between RM 7.5 and 5.5 was understood to already have a restoration effort underway, so concepts were not developed along that stretch of river. The concepts were organized into restoration project areas based on the prioritization reaches defined in the broader LCRA. Prioritization reaches are used within the LCRA to describe two assessment units, Chewuch-Pearrygin and Chewuch-Doe, which are components of the Habitat Action Prioritization within the Upper Columbia River Basin (UCRTT 2021a; UCRTT 2021b). Figure 2 shows the location of the project areas and the concept maps included in appendices A and B. The project areas are delineated by RM and generally correspond to different prioritization reaches within the Pearrygin assessment unit:

- RM 9.5–8.5: Pearrygin 8
- RM 8.5–7.5: Pearrygin 7
- RM 5.5–4: Pearrygin 4
- RM 4–.5: Pearrygin 3
- RM 2.5–1: Pearrygin 2

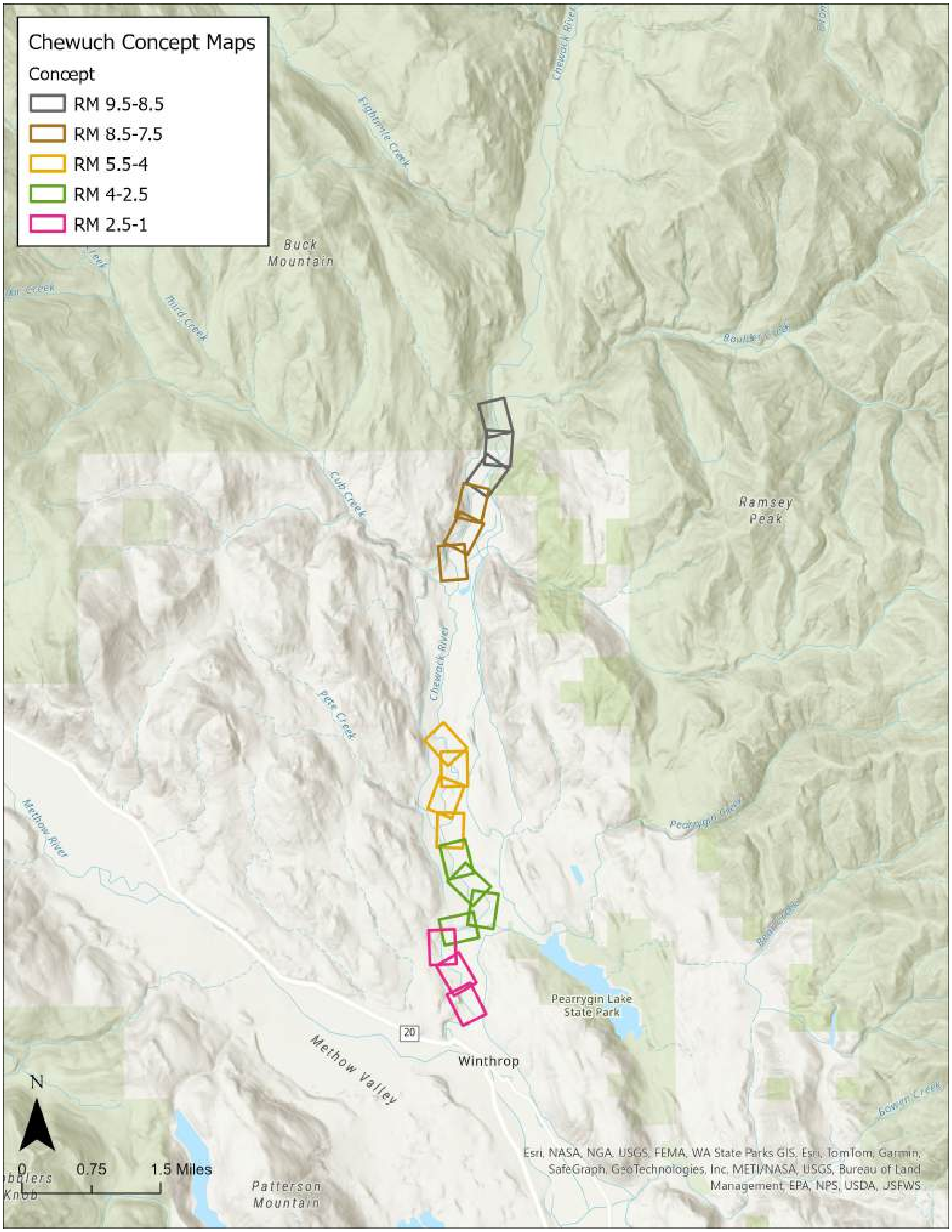


Figure 2.—Concept locations between Chewuch RM 9.5 and 1 developed for the Lower Chewuch Reach Assessment. See appendices A and B for maps and concept details within each polygon.

1.3 Lower Chewuch River Hydrology

Hydrologic analysis for the hydraulic modeling and geomorphic assessment that supported the LCRA documented ecologically relevant flows at the Chewuch River gage (U.S. Geological Survey [USGS] gage 12448000) (Byrne and Hurst 2025; LCRA 2025). The Chewuch River gage is located at approximately RM 0 at the confluence of the Chewuch River with the Methow River in Winthrop, WA. As part of the hydraulic modeling of the reach, the gage flow was partitioned into contributing area-weighted flows at the major tributary locations. The proportioned flows represented estimates of the contributions of the largest, ungauged tributaries in the basin.

The restoration concepts developed between RM 0 and 9.5 include two of these large Chewuch River tributaries: Boulder Creek and Cub Creek. Boulder Creek is located at approximately RM 9.5 and provides the upper boundary of the concept development. Cub Creek flows into the Chewuch River at approximately RM 7 and was the last large tributary included in the area-weighted proportioning of flows. Therefore, the restoration concepts developed from RM 9.5 to 7.5 were informed using the hydrology between Boulder Creek and Cub Creek, while the concepts from RM 5.5 and 1 were informed with the flow totals downstream from Cub Creek, which are also equal to those at the Chewuch River gage (table 1).

Table 1.—Hydrology of reaches of interest in restoration concept development (adapted from Byrne and Hurst 2025)

Flow Description	Estimated Flow Between Boulder Creek and Cub Creek (cubic feet per second [ft³/s])	Estimated Flow Downstream from Cub Creek at Chewuch Gage (ft³/s)
Mean annual low	43	47
September mean	72	79
August mean	114	126
March mean	129	142
July mean	373	412
April mean	540	596
1.01-yr event	625	689
1.05-yr event	1208	1333
1.11-yr event	1597	1762
1.25-yr event	2159	2382
1.5-yr event	2798	3087
2-yr event	3605	3977
2023 peak	5385	5940
5-yr event	5562	6136
10-yr event	6569	7247
25-yr event	7807	8612
50-yr event	9282	10240
100-yr event	10669	11770

1.4 Lower Chewuch River Hydraulic Modeling

The modeling conducted for the LCRA geomorphology and hydraulics report was used to inform restoration concept development (Byrne and Hurst 2025). The modeling terrain was developed from a combination of 2022 topobathymetric and 2018 topographic lidar datasets. Several direct products of the hydraulic modeling were used to inform concept development including depth, velocity, inundation extent, and water surface elevation. Secondary products created using hydraulic model outputs and used in concept development included unit stream power and relative elevation maps. All hydraulic model outputs will be included with a geodatabase supplementary to the full LCRA.

The restoration concept maps included in appendices A and B display two of the products that informed concept development: the September mean flow depth and the relative elevation of the ground surface to the July mean water surface elevation. The September mean flow was chosen as an indicator of the lowest average monthly flow. For the RM 0 to 9 reaches, large wood and rock structures were placed to always interact with flow throughout the year. Higher flow depths and velocities were also used to understand different scenarios, while bankfull unit stream power was used to best understand transport capacity throughout the project areas. Finally, higher flow inundation extents and the relative elevation mapping was used to understand floodplain surface elevations in relation to side channel activation and potential enhancement.

The concepts were developed with river conditions defined by the latest lidar flight in 2022 and hydraulic modeling and geomorphic analysis based on the lidar dataset (Byrne and Hurst 2025). Because of the dynamic nature of rivers, topography along the river may have shifted since the lidar flight. Additionally, in at least one location, construction of an altered diversion-canal system was not included in the 2022 terrain.

1.5 Large Wood Risk Assessment

A large wood risk assessment was also completed for the LCRA geomorphology and hydraulics report (Byrne and Hurst 2025). The large wood risk assessment quantified risk potential based on Reclamation's Property Damage Risk Matrix (Reclamation 2014). Hydraulic modeling results including depth and velocity, as well as river characteristics like slope, longitudinal distance, and lateral distance, were used calculate a risk score for property damage. The results of the risk analysis are shown in figure 3 (Byrne and Hurst 2025).

As is indicated by the red shading in figure 3, the two most upstream restoration sites have the greatest risk found in the lower 20 miles of the Chewuch River. The high risk between RM 9.5 and 7.5 is due to both high stream power and infrastructure along the river, which elevate the stream response risk and property risk, respectively. The property risk remains relatively high for the entirety of the RM 0 to 9 reach, which is to be expected as the river approaches the more populated portions of the Chewuch River valley near Winthrop, WA. Decreases in property risk between RM 5.5 and 2.5 indicate good locations for broader floodplain restoration due to a lack of infrastructure, but risk to infrastructure further downstream should still be considered. Because of these risk factors, restoration concept development for the project areas considered only engineered large wood structures rather than self-ballasted loose large wood placement.

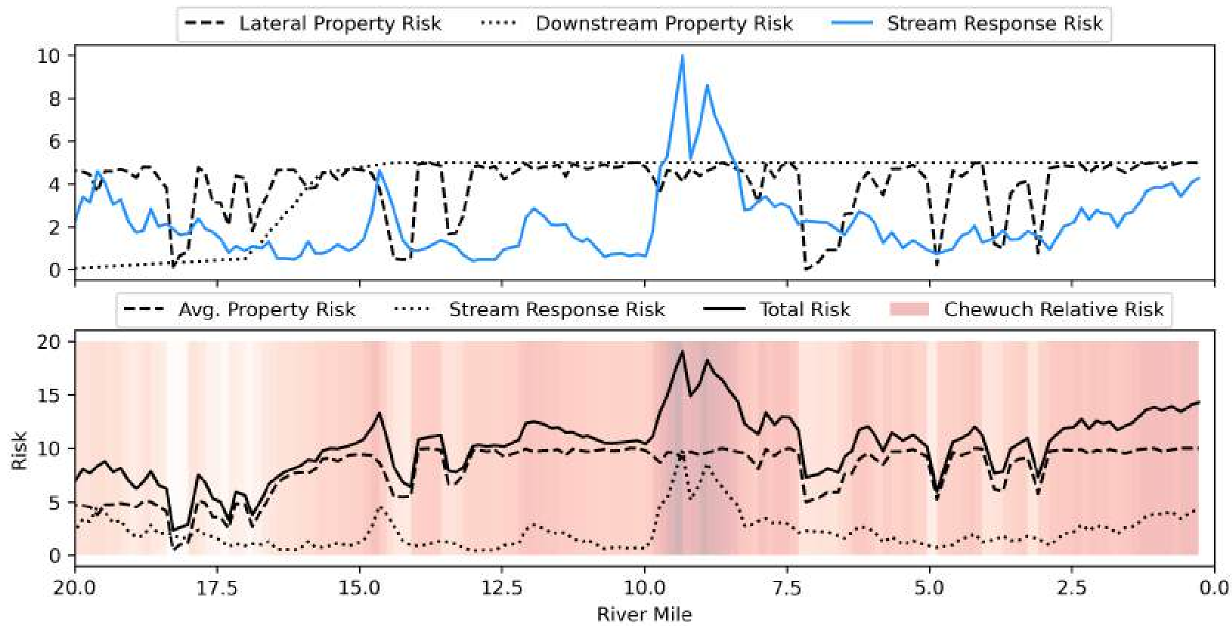


Figure 3.—Components of risk computation and overall risk score calculated at each 1/8-mile segment. The top plot shows the individual risk scores for lateral and downstream property risk as well as stream response risk. The bottom plot shows property risk and stream response risk, which are combined to estimate total risk. Darker shades of red represent more risk. (from Byrne and Hurst 2025).

2.0 Chewuch River Restoration Framework

The restoration concepts were developed in supplement to the LCRA, which provides the full framework for restoration needs and objectives within RM 0 to 9.5. However, a summarized approach to restoration needs and objectives is presented below. In addition, this report documents the specific actions within the restoration design concept maps to help interpret how each restoration action is addressing the needs and objectives.

2.1 Restoration Needs

The LCRA developed revised limiting factors for each of the reaches in the lower 20 miles of the Chewuch River including those that are the focus of these conceptual restoration designs: Pearrygin 2, Pearrygin 3, Pearrygin 4, Pearrygin 7, and Pearrygin 8 (table 2). Restoration needs are largely defined by the target species of interest, which include Bull Trout (*Salvelinus confluentus*), Upper Columbia Spring Chinook (*Oncorhynchus tshawytscha*), and Upper Columbia Summer Steelhead(*Oncorhynchus mykiss*). Based on the LCRA's analysis of current Chewuch River conditions and the development of reach-based ecosystem indicators, limiting factors were developed for each prioritization reach.

The rating given to each Pearrygin and Doe reach for each limiting factor are shown in table 2. All the reaches with design concepts presented here were rated unacceptable regarding summer base flow and rearing temperature conditions. Most of the reaches of interest are also rated unacceptable for pool quantity and quality and wood cover conditions. Other largely at-risk limiting factors for these reaches include floodplain connectivity, the riparian condition, and riparian canopy cover. Pearrygin 2, 3, 7, and 8 were also rated as either unacceptable or at risk for bed conditions including grain embeddedness and the quantity of fines in a reach. For fish spawning, reaches would not have too coarse or too fine material, but have a large percentage of gravels or small cobbles.

Table 2.—Limiting factors for the Pearrygin and Doe reaches as defined in the LCRA

Prioritization Limiting Factor	Pearrygin 1	Pearrygin 2	Pearrygin 3	Pearrygin 4	Pearrygin 5	Pearrygin 6	Pearrygin 7	Pearrygin 8	Pearrygin 9	Pearrygin 10	Pearrygin 11	Doe 1	Doe 2	Doe 3	Doe 4	Doe 5	Doe 6
Bank Stability	🟢	🟢	🟢	🟢	🟡	🟡	🟡	🟢	🟡	🟡	🟡	🟢	🟢	🟢	🟢	🟢	🟢
Coarse Substrate	🟢	🟢	🟢	🟢	🟢	🟢	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Embeddedness	🔴	🔴	🟡	🟢	🟢	🟢	🟡	🔴	🟢	🟢	🟡	🔴	🔴	🔴	🔴	🟡	🟢
Fines	🟡	🔴	🟡	🟢	🟢	🟢	🔴	🔴	🟡	🟡	🟡	🔴	🔴	🟡	🔴	🔴	🟡
Floodplain Connectivity	🟢	🟢	🟡	🟡	🟡	🔴	🔴	🟡	🟢	🔴	🔴	🟢	🟡	🟢	🟢	🟢	🟢
Off/Side Channels	🟢	🟢	🟡	🟢	🟢	🟡	🟡	🟡	🟢	🟡	🟢	🟡	🟢	🟢	🟡	🟢	🟢
Pool Quantity and Quality	🟢	🔴	🟡	🔴	🔴	🔴	🔴	🟡	🟡	🟡	🟡	🟡	🟡	🔴	🟡	🟡	🔴
Riparian Condition	🔴	🔴	🟡	🟡	🟢	🟡	🟡	🔴	🟡	🟡	🟡	🟡	🟢	🔴	🟡	🟡	🟡
Riparian – Canopy Cover	🔴	🔴	🟡	🟡	🟡	🟡	🔴	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡
Summer Base Flow	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡
Temperature - Rearing	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴
Wood - Cover	🟡	🔴	🔴	🟡	🔴	🔴	🔴	🟡	🔴	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡

🟢 Adequate | 🟡 At Risk | 🔴 Unacceptable

2.2 Restoration Objectives

The goals of the restoration design concepts are to improve river conditions for the benefit of the salmonid species of interest and address the limiting factors considered for each reach. However, individual restoration actions can also address specific restoration objectives common to a process-based understanding of river corridors and the characteristics that are symptomatic of beneficial fish habitat. Those process-based habitat characteristics include the hydraulic, geomorphic, biological, and water temperature conditions of the river. The restoration objectives for each of these characteristics are described below.

2.2.1 Hydraulic and Geomorphic Objectives

A main objective of the design concepts was to create more dynamic and heterogeneous hydraulic flow conditions within the Chewuch River main and side channels. Specific restoration actions that can greatly impact river hydraulics include the addition of large wood structures or boulders. In addition, a new or more frequent connection to a side channel can also drive hydraulic complexity in those locations. For large wood or boulders, the addition of structure and roughness within the main channel will decrease flow conveyance at that location but increase conveyance adjacent to the structures. This will drive differences in flow depths and velocities across a river cross-section to provide a wider distribution of flow environments within a channel. Increasing flow through side channels will redistribute flow conditions at the flow split at the channel entrance but also increase flow through more complex off-channel habitats. However, the amount of flow diverted off the main channel should be considered during periods of lower discharge in the river.

Geomorphic objectives and specific actions are often closely linked with changes in river hydraulics. Creating more diversity in flow conditions is also likely to create greater amounts of sediment sorting within the channel. Large wood and boulder additions will also have geomorphic effects. Scour pools generally form around wood, providing increased depths that also have the benefit of providing cover. Individual boulders, while unlikely to create a deep scour pool, are a geomorphic feature themselves, which will alter flow velocities in the surrounding area leading to local sediment sorting as well. Other restoration actions can also impact the geomorphology of the riparian and floodplain areas. Large wood structures can help build a floodplain, while infrastructure removal or benching of a channel bank can directly alter the surfaces and provide increased connectivity within a river system. In addition, the placement of structures within the channel can initiate more dynamic river processes and alter channel banks or initiate indirect changes in river form. A more diverse and dynamic geomorphic river corridor will likely produce a more diverse and dynamic biological system as well.

2.2.2 Biological Objectives

As noted, the overall goal of the LCRA and these restoration design concepts is to promote suitable habitat for and recovery of Bull Trout, Upper Columbia Spring Chinook, and Upper Columbia Summer Steelhead. While it is the objective of the complete restoration concept designs to propose enough improvement in river conditions to achieve that goal, individual restoration actions are likely to be beneficial to specific species or life stages of the target species. For example, a deep scour pool near a wood structure might be good habitat for adult holding, while riparian and side channel connections are likely better for juvenile rearing. Each of the restoration actions introduced above has a biological impact on the river corridor and will promote increased beneficial habitat to the fish species.

2.2.3 Temperature Objectives

As shown in table 2, water temperature is a major limiting factor across all prioritization reaches of the Chewuch River. The LCRA documents specific locations within the lower 20 miles of the Chewuch River that provide cold water inputs. However, none of those cold-water input locations occur within the design concept locations here. Therefore, no direct temperature restoration actions, such as increased canopy or large wood cover at a cold-water input, are introduced here. However, several of the restoration actions taken across the reaches discussed in this report will impact river temperatures. In general, large wood should help to provide cover and shade to the water column to prevent further warming. Wood structures that develop a deeper scour pool will also produce colder water habitat in those locations. Increased riparian and canopy cover can help provide cover and shade. Side channel grading may allow connection to shaded cold-water patches as well.

2.3 Restoration Actions

The restoration design concepts developed within this report are focused on four types of instream, riparian, and floodplain actions as defined in the LCRA: (1) instream habitat complexity, (2) riparian restoration, (3) side channel and off-channel habitat restoration, and (4) floodplain restoration and reconnection. Restoration actions identified within this report include increasing instream habitat through the addition of large wood and boulders, creation of or improving riparian habitat, and improving connectivity and side channel habitat through the grading of the existing topography. Each of the proposed actions is discussed below with descriptions of what the structure or treatment might include.

2.3.1 Large Wood

Different types of large wood structures are used throughout the restoration community. Within this document, we have selected several engineered structure types that may serve as conceptual placeholders for more specific project designs. The size and location of the structures within this report is meant to represent a unique symbol on the design maps in the appendices. However, if a design moves forward to a project scale, practitioners should perform project-scale analyses to determine the most appropriate structure designs and specific locations. Several types of jams are described below. All wood, apart from floodplain wood assumed to be added with side channel enhancement, were placed to be in contact with river surface water at low flow. Under high flow conditions, many of these structures are completely within the river flow or at least a substantial amount of the structure interacts with the river.

Larger wood jams like apex, bar-development, and deflector jams will have substantial effects on river hydraulics, especially at high flows when sediment is being transported. Therefore, those structures also will likely influence not just hydraulics, but sediment sorting within the channel. Smaller wood structures like those made for bank habitat or within side channels are likely to have local scouring around individual logs but may not alter channel form to the same degree.

The large wood risk assessment introduced above considers the potential risk of large wood to infrastructure based on stream power conditions but does not consider instream risk of large wood to river recreators and boaters. While river users were discussed during concept development, it was decided that the reaches were appropriate for large wood structures, but that recreator and boater risk should be considered a project level constraint. Therefore, future project development should further consider large wood structure risk to river users.

2.3.1.1 *Apex Jam*

Apex jams are large structures at the apex of a mid-channel bar or other location where a goal is to accentuate or create a flow split. Apex jams typically develop large scour pools at the upstream extent of the jam as well as cover within this pool, especially if root wads are included in the upstream facing portion of the jam. These jams can mimic natural wood racking that might occur at a bar apex, but also once in place rack more wood to increase the size of the jam as well. If a bar does not already exist at a location where an apex jam is constructed, a downstream wake zone and eddy may lead to the creation of a bar behind the structure, with local flow acceleration around the sides. Typically, apex jams were placed at the apex of an existing mid-channel bar or on a point bar to encourage split flow around the jam. In addition, these structures were also at times place immediately downstream from a side channel connection to help enhance connectivity.

2.3.1.2 *Bank Habitat Structure*

Bank habitat structures are typically smaller structures embedded into the channel bank to create scour pools and provide cover habitat. Bank habitat structures impact local hydraulics and channel form but are likely not large enough to substantially alter the hydraulics and form of the entire channel. Bank habitat structures are often important in systems with degraded riparian connectivity and cover. Placement of these features often focused on locations with banks that lacked cover, shade, or riparian complexity, especially locations with deeper water that could provide more habitat.

2.3.1.3 *Bar-Development Jam*

A bar-development jam is a relatively large jam that is constructed along a channel bank. Typically, the structure would protrude into the main channel and push flow toward the opposite bank while simultaneously creating lower velocities behind the jam, especially at high flows. Either with excavated material placed behind the jam or by natural deposition in the downstream shadow of the structure, a bar can develop, and a higher surface created. This type of feature can therefore be used to constrict the channel and concentrate flow along the opposite bank. This type of jam often takes up a significant portion of the original channel width so it can have large effects on the river thalweg and channel shape. Placement of bar-development jams along the Chewuch River focused on locations where the river is relatively straight and forcing water toward the opposite bank may increase geomorphic processes.

2.3.1.4 *Deflector Jam*

Deflector jams are a moderately sized wood jam placed along one side of the river. The purpose of such a jam is to deflect flow toward the opposite bank. These types of structures could be used in tandem with other jams. For example, often in these concepts the jams are placed slightly upstream of an apex jam to increase the amount of flow that is pushed against the apex jam. A deflector jam could also be used to push water toward the opposite bank with bank habitat jams or without any other wood to concentrate flow and create more hydraulic and geomorphic heterogeneity throughout the reach. In addition, these jams can help side channel connectivity if placed immediately downstream from the mouth of a side channel.

2.3.1.5 *Floodplain Wood*

Floodplain wood is typically smaller than main channel wood and added to existing or enhanced side channels. The wood can provide hydraulic complexity and cover within side channels that is beneficial to off-channel habitat. Often, this wood is not ballasted or secured as much as main channel wood due to the lower flow depths and velocities. That means the wood can mobilize at higher flow events but is likely to re-rack on nearby wood in complex side channel settings or have little risk if transported further downstream. Floodplain wood was not shown specifically on design concept maps, and placement would need to be a focus at the project-scale.

Low-tech restoration strategies could also be used in existing or enhanced side channels. Low-tech restoration typically involves the introduction of pile assisted log structures or beaver dam analogues. On a larger river like the Lower Chewuch River, these strategies are likely too small for the main channel but could be used to mimic or enhance beaver activity along the floodplains of the Chewuch River. Some beaver activity has been noted along the Chewuch River, though limited in scale and impact. The beaver activity that does exist is often at the downstream end of river meanders on the floodplain surface.

2.3.1.6 *Representation of Large Wood Structures in Design Concept Maps*

While most of the restoration concepts are depicted as lines or polygons on the maps, three types of large wood structures were created using simplified, scaled large wood drawings. Pieces of large wood in these structures were 40 ft long, 1.5 ft wide along the trunk, and 3 ft wide at the root wad. This size was used to represent a realistic size log used in restoration projects. The three large wood structures with identifiable drawings were the apex, deflector, and bar-development jams. Bank habitat wood was depicted as polygons as multiple structures could be placed in these locations. An example of the shapes of the different wood structures is shown in figure 4.

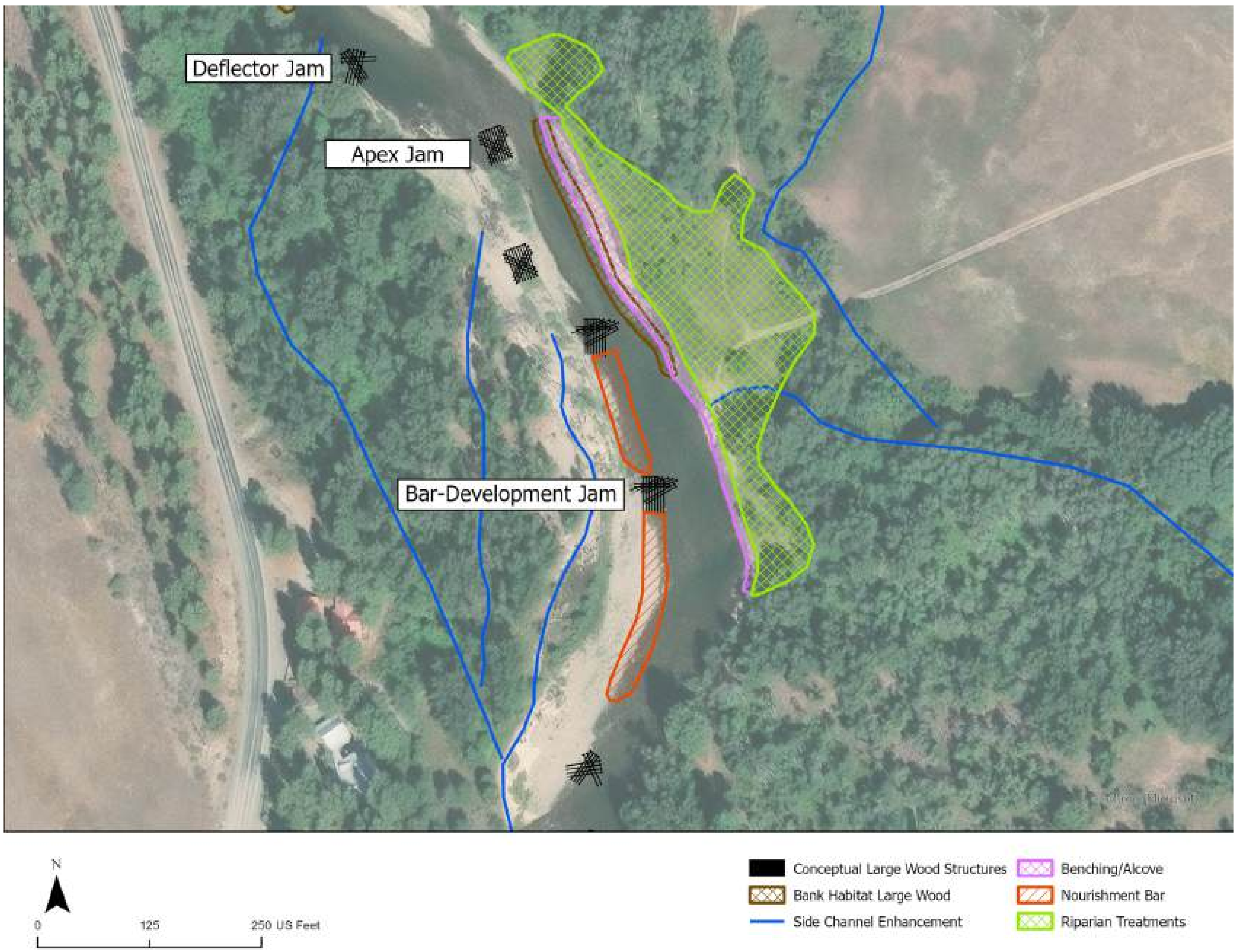


Figure 4.—Example of shapes used to represent the large wood structures depicted in the concept maps.

2.3.2 Boulders

In addition to large wood, boulders are also commonly used in river design and restoration. In these restoration concepts, boulders are not used in the context of riverbank stabilization like rip-rap. Instead, boulders are used within these concepts to adjust river form or provide structural impediments to flow that will alter flow hydraulics and geomorphic characteristics of the river corridor. Boulders can also provide habitat benefits to both adults and juvenile fish. Often boulders in the design concepts were placed as clusters in sections of river along valley walls where large wood may not be as common. Also, boulder piles were used in place of large wood jams in the highest stream power areas where there may be too much risk to place wood jam.

2.3.3 Riparian Treatments

Riparian treatments include revegetation and riparian enhancement of the floodplain and along channel banks. Often floodplain surfaces can be degraded due to logging, historical land use, disconnection from the water table, fire, or various other reasons. If a previously forested reach no longer has a canopy, that can lead to warming of the river and lack of large wood recruitment. Revegetating the floodplain surface can help, in the long-term, reverse those trends. More immediate effects to the riparian corridor can be achieved with the planting of willows or other near-channel species that may become inundated annually and provide cover along river margins or side channels for fish. Finally, riparian treatments may be included with side channel enhancement to provide improved conditions on a newly excavated channel.

2.3.4 Channel and Floodplain Grading Strategies

2.3.4.1 *Benching*

Benching is a technique to lower a high channel bank to become inundated by river flows more frequently. Because the surface will inundate more frequently and is closer to groundwater when not inundated, the surface can be planted with riparian vegetation, if desired. Benching can provide refugia for juvenile fish, which can be lacking in a system with high, infrequently inundated banks without riparian vegetation. While used in limited amounts within these design concepts, high baren riverbanks were the focus of benching locations.

2.3.4.2 *Nourishment Bar Development*

Nourishment bars are proposed in certain locations with native, excavated material from side channels. The placement of the fill allows the sediment to become mobile at higher flows when the sediment can be redistributed naturally by the river flow. If placed in locations with complexity, whether in the form of large wood jams or other features to create a range of hydraulic conditions, the river is likely to sort the sediment into size classes, some of which are beneficial to fish spawning.

2.3.4.3 *Side Channel Enhancement*

Side channel enhancement in these restoration design concepts focused on existing side channel locations that would provide the easiest opportunities for improved functionality. Side channels were identified using hydraulic model outputs to determine the predicted frequency of connection at higher flows. Enhancing these existing side channels may include excavation of the channels to increase the frequency of inundation. Large wood or riparian planting along the side channel may also be utilized to promote structure and cover along the side channel.

2.4 Expected Effects of Restoration Actions

Each restoration action in the design concepts addresses a specific reach limiting factor and affects the hydraulic, geomorphic, biological, and water temperature objectives. Table 3 identifies the limiting factor that can be altered by each restoration action. Restoration action effects on the limiting factor might be immediate or due to geomorphic changes created by the restoration action. For example, an apex jam will immediately provide wood cover, but the structure will also alter river hydraulics and likely lead to changes in river substrate. Table 4 lists the specific restoration actions and their potential effects on river hydraulics, geomorphology, biology, and water temperature. All the restoration actions have multiple beneficial effects on the process-based habitat characteristics.

Table 3.—Identifying the restoration actions that help address each of the limiting factors

	Large Wood					Form Addition	Vegetation	Channel and Floodplain Grading			
Prioritization Limiting Factor	**Apex Jam**	**Bank Habitat Structure**	**Bar-Development Jam**	**Deflector Jam**	**Floodplain Wood**	**Boulders**	**Riparian Treatments**	**Benching/Alcoves**	**Infrastructure Removal**	**Nourishment Bars**	**Side Channel Enhancement**
Bank stability		X	X				X				
Coarse substrate	X		X	X		X				X	
Embeddedness	X		X	X		X				X	
Fines	X		X	X		X				X	
Floodplain connectivity			X					X	X		X
Off/side channels					X			X			X
Pool quantity and quality	X	X	X	X							
Riparian condition							X	X	X		X
Riparian – canopy cover							X	X			X

	Large Wood					Form Addition	Vegetation	Channel and Floodplain Grading			
Prioritization Limiting Factor	**Apex Jam**	**Bank Habitat Structure**	**Bar-Development Jam**	**Deflector Jam**	**Floodplain Wood**	**Boulders**	**Riparian Treatments**	**Benching/Alcoves**	**Infrastructure Removal**	**Nourishment Bars**	**Side Channel Enhancement**
Summer base flow	X	X			X	X					X
Temperature - rearing		X			X						X
Wood - cover	X	X	X	X	X						

Table 4.—Restoration actions and corresponding hydraulic and geomorphic, biological, and temperature objective effects on river conditions

LCRA Restoration Actions			
Engineered Wood			
Structure Type	**Hydraulic and Geomorphic Effects**	**Biological Effects**	**Temperature Effects**
Apex jam	-Raise upstream water surface elevations -Redistribute flood flow -Increase flow complexity/heterogeneity -Create and maintain scour pool -Create low velocity (depositional) areas downstream from structure	-Adult holding and cover -Juvenile cover and feeding habitat -Adult carcass racking/retainment	-Creates deep colder pool -Possible location of hyporheic exchange/expression
Bar-development jam	-Create low velocity (depositional) areas downstream from structure -Promote deposition of finer grain substrates downstream from structure -Push water toward the opposite riverbank -Create flow convergence within channel adjacent to structure -Increase flow complexity/heterogeneity	-Floodplain vegetation growth -Juvenile flood refugia habitat -Potential adult spawning habitat development	-Possible location of hyporheic exchange/expression
Bank habitat jam	-Dissipate velocities along bank -Local scour around wood -Bank stabilization -Increase flow complexity/heterogeneity	-Juvenile cover and feeding habitat -Adult holding and cover	-Wood structure provides shading along river bank
Deflector jam	-Create decreased velocities behind the jam to a lesser extent than a bar-development structure -Create flow convergence adjacent to the jam, which may scour the thalweg -Increase stream bed heterogeneity	-Juvenile cover and feeding habitat -Adult spawning habitat development??	
Floodplain wood	-Add structure to side channels and flow paths -Increase variability of flow conditions within side channels	-Floodplain vegetation growth -Juvenile flood refugia habitat	

LCRA Restoration Actions			
Other River Form Additions			
Form Addition	**Hydraulic and Geomorphic Effects**	**Biological Effects**	**Temperature Effects**
Boulders	-Add flow complexity/heterogeneity to channel -Dissipate hydraulic energy -Create hydraulic scale deposition and erosion around boulder -Push flow into accessible side channels in high energy locations	-Adult holding and cover -Juvenile cover and feeding habitat, primarily steelhead	
Mechanical Adjustment of River and Floodplain Form			
Adjustment type	**Hydraulic and Geomorphic Effects**	**Biological Effects**	**Temperature Effects**
Infrastructure removal	-Allow for more natural flow dynamics on floodplain surface -Remove infrastructure control of channel form -Increase/promote lateral migration and bank erosion	-Increased habitat diversity and connectivity for all life stages	-Potential to increase floodplain connectivity and associated recharge of shallow groundwater and returns to the river
Side channel grading	-Increase frequency of inundation on higher surfaces adjacent to main channel -Restore low(er) flow connections between mainstem and side channels	-Increase juvenile habitat volume and connectivity	-Enhance access to off-channel cold water patches
Benching	-Increase frequency of inundation along channel margins -Can be used to increase channel conveyance adjacent to wood structure	-Enhance riparian/bank vegetation (shade and cover at channel margins) -Flood flow refugia, primarily for juveniles	
Nourishment bars	-Provide native river material to reorganize, an important process in sediment sorting	-Potential development of sorted bed material used for spawning	

LCRA Restoration Actions			
Riparian Treatments			
Type	**Hydraulic and Geomorphic Effects**	**Biological Effects**	**Temperature Effects**
Willow baffles	-Slow streambank velocities/increase bank roughness -Create undercut banks	-Juvenile cover and feeding habitat	-Localized shade
Floodplain revegetation	-Floodplain and streambank roughness -Slow floodplain flow velocities	-Increase riparian species diversity, structure, and canopy cover	-Increase shade for stream temperature moderation

3.0 Restoration Concept Summary

Reach-scale restoration design concepts are detailed on maps in appendices A and B between RM 9.5 and 0. The restoration concepts were developed using the restoration strategies described above to most appropriately address the limiting factors within the prioritization reaches of interest. The limiting factors of each reach are included in table 2 above and on each concept map. The restoration strategies that address each limiting factor are also noted on the map. The reach-based restoration design concept shapefiles as well as supporting modeling and relative elevation mapping will be released as part of a geodatabase associated with the LCRA.

The Chewuch River exhibits considerably different characteristics in several of the project areas of interest, and this leads to differences in concepts. Each project area is summarized below according to its defining geomorphic and hydraulic characteristics:

- RM 9.5–8.5: Pearrygin 8 – A steep reach with high stream power. It has a large floodplain but also contains infrastructure, and much of the floodplain surface is protected by a boulder fill levee. A perennial side channel on the surface exists through a diversion. Chewuch Dam defines the downstream end of this reach.
- RM 8.5–7.5: Pearrygin 7 – This reach has decreasing stream power from the upstream reach, but stream power is still relatively high. Two side channels, which connect annually or every other year, exist on a low floodplain surface. The downstream end of the reach is constricted between a large alluvial or colluvial fan on the east and the bedrock valley wall on the west, but a smaller floodplain surface exists between the two geomorphic features.
- RM 5.5–4: Pearrygin 4 – A meandering portion of the Chewuch River that has a substantial floodplain surface. However, the river is still partly confined, and the outer bank of the channel is eroding into the valley wall for a length of the river. A large number of side channels could provide opportunities for further floodplain connection.
- RM 4–2.5: Pearrygin 3 – The first mile of the reach is defined by an expansive floodplain before a combination of riverbank armoring and valley wall confine the river down to a smaller corridor. The upstream mile of the reach has ample opportunities for floodplain connection or increased river channel complexity, while the downstream half mile is likely limited to smaller pockets of restoration opportunities.
- RM 2.5–1: Pearrygin 2 – A confined reach of the Chewuch River, small pockets may exist for wood or boulder enhancement of the channel. The downstream extent of the reach ends at Fulton Dam, which provides a hydraulic control for about a quarter of a mile upstream.

Because this document is in support of a reach assessment, the focus of the restoration concepts is based on reach-scale hydraulic modeling and assessment. Further data collection and inspection of project-specific sites is likely needed as specific projects move toward alternative selection and final design.

4.0 References

Byrne, Colin and Aaron Hurst. 2025. "Chewuch River Reach Assessment – Geomorphology and Hydraulics." ENV-2025-020. Bureau of Reclamation, Technical Service Center, Denver, Colorado.

Bureau of Reclamation (Reclamation). 2014. "Large Woody Material – Risk Based Design Guidelines." Pacific Northwest Region Resource & Technical Services. Boise, Idaho.

Byrne, Colin, Aaron Hurst, and Nathan Holste. 2024. "Chewuch River Risk Assessment and Restoration Design Concepts." ENV-2024-077. Bureau of Reclamation, Technical Service Center, Denver, Colorado.

Upper Columbia Regional Technical Team (UCRTT). 2021a. "Habitat Action Prioritization within the Upper Columbia River Basin." Report to the Upper Columbia Salmon Recovery Board, Wenatchee, Washington.

Upper Columbia Regional Technical Team (UCRTT). 2021b. "A Biological Strategy to protect and restore salmonid habitat in the Upper Columbia Region." Report to the Upper Columbia Salmon Recovery Board, Wenatchee, Washington.

U.S. Geological Survey. 2019. The StreamStats program, online at https://streamstats.usgs.gov/ss/, accessed on September 11, 2025.

Appendix A

Restoration Design Concepts with Aerial Imagery

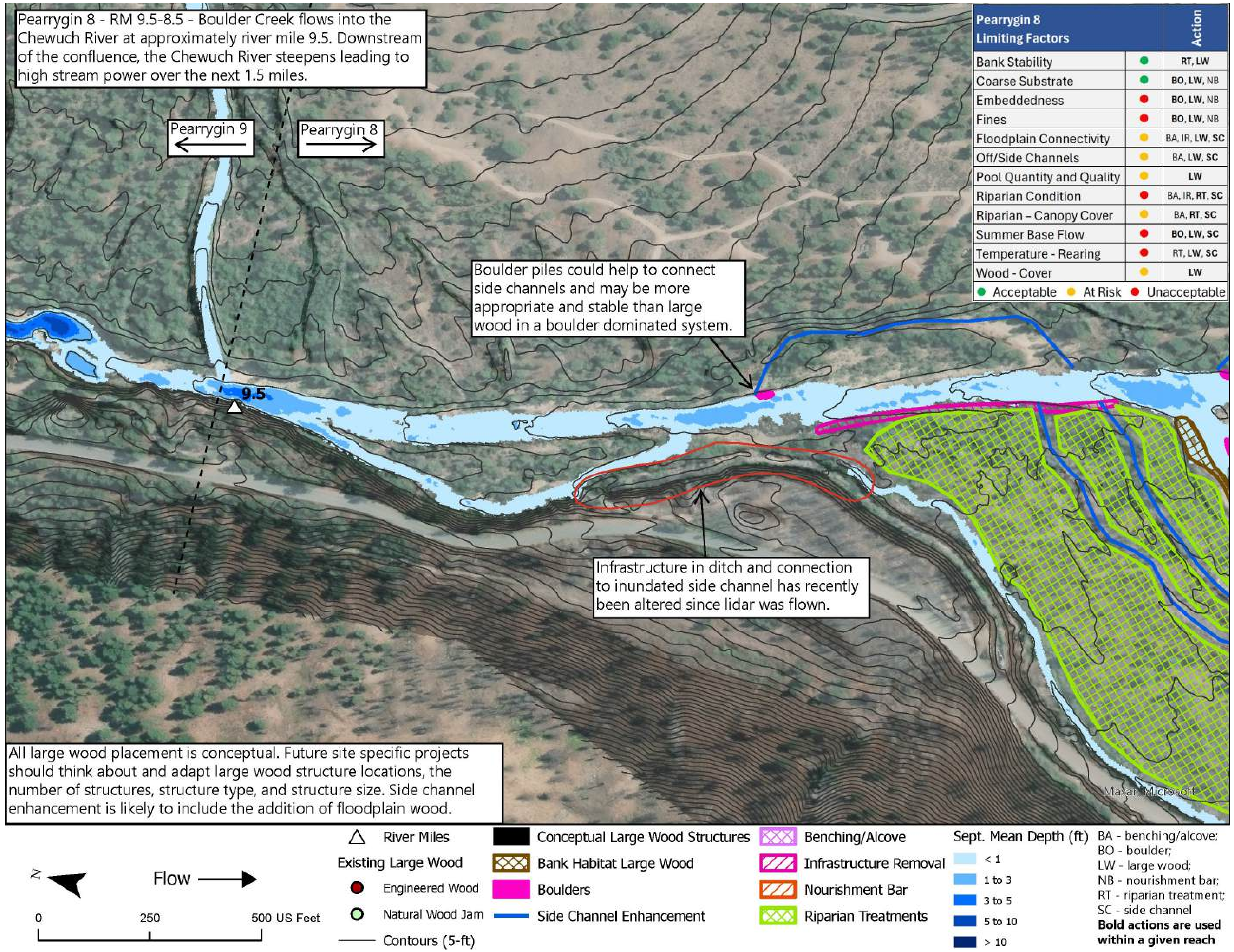


Figure A-1.—Design concepts for the Chewuch River within a portion of Pearrygin 8.

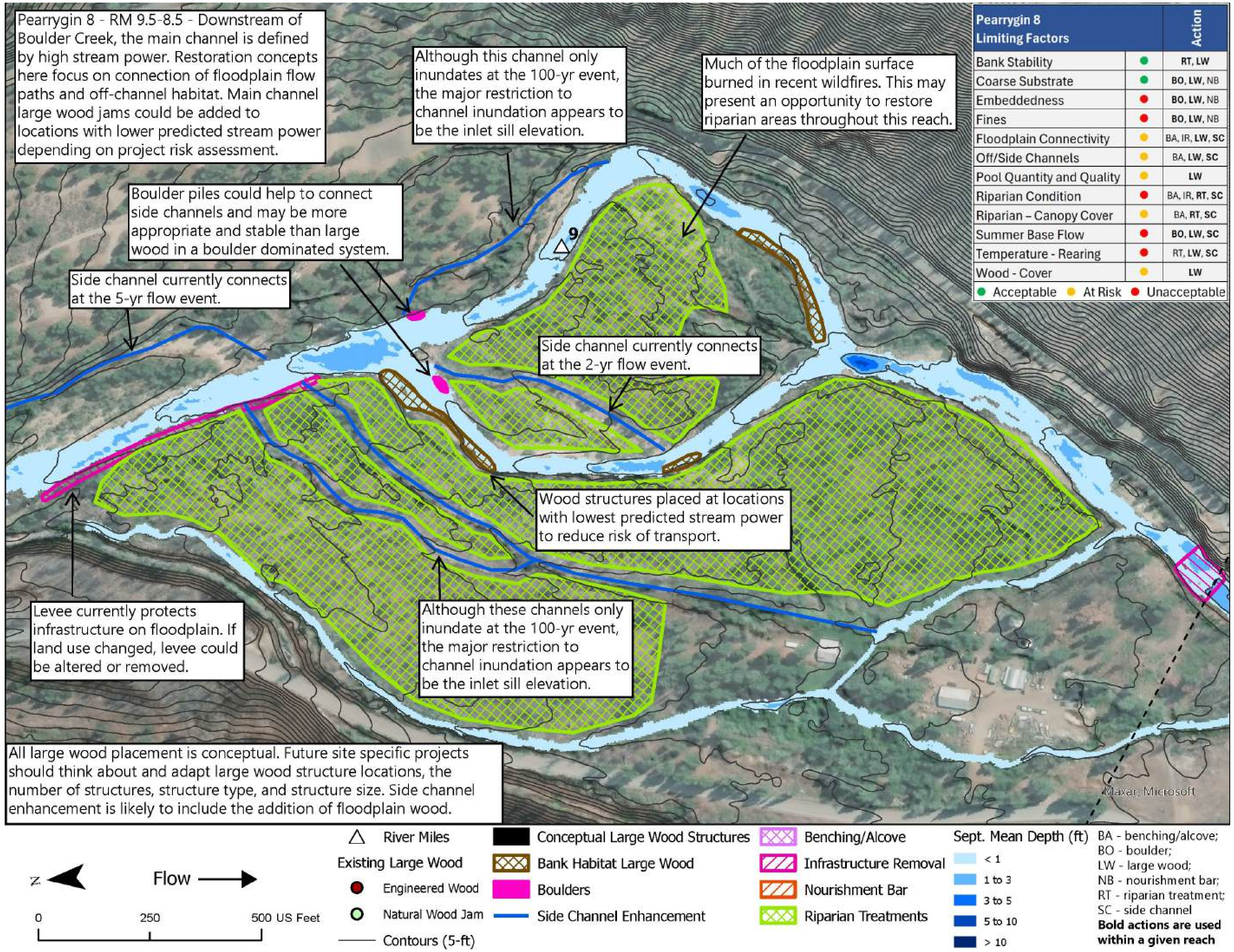


Figure A-2.—Design concepts for the Chewuch River within a portion of Pearrygin 8.

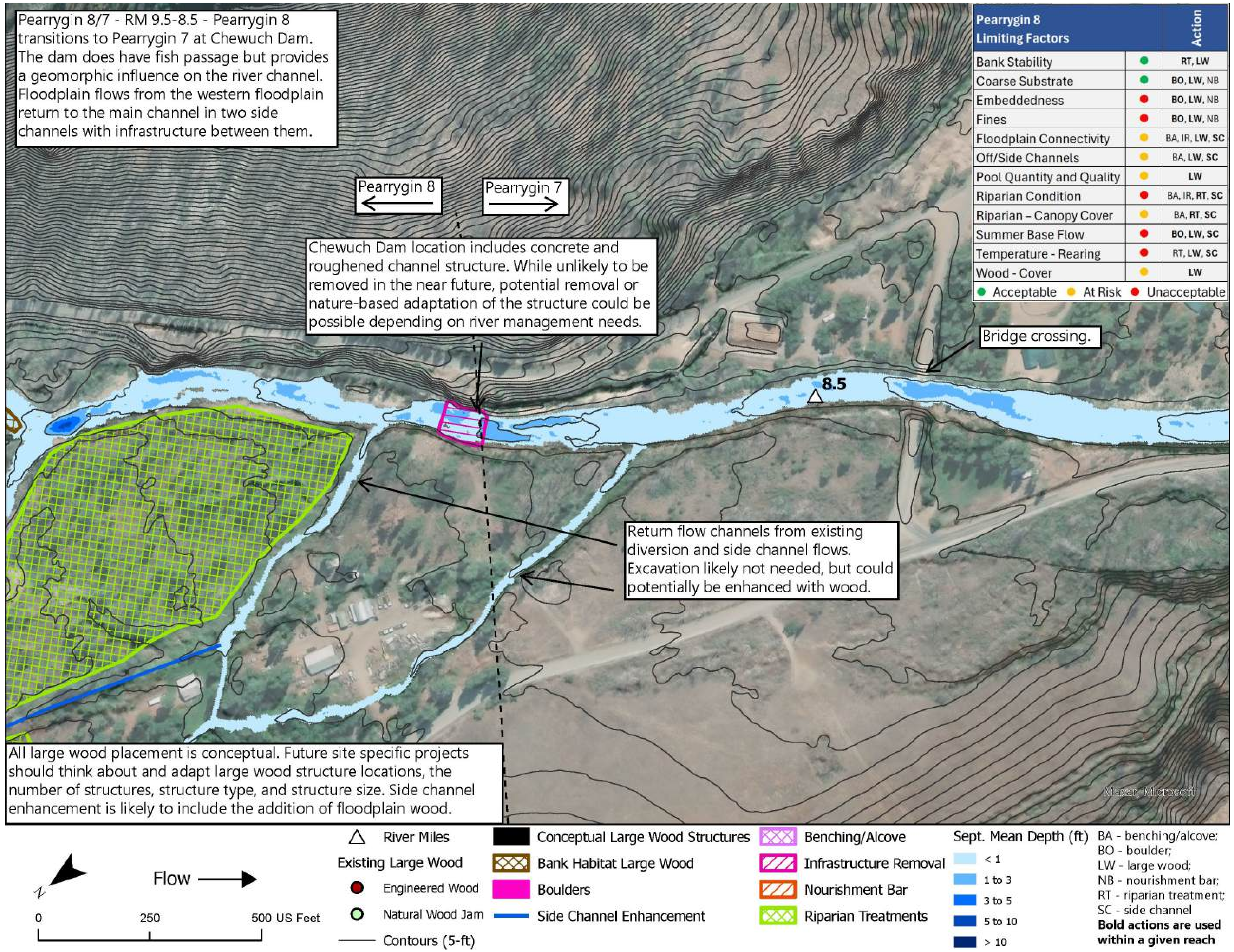


Figure A-3.—Design concepts for the Chewuch River within a portion of Pearrygin 8.

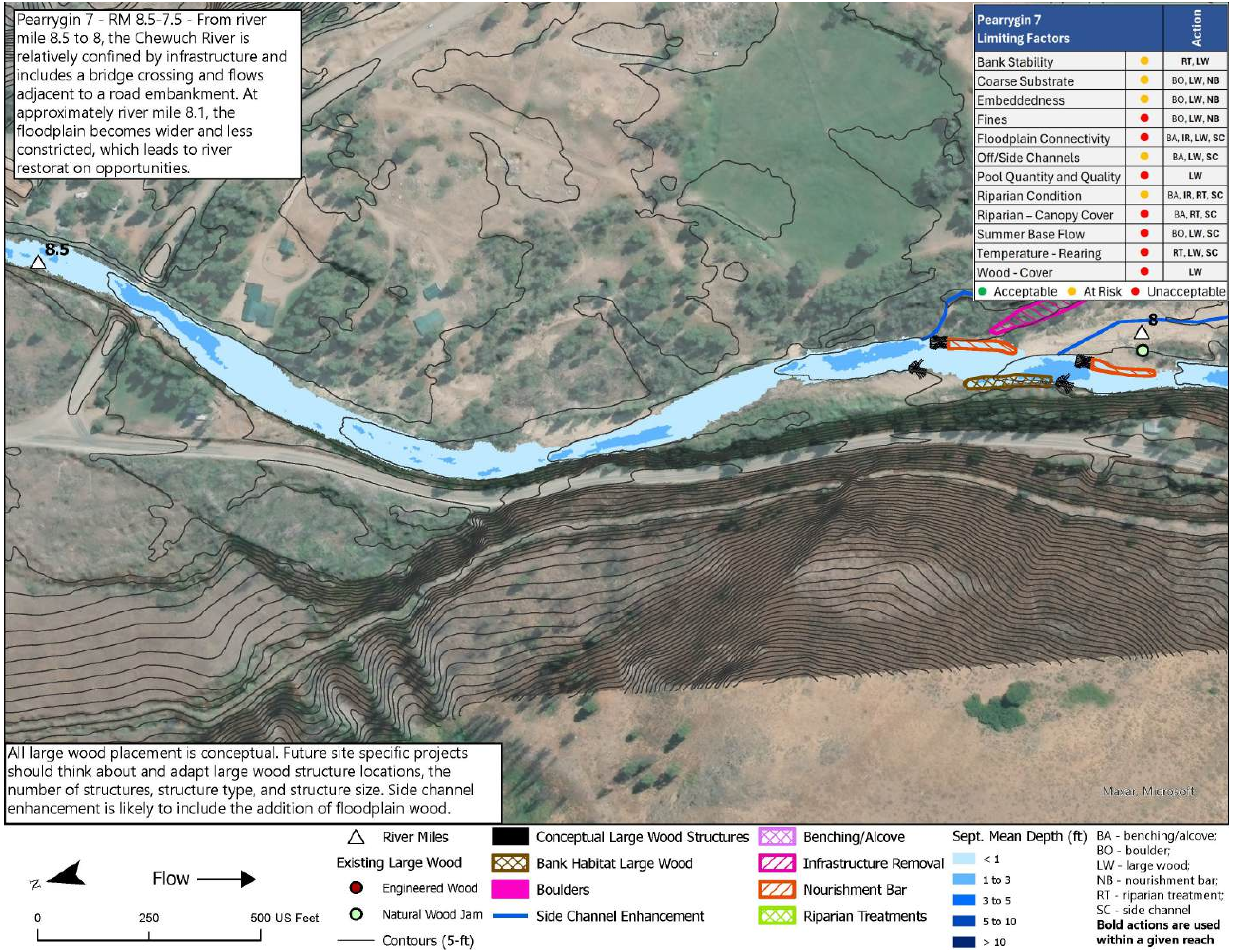


Figure A-4.—Design concepts for the Chewuch River within a portion of Pearrygin 7.

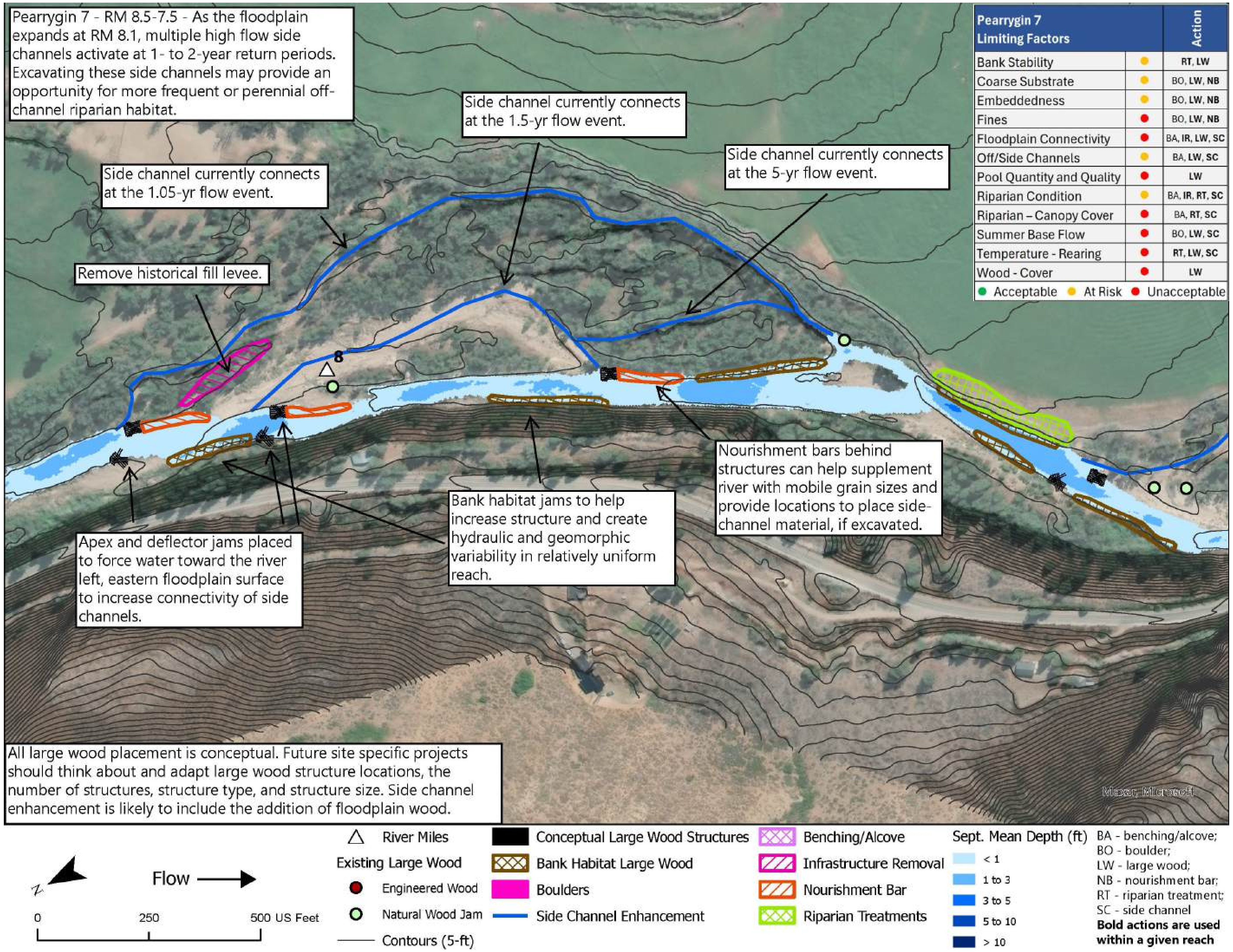


Figure A-5.—Design concepts for the Chewuch River within a portion of Pearrygin 7.

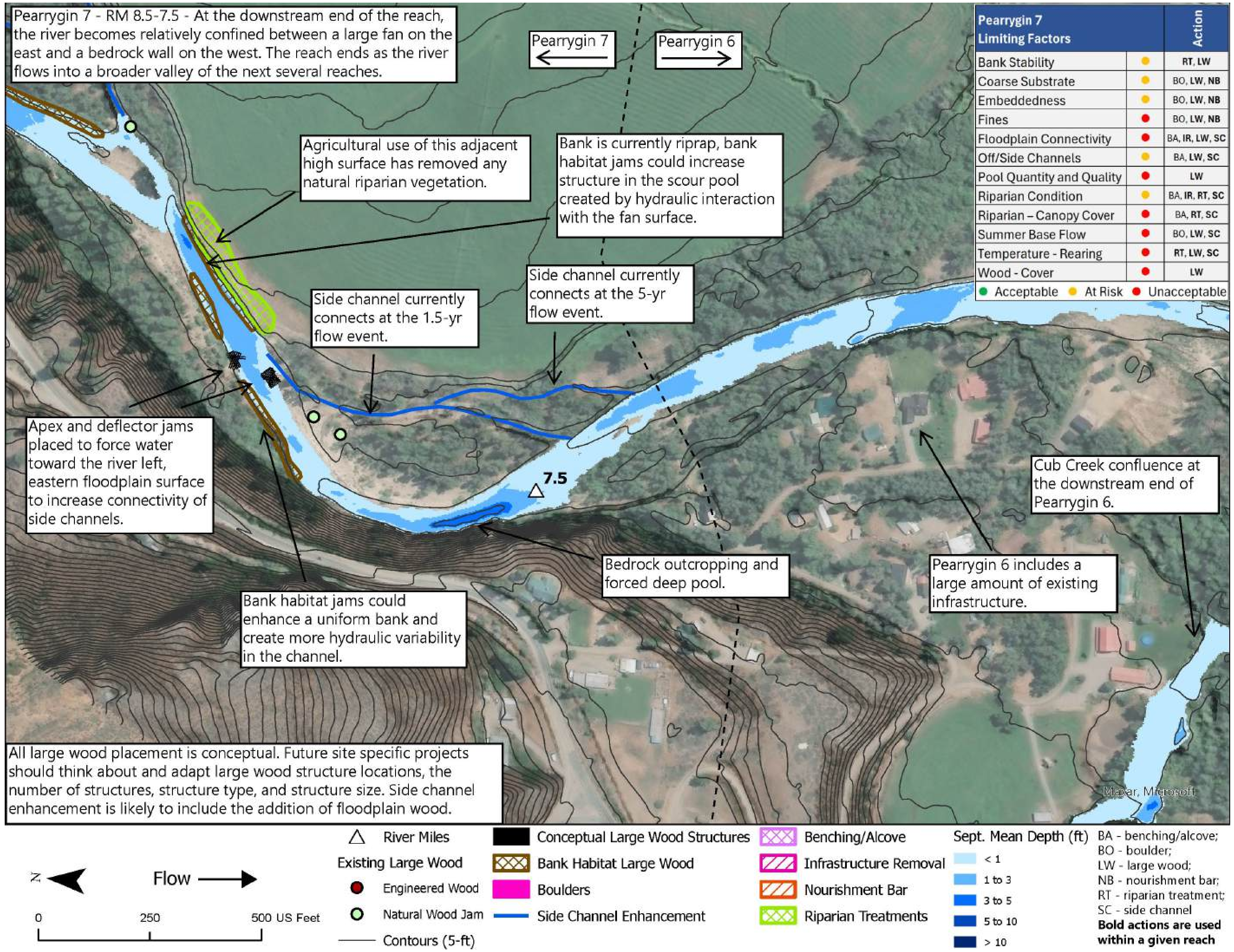


Figure A-6.—Design concepts for the Chewuch River within a portion of Pearrygin 7.

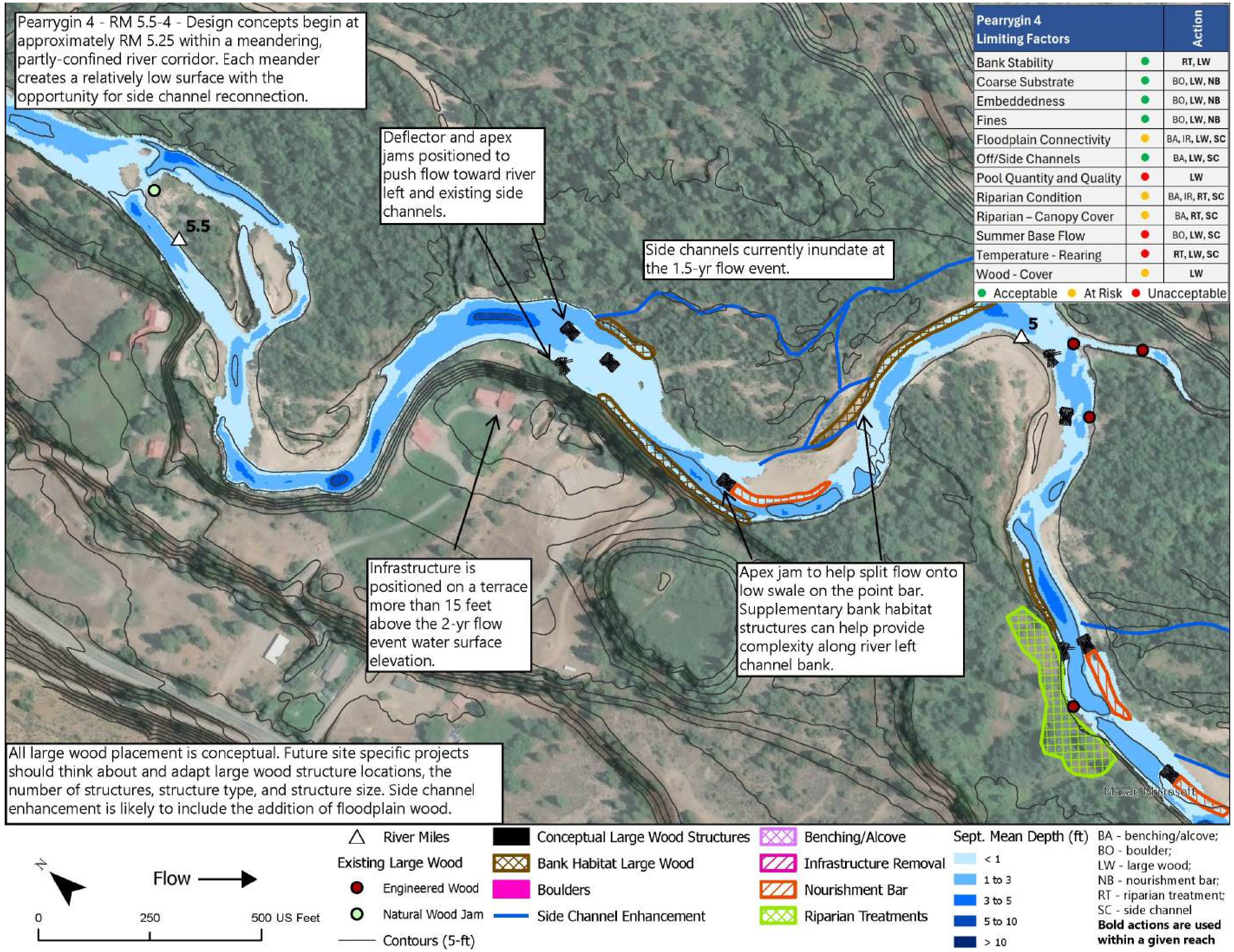


Figure A-7.—Design concepts for the Chewuch River within a portion of Pearrygin 4.

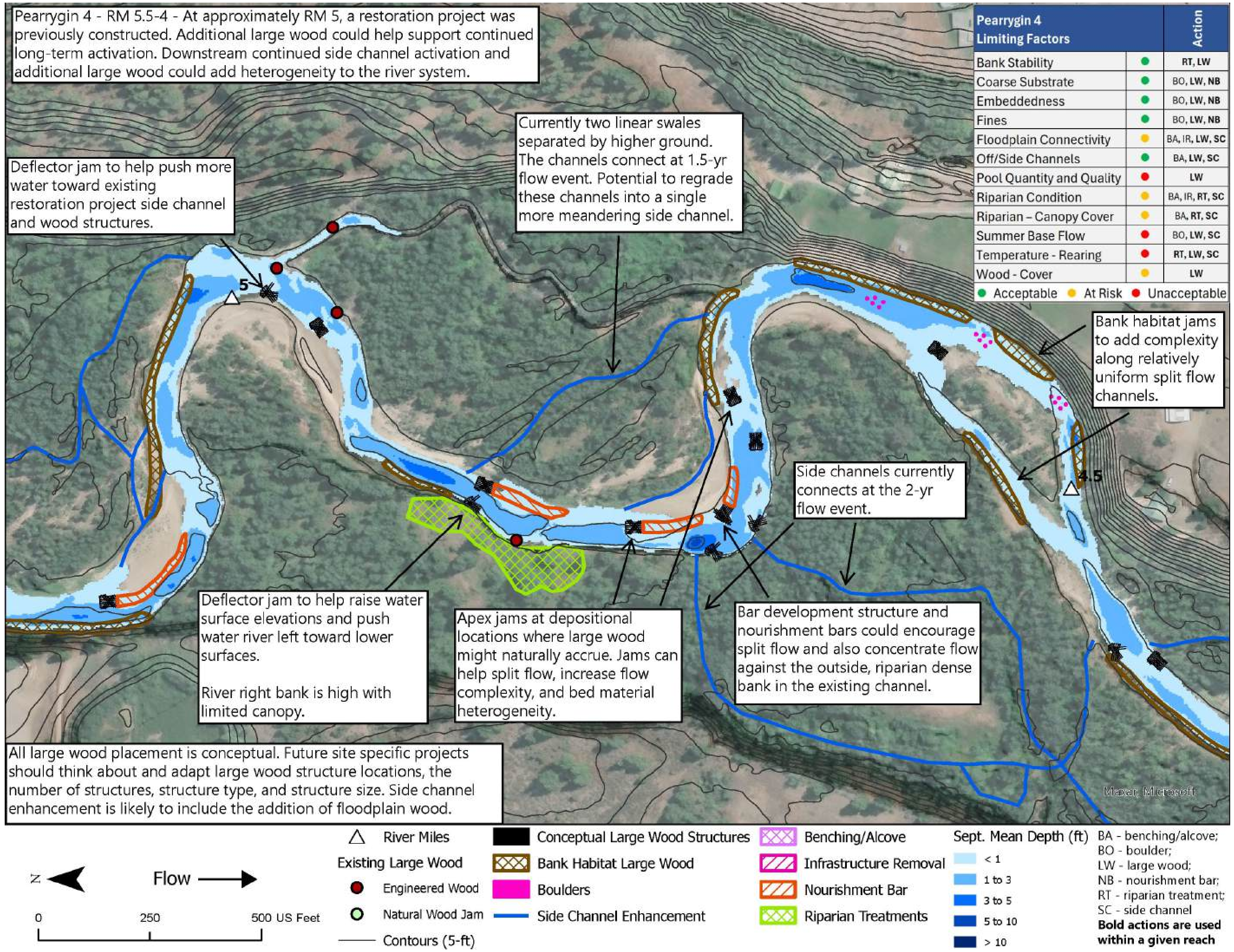


Figure A-8.—Design concepts for the Chewuch River within a portion of Pearrygin 4.

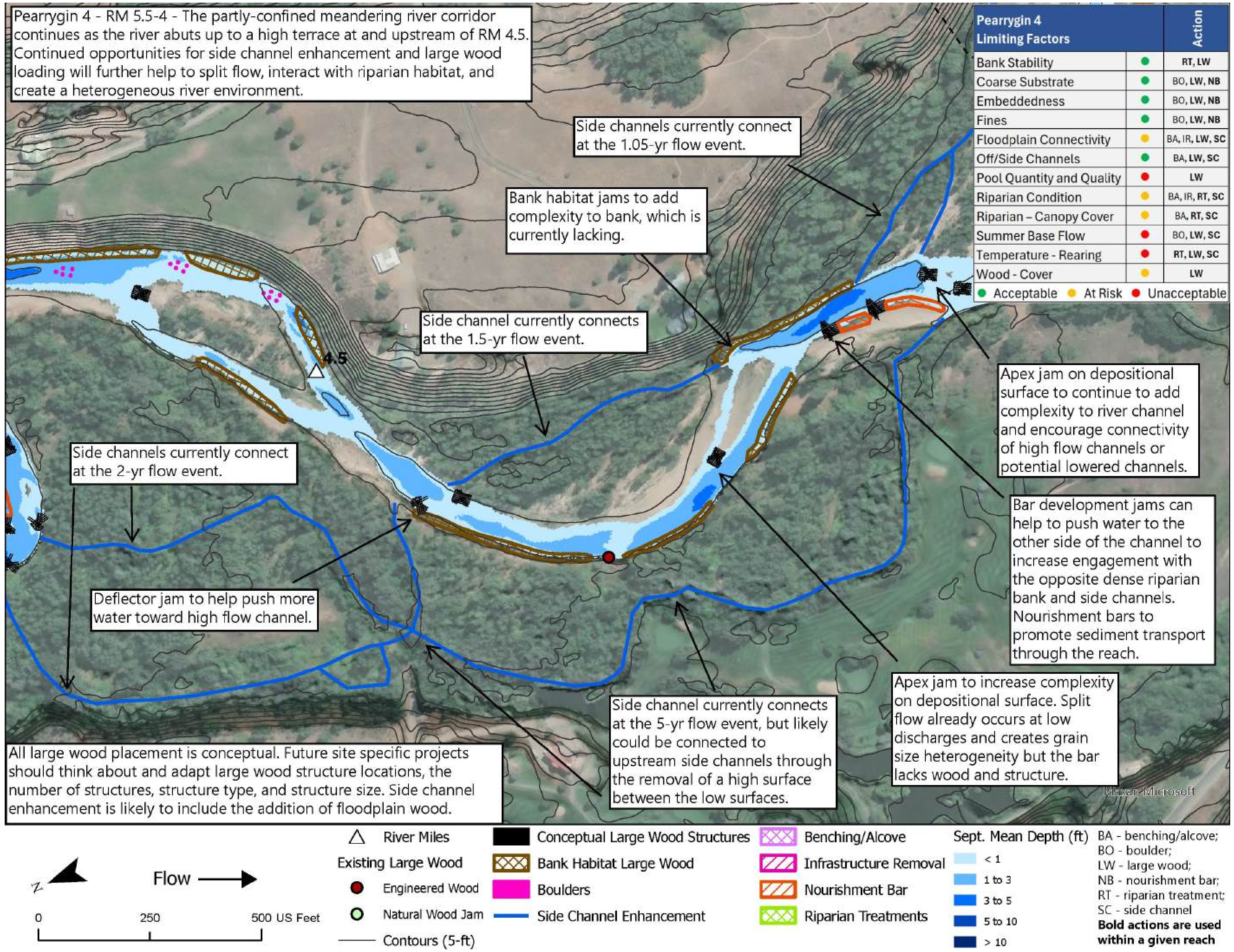
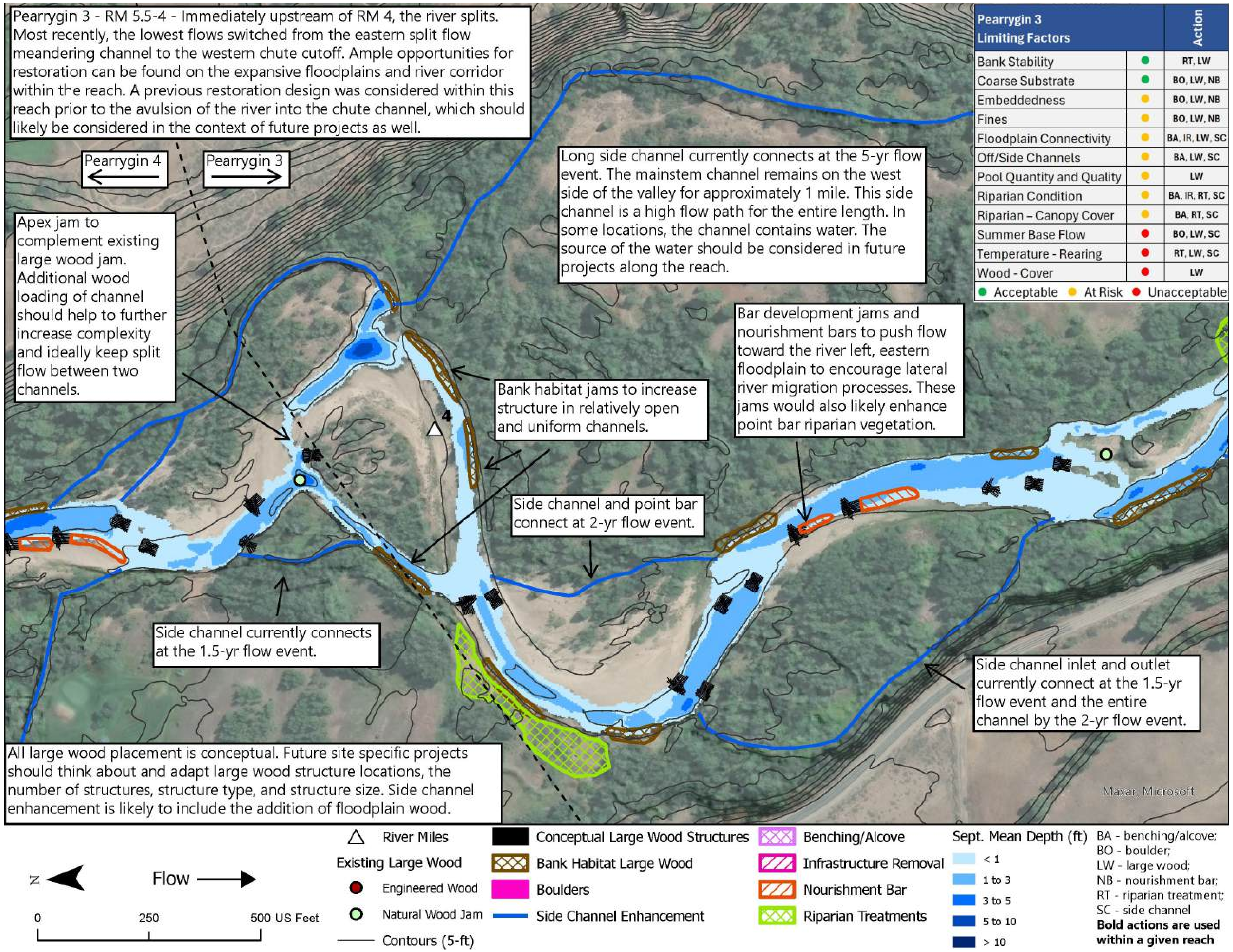


Figure A-9.—Design concepts for the Chewuch River within a portion of Pearrygin 4.



Pearrygin 3 Limiting Factors		Action
Bank Stability	● Acceptable	RT, LW
Coarse Substrate	● Acceptable	BO, LW, NB
Embeddedness	● At Risk	BO, LW, NB
Fines	● At Risk	BO, LW, NB
Floodplain Connectivity	● At Risk	BA, IR, LW, SC
Off/Side Channels	● At Risk	BA, LW, SC
Pool Quantity and Quality	● At Risk	LW
Riparian Condition	● At Risk	BA, IR, RT, SC
Riparian – Canopy Cover	● At Risk	BA, RT, SC
Summer Base Flow	● Unacceptable	BO, LW, SC
Temperature - Rearing	● Unacceptable	RT, LW, SC
Wood - Cover	● Unacceptable	LW

● Acceptable ● At Risk ● Unacceptable

Figure A-10.—Design concepts for the Chewuch River within a portion of Pearrygin 3.

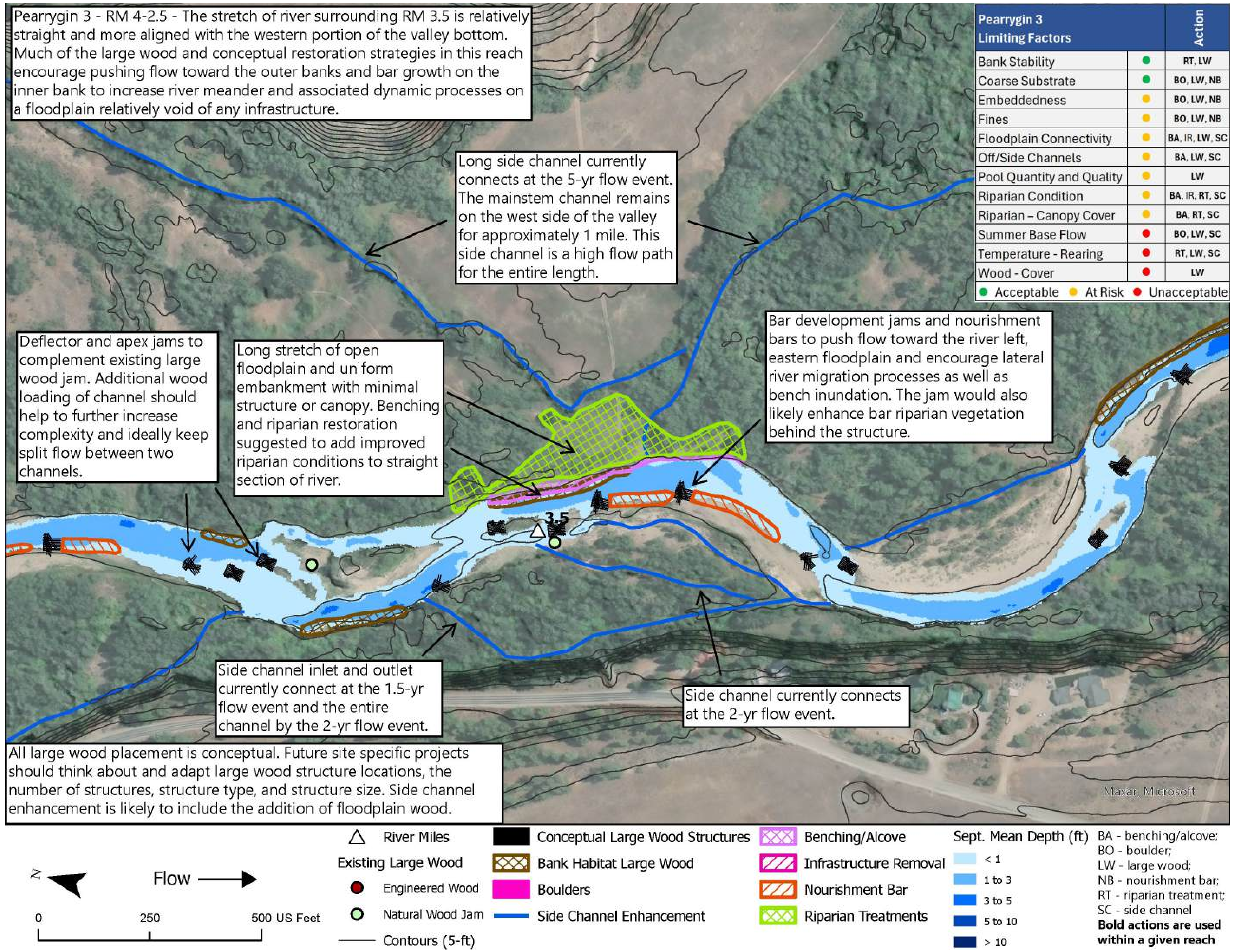


Figure A-11.—Design concepts for the Chewuch River within a portion of Pearrygin 3.

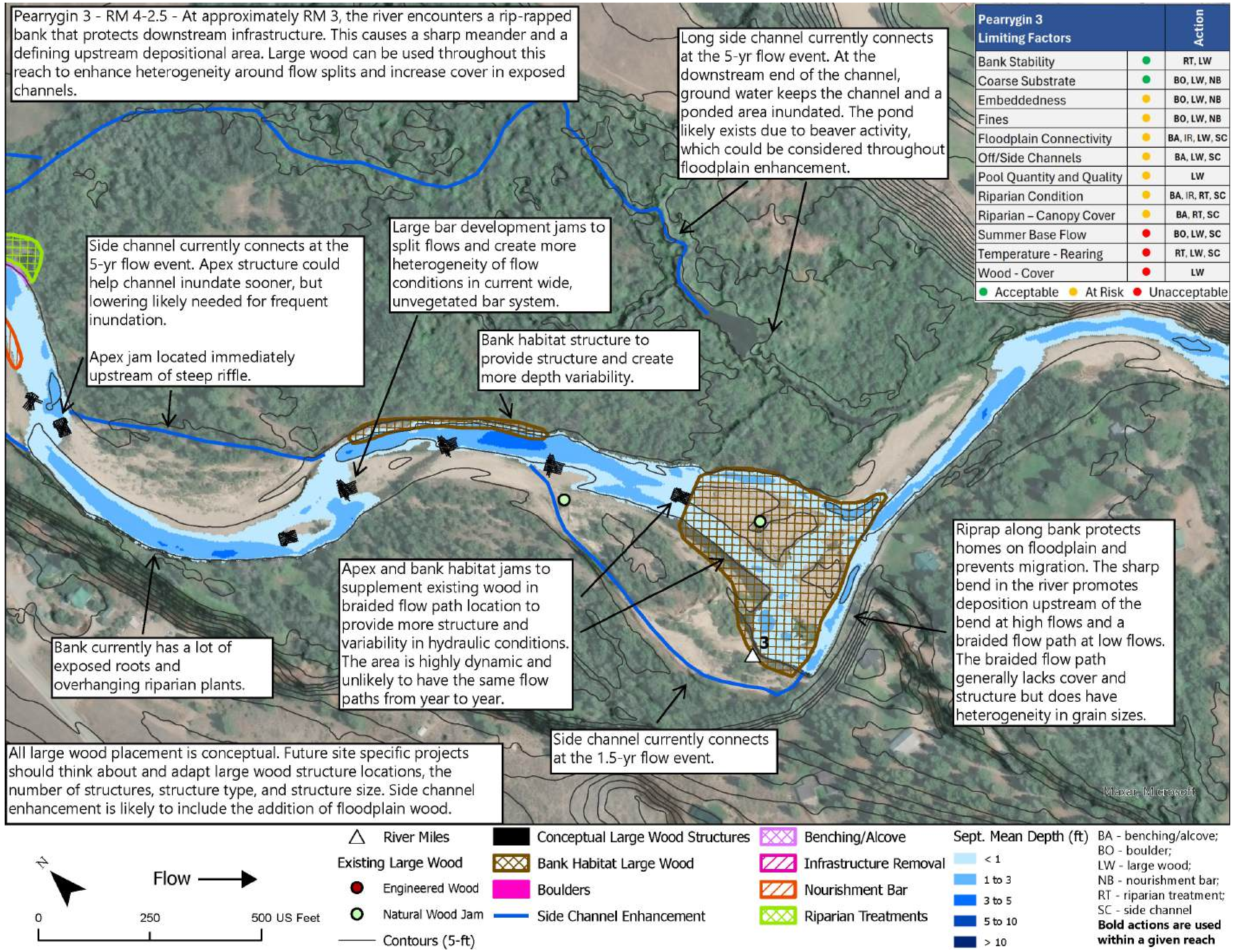
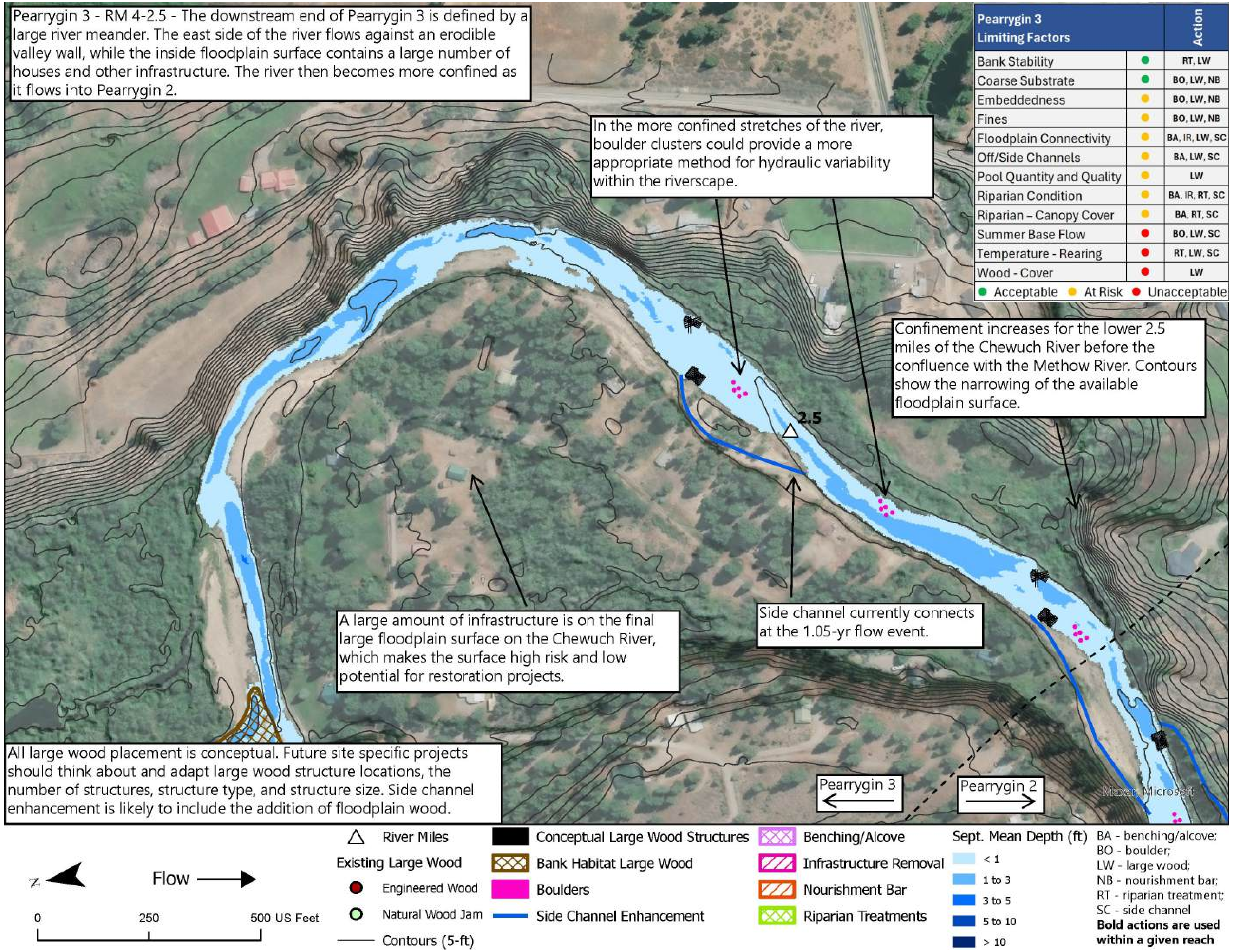


Figure A-12.—Design concepts for the Chewuch River within a portion of Pearrygin 3.



Pearrygin 3 Limiting Factors		Action
Bank Stability	● (Acceptable)	RT, LW
Coarse Substrate	● (Acceptable)	BO, LW, NB
Embeddedness	● (At Risk)	BO, LW, NB
Fines	● (At Risk)	BO, LW, NB
Floodplain Connectivity	● (At Risk)	BA, IR, LW, SC
Off/Side Channels	● (At Risk)	BA, LW, SC
Pool Quantity and Quality	● (At Risk)	LW
Riparian Condition	● (At Risk)	BA, IR, RT, SC
Riparian – Canopy Cover	● (At Risk)	BA, RT, SC
Summer Base Flow	● (Unacceptable)	BO, LW, SC
Temperature - Rearing	● (Unacceptable)	RT, LW, SC
Wood - Cover	● (Unacceptable)	LW

● Acceptable ● At Risk ● Unacceptable

Figure A-13.—Design concepts for the Chewuch River within a portion of Pearrygin 3.

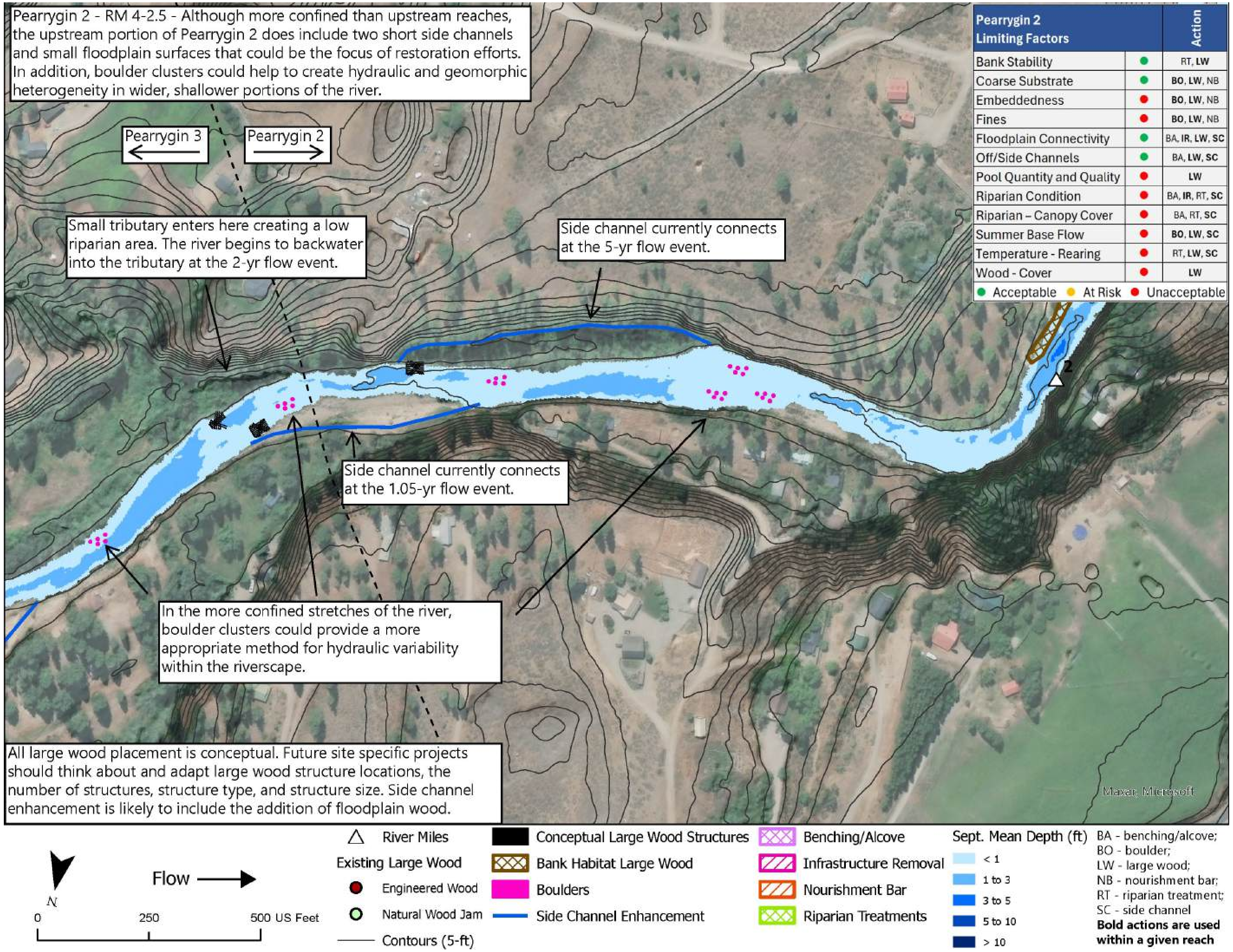
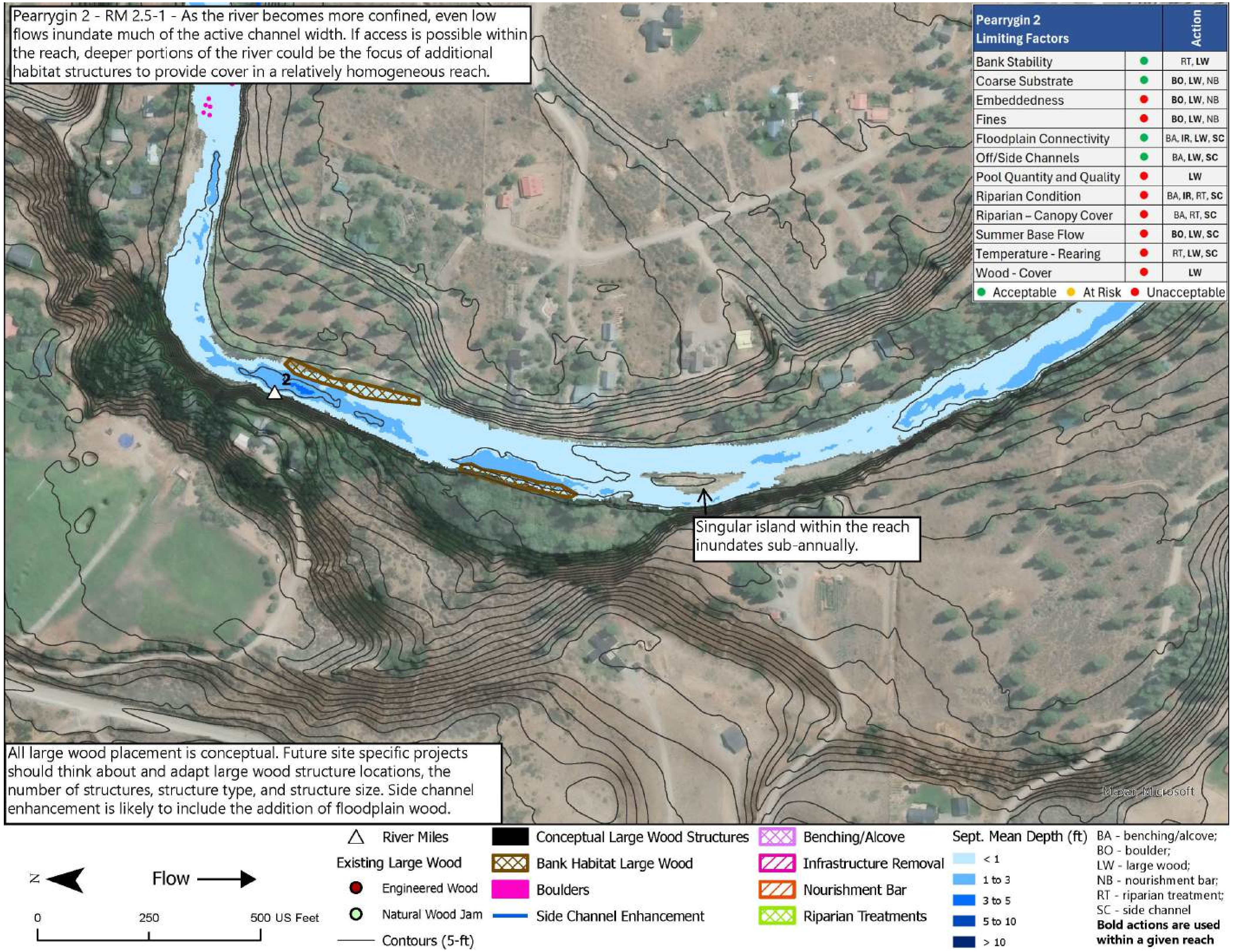


Figure A-14.—Design concepts for the Chewuch River within a portion of Pearrygin 2.



Pearrygin 2 Limiting Factors		Action
Bank Stability	● (Acceptable)	RT, **LW**
Coarse Substrate	● (Acceptable)	**BO**, **LW**, NB
Embeddedness	● (Unacceptable)	**BO**, **LW**, NB
Fines	● (Unacceptable)	**BO**, **LW**, NB
Floodplain Connectivity	● (Acceptable)	BA, **IR**, **LW**, **SC**
Off/Side Channels	● (Acceptable)	BA, **LW**, **SC**
Pool Quantity and Quality	● (Unacceptable)	**LW**
Riparian Condition	● (Unacceptable)	BA, **IR**, RT, **SC**
Riparian – Canopy Cover	● (Unacceptable)	BA, RT, **SC**
Summer Base Flow	● (Unacceptable)	**BO**, **LW**, **SC**
Temperature - Rearing	● (Unacceptable)	RT, **LW**, **SC**
Wood - Cover	● (Unacceptable)	**LW**

● Acceptable ● At Risk ● Unacceptable

Figure A-15.—Design concepts for the Chewuch River within a portion of Pearrygin 2.

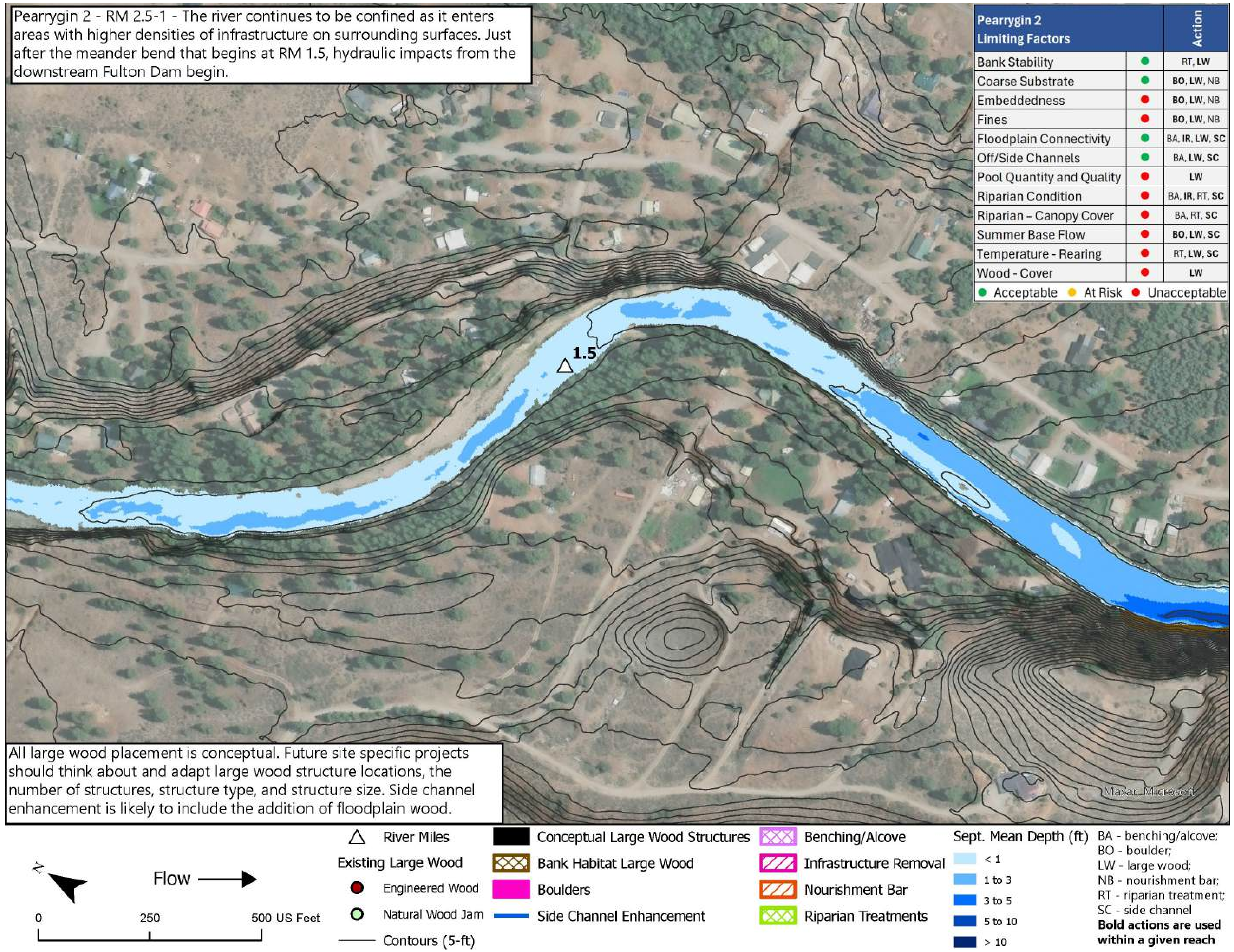


Figure A-16.—Design concepts for the Chewuch River within a portion of Pearrygin 2.

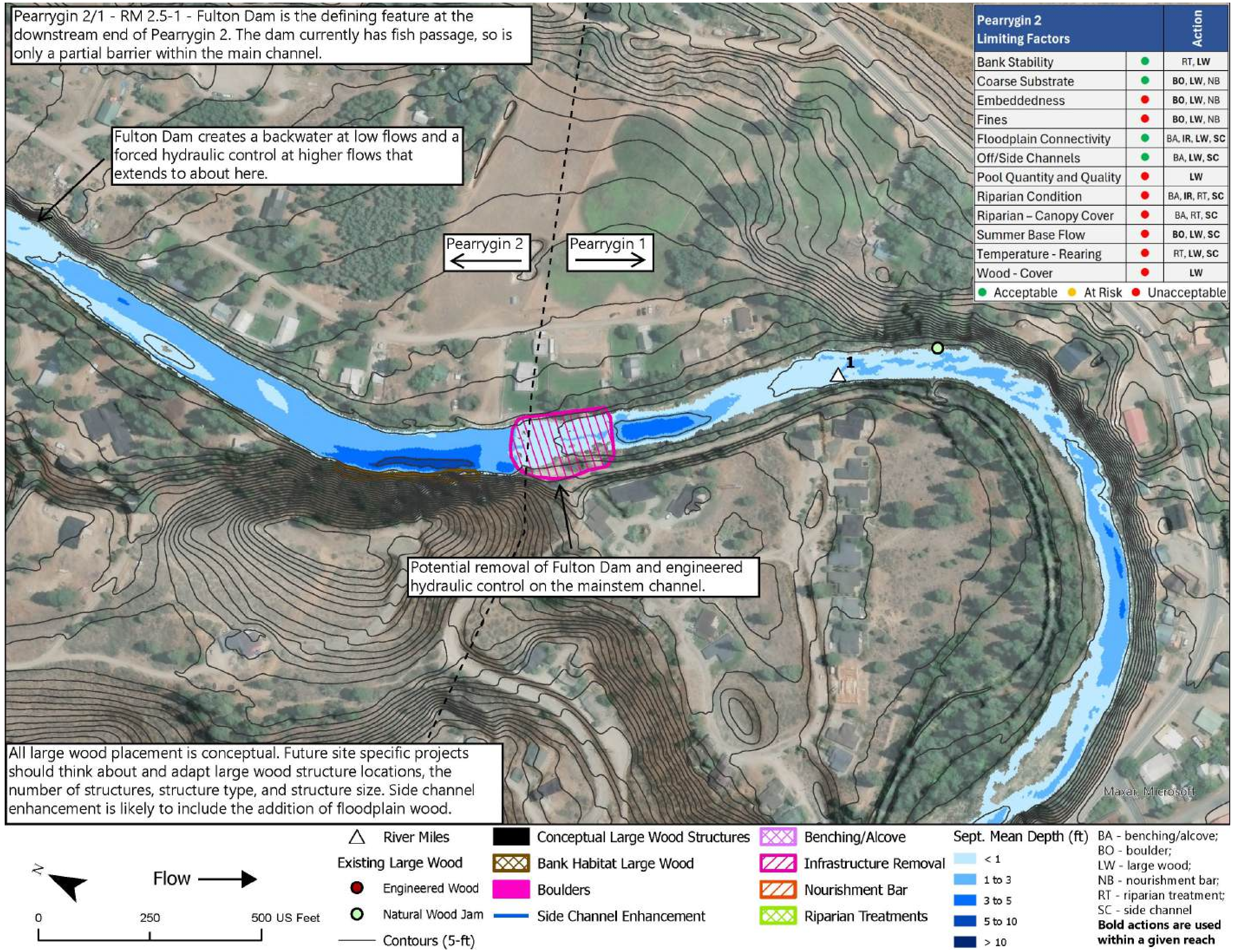
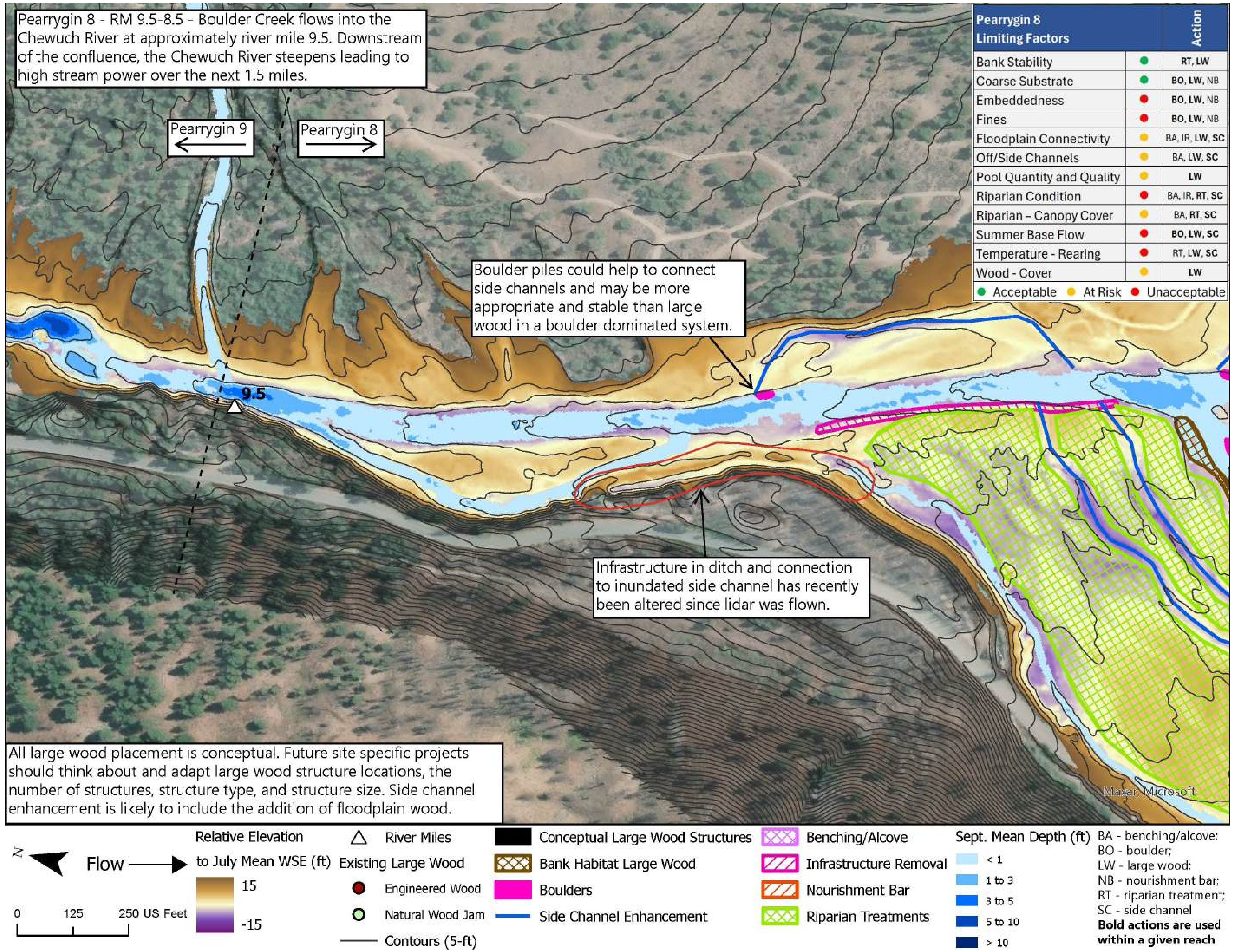


Figure A-17.—Design concepts for the Chewuch River within a portion of Pearrygin 2.

Appendix B

Restoration Design Concepts with Relative Elevation



Pearrygin 8 Limiting Factors		Action
Bank Stability	● (Acceptable)	RT, LW
Coarse Substrate	● (Acceptable)	BO, LW, NB
Embeddedness	● (Unacceptable)	BO, LW, NB
Fines	● (Unacceptable)	BO, LW, NB
Floodplain Connectivity	● (At Risk)	BA, IR, LW, SC
Off/Side Channels	● (At Risk)	BA, LW, SC
Pool Quantity and Quality	● (At Risk)	LW
Riparian Condition	● (Unacceptable)	BA, IR, RT, SC
Riparian – Canopy Cover	● (At Risk)	BA, RT, SC
Summer Base Flow	● (Unacceptable)	BO, LW, SC
Temperature - Rearing	● (Unacceptable)	RT, LW, SC
Wood - Cover	● (At Risk)	LW

● Acceptable ● At Risk ● Unacceptable

Figure B-1.—Design concepts for the Chewuch River within a portion of Pearrygin 8.

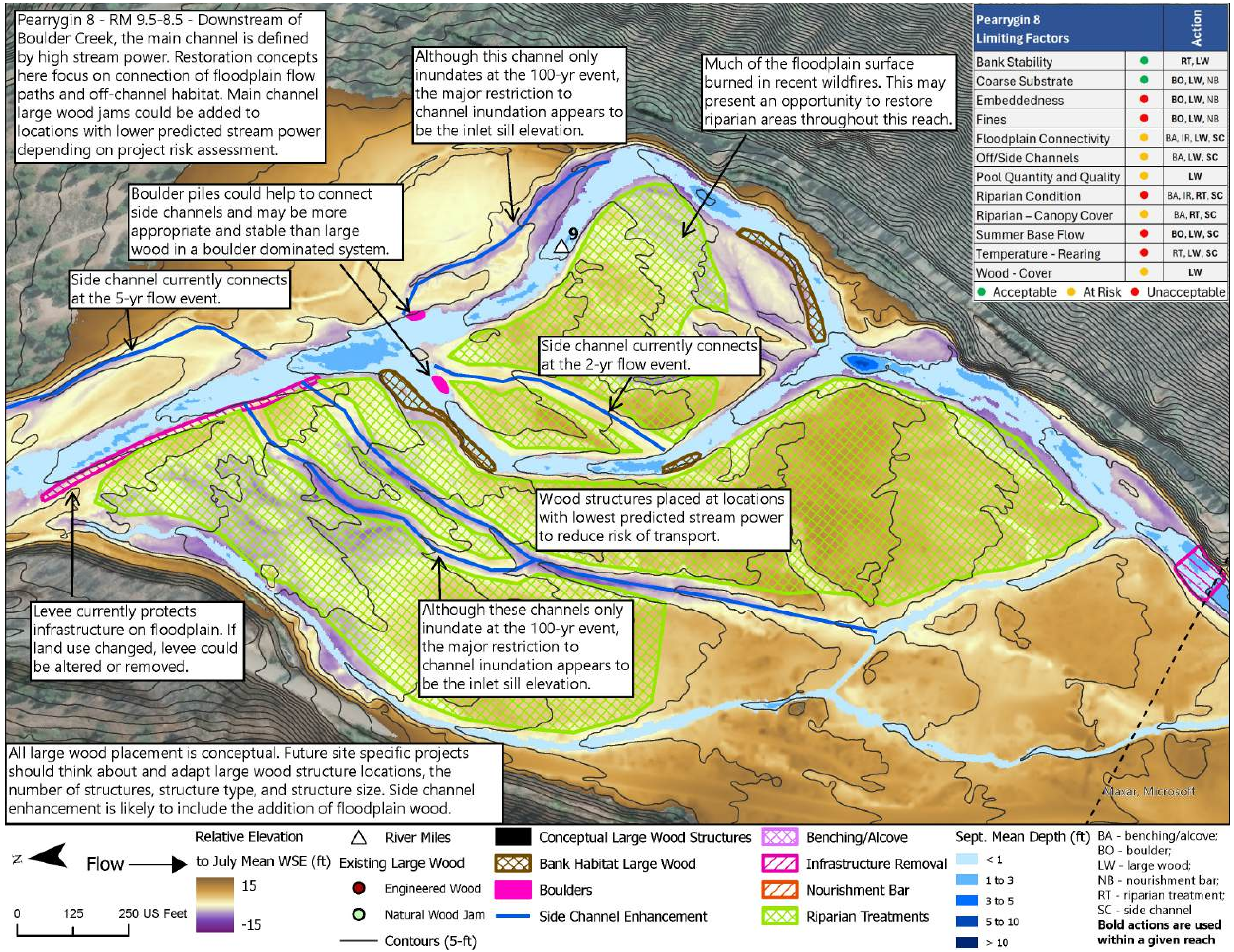


Figure B-2.—Design concepts for the Chewuch River within a portion of Pearrygin 8.

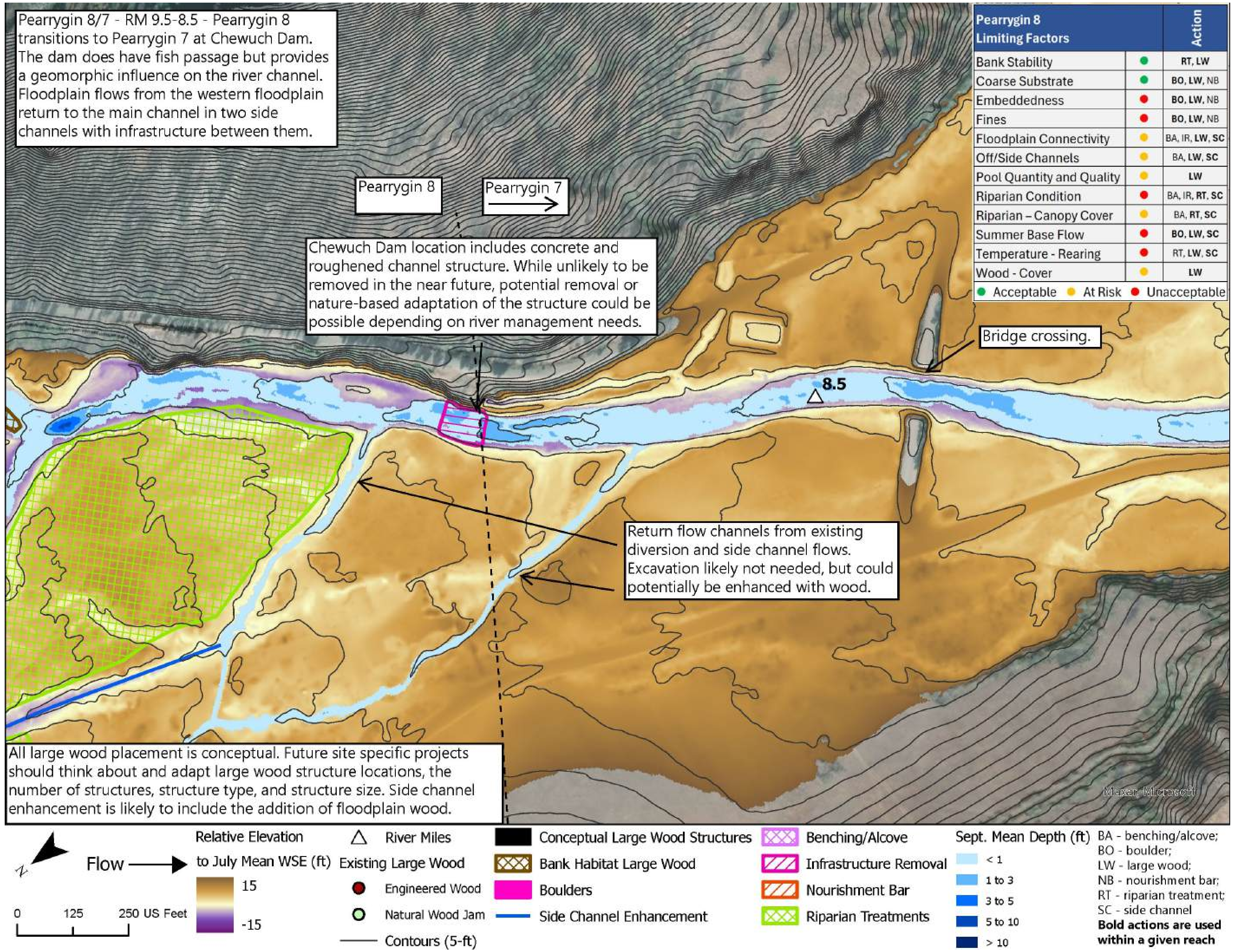
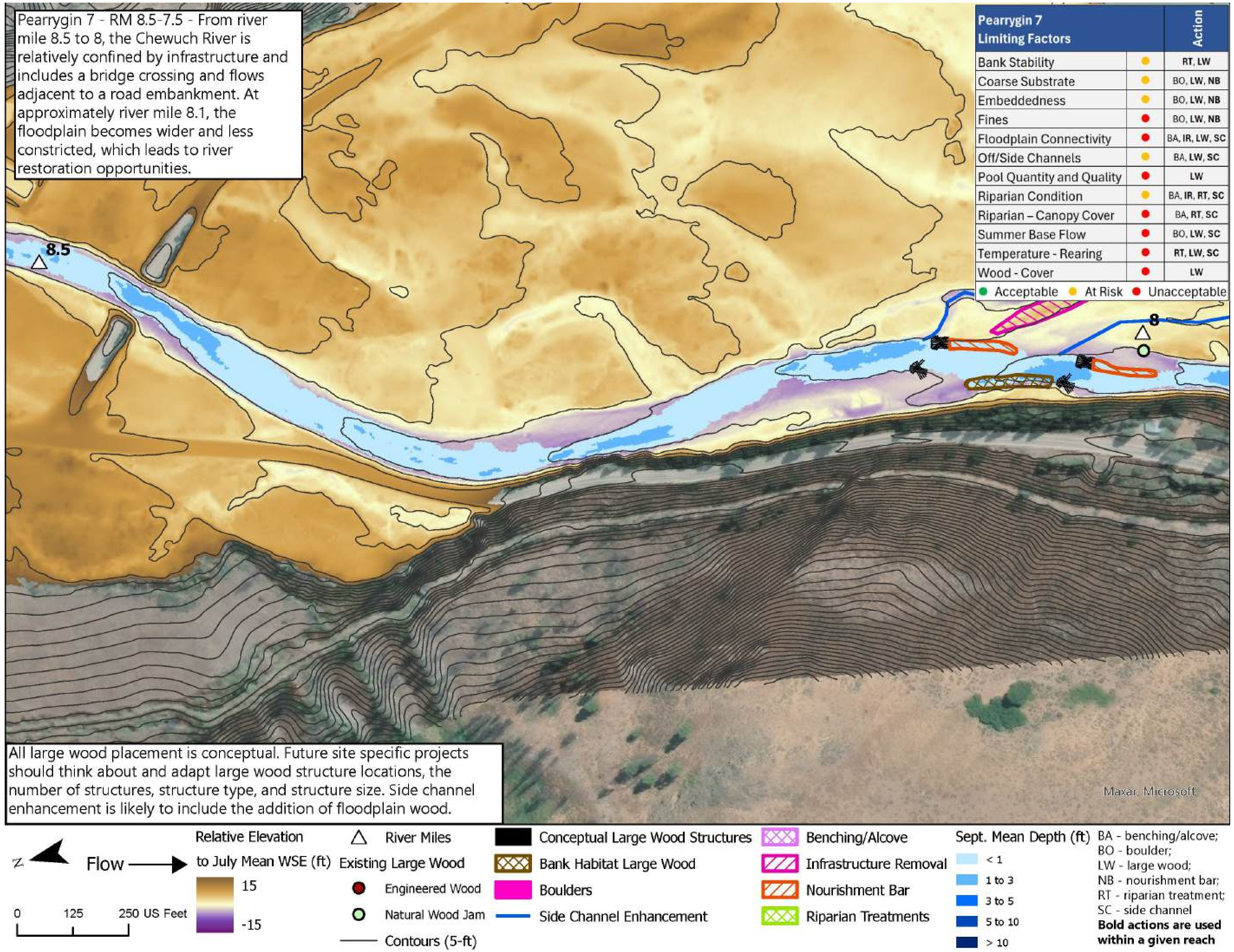


Figure B-3.—Design concepts for the Chewuch River within a portion of Pearrygin 8.



Pearrygin 7 Limiting Factors		Action
Bank Stability	At Risk	**RT**, **LW**
Coarse Substrate	At Risk	BO, **LW**, **NB**
Embeddedness	At Risk	BO, **LW**, **NB**
Fines	Unacceptable	BO, **LW**, **NB**
Floodplain Connectivity	Unacceptable	BA, **IR**, **LW**, **SC**
Off/Side Channels	At Risk	BA, **LW**, **SC**
Pool Quantity and Quality	Unacceptable	**LW**
Riparian Condition	At Risk	BA, **IR**, **RT**, **SC**
Riparian – Canopy Cover	Unacceptable	BA, **RT**, **SC**
Summer Base Flow	Unacceptable	BO, **LW**, **SC**
Temperature - Rearing	Unacceptable	**RT**, **LW**, **SC**
Wood - Cover	Unacceptable	**LW**

Acceptable, At Risk, Unacceptable

Figure B-4.—Design concepts for the Chewuch River within a portion of Pearrygin 7.

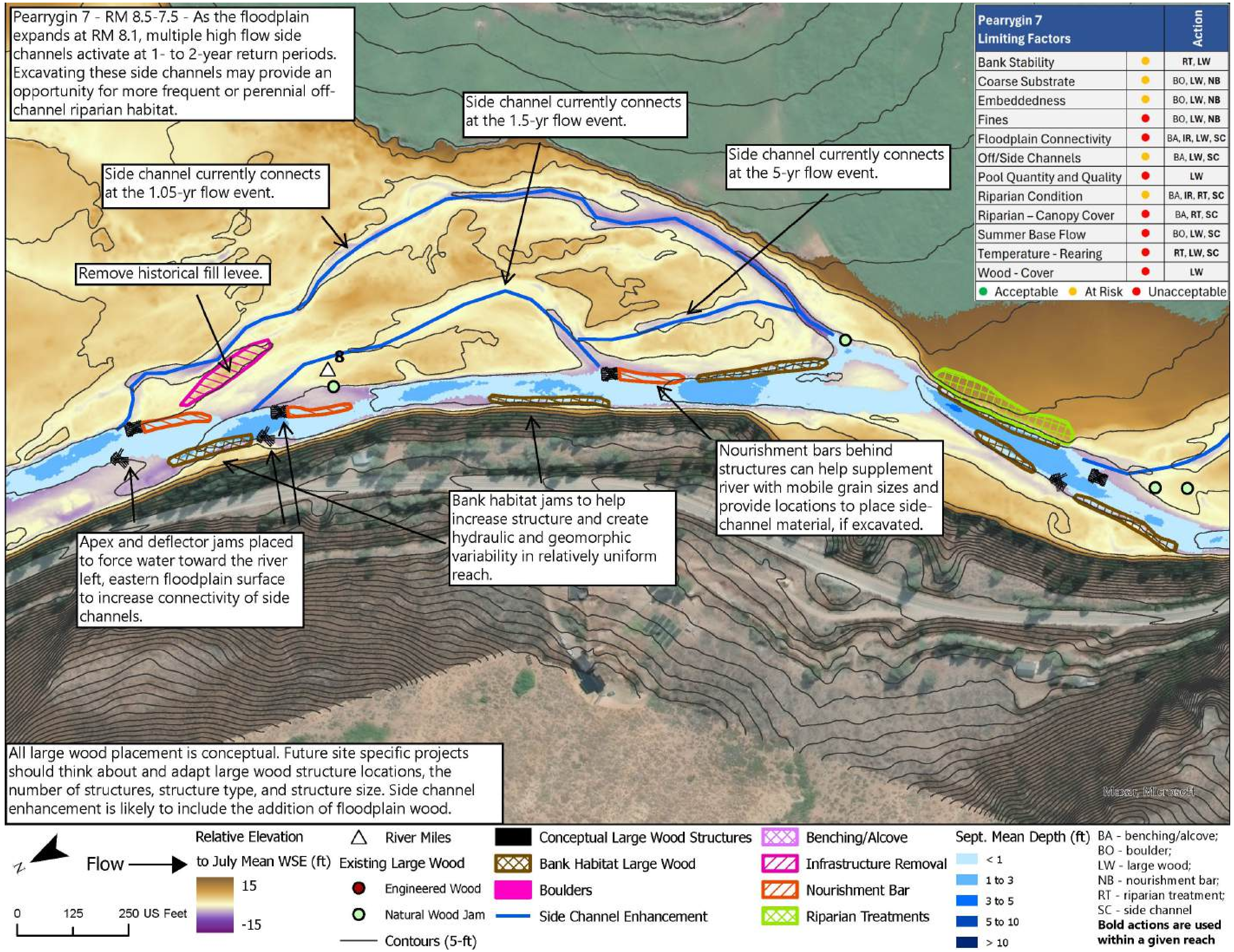


Figure B-5.—Design concepts for the Chewuch River within a portion of Pearrygin 7.

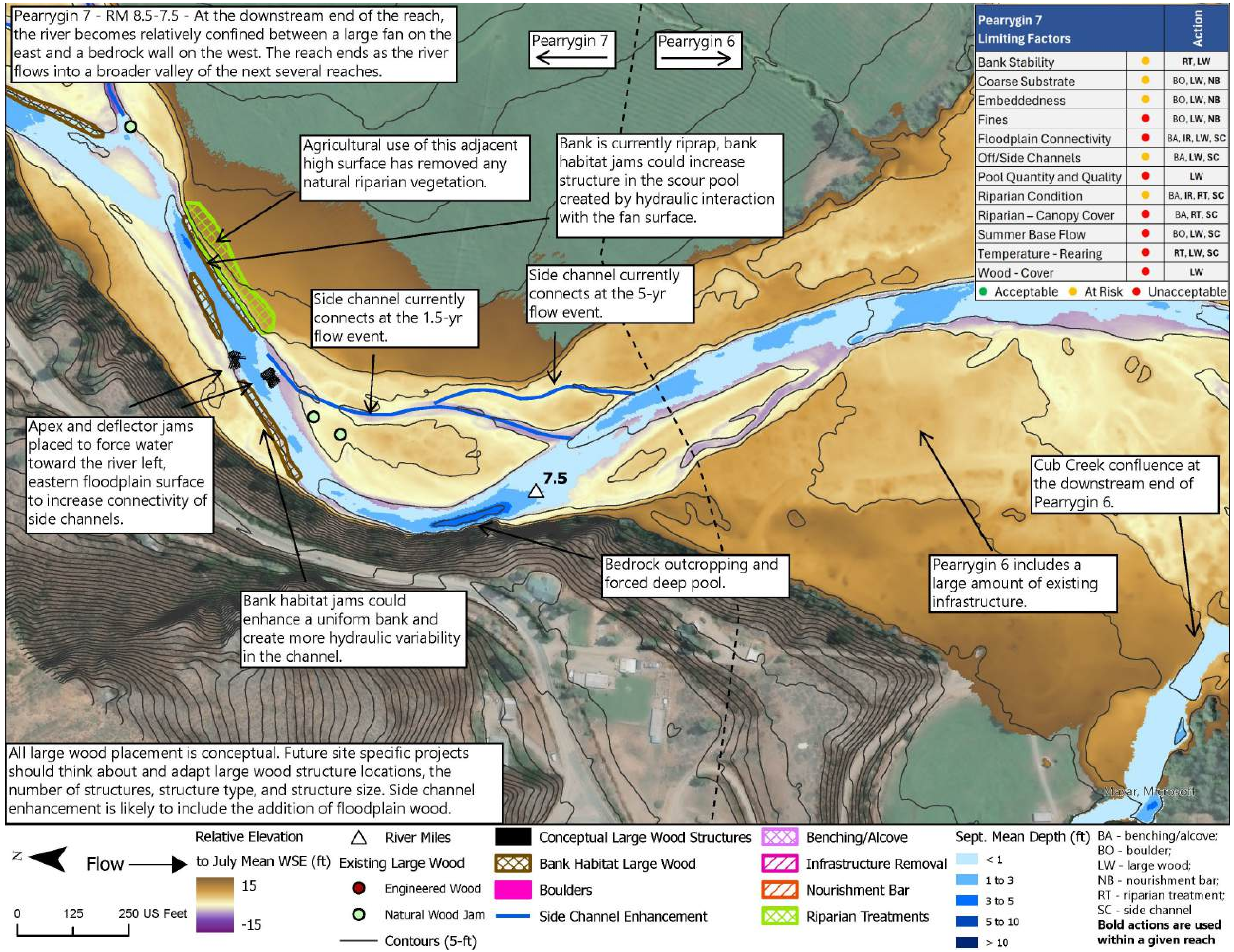


Figure B-6.—Design concepts for the Chewuch River within a portion of Pearrygin 7.

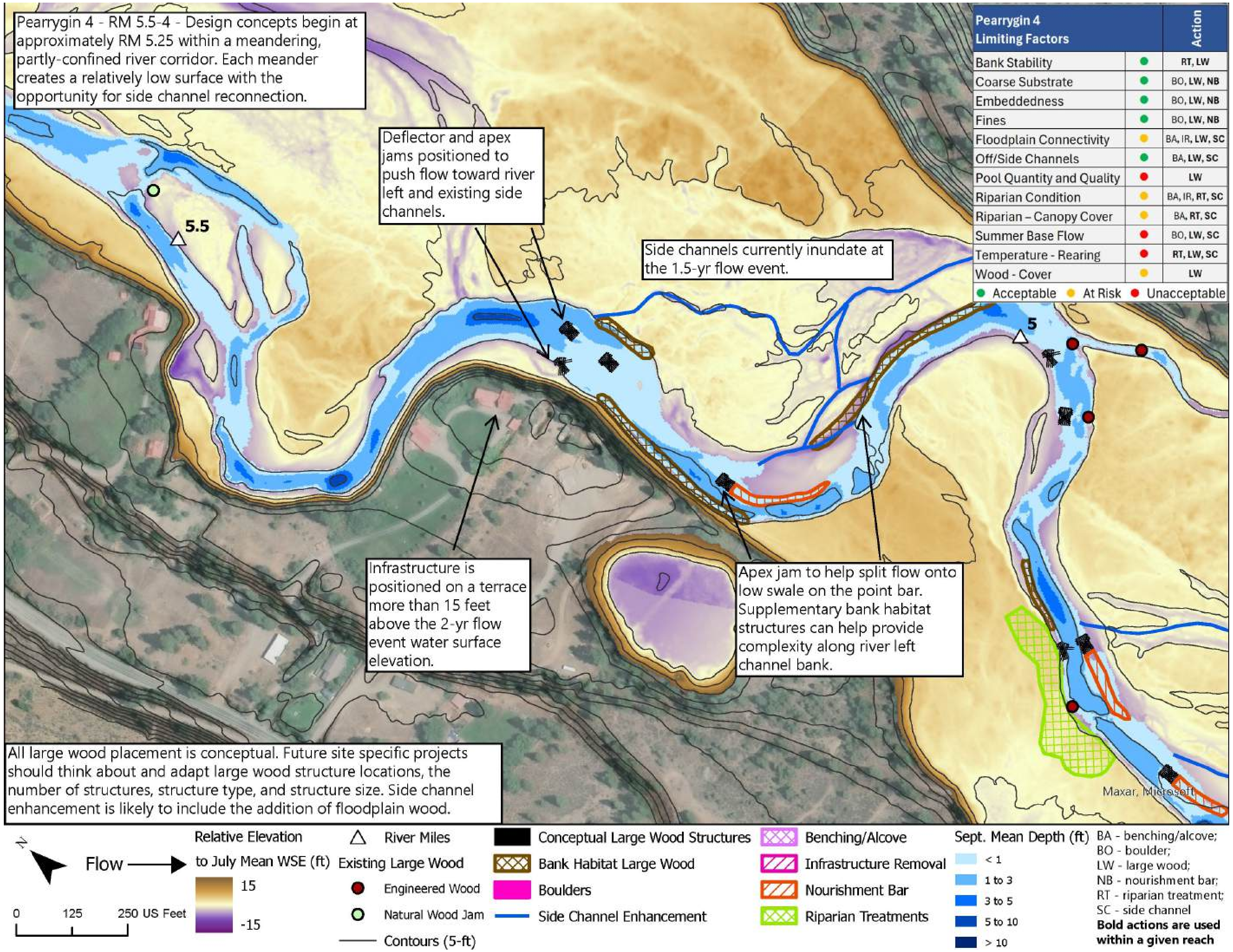


Figure B-7.—Design concepts for the Chewuch River within a portion of Pearrygin 4.

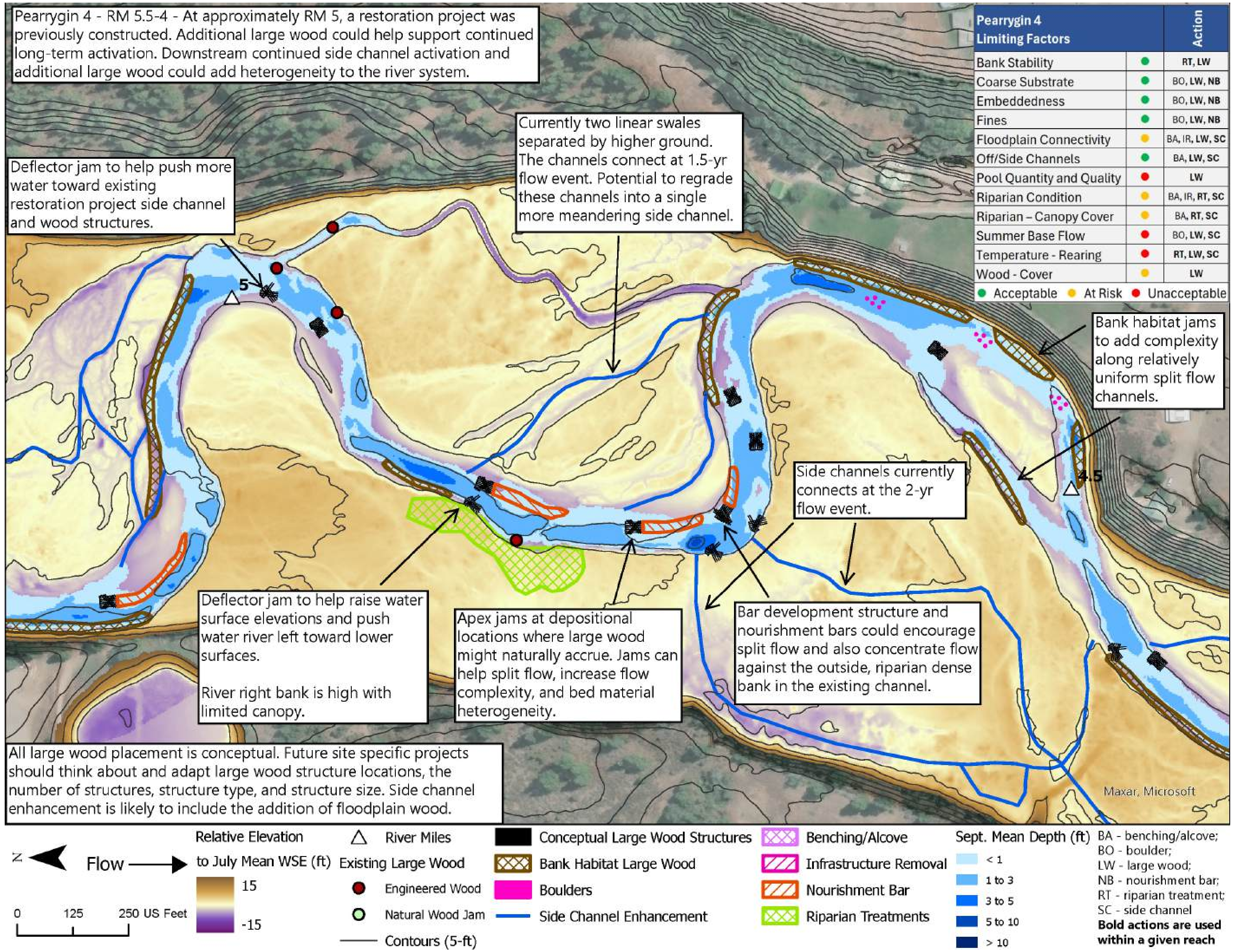
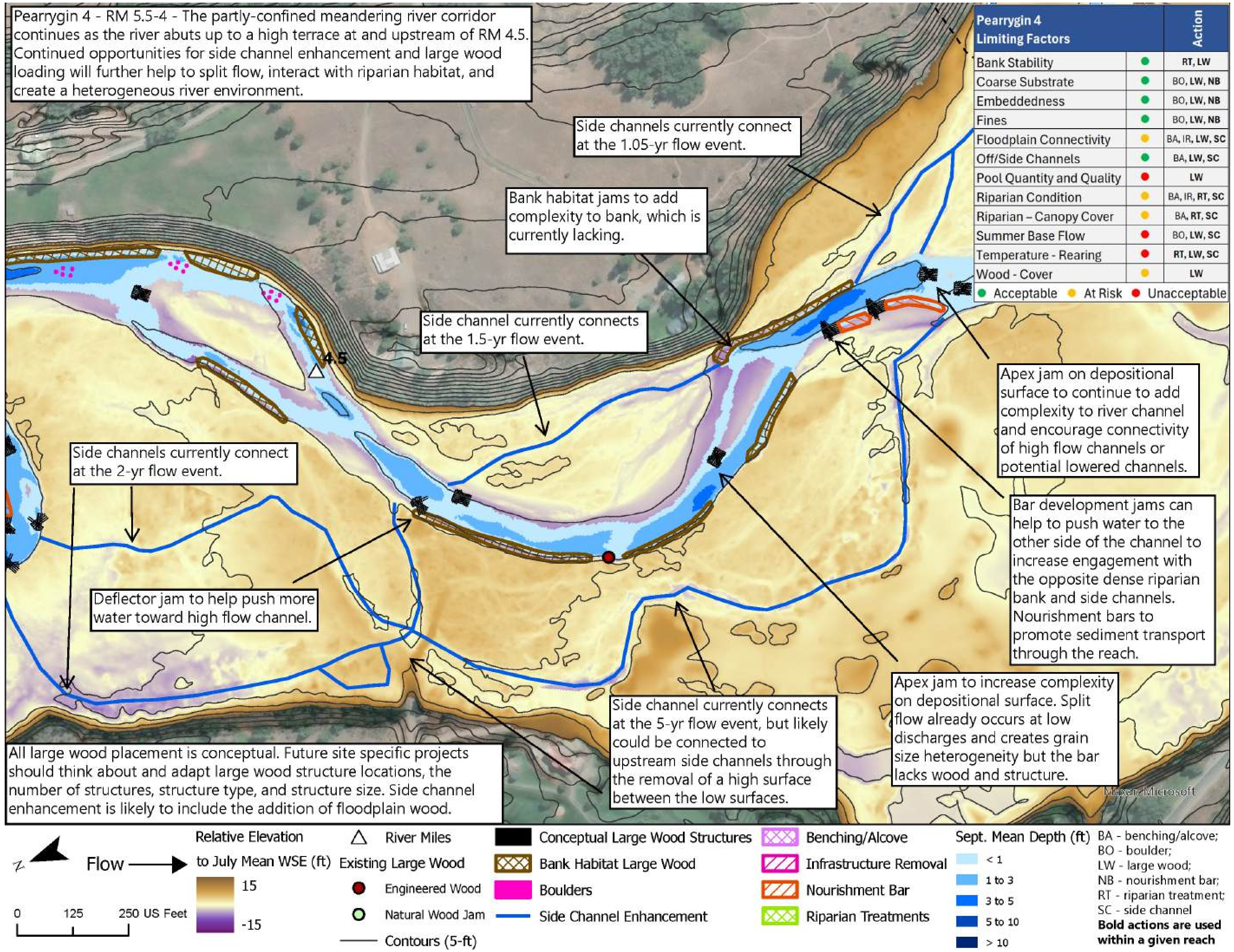


Figure B-8.—Design concepts for the Chewuch River within a portion of Pearrygin 4.



Pearrygin 4 Limiting Factors		Action
Bank Stability	● Acceptable	**RT, LW**
Coarse Substrate	● Acceptable	BO, **LW, NB**
Embeddedness	● Acceptable	BO, **LW, NB**
Fines	● Acceptable	BO, **LW, NB**
Floodplain Connectivity	● At Risk	BA, IR, **LW, SC**
Off/Side Channels	● Acceptable	BA, **LW, SC**
Pool Quantity and Quality	● Unacceptable	**LW**
Riparian Condition	● At Risk	BA, IR, **RT, SC**
Riparian – Canopy Cover	● At Risk	BA, **RT, SC**
Summer Base Flow	● Unacceptable	BO, **LW, SC**
Temperature - Rearing	● Unacceptable	**RT, LW, SC**
Wood - Cover	● At Risk	**LW**

● Acceptable ● At Risk ● Unacceptable

Figure B-9.—Design concepts for the Chewuch River within a portion of Pearrygin 4.

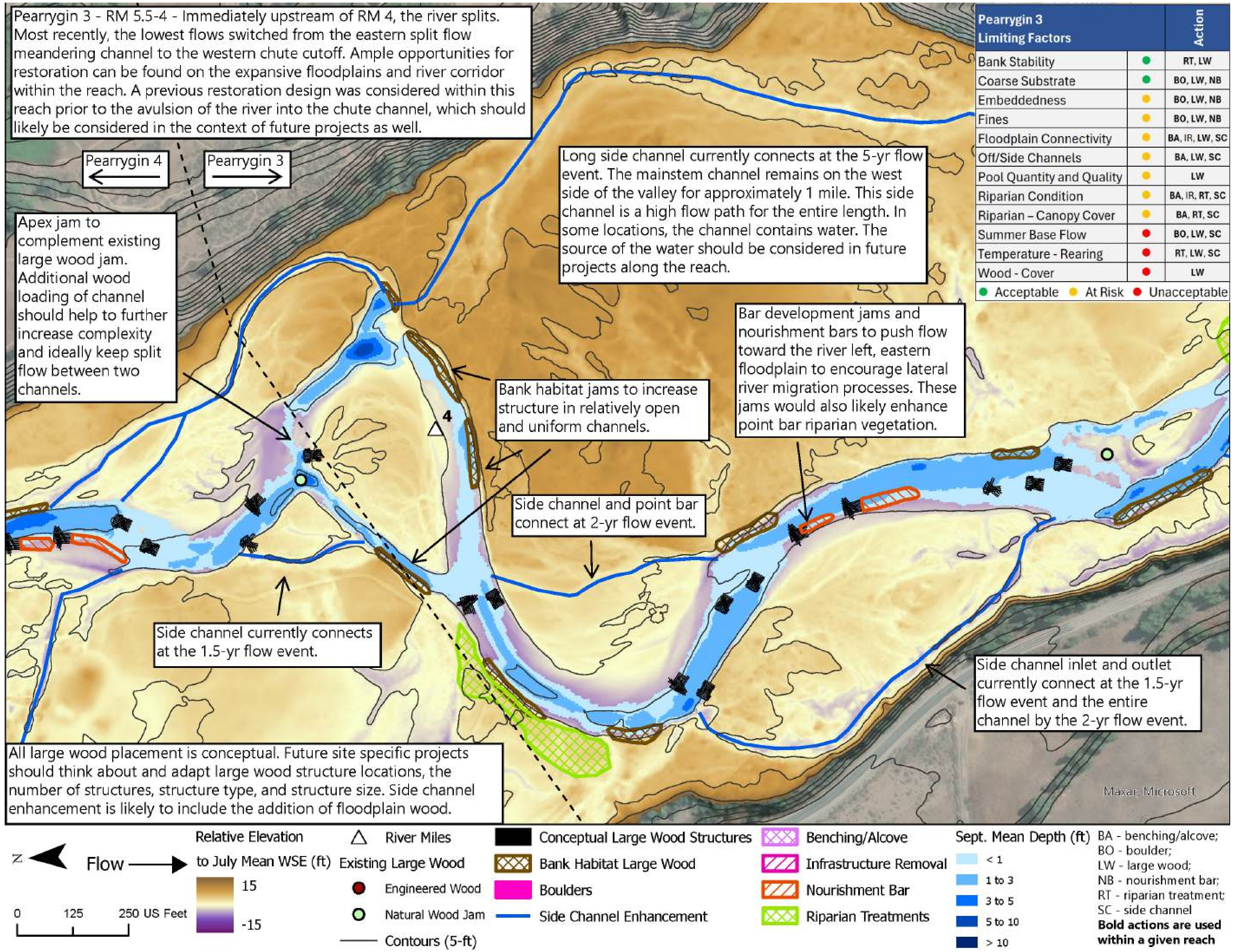
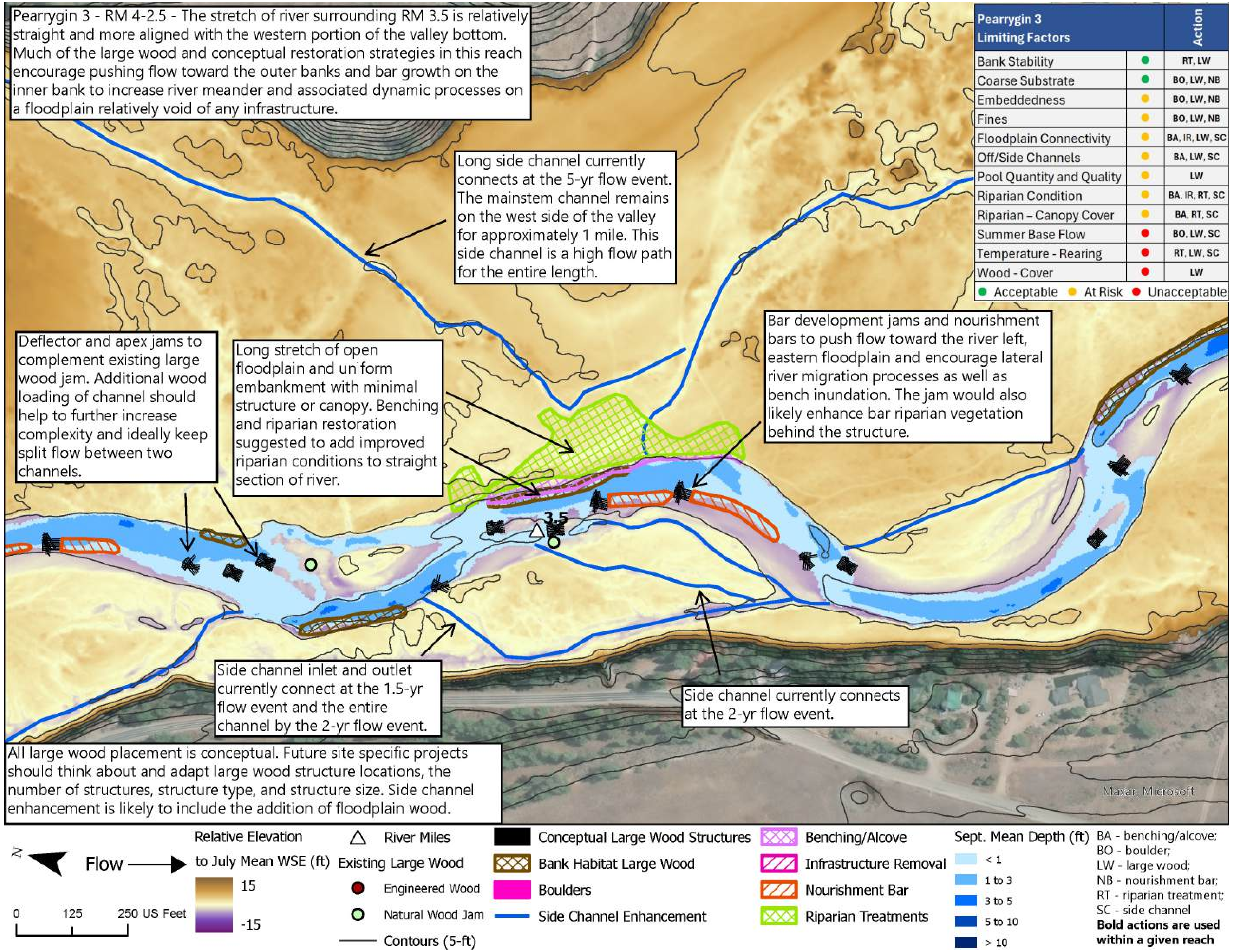


Figure B-10.—Design concepts for the Chewuch River within a portion of Pearrygin 3.



Pearrygin 3 Limiting Factors		Action
Bank Stability	Acceptable	RT, LW
Coarse Substrate	Acceptable	BO, LW, NB
Embeddedness	At Risk	BO, LW, NB
Fines	At Risk	BO, LW, NB
Floodplain Connectivity	At Risk	BA, IR, LW, SC
Off/Side Channels	At Risk	BA, LW, SC
Pool Quantity and Quality	At Risk	LW
Riparian Condition	At Risk	BA, IR, RT, SC
Riparian – Canopy Cover	At Risk	BA, RT, SC
Summer Base Flow	Unacceptable	BO, LW, SC
Temperature - Rearing	Unacceptable	RT, LW, SC
Wood - Cover	Unacceptable	LW

Figure B-11.—Design concepts for the Chewuch River within a portion of Pearrygin 3.

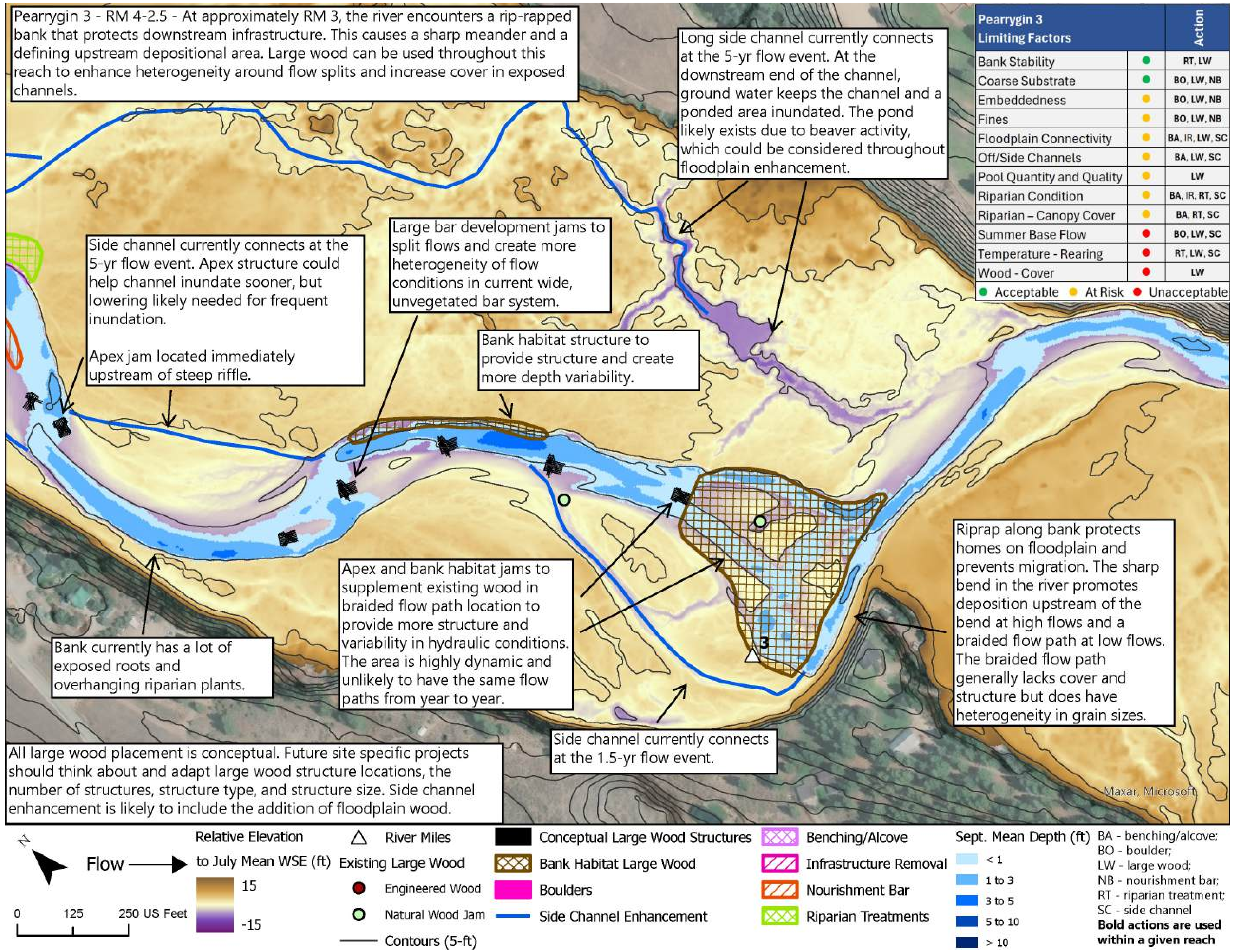


Figure B-12.—Design concepts for the Chewuch River within a portion of Pearrygin 3.

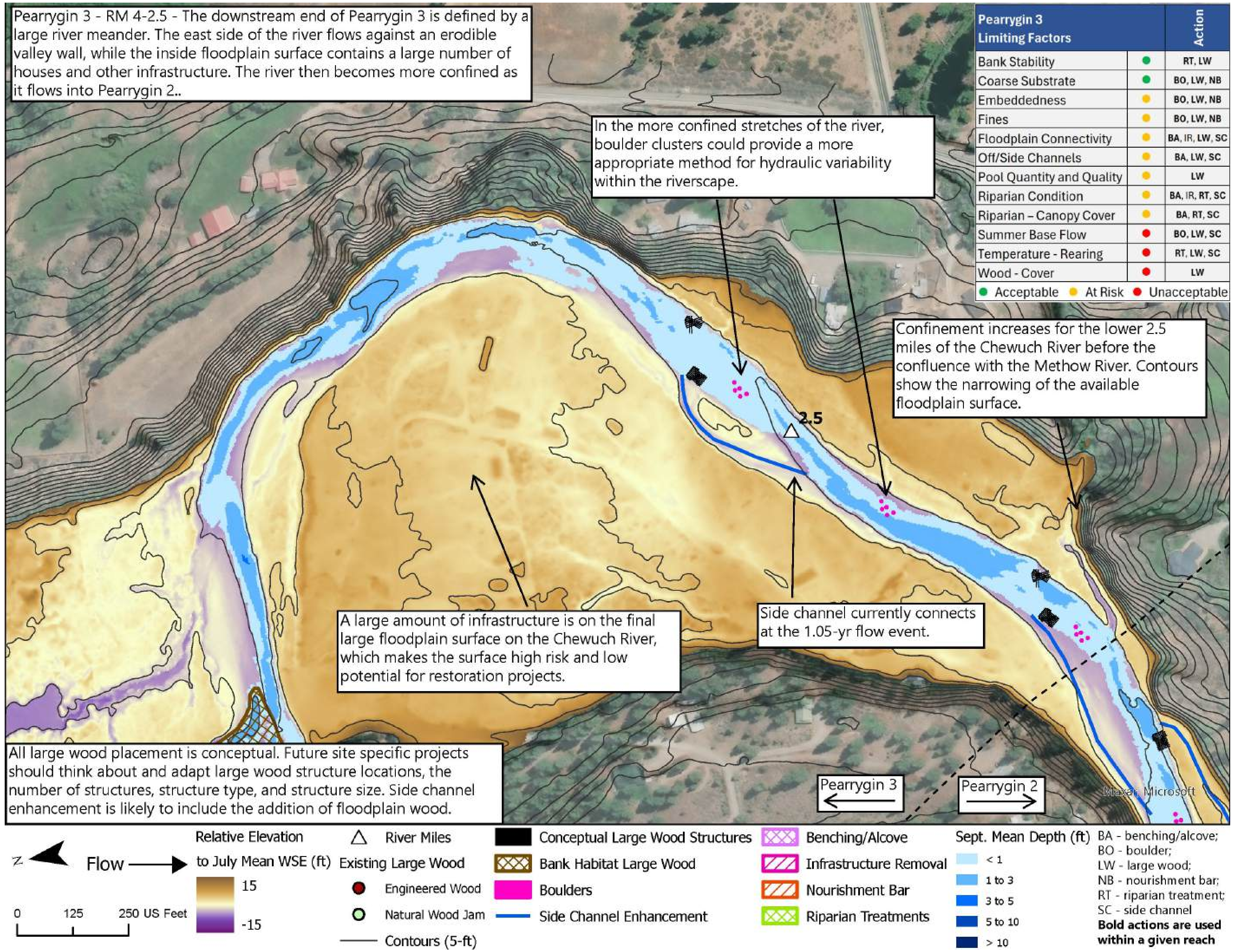


Figure B-13.—Design concepts for the Chewuch River within a portion of Pearrygin 3.

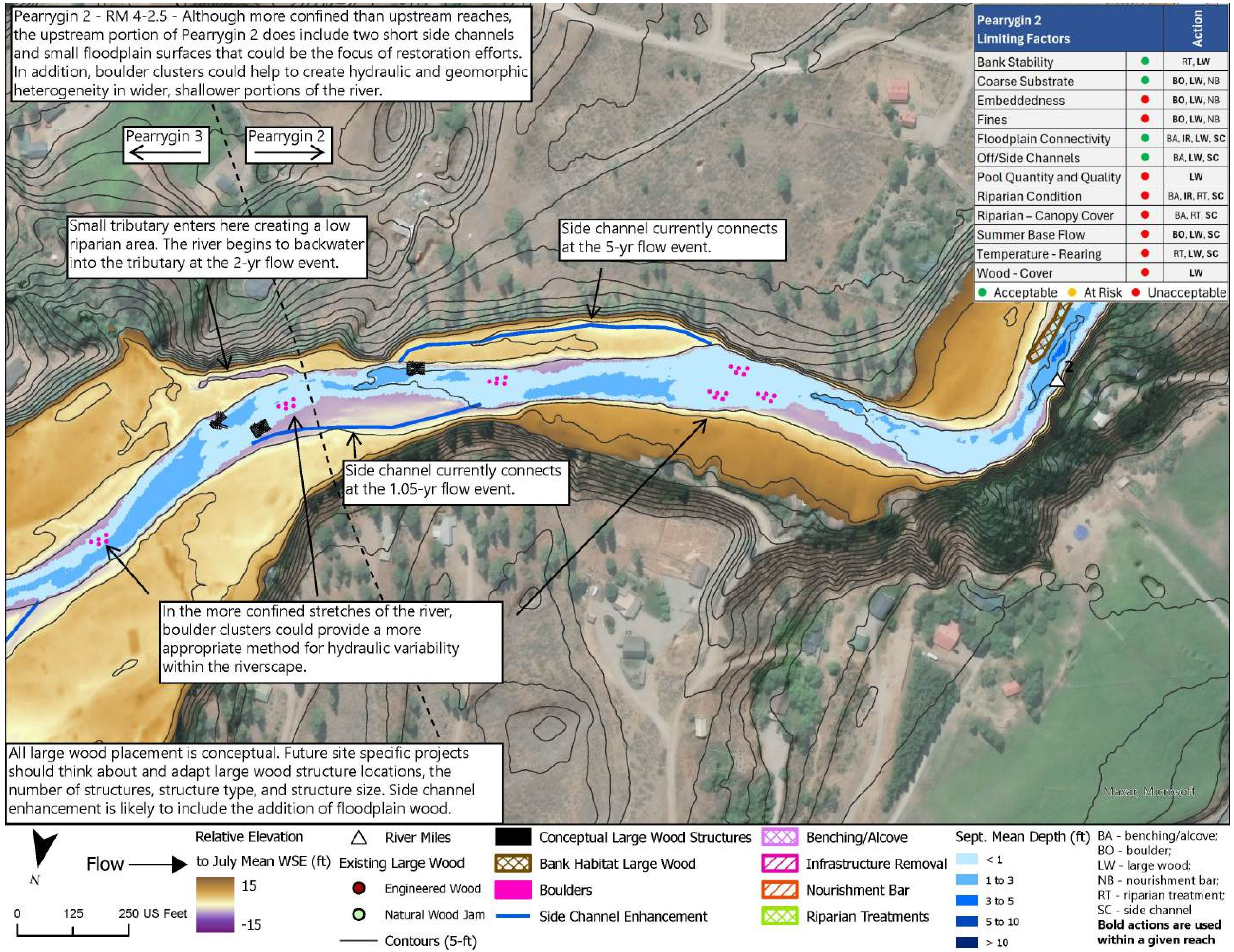


Figure B-14.—Design concepts for the Chewuch River within a portion of Pearrygin 2.

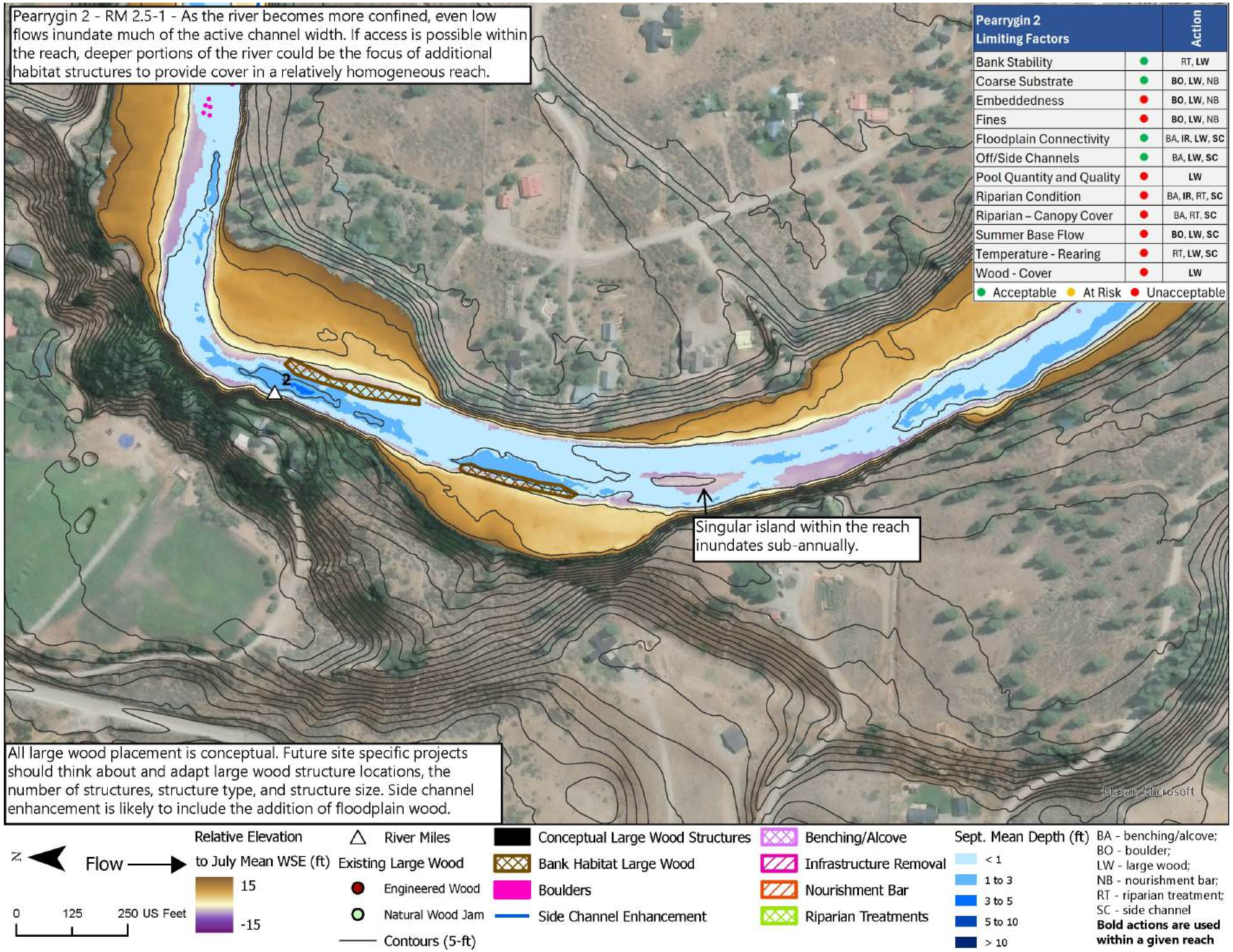


Figure B-15.—Design concepts for the Chewuch River within a portion of Pearrygin 2.

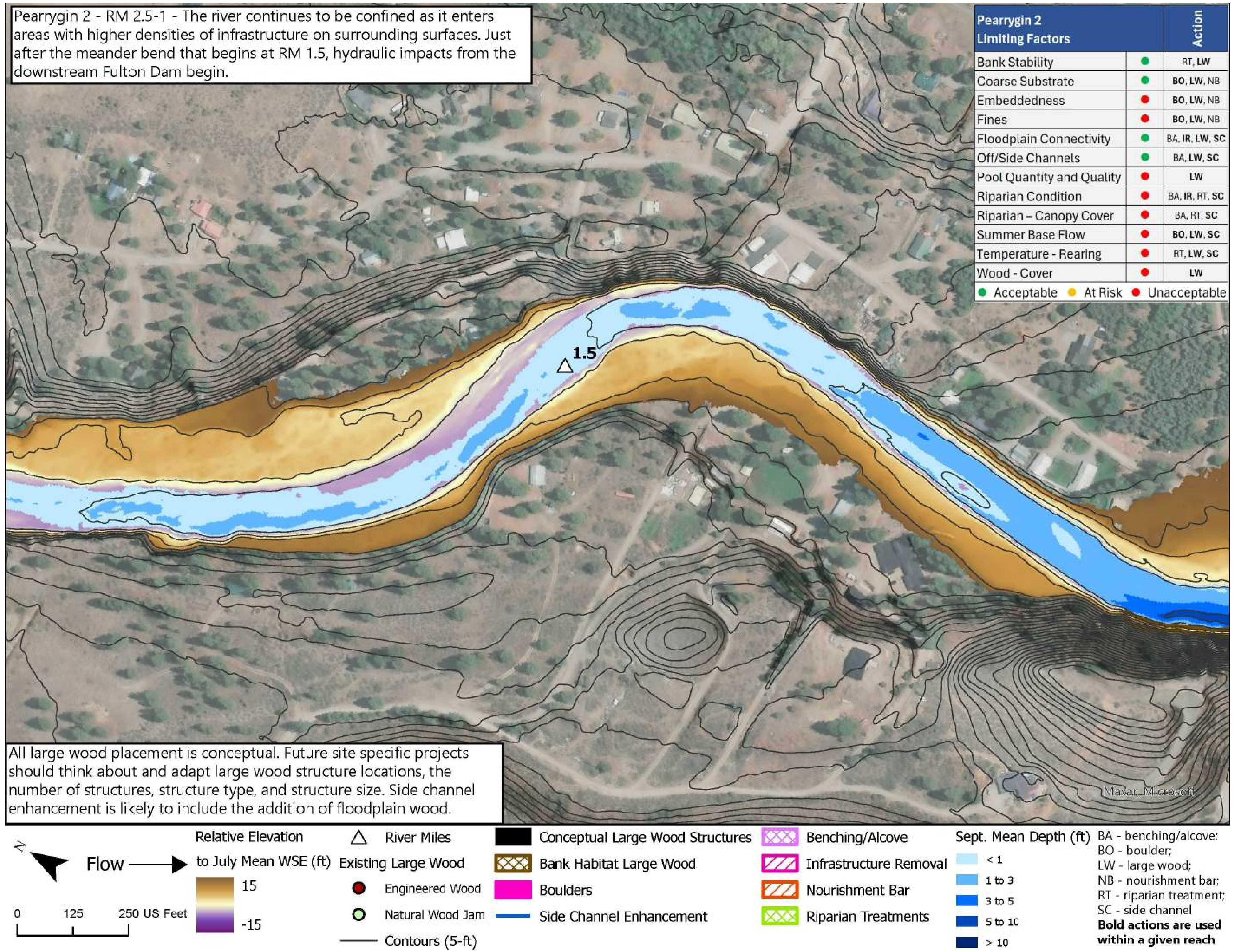


Figure B-16.—Design concepts for the Chewuch River within a portion of Pearrygin 2.

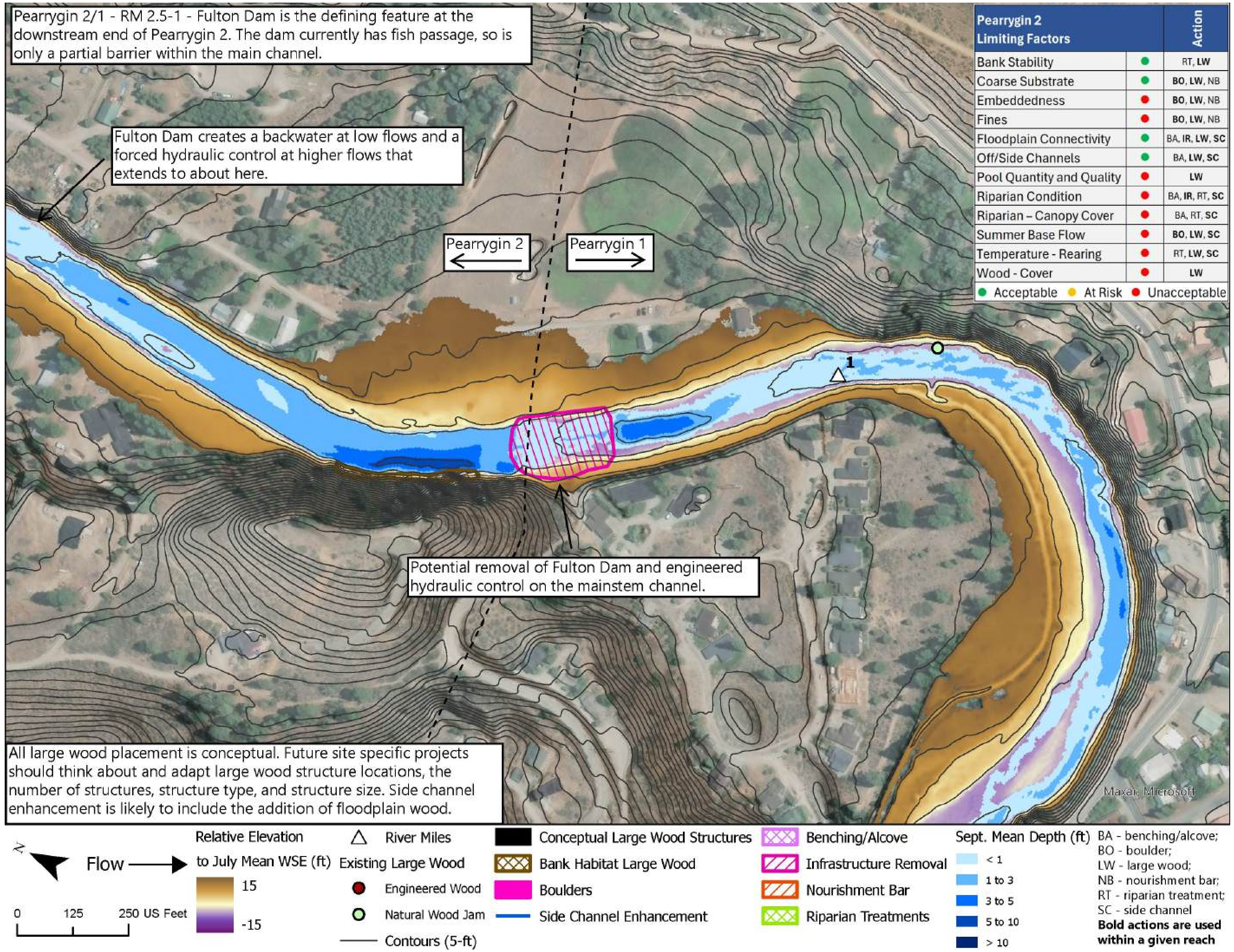


Figure B-17.—Design concepts for the Chewuch River within a portion of Pearrygin 2.