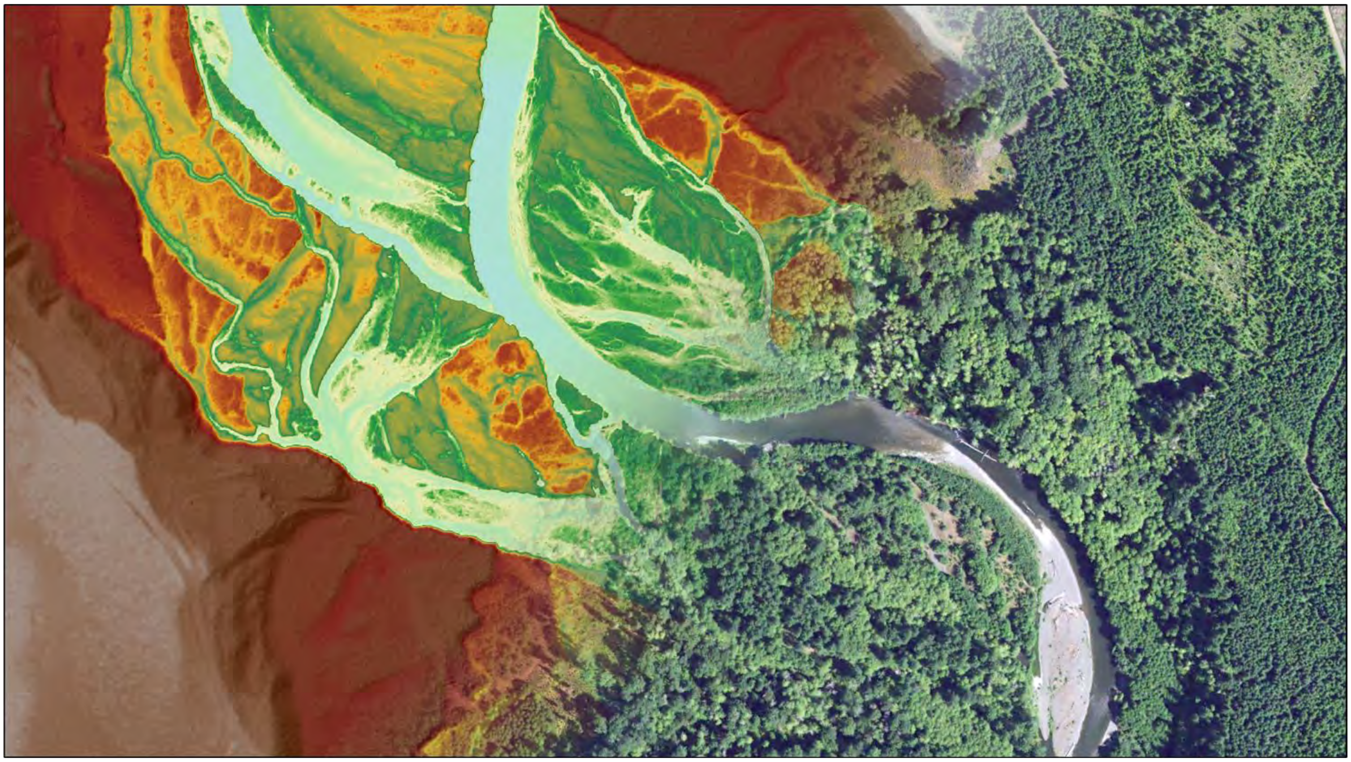
SATSOP AND WYNOOCHEE AQUATIC HABITAT RESTORATION PLANNING AND PRIORITIZATION

Restoration and Protection Opportunities



Prepared for:

Grays Harbor Conservation District
330 Pioneer Avenue West, Suite D
Montesano, WA 98563

Prepared by:

Reid Camp, Phil Roni, and Meghan Camp
Cramer Fish Sciences
1125 12th Ave. NW, Suite B-1
Issaquah, WA 98027

Susan Dickerson-Lange and Danny Stratten
Natural Systems Design
1900 N. Northlake Way, Suite 211
Seattle, WA 98103

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EXECUTIVE SUMMARY

The Chehalis Basin is a region rich in diverse native wildlife and amphibians, working lands, and cultural significance and is one of the only remaining river basins in Washington where no salmon species are listed as threatened or endangered. The basin is therefore economically and ecologically vital to the state and region. However, aquatic habitat conditions in the Satsop and Wynoochee River systems within the Chehalis Basis have been impacted by the removal of in-stream large wood, splash dam operation, the development of road networks, and timber harvest. This has resulted in systems with impaired aquatic habitat formation and maintenance processes. Therefore, Phase I of the Aquatic Species Restoration Plan (ASRP), a major element of the Chehalis Basin Strategy, prioritized certain geospatial units (GSUs) for protection and restoration project development to maximize aquatic species benefits. Consequently, Cramer Fish Sciences (CFS) was contracted by Grays Harbor Conservation District (GHCD) to complete a watershed assessment and identify restoration opportunities in the priority GSUs withing the Satsop and Wynoochee River systems. The priority GSUs evaluated in this report are the mainstem channels of Bingham Creek, Decker Creek, East Fork Satsop River, Stillwater Creek, and Wynoochee River. The objectives of this project were to 1) delineate and characterize geomorphic reaches for 93 miles of the Satsop/Wynoochee river reaches, 2) use the analysis to develop a reach-by-reach prioritization matrix for restoration and protection, 3) describe typical restoration techniques for the identified reaches, and 4) create reach scale conceptual restoration plans for 13 of the high priority reaches. To accomplish these objectives, we first conducted a geomorphic assessment through a GIS analysis of the hydro-geomorphological stream conditions. Geomorphic segments were delineated based on surficial geology and soils, valley bottom width, valley slope, valley sinuosity, and major tributaries. These segments represent areas with relatively consistent physical controls and ultimately are the driving force for identifying expected river character and behavior. We further divided geomorphic segments into geomorphic reaches that exhibited consistent channel and floodplain characteristics. Data from the remote sensing analysis was used to identify and delineate reaches based on channel slope, channel sinuosity, channel width, large wood density, floodplain area, and confinement. We identified 31 geomorphic segments, containing 83 geomorphic reaches across the six priority rivers. These reaches represent stretches of river with common physical characteristics and are influenced by relatively consistent physical constraints. Next, using stakeholder input, we developed a prioritization matrix for comparing restoration potential among stream reaches to select high priority reaches to move forward to the conceptual plan development stage. The prioritization goals were to classify reaches for protection or restoration and prioritize reaches based on restoration potential. Reaches were first classified as “protection” or

“restoration” reaches. Next, a prioritized list of restoration reaches was developed to address impaired watershed processes, focusing on in-stream work that can be built into a broader aquatic restoration plan. Specific criteria included in the prioritization scoring were derived from results of the assessment, including confinement, large wood deficit, potential increase in floodplain connection, and number of fish species benefiting. Out of the 83 reaches identified in the assessment, we classified 54 restoration reaches and 29 protection reaches. We then developed conceptual restoration plans for 13 restoration reaches within the Satsop and Wynoochee watersheds that were ranked as High priority. Each concept includes maps, site description, conceptual project actions, expected benefits, and potential challenges and considerations.

LIST OF ACRONYMS

BFW	Bankfull Width
CFS	Cramer Fish Sciences
EF	East Fork
GHCD	Grays Harbor Conservation District
GIS	Geographic Information System
GPS	Global Positioning System
LW	Large Wood
MCD	Mason Conservation District
NSD	Natural Systems Design
RL	River Left
RM	River Mile
RR	River Right
VB	Valley bottom
WDFW	Washington Department of Fish and Wildlife

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1.0 BACKGROUND

The Chehalis Basin is a region rich in diverse native wildlife and amphibians, working lands, and cultural significance and is one of the only remaining river basins in Washington where no salmon species are listed as threatened or endangered. The basin is therefore economically and ecologically vital to the state and region. However, the ecosystem has been substantially changed from historical conditions through activities such as removal of wood from rivers, use of splash dams, channel straightening, and removal of riparian forest. These actions contributed to channel incision that disconnected the river from side channels and floodplain wetlands and reduced cover, shading, and aquatic habitat area. Specifically, aquatic habitat conditions within the Satsop and Wynoochee River systems have been impacted by the removal of in-stream large wood, splash dam operation, the development of road networks, and timber harvest of the source of future large wood inputs. This has resulted in systems with impaired aquatic habitat formation and maintenance processes.

The Aquatic Species Restoration Plan (ASRP), a major element of the Chehalis Basin Strategy, is an initiative led by the State Office of the Chehalis Basis and was developed in collaboration with the Quinault Indian Nation, the Confederated Tribes of the Chehalis Reservation, and the Washington Department of Fish and Wildlife. According to ASRP Phase 1, the limiting factors for the Satsop and Wynoochee watersheds include: high water temperatures, low habitat diversity (lack of side channels, large wood, floodplain connectivity, and beaver ponds), reduced quantity and quality of instream habitats, channel lengths and widths, sediment load (fine sediments), fish passage barriers, predation (non-native fish species), channel instability, and flow (primarily low flow). To address these limiting factors, the ASRP Phase 1 recommends placement of instream wood to improve channel stability, trap alluvium, increase variations in bed textures, increase number of pool and cover, raise streambeds, increase floodplain connectivity, and promote groundwater recharge. The ASRP also recommends reconnection of floodplains to restore and increase off-channel habitats that are important for juvenile coho and Chinook salmon. Furthermore, there are highly functioning habitats in the East Fork Satsop watershed and its tributaries, including existing wetlands and cold-water recharge pathways, which the ASRP identifies as a priority for protection.

Phase I of the ASRP prioritized certain geospatial units (GSUs) for protection and restoration project development to maximize aquatic species benefits. In the Olympic Mountains Ecological Region (OMER) of the Chehalis, the ASRP prioritized several GSUs that overlap almost completely with two timber-land ownerships—Green Diamond Natural Resource Company and Weyerhaeuser. The priority GSUs evaluated in this report are the mainstem channels of Bingham Creek, Decker Creek, East Fork Satsop River, Stillwater Creek, and Wynoochee River (Figure 1). The objectives of this project were to 1) delineate and characterize geomorphic reaches for 93 miles of the Satsop/Wynoochee river reaches, 2) use the analysis to develop a reach-by-reach prioritization matrix for restoration and protection, 3) develop typical restoration techniques for the identified reaches, and 4) create reach scale conceptual restoration plans for 13 of the high priority reaches.

To achieve these objectives, GHCD and the CFS team identified the following tasks:

1) Conduct a GIS analysis of hydro-geomorphological stream conditions.
2) Using stakeholder input, develop a prioritization matrix for comparing restoration potential between stream reaches and select high priority reaches that will move forward to the conceptual plan development phase.
3) Create conceptual restoration plans for high priority reaches.

The following report documents and summarizes these four components. Section 2.0 describes the results of the geomorphic assessment and reach characterization; Section 3.0 describes the prioritization process and final list of prioritized actions as well as recommended next steps. Section 4.0 contains conceptual restoration plans, Section 5.0 contains References, and section 6.0, Appendices, provides additional documentation.

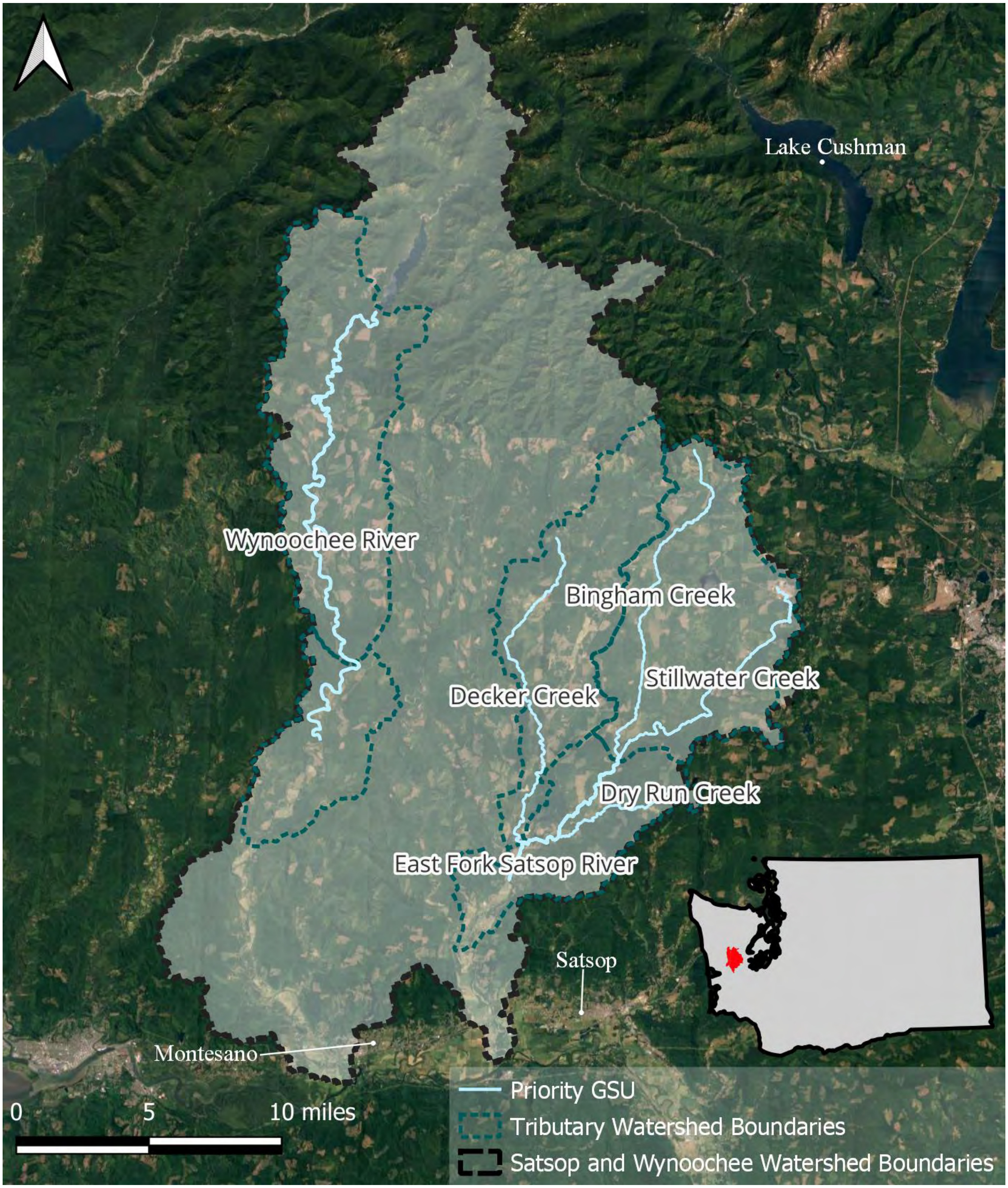


Figure 1. Overview map of prioritized geospatial units (GSU) in the Wynoochee and Satsop watersheds from the Chehalis Basin Strategy Aquatic Species Restoration Plan (ASRP).

2.0 ASSESSMENT METHODS AND RESULTS

2.1 Segment Classification

Geomorphic segments represent sections of the river that are influenced by similar valley-scale characteristics (Brierley and Fryirs 2005; Roni and Beechie 2013; Gurnell et al. 2016). Major changes in geology, soils, tributary confluences, gradient, and valley confinement constitute a change in a segment (Gurnell et al. 2016; Rinaldi et al. 2016; Fryirs et al. 2016). Geomorphic segments are typically several miles long (<10 km), and the physical conditions they impose on a river dictate a range of expected channel characteristics (Church 2002; Gurnell et al. 2016). We identified and delineated geomorphic segments in GIS based on the attributes described below using publicly available spatial datasets and derivatives. Segments were then characterized for the mainstems of the priority rivers.

Geomorphic segments were delineated based on surficial geology and soils (Table 1), valley bottom width, valley slope, valley sinuosity, and major tributaries (Table 2 and Table 3). These segments represent areas with relatively consistent physical controls and ultimately are the driving force for identifying expected river character and behavior. For example, steep and confined segments are not expected to have a high abundance of LW or multiple channels, and unconfined segments are expected to have a high abundance of bars (Brierley and Fryirs 2005; Millington and Sear 2007). Identifying and understanding the differences between what is expected versus what is present in a river provides the foundation for locating beneficial restoration opportunities. Overview maps of segments within each priority river are available in Appendix A.

Dominant geology was derived from the WA DNR 1:100,000 scale geologic maps using GIS. The lithology within the valley bottom and adjacent hillslopes of each reach was recorded.

Dominant valley bottom soils were derived from the USDA NRCS Gridded National Soil Survey Geographic Database (gNATSGO) using GIS. The dominant soil types within each reach's valley bottom were recorded. Soils within the valley bottom provide insight to the history of the valley bottom, and what caliber of sediment could be recruited to the channel through erosional processes. Descriptions and basic taxonomy of each soil type present within the assessed area is provided in Table 1.

Dominant hillslope soils were derived from the USDA NRCS Gridded National Soil Survey Geographic Database (gNATSGO) using GIS. The dominant soil types within each reach's adjacent hillslopes were recorded. Soil types on adjacent hillslopes provide insight into the caliber of sediment sources for the valley bottom or channel during rainstorms or mass wasting events. Descriptions and basic taxonomy of each soil type present within the assessed area is provided in Table 1.

Valley bottom width represents the current width of the area within the valley that contains the floodplain and bankfull channel. The valley bottom tool in the Fluvial Corridor Toolbox (Roux et al. 2015) was used to create continuous valley bottom polygons for each priority river. The tool was run iteratively for each river and validated against LiDAR elevation data to determine an appropriate cut-off elevation that represents the max extent of the valley bottom. A centerline was created from each polygon and disaggregated at 33-foot (10 m) intervals. The end vertex of each line was converted to a point and the width of the polygon was measured at a perpendicular angle to the centerline at every point. The mean valley bottom width was then calculated for each segment.

Valley slope is the percent gradient of the valley, independent of the river channel. Major discrepancies between the valley slope and channel slope can provide insight into disconnected or poorly functioning fluvial processes at the reach-scale. Conversely, major discrepancies can also indicate a highly functioning and dynamic reach (e.g., large sediment sinks forced by wood jams). Therefore, this metric is used as an indicator to investigate certain reaches more closely. The valley bottom polygon was converted to lines and disaggregated at 1,640-foot (500 m) intervals. Slope was calculated for each line section and averaged for each segment.

Valley sinuosity represents that relative magnitude of curves or bends in the valley, independent of the channel. If channel sinuosity is evaluated alone, it could be misrepresented if the river is merely flowing within the constraints of the valley margins. A centerline was derived from the valley bottom polygon and disaggregated at 3,280-foot (1000 m) intervals. Sinuosity was calculated as the length of each line section divided by the straight-line length between the top and bottom ends of each line section. The sinuosity values were then averaged for each segment.

Contributing tributaries were recorded if an official Geographic Names Information System (GNIS) name was available in the National Hydrography Dataset (NHD). All tributary junctions were considered when delineating segments; however, only those with names were included in this report for additional spatial context for each segment.

Table 1. Name, description, and taxonomic class of soil types within the valley bottom and adjacent hillslopes of the priority rivers (NRCS Web Soil Survey).

Soil Type	Description	Taxonomic class
Rennie-Grehalem (s8540)	The Rennie series consists of very deep, poorly drained soils that formed in oxbows, backswamps, and other depressions in river valleys. Rennie soils are on floodplains with slopes of 0 to 5 percent. The Grehalem series consists of very deep, well drained soils that formed in alluvium derived from basic igneous and sedimentary rocks. Grehalem soils are on floodplains with slopes of 0 to 3 percent.	Fine-silty; Fine-loamy
Le Bar-Hoquiam (s8543)	The Le Bar series consists of deep, well drained soils formed in loess and old alluvium. These soils are on terraces and terrace escarpments and have 0 to 65 percent slopes. The Hoquiam series consists of deep to cemented till, well drained soils that formed in old alluvium deposited over glacial drift. These soils are on ground moraine positions in uplands and have slopes ranging from 1 to 65 percent.	Medial; Medial
Zenker-Hoquiam-Elochoman (s8545)	The Zenker series consists of very deep and deep, well drained soils formed in weathered sandstone. Zenker soils are on colluvial mountain slopes and have slopes of 8 to 90 percent. The Hoquiam series consists of deep to cemented till, well drained soils that formed in old alluvium deposited over glacial drift. These soils are on ground moraine positions in uplands and have slopes ranging from 1 to 65 percent. The Elochoman series consists of very deep, well drained soils formed in material from deeply weathered sandstone. Elochoman soils are on foothills and mountains and have slopes of l to 65 percent.	Medial; Medial; Medial
Shelton-Alderwood (s8556)	The Shelton series consists of moderately deep, moderately well drained soils that formed in glacial till. Shelton soils are on undulating to rolling glacial moraines. The Alderwood series consists of moderately deep, moderately well drained soils formed in glacial till. Alderwood soils are on glacially modified foothills and valleys and have slopes of 0 to 65 percent.	Medial-skeletal; Loamy-skeletal
Solduc-Palix-Hoko-Halbert (s8519)	The Solduc series consists of very deep, somewhat excessively drained soils that formed in glacial outwash on glacial outwash plains or terraces and associated escarpments. Slopes are 0 to 65 percent. The Palix series consists of deep, well drained soils that formed in colluvium and residuum from bedrock of siltstone, sandstone, and conglomerate lithologies. Palix soils are on hills and mountains and have slopes of 8 to 90 percent. The Hoko series consists of moderately deep to cemented till, moderately well drained soils formed in alpine glacial till. These soils are on till plains and mountains. Slopes are 0 to 60 percent. The Halbert series consists of shallow, very poorly drained soils that formed in silty glaciolacustrine sediments over glacial outwash. Halbert soils are in depressions	Medial-skeletal over sandy or sandy-skeletal; Medial; Medial-skeletal; Loamy

Soil Type	Description	Taxonomic class
	on glacial outwash terraces and till plains and have 0 to 10 percent slopes.	
Rock outcrop-Knappton-Katula-Bunker (s8549)	Rock outcrops are exposed or shallow bedrock of the dominant surficial geology. The Knappton series consists of deep and very deep, well drained soils that formed in material weathered from basalt colluvium. Knappton soils are on mountainous uplands and have slopes of 1 to 90 percent. The Katula series consists of moderately deep, well drained, moderately permeable soils formed in basalt and an admixture of volcanic ash. Katula soils are on narrow ridges, shoulders, and back slopes of mountainous areas and have slopes of 5 to 90 percent. The Bunker series consists of deep, well drained soils weathered from colluvial basalt on foothills and mountains. Slopes are 1 to 90 percent.	Rock outcrop; Medial; Medial-skeletal; Medial over clayey
Zenker-Lytell-Astoria (s8544)	The Zenker series consists of very deep and deep well drained soils formed in weathered sandstone. Zenker soils are on colluvial mountain slopes and have slopes of 8 to 90 percent. The Lytell series consists of deep, well drained soils formed in material weathered from siltstone or very fine grained sandstone. Lytell soils are on hillsides and ridgetops and have slopes of 5 to 90 percent. The Astoria series consists of deep and very deep well drained soils that formed in colluvium and residuum weathered mostly from shale and siltstone. Astoria soils are on mountains and have slopes of 0 to 90 percent.	Medial; Medial; Fine

Table 2. Characteristics and large-scale physical controls influencing geomorphic segments in the priority rivers (segment 1 begins at the mouth of each river).

River	Segment	Length (mi)	Upstream Drainage Area (mi^2)	Mean VB Width (ft)	Mean Valley Slope	Mean Valley Sinuosity	Contributing Tributaries (if named)
Bingham	**1**	1.6	34.1	608	0.0012	1.18	NA

River	Segment	Length (mi)	Upstream Drainage Area (mi^2)	Mean VB Width (ft)	Mean Valley Slope	Mean Valley Sinuosity	Contributing Tributaries (if named)
Bingham	2	0.9	29.1	148	0.0011	1.09	NA
Bingham	3	3.4	21.6	301	0.0009	1.03	Outlet Creek
Bingham	4	5.3	15.2	355	0.0010	1.09	NA
Bingham	5	4.5	7.9	276	0.0149	1.13	NA
Decker	1	0.5	46.2	892	0.0009	1.74	NA
Decker	2	4.7	44.7	1,317	0.0012	1.14	NA
Decker	3	4.4	34.8	496	0.0011	1.11	Dry Bed Creek
Decker	4	4.5	11.5	732	0.0007	1.07	NA
Decker	5	2.4	3.2	831	0.0009	1.19	NA
Dry Run	1	1.5	6.8	511	0.0022	1.23	NA
Dry Run	2	1.8	6.2	278	0.0011	1.29	NA
Dry Run	3	2.1	5.0	785	0.0006	1.12	NA
Dry Run	4	1.6	1.2	245	0.0013	1.05	NA
EF Satsop	1	0.9	187.9	589	0.0006	1.05	NA
EF Satsop	2	2.4	128.2	1,054	0.0005	1.36	Decker Creek; Comfort Creek; Dry Run Creek
EF Satsop	3	0.9	79.7	131	0.0010	1.05	NA
EF Satsop	4	3.3	70.4	524	0.0009	1.14	NA
EF Satsop	5	0.8	65.4	461	0.0005	1.15	Helene Creek
Stillwater	1	1.7	29.0	688	0.0007	1.07	NA
Stillwater	2	2.9	27.6	723	0.0006	1.30	NA
Stillwater	3	3.6	18.2	1,227	0.0006	1.15	NA
Stillwater	4	1.6	11.2	648	0.0002	1.02	NA
Stillwater	5	4.0	4.7	334	0.0006	1.17	Phillips Creek
Stillwater	6	0.8	2.2	683	0.0005	1.25	NA
Wynoochee	1	7.9	111.1	290	0.0082	1.38	Schafer Creek
Wynoochee	2	3.6	91.7	1,159	0.0052	1.13	NA
Wynoochee	3	7.5	88.8	364	0.0079	1.34	Save Creek
Wynoochee	4	4.9	75.4	130	0.0304	1.36	Larsen Creek; Falls Creek
Wynoochee	5	3.1	68.6	726	0.0065	1.37	Anderson Creek; Harris Creek
Wynoochee	6	3.5	55.1	240	0.0105	1.24	Big Creek

Table 3. Dominant geology and soils by segment of the priority rivers (VB = valley bottom).

River	Segment	Dominant Geology	Dominant VB Soils	Dominant Hillslope Soils
Bingham	**1**	alluvium	Zenker-Hoquiam-Elochoman (s8545)	Zenker-Hoquiam-Elochoman (s8545)
Bingham	**2**	continental glacial outwash, Fraser-age	Zenker-Hoquiam-Elochoman (s8545)	Zenker-Hoquiam-Elochoman (s8545)
Bingham	**3**	continental glacial outwash, Fraser-age	Zenker-Hoquiam-Elochoman (s8545) (~38%); Shelton-Alderwood (s8556) (~62%)	Zenker-Hoquiam-Elochoman (s8545) (~38%); Shelton-Alderwood (s8556) (~62%)
Bingham	**4**	continental glacial outwash, Fraser-age	Shelton-Alderwood (s8556)	Shelton-Alderwood (s8556)
Bingham	**5**	continental glacial outwash, Fraser-age	Le Bar-Hoquiam (s8543)	Le Bar-Hoquiam (s8543); Rock outcrop-Knappton-Katula-Bunker (s8549); Zenker-Lytell-Astoria (s8544)
Decker	**1**	alluvium	Zenker-Hoquiam-Elochoman (s8545)	Zenker-Hoquiam-Elochoman (s8545)
Decker	**2**	alluvium	Zenker-Hoquiam-Elochoman (s8545)	Zenker-Hoquiam-Elochoman (s8545)
Decker	**3**	alluvium	Zenker-Hoquiam-Elochoman (s8545)	Zenker-Hoquiam-Elochoman (s8545)
Decker	**4**	continental glacial outwash, Fraser-age	Le Bar-Hoquiam (s8543)	Le Bar-Hoquiam (s8543); Zenker-Hoquiam-Elochoman (s8545)
Decker	**5**	continental glacial till, Fraser-age	Le Bar-Hoquiam (s8543)	Le Bar-Hoquiam (s8543)
Dry Run	**1**	alluvium	Rennie-Grehalem (s8540)	Rennie-Grehalem (s8540); Zenker-Hoquiam-Elochoman (s8545)
Dry Run	**2**	continental glacial outwash, Fraser-age	Zenker-Hoquiam-Elochoman (s8545)	Zenker-Hoquiam-Elochoman (s8545)
Dry Run	**3**	continental glacial outwash, Fraser-age	Zenker-Hoquiam-Elochoman (s8545)	Zenker-Hoquiam-Elochoman (s8545)
Dry Run	**4**	continental glacial outwash, Fraser-age	Zenker-Hoquiam-Elochoman (s8545)	Zenker-Hoquiam-Elochoman (s8545)
EF Satsop	**1**	alluvium	Rennie-Grehalem (s8540)	Rennie-Grehalem (s8540)
EF Satsop	**2**	alluvium	Rennie-Grehalem (s8540)	Rennie-Grehalem (s8540); Zenker-Hoquiam-Elochoman (s8545)

River	Segment	Dominant Geology	Dominant VB Soils	Dominant Hillslope Soils
EF Satsop	3	alluvium	Zenker-Hoquiam-Elochoman (s8545)	Zenker-Hoquiam-Elochoman (s8545)
EF Satsop	4	alluvium	Zenker-Hoquiam-Elochoman (s8545)	Zenker-Hoquiam-Elochoman (s8545)
EF Satsop	5	alluvium	Zenker-Hoquiam-Elochoman (s8545)	Zenker-Hoquiam-Elochoman (s8545)
Stillwater	1	alluvium	Zenker-Hoquiam-Elochoman (s8545)	Zenker-Hoquiam-Elochoman (s8545)
Stillwater	2	continental glacial outwash, Fraser-age	Zenker-Hoquiam-Elochoman (s8545)	Zenker-Hoquiam-Elochoman (s8545); Shelton-Alderwood (s8556)
Stillwater	3	continental glacial outwash, Fraser-age	Shelton-Alderwood (s8556)	Shelton-Alderwood (s8556)
Stillwater	4	continental glacial outwash, Fraser-age; alluvium	Shelton-Alderwood (s8556)	Shelton-Alderwood (s8556)
Stillwater	5	alluvium	Shelton-Alderwood (s8556)	Shelton-Alderwood (s8556)
Stillwater	6	continental glacial till, Fraser-age	Shelton-Alderwood (s8556)	Shelton-Alderwood (s8556)
Wynoochee	1	alluvium (~60%); marine sedimentary rocks (~30%)	Rennie-Grehalem (s8540)	Rennie-Grehalem (s8540); Le Bar-Hoquiam (s8543)
Wynoochee	2	alluvium	Le Bar-Hoquiam (s8543)	Le Bar-Hoquiam (s8543)
Wynoochee	3	alluvium	Le Bar-Hoquiam (s8543)	Le Bar-Hoquiam (s8543); Solduc-Palix-Hoko-Halbert (s8519)
Wynoochee	4	basalt flows and flow breccias, Crescent Formation (~45%); glacial outwash, alpine, Fraser-age (~35%)	Le Bar-Hoquiam (s8543)	Le Bar-Hoquiam (s8543); Rock outcrop-Knappton-Katula-Bunker (s8549)
Wynoochee	5	alluvium	Le Bar-Hoquiam (s8543)	Le Bar-Hoquiam (s8543)
Wynoochee	6	alluvium	Le Bar-Hoquiam (s8543)	Le Bar-Hoquiam (s8543)

2.2 Reach Classification

We further divided geomorphic segments into geomorphic reaches that exhibited consistent channel and floodplain characteristics (Rinaldi et al. 2013; Gurnell et al. 2016). Several reaches typically make up a segment because local boundary conditions are often variable along several miles of river. Data from the remote sensing analysis was used to identify and delineate reaches based on channel slope, channel sinuosity, channel width, large wood density, floodplain area, and confinement (e.g., Brierley and Fryirs

2005; Rinaldi et al. 2013; Gurnell et al. 2016). The accuracy, precision, and availability of the above metrics is ultimately determined by the resolution and quality of related remote sensing data. Field validation would be required to ground truth and refine the metrics and reach breaks. Reach metrics are described in detail below.

Channel slope is the percent gradient of the river channel within the reach. Slope was calculated continuously along a stream network that was disaggregated into 330-foot (100 m) sections. Elevation values derived from LiDAR at the start and end of each line section were used to calculate the elevation gain (rise) over the length of the section (run). Slope was then simply calculated as rise divided by run. The slope values were then plotted for each river as a longitudinal profile and visualized in GIS to identify consistent patterns and discontinuities. Overview maps of each river showing channel slope are available in Appendix A.

Channel sinuosity represents how much the channel curves and bends between two points. Sinuosity was calculated continuously throughout a stream network that was disaggregated at 1,640-foot (500 m) intervals. Sinuosity was calculated as the length of the line section divided by the straight-line length between the start and end of the line section. The sinuosity values were then plotted along the length of each river and visualized in GIS to identify consistent patterns and discontinuities. Overview maps of each river showing channel sinuosity are available in Appendix A.

Channel width is defined as the width of the bankfull channel. A polygon was drawn around the perimeter of each river's bankfull channel based on visual cues from 2020 NAIP imagery, 2021 Google imagery, and digital terrain models from recent LiDAR acquisitions. A centerline for each polygon was derived and converted into points at an average spacing of 32 feet (10 m). The width of the channel polygon was then measured at every point using cross sections perpendicular to the centerline. The channel width values were plotted along the length of each river and visualized in GIS to identify consistent patterns and discontinuities.

Large wood density is defined as the number of pieces of wood per 330 feet (100 m). Large wood (LW) is defined as wood pieces >8 inches in diameter and >6.5 feet long (20 cm diameter and 2 m long). 2021 Google imagery was used to identify and enumerate all visible LW within the bankfull channel of each stream. In GIS, a point was placed for each wood piece and jam. Additionally, a polygon was drawn around the perimeter of all jams with an area >60 yd^2 (50 m^2). If the bankfull channel was not visible in the imagery due to canopy cover, a value of "NA" was recorded.

Floodplain area is defined as the total area within the reach that likely acts as the modern floodplain. The valley bottom (VB) tool from the Fluvial Corridor Toolbox (Roux et al. 2015) was used to generate polygons for each river that approximates the floodplain extent. A centerline for each polygon was then derived and converted into points at an average spacing of 32 feet (10 m). The width of the floodplain polygon was measured at every point using cross sections perpendicular to the centerline. The floodplain width values were then plotted along the length of each river and visualized in GIS to identify consistent patterns and discontinuities.

Confinement represents the lateral space a river channel has available to shift and move. The confinement index was calculated as the mean valley bottom width divided by the mean channel width in each reach (Rinaldi et al. 2013). The resulting ratio was categorized into low, medium, or high confinement, depending on the planform of the reach:

- High confinement = index ranging from 1 to 1.5
- Medium confinement = index ranging from 1.5 to *n*
- Low confinement = index greater than *n*

  Where *n* = 5 for single-thread channels and *n* = 2 for multi-thread channels.

Changes in the above channel metrics represent a potential reach break. Each metric was evaluated individually and collectively to identify consistent longitudinal patterns (i.e., reaches) and discontinuities (i.e., reach breaks). Moreover, characterizing each reach within the context of large-scale physical controls (segments) ensures that recommended actions are geomorphically appropriate. Finally, the proportion of each reach within Green Diamond ownership was calculated to assist with prioritization. The results of each metric by river and reach are summarized in Table 4 and Table 5. Overview maps of reaches within each priority river are available in Appendix A.

Table 4. Descriptive attributes and characteristics of geomorphic reaches in the priority rivers (1/2).

River	Segment	Reach	Length (ft)	Length within Green Diamond Parcel (ft)	% Length within Green Diamond	Confinement Category
Bingham	1	**1**	4,525	0	0%	Low

River	Segment	Reach	Length (ft)	Length within Green Diamond Parcel (ft)	% Length within Green Diamond	Confinement Category
Bingham	1	**2**	3,681	0	0%	Medium
Bingham	2	**3**	4,857	2,751	57%	High
Bingham	3	**4**	17,795	11,670	66%	Low
Bingham	4	**5**	8,701	8,647	99%	Low
Bingham	4	**6**	5,447	4,145	76%	Low
Bingham	4	**7**	3,103	3,103	100%	Low
Bingham	4	**8**	4,478	4,034	90%	Low
Bingham	4	**9**	6,478	6,478	100%	Low
Bingham	5	**10**	11,016	11,016	100%	Low
Bingham	5	**11**	4,049	3,999	99%	Low
Bingham	5	**12**	2,353	2,353	100%	Low
Bingham	5	**13**	6,319	6,319	100%	Medium
Decker	1	**1**	2,488	1,405	56%	Low
Decker	2	**2**	2,237	0	0%	Low
Decker	2	**3**	4,339	0	0%	Low
Decker	2	**4**	5,945	5,026	85%	Low
Decker	2	**5**	4,498	4,498	100%	Low
Decker	2	**6**	3,320	3,109	94%	Low
Decker	2	**7**	4,474	0	0%	Low
Decker	3	**8**	5,209	1,225	24%	Low
Decker	3	**9**	3,885	0	0%	Low
Decker	3	**10**	3,197	3,020	94%	Low
Decker	3	**11**	2,714	2,714	100%	Low
Decker	3	**12**	6,102	6,102	100%	Low
Decker	3	**13**	2,239	1,950	87%	Low
Decker	4	**14**	10,238	1,585	15%	Low
Decker	4	**15**	5,851	912	16%	Low
Decker	4	**16**	7,559	562	7%	Low
Decker	5	**17**	3,365	867	26%	Low
Decker	5	**18**	5,048	335	7%	Low
Decker	5	**19**	4,116	3,588	87%	Low
Dry Run	1	**1**	7,983	2,536	32%	Low
Dry Run	2	**2**	6,965	6,039	87%	Low
Dry Run	2	**3**	2,702	0	0%	Low
Dry Run	3	**4**	5,019	4,960	99%	Low
Dry Run	3	**5**	1,632	1,632	100%	Low
Dry Run	3	**6**	2,080	1,723	83%	Low
Dry Run	3	**7**	2,547	0	0%	Low

River	Segment	Reach	Length (ft)	Length within Green Diamond Parcel (ft)	% Length within Green Diamond	Confinement Category
Dry Run	4	**8**	2,098	0	0%	Low
Dry Run	4	**9**	6,367	0	0%	Low
EF Satsop	1	**1**	4,603	3,613	78%	Low
EF Satsop	2	**2**	5,077	1,778	35%	Low
EF Satsop	2	**3**	2,495	0	0%	Low
EF Satsop	2	**4**	5,001	0	0%	Low
EF Satsop	3	**5**	4,862	2,906	60%	Medium
EF Satsop	4	**6**	6,371	4,490	70%	Low
EF Satsop	4	**7**	3,849	2,707	70%	Low
EF Satsop	4	**8**	2,050	0	0%	Low
EF Satsop	4	**9**	5,167	2,373	46%	Low
EF Satsop	5	**10**	4,183	2,836	68%	Low
Stillwater	1	**1**	4,033	2,040	51%	Low
Stillwater	1	**2**	4,902	4,902	100%	Low
Stillwater	2	**3**	3,428	3,428	100%	Low
Stillwater	2	**4**	4,266	4,266	100%	Low
Stillwater	2	**5**	7,469	7,469	100%	Low
Stillwater	3	**6**	4,575	4,575	100%	Low
Stillwater	3	**7**	8,682	8,682	100%	Medium
Stillwater	3	**8**	5,677	5,677	100%	Low
Stillwater	4	**9**	8,185	7,190	88%	Low
Stillwater	5	**10**	6,043	4,555	75%	Low
Stillwater	5	**11**	15,287	9,624	63%	Low
Stillwater	6	**12**	4,226	4,076	96%	Low
Wynoochee	1	**1**	13,020	2,105	16%	High
Wynoochee	1	**2**	12,525	5,634	45%	High
Wynoochee	1	**3**	9,427	6,769	72%	Low
Wynoochee	1	**4**	6,714	3,191	48%	Low
Wynoochee	2	**5**	8,052	6,966	87%	Low
Wynoochee	2	**6**	6,936	2,828	41%	Low
Wynoochee	2	**7**	4,269	4,091	96%	Low
Wynoochee	3	**8**	10,500	6,774	65%	Medium
Wynoochee	3	**9**	10,952	8,122	74%	Low
Wynoochee	3	**10**	8,823	0	0%	High
Wynoochee	3	**11**	9,427	9,363	99%	High
Wynoochee	4	**12**	9,281	9,279	100%	High
Wynoochee	4	**13**	7,313	7,313	100%	High
Wynoochee	4	**14**	9,097	9,097	100%	High

River	Segment	Reach	Length (ft)	Length within Green Diamond Parcel (ft)	% Length within Green Diamond	Confinement Category
Wynoochee	5	**15**	9,192	5,686	62%	Low
Wynoochee	5	**16**	6,946	2,115	30%	Medium
Wynoochee	6	**17**	5,574	5,109	92%	Medium
Wynoochee	6	**18**	4,775	1,542	32%	High
Wynoochee	6	**19**	7,761	1,337	17%	Low
Wynoochee	6	**20**	440	0	0%	Low

Table 5. Descriptive attributes and characteristics of geomorphic reaches in the priority rivers (2/2).

River	Segment	Reach	Mean Channel Slope	Mean Channel Sinuosity	Mean Channel Width (ft)	LWD Density (#/330 ft)	LWD Jam Area (yd^2)	Total Floodplain Acres
Bingham	1	1	0.015	1.08	66.73	1.16	152.6	502
Bingham	1	2	0.008	1.09	147.77	2.23	235.7	216
Bingham	2	3	0.013	1.07	124.80	2.77	652.4	148
Bingham	3	4	0.012	1.05	110.35	1.49	741.3	1,131
Bingham	4	5	0.010	1.05	54.47	1.28	NA	514
Bingham	4	6	0.011	1.07	46.58	5.42	406.0	443
Bingham	4	7	0.017	1.03	50.00	5.18	293.9	213
Bingham	4	8	0.012	1.07	43.17	3.22	NA	464
Bingham	4	9	0.014	1.08	41.44	2.48	284.4	583
Bingham	5	10	0.022	1.25	26.26	2.08	241.8	1,011
Bingham	5	11	0.047	1.11	28.57	NA	NA	174
Bingham	5	12	0.091	1.10	22.85	NA	NA	71
Bingham	5	13	0.604	1.02	23.66	NA	NA	63
Decker	1	1	0.011	1.07	65.94	1.98	NA	280
Decker	2	2	0.012	1.03	76.72	0.44	NA	224
Decker	2	3	0.015	1.06	59.52	8.62	631.4	665
Decker	2	4	0.015	1.04	89.85	6.13	1433.3	1,086
Decker	2	5	0.011	1.03	71.52	1.75	107.2	544
Decker	2	6	0.015	1.09	89.30	4.05	464.2	312
Decker	2	7	0.015	1.08	61.10	2.27	NA	678
Decker	3	8	0.011	1.09	52.42	1.57	263.5	664
Decker	3	9	0.012	1.06	60.45	3.04	303.5	398
Decker	3	10	0.012	1.07	58.96	3.80	167.6	183
Decker	3	11	0.011	1.06	56.75	2.05	125.9	228
Decker	3	12	0.016	1.09	59.55	3.82	343.1	395
Decker	3	13	0.005	1.06	50.36	2.64	143.7	128

River	Segment	Reach	Mean Channel Slope	Mean Channel Sinuosity	Mean Channel Width (ft)	LWD Density (#/330 ft)	LWD Jam Area (yd^2)	Total Floodplain Acres
Decker	4	14	0.010	1.08	54.88	1.70	NA	2,557
Decker	4	15	0.017	1.07	36.10	0.28	NA	2,042
Decker	4	16	0.015	1.09	29.64	0.82	134.6	2,378
Decker	5	17	0.017	1.13	40.09	3.02	365.1	1,014
Decker	5	18	0.017	1.08	46.05	NA	NA	875
Decker	5	19	0.009	1.11	25.72	1.59	NA	360
Dry Run	1	1	0.023	1.23	48.58	1.77	223.5	623
Dry Run	2	2	0.015	1.18	65.67	0.52	NA	295
Dry Run	2	3	0.009	1.07	63.50	0.12	NA	100
Dry Run	3	4	0.002	1.24	61.62	NA	NA	792
Dry Run	3	5	0.013	1.40	40.91	0.20	NA	109
Dry Run	3	6	0.007	1.43	46.43	0.95	NA	312
Dry Run	3	7	0.012	1.20	21.84	0.13	NA	267
Dry Run	4	8	0.014	1.16	31.19	0.31	NA	106
Dry Run	4	9	0.016	1.22	33.71	0.52	NA	344
EF Satsop	1	1	0.007	1.22	83.81	0.14	NA	151
EF Satsop	2	2	0.013	1.18	100.74	6.85	737.6	1,186
EF Satsop	2	3	0.011	1.12	100.78	2.50	299.8	194
EF Satsop	2	4	0.009	1.17	83.96	5.18	683.3	816
EF Satsop	3	5	0.008	1.14	79.72	0.54	NA	128
EF Satsop	4	6	0.017	1.20	90.94	9.06	2810.2	932
EF Satsop	4	7	0.006	1.16	107.59	3.07	378.3	308
EF Satsop	4	8	0.012	1.18	70.51	NA	NA	56
EF Satsop	4	9	0.009	1.14	72.55	2.22	730.7	363
EF Satsop	5	10	0.006	1.13	79.34	0.86	378.0	375
Stillwater	1	1	0.013	1.09	85.22	0.73	NA	405
Stillwater	1	2	0.008	1.10	67.82	1.81	NA	428
Stillwater	2	3	0.009	1.09	64.65	5.55	364.8	166
Stillwater	2	4	0.008	1.13	58.12	2.31	213.9	591
Stillwater	2	5	0.004	1.22	74.86	1.76	NA	935
Stillwater	3	6	0.003	1.15	55.01	1.86	NA	393
Stillwater	3	7	0.007	1.18	75.00	1.70	73.1	588
Stillwater	3	8	0.003	1.19	78.37	7.05	NA	279
Stillwater	4	9	0.002	1.15	72.25	3.53	118.3	1,201
Stillwater	5	10	0.014	1.14	43.41	6.41	NA	322
Stillwater	5	11	0.006	1.20	25.03	1.72	345.9	1,864
Stillwater	6	12	0.008	1.14	13.64	NA	0.0	1,465
Wynoochee	1	1	0.006	1.02	191.89	2.12	956.0	629

River	Segment	Reach	Mean Channel Slope	Mean Channel Sinuosity	Mean Channel Width (ft)	LWD Density (#/330 ft)	LWD Jam Area (yd^2)	Total Floodplain Acres
Wynoochee	1	2	0.008	1.03	205.57	1.70	721.6	571
Wynoochee	1	3	0.007	1.03	185.46	3.62	1380.2	709
Wynoochee	1	4	0.006	1.05	164.67	3.81	755.9	493
Wynoochee	2	5	0.008	1.04	187.72	27.26	9931.4	1,154
Wynoochee	2	6	0.008	1.03	241.92	20.48	6453.9	1,653
Wynoochee	2	7	0.005	1.01	162.05	2.61	325.0	1,531
Wynoochee	3	8	0.010	1.09	160.23	1.72	NA	617
Wynoochee	3	9	0.007	1.11	160.52	3.59	1296.0	1,208
Wynoochee	3	10	0.009	1.11	158.55	1.82	612.6	482
Wynoochee	3	11	0.006	1.15	176.38	7.03	2885.3	452
Wynoochee	4	12	0.010	1.09	162.36	0.14	NA	238
Wynoochee	4	13	0.020	1.06	144.76	0.18	NA	163
Wynoochee	4	14	0.008	1.10	151.16	2.20	803.4	394
Wynoochee	5	15	0.010	1.15	202.34	7.28	3991.1	788
Wynoochee	5	16	0.013	1.13	214.32	14.27	3719.6	1,179
Wynoochee	6	17	0.010	1.11	129.46	0.82	NA	243
Wynoochee	6	18	0.031	1.05	79.18	NA	NA	78
Wynoochee	6	19	0.011	1.08	94.36	NA	NA	512
Wynoochee	6	20	0.009	1.14	169.96	NA	NA	43

3.0 PRIORITIZATION

3.1 Background

The reach characterization and assessment identified 83 geomorphic reaches across the six priority rivers. These reaches represent stretches of river with common physical characteristics and are influenced by relatively consistent physical constraints. Therefore, each reach is a potential project area where appropriate restoration actions may be prescribed. The primary limiting factors identified in the ASRP Phase 1 and the primary focus of the assessment were LW density and floodplain connection. A prioritization matrix was created that highlights two metrics for assessing LW deficiency and floodplain connection potential by reach.

A key component of the assessment was prioritization of the reaches with input from stakeholders and those familiar with the Satsop and Wynoochee watersheds including GHCD, MCD, Green Diamond, WDFW, and others. The overall objectives of the prioritization were to produce a ranked list of all 83 reaches to serve as a guide for protecting reaches, sequencing restoration actions within the watershed, and providing a pathway for watershed recovery.

There are several key steps in any prioritization process that ensure a robust, transparent, and repeatable process, which include identifying goals and objectives, who will prioritize projects, the prioritization approach (method), the prioritization criteria, the scoring and weighting, and a process for examining the scores and project rankings (Figure 2; Roni et al. 2013). Following and documenting these steps is important because projects typically need to be periodically reprioritized as projects are completed, new information becomes available, or project costs and other factors change. In this chapter, we describe the process developed to prioritize projects in the Satsop and Wynoochee watersheds for each of these steps. We provide a table with the project rankings and the highest priority projects, and recommended next steps.

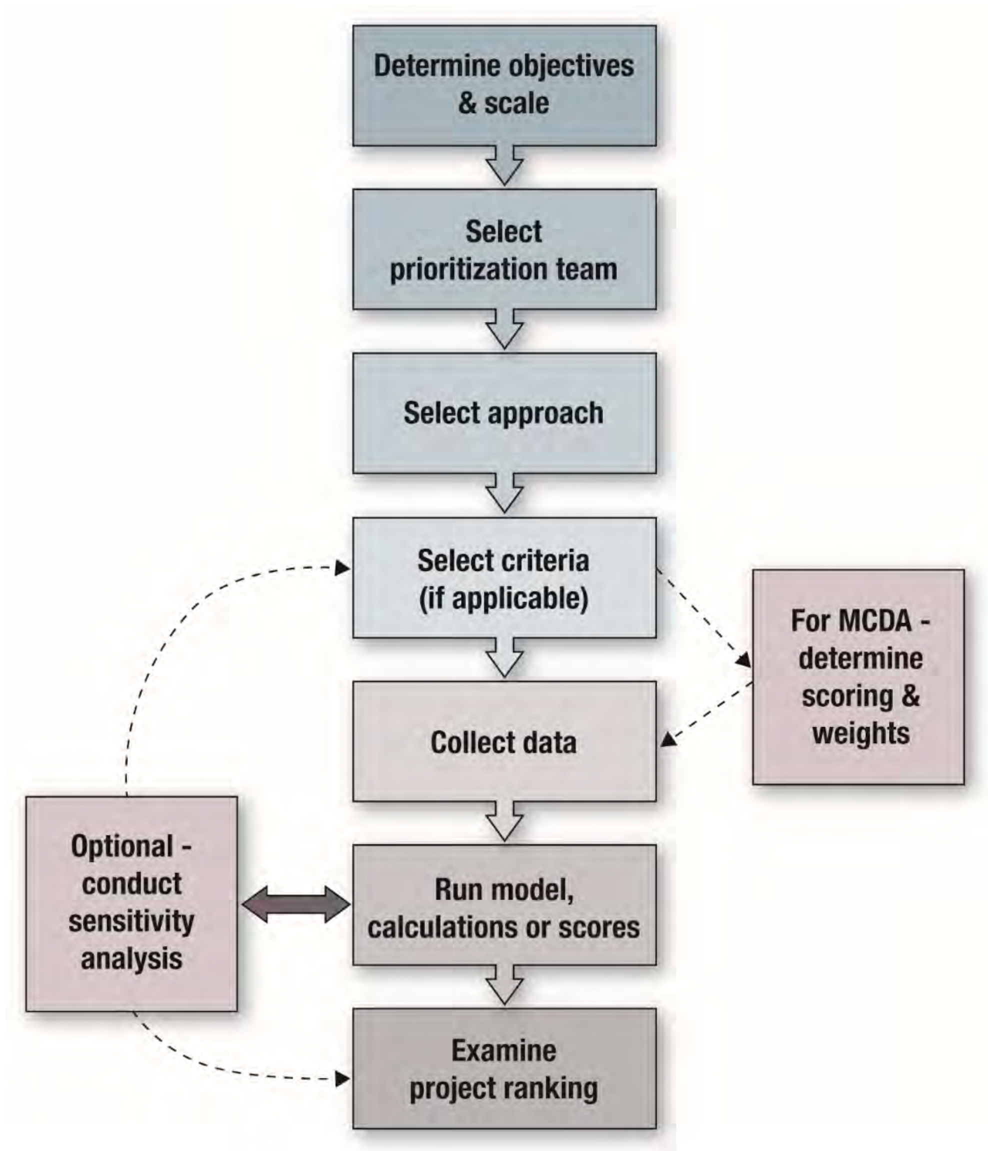


Figure 2. Steps to follow for developing an effective and repeatable prioritization process (modified from Roni and Beechie 2013; Chapter 6). A sensitivity analysis is typically only done for complex computer models and was not necessary for the scoring approach used in the priority Geospatial Units. MCDA = multi-criteria decisions analysis often called a simple scoring approach.

3.2 Prioritization Team, Goals, Objectives, and Scale

3.2.1 Prioritization Team

To complete the prioritization in a timely fashion, GHCD determined that GHCD, MCD, Green Diamond, Trout Unlimited, and the CFS/NSD team would assist with the prioritization process including setting goals and objectives, criteria selection and prioritization, scoring, and discussion and fine-tuning of cut-off values for criteria ranking (Table 6). Ultimately, the Prioritization Team selected quantitative criteria that could be calculated with data, so no subjective scoring or ranking of projects was done by the team.

Table 6. List of participants who provided input on the prioritization process, including selecting criteria, scoring projects, and discussion of project rankings.

Name	Affiliation	Criteria	Discussion of project rankings
Gustafson, Alex	Trout Unlimited	X	
Bauder, Evan	MCD	X	
Underwood, Keith	MCD	X	
Golliet, Mark	Green Diamond	X	X
Wood, Glen	Green Diamond	X	X
Waldrop, Anthony	GHCD	X	X
Kollasch, Tom	GHCD	X	
Dickerson-Lange, Susan	NSD	X	X
Stratton, Danny	NSD	X	X
Soden, John	NSD	X	X
Camp, Reid	CFS	X	X
Roni, Phil	CFS	X	X

MCD = Mason Conservation District, GHCD = Grays Harbor Conservation District, NSD = Natural Systems Design, CFS = Cramer Fish Sciences

3.2.2 Goals and Objectives

The prioritization goals of the Satsop and Wynoochee Aquatic Habitat Restoration Planning and Prioritization project were to classify reaches for protection or restoration and prioritize reaches based on restoration potential. High-level conceptual designs were then developed for 13 restoration reaches with the highest priority ranking. A common problem in restoration prioritization is when prioritization and protection reaches are prioritized together, protection reaches often receive lower ranking. To overcome this problem, the team decided to prioritize reaches for protection and restoration separately. With input from the prioritization team (Table 6), this goal was refined into a classification goal and prioritization goal including:

Classification Goal: Identify reaches in relatively good condition to be managed as 'protection reaches' and reaches in relatively poor condition to managed as 'restoration reaches'. Protection reaches are good candidates for land acquisition, easements, and light-touch restoration actions, or left alone to continue recovering passively. Restoration reaches are good candidates for specific recovery actions to improve hydrogeomorphic conditions, fish habitat, and kick-start fluvial processes.

Prioritization Goal: Develop a prioritized list of restoration reaches to address impaired watershed processes, focusing on in-stream work that can be built into a broader aquatic restoration plan. Scores for restoration and protection reaches were calculated separately.

Specific objectives and factors identified during the process to include in the prioritization process were:

- Channel confinement
- Large wood density
- Potential to increase floodplain access
- Number of fish species benefiting from restoration actions
- Suitable restoration actions
- Geomorphic benefits
- Biological benefits
- Logistical challenges and constraints

3.2.3 Scale

The next step was to define the scale or scales that the prioritization will operate at. Some groups first prioritize reaches or sub-basins and then use that as a criterion for a larger process to prioritize projects across a watershed or region. Our assessment and identification of restoration components were done at the reach scale, with 83 reaches identified across the six priority rivers. Therefore, reaches were prioritized irrespective of river and the scale at which prioritization occurred was at the reach level (0.1 – 3.4 miles).

3.3 Prioritization Approach, Criteria, and Scoring

3.3.1 Approach

Numerous methods exist for prioritizing restoration and conservation measures, ranging from professional opinion to complex computer models (Roni et al. 2002, 2013; Beechie et al. 2008). The ability to incorporate both technical and qualitative information for prioritization of restoration projects is critical. While technical issues can limit the extent and costs of restoration, social and economic constraints frequently limit the pace of restoration actions and their extent (Souder 2013). Typically, there is a diversity of values that often exist with stakeholders in a watershed. The best and most transparent approach for incorporating biological (e.g., fish abundance, species diversity), physical (e.g., project size, habitat type, process restored), socio-economic (e.g., cost, cost-benefit), and stakeholder involvement is a scoring system, often called multi-criteria decision analysis or MCDA (Beechie et al. 2008; Roni et al.

2013). This approach was successfully used for the Middle Nemah River Habitat Assessment and Design Project (Camp et al. 2020) and the Habitat Assessment and Prioritization of Forks Creek Restoration Opportunities Project (Camp et al. 2021) in neighboring Pacific County.

3.3.2 Criteria Selection

Criteria within the prioritization framework came from results of the assessment and were discussed and selected by the prioritization team (assessment criteria). First, the confinement category, large wood deficit, increased floodplain potential, and fish use were added as assessment criteria. These criteria were individually ranked with a value of 1-5, then summed to provide an assessment-based score for each reach. The higher the score, the higher the priority. Definitions and rationale for each assessment criteria are provided below and in Table 7.

Confinement category was determined for every reach during the assessment based on the confinement index (Rinaldi et al. 2013). As a criterion for ranking, we used the confinement category as a proxy for the area available to the river and the river's natural affinity to lateral adjustments. If a river has more room to move around and engage with its entire fluvial corridor, then the ecological uplift from protection or restoration actions should be inherently greater than rivers that are physically constrained.

Large wood deficiency is based on the discrepancy between current LW density and target LW densities for western Washington rivers described by Fox and Bolton (2007). The target LW density for rivers with a bankfull width <33 feet (10 m) was 11 pieces per 100 m and for rivers with a bankfull width >33 feet (10 m) was four pieces per 100 m. The LW deficiency metric was calculated as current LW density divided by target LW density. Reaches with a ratio <1 were deficient in LW and those with a ratio >1 were meeting or exceeding target LW densities.

Increased floodplain potential represents the relative ease of increasing accessible floodplain area. Two valley bottom polygons were delineated using the valley bottom tool in the Fluvial Corridor Toolbox (Roux et al. 2015). The first represents the current valley bottom and extent of available floodplain. The second polygon was created at an elevation of 5-6 feet higher than the first polygon and approximates the maximum potential floodplain available in the valley. The second polygon represents the maximum potential floodplain extent if channel incision was reversed. We chose a range of 5-6 feet based on evaluating bar elevations across time versus aerial imagery. As channels incised over the last several decades, historic bars were abandoned and became visibly vegetated in aerial imagery. We extracted elevational changes by differencing LiDAR acquisitions spanning 10-15 years, depending on location. Increased floodplain potential was calculated as potential maximum floodplain area divided by the current floodplain area. Values equal to 1.0 have no potential for increased floodplain area and values >1.0 have greater potential to increase floodplain area.

Number of fish species benefiting is a direct count of the number of priority fish species that have a documented presence within the reach based on the Washington Statewide Integrated Fish Distribution dataset (SWIFD). Priority fish species included steelhead/rainbow trout, cutthroat trout, Chinook salmon, chum salmon, and coho salmon.

Table 7. Description of assessment criteria, scoring approach, and rationale for their selection.

Criteria	Scoring	Rationale
Confinement Category	Low = 5 Medium = 3 High = 1	Confinement is used as a proxy for the amount of area available to the river and the river's natural affinity to lateral adjustments (ability of the river to wander and erode laterally).
Large wood deficit (Restoration)	<0.25 = 5 0.25-0.50 = 4 0.50-0.75 = 3 0.75-1.0 = 2 >1.0 = 1	Based on the percent difference in current LW/100m versus Fox and Bolton 2007 targets. For restoration reaches, a lower percentage results in a higher score.
Large wood deficit (Protection)	<0.5 = 1 0.5-1.0 = 2 1.0-1.25 = 3 1.25-1.5 = 4 >1.5 = 5	Based on the percent difference in current LW/100m versus Fox and Bolton 2007 targets. For protection reaches, a higher percentage results in a higher score.
Potential increase in floodplain connection (Restoration)	<1.25 = 1 1.25-1.5 = 2 1.5-2.0 = 3 2.0-3.0 = 4 >3.0 = 5	Based on potential increase in floodplain connection due to restoration actions. Floodplain areas were delineated at 2m and 4m above the mainstem channel. For restoration reaches, a higher percentage results in a higher score.
Potential increase in floodplain connection (Protection)	<1.25 = 5 1.25-1.5 = 4 1.5-2.0 = 3 2.0-3.0 = 2 >3.0 = 1	Based on potential increase in floodplain connection due to restoration actions. Floodplain areas were delineated at 2m and 4m above the mainstem channel. For protection reaches, a higher percentage results in a lower score.
Number of fish species benefiting	5 species = 5 4 species = 4 3 species = 3 2 species = 2 1 species = 1	The number of priority fish species that are known to use the reach based on the statewide integrated fish distribution dataset (SWIFD).

3.4 Prioritization Results and Final Ranking

Out of the 83 reaches identified in the assessment, we classified 54 restoration reaches and 29 protection reaches. We developed an Excel spreadsheet to compile the key results from the assessment used for prioritization. Cells in the spreadsheet were set up to assign the appropriate score for each assessment criteria as listed in the assessment criteria tables. Designated restoration and protection reaches were scored separately based on the assessment criteria tables. We summed the individual criteria scores for each reach to assign a total score out of 20 possible points. Total scores ranged from nine to 20 for restoration reaches and from 10 to 19 for protection reaches. We assigned a final priority rank (High to Low) based on the distribution of total scores among restoration and protection reaches (Table 8). The final priority ranking resulted in 14 High priority restoration reaches and six High priority protection reaches (Table 9).

Table 8. Final rank designation for restoration and protection reaches based on the total combined score of assessment criteria.

Restoration Reach Score	Protection Reach Score	Rank
17 to 20	17 to 20	High
16	15 to 16	Medium-High
14 to 15	13 to 14	Medium
12 to 13	12	Medium-Low
<=11	<=11	Low

Table 9. Summary of priority rank by restoration and protection reaches.

Priority Rank	Restoration Reaches	Protection Reaches	Total
High	14	6	20
Medium-High	10	6	16
Medium	13	8	21
Medium-Low	10	3	13
Low	7	6	13
Total	54	29	83

Scores were evaluated by the prioritization team during a workshop on February 14, 2022. Because we used a quantitative approach to crosswalk results from the assessment to scores, the team was able to provide feedback and recommendations during this workshop. The prioritization team came to agreement on the assessment criteria, the crosswalk between assessment results and scores, the distribution of priority rankings, and the final priority rankings. Although the team did not provide additional scoring criteria based on expert opinion, we made minor changes to the cut-offs between criteria scores and updated the priority ranks to include five categories based on the team's feedback. We updated the prioritization spreadsheet to finalize the numbers and made it available for future project scoping and to update the prioritization in the future as projects are implemented (Table 10 and Table 11). We then developed conceptual restoration plans and maps for the High priority restoration reaches based on the final rankings. After further evaluation, we did not develop concepts for East Fork Satsop River Segment 1 Reach 1 because it is not logistically feasible or cost-effective to implement restoration actions that would provide geomorphic or biologic uplift. Therefore, we developed concepts for 13 of the 14 High priority restoration reaches (see Chapter 4).

Table 10. Summary table of assessment criteria scores, total assessment score, and final priority ranking for restoration reaches.

Reach Info				Scoring					
River	Segment	Reach	Length (mi)	Confinement score	Large wood deficit score	Potential increase in floodplain area score	Number of fish species benefiting score	Total assessment score	Priority Rank
Dry Run	2	3	0.5	5	5	5	5	20	High
Dry Run	2	2	1.3	5	5	4	5	19	High
Bingham	1	1	0.9	5	4	4	5	18	High
Decker	3	13	0.4	5	3	5	5	18	High
EF Satsop	1	1	0.9	5	5	3	5	18	High
EF Satsop	5	10	0.8	5	5	3	5	18	High
Decker	1	1	0.5	5	4	3	5	17	High
Decker	2	5	0.9	5	4	3	5	17	High
Decker	4	16	1.4	5	5	2	5	17	High
Dry Run	1	1	1.5	5	4	3	5	17	High
EF Satsop	2	3	0.5	5	3	4	5	17	High
EF Satsop	4	8	0.4	3	5	4	5	17	High
Stillwater	1	1	0.8	5	5	4	3	17	High
Wynoochee	3	8	2.0	3	4	5	5	17	High
Bingham	3	4	3.4	5	4	3	4	16	Medium-High
Bingham	4	5	1.6	5	4	4	3	16	Medium-High
Decker	2	2	0.4	5	5	1	5	16	Medium-High
Decker	3	8	1.0	5	4	2	5	16	Medium-High
Decker	3	12	1.2	5	2	4	5	16	Medium-High
Dry Run	4	8	0.4	5	5	3	3	16	Medium-High
Dry Run	4	9	1.2	5	5	3	3	16	Medium-High
EF Satsop	3	5	0.9	3	5	3	5	16	Medium-High
Wynoochee	1	3	1.8	5	2	4	5	16	Medium-High
Wynoochee	1	4	1.3	5	2	4	5	16	Medium-High

Dry Run	3	7	0.5	5	5	2	3	15	Medium
EF Satsop	4	9	1.0	5	3	2	5	15	Medium
Wynoochee	2	7	0.8	5	3	2	5	15	Medium
Decker	2	7	0.8	5	3	1	5	14	Medium
Decker	3	9	0.7	5	2	2	5	14	Medium
Decker	3	10	0.6	5	2	2	5	14	Medium
Decker	3	11	0.5	5	3	1	5	14	Medium
EF Satsop	2	4	0.9	5	1	3	5	14	Medium
EF Satsop	4	7	0.7	5	2	2	5	14	Medium
Stillwater	2	4	0.8	5	3	3	3	14	Medium
Wynoochee	1	1	2.5	1	3	5	5	14	Medium
Wynoochee	1	2	2.4	1	4	4	5	14	Medium
Wynoochee	3	9	2.1	5	2	2	5	14	Medium
Bingham	4	7	0.6	5	1	4	3	13	Medium-Low
Decker	2	3	0.8	5	1	2	5	13	Medium-Low
Decker	2	4	1.1	5	1	2	5	13	Medium-Low
Decker	2	6	0.6	5	1	2	5	13	Medium-Low
EF Satsop	2	2	1.0	5	1	2	5	13	Medium-Low
Stillwater	1	2	0.9	5	4	1	3	13	Medium-Low
Bingham	1	2	0.7	3	3	2	4	12	Medium-Low
Bingham	4	6	1.0	5	1	3	3	12	Medium-Low
Bingham	4	8	0.8	5	2	2	3	12	Medium-Low
EF Satsop	4	6	1.2	5	1	1	5	12	Medium-Low
Decker	5	17	0.6	5	2	2	2	11	Low
Decker	5	18	1.0	5	1	3	2	11	Low
Wynoochee	3	10	1.7	1	4	1	5	11	Low
Wynoochee	4	14	1.7	1	3	3	4	11	Low
Bingham	2	3	0.9	1	3	2	4	10	Low
Stillwater	2	3	0.6	5	1	1	3	10	Low
Stillwater	6	12	0.8	5	1	2	1	9	Low

Table 11. Summary table of assessment criteria scores, total assessment score, and final priority ranking for protection reaches.

Reach Info				Scoring					
River	Segment	Reach	Length (mi)	Confinement score	Large wood deficit score	Potential increase in floodplain area score	Number of fish species benefiting score	Total assessment Score	Priority Rank
Wynoochee	2	5	1.5	5	5	4	5	19	High
Wynoochee	2	6	1.3	5	5	4	5	19	High
Dry Run	3	4	1.0	5	5	4	4	18	High
Stillwater	3	8	1.1	5	5	4	3	17	High
Stillwater	5	10	1.1	5	5	4	3	17	High
Wynoochee	5	15	1.7	5	5	3	4	17	High
Wynoochee	3	11	1.8	1	5	5	5	16	Medium-High
Wynoochee	5	16	1.3	3	5	4	4	16	Medium-High
Bingham	5	12	0.4	5	5	3	2	15	Medium-High
Decker	4	15	1.1	5	1	4	5	15	Medium-High
Stillwater	4	9	1.6	5	2	5	3	15	Medium-High
Wynoochee	6	20	0.1	5	1	5	4	15	Medium-High
Bingham	5	11	0.8	5	5	2	2	14	Medium
Decker	4	14	1.9	5	1	3	5	14	Medium
Stillwater	3	6	0.9	5	1	5	3	14	Medium
Bingham	4	9	1.2	5	2	3	3	13	Medium
Bingham	5	10	2.1	5	1	4	3	13	Medium
Bingham	5	13	1.2	3	5	4	1	13	Medium
Dry Run	3	6	0.4	5	1	4	3	13	Medium
Wynoochee	6	19	1.5	5	1	3	4	13	Medium
Dry Run	3	5	0.3	5	1	3	3	12	Medium-Low
Stillwater	2	5	1.4	5	1	3	3	12	Medium-Low
Stillwater	3	7	1.6	3	1	5	3	12	Medium-Low
Decker	5	19	0.8	5	1	3	2	11	Low

Stillwater	5	11	2.9	5	1	4	1	11	Low
Wynoochee	4	12	1.8	1	1	5	4	11	Low
Wynoochee	4	13	1.4	1	1	5	4	11	Low
Wynoochee	6	17	1.1	3	1	3	4	11	Low
Wynoochee	6	18	0.9	1	1	4	4	10	Low

4.0 CONCEPTUAL RESTORATION PLANS

We developed conceptual restoration plans for 13 restoration reaches within the Satsop and Wynoochee watersheds that were ranked as High priority (Figure 3). Segment 1, Reach 1 of the East Fork Satsop River was ranked High, but we did not develop a concept because it is not logistically feasible or cost-effective to implement restoration actions that would provide geomorphic or biologic uplift. We organized the concepts in this chapter by river, segment, and reach. The section for each reach contains:

1. Overview map of the reach
2. Planform maps showing the relative elevation model, current floodplain, potential floodplain, secondary channels, off-channel habitats, mile markers, major roads, Green Diamond parcels, and points marking conceptual restoration actions. Key areas on the map are labeled or annotated for cross reference with the text accompanying each concept.
3. Site description
4. Conceptual project actions
5. Expected geomorphic benefits from restoration activities
6. Expected biological benefits from restoration activities
7. Potential logistical challenges and considerations

The recommended conceptual restoration actions are described at a relatively high level because we expect that further planning and evaluation will be required as projects move forward in development. We considered all feasible restoration activities for working within the valley bottom of the reaches. However, because the assessment was focused primarily on LW deficiencies and floodplain connectivity, we focused on actions and locations that are expected to provide an immediate short-term uplift while kick-starting fluvial processes to allow the river to create and maintain quality habitats into the future. Therefore, most recommended actions focus on LW additions, in-channel habitat enhancement, off-channel habitat connection and enhancement, improving secondary channel access and quality, and improving access to the current and potential floodplain. Overall, we recommend the priority for all reaches is to rehabilitate and reconnect fluvial processes which primarily means focusing on retaining water and sediment across the reach-scale.

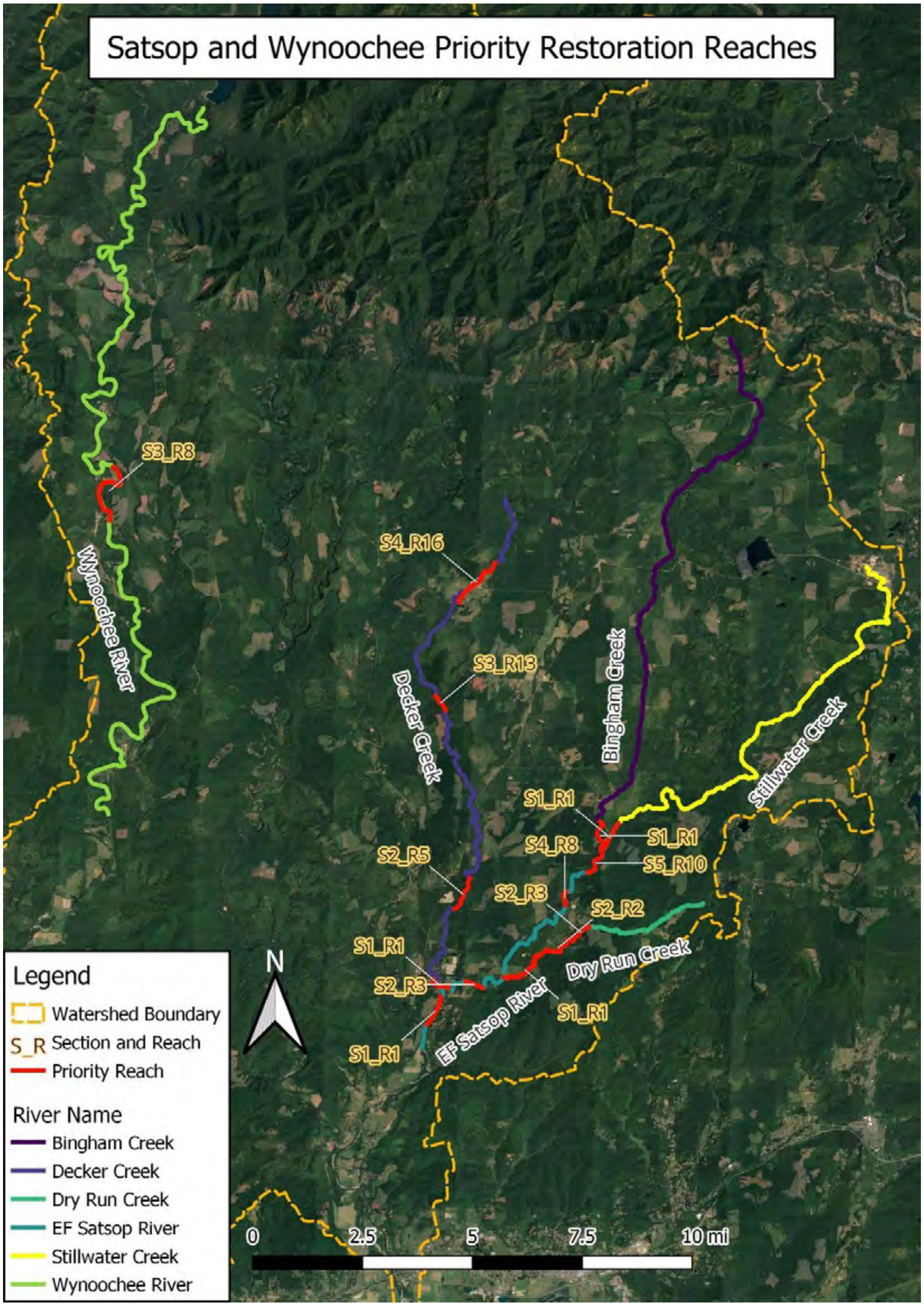


Figure 3. Overview map of priority restoration reaches identified in the evaluated portions of the Wynoochee River and East Fork Satsop River watersheds.

4.1 Bingham Creek

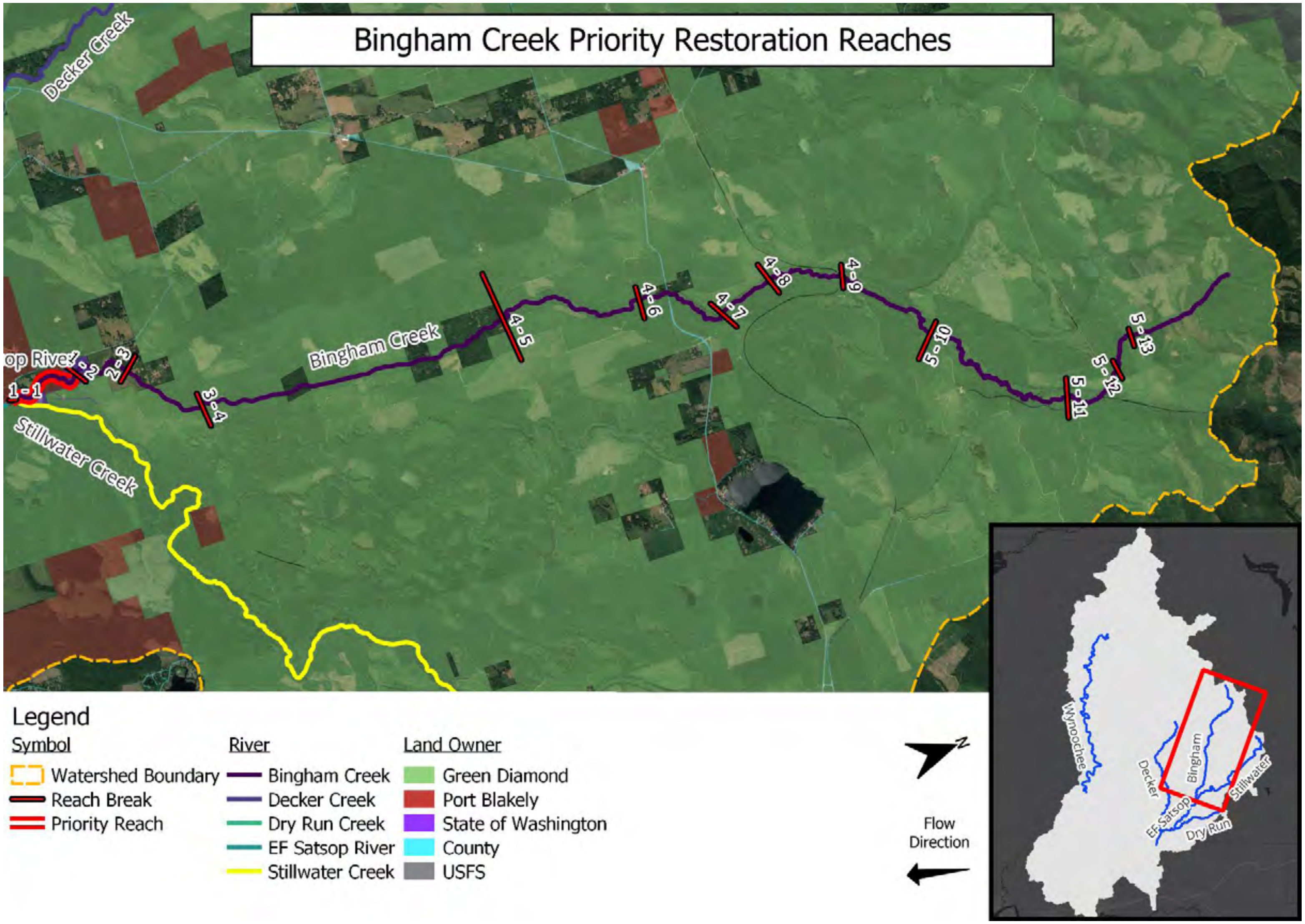


Figure 4. Overview map of priority restoration reaches in Bingham Creek.

4.1.1 Bingham Creek – Segment 01 – Reach 01

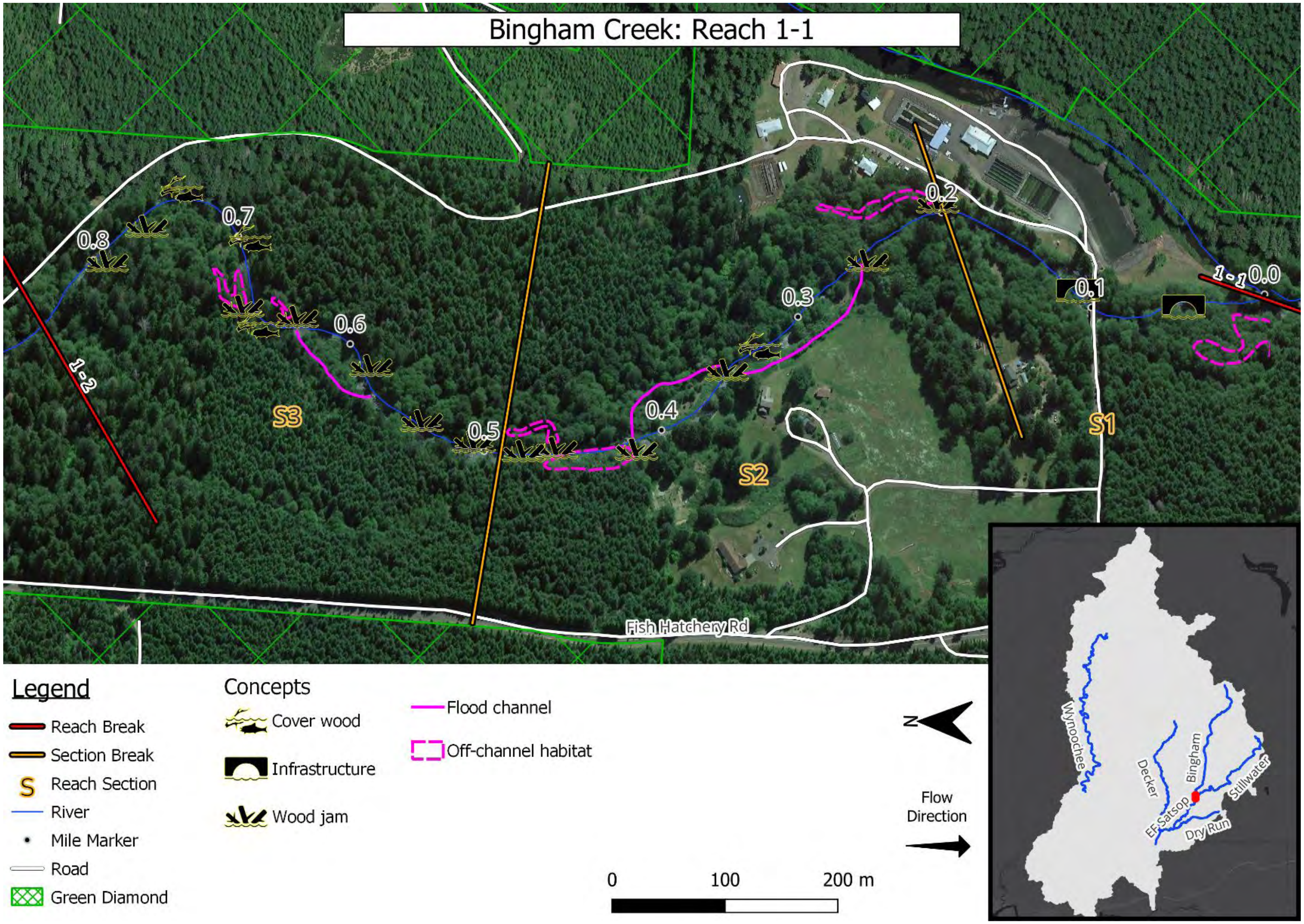


Figure 5. Overview map of Bingham Creek Segment 1, Reach 1.

4.1.1.1 Site Description

This reach on Bingham Creek begins at the confluence with Stillwater Creek near the Bingham Creek Fish Hatchery and ends near river mile (RM) 0.85. The West Fish Hatchery Road bridge spans the channel at RM 0.1. In the lower 0.4 RMs, the creek flows between the Bingham Creek Fish Hatchery on river left and private parcels on river right. From RM 0.4 to RM 0.7, the creek flows through timber company property and ends on land owned by WA state. The channel abuts against steep valley walls (up to 40 feet tall) on the outside of long meander bends, usually leaving accessible floodplain pockets on the inside of the bends. Wood density is low, and the distribution is mostly limited to a few jams. Bar development in the channel is appropriate given the channel width and planform. However, sediment supply to this reach may be partially limited by a weir located about 300 feet upstream of the reach.

4.1.1.2 Conceptual Project Actions

The primary actions proposed for this reach include LW additions, improving access to flood channels and off-channel habitats, and enhancing off-channel habitats. LW additions should focus on sorting sediment to increase suitable spawning beds and providing refuge for migrating adult and rearing juvenile salmonids. LW structures focused on geomorphic change will need to be engineered to remain stable. Alternatively, wood pieces could be added to existing pools by felling them directly into the channel to increase cover. Several wood jams are proposed to improve access to flood channels and off-channel habitats by either creating a backwater effect at key access points or directly shunting flow towards key access points. Minimal excavation at the upstream ends of flood channels may be considered if equipment access is viable. Off-channel habitats can be enhanced with simple wood additions to provide refuge from predators.

4.1.1.3 Geomorphic Benefits

The expected geomorphic benefits of adding wood structures include sediment sorting, channel aggradation, increase streambed complexity, and improved access to the floodplain. Wholesale changes to the channel planform and hydrologic function of this reach are not expected given the physical constraints. However, adding more structural elements to the channel will promote water and sediment retention, and will increase lateral variability in the thalweg. Minor channel incision has occurred in this reach and focusing LW additions at riffles will help promote aggradation at these natural grade controls. Most floodplain pockets are accessible, but all will benefit from modest LW additions.

4.1.1.4 Biological Benefits

LW added to this reach will provide refuge from high water velocities and predators for sensitive salmonid species of all age classes. While the structures themselves will provide cover, the increased variability in local hydraulics will lead to sediment sorting, ultimately creating substrate patches that are more suitable for spawning. Improving access to and enhancing flood channels and off-channel habitats increases the amount of space for juvenile salmonids to rear in highly suitable and protected environments.

4.1.1.5 Logistical Challenges and Considerations

Any restoration actions implemented in this reach will need to consider impacts to infrastructure and private property, particularly in the lower 0.4 RMs. The bridge at RM 0.1 is about 100 feet wide and approximately 15 feet above the channel bed. However, there is already a large bar and wood jam upstream of the bridge and additional wood racking at this location could threaten infrastructure. Between RM 0.1 and 0.2, the river is attempting to continue its lateral migration towards the east but is effectively restricted by a large levee protecting the fish hatchery. This situation makes effective restoration difficult, but minor modifications could be made to the existing back protection to improve this section as a migratory corridor. Based on the trajectory of the creek, the private parcels on the west side are likely not at risk of rapid bank erosion or avulsions. However, the existing flood channel near RM 0.3 indicates that the channel is attempting to widen and, over a long period of time, will eventually occupy more area to the west. Further upstream, the steep valley walls pose logistical challenges for accessing the valley bottom during construction.

Legend

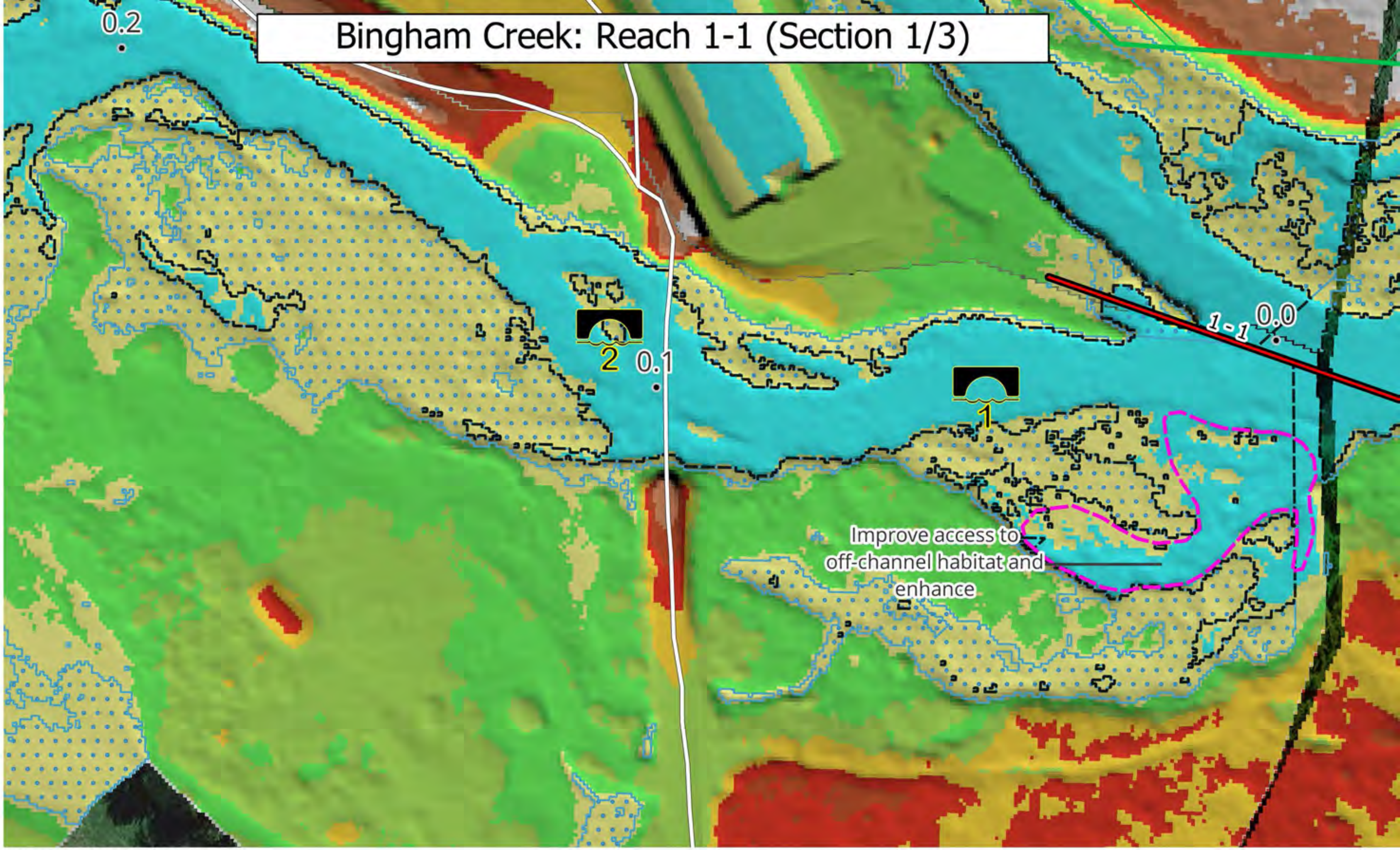
- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

- Infrastructure
- Off-channel habitat



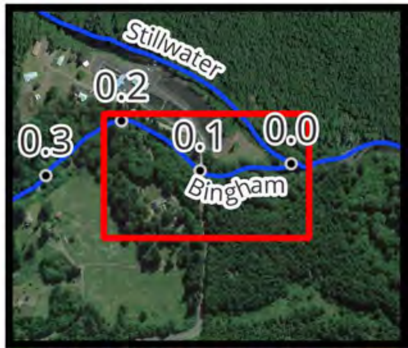
Concepts Key

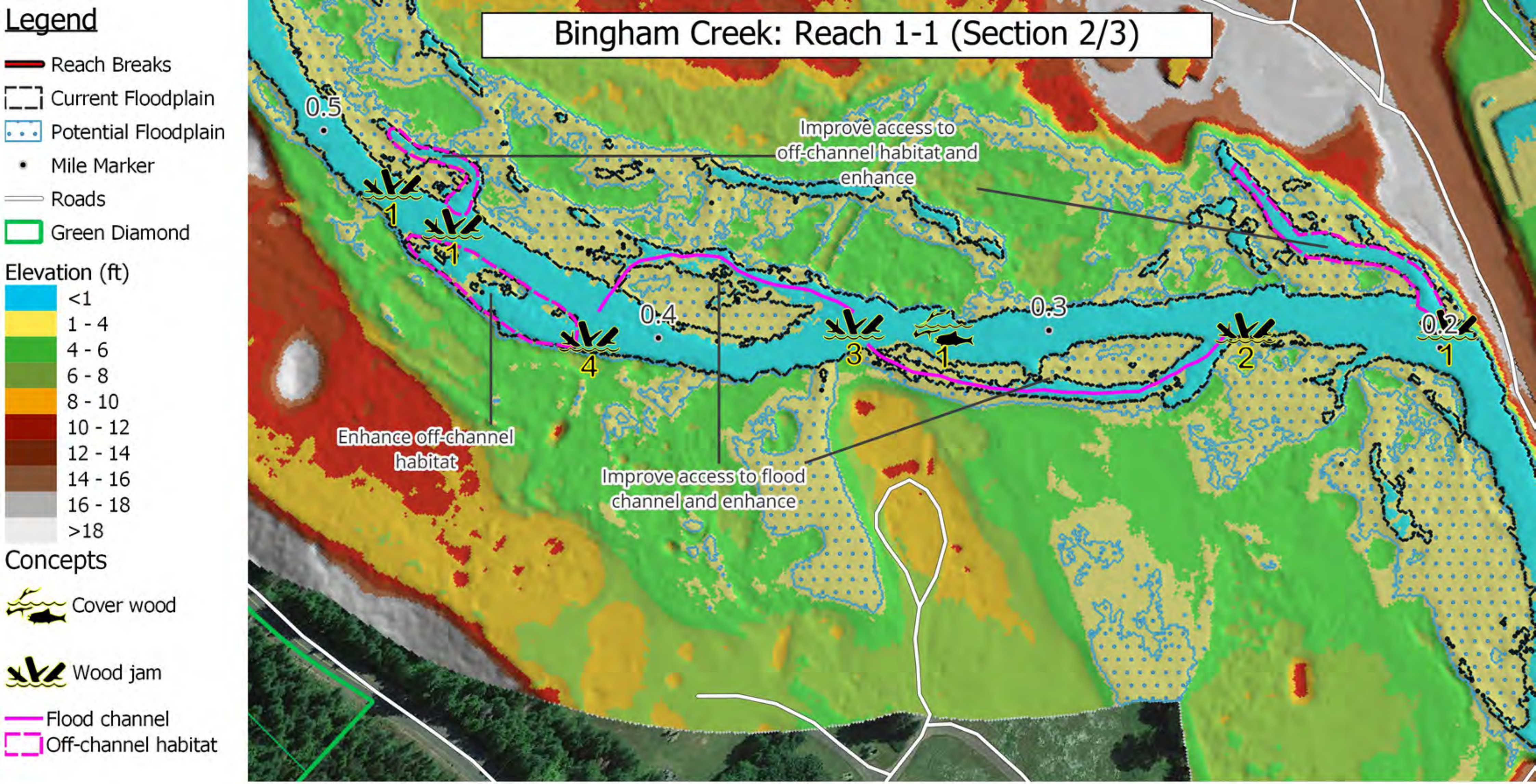
Infrastructure 1: Assess bridge impacts before working downstream.
Infrastructure 2: Large bar forced by constriction at bridge. Assess and evaluate impacts.

0 50 100 m

N

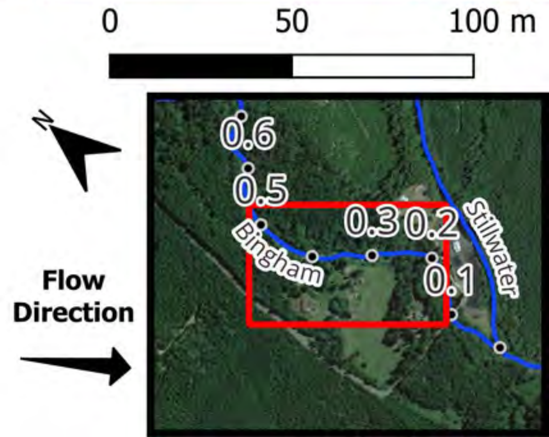
Flow Direction





Concepts Key

Cover wood 1: Enhance existing jam to provide refuge for fish
Wood jam 1: Bank attached jam to support off-channel habitat
Wood jam 2: Bank attached jam to support flood channel and increase cover in pool
Wood jam 3: Bank attached jam to support flood channel
Wood jam 4: Bank attached jam to support off-channel habitat and flood channel



Bingham Creek: Reach 1-1 (Section 3/3)

Legend

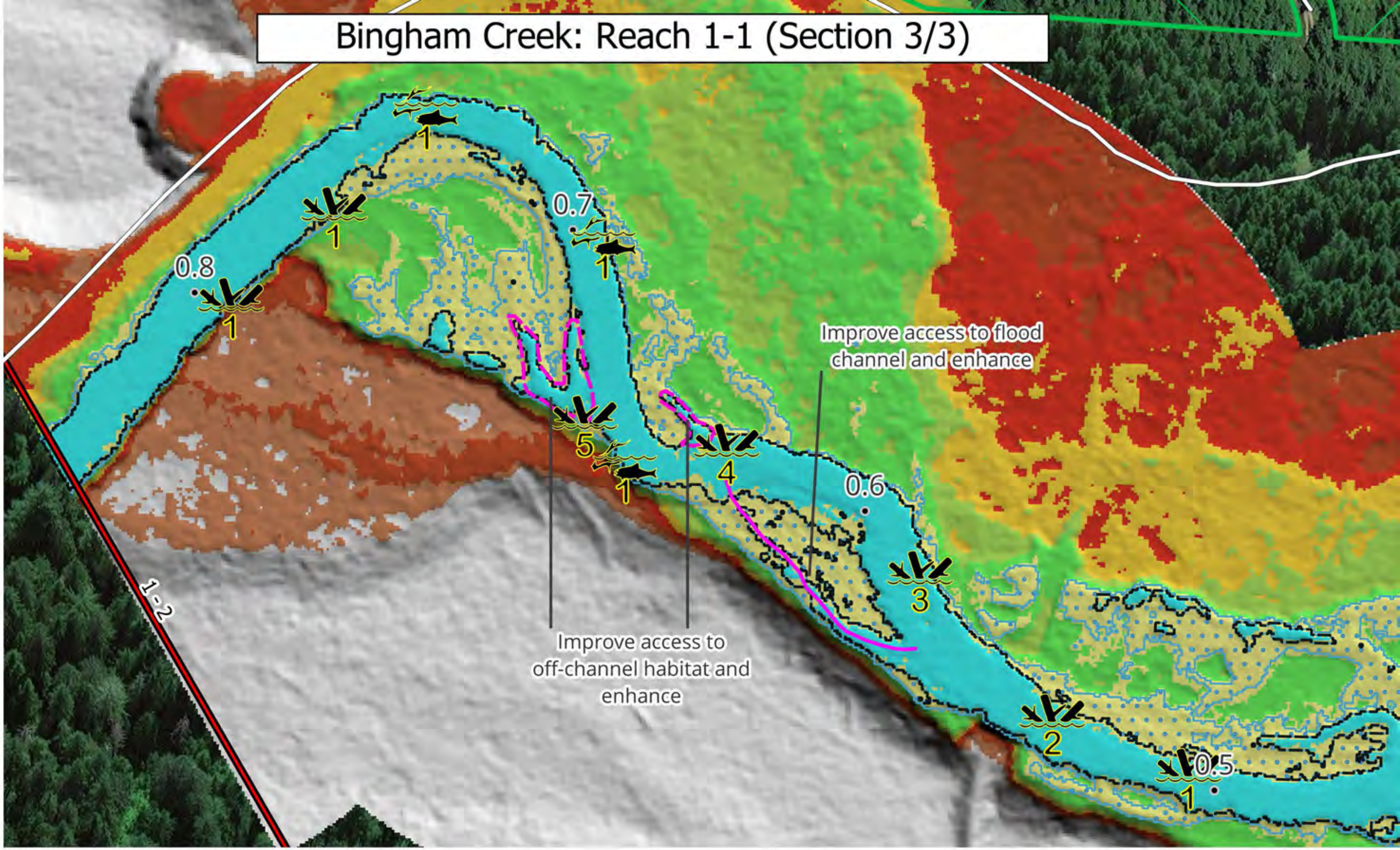
- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

- Cover wood
- Wood jam
- Flood channel
- Off-channel habitat



0 50 100 m

Flow Direction

Concepts Key

Cover wood 1: Add wood pieces for refuge in pool
Wood jam 1: Bank attached jam to sort sediment and provide refuge
Wood jam 2: Bank attached jam at riffle to sort sediment and aggrade
Wood jam 3: Add wood to existing jam in pool to increase cover and support flood channel
Wood jam 4: Channel spanning jam at riffle to support flood channel and off-channel habitat
Wood jam 5: Bank attached jam to support off-channel habitat

4.2 Decker Creek

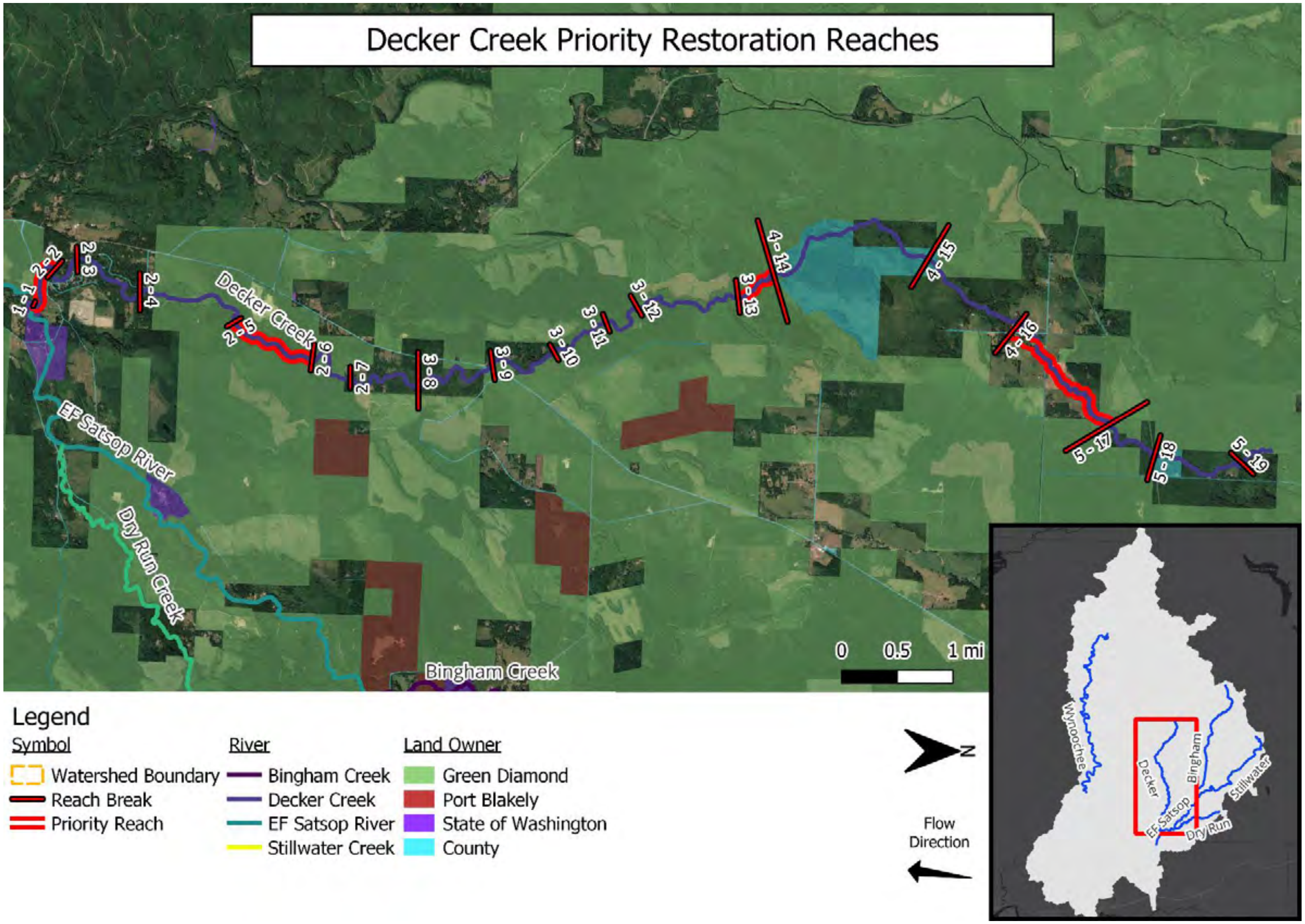


Figure 6. Overview map of priority reaches in Decker Creek.

4.2.1 Decker Creek – Segment 01 – Reach 01

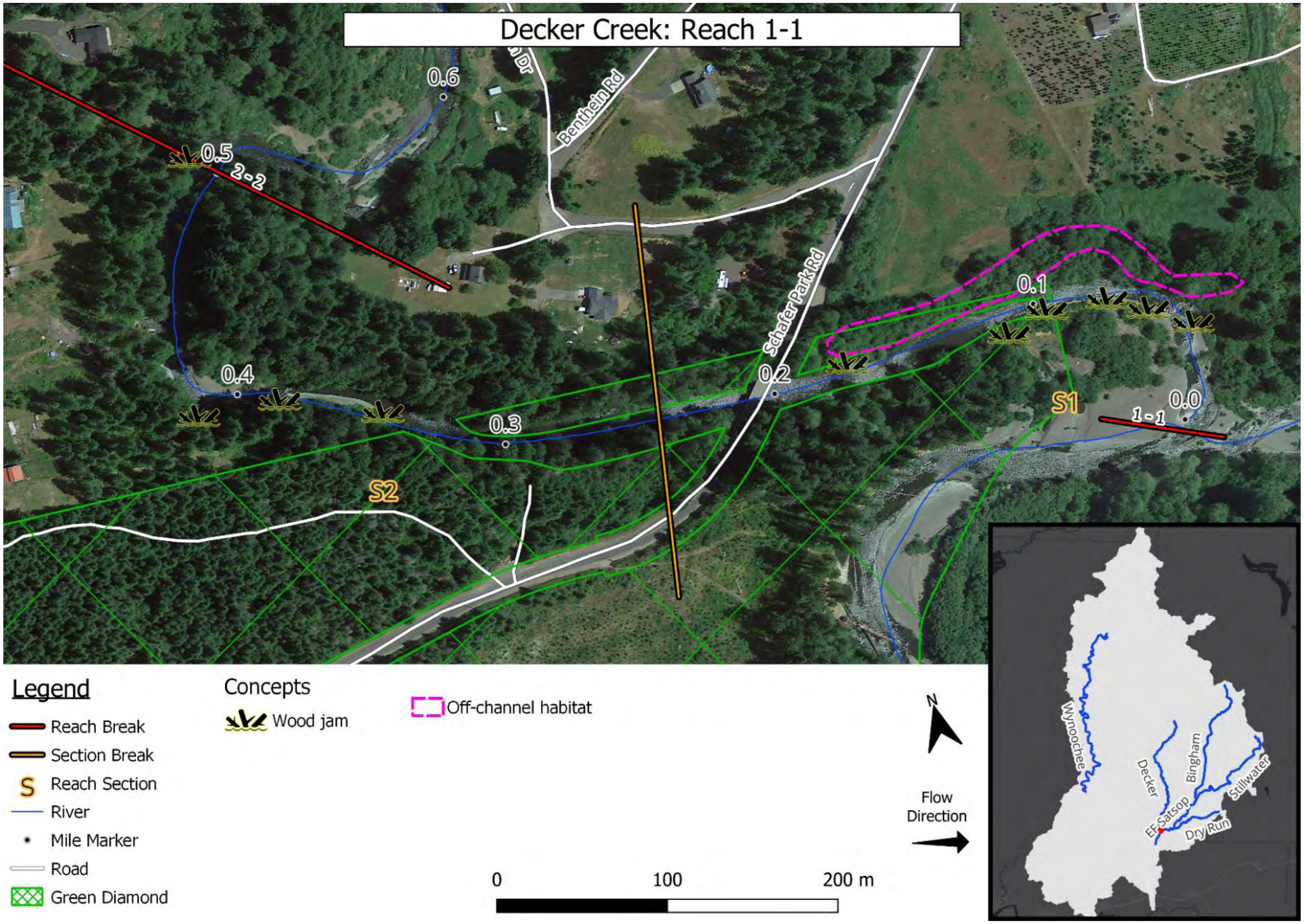


Figure 7. Overview map of Decker Creek Segment 1, Reach 1.

4.2.1.1 Site Description

This reach on Decker Creek begins at its confluence with the East Fork Satsop River and ends at RM 0.5. There is a large compound bar complex at the confluence that has slowly doubled in size over the last 20 years as Decker Creek migrates east. Lateral migration towards the east is expected to continue at a similar rate as it erodes into a vegetated point bar on the East Fork Satsop River upstream of the confluence. At RM 0.2, the channel passes under the West Schafer Park Road bridge and is confined within a straight 25-40-foot-deep canyon. Two stable bank-attached bars have developed within the canyon that force slight cross-sectional variability in the channel.

4.2.1.2 Conceptual Project Actions

Suitable and safe actions are fairly limited in this reach due to high confinement, high stream power, and limited access in the canyon. However, the dynamic behavior at the confluence presents an opportunity to improve habitat for salmonids as they prepare to migrate further upstream into Decker Creek. LW structures may be added at strategic locations in the lower 0.2 RMs to encourage further lateral migration to the east, increase access to off-channel habitat, and promote advancement of the chutes on the compound bar. Topographic scars left by the historic channel on river left near the confluence present an opportunity to increase access to off-channel habitats. This area should also be examined for opportunities to enhance off-channel habitats to increase suitability for juvenile salmonids. Further upstream, access becomes more difficult and there are few opportunities to construct stable jams. Within the canyon stretch, jams should be built in areas where wood would naturally accumulate such as outside meander bends and on bars.

4.2.1.3 Geomorphic Benefits

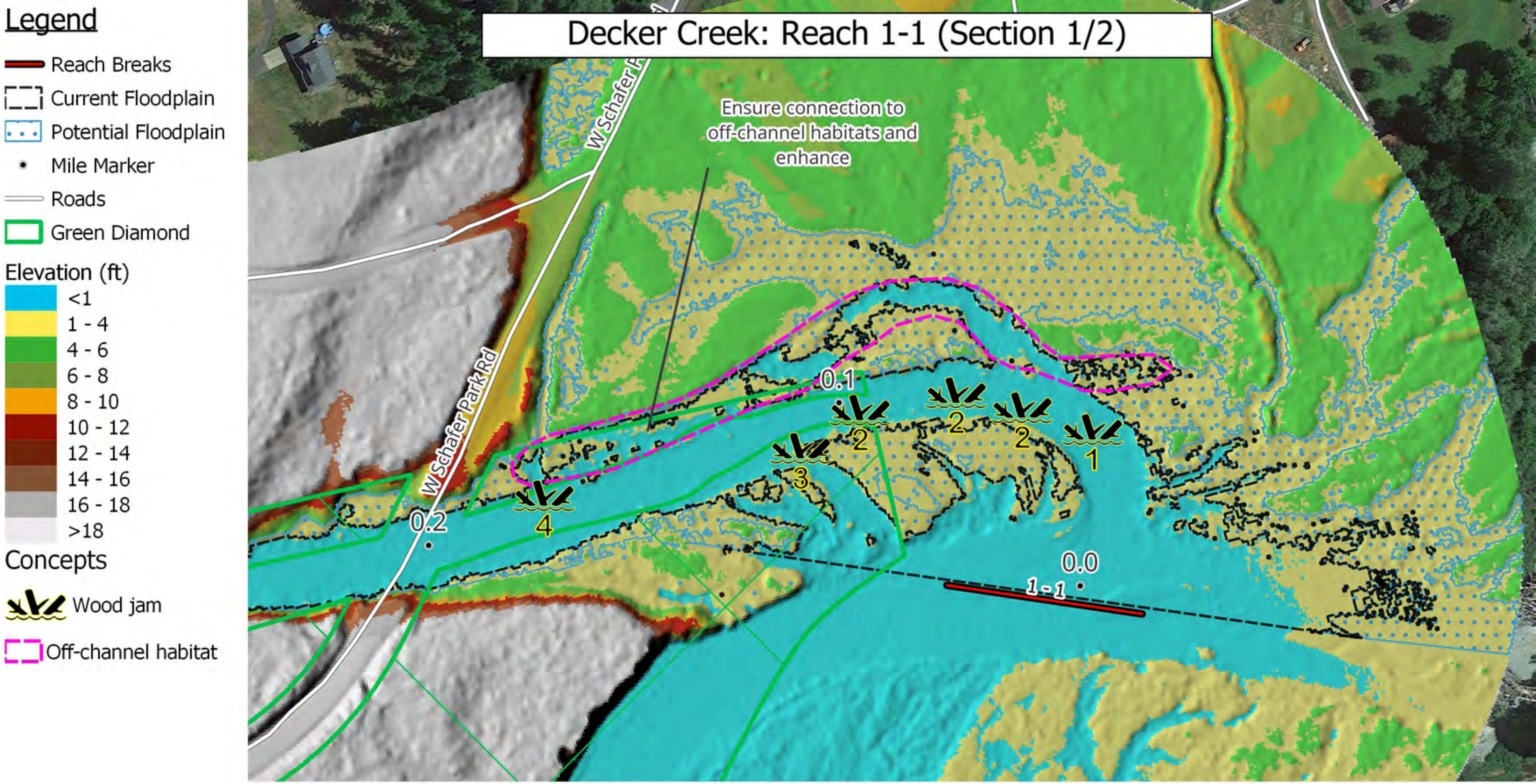
The geomorphic benefits of restoration actions at this site would likely be minimal. The most benefit can be gained by working near the confluence with the East Fork Satsop by expediting its current trajectory. Given wood stability concerns and confinement in the canyon stretch, LW jams would primarily provide biological benefits.

4.2.1.4 Biological Benefits

River confluences are natural hotspots for fish to congregate because of the variable hydraulics and complex topography. Adding structures around the confluence provides additional cover for migrating adults and rearing juvenile salmonids. As Decker Creek continues to migrate east, more off-channel habitats will be created through scour during flooding events and as chutes on the compound bar as it grows. In the canyon stretch, structures create resting areas for fish by creating pockets of slow water. The physical presence of wood also provides visual cover from predators.

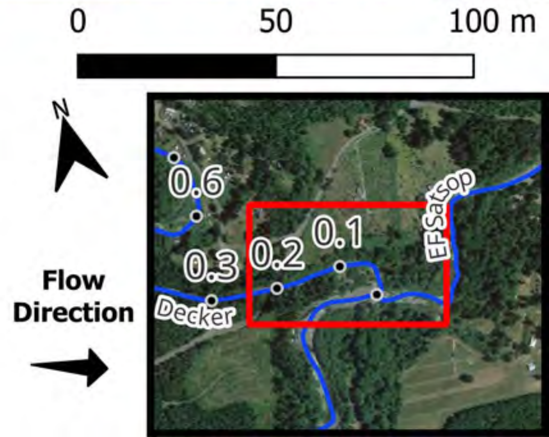
4.2.1.5 Logistical Challenges and Considerations

Access within the canyon is limited and will make constructing LW jams challenging. There are also several different landowners along the canyon that should be included in the planning process. Any LW added will need to consider the potential impacts to the West Schafer Park Road bridge. The bridge is wide and 10-15 feet above the channel, but dislodged wood could rack against the abutments and cause negative impacts. Any restoration work near the confluence that expedites lateral migration will need to consider adaptive management and maintenance as the main channel advances to the east.

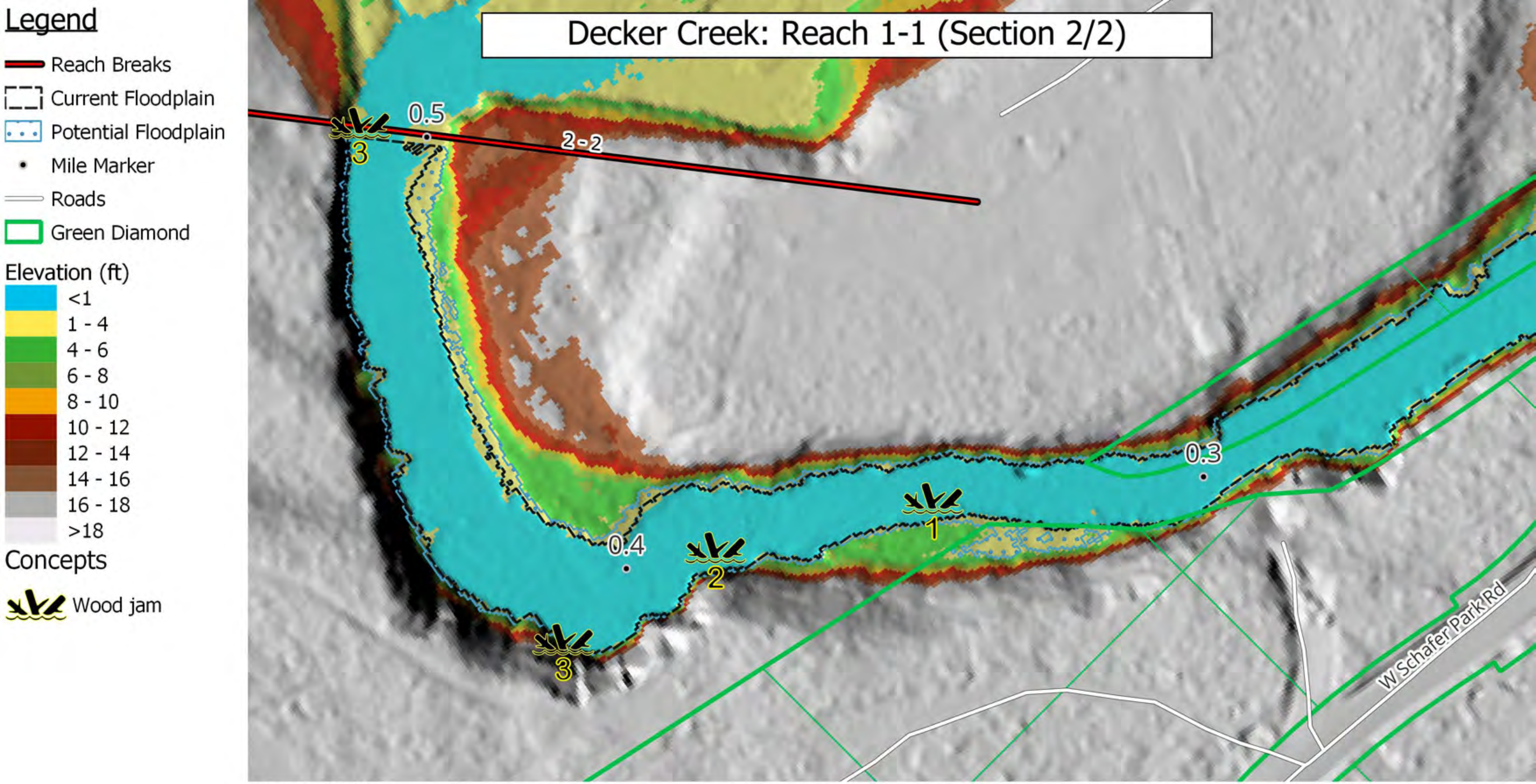


Concepts Key

Wood jam 1: Wood jam to enhance pool
Wood jam 2: Wood jam to shunt flows towards river left
Wood jam 3: Wood jam to maintain flow separation
Wood jam 4: Jam to support off-channel habitats

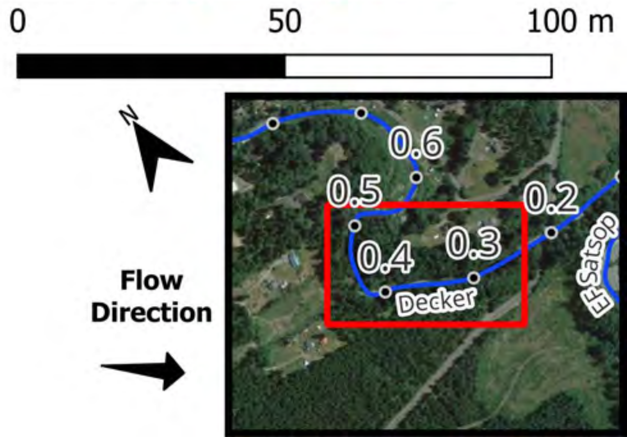


Decker Creek: Reach 1-1 (Section 2/2)



Concepts Key

Wood jam 1: Large jam to enhance riffle and promote aggradation
Wood jam 2: Wood jam to maintain bar
Wood jam 3: Wood jam to enhance lateral scour pool



4.2.2 Decker Creek – Segment 02 – Reach 05

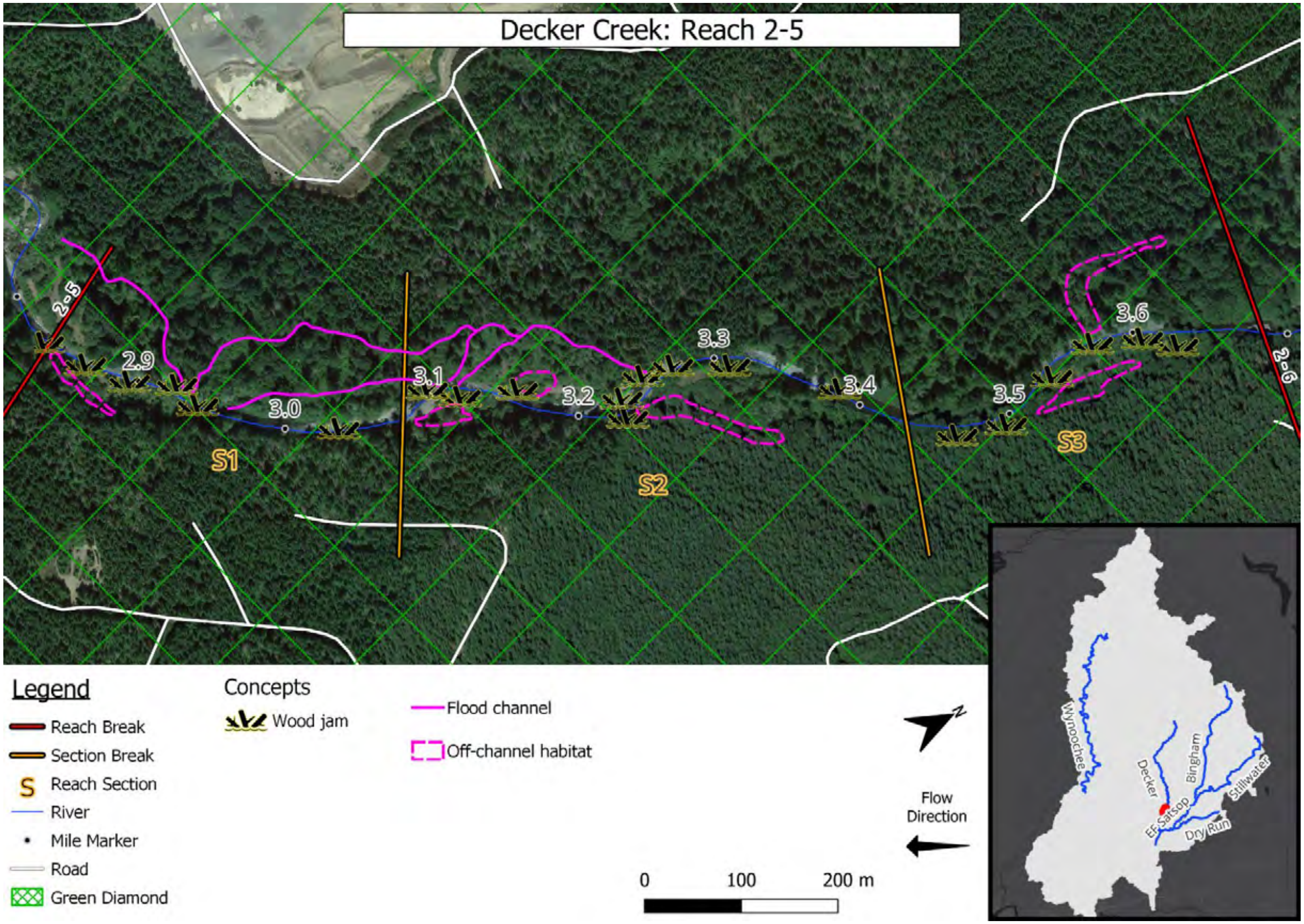


Figure 8. Overview map of Decker Creek Segment 2, Reach 5.

4.2.2.1 Site Description

This reach on Decker Creek begins at RM 2.8 and ends at RM 3.7. The channel is partly confined and has access to several floodplain pockets. The channel wanders back and forth through the reach as it bounces off the margins of the valley bottom, leaving off-channel habitats and flood channels on the inside of meander bends. However, the channel has incised up to two feet in the last couple decades, leaving some floodplain pockets less accessible. There are wood jams present in the reach that are forcing positive geomorphic change; however, wood density is low. There is ample sediment supply upstream and within the reach that will help build quality habitats if structural elements are added.

4.2.2.2 Conceptual Project Actions

Restoration actions in this reach should focus on promoting aggradation in the channel to raise the streambed and improve access to floodplain pockets. LW structures should be added on the inside of meander bends to promote lateral migration, at riffles to promote aggradation, and at the entrances and exits of flood channels and off-channel habitats. In some cases, it is appropriate to add wood on the outside of meander bends where pools are well-developed but lack structural cover for fish. Improving access to the floodplain can be achieved by directly shunting flow towards the entrance and backing water up into the exit. Off-channel habitats should be assessed for quality and wood pieces may be added to increase cover.

4.2.2.3 Geomorphic Benefits

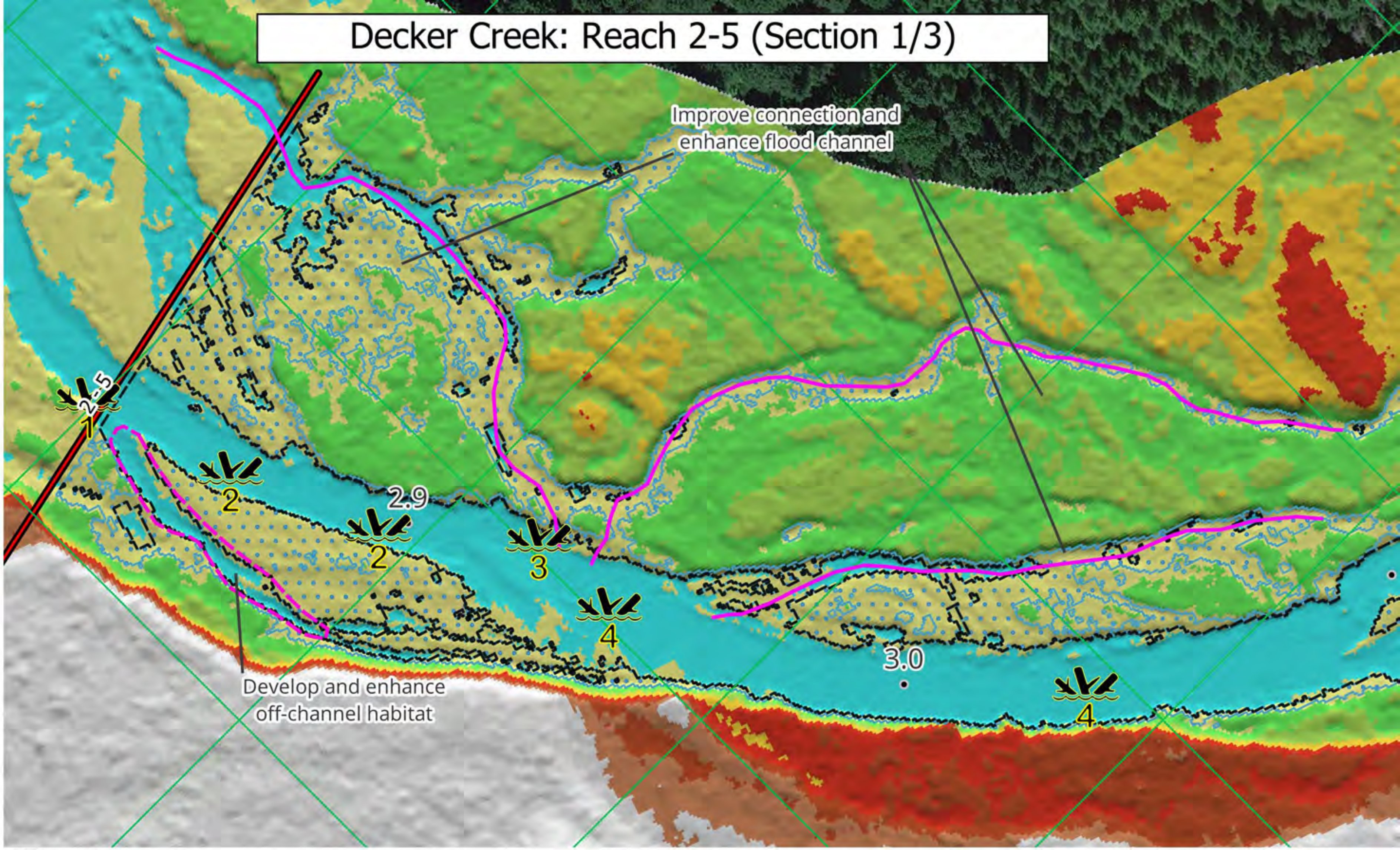
The channel's meander pattern and width are controlled by hillslopes, so it is paramount to maintain access to the valley bottom in this reach and arrest incision processes. Given the ample sediment supply in this reach, positive geomorphic responses will occur quickly following adequate flood events. Because the channel has incised and become less connected to some floodplain pockets, increasing aggradation provides an opportunity to reverse this damaging process. Maintaining and improving connection to the floodplain pockets and flood channels will reduce water velocity during floods and encourage deposition along with the strategic placement of LW jams.

4.2.2.4 Biological Benefits

In addition to aggrading the streambed, LW jams will help sort sediment to create patches of suitable spawning gravels for adult salmonids. Jams will also improve access to flood channels and off-channel habitats that provide refuge during flood events and highly suitable rearing habitat for juvenile salmonids. The jams themselves also provide cover for fish of all age classes. Large pools form on the outside of meander bends as the channel abuts against the hillslope, but these pools lack cover making them less suitable for aquatic species.

4.2.2.5 Logistical Challenges and Considerations

This project will need to consider the risk of LW mobilizing and affecting private property and infrastructure downstream. Construction access may be limited in some sections of the reach, but old forest access roads may be improved and used to get into the valley bottom. To improve access to flood channels, excavation at their entrance may be considered. If this approach is used, practitioners should consider spoiling the excavated material into the channel as a form of sediment augmentation if the sediment composition is suitable.



Legend

- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

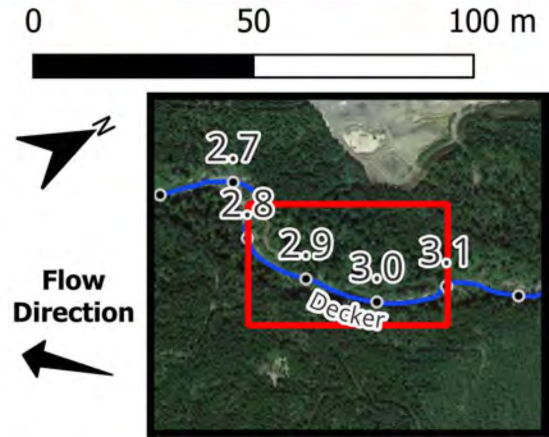
- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

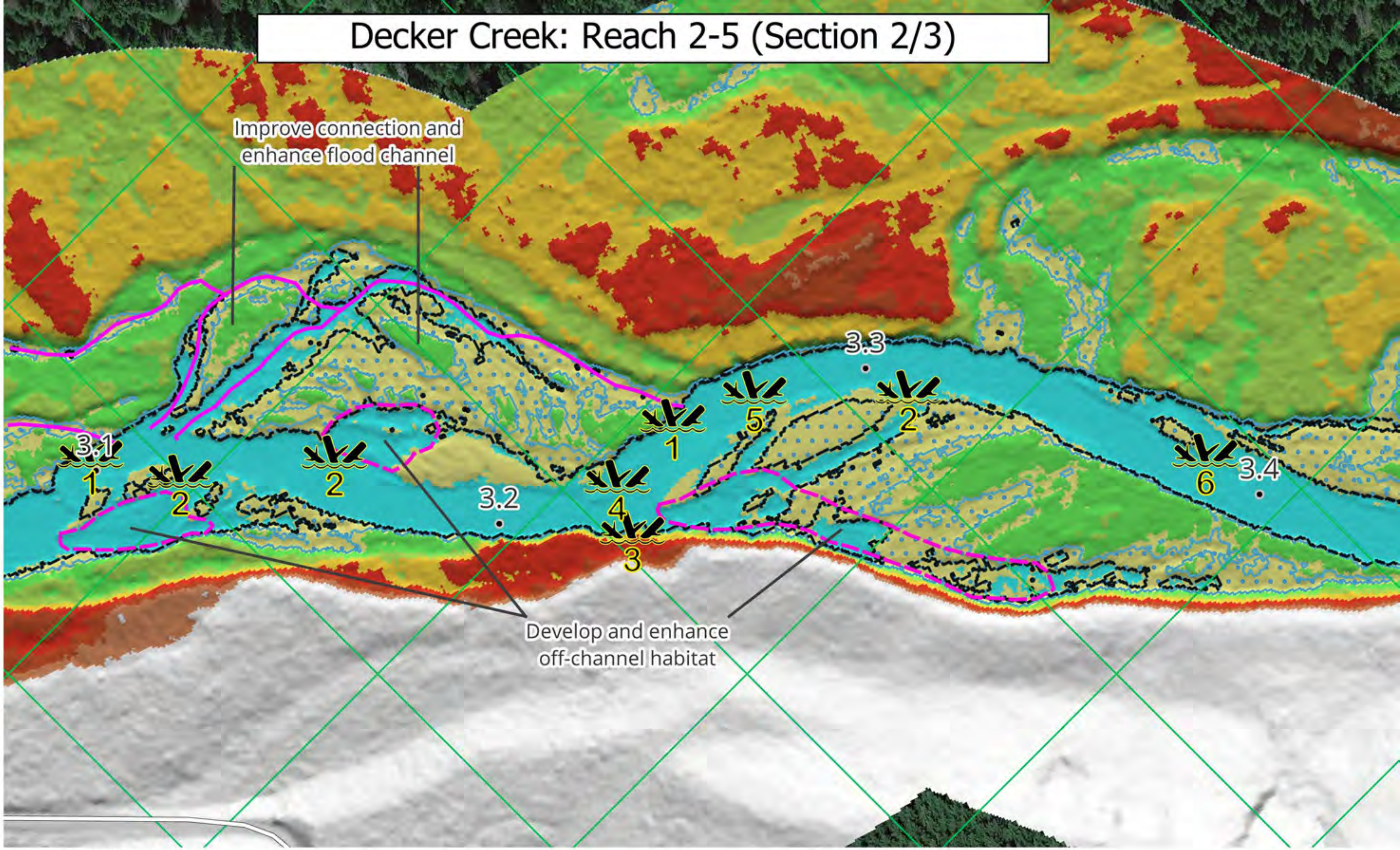
Concepts

- Wood jam
- Flood channel
- Off-channel habitat

Concepts Key

Wood jam 1: Wood jam to support off-channel habitat
Wood jam 2: Wood jam to push flows towards river right
Wood jam 3: Wood jam to support flood channels
Wood jam 4: Wood jam at riffle to promote aggradation





Legend

- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

- Wood jam
- Flood channel
- Off-channel habitat

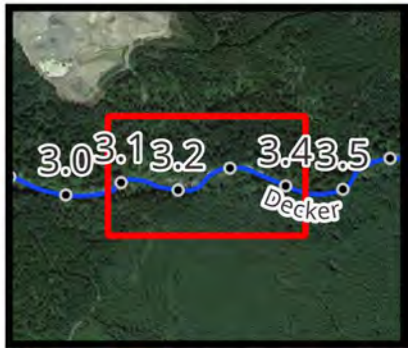
Concepts Key

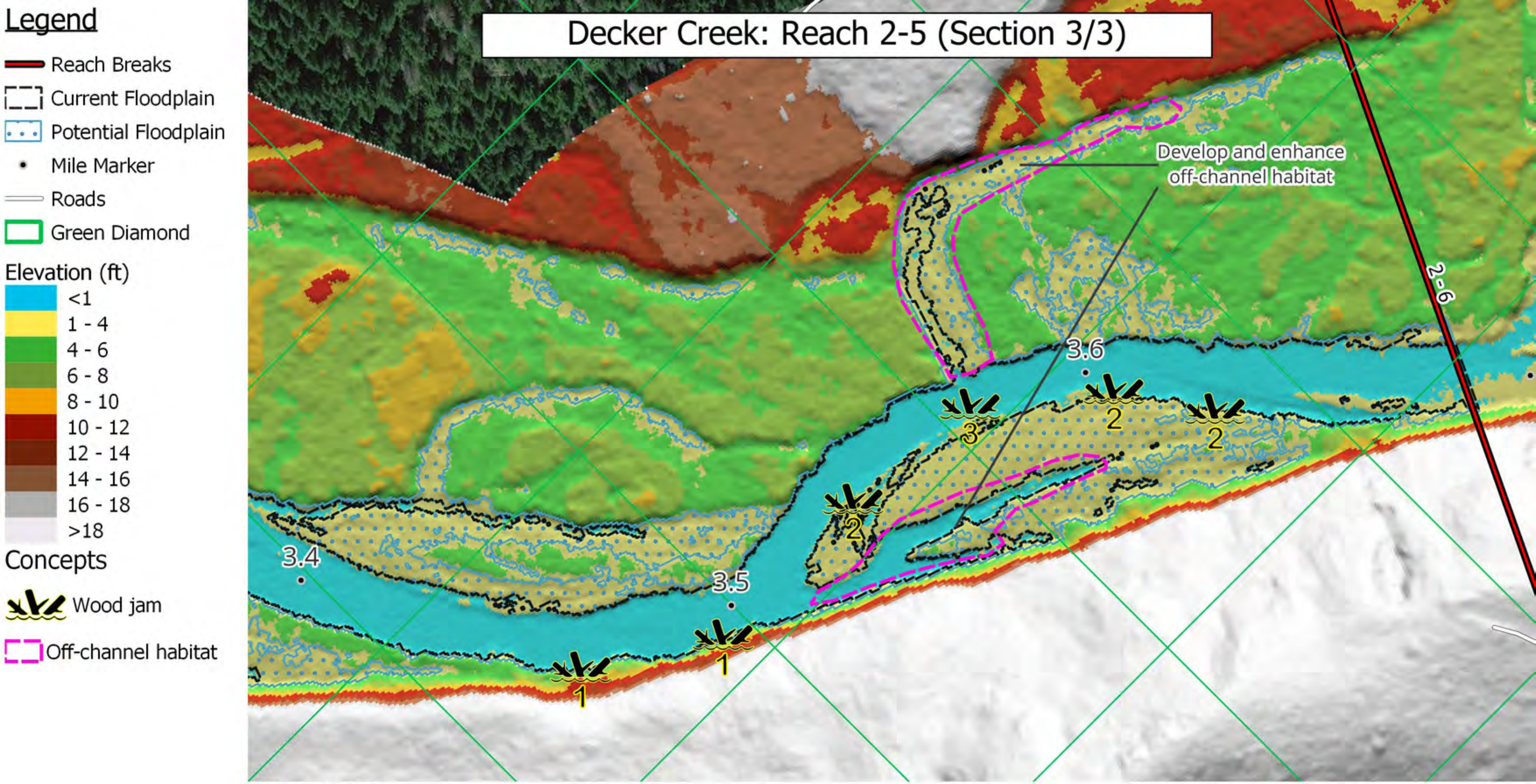
Wood jam 1: Wood jam to support flood channel
Wood jam 2: Wood jam to support off-channel habitat
Wood jam 3: Wood jam to enhance lateral scour pool and support off-channel habitat
Wood jam 4: Wood jam to maintain mid-channel bar and promote aggradation
Wood jam 5: Wood jam to push flows towards river right
Wood jam 6: Wood jam to maintain bar and enhance edge habitat

0 50 100 m

N

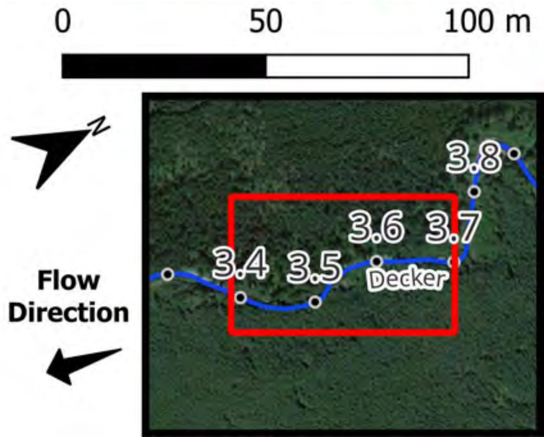
Flow Direction





Concepts Key

Wood jam 1: Wood jam to enhance lateral scour pool
Wood jam 2: Wood jam to push flows towards river right
Wood jam 3: Channel spanning jam to support off-channel habitats



4.2.4 Decker Creek – Segment 03 – Reach 13

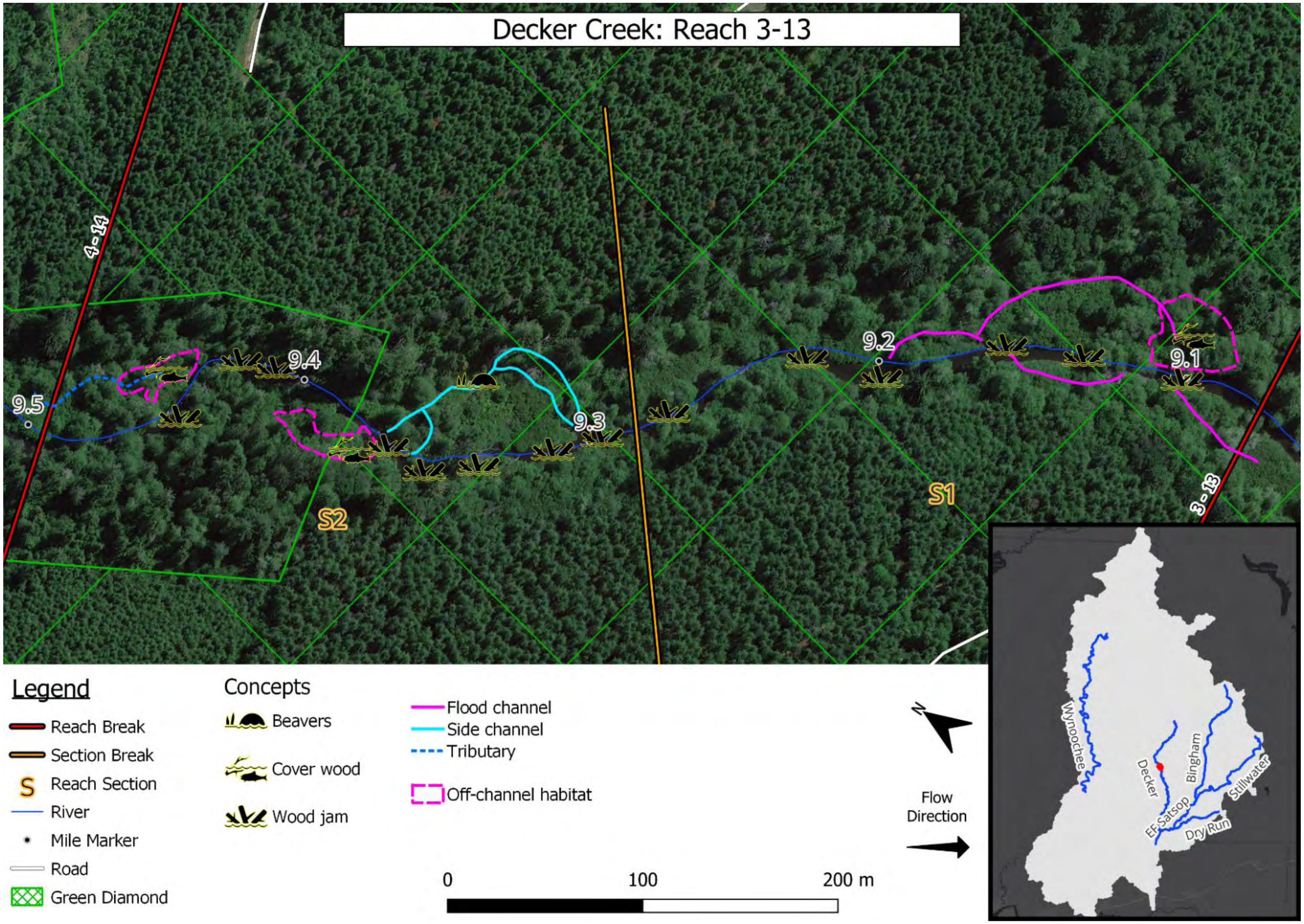


Figure 9. Overview map of Decker Creek Segment 3, Reach 13.

4.2.4.1 Site Description

This reach on Decker Creek begins at RM 9.05 and ends at RM 9.5. Relatively small unnamed tributaries mark the upstream and downstream boundaries. The channel is partly confined as it bounces back and forth between the hillslope on river right and a terrace on river left, but the valley bottom is relatively wide compared to the channel width. There is a side channel complex near RM 9.3 that appears to be maintained by beaver activity. There are many historic channel scars from that now act as flood channels and provide opportunities for improved floodplain connection. The main channel is composed of a few very long pools separated by short riffles. Directly upstream, the valley bottom widens greatly, and beaver activity is prevalent.

4.2.4.2 Conceptual Project Actions

Restoration actions in this reach should focus on spreading flows laterally to increase the frequency of floodplain connection. Doing so is expected to spur more beaver activity in this reach. LW jams may be placed at strategic locations to shunt flows towards the entrance of flood channels and low-lying floodplain. LW jams placed at the riffles will help aggrade the channel and further improve floodplain connection. Placing jams within the long pools may lead to increased topographic diversity in the streambed, but their primary benefit will be to increase cover for aquatic species.

4.2.4.3 Geomorphic Benefits

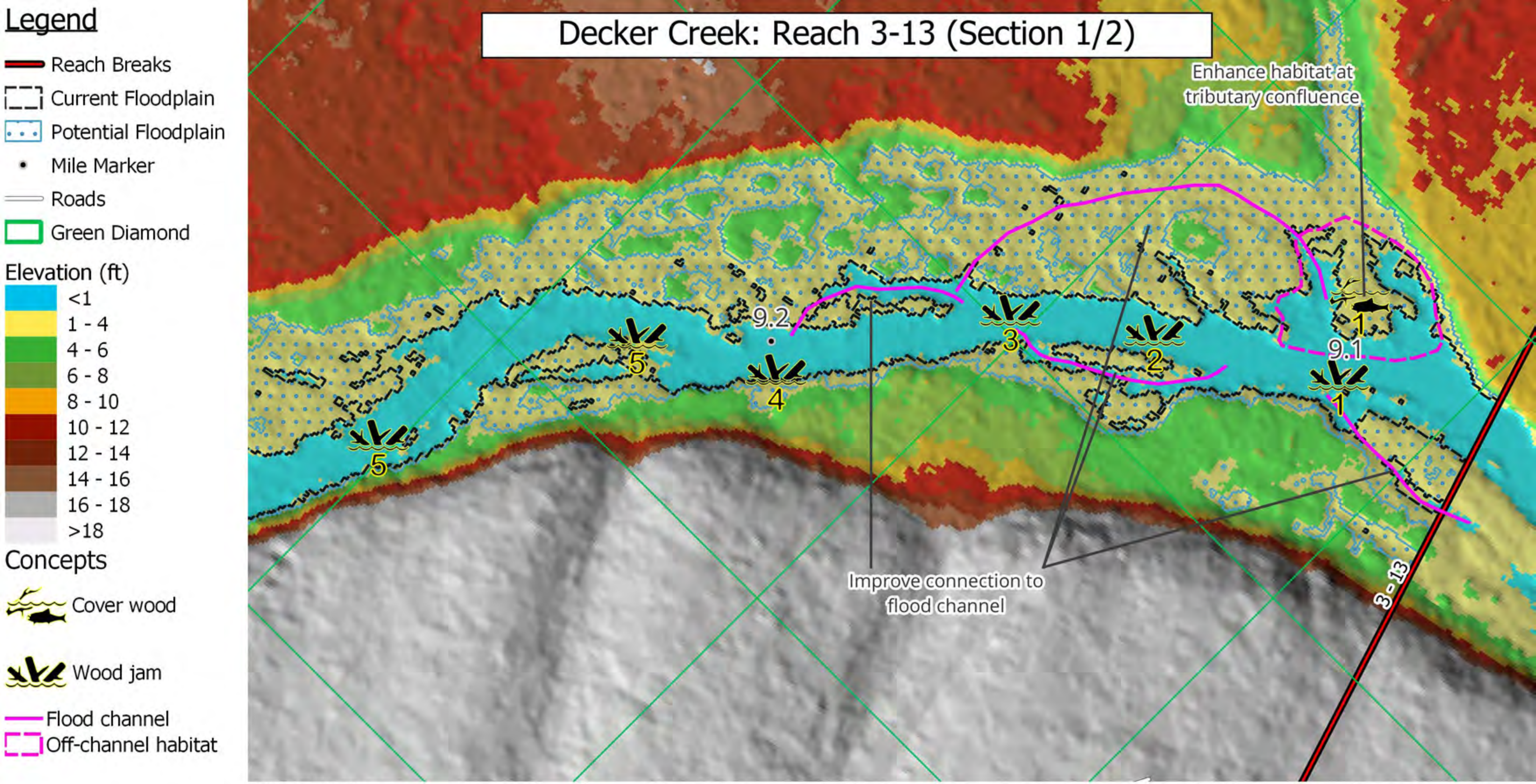
LW structures are expected to slow water velocity during flood events which would promote sediment deposition and channel aggradation. The physical placement of the structures also provides hardpoints in the valley bottom for beavers to utilize, giving them more opportunities to modify the landscape.

4.2.4.4 Biological Benefits

Increasing suitability for beavers in this reach will allow them to create and maintain habitats highly suitable for rearing juvenile salmonids. The ecogeomorphic feedback between beaver activity and fluvial processes will help create a highly functional and self-sustaining valley bottom. More frequent access to the floodplain and existing off-channel habitats will increase the carrying capacity for salmonids within the reach.

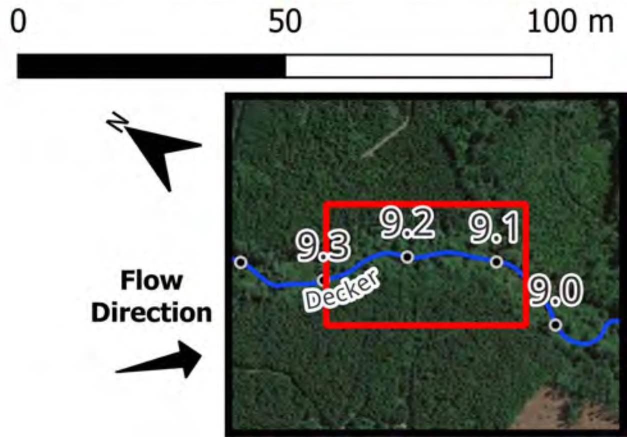
4.2.4.5 Logistical Challenges and Considerations

Portions of the valley bottom may be difficult to access with heavy equipment. Direct felling should be considered as an option to supplement wood density. When possible, additional wood should be added to the existing jams to increase their spatial coverage and effectiveness.



Concepts Key

Cover wood 1: Add wood pieces to increase fish cover
Wood jam 1: Large jam to support off-channel habitat and access to flood channel
Wood jam 2: Large jam to spread flows laterally towards floodplain on both sides
Wood jam 3: Large jam to support access to flood channel and floodplain on both sides
Wood jam 4: Large wood jam to support flood channel
Wood jam 5: Wood jam to push flows towards river left



Legend

Reach Breaks

Current Floodplain

Potential Floodplain

Mile Marker

Roads

Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

Beavers

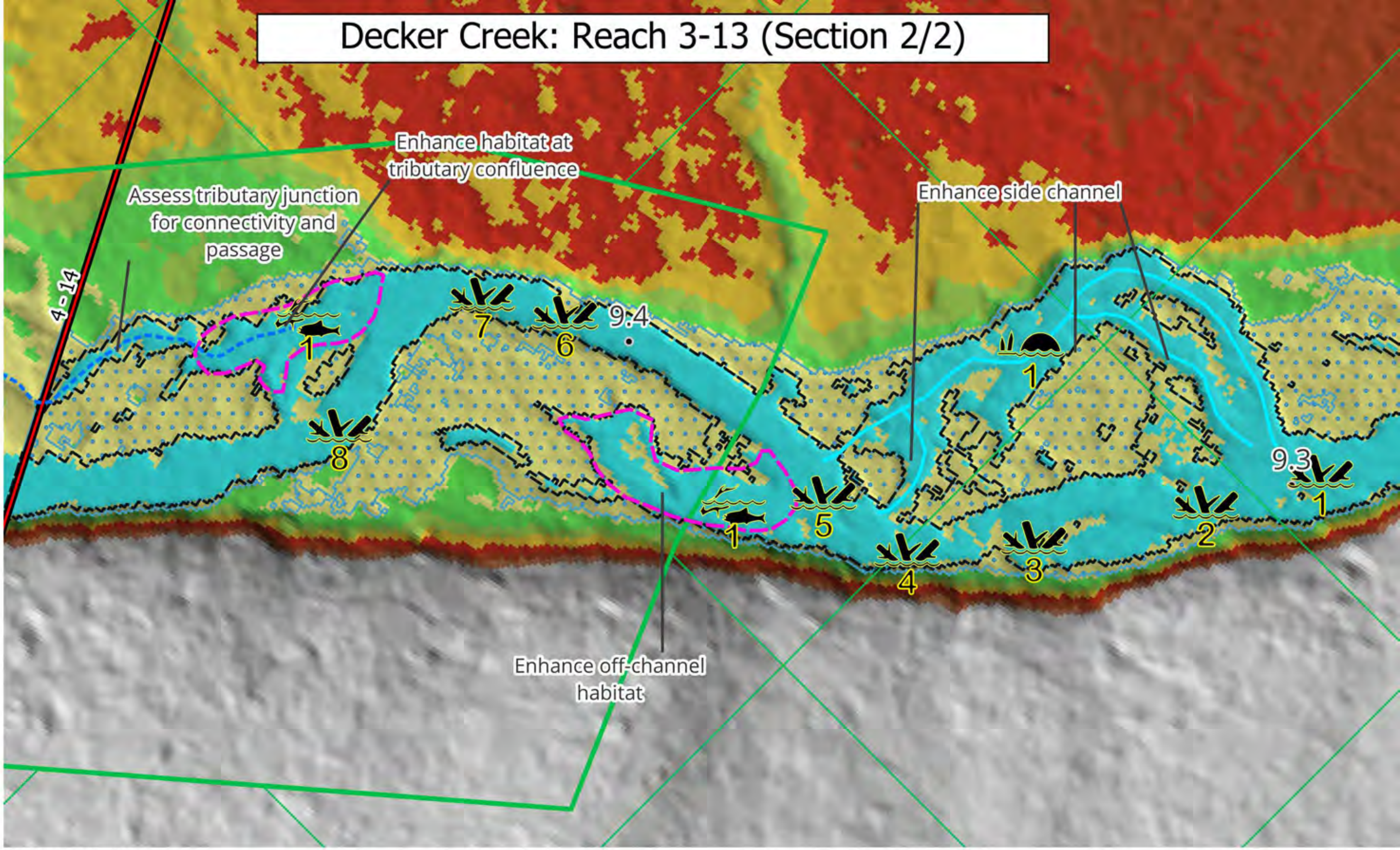
Cover wood

Wood jam

Side channel

Tributary

Off-channel habitat



Concepts Key

Beavers 1: Potential beaver activity

Cover wood 1: Add wood pieces to increase fish cover

Wood jam 1: Large jam to support side channel junction and confluence pool

Wood jam 2: Large jam at riffle to spread flows laterally and aggrade channel

Wood jam 3: Wood jam to split flows, majority towards river left

Wood jam 4: Large wood jam to support side channel

Wood jam 5: Large jam to support off-channel habitat and side channel

Wood jam 6: Wood jam at riffle to aggrade channel and push flows towards river right

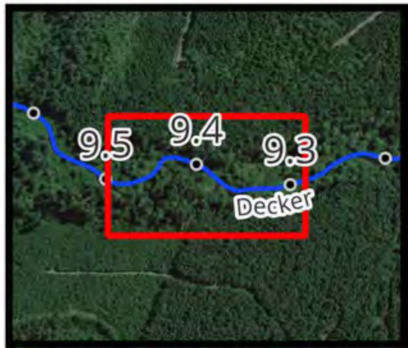
Wood jam 7: Wood jam at riffle to support tributary junction and aggrade channel

Wood jam 8: Wood jam to spport tributary junction through backwater

0 50 100 m

N

Flow Direction



4.2.5 Decker Creek – Segment 04 – Reach 16

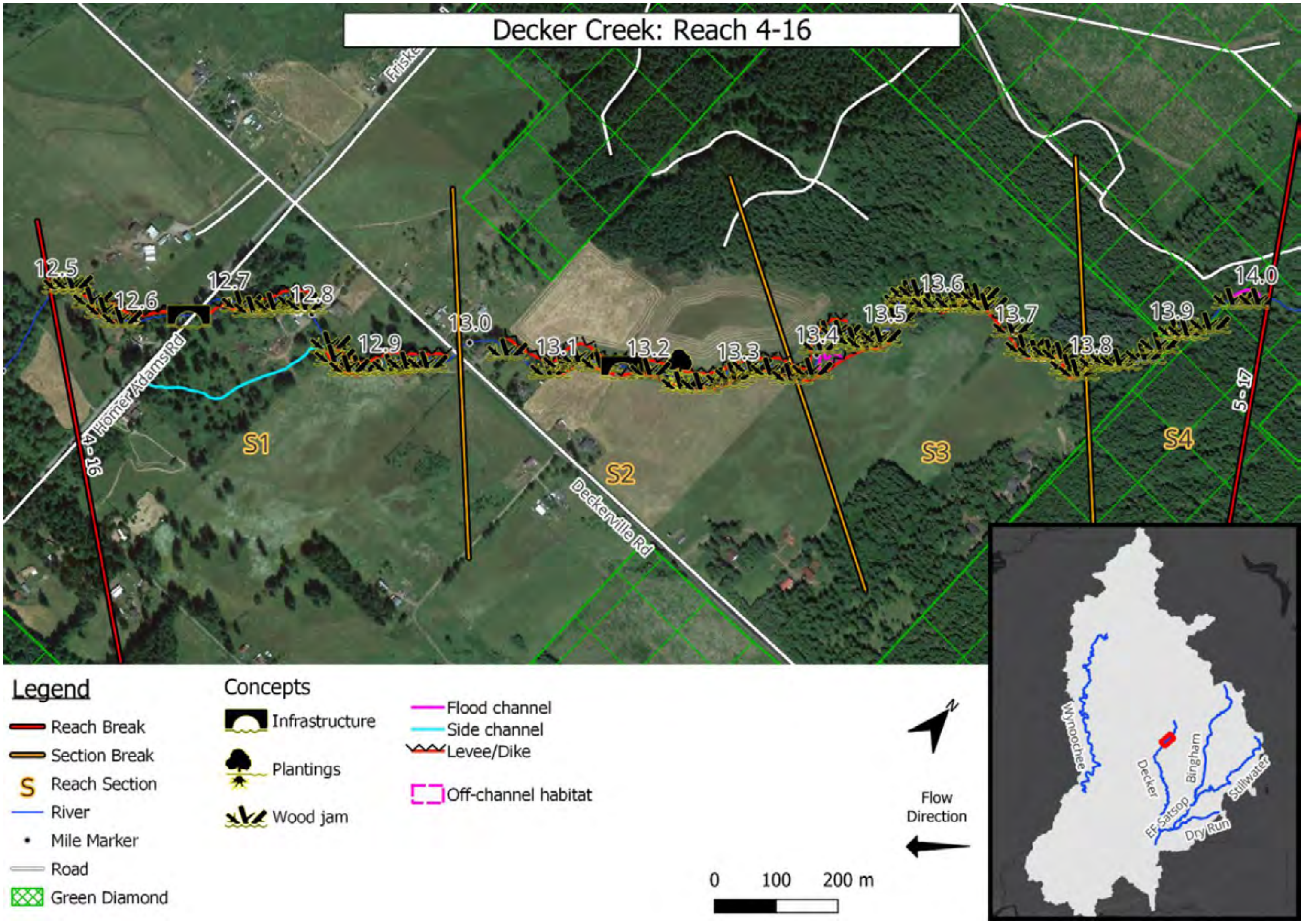


Figure 10. Overview map of Decker Creek Segment 4, Reach 16.

4.2.5.1 Site Description

This reach on Decker Creek begins at RM 12.5 and ends at RM 14.0. The valley bottom in this reach is very wide, especially in relation to the current incised stream channel. Several levees or push-up dikes line the channel to protect adjacent working lands. Ecologically, the levees restrict the creek's ability to maintain a healthy and wide riparian corridor. Although the channel is small and restricted in its current channel, geomorphic indicators suggest that the valley bottom was a wet meadow and may have been an anastomosing reach. Visible channel scars in the LiDAR and aerial imagery suggest that the channel has been moved in recent history. The channel flows under West Homer Adams Road at RM 12.65 but must make a nearly 90-degree turn to flow through. The channel also passes under West Deckerville Road near RM 13.0.

4.2.5.2 Conceptual Project Actions

Ideally, the primary restoration actions in this reach would focus on providing more space to the creek so it can create quality habitats and develop a wider riparian corridor. To maintain the viability of working lands, the current levees and push-up dikes could be set back to provide more space for the channel while still controlling the extent of inundation. Alternatively, a high density of small LW jams may be placed in the channel to improve habitat quality for salmonids. The jams may be sized and configured to create small pools and bars without causing a wholesale change in the rate of sediment aggradation. An additional alternative would be to plant woody riparian species or implement a grass buffer strip to protect the stream from excessive nutrients from agricultural run-off. The channel crossing at West Homer Adams Road should be assessed and, if necessary, the channel should be reconfigured to avoid making a 90-degree turn before entering the culvert.

4.2.5.3 Geomorphic Benefits

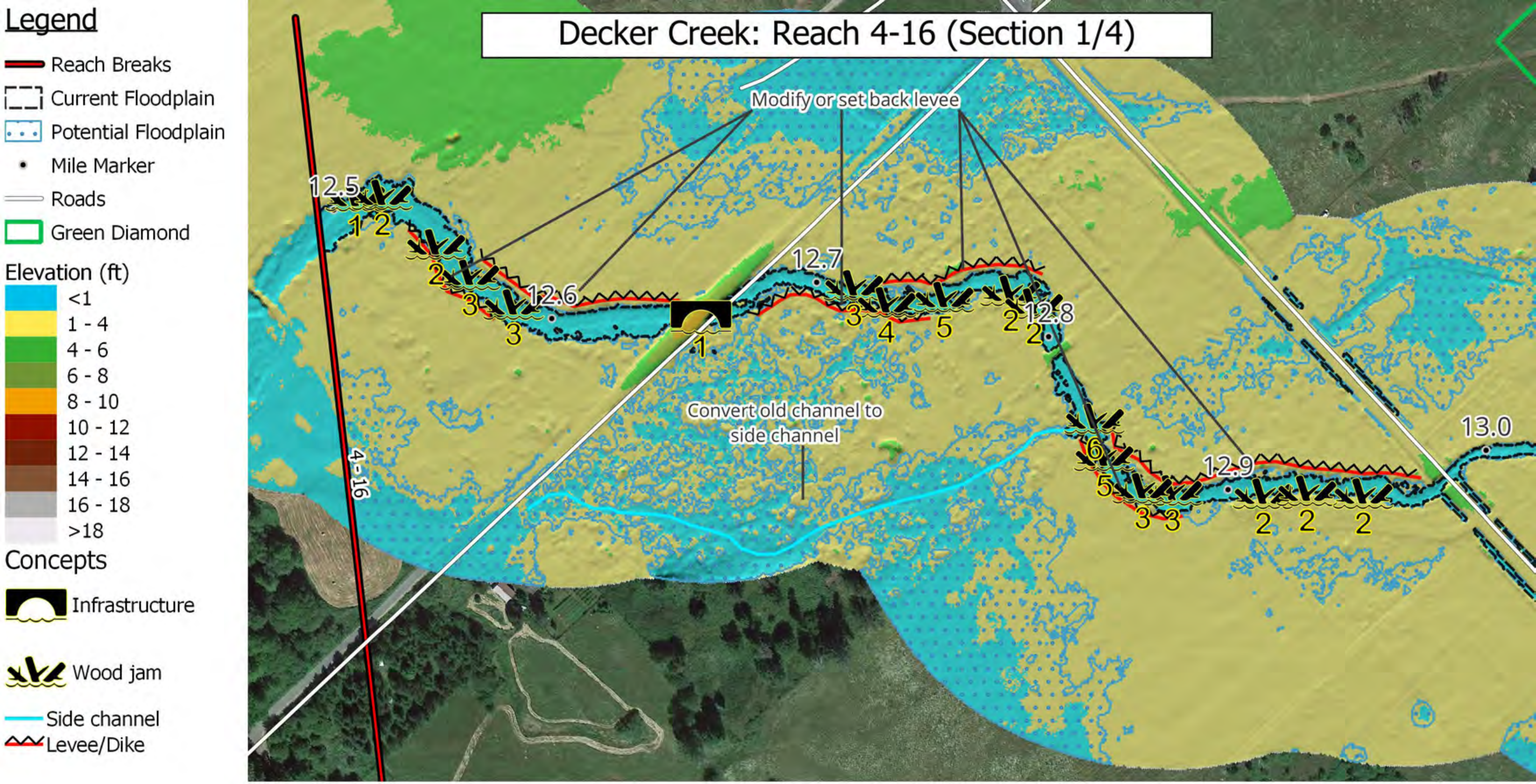
Giving the creek more space to meander and flood will result in a healthier riparian corridor. If more space is given to the river, the LW structures will help initiate lateral migration to increase sinuosity and increase infiltration of water into the adjacent soils. There are several locations where the creek appears to be attempting to widen but is locked in place by the frequent levees and push-up dikes. LW structures will also help sort sediment to create cleaned patches of gravel. Focusing solely on riparian plantings or grass buffer strips will not provide much geomorphic benefit if the confining features remain in place, but those actions will provide biological uplift.

4.2.5.4 Biological Benefits

Increasing the width and density of the riparian corridor will filter excessive nutrients that commonly result from agricultural land use practices. More shrub and canopy species will shade the river to buffer stream temperature increases as the creek flows between shaded forest lands. LW structures will provide cover for salmonids and other aquatic species as well as sort sediment to provide pockets of gravels suitable for spawning.

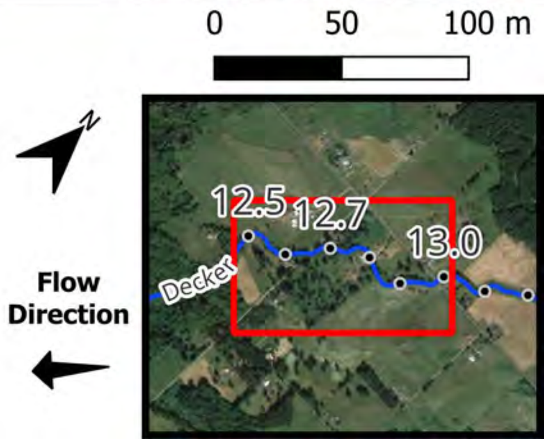
4.2.5.5 Logistical Challenges and Considerations

This reach is mostly surrounded by working lands. Any restoration or conservation actions will need to consider the current land use and potential negative effects on agricultural and grazing practices. Levees and dikes that directly protect buildings and other infrastructure should be left alone or improved. Bioengineering techniques should be considered as a bank-protection alternative to add some ecological benefit, even if it results in minor gains.



Concepts Key

Infrastructure 1: Assess creek alignment to culvert/bridge
Wood jam 1: Wood jam at riffle to push flows towards river right and aggrade channel
Wood jam 2: Wood jam to push flows towards river right
Wood jam 3: Wood jam to push flows towards river left
Wood jam 4: Channel spanning jam to take advantage of inset floodplain
Wood jam 5: Channel spanning wood jam to take advantage of inset floodplain
Wood jam 6: Wood jam to push flows river left; improve access to side channel if improved



Legend

Reach Breaks
Current Floodplain
Potential Floodplain
Mile Marker
Roads
Green Diamond

Elevation (ft)
<1
1 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16 - 18
>18

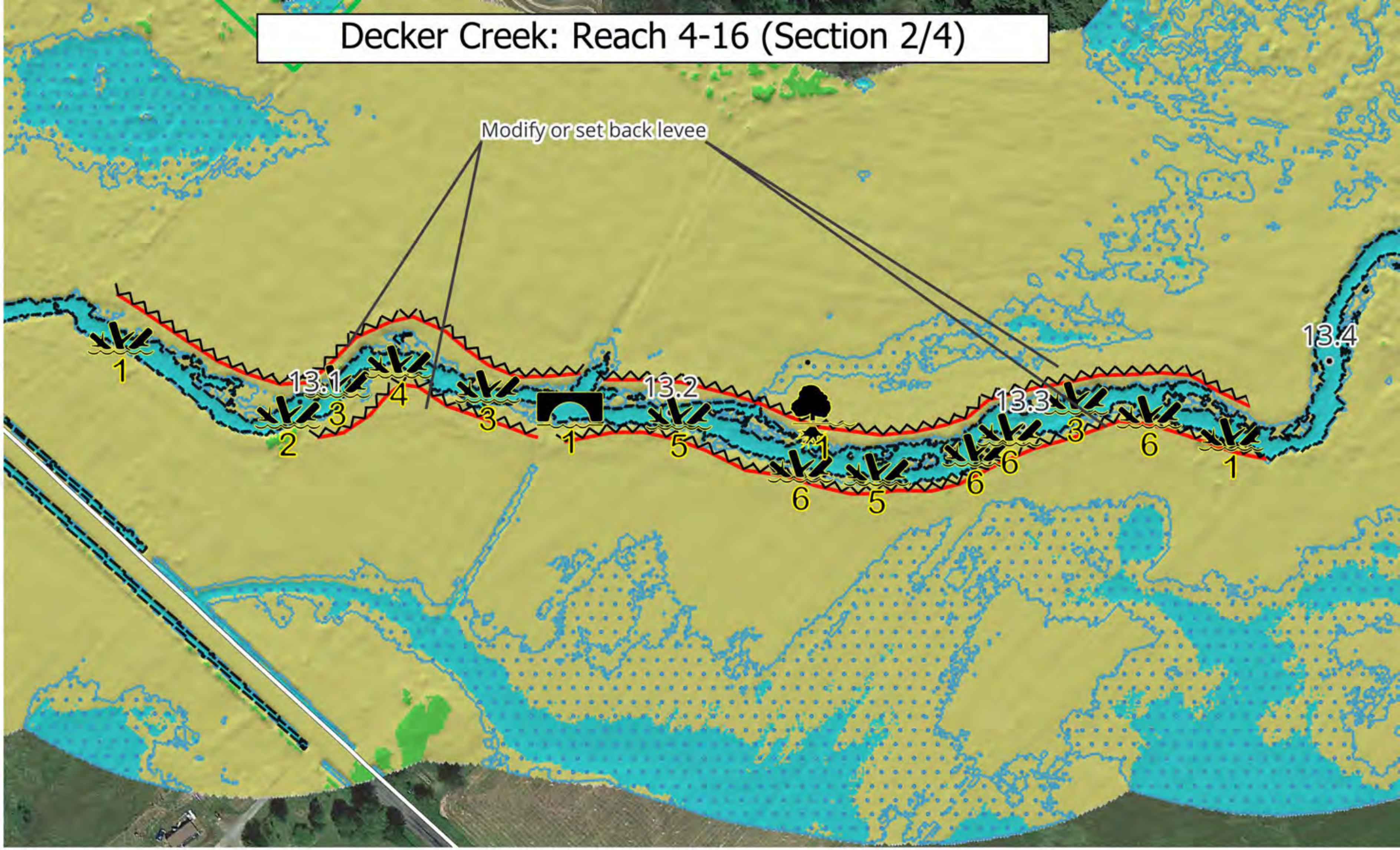
Concepts

Infrastructure

Plantings

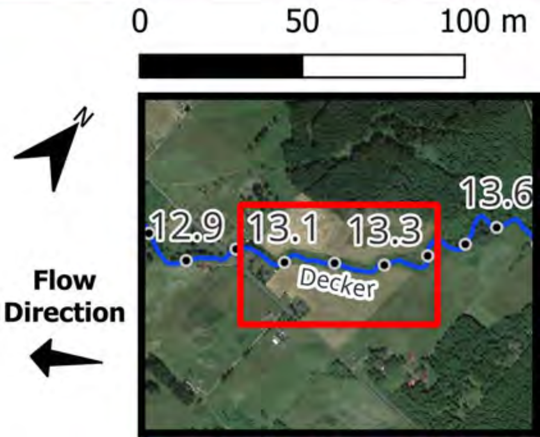
Wood jam

Levee/Dike

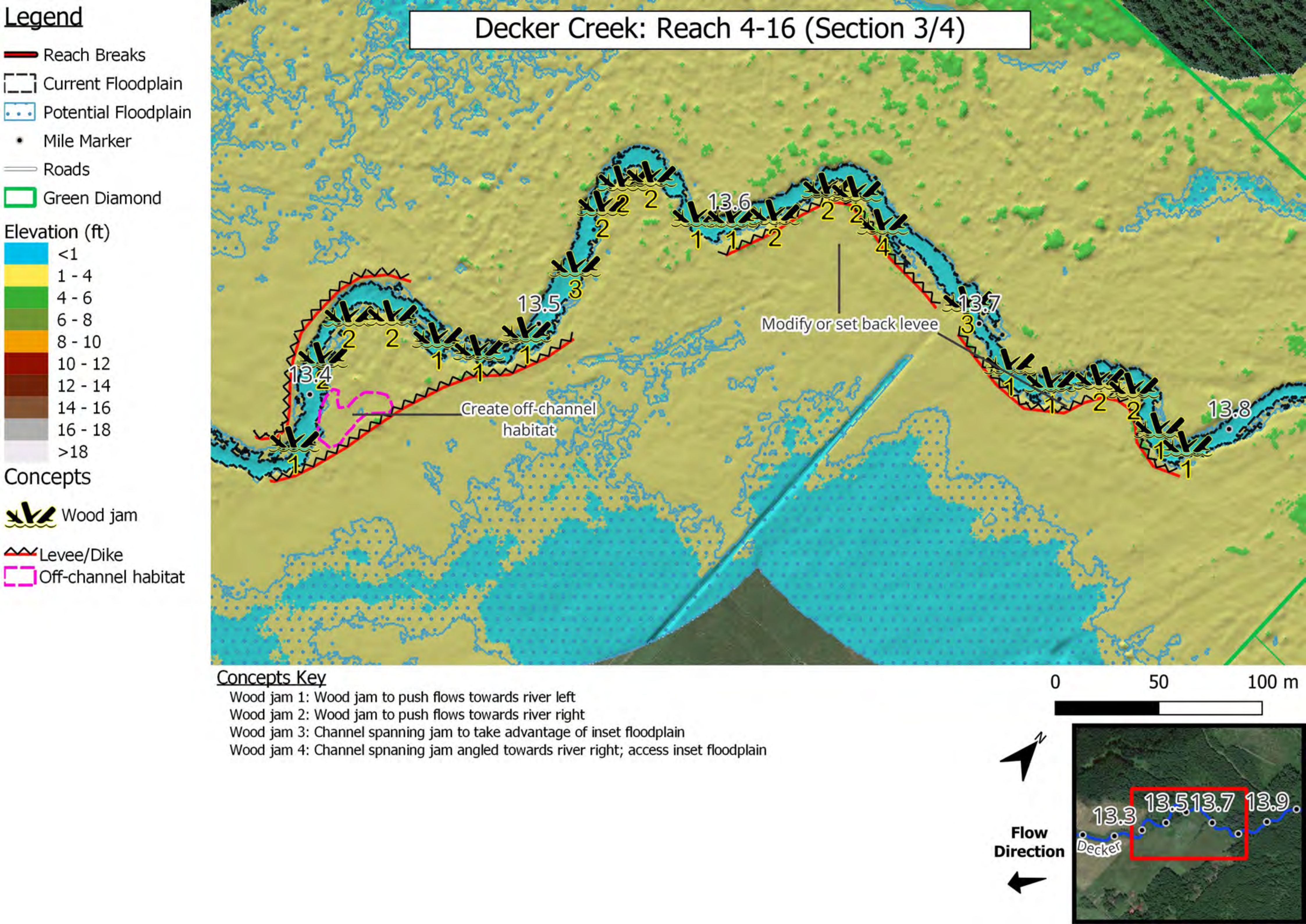


Concepts Key

Infrastructure 1: Assess ford for potential improvements
Plantings 1: Riparian plantings to improve buffer
Wood jam 1: Channel spanning wood jam to take advantage of inset floodplain
Wood jam 2: Enhance existing jam to split flows and access inset floodplain
Wood jam 3: Wood jam to push flows towards river left
Wood jam 4: Large jam to push flows towards river right and access inset floodplain
Wood jam 5: Channel spanning jam to take advantage of inset floodplain
Wood jam 6: Wood jam to push flows towards river right



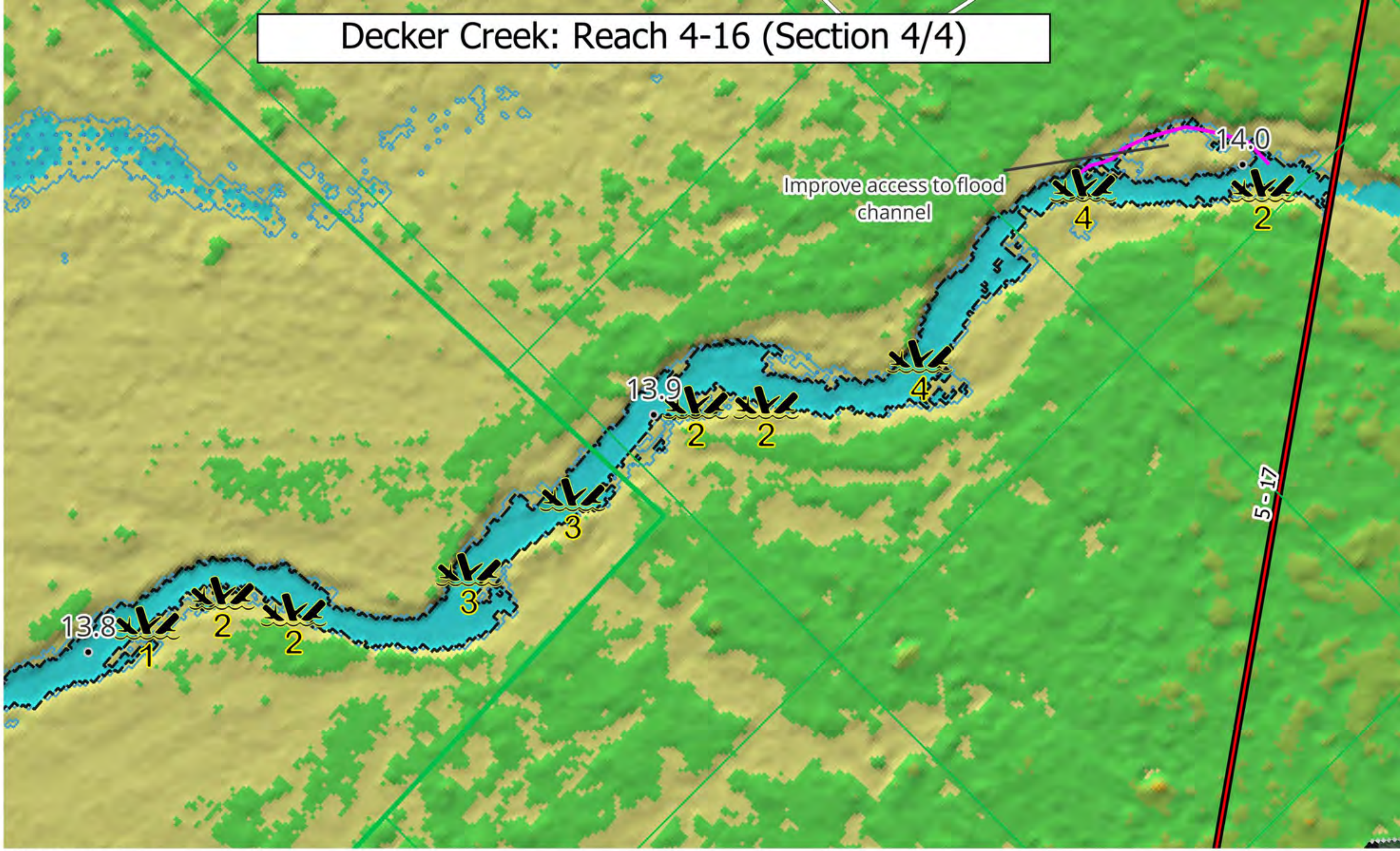
Decker Creek: Reach 4-16 (Section 3/4)



Concepts Key

Wood jam 1: Wood jam to push flows towards river left
Wood jam 2: Wood jam to push flows towards river right
Wood jam 3: Channel spanning jam to take advantage of inset floodplain
Wood jam 4: Channel spnaning jam angled towards river right; access inset floodplain

Decker Creek: Reach 4-16 (Section 4/4)



Legend

- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

- Wood jam
- Flood channel

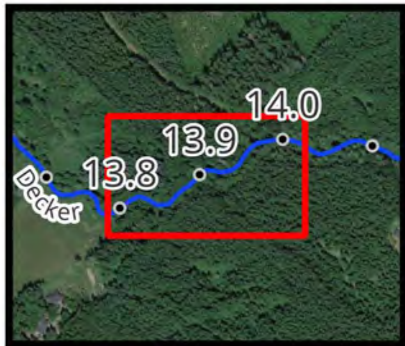
Concepts Key

Wood jam 1: Wood jam to push flowstowards river right
Wood jam 2: Wood jam to push flows towards river right
Wood jam 3: Channel spanning jam to take advantage of inset floodplain
Wood jam 4: Channel spanning jam angled towards river left

0 50 100 m

N

Flow Direction



4.3 Dry Run Creek

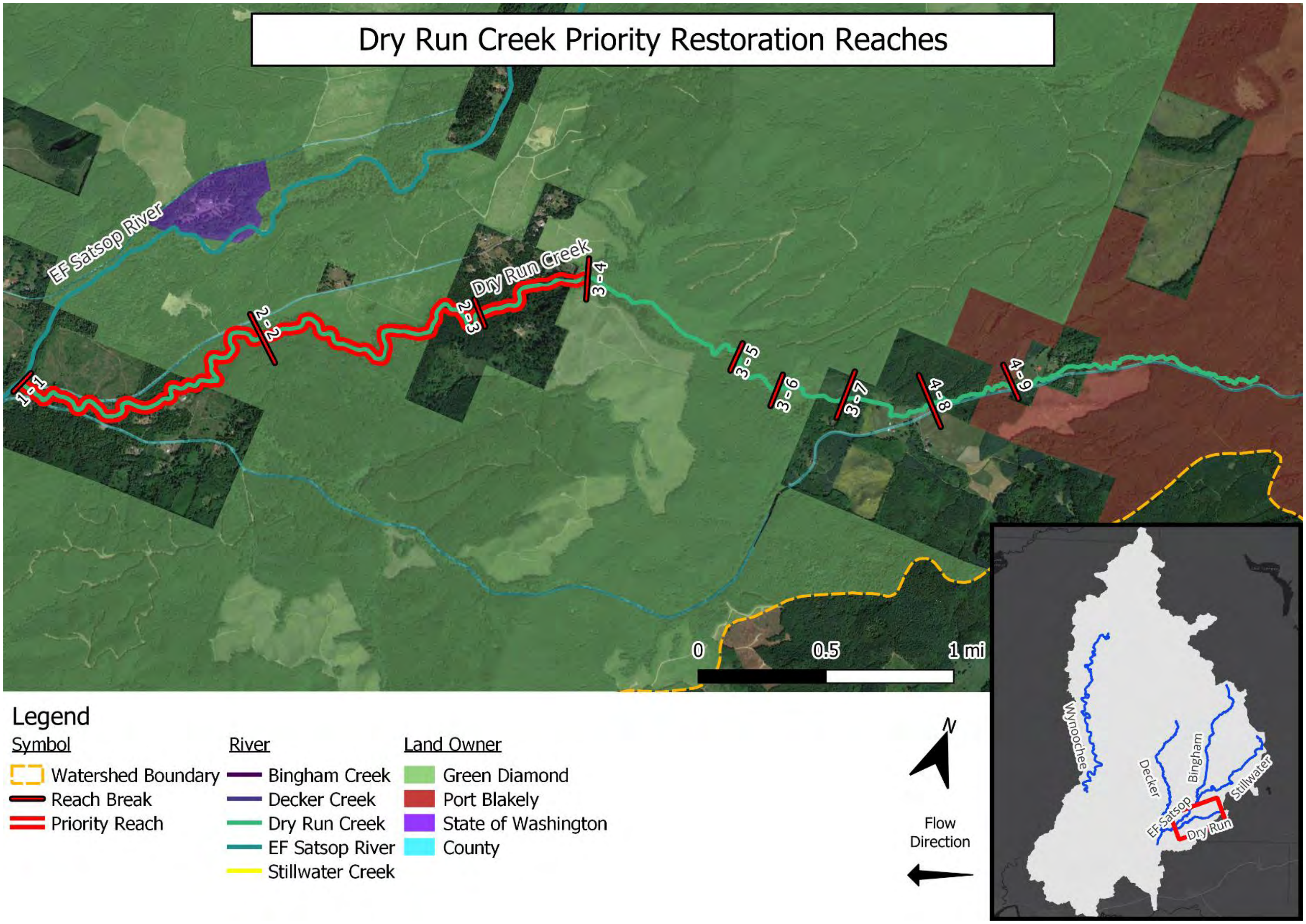


Figure 11. Overview map of priority restoration reaches in Dry Run Creek.

4.3.1 Dry Run Creek – Segment 01 – Reach 01

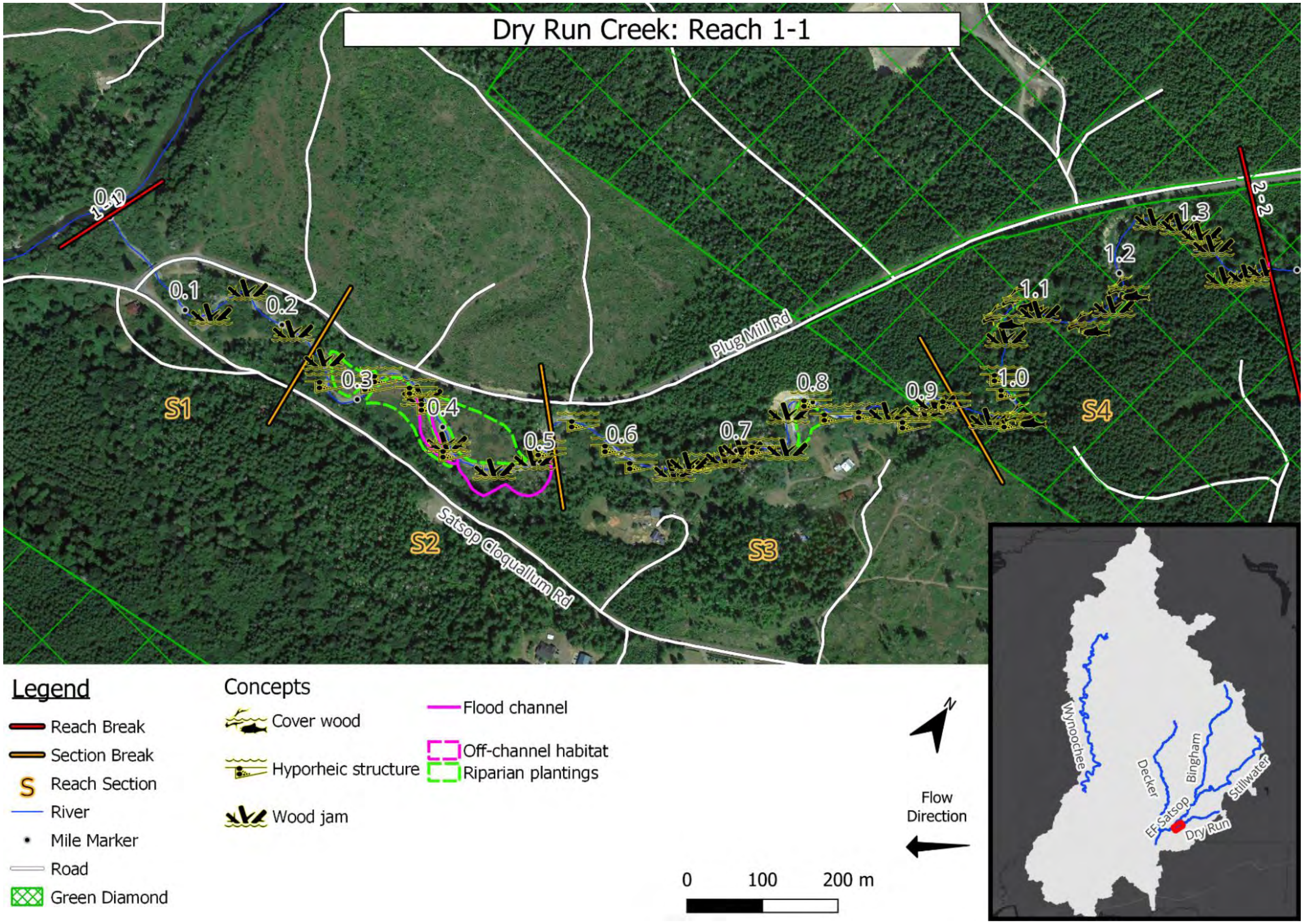


Figure 12. Overview map of Dry Run Creek Segment 1, Reach 1.

4.3.1.1 Site Description

This reach on Dry Run Creek begins at its confluence with the East Fork Satsop River at RM 0.0 and ends at RM 1.35. Most of the creek in this reach goes subsurface during summer months as it enters deep and well-drained alluvial deposits. Based on the geology, soils, historic imagery, and the name of the creek, it is likely the natural condition for this reach to go subsurface. However, there are extensive clear-cuts bordering the valley and evidence of channel incision that would have explicit impacts on the hydrology by extending the length and duration of subsurface flows. The channel also passes under West Plug Mill Road at the bottom of the reach.

4.3.1.2 Conceptual Project Actions

Restoration actions in this reach should focus on improving the reach as a migratory corridor for salmonids in the short-term and retaining water in the long-term. LW structures may be placed to provide refuge for migrating adult salmonids. LW jams may also be used to spread flood waters laterally and improve access to the floodplain. Hyporheic structures are also proposed and may be used as an attempt to retain surface flows for longer. There are several opportunities for riparian plantings that should be considered in conjunction with improving floodplain access.

4.3.1.3 Geomorphic Benefits

Placing LW structures in the channel will help sort sediment as it is transported through the reach. Fine sediment deposits that accumulate in the eddies and low-velocity zones around structures clog interstitial spaces between larger substrate and can help retain surface flows. Moreover, accumulating fine sediment in these areas and on the floodplain will aid the reproduction and increased distribution of riparian species. Increasing the density of riparian species will also increase the channel's resiliency against future flood events.

4.3.1.4 Biological Benefits

It may not be possible to force this reach into maintaining perennial surface flow; however, extending the duration of surface flows and improving connection to floodplain habitats will provide fish with more opportunities to survive changing climatic conditions. Increasing the density of riparian species and limiting clear-cut logging practices in the drainage will slow the rate of infiltration, reduce evaporation, and help retain more water in the soil to support basin-wide hydrology.

4.3.1.5 Logistical Challenges and Considerations

It is likely that the natural state of this reach is to go subsurface. Therefore, any actions aimed at increasing surface flow duration will be considered a created condition and will be difficult to achieve. If this goal is deemed a priority, then a phased approach should be considered, starting from upstream and working downstream. Great care should be taken not to create habitats that lead to fish stranding during summer months as water levels recede. Any created off-channel habitats should remain connected to surface flow in the main channel to allow aquatic species the opportunity to follow the receding waters upstream to perennial flow or downstream to the East Fork Satsop River.

Legend

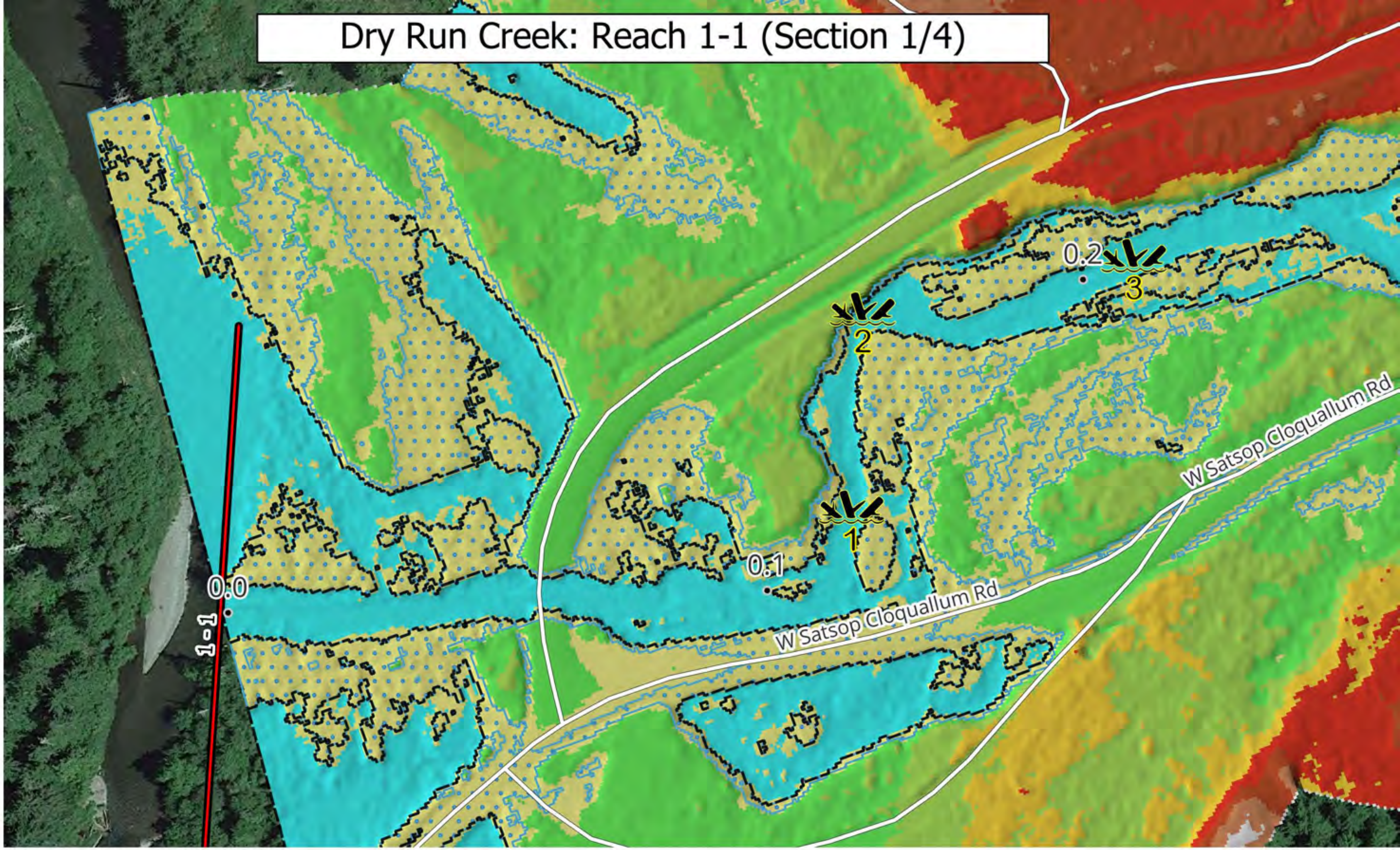
Reach Breaks
Current Floodplain
Potential Floodplain
Mile Marker
Roads
Green Diamond

Elevation (ft)

<1
1 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16 - 18
>18

Concepts

Wood jam



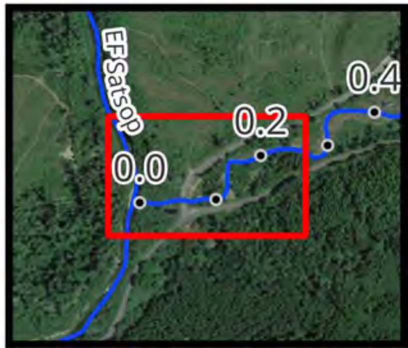
Concepts Key

Wood jam 1: Channel spanning jam angled towards river left
Wood jam 2: Wood jam against outside bend on river right
Wood jam 3: Channel spanning jam to improve floodplain access on river right

0 50 100 m

N

Flow Direction

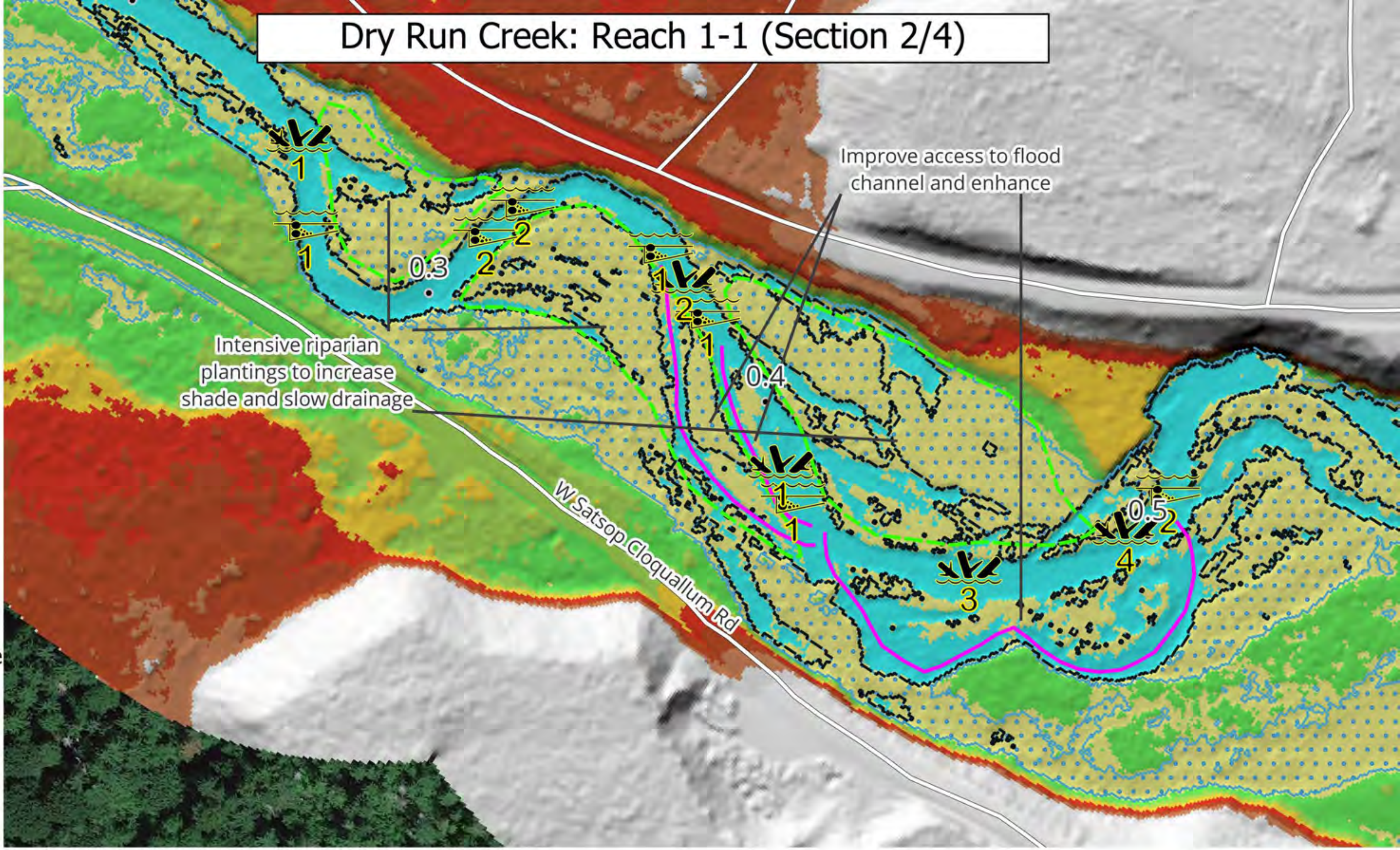


Legend

Reach Breaks
Current Floodplain
Potential Floodplain
Mile Marker
Roads
Green Diamond

Elevation (ft)
- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts
- Hyporheic structure
- Wood jam
- Flood channel
- Riparian plantings



Concepts Key
- Hyporheic structure 1: Buried wood at riffle to improve hyporheic processes
- Hyporheic structure 2: Buried wood to improve hyporheic processes
- Wood jam 1: Channel spanning jam to improve floodplain access on both sides
- Wood jam 2: Enhance existing wood jam to increase spatial coverage
- Wood jam 3: Channel spanning jam angled toward river left
- Wood jam 4: Channel spanning jam angled toward river left to improve access to floodplain

0 50 100 m

N

Flow Direction

Legend

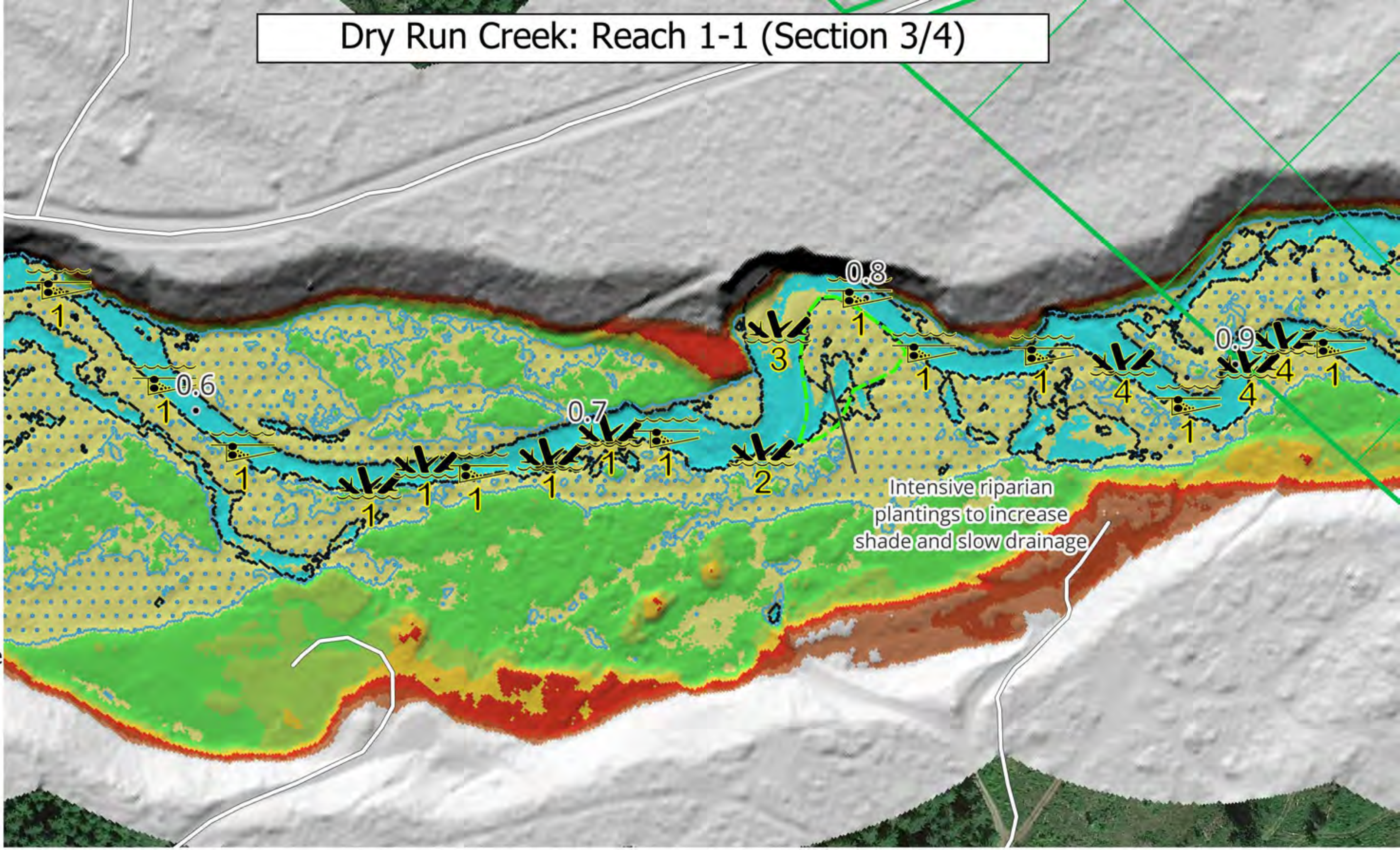
- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

- Hyporheic structure
- Wood jam
- Riparian plantings



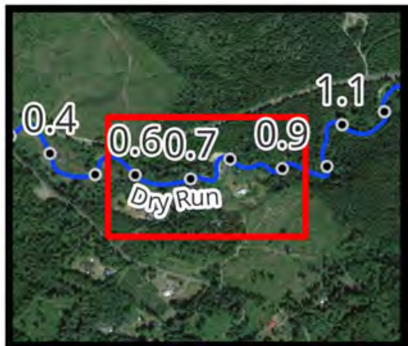
Concepts Key

Hyporheic structure 1: Buried wood at riffle to improve hyporheic processes
Wood jam 1: Bank attached wood jam to sort sediment and provide refuge
Wood jam 2: Large jam on outside of meander bend to reduce velocity and improve habitat
Wood jam 3: Wood jam at riffle to maintain bar and split flows
Wood jam 4: Wood jam to push flows towards river right

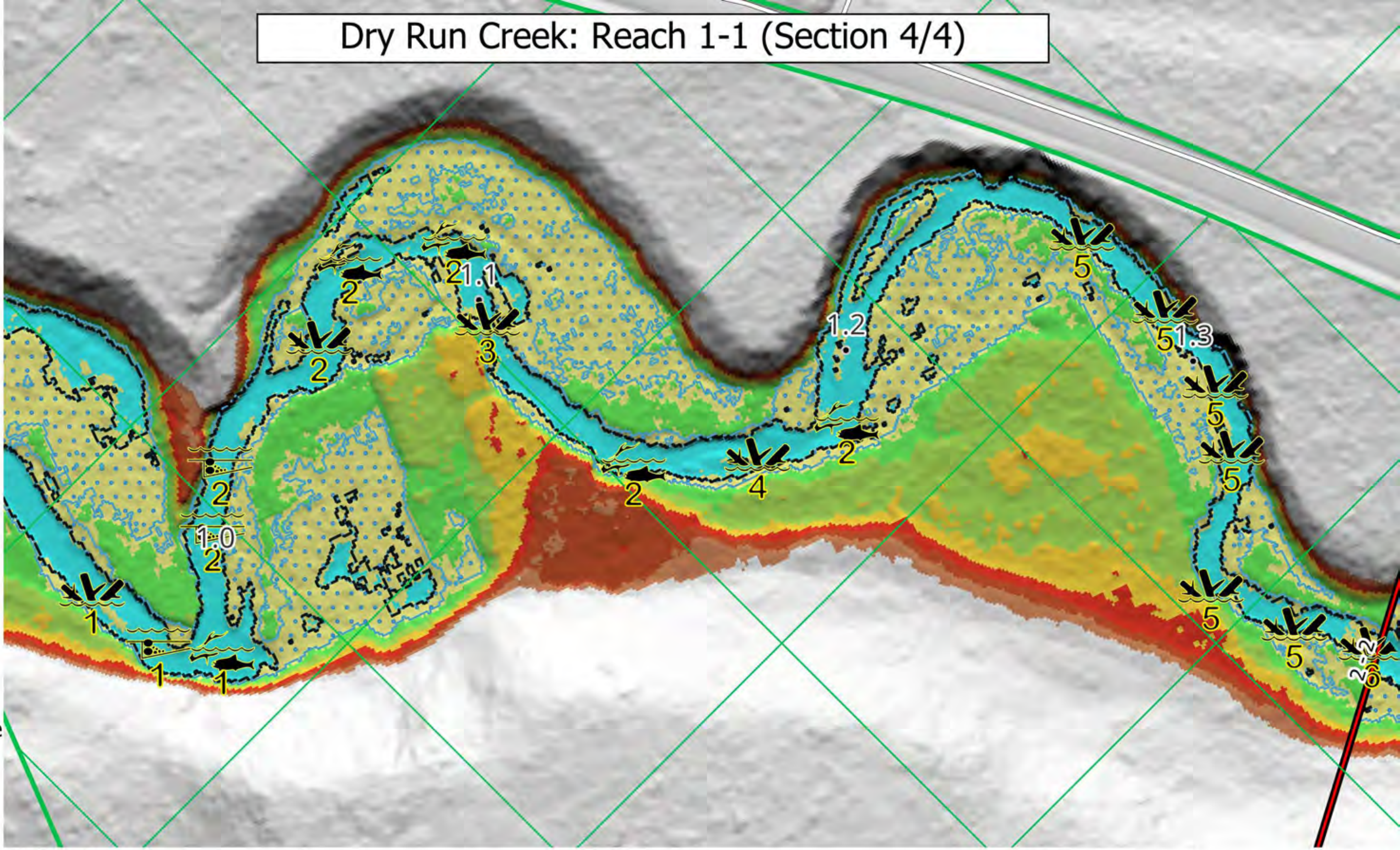
0 50 100 m

N

Flow Direction



Dry Run Creek: Reach 1-1 (Section 4/4)



Legend

- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

- Cover wood
- Hyporheic structure
- Wood jam

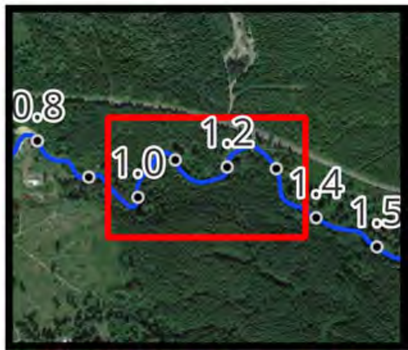
Concepts Key

Cover wood 1: Wood jam on river right for fish cover
Cover wood 2: Add wood pieces to pool to enhance habitat
Hyporheic structure 1: Buried wood at riffle to improve hyporheic processes
Hyporheic structure 2: Buried wood to improve hyporheic processes
Wood jam 1: Bank attached jam to sort sediment and provide refuge
Wood jam 2: Enhance existing jam to span channel
Wood jam 3: Channel spanning jam to access floodplain pockets
Wood jam 4: Wood jam to maintain chute on river left
Wood jam 5: Bank attached wood jam to sort sediment and provide refuge
Wood jam 6: Channel spanning jam to maintain connection with recaptured meander and aggrade

0 50 100 m

N

Flow Direction



4.3.2 Dry Run Creek – Segment 02 – Reach 02

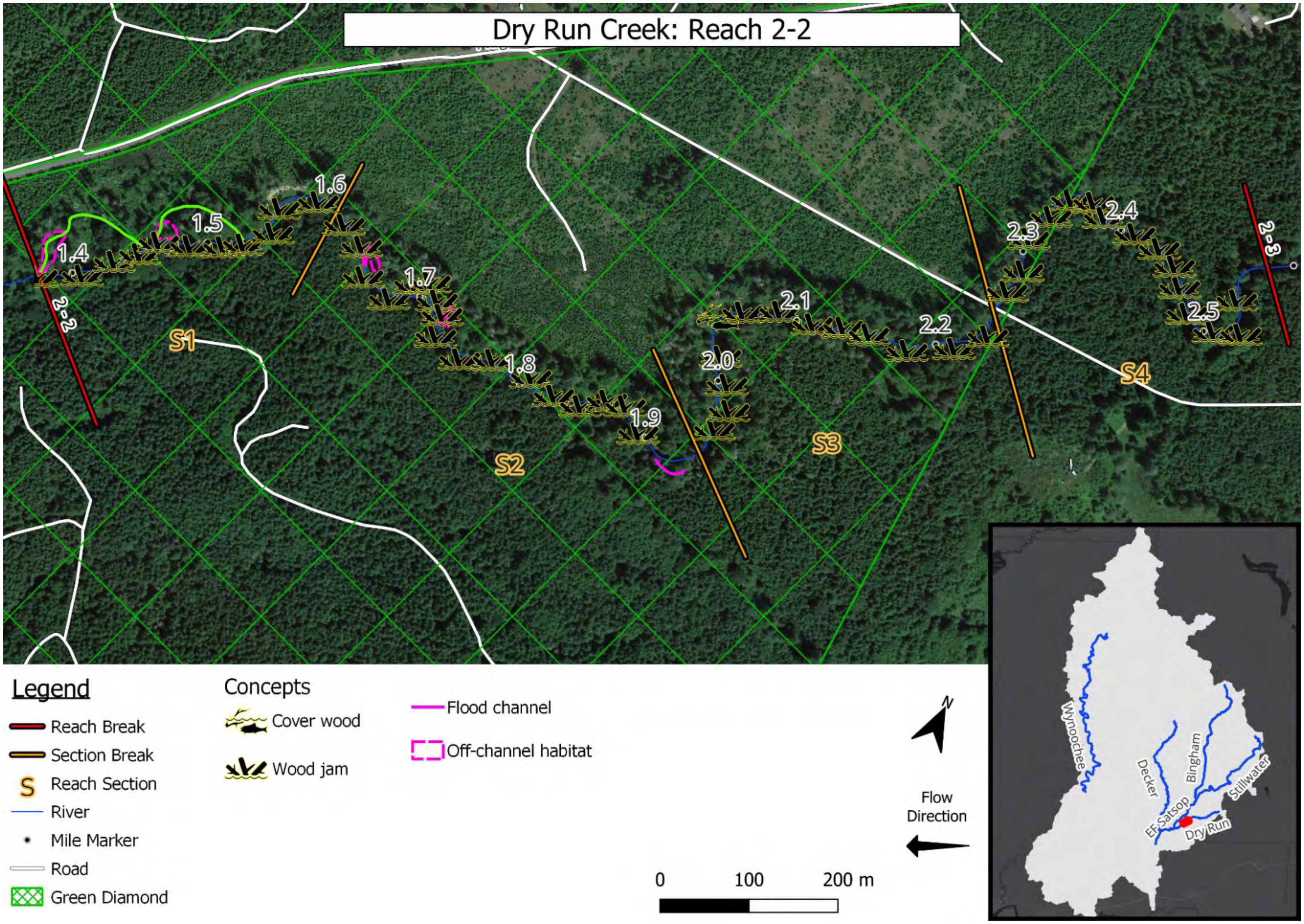


Figure 13. Overview map of Dry Run Creek Segment 2, Reach 2.

4.3.2.1 Site Description

This reach on Dry Run Creek begins at RM 1.35 and ends at RM 2.6. Downstream of this reach, Dry Run Creek goes subsurface during summer months, but this reach typically retains surface flow for a longer period outside of extended droughts. The channel is confined with floodplain pockets but appears to have incised by as much as three feet in recent history. Several floodplain pockets are no longer accessible which increases the water transport rate through the reach. Wood density is very low which likely contributed to the recent incision.

4.3.2.2 Conceptual Project Actions

Restoration actions in this reach should focus on retaining water in the valley bottom and improving salmonid habitat. Installing a high density of LW structures is proposed to slow water transport and aggrade the channel. In some cases, this may require structures to force channel widening before any significant aggradation can occur. Incision is less drastic near the downstream extent of the reach and recently abandoned meanders are present on river right. Excavation may be required to reengage these meanders, but the amount of excavation can be reduced if LW structures are installed to help shunt flood waters towards the floodplain.

4.3.2.3 Geomorphic Benefits

Decreasing water velocity throughout this reach will also result in increased aggradation. This will help reconnect floodplain pockets and force a feedback loop that promotes future floodplain inundation after the LW structures have reached their sediment storage capacity. Slowing water transport and retaining more water in the valley bottom will help support extended surface flows to the downstream reach as well.

4.3.2.4 Biological Benefits

Increasing the duration of surface flows will increase the amount of time that aquatic species can remain in this reach. The proposed actions are also expected to increase resiliency against climate change impacts. LW structures will create pools, sort sediment, and provide cover for fish species at all life stages.

4.3.2.5 Logistical Challenges and Considerations

Aggrading the channel may occur slowly without first allowing structures to widen the channel through bank erosion processes. Soils in the area contain gravelly and sandy loam that may be suitable for rebuilding the channel bed if enough structures are placed to provide ample opportunity for sediment sorting.

Dry Run Creek: Reach 2-2 (Section 1/4)

Legend

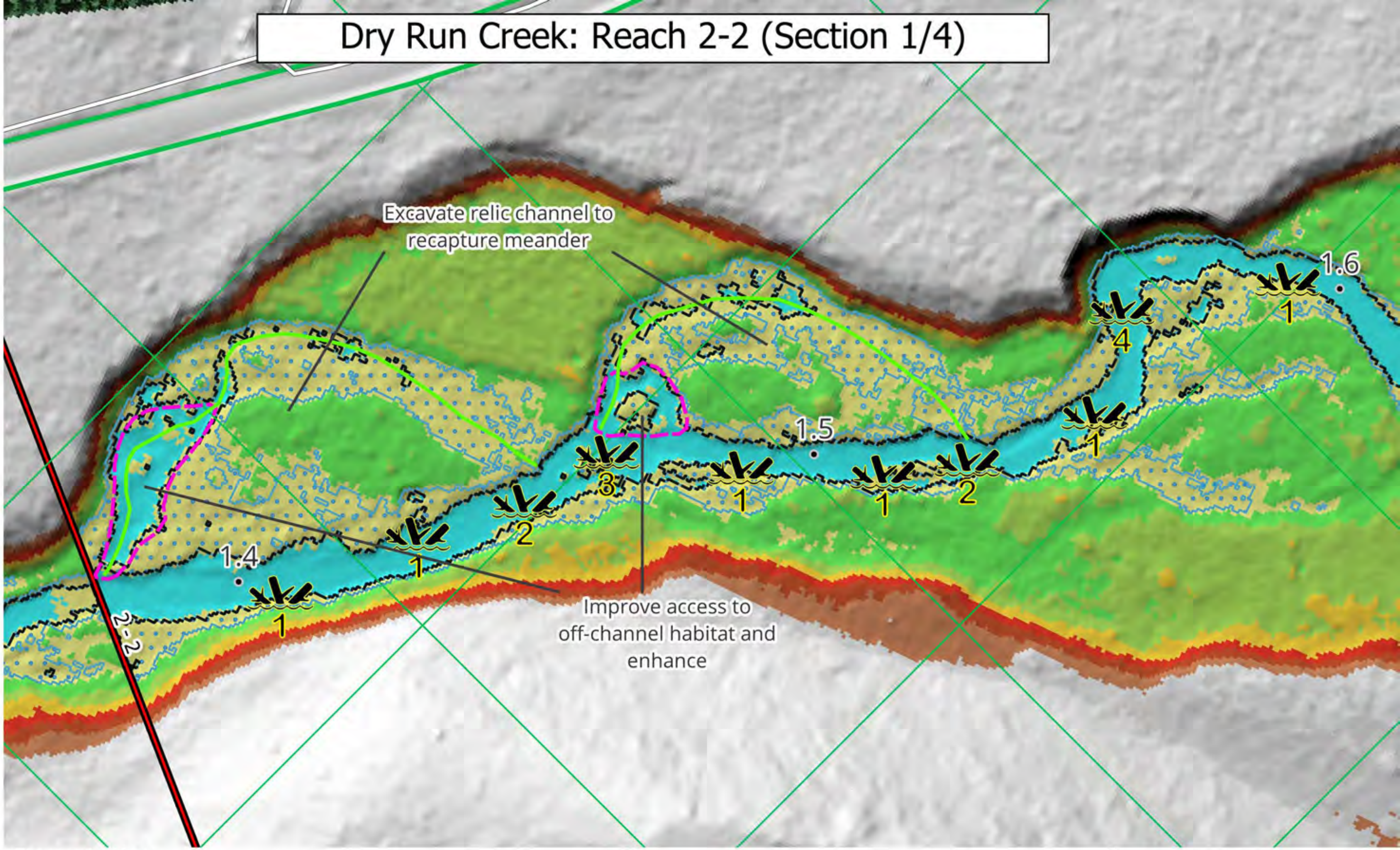
- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

- Wood jam
- Off-channel habitat



Concepts Key

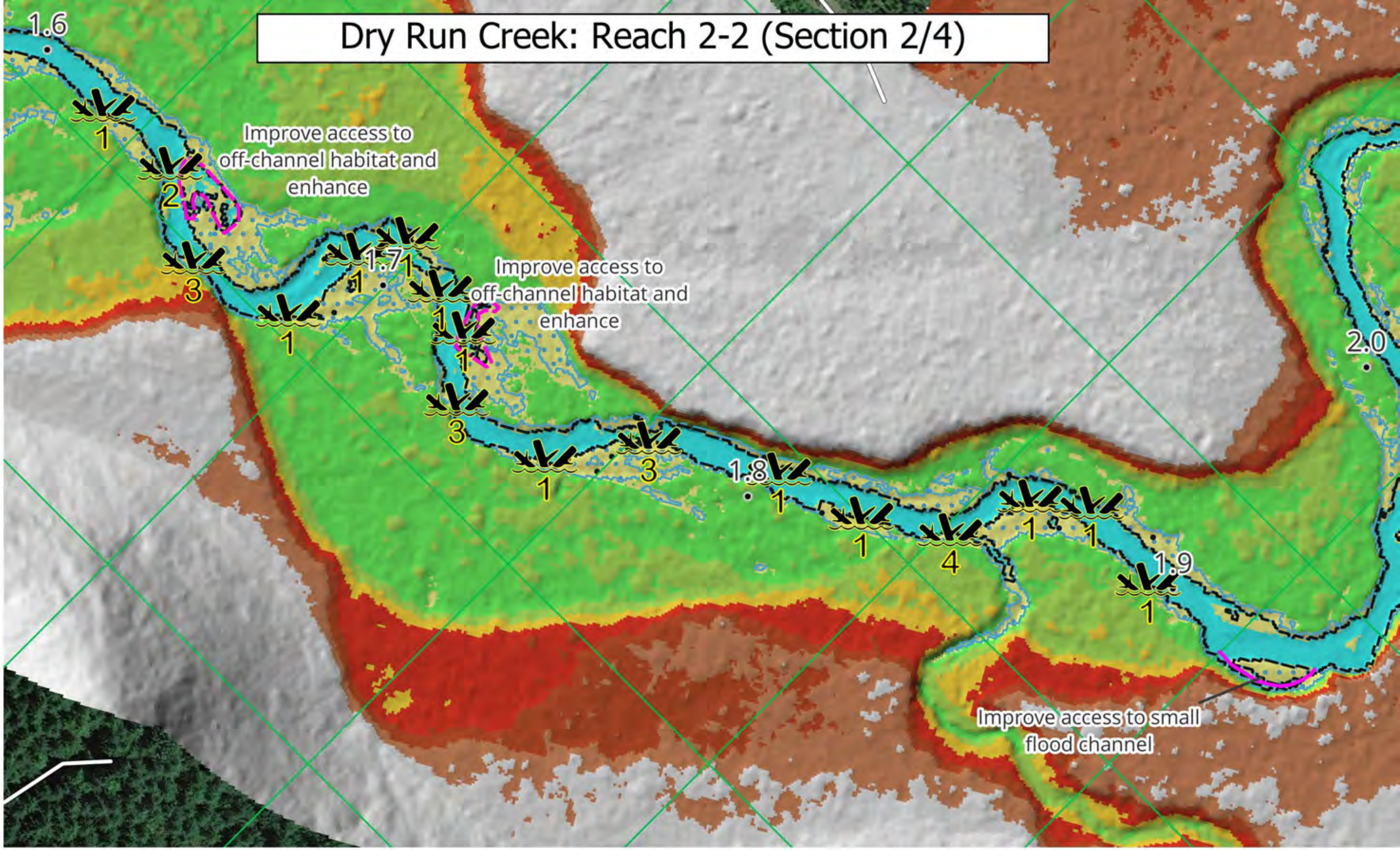
Wood jam 1: Bank attached wood jam to sort sediment and provide refuge
Wood jam 2: Channel spanning structure to support recaptured meander and aggrade
Wood jam 3: Channel spanning jam to support recaptured meander and aggrade
Wood jam 4: Enhance existing jam to increase spatial coverage and aggrade channel

0 50 100 m

N

Flow Direction

Dry Run Creek: Reach 2-2 (Section 2/4)



Legend

- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

- Wood jam
- Flood channel
- Off-channel habitat

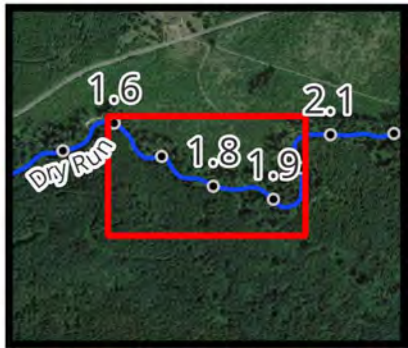
Concepts Key

Wood jam 1: Bank attached wood jam to sort sediment and provide refuge
Wood jam 2: Channel spanning structure to support off-channel habitat and aggrade
Wood jam 3: Bank attached wood jam at riffle to sort sediment and provide refuge
Wood jam 4: Bank attached wood jam to sort sediment, provide refuge, and support off-channel

0 50 100 m

N

Flow Direction



Dry Run Creek: Reach 2-2 (Section 3/4)

Legend

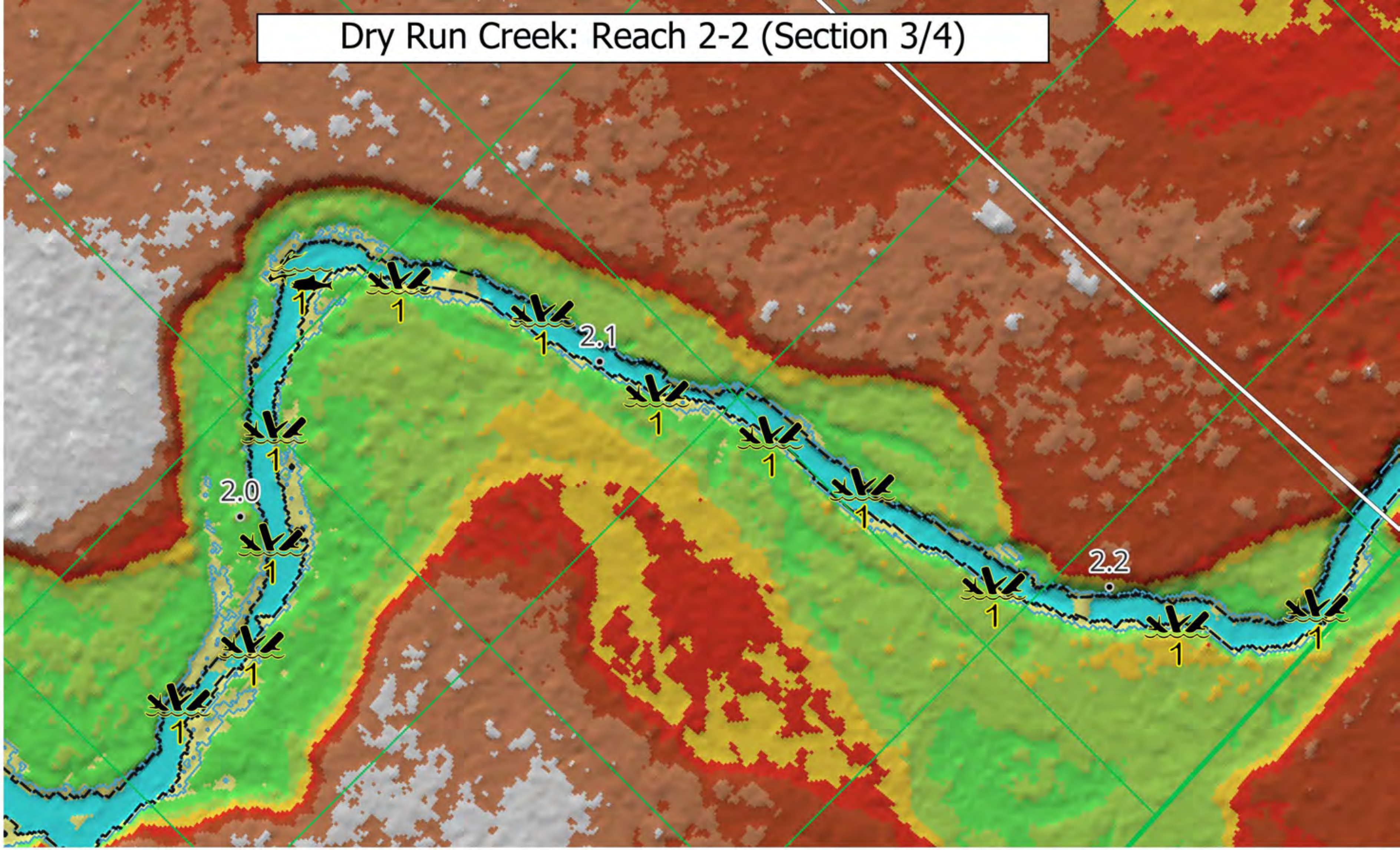
- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

- Cover wood
- Wood jam



Concepts Key

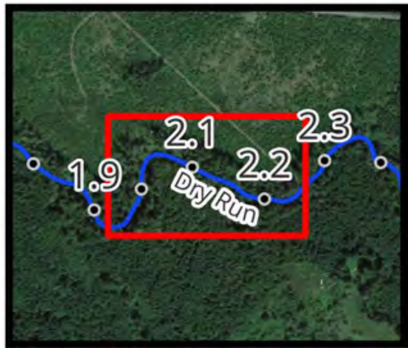
Cover wood 1: Add wood pieces to improve fish habitat

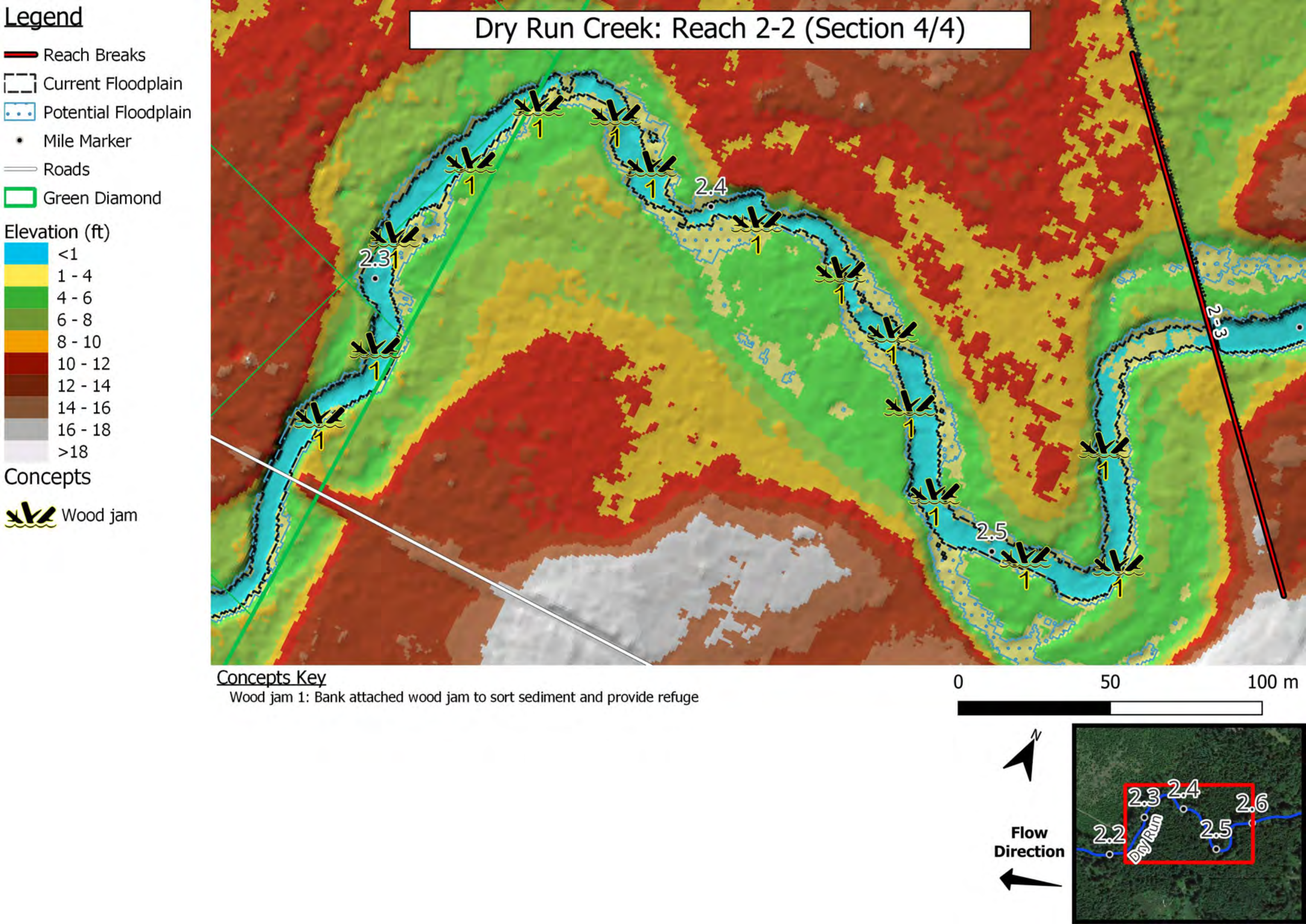
Wood jam 1: Bank attached wood jam to sort sediment and provide refuge

0 50 100 m

N

Flow Direction




Dry Run Creek: Reach 2-2 (Section 4/4)
Legend
Reach Breaks
Current Floodplain
Potential Floodplain
Mile Marker
Roads
Green Diamond
Elevation (ft)
<1
1 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16 - 18
>18
Concepts
Wood jam
2.3
2.4
2.5
2-3
1
Concepts Key
Wood jam 1: Bank attached wood jam to sort sediment and provide refuge
0
50
100 m
N
Flow Direction
2.2
2.3
2.4
2.5
2.6
Dry Run

4.3.3 Dry Run Creek – Segment 02 – Reach 03

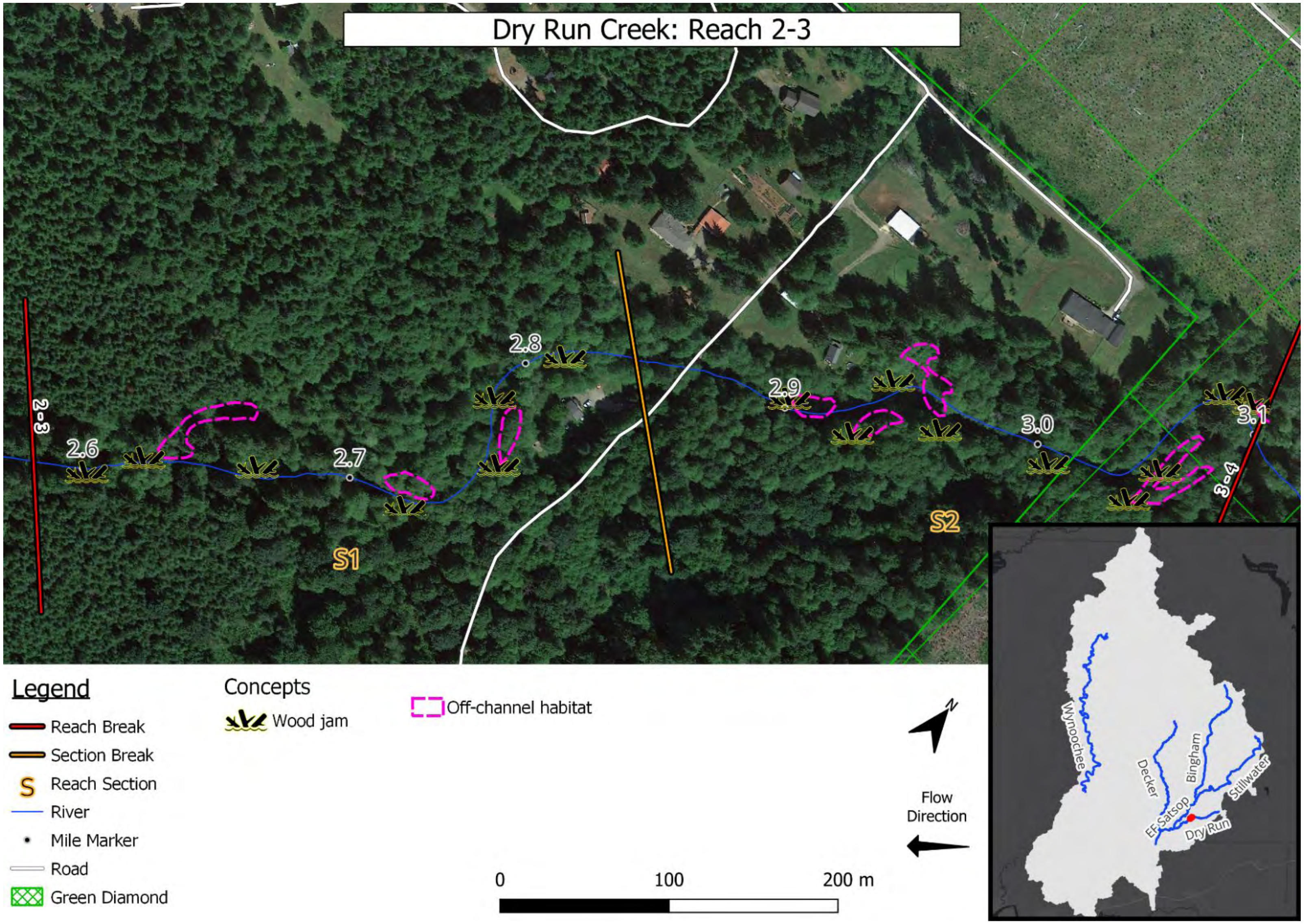


Figure 14. Overview map of Dry Run Creek Segment 2, Reach 3.

4.3.3.1 Site Description

This reach on Dry Run Creek begins at RM 2.6 and ends at RM 3.1, where the stream flows through a peat meadow. The channel is incised up to five feet and floodplain pockets are minimal. Despite the relatively high confinement due to incision, there are channel spanning jams in the reach that can sustain high flow events because the channel slope is very low. The low slope combined with high confinement suggest that the channel may have incised down to a hard layer that will slow or prevent future incision. If this is the case, then alluvium on the streambed is lacking and further reduces the water storage potential within the reach.

4.3.3.2 Conceptual Project Actions

Because of the high level of incision, restoration opportunities in this reach are limited. Actions should focus on channel spanning or nearly-channel spanning LW jams to slow water transport and retain sediment. Reversing incision in this manner will likely not be at the scale to reconnect abandoned floodplain pockets; however, it will increase the water storage capacity of the channel. LW jams should also be placed near off-channel habitats to improve their connection to surface flows.

4.3.3.3 Geomorphic Benefits

Adding LW structures will support sediment retention in the channel to help rebuild the streambed. Retaining more water through this reach is expected to contribute to improved hydrology in downstream reaches. As alluvium accumulates, the structures will also sort the sediment to create patches of spawning gravel and small inset floodplain pockets.

4.3.3.4 Biological Benefits

LW structures will provide refuge for migrating adult salmonids attempting to reach upstream reaches that contain more suitable habitat. Large pools created by channel spanning jams will provide rearing habitat for juvenile salmonids. Improving connection to off-channel habitats will increase the amount of space available for aquatic species to occupy.

4.3.3.5 Logistical Challenges and Considerations

Most of this reach is within private residential properties. If attempting to widen the channel, care should be taken to not adversely affect private property.

Dry Run Creek: Reach 2-3 (Section 1/2)

Legend

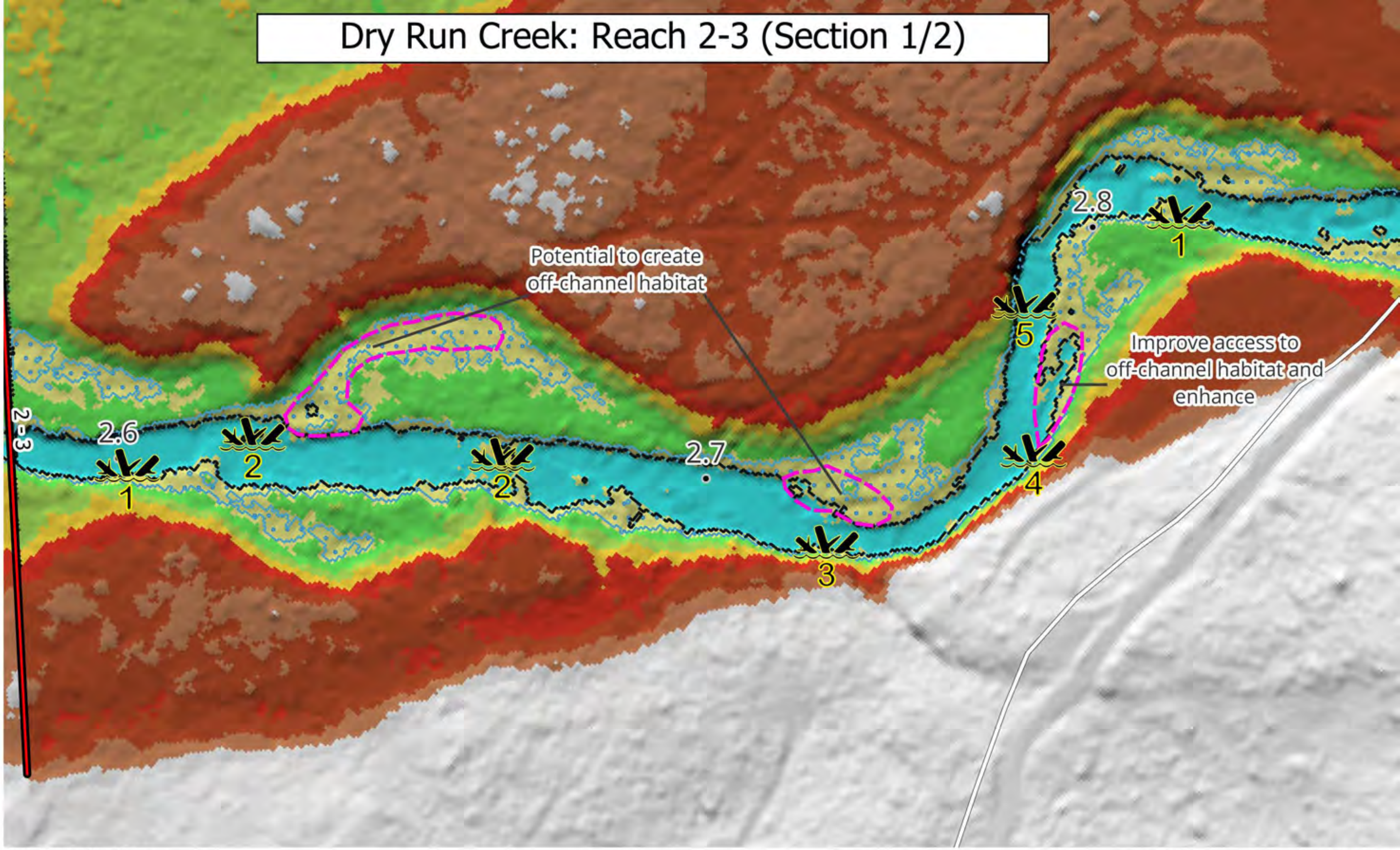
- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

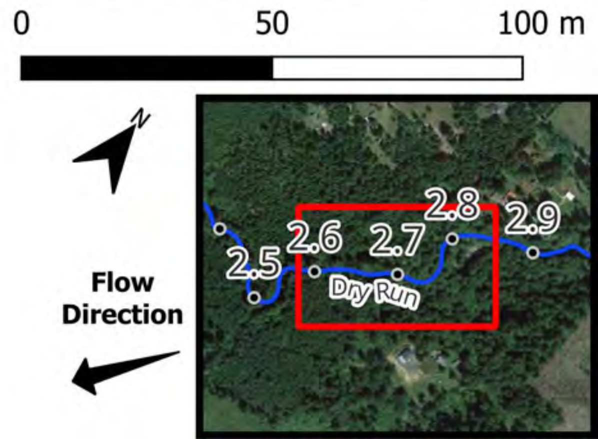
Concepts

- Wood jam
- Off-channel habitat



Concepts Key

Wood jam 1: Bank attached wood jam to sort sediment and provide refuge
Wood jam 2: Assess and enhance existing jam
Wood jam 3: Channel spanning wood jam at riffle to sort sediment and aggrade
Wood jam 4: Bank attached wood jam to support off-channel habitat
Wood jam 5: Bank attached wood jam at riffle to sort sediment and aggrade



<u>Legend</u>

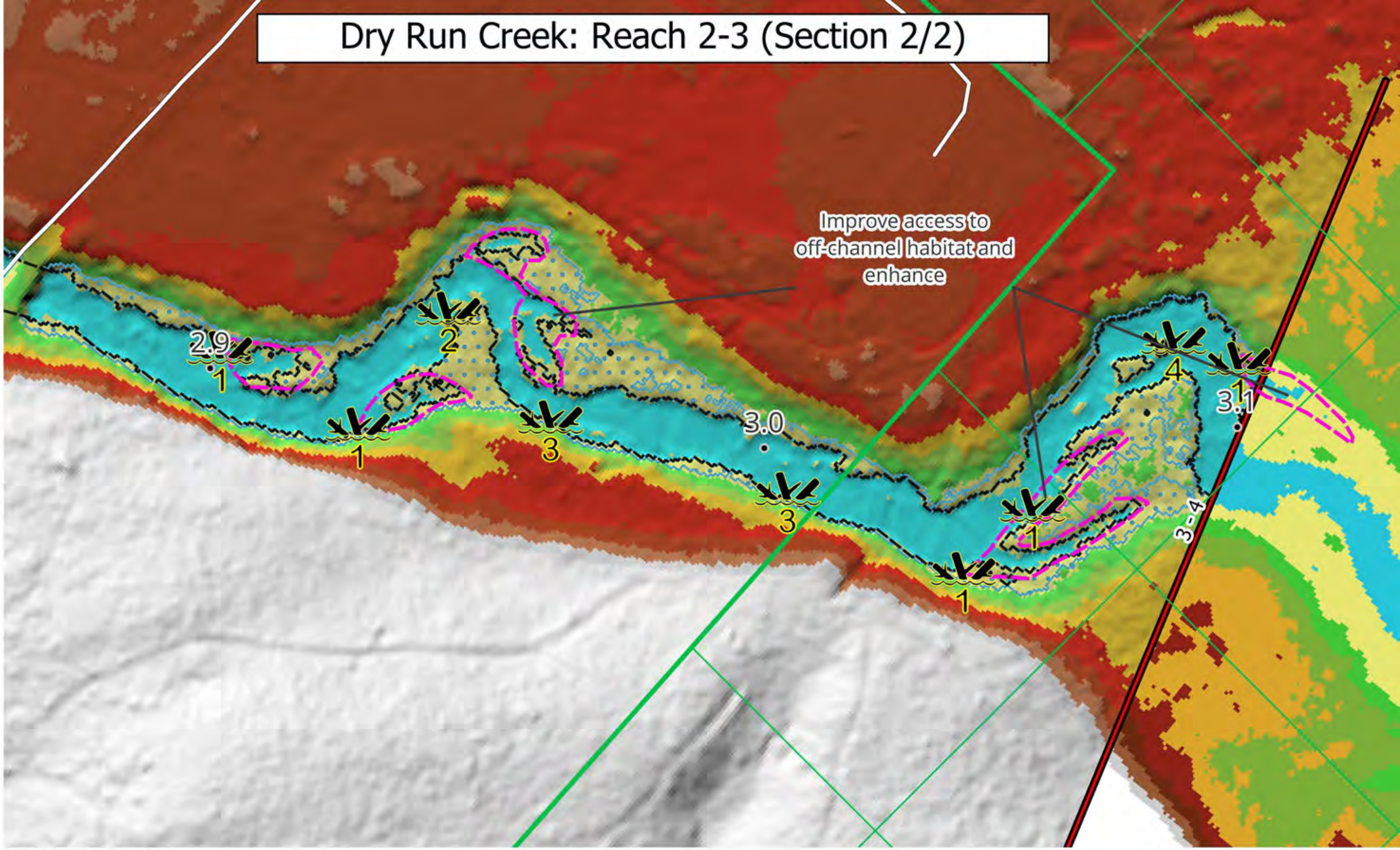
Reach Breaks
Current Floodplain
Potential Floodplain
Mile Marker
Roads
Green Diamond

Elevation (ft)
- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

Wood jam

Off-channel habitat



<u>Concepts Key</u>

Wood jam 1: Bank attached wood jam to support off-channel habitat
Wood jam 2: Channel spanning jam to support off-channel development and aggrade
Wood jam 3: Bank attached wood jam to sort sediment and provide refuge
Wood jam 4: Assess and enhance existing jam

0 50 100 m

N

Flow Direction

4.4 East Fork Satsop River

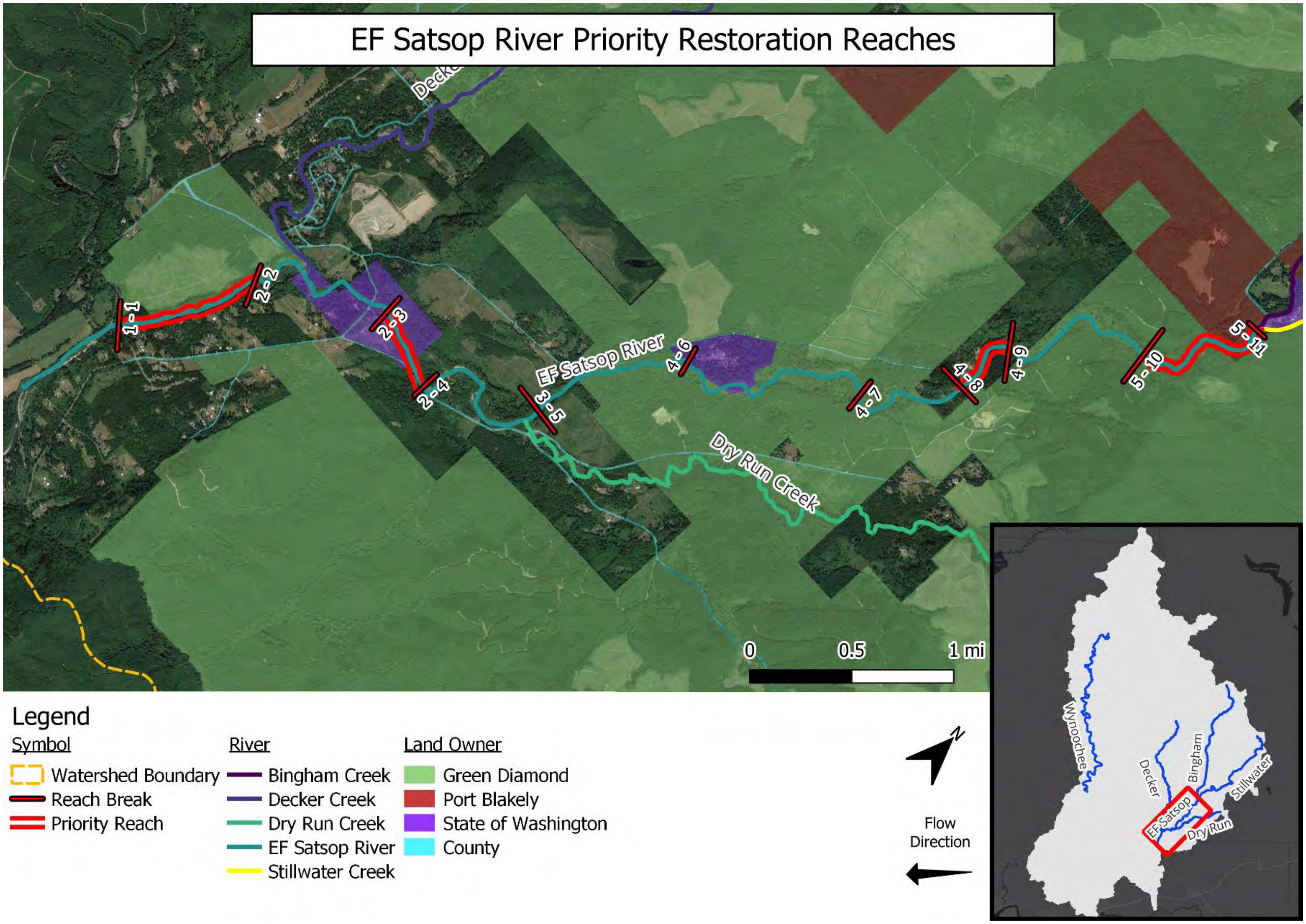


Figure 15. Overview map of priority restoration reaches on the East Fork Satsop River.

4.4.1 East Fork Satsop River – Segment 02 – Reach 03

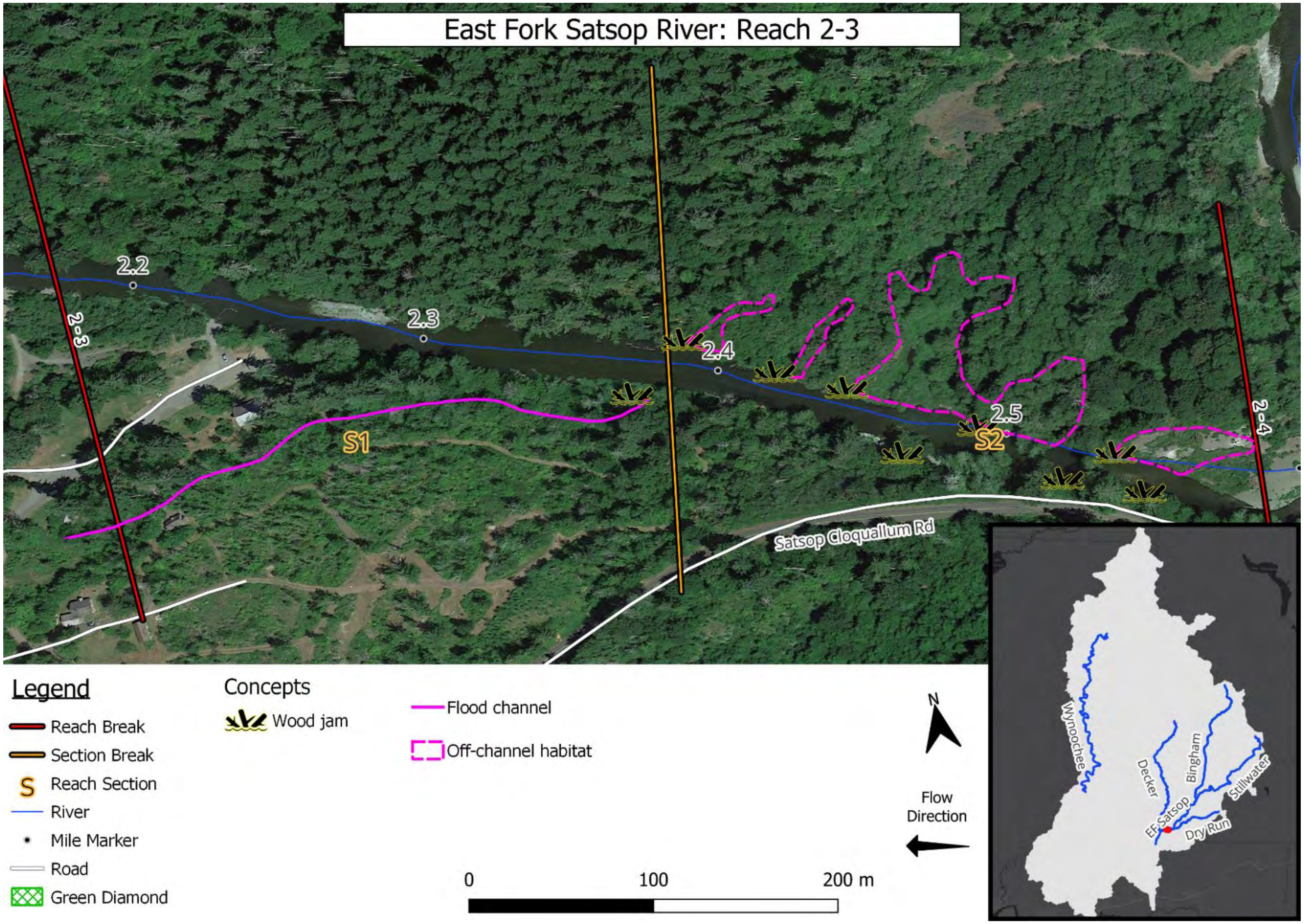


Figure 16. Overview map of East Fork Satsop River Segment 2, Reach 3.

4.4.1.1 Site Description

This reach on the East Fork Satsop River begins at RM 2.2 upstream of the West Schafer Park Road bridge and ends at a sharp meander bend at RM 2.6. The channel is adjacent to Schafer State Park for the first 500 yards before entering private property. The channel is straight but has developed transient alternate bars through the reach. There are several pockets of off-channel habitat on river right near the meander at the upstream end of the reach. An avulsion occurred sometime between 1991 and 2005 that created this large meander. The off-channel habitats are remnants of the channel's old flowpath and some were developed from chutes attempting to dissect the inside of the meander bend. These flowpaths are likely only activated during flood events; however, the downstream ends are still connected to the main channel, providing access for aquatic species. The upstream end of the old channel location is only two feet above the current channel, so there is potential for a future avulsion to reoccupy the old flowpath and abandon the meander.

4.4.1.2 Conceptual Project Actions

Restoration actions in this reach should focus on supporting the pockets of off-channel habitat near the upstream extent of the reach. These areas appear to be connected to the main channel and are heavily covered by canopy species. Because this reach is within Schafer State Park, there are opportunities to improve the multi-use benefit for recreationists. LW jams or cover wood could be added along the river right bank to improve fishing opportunities. The flood channel running through the middle of the park could be designed to accommodate perennial flow, providing more activities for campers and potentially act as an educational site for the community.

4.4.1.3 Geomorphic Benefits

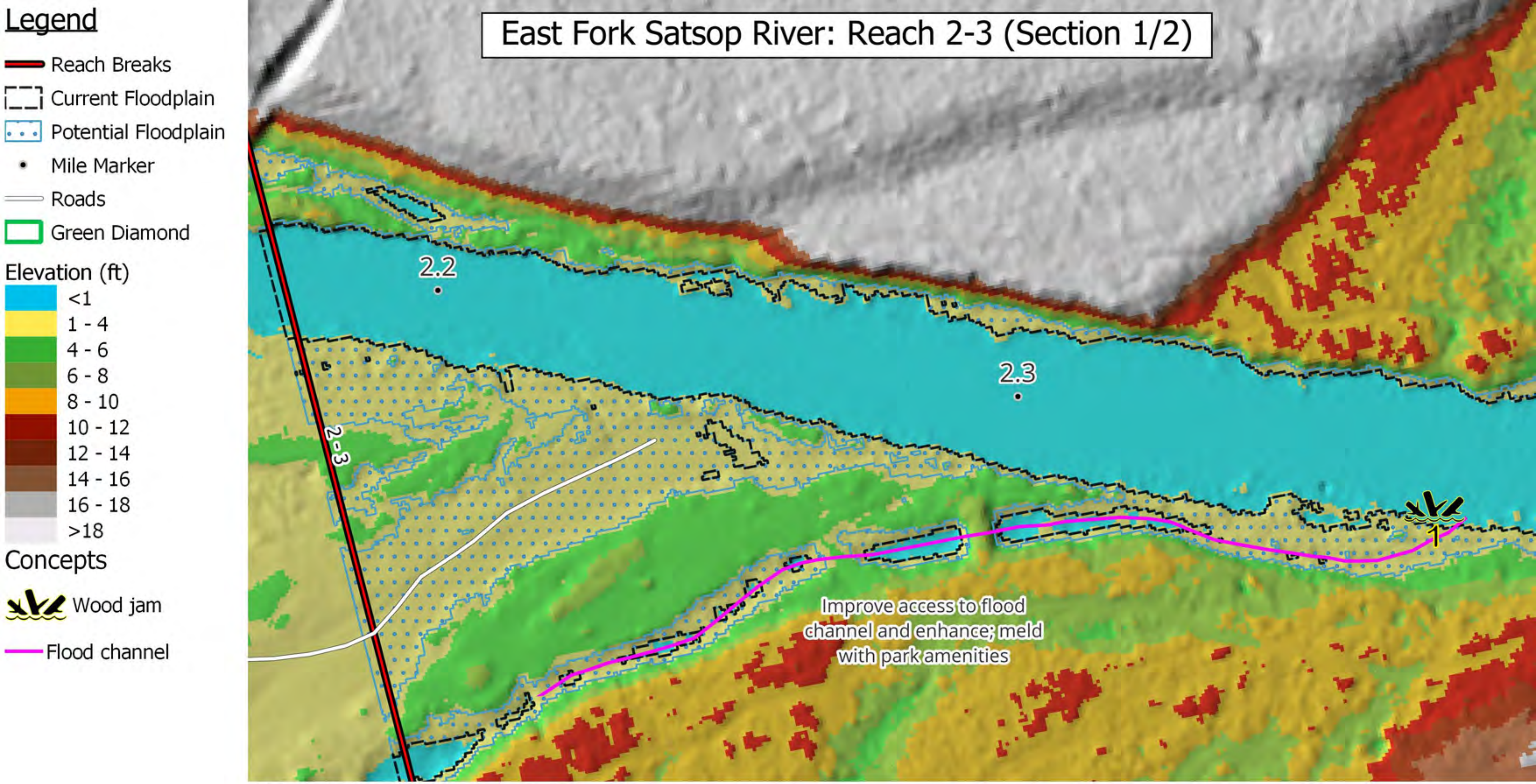
Overall, the geomorphic benefits of restoration actions in this reach are likely minimal. LW structures will capture and sort sediment; however, structures in this reach should be built relatively small and stable to limit risk to downstream infrastructure. More aggressive actions could be considered, but the combination of limited accommodation space and proximity to infrastructure would make large-scale channel changes risky. Improving connection to the flood channel or converting it to a side channel may provide some relief from flood waters, but the channel likely does not have the capacity to transport enough water to see a large difference downstream.

4.4.1.4 Biological Benefits

Adding LW structures will trap and sort suitable spawning gravels for adult salmonids and help maintain connection to off-channel habitats for rearing juvenile salmonids. LW structures will also provide refuge from high water velocity and predators in an otherwise homogenous channel. Converting the flood channel to a perennial side channel will provide more space for aquatic species to occupy.

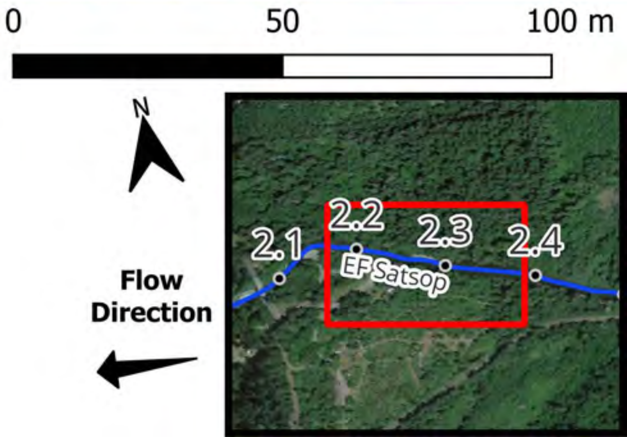
4.4.1.5 Logistical Challenges and Considerations

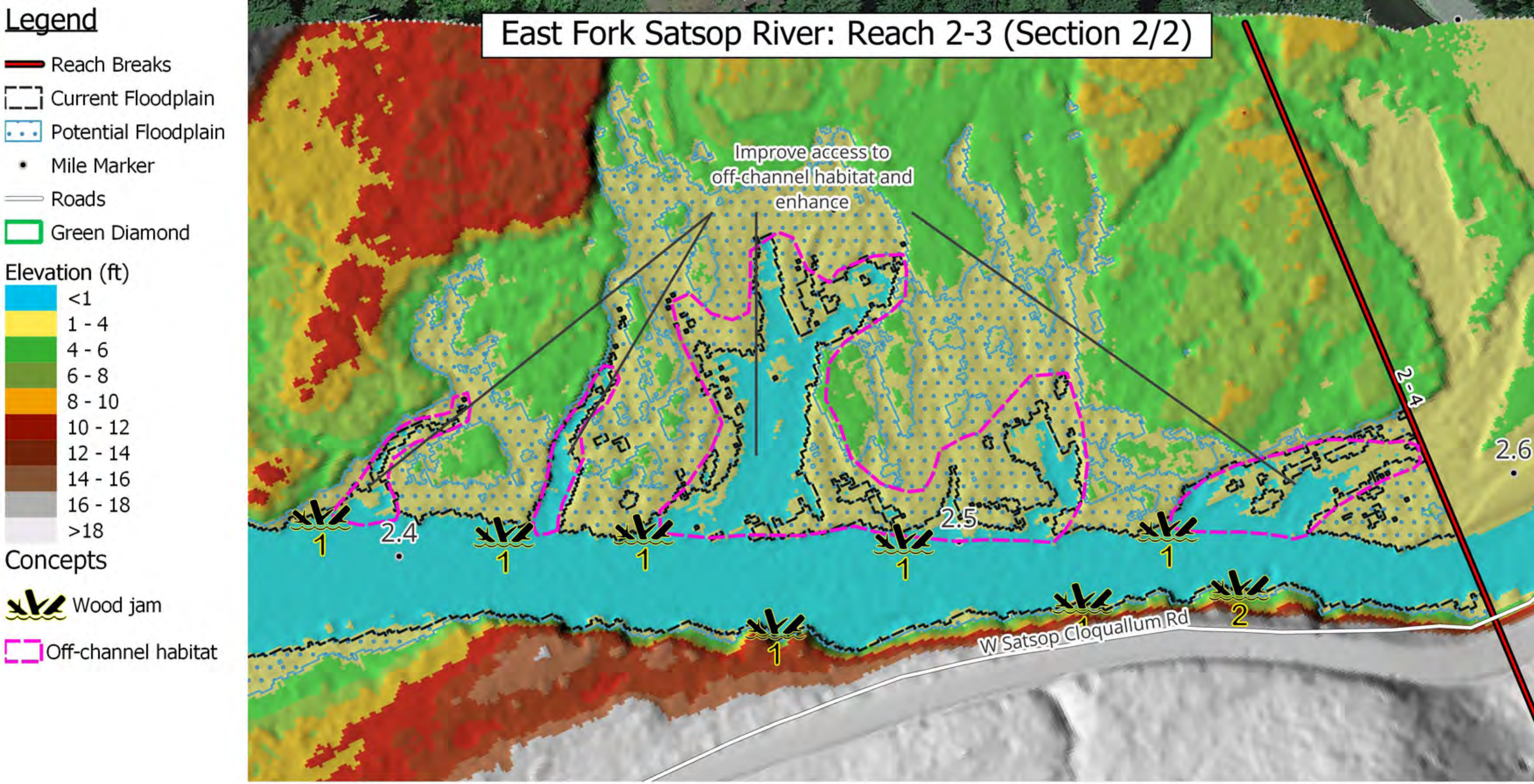
This project will need to consider impacts and risks to downstream infrastructure including the West Schafer Road bridge and Schafer State Park. Designs should be mindful of the potential for an avulsion at the upstream end of the reach and an adaptive management plan should be prepared. The flood channel conversion concept would be a good opportunity to engage the community in river and salmon restoration efforts.



Concepts Key

Wood jam 1: Bank attached jam to support flood channel

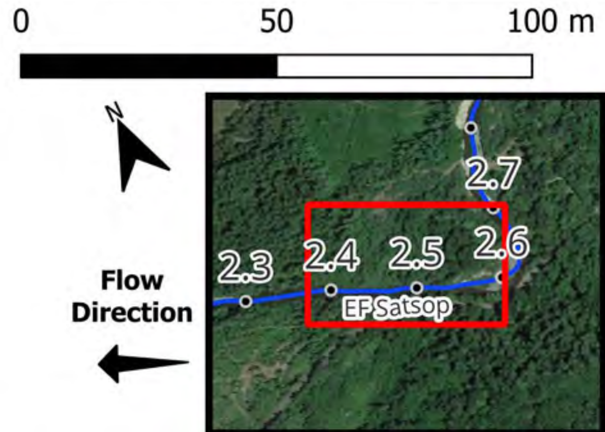




Concepts Key

Wood jam 1: Bank attached jam to support off-channel habitat

Wood jam 2: Bank attached jam to push flows towards river right and support off-channel



4.4.2 East Fork Satsop River – Segment 04 – Reach 08

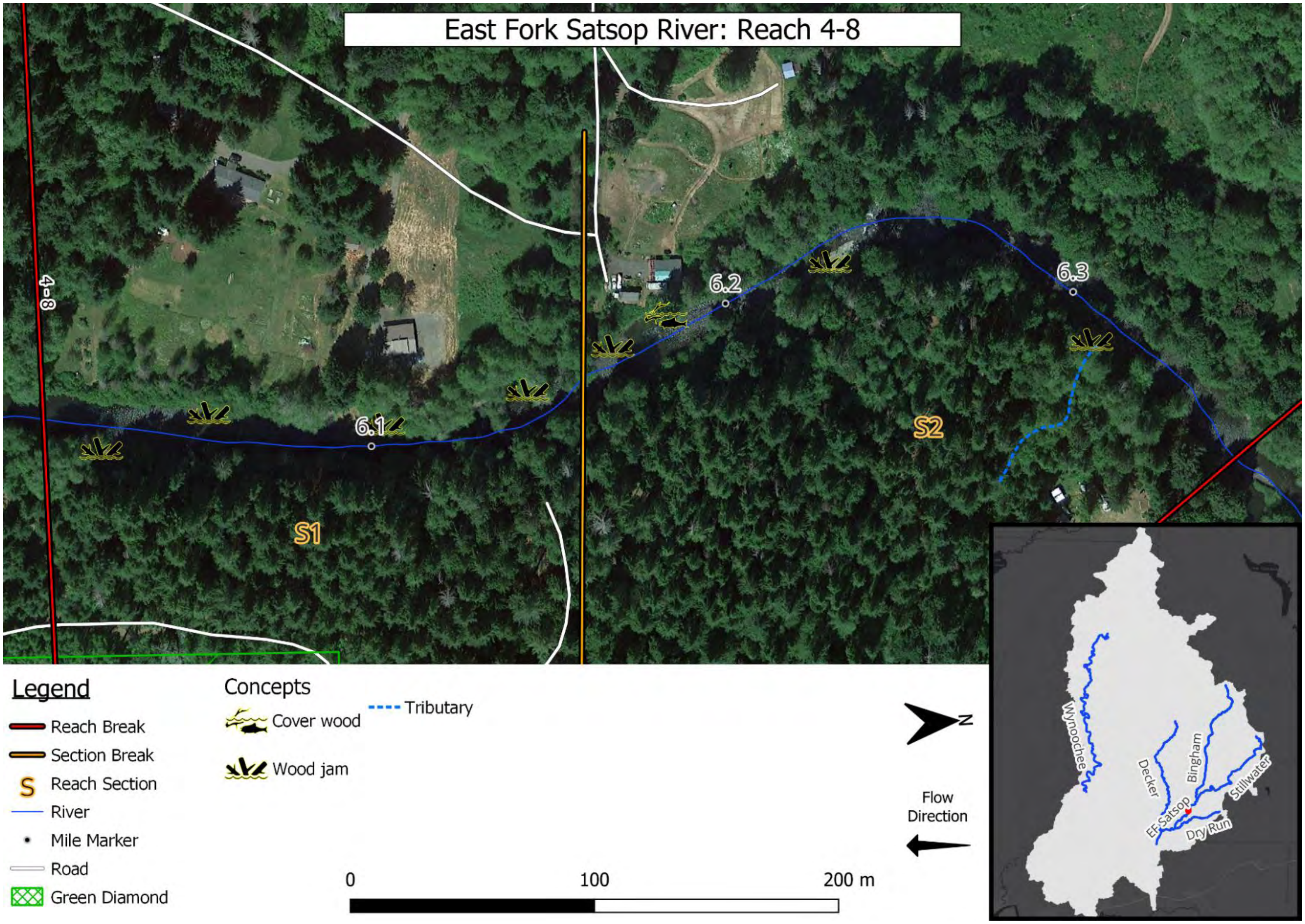


Figure 17. Overview map of East Fork Satsop River Section 4, Reach 8.

4.4.2.1 Site Description

This reach on the East Fork Satsop River begins at RM 6.0 and ends at RM 6.35. The channel is confined on river right by a 20-foot-high cliff and 5-10-foot-high banks on river left. The channel has incised by about two feet in the last couple of decades. Based on available historic imagery, the channel has become narrower since 1951. Wood density is very low in this reach. While it is typical for confined reaches to have fewer jams than their unconfined counterparts, the gradient and stream power are low in this reach, so more wood accumulation is expected, specifically along the channel margins. The reach contains large pools and glides separated by short riffles.

4.4.2.2 Conceptual Project Actions

Restoration actions in this reach should focus on creating pockets of suitable habitat for salmonids of all life stages. This can be achieved by adding LW structures at strategic locations to promote predictable zones of erosion and deposition. Riffles should be targeted for structure locations to promote aggradation and wood should be added to pools to provide refuge for aquatic species. LW structures should also be built at the head of alternate bars to encourage aggradation. The confluence of a small tributary at the upstream end of the reach presents an opportunity to create off-channel habitat.

4.4.2.3 Geomorphic Benefits

Adding more structure to the channel will encourage aggradation to help arrest incision processes and potentially reverse recent incision to a small degree. Raising the channel bed to reach the historic floodplain will not be feasible, so the primary benefit of addressing incision is to retain alluvium and prevent future incision from reaching bedrock or hardpan clay.

4.4.2.4 Biological Benefits

LW structures will lead to more diverse topography along the streambed, creating more diverse habitats for juvenile salmonids. The structures themselves will also provide refuge from high flows and predators in a reach that otherwise has minimal cover. Structures will also sort sediment to create pockets of gravel highly suitable for spawning salmonids.

4.4.2.5 Logistical Challenges and Considerations

Reversing reach-scale incision in this reach would be challenging and risky. The concepts are expected to produce small gains in channel aggradation but focus more on creating stable hotspots of heterogeneity on the streambed. Most of the LW structures are on river left to reduce the risk of bank erosion near houses adjacent to the channel.

East Fork Satsop River: Reach 4-8 (Section 1/2)

Legend

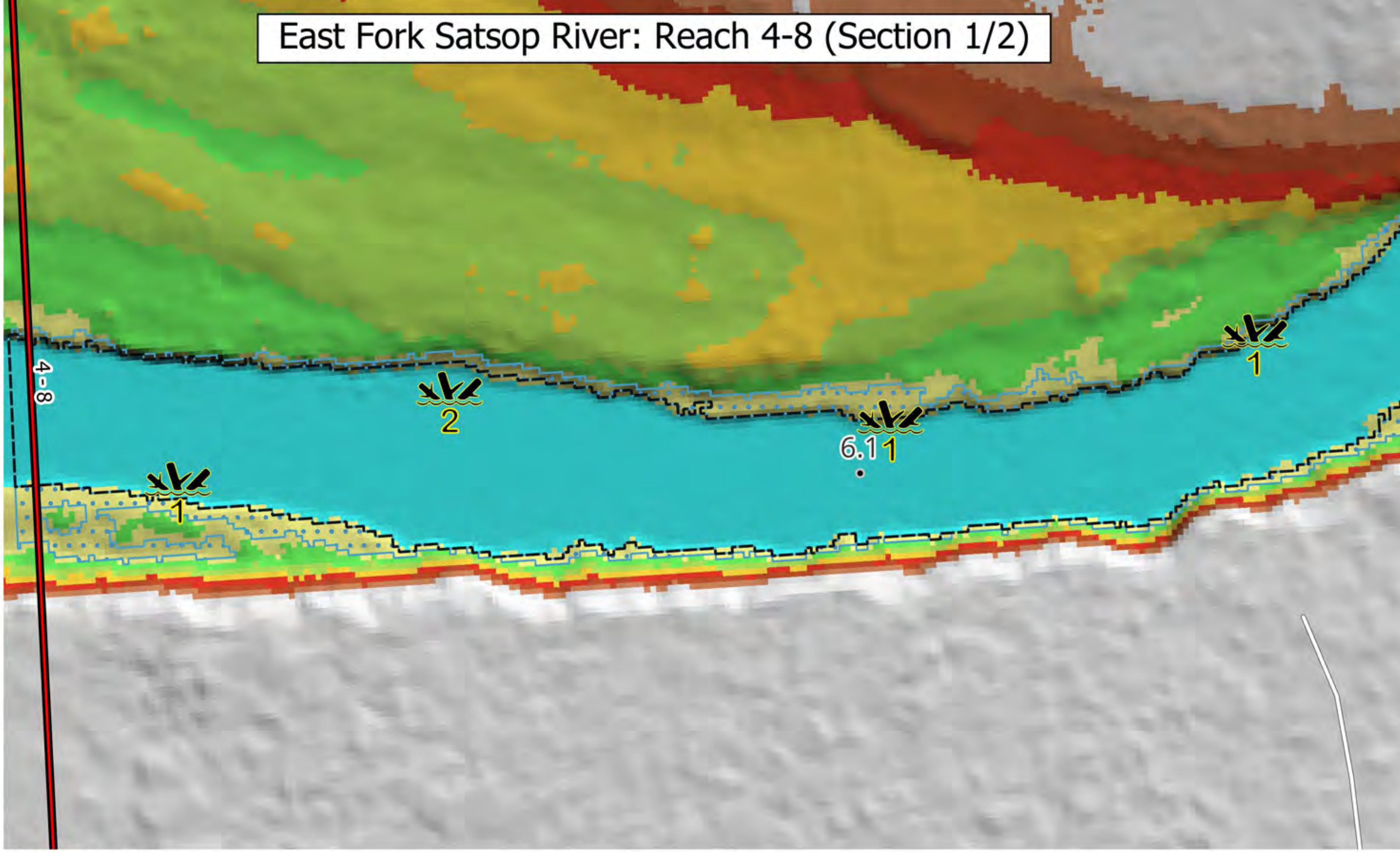
Reach Breaks
Current Floodplain
Potential Floodplain
Mile Marker
Roads
Green Diamond

Elevation (ft)

<1
1 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16 - 18
>18

Concepts

Wood jam



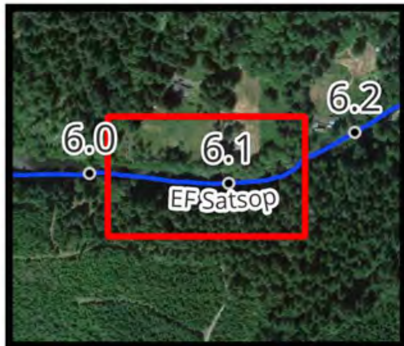
Concepts Key

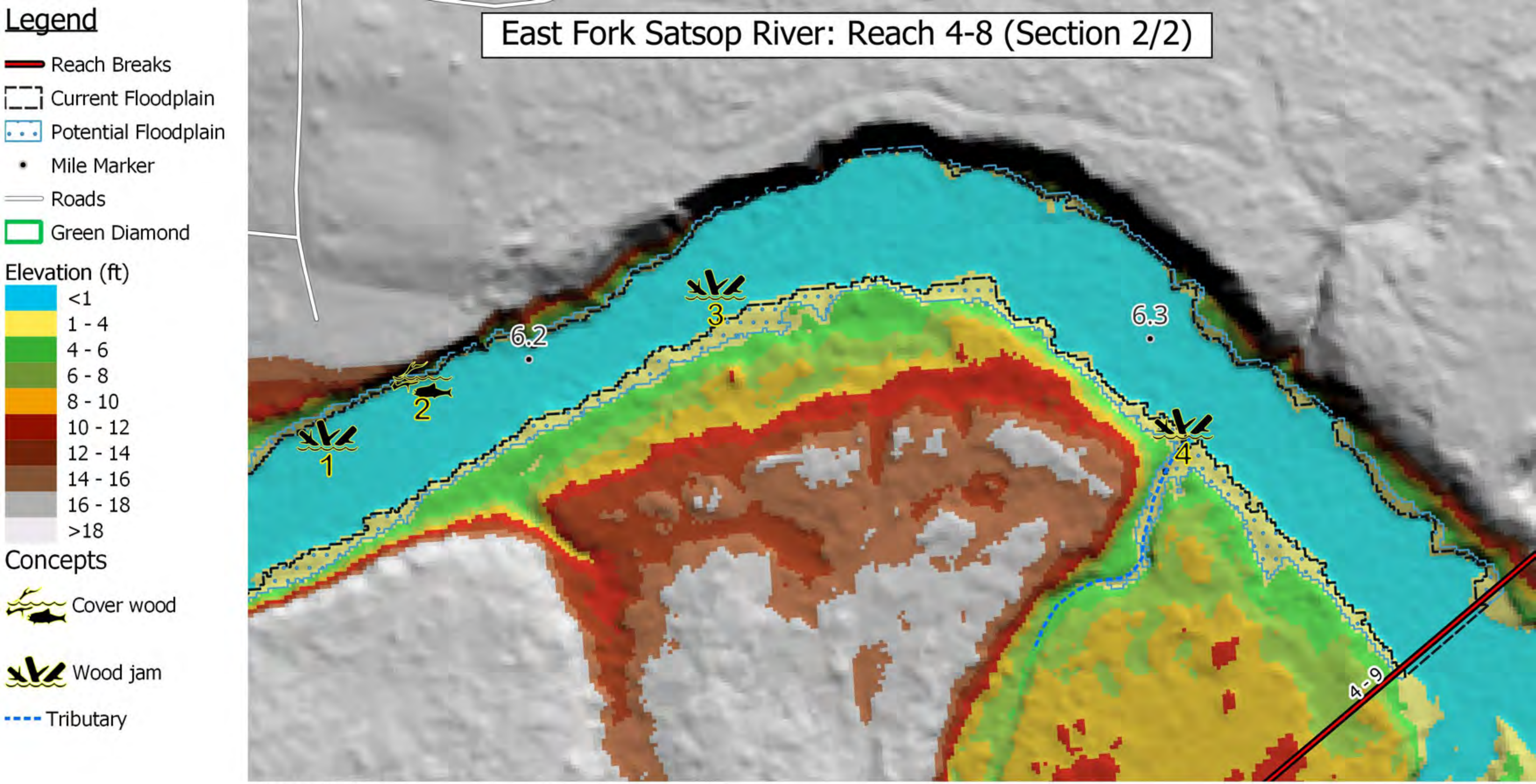
Wood jam 1: Bank attached jam to sort sediment and provide refuge
Wood jam 2: Bank attached jam at riffle to sort sediment and aggrade

0 50 100 m

N

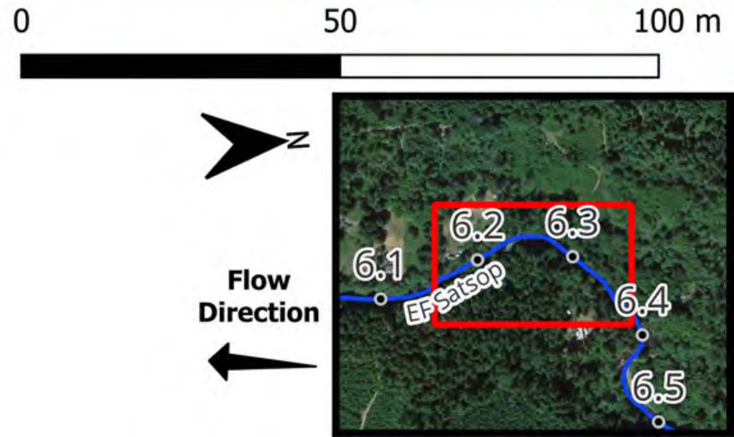
Flow Direction





Concepts Key

Cover wood 2: Add wood pieces to pool for refuge
Wood jam 1: Bank attached jam at riffle to sort sediment and aggrade
Wood jam 3: Bank attached jam to maintain bar and provide refuge
Wood jam 4: Bank attached jam near confluence with small tributary



4.4.3 East Fork Satsop River – Segment 05 – Reach 10

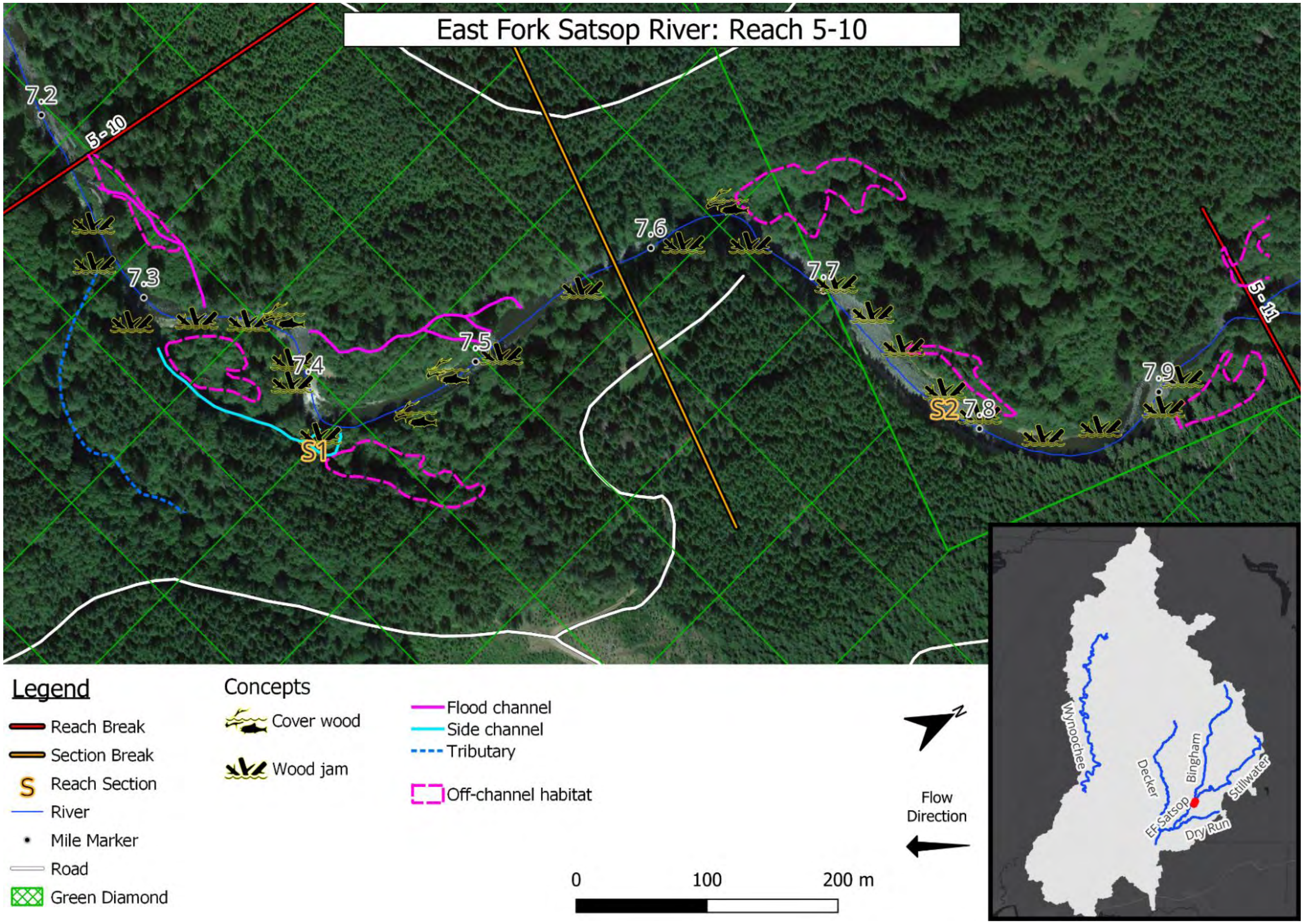


Figure 18. Overview map of the East Fork Satsop River Segment 5, Reach 10.

4.4.3.1 Site Description

This reach on the East Fork Satsop River begins at RM 7.2 and ends at RM 7.95 at the confluence of Bingham and Stillwater creeks. This reach contains three large meanders as the channel bounces back and forth between steep canyon walls as tall as 30 feet. The valley bottom contains many channel scars left over from the advancement of point bars on the inside of the meander bends. Some of these areas likely still act as flood channels, but the downstream ends certainly provide opportunities for fish to access off-channel habitat. Wood density is very low, but there are a few jams that are creating local hotspots of habitat complexity. One jam near the downstream end of the reach is maintaining a short meander, side channel, and off-channel habitat complex. This side channel and off-channel complex has remained in place since at least 1973 but is a potential avulsion pathway. There is no infrastructure in this reach and the nearest channel-crossing structure is the West Schafer Road Bridge 5 miles downstream.

4.4.3.2 Conceptual Project Actions

Restoration actions in this reach should focus on retaining sediment, promoting lateral migration, and increasing topographic complexity along the streambed. The confluence with Helene Creek near the bottom of the reach presents an opportunity to ensure fish access up the tributary and to create refugia. The existing jam maintaining the side channel and off-channel habitat complex at the downstream end of the reach should be enhanced to increase its spatial coverage and ensure stability. LW structures may be placed on the inside of meander bends to encourage lateral migration. The lowest meander presents the best opportunity to expand accommodation space for the river through lateral migration. The two upstream meanders are against steep hillslopes that will not rapidly erode but encouraging erosion will expedite natural processes. There are several opportunities to improve connection to flood channels and off-channel habitats using LW structures.

4.4.3.3 Geomorphic Benefits

The primary geomorphic benefit of the proposed actions in this reach includes taking advantage of sediment delivered from Bingham and Stillwater creeks to increase topographic diversity in the streambed. LW structures will capture and sort sediment to create predictable zones of erosion and deposition. Structures aimed at encouraging lateral channel migration will expedite the river’s current efforts to widen the valley bottom. Maintaining and improving access to flood channels will reduce water velocity in the main channel during flood events to further promote aggradation.

4.4.3.4 Biological Benefits

LW structures that sort sediment will create pockets of highly suitable spawning gravels for adult salmonids. The reach is composed of long glides and pools separated by short riffles. Adding wood to the pools and glides will create diverse microhabitats along the streambed and provide refuge from predators and high flows for juvenile salmonids. Improving access to and enhancing off-channel habitats provides high quality habitat for aquatic species of all life stages.

4.4.3.5 Logistical Challenges and Considerations

Because this reach is directly downstream of the confluence of Bingham and Stillwater creeks, it is expected to respond quickly to restoration actions. Access should not be a major issue, but some access routes will likely need to be established for instream work.

Legend

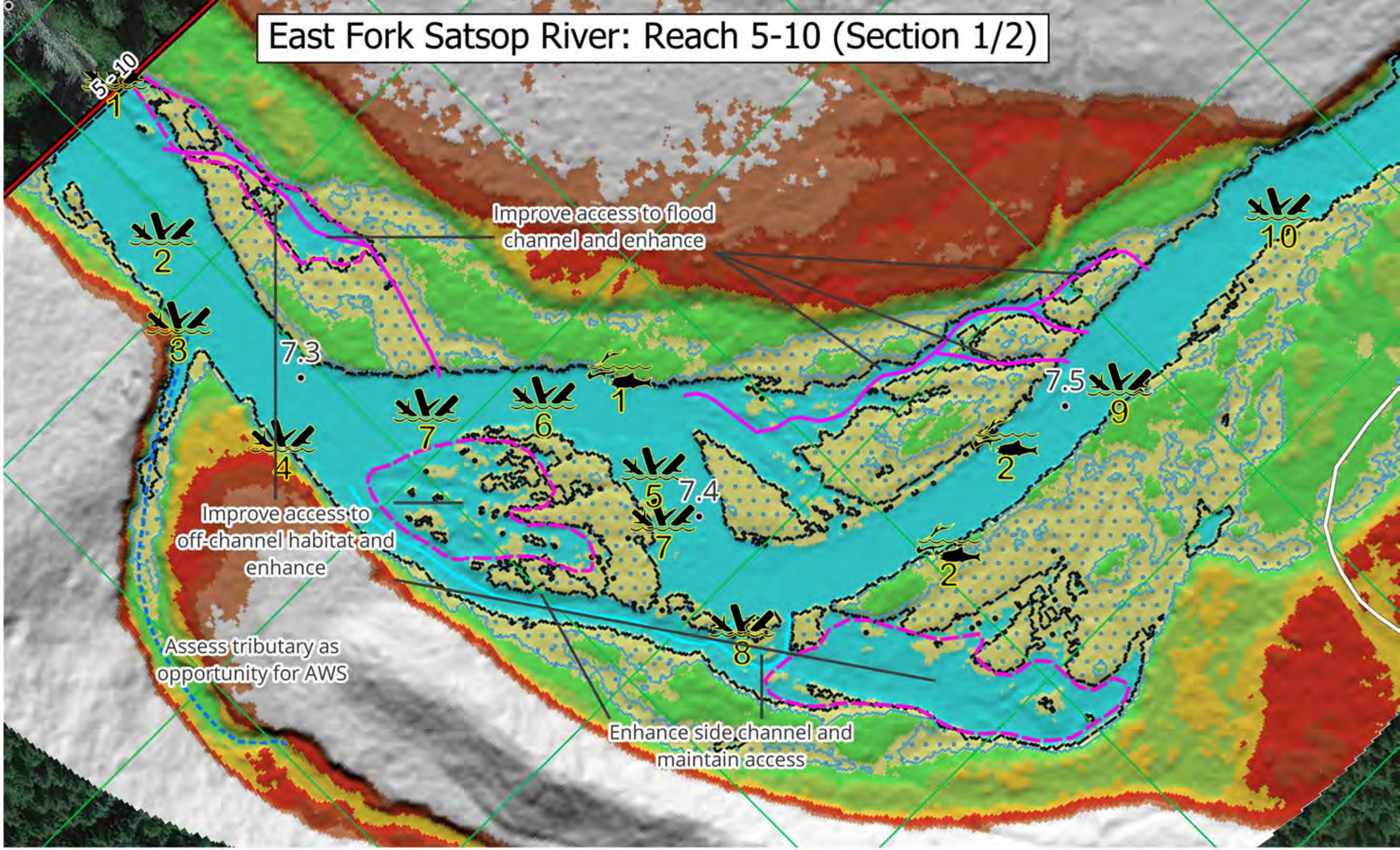
- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

- Cover wood
- Wood jam
- Flood channel
- Side channel
- Tributary
- Off-channel habitat



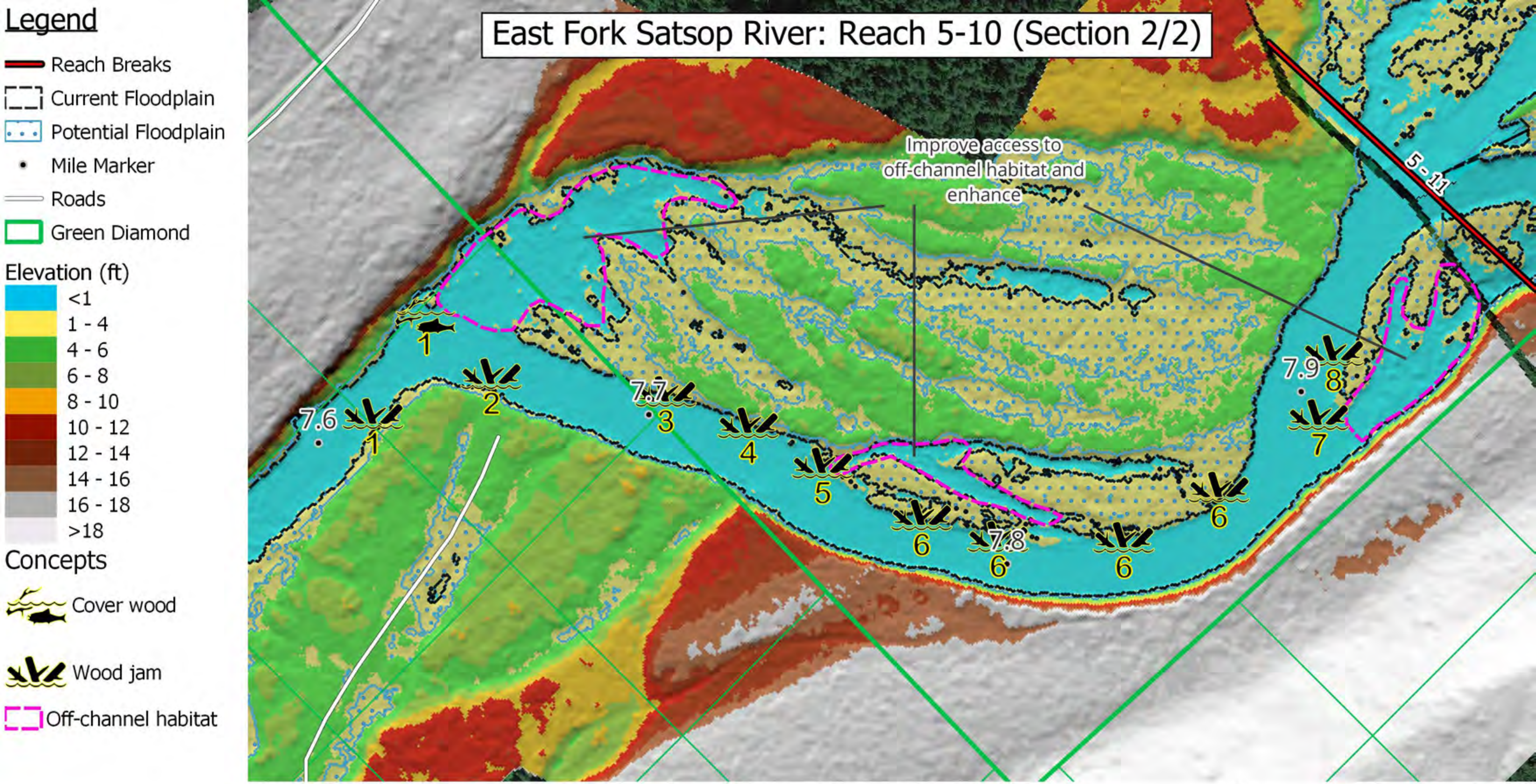
Concepts Key

Cover wood 1: Add wood pieces to pool for refuge
Cover wood 2: Add wood pieces for refuge
Wood jam 1: Bank attached jam to support off-channel habitat
Wood jam 10: Bank attached jam to provide refuge and push flows towards river right
Wood jam 2: Mid-channel or channel spanning jam to maintain bar
Wood jam 3: Bank attached jam to support tributary confluence
Wood jam 4: Bank attached jam to support side channel and off-channel habitat
Wood jam 5: Bank attached jam at riffle to sort sediment and aggrade
Wood jam 6: Bank attached jam to maintain bar and push flows towards river right
Wood jam 7: Enhance existing jam to increase spatial coverage and stability
Wood jam 8: Large jam complex to maintain side channel access and increase pool cover
Wood jam 9: Channel spanning jam angled toward river right at head of pool

0 50 100 m

N

Flow Direction



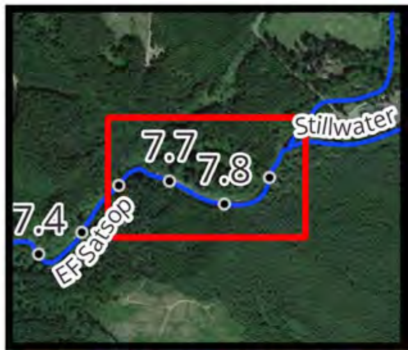
Concepts Key

Cover wood 1: Large jam on outside meander to provide refuge in big pool
Wood jam 1: Bank attached jam to push flows towards river right
Wood jam 2: Large bank attached jam to push flows towards river right
Wood jam 3: Bank attached jam to sort sediment and provide refuge
Wood jam 4: Bank attached jam at riffle to sort sediment and provide refuge
Wood jam 5: Bank attached jam to support off-channel habitat
Wood jam 6: Bank attached jam to promote bar formation and lateral migration
Wood jam 7: Wood jam at flow separation to support off-channel habitat
Wood jam 8: Bank attached jam at riffle to sort sediment and aggrade

0 50 100 m

N

Flow Direction



4.5 Stillwater Creek

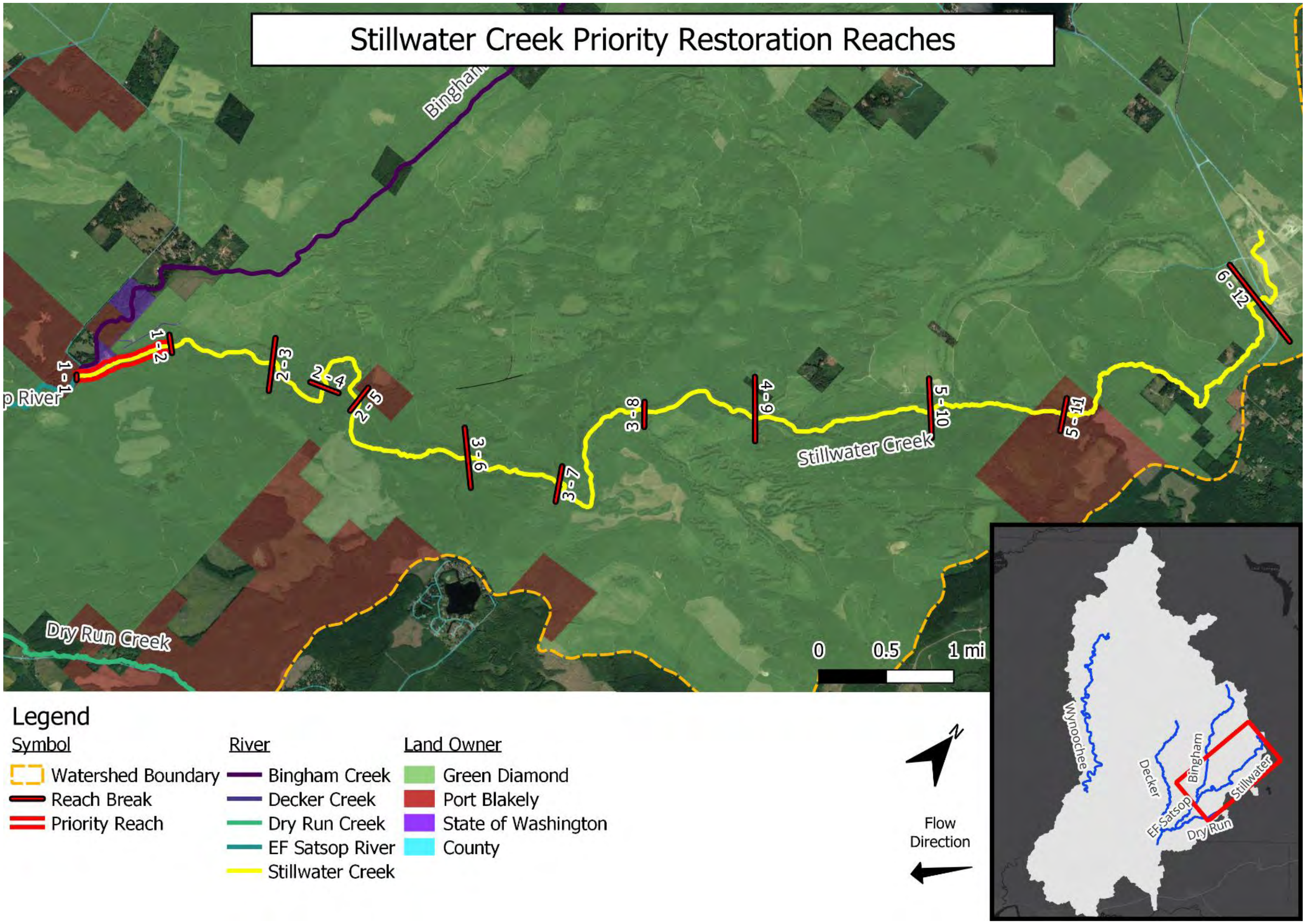


Figure 19. Overview map of priority restoration reaches in Stillwater Creek.

4.5.1 Stillwater Creek – Segment 01 – Reach 01

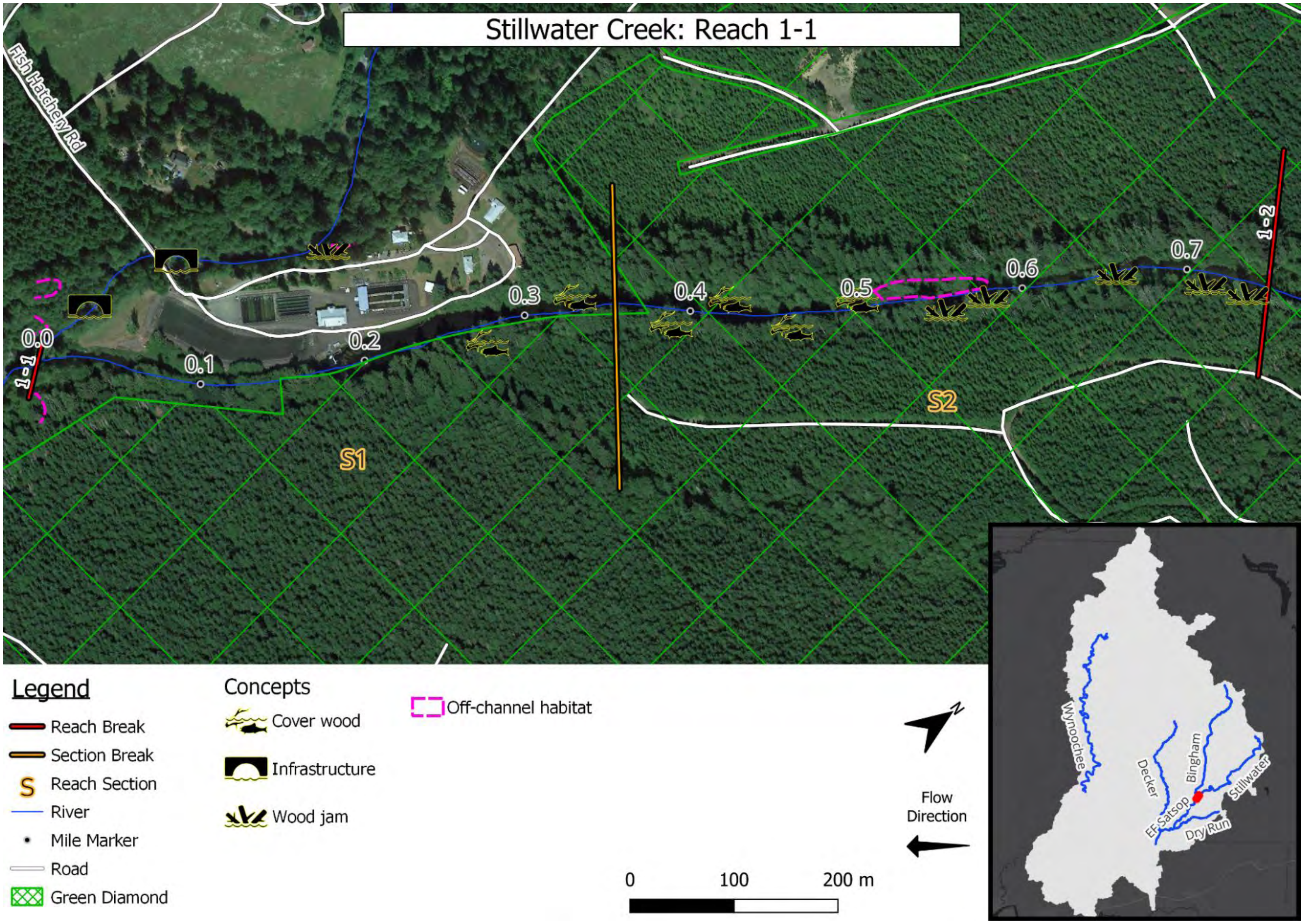


Figure 20. Overview map of Stillwater Creek Segment 1, Reach 1.

4.5.1.1 Site Description

This reach on Stillwater Creek begins at its confluence with Bingham Creek at RM 0.0 and ends upstream of the Bingham Creek Fish Hatchery at RM 0.75. For the first 500 yards, the channel is straight and pinned between a levee protecting the fish hatchery on river left and a gentle hillslope on river right. The channel crosses a weir at RM 0.2 that creates a substantial upstream ponding effect that extends about halfway through the reach. It is likely that the weir also disrupts bed load transport. A small unnamed tributary enters the reach 50 yards upstream of the weir.

4.5.1.2 Conceptual Project Actions

The restoration actions in this reach should focus on improving fish habitat. No actions are proposed downstream of the weir. Upstream of the weir, within the ponded extent, wood pieces may be added to increase cover for fish. These wood pieces should not be designed to modify the streambed unless analysis can be conducted to show little to no negative impact to the weir and other hatchery infrastructure. Upstream of the ponded extent, there are several opportunities to add LW structures that can create a greater diversity of habitats for fish by modifying the streambed or pushing flows towards inset floodplains and off-channel habitats.

4.5.1.3 Geomorphic Benefits

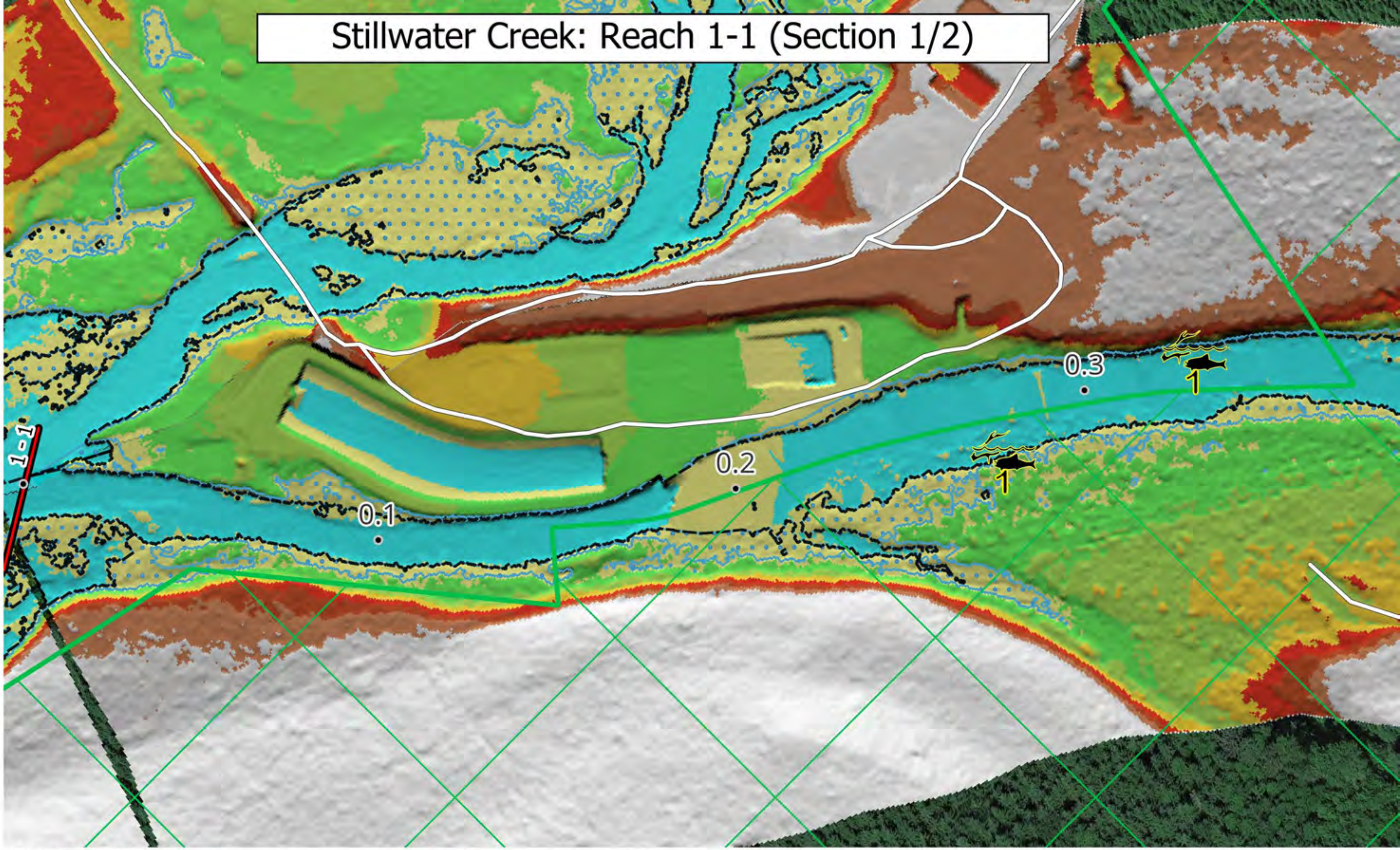
The cover wood proposed in the ponded section are not expected to modify geomorphic features. The LW structures upstream of the ponded area will capture and sort sediment to build pools and bars. There are indicators in upstream reaches that gravels are being transported to this reach. The structures will help sort gravels from other substrate sizes. Structures will also improve connection to the inset floodplain during smaller flood events.

4.5.1.4 Biological Benefits

Although the ponding effect of the weir provides deep water cover for fish, there is little to no structural cover in the channel. Wood pieces with abundant branches laying within the water column will provide refuge from predators. LW structures upstream of the ponded area will sort gravels and build bars to provide suitable spawning grounds for adult salmonids. The structures will also provide refuge from predators and high flows for rearing juvenile salmonids. Improving access to and enhancing off-channel habitats increases the amount of space for aquatic species to occupy.

4.5.1.5 Logistical Challenges and Considerations

No actions are proposed downstream of the weir due to the risk of impacting hatchery infrastructure. Any wood added upstream of the hatchery will need to be well-stabilized to prevent mobilized wood from damaging hatchery infrastructure.



Legend

- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

- Cover wood

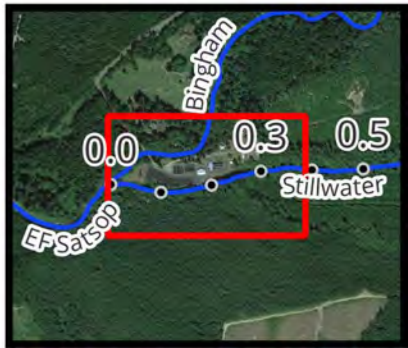
Concepts Key

Cover wood 1: Add stable wood pieces to provide cover upstream of hatchery

0 50 100 m

N

Flow Direction



Stillwater Creek: Reach 1-1 (Section 2/2)

Legend

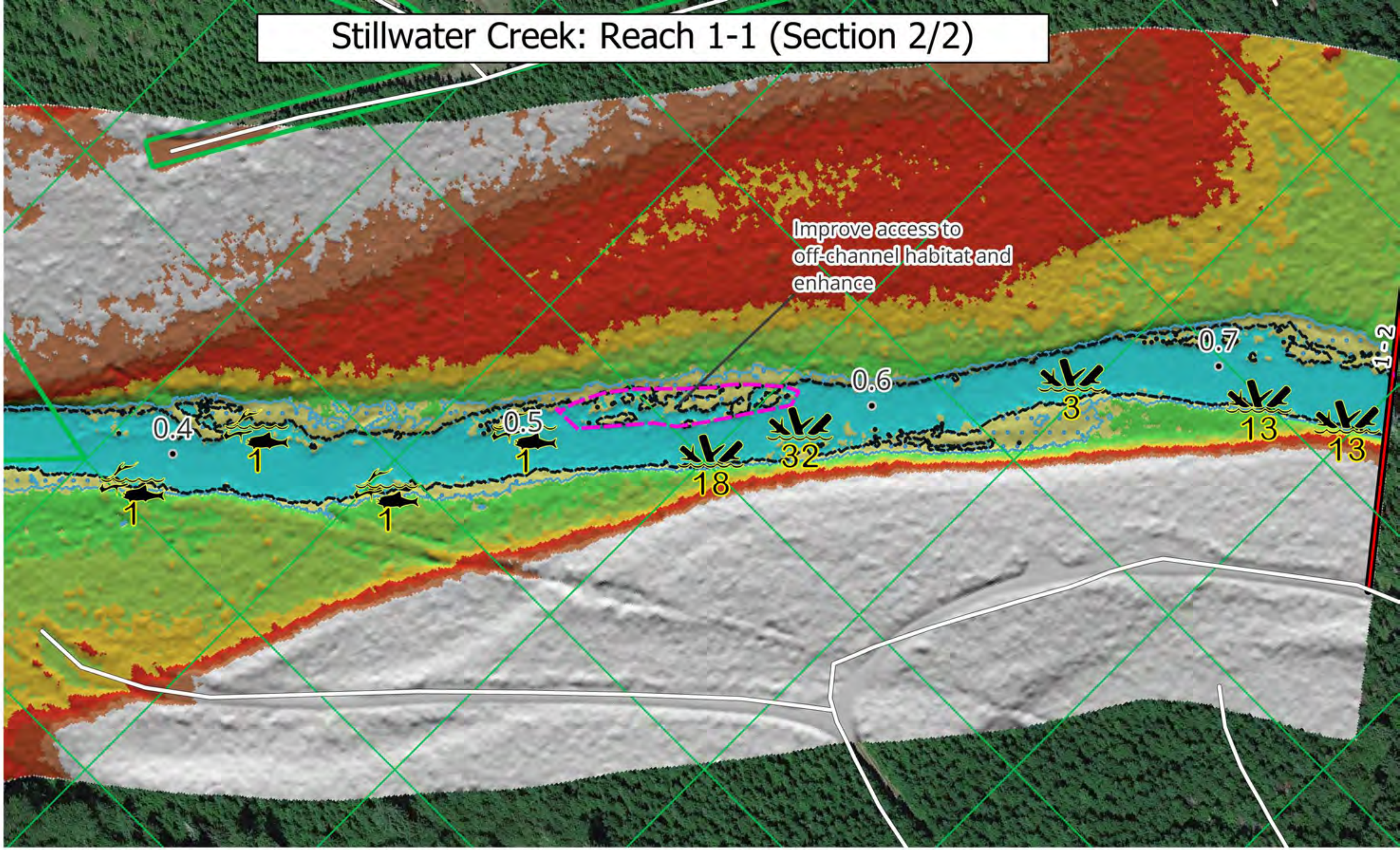
Reach Breaks
Current Floodplain
Potential Floodplain
Mile Marker
Roads
Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

Cover wood
Wood jam
Off-channel habitat



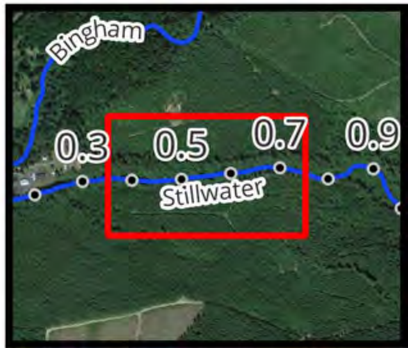
Concepts Key

Cover wood 1: Add stable wood pieces to provide cover upstream of hatchery
Wood jam 13: Bank attached jam to push flows towards river right
Wood jam 18: Bank attached jam to support off-channel habitat
Wood jam 3: Add wood to existing pieces to create large wood jam complex
Wood jam 32: Channel spanning jam at riffle to support off-channel and aggrade

0 50 100 m

N

Flow Direction



4.6 Wynoochee River

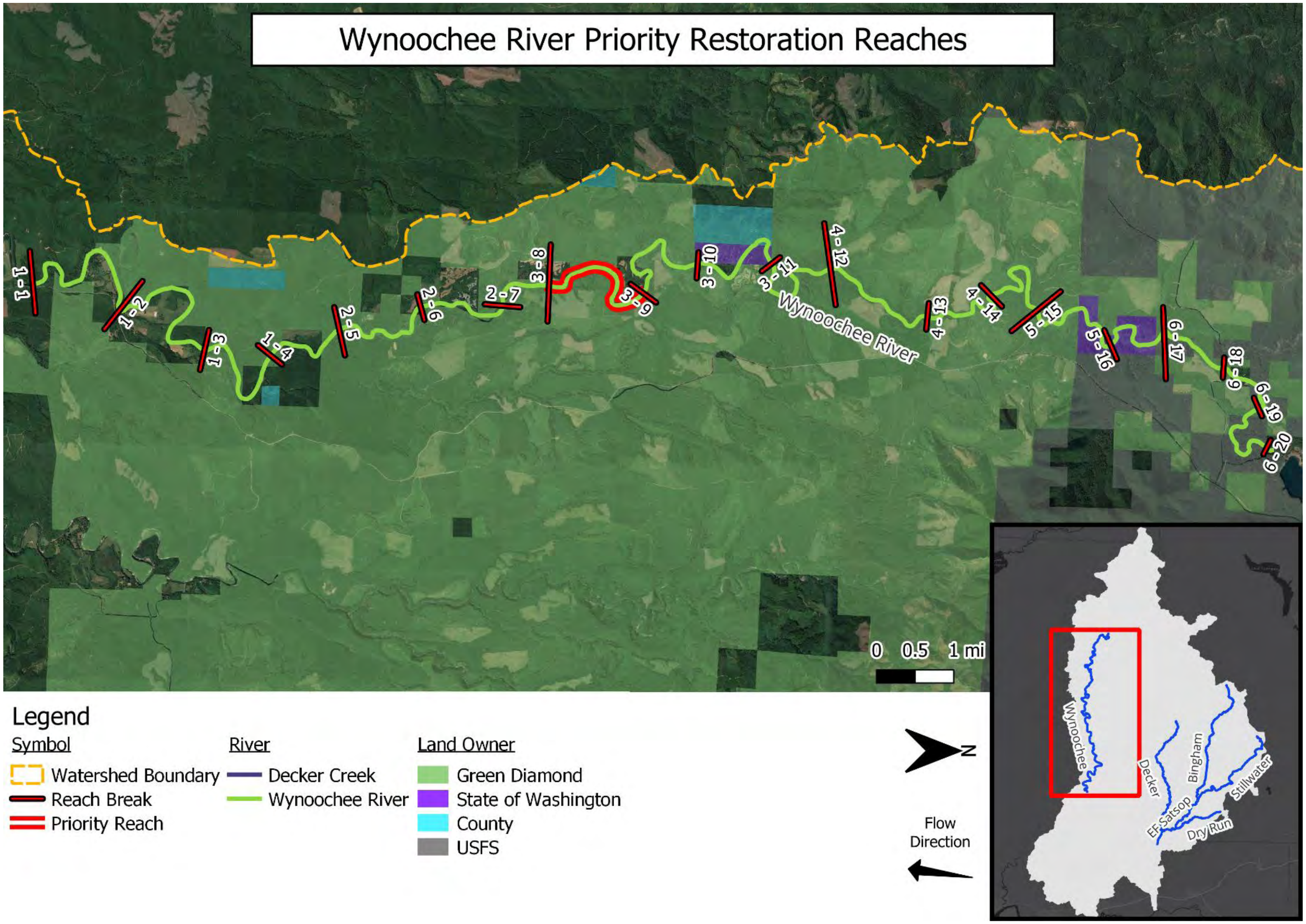


Figure 21. Overview map of priority restoration reaches on the Wynoochee River.

4.6.1 Wynoochee River – Segment 03 – Reach 08

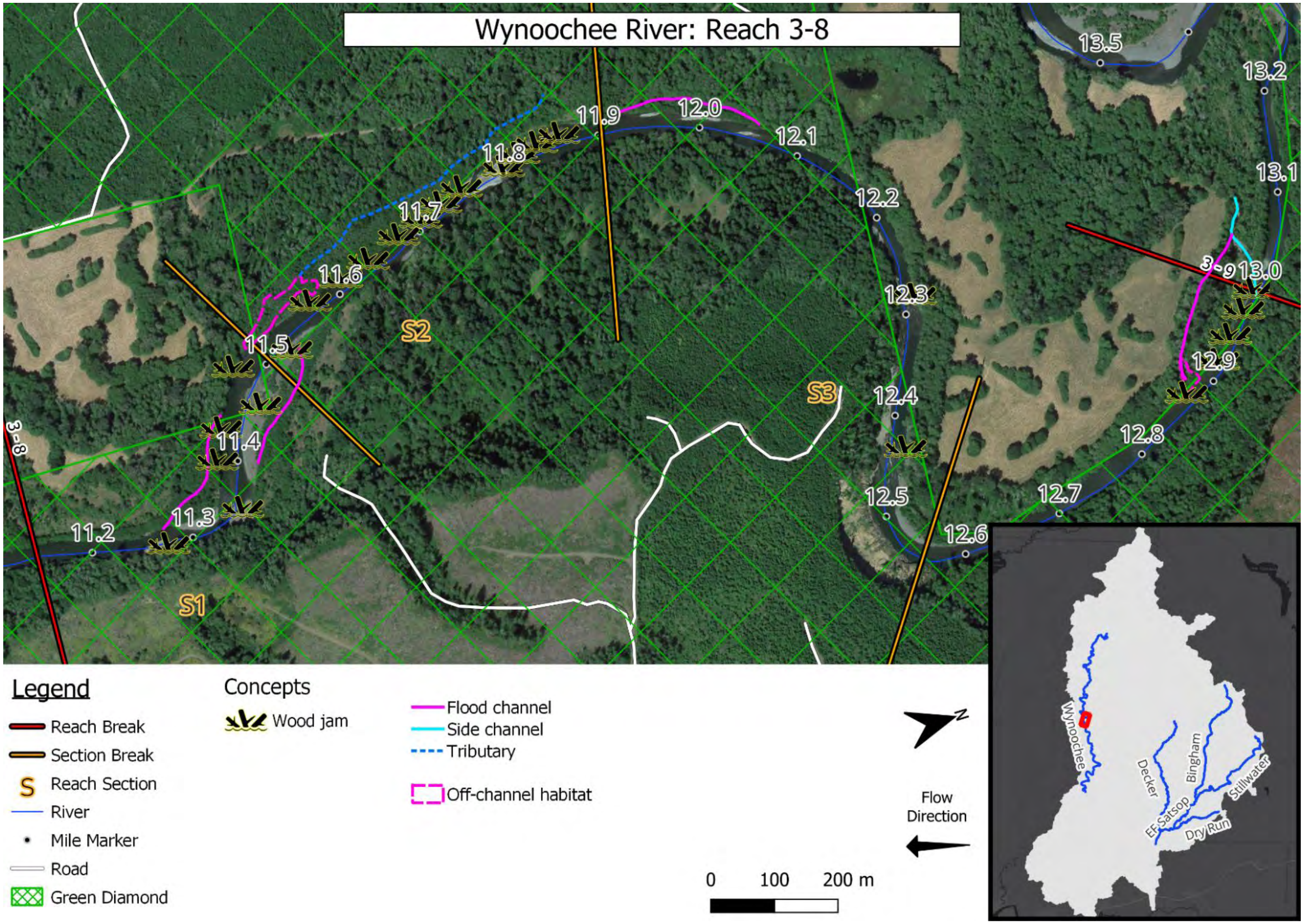


Figure 22. Overview map of Wynoochee River Segment 3, Reach 8.

4.6.1.1 Site Description

This reach on the Wynoochee River begins at RM 11.1 and ends at RM 13.0. The reach includes two long meanders and ends after an abrupt turn towards river right. The channel spans most of the valley bottom with some inset floodplain pockets. The channel has incised as much as five feet in the last few decades and the planform has adjusted very little. Near RM 12.5, the channel is eroding into the hillslope causing a very steep cutbank mostly devoid of vegetation. The size of the cutbank has grown in the last 20 years and provides a sediment source for downstream reaches. The channel flows over a couple bedrock ledges starting at the cut bank and extending approximately 400 yards downstream. There are several bank-attached and mid-channel bars that provide some topographic complexity in the channel. A small yazoo tributary enters the valley bottom at RM 11.85 and follows the river for about 500 yards.

4.6.1.2 Conceptual Project Actions

Restoration actions in this reach should focus on reducing water velocity and retaining sediment to aggrade the channel. LW structures may be placed along the channel edge to increase roughness and at the heads of existing bars. Some structures may be used to improve access to flood channels and off-channel habitats. The yazoo tributary should be assessed for opportunities to provide habitat and to ensure that it is accessible at the confluence with the main channel. Very few actions are proposed through the middle of the reach due to access issues and the low probability of being able to sufficiently stabilize structures.

4.6.1.3 Geomorphic Benefits

LW structures at the upstream end of existing bars will help them persist and promote channel aggradation. LW structures will promote further aggradation by reducing water velocity and trapping sediment. Improving connection to floodplain pockets will also help spread flows and reduce water velocity in the main channel.

4.6.1.4 Biological Benefits

LW structures placed along the channel margin will enhance edge habitat and provide refuge for aquatic species. The two proposed LW structures near the bedrock ledges are primarily to provide cover in the deep scour pools and more could be added to increase the spatial extent of suitable cover. Improving access to off-channel habitats increases the amount of space for aquatic species to occupy. The yazoo tributary presents a unique opportunity to improve fish habitat and water retention within the valley bottom of the reach without working in the mainstem channel.

4.6.1.5 Logistical Challenges and Considerations

The channel abuts directly against a steep hillslope in many locations, making access difficult and limiting ideal structure placement. Because of the level of incision and the Wynoochee Dam limiting sediment supply from the headwaters, aggrading the channel will take a long time, but doing so will provide access to a much greater floodplain extent. Sediment delivery into this reach will be limited upstream sources from the valley bottom and hillslopes (e.g., bars, avulsions, landslides, etc.). The long gap in proposed actions in the middle of the reach should be assessed in the field for additional opportunities.

Wynoochee River: Reach 3-8 (Section 1/4)

Legend

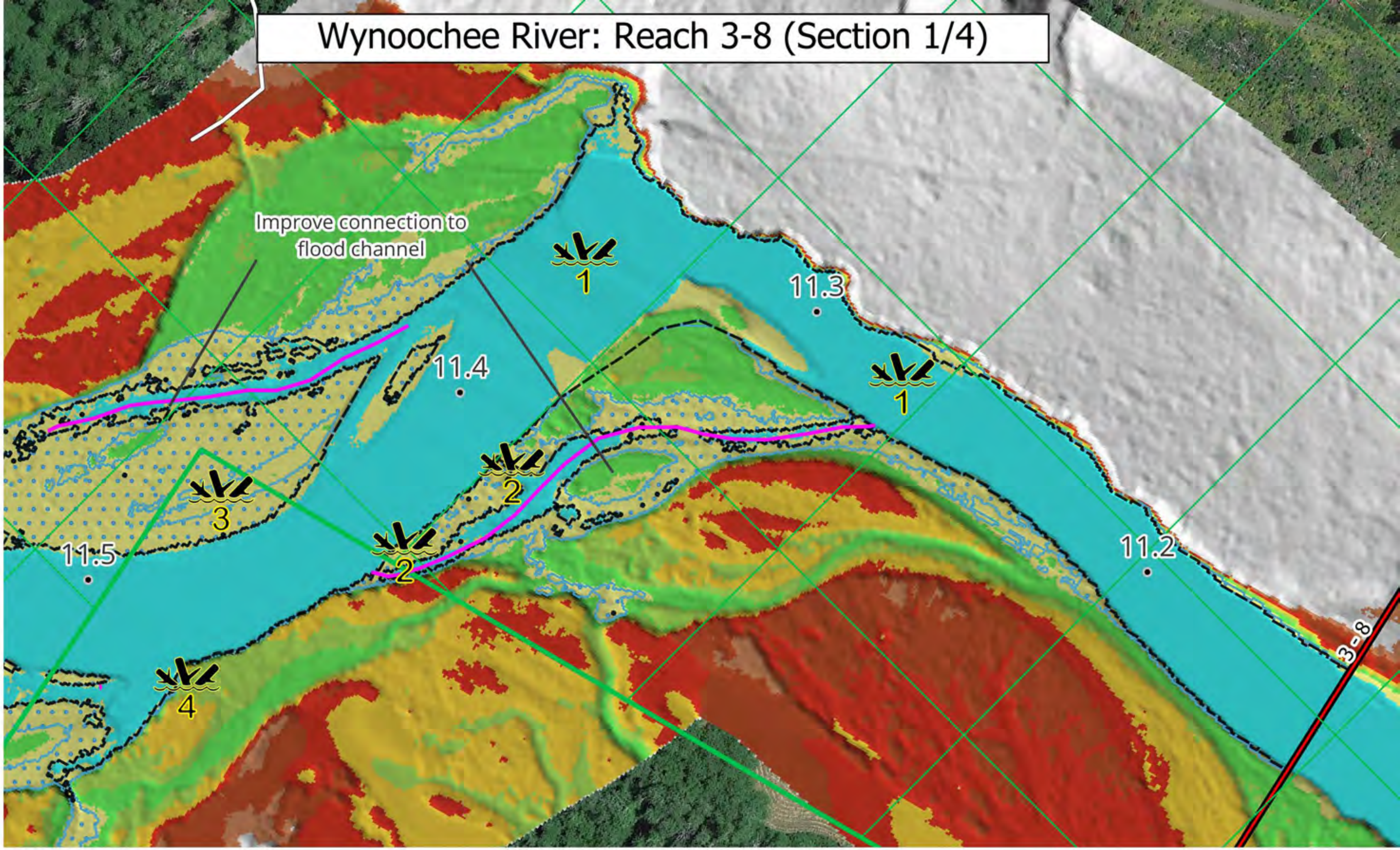
- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

- Wood jam
- Flood channel
- Off-channel habitat

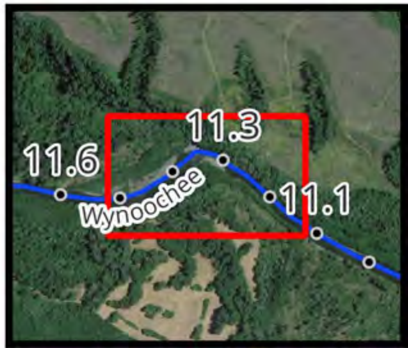


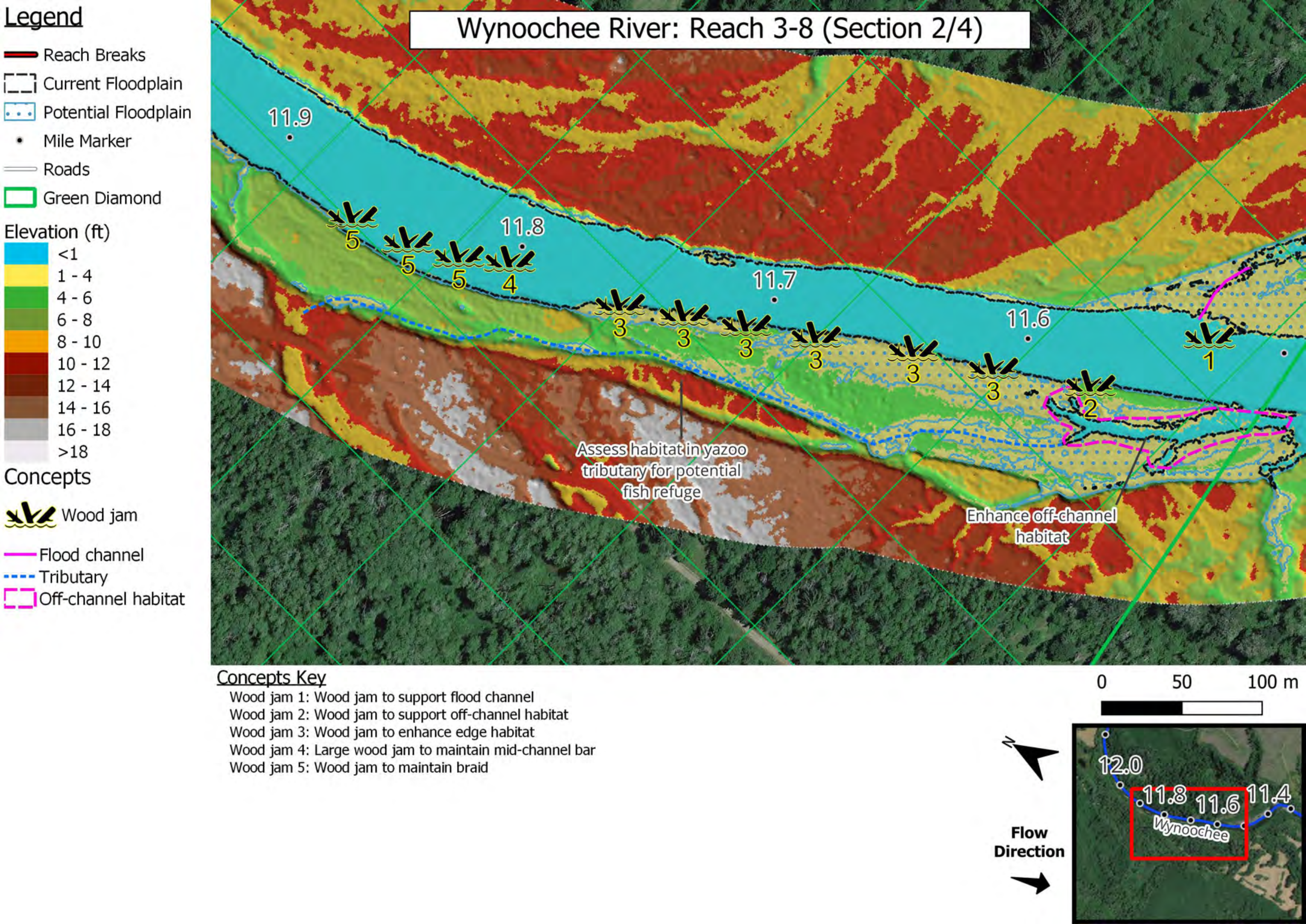
Concepts Key

Wood jam 1: Wood jam to maintain bar
Wood jam 2: Wood jam to support flood channel
Wood jam 3: Add small wood jams for roughness on bar
Wood jam 4: Large wood jam to enhance lateral scour pool

0 50 100 m

Flow Direction





Concepts Key

Wood jam 1: Wood jam to support flood channel
Wood jam 2: Wood jam to support off-channel habitat
Wood jam 3: Wood jam to enhance edge habitat
Wood jam 4: Large wood jam to maintain mid-channel bar
Wood jam 5: Wood jam to maintain braid

Wynoochee River: Reach 3-8 (Section 3/4)

Legend

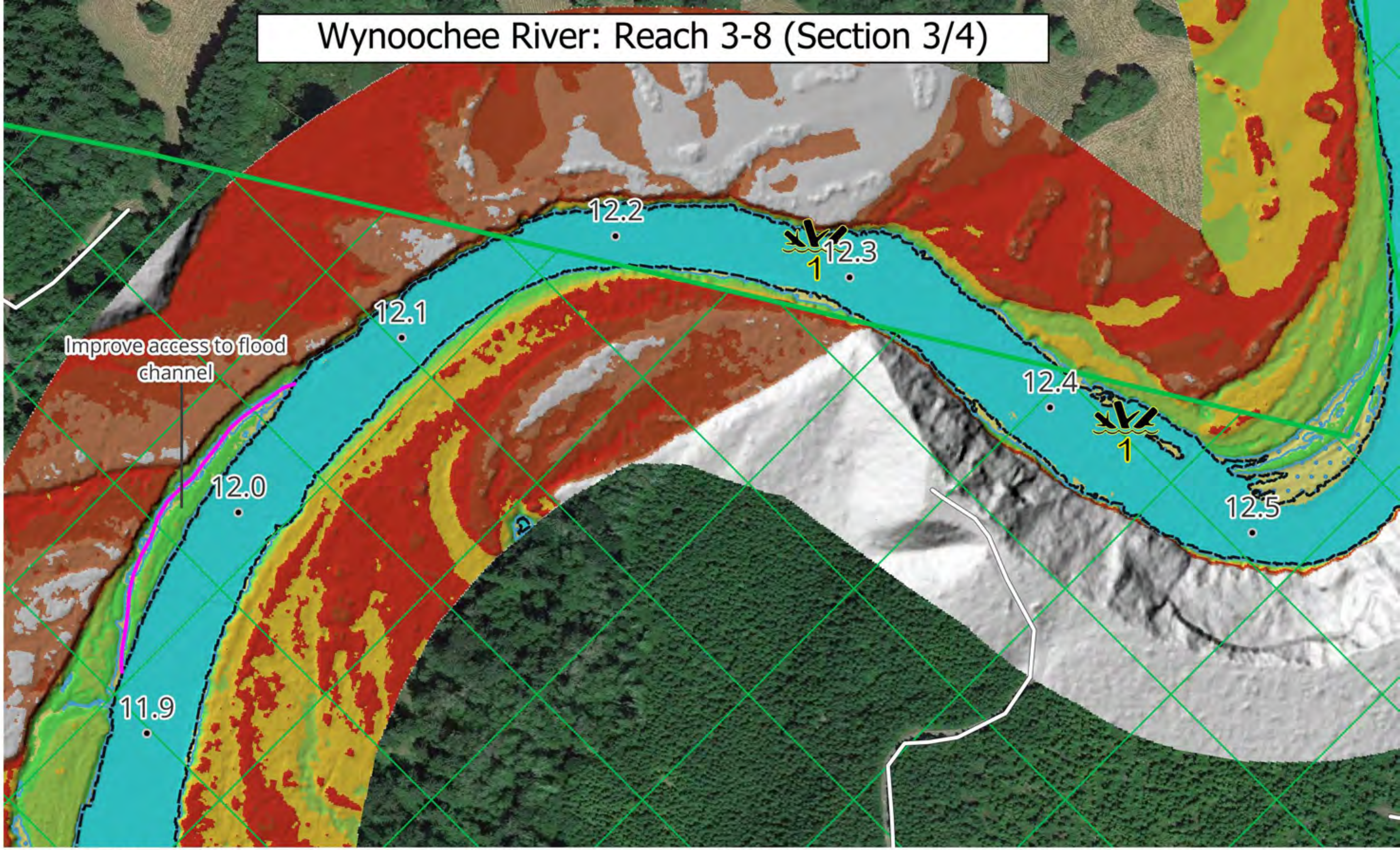
- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

- Wood jam
- Flood channel



Concepts Key

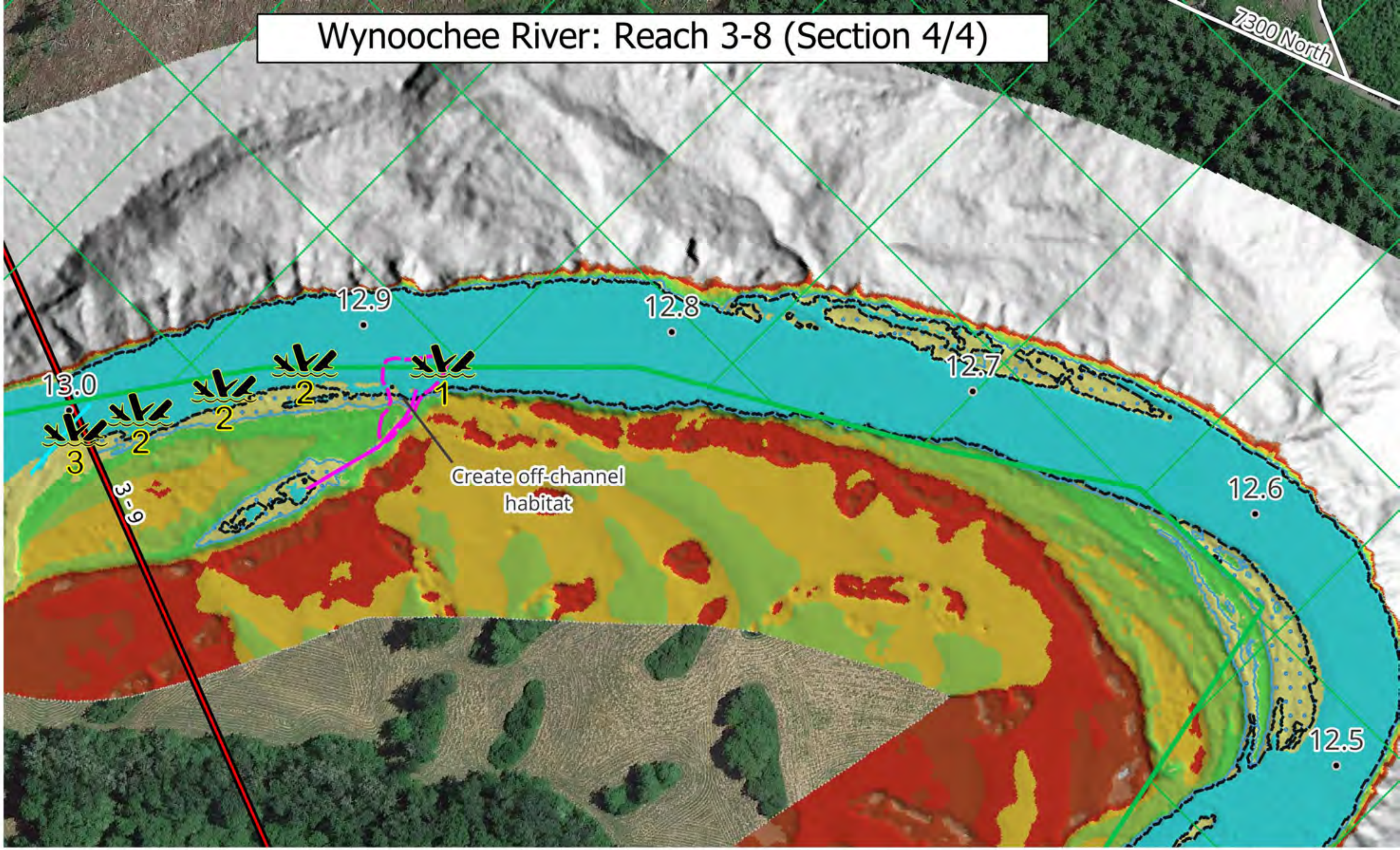
Wood jam 1: Large jam to enhance pool

0 50 100 m

N

Flow Direction

Wynoochee River: Reach 3-8 (Section 4/4)



Legend

- Reach Breaks
- Current Floodplain
- Potential Floodplain
- Mile Marker
- Roads
- Green Diamond

Elevation (ft)

- <1
- 1 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- >18

Concepts

- Wood jam
- Flood channel
- Side channel
- Off-channel habitat

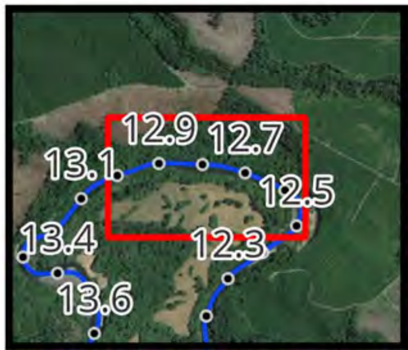
Concepts Key

Wood jam 1: Wood jam to support flood channel and proposed off-channel habitat
Wood jam 2: Wood jam to enhance edge habitat
Wood jam 3: Wood jam to support side channel connection

0 50 100 m

N

Flow Direction



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6.0 APPENDIX A: MAPS

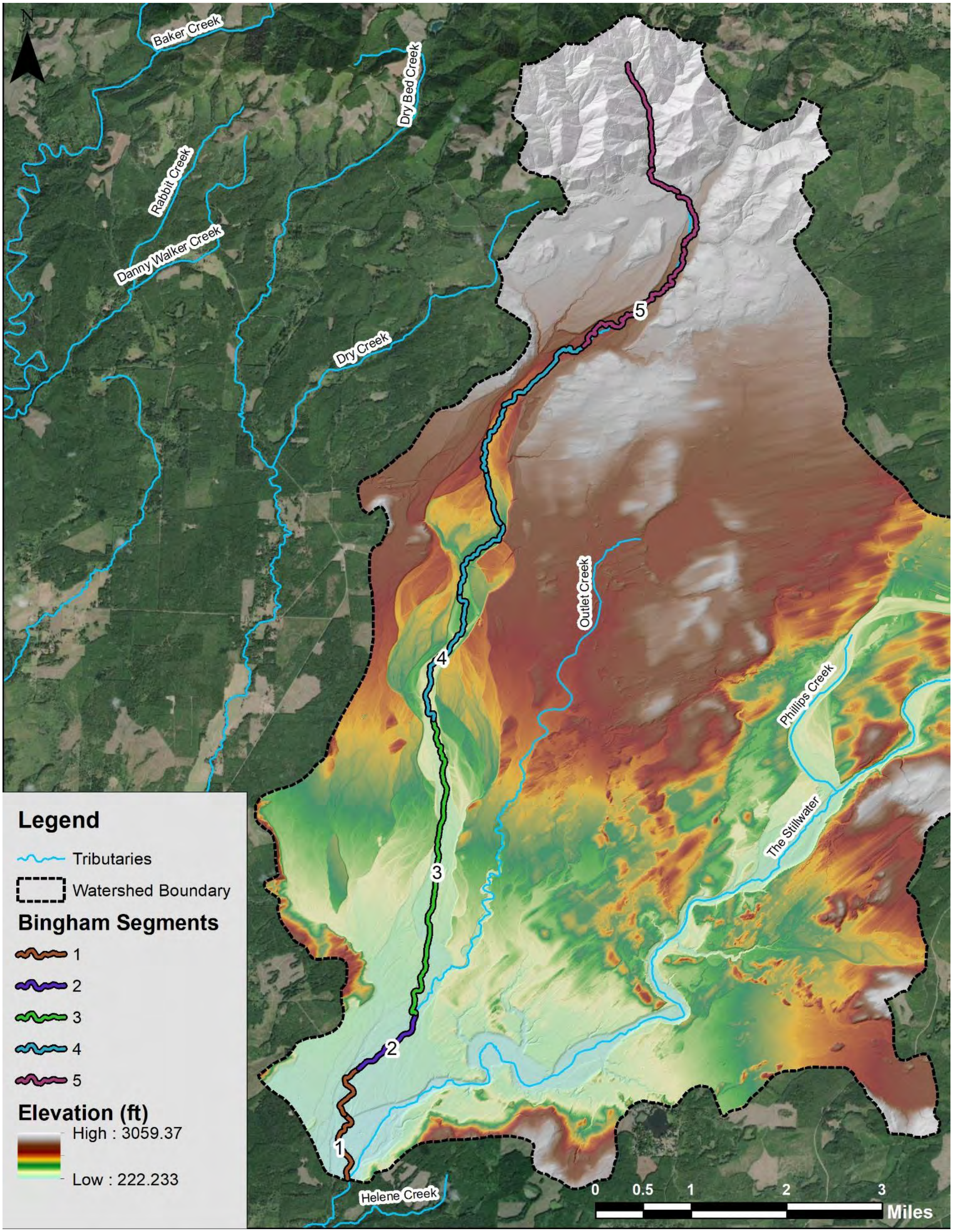


Figure 1. Overview map showing geomorphic segments of Bingham Creek.

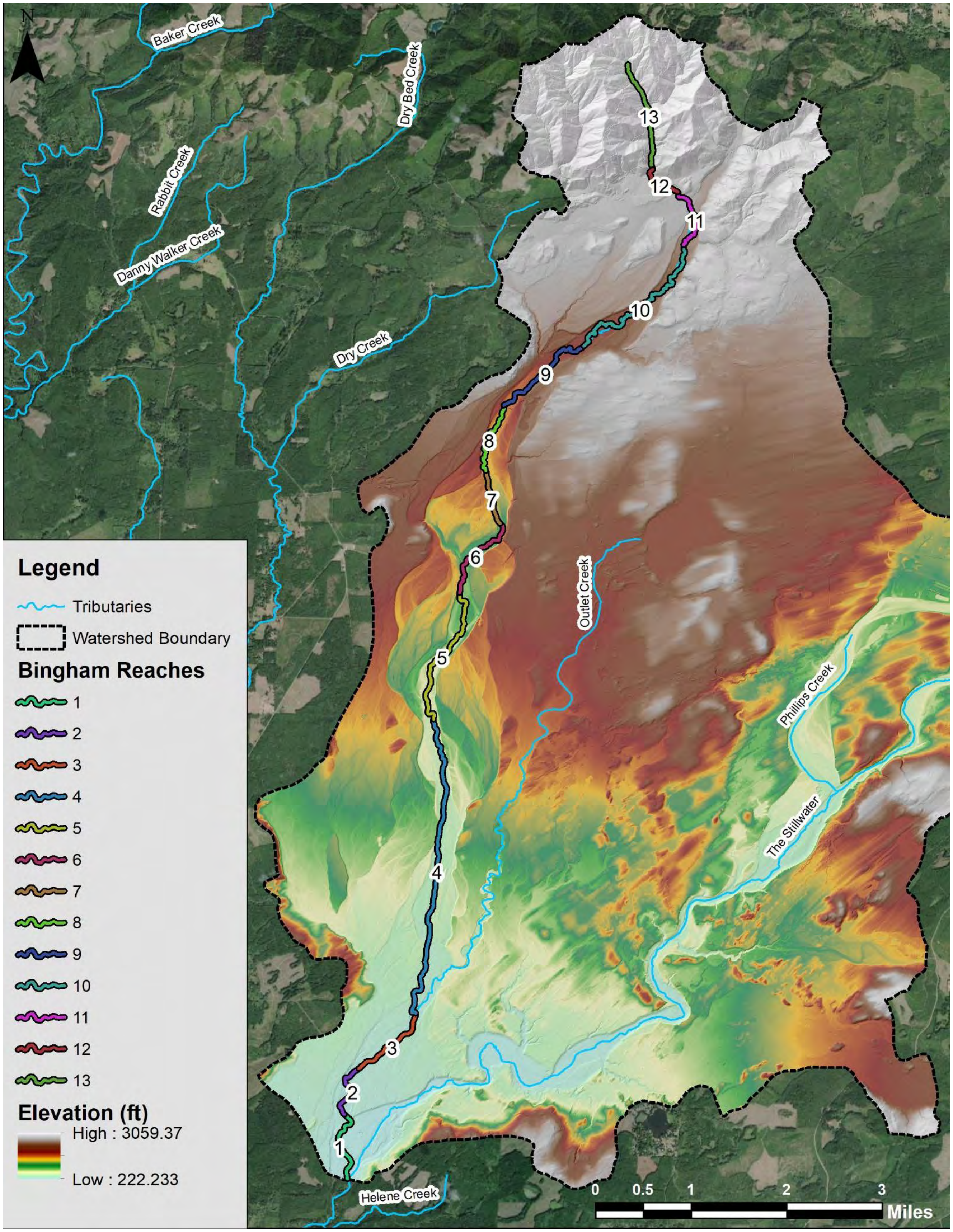


Figure 2. Overview map showing geomorphic reaches of Bingham Creek.

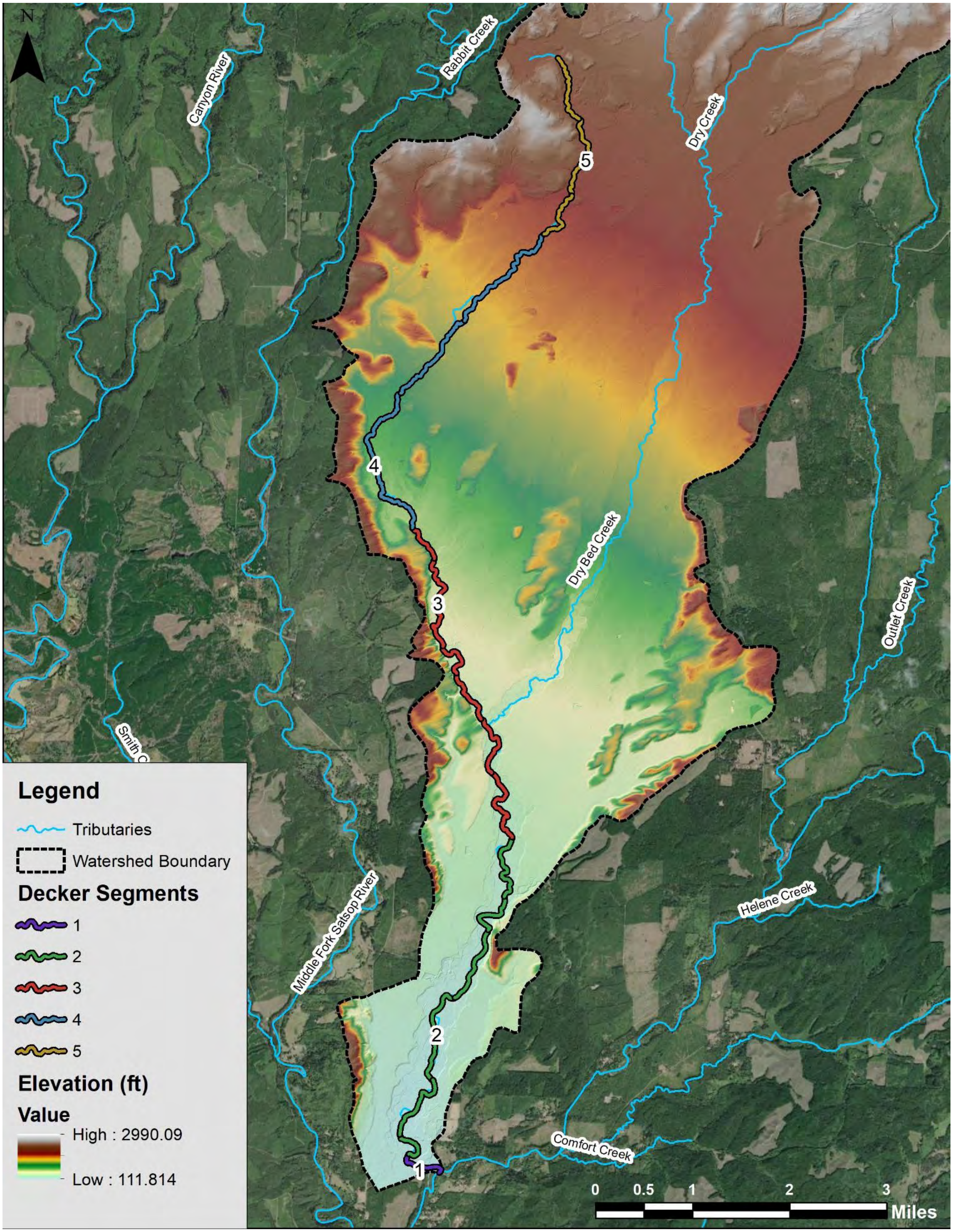


Figure 3. Overview map showing geomorphic segments of Decker Creek.

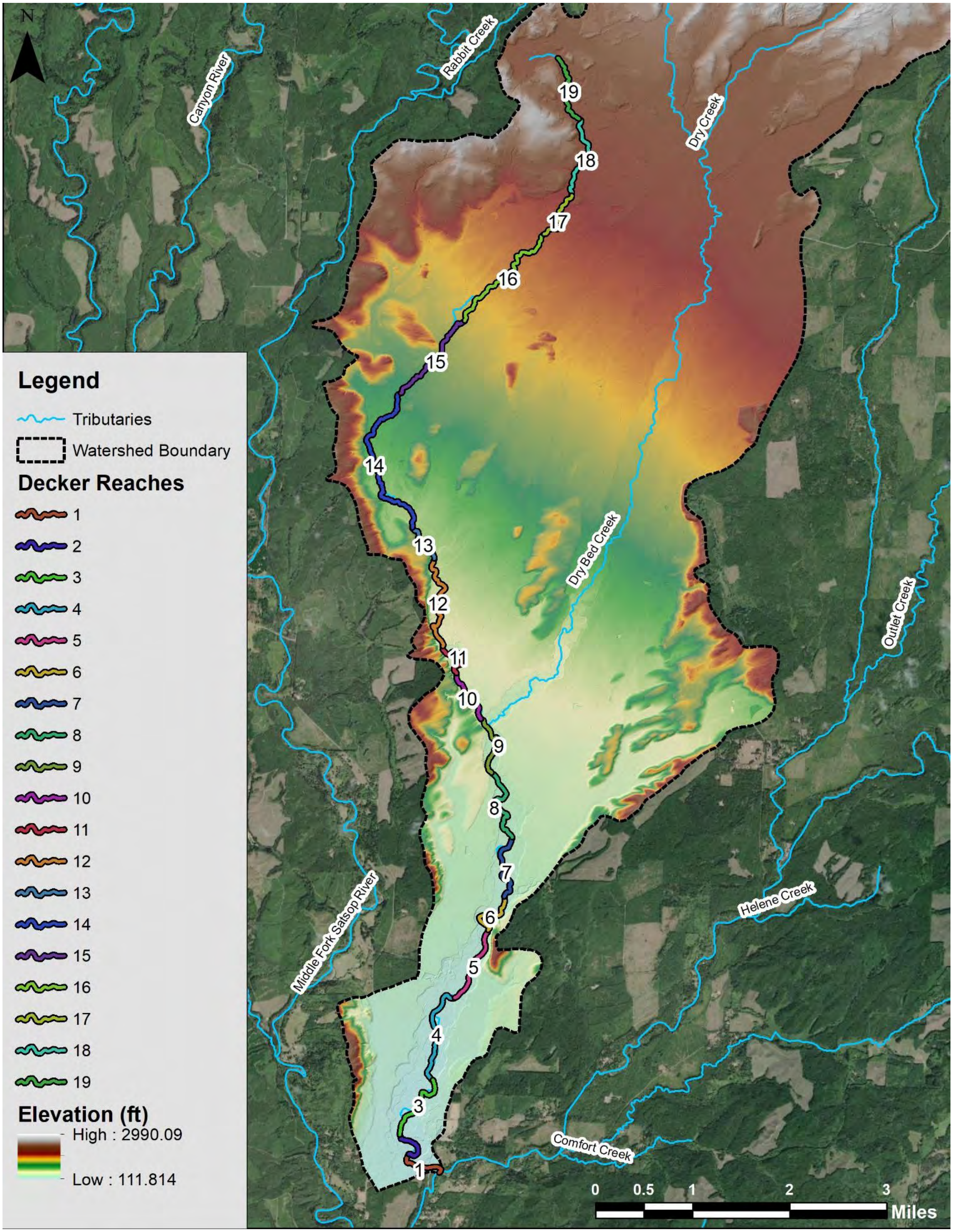


Figure 4. Overview map showing geomorphic reaches of Decker Creek.

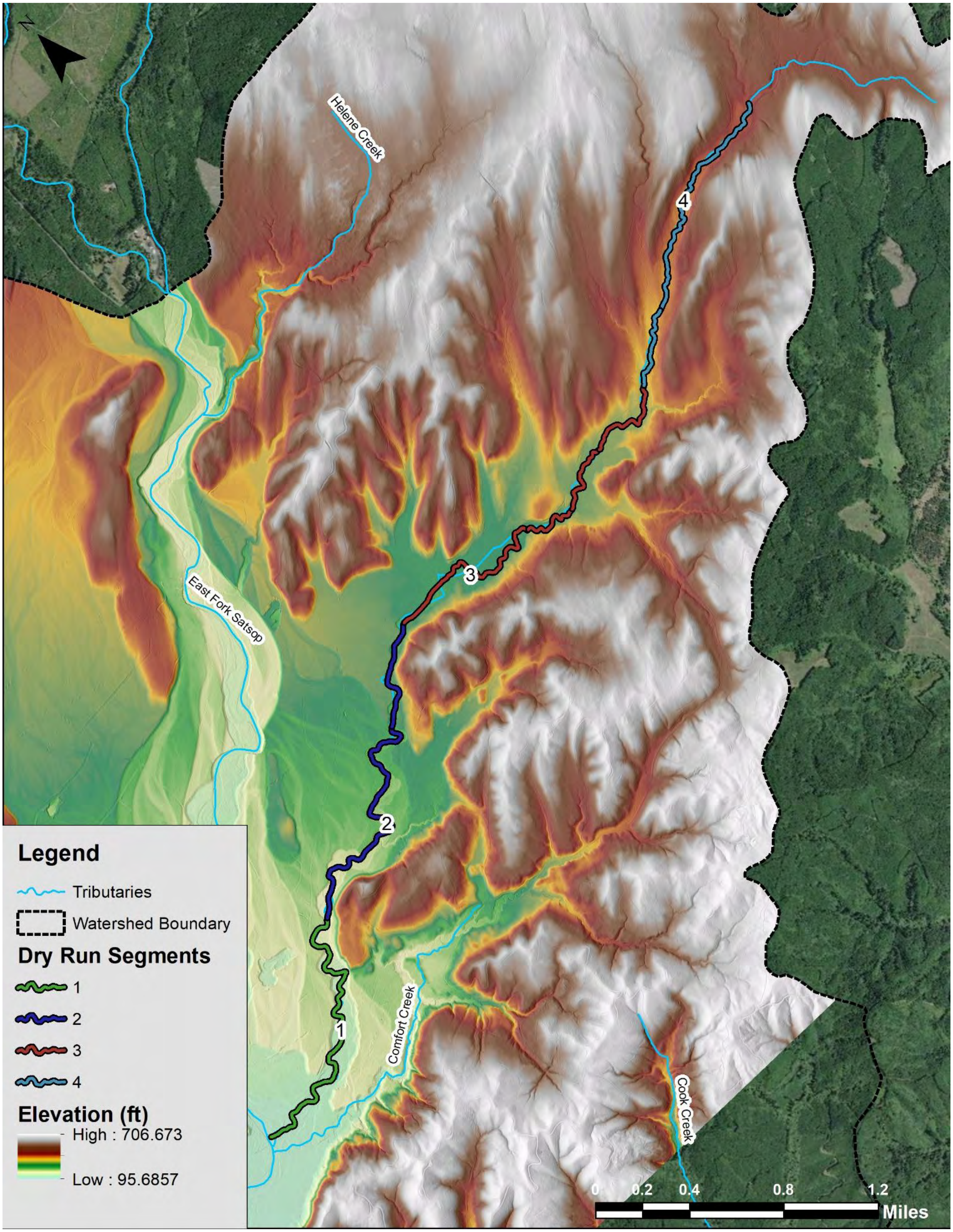


Figure 5. Overview map showing geomorphic segments of Dry Run Creek.

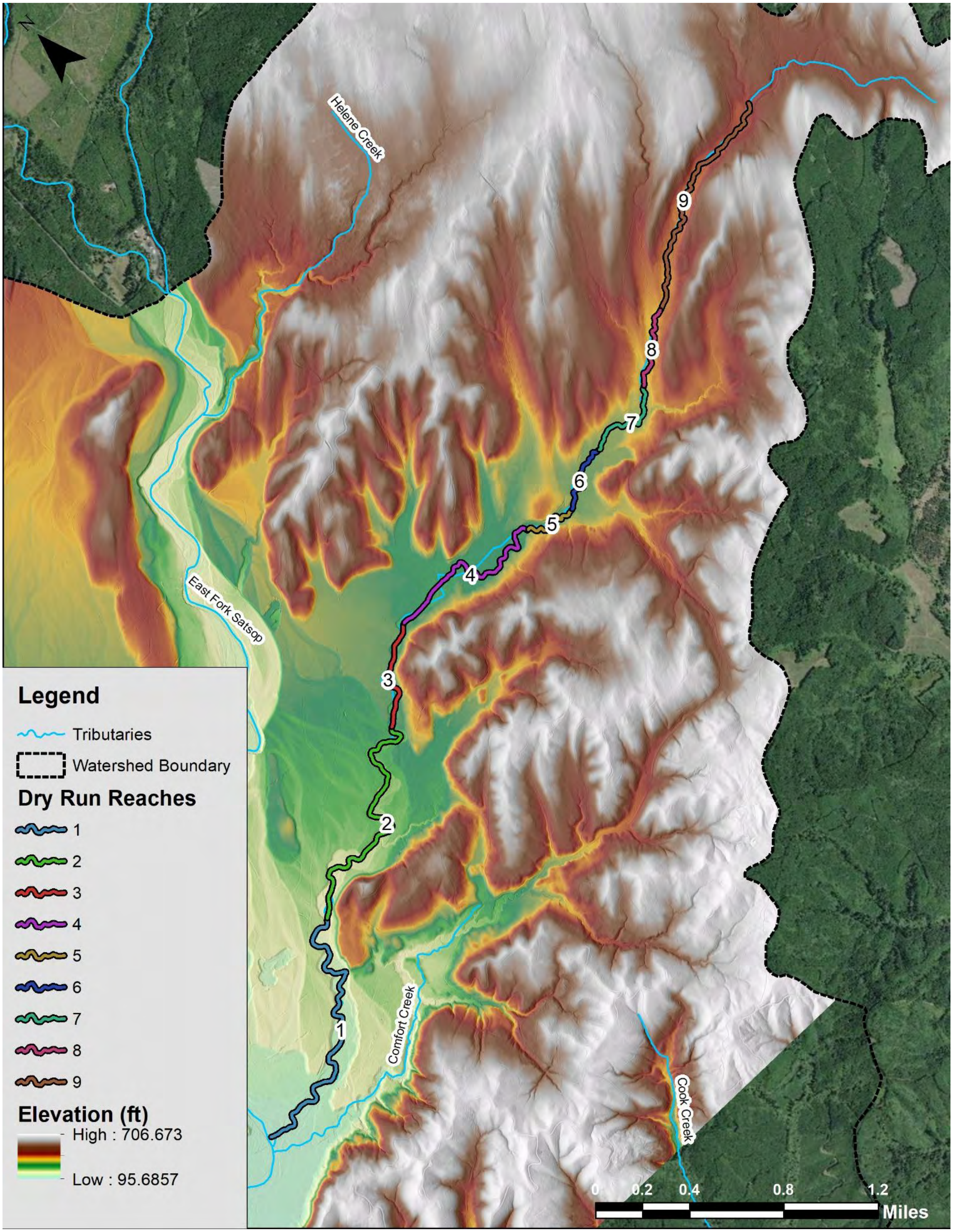


Figure 6. Overview map showing geomorphic reaches of Dry Run Creek.

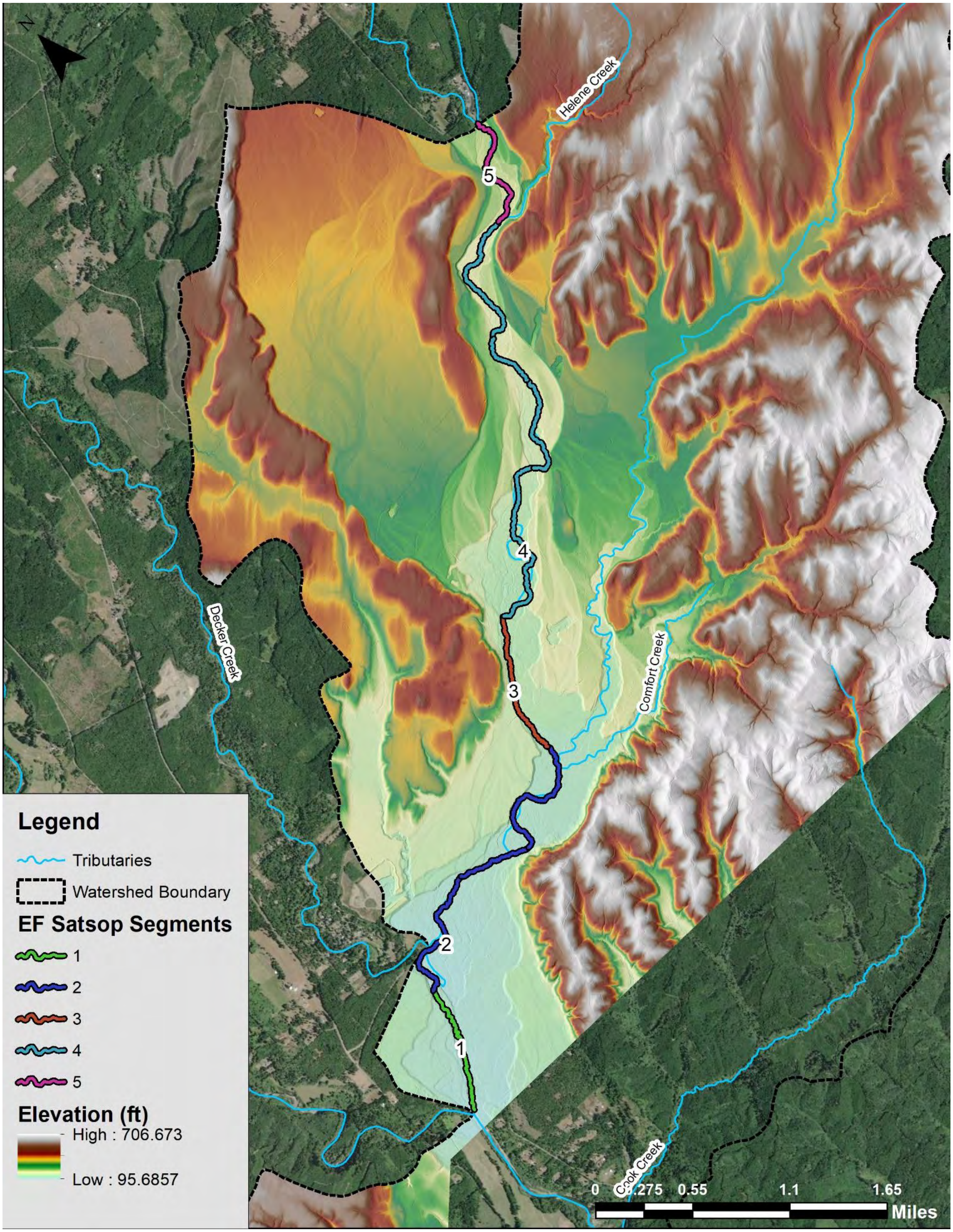


Figure 7. Overview map showing geomorphic segments of East Fork Satsop River.

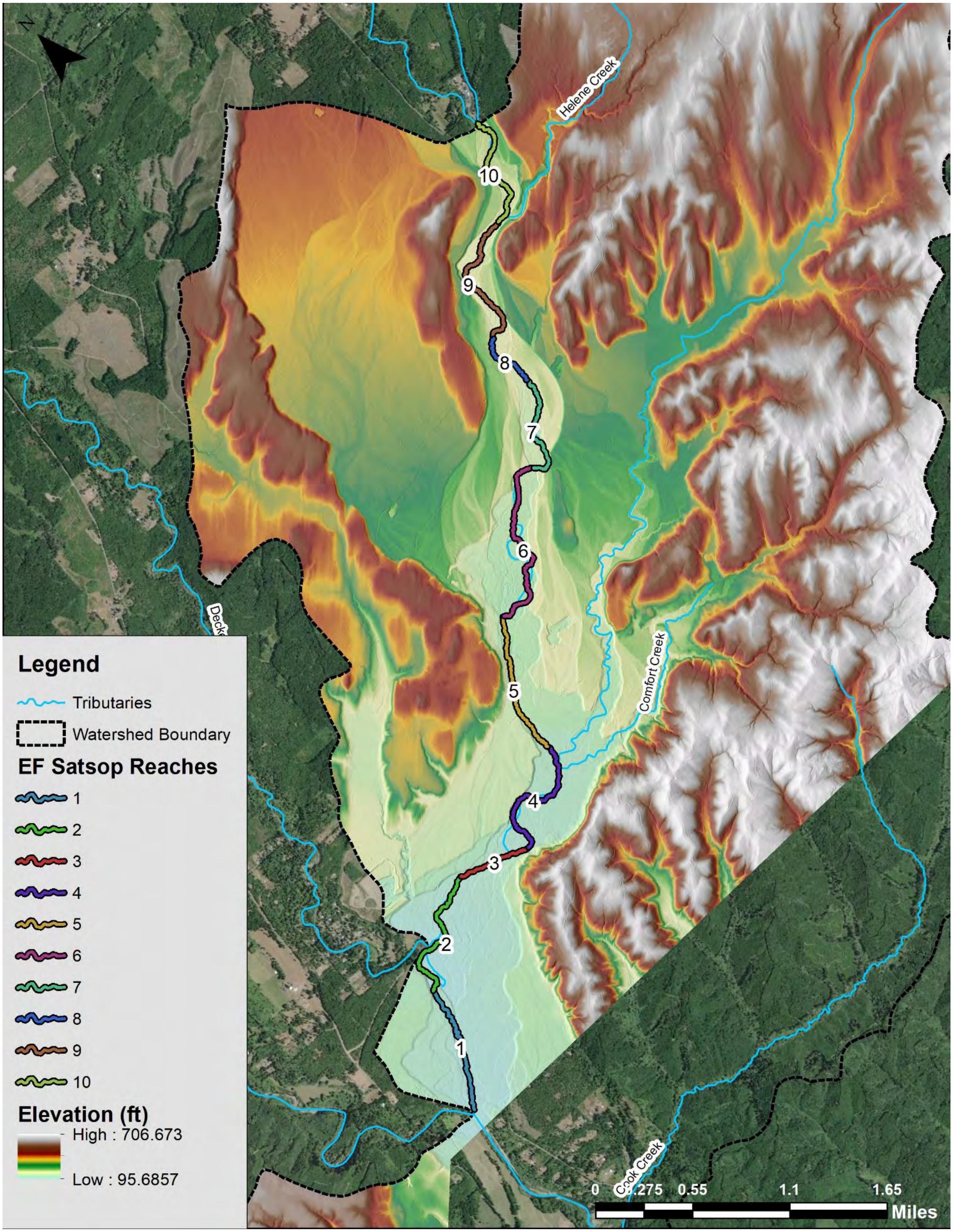


Figure 8. Overview map showing geomorphic reaches of East Fork Satsop River.

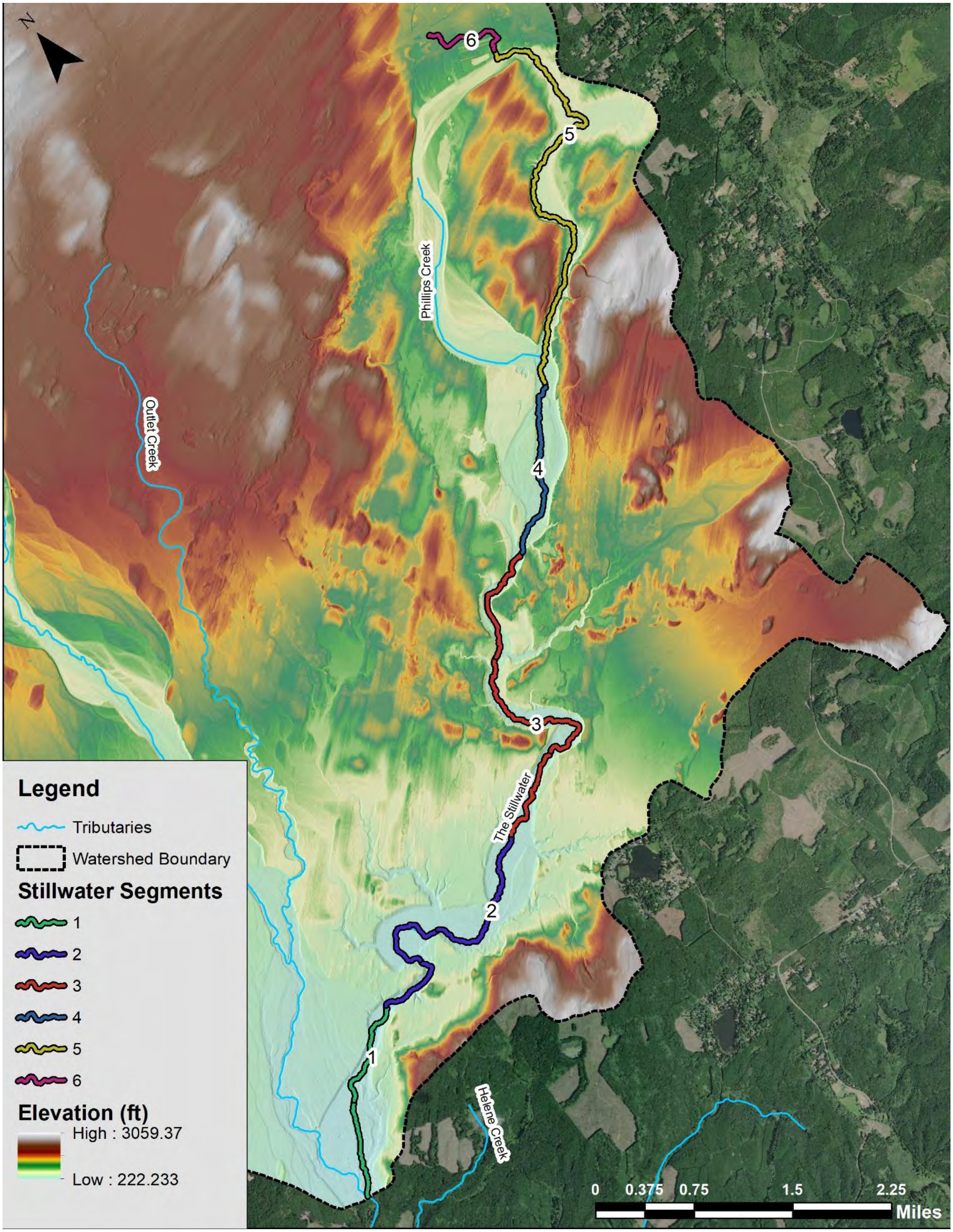


Figure 9. Overview map showing geomorphic segments of Stillwater Creek.

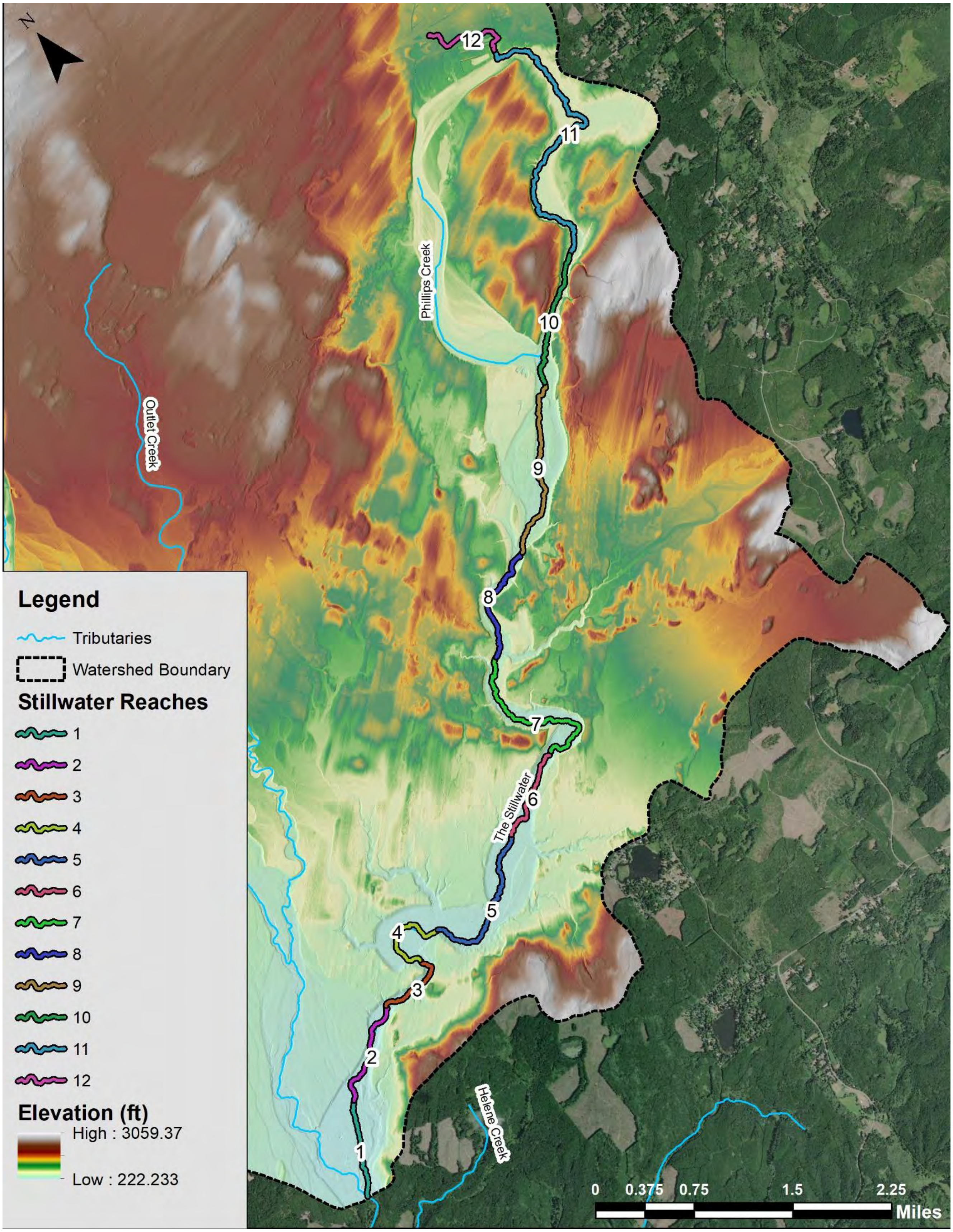


Figure 10. Overview map showing geomorphic reaches of Stillwater Creek.

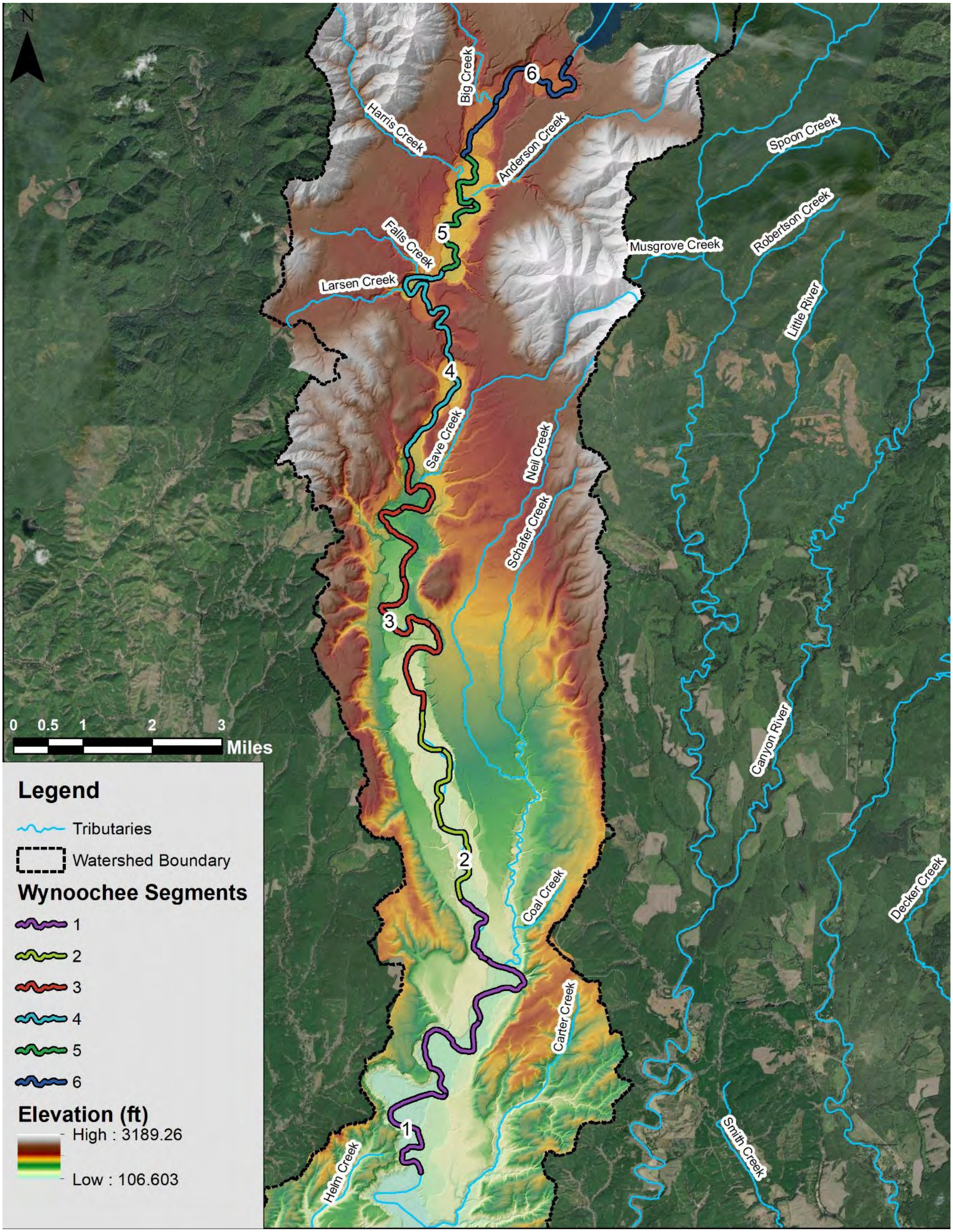


Figure 11. Overview map showing geomorphic segments of the Wynoochee River.

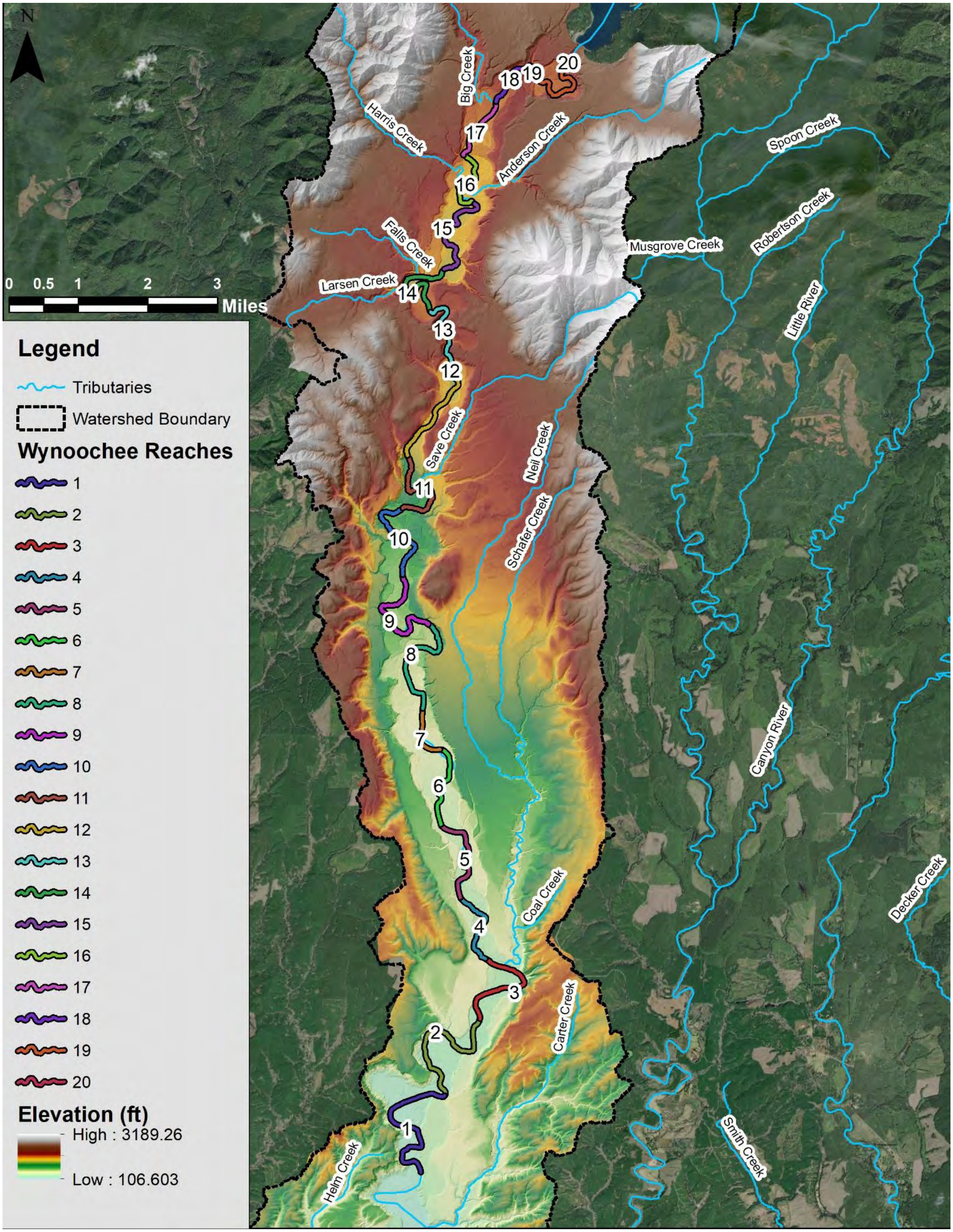


Figure 12. Overview map showing geomorphic reaches of the Wynoochee River.

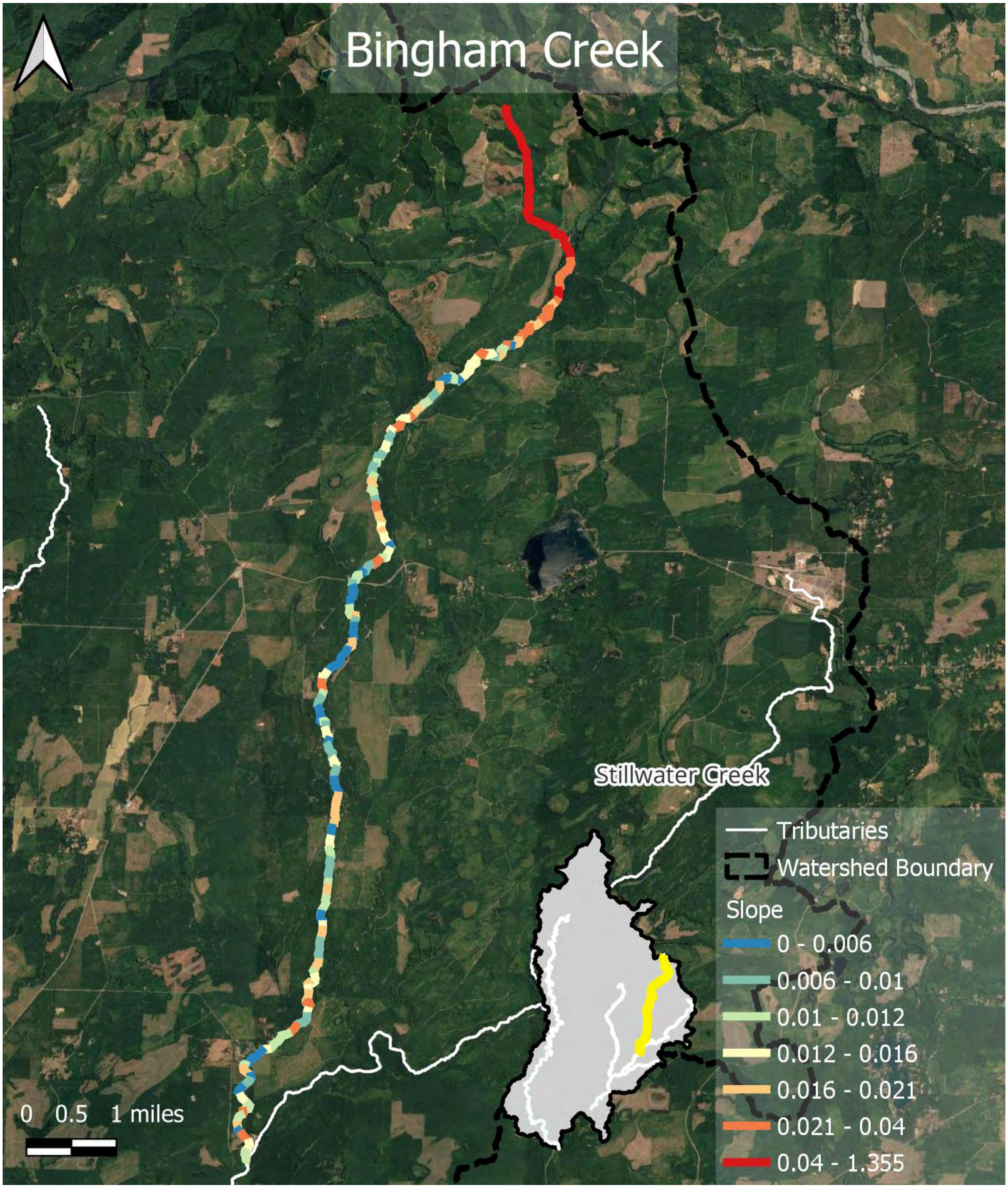


Figure 13. Overview map showing channel slope along the mainstem of Bingham Creek.

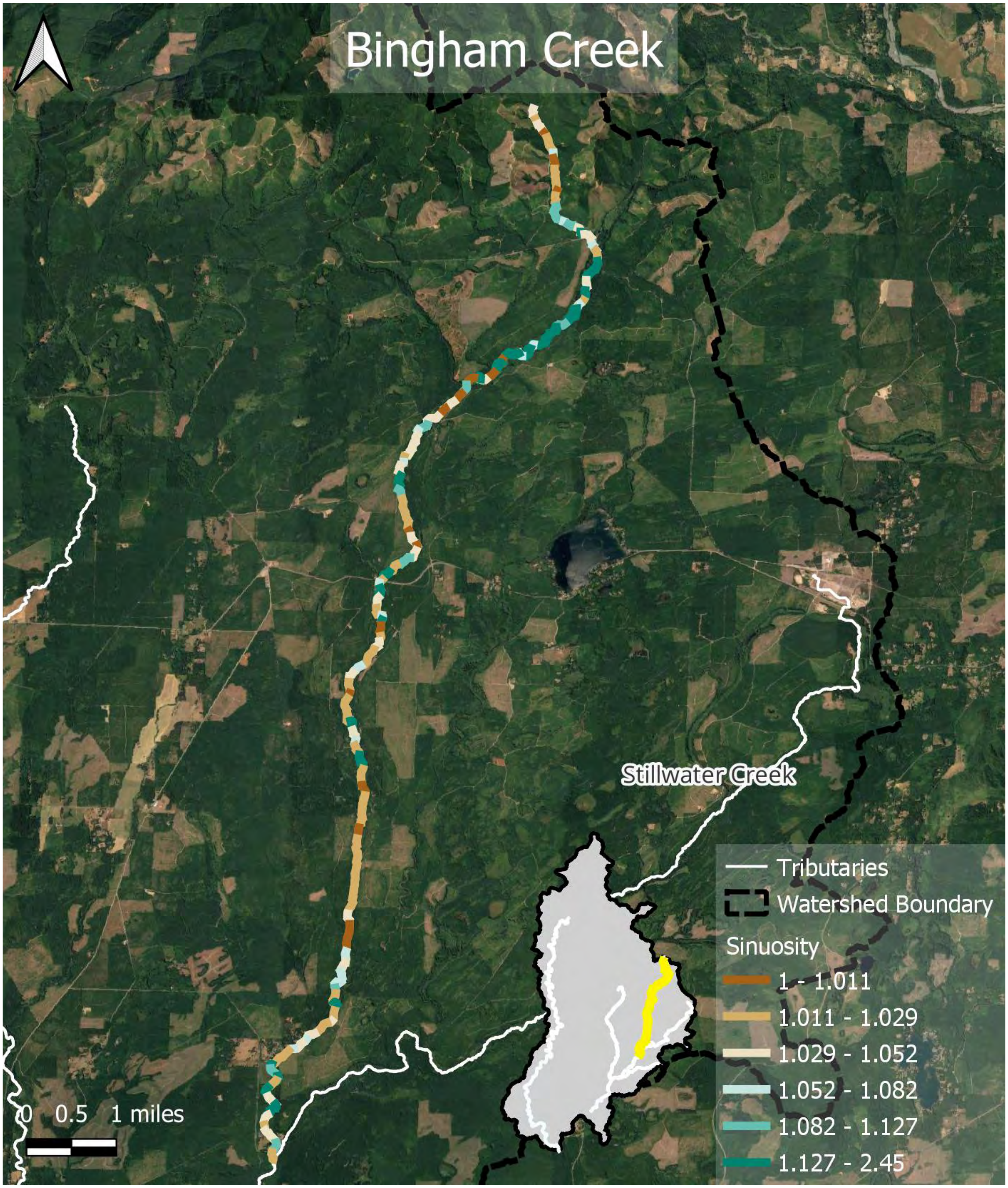


Figure 14. Overview map showing channel sinuosity along the mainstem of Bingham Creek.

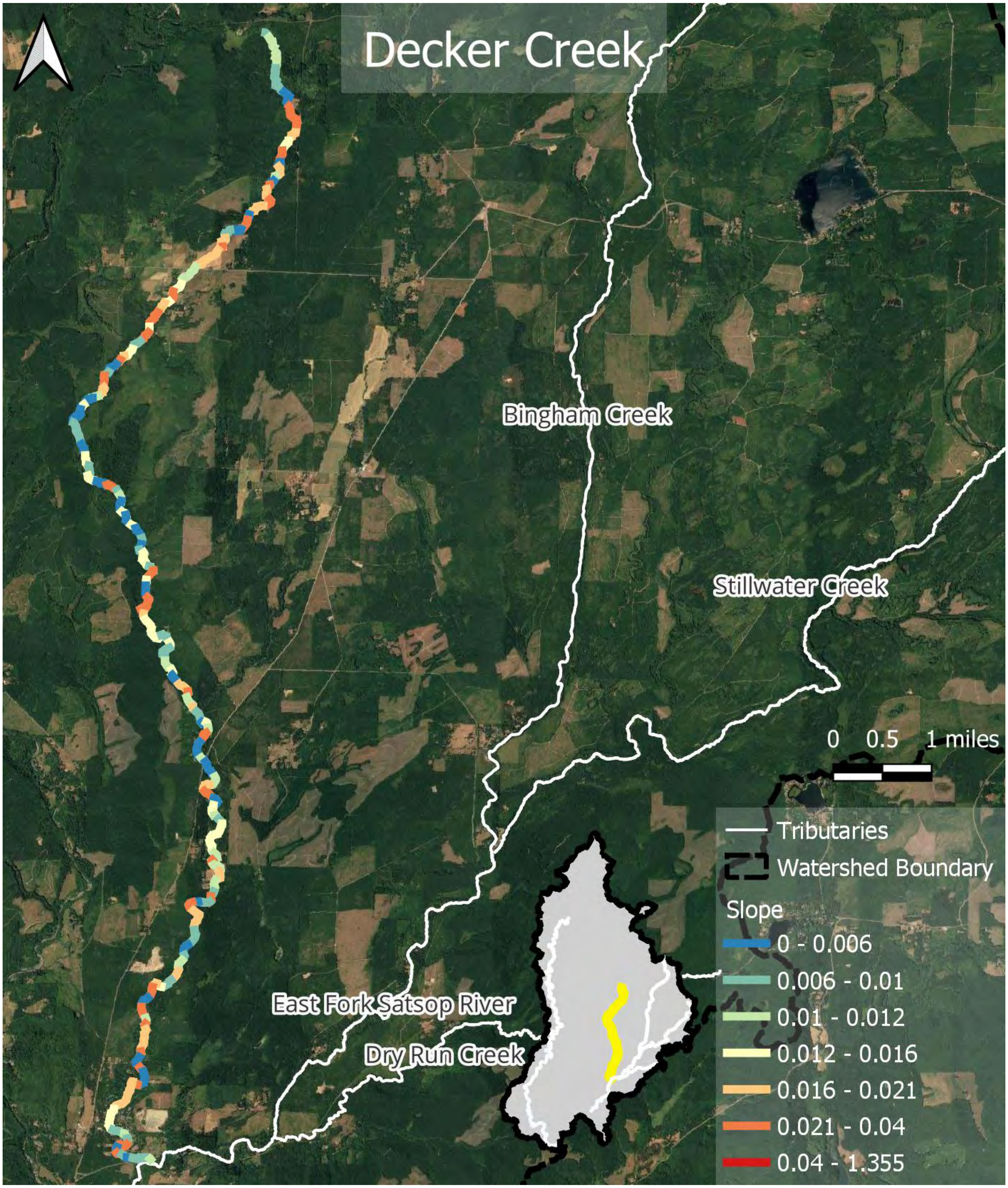


Figure 15. Overview map showing channel slope along the mainstem of Decker Creek.

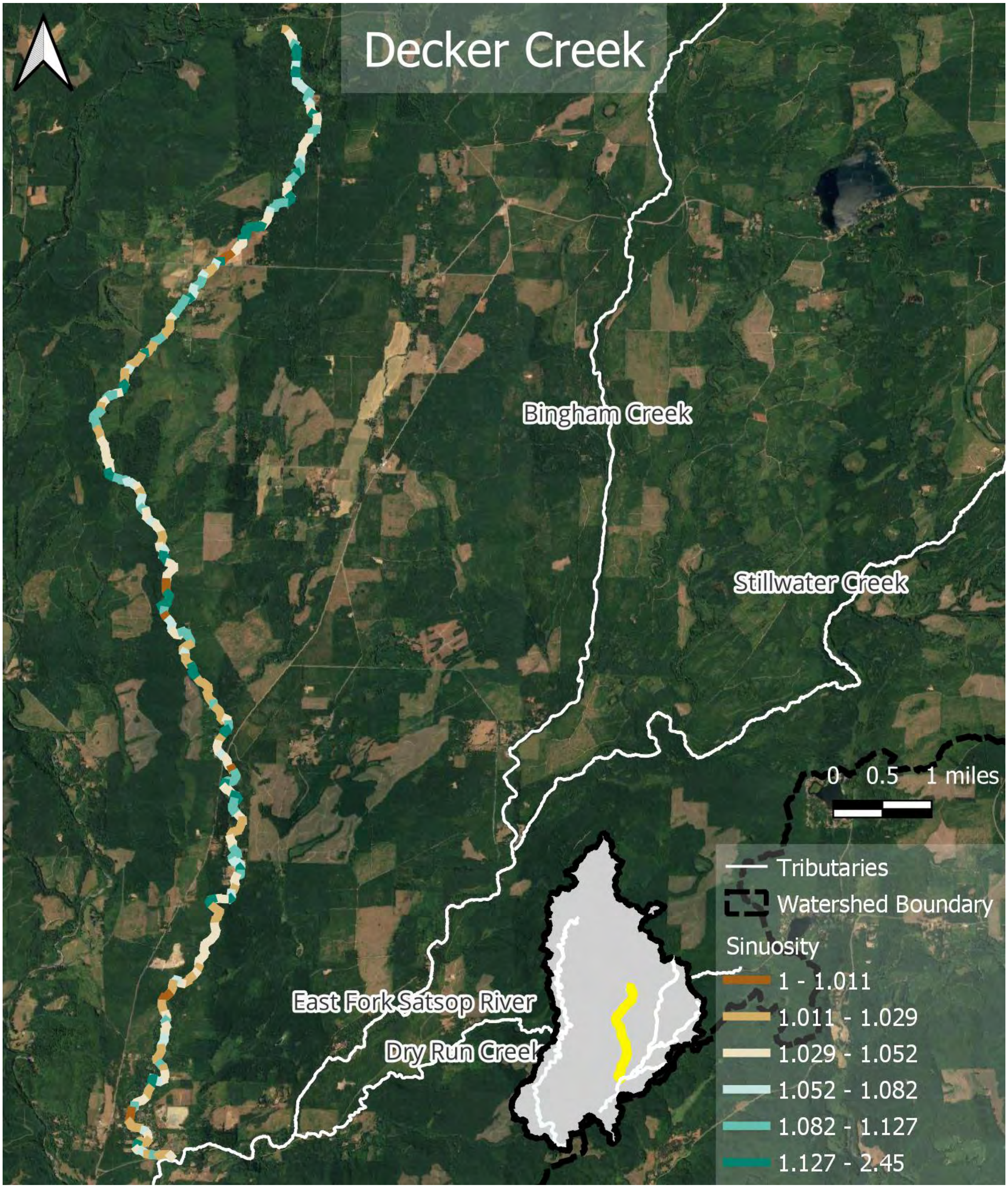


Figure 16. Overview map showing channel sinuosity along the mainstem of Decker Creek.

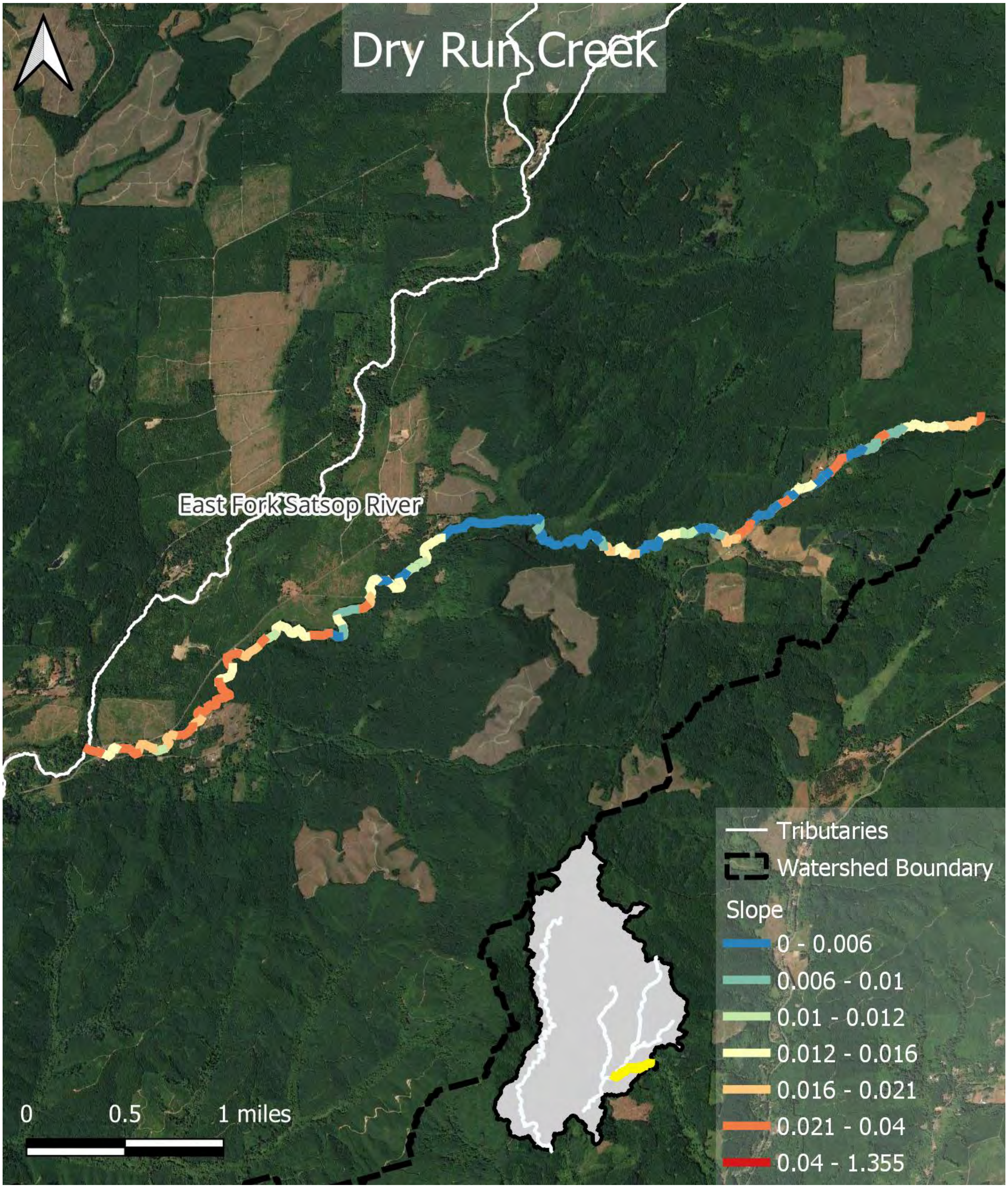


Figure 17. Overview map showing channel slope along the mainstem of Dry Run Creek.

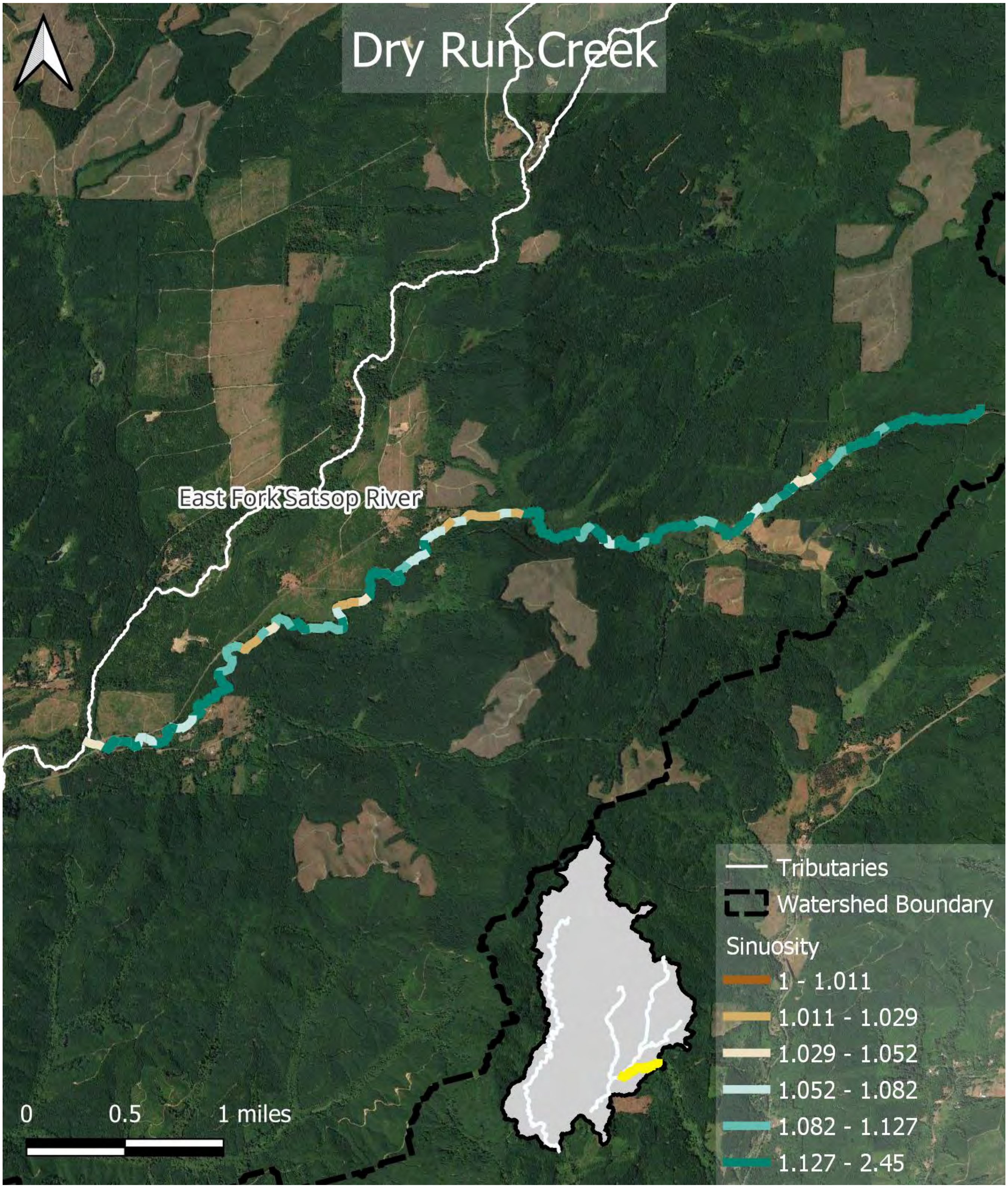


Figure 18. Overview map showing channel sinuosity along the mainstem of Dry Run Creek.

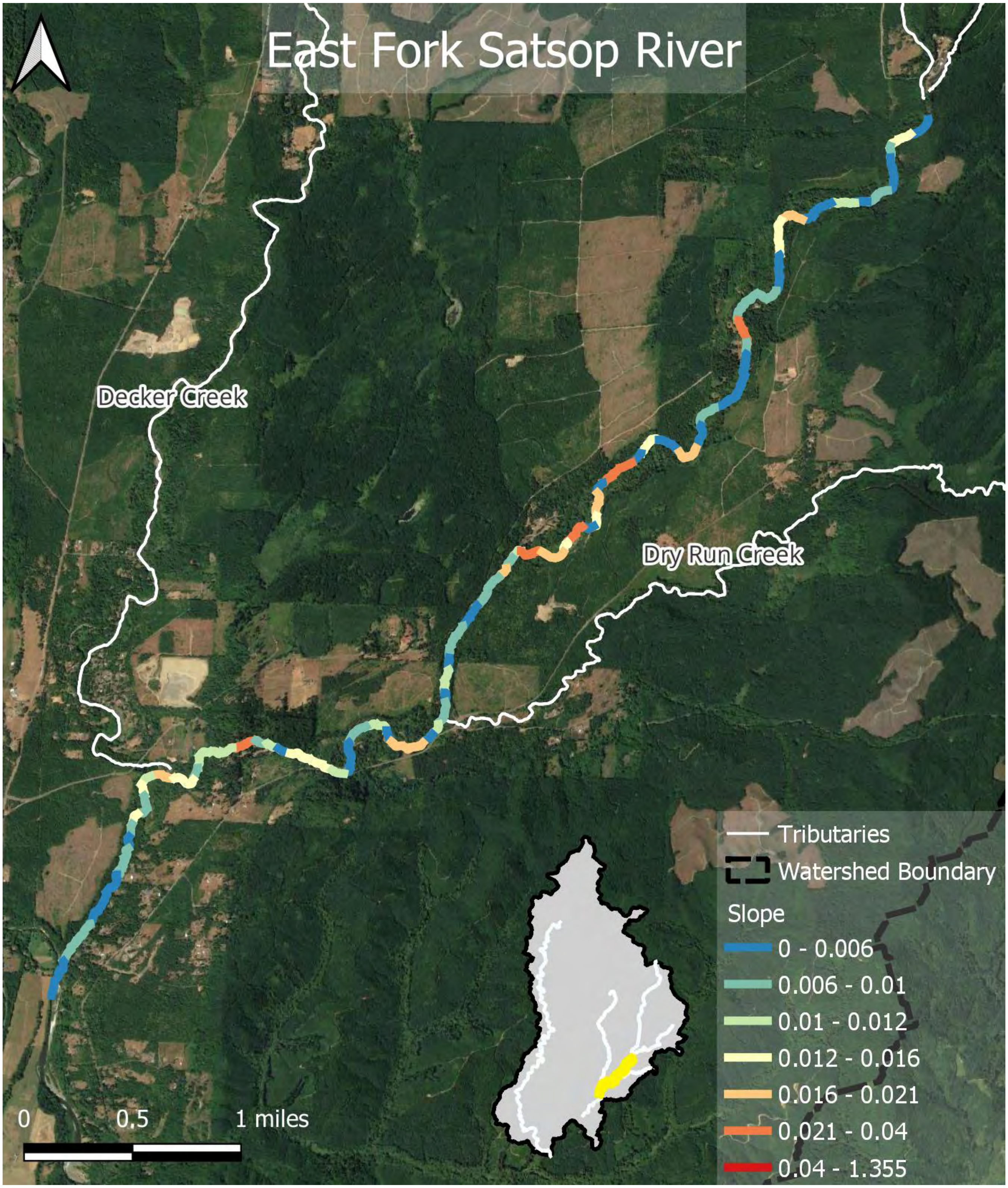


Figure 19. Overview map showing channel slope along the mainstem of the East Fork Satsop River.

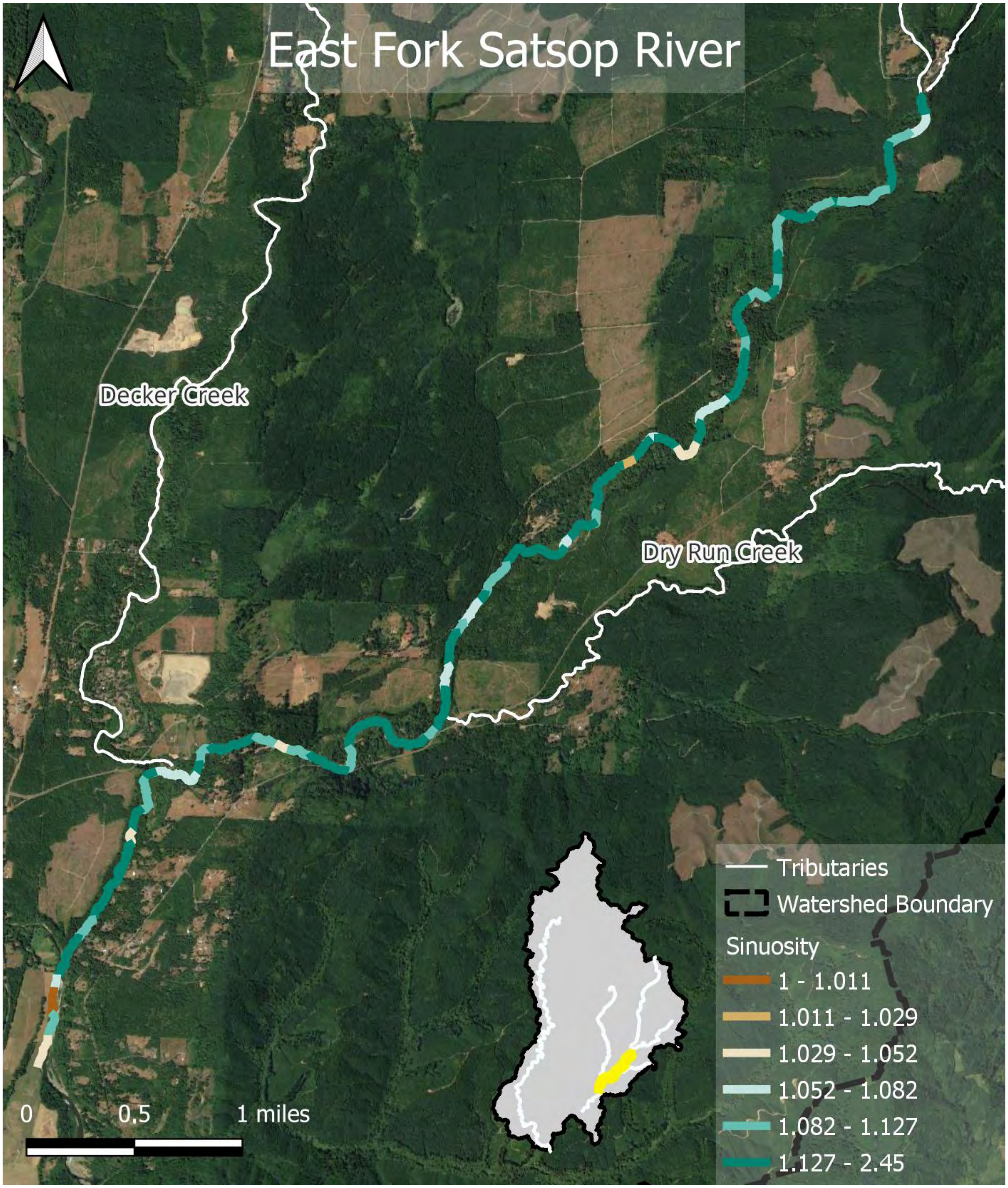


Figure 20. Overview map showing channel sinuosity along the mainstem of the East Fork Satsop River.

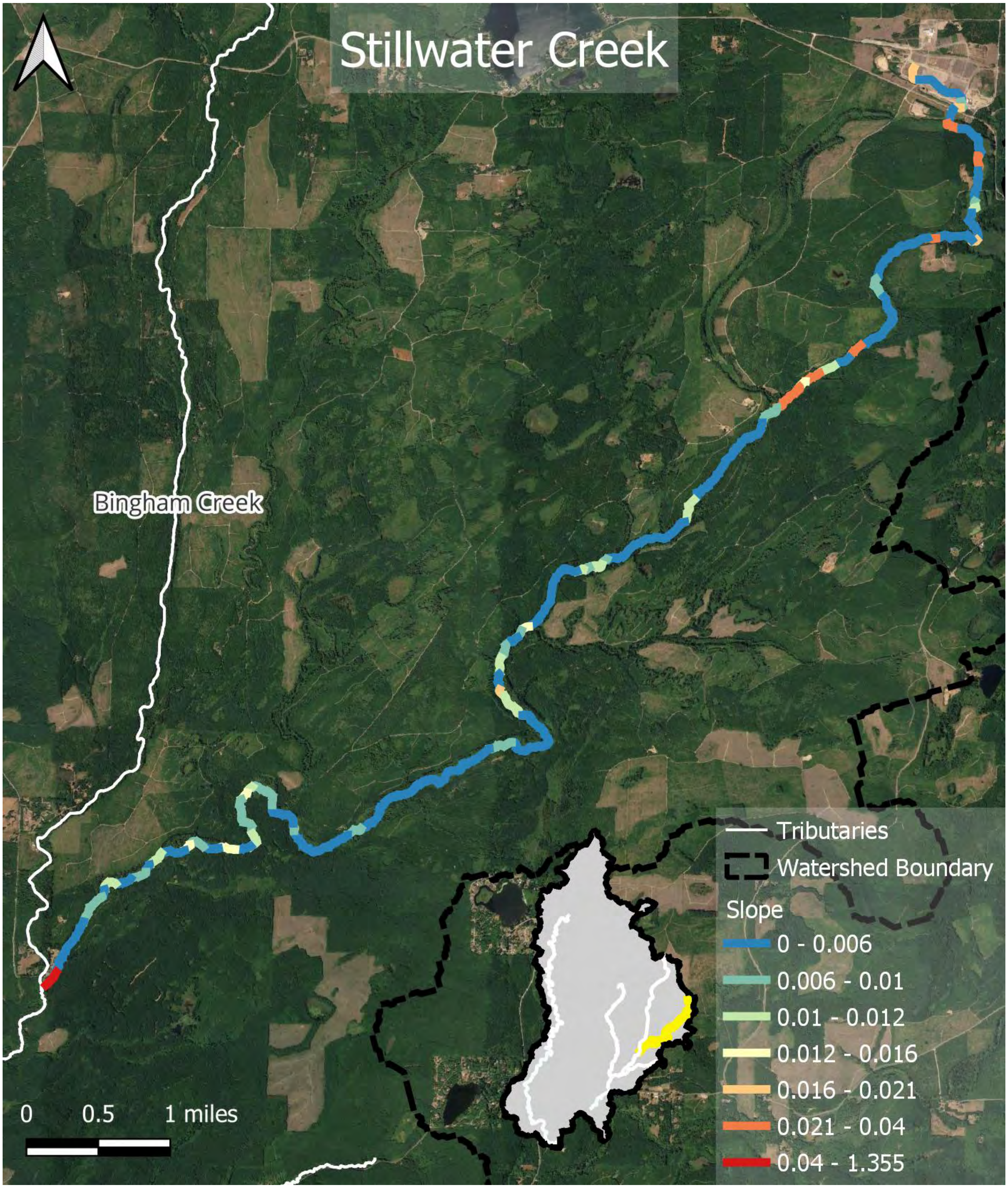


Figure 21. Overview map showing channel slope along the mainstem of Stillwater Creek.

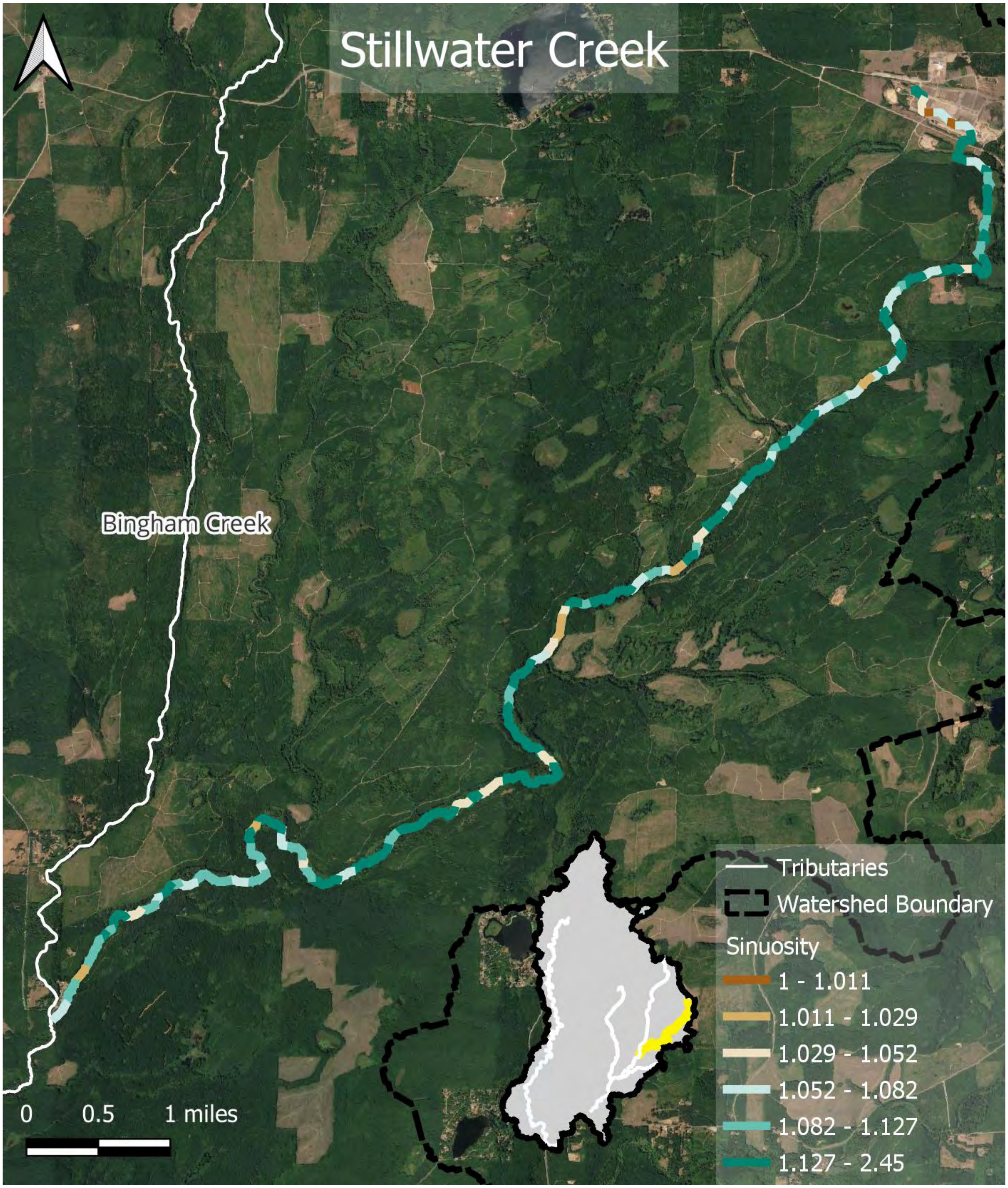


Figure 22. Overview map showing channel sinuosity along the mainstem of Stillwater Creek.

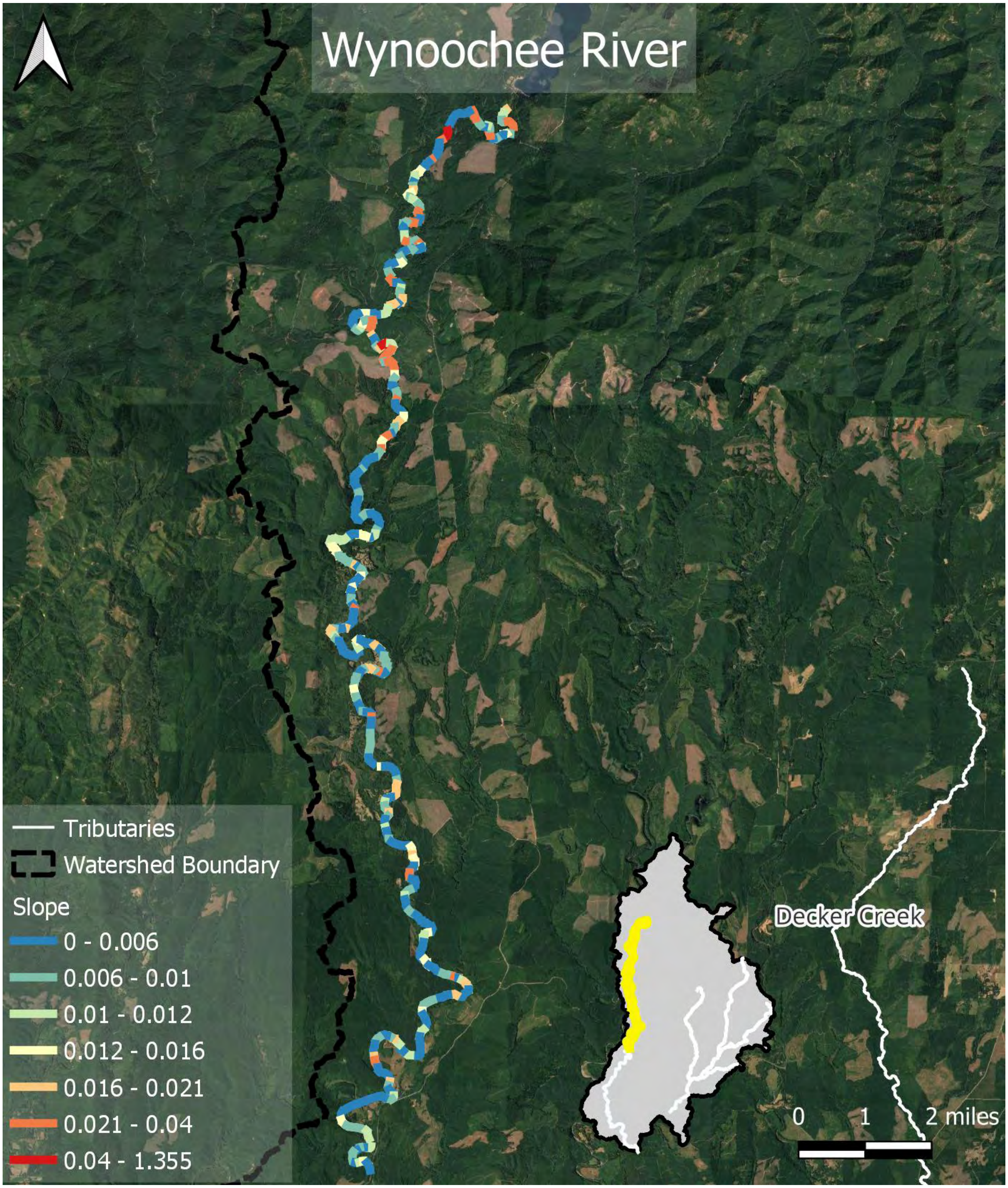


Figure 23. Overview map showing channel slope along the mainstem of the Wynoochee River.

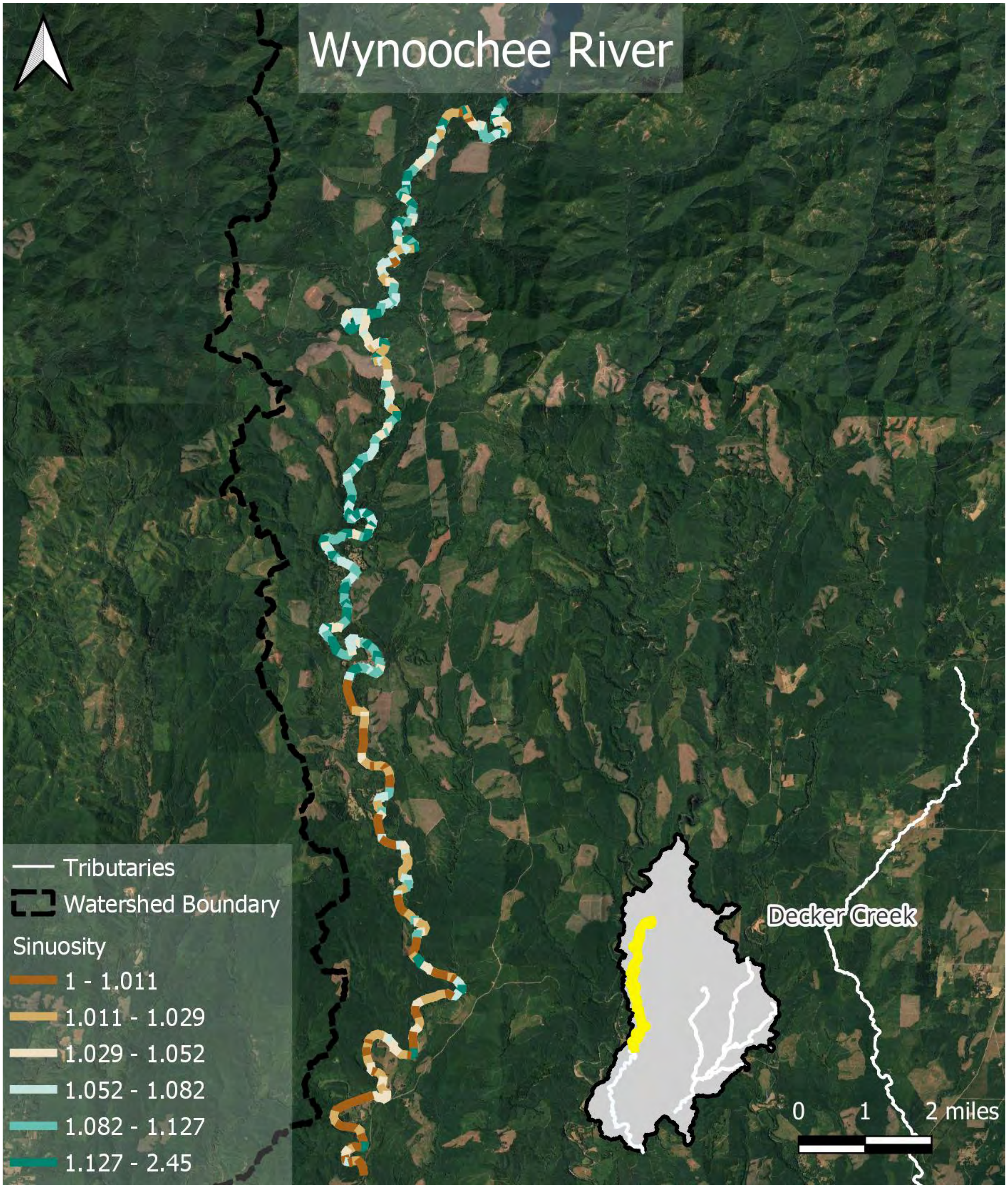
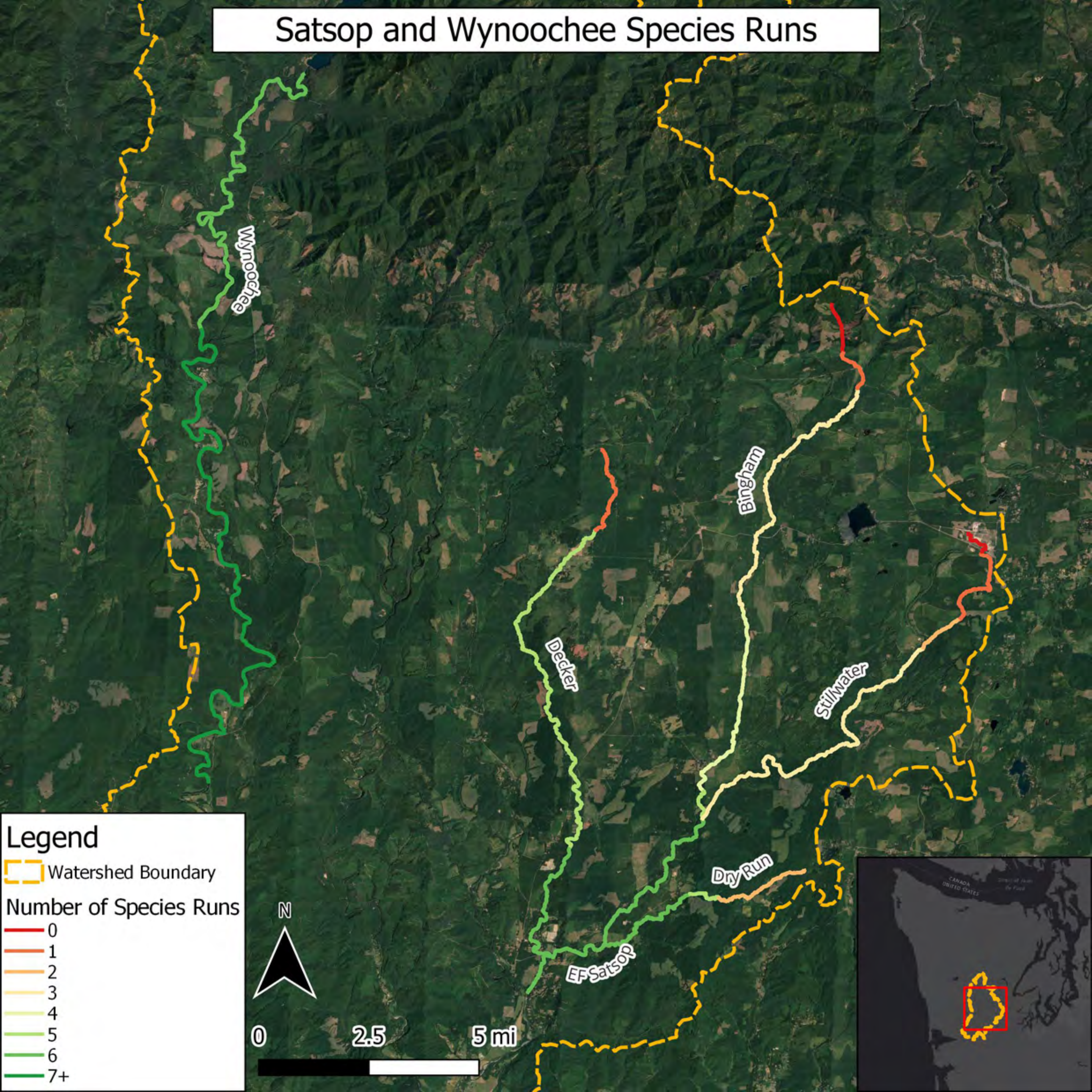
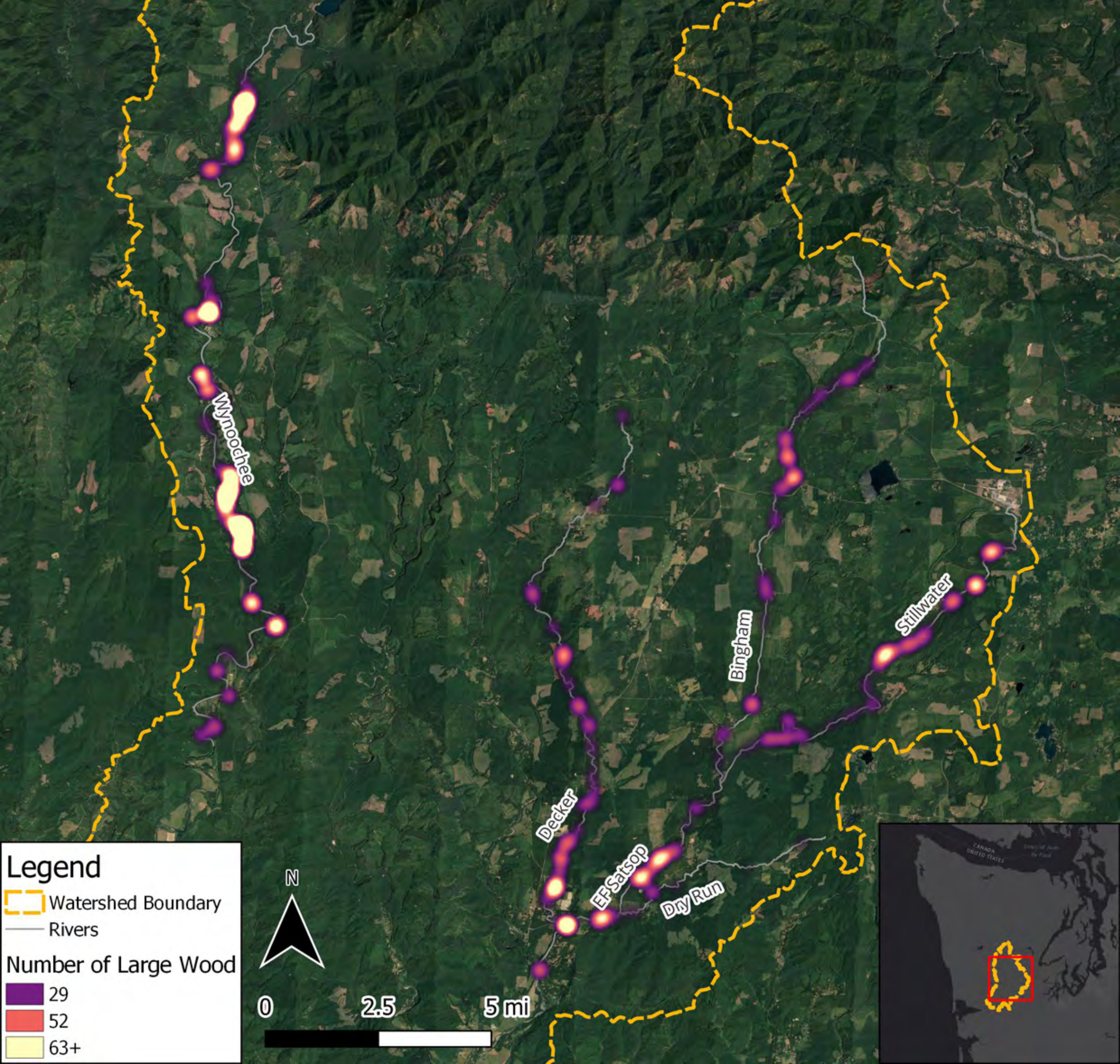


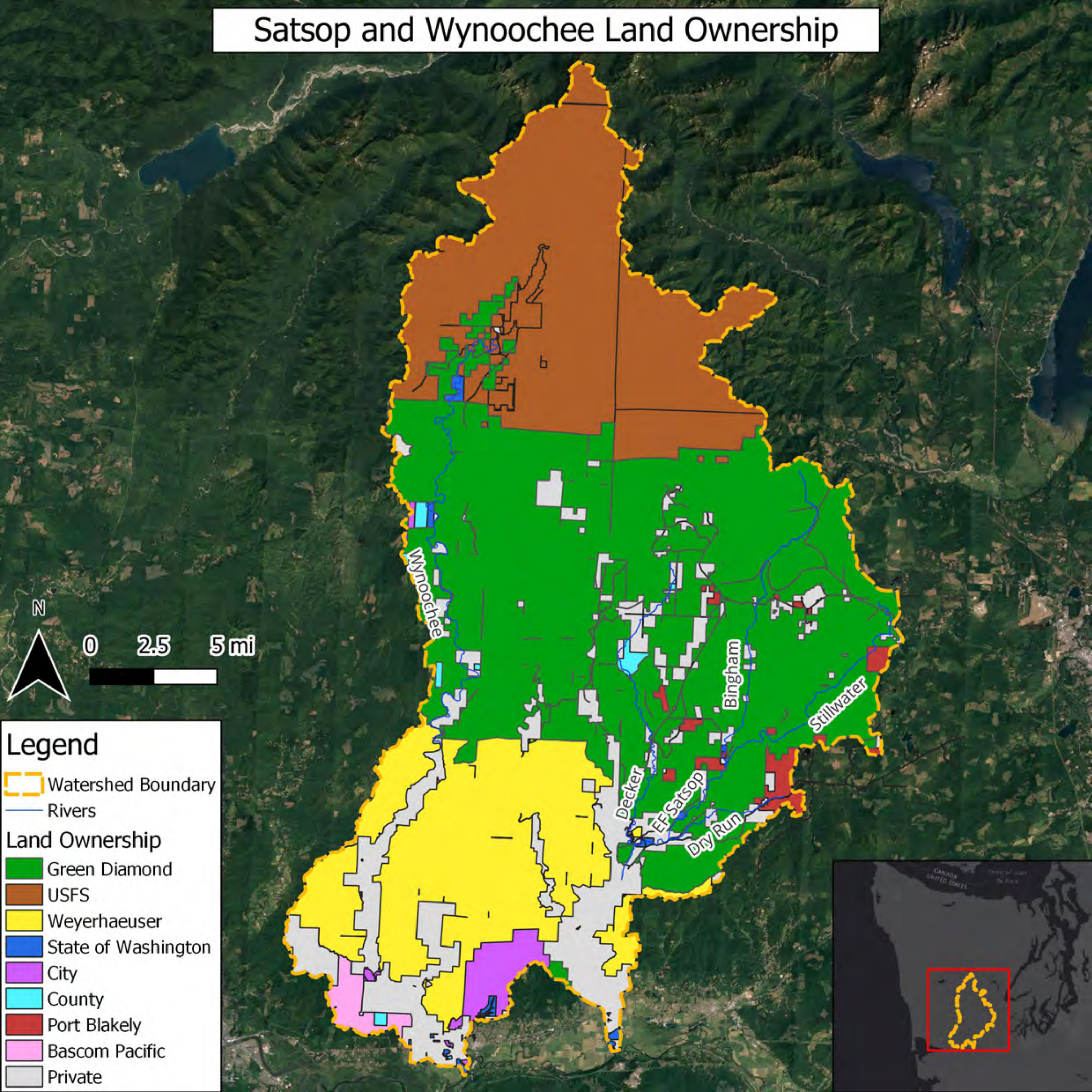
Figure 24. Overview map showing channel sinuosity along the mainstem of the Wynoochee River.



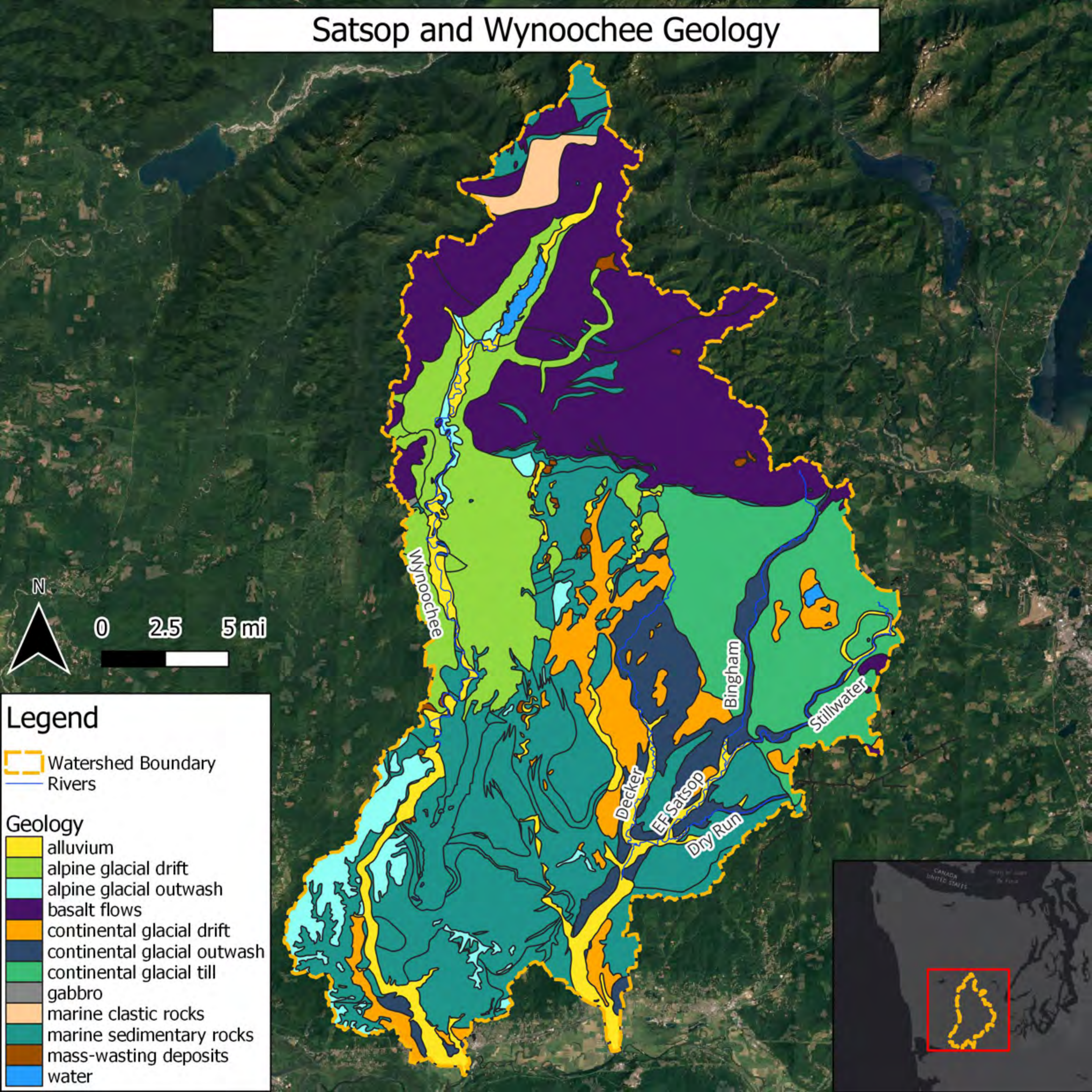
Satsop and Wynoochee Species Runs
Wynoochee
Decker
Bingham
Stillwater
Dry Run
EF Satsop
N
0
2.5
5 mi
Legend
Watershed Boundary
Number of Species Runs
0
1
2
3
4
5
6
7+

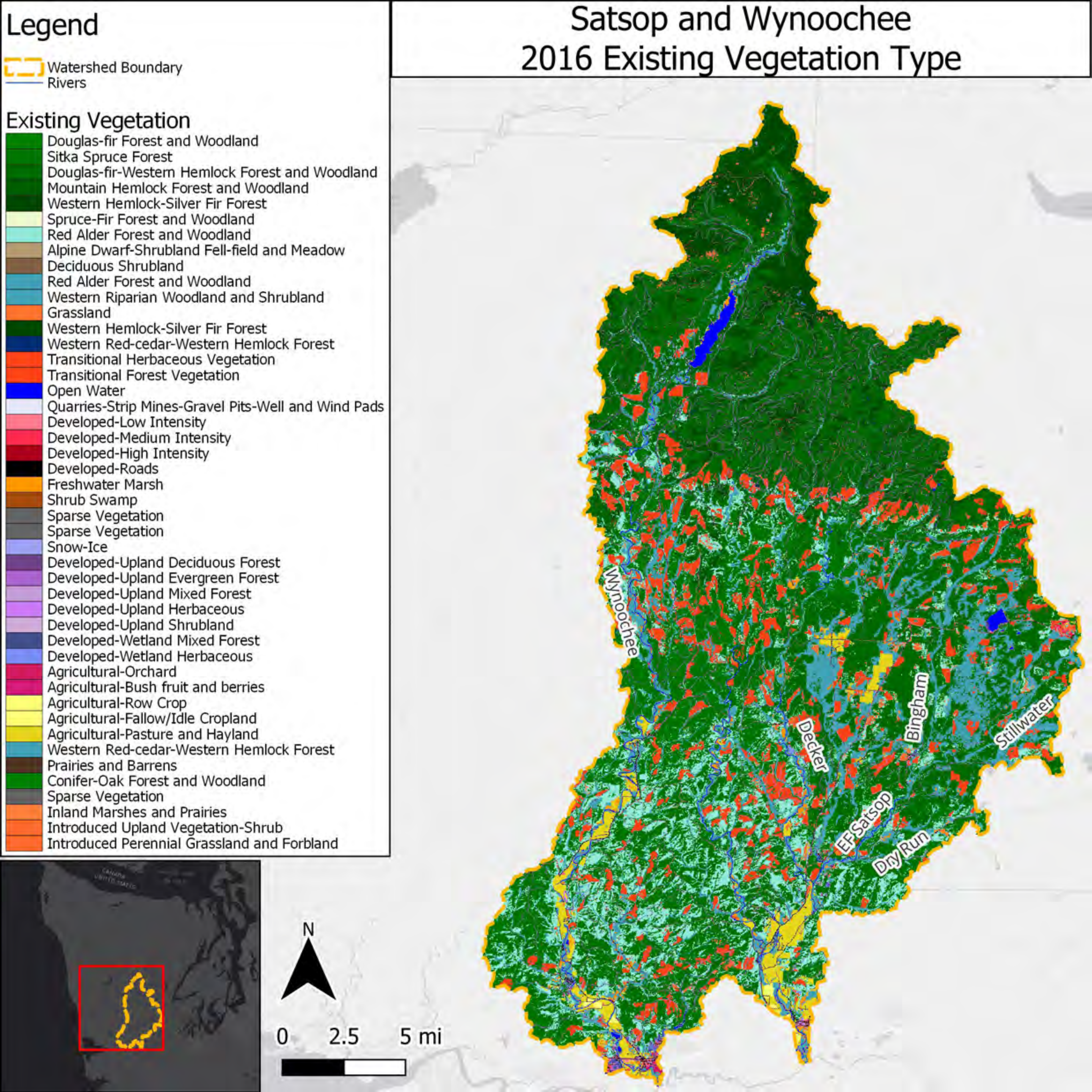
Satsop and Wynoochee Large Wood



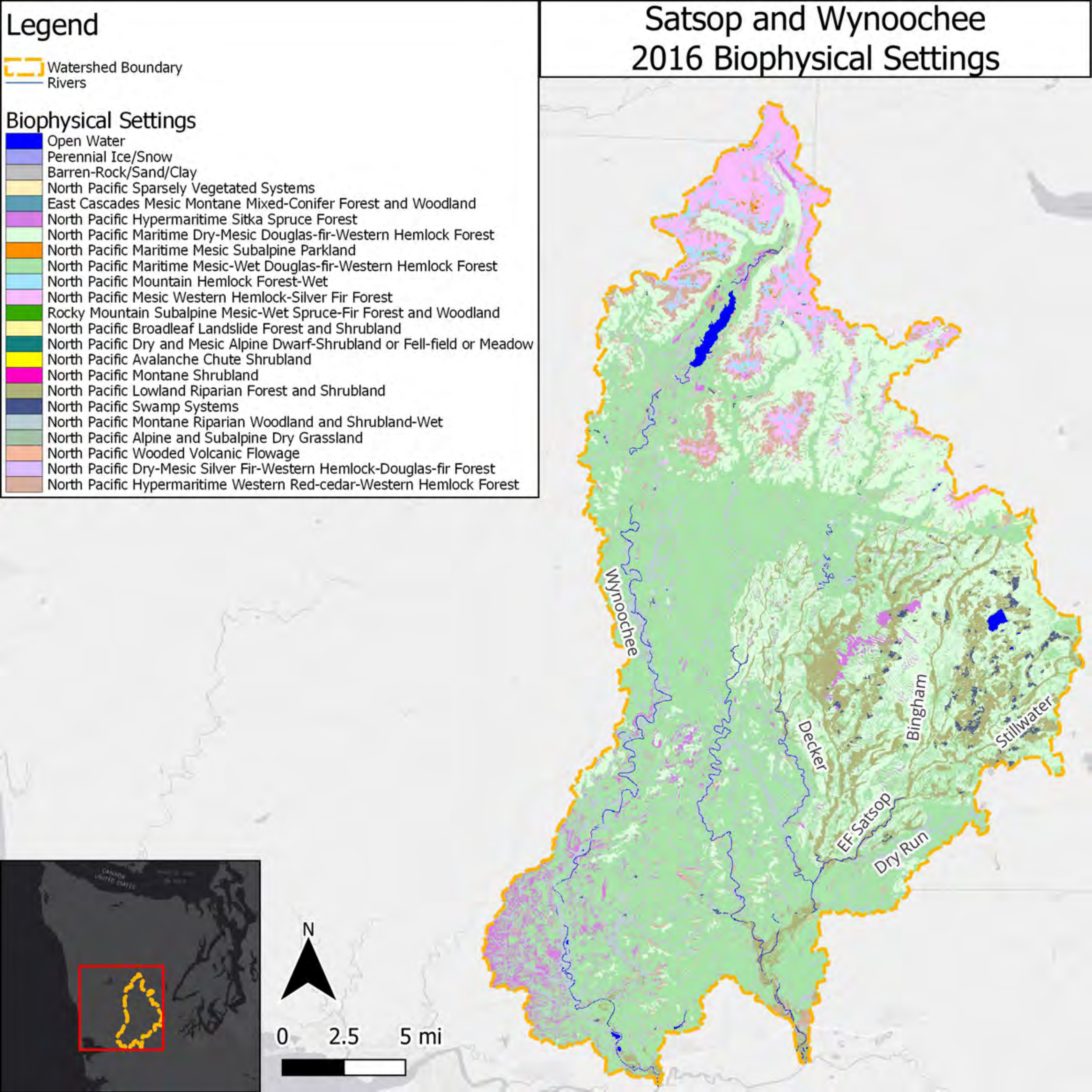


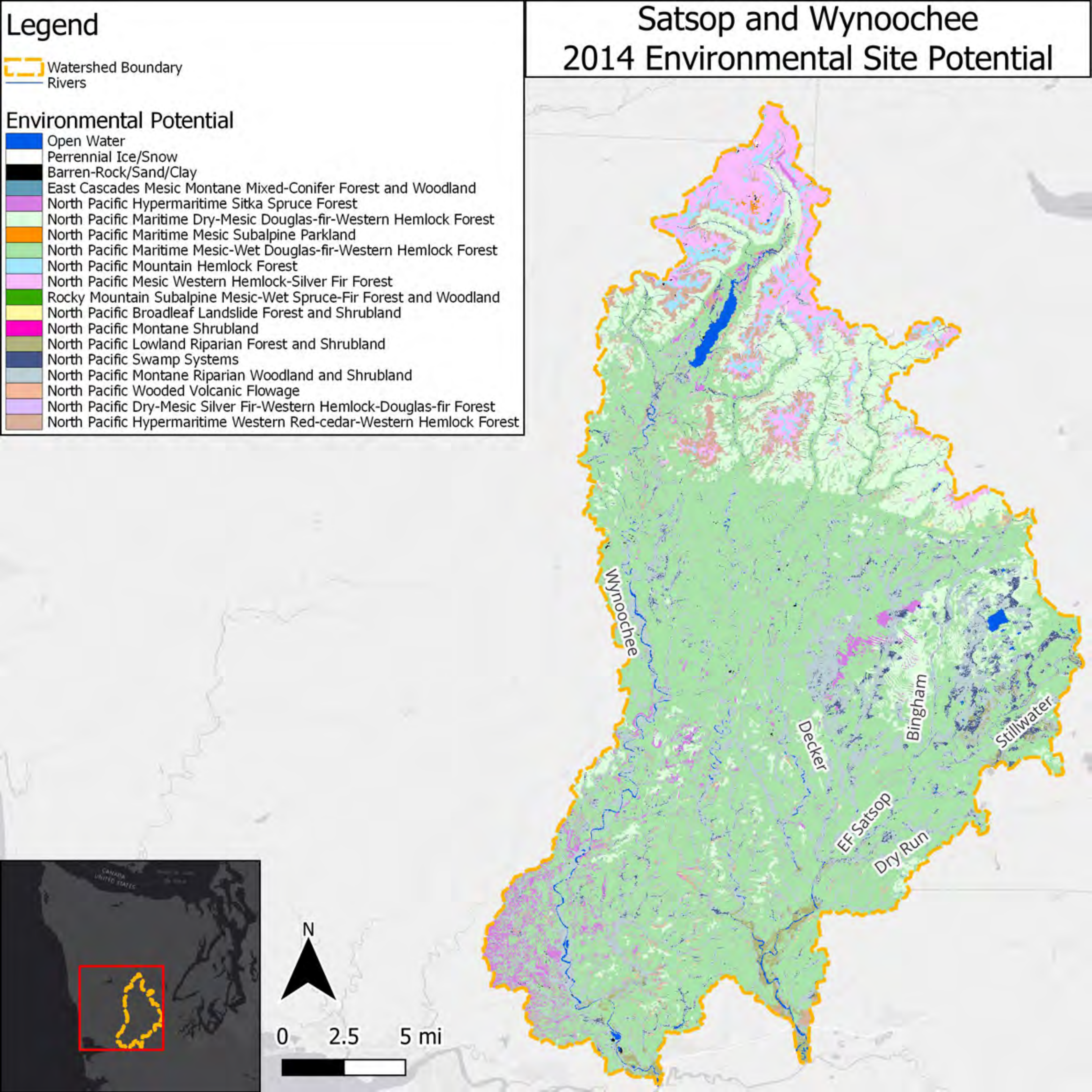
Satsop and Wynoochee Land Ownership
N
0
2.5
5 mi
Wynoochee
Bingham
Stillwater
Decker
EF Satsop
Dry Run
Legend
Watershed Boundary
Rivers
Land Ownership
Green Diamond
USFS
Weyerhaeuser
State of Washington
City
County
Port Blakely
Bascom Pacific
Private


Satsop and Wynoochee Geology
N
0
2.5
5 mi
Legend
Watershed Boundary
Rivers
Geology
alluvium
alpine glacial drift
alpine glacial outwash
basalt flows
continental glacial drift
continental glacial outwash
continental glacial till
gabbro
marine clastic rocks
marine sedimentary rocks
mass-wasting deposits
water
Wynoochee
Bingham
Stillwater
Decker
EF Satsop
Dry Run



Satsop and Wynoochee
2016 Existing Vegetation Type
Legend
Watershed Boundary
Rivers
Existing Vegetation
Douglas-fir Forest and Woodland
Sitka Spruce Forest
Douglas-fir-Western Hemlock Forest and Woodland
Mountain Hemlock Forest and Woodland
Western Hemlock-Silver Fir Forest
Spruce-Fir Forest and Woodland
Red Alder Forest and Woodland
Alpine Dwarf-Shrubland Fell-field and Meadow
Deciduous Shrubland
Red Alder Forest and Woodland
Western Riparian Woodland and Shrubland
Grassland
Western Hemlock-Silver Fir Forest
Western Red-cedar-Western Hemlock Forest
Transitional Herbaceous Vegetation
Transitional Forest Vegetation
Open Water
Quarries-Strip Mines-Gravel Pits-Well and Wind Pads
Developed-Low Intensity
Developed-Medium Intensity
Developed-High Intensity
Developed-Roads
Freshwater Marsh
Shrub Swamp
Sparse Vegetation
Sparse Vegetation
Snow-Ice
Developed-Upland Deciduous Forest
Developed-Upland Evergreen Forest
Developed-Upland Mixed Forest
Developed-Upland Herbaceous
Developed-Upland Shrubland
Developed-Wetland Mixed Forest
Developed-Wetland Herbaceous
Agricultural-Orchard
Agricultural-Bush fruit and berries
Agricultural-Row Crop
Agricultural-Fallow/Idle Cropland
Agricultural-Pasture and Hayland
Western Red-cedar-Western Hemlock Forest
Prairies and Barrens
Conifer-Oak Forest and Woodland
Sparse Vegetation
Inland Marshes and Prairies
Introduced Upland Vegetation-Shrub
Introduced Perennial Grassland and Forbland
Wynoochee
Decker
Bingham
Stillwater
EF Satsop
Dry Run
N
0
2.5
5 mi


Legend
Watershed Boundary
Rivers
Biophysical Settings
Open Water
Perennial Ice/Snow
Barren-Rock/Sand/Clay
North Pacific Sparsely Vegetated Systems
East Cascades Mesic Montane Mixed-Conifer Forest and Woodland
North Pacific Hypermaritime Sitka Spruce Forest
North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest
North Pacific Maritime Mesic Subalpine Parkland
North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest
North Pacific Mountain Hemlock Forest-Wet
North Pacific Mesic Western Hemlock-Silver Fir Forest
Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland
North Pacific Broadleaf Landslide Forest and Shrubland
North Pacific Dry and Mesic Alpine Dwarf-Shrubland or Fell-field or Meadow
North Pacific Avalanche Chute Shrubland
North Pacific Montane Shrubland
North Pacific Lowland Riparian Forest and Shrubland
North Pacific Swamp Systems
North Pacific Montane Riparian Woodland and Shrubland-Wet
North Pacific Alpine and Subalpine Dry Grassland
North Pacific Wooded Volcanic Flowage
North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest
North Pacific Hypermaritime Western Red-cedar-Western Hemlock Forest
Satsop and Wynoochee
2016 Biophysical Settings
Wynoochee
Decker
Bingham
Stillwater
EF Satsop
Dry Run
N
0
2.5
5 mi


Satsop and Wynoochee
2014 Environmental Site Potential
Legend
Watershed Boundary
Rivers
Environmental Potential
Open Water
Perrennial Ice/Snow
Barren-Rock/Sand/Clay
East Cascades Mesic Montane Mixed-Conifer Forest and Woodland
North Pacific Hypermaritime Sitka Spruce Forest
North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest
North Pacific Maritime Mesic Subalpine Parkland
North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest
North Pacific Mountain Hemlock Forest
North Pacific Mesic Western Hemlock-Silver Fir Forest
Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland
North Pacific Broadleaf Landslide Forest and Shrubland
North Pacific Montane Shrubland
North Pacific Lowland Riparian Forest and Shrubland
North Pacific Swamp Systems
North Pacific Montane Riparian Woodland and Shrubland
North Pacific Wooded Volcanic Flowage
North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest
North Pacific Hypermaritime Western Red-cedar-Western Hemlock Forest
Wynoochee
Decker
Bingham
Stillwater
EF Satsop
Dry Run
N
0
2.5
5 mi