



TECHNICAL MEMO (DRAFT)

DATE:	April 17, 2025
TO:	Cascadia Conservation District
FROM:	Lichen: Nick Legg, LG, Dominique Shore RSI: Gabe Williams, PE
PROJECT:	Roaring Creek Restoration Project
SUBJECT:	Conceptual Design - Alternatives Selection

1 Introduction

This memorandum (memo) summarizes the conceptual alternatives and selection process for the Roaring Creek Restoration Project. The project area includes river miles 1.4-2.8 of Roaring Creek, a major tributary of the Entiat River in Chelan County, Washington. The goals of the project are to reconnect floodplains, improve complexity, restore streamflow, and enhance habitat for listed salmonids, particularly steelhead as prioritized in the Upper Columbia Salmon Recovery Board's (UCSRB's) strategy. This memo introduces three potential design alternatives intended to address project goals and objectives.

Cascadia Conservation District (CCD) is leading and sponsoring the project with existing funding support from the Washington Department of Ecology and the US Forest Service. CCD is also seeking funding from Washington's Salmon Recovery Funding Board. Lichen Land and Water, Resource Specialists Inc., and Wolf Water Resources are leading the site evaluation and design engineering.

This memo is accompanied by two attachments:

A: Existing Conditions Maps

B: Conceptual Design Alternatives Plans

The information in this memorandum is planned for incorporation into the Preliminary (30%) Basis of Design Report, where more extensive project background will be included. Therefore, this memorandum may not provide all background material.

2 Site Description and Summary

2.1 Project Area Description

Roaring Creek is a right-bank tributary to the lower Entiat River, entering river mile 6.1 near the town of Farris, Washington. Restoration actions will be focused within river miles 1.4 – 2.8. The project area lies entirely with United States Forest Service (USFS) land and accessed by USFS road 110. The historical floodplain, which ranges from 40 to 300 feet, generally defines the lateral extents of the project area.

For the purposes of project design, the project reach has been subdivided into three sub-reaches (“upstream”, “middle”, and “downstream”) to account for the geomorphic differences within the project area. The upstream and downstream sub-reaches have wider valley bottoms whereas the middle reach is more naturally confined by hillslopes and related deposits. The upper and lower sub-reaches have historical floodplains averaging 180 feet in width and greater than 10 times the bankfull width. Floodplains in the middle reach are generally less than 80 feet with the exception of localized pocket floodplain areas that expand out to 150 feet.

2.2 Fish Use and Identified Priorities

Roaring Creek is identified as a priority for steelhead restoration and protection by the Upper Columbia Salmon Recovery (UCSRB, 2021). The reach has a documented spawning use in WDFW redd surveys and is categorized as a high priority assessment unit (AU) for adult migration, spawning, fry colonization, and summer rearing. The project area spans Roaring Creek Entiat Reaches 02 & 03. Low summer base flows are listed as an unacceptable limiting factor. Channel modification, instream enhancement, and upland management are identified as action categories.

Based on review of published fish use timing in nearby tributaries (Inter-Fluve and Yakama Nation, 2018), adult migration of steelhead primarily occurs from December – February with spawning following in the later winter-early summer and fry emergence within the summer. Potential rearing use is distributed throughout the year.

2.3 Summary of Existing Floodplain Conditions

The project reach currently suffers from the effects of relatively extreme incision and disconnection of the creek from its floodplain (Figure 1). For a vast majority of the floodplain segments, the creek is entrenched below its historical floodplain level by 5-6 feet, which exceeds the creek’s average bankfull depth (~1.5 feet) by a factor of three. The creek sits in an incision trench typically narrower than 20 feet wide, which is less than 2 times wider than the creek’s bankfull width of 13 feet. These basic statistics indicate the degree of entrenchment and diminished floodplain connection.

Within the incision trench, the creek has developed little adjacent (inset) floodplain since the original incision. Vegetation within the incision trench is young deciduous trees (<6 inches diameter). These patterns indicate the incision likely occurred within the post-settlement period, likely from beaver trapping/removal and localized land-use impacts including historical homesteading.

As a result of the incision, the stream is primarily single-threaded with little off-channel habitat or floodplain connectivity. The creek has an observed lack of large wood and pools and naturally has elevated stream power as a result of the entrenchment.

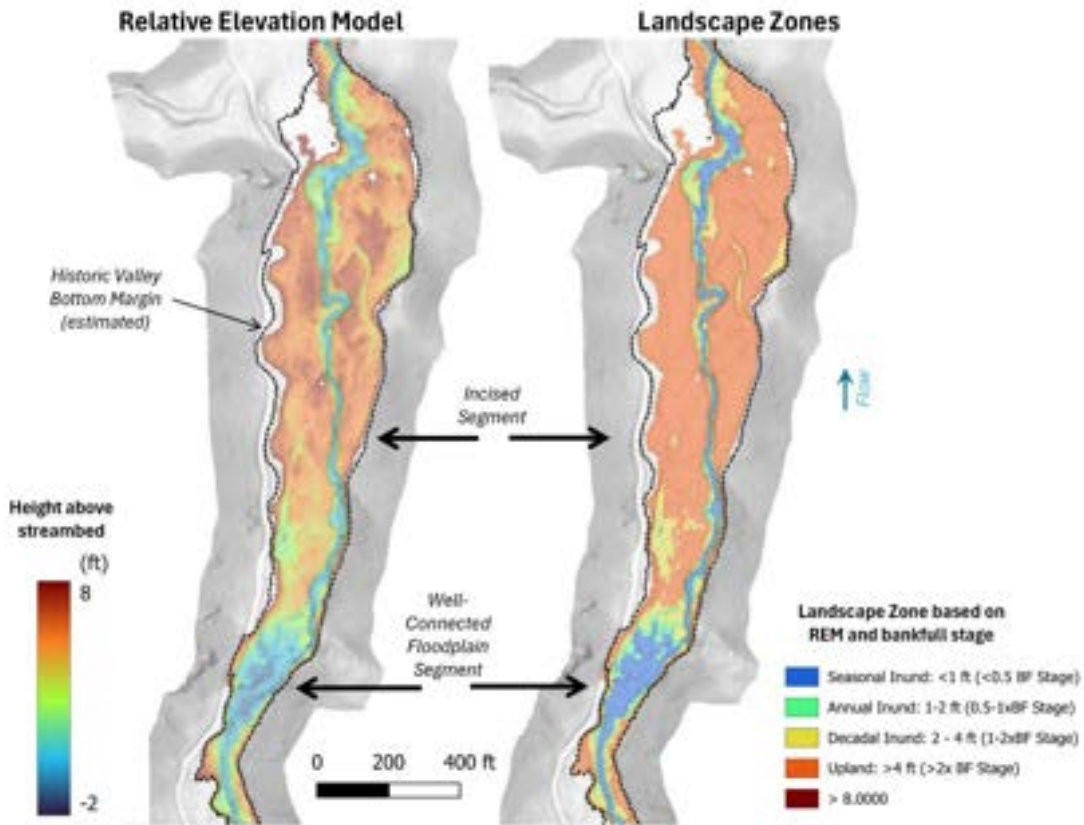


FIGURE 1: RELATIVE ELEVATION MAP OF THE LOWER SUB-REACH, SHOWING THE PERVASIVE DISCONNECTION OF THE FLOODPLAIN WITH EXCEPTION OF A SMALL SEGMENT OF FLOODPLAIN IN THE LOWER PART OF THE MAP.

Despite the degradation, the potential for a functioning and expansive floodplain is present and observable. Specific indicators include:

- A network of relict side channels within the historical floodplain surface
- Active beaver use in localized segments of the site, and immediately upstream
- A single isolated segment of well-connected floodplain as shown in Figures 1 and 2. This floodplain segment has multiple threads, dense riparian vegetation indicative of near-surface groundwater, and beaver use.

Together the site conditions suggest a strong opportunity for floodplain reconnection as a way to reduce stream power, improve connection with the alluvial aquifer, and promote riparian vegetation. Promoting these physical and ecosystem responses will have direct benefits for spawning (e.g. gravel retention) and rearing (e.g. increased off-channel and edge habitats) for steelhead.



FIGURE 2. PHOTOS OF AN ISOLATED SEGMENT OF WELL-CONNECTED FLOODPLAIN (LEFT), AND THE MORE PERVASIVE INCISED CONDITIONS (RIGHT).

3 Project Goals and Objectives

The following goals were identified through discussion with the project team. In recognition that realistic SMART (Specific, Measurable, Achievable, Relevant, and Time-Bound) objectives depend on the chosen alternative, detailed objectives have not been developed at this juncture.

1. **Floodplain Ecosystem Function** - The Roaring Creek floodplain is degraded due to historical impacts that have caused the stream to incise and disconnect from its floodplain. The project seeks wholesale and sustainable ecosystem uplift through improved connectivity, improved riparian function, reduced stream power, improved sediment retention, and improved water storage and quality.
 - The reach also has active and localized beaver use. Ecosystem improvements seek to expand and increase sustainability of beaver populations.
 - Reestablishing a well-connected and robust riparian zone also will add resilience to wildfire.
 - Improved ecosystem function and connectivity are expected to provide increased capacity for steelhead using the reach.
2. **Target Fish Species Benefits** - The reach is identified as critical habitat for steelhead, with adult migration, spawning, and rearing uses. The project seeks to improve productivity for steelhead, addressing known limiting factors related to instream complexity, floodplain connectivity, and limited baseflow.
3. **Streamflow Improvement** - Roaring Creek is known to go dry on an intermittent basis in the reaches downstream of the project area. The project seeks to raise groundwater tables and seasonal water storage to improve streamflow and connectivity within the reach and downstream.

4. **Value** - The project seeks to maximize value from public funding. For the purposes of this project, value conceptually considers benefits relative to costs as well as the durability (longevity) of anticipated benefits.
5. **Learning** - The benefits of headwater stream restoration are often described qualitatively but rarely quantified with regionally specific studies. This project has a head-start on monitoring for ecosystem benefits and streamflow augmentation. A key goal of this project is to build off these initial efforts to create a learning laboratory that enumerates the benefits (and risks) of headwater stream restoration to inform regional strategies for watershed restoration and management. Furthermore, this project has an opportunity to serve as a regional pilot for full-floodplain restoration in a system with active beaver use.

4 Restoration Alternatives

Based on early project discussions, and the recognized need to expand floodplain connectivity and address incision, the team identified three alternative restoration strategies for consideration. Conceptual design plans for each alternative are included in Attachment B: Conceptual Design Alternatives Plans.

Alternative 1 | Low-tech Only – This alternative includes instream placement of beaver-dam analog (BDA) and post-assisted log structures (PALs) as well as opportunistic winching of local conifers and riparian trees. These structures would be focused on providing localized complexity while improving floodplain activation by increasing roughness and aggrading the stream to the historic floodplain where possible. In cases where incision is too extensive to reconnect the historic floodplain, structures will focus on encouraging bank erosion to promote the development of inset floodplains.

Alternative 2 | Wood Enhancement and Targeted Floodplain Grading – This alternative includes instream treatment of equipment-placed log jams coupled with targeted floodplain lowering and side-channel grading. Large wood will be placed primarily as discrete jam structures, with broader wood loading applied selectively in areas with strong floodplain connectivity. Grading will widen the floodplain at the existing channel elevation, which may be below the current valley floor resulting in a widened inset floodplain. This alternative promotes recovery towards a “Stage 8” condition according to the Stream Evolution Model (SEM, Cluer and Thorne, 2014).

Alternative 3 | Stage 0 & Targeted Landslide Simulation – This alternative involves full floodplain reconnection in the floodplain reaches through channel fill and distributed wood loading. Alluvial fill placed in the existing (incised) channel would be sourced from high areas and margins of the historical floodplain. This alternative promotes recovery towards a “Stage 0” condition according to the Stream Evolution Model (SEM, Cluer and Thorne, 2014), which means that restoration actions seek to reconnect the historical valley bottom.

The exception to the Stage 0 approach is within the middle reach, where the floodplain is narrower, and the riparian zone is more intact. Here, the proposed strategy is to install natural accumulations of large wood that simulate landslides. This approach aligns with the geomorphic setting, promotes sediment retention, and minimizes disturbance of the riparian zone.

Proposed treatments generally vary by sub-reach within each alternative, as summarized in Table 1.

TABLE 1. RESTORATION ACTIONS BY REACH AND ALTERNATIVE.

Alternative	Upper Reach	Middle Reach	Lower Reach
Alternative 1 Low-tech Only	BDAs, PALs & winching where appropriate		
Alternative 2 Wood Enhancement and Targeted Floodplain Grading	LWD placement and targeted floodplain lowering & side channel grading	LWD placement	LWD placement and targeted floodplain lowering & side channel grading
Alternative 3 Stage 0 & Earthwork	Stage 0 (streambed raising) with distributed wood loading	Targeted Landslide simulation with wood & wood enhancement	Stage 0 (streambed raising) with distributed wood loading

4.1 Alternatives Analysis

The alternatives analysis involved a combination of quantitative and qualitative analysis to inform a preferred alternative.

4.1.1 Quantitative Analyses

Quantitative analyses (Table 2) included estimation of reconnected floodplain area and construction costs.

- Reconnected floodplain area informs potential benefits from multiple ecosystem and fish-focused perspectives, including riparian response, wetland expansion, stream power reduction, spawning gravel retention, rearing habitat area, and large woody debris retention.
- Construction costs (and cost per acre reconnected) were calculated using preliminary estimates of structure/wood densities, grading volumes, and installation methods.

TABLE 2. QUANTITATIVE (HIGH-LEVEL) COMPARISON OF ALTERNATIVES

Metric	Existing	Alt 1	Alt 2	Alt 3
Well-Connected Floodplain Area (ac)	4	6	13	19
Floodplain Area Gained (ac)	-	2	9	15
Estimated Construction Costs	-	\$180,000	\$600,000	\$1,000,000

Estimated Cost per Acre Floodplain Reconnected	-	\$90,000	\$70,000	\$70,000
<i>**Does not account for longevity of benefits</i>				

4.1.2 Qualitative Analyses

Qualitative analyses were logic-based, drew on the quantitative results above, and followed the categories specified in SRF Board’s Manual 18. The direct tie of these SRF Board evaluation categories to project goals are indicated. Qualitative (comparative) ratings are summarized in Table 3.

4.1.2.1 Tangible benefit to all targeted species and life-stages (Goal 1 and 2)

The potential for added floodplain connectivity was identified as the most fundamental driver of benefits to steelhead. Specifically, expanded floodplain connection improves ecosystem function, spawning gravel retention, redd resilience, rearing habitat (quantity and quality), instream complexity, and riparian function. Therefore, Alternative 3 appears to have the greatest overall benefit, and Alternative 1 the least.

Note, further design level refinements are required to address risk factors like summer passage and stranding. At this time, these risks are considered addressable for all alternatives.

4.1.2.2 Community comments and support

At this time, we have support for restoration from the primary landowner (USFS). We are actively seeking input from USFS and other partners on the preferred alternative. The site experiences minor recreation use. The USFS has indicated support for the relatively minor impacts to recreational use from this project.

The project currently has funding support from the WA Department of Ecology and USFS.

4.1.2.3 Likelihood of Success (Goals 1-3)

Maximized floodplain connectivity is considered essential to achieve benefits to overall ecosystem function (Goal 1), direct benefits to target species (Goal 2), and streamflow (Goal 3).

Alternative 1 was identified as having the least likelihood of success based on questionable long-term benefits to floodplains based on the need for maintenance and uncertain effectiveness in addressing incision within reasonable timescales.

Alternative 2 improves connectivity broadly and has a high likelihood of improving ecosystem function and habitat for fish species. However, the alternative does not raise the streambed and therefore does not raise groundwater levels.

Alternative 3 is considered the most likely to have success in all three categories based on the strategy to address the core issue of incision and resulting expansion of connected floodplain and alluvial aquifer.

4.1.2.4 On-going Maintenance Requirements (Goal 4)

Alternative 1 is most likely to require regular maintenance given that several rounds of low-tech structures would be necessary to address the effects of incision.

Alternatives 2 and 3 are expected to require relatively minimal maintenance.

4.1.2.5 Economic Feasibility (Goal 4)

As shown in Table 2, the estimated cost per area of connected floodplain is similar across alternatives. However, those calculations did not account for the need for on-going maintenance (especially in Alternative 1). Given these considerations, Alternatives 2 and 3 are likely to have the most preferable value from the perspective of long-term floodplain reconnection benefits. Alternative 3 is considered to have the most overall value, given that it provides more anticipated groundwater and streamflow benefits than Alternative 2.

All alternatives were considered to have equal feasibility in constructability and permitting feasibility. The site has limited wetland area that can be avoided with ground disturbance areas. Cultural resources are the most significant unknown at this stage.

4.1.2.6 Project Sustainability and Resilience (Goals 1-4)

Alternative 3 addresses the core issue of incision and reconnects the most floodplain. As a result, Alternative 3 is identified as the most sustainable and resilient.

Alternative 1 has the largest requirement for on-going maintenance and has questionable ability to sustainably reconnect floodplains based on the severity of incision.

Alternative 2 is considered to have moderate sustainability and resilience.

4.1.2.7 Connection to project goals and objectives

As discussed above, the relative benefits for Goals 1-4 are least for Alternative 1 and most for Alternative 3.

The goal not directly covered above is learning. Given the ongoing streamflow monitoring effort, this project specifically has potential to inform the streamflow augmentation benefits from floodplain restoration in headwater streams. Alternative 3 provides the most potential for learning because it is likely to connect the largest volume of alluvial aquifer and therefore have the most measurable changes to streamflow.

TABLE 3. QUALITATIVE COMPARISON OF ALTERNATIVES, SUMMARIZING DISCUSSION ABOVE. CATEGORIES FOLLOW THOSE SPECIFIED IN SRFBOARD’S MANUAL 18.

Objective	Corresponding Goals	Alt 1	Alt 2	Alt 3
Tangible Benefit to All Targeted Species and Life Stages	1 & 2	Least	Mid	Most
Community and Partner Support	-	Conversations in progress on preferred alternative		
Likelihood Of Success	1, 2, & 3	Least	Mid	Most
Ongoing Maintenance Requirements	4	Most	Least	Least
Economic Feasibility (Appropriate Cost-To-Benefit Ratio)	4	Least	Mid	Most
Project Sustainability and Resilience	1-4	Least	Mid	Most
Connection to Project Goals and Objectives	1-5	Least	Mid	Most

5 Preferred Alternative

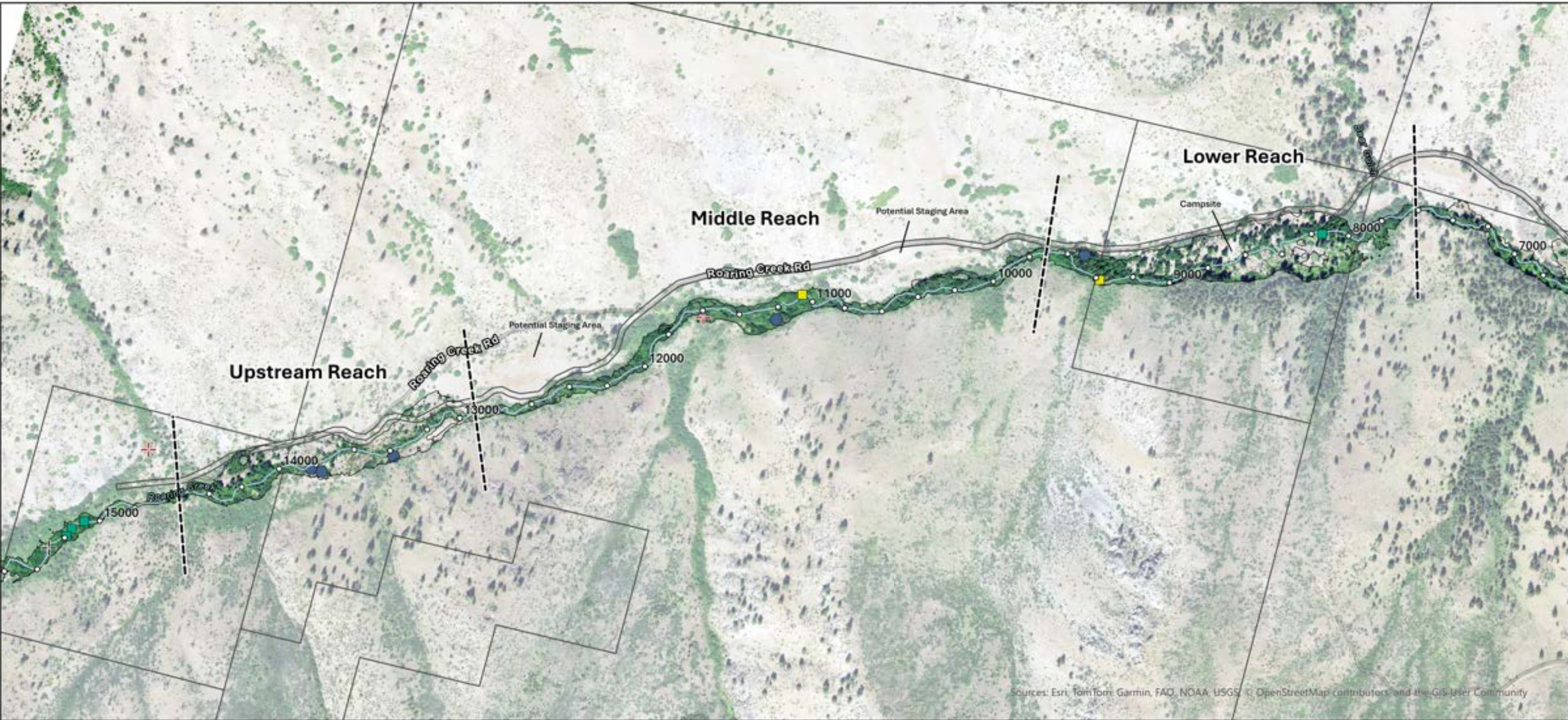
Alternative 3 – Stage 0 & Targeted Landslide Simulation – is determined to have the most overall benefit based on quantitative and qualitative comparisons above.

6 References

Cluer, B., & Thorne, C. (2014). A stream evolution model integrating habitat and ecosystem benefits. *River Research and Applications*, 30(2), 135-154.

Inter-Fluve and Yakama Nation, 2018, Lower Mad River Reach Assessment and Restoration Strategy Report

Upper Columbia Salmon Recovery Funding Board, 2021, Biological Prioritization and Restoration Strategy



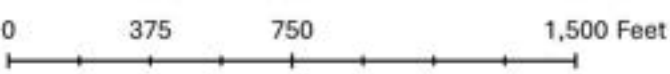
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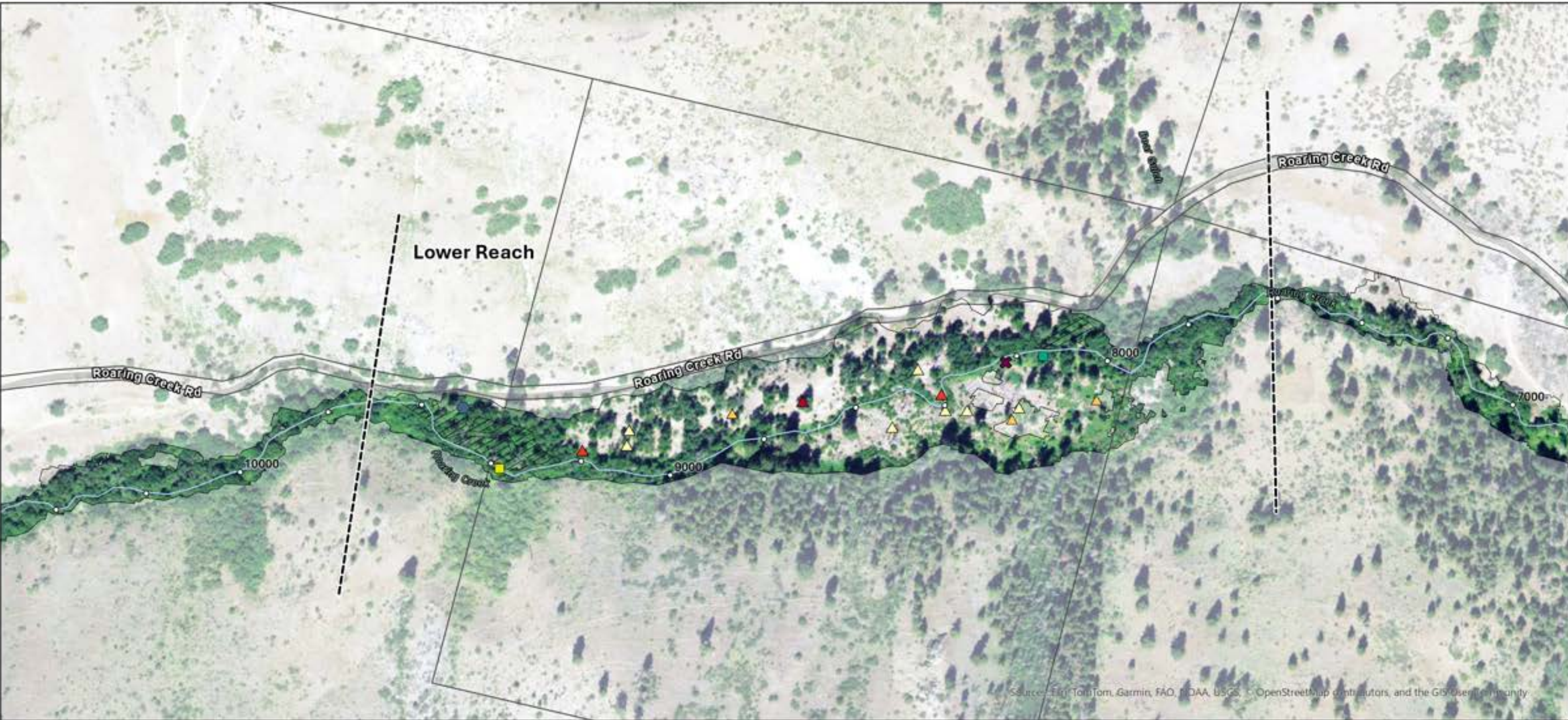
- Roaring Creek
 - Station (ft)
 - Tax Parcels (approx.)
 - - - Reach Boundaries
 - Historic Valley Bottom (approx.)
 - Observed Wetland
 - ▨ Observed Wetlands
- Monitoring**
 - + Hobo Logger
 - + Streamflow Gage
- Complexity Features**
 - Beaver Dam Analogs
 - Beaver Dam

Existing Conditions Map (Aerial)

Roaring Creek Floodplain Restoration Design

Imagery: National Agriculture Imagery Program (NAIP), 2021, State of Washington, USDA NRCS

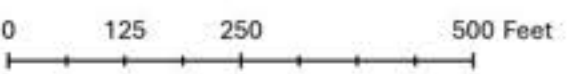




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- ✖ Headcut
- Monitoring**
- + Hobo Logger
- + Streamflow Gage
- Complexity Features**
- Beaver Dam Analogs
- Beaver Dam

- Depth to Gravel (in)**
- △ Gravel at Surface
 - ▲ 0 - 5
 - ▲ 5 - 15
 - ▲ 15 - 36
 - ▲ No gravel observed in soil pit

Imagery: National Agriculture Imagery Program (NAIP), 2021, State of Washington, USDA NRCS



Source: Esri, TomTom, Garmin, FAO, NOAA, USGS, OpenStreetMap contributors, and the GIS User Community



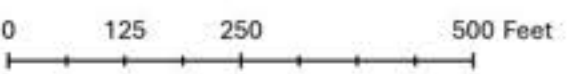


Sources: Esri TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

Existing Conditions Map (Aerial) Roaring Creek Floodplain Restoration Design

- | | | |
|------------------------------------|----------------------------|----------------------------------|
| — Roaring Creek | ✘ Headcut | Depth to Gravel (in) |
| ○ Station (ft) | Monitoring | △ Gravel at Surface |
| □ Tax Parcels (approx.) | + Hobo Logger | ▲ 0 - 5 |
| - - - Reach Boundaries | + Streamflow Gage | ▲ 5 - 15 |
| □ Historic Valley Bottom (approx.) | Complexity Features | ▲ 15 - 36 |
| ● Observed Wetland | ■ Beaver Dam Analogs | ▲ No gravel observed in soil pit |
| ▨ Observed Wetlands | ■ Beaver Dam | |

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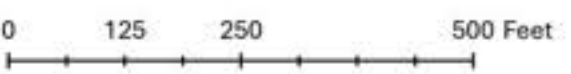
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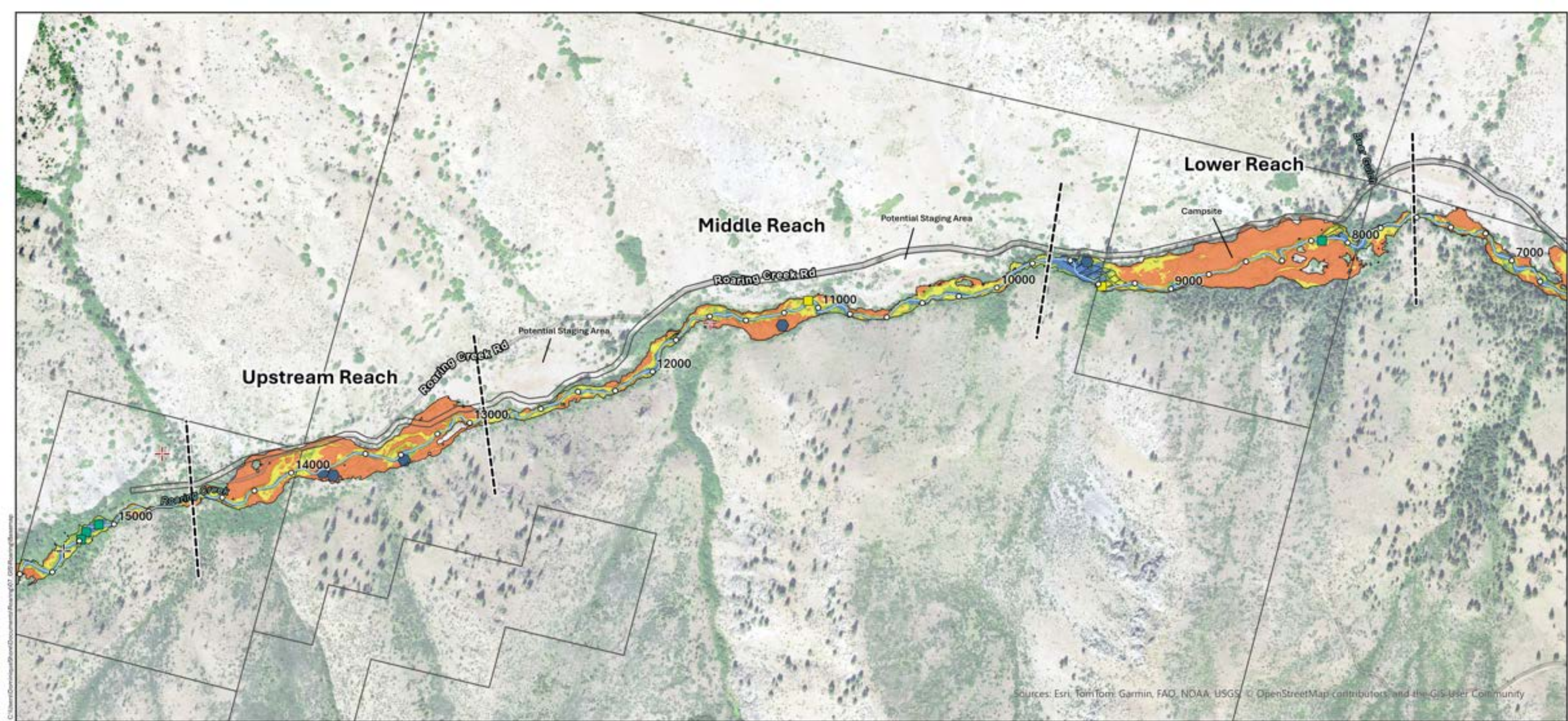
- | | | |
|------------------------------------|----------------------------|----------------------------------|
| — Roaring Creek | ✖ Headcut | Depth to Gravel (in) |
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Existing Conditions Map (Aerial)

Roaring Creek Floodplain Restoration Design

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 - Observed Wetland
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 - Beaver Dam Analogs
 - Beaver Dam
- Landscape Zones based on REM* and bankfull stage**
 - Seasonal Inundation: <1 ft (<0.5x BF Stage)
 - Annual Inundation: 1-2 ft (0.5-1x BF Stage)
 - Decadal Inundation: 2-4 ft (1-2x BF Stage)
 - Upland: >4ft (>2x BF Stage)

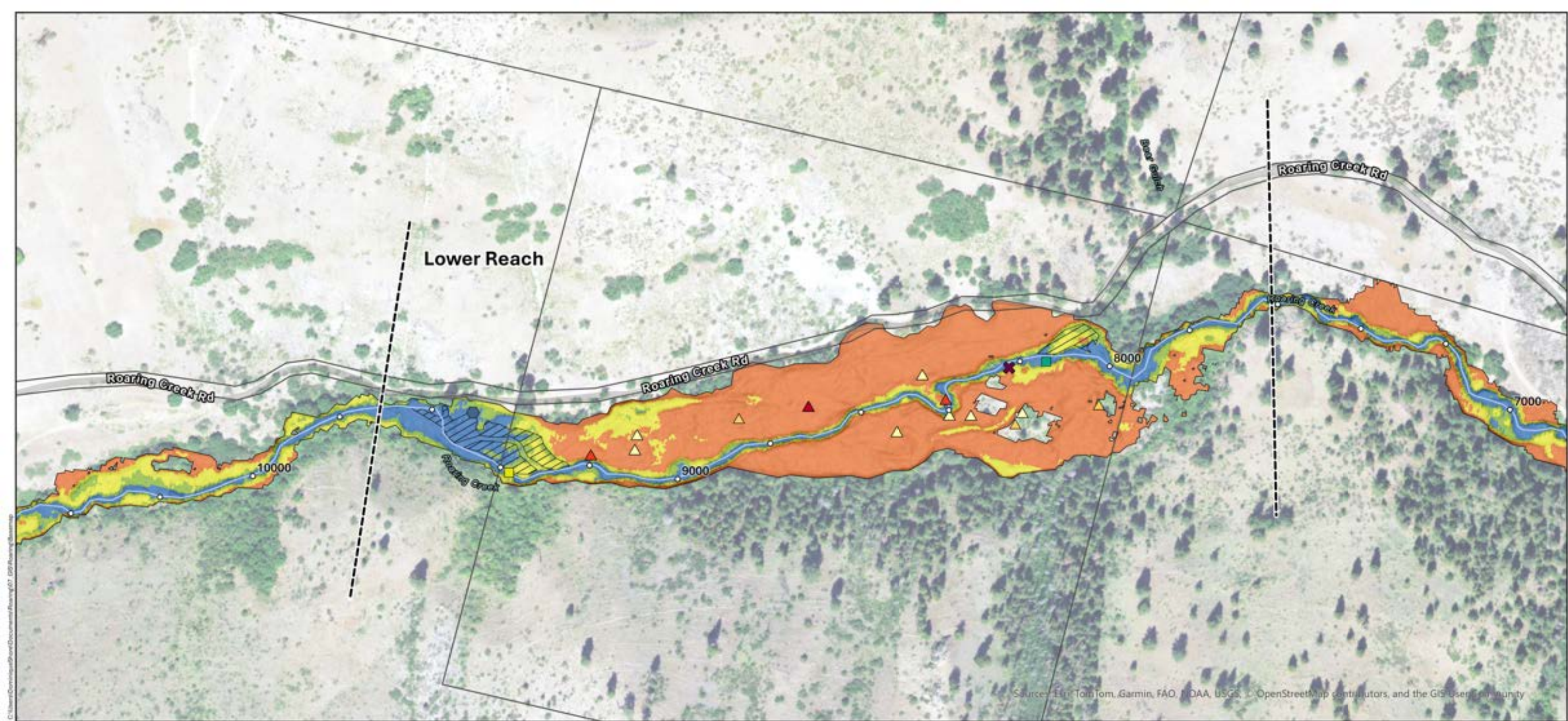
Existing Conditions Map (HAWS)

Roaring Creek Floodplain Restoration Design

* Classified landscape zones based on relative elevation model (REM) tied to the streambed centerline elevation. The REM used for landscape classification was developed using topobathymetric LIDAR collected by NV5 Geospatial on behalf of WA Department of Natural Resources (2022).

0 375 750 1,500 Feet





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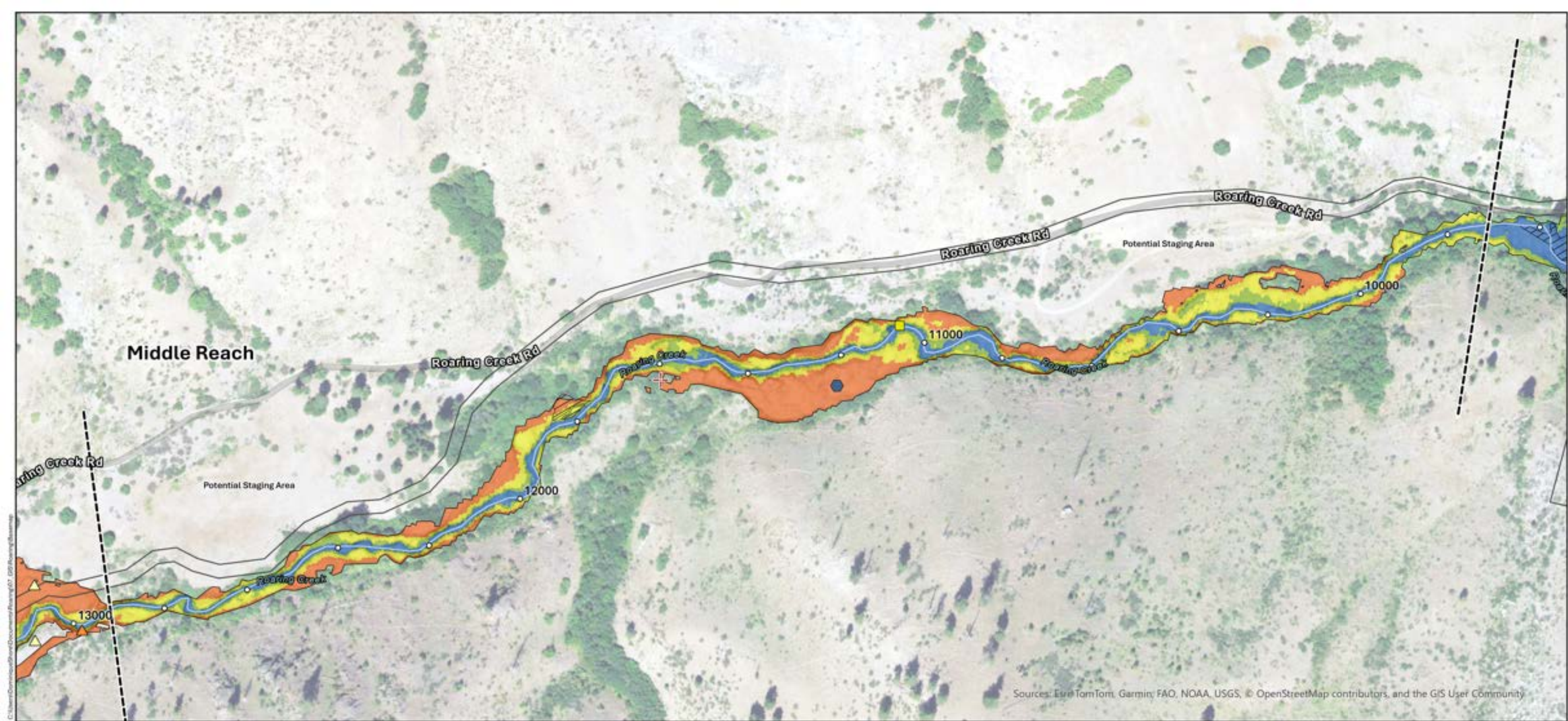
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0 125 250 500 Feet





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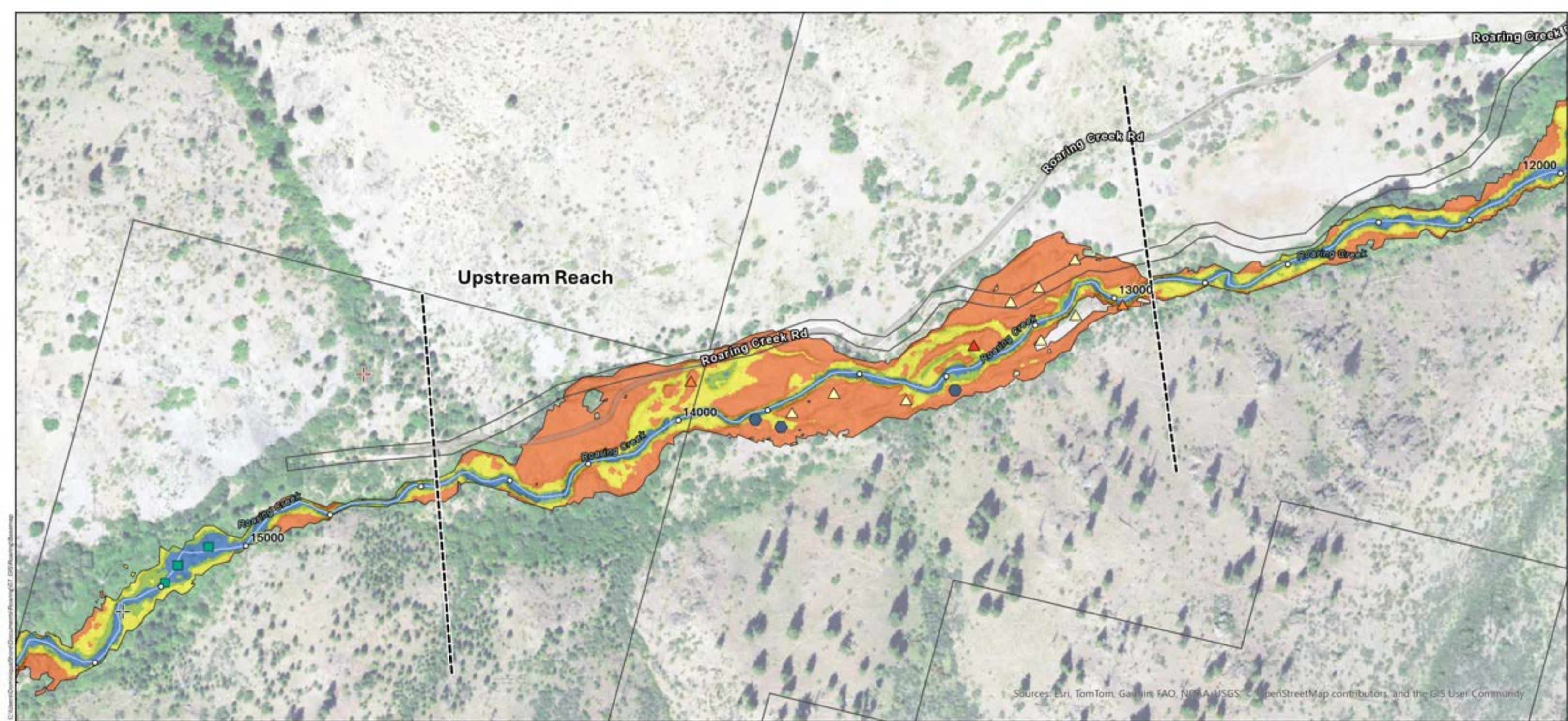
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Roaring Creek Floodplain Restoration Design

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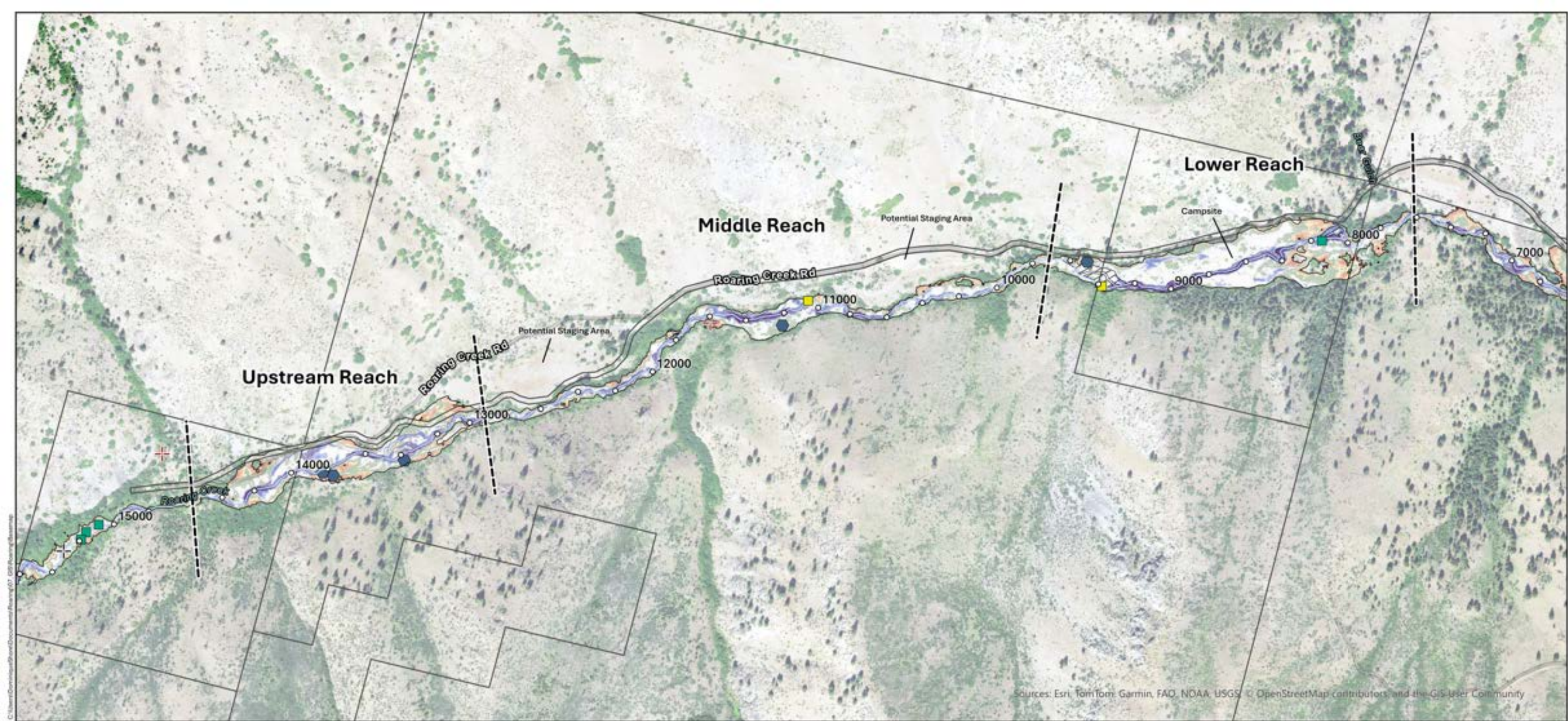
Existing Conditions Map (HAWS)

Roaring Creek Floodplain Restoration Design

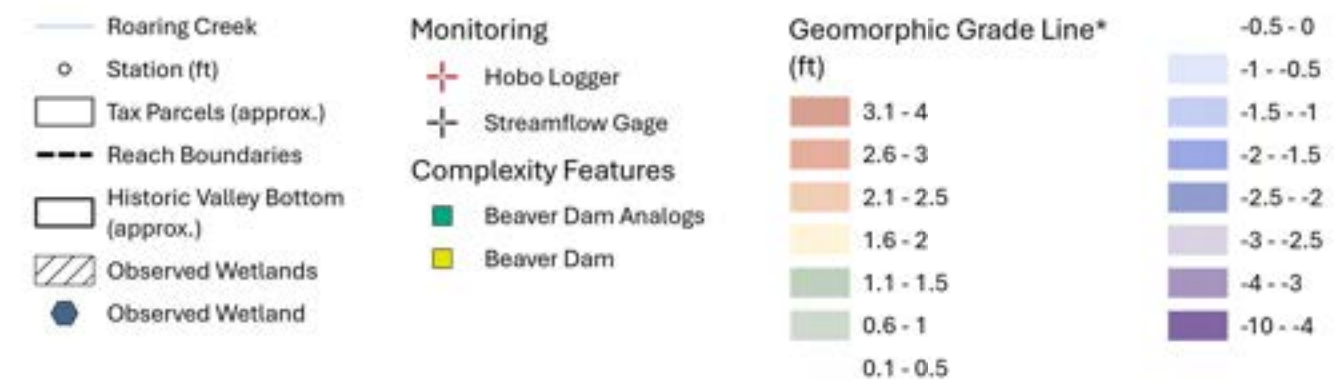
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0 125 250 500 Feet





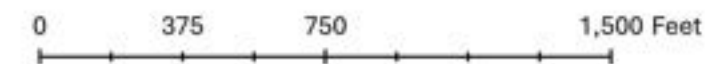
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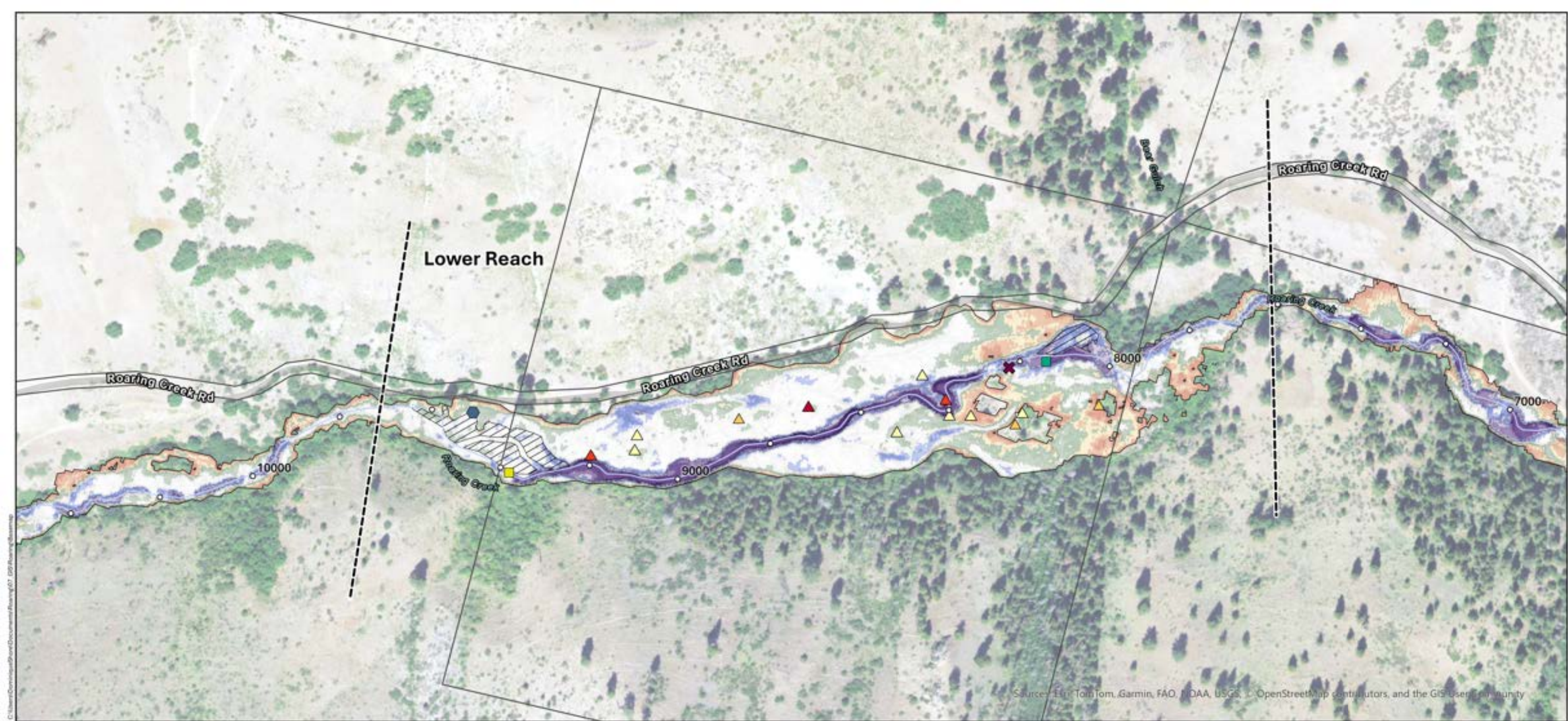


Existing Conditions Map (GGL)

Roaring Creek Floodplain Restoration Design

* Geomorphic Grade Line (GGL) Relative Elevation Model (REM) relative to estimated of historic floodplain elevation along baseline shown. GGL REM developed using topobathymetric LiDAR collected by NV5 Geospatial on behalf of WA Department of Natural Resources (2022)





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- Depth to Gravel (in)**
- Gravel at Surface
 - 0 - 5
 - 5 - 15
 - 15 - 36
 - No gravel observed in soil pit

- Geomorphic Grade Line* (ft)**
- 3.1 - 4
 - 2.6 - 3
 - 2.1 - 2.5
 - 1.6 - 2
 - 1.1 - 1.5
 - 0.6 - 1
 - 0.1 - 0.5

- 0.5 - 0
- 1 - -0.5
- 1.5 - -1
- 2 - -1.5
- 2.5 - -2
- 3 - -2.5
- 4 - -3
- 10 - -4

Existing Conditions Map (GGL)

Roaring Creek Floodplain Restoration Design

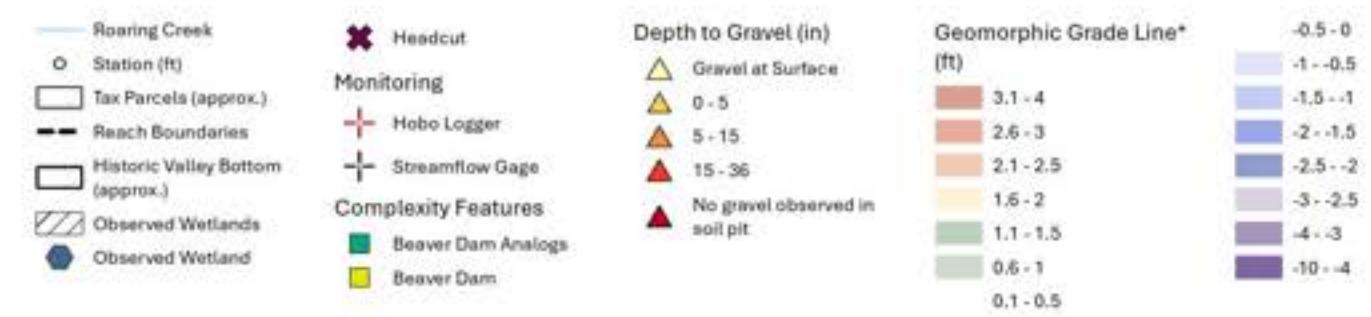
* Geomorphic Grade Line (GGL) Relative Elevation Model (REM) relative to estimated of historic floodplain elevation along baseline shown. GGL REM developed using topobathymetric LiDAR collected by NV5 Geospatial on behalf of WA Department of Natural Resources (2022)

0 125 250 500 Feet



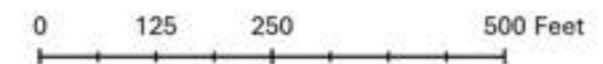


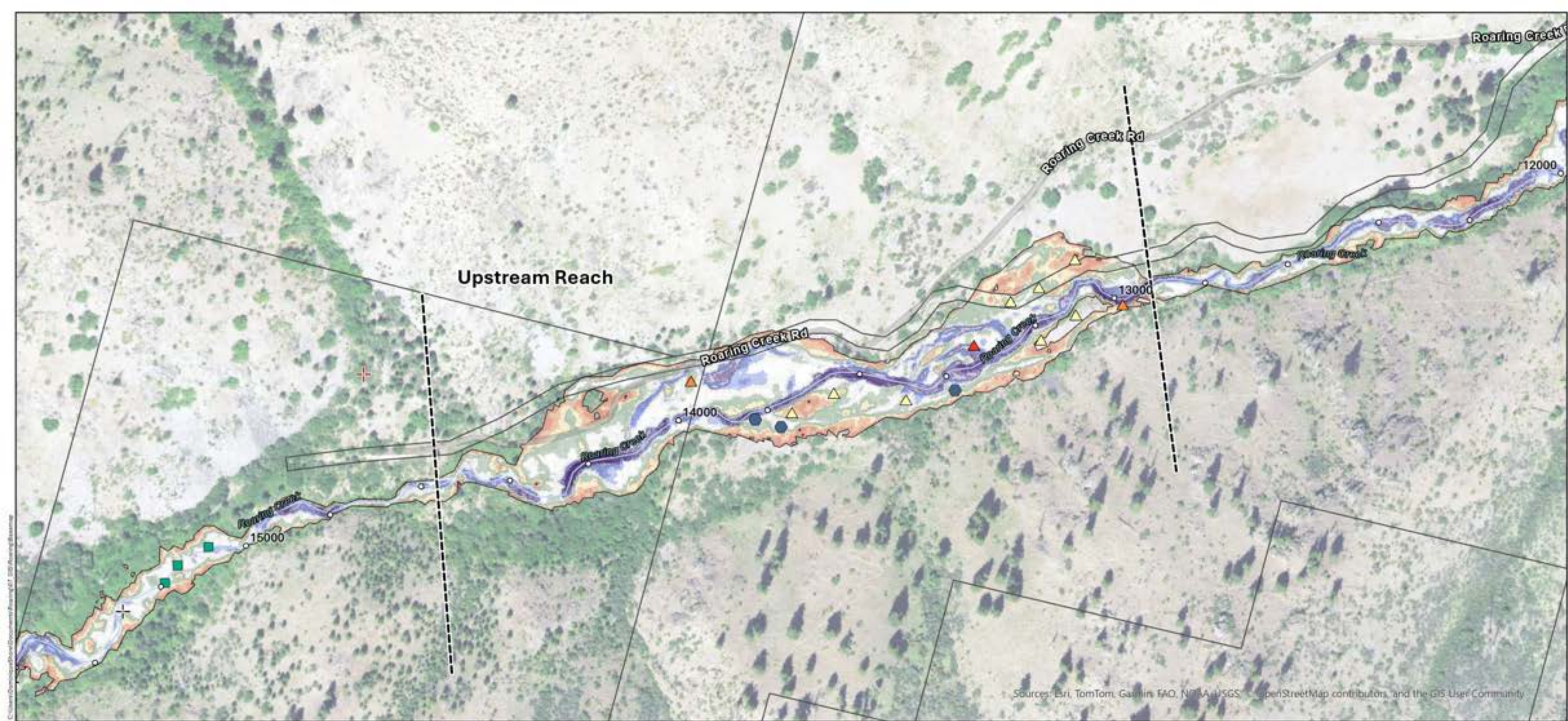
Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community



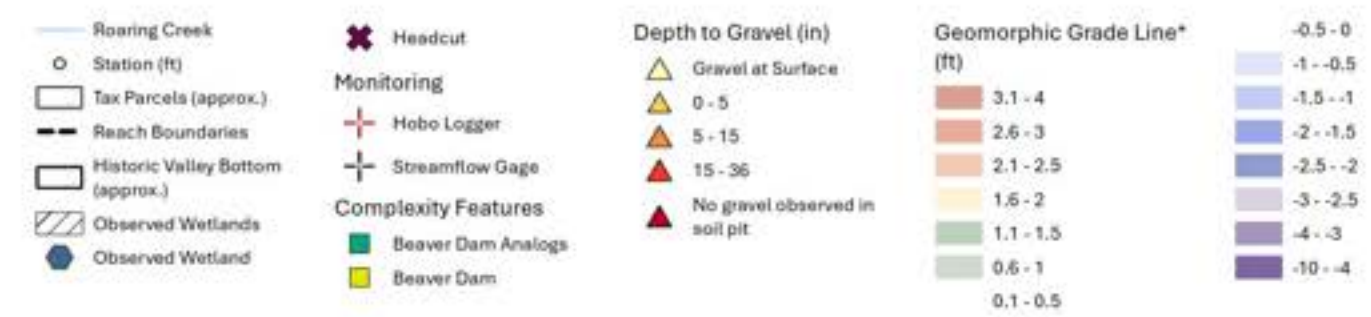
Existing Conditions Map (GGL) Roaring Creek Floodplain Restoration Design

* Geomorphic Grade Line (GGL) Relative Elevation Model (REM) relative to estimated of historic floodplain elevation along baseline shown. GGL REM developed using topobathymetric LIDAR collected by NV5 Geospatial on behalf of WA Department of Natural Resources (2022)





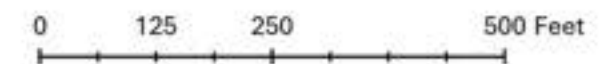
Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, OpenStreetMap contributors, and the GIS User Community



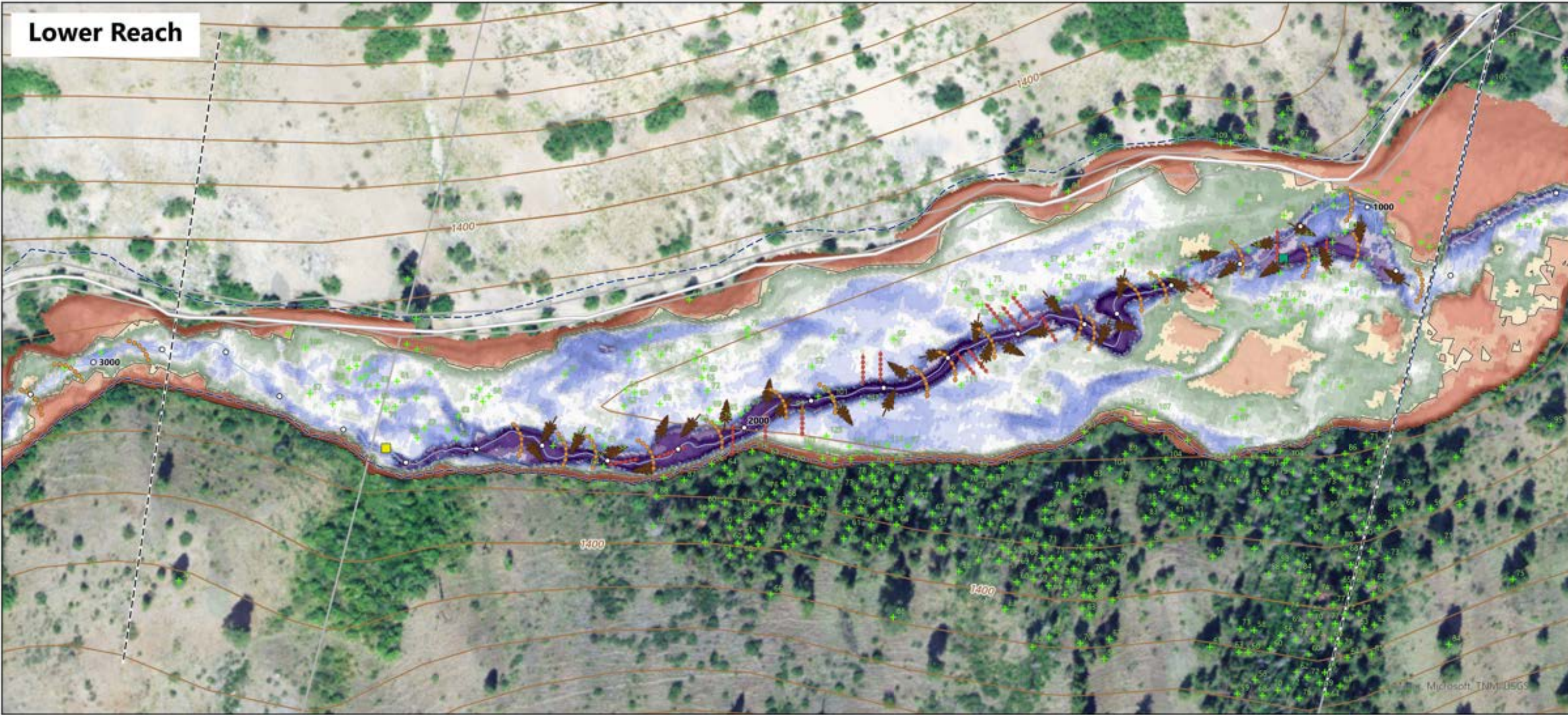
Existing Conditions Map (GGL)

Roaring Creek Floodplain Restoration Design

* Geomorphic Grade Line (GGL) Relative Elevation Model (REM) relative to estimated of historic floodplain elevation along baseline shown. GGL REM developed using topobathymetric LIDAR collected by NV5 Geospatial on behalf of WA Department of Natural Resources (2022)



Lower Reach



Geomorphic Grade Line built from topobathymetric LiDAR (2022) collected by NV5 on behalf of Washington Department of Natural Resources

Basemap Imagery: National Agriculture Imagery Program (NAIP), 2021, State of Washington, USDA NRCS.

<ul style="list-style-type: none"> — Roaring Creek Channel ○ Stationing (ft) - - - Reach Boundaries — USFS Road □ Taxlots (approx.) - - - Area of Potential Effects (est.) 	<ul style="list-style-type: none"> □ Estimated Historic Valley Bottom □ Estimated Wetland ■ Beaver Dam Analogs ■ Beaver Dam ★ Trees >55 ft 	Proposed Structures <ul style="list-style-type: none"> — Post-Assisted Log Structure (PAL) — Felled Tree — Beaver Dam Analog (BDA) 	Elevations relative to the Geomorphic Grade Line (ft) <ul style="list-style-type: none"> 7 - 10 6 - 7 5 - 6 4 - 5 3 - 4 2.5 - 3 2 - 2.5 1.5 - 2 	<ul style="list-style-type: none"> 1 - 1.5 0.5 - 1 0 - 0.5 -0.5 - 0 -1 - -0.5 -1.5 - -1 -2 - -1.5 -2.5 - -2 -3 - -2.5 -4 - -3 < -4
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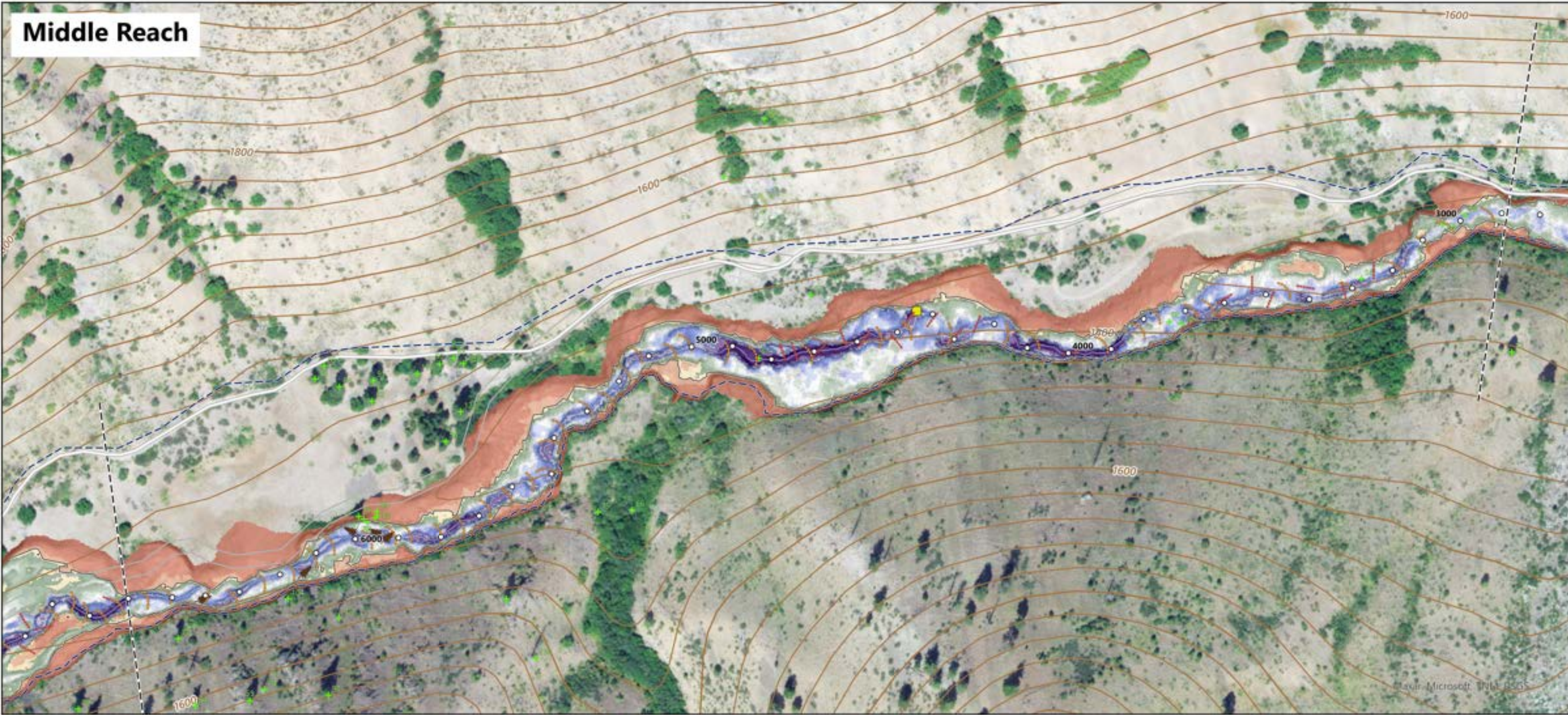


Alternative 1 - Low Tech Restoration Strategy

Roaring Creek Floodplain Restoration Design

03/18/2025





Geomorphic Grade Line built from topobathymetric LiDAR (2022) collected by NV5 on behalf of Washington Department of Natural Resources

Basemap Imagery: National Agriculture Imagery Program (NAIP), 2021, State of Washington, USDA NRCS.

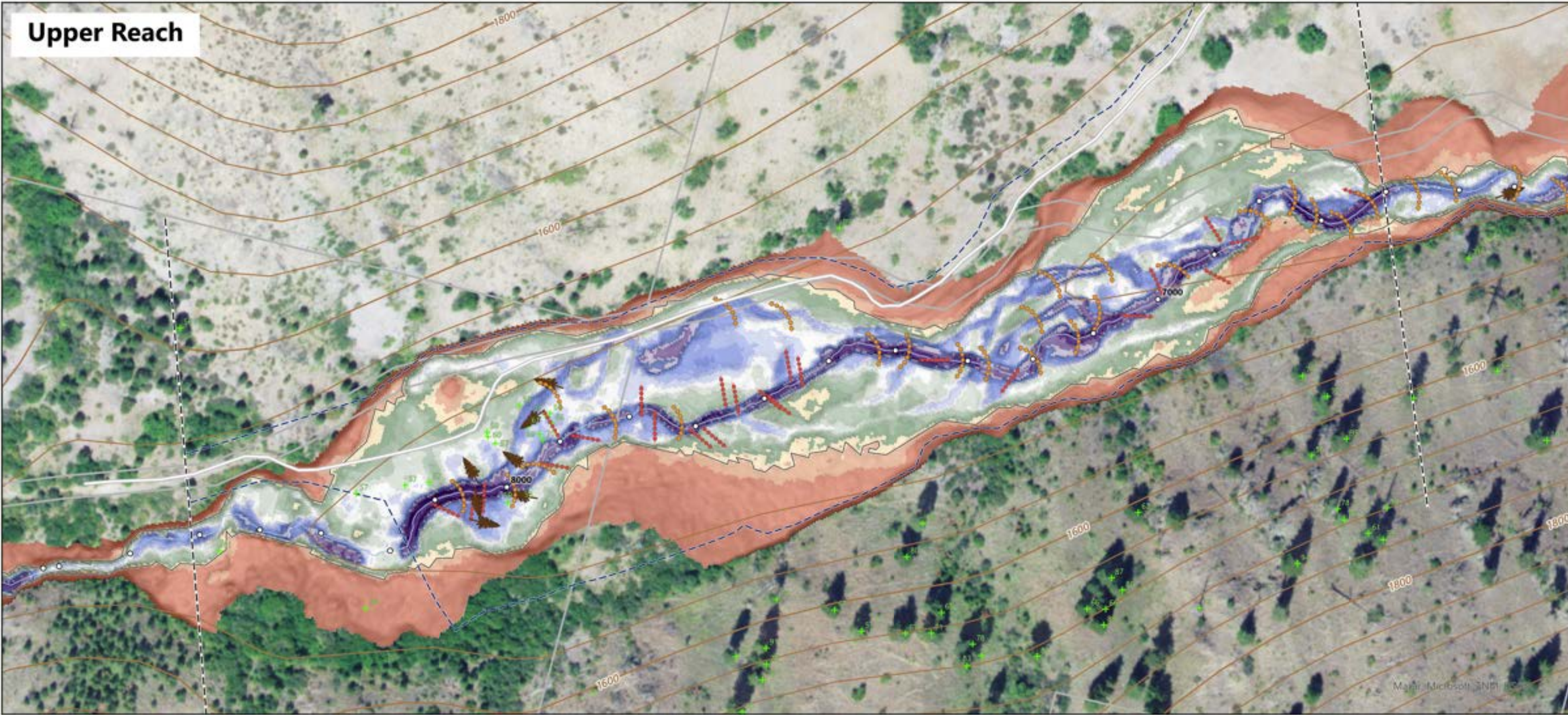
<ul style="list-style-type: none"> — Roaring Creek Channel ○ Stationing (ft) - - - Reach Boundaries — USFS Road □ Taxlots (approx.) - - - Area of Potential Effects (est.) 	<ul style="list-style-type: none"> □ Estimated Historic Valley Bottom ▨ Estimated Wetland ■ Beaver Dam Analogs ■ Beaver Dam ★ Trees >55 ft 	<p>Proposed Structures</p> <ul style="list-style-type: none"> — Post-Assisted Log Structure (PAL) — Felled Tree — Beaver Dam Analog (BDA) 	<p>Elevations relative to the Geomorphic Grade Line (ft)</p> <ul style="list-style-type: none"> 7 - 10 6 - 7 5 - 6 4 - 5 3 - 4 2.5 - 3 2 - 2.5 1.5 - 2 	<ul style="list-style-type: none"> 1 - 1.5 0.5 - 1 0 - 0.5 -0.5 - 0 -1 - -0.5 -1.5 - -1 -2 - -1.5 -2.5 - -2 -3 - -2.5 -4 - -3 < -4
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Alternative 1 - Low Tech Restoration Strategy
 Roaring Creek Floodplain Restoration Design
 03/18/2025



Upper Reach



Geomorphic Grade Line built from topobathymetric LiDAR (2022) collected by NVS on behalf of Washington Department of Natural Resources

Basemap Imagery: National Agriculture Imagery Program (NAIP), 2021, State of Washington, USDA NRCS.

<ul style="list-style-type: none"> — Roaring Creek Channel ○ Stationing (ft) - - - Reach Boundaries — USFS Road □ Taxlots (approx.) - - - Area of Potential Effects (est.) 	<ul style="list-style-type: none"> □ Estimated Historic Valley Bottom □ Estimated Wetland ■ Beaver Dam Analogs ■ Beaver Dam ★ Trees >55 ft 	<p>Proposed Structures</p> <ul style="list-style-type: none"> — Post-Assisted Log Structure (PAL) — Felled Tree — Beaver Dam Analog (BDA) 	<p>Elevations relative to the Geomorphic Grade Line (ft)</p> <ul style="list-style-type: none"> 7 - 10 6 - 7 5 - 6 4 - 5 3 - 4 2.5 - 3 2 - 2.5 1.5 - 2 	<ul style="list-style-type: none"> 1 - 1.5 0.5 - 1 0 - 0.5 -0.5 - 0 -1 - -0.5 -1.5 - -1 -2 - -1.5 -2.5 - -2 -3 - -2.5 -4 - -3 < -4
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Alternative 1 - Low Tech Restoration Strategy

Roaring Creek Floodplain Restoration Design

03/18/2025



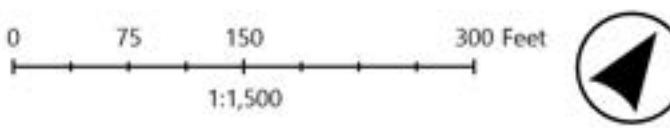
Lower Reach



Geomorphic Grade Line built from topobathymetric LIDAR (2022) collected by NVS on behalf of Washington Department of Natural Resources

Basemap Imagery: National Agriculture Imagery Program (NAIP), 2021, State of Washington, USDA NRCS.

Wood structures and pieces shown on map are for reference only. The actual number of features installed will vary from what is depicted.



- Roaring Creek Channel
- Stationing (ft)
- - - Reach Boundaries
- USFS Road
- Taxlots (approx.)
- - - Area of Potential Effects (est.)

- Estimated Historic Valley Bottom
- ▤ Estimated Wetland
- Beaver Dam Analogs
- Beaver Dam
- Trees > 55 ft

- Earthwork (Grading)**
- ▨ Floodplain Lowering
 - ▨ Channel Aggradation
- Wood Structures**
- ⌵ Large Log Jam
 - ⌵ Log Jam
 - ⌵ Single Log

- Elevations relative to the Geomorphic Grade Line (ft)**
- 7 - 10
 - 6 - 7
 - 5 - 6
 - 4 - 5
 - 3 - 4
 - 2.5 - 3
 - 2 - 2.5
 - 1.5 - 2

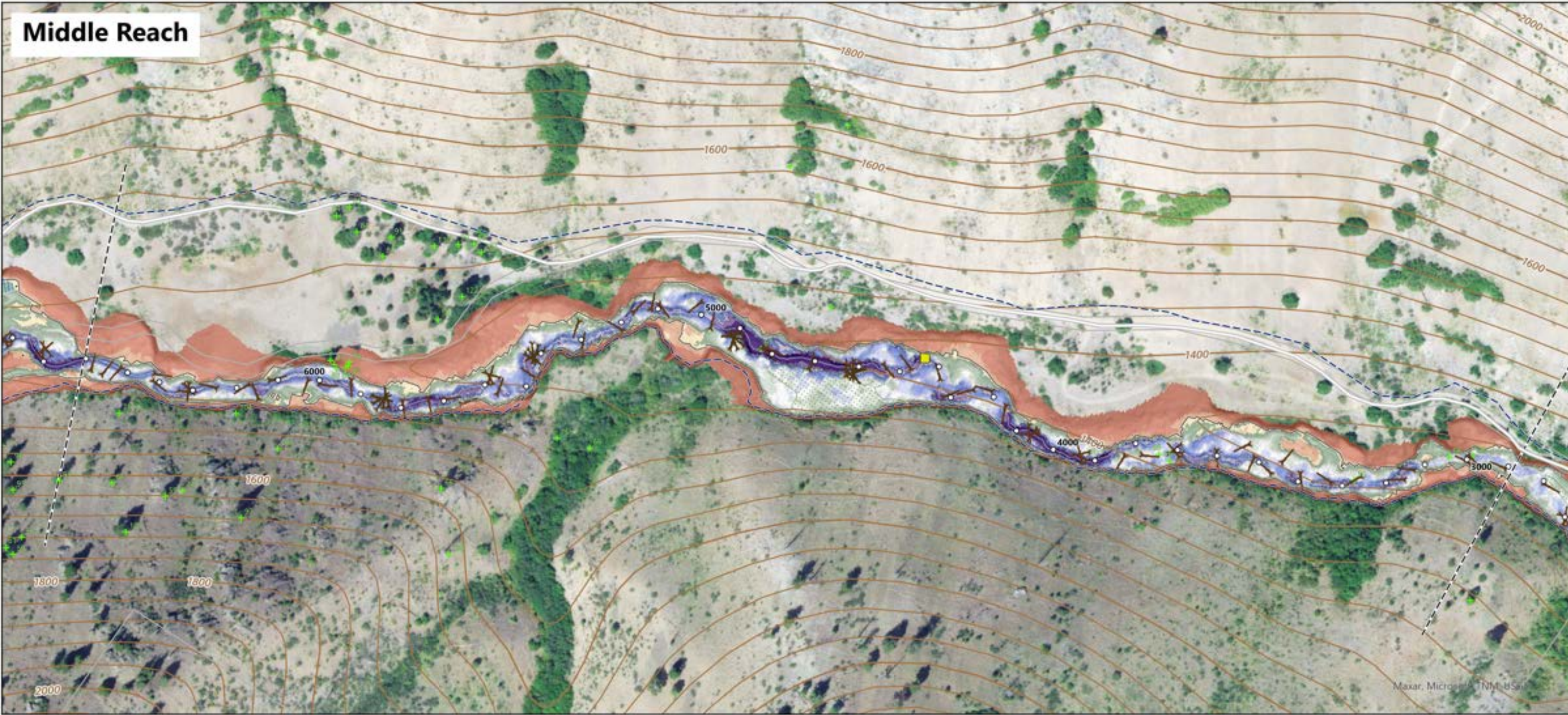
- 1 - 1.5
- 0.5 - 1
- 0 - 0.5
- 0.5 - 0
- 1 - -0.5
- 1.5 - -1
- 2 - -1.5
- 2.5 - -2
- 3 - -2.5
- 4 - -3
- < -4

Alternative 2 - Wood Enhancement and Targeted Floodplain Grading

Roaring Creek Floodplain Restoration Design

03/18/2025





Geomorphic Grade Line built from topobathymetric LIDAR (2022) collected by NVS on behalf of Washington Department of Natural Resources

Basemap Imagery: National Agriculture Imagery Program (NAIP), 2021, State of Washington, USDA NRCS.

Wood structures and pieces shown on map are for reference only. The actual number of features installed will vary from what is depicted.



- Roaring Creek Channel
- Stationing (ft)
- - - Reach Boundaries
- USFS Road
- Taxlots (approx.)
- - - Area of Potential Effects (est.)

- Estimated Historic Valley Bottom
- ▨ Estimated Wetland
- Beaver Dam Analogs
- Beaver Dam
- Trees > 55 ft

- Earthwork (Grading)**
- ▨ Floodplain Lowering
 - ▨ Channel Aggradation
- Wood Structures**
- ⌵ Large Log Jam
 - ⌵ Log Jam
 - ⌵ Single Log

- Elevations relative to the Geomorphic Grade Line (ft)**
- 7 - 10
 - 6 - 7
 - 5 - 6
 - 4 - 5
 - 3 - 4
 - 2.5 - 3
 - 2 - 2.5
 - 1.5 - 2

- 1 - 1.5
- 0.5 - 1
- 0 - 0.5
- 0.5 - 0
- 1 - -0.5
- 1.5 - -1
- 2 - -1.5
- 2.5 - -2
- 3 - -2.5
- 4 - -3
- < -4

Alternative 2 - Wood Enhancement and Targeted Floodplain Grading

Roaring Creek Floodplain Restoration Design

03/18/2025



Upper Reach



Geomorphic Grade Line built from topobathymetric LIDAR (2022) collected by NVS on behalf of Washington Department of Natural Resources

Basemap Imagery: National Agriculture Imagery Program (NAIP), 2021, State of Washington, USDA NRCS.

Wood structures and pieces shown on map are for reference only. The actual number of features installed will vary from what is depicted.



- Roaring Creek Channel
- Stationing (ft)
- - - Reach Boundaries
- USFS Road
- Taxlots (approx.)
- - - Area of Potential Effects (est.)

- Estimated Historic Valley Bottom
- Estimated Wetland
- Beaver Dam Analogs
- Beaver Dam
- Trees > 55 ft

- Earthwork (Grading)**
- /// Floodplain Lowering
- /// Channel Aggradation
- Wood Structures**
- ⌵ Large Log Jam
- ⌵ Log Jam
- ⌵ Single Log

- Elevations relative to the Geomorphic Grade Line (ft)
- 7 - 10
 - 6 - 7
 - 5 - 6
 - 4 - 5
 - 3 - 4
 - 2.5 - 3
 - 2 - 2.5
 - 1.5 - 2

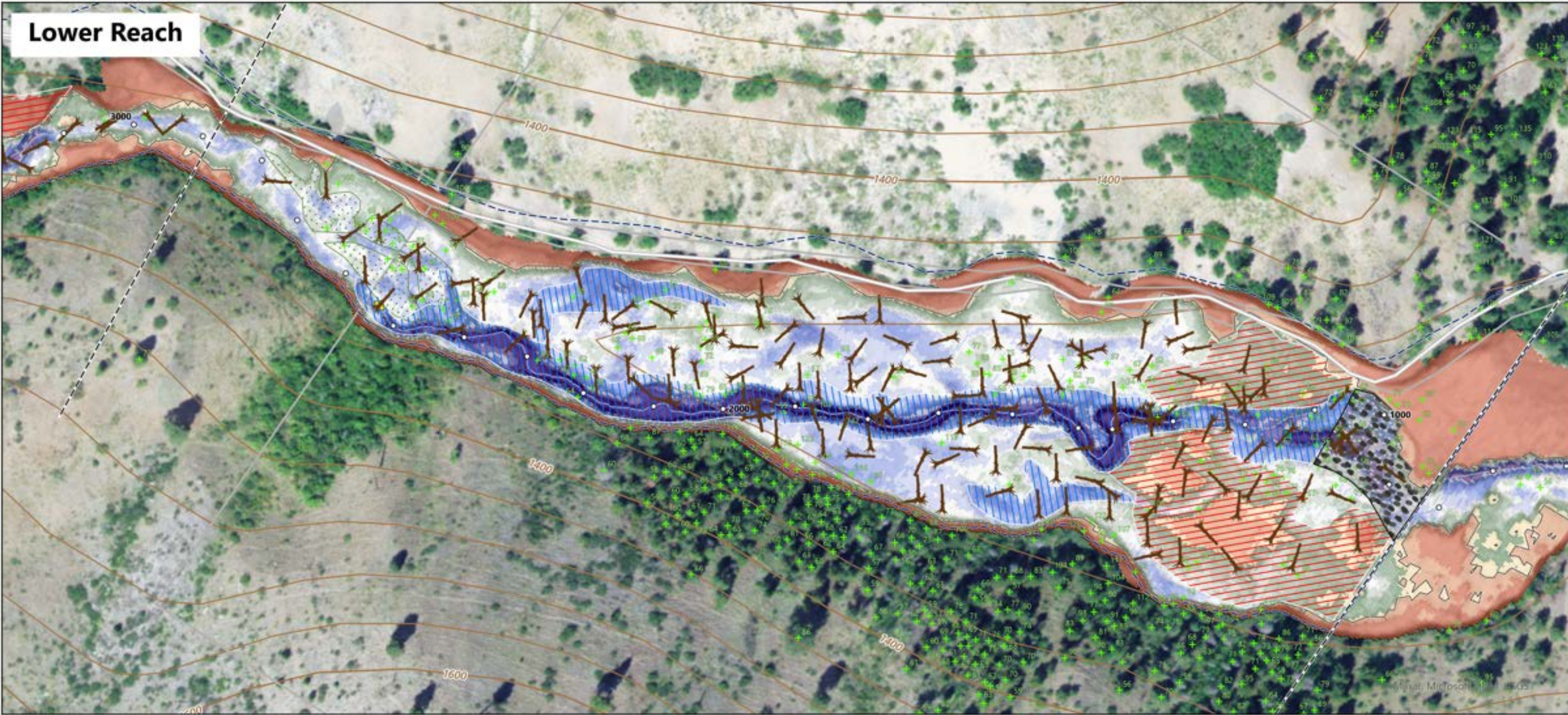
- 1 - 1.5
- 0.5 - 1
- 0 - 0.5
- 0.5 - 0
- 1 - -0.5
- 1.5 - -1
- 2 - -1.5
- 2.5 - -2
- 3 - -2.5
- 4 - -3
- < -4

Alternative 2 - Wood Enhancement and Targeted Floodplain Grading

Roaring Creek Floodplain Restoration Design
03/18/2025



Lower Reach



Geomorphic Grade Line built from topobathymetric LiDAR (2022) collected by NVS on behalf of Washington Department of Natural Resources

Basemap Imagery: National Agriculture Imagery Program (NAIP), 2021, State of Washington, USDA NRCS.

Wood structures and pieces shown on map are for reference only. The actual number of features installed will likely exceed what is depicted.



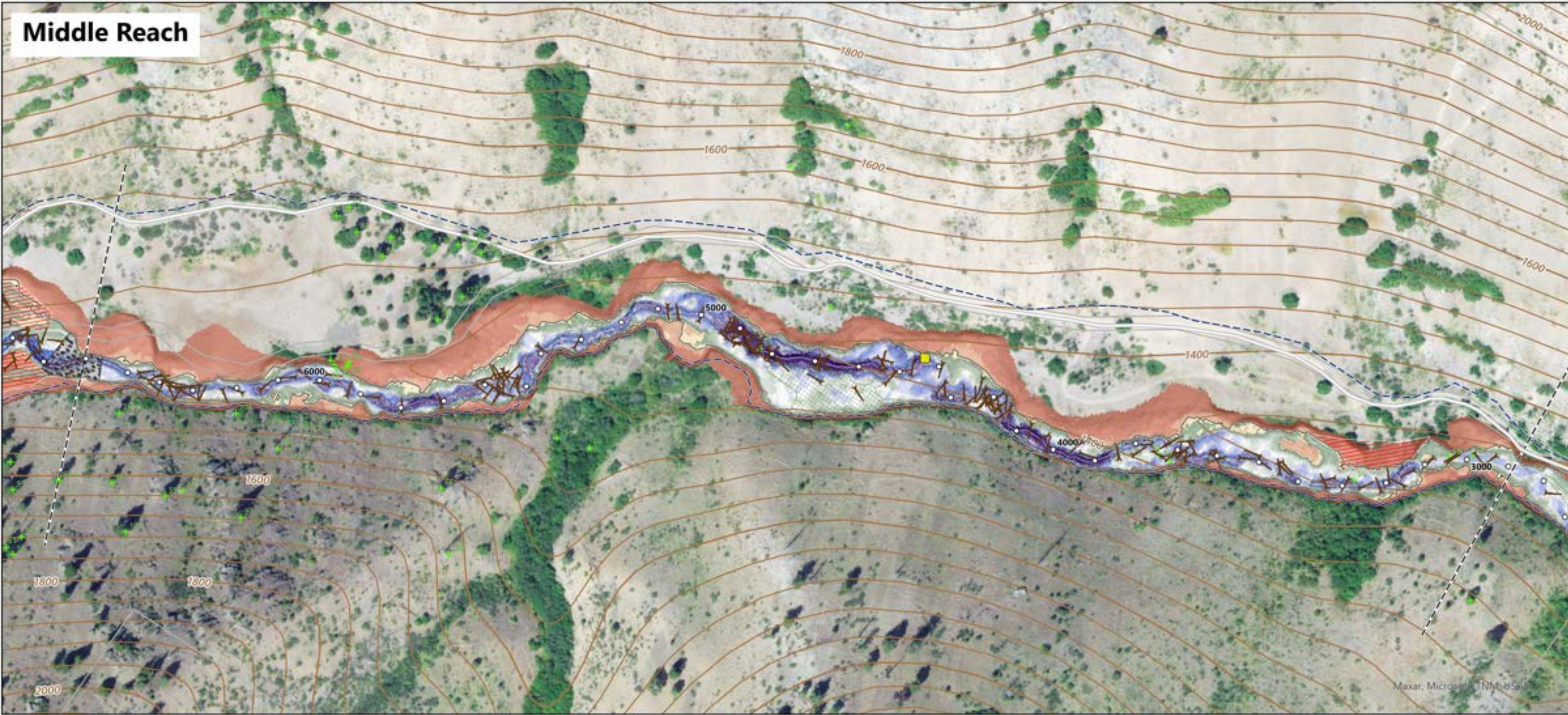
<ul style="list-style-type: none"> — Roaring Creek Channel ○ Stationing (ft) - - - Reach Boundaries — USFS Road □ Taxlots (approx.) - - - Area of Potential Effects (est.) 	<ul style="list-style-type: none"> □ Estimated Historic Valley Bottom □ Estimated Wetland ■ Beaver Dam Analogs ■ Beaver Dam ● Trees >55 ft 	<p>Earthwork (Grading)</p> <ul style="list-style-type: none"> /// Floodplain Lowering /// Channel Aggradation ▣ Roughened Channel <p>Wood Structures</p> <ul style="list-style-type: none"> ⊗ Large Log Jam ⊗ Log Jam ┆ Single Log 	<p>Elevations relative to the Geomorphic Grade Line (ft)</p> <ul style="list-style-type: none"> 7 - 10 6 - 7 5 - 6 4 - 5 3 - 4 2.5 - 3 2 - 2.5 1.5 - 2 	<ul style="list-style-type: none"> 1 - 1.5 0.5 - 1 0 - 0.5 -0.5 - 0 -1 - -0.5 -1.5 - -1 -2 - -1.5 -2.5 - -2 -3 - -2.5 -4 - -3 < -4
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Alternative 3 - Stage 0 and Simulated Landslide

Roaring Creek Floodplain Restoration Design

03/18/2025





Middle Reach

Geomorphic Grade Line built from topobathymetric LiDAR (2022) collected by NV5 on behalf of Washington Department of Natural Resources

Basemap Imagery: National Agriculture Imagery Program (NAIP), 2021, State of Washington, USDA NRCS.

Wood structures and pieces shown on map are for reference only. The actual number of features installed will likely exceed what is depicted.



<ul style="list-style-type: none"> — Roaring Creek Channel ○ Stationing (ft) - - - Reach Boundaries — USFS Road □ Taxlots (approx.) - - - Area of Potential Effects (est.) 	<ul style="list-style-type: none"> □ Estimated Historic Valley Bottom ▨ Estimated Wetland ■ Beaver Dam Analogs ■ Beaver Dam ● Trees >55 ft 	<p>Earthwork (Grading)</p> <ul style="list-style-type: none"> ▨ Floodplain Lowering ▨ Channel Aggradation ▨ Roughened Channel <p>Wood Structures</p> <ul style="list-style-type: none"> ⊗ Large Log Jam ⊗ Log Jam ⊥ Single Log 	<p>Elevations relative to the Geomorphic Grade Line (ft)</p> <ul style="list-style-type: none"> 7 - 10 6 - 7 5 - 6 4 - 5 3 - 4 2.5 - 3 2 - 2.5 1.5 - 2 	<ul style="list-style-type: none"> 1 - 1.5 0.5 - 1 0 - 0.5 -0.5 - 0 -1 - -0.5 -1.5 - -1 -2 - -1.5 -2.5 - -2 -3 - -2.5 -4 - -3 < -4
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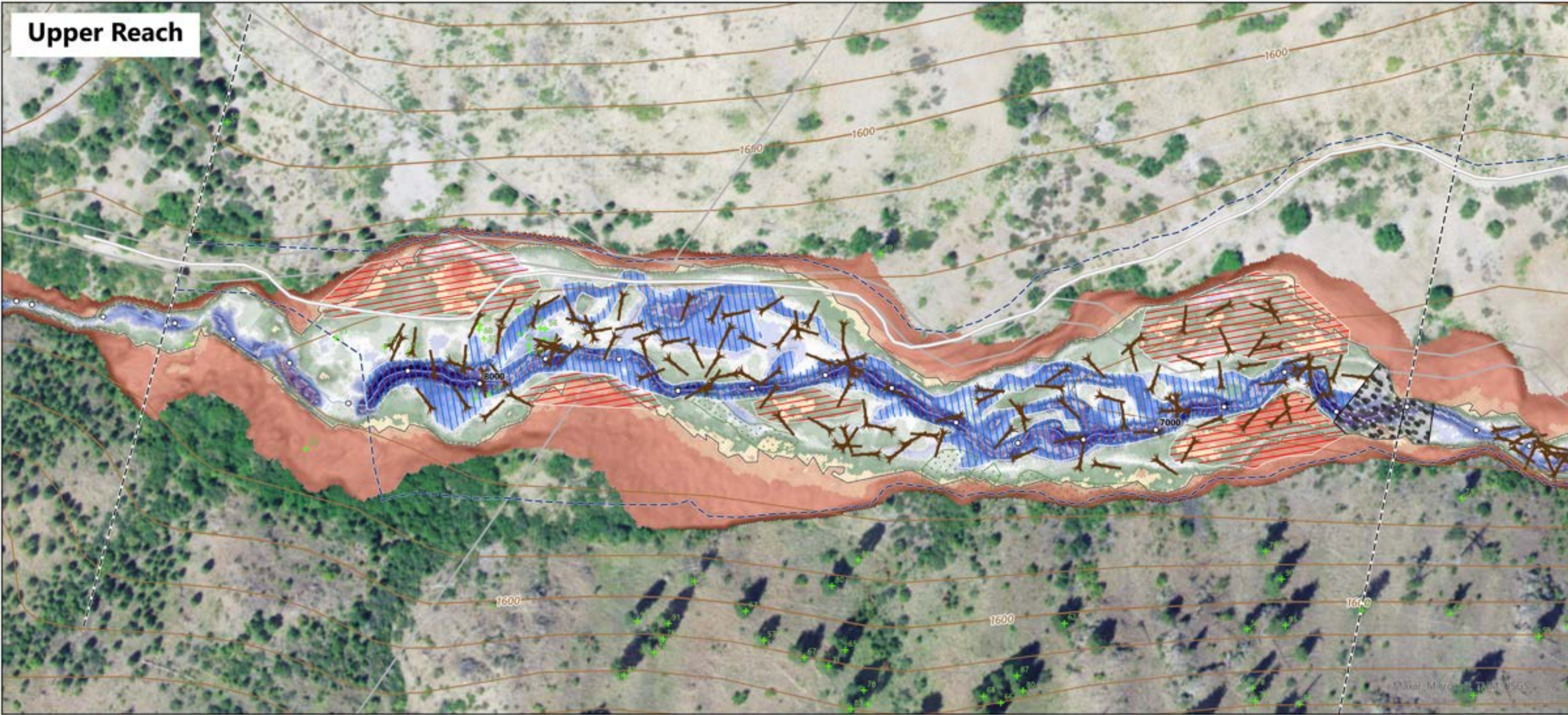
Alternative 3 - Stage 0 and Simulated Landslide

Roaring Creek Floodplain Restoration Design

03/18/2025



Upper Reach



Geomorphic Grade Line built from topobathymetric LiDAR (2022) collected by NVS on behalf of Washington Department of Natural Resources

Basemap Imagery: National Agriculture Imagery Program (NAIP), 2021, State of Washington, USDA NRCS.

Wood structures and pieces shown on map are for reference only. The actual number of features installed will likely exceed what is depicted.



<ul style="list-style-type: none"> — Roaring Creek Channel ○ Stationing (ft) - - - Reach Boundaries — USFS Road □ Taxlots (approx.) - - - Area of Potential Effects (est.) 	<ul style="list-style-type: none"> □ Estimated Historic Valley Bottom □ Estimated Wetland ■ Beaver Dam Analogs ■ Beaver Dam ★ Trees >55 ft 	<p>Earthwork (Grading)</p> <ul style="list-style-type: none"> /// Floodplain Lowering /// Channel Aggradation ▣ Roughened Channel <p>Wood Structures</p> <ul style="list-style-type: none"> ★ Large Log Jam ★ Log Jam ┆ Single Log 	<p>Elevations relative to the Geomorphic Grade Line (ft)</p> <ul style="list-style-type: none"> 7 - 10 6 - 7 5 - 6 4 - 5 3 - 4 2.5 - 3 2 - 2.5 1.5 - 2 	<ul style="list-style-type: none"> 1 - 1.5 0.5 - 1 0 - 0.5 -0.5 - 0 -1 - -0.5 -1.5 - -1 -2 - -1.5 -2.5 - -2 -3 - -2.5 -4 - -3 < -4
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Alternative 3 - Stage 0 and Simulated Landslide Roaring Creek Floodplain Restoration Design 03/18/2025

