Title: South Fork Salmon River Tributary Salmonid Enhancement Monitoring Project

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One Sentence Summary: Monitoring of instream large wood structure placement within two anadromous tributaries in California's South Fork Salmon River watershed demonstrates increased and enhanced fish habitat through gravel substrate retention, accelerated recruitment of wood cover and increased variable hydraulic refugia.

Abstract: This project, the first large wood stream restoration project of its kind in California's Salmon River (Cal Salmon) watershed was undertaken to better understand channel dynamics and hydraulic responses to large wood placement in two higher gradient, boulder bedded tributary streams (Knownothing and Methodist Creeks). With a number of possible outcomes, an effectiveness monitoring program was designed to analyze geomorphic effects, hydraulic effects and fish habitat enhancement. The three-year project included a total of three-phases: (1) pre-implementation documentation and analysis of channel conditions, (2) implementation (construction) of instream large wood structures, and (3) post-implementation monitoring and conditions analysis. A significant part of this instream enhancement project is the effectiveness monitoring component using unique techniques to assist and compare with classical monitoring techniques. In addition to conducting a detailed total station survey of each the 19 large wood sites, an unmanned aerial vehicle (UAV) was used to detect overall change that would have been too expensive and labor intensive if only done using traditional surveying techniques. It was found that large wood implementation increased smaller substrate retention, created additional viable fish habitat (cover), and altered site specific hydraulics and channel geomorphology in ways deemed favorable to anadromous fish.

1 INTRODUCTION

The goal of this restoration project was to restore natural stream process and improve salmonid habitat by reintroducing large wood that was once persistent in these creeks. By reintroducing large wood to the system, the balance of organics, water and sediment can be put on a trajectory that will better support spawning, high flow refugia, cover, and foraging habitat for adult and juvenile salmonids. These are key habitat features that adult and juvenile salmonids need to survive and thrive, and that have been drastically modified in these watersheds, riparian zones and channels as a result of past homesteading, mining and logging practices over the last 150 years. These land use practices used streams as a means of transport and for the extraction of wood and alluvial mineral deposits without regard to natural stream function or ecology. Over the decades these practices caused significant loss of instream and riparian wood and alluvial gold mining resulted in the loss of smaller alluvial substrate, leaving a lag of course boulder substrate that is largely unsuitable for salmonid spawning and rearing.

In 2015, the Salmon River Restoration Council (SRRC) began efforts to restore the native salmonid fishery by designing, implementing and monitoring large wood augmentation projects in Knownothing and Methodist Creeks, two important anadromous tributaries to the South Fork of the Salmon River in the Klamath National Forest (Figure 1).

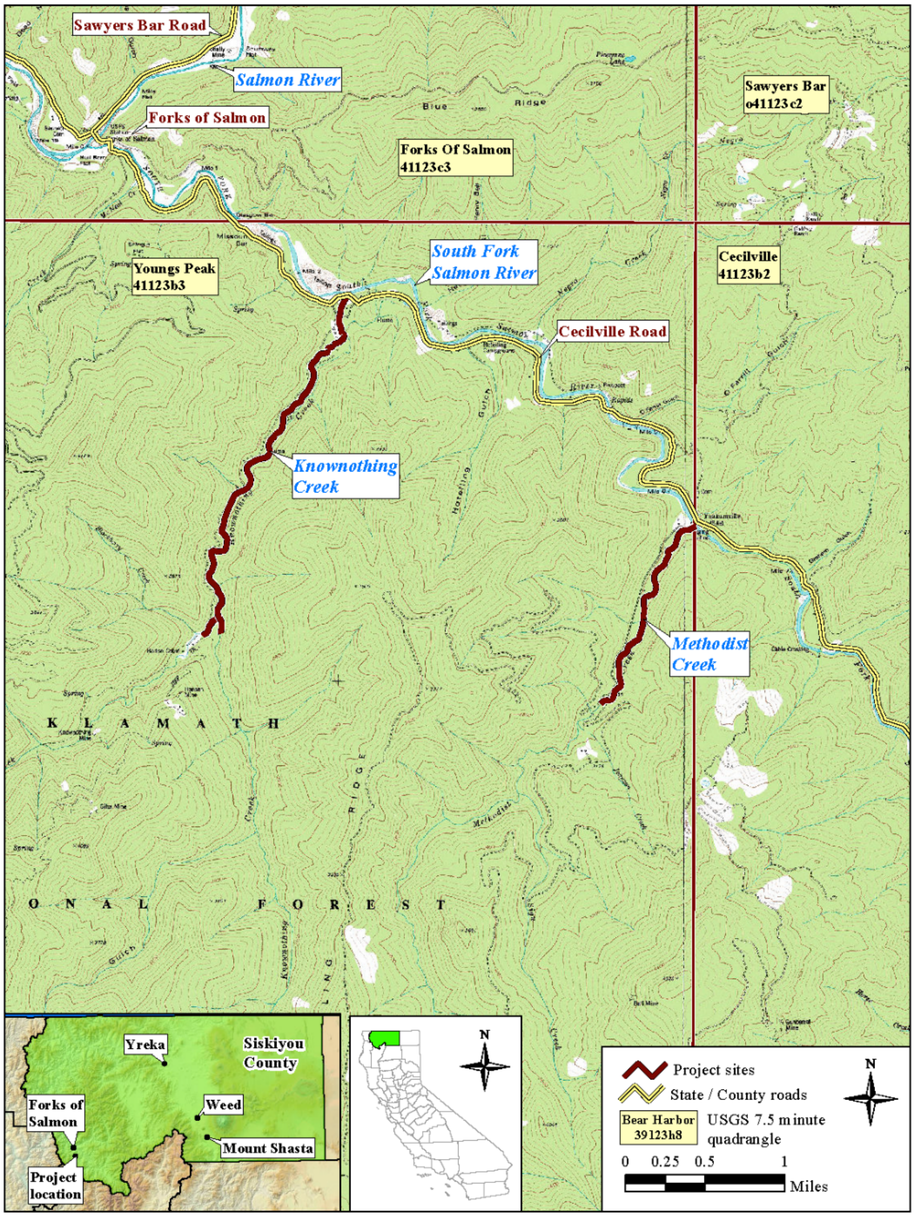


Figure 1. A location map of the project reaches on Knownothing and Methodist Creeks in the California Salmon River watershed.

This project, as completed, included three phases: (1) pre-implementation documentation and analysis of existing geomorphic and habitat conditions, (2) construction of instream large wood habitat structures, and (3) post-implementation monitoring and conditions analysis. At the project scale, this restoration project type and effectiveness monitoring strategy are the first of this kind completed in the Cal Salmon watershed. Funding for this project was provided by a grant from the California Department of Fish and Wildlife's (CDFW) Fisheries Restoration Grant Program (FRGP), with in-kind funds from the United States Forest Service, the Karuk Tribe, and SRRC.

Studies in coastal river systems in the Western United States have shown that the construction or augmentation of instream large wood can lead to increased habitat enhancement and geomorphic response in a variety stream channel types (Abbe, 2003). Specifically, this project was undertaken to better understand channel dynamics and geomorphic responses to large wood placement in higher gradient, boulder bedded streams such as those in the Cal Salmon watershed. In order to document geomorphic, hydraulic and fish habitat changes, an extensive monitoring program was conducted in concert with the implementation of large wood placement. The monitoring study design incorporated several well-established contemporary physical and ecological monitoring protocols selected on the basis of their ability to provide feedback regarding whether, and to what extent, the project was meeting specific restoration objectives (CHaMP, 2019). In conjunction with biological monitoring, ground-based and aerial surveying methods were used to document conditions before and after the large wood features were constructed. SRRC and the U.S. Forest Service teamed together to conduct adult fish, juvenile and redd counts along both creeks. Pacific Watershed Associates (PWA) and Merkel & Associates (MA) teamed together to conduct unmanned aerial vehicle (UAV) (aka, drone) ortho-imagery flights in addition to detailed total station topographic surveys at each site. The primary focus of the non-biological effectiveness monitoring efforts were to measure and detect geomorphic change and habitat enhancement effects in the stream corridor associated with the constructed large wood features.

In the fall of 2017, large instream wood structures were designed and constructed in the monitored reaches of Knownothing and Methodist Creeks. Large wood structures were constructed with one or more of the following three principal goals in mind: (1) favorable geomorphic effects, (2) improved hydraulic conditions, and/or (3) fish habitat enhancement. Each of these principal goals provided the framework for how, why and where to build structures and monitor for change of conditions. Large wood structures were designed to not only engage the active base flow channel, but also to connect the adjacent floodplain, where feasible, so that the entire stream corridor would benefit from this restoration technique.

During pre-implementation geomorphic assessments of Knownothing and Methodist Creeks, an overall lack of high flow refugia for adult and juvenile salmonids during high flow conditions was apparent. With this in mind, large wood structures were designed to allow more refuge for fish within the channel, as well as on the floodplain, at specific locations. By designing structures to interact with the entire stream corridor, these valuable pieces of large wood can significantly affect channel and floodplain function by allowing more paths for the biotic and abiotic components of the stream ecology to interact with the larger ecosystem (Wohl, et al., 2019).

In total, 19 wood structures, comprised of 91 pieces of large wood, were constructed within a total of approximately 4 miles of stream reach (2.6 miles in Knownothing Creek and 1.4 miles in Methodist Creek). Individual large wood pieces were a minimum of 20 inches in diameter and ranged from 20-40 feet long, with high preference for logs with rootwads attached. A maximum of 40 foot logs were used because the large wood had to be trucked in from the North Fork and mainstem Salmon River using logging trucks. The large wood was donated from the Klamath National Forest, private land owners, and purchased from private timber sales and the Yurok Tribe. To ensure these features persist through relatively large magnitude, high shear flow events, wood was wedged within existing living riparian trees and connected together with metal anchoring. Each large wood habitat feature was built with a hydraulic excavator using existing access roads constructed during previous logging and mining activities. After each feature was constructed, labor crews anchored logs together using DYWIDAG™ threaded bar, plates, and nuts. Instream implementation heavy equipment and labor crews were provided by Travis Carmesin Construction from McKinleyville, California, with local logging contractors supplying log materials and transportation. When available, small and medium wood was also incorporated into a feature at the point during construction to help with immediate habitat needs and to encourage the racking of natural wood transported from upstream areas during high flow events.

2 METHODS

Our study consisted of monitoring treated instream reaches in Methodist and Knownothing Creeks over a three-year period using a before-after analytical approach (Merz and Setka, 2004). Given the general drought conditions that have been affecting northern California over the last decade, it was determined that the project should be monitored for a minimum of two consecutive years following implementation of the instream large wood structures to increase the likelihood that the project would be subjected to a sufficient number of medium- to high-flow events to initiate the full channel response to wood loading streams (Reeves, et al., 1997). The first year of monitoring (2017) was conducted prior to wood loading implementation, followed by two consecutive years of post-implementation monitoring (2018 & 2019).

The study design incorporated several well-established contemporary physical and ecological monitoring protocols selected on the basis of their ability to provide feedback regarding whether, and to what extent, we were meeting specific restoration objectives (CHaMP, 2019). The following list describes the monitoring protocols used in the monitoring study during both the pre- and post-implementation monitoring time periods.

2.1 Topographic Surveys

Thalweg profiles and channel spanning cross-sections were surveyed within treated stream reaches to determine channel gradient, bankfull width and depth, sinuosity, pool frequency, and residual pool depth. Topographic surveying was a key element of our monitoring study because it provides valuable information upon which to evaluate and integrate observed changes to the stream channel at site-specific, channel unit and reach scales. The topographic surveying component of the monitoring study was based on protocols developed by Harrelson (1994). Residual pool depths were calculated from the topographic survey data by subtracting pool tail crest depths from measured pool depths (Lisle, 1987).

In order to evaluate post-implementation channel geomorphic effects, a detailed thalweg profile and cross-section survey was completed at each site prior to implementation (year 2017) and resurveyed for two post-implementation winter periods (years 2018 & 2019). Pre- and post-survey data was used to evaluate changes in geomorphic parameters that include: channel gradient, bankfull width and depth, sinuosity, pool frequency, and residual pool depth. In order to capture pre-implementation conditions, cross-sections and thalweg profiles were surveyed before the large wood was placed in the stream. In the hopes of detecting the most significant channel geomorphic changes, cross-sections were primarily installed just downstream from the proposed large wood site design location, usually no farther than 50 feet downstream from the projected large wood site placement. However, due to a variety of factors, at one location (Methodist # 4) as-built conditions were modified from the original designs leading to the surveyed cross-sections being located upstream from the placed instream feature.

Using a total station, control network traverse loops were established from the top to the bottom of the project areas in both the Knownothing and Methodist Creek study reaches. Wooden lath and galvanized nail spikes were set into the ground to be used and reoccupied as control network instrument stations for the post-implementation channel surveys. From these control networks, over 3,000 points were shot along existing cross-sections and thalweg profiles to document channel geomorphic changes through time. During the thalweg profile and cross-section transect surveys, the total station was set up on control network stations with the best visibility to the stream, and points were shot at slope breaks within the thalweg or perpendicular to profiles at cross-section transects. In general, the thalweg surveys initiated and terminated at least 100 ft upstream and downstream of the installed in-channel structures.

Northing, easting, and elevation (NEZ) coordinates were developed for all points. These coordinates were imported into SurveyPro software to export the data to MS Excel for data analysis. During the field surveys, no horizontal or vertical benchmarks were located or surveyed to, therefore all N, E and Z coordinates generated for the survey are relative.

2.2 Large Wood Inventory

Pre-project large wood was inventoried at the sites using UAV photography and analysis, according to the minimum size criteria established in the California Salmonid Stream Restoration Manual, 4th Edition (Part 3: Habitat Inventory Methods) (Flosi, et al., 2010). Key wood greater than 1 foot diameter and greater than or equal to 20 feet in length, located within or suspended directly over the bankfull discharge prism of the surveyed channel reach, was included in the inventory (Schuett-Hames, et al., 1999). The plan view cross-sectional area of each piece of large wood included in the inventory was used to determine total woody cover and total racked woody cover following the 3-year monitoring period.

2.3 Particle Size Distribution

Wolman pebble counts (Wolman, 1954) were conducted at each of the 19 placed large wood sites along the associated topographic cross-section locations. Pebble counts were conducted to characterize substrate quality with respect to spawning as well as expressing the condition of future geomorphic change. Due to the narrow stream channel, a sample size of 50 pebbles (rather than 100) were collected randomly from each of the defined cross-sections. Particle size class distribution for the ranges of D5, D16, D50, D84 and D95 were determined for each survey using MS Excel. These surveys were conducted for two years post-implementation (2018 & 2019).

2.4 Pool Tail Embeddedness

Cobble embeddedness, expressed as an integer, was determined at pool tail-outs where coho or other salmonids are likely to spawn within the treatment reaches. A minimum of five small cobbles were sampled at each pool tail-out survey in the fall of 2018 and 2019. Embeddedness values were averaged to generate a mean cobble embeddedness rating for each surveyed pool. Embeddedness data collection and analysis was consistent to the criteria established in Part Three (Habitat Inventory Methods) of the California Salmonid Stream Restoration Manual 4th Edition (Flosi, et al., 2010).

2.5 Photographic Monitoring and UAV Surveys

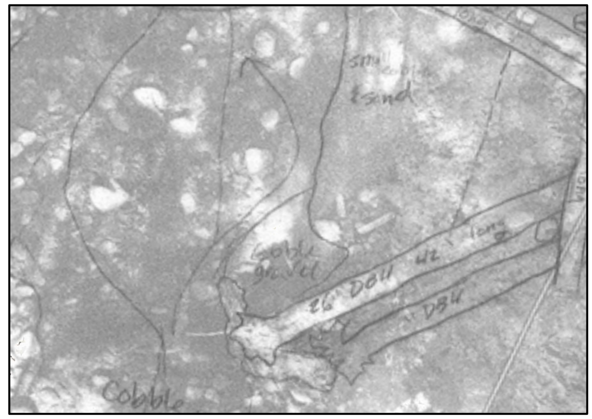
In addition to conducting traditional photographic monitoring of each large wood site (Hall 2001), low-altitude aerial imagery was captured of pre- and post-implementation of large wood structures. While traditional photographic monitoring is a well-established protocol for documenting restoration projects, recently developed photogrammetric software and UAV technologies are facilitating the development of low-cost, high resolution orthophotography and digital elevation models (DEM) (Figure 2). These new UAV assisted monitoring techniques were used in conjunction with total station topographic surveys as a way to supplement and extend physical data in a more efficient manner in regard to time and money (Bird, et al., 2010). These UAV survey flights included each large wood site, active channel reach, and hillslope margins for greater site context. As part of the post-processing analysis of the orthoimagery, detailed facies mapping was conducted in the field. Facies mapping was conducted to help calibrate the imagery to reality for the finer details and distorted sections of the imagery. Until UAV ortho-imagery technology becomes more advanced in detection with developed algorithms, facies mapping is crucial for this level of analysis.

Traditional photographic monitoring was conducted in 2016, 2017, 2018 and 2019 from an array of positions surrounding each large wood feature to optimize the best angle for repeatability that would allow for visual evidence of change. UAV surveys were conducted in the summer of 2016, twice in 2017 (pre-implementation (summer) and post-implementation (fall)), then in the fall of 2018 and 2019. In addition to site specific flights, a high altitude flight was conducted in 2016 for the entirety of each project reaches in Knownothing and Methodist Creeks. Facies mapping was conducted in the fall of 2019.

A Phantom 3 Professional UAV equipped with a 12 megapixel digital camera was used to capture overlapping, true color aerial imagery at each site. The photographs taken by each UAV survey was imported into Structure from Motion (SFM) photogrammetry software (Agisoft Photoscan Professional) to develop high-resolution site-scale orthomosaics. Orthomosaic georeferencing was accomplished using a combination of the Phantom 3 Pro’s on-board GPS receiver, which embeds positional information in the metadata of each digital image, and supplemental ground control targets surveyed with a D-GPS receiver.

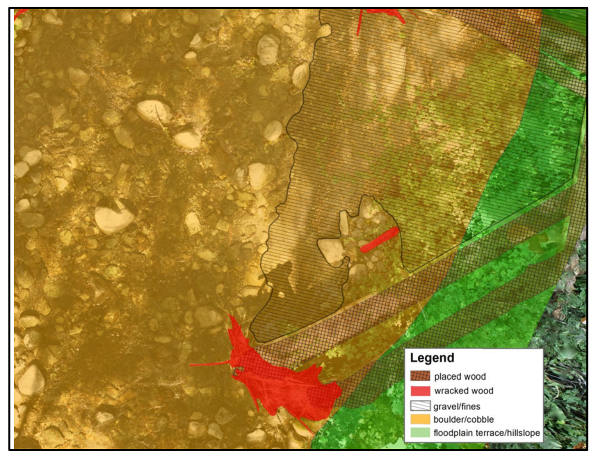
UAV-based orthoimagery was used to develop post-implementation (as-built) site mosaics in the fall of 2017. The process was then repeated during low-water conditions in the fall of 2018 and 2019.

Step 1. Post-construction site scale orthomosaics are developed prior to high-flow engagement of the site.



Step 3. Post-high flow orthomosaics are laminated with Mylar to provide a base for facies mapping in the field.

Step 2. Post-high flow orthomosaics are developed and co-registered to post-construction orthomosaics to support change analysis and effectiveness monitoring.



Step 4. Interpreted field map is brought into GIS software for digitizing of substrate facies, LWD and racked wood features.

Figure 2. An example of the multiple steps taken to make the final post-implementation analysis map used to quantify site changes and evaluate effectiveness.

3 RESULTS AND DISCUSSION

3.1 Topographic Channel Surveys

Thalweg profiles and channel cross-sections were physically surveyed for each large wood site location reach prior to construction and for two additional years following the winter flow seasons (Figure 3).

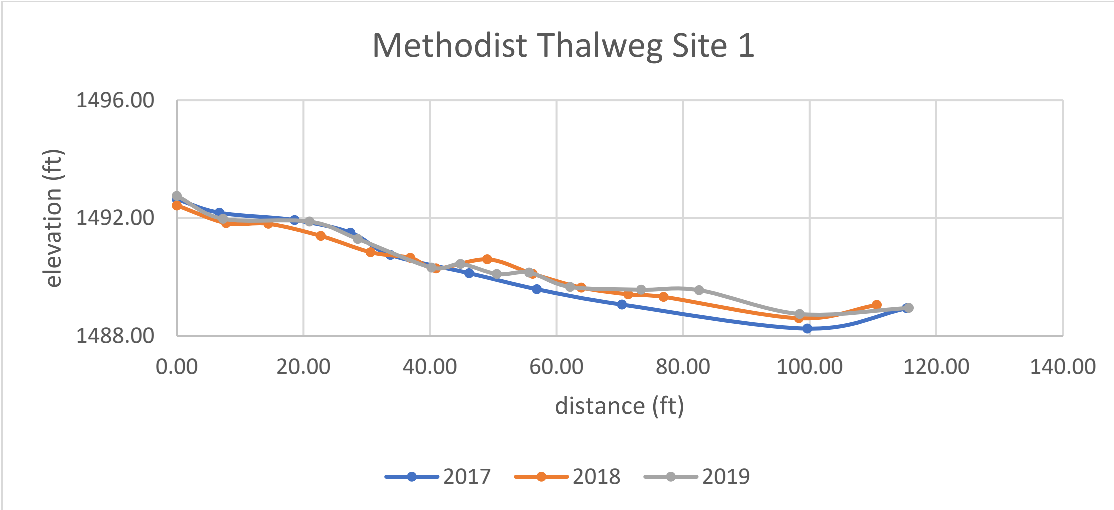


Figure 3. Channel thalweg survey plot, Site # 1 Methodist Creek.

Physical channel metrics obtained from the surveys include: channel gradient, bankfull width and depth, sinuosity, pool frequency and residual pool depth. Results from the topographic channel surveys are shown in Tables 1a and 1b, below. Additional thalweg profiles and channel cross-sections are included in Appendix A.

Channel gradients remained relatively stable at treated reach scales. However, localized scour and deposition can be noted in the physical surveys and data metrics. Overall reach scale channel gradients ranged from 0.0-5.2% in Knownothing and Methodist Creeks, but individual sites varied only slightly over the monitoring period (Tables 1a and1b). Sites in both Knownothing and Methodist Creeks displayed either slightly increased, slightly decreased or neutral channel gradient changes, with no overall consistent pattern (Tables 1a and 1b; Appendix A). This may be a result of the coarse boulder and bedrock dominated substrates in both Knownothing and Methodist Creeks, making for a relatively "hardened" and immobile stream bed, and the relatively low to modest stream flow regimes that occurred over the monitoring period.

Surveyed cross-sections near installed wood structures showed a variety of localized changes. Detectable changes in bankfull cross-sectional area was principally driven by localized changes in bankfull depth associated with scour and/or aggradation at features that engaged sufficiently under high-flow conditions and triggered a geomorphic response of the channel bed through deposition and/or scour (Tables 1a and 1b). However, similar to the thalweg survey results, features in both Knownothing and Methodist Creeks had showed either slightly increased, slightly decreased or neutral channel cross-sectional area changes, with no overall consistent pattern (Tables 1a and 1b). Detectible change in bankfull depth relative to width ranged from 0.0 to $\pm$ 1.1ft in Knownothing Creek and from 0.0 to $\pm$ 0.7ft in Methodist Creek, respectively (Tables 1a and 1b).

Table 1a. Knownothing Creek Topographic Survey Metrics Results.

Site	Year	Channel gradient (%)	Bankfull width (feet)	Bankfull depth (feet)	Sinuosity (ratio)	Pool frequency	Residual pool depth (feet)
KN 1	2017	0.0	29.0	3.8	1.05	1	0.71
KN 1	2018	0.0	29.0	3.8	1.11	2	1.65, 1.93
KN 1	2019	0.0	29.0	4.6	1.18	2	2.58, 1.58
KN 2	2017	5.3	40.0	4.5	1.03	1	2.87
KN 2	2018	5.2	40.0	4.5	1.09	1	3.56
KN 2	2019	4.8	40.0	4.6	1.07	1	2.64
KN 3	2017	1.5	60.5	3.2	1.07	1	0.00
KN 3	2018	1.8	60.5	3.1	1.10	1	0.42
KN 3	2019	1.9	60.5	3.7	1.12	1	2.00
KN 4	2017	1.5	39.2	2.0	1.07	1	0.00
KN 4	2018	1.8	39.2	2.2	1.10	1	0.00
KN 4	2019	1.9	39.2	1.8	1.12	1	1.30
KN 5	2017	1.2	46.4	7.0	1.04	2	1.46, 2.31
KN 5	2018	1.3	46.4	6.7	1.08	2	1.20, 3.21
KN 5	2019	1.4	46.4	7.0	1.08	2	2.39, 3.05
KN 6	2017	1.9	25.2	2.5	1.03	1	1.25
KN 6	2018	2.1	25.2	2.0	1.06	1	1.32
KN 6	2019	1.8	25.2	2.5	1.06	1	1.92
KN 7	2017	2.1	0.0	0.0	1.03	0	0.00
KN 7	2018	2.0	30.0	2.6	1.06	0	0.00
KN 7	2019	2.1	30.0	2.6	1.07	0	0.00
KN 8	2017	1.5	26.0	2.0	1.05	1	1.99
KN 8	2018	1.8	26.0	2.4	1.12	1	1.50
KN 8	2019	2.1	26.0	2.0	1.05	1	1.48
KN 11	2017	0.0	38.9	1.7	1.10	1	1.46
KN 11	2018	0.1	38.9	1.9	1.10	1	1.10
KN 11	2019	0.0	38.9	1.7	1.10	1	1.58
KN 12B	2017	1.3	21.0	1.4	1.10	0	0.00
KN 12B	2018	1.2	21.0	1.9	1.16	0	0.00
KN 12B	2019	1.4	21.0	2.3	1.12	0	0.00
KN 12A	2017	1.3	25.8	2.3	1.10	1	2.31
KN 12A	2018	1.2	25.8	2.3	1.16	1	1.92
KN 12A	2019	1.4	25.8	2.4	1.12	1	1.96

Table 1b. Methodist Creek Topographic Survey Metrics Results.

Site	Year	Channel gradient (%)	Bankfull width (feet)	Bankfull depth (feet)	Sinuosity (ratio)	pool frequency	residual pool depth (feet)
M 1	2017	3.2	20.3	3.8	1.06	0	0.00
M 1	2018	3.0	20.3	3.6	1.07	0	0.00
M 1	2019	3.3	20.3	3.2	1.09	0	0.00
M 2	2017	2.0	24.6	2.8	1.04	1	2.13
M 2	2018	1.4	24.6	2.3	1.12	1	0.82
M 2	2019	2.0	24.6	2.4	1.08	1	0.82
M 3	2017	3.9	36.1	2.2	1.07	0	0.00
M 3	2018	3.6	36.1	2.1	1.16	0	0.00
M 3	2019	4.2	36.1	2.3	1.09	0	0.00
M 4	2017	1.5	22.5	1.8	1.10	1	1.43
M 4	2018	1.4	22.5	2.1	1.10	1	1.78
M 4	2019	2.4	22.5	2.1	1.05	1	1.27

Site	Year	Channel gradient (%)	Bankfull width (feet)	Bankfull depth (feet)	Sinuosity (ratio)	pool frequency	residual pool depth (feet)
M 5	2017	1.9	25.9	0.5	1.15	0	0.00
M 5	2018	2.3	25.9	0.9	1.14	0	0.00
M 5	2019	2.5	25.9	0.9	1.12	0	0.00
M 6	2017	2.0	27.4	0.7	1.05	0	0.00
M 6	2018	2.0	27.4	1.1	1.12	0	0.00
M 6	2019	2.1	27.4	0.9	1.08	0	0.00
M 7	2017	3.8	34.1	0.7	1.12	0	0.00
M 7	2018	4.3	34.1	1.2	1.22	0	0.00
M 7	2019	3.8	34.1	0.9	1.18	0	0.00
M 8	2017	3.7	33.8	2.4	1.12	0	0.00
M 8	2018	3.8	33.8	2.3	1.19	0	0.00
M 8	2019	4.2	33.8	2.4	1.14	0	0.00

Topographic and aerial survey results generally indicate detectable channel changes were focused locally near the wood structures. This is shown through aggraded gravels/fines deposited within treatment reaches and localized lowering of the channel bed (scouring). By monitoring year 2019, Knownothing Creek had approximately 2,332 square feet of additional gravel/fines deposited throughout the treatment reaches while Methodist Creek had an additional 675 square feet gravel/fines deposited throughout their treatment reaches (Table 2a and 2b).

Table 2a. Knownothing Creek UAV Orthomosaic Survey Metrics Results.

Site	Year	Placed LWD area/abundance (square feet)	Wood cover within bankfull (square feet)	Wood Racked (square feet)	Gravel/fines deposited (square feet)	LWD Count (#)	LWD Persistence (%)
KN 1	2017	79.7	50.4	-	-	3	100
KN 1	2018	-	-	-	-	3	100
KN 1	2019	-	88.2	59.0	20.2	3	100
KN 2	2017	176.8	54.0	-	-	4	100
KN 2	2018	-	-	-	-	4	100
KN 2	2019	-	58.0	5.4	6.7	4	100
KN 3	2017	483.2	351.8	-	-	10	100
KN 3	2018	-	-	-	-	10	100
KN 3	2019	-	647.9	299.2	92.7	10	100
KN 4	2017	562.8	264.7	-	-	10	100
KN 4	2018	-	-	-	-	10	100
KN 4	2019	-	308.8	89.4	726.5	10	100
KN 5	2017	190.6	49.3	-	-	4	100
KN 5	2018	-	-	-	-	4	100
KN 5	2019	-	52.1	16.4	264.2	4	100
KN 6	2017	48.7	19.4	-	-	2	100
KN 6	2018	-	-	-	-	2	100
KN 6	2019	-	40.4	32.6	186.6	2	100
KN 7	2017	186.5	33.6	-	-	4	100
KN 7	2018	-	-	-	-	4	100
KN 7	2019	-	59.4	117.7	374.3	4	100
KN 8	2017	218.6	64.1	-	-	6	100

Site	Year	Placed LWD area/abundance (square feet)	Wood cover within bankfull (square feet)	Wood Racked (square feet)	Gravel/fines deposited (square feet)	LWD Count (#)	LWD Persistence (%)
KN 8	2018	-	-	-	-	6	100
KN 8	2019	-	96.4	98.8	82.7	6	100
KN 11	2017	59.9	32.9	-	-	2	100
KN 11	2018	-	-	-	-	2	100
KN 11	2019	-	36.6	9.6	96.8	2	100
KN 12B	2017	559.5	158.8	-	-	7	100
KN 12B	2018	-	-	-	-	7	100
KN 12B	2019	-	176.1	35.9	240.6	7	100
KN 12A	2017	559.5	158.8	-	-	6	100
KN 12A	2018	-	-	-	-	6	100
KN 12A	2019	-	176.1	35.9	240.6	6	100

Table 2b. Methodist Creek UAV Orthomosaic Survey Metrics Results.

Site	Year	Placed LWD area/abundance (square feet)	Wood cover within bankfull (square feet)	Wood Racked (square feet)	Gravel/fines deposited (square feet)	LWD Count	LWD Persistence (%)
M 1	2017	118.6	118.5	-	-	4	100
M 1	2018	-	-	-	-	4	100
M 1	2019	-	246.7	169.7	26.6	4	100
M 2	2017	59.9	41.8	-	-	2	100
M 2	2018	-	-	-	-	2	100
M 2	2019	-	77.0	29.5	101.6	2	100
M 3	2017	227.9	159.5	-	-	5	100
M 3	2018	-	-	-	-	5	100
M 3	2019	-	56.4	9.4	0.0	3	33
M 4	2017	467.3	227.2	-	-	5	100
M 4	2018	-	-	-	-	5	100
M 4	2019	-	275.5	180.8	186.1	5	100
M 5	2017	151.3	135.9	-	-	5	100
M 5	2018	-	-	-	-	5	100
M 5	2019	-	172.9	52.7	196.1	5	100
M 6	2017	210.9	81.7	-	-	5	100
M 6	2018	-	-	-	-	5	100
M 6	2019	-	156.8	127.4	52.9	5	100
M 7	2017	149.5	115.2	-	-	3	100
M 7	2018	-	-	-	-	3	100
M 7	2019	-	180.6	34.4	38.4	3	100
M 8	2017	243.5	98.9	-	-	4	100
M 8	2018	-	-	-	-	4	100
M 8	2019	-	110.1	12.5	72.8	4	100

Retention of smaller bedload particle sizes can further be demonstrated from the pebble count results (Tables 3a and 3b). There was a general trend of smaller particle sizes being retained at nearly all treated project reaches except for project reach Knownothing Site #4 and where bedrock was more exposed due to post-project scour (Table 3a; KN2 and Table 3b; M7, M8).

Knownothing Site #4 is an interesting anomaly in that this large wood structure deposited the highest area of gravels and fines and created a scour pool between the opposing large wood structures, but the data shows a particle size increase from year 2018 to 2019. This anomaly could be explained in that the cross-section location was far enough downstream that the retention of gravels and fines along the large wood “starved” the downstream channel bed of smaller particle sizes giving way to larger particle size detection in the pebble counts.

Table 3a. Knownothing Creek Pebble Count Data Results.

Site	Year	Substrate Particle Distribution (D5) (in)	Substrate Particle Distribution (D16) (in)	Substrate Particle Distribution (D50) (in)	Substrate Particle Distribution (D84) (in)
KN 1	2017	-	-	-	-
KN 1	2018	1.40	1.70	4.01	8.81
KN 1	2019	0.12	0.50	2.52	8.11
KN 2	2017	-	-	-	-
KN 2	2018	1.88	2.96	5.80	8.67
KN 2	2019	0.73	1.92	4.16	9.16
KN 3	2017	-	-	-	-
KN 3	2018	2.33	3.97	6.51	8.90
KN 3	2019	0.54	1.77	4.21	7.13
KN 4	2017	-	-	-	-
KN 4	2018	0.34	0.60	1.77	6.16
KN 4	2019	0.93	1.35	2.71	9.22
KN 5	2017	-	-	-	-
KN 5	2018	0.41	0.79	4.29	8.60
KN 5	2019	0.19	0.31	1.35	6.29
KN 6	2017	-	-	-	-
KN 6	2018	0.82	2.15	5.61	10.08
KN 6	2019	0.09	0.22	1.99	5.93
KN 7	2017	-	-	-	-
KN 7	2018	0.69	1.60	5.67	9.59
KN 7	2019	0.11	0.36	2.89	7.10
KN 8	2017	-	-	-	-
KN 8	2018	-	-	-	-
KN 8	2019	0.09	1.14	4.29	8.90
KN 11	2017	-	-	-	-
KN 11	2018	-	-	-	-
KN 11	2019	0.33	0.63	2.96	7.13
KN 12B	2017	-	-	-	-
KN 12B	2018	0.38	1.60	4.79	9.19
KN 12B	2019	0.12	0.50	2.52	8.11
KN 12A	2017	-	-	-	-
KN 12A	2018	0.40	1.95	6.21	10.01
KN 12A	2019	0.21	0.52	2.40	7.45

Table 3b. Methodist Creek Pebble Count Data Results.

Site	Year	Substrate Particle Distribution (D5) (in)	Substrate Particle Distribution (D16) (in)	Substrate Particle Distribution (D50) (in)	Substrate Particle Distribution (D84) (in)
M 1	2017	-	-	-	-
M 1	2018	0.54	1.11	3.54	7.13
M 1	2019	0.15	0.59	2.20	6.99
M 2	2017	-	-	-	-
M 2	2018	0.76	3.13	5.70	8.44
M 2	2019	0.21	0.48	1.60	4.74
M 3	2017	-	-	-	-
M 3	2018	2.48	3.56	6.17	11.97
M 3	2019	0.69	1.23	3.40	8.87
M 4	2017	-	-	-	-
M 4	2018	0.14	0.47	4.37	12.32
M 4	2019	0.27	0.52	1.83	6.00
M 5	2017	-	-	-	-
M 5	2018	0.42	0.70	4.14	8.99
M 5	2019	0.25	0.63	2.52	8.60
M 6	2017	-	-	-	-
M 6	2018	0.61	1.34	3.92	8.19
M 6	2019	0.43	1.09	2.90	7.93
M 7	2017	-	-	-	-
M 7	2018	0.70	2.72	6.08	10.03
M 7	2019	0.39	1.42	5.04	13.47
M 8	2017	-	-	-	-
M 8	2018	0.59	2.27	5.67	10.55
M 8	2019	0.59	1.18	6.20	22.49

3.2 UAV Aerial Surveys and Photography

UAV-based orthoimagery was used to develop high resolution DEMs and photography that ultimately enabled us to evaluate post-construction site changes and associated effectiveness metrics such as cover, racked wood and channel substrate characteristics. Figures 4a and 4b, below, shows examples of orthomosaic models created for a site in both Knownothing and Methodist Creeks. All of the completed orthomosaic models are included in Appendix B.

Due to the lack of significant high-flow discharge events and minimal response of the large wood features to winter stream flows in 2017/2018, only the feature-scale aerial imagery collected in Fall of 2019 was used to evaluate post-construction effectiveness metrics such as cover, racked wood and substrate area.

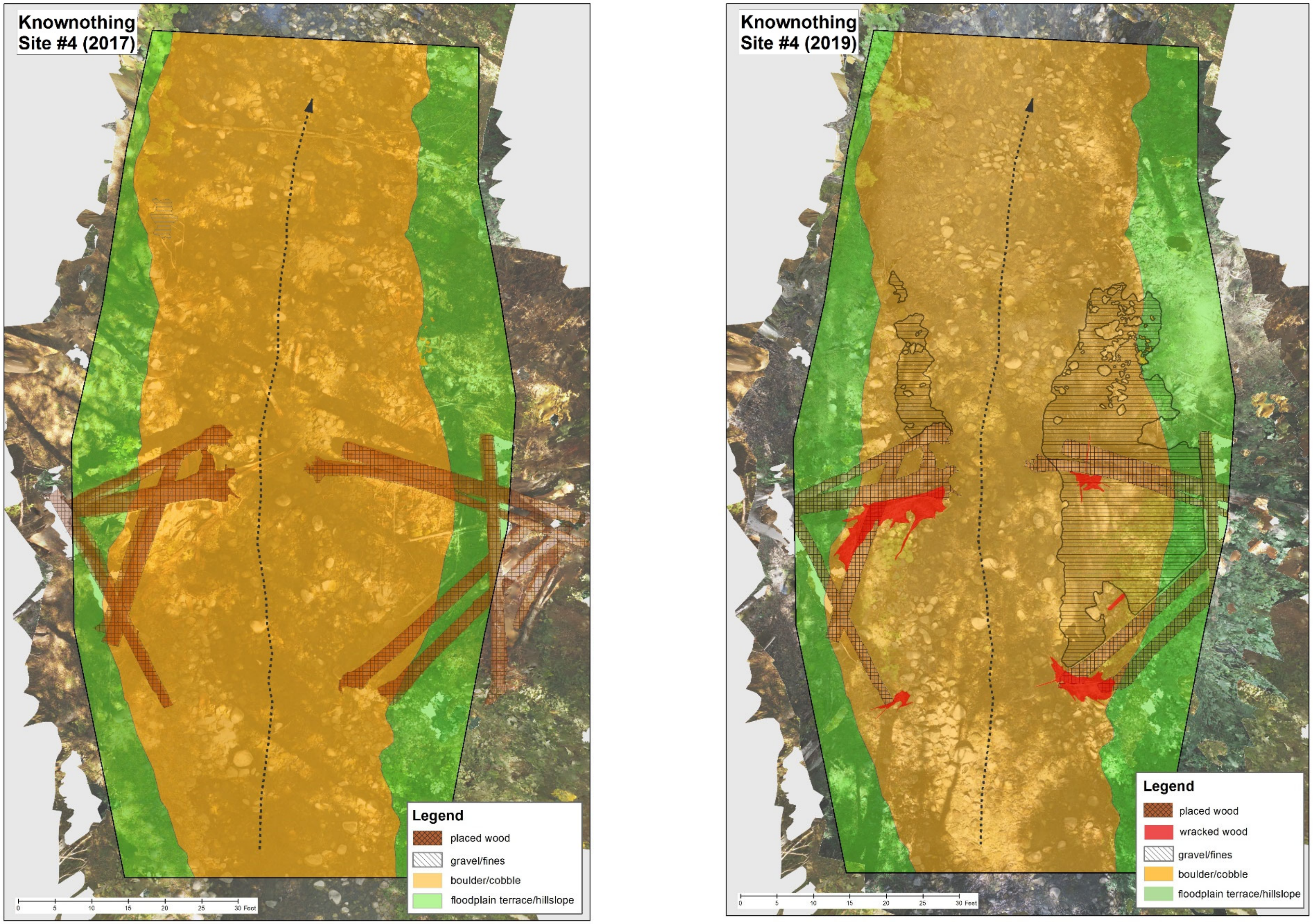


Figure 4a. Orthomosaic model for Site #4 in Knownothing Creek.

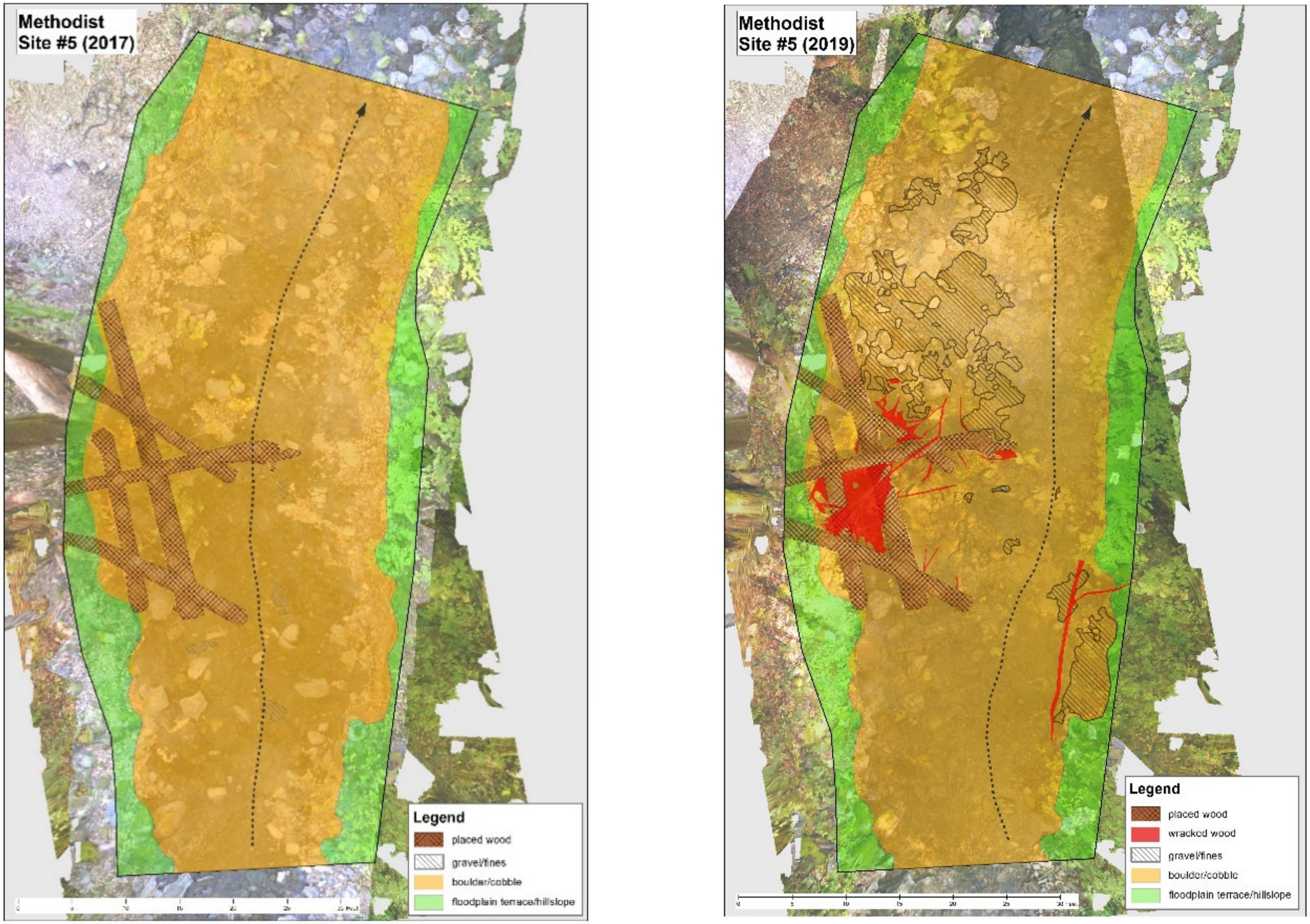


Figure 4b. Orthomosaic model for Site #5 in Methodist Creek.

UAV orthoimagery analysis demonstrated that constructed large wood structures remained relatively stable over the 3-year monitoring period in both Knownothing and Methodist Creeks (Tables 2a and 2b; Appendix B). Eighteen features (excluding M3) showed a measurable increase in woody cover, obtained through the retention of racked wood. This is a positive result considering one of the primary goals of the project was to create key log jams where additional wood could rack and thereby increase habitat cover and localized channel changes over time.

Large wood implementation techniques (wedging and metal anchoring) retained 89 logs, with two logs from M3 migrating downstream. The two logs that mobilized moved approximately 240 feet down stream where they racked into existing vegetation approximately 60 feet upstream from M1. These two logs were anchored together with metal, holding the pieces together as one larger piece. By having the two logs together, it made it more difficult for them to move out of the restoration reach and allowed them to rack into living vegetation along the banks. The wedge point in the living vegetation for these two logs became weak during high flows. As a result, the living vegetation that was scoured out of the bank allowed the two logs to break free and remobilize. The implementation techniques were not the reason for mobilization, but rather the design. The living wedge points were not strong enough to maintain the necessary shear resistance to high flows. However, in the new racked position, these logs performed very well in sorting gravels, displacing high flows, and establishing cover in an area that was previously lacking instream habitat. Total placed LWD, persistence, cover, racked wood and gravel/fines deposition metrics are included in Tables 2a and 2b, above.

4 CONCLUSIONS

The limitations of conducting such a monitoring design program as was completed here, lie in the cyclical natural environmental variability in fish populations, climatic conditions and the hydrologic flow regimes that trigger the changes we observed. This natural variability can pose a challenge to an effectiveness monitoring design of this nature, given the temporal constraints (short evaluation period) included in the grant-funded monitoring program. Had we not observed a relatively modest 2018/2019 water year hydrologic regime, compared to the meager 2017/2018 water year, measureable changes would have likely been minimal, at best. In addition, the cyclical nature of fish population dynamics and ocean conditions limit any conclusions about biological fish response given the 3-year monitoring time frame. Because of this we did not provide any discussion around fish survey results. However, SRRC fish survey data for the 3-year monitoring period are included in Appendix C.

Given the biological complications and temporal constraints discussed, the monitoring design program framework included the measurement and observation of physical channel parameters such as geomorphic-gravel retention and sorting, hydraulic-velocity refugia, habitat-cover, and carbon enrichment of the aquatic food web to be used as a proxy for project effectiveness success criteria. Based on the measurable observations discussed, including an increase in overall gravel retention, increases in retained woody cover, creation of localized hydraulic refugia among structures, it can be reasonably stated that the instream large wood habitat implementation project was successful in creating and enhancing habitat for anadromous salmonids over the monitoring timeframe.

4.1 Lessons Learned

Fall proved to be the preferred UAV and topographical survey time period because of the low water stage, maximum water clarity and more open sightlines from a leafless canopy. These field conditions allowed better visualization of the project reach and had higher rates of substrate exposure needed for photographic (aerial) analysis. To employ this survey time period strategy, it was imperative to wait long enough to allow the riparian trees to drop leaves but also conduct the aerial surveys before fall rains raised the water levels and increased turbidity. Higher water levels created more disturbed water (whitewater, turbidity) that was counterproductive to using UAV photographic analysis. With that said, winter could also be an optimal time for overall reach UAV flights. If detailed channel bed information is not as important as the overall reach characteristics, mid-winter could be a more optimal time frame to obtain unobstructed (leafless) photography.

Cross-section locations were assigned after designs were created, but before actual construction of the wood structures had commenced. It was thought to be imperative to gain all the total station survey information prior to large wood being placed, however this order of operations became problematic for optimal post-implementation monitoring effectiveness. Future monitoring strategies would suggest assigning cross-section locations after the large wood is placed, but before flows had begun to rise for the year. The project design intended to place all the cross-sections downstream of each large wood structure so as to gain the most knowledge and maintain the most efficient expenditure of time and money. It is now thought that having two or three cross-sections per site would likely provide a more comprehensive analysis and characterization of the overall channel and habitat effects of the wood placement. However, this leads to the labor/cost-balance dilemma typically present with grant funded projects with limited budgets. At minimum, one cross-section is suggested to be assigned 5-30 feet downstream of the large wood and, if budget and time allows, additional cross-sections are recommended to be assigned amongst the large wood and within 10 feet upstream of the large wood.

Because this project was the first of its type and scale for large wood restoration projects implemented in the Cal Salmon River watershed, the design of each site employed a high level of caution. The caution used during the design process owed to the large substrate and confined stream corridors that may have more mobilizing and potential damaging effects on the placed large wood, possibly giving way to the partial or loss of the structures during high flow events. This suggests that riparian planting of trees would be a necessary supplement to placed large wood structures, thereby providing for better long term wood recruitment in these streams. In addition, funding requirements and NEPA permitting constrained the overall size, typeand location of structures being placed. Though two logs did mobilize, it is now speculated that if the designs were to be more aggressively engaging the main channel, and significantly larger in scale, the outcome of gravel retention and habitat enhancement increases may have been reflected sooner and to a larger magnitude than the observed outcome from these relatively low-to-moderate flow years. The large wood structures constructed in this project are having a positive effect on the quality of the stream habitat, but these instream improvements are just scratching the potential for the use of large wood restoration techniques in the watershed. It may be beneficial to consider the augmentation of existing sites with additional wood, as well as more instream wood structures to be added to the treatment reaches overall. We would additionally recommend that intermittent monitoring of these project sites be continued into the near future, at least until the large wood structures have experienced a wider range of winter stream flows.

Finally, having a nearby control stream to monitor concurrent with the modified implementation stream reaches would have enabled a better overall picture of the results compared to un-modified conditions.

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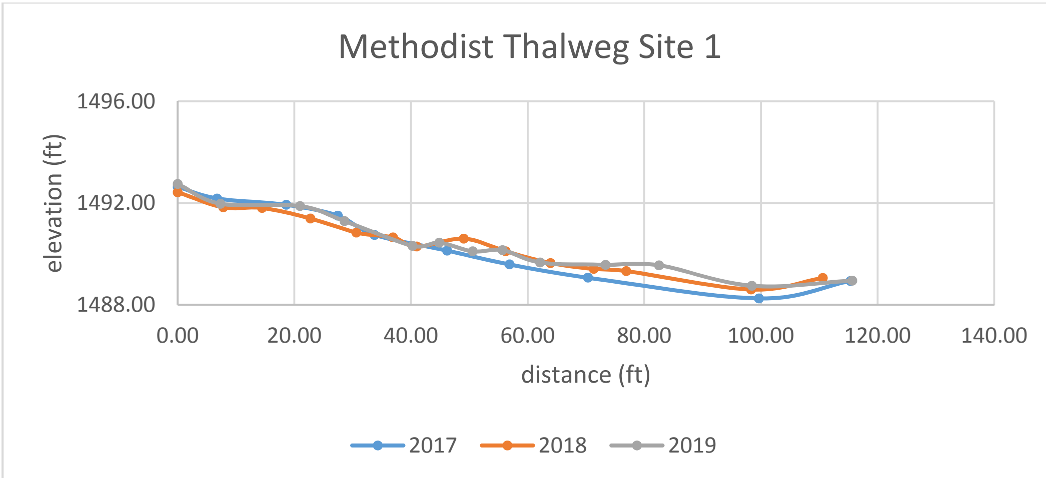
6 APPENDICES

6.1 Appendix A – Site Thalweg Profiles and Cross-Sections

6.2 Appendix B – Site Orthomosaic Models

6.3 Appendix C – SRRC Fish Survey Results

6.1 *Appendix A – Site Thalweg Profiles and Cross-Sections*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1488.00
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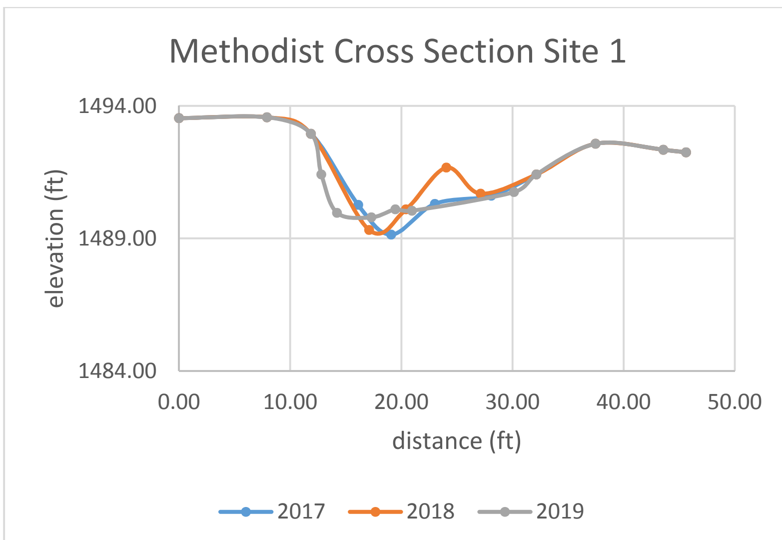
distance (ft)
2017
2018
2019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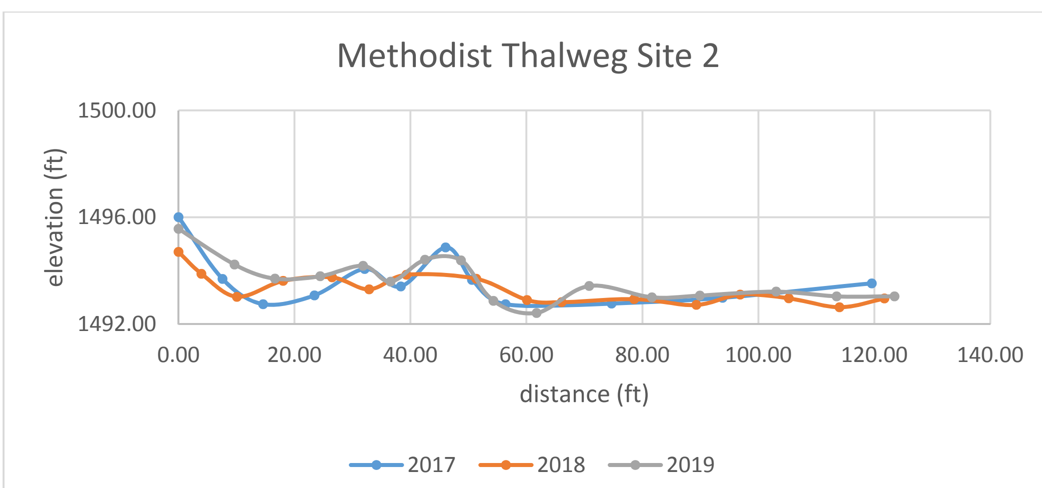
distance (ft)
2017
2018
2019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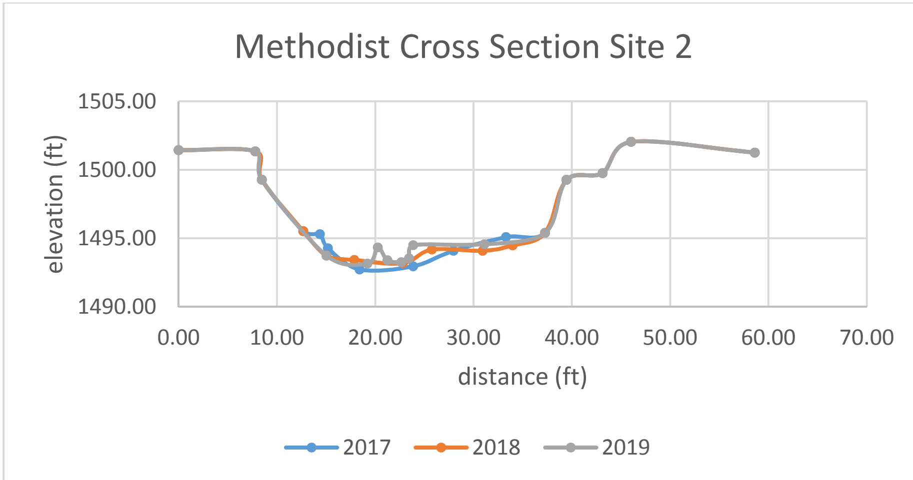
80.00
100.00
120.00
140.00
distance (ft)
2017
2018
2019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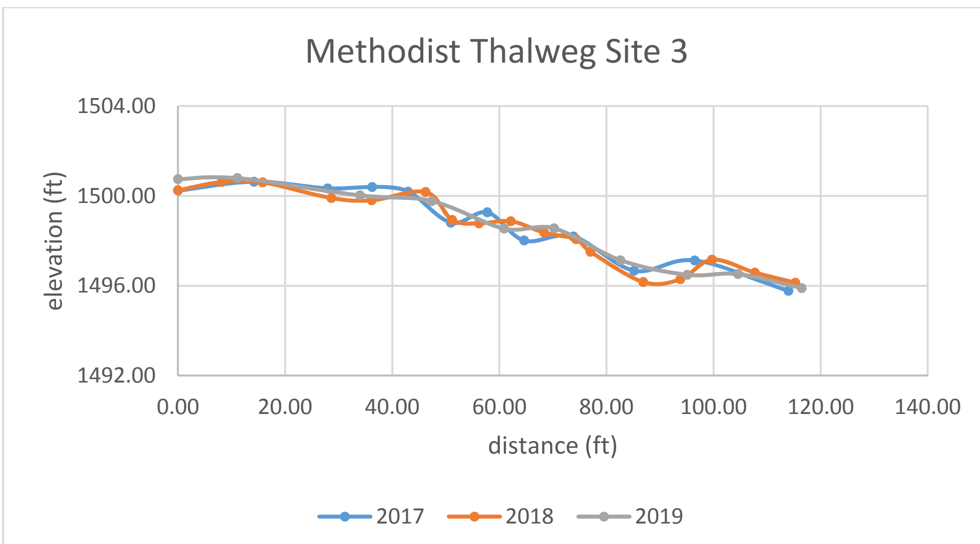
60.00
70.00
distance (ft)
2017
2018
2019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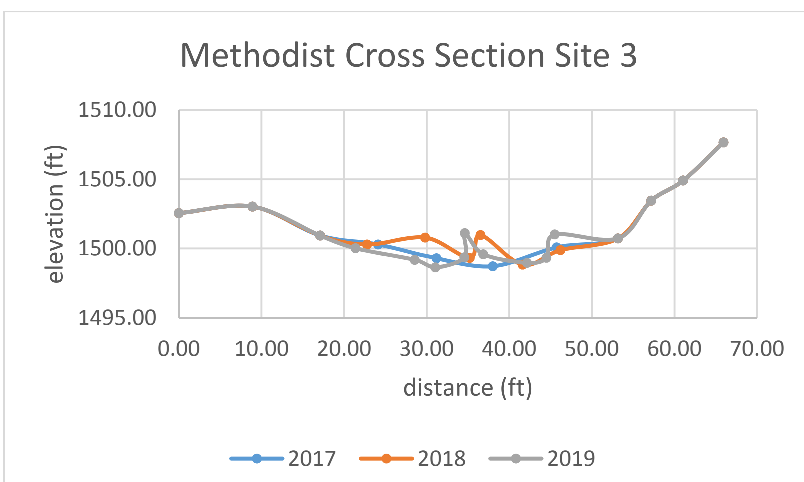
80.00
100.00
120.00
140.00
distance (ft)
2017
2018
2019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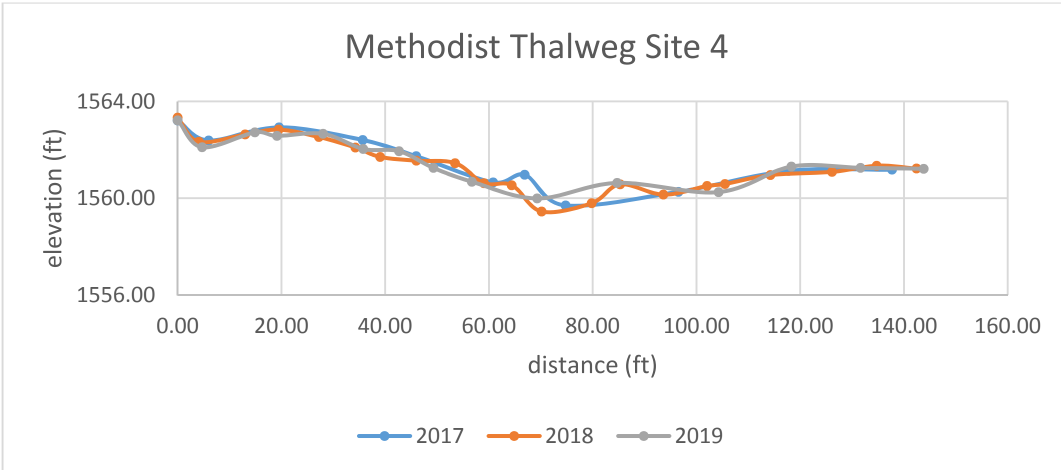
50.00
60.00
70.00
distance (ft)
2017
2018
2019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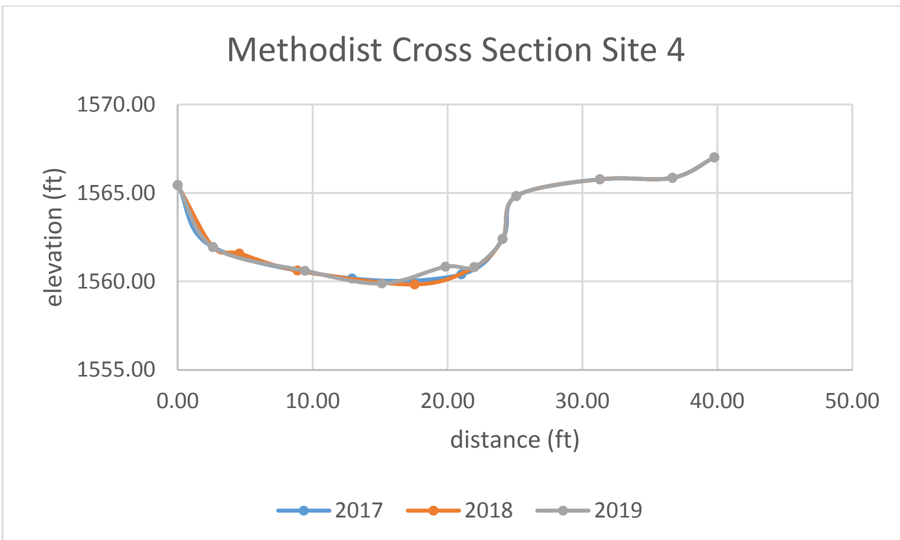
distance (ft)
2017
2018
2019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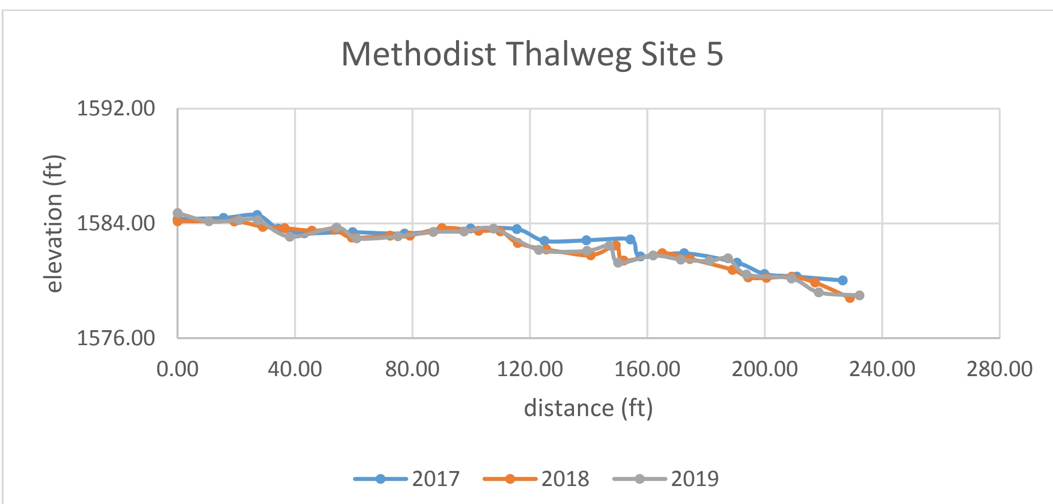
distance (ft)
2017
2018
2019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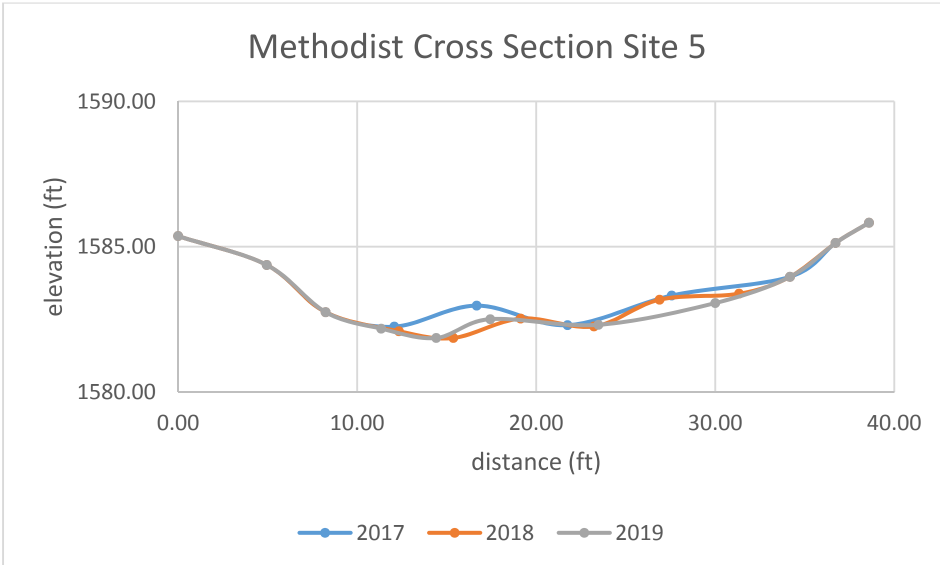
200.00
240.00
280.00
distance (ft)
2017
2018
2019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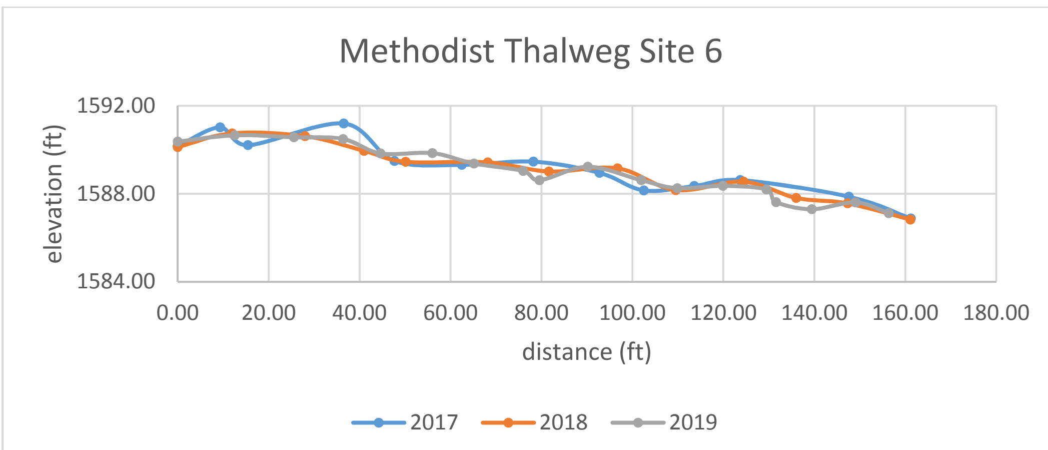
10.00
20.00
30.00
40.00
distance (ft)
2017
2018
2019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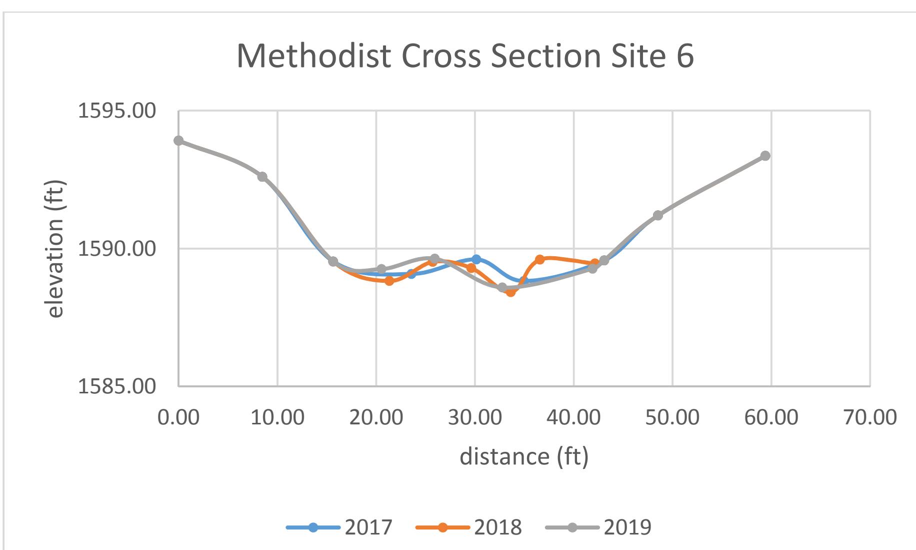
distance (ft)
2017
2018
2019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1585.00
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20.00
30.00
40.00
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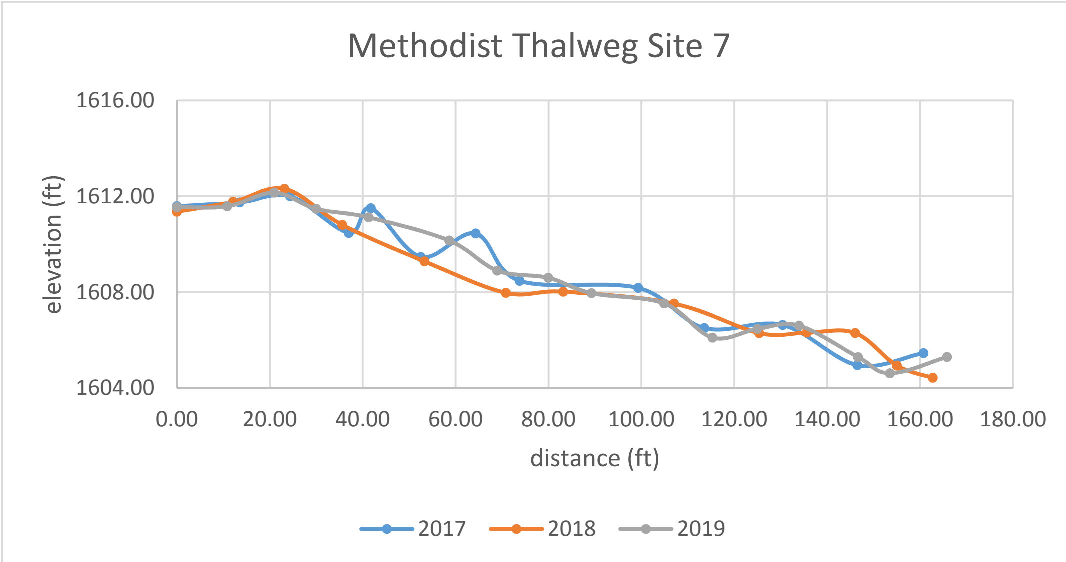
distance (ft)
2017
2018
2019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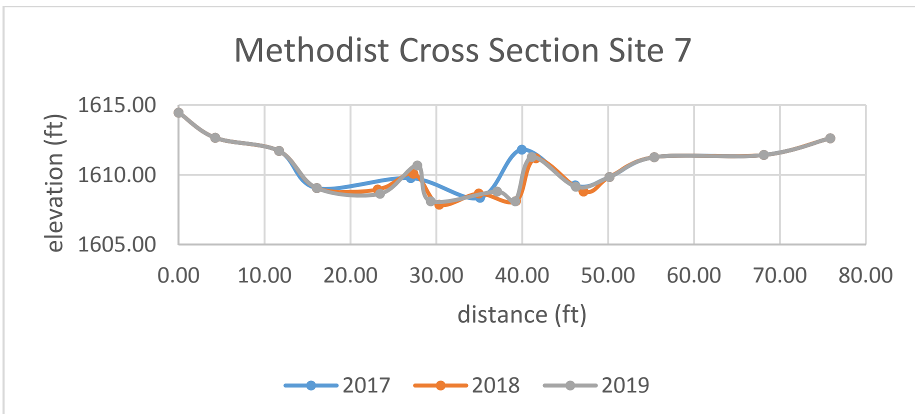
140.00
160.00
180.00
distance (ft)
2017
2018
2019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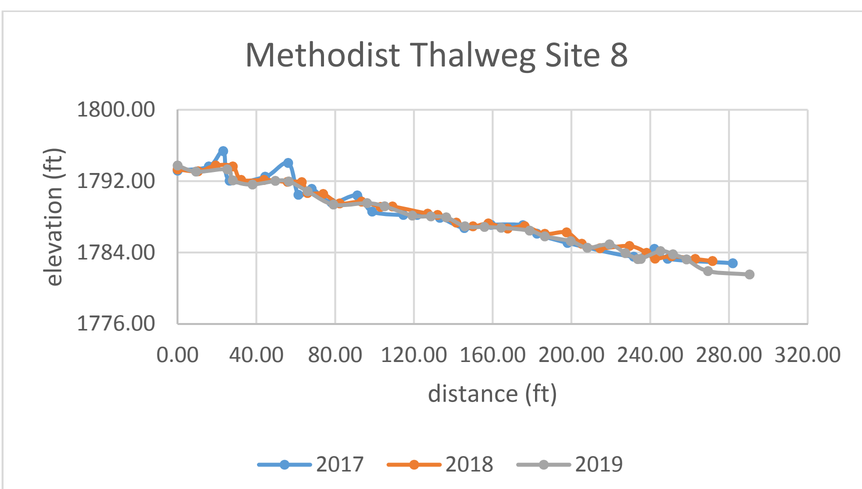
distance (ft)
2017
2018
2019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1792.00
1784.00
1776.00
0.00
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80.00
120.00
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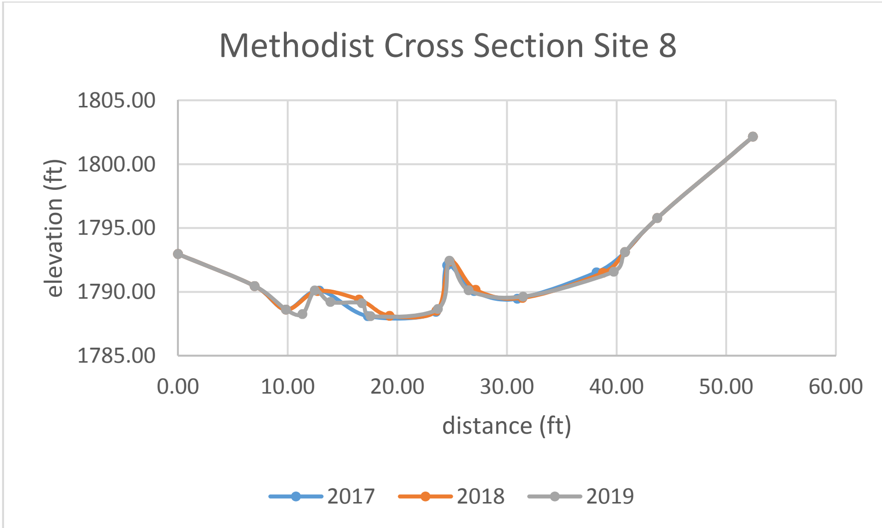
200.00
240.00
280.00
320.00
distance (ft)
2017
2018
2019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1790.00
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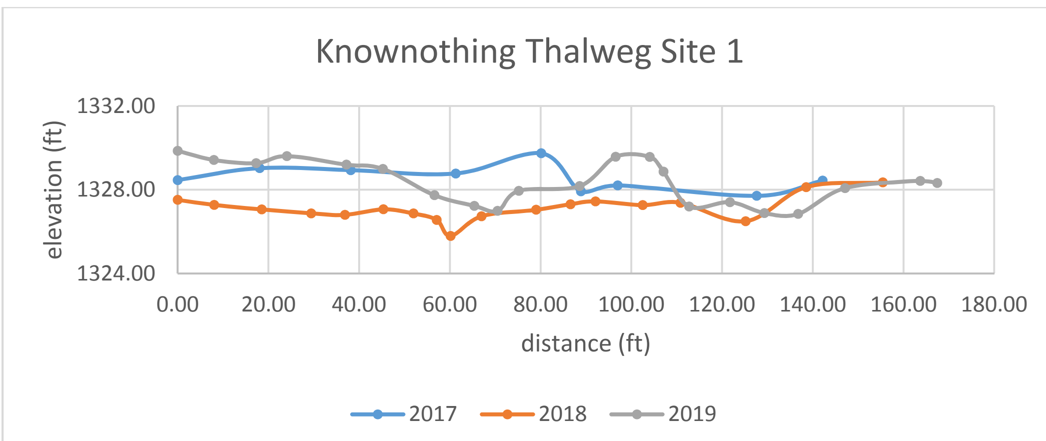
30.00
40.00
50.00
60.00
distance (ft)
2017
2018
2019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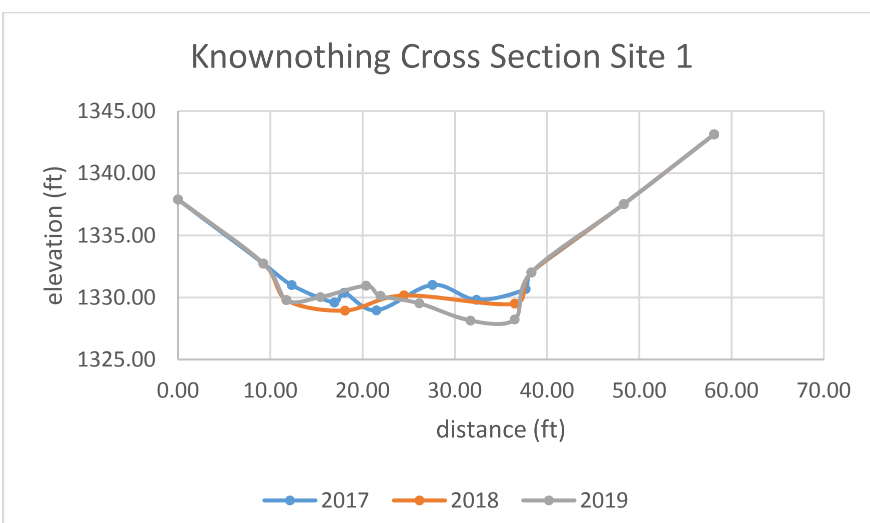
100.00
120.00
140.00
160.00
180.00
distance (ft)
2017
2018
2019


Knownothing Cross Section Site 1
elevation (ft)
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1335.00
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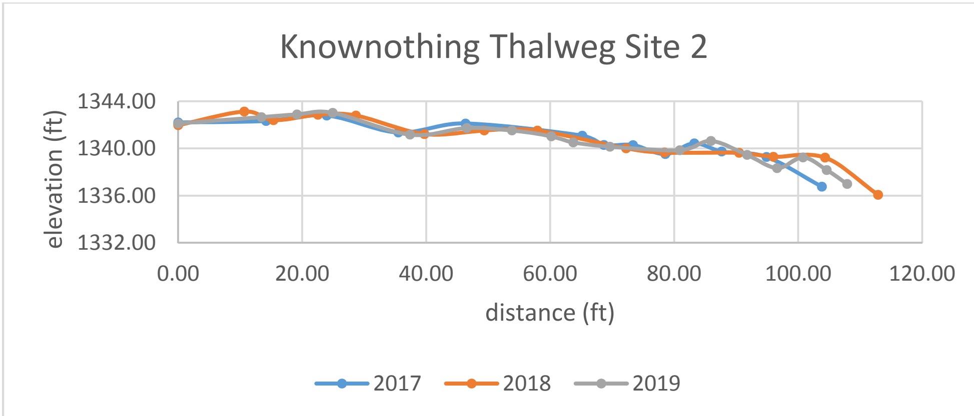
40.00
50.00
60.00
70.00
distance (ft)
2017
2018
2019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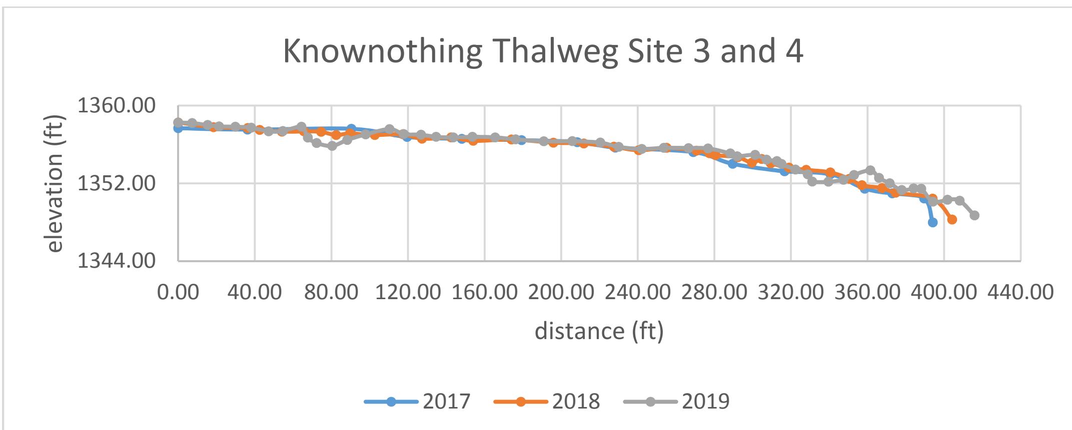
80.00
100.00
120.00
distance (ft)
2017
2018
2019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80.00
120.00
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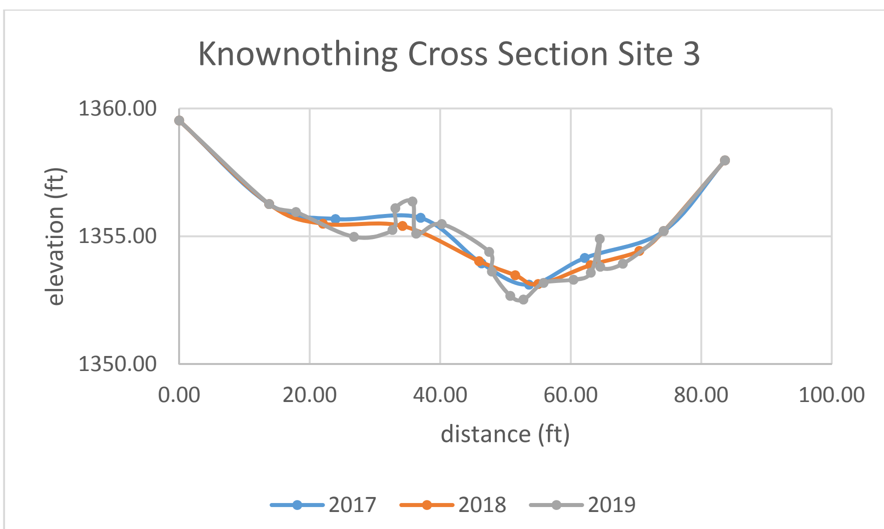
200.00
240.00
280.00
320.00
360.00
400.00
440.00
distance (ft)
2017
2018
2019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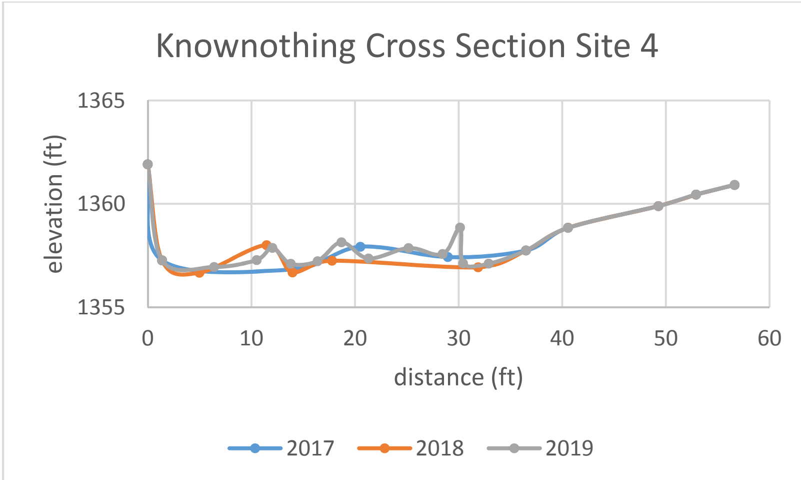
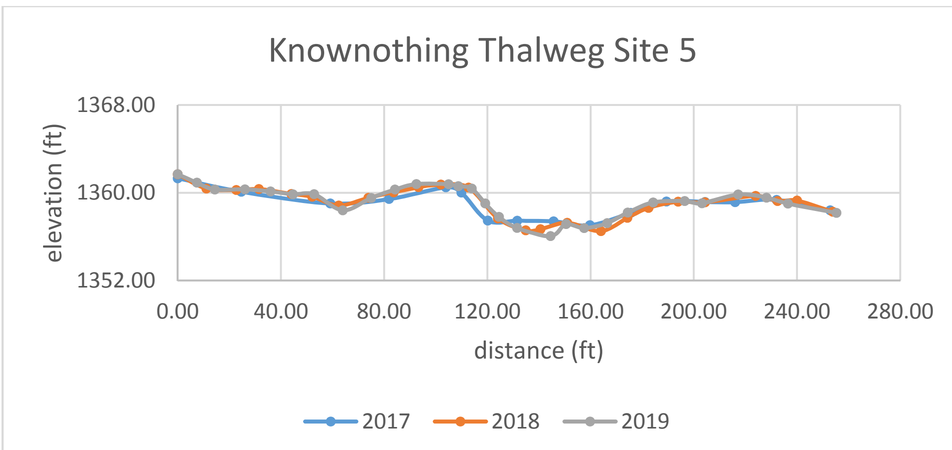
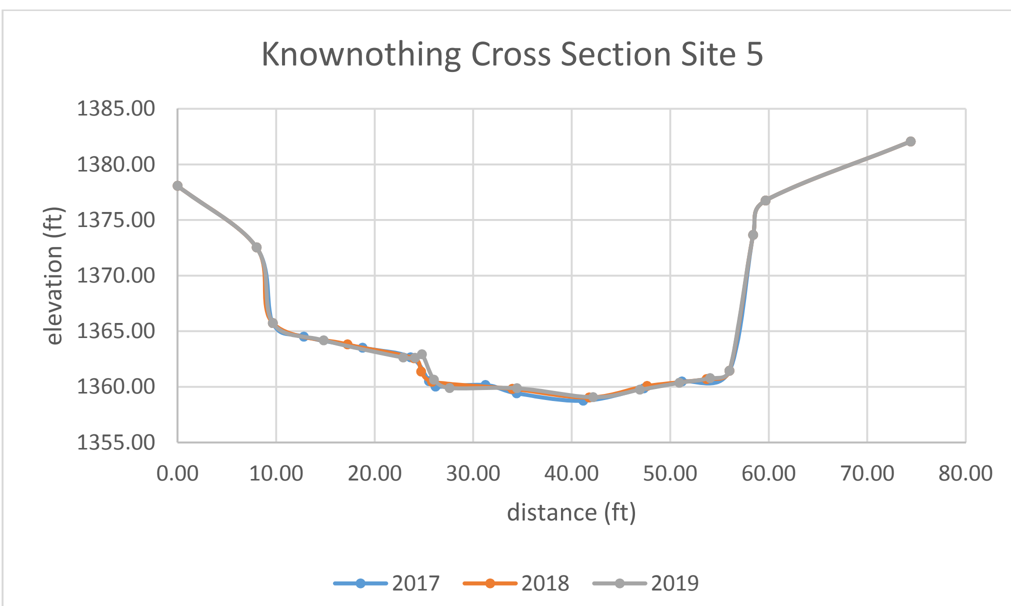
60.00
80.00
100.00
distance (ft)
2017
2018
2019



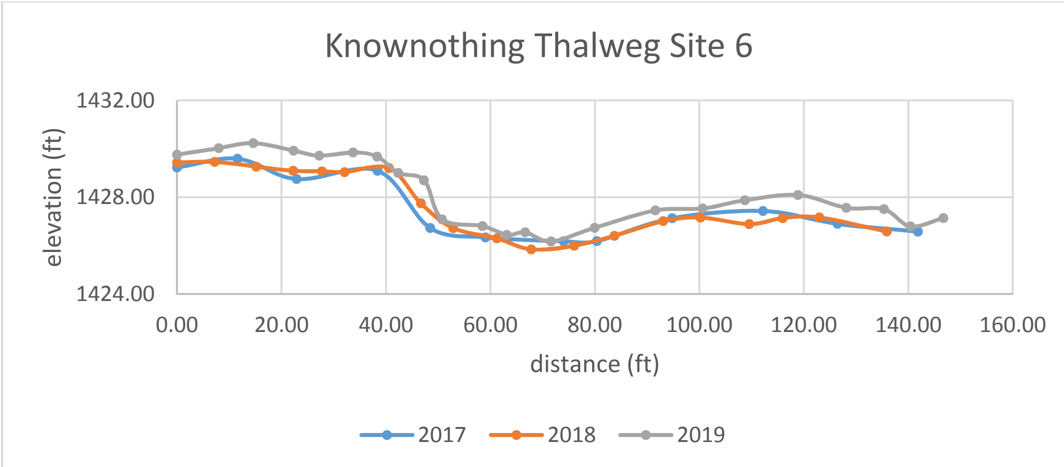
Knownothing Cross Section Site 4
elevation (ft)
1365
1360
1355
0
10
20
30
40
50
60
distance (ft)
2017
2018
2019

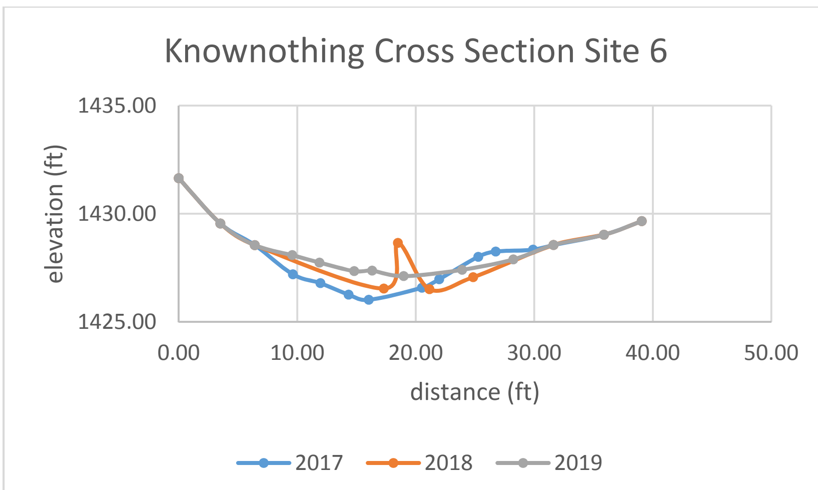


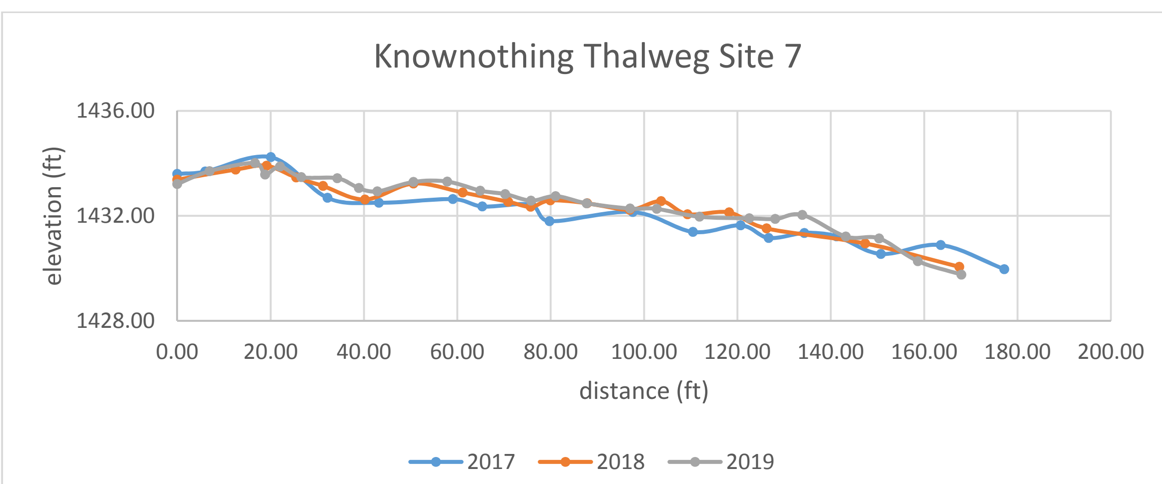
Knownothing Thalweg Site 5
elevation (ft)
1368.00
1360.00
1352.00
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
distance (ft)
2017
2018
2019

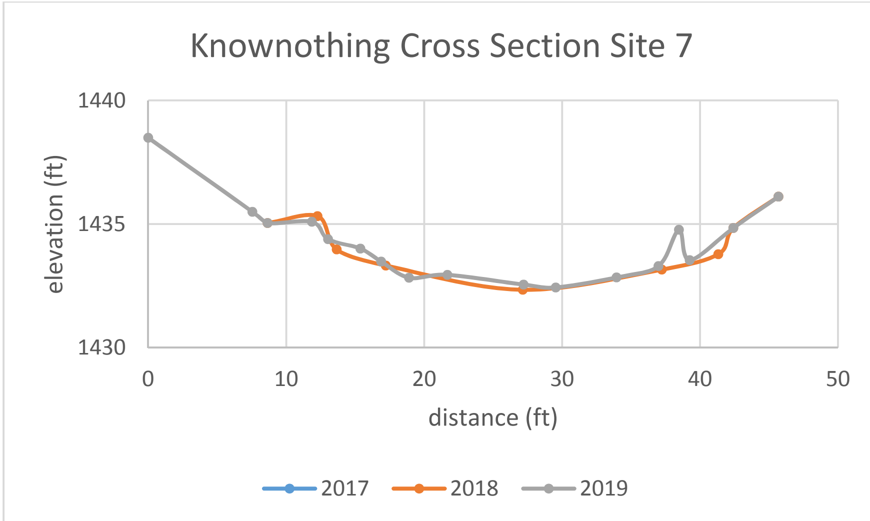


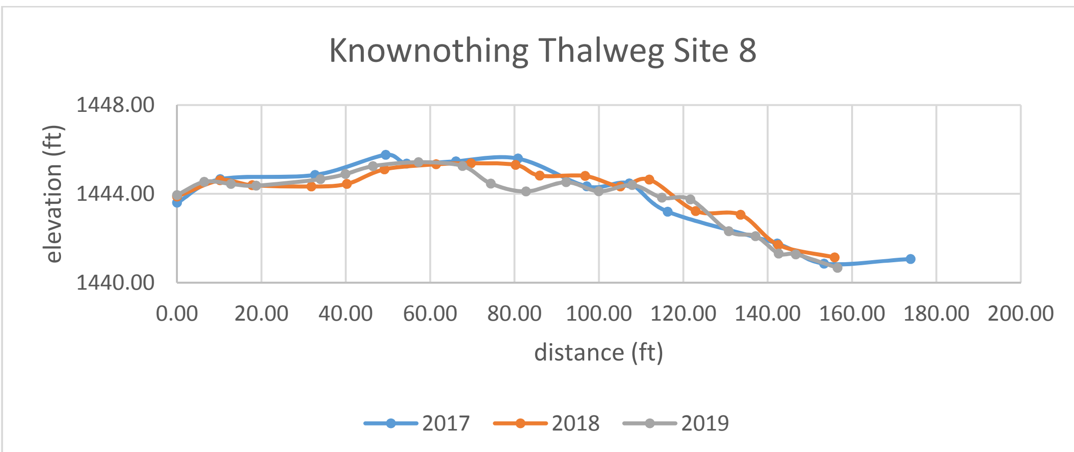
Knownothing Cross Section Site 5
elevation (ft)
1385.00
1380.00
1375.00
1370.00
1365.00
1360.00
1355.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
distance (ft)
2017
2018
2019

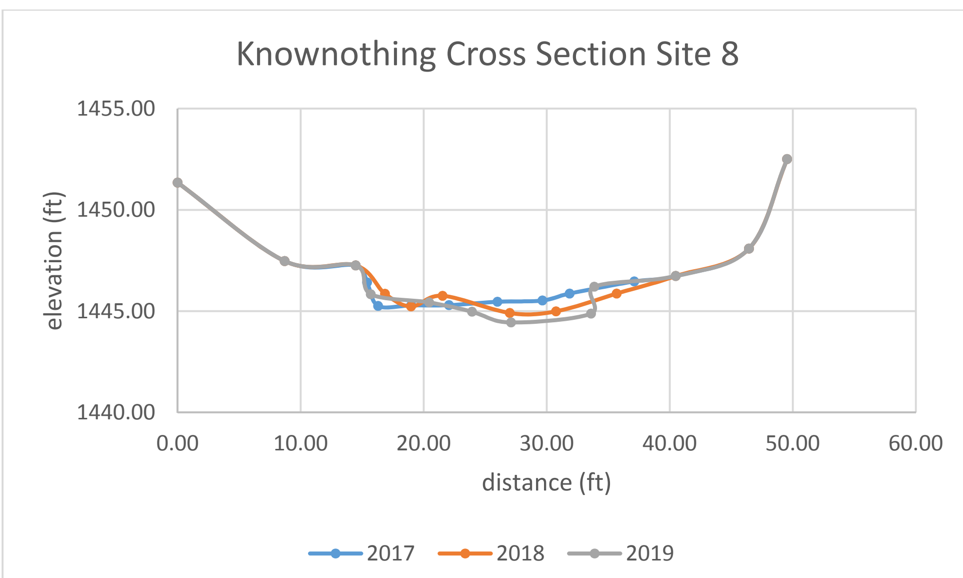

Knownothing Thalweg Site 6
1432.00
1428.00
1424.00
elevation (ft)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
distance (ft)
2017
2018
2019

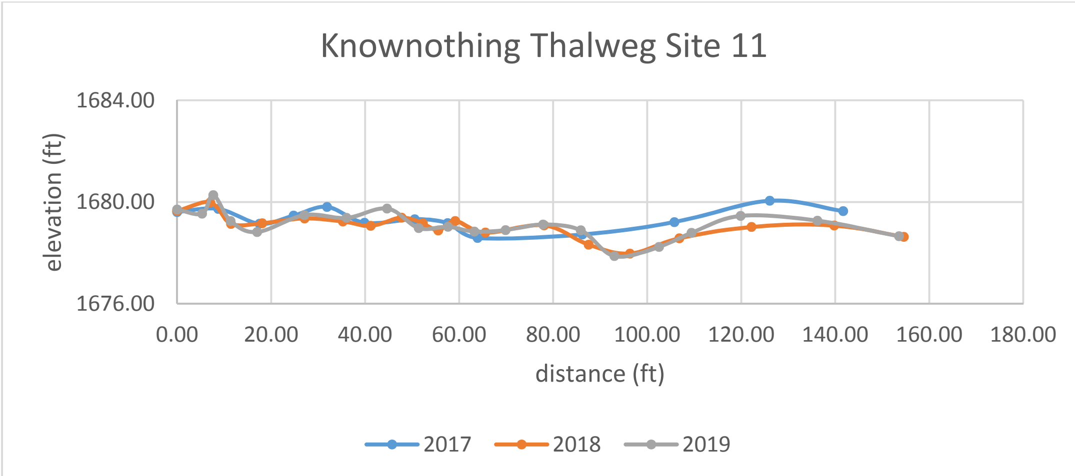

Knownothing Cross Section Site 6
1435.00
1430.00
1425.00
elevation (ft)
0.00
10.00
20.00
30.00
40.00
50.00
distance (ft)
2017
2018
2019

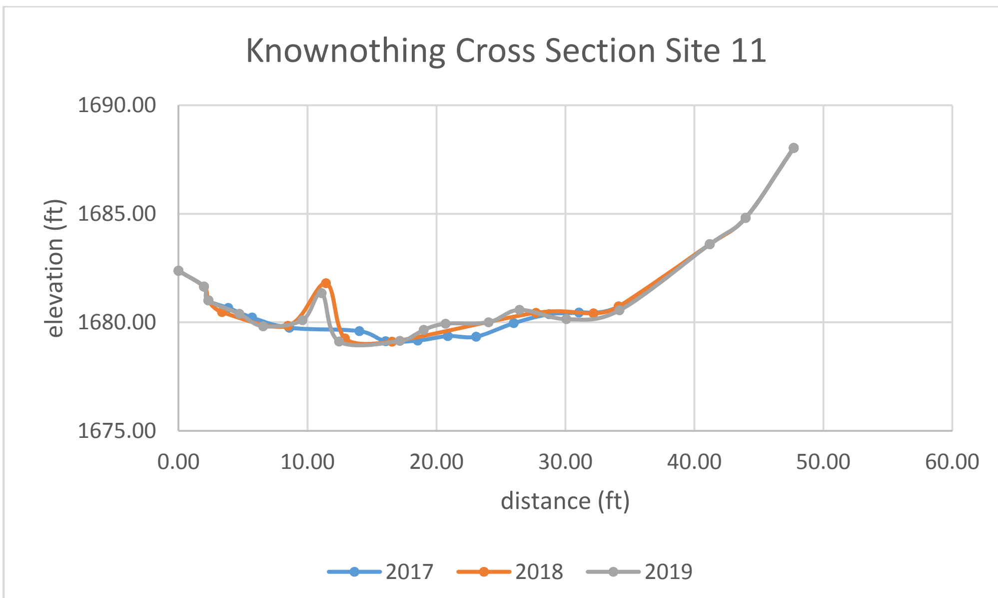

Knownothing Thalweg Site 7
1436.00
1432.00
1428.00
elevation (ft)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
distance (ft)
2017
2018
2019

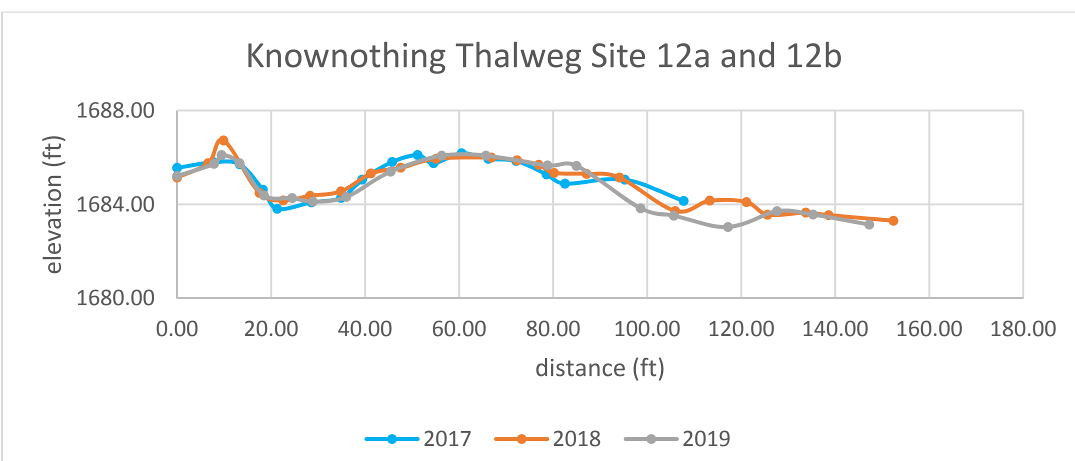

Knownothing Cross Section Site 7
1440
1435
1430
elevation (ft)
0
10
20
30
40
50
distance (ft)
2017
2018
2019

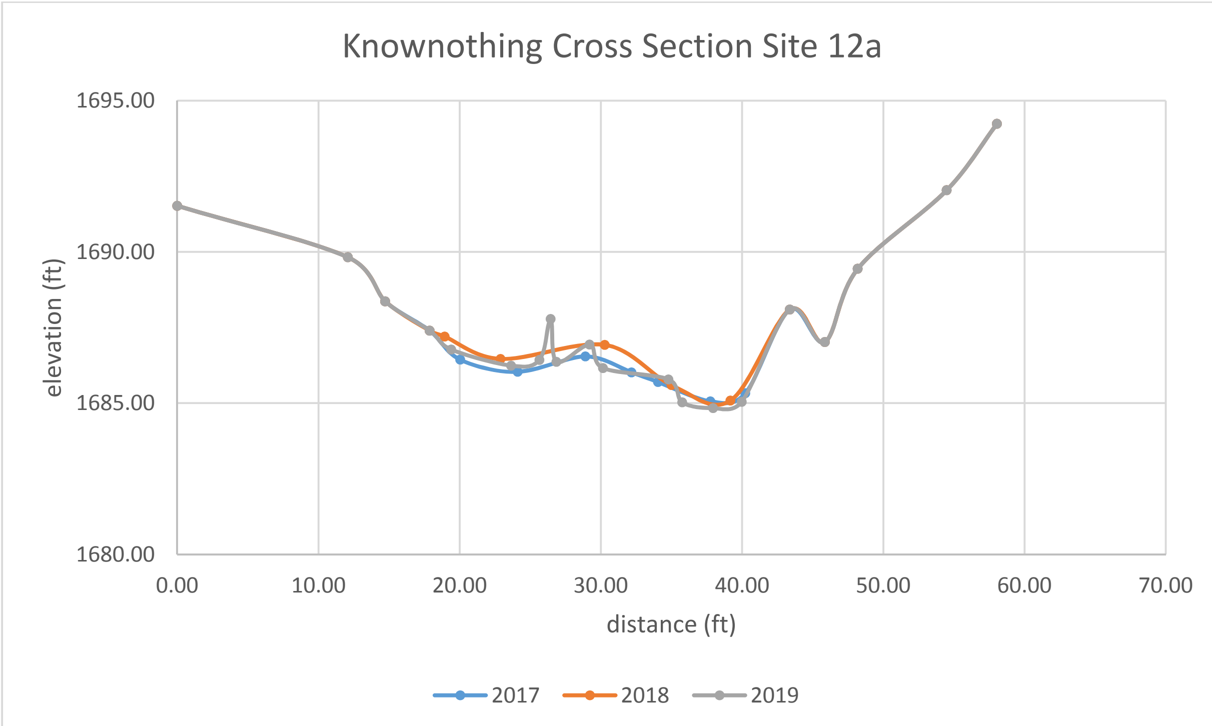

Knownothing Thalweg Site 8
1448.00
1444.00
1440.00
elevation (ft)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
distance (ft)
2017
2018
2019

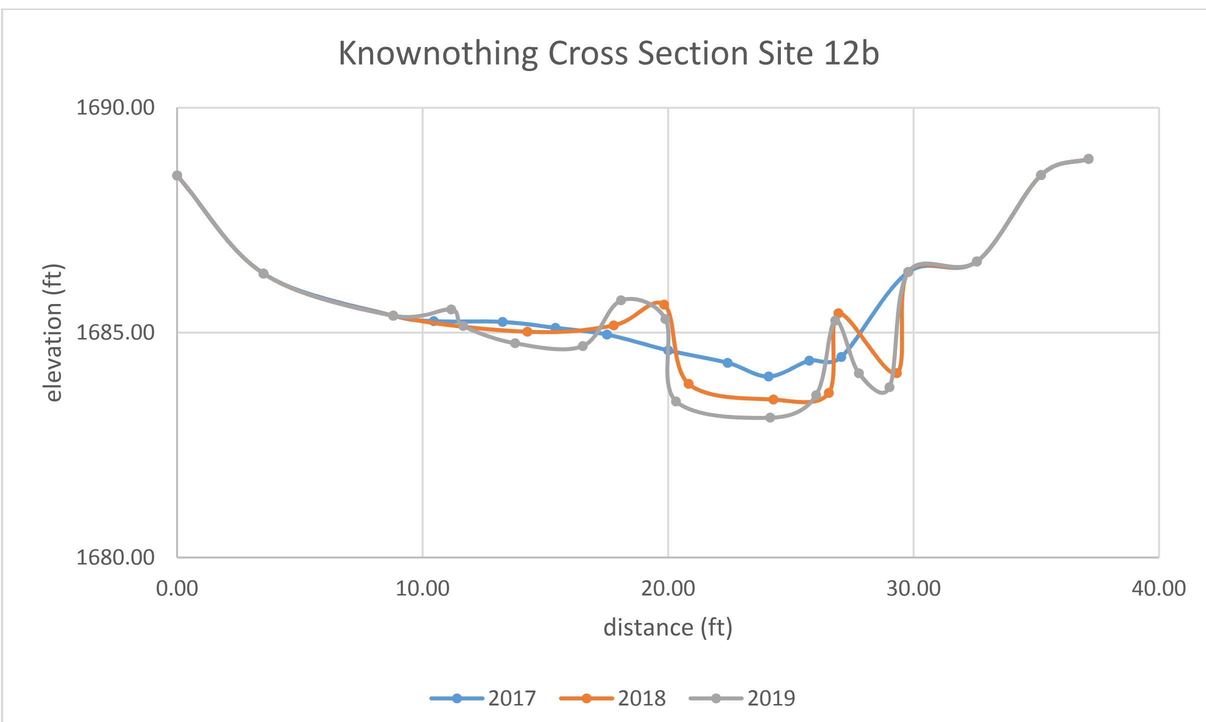

Knownothing Cross Section Site 8
1455.00
1450.00
1445.00
1440.00
elevation (ft)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
distance (ft)
2017
2018
2019


Knownothing Thalweg Site 11
1684.00
1680.00
1676.00
elevation (ft)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
distance (ft)
2017
2018
2019


Knownothing Cross Section Site 11
1690.00
1685.00
1680.00
1675.00
elevation (ft)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
distance (ft)
2017
2018
2019

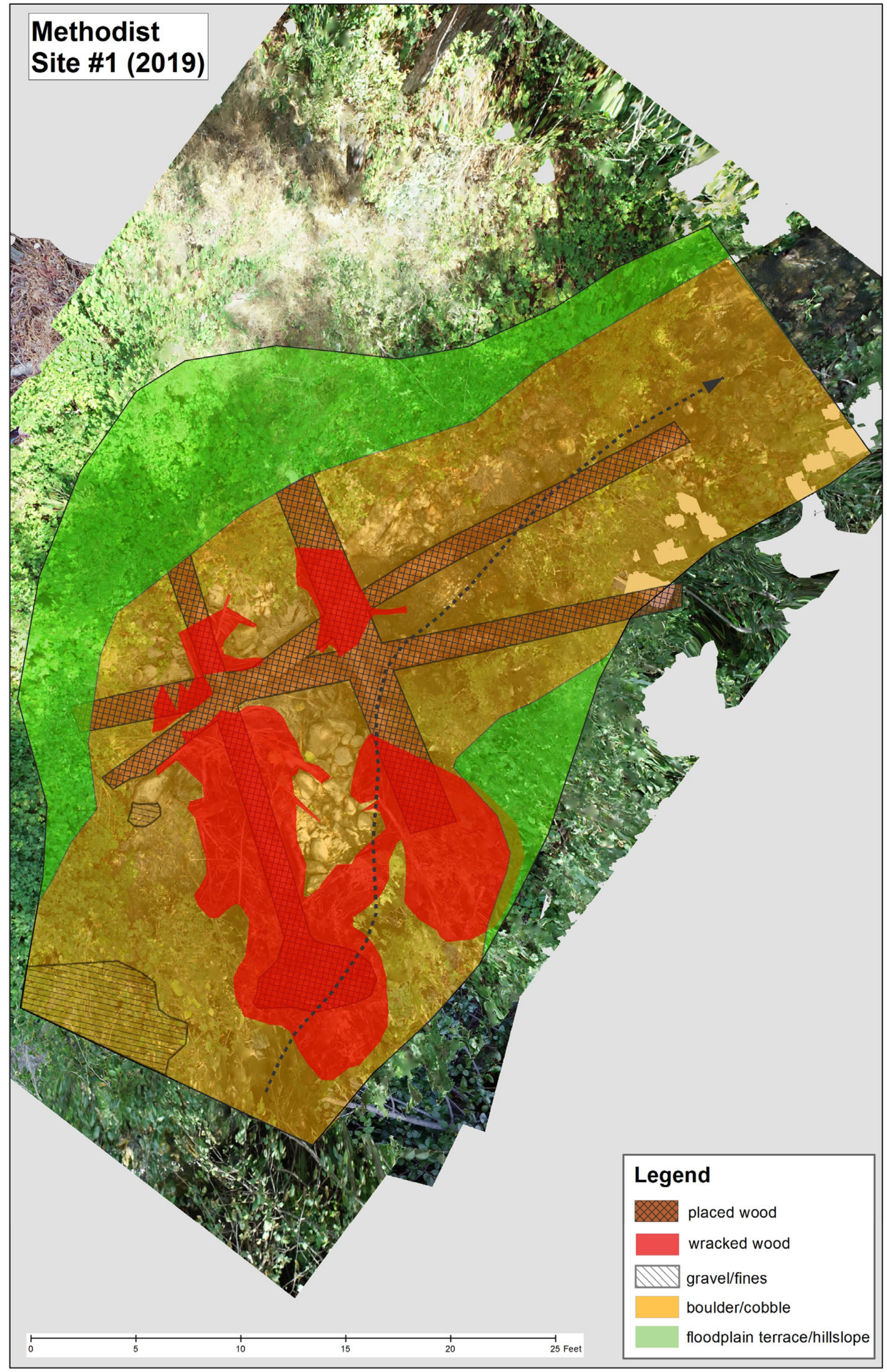

Knownothing Thalweg Site 12a and 12b
1688.00
1684.00
1680.00
elevation (ft)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
distance (ft)
2017
2018
2019


Knownothing Cross Section Site 12a
1695.00
1690.00
1685.00
1680.00
elevation (ft)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
distance (ft)
2017
2018
2019

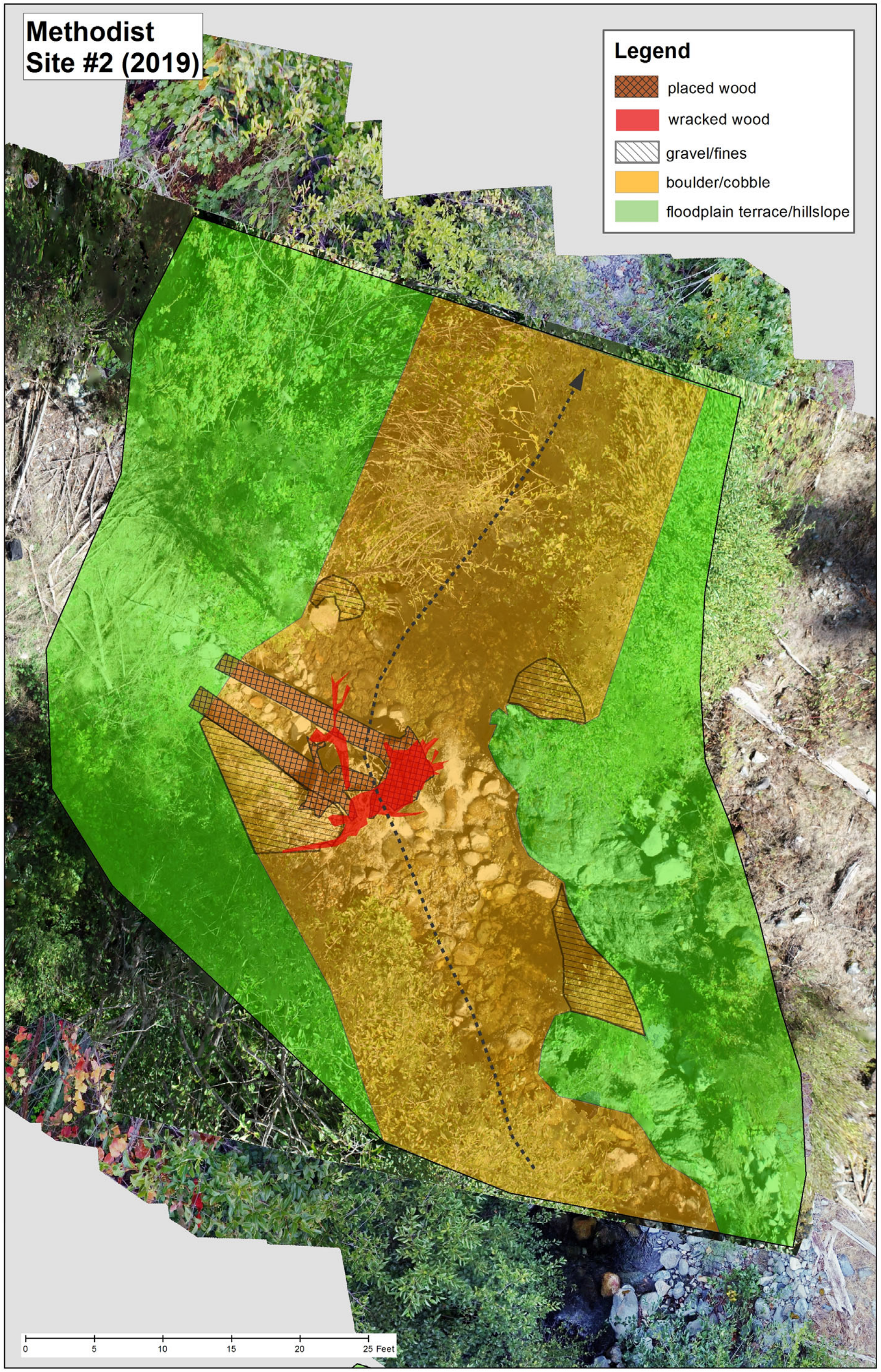

Knownothing Cross Section Site 12b
1690.00
1685.00
1680.00
elevation (ft)
0.00
10.00
20.00
30.00
40.00
distance (ft)
2017
2018
2019

6.2 Appendix B – Site Orthomosaic Models

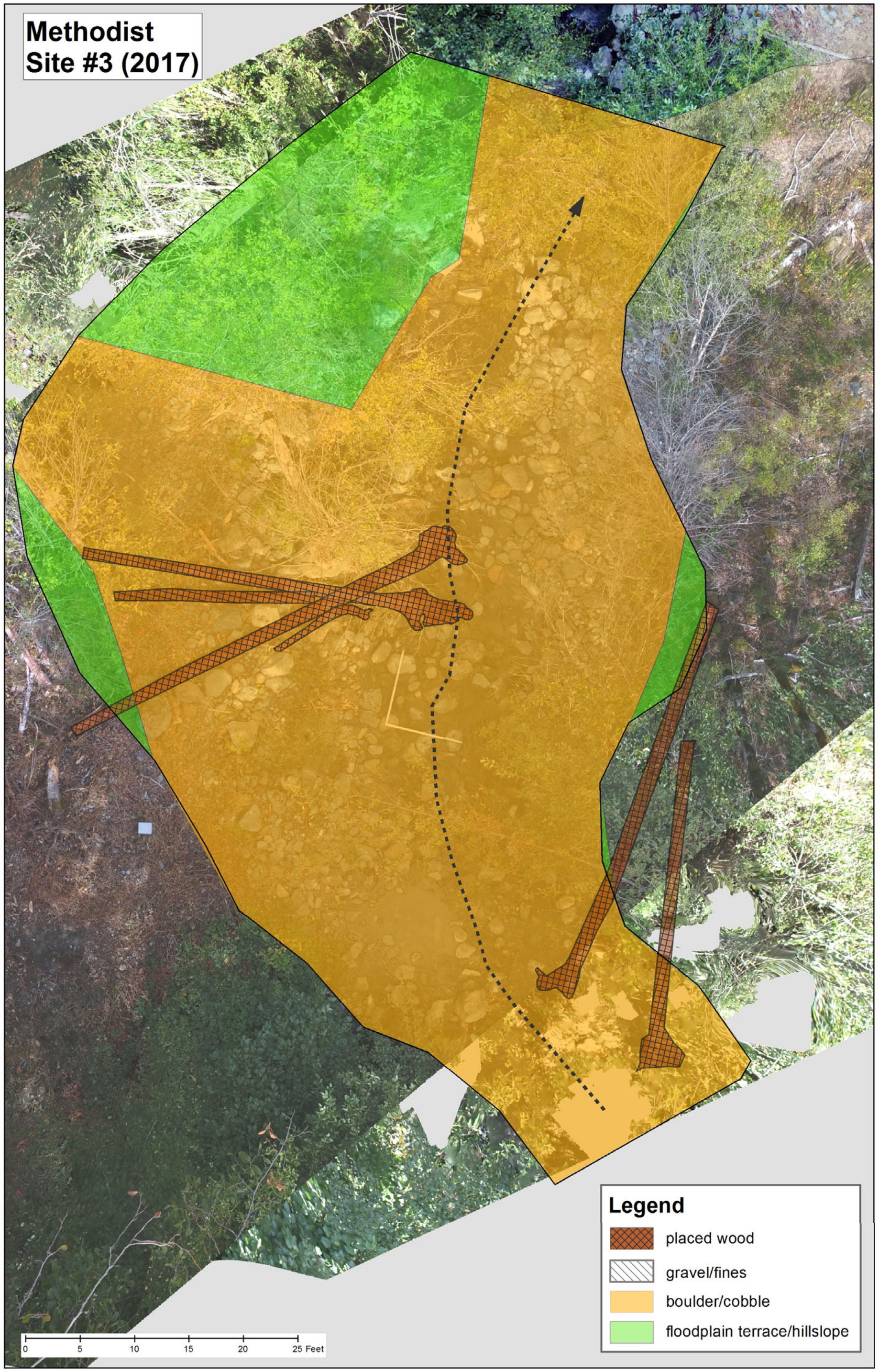

Methodist
Site #1 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet


Methodist
Site #1 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet

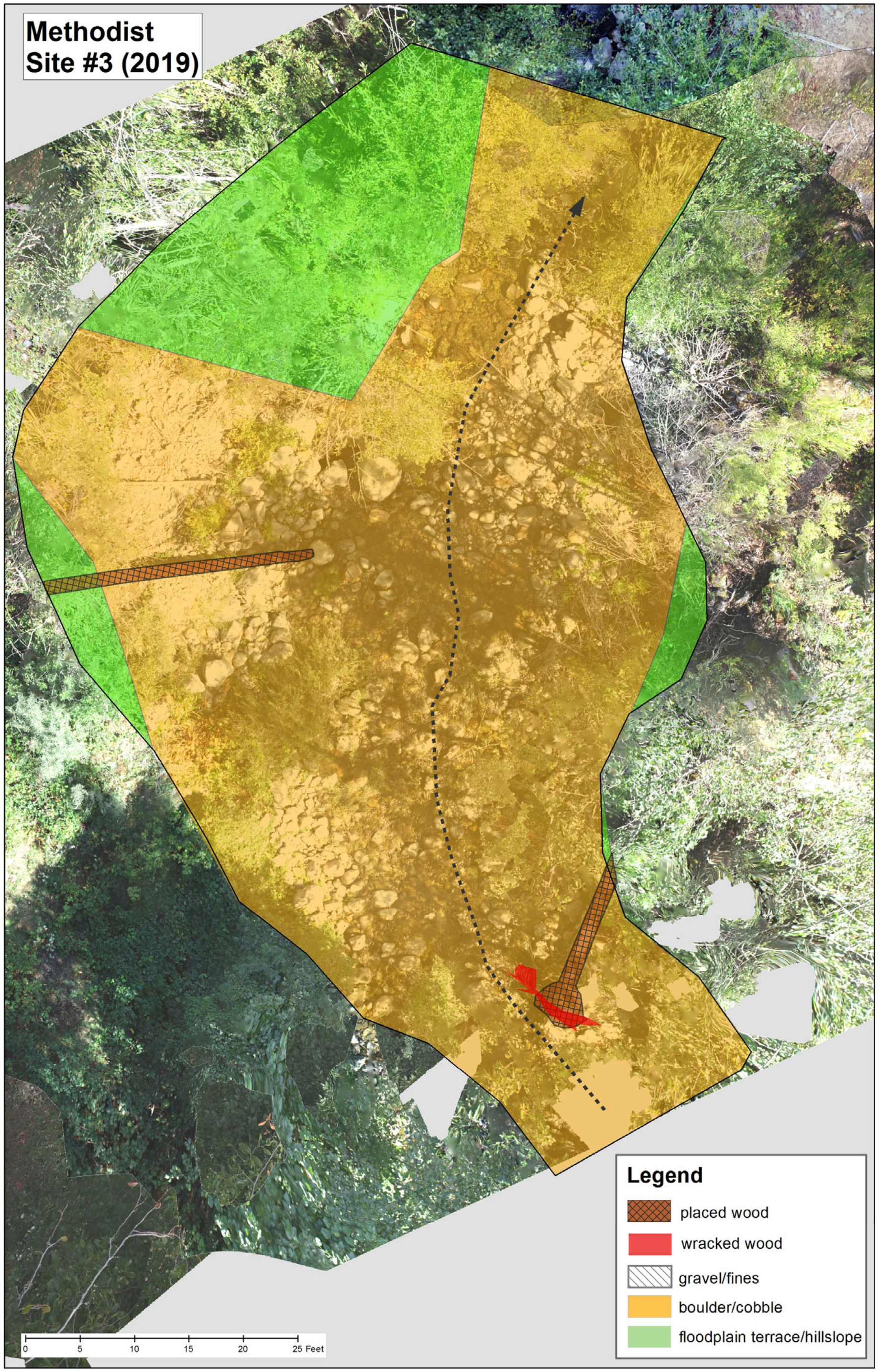
Methodist Site #2 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet



Methodist Site #2 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet



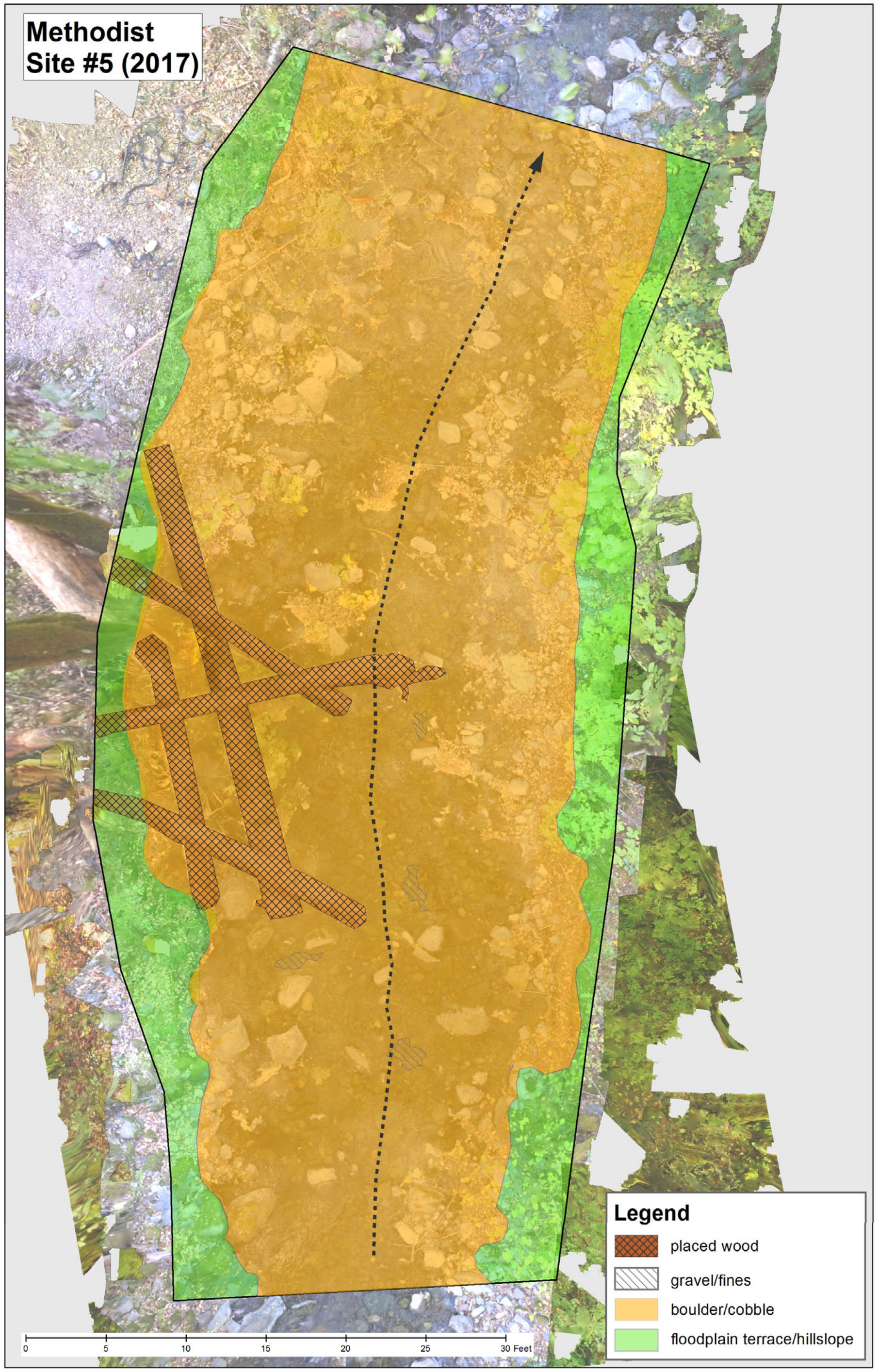
Methodist Site #3 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0 5 10 15 20 25 Feet

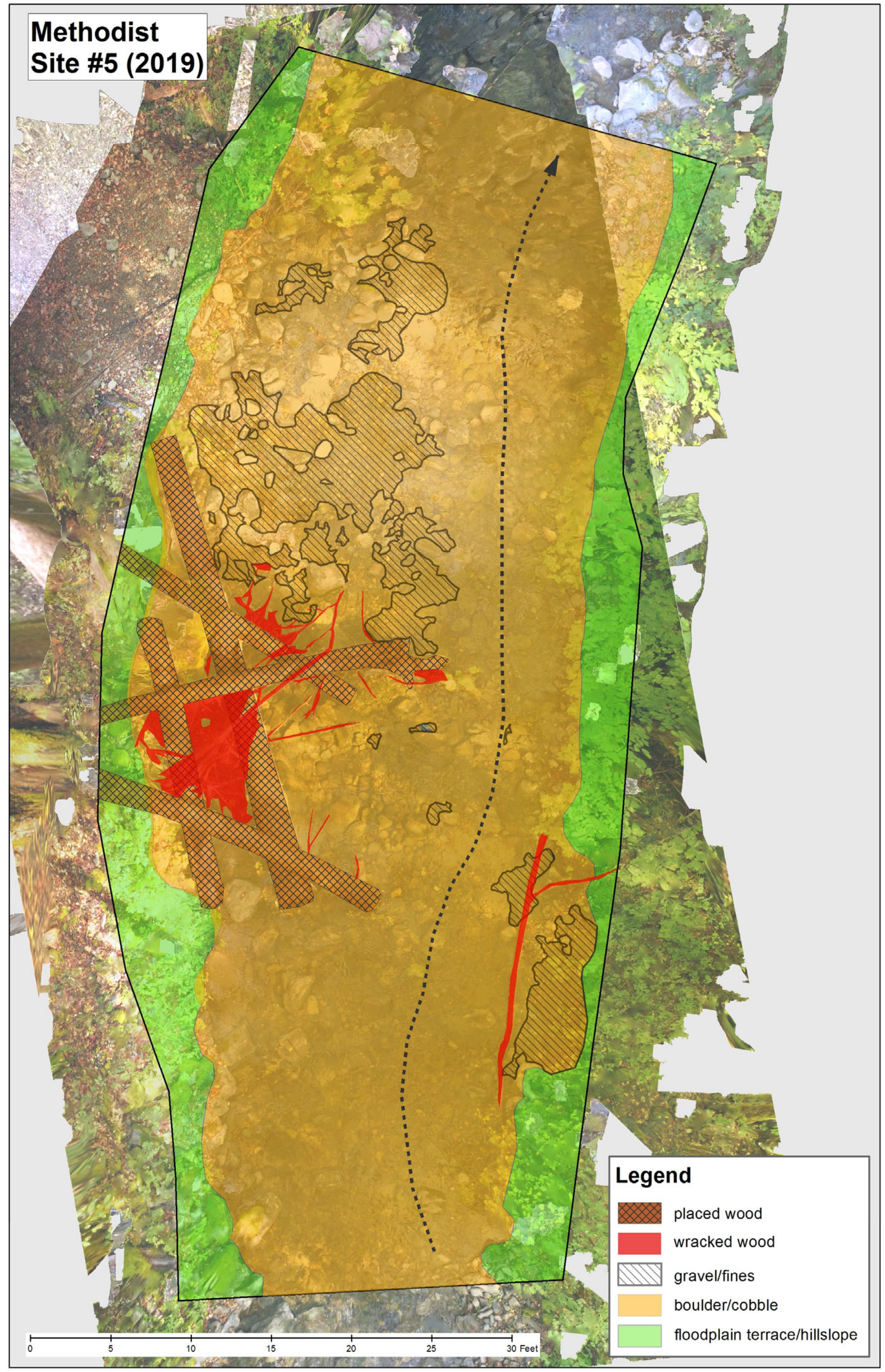


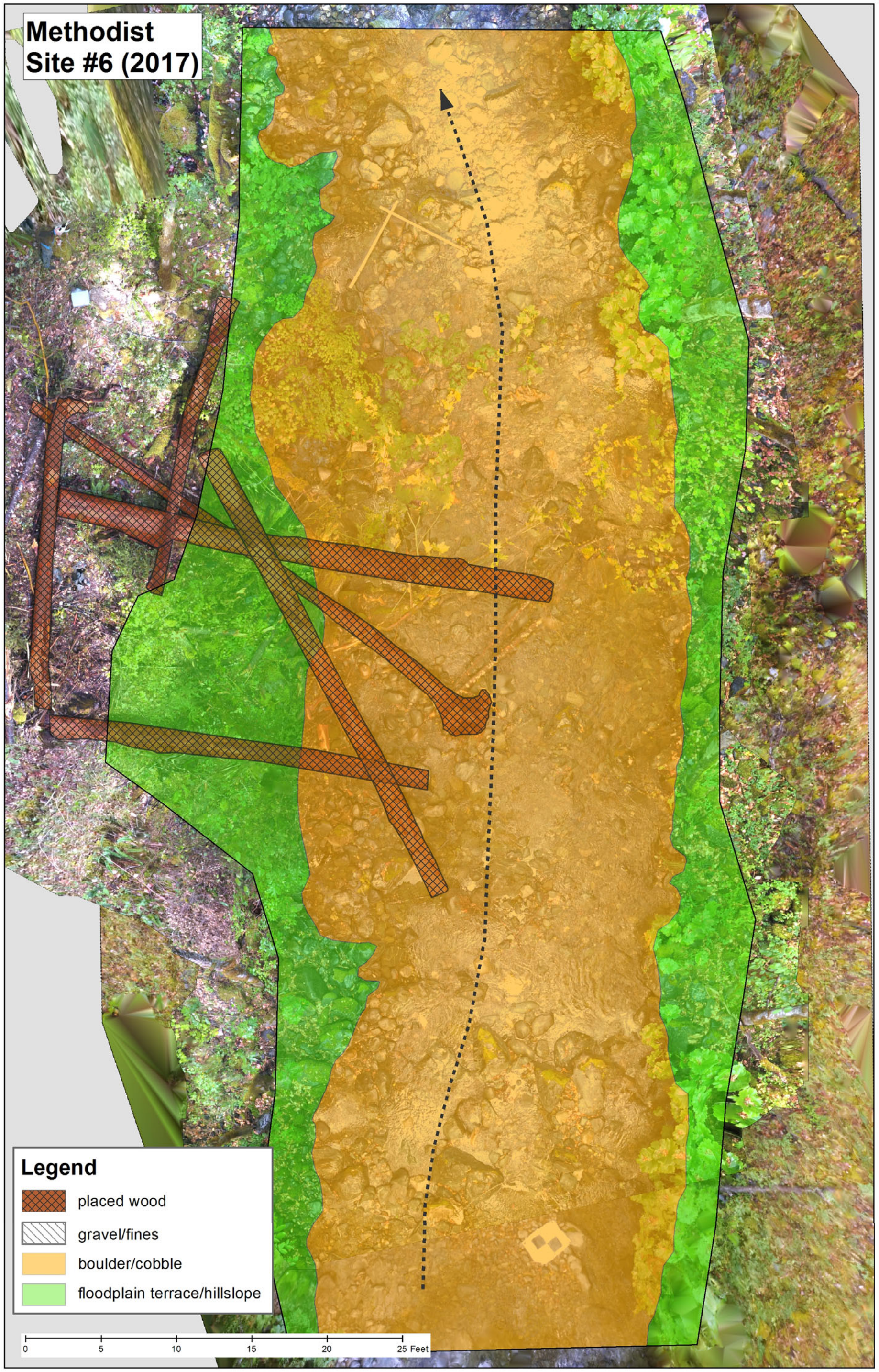
Methodist Site #3 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0 5 10 15 20 25 Feet


Methodist
Site #4 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0 5 10 15 20 25 Feet

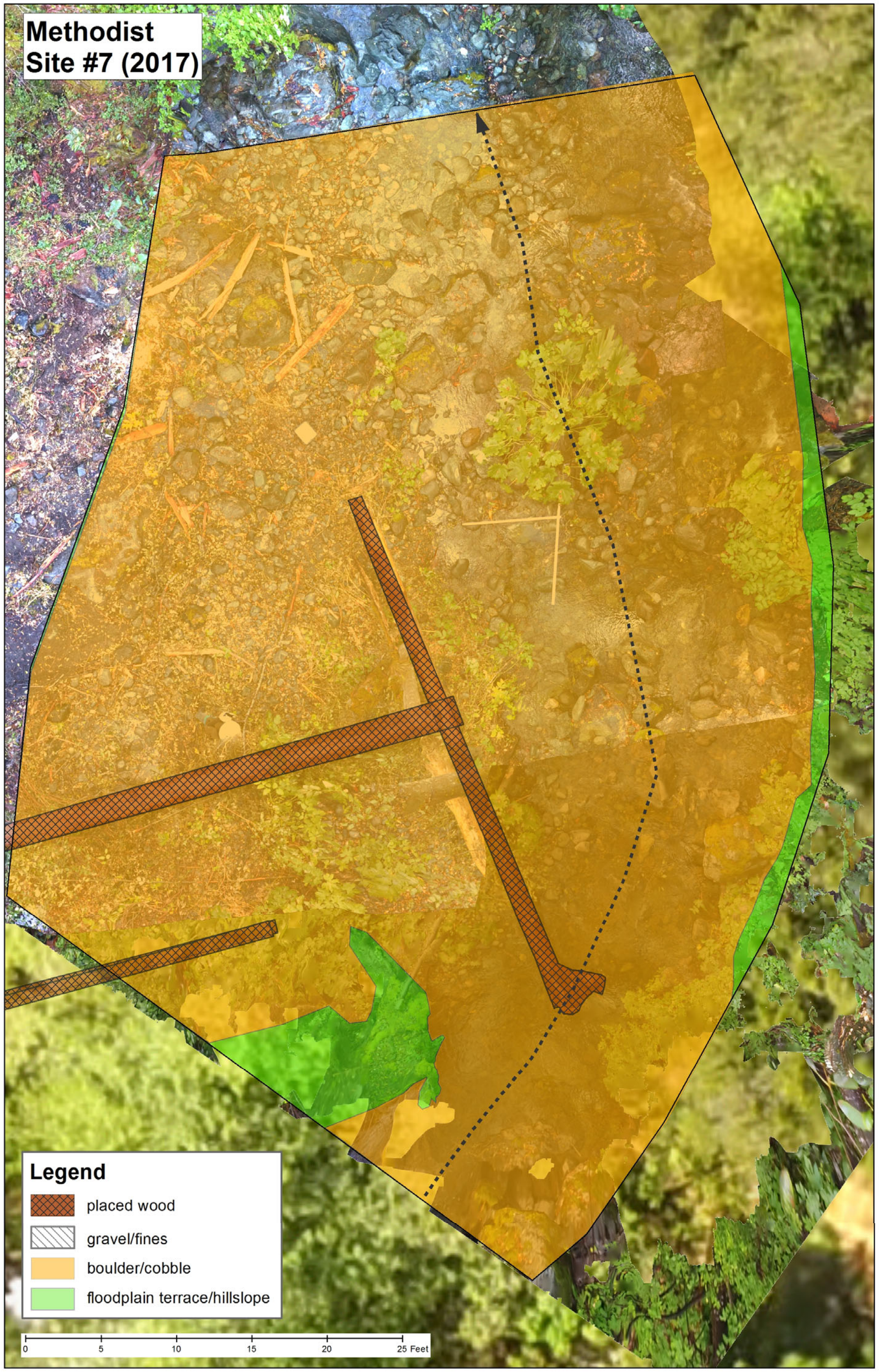

Methodist
Site #4 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0 5 10 15 20 25 Feet


Methodist
Site #5 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25
30 Feet


Methodist
Site #5 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25
30 Feet


Methodist
Site #6 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet


Methodist
Site #6 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet


Methodist
Site #7 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet

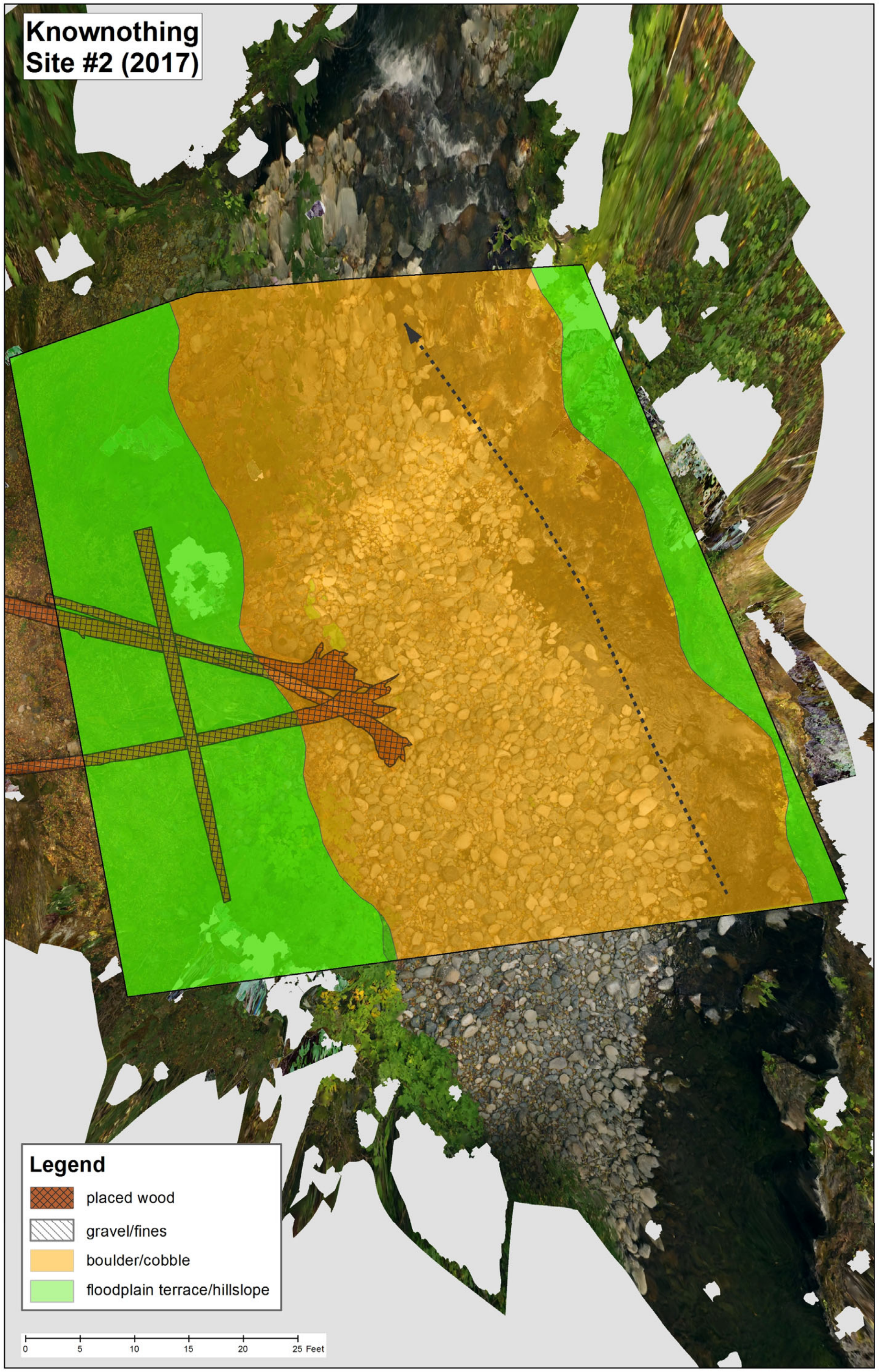

Methodist
Site #7 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet

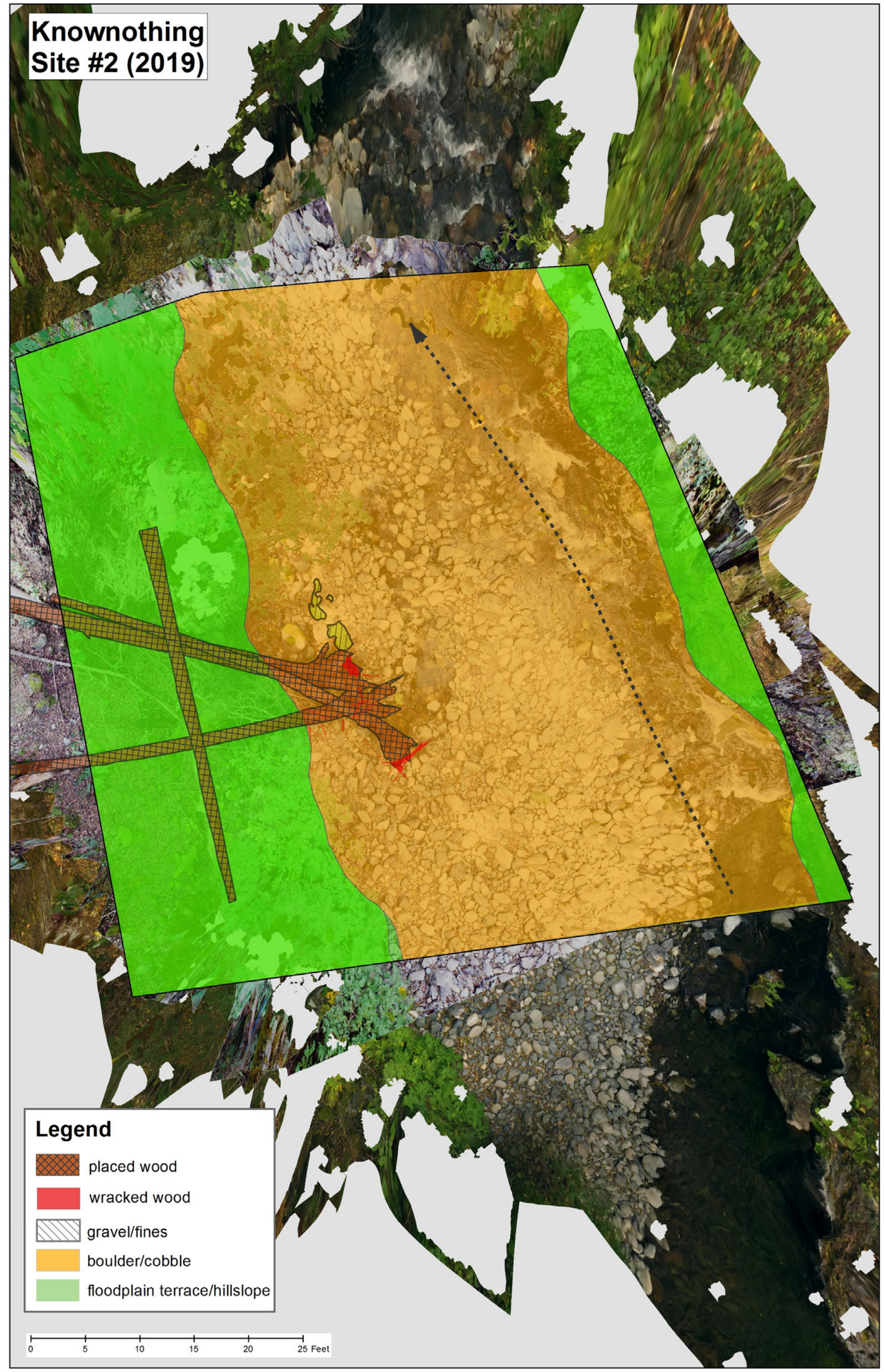

Methodist
Site #8 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0 5 10 15 20 25 Feet


Methodist
Site #8 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0 5 10 15 20 25 Feet


Knownothing
Site #1 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet

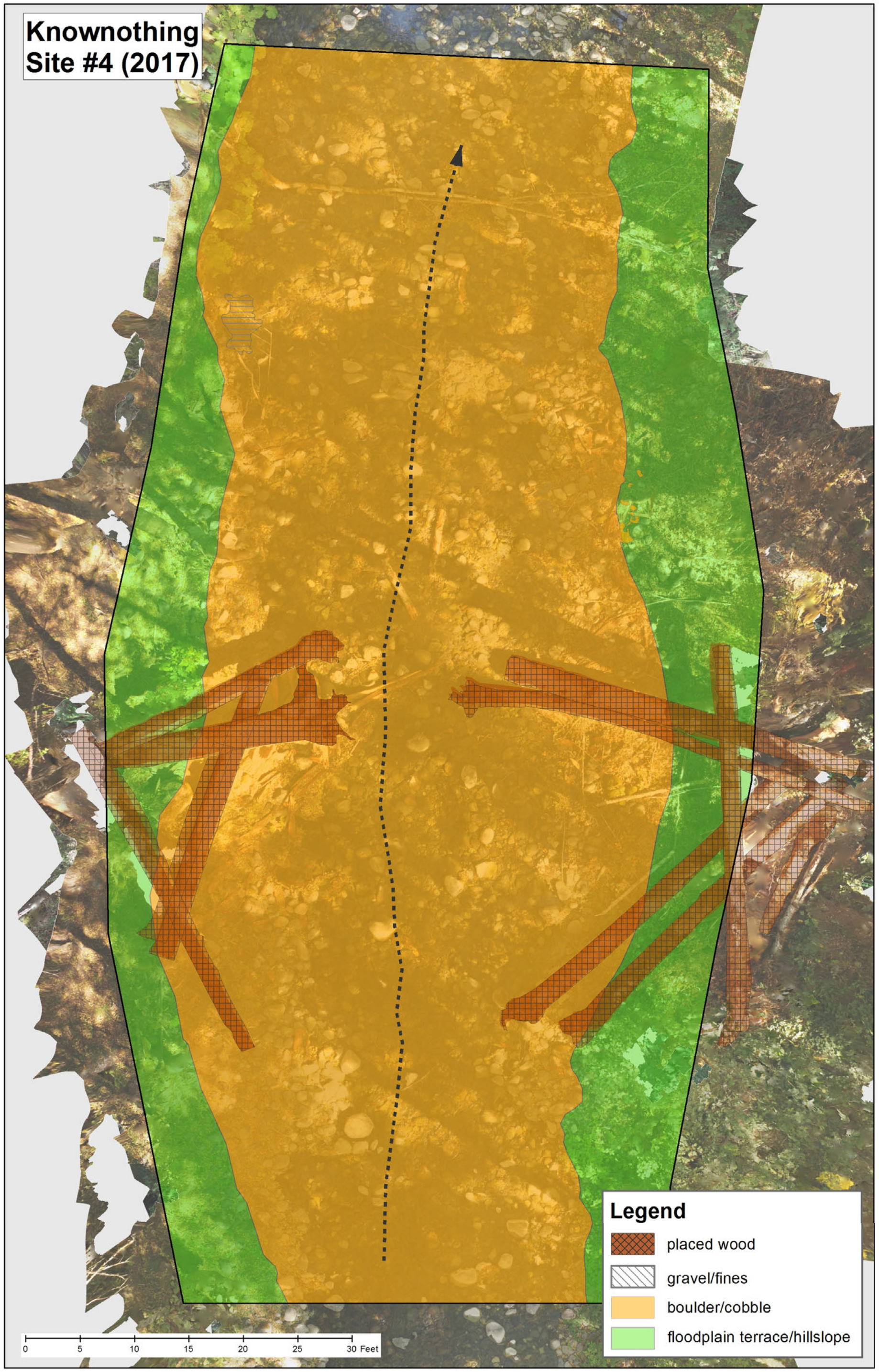

Knownothing
Site #1 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet

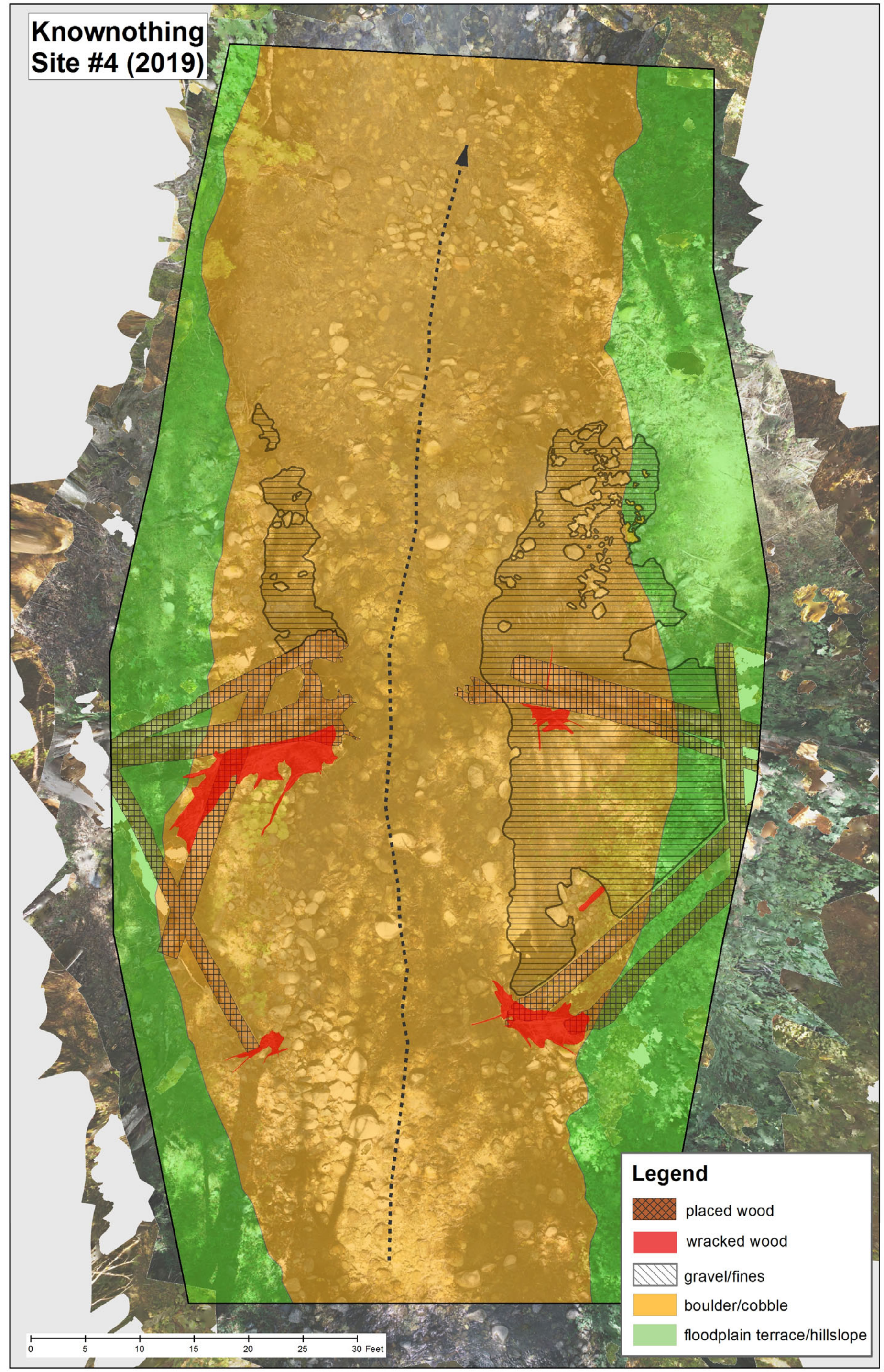

Knownothing
Site #2 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet

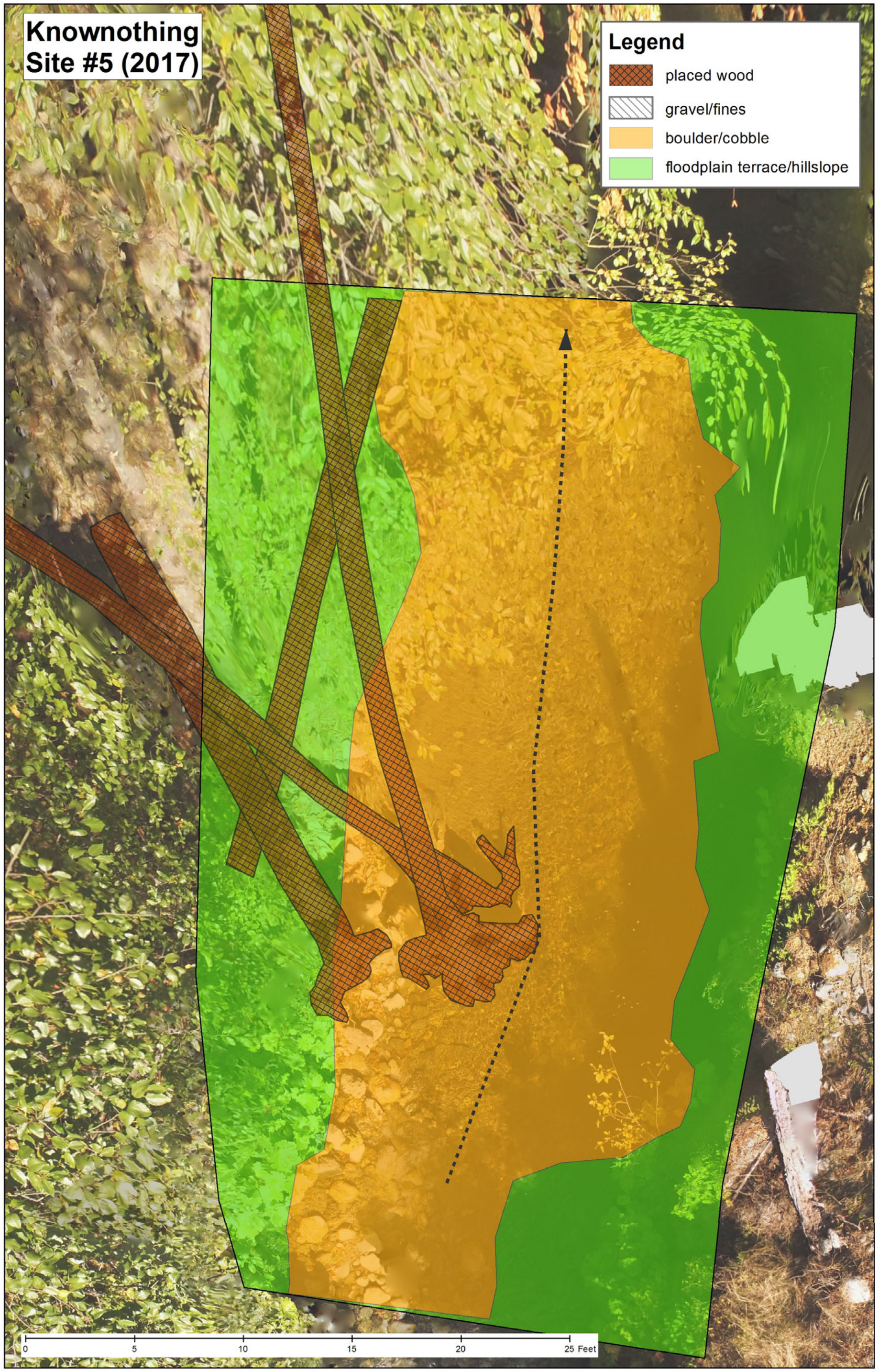

Knownothing
Site #2 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet

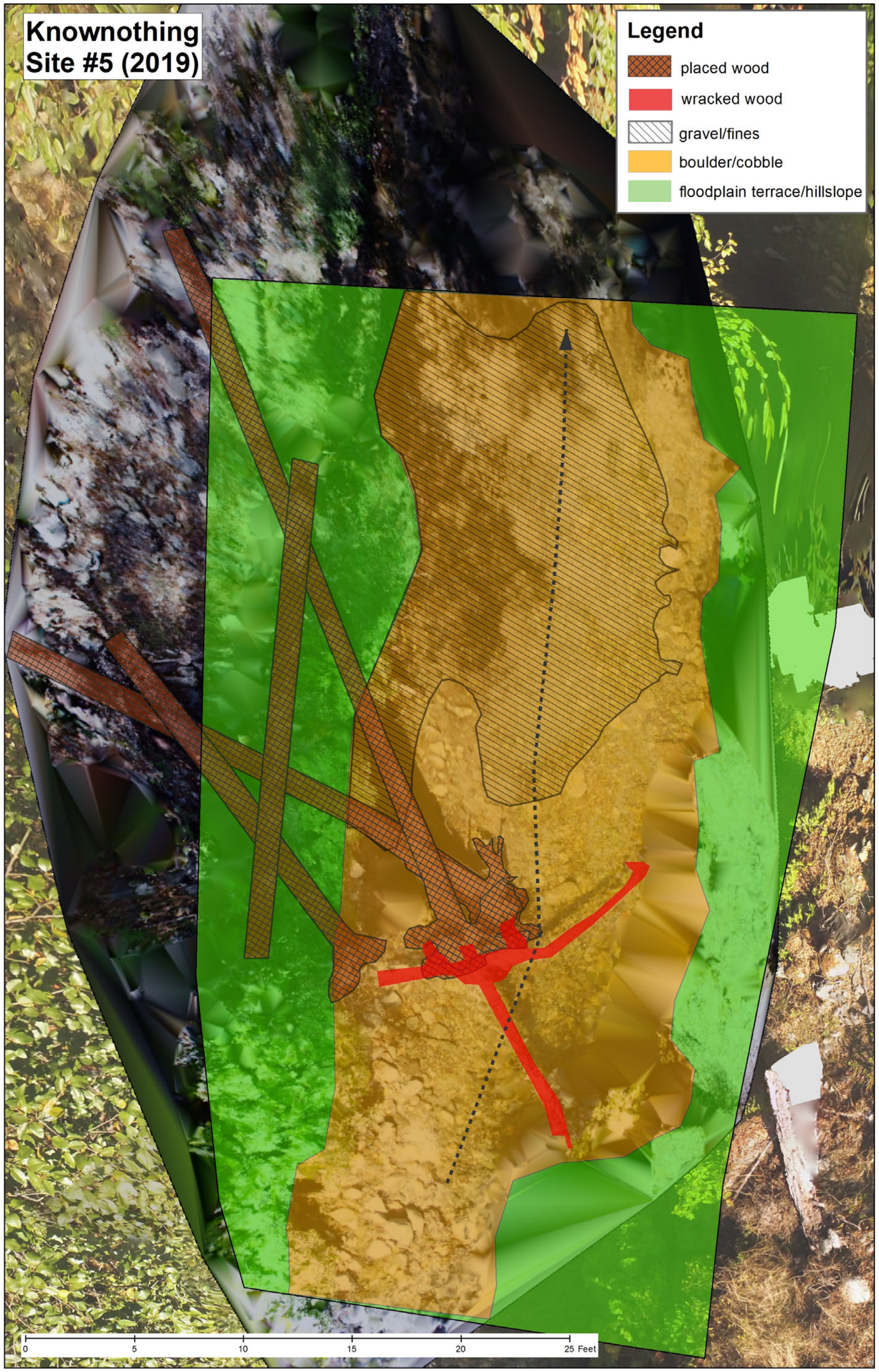

Knownothing
Site #3 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0 5 10 15 20 25 Feet


Knownothing
Site #3 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0 5 10 15 20 25 Feet

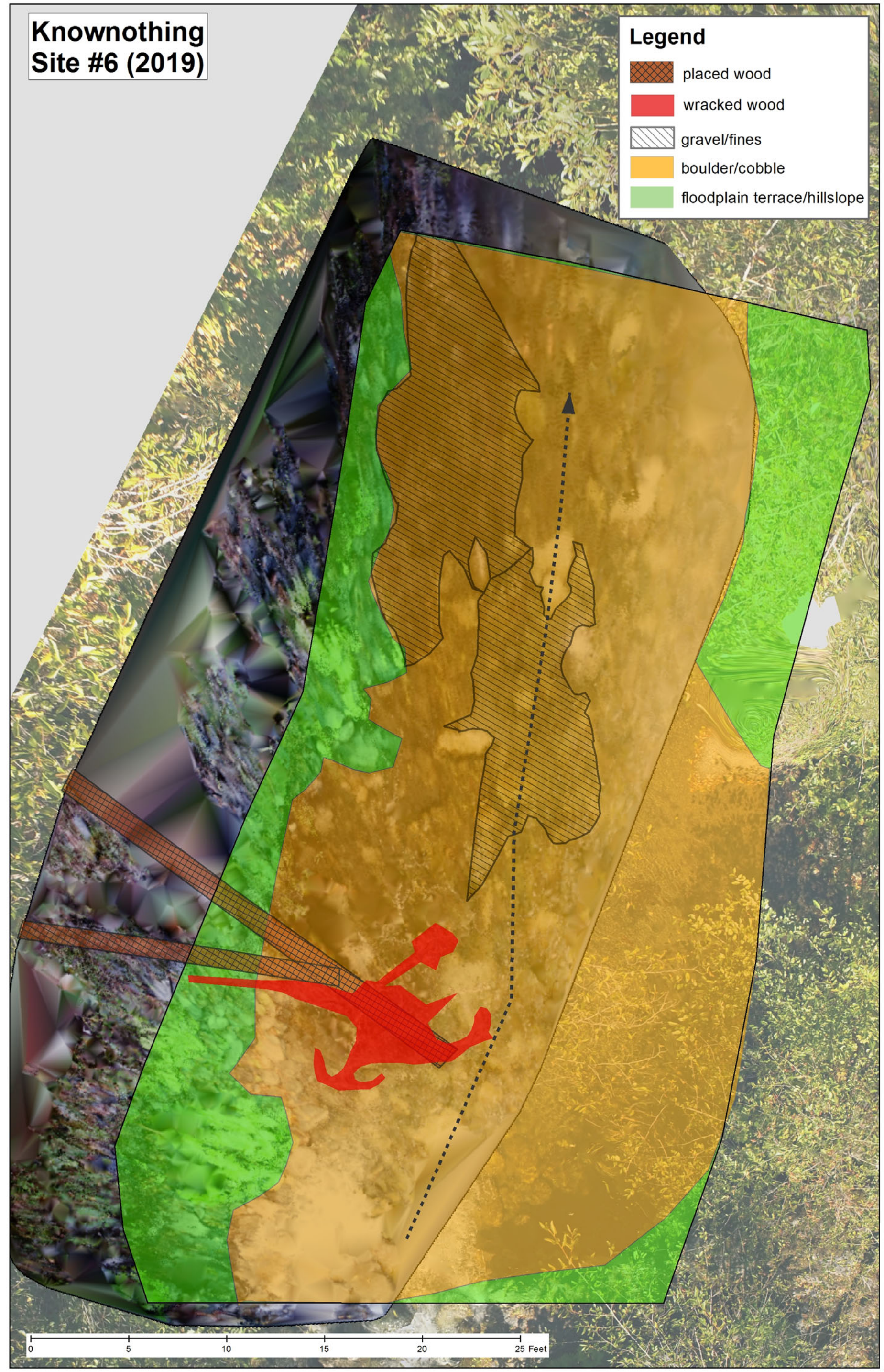

Knownothing
Site #4 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0 5 10 15 20 25 30 Feet

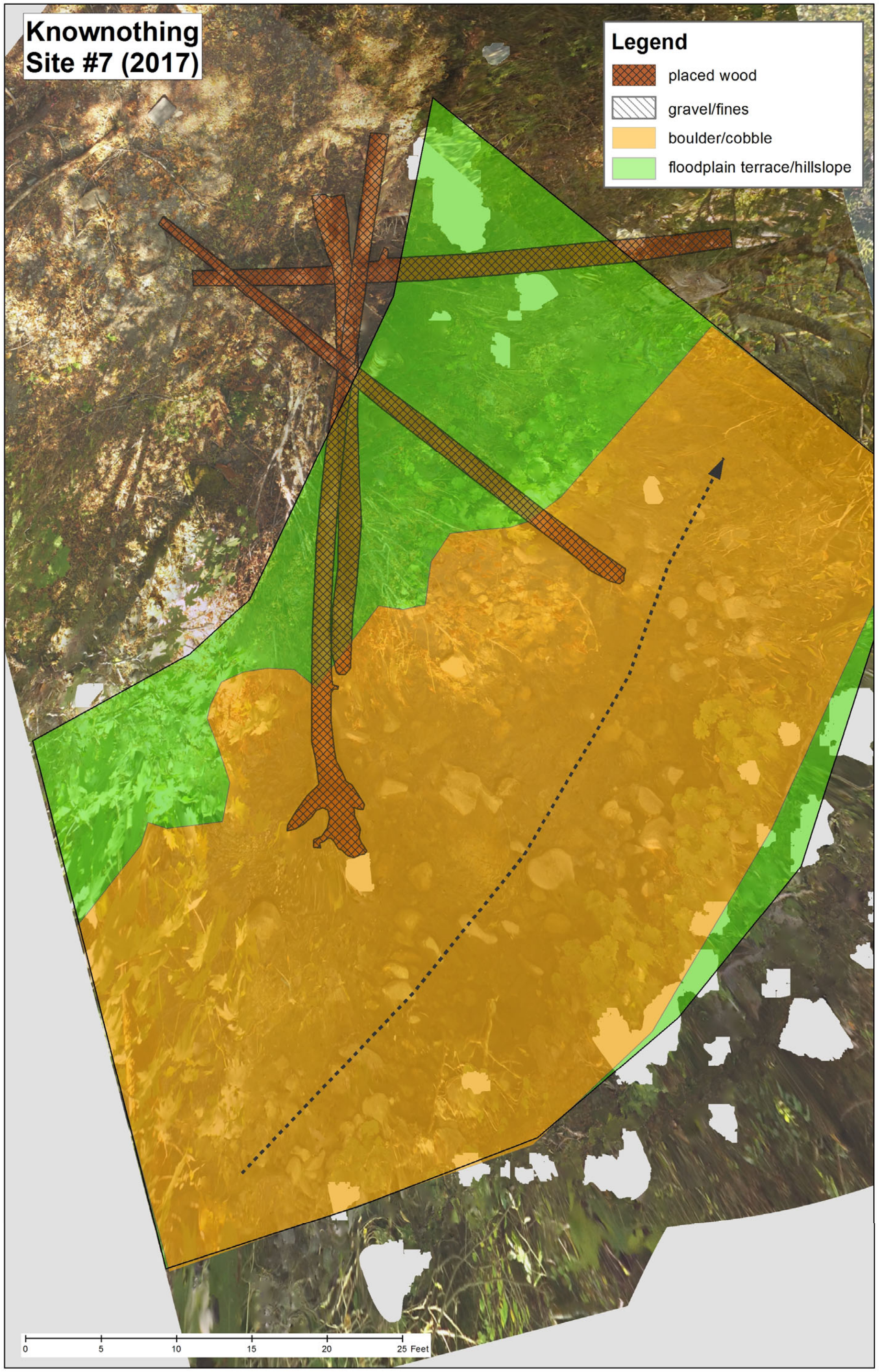

Knownothing
Site #4 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0 5 10 15 20 25 30 Feet

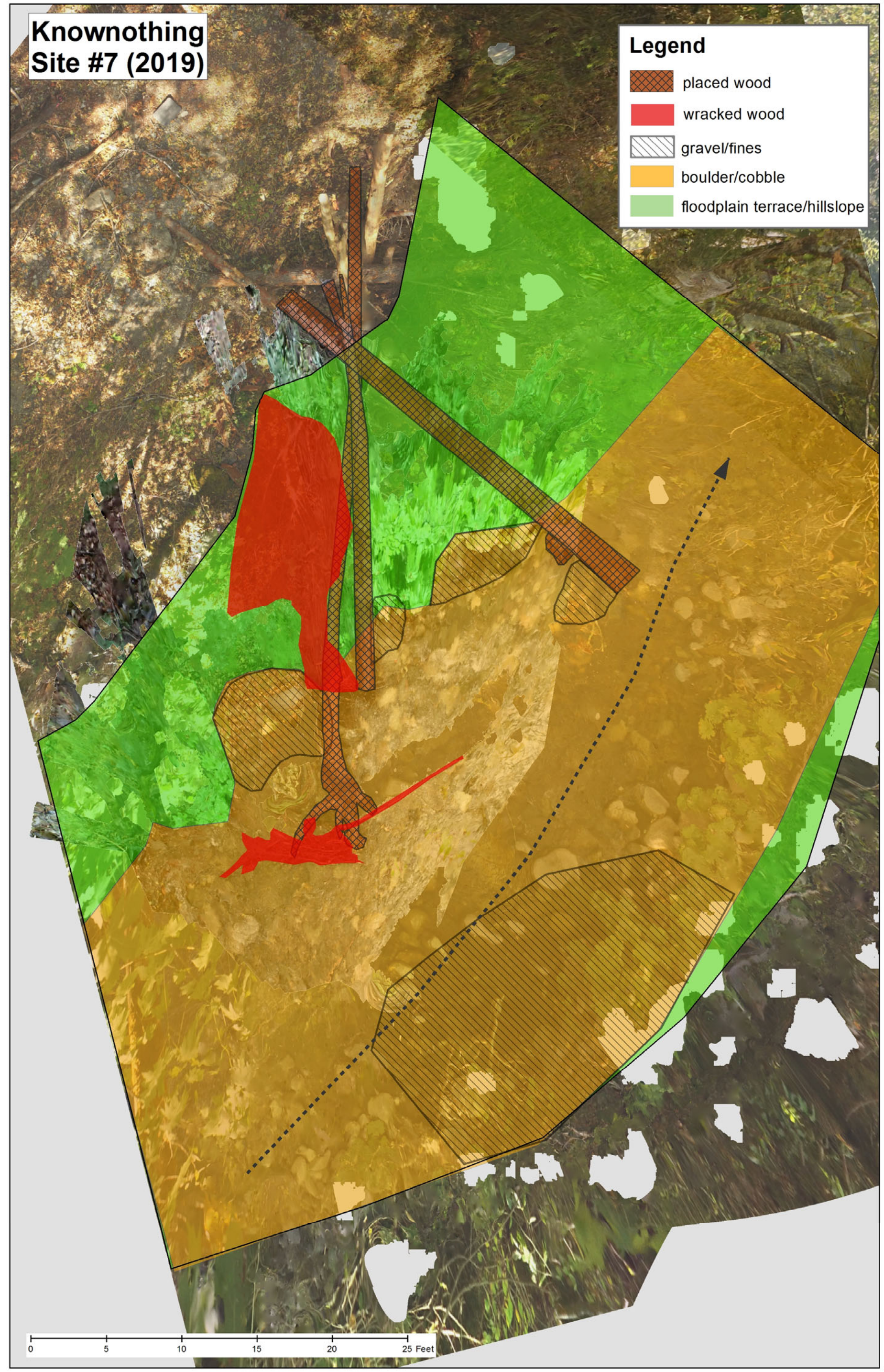

Knownothing
Site #5 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet

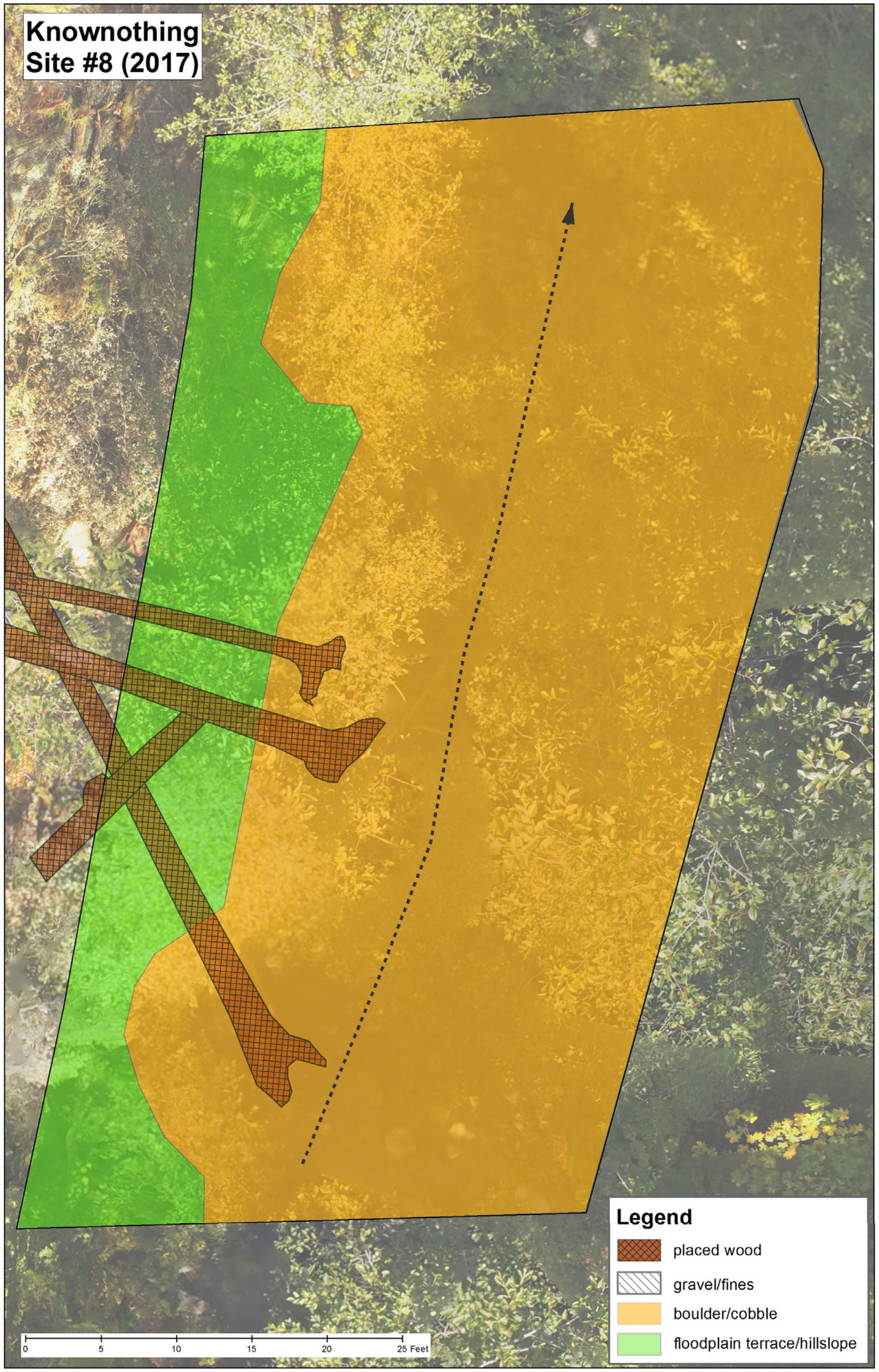

Knownothing
Site #5 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet

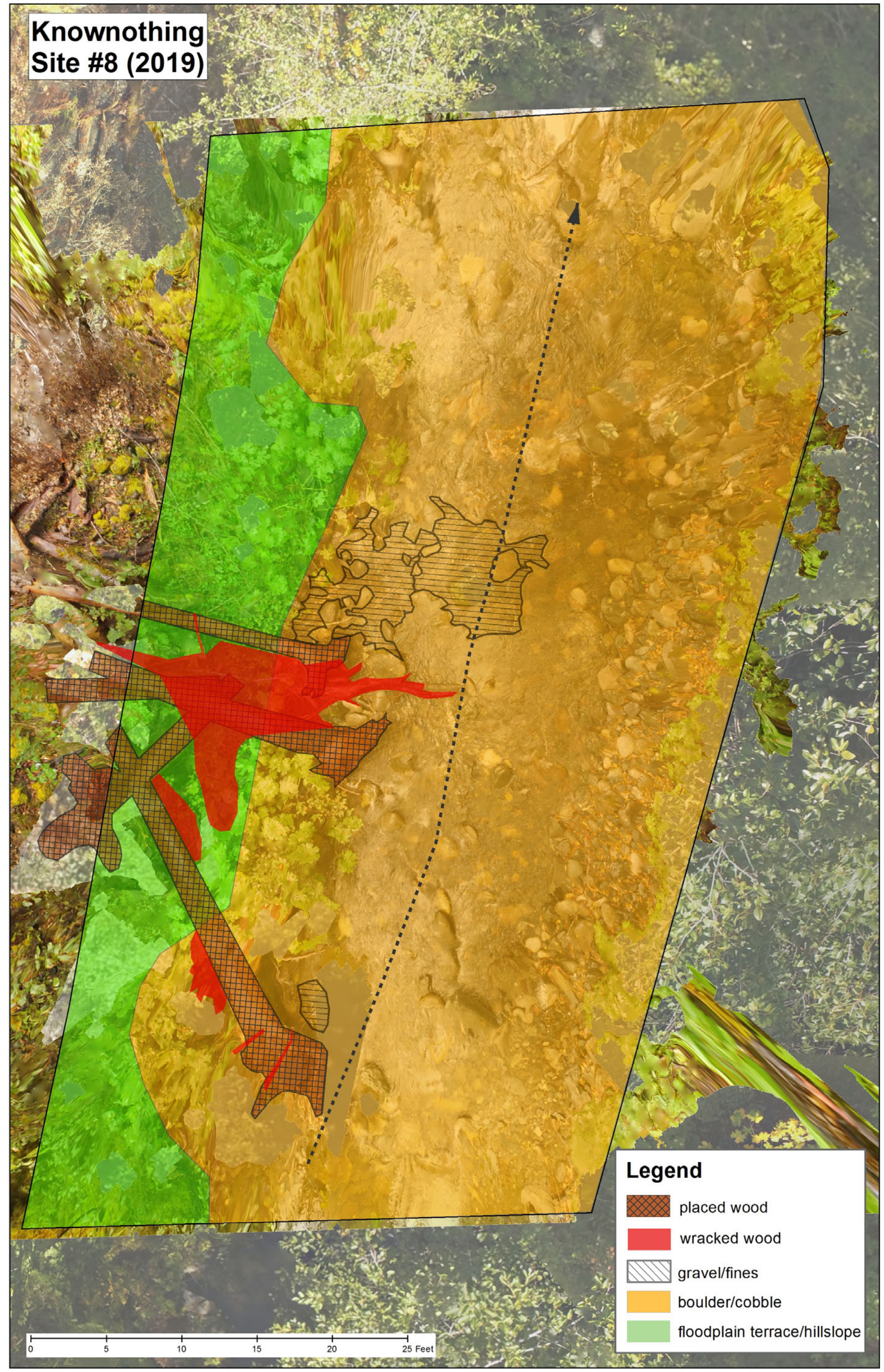

Knownothing
Site #6 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet

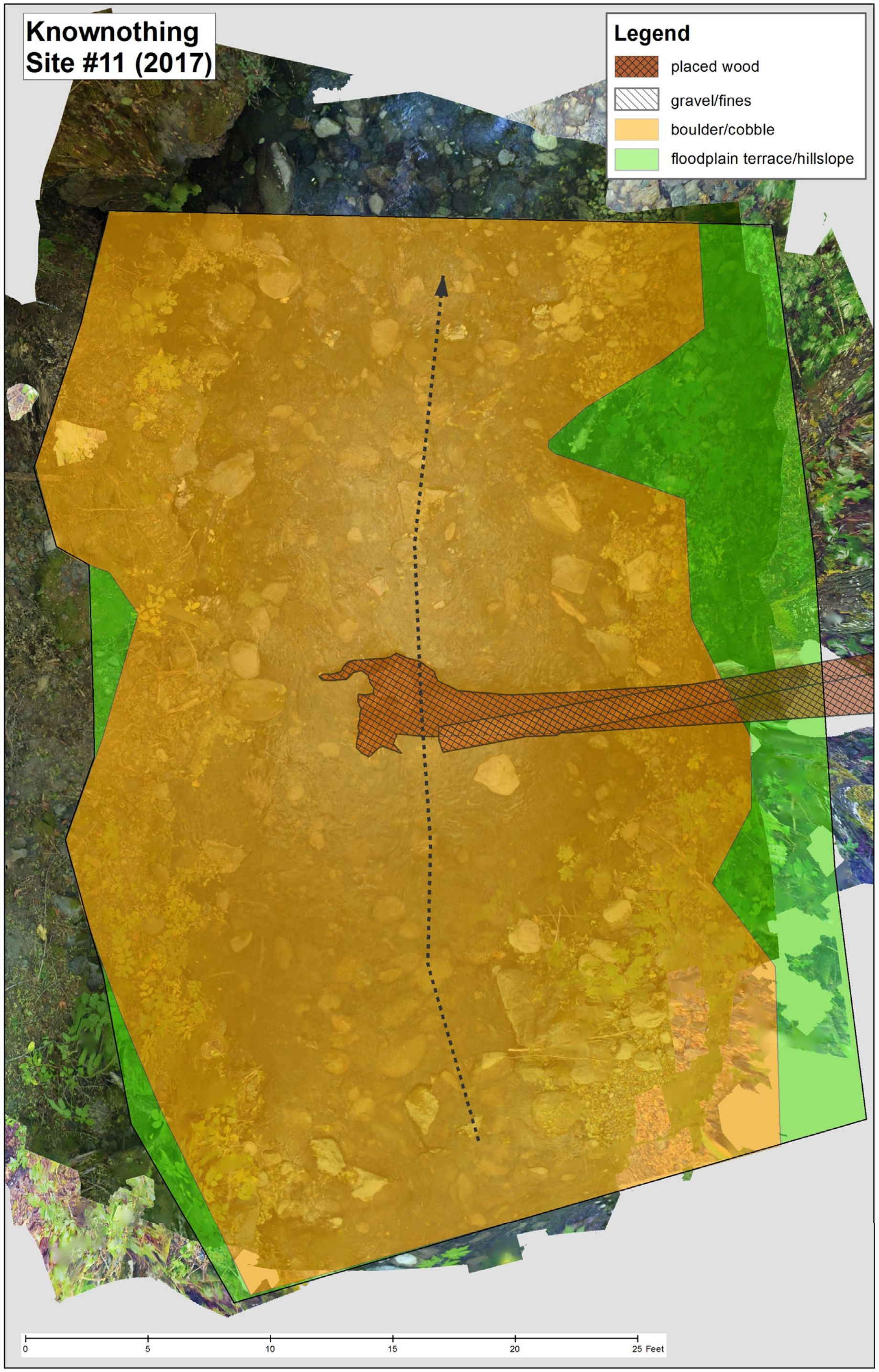

Knownothing
Site #6 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet

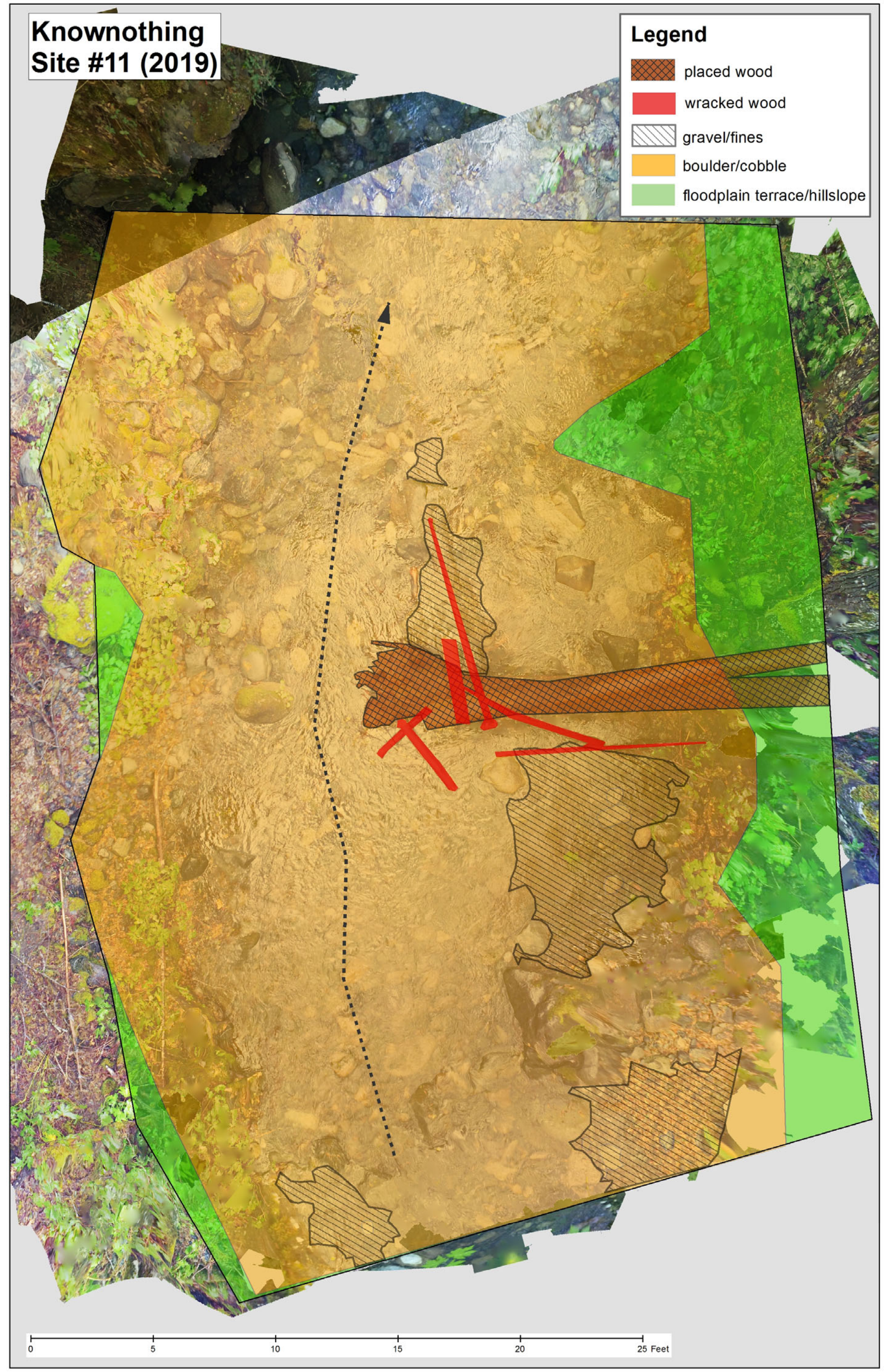

Knownothing
Site #7 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet

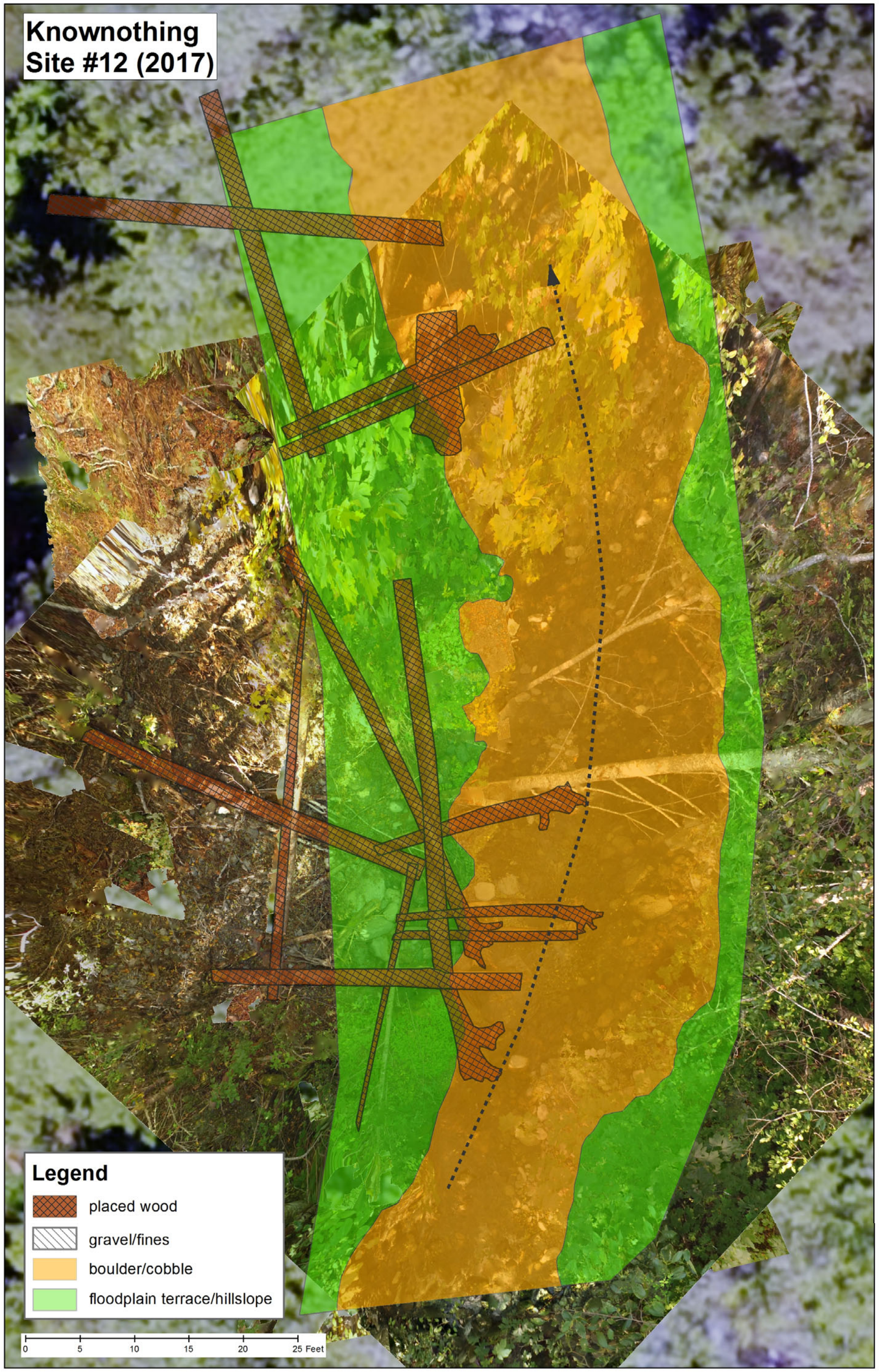

Knownothing
Site #7 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet

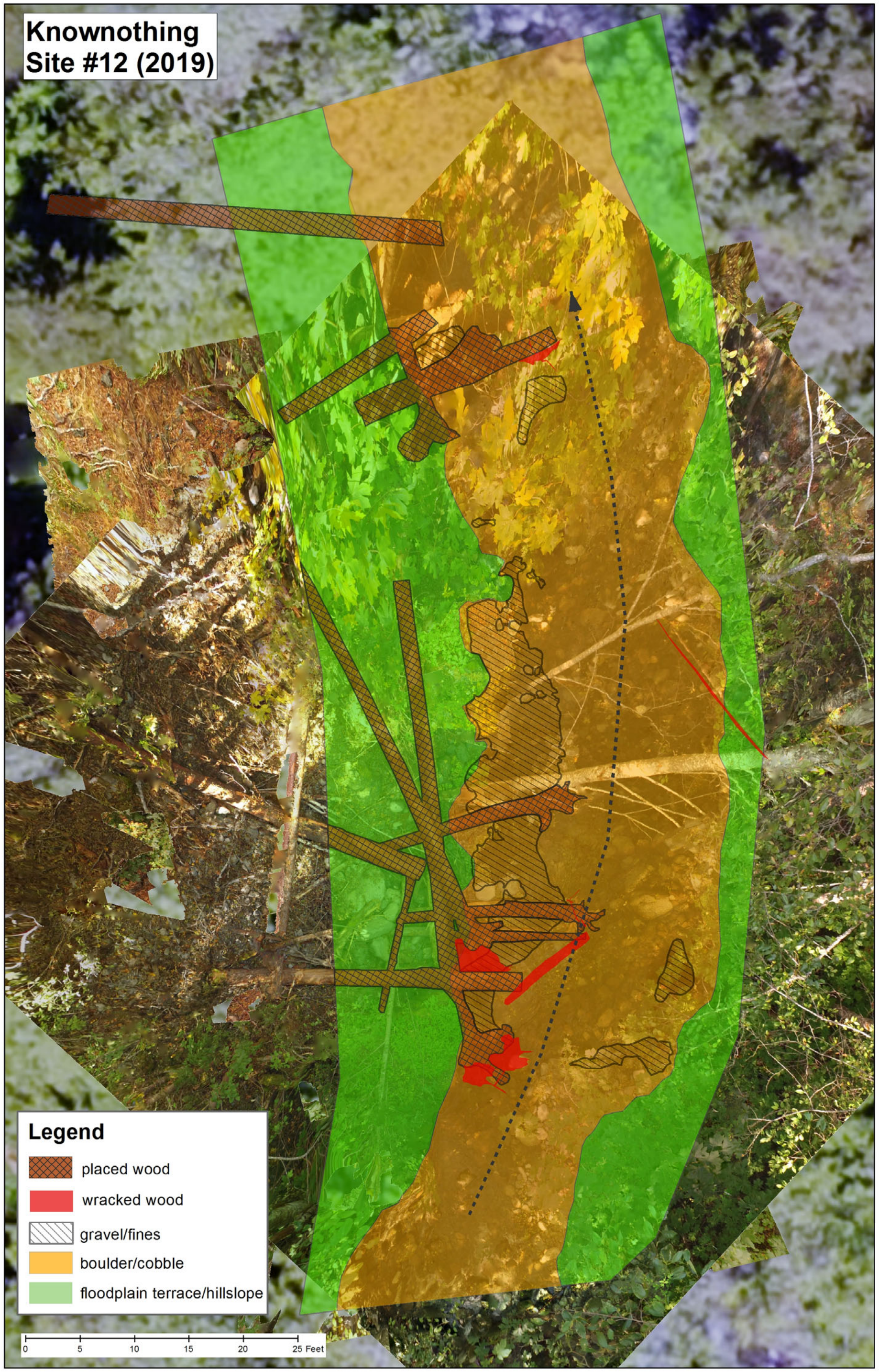

Knownothing
Site #8 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet


Knownothing
Site #8 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet


Knownothing
Site #11 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet


Knownothing
Site #11 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0
5
10
15
20
25 Feet


Knownothing
Site #12 (2017)
Legend
placed wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0 5 10 15 20 25 Feet


Knownothing
Site #12 (2019)
Legend
placed wood
wracked wood
gravel/fines
boulder/cobble
floodplain terrace/hillslope
0 5 10 15 20 25 Feet

6.3 Appendix C – SRRC Fish Survey Results

*** Structure reach includes 100 ft upstream and downstream of structure**

Creek	Date	Pre- or post-implementation?	Survey type	Structure or section	Juvenile Coho	Juvenile Chinook	YOY Trout	1+ Trout	Adult salmonid
Knownothing	7/12/2017	Pre	Presence-absence	K1 - 100 ft downstream	0	0	2	4	0
Knownothing	7/12/2017	Pre	Presence-absence	K1 - 100 ft upstream	0	0	3	4	0
Knownothing	7/12/2017	Pre	Presence-absence	K2 - 100 ft downstream	1	0	15	10	0
Knownothing	7/12/2017	Pre	Presence-absence	K2 - 100 ft upstream	4	0	20	23	0
Knownothing	7/12/2017	Pre	Presence-absence	K3 - 100 ft downstream	3	0	17	20	0
Knownothing	7/12/2017	Pre	Presence-absence	K3 - 100 ft upstream	5	0	15	10	0
Knownothing	7/12/2017	Pre	Presence-absence	K4 - 100 ft downstream	4	0	20	23	0
Knownothing	7/12/2017	Pre	Presence-absence	K4 - 100 ft upstream	3	0	35	20	0
Knownothing	7/12/2017	Pre	Presence-absence	K5 - 100 ft downstream	5	0	20	23	0
Knownothing	7/12/2017	Pre	Presence-absence	K-5 - 100 ft upstream	7	1	15	17	0
Knownothing	7/12/2017	Pre	Presence-absence	K6 - 100 ft downstream	8	0	20	30	0
Knownothing	7/12/2017	Pre	Presence-absence	K6 - 100 ft upstream	5	0	25	29	0
Knownothing	7/12/2017	Pre	Presence-absence	K7 - 100 ft downstream	6	0	30	25	0
Knownothing	7/12/2017	Pre	Presence-absence	K7 - 100 ft upstream	8	0	20	17	0
Knownothing	7/12/2017	Pre	Presence-absence	K8 - 100 ft downstream	0	0	15	20	0
Knownothing	7/12/2017	Pre	Presence-absence	K8 - 100 ft upstream	2	0	25	30	0
Knownothing	7/12/2017	Pre	Presence-absence	K11 - 100 ft downstream	0	0	4	3	0
Knownothing	7/12/2017	Pre	Presence-absence	K11 - 100 ft upstream	0	0	10	12	0
Knownothing	7/12/2017	Pre	Presence-absence	K12 - 100 ft downstream	0	0	10	12	0
Knownothing	7/12/2017	Pre	Presence-absence	K12 - 100 ft upstream	0	0	15	14	0
				Totals	**61**	**1**	**336**	**346**	**0**
Knownothing	9/8/2017	Post	Presence-absence	K1 - 100 ft downstream	0	0	4	1	0
Knownothing	9/8/2017	Post	Presence-absence	K1 - 100 ft upstream	0	0	5	0	0
Knownothing	9/8/2017	Post	Presence-absence	K2 - 100 ft downstream	0	0	4	2	0
Knownothing	9/8/2017	Post	Presence-absence	K2 - 100 ft upstream	0	0	6	4	0
Knownothing	9/8/2017	Post	Presence-absence	K3 - 100 ft downstream	0	0	2	0	0
Knownothing	9/8/2017	Post	Presence-absence	K3 - 100 ft upstream	0	0	6	2	0
Knownothing	9/8/2017	Post	Presence-absence	K4 - 100 ft downstream	0	0	2	0	0
Knownothing	9/8/2017	Post	Presence-absence	K4 - 100 ft upstream	0	0	5	1	0
Knownothing	9/8/2017	Post	Presence-absence	K5 - 100 ft downstream	0	0	3	0	0
Knownothing	9/8/2017	Post	Presence-absence	K-5 - 100 ft upstream	0	0	4	3	0
Knownothing	9/8/2017	Post	Presence-absence	K6 - 100 ft downstream	0	0	8	3	0
Knownothing	9/8/2017	Post	Presence-absence	K6 - 100 ft upstream	0	0	14	6	0
Knownothing	9/8/2017	Post	Presence-absence	K7 - 100 ft downstream	0	0	4	2	0
Knownothing	9/8/2017	Post	Presence-absence	K7 - 100 ft upstraem	0	0	3	1	0
Knownothing	9/8/2017	Post	Presence-absence	K8 - 100 ft downstream	0	0	12	6	0
Knownothing	9/8/2017	Post	Presence-absence	K8 - 100 ft upstream	0	0	15	3	0
Knownothing	9/8/2017	Post	Presence-absence	K11 - 100 ft downstream	0	0	5	3	0
Knownothing	9/8/2017	Post	Presence-absence	K11 - 100 ft upstream	0	0	7	2	0
Knownothing	9/8/2017	Post	Presence-absence	K12 - 100 ft downstream	0	0	4	0	0
Knownothing	9/8/2017	Post	Presence-absence	K12 - 100 ft upstream	0	0	4	2	0
				Totals	**0**	**0**	**113**	**40**	**0**
Knownothing	6/26/2018	Post	Presence-absence	Mixing area	0	150	A few	Lots	0
Knownothing	6/26/2018	Post	Presence-absence	Mouth - K1	0	15	11	8	0
Knownothing	6/26/2018	Post	Presence-absence	K1	0	13	6	37	0
Knownothing	6/26/2018	Post	Presence-absence	K1 - K2	0	0	3	18	0
Knownothing	6/26/2018	Post	Presence-absence	K2	0	6	4	45	0
Knownothing	6/26/2018	Post	Presence-absence	K3	0	0	6	8	0
Knownothing	6/26/2018	Post	Presence-absence	K4	0	0	2	3	0
Knownothing	6/26/2018	Post	Presence-absence	K5	0	0	2	28	0
Knownothing	6/26/2018	Post	Presence-absence	K5 - K6	0	3	6	203	0
Knownothing	6/26/2018	Post	Presence-absence	K6	0	0	0	15	0
Knownothing	6/26/2018	Post	Presence-absence	K7	0	0	0	13	0
Knownothing	6/26/2018	Post	Presence-absence	K7 - K8	0	0	0	75	0
Knownothing	6/26/2018	Post	Presence-absence	K8	0	0	0	30	0
Knownothing	6/26/2018	Post	Presence-absence	K8	0	0	0	11	0
Knownothing	6/26/2018	Post	Presence-absence	K8 - K11	0	0	86	484	0
Knownothing	6/26/2018	Post	Presence-absence	K11	0	0	5	10	0
Knownothing	6/26/2018	Post	Presence-absence	K12	0	0	17	30	0
				Totals	**0**	**187**	**> 148**	**> 1018**	**0**
Knownothing	8/28/2018	Post	Presence-absence	Mixing area	0	20	21	32	0
Knownothing	8/28/2018	Post	Presence-absence	Mouth - K1	0	65	40	15	0
Knownothing	8/28/2018	Post	Presence-absence	K1	0	22	20	33	0
Knownothing	8/28/2018	Post	Presence-absence	K1 - K2	0	6	15	11	0
Knownothing	8/28/2018	Post	Presence-absence	K2	0	12	32	31	0
Knownothing	8/28/2018	Post	Presence-absence	K3	0	0	5	8	0
Knownothing	8/28/2018	Post	Presence-absence	K4	0	0	1	0	0
Knownothing	8/28/2018	Post	Presence-absence	K5	0	12	15	17	0
Knownothing	8/28/2018	Post	Presence-absence	K5 - K6	0	29	121	190	0
Knownothing	8/28/2018	Post	Presence-absence	K6	0	1	4	11	0
Knownothing	8/28/2018	Post	Presence-absence	K7	0	0	13	5	0
Knownothing	8/28/2018	Post	Presence-absence	K7 - K8	0	4	17	79	0
Knownothing	8/28/2018	Post	Presence-absence	K8	0	0	7	16	0
Knownothing	8/28/2018	Post	Presence-absence	K8	0	0	48	24	0
Knownothing	8/28/2018	Post	Presence-absence	K8 - K11	0	6	500	350	0
Knownothing	8/28/2018	Post	Presence-absence	K11	0	0	8	5	0
Knownothing	8/28/2018	Post	Presence-absence	K12	0	0	10	15	0
				Totals	**0**	**177**	**877**	**842**	**0**
Knownothing	6/25/2019	Post	Presence-absence	Mixing area & mouth	0	15	13	25	0
Knownothing	6/25/2019	Post	Presence-absence	Mouth - K1	0	0	46	35	0
Knownothing	6/25/2019	Post	Presence-absence	K1	0	0	11	14	0
Knownothing	6/25/2019	Post	Presence-absence	K1 - K2	0	0	4	14	0
Knownothing	6/25/2019	Post	Presence-absence	K2	0	0	60	41	0
Knownothing	6/25/2019	Post	Presence-absence	K3	0	0	9	9	0
Knownothing	6/25/2019	Post	Presence-absence	K4	0	0	26	21	0
Knownothing	6/25/2019	Post	Presence-absence	K5	0	0	17	7	0
Knownothing	6/25/2019	Post	Presence-absence	K5 - K6	0	0	90	184	0
Knownothing	6/25/2019	Post	Presence-absence	K6	0	0	19	2	0
Knownothing	6/25/2019	Post	Presence-absence	K7	0	0	5	3	0
Knownothing	6/25/2019	Post	Presence-absence	K7 - K8	0	0	56	80	0
Knownothing	6/25/2019	Post	Presence-absence	K8	0	0	9	17	0
Knownothing	6/25/2019	Post	Presence-absence	K8	0	0	5	29	0
Knownothing	6/25/2019	Post	Presence-absence	Dam - K8	0	0	31	110	0
Knownothing	6/25/2019	Post	Presence-absence	K11 - Dam	0	0	53	404	0
Knownothing	6/25/2019	Post	Presence-absence	K11	0	0	10	21	0
Knownothing	6/25/2019	Post	Presence-absence	K12	0	0	9	23	0
				Totals	**0**	**15**	**473**	**1039**	**0**
Knownothing	8/20/2019	Post	Presence-absence	Mixing area & mouth	0	10	35	30	0
Knownothing	8/20/2019	Post	Presence-absence	Mouth - K1	0	2	150	24	0
Knownothing	8/20/2019	Post	Presence-absence	K1	0	6	64	32	0
Knownothing	8/20/2019	Post	Presence-absence	K1 - K2	0	0	60	27	0
Knownothing	8/20/2019	Post	Presence-absence	K2	0	2	84	50	0
Knownothing	8/20/2019	Post	Presence-absence	K3	0	0	49	27	0
Knownothing	8/20/2019	Post	Presence-absence	K4	0	0	72	31	0
Knownothing	8/20/2019	Post	Presence-absence	K5	0	3	74	56	0
Knownothing	8/20/2019	Post	Presence-absence	K5 - K6	0	3	670	297	0
Knownothing	8/20/2019	Post	Presence-absence	K6	0	0	100	40	0
Knownothing	8/20/2019	Post	Presence-absence	K7	0	0	46	60	0
Knownothing	8/20/2019	Post	Presence-absence	K7 - K8	0	0	191	123	0
Knownothing	8/20/2019	Post	Presence-absence	K8	0	0	96	60	0
Knownothing	8/20/2019	Post	Presence-absence	K8-K11	NA	NA	NA	NA	0
Knownothing	8/20/2019	Post	Presence-absence	K11	0	0	43	42	0
Knownothing	8/20/2019	Post	Presence-absence	K12	0	0	66	45	0
				Totals	**0**	**26**	**1800**	**944**	**0**

Creek	Date	Pre- or post-implementation?	Survey type	# live spawners	# redds	# carcasses
Knownothing	11/3/2015	Pre	Fall Chinook spawning survey	0	0	0
Knownothing	12/1/2015	Pre	Fall Chinook spawning survey	0	0	0
Knownothing	11/7/2017	Post	Fall Chinook spawning survey	0	0	0
Knownothing	11/13/2018	Post	Fall Chinook spawning survey	0	0	0
Knownothing	12/13/2018	Post	Coho spawning survey	0	0	0
Knownothing	4/2/2019	Post	Steelhead spawning survey	2	0	0
Knownothing	4/16/2019	Post	Steelhead spawning survey	1	0	0
Knownothing	11/12/2019	Post	Fall Chinook spawning survey	1	1	0
Knownothing	12/10/2019	Post	Coho spawning survey	0	0	0

Creek	Date	Pre- or post-implementation?	Survey type	Structure or section*	Juvenile Coho	Juvenile Chinook	YOY Trout	1+ Trout	Adult salmonid
Methodist	7/12/2017	Pre	Presence-absence	M1 - 100 ft downstream	0	0	24	17	0
Methodist	7/12/2017	Pre	Presence-absence	M1 - 100 ft upstream	0	0	12	4	0
Methodist	7/12/2017	Pre	Presence-absence	M2 & M3 - 100 ft downstream	0	0	10	1	0
Methodist	7/12/2017	Pre	Presence-absence	M2 & M3 - 100 ft upstream	0	0	21	8	0
Methodist	7/12/2017	Pre	Presence-absence	M4 - 100 ft downstream	0	2	41	13	0
Methodist	7/12/2017	Pre	Presence-absence	M4 - 100 ft upstream	0	0	18	6	0
Methodist	7/12/2017	Pre	Presence-absence	M5 - 100 ft downstream	0	0	16	3	0
Methodist	7/12/2017	Pre	Presence-absence	M5 - 100 ft upstream	0	0	17	5	0
Methodist	7/12/2017	Pre	Presence-absence	M6 - 100 ft downstream	0	0	21	6	0
Methodist	7/12/2017	Pre	Presence-absence	M6 - 100 feet upstream	0	0	10	4	0
Methodist	7/12/2017	Pre	Presence-absence	M7 - 100 ft downstream	0	1	7	5	0
Methodist	7/12/2017	Pre	Presence-absence	M7 - 100 ft upstream	0	0	27	13	0
Methodist	7/12/2017	Pre	Presence-absence	M8 - 100 ft downstream	0	0	48	17	0
Methodist	7/12/2017	Pre	Presence-absence	M8 - 100 ft upstream	0	0	24	4	0
				Totals	**0**	**3**	**296**	**106**	**0**
Methodist	6/19/2018	Post	Presence-absence	Mixing area	40	0	5	17	0
Methodist	6/19/2018	Post	Presence-absence	Mouth - M1	3	0	5	9	0
Methodist	6/19/2018	Post	Presence-absence	M1	1	0	7	3	0
Methodist	6/19/2018	Post	Presence-absence	M2	6	0	24	8	0
Methodist	6/19/2018	Post	Presence-absence	M3	0	0	26	5	0
Methodist	6/19/2018	Post	Presence-absence	M3 - M4	4	0	57	38	0
Methodist	6/19/2018	Post	Presence-absence	M4	0	0	17	12	0
Methodist	6/19/2018	Post	Presence-absence	M4 - M5	0	0	24	13	0
Methodist	6/19/2018	Post	Presence-absence	M5	0	0	21	7	0
Methodist	6/19/2018	Post	Presence-absence	M6	0	0	22	14	0
Methodist	6/19/2018	Post	Presence-absence	M6 - M7	0	0	7	21	0
Methodist	6/19/2018	Post	Presence-absence	M7	0	0	4	10	0
Methodist	6/19/2018	Post	Presence-absence	M8	0	0	5	17	0
				Totals	**54**	**0**	**224**	**174**	**0**
Methodist	8/22/2018	Post	Presence-absence	Mixing area	0	0	2	3	1 Chinook jack
Methodist	8/22/2018	Post	Presence-absence	Mouth - M1	0	11	9	13	0
Methodist	8/22/2018	Post	Presence-absence	M1	0	4	8	2	0
Methodist	8/22/2018	Post	Presence-absence	M2	0	12	50	20	0
Methodist	8/22/2018	Post	Presence-absence	M3	0	1	26	12	0
Methodist	8/22/2018	Post	Presence-absence	M3 - M4	0	13	186	66	0
Methodist	8/22/2018	Post	Presence-absence	M4	0	6	45	33	0
Methodist	8/22/2018	Post	Presence-absence	M4 - M5	0	0	34	18	0
Methodist	8/22/2018	Post	Presence-absence	M5	0	0	20	8	0
Methodist	8/22/2018	Post	Presence-absence	M6	0	0	32	4	0
Methodist	8/22/2018	Post	Presence-absence	M6 - M7	0	3	42	18	0
Methodist	8/22/2018	Post	Presence-absence	M7	0	0	12	6	0
Methodist	8/22/2018	Post	Presence-absence	M8	0	0	25	20	0
				Totals	**0**	**50**	**491**	**223**	**1**
Methodist	6/13/2019	Post	Presence-absence	Mixing Area	0	2	1	1	0
Methodist	6/13/2019	Post	Presence-absence	Mouth - M1	0	0	19	20	0
Methodist	6/13/2019	Post	Presence-absence	M1	0	0	4	5	0
Methodist	6/13/2019	Post	Presence-absence	M2	0	0	20	5	0
Methodist	6/13/2019	Post	Presence-absence	M3	0	0	4	3	0
Methodist	6/13/2019	Post	Presence-absence	M3 - M4	0	0	161	70	0
Methodist	6/13/2019	Post	Presence-absence	M4	0	0	16	5	0
Methodist	6/13/2019	Post	Presence-absence	M4 - M5	0	0	49	10	0
Methodist	6/13/2019	Post	Presence-absence	M5	0	0	12	6	0
Methodist	6/13/2019	Post	Presence-absence	M6	0	0	22	14	0
Methodist	6/13/2019	Post	Presence-absence	M6 - M7	0	0	20	3	0
Methodist	6/13/2019	Post	Presence-absence	M7	0	0	28	14	0
Methodist	6/13/2019	Post	Presence-absence	M8	0	0	3	5	0
				Totals	0	2	359	161	0
Methodist	8/20/2019	Post	Presence-absence	Mixing area & mouth	0	11	5	0	0
Methodist	8/20/2019	Post	Presence-absence	Mouth - M1	0	0	20	17	0
Methodist	8/20/2019	Post	Presence-absence	M1	0	0	10	6	0
Methodist	8/20/2019	Post	Presence-absence	M2	0	0	27	19	0
Methodist	8/20/2019	Post	Presence-absence	M3	0	0	29	20	0
Methodist	8/20/2019	Post	Presence-absence	M3 - M4	0	0	143	108	0
Methodist	8/20/2019	Post	Presence-absence	M4	0	0	21	10	0
Methodist	8/20/2019	Post	Presence-absence	M4 - M5	0	0	61	11	0
Methodist	8/20/2019	Post	Presence-absence	M5	0	0	24	6	0
Methodist	8/20/2019	Post	Presence-absence	M6	0	0	35	12	0
Methodist	8/20/2019	Post	Presence-absence	M7	0	0	39	5	0
Methodist	8/20/2019	Post	Presence-absence	M8	0	0	22	3	0
				Totals	**0**	**11**	**436**	**217**	**0**

*** Structure reach includes 100 ft upstream and downstream of structure**

Creek	Date	Pre- or post-implementation?	Survey type	# live spawners	# redds	# carcasses	Notes
Methodist	11/3/2015	Pre	Fall Chinook spawning survey	0	0	0	
Methodist	12/1/2015	Pre	Fall Chinook spawning survey	0	0	0	
Methodist	11/7/2017	Post	Fall Chinook spawning survey	0	0	0	
Methodist	12/13/2018	Post	Coho spawning survey	0	0	0	
Methodist	3/14/2019	Post	Steelhead spawning survey	0	0	0	
Methodist	4/16/2019	Post	Steelhead spawning survey	0	2	0	Redds associated with instream sturcture
Methodist	11/12/2019	Post	Fall Chinook spawning survey	0	0	0	
Methodist	12/10/2019	Post	Coho spawning survey	0	0	0	