Ammonoosuc River Phase 3 Assessment: Salmon Hole Stream Restoration Designs

Prepared for

Connecticut River Joint Commissions
Lebanon, NH

Prepared by

Dr. John Field
Field Geology Services
Farmington, ME

October 2011

Field Geology Services
Fluvial Geomorphology

The Ammonoosuc Conservation Trust, Ammonoosuc Local Advisory Committees, Connecticut River Joint Commissions, and Field Geology Services have developed on a land conservation and stream restoration plan and design for the Salmon Hole section of the Ammonoosuc River upstream of the village of Lisbon (Figure 1). Land conservation and conservation easements administered by the Ammonoosuc Conservation Trust will be an integral component of stream restoration work designed by Field Geology Services and provides a multi-tiered watershed solution to flooding, bank erosion, and habitat degradation. The goals of this work include: 1) restoring upland forest habitat through revegetation of the floodplain and riparian corridor; 2) increasing sediment storage both instream and on the floodplain to reduce downstream sediment delivery; 3) encouraging meander migration to reduce flow velocities; and 4) improving instream habitat by increasing pool habitat, cover, sediment sorting, and flow complexity.

The Salmon Hole section of the Ammonoosuc River was selected for land conservation and stream restoration based on the interests of involved stakeholders and cooperative landowners. This section of the river was identified in the Phase 2 geomorphic assessment completed by Field Geology Services as a high priority reach for restoration and conservation (Field, 2011). The need for restoration in this area is largely due to past management efforts. Historically, the entire reach was artificially straightened that resulted in increased flow velocities and sediment transport capacity. In the early 1980's, a major channel avulsion, precipitated by floodplain gravel mining, mobilized a large quantity of sediment. This sediment has been deposited as enlarged bars within the reach and transported downstream to Lisbon where the increased flow velocities and excess sediment load are resulting in significant bank erosion at the town's practice soccer field.

Ice jams forming downstream of the Route 302 bridge at Salmon Hole have become a common occurrence in recent years. Ice from upstream on the mainstem of the Ammonoosuc and/or from the Gale River flows down the channel and starts jamming up at the sharp meander bends at Salmon Hole, effectively damming the river. The backwatering upstream of the ice jams results in flow being diverted across the left bank (looking downstream) floodplain. These flows have apparently stripped much of the fine sediment and topsoil off portions of the floodplain, leading to degraded riparian habitat. Restoration of the floodplain forest, as part of this project, will be achieved through a combination of riparian plantings, live dormant staking, and flow diversion.

Riparian plantings proposed for the project will be composed of native tree species suitable to the floodplain ecosystem. Fast-growing floodplain trees such as silver maple and box elder will be planted along with sugar maples, oaks, pine, hemlock, and ash species. The planview map of the proposed restoration project shows buffer planting strips 50 feet wide oriented perpendicular to flow in an effort to limit the formation of side channels on the floodplain when flooding occurs during ice jams or other highwater events (Figure 2). The planting of live willow and dogwood stakes along the channel margins and low elevation features, such as emergent gravel bars, islands, and floodplain swales, is recommended as an additional low cost revegetation and bank stabilization treatment. Vegetation on the floodplain and channel margins increases roughness, lowers

flow velocities, and promotes the deposition and stabilization of sediment. This is an important element for achieving the restoration goals of reducing downstream sediment loading and improving riparian forest habitat.

Bank cutting/flow diversion is a restoration treatment wherein a portion of the bank is lowered in order to promote side channel activation. Given the frequent scouring across the left bank floodplain resulting from ice jams, this design calls for bank cutting at a specific location as a means of concentrating these floodplain flows into a defined channel (Figure 3). By allowing the river to access a flood channel at a defined location, the tendency for the river to scour the surface of the floodplain over a larger area is reduced. This should, therefore, improve the success of restoring floodplain vegetation. Bank cutting will require a careful assessment of existing flood channels and the elevation of the bank cut relative to the channel bed. The design calls for the installation of rootwads within the flood channel to provide increased roughness and discourage headcut migration that might allow the entire river to shift into the flood channel.

Encouraging the formation of meanders along the project reach is key to restoring equilibrium geomorphic processes and creating improved instream habitat. Increasing the channel's sinuosity increases the length of the stream and reduces the stream's gradient. This ameliorates the impacts of increased flow velocities and sediment transport capacity. The proposed planview shows the remeandering path occupying the deepest portions of the existing channel (Figure 2). A careful assessment of the site reveals that the river is preferentially eroding the banks in certain areas and depositing sediment in others. This represents the first steps in reestablishing the sinuosity that was lost when the channel was straightened. The proposed design uses bank cutting and instream structures to further encourage the redevelopment of meanders (Figure 2). The goal is not to impose a meandering planform by fully constructing the meanders, but rather to give the river the structure to establish its own meanders over time. The process of meander formation is important for developing flow complexity and other important habitat features that would not result by restoring meanders to a final form. Many instream restoration techniques, described below, can be used to encourage meander reformation, bank stabilization, and other improvements to aquatic habitat.

Engineered log jams, mimicking natural log jams in their form, are structures with multiple layers of interlocking stacked logs partially buried in the channel bed. At the Salmon Hole project site the engineered log jams will be situated in the middle of the active channel to divert flow into the banks and encourage meander reformation (Figure 4). They will also increase flow complexity by promoting zones of sedimentation and scour in and around the structure. Deep scour pools are expected to form and be maintained adjacent to the structure where they will provide important pool and cover habitat for coldwater fish species including trout and other salmonids. Engineered log jams have been used extensively in the western United States and have been installed in New Hampshire on the lower Mohawk River and Nash Stream.

Boulder-supported log jams are a treatment that mimics natural features observed in the Ammonoosuc River watershed where large boulders near the margin of the channel trap logs between the boulder and the banks. Constructed boulder-supported log jams

will utilize large boulders to support an anchor log placed against the upstream face of the boulders and partially buried in the bank (Figure 5). Additional logs will be intertwined between the boulder, anchor log, and bank. Similar to the engineered log jams, these structures will deflect flow, increase flow complexity and encourage the redevelopment of meanders along the straightened channel. The expected formation of deep scour pools will provide additional habitat benefits.

The placement of wood in the channel is a treatment where logs are installed individually in the low flow channel. Instream logs provide additional roughness and alter flow velocity sufficiently to create distinct zones of scour and deposition. This treatment is most effective when logs are used with their rootwads attached. The proposed design calls for instream wood additions in wide shallow channels where flow complexity and cover habitat are absent (Figure 6). Placed wood in channel is an easy and inexpensive treatment option that increases flow complexity, encourages sediment sorting, and provides pool habitat.

The placement of wood on sand/gravel bars is a treatment where individual logs are added to the tops of the bars to provide increased roughness during high flow events and promote deposition of finer substrate particles. The treatment is most effective when logs are used with their rootwads attached. The design calls for wood additions on large unvegetated bars where wood could stabilize the bar and promote the growth of vegetation (Figure 7). By trapping fine sediment on bars, the bar surfaces will vertically accrete and slowly transition to the floodplain surface, continuing to provide flood relief but allowing a narrower river channel to develop over time. River channel narrowing is important for maintaining deeper and, therefore cooler summer flows.

Rootwad revetments are a bank stabilization treatment where rootwads are pushed into the base of an eroding bank in order to help stabilize the base of the bank (Figure 8). Rootwads oriented perpendicular to flow or angled upstream and supported by large boulders, provide roughness and reduce shear stress along the toe of the eroding bank. Rootwad revetments will aid in bank stabilization and bank revegetation while encouraging pool formation and sediment deposition. The rootwads will also provide valuable cover habitat along the channel margin. The design calls for rootwad revetments in areas where stabilizing the eroding river bank is the desired outcome.

Surveyed channel cross sections are included as part of this restoration design packet (Figures 9-12) along with preliminary cost estimates for completing the project (Table 1). The cost estimates are meant as a rough guide of material and installation costs. The costs include all site preparation, trucking of materials, machinery and operators, construction oversight, and fair market values for the trees and boulders needed.

<u>References</u>

Field, J., 2011, Ammonoosuc River geomorphic assessment, floodplain conservation, and river corridor planning: Unpublished report prepared for the Connecticut River Joint Commissions, Lebanon, NH.

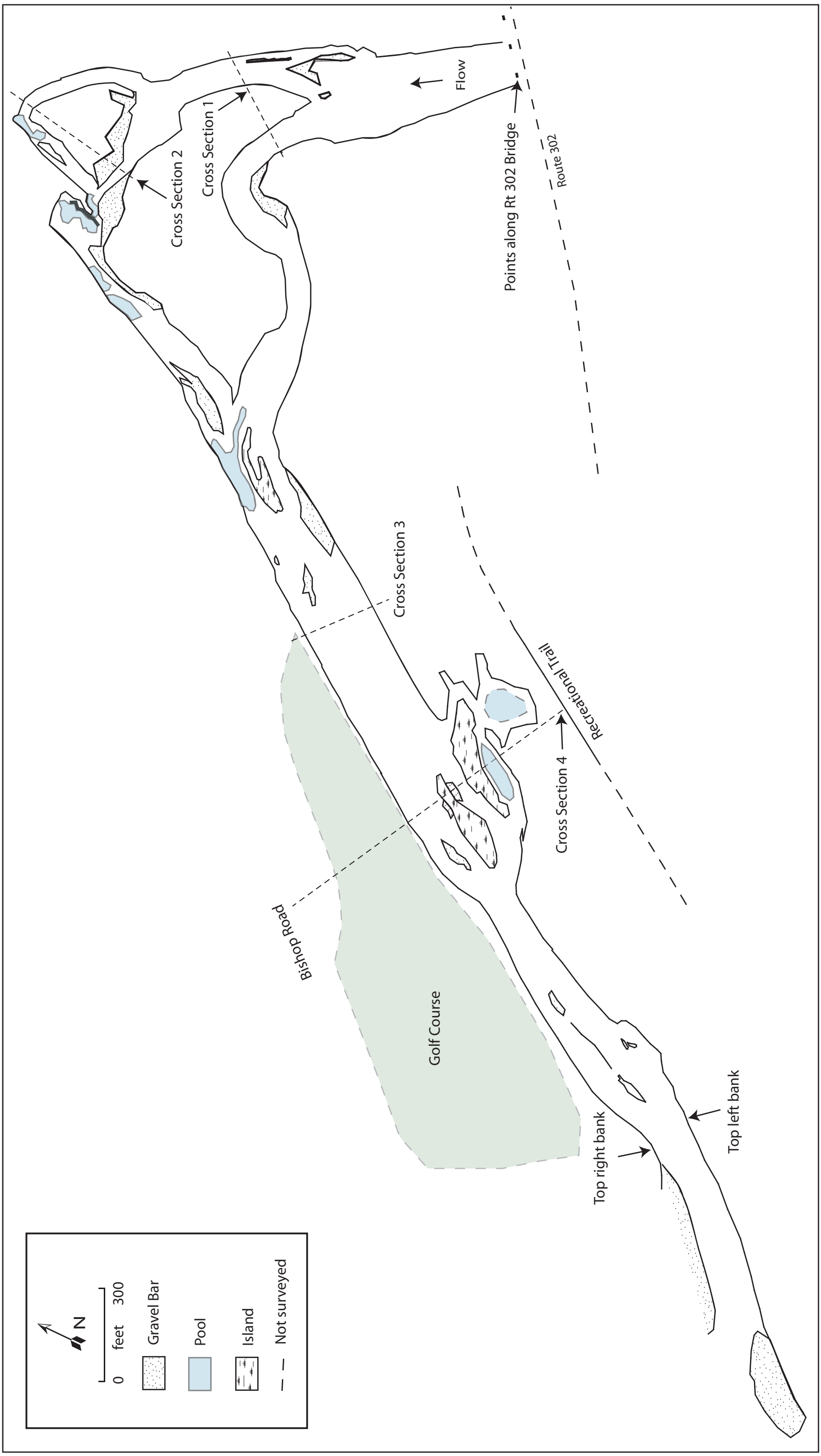


Figure 1. Existing condition planview map of Salmon Hole restoration site.

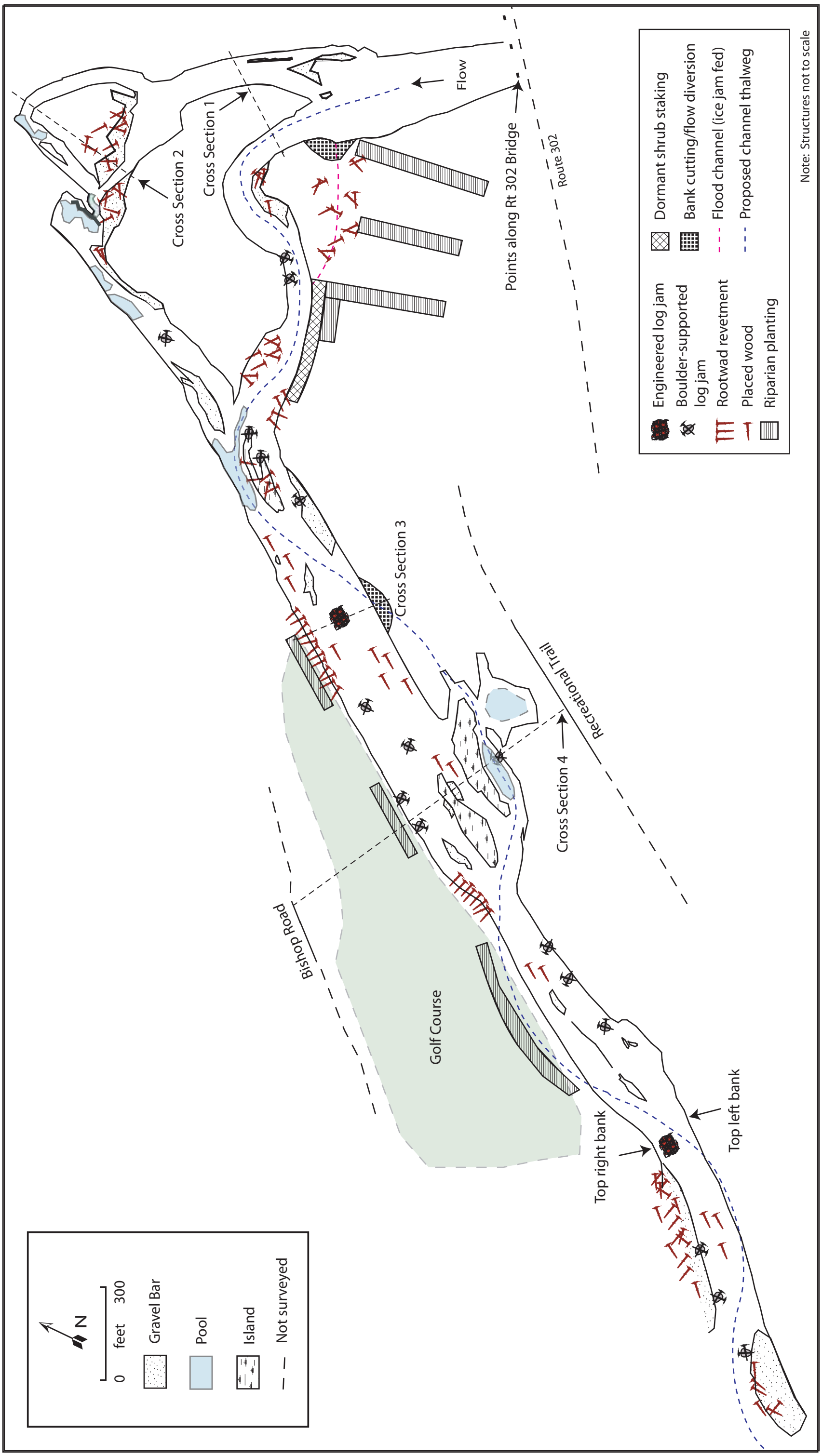
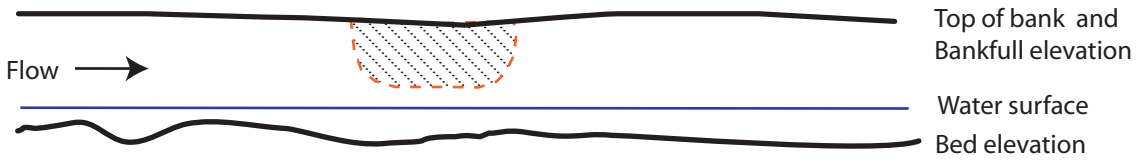
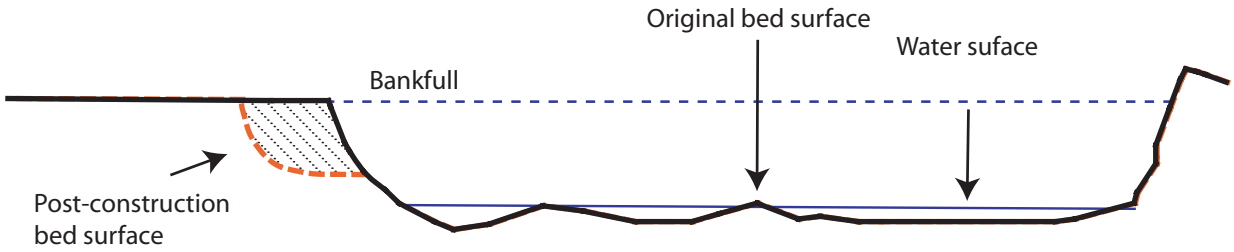


Figure 2. Proposed condition planview map of Salmon Hole restoration site.

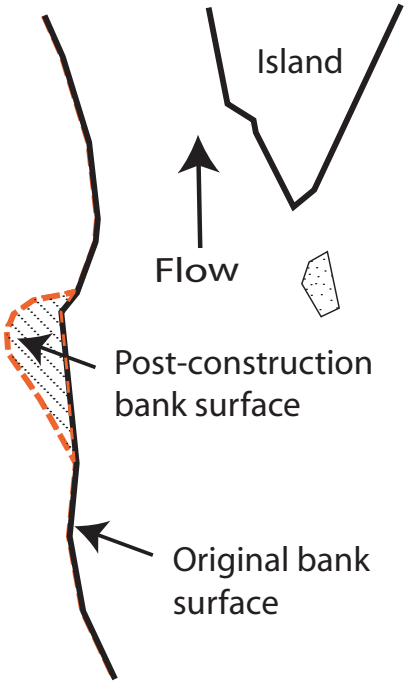
Longitudinal view conceptual



Side view conceptual



Plan view conceptual



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Note: Drawings are not to scale

Figure 3. Bank cutting/Flow diversion design typical.

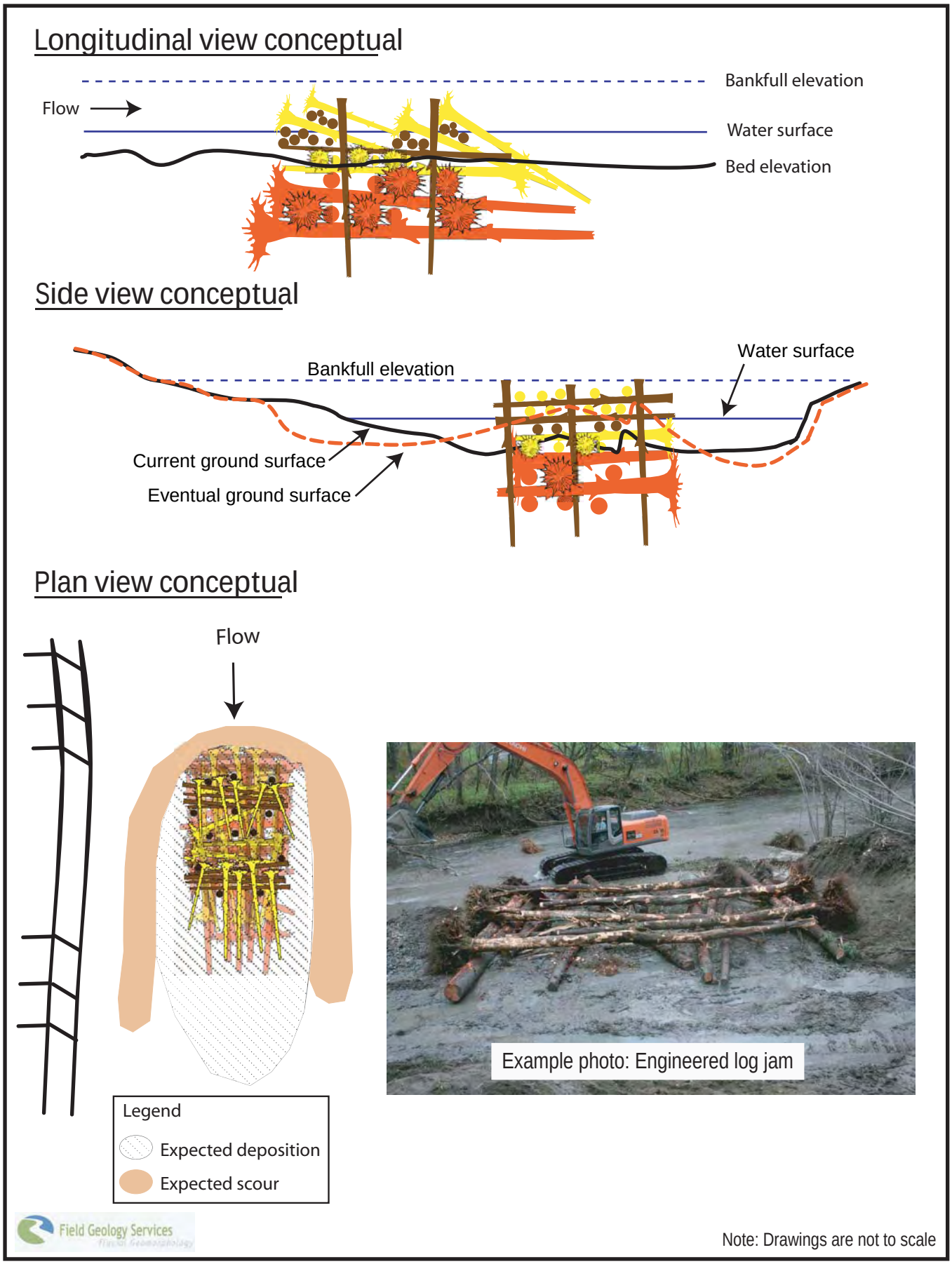
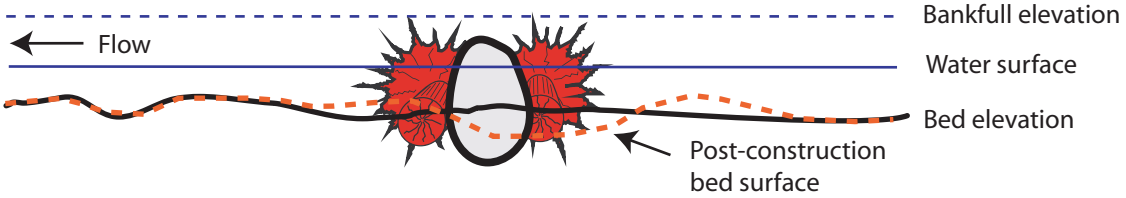
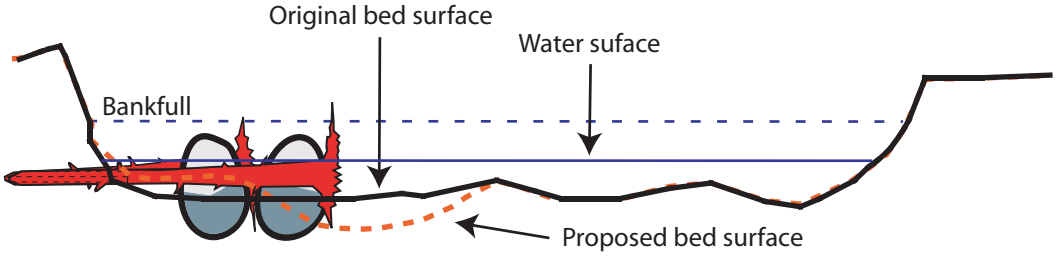


Figure 4. Engineered log jam design typical.

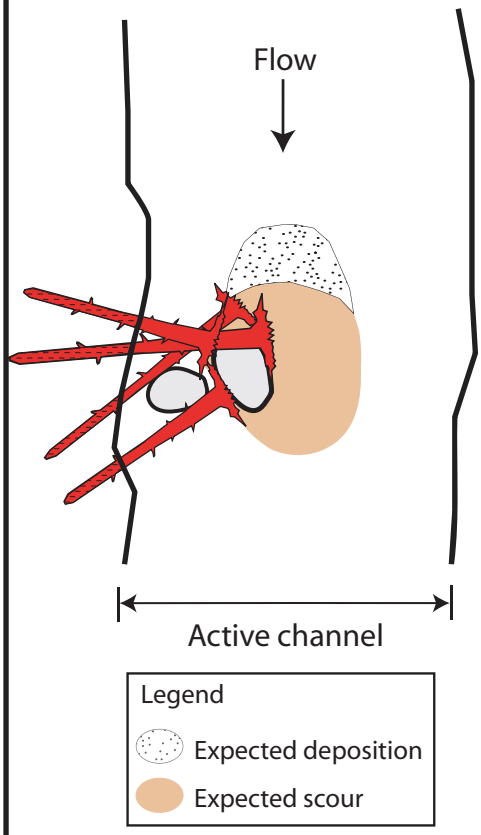
Longitudinal view conceptual



Side view conceptual



Plan view conceptual



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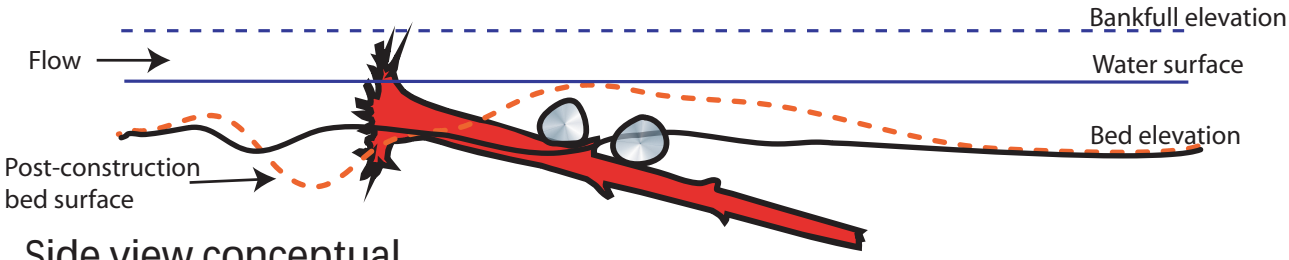
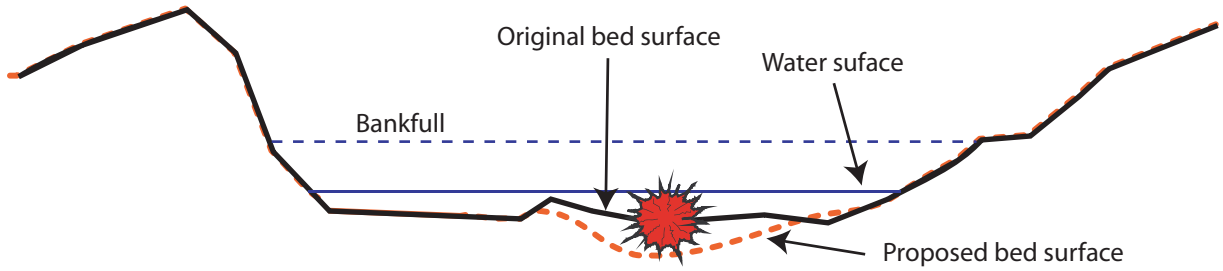
Note: Drawings are not to scale

Figure 5. Boulder-supported log jam design typical.

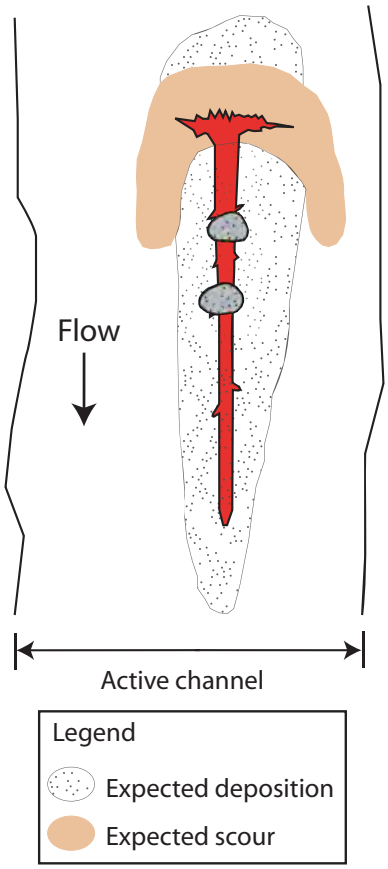
Longitudinal view conceptual



Side view conceptual



Plan view conceptual



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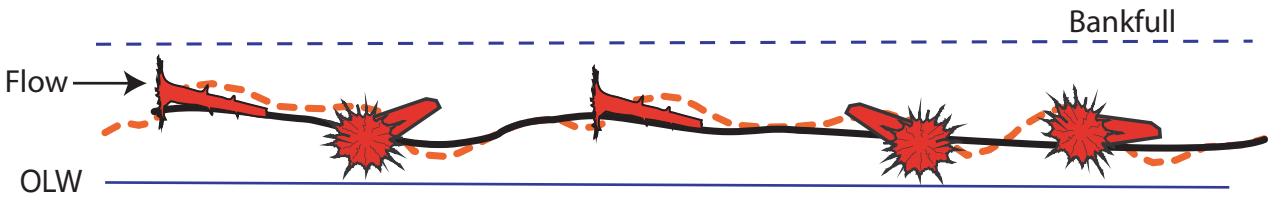
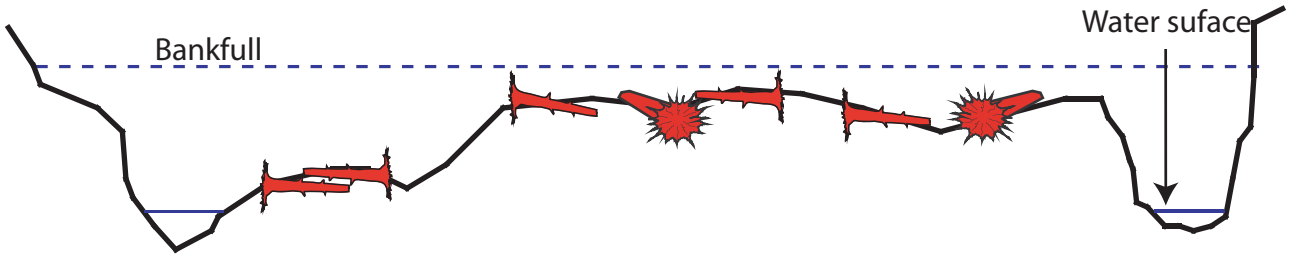
Note: Drawings are not to scale

Figure 6. Placed wood in channel design typical.

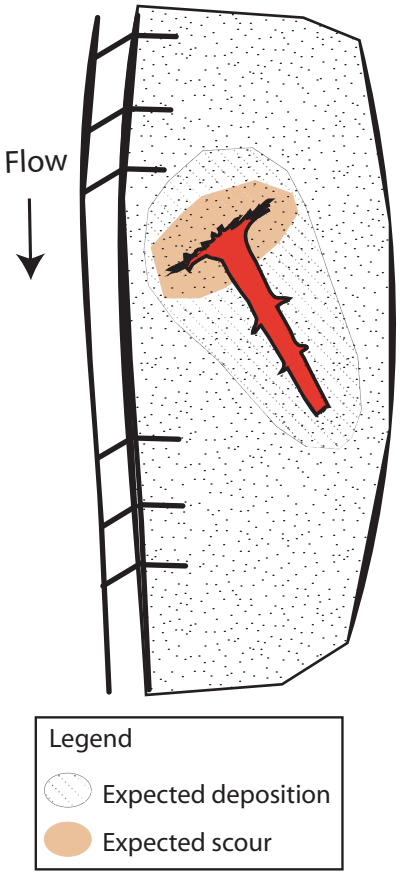
Longitudinal view conceptual



Side view conceptual



Plan view conceptual



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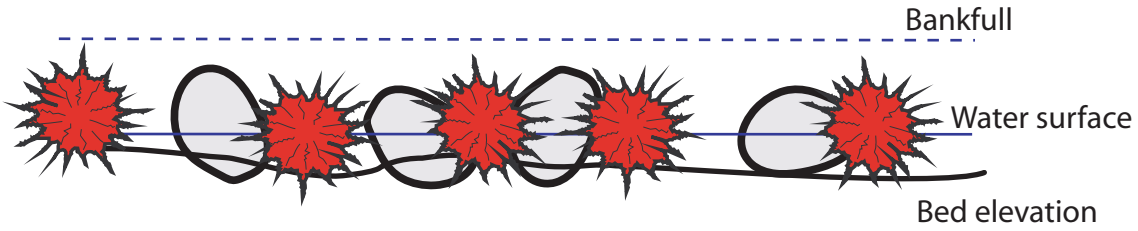
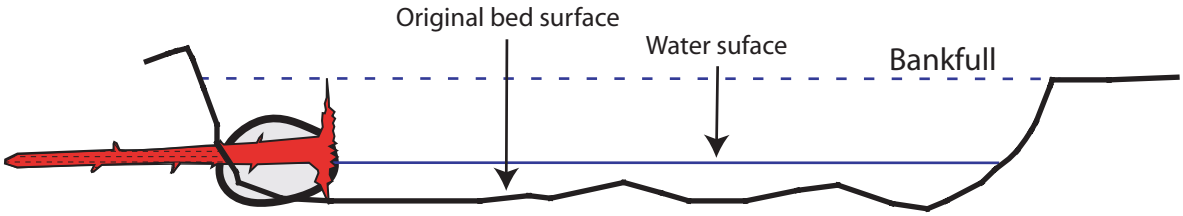
Note: Drawings are not to scale

Figure 7. Placed wood on bar design typical.

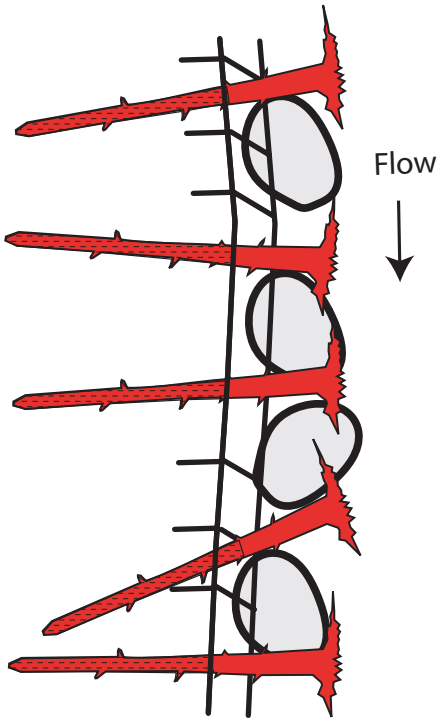
Longitudinal view conceptual



Side view conceptual



Plan view conceptual



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Note: Drawings are not to scale

Figure 8. Rootwad revetment design typical.

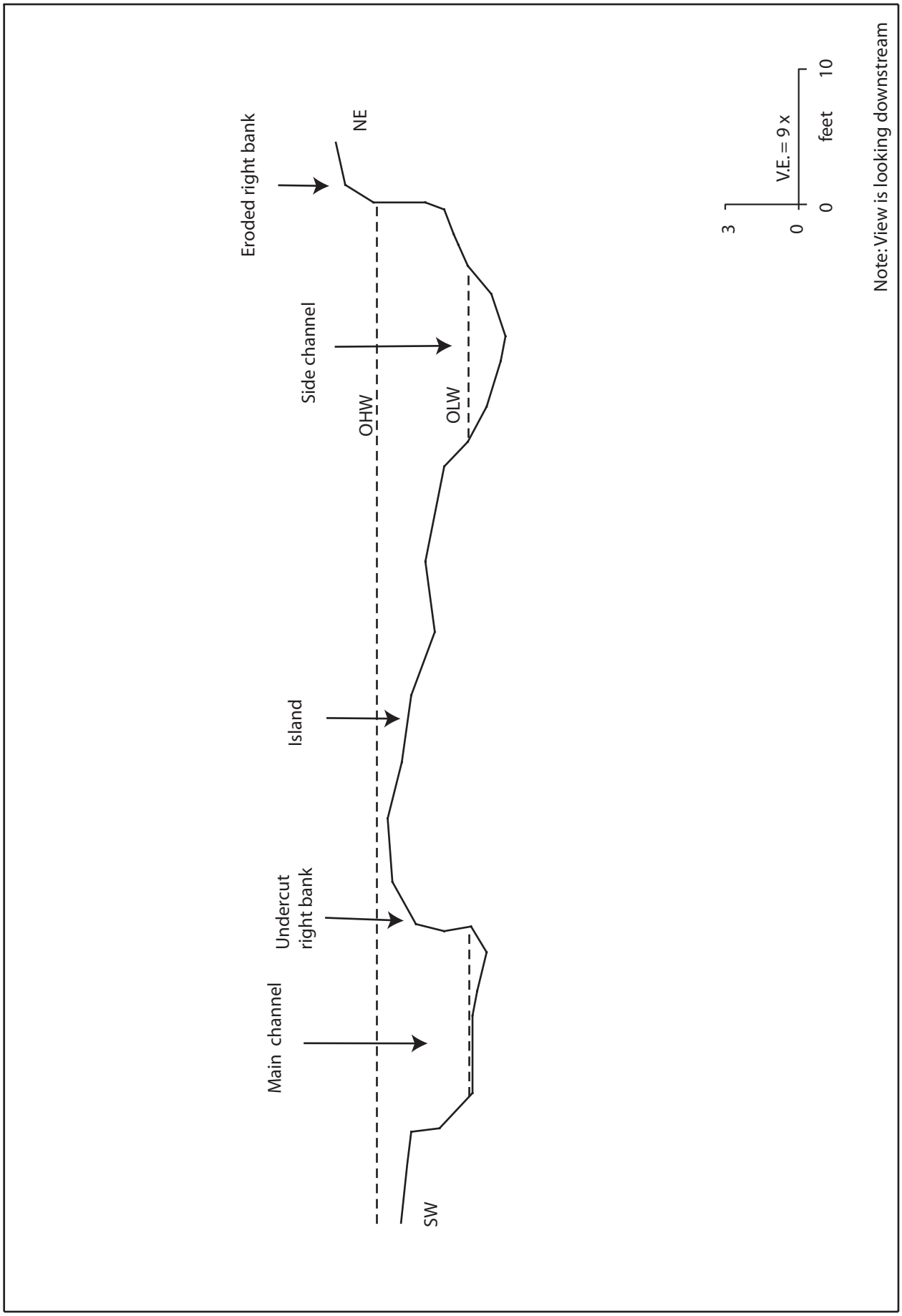

Figure 9. Surveyed cross section #1 showing existing conditions.

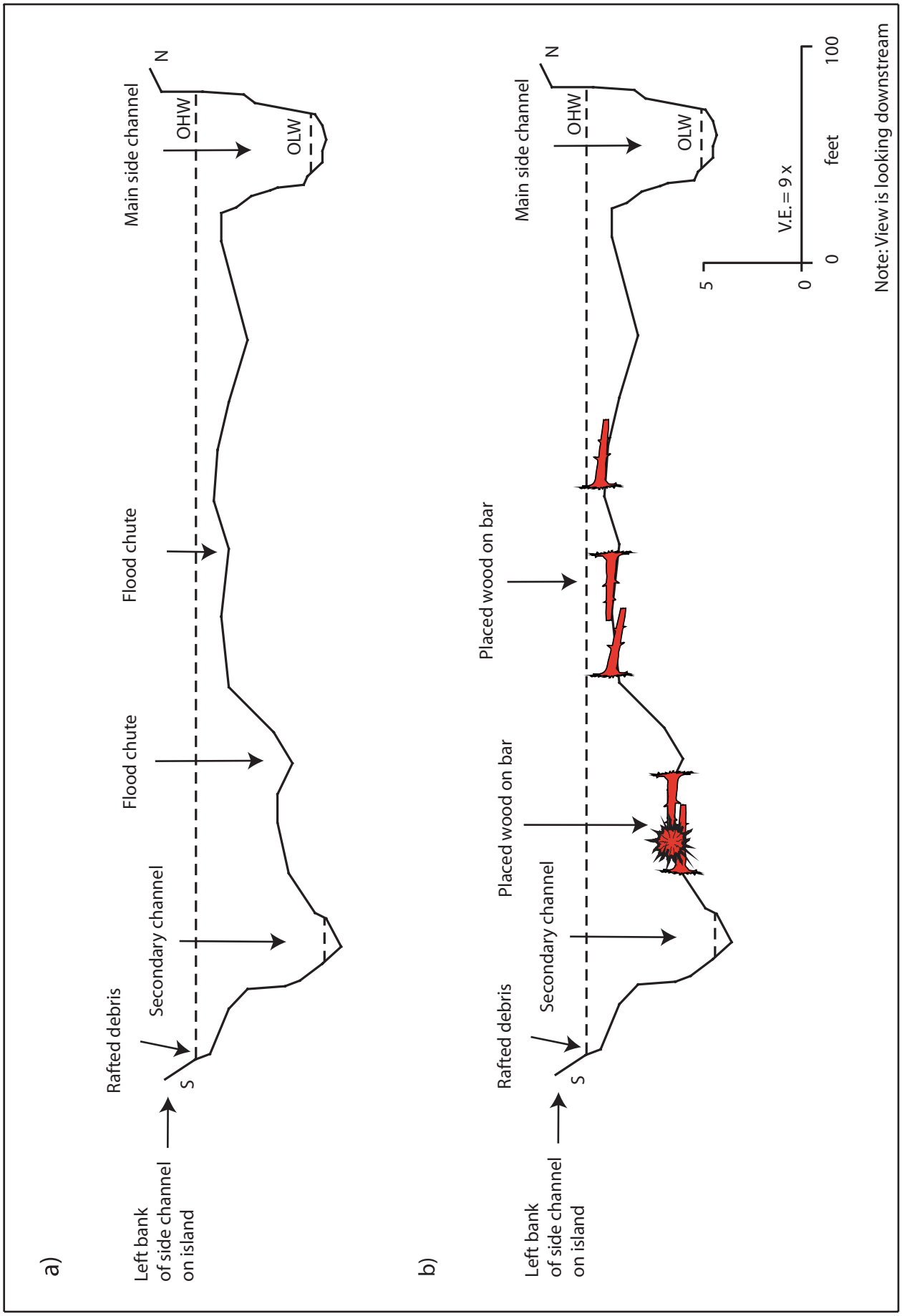

Figure 10. Surveyed cross section #2 showing a) existing and b) proposed conditions.

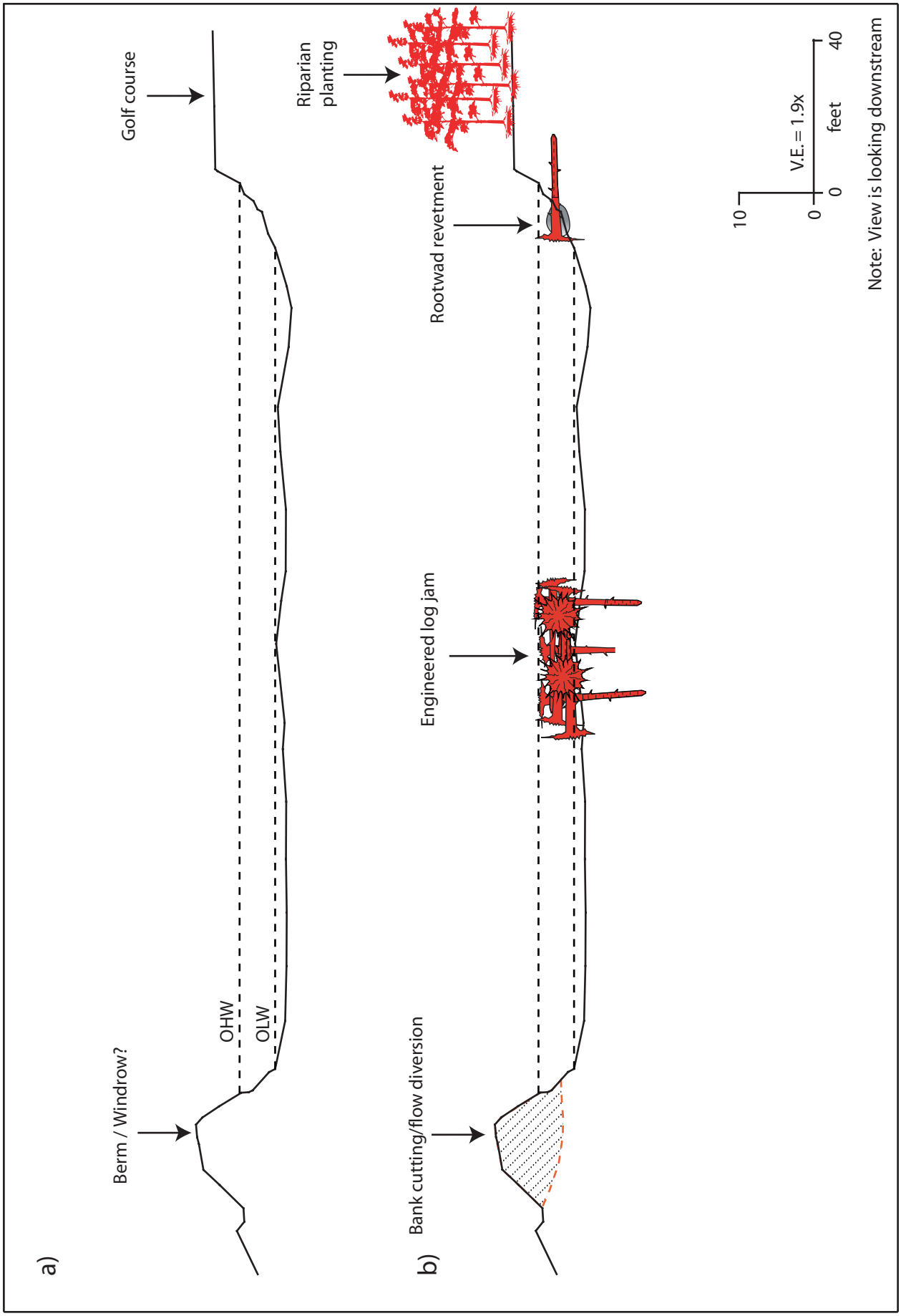

Figure 11. Surveyed cross section #3 showing a) existing and b) proposed conditions.

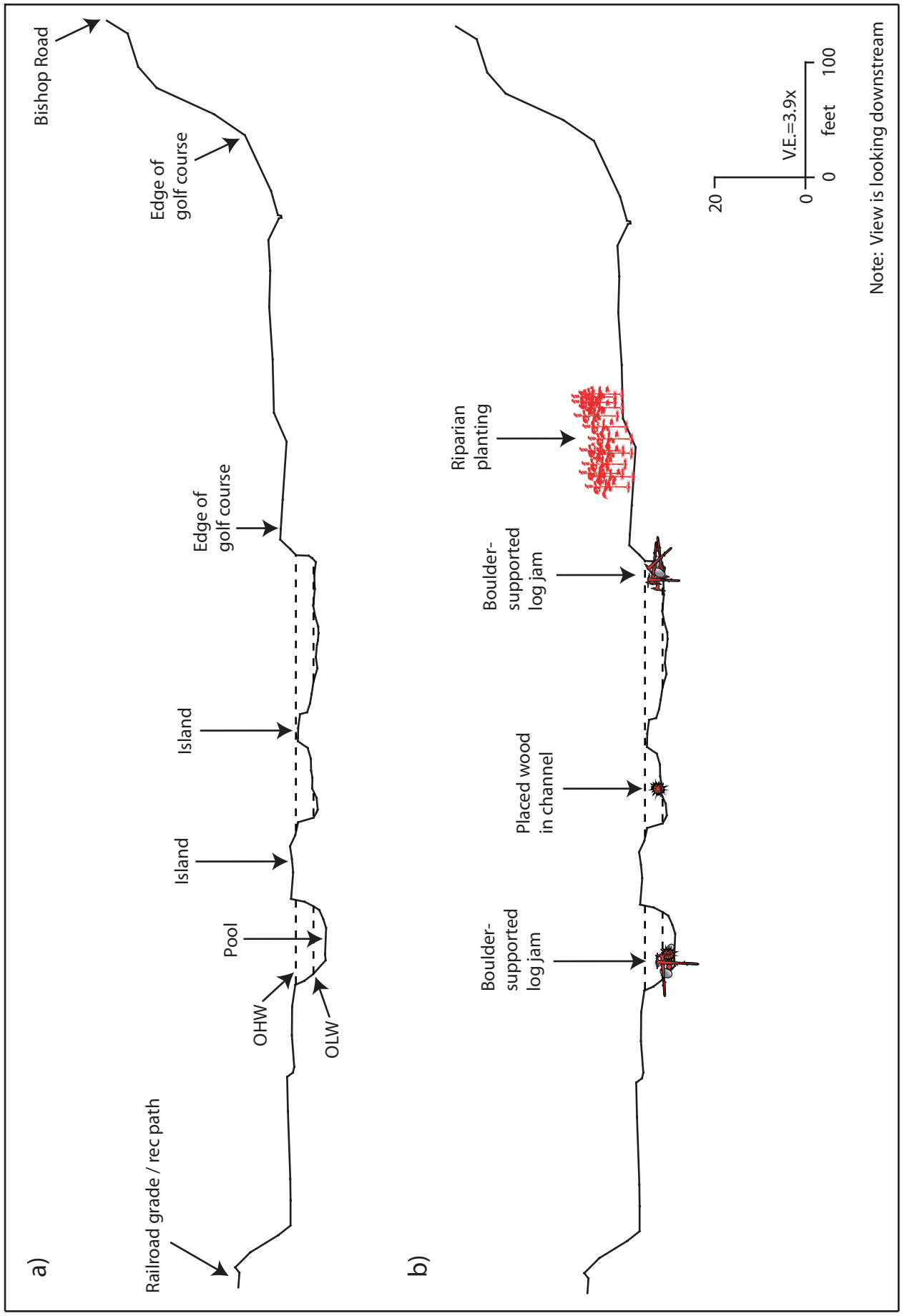

Figure 12. Surveyed cross section #4 showing a) existing and b) proposed conditions.

Table 1. Preliminary cost estimates for Salmon Hole restoration treatment options.

Treatment	Estimated cost per structure/piece	Number of structures/pieces	Estimated cost for project site
Bank cutting/flow diversion	15000	2	30000
Engineered log jam	50000	2	100000
Boulder-supported log jam	7500	17	127500
Placed wood in channel*	1000	15	15000
Placed wood on bar*	800	70	56000
Rootwad revetments*	800	24	19200
Preparation of construction ready plans and permitting			20000
		Project total	367700

* Cost estimates are per rootwad installed.