Stream and Valley Floor Restoration Vision

Scott Brown and Barry Hecht

Balance Hydrologics, Inc.

November 19, 2009

I. Introduction

The Miller Creek valley has incised over historical times. While this is most easily seen following construction of Grady Bridge in 1940, incision likely has been ongoing for many years. We can see it in the vegetation along the banks – almost all older than 50 to 100 years. We see it in concrete structures built in the 1920s, 1930s, 1940s as incision seems to have threatened structures and roads. It is not hard to understand the bridge itself as testimony to the progressive downcutting of the creek, which by 1940 finally had become a serious obstacle to cross – after years first of fording and then (reportedly) a wooden bridge.

The Miller Creek valley is also typical of headwater valleys throughout Marin and Sonoma Counties which had once been intrinsically connected with the channels flowing through them. The dry-meadow valleys or headwater bowls were widespread, sometimes called by their Spanish name, "vegas". One by one, they were incised, perhaps as cattle compacted the hillsides, as owners narrowed the riparian corridors along the streams, and as roads and drainageways sped stormwaters into the stream channels. Now, few intact headwater valleys remain.

The Grady Ranch project offers an opportunity to restore one such valley to its original form. With restoration may come:

- Modulation of winter runoff
- Higher spring-month baseflows
- Increased vigor and width of riparian buffers
- An opportunity for more steelhead smolt to reach the Bay
- Diminished sediment yields.

Restoring the form of the valley floor is not enough without restoring processes that sustained the intact valleys or reversing the causes of the stream instability. In many cases, streams began to destabilize at the onset of widespread ranching and other watershed changes resulting in soil compaction and corresponding increased runoff, with a parallel destabilization of the banks due to trampling and reduction in vegetative cover. These factors caused the stream to incise within its valley fill (at times quite rapidly) which resulted in a separation of the stream from its floodplain. With the loss of the overbank flood areas, stormflows were generally confined to an incised channel, creating an erosive feedback cycle that further entrenched the valley system. This was compounded by the practice of removing woody debris from the stream system, which resulted in decreased channel complexity and roughness, resulting in the loss of in-stream sediment storage and metering, and higher stream velocity.

In addition, stream incision has likely lowered groundwater levels in the alluvial aquifer adjacent to the creek, with the lower stream elevation acting as a 'drain' cutting through the middle of the alluvium. Lower groundwater levels have led to stranding of banktop vegetation, decreased aquifer storage volume and decreased baseflow in downstream reaches of Miller Creek.

II. Objectives

The Grady Ranch project provides an opportunity to reverse the effects of incision that have been ongoing over the past several decades, and to return the upper watershed to a healthy, functioning system. The objectives of the restoration effort are as follows:

1. Remove fish passage barriers within Miller and Grady Creeks to allow access to perennial pools in the bedrock reaches of tributary sub-watersheds;
2. Reduce sediment inputs to Miller Creek by stabilizing the stream banks and stream grades of Miller Creek and its tributaries;
3. Attenuate flows by creating an inset floodplain and increasing channel roughness and complexity;
4. Increase available groundwater storage in the alluvial aquifer;
5. Re-establish the connection between the stream corridor and the rest of the valley floor.

These efforts, along with the reduction in cattle grazing that has already occurred at the project site will provide for a restoration of an intact alluvial valley system—looking beyond simply restoring the functions of the stream channel.

III. Elements of Restoration

Details of the proposed restoration are discussed in separate reports in the previous April, 2009 PDP submittal, and elsewhere within this PDP submittal, including layout of restoration elements on Sheet EN7.1. The following text briefly discusses each of the elements of the restoration program, and how the element meets the goals described above. A schematic plan view is provided in Figure 1 that illustrates the style of the proposed restoration.

Channel and floodplain system

Boulder weirs and step-pool sequences will provide stability to the stream system, establishing a channel grade that is in sync with the flow and sediment transport regime of the watershed. These features will also provide increased channel roughness and complexity, providing both flow and sediment attenuation within the watershed. Attached Figures 2 and 3 show visualizations of what these elements will look like after restoration has been completed. Figure 4 illustrates one planned style of boulder weir in plan view and in cross section.

Re-introduction of woody debris into the system will add additional channel complexity and where added as secure structures will help dissipate flow energy and increase bank stability. Figure 1 shows how woody debris might be initially placed to also provide additional bank protection. The added roughness of the woody debris, along with the boulder weirs, will also provide flow attenuation to downstream reaches.

Raising the base level of Miller Creek and portions of its tributaries in the lower portions will eliminate the fish passage barriers within Miller and Grady Creeks as shown in Figures 5a and 5b. The stream profile will step up gradually from existing grade near the downstream property line to the elevation of the Grady Bridge in a series of step pool sets with six-inch jumps. More generally, this element will allow for the creation of an inset floodplain without the need to remove much alluvial bank material, as it will allow for reactivation of existing floodplain terraces adjacent to the channel. Figures 6a and 6b illustrate how this may be implemented. This re-activated floodplain area will allow stormflows to spread out and slow, providing flood attenuation benefits to downstream reaches. In addition, the raised stream bed will provide more intact and contiguous valley floor.

Laying back stream banks and expanding flood plain terraces in selected segments of the stream will provide additional overbank area for flood attenuation and, with associated plantings, will provide additional stability of the bank material.

Aquifer system

Reactivation of inset terrace surfaces will provide an area for storm flows to spread out, allowing some additional water to infiltrate into the alluvial aquifer. This water will be stored within the alluvium and either discharge to Miller Creek within the project site to extend the baseflow recession (likely during mid-winter and early spring periods), or migrate within the aquifer down-valley, to support baseflows in those reaches (late-spring through summer, or possibly longer).

Raising the bed level of Miller Creek and portions of the tributaries will allow for additional groundwater storage within the alluvial aquifer. Currently, the lowered base level of Miller Creek acts as a low drain splitting the alluvial aquifer. Raising the streambed elevation will essentially 'plug' the drain, allowing portions of the alluvial aquifer above the existing base level to be used for groundwater storage, and to improve the continuity of aquifer as a whole. Figure 9 shows the estimated benefit to groundwater levels expected as a result of raising stream base level (note that terrace reactivation/expansion is not illustrated on this conceptual drawing). These higher aquifer levels will bring the groundwater closer to the existing terrace surfaces, allowing existing and planted vegetation better access to groundwater. Additional groundwater storage will also support extended baseflow periods in downstream segments of Miller Creek, as described below.

Benefits to steelhead

We recognize that one primary goal of the restoration is improvement in steelhead habitat within the project site as well as in downstream reaches, and therefore provide additional discussion of these benefits below.

Stream and corridor restoration

Beyond the direct removal of fish passage barriers, as mentioned above, the proposed restoration would also potentially significantly reduce the introduction and transport of fine sediment into Miller Creek, a known limiting factor for steelhead within the watershed. Incising streams in the Bay Area can have sediment transport rates that are up to seven times the rate of transport in non-incising systems of similar size and watershed influences[1].

[1] See, for example, Hecht, B., 2007, Quantitative analysis of sediment rating curves in assign changes in sediment transport: Examples from the San Francisco Bay Area. Association of American Geographers Annual Meeting, San Francisco, California, April 18, 2007

Estimated current sediment loads in Miller Creek at the project boundary are approximately 38,000 cubic yards over a 5-10 year period, so a reduction in sediment by even a portion of the seven-fold increase would certainly be an appreciable improvement.

Improved connectivity of the channel and floodplain will add vigor and extent to a riparian corridor that is increasingly isolated from the incised channel, and a channel that is (as often occurs when channels downcut) progressively undermining large, mature, heritage trees. The reinvigorated corridor will sustain a large woody debris supply to the channel, help cool the waters, discourage establishment of exotic vegetation, and enhance the channel in other ways that are coming to be understood and valued as integral to restoring aquatic habitat in local channels.[1]

Aquifer recharge as restoration

The question can reasonably be asked, "Can more groundwater in storage really translate into better steelhead habitat?" We understand that the key constraint, year to year, for steelhead in small streams such as Miller Creek is sustaining sufficient flow for downstream migration of smolts, the maturing juveniles ready to go out to the ocean. In other Marin Creek channels, steelhead smolts are reported to migrate downstream in late April and May.[2] During many years, Miller Creek either on Grady Ranch or further downstream seems to go dry for at a least the latter portion of this period. While smolts can normally proceed downstream with even a very minimal continuous thread of flow, a dry stream poses a fatal obstacle.

As discussed above, raising the level of the Miller Creek will allow for additional storage within the alluvial aquifer. Much of this water, we estimate, will discharge to Miller Creek downstream of Grady Ranch during the first few months after the aquifer reaches its late-winter high, commonly in March.[3] The discharge of the additional, stored water would enhance flow in Miller Creek downstream of Grady Ranch during the peak of the smolt outmigration period in late April or early May, likely significantly expanding the window for outmigration. It is important to note that the Miller Creek channel will remain dry at Grady Ranch itself through much of the spring and summer, as it is under existing conditions, but the effects downstream will be appreciable.

---

[1] See the Riparian and Sediment Management Plan for Lagunitas Creek (Prunuske Chatham and others, 1997), as well as recent restoration plans for the San Geronimo Valley sponsored by the County, MMWD, and others.

[2] Based on the trapping results of D. W. Kelley and his coworkers during the early 1980s, and subsequent work by Stillwater, SPAWN, and others during the past 5 years.

[3] Based on data from San Geronimo Valley and other West Marin catchments.

IV. Conclusion

The elements discussed above should be considered more than simply a stream restoration. We consider the proposed plan an effort to restore an intact stream and valley corridor. The benefits to looking beyond the stream are real, as demonstrated by the aquifer recharge and baseflow support numbers provided above. It is important to point out that the benefits of valley restoration have been recognized in other parts of the state. One example is the Central Sierra. Figure 8 is a depiction of the problems associated with incising streams, adapted from the National Fish and Wildlife Foundation Sierra Nevada Meadow Restoration (2009) report, which explores concepts of 'reversing' stream incision. While the physiographic setting is quite different from that of Grady Ranch, the concepts for the glacial valleys are surprisingly applicable to the dry meadow setting at Grady Ranch.

Because the Grady Ranch incorporates most of the upper reaches of the Miller Creek headwaters (and the entire northern portion of the mainstem and headwaters), we have the unique opportunity to look at watershed-scale restoration efforts and to incorporate elements that may not be feasible in other, more segmented settings. For example, raising the base level of Miller Creek would not be possible in downstream segments, as there would not be an appropriate way to connect the restoration reach with the upstream segments. Because the proposed restoration extends up to the primarily 'undisturbed' portion of the channel, Grady Ranch provides a unique, "landmark" opportunity to re-establish the pre-incision form, and in fact we feel that it would be inappropriate to miss an opportunity to do so.

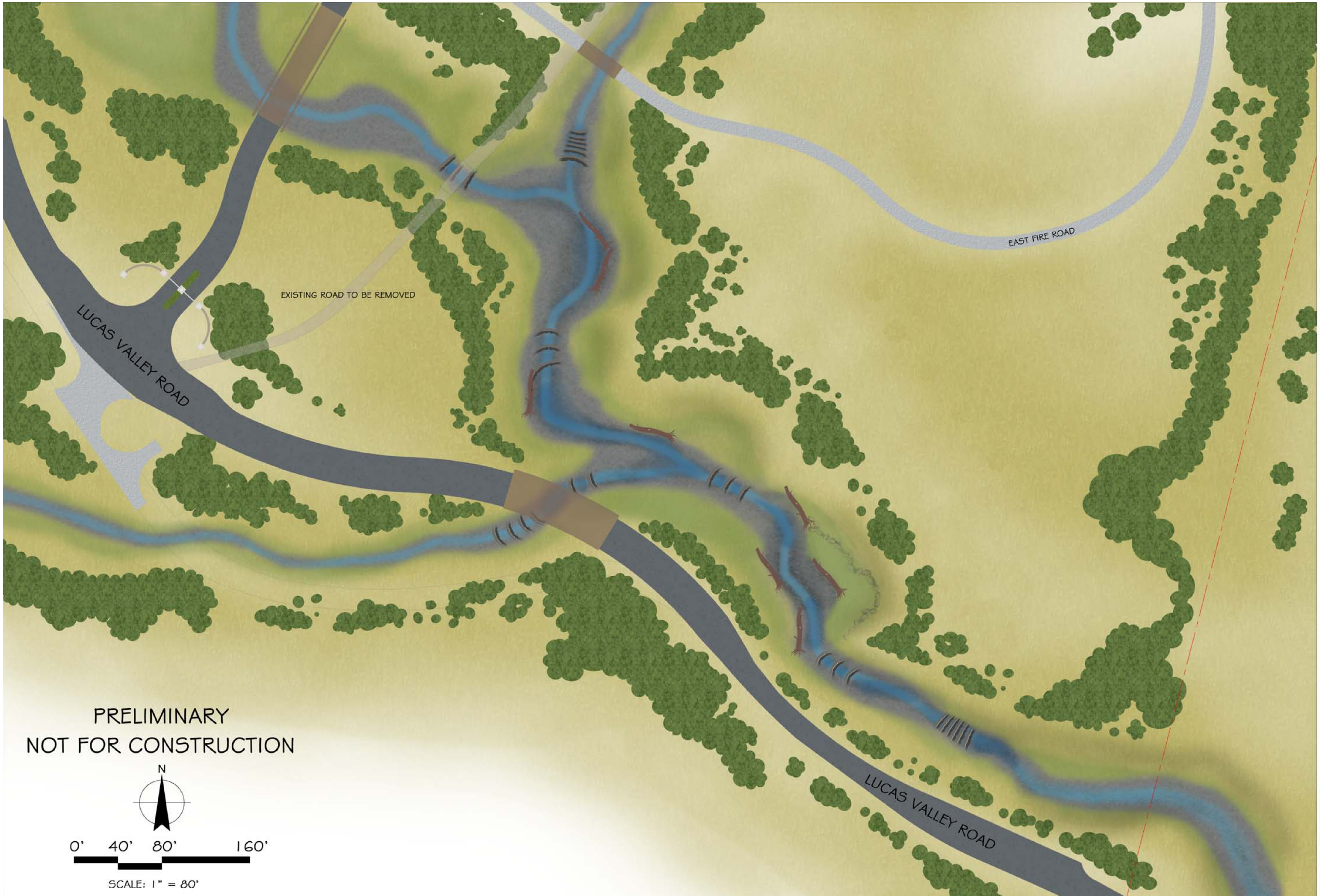


Figure 1. Conceptual plan view of restoration opportunities for Miller Creek and valley floor system, Marin County, California.

Figure is schematic, showing representative elements and examples of likely arrangement in the channel. Additional design criteria are expected and will inform development of a permittable conceptual model. This schematic is intended to illustrate the style of the restoration, and does not reflect the latest restoration designs, including the realignment of the S-4 tributary.

Balance Hydrologics, Inc.
800 Bancroft Way, Ste 101 • Berkeley, CA 94710
(510) 704-1000 • (fax) 704-1001
email: office@balancehydro.com

\\World\GIS\CADProjects\208164 Grady Ranch\BH GRADING.dwg

Miller Creek looking upstream at bridge, existing conditions, photograph taken August 2008. Boulders are riprap placed to protect bridge.

Proposed improvements, including raised bed and floodplain elevations, boulder weirs with steps and bridge removal.

Figure 2. Conceptual view of existing conditions and 10 years following construction of boulder weirs at Miller Creek and valley floor system.

Figure is schematic, showing representative elements and examples of likely arrangement in the channel.
Additional design criteria are expected and will inform development of a permittable conceptual model.

Balance Hydrologics, Inc.
800 Bancroft Way, Ste 101 · Berkeley, CA 94710
(510) 704-1000 · (fax) 704-1001
email: office@balancehydro.com

\\World\GIS\CADProjects|208164 Grady Ranch\Figure 2 Boulder Weir 093009.psd

Balance Hydrologics, Inc.
800 Bancroft Way, Ste 101 · Berkeley, CA 94710
(510) 704-1000 · (*fax*) 704-1001
email: office@balancehydro.com

Figure 3. Conceptual view of proposed step pool weirs at Miller Creek, Marin County, California.

Figure is schematic, showing representative elements and examples of likely arrangement in the channel. Additional design criteria are expected and will inform development of a permitable conceptual model.

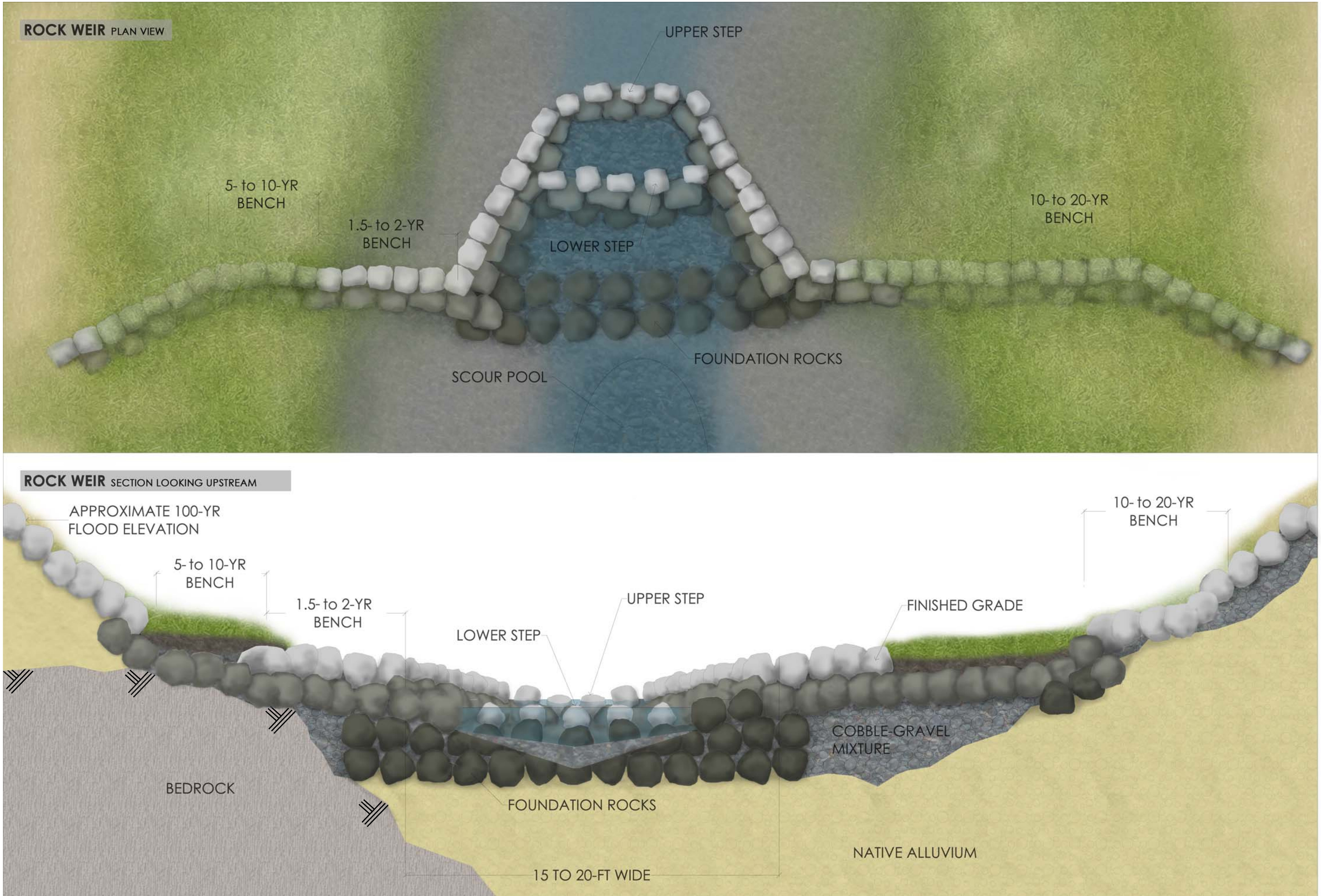
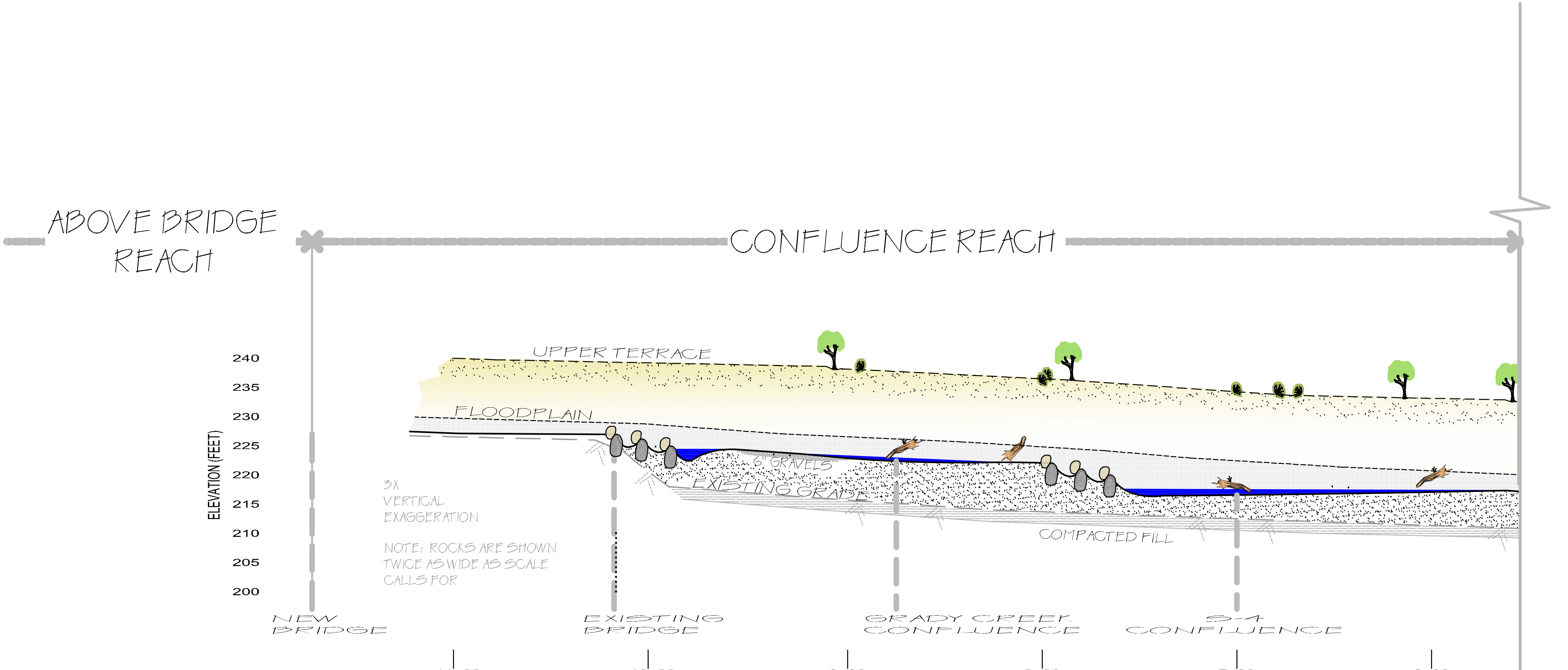


Figure 4. Schematic of a typical boulder weir for Miller Creek, looking upstream.
The upstream step of the boulder weir is approximately 2-feet lower than the "sill" rocks, which correspond to the 2-year "floodplain." This height differential maintains the bankfull dimensions and when combined with the additional elevation drop of the steps, helps concentrate high flows to the center of the weir.

Balance Hydrologics, Inc.
800 Bancroft Way, Ste 101 • Berkeley, CA 94710
(510) 704-1000 • (fax) 704-1001
email: office@balancehydro.com

\\World\GIS\CADProjects\208164 Grady Ranch\Conceptual Weir.dwg

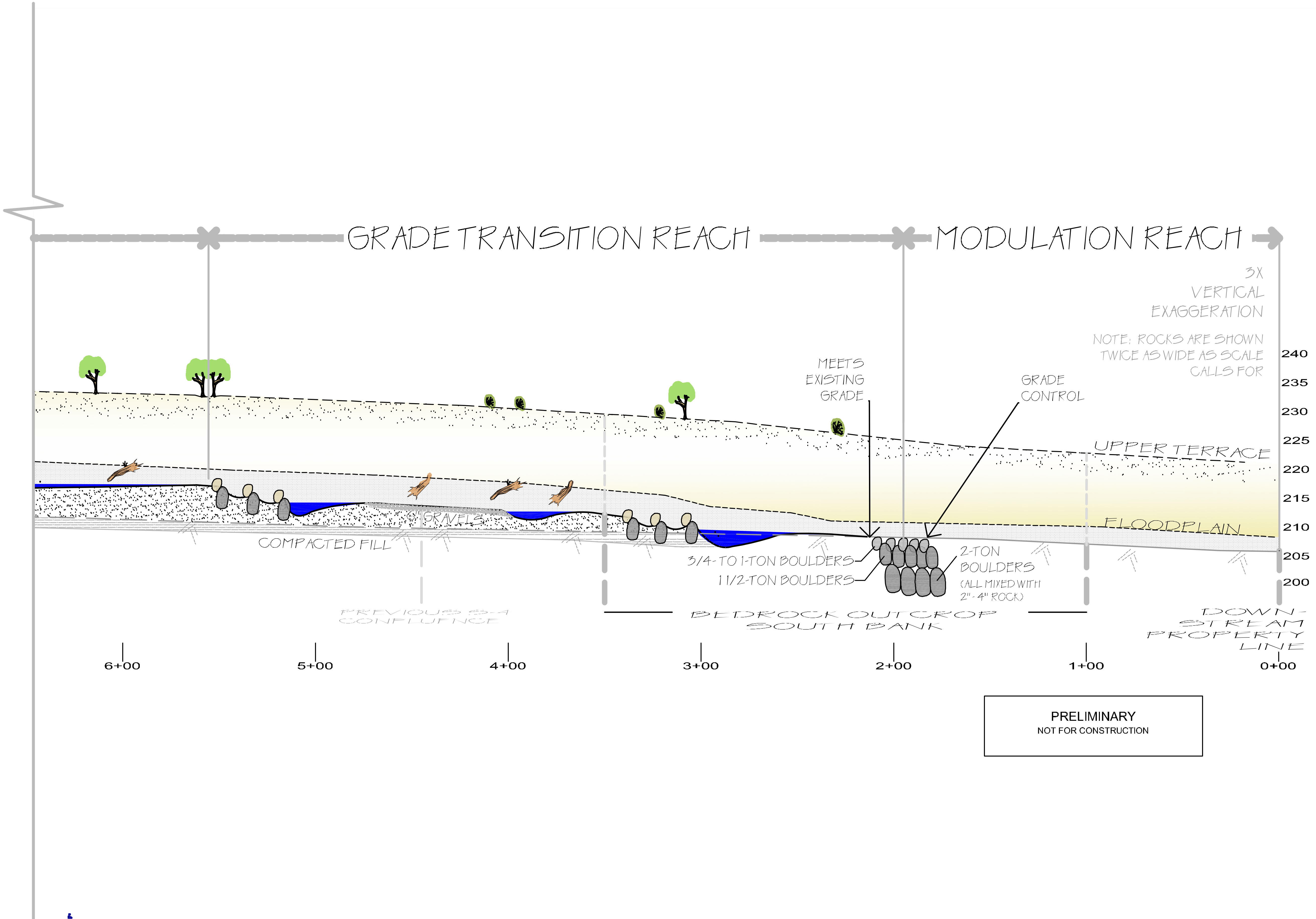


PRELIMINARY
NOT FOR CONSTRUCTION

Balance Hydrologics, Inc.

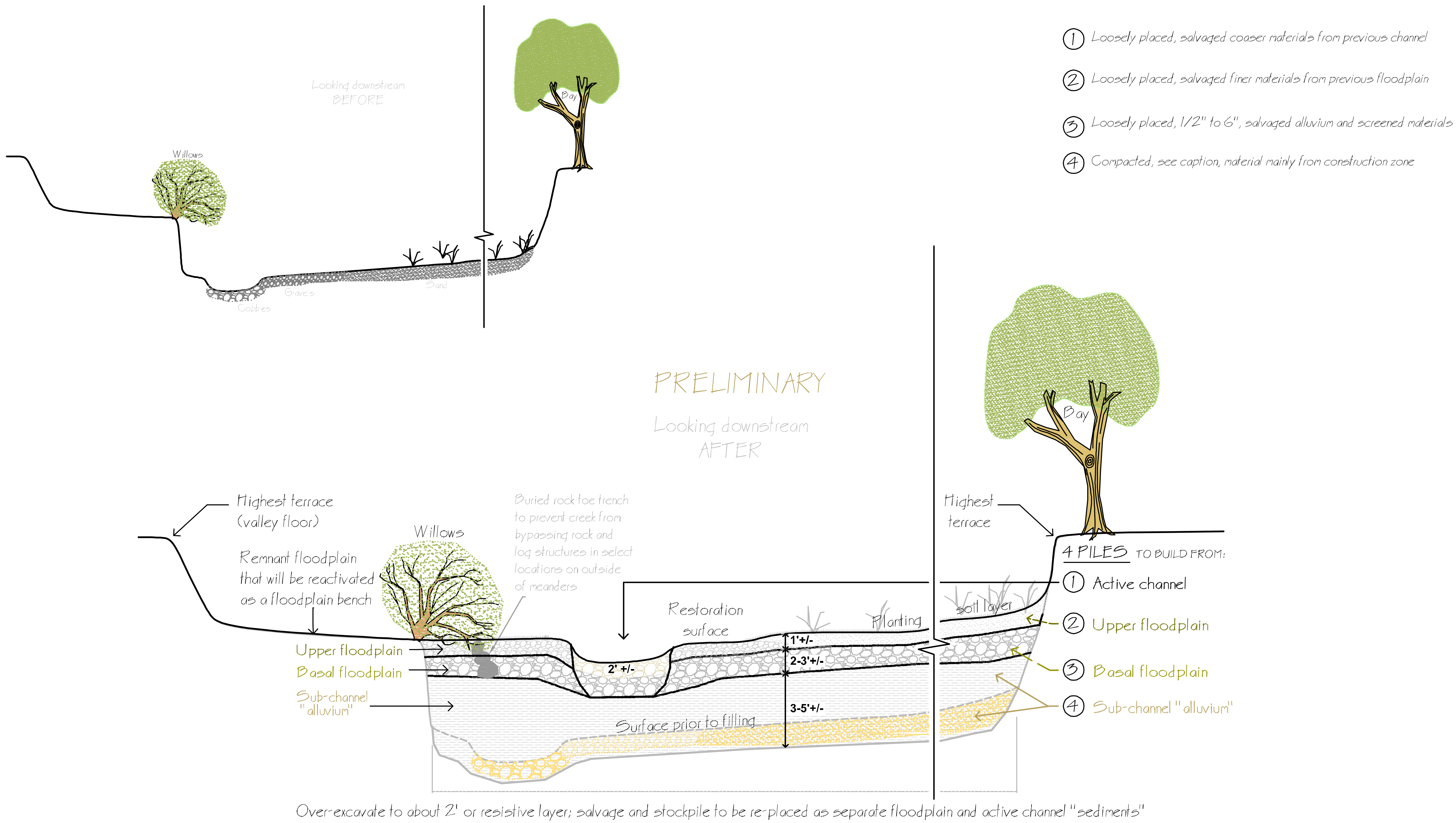
Figure 5a. Longitudinal profile of Miller Creek downstream of Grady Bridge, showing existing and proposed restoration levels for the channel bed. Figure is schematic, showing representative elements and examples of likely arrangement in the channel. Additional design criteria are expected and will inform development of a permittable conceptual model.

208164 Miller Creek sections 4.dwg



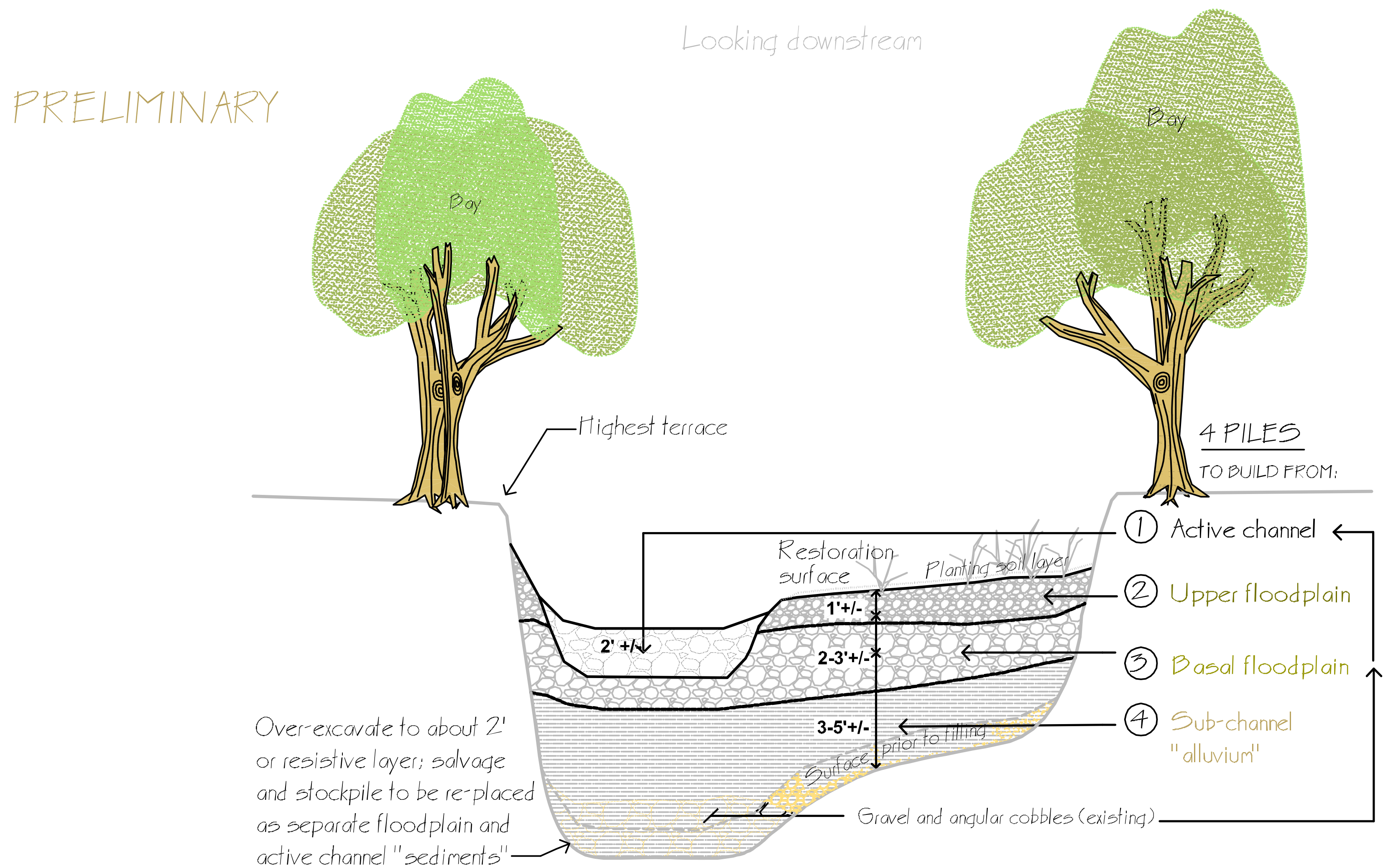
Balance Hydrologics, Inc.

Figure 5b. **Longitudinal profile of Miller Creek downstream of Grady Bridge, showing existing and proposed restoration levels for the channel bed.** Figure is schematic, showing representative elements and examples of likely arrangement in the channel. Additional design criteria are expected and will inform development of a permittable conceptual model.



Balance Hydrologics, Inc.

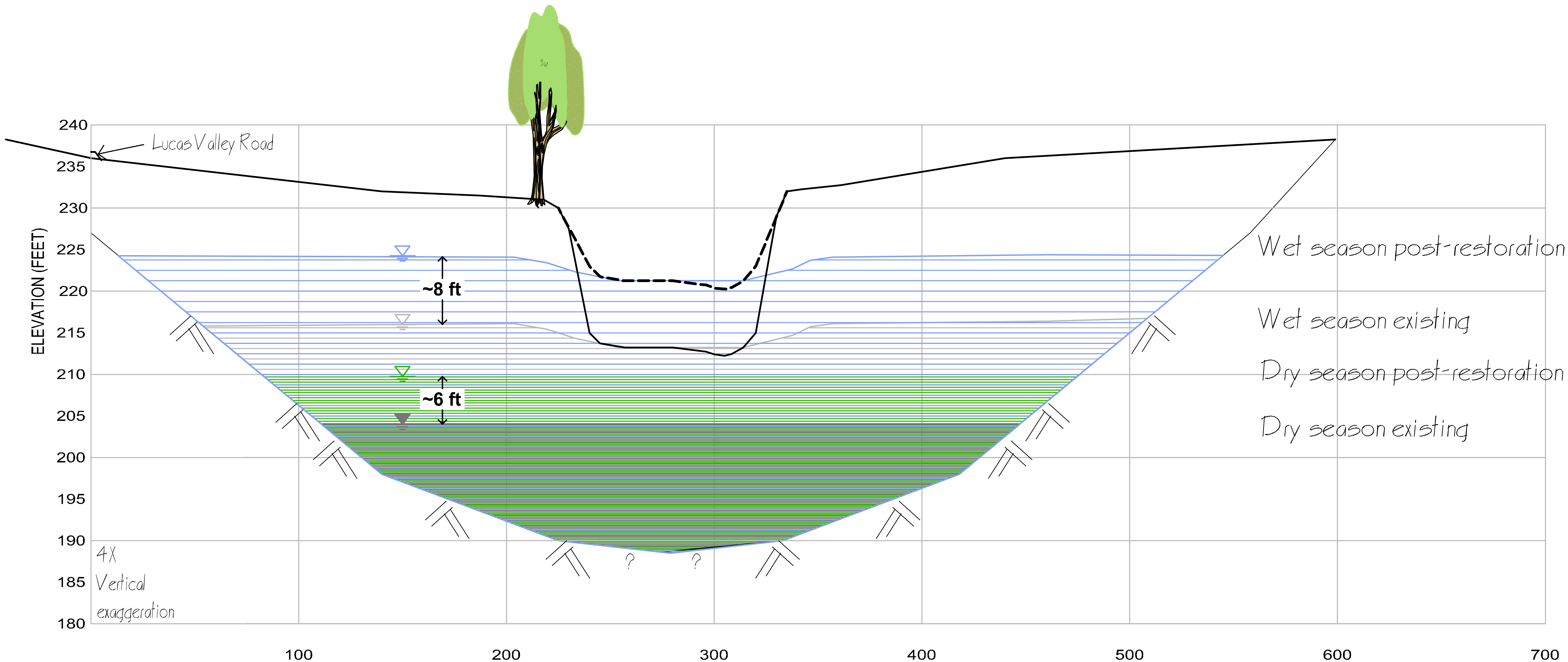
Figure 6a. Schematic section of a restored Miller Creek, between structures. Channel and floodplain materials will be replaced with salvaged sediments of same type. Subchannel "alluvium" will be materials of similar sizes and compaction as existing bank materials. More than one layer may be used.



Balance Hydrologics, Inc.

Figure 6b. **Schematic section of a restored Miller Creek in the "Meander Reach."** Channel shown betwen boulder weir structures. Channel and floodplain materials will be replaced with salvaged sediments of same type. Subchannel "alluvium" will be materials of similar sizes and compaction as existing bank materials. More than one layer may be used.

208164 Miller Creek sections2.dwg 10-1-09



Balance Hydrologics, Inc.

Figure 7. Idealized cross section of the Miller Creek Valley just downstream from the confluence with Grady Creek. This is the only location where groundwater levels are presently known. Restoration of the valley system is expected to raise the winter and summer water tables, with more aquifer storage available to sustain downstream flows in Miller Creek, expecially during April and May.

208164 Miller Creek sections4.dwg 10-5-09

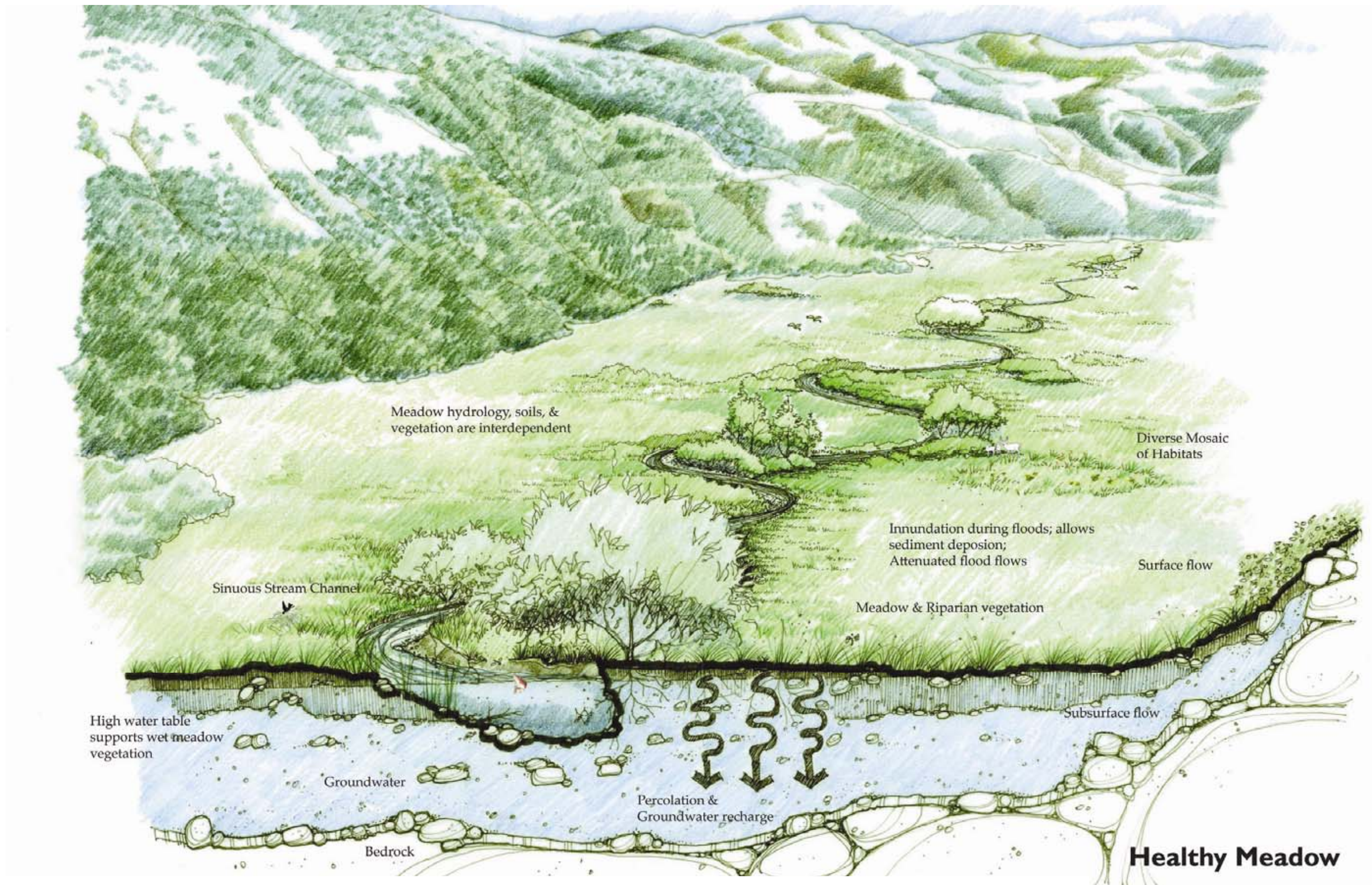


Diagram of a healthy meadow system with a naturally meandering creek supporting native fish, riparian cover including willow thicket, wetland vegetation, healthy soils and high levels of infiltration into groundwater, which subsequently recharges streams during drier months and more biological diversity.

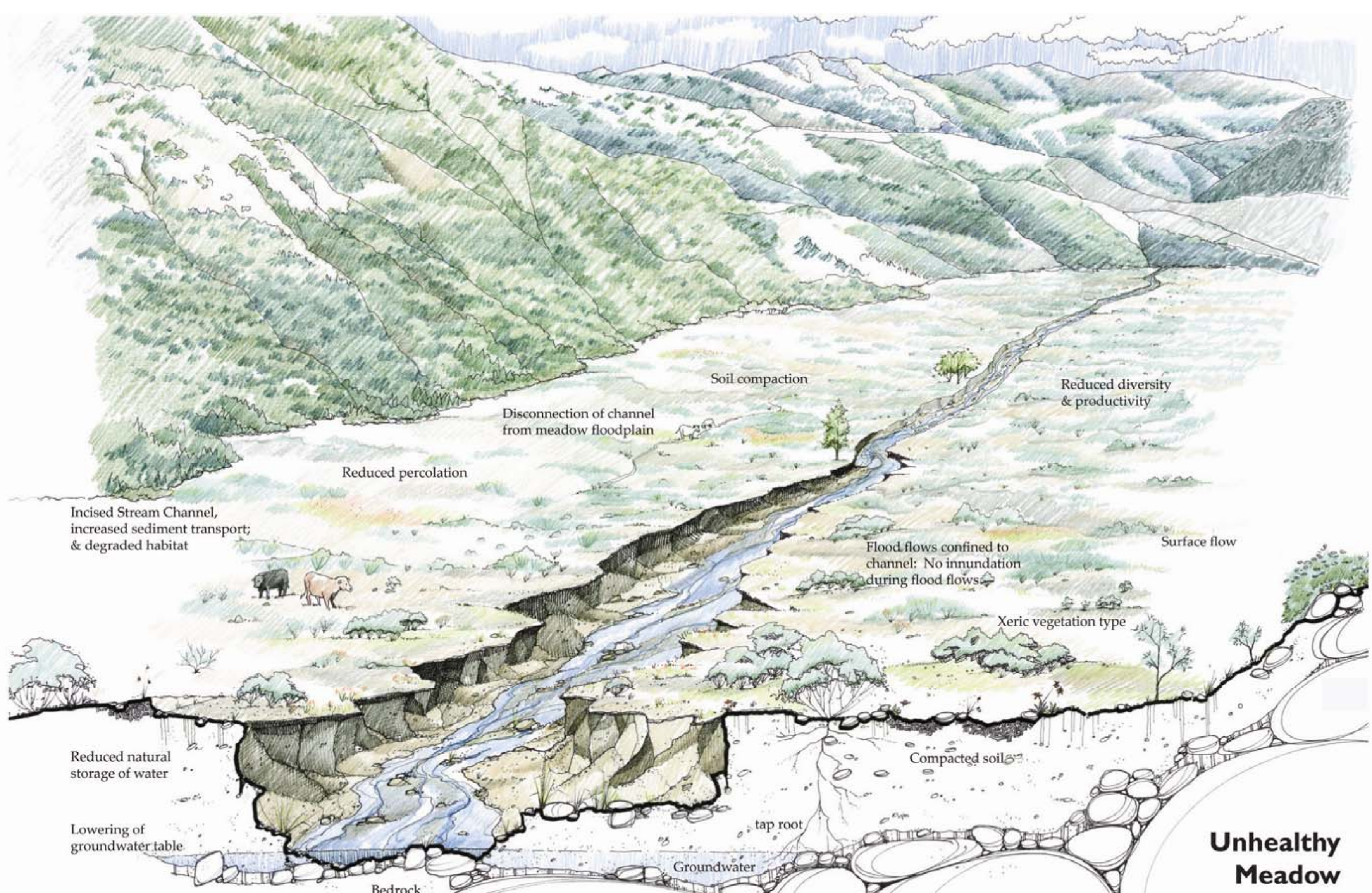


Diagram of a degraded meadow system with a deeply eroded stream channel directing runoff quickly downstream, and drawing down meadow water tables resulting in drier community vegetation. Little habitat exists for riparian species when the water table has dropped below the root zone.

Source: National Fish and Wildlife Foundation, 2009, Draft Business Plan: Sierra Nevada Meadow Restoration

Balance Hydrologics, Inc.

Figure 8. **Generalized diagram showing effects of channel incision on groundwater levels, riparian vegetation, channel width, and near-future erosion rates.** While prepared for the glaciated valleys of the Sierra Nevada, a very different physiographic setting, the relationships are surprisingly applicable to the Miller Creek ***vega*****,** or dry meadow. The restoration may be best seen as shifting a degraded valley system to an intact, healthy one**.**