One Weird Creek: Measurements and Analysis of San Pedro Creek in Pacifica, California

Clay Breitweiser, Jaime Lease, Drew Potter, and Caitlin McLaughlin

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Introduction

The San Pedro Creek watershed is located in Pacifica, California, which is about 20 miles south of San Francisco, California. The watershed is composed of five main tributaries and covers an area of approximately 8 square miles, from the northern tip of the Santa Cruz Mountains, across the San Pedro valley and to the Pacific Ocean (Amato 1). The north, middle, and south forks of the creek converge at the valley floor, where the water flows northwest towards lower elevations, along what is called the upper reach, and then to the ocean (SPCWC). The specific area of study covers approximately 350 meters between the Sanchez Art Center and the Capistrano Bridge. By measuring the linear profile and cross sections of the creek, we would like to compare and quantify the changes that have occurred over time. The intent of this study is to analyze the measureable changes since the restoration project in 2005.

Overtime, land use changes have directly affected the dynamics of the creek. As urbanization increased, so did impervious surfaces, causing faster and more powerful water runoff. Increased stream power along with a lack of percolation and filtration from vegetation, contaminates from roads, and other anthropogenic influences have all taken a toll on the health of the stream. Streams are constantly changing and anthropogenic factors, as well as natural events such as landslides and sediment erosion on upstream hillsides, have contributed to the changes. The high banks within the area of study, range from 10 to 30 vertical feet, and are up against residents' backyards and homes. These high banks make the creek vulnerable to instability (San Pedro Creek Restoration Plan). The stage of the stream has to do with a variety of components that contribute to where it's at in equilibrium (Rosgen 1994). The fast moving waters and heavy stream loads combine to create net erosion, which is also known as degradation. Vegetation helps maintain hillsides as well as habitat, and most of the creek was covered with native and non-native plant species before the restoration project in 2005. However, due to anthropogenic factors and the geomorphology of the area overtime some areas were not vegetated and were susceptible to erosion and stream destabilization. A range of factors discussed cause the loss of habitat, barriers to fish migration, and erosion along the creek. Such a drastic down cutting and an ineffective fish latter under the Capistrano Bridge, contributed to the restoration project in 2005.

In 2005, the City of Pacifica removed the ineffective fish latter and filled the bank with 12,000 cubic yards of fill with efforts to mediating the gradient of the creek and inhibit fish migration. They installed a series of log weirs, which we used as benchmarks in our study, to establish the gradient control with pools and riffles. This was a very appropriate restoration method to use, given the narrow room for passage and drop in elevation, the pools and riffles allow for habitat areas, gradient control, and an overall more controlled flow. Non-native plants were removed and natives were planted along the banks in an effort to provide bank stabilization, shade for lower water temperatures, and shelter from weather conditions. Along with vegetation, revetments, terraces, and riprap were incorporated for bank stabilization as well. We were able to see evidence of these efforts and we were amazed by how much vegetative growth has occurred since the restoration project. On a larger scale, but still within the watershed are three culverts that also act as barriers to migrating fish. The City of Pacifica has intentions to remove the culvert bases on the Adobe, Linda Mar, and Oddstad Bridges, to enhancing the steelhead habitat and migration.

Steelhead Salmon

Steelhead salmon are a robust species directly related to the more familiar rainbow trout. There are several distinctive differences between the two, such as the steelhead's ability to live in both salt- and freshwater. Steelhead can also spawn several times throughout their lives and can live up to eleven years. They are naturally found worldwide and specifically along the Pacific Northwest coast. Nonetheless, the Coastal California steelhead population has dwindled from "over 500,000 individuals in the 1970s to roughly 250,000"[1] and consequently has been listed as "threatened" under the Endangered Species Act since 1997. This precondition is of particular interest to those concerned with San Pedro Creek in Pacifica, CA, "the *only* creek within 30 miles of San Francisco providing" steelhead salmon spawning habitat.[2] Restoration of San Pedro Creek has been underway for several years in an effort to restore this crucial spawning habitat for the migrating steelhead.

Vegetation, sedimentation, and water depth are all interconnected in the maintenance of the steelhead's ideal habitat. Dense riparian vegetation is necessary for shelter, bank stability, and habitat of insects, an integral part of the steelhead diet. They require shelter in the networks of boulders, cobbles, and gravel as well as tree root systems of riparian species such as sycamores, redwoods, alders, and willows. These hiding places are especially crucial for juvenile trout, which can live in the freshwater streams for up to two years before heading out to sea. Aging trees "may eventually fall into the stream and their trunks and branches alter flow patterns and provide hard structures resulting in scouring of pools"[3], thus naturally maintaining ideal steelhead habitat. These pools are essential for shelter from the ocean during the spawning season. Adult trout prefer depths averaging "0.5 to 1.5 feet in small streams, [and] they generally occur at greater densities in streams with more pools"[4] averaging

[1] http://www.savesfbay.org
[2] www.PedroCreek.org
[3] Hagar Environmental Science *Steelhead Habitat Assessment for the San Pedro Creek Watershed*
[4] Hagar Environmental Science *Steelhead Habitat Assessment for the San Pedro Creek Watershed*

1.5 to 2.5 feet or deeper. Sand and other fine sediment can be detrimental to these preferences, as excessive amounts may settle in the nooks of boulders and cobble, referred to as “embedding”, and make pools shallower. Consequently, fish density decreases as embededness increases. Fish less than one year cannot tolerate embededness over 10% and juveniles cannot tolerate embededness levels over 50%.[5]

Fortunately, steelhead females prefer to nest in “gravel-bottomed, fast-flowing, well-oxygenated rivers and streams.”[6] They are the ocean-maturing type, meaning that they reach sexual maturity while living out in the ocean and then migrate to freshwater streams between November and April to reproduce. This is contrary to the stream-maturing type, which spends several months developing in freshwater streams around summertime. This ability to live in both salt- and fresh-water conditions makes this fish anadromous. New born fish typically live in freshwater systems for about two years before heading out to the open ocean, where they will mature within another two years before returning to the place of their birth. Females will “deposit eggs in four to five ‘nesting pockets’ within a single redd” - AKA nest - and the eggs will hatch about four to five weeks later.[7] Fortunately for this threatened species, it can spawn multiple times throughout its life, a distinctive feature among its salmonid counterparts. Another favorable quality is its tolerance of a wide range of temperatures. They prefer deep, low-lying pools during the winter months and “they do best where dissolved oxygen concentration is at least 7 parts per million.”[8]

Unfortunately, San Pedro Creek has been anthropogenically manipulated which has faced the steelhead salmon with several obstacles. These include “low base flows, mobilization and accumulation of fine sediments… [and] deterioration of water quality”[9] - consequences of the many culverts and bridges

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[5] Hagar Environmental Science *Steelhead Habitat Assessment for the San Pedro Creek Watershed*
[6] http://nmfs.noaa.gov
[7] http://nmfs.noaa.gov
[8] http://nmfs.noaa.gov
[9] Hagar Environmental Science *Steelhead Habitat Assessment for the San Pedro Creek Watershed*

installed throughout the watershed several years ago. Since the steelhead's inclusion on the EPA's threatened species list, these obstructions to its spawning migration are considered "takes" under the Endangered Species Act and are thus a violation of federal law. Specifically, the stretch of stream that this report focuses on is downstream from the Capistrano Bridge. The fish ladder that has been built at the entrance of the Capistrano Bridge is about four feet high from the surface of its downstream pool. This is an insurmountable reach for migrating adult steelhead, which are estimated to jump a maximum of only one foot from the water's surface during all levels of flow.[10] As it is now, the intentionally placed log and boulder weirs do not provide sufficient height to navigate the fish ladder at all flows. This is only one small example of the several obstacles currently facing the steelhead along San Pedro Creek.

This report is mainly concerned with only a small portion of San Pedro Creek, but it is important to remember that steelhead survival depends on the quality of the watershed as a whole. Salmon migrate upstream, so areas of refuge must be accessible throughout all stretches if the recolonization of steelhead trout is going to take place. As it is now, "the upper reaches of San Pedro Creek have healthy riparian areas and winter flows that support migrating steelhead [but] the lower reaches of the creek have migration barriers which make it difficult in certain flow conditions for fish to reach the prime spawning habitat."[11] The quality of steelhead habitat upstream does not benefit the population if it is unable to reach it. In addition, even though "the North Fork, Shamrock Branch, and Sanchez Branch are not considered" likely habitat for steelhead, they continue to contribute to the water quality, sediment levels, and flow conditions of the main stretch "and thereby have significant potential to impact steelhead populations."[12]

The steelhead salmon are a threatened species in need of spawning habitat along the California Coast, and greatly rely on San Pedro Creek for this reason. It is the only suitable spawning habitat within thirty

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[10] Hagar Environmental Science *Steelhead Habitat Assessment for the San Pedro Creek Watershed*
[11] www.PedroCreek.org
[12] Hagar Environmental Science *Steelhead Habitat Assessment for the San Pedro Creek Watershed*

miles of San Francisco, and salmon instinctively migrate there if it was the place of their birth. The success of San Pedro's restoration efforts is crucial for the recolonization of Steelhead Salmon along the central California Coast, as well as the City of Pacifica's compliance with the Endangered Species Act.

Materials and Methodology

The main goals of our fieldwork included performing a longitudinal survey of the Capistrano Fish Passage restoration area, and five cross-sectional surveys at various points along the reference reach. The equipment used for these surveys ranged from "old school" survey equipment to cutting edge, highly sophisticated computerized equipment. With rubber waders to keep our feet dry (mostly), we were able to spend long hours in the stream without frostbitten toes. Flagging tape and removable stakes were used to mark notable points along the way, such as log weirs. A 100 meter survey tape marked with meters and feet was used to keep track of our position while surveying. Two way radios were used to enhance communication between group members. A hand compass was used in conjunction with our digital level to help us calculate our geographic position along our survey. Our main workhorse for this project was a Leica Sprinter 100m digital level, used in conjunction with a special stadia rod, readable by the digital aspect of the level. This device allowed us to capture elevation data as well as distance readings. The memory function of the Leica Sprinter provided us with a backup of our hand written measurements. Using a Suunto compass to set the horizontal circle on the level, we were also able to track our absolute geographic coordinates along our longitudinal survey, which would enable us to create a controlled planimetric map of our survey. We also used weatherproof field notebooks for field data collection, and Microsoft Excel for data analysis.

We began our longitudinal profile behind the Sanchez Art Center in Pacifica. After staking the starting end of our survey tape to a stick in the middle of the stream, we worked our way upstream, running the tape along the thalweg of the stream. We then set up our level on the north side of the stream, and used our compass to set the horizontal circle to read true azimuths. Our survey started with a back sight (BS) to a benchmark (BM) of known elevation and geographic location (Figure 1).

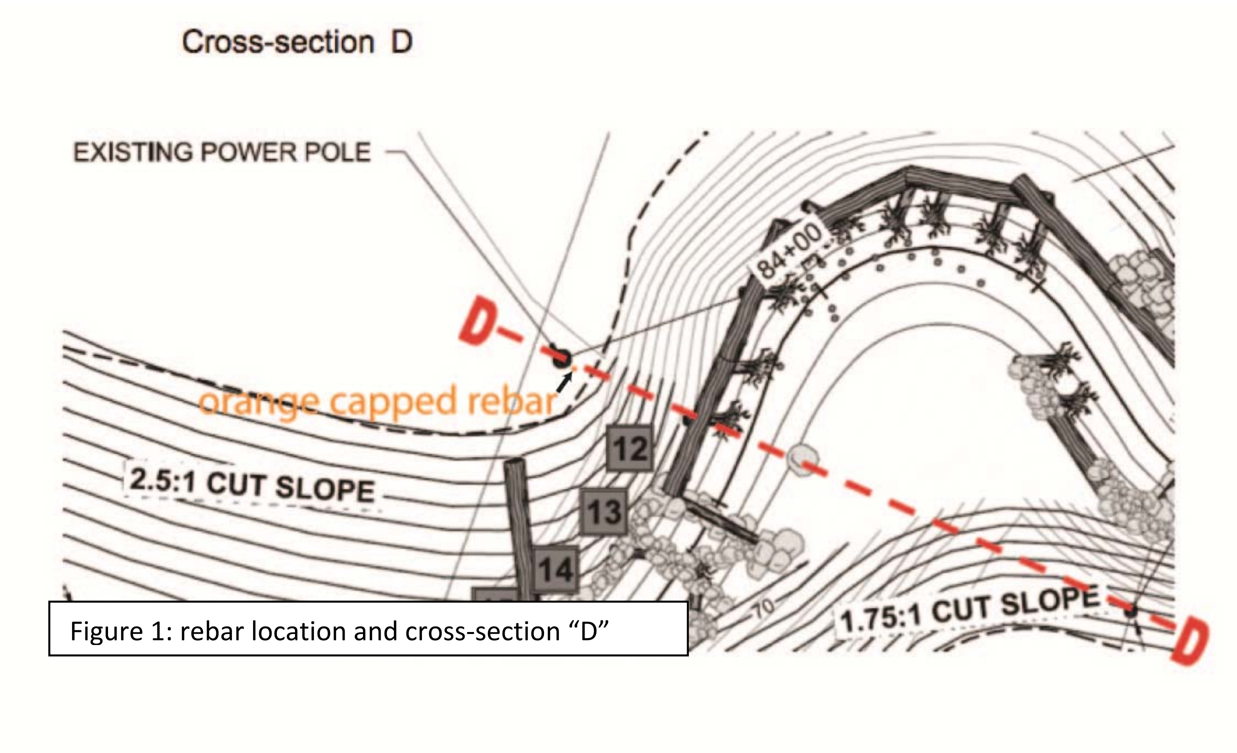


Figure 1: rebar location and cross-section “D”

This benchmark, or monument, consists of a piece of orange-capped rebar hammered into the ground near a power pole, by a previous research group (2006). Our entire longitudinal survey, as well as each cross-section, relates back to this monument for geographic positioning and elevation reference. We then proceeded to take elevation readings of the stream channel along its thalweg, every half-meter or meter, taking into consideration the very important points (VIP’s). These VIP’s include knickpoints, such as log or rock weirs, the deepest sections of pools, the beginning and ending of pools, riffles, and other noteworthy changes in geomorphology. We also gathered additional data along the way, including water depth, bed material, and bankfull measurements. Eventually we would need to move the level in order to continue taking measurements along the thalweg, usually due to obtrusive vegetation or the serpentine nature of the waterway. This involved taking a foresight (FS) to a turning point (TP), which was usually a boulder or log with a defined notch for placing the stadia rod. After moving the level to the new position and resetting the horizontal circle, we would then take a BS to the same turning point to establish the elevation and absolute position of the new instrument location. The survey was then continued upstream until the process was repeated. Periodically, we would reach the end of our survey tape, in which case we would mark the location and reset the tape to start at the location, once again stretching it upstream along the thalweg. After five field days, we reached the Capistrano Bridge, and concluded our longitudinal survey.

Most of the locations for our cross-sectional surveys were predetermined by the 2006 study, and we tried the best we could to find these same locations, with mixed results. To maintain vertical and horizontal control for each cross-section, we took a BS to a previously used BM for our turning points. Cross-section “A” was taken at a new spot near the Capistrano Bridge (Figure 2), due to an uncertainty of the exact location surveyed by former studies.

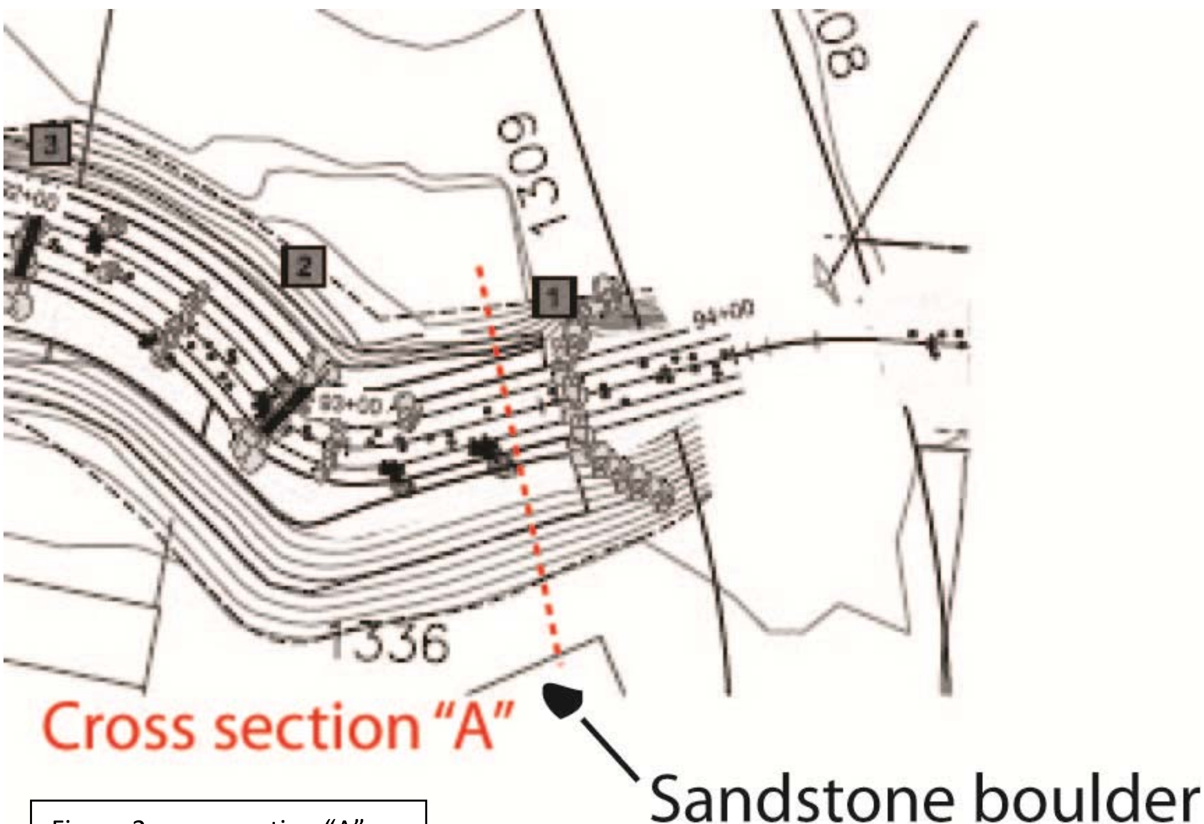


Figure 2: cross-section “A”

We began this survey by setting up the level on the south side of the creek, near a large sandstone boulder.

We recorded a true azimuth of 359 degrees from the level, across the highest peak of the boulder, to the north side of the creek. We then stretched our survey tape across this expanse and took measurements with our level and stadia rod every meter, recording the VIP's such as abrupt changes in elevation, vegetation, substrate, location of water edge, and the depth of the water.

We were able to determine the exact location of a previous study's site for cross-section "B", thanks to rebar placed on both sides of the creek (Figure 3).

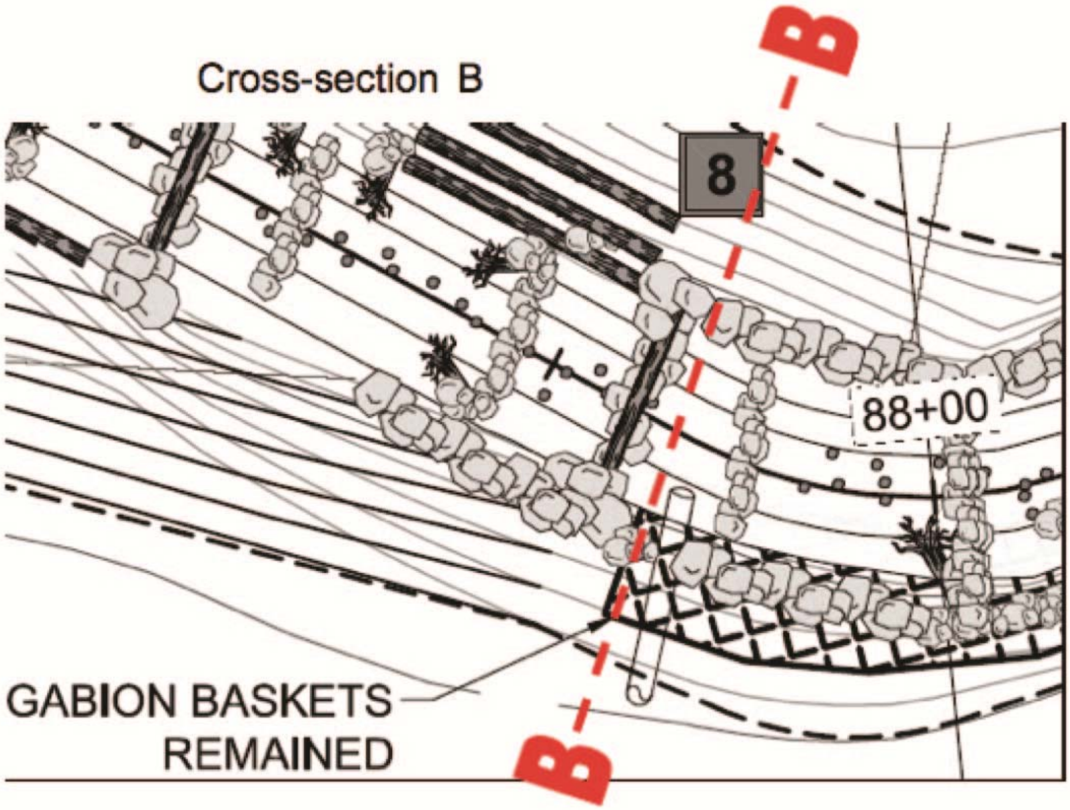


Figure 3: cross-section "B"

The level was set up on the south side of the creek, in line with the rebar. Note: the rebar is fairly high on the banks, growing over in vegetation, and difficult to locate, but its there. We commenced surveying of the cross-section, once again taking VIP's into consideration. The location of this cross-section was originally decided upon due to its location immediately downstream of a storm drain. This cross section included measuring the elevation of a gabion revettment, in order to monitor the stability of the retaining feature.

The 2006 study group chose the location of cross-section “C”, for no other reasons than because it represents a typical reach of the stream.

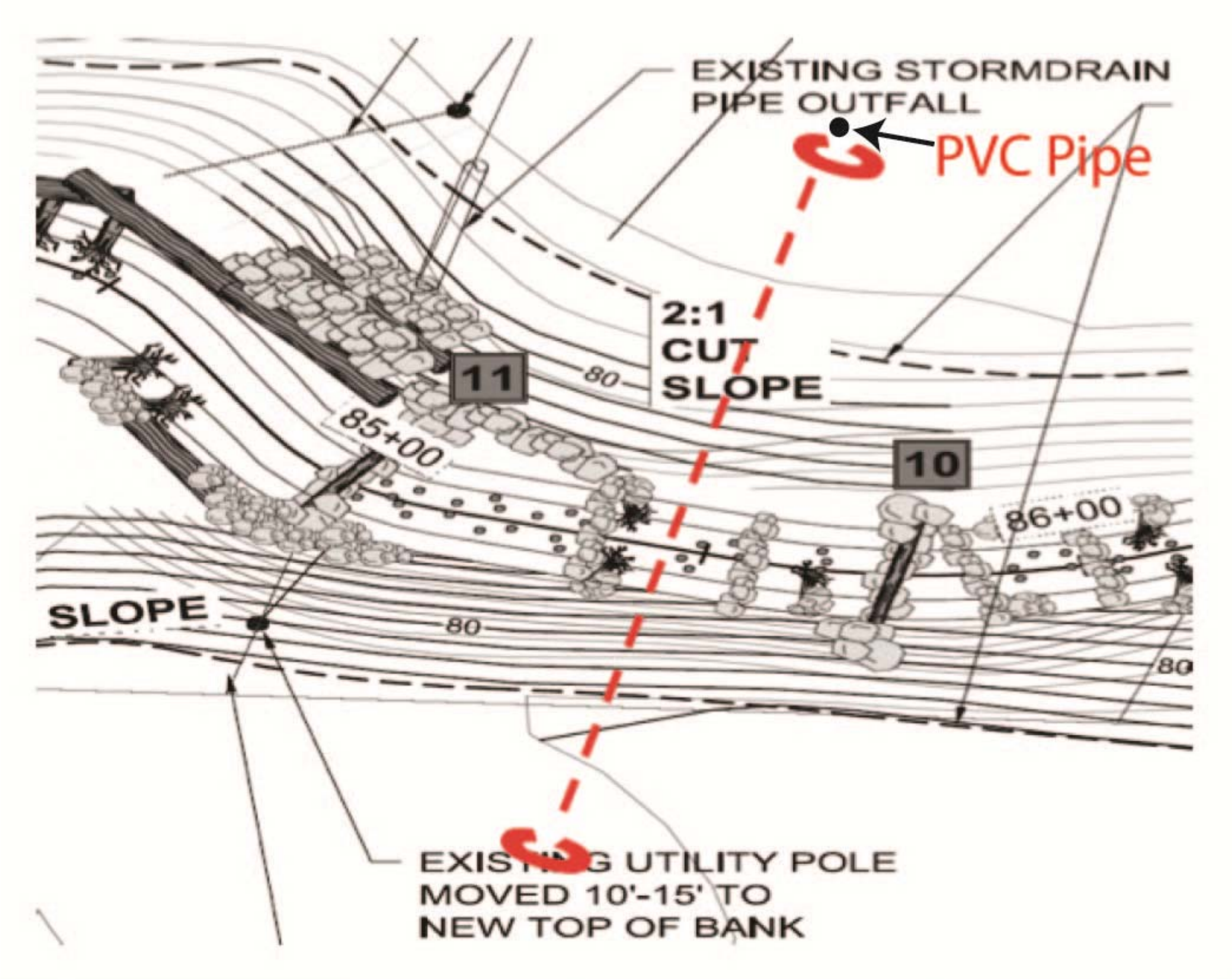


Figure 4: cross-section “C”

The only monument we could find was a PVC pipe stem on the north side of the creek, referred to by the 2006 group (Figure 5).

Figure 5: PVC pipe

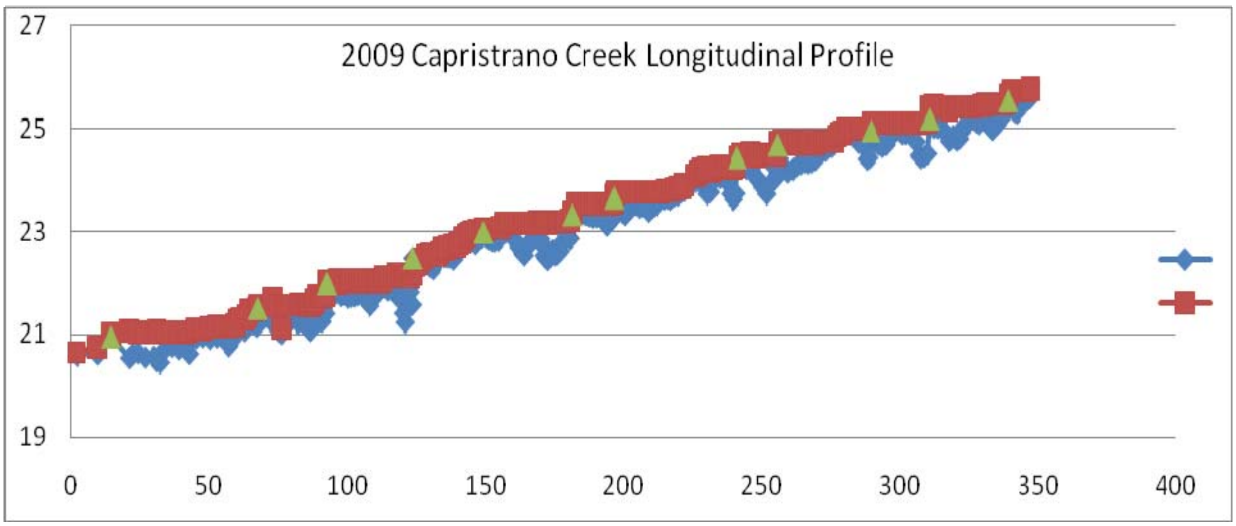
We attached our survey tape to this PVC and ran the tape across the creek at a true azimuth of 204.5. We set up our level on the North side of the creek, in-line with the PVC and tape, and surveyed across the creek. Dense vegetation prevented us from surveying high up the sloped banks.

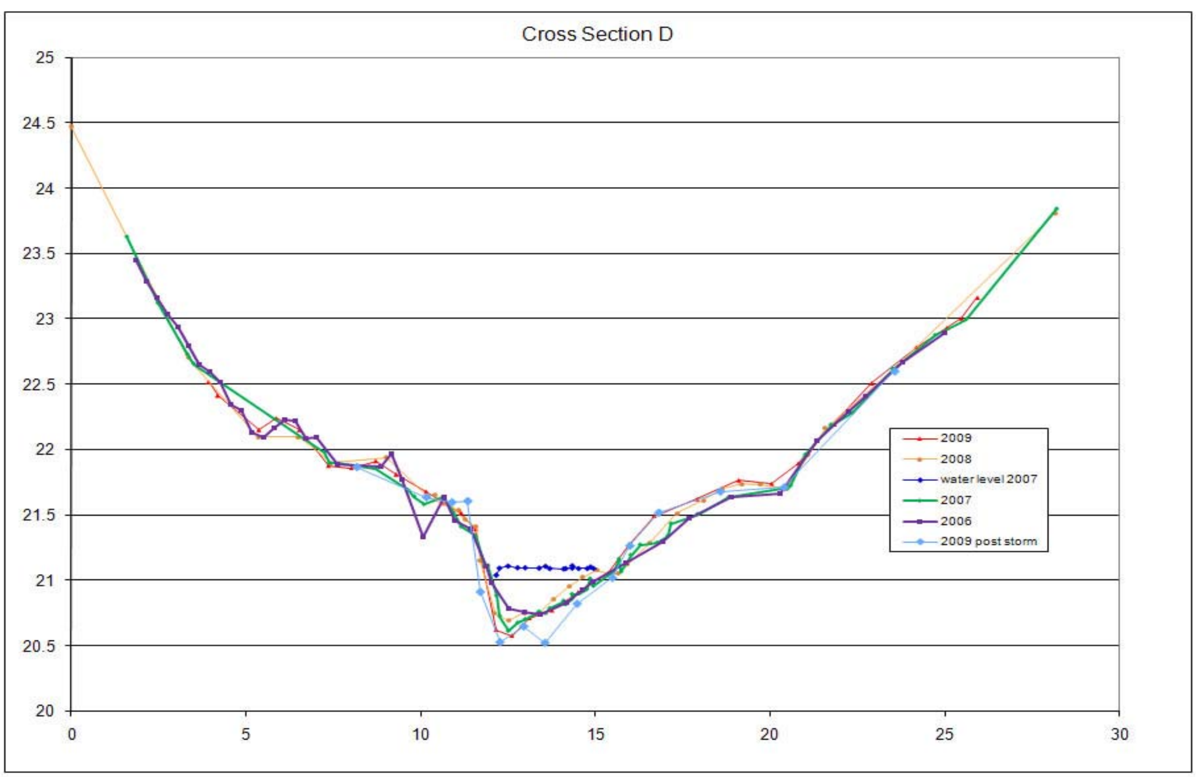
The location for cross-section "D" is clearly marked with rebar, and used the same benchmark as the longitudinal profile (Figure 1). We surveyed this cross section twice, before any noteworthy precipitation had occurred in 2009, and following a sizable storm event, with the intent of comparing the two. It is at this cross section that the most data points were gathered, for there is no dense vegetation to contend with. This data set will be compared to several years' worth of cross sections taken in the same location.

For data analysis and visualization, we used Microsoft Excel to create graphs of each cross section, and the longitudinal profile. Comparisons between previous studies and the original restoration plan will be made, and conclusions drawn. We also incorporated a small element of geographic information systems analysis, including sediment source analysis and watershed delineation for mapping purposes. A land cover map was also created by remote image sensing software. Our findings will be presented with a poster accompanied by a brief presentation.

Results and Conclusion

Taken by itself, this profile of the stream reach we surveyed is only a geomorphic snapshot. No conclusions concerning the biological and morphological processes in action on this stream system and watershed can be drawn from this data by itself. The data presented here cannot provide information about the forces at work on the stream such as erosion rates, bankfull frequency, etc. However, certain conclusions can be obtained by comparing this data with that of previous studies. By looking at the cross section D profile we created compared to that of the 2006 study, it is apparent that significant scouring is occurring, seemingly creating a split thalweg effect as water cuts away at the bed on both sides of boulders at the top of weir 12. Though the bank does not appear to be eroding on either side, and the thalweg does not appear to be getting deeper, the two cross sectional profiles vary significantly in their representation of the stream bed, indicating measurable levels of erosion. Furthermore, by comparing our longitudinal profile with that of the 2006 study, it becomes apparent that the same scouring processes at work in the 2006 study have continued, cutting away at the stream bed at both the top and bottom of most of the weirs, so much so that water has completely undercut weir 9 and begun flowing under it. It does not appear that the sediment eroding away is being deposited anyplace in particular. The pools do not seem particularly shallower or deeper compared to the 2006 study. Other notable differences would include significant foliage growth on both sides of the stream, so much so that the cross sectional profiles up stream were limited to the immediate stream bank. Given the short time period of study we think it would be unreasonable to try to draw further conclusions or project trends into the future based on this data.





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