Evolution of a Compound Channel:
Tassajara Creek, Dublin, California

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Abstract

Between 1960 and 1990, Tassajara Creek in Dublin, CA underwent incision due to anthropogenic sources. The downcutting of the channel bottom was problematic because the process built upon itself and caused disconnection between the channel and floodplain. The incision of Tassajara Creek created a flooding problem and motivated the search for solutions. The need for flood control increased as development increased around the creek. During the 1990s, plans were made to restore Tassajara Creek and provide flood control through the creation of a compound channel. In addition to drainage, the restoration plan's secondary goals were to increase vegetation, riparian habitat, and public access. A one-mile reach of Tassajara Creek was reconstructed in 1999 and a series of post project appraisals have been conducted since with mixed results. We reviewed and summarized the results of the past studies. We continued the monitoring of the channel evolution by resurveying three of the established cross sections and a partial long profile and compared our data to previous data sets. We also conducted a qualitative analysis of the project's secondary goals by through observations and photograph comparisons. Our survey data indicated that deposition was occurring on the majority of the floodplain. The channel bottom evolved differently between cross-sections. We found instances of local incision for the most upstream cross-section, E-E'. The channel bottom for the more downstream cross-sections F-F' and G-G' aggraded especially at G-G' where dense cattails encouraged aggradation in the channel. We concluded from a comparison to previous data that the channel is still actively evolving since there was no clear trend towards either incision or aggradation. Our comparison of previous with current photographs showed an increase in vegetation since 2004. The further downstream reach had a lot of diverse vegetation which provided habitat for macroinvertebrates. We concluded the secondary goals were well achieved with a significant increase in the amount of vegetation and habitat with a healthy population of macro-invertebrates.

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Introduction

The public outlook on rivers has shifted realizing the potential that rivers have to improve the quality of life for humans and animals in addition to flood control. Tassajara Creek originates in Mount Diablo in southern Contra Costa County and flows to a convergence with the Arroyo de Laguna in northern Alameda County (Figure 2). It drains a 23.2 square mile watershed north of Interstate 580 (I-580) in Dublin, California (Hudzik and Truitt, 2001). Extensive agricultural use and urbanization near the creek has led to a high degree of incision and erosion. To control incision on a parcel upstream of I-580, which was a naval hospital, military engineers simplified the geometry into a trapezoid and lined the banks with concrete in the 1960s. However, by 1992 nearly all the concrete had been undercut or destroyed (Lave, 2002).

Alameda County acquired property along Tassajara Creek in the 1990s. At the time, the county's primary concern was development and flood control. As development plans progressed, Brian Kangas Fouke (BFK) Engineers were enlisted to create a drainage and flood control plan. The county later realized the Creek's potential for community recreation and began the initial stages of restoration. In 1996 the Eastern Dublin Comprehensive Stream Restoration Program was completed by Sycamore Associates to guide restoration projects in the area (Tompkins, 2006). The Tassajara Creek project reach is approximately 1 mile long with boundaries at Gleason Road to the North and I-580 to the South.

A formal set of goals and design clarifications were compiled by Tompkins in 2006 largely based on the Sycamore Associates document and personal communication with project planners:

- Provide a natural open channel capable of providing for storm water conveyance and sediment loads
- Allow channel crossing and maintenance access
- Facilitate natural processes like scour and meandering of the creek.
- Supply new and maintain existing riparian habitat for wildlife.
- Protect any existing native trees or other native vegetation with special consideration for old growth oak trees.
- Replace exotic vegetation with native vegetation.
- Improve water quality to meet standards and include best management practices.
- Provide safe public access and visibility of the stream.

UC Berkeley researchers Matthias Kondolf and Graham Matthews provided geomorphical analysis and conceptual restoration design. They documented a large degree of incision through a series of pre-project surveys performed in 1996 and 1997. These surveys provided important baseline data that helped monitor the project after completion (Oden, 2004). Their design called for the creation of a compound channel to allow the lateral connectivity between the channel and its floodplain. River-floodplain interactions have many complex functions in a healthy river ecosystem. This lateral connectivity is recognized as a vital but frequently overlooked aspect of river restoration (Tompkins, 2006). A compound channel can provide a wide habitat range, flood control, and channel migration.

Construction began in 1999. The project was undertaken in two separate reaches. Reach One, from Dublin Blvd to I-580, was completed reconstructed to provide a low flow channel to covey the two year flood set within a trapezoidal floodplain to convey the 100 year flood. In Reach Two, from Gleason Avenue to Dublin Blvd, the low flow channel was already capable of transporting the five year flood and was largely left intact. It is situated in a larger flood corridor also capable of carrying the 100 year flood. Five grade control structures were placed throughout the channel to prevent further incision (Sycamore Associates, 1996). The stream was also rerouted in several sites to avoid damage to several old growth oak trees.

In fall of 2001, Hudzik and Truitt conducted the first in a series of post-project appraisals of the Tassajara Creek restoration project by University of California, Berkeley students. They established and surveyed eight cross-section surveys within the project reach (Figure 5). They found evidence of continued incision and created a monitoring plan to evaluate changes in the channel form over time to ensure that the goals of the restoration project were met (Hudzik and Truitt, 2001). In the following year, Rebecca Lave completed a long-profile survey which tied into the Hudzik and Truitt cross-sections. In 2003, Krofta and Novotney resurveyed the cross sections and adjusted the monitoring plan. In 2006, Chan and Heard resurveyed four of the cross sections and performed a hydrologic analysis. During 2005 and 2006, as part of his PhD thesis, Mark Tompkins resurveyed the cross sections and long profile and gathered more qualitative data on the restoration. This previous work is summarized in Table 1. Although there were a range of objectives and mixed results from these post-projects appraisals, each concluded that further monitoring was necessary to assess the channel's evolution.

This study addresses the need for further monitoring and focuses on recent changes in channel morphology. During each water year, the channel changes its form, sediments loads vary, and habitat is destroyed and created. Those changes need be well documented to determine the ultimate success of this, or any, river restoration project. We concentrated our data collection on the downstream reach since that section was completely reconstructed. The reconstruction has resulted in an extensive change in comparison to pre-project conditions. We collected survey data that was compared to data from previous appraisals. Our survey data along with field observations were used to both quantitatively and qualitatively evaluate how well the initial goals laid out by project designers have been met thus far.

Methods

To gather background information about Tassajara Creek, we reviewed five documents that include post project monitoring data. Table 2 summarizes the important points of the five documents reviewed. We reviewed aerial photographs and talked to several people who lived near the creek. We also walked the project site with Mark Tompkins who researched the project design goals, interviewed project designers, and resurveyed the channel form for his doctoral dissertation.

We conducted a partial resurvey of the long profile and resurveyed three cross-sections to determine changes in the channel morphology for Tassajara Creek since it was last surveyed in 2006 (Tompkins, 2006). The reach between the Dublin Boulevard Bridge (the Bridge) and I-580 was chosen to be resurveyed for the long profile to document how the thalweg had changed. To further document how the channel form has evolved, we resurveyed cross-sections E-E', F-F', and G-G' from the eight cross sections established by Hudzik and Truitt (2001). We also took photographs of the cross-sections, the long profile reach, and established reference points and compared the images with pre- and post- restoration photos (Oden and DeHollan, 2004).

Long Profile Resurvey

On Saturday, November 10th, 2007, we conducted a long-profile survey of the thalweg for Tassajara Creek from the downstream side of the Bridge to I-580. We used an automatic level, a 15–foot survey rod, and three 50 feet soft plastic measuring tapes. We began the survey from a benchmark on the Bridge (Figure 6) that was determined to be 356.46 ft. above mean sea level (MSL) by the United States Geological Survey (USGS) (Krofta, 2003). The MSL elevations for our measurements were determined by using the benchmark to correct all height measurements. We used four turning points, but were unable to close the survey that day due to inclement weather and equipment malfunctions. We placed flags at each turning point on November 10th and resurveyed turning points on Saturday, November 17, 2007 to verify the elevations previously measured.

To determine the position of the long-profile survey measurements along the Creek reach, we set a zero point on the downstream side of the Bridge. All distances downstream along the reach were measured from this point. The 50 ft. measuring tapes were suspended about two ft. above the ground supported by stakes at their ends. The 50 ft. mark on one tape was joined by duct tape to the zero ft. mark on the successive tape. When the tapes needed to be moved, they were separated, all stakes except the final one were moved, and then the tapes were restrung between the stakes and rejoined using the previous final stake as the new starting point. The path of the tapes approximately followed the right bank and was strung so it never sharply curved.

Thalweg elevations were measured along the Creek approximately every ten feet for the first 50 feet because biofilms or vegetation on the water surface made it difficult to visually determine if the channel bottom elevation changed significantly. Thalweg elevations were measured approximately every twenty feet for the remaining length of the long profile except where localized features were present. Where slope breaks, pools, or localized incision occurred we measured elevations at the intervals necessary to capture these features. We plotted both our data and Tompkins' aligned data (2006) using Microsoft Excel (Figure 13 and Appendix B).

Cross-Section Resurvey

On Saturday, November 17, 2007, we resurveyed the established cross sections E-E', F-F', and G-G' along Tassajara Creek to monitor changes in the channel morphology (Figure 5). We used an automatic level, 25 ft. survey rod, and a 300 ft. measuring tape. The benchmark on the Bridge was used again to establish the elevation relative to MSL for all elevation measurements. Turning points were necessary for all cross-sections and we closed each cross-section to the benchmark on the Bridge.

At each cross-section, we strung our measuring tape above the channel to establish the distance across the channel for elevation measurements. Figure 5 shows the locations of our cross-sections. Cross-section G-G' was so heavily vegetated we were unable to resurvey between the two points used in previous reports. We used the original left bank tie off point (Figure 11.LB) and shifted the right bank tie off point upstream (Figure 11.RB). We recorded elevations along each cross-section at the increments needed to describe the features for the floodplain and channel. We plotted both our data and the data compiled by Tompkins (2006) for each cross-section using Microsoft Excel (Figure 7, 9, 11, and Appendix A).

Results and Discussion

Thalweg Elevation

A comparison of the cross-section data and plots with previous survey data (Table 3) suggests that the thalweg incised in some locations and aggraded in others. At cross section E-E' we see that there was 0.52 ft. of incision since Tompkins' 2006 survey. This reverses the trend of the past seven years during which the channel had been aggrading and returns the thalweg elevation to nearly 2001-2003 levels. We attempted to resurvey the same cross-section as previous years based on the best available information, but many of the landmarks previously used had changed substantially. The original signpost used by Hudzik and Truitt on the right bank for section E-E' was removed so we estimated a position for that point (Figure 7.RB). We noticed that the channel formed a pool in the location where we measured our cross-section, so small deviations upstream or downstream could significantly change the thalweg elevation. It is possible that the incision indicated by our data is due to the cross-section being shifted from previous years. The thalweg at cross-section F-F' has varied between incising, aggrading, incising, and now, according to our data, aggrading again. Our data shows that the thalweg at F-F' has aggraded 0.28 ft. since the 2005 survey. The thalweg at cross-section G-G' has also varied between incising, aggrading, incising, and now, according to our data, again aggrading. Our data indicated the thalweg at G-G' aggraded 0.44 ft. since the 2005 survey. Though we shifted the right bank point upstream, we believe the channel aggraded since we observed that there was not much variation in the thalweg elevation upstream or downstream of the cross-section.

Cross Section Morphology

Over time, we would expect the cross sections to change as the channel evolves naturally. We were able to observe high water marks on the floodplain throughout the project reach indicating that the creek was laterally reconnected. This connectivity is further shown by the deposition measured on the banks in each of the cross sections. We were also able to quantify the degree of incision, erosion, and aggradation that had occurred in the channel.

When we plot cross-section E-E' data with previous survey data (Figure 7), we see that the left bank has been eroded and the channel is meandering towards the left. Based on our data the thalweg incised as it moved towards the left bank, but the degree of incision between subsequent appraisals is uncertain due to previously mentioned survey inaccuracies. Cross section F-F' is plotted in Figure 9. The left bank had dense bulrushes growing (Figure 10.1) whose roots appeared to be stabilizing the upper bank and perhaps facilitating the aggradation measured in our data. Although it was not captured by the survey, the lower bank was beginning to undercut below the bulrush. The channel bottom was composed of extremely fine, soft sediments, a finding that supports the aggradation seen in our data. Section G-G' is plotted and compared to previous data in Figure 11. The channel was heavily vegetated at the cross-section (Figure 12.1 and 12.2) and we believe the vegetation stabilized the channel bottom and reduced flow velocities, increasing aggradation. We observed during our survey that the channel was braided upstream and downstream of this cross-section with two of the braids actively conveying water. We noticed a third braid which would fill during higher flows, but was not conveying water during our surveying. Previous reports and data do not mention any braiding, so we conclude that the braiding is a recent development that results from the in-channel vegetation and aggradation.

Long Profile Analysis

According to our long profile survey data, Tassajara Creek has generally aggraded downstream of the Dublin Blvd. Bridge, but still is local incising at some points (Figure 13). It is difficult for us to draw specific conclusions about the evolution of Tassajara Creek from comparisons of our long profile data with previous years. We only have data from a 2006 long profile to compare our data with and the previous data had a much larger increment between measurements. Many features we captured in our survey data would not appear in the previous year's data since the increments were so much larger. We can make several general conclusions though. We believe the aggradation seen in our data between 600 ft. and 1000 ft. upstream of I-580 is a real change from the previous year and not an artifact of our increased resolution. We observed significant cattail and bulrush growth in the channel throughout this reach which we think promoted aggradation of the channel bottom. Our data also indicates that there is a step-pool formation occurring between 700 ft. and 900 ft. upstream of I-580. We interpret the local incision shown in our data around 1200 ft. though as possibly an artifact of our smaller increment between measurements than previous years. Further monitoring at high resolutions would be necessary to determine if the incision is real.

Qualitative Analysis of Riparian Habitat

The riparian habitat of the project reach appeared to be very successfully thriving, providing habitat for wildlife, and recreational opportunities for people. Photographs taken at the cross-sections upstream and downstream by Oden and DeHollan in 2004 were compared to photos we took at each cross-section. At cross-section E-E', the vegetation appears to have thinned since 2004 (Figure 8). The vegetation at E-E' still is growing well and will naturally vary from year to year, so we do not consider the reduced vegetation indicating a problem with habitat. At cross-section F-F', the amount of vegetation appears to be the same (Figure 10). The vegetation at cross-section G-G' has significantly increased since 2004 (Figure 12). At G-G', the vegetation was growing thickly enough to impede our resurvey. We observe from a photograph time series taken around Gleaseon Ave (Figure 14) that the vegetation has significantly increased over time. We conclude that the project has successfully increased riparian vegetation and habitat by comparing pre restoration riparian vegetation (Figure 14.1) with current vegetation (Figure 14.4). We interpret our photograph comparison to prove that the riparian vegetation is flourishing. We observed wildlife in the vegetation in numerous locations and macroinvertebrates, including spiders and shellfish, were found extensively along the reach resurveyed. We found make-shift chairs next to the project reach and people were observed regularly using the path adjacent to the creek.

Conclusions

Since monitoring is one of the most important aspects of a river restoration project, it is crucial that cross section locations are easy to locate and resurvey. This was a major hindrance in our data collection so we attempted to clearly document our cross section locations and bank base points to facilitate resurveying. Overall, we believed this project was successful in meeting its goals (Table 3). We were able to determine the measure of success based on data collection, qualitative analysis, personal interviews, and literature review. The channel form of Tassajara

Creek has continued to evolve with our resurvey indicating aggradation occurred at cross-sections F-F’ and G-G’, while cross-section E-E’ underwent incision. The floodplain of all cross-sections had varying levels of deposition, with only one minor instance of floodplain erosion. Our evaluation of the changes in thalweg elevation led us to conclude that incision may be stalled near the current elevations for each cross-section. Further monitoring will be necessary to determine if the original project goal of preventing continued incision has been achieved for the entire project. The Tassajara Creek project has also successfully achieved the goals of providing new riparian habitat. Our comparison of current riparian vegetation at the cross-sections with past photos indicates a well-vegetated riparian habitat. The emergent vegetation at cross-section G-G’ especially appeared to be thriving. We found wildlife and macroinvertebrates at all cross-sections indicating that the riparian vegetation was providing suitable habitat. The compound channel design facilitated the lateral connectivity with the floodplains. This is evident by the deposition and high water marks on the floodplain. From our observation of people interacting with the project site, we conclude the project also successfully met the design goal of providing public access. It will be important to continue monitor this project for at least ten more years to determine if it is ultimately successful.

References

Brian Kangas Foulk Engineers. (1995). Santa Rita Drainage Master Plan.

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Krofta, C. and Novotney, M. (2003). Looking Forward, Look Back: Monitoring the Tassajara Creek Restoration Project. UC Berkeley Water Resources Archive.

Lave, Rebecca. (2002). Monitoring Changes in Bed Elevation Tassajara Creek. UC Berkeley Water Resources Archive.

Oden, M. and DeHollan, A. (2004). Continued Monitoring of the Tassajara Creek Project 2004. UC Berkeley Water Resources Archive.

Sycamore Associates, Balance Hydrologics, and dk Associates. (1996). Eastern Dublin Comprehensive Stream Restoration Program.

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Table of Tables

Table 1: Summary of previous work

Authors	Date	Data Collection	Results
Hudzic and Truitt	2001	eight cross sections; baseline data; pre-project, construction, and post-project photographs	found evidence of continued incision; creation of future monitoring plan
Lave	2002	Long profile survey of Reach 2	Identification of localized instances of continued incision
Krafta and Novotney	2003	eight cross sections; partial long profile	Identification of exposed tree roots and debris jam; Improvement of monitoring plan
Oden and DeHollan	2004	surveyed 4 downstream cross sections and long profile of Reach 1	Evidence of aggredation
Tompkins	2006	8 cross sections; long profile; clarification of design goals; historical and current aerial photographs	Project is generally successful but continue monitoring
Chan and Heard	2006	Hydrologic climate data and storm monitoring	Assessment of flow capacity for compound channel

Table 2: Evaluation of project goals

Goal	Degree of Success	Notes/Reference
open natural channel	very successful	shown by qualitative comparison of photos and field observations
dynamic low flow channel	very successful	field observations and comparison of previous survey data
conveyance of 100 year flood	successful	flood corridor contains 100 year storm (Chan and Heard 2006)
conveyance of variable sediment load	moderately successful	further evaluation is necessary
improve water quality	possibly	vegetation may provide nutrient removal and metal adsorption sites
enhanced public access	very successful	easy pedestrian access and common usage during field observations
protect exisiting native vegeatation	not evaluated	
reconnect with floodplain	successful	high water marks on floodplain suggest connection; changin sediment load show deposition on floodplain
revegetate floodplain surfaces	very successful	shown by qualitative comparison of photos and field observations
provide riparian habitat	very successful	increased vegetation provide habitat for macroinvertabreates and animals
incision control	inconclusive	some local incision along project reach specifically downstream
erosion protection	not evaluated	

Table 3: Thalweg Elevations

Cross Section	Design	As-Built 2000	Hudzick & Truitt, 2001	Lave, 2003	DeHollan & Oden, 2004	Tompkins, 2005	Nolan & Butler, 2007
E-E': South of Central Parkway	345.6	343.4	343.78	343.78	344.03	344.4	343.88
F-F': North of Dublin Blvd.	344.5	344.7	343.59	343.43	344.32	343.24	343.52
G-G': South of Dublin Blvd.	341.4	341.6	341.33	341.68	342.6	341.73	342.17

Table of Figures

Figure 1


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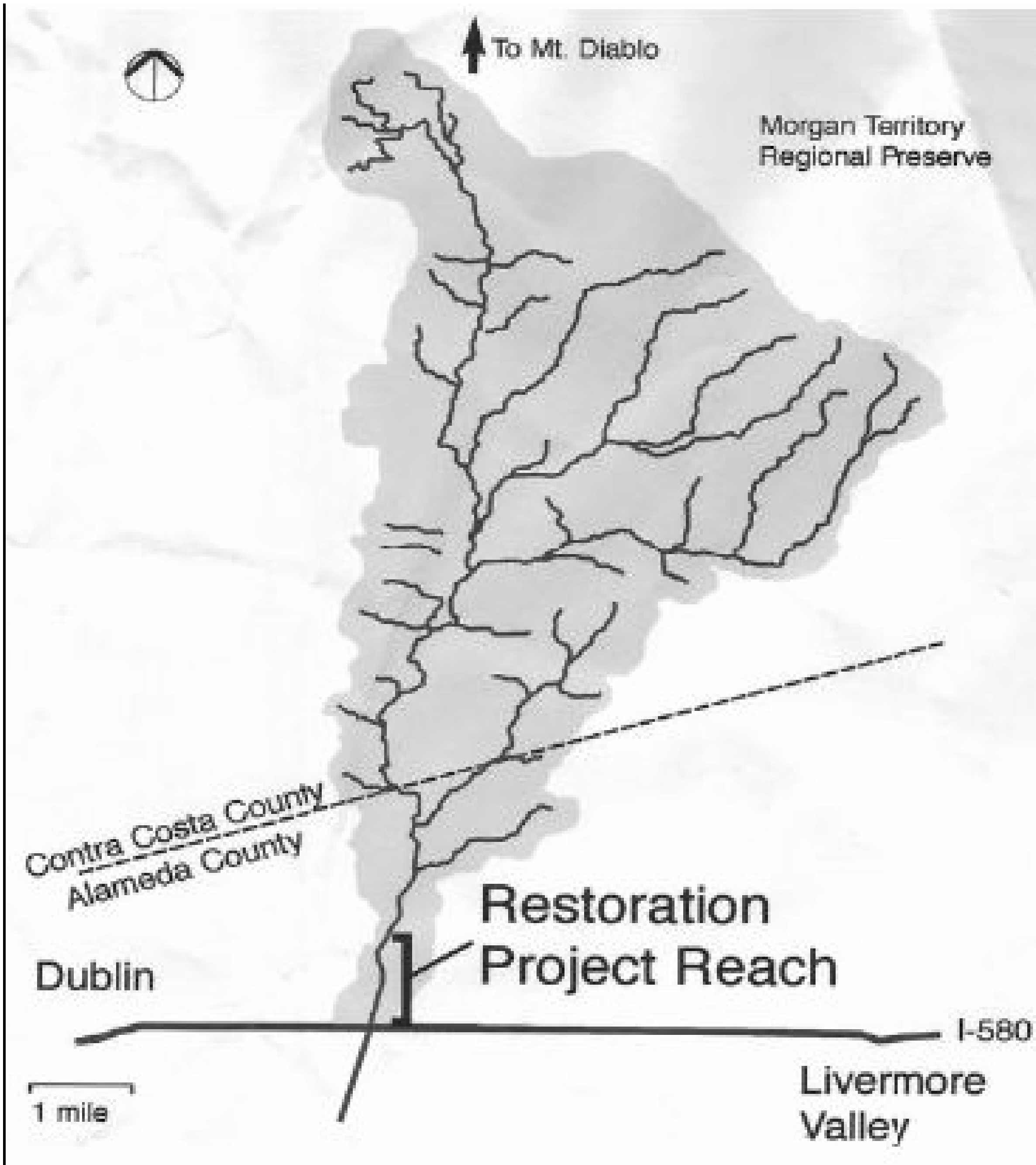
100 mi
N
Sacramento
Oakland
San Francisco
PROJECT AREA
Los Angeles
San Diego

Figure 2



(Hudzik and Truitt, 2001)

Figure 3 (Tompkins, 2006)

Figure 4:

Recommended Monitoring Plan for the Tassajara Creek Restoration Project: Modified from Hudzik and Truitt (2001)		
Action	**Tassajara Creek Monitoring Plan**	**Completed as part of our study**
Establish objectives: Set goals that will guide the evolution of this plan.	Objective: Evaluate the success of the project in meeting the restoration objectives outlined in the 1996 plan.	X
Establish a database of baseline and existing data: Identify the data necessary to evaluate the success of the project.	Cross-section and long-profile surveys, site photos, and site observations tied into nearby landmarks and benchmarks.	X
Analyze data: Identify and fill in gaps in data.	Data needed: Professional assessment of the exposed oak tree roots health and the debris jam .	
Establish Sampling and Data Protocols: Ensure that data are comparable over time.	Quantitative: Survey cross sections in the same pre-established locations and plot survey data against pre-existing cross sections to identify any changes in channel form.	X
	Qualitative: Take photographs of the channel at each cross section and compare photographs to pre-existing images to identify noticeable changes in channel form. Take photographs of exposed roots and compare to pre-existing photos to determine if root exposure is persisting. Monitor debris jam for substances that may degrade water quality.	X
Determine frequency of monitoring events	Monitoring should be completed at least once per year, as well as after significant floods.	X
Development of implementation plan	Identify agency or organization and staff person resposible for overseeing monitoring. Create a regular schedule for monitoring. Identify people responsible for field monitoring.	

Figure 5:

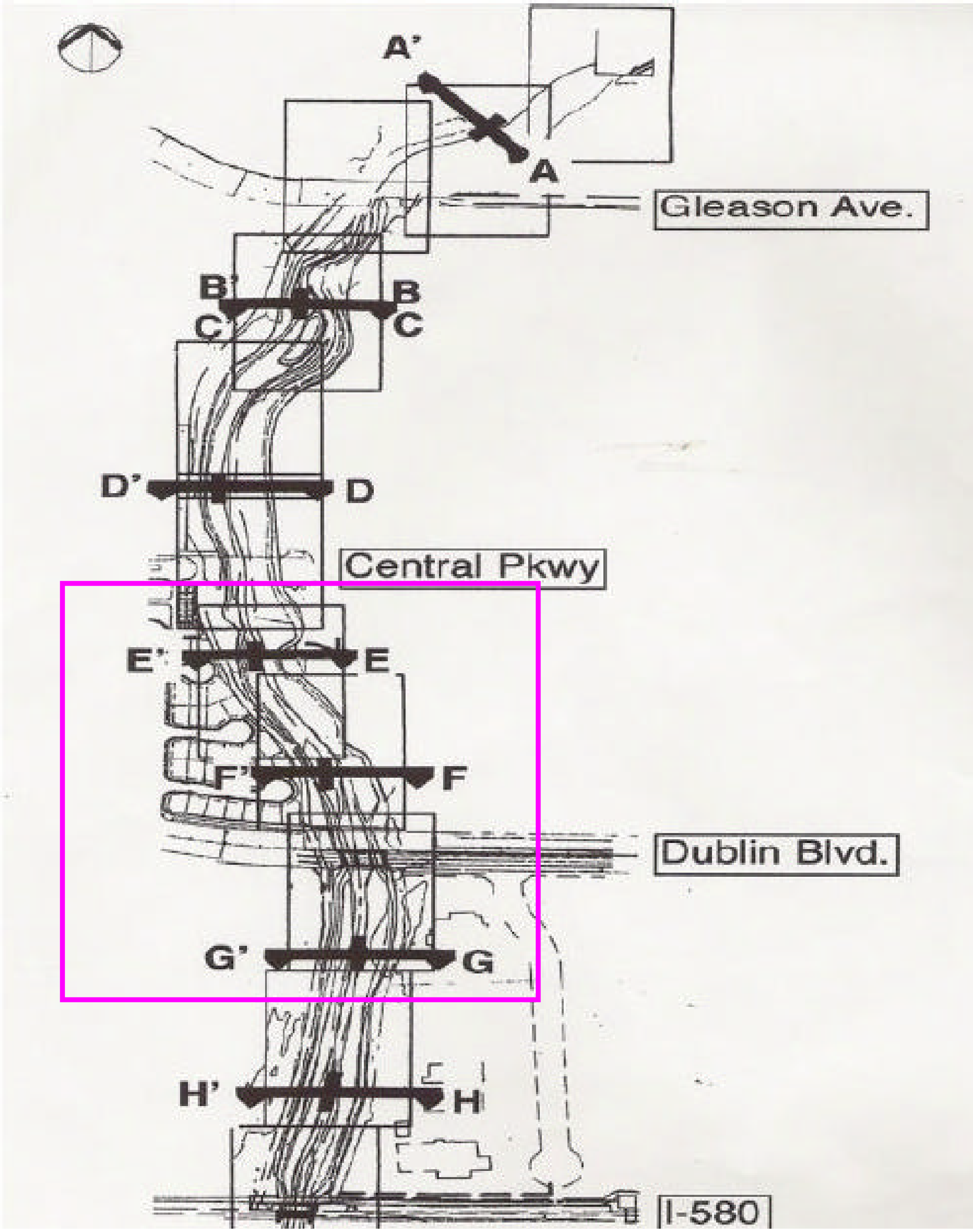

A'
A
Gleason Ave.
B'
B
C
C
D'
D
Central Pkwy
E'
E
F'
F
Dublin Blvd.
G'
G
H'
H
I-580

Figure 6. Benchmark Location on the Dublin Blvd. Bridge

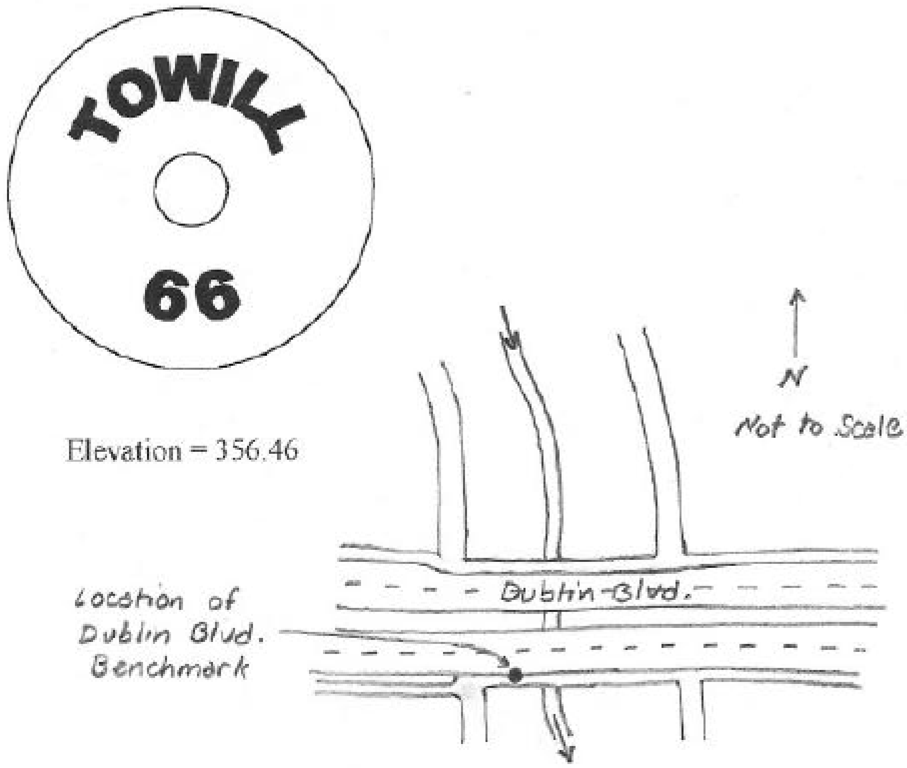
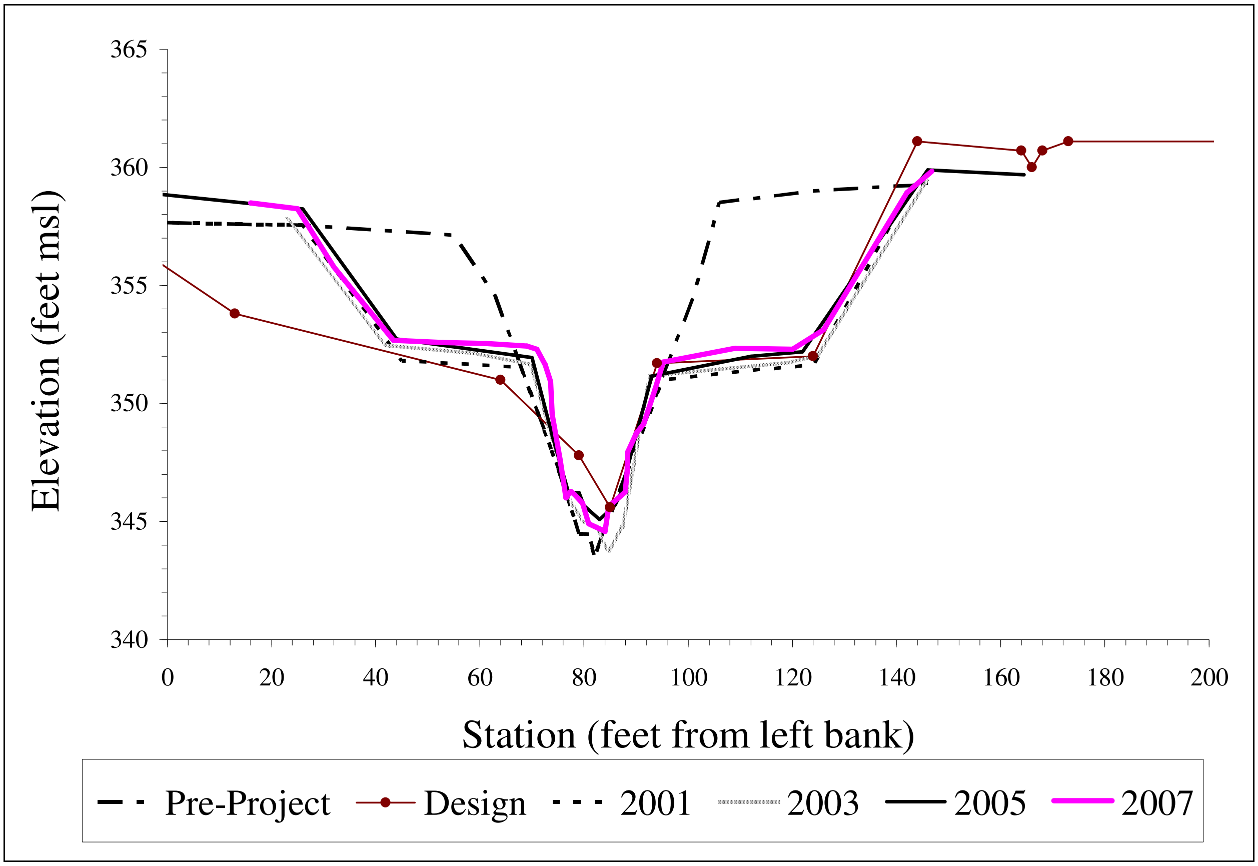


Figure 7: Cross Section E-E' Downstream of the Central Pkwy. Bridge



Survey Specifications:
On the right bank, we tied off the survey rope to the second fencepost downstream from the gate to Owl Court (Figure 7.RB). On the left bank, we tied off the survey rope to the second large oak tree (Figure 7.LB).

Figure 7.RB: Right bank tie off point

Figure 7.LB: View from right bank to left bank showing second large oak tree

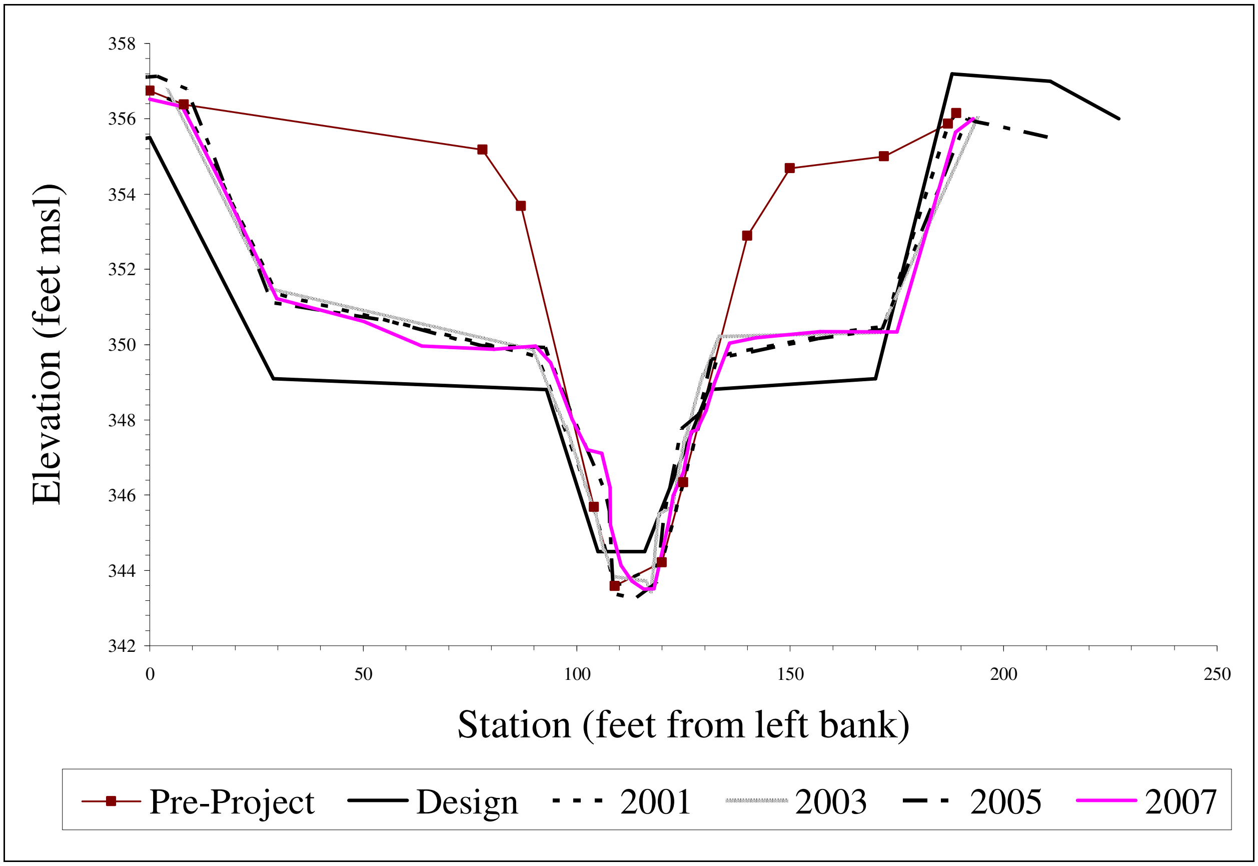
Figure 8.1: EE' Looking upstream from thalweg (2007)

Figure 8.2: EE' Looking downstream of thalweg (2007)

Figure 8.3: 2004 EE' Looking upstream from creek level (Oden and DeHollan, 2004)

Figure 8.4: 2004 EE' Looking downstream from creek level (Oden and DeHollan, 2004)

Figure 9: Cross Section F-F' Upstream of the Dublin Blvd. Bridge



Survey Specifications:
On the right bank, we tied off the survey tape to the buckeye tree upstream from the gate to Peakcock Court (Figure 9.RB). On the left bank, we tied off the survey rope to a small tree (Figure 9.LB).

Figure 9.RB: Right bank tie off point

Figure 9.LB: Left bank tie off point

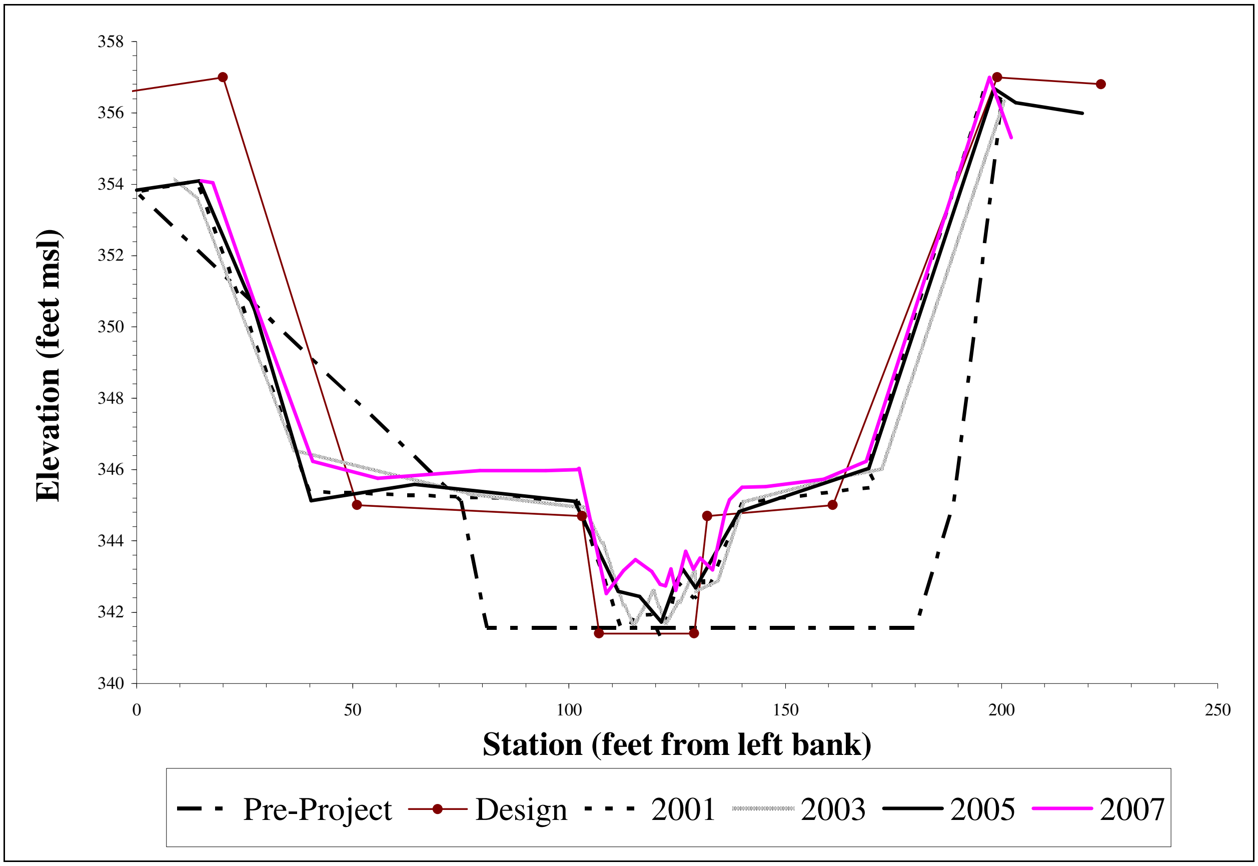
Figure 10.1: FF' Looking upstream from thalweg (2007)

Figure 10.2: FF' Looking downstream from thalweg, Dublin Blvd. Bridge background

Figure 10.3: 2004 FF' Looking upstream from creek level (Oden and DeHollan, 2004)

Figure 10.4: 2004 FF' Looking downstream from creek level (Oden and DeHollan, 2004)

Figure 11: Cross Section G-G' South of Dublin Blvd. Bridge



Survey Specifications:
On the right bank, we tied off the survey tape to a fencepost upstream from the shed in the Extended Stay America (Figure 11.RB). On the left bank, we tied off the survey tape to a pink flagged fencepost (Figure 11.LB).

Figure 11.RB: Right bank tie off point

Figure 11.LB: Left bank tie off point

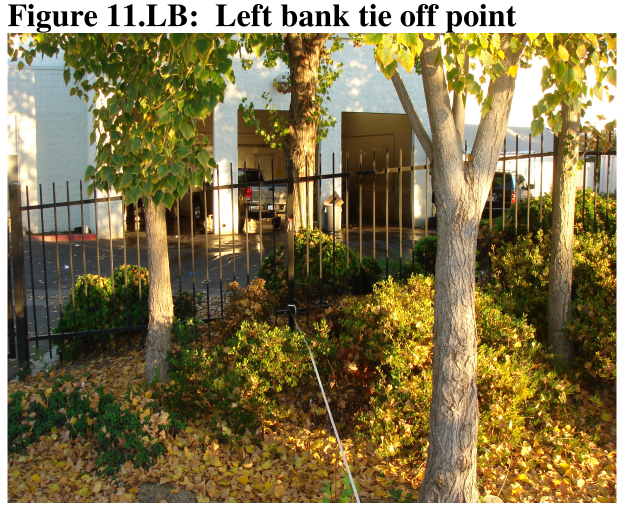


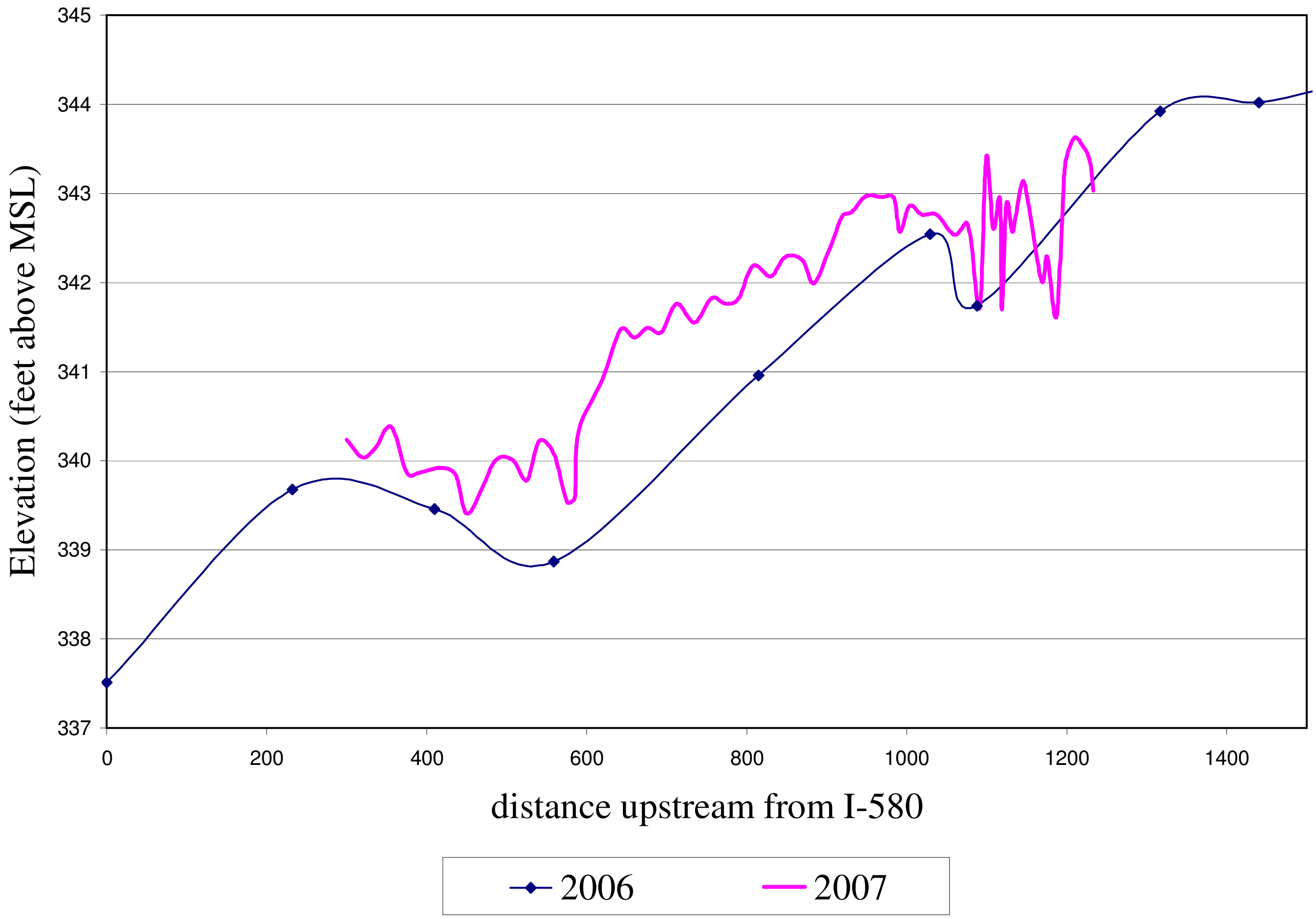
Figure 12.1: GG' Looking upstream from thalweg (Dublin Blvd. Bridge in background) (2007)

Figure 12.2: GG' Looking downstream from thalweg (2007)

Figure 12.3: 2004 GG' Looking upstream from creek level (Oden and DeHollan, 2004)

Figure 12.4: 2004 GG' Looking downstream from creek level (Oden and DeHollan, 2004)

Figure 13: Long Profile Plot from Dublin Blvd. Bridge toward I-580



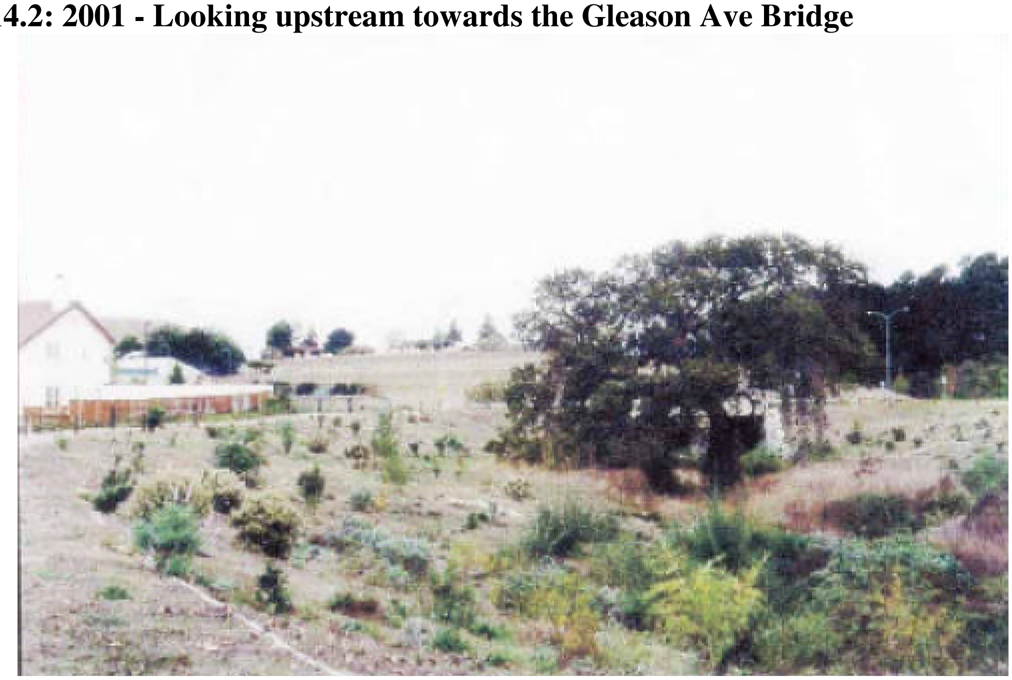
Survey Specifications:
The survey began from the downstream side of the Dublin Boulevard Bridge and proceeded downstream with the survey tape primarily following the right bank.

Figure 14: Photograph Time Series near Gleason Ave.

Figure 14.1: Pre-restoration - looking upstream towards Gleason Ave Bridge

(Kondolf)

Figure 14.2: 2001 - Looking upstream towards the Gleason Ave Bridge



(Hudzik and Truitt, 2001)

Figure 14.3: 2004 - looking upstream towards the Gleason Ave Bridge from the right bank

(Oden and DeHollan, 2004)

Figure 14.4: 2007 - standing on Gleason Ave Bridge looking downstream – mid bridge 3rd vertical railing shown; oak tree seen in all previous photos seen in upper right corner

APPENDIX A: Cross Section Survey Data

Project: Tassajara Creek — Cross Section E-E'
Level: NB
Rod: LN
Date: 11/17/2007
Record: LN
Weather: 75°F, Sunny

Station	Backsight	Foresight	HI	Height	Elevation	Notes
BM	4.03		3.75	360.49	356.46	
TP1		3.04			357.45	near metal stake
	5.58		3.95	363.03		
153.8		3.91			359.12	inner edge of path
(TP2)	1.04		3.46	360.16		right bank
149		1.95	3.46		358.21	linearly sloping down towards channel
133		7.74	3.46		352.42	
127		8.56	3.46		351.6	
116		8.52	3.46		351.64	
102.2		9.1	3.46		351.06	edge of upper corridor
100.6		10.27	3.46		349.89	
98.5		11.72	3.46		348.44	descending to channel
97.1		12.12	3.46		348.04	
95.4		12.92	3.46		347.24	
95.3		13.79	3.46		346.37	
94.9		14.61	3.46		345.55	
92.4		15.1	3.46		345.06	point bar in channel
91.7		15.38	3.46		344.78	end point bar, begin water
91		16.28	3.46		343.88	thalweg
90.4		16.21	3.46		343.95	
87.9		15.94	3.46		344.22	
86.7		15.09	3.46		345.07	left bank, end water
85.2		14.72	3.46		345.44	point bar along channel
84.4		14.59	3.46		345.57	end bar
83.5		14.85	3.46		345.31	slope break
82.4		13.26	3.46		346.9	
80.9		11.33	3.46		348.83	
80.6		9.95	3.46		350.21	
79.6		9.22	3.46		350.94	begin upper floodplain
78		8.57	3.46		351.59	
76		8.44	3.46		351.72	
68.2		8.33	3.46		351.83	
59.9		8.29	3.46		351.87	
50.4		8.2	3.46		351.96	linearly sloping up from channel
39		5.09	3.46		355.07	
32		2.62	3.46		357.54	
23		2.37	3.46		357.79	flat, end cross section
TP2		1.04	3.46		359.12	
	4.02		1.23	363.14		

Project:	Tassajara Creek	**Level:**	NB
	Cross Section F-F'	**Rod:**	LN
Date:	11/17/2007	**Record:**	LN
Weather:	75°F, Sunny		

Station	Backsight	Foresight	HI	Height	Elevation	Notes
TP1		6.7	1.23		356.44	
	4.23		1.2	360.67		
213.9		5.67	1.2		355	inner path on right bank
209.8		6.03	1.2		354.64	
196		11.34	1.2		349.33	
178		11.32	1.2		349.35	
163		11.49	1.2		349.18	
TP3	7.29		3.96	356.47		
156.8		7.43	3.96		349.04	end upper floodplain
153.3		8.49	3.96		347.98	
151.3		9.22	3.96		347.25	
149.2		9.74	3.96		346.73	
147.8		9.79	3.96		346.68	
146		10.86	3.96		345.61	
143.6		11.48	3.96		344.99	
142.5		12.23	3.96		344.24	right edge of low flow channel
139.1		13.95	3.96		342.52	thalweg
136.8		13.96	3.96		342.51	thalweg
134		13.76	3.96		342.71	
131.4		13.33	3.96		343.14	
129		12.26	3.96		344.21	left bank
128.8		11.27	3.96		345.2	top of bank
126.9		10.36	3.96		346.11	
123.5		10.27	3.96		346.2	
119.9		9.45	3.96		347.02	
114.9		7.96	3.96		348.51	
111.4		7.51	3.96		348.96	edge of upper bank
101.6		7.59	3.96		348.88	large floodplain corridor
84.8		7.51	3.96		348.96	
71.1		6.86	3.96		349.61	
50.8		6.25	3.96		350.22	end floodplain
37.5		3.13	3.96		353.34	
28.6		1.15	3.96		355.32	
21		0.95	3.96		355.52	inner path on left bank
TP4		2.81	3.96		353.66	
	4.63		3.87	358.29		
BM		4.38	3.87		353.91	

Project:	Tassajara Creek	**Level:**	NB
	Cross Section G-G'	**Rod:**	LN
Date:	11/17/2007	**Record:**	LN
Weather:	75°F, Sunny		

Station	Backsight	Foresight	HI	Height	Elevation	Notes
BM	5.75			362.21	356.46	
TP5		5.96			356.25	
	4.88			361.13		
26.4		5.81			355.32	inner edge of path on right bank
31.4		4.13			357	sloping downward towards channel
59.9		14.9			346.23	
69.7		15.4			345.73	
83.1		15.61			345.52	
88.6		15.62			345.51	
91.5		15.98			345.15	
126.7		15.13			346	skipping to other side of bank
134		15.15			345.98	
149.2		15.16			345.97	
172.8		15.38			345.75	
187.8		14.89			346.24	
201.7		10.31			350.82	
211		7.09			354.04	
213.6		7.04			354.09	inner edge of path on left bank
TP6		6.12			355.01	
	3.19			358.2		
91		12.97			345.23	still g but back to mid points
92.5		13.4			344.8	bc couldn't see from previous position
95.4		15.01			343.19	in low flow channel
98.3		14.68			343.52	
99.8		15			343.2	channel becomes braided
101.7		14.49			343.71	
103.9		15.59			342.61	
105		14.99			343.21	water
106.3		15.47			342.73	Thalweg
107.6		15.42			342.78	
109.5		15.06			343.14	left bank
113.2		14.73			343.47	
116		15.03			343.17	Thalweg of dry braid in channel
120		15.68			342.52	
126.3		12.16			346.04	end g
LP point		12.88			345.32	checking elevation of flag turning point in LP
TP7		1.92			356.28	
	5.91			362.19		closing survey
BM		5.69			356.5	

Compiled Data for Cross Section E-E'

Kondolf, Pre-Project 1997

Station	Elev.
0	357.66
26	357.55
55	357.13
63	354.53
75	347.26
78	345.21
79	344.48
81	344.46
82	343.51
101	354.50
106	358.5
124	359
143	359.24
146	359.33

BFK Engineering, As-Built 2000

Station	Corrected Station	Elev.
200	-117	361.1
162	-79	360.9
156	-73	361.1
154	-71	360.4
152	-69	361.1
137	-54	361.4
111	-28	359.9
70	13	353.8
19	64	351.0
4	79	347.8
-2	85	345.6
-11	94	351.7
-41	124	352.0
-61	144	361.1
-81	164	360.7
-83	166	360.0
-85	168	360.7
-90	173	361.1
-122	205	361.1

Hudzik and Truitt, 2001

Station	Corrected Station	Elev.
146	146	359.33
143	143	359.24
124	124	351.62
111	111	351.38
95	95	351.00
82	82	343.51
81	81	344.46
79	79	344.48
78	78	345.21
75	75	347.26
68	68	351.53
45	45	351.82
26	26	357.55
0	0	357.66

Lave, 2003

Station	Corrected Station	Elev.
123.1	146.0	359.38
101.7	124.6	352.01
96.9	119.8	351.73
69.8	92.7	351.17
64.5	87.4	344.75
61.8	84.7	343.78
59.3	82.2	344.78
56.9	79.8	345.03
54.9	77.8	345.65
46.7	69.6	351.65
36.9	59.8	352.09
19.2	42.1	352.46
0.0	22.9	357.78

*adjusted to more closely match H&

Tompkins, 2005

Station	Corrected Station	Elev.	Corrected Elev.
-52	0	359.38	360.06
-45	7	359.53	360.21
-40	12	359.61	360.29
-37	15	359.65	360.33
-21	31	358.63	359.31
26	78	357.55	358.23
44	96	352.04	352.72
70	122	351.26	351.94
74	126	347.88	348.56
77	129	345.54	346.22
79	131	345.54	346.22
80	132	345	345.68
83	135	344.4	345.08
86	138	345.03	345.71
87	139	345.52	346.2
93	145	350.48	351.16
112	164	351.31	351.99
122	174	351.5	352.18
146	198	359.2	359.88
164.5	216.5	359	359.68

Butler and Nolan, 2007

Station	Corrected Station	Elev.
153.8	145.8	359.12
149	141	358.21
133	125	352.42
127	119	351.6
116	108	351.64
102.2	94.2	351.06
100.6	92.6	349.89
98.5	90.5	348.44
97.1	89.1	348.04
95.4	87.4	347.24
95.3	87.3	346.37
94.9	86.9	345.55
92.4	84.4	345.06
91.7	83.7	344.78
91	83	343.88
90.4	82.4	343.95
87.9	79.9	344.22
86.7	78.7	345.07
85.2	77.2	345.44
84.4	76.4	345.57
83.5	75.5	345.31
82.4	74.4	346.9
80.9	72.9	348.83
80.6	72.6	350.21
79.6	71.6	350.94
78	70	351.59
76	68	351.72
68.2	60.2	351.83
59.9	51.9	351.87
50.4	42.4	351.96
39	31	355.07
32	24	357.54
23	15	357.79

Compiled Data for Cross Section F-F'

Kondolf, Pre-Project 1997

Station	Elev.
0	356.74
8	356.38
78	355.18
87	353.68
104	345.69
109	343.59
120	344.22
125	346.34
140	352.89
150	354.69
172	355
187	355.86
189	356.14

BFK Engineering, As-Built 2000

Station	Corrected Station	Elev.
136	-25	355.0
111	0	355.5
82	29	349.1
18	93	348.8
6	105	344.5
-5	116	344.5
-20	131	348.8
-59	170	349.1
-77	188	357.2
-100	211	357.0
-116	227	356.0

Hudzik and Truitt, 2001

Station	Corrected Station	Elev.
189	189	356.14
187	187	355.86
172	172	350.48
162	162	350.33
133	133	349.69
125	125	346.34
120	120	344.22
109	109	343.59
104	104	345.69
91	91	349.68
30	30	351.34
8	8	356.38
0	0	356.74

Lave, 2003

Station	Corrected Station	Elev.	Corrected Elev.
190.0	194.0	190.0	356.02
166.9	170.9	166.9	350.32
129.5	133.5	129.5	350.22
125.6	129.6	125.6	349.19
121.4	125.4	121.4	347.53
118.4	122.4	118.4	345.72
115.2	119.2	115.2	345.48
113.4	117.4	113.4	343.43
112.2	116.2	112.2	343.71
104.9	108.9	104.9	343.84
102.4	106.4	102.4	344.53
100.4	104.4	100.4	345.53
93.5	97.5	93.5	347.81
85.6	89.6	85.6	349.87
24.1	28.1	24.1	351.5
0.0	4.0	0.0	356.75

Butler and Nolan, 2007

Station	Corrected Station	Elev.	Corrected Elev.
213.9	192.9	355	356
209.8	188.8	354.64	355.64
196	175	349.33	350.33
178	157	349.35	350.35
163	142	349.18	350.18
156.8	135.8	349.04	350.04
153.3	132.3	347.98	348.98
151.3	130.3	347.25	348.25
149.2	128.2	346.73	347.73
147.8	126.8	346.68	347.68
146	125	345.61	346.61
143.6	122.6	344.99	345.99
142.5	121.5	344.24	345.24
139.1	118.1	342.52	343.52
136.8	115.8	342.51	343.51
134	113	342.71	343.71
131.4	110.4	343.14	344.14
129	108	344.21	345.21
128.8	107.8	345.2	346.2
126.9	105.9	346.11	347.11
123.5	102.5	346.2	347.2
119.9	98.9	347.02	348.02
114.9	93.9	348.51	349.51
111.4	90.4	348.96	349.96
101.6	80.6	348.88	349.88
84.8	63.8	348.96	349.96
71.1	50.1	349.61	350.61
50.8	29.8	350.22	351.22
37.5	16.5	353.34	354.34
28.6	7.6	355.32	356.32
21	0	355.52	356.52

Tompkins, 2005

Station	Elev.
-15.3	356.85
-9	357
-0.4	357.11
1.6	357.12
8.6	356.79
28.6	351.12
55.6	350.64
77.6	349.97
92.6	349.92
98.6	348.21
106.6	346.11
107.6	345.59
108.6	343.39
113.6	343.24
118.6	343.67
120.6	345.51
124.6	347.76
128.6	348.15
131.6	349.61
156.6	350.16
171.6	350.4
191.6	356.01
193.6	355.92
211.6	355.49

Compiled Data for Cross Section G-G'

Kondolf, Pre-Project 1997

Station	Elev.
200	356.37
189	345.08
180	341.57
171	341.57
140	341.57
132	341.57
131	341.57
131	341.57
129	341.57
125	341.57
124	341.57
121	341.57
119	341.57
115	341.57
114	341.57
112	341.57
102	341.57
81	341.57
75	345.13
0	353.79

BFK Engineering, As-Built 2000

Station	Corrected Station	Elev.
122	-2	356.6
100	20	357.0
69	51	345.0
17	103	344.7
13	107	341.4
-9	129	341.4
-12	132	344.7
-41	161	345.0
-79	199	357.0
-103	223	356.8

Hudzik and Truitt, 2001

Station	Corrected Station	Elev.
200	200	356.37
196	196	356.65
169	169	346.03
171	171	345.52
140	140	345.08
132	132	342.61
131	131	342.92
131	131	342.67
129	129	342.39
125	125	342.86
124	124	342.33
121	121	341.33
119	119	341.93
115	115	341.91
114	114	341.57
112	112	341.57
102	102	345.13
40	40	345.38
14	14	354.10
0	0	353.79

Lave, 2003

Station	Corrected Station	Elev.
0.0	9.0	354.16
4.9	13.9	353.60
27.5	36.5	346.55
67.9	76.9	345.32
94.3	103.3	344.93
98.8	107.8	343.94
103.8	112.8	342.18
105.9	114.9	341.68
108.9	117.9	342.22
110.5	119.5	342.59
111.8	120.8	342.14
113.3	122.3	341.70
116.5	125.5	342.29
120.1	129.1	343.13
120.5	129.5	342.58
125.3	134.3	342.88
131.5	140.5	345.09
149.8	158.8	345.69
163.3	172.3	346.03
191.8	200.8	356.33

Tomkins, 2005

Station	Corrected Station	Elev.
0	25.1	353.84
14.5	39.6	354.1
27.3	52.4	350.48
40.3	65.4	345.12
64.3	89.4	345.58
101.3	126.4	345.11
111.3	136.4	342.59
116.3	141.4	342.44
121.3	146.4	341.73
124.3	149.4	342.72
126.3	151.4	343.2
129.3	154.4	342.68
139.3	164.4	344.82
169.3	194.4	346.04
198.3	223.4	356.68
203.3	228.4	356.29
218.7	243.8	355.99

Butler and Nolan, 2007

Station	Corrected Station	Elev.
26.4	202.2	355.32
31.4	197.2	357
59.9	168.7	346.23
69.7	158.9	345.73
83.1	145.5	345.52
88.6	140	345.51
91.5	137.1	345.15
92.5	136.1	344.8
95.4	133.2	343.19
98.3	130.3	343.52
99.8	128.8	343.2
101.7	126.9	343.71
103.9	124.7	342.61
105	123.6	343.21
106.3	122.3	342.73
107.6	121	342.78
109.5	119.1	343.14
113.2	115.4	343.47
116	112.6	343.17
120	108.6	342.52
126.3	102.3	346.04
126.7	101.9	346
134	94.6	345.98
149.2	79.4	345.97
172.8	55.8	345.75
187.8	40.8	346.24
201.7	26.9	350.82
211	17.6	354.04
213.6	15	354.09

APPENDIX B: Long Profile Survey Data

Project: Tassajara Creek Long Profile | **Level:** NB
Rod: LN
Date: 11/10/2007 | **Record:** LN
Weather: 60°F, Cloudy

Station	Backsight	Foresight	Height	Elevation	Notes
BM	16.26		372.72	356.46	
TP1		24.95		347.77	
	13.9		361.67		
2		18.64		343.03	
7		18.28		343.39	
18		18.1		343.57	
26.6		18.05		343.62	
37.5		18.37		343.3	high organic sediments
47.9		20.04		341.63	pool
59.7		19.38		342.29	submerged woody debris
66.7		19.65		342.02	
84.2		18.75		342.92	
89.9		18.53		343.14	
99.5		18.93		342.74	
103.3		19.1		342.57	pool
110.79		18.79		342.88	incised low flow channel
116.5		19.97		341.7	
118.8		18.74		342.93	
127.1		19.06		342.61	main channel
136.2		18.26		343.41	main channel
143.6		19.94		341.73	main channel
154.6		19.21		342.46	main channel - incised
160.3		19		342.67	main channel
167.3		19.07		342.6	main channel
127.1		18.38		343.29	side channel
136.2		18.56		343.11	side channel
143.6		18.41		343.26	side channel
154.6		18.41		343.26	side channel
160.3		18.37		343.3	side channel
167.3		18.39		343.28	side channel
177.6		19.13		342.54	
198.2		18.91		342.76	
216.6		18.91		342.76	
TP2	13.96	16.18	359.45	345.49	
232		16.59		342.86	
244		16.88		342.57	
251.4		16.5		342.95	
267.1		16.49		342.96	channel becomes braided
286		16.48		342.97	
304.8		16.66		342.79	
316.4		16.71		342.74	
332.3		17.07		342.38	
351.5		17.46		341.99	
365.8		17.2		342.25	
387.1		17.16		342.29	

Project:	Tassajara Creek	**Level:**	NB
	Long Profile	**Rod:**	LN
Date:	11/10/2007	**Record:**	LN
Weather:	60°F, Raining		

Station	Backsight	Foresight	Height	Elevation	Notes
TP3	15.71	16.63	358.53	342.82	
405.4		16.46		342.07	
427.2		16.34		342.19	
445.9		16.71		341.82	
461.6		16.77		341.76	
479.4		16.7		341.83	
500.5		16.98		341.55	
522.9		16.77		341.76	
542.3		17.09		341.44	
559.5		17.04		341.49	
575.7		17.15		341.38	
593.5		17.06		341.47	
615.6		17.61		340.92	
645.5		18.19		340.34	
650.5		18.94		339.59	pool
659.7		18.99		339.54	pool
676.7		18.45		340.08	pool
694.7		18.31		340.22	
710.2		18.75		339.78	
728		18.52		340.01	
749.6		18.53		340	
783.5		19.12		339.41	soft sediment - rod sinking
799.1		18.69		339.84	
TP4	16.5	16.48	358.53	342.05	
820.2		18.61		339.92	
843		18.66		339.87	
859.9		18.67		339.86	local incision
879.9		18.15		340.38	
900.3		18.39		340.14	
916		18.49		340.04	
935.3		18.29		340.24	

due to inclement weather we were unable to close the survey

Compiled survey data

Tomkins, 2006

Station	Corrected	Elevation
0	4118	360.18
64	4054	357.28
101	4017	356.17
267	3851	353.87
413	3705	352.36
519	3599	351.1
611	3507	351.32
740	3378	350.19
898	3220	350.51
980	3138	348.96
1179	2939	349.04
1447	2671	348.2
1673.5	2444.5	346.95
1990.5	2127.5	345.17
2154.5	1963.5	344.96
2410.8	1707.2	342.99
2538.8	1579.2	344.13
2678	1440	344.02
2801	1317	343.92
3030	1088	341.74
3089	1029	342.54
3303	815	340.96
3559	559	338.87
3708	410	339.46
3886	232	339.68
4118	0	337.51

Butler and Nolan, 2007

Station	Corrected	Elevation	Station	Corrected	Elevation
2	1233.3	343.03	351.5	883.8	341.99
7	1228.3	343.39	365.8	869.5	342.25
18	1217.3	343.57	387.1	848.2	342.29
26.6	1208.7	343.62	405.4	829.9	342.07
37.5	1197.8	343.3	427.2	808.1	342.19
47.9	1187.4	341.63	445.9	789.4	341.82
59.7	1175.6	342.29	461.6	773.7	341.76
66.7	1168.6	342.02	479.4	755.9	341.83
84.2	1151.1	342.92	500.5	734.8	341.55
89.9	1145.4	343.14	522.9	712.4	341.76
99.5	1135.8	342.74	542.3	693	341.44
103.3	1132	342.57	559.5	675.8	341.49
110.79	1124.51	342.88	575.7	659.6	341.38
116.5	1118.8	341.7	593.5	641.8	341.47
118.8	1116.5	342.93	615.6	619.7	340.92
127.1	1108.2	342.61	645.5	589.8	340.34
136.2	1099.1	343.41	650.5	584.8	339.59
143.6	1091.7	341.73	659.7	575.6	339.54
154.6	1080.7	342.46	676.7	558.6	340.08
160.3	1075	342.67	694.7	540.6	340.22
167.3	1068	342.6	710.2	525.1	339.78
177.6	1057.7	342.54	728	507.3	340.01
198.2	1037.1	342.76	749.6	485.7	340
216.6	1018.7	342.76	783.5	451.8	339.41
232	1003.3	342.86	799.1	436.2	339.84
244	991.3	342.57	820.2	415.1	339.92
251.4	983.9	342.95	843	392.3	339.87
267.1	968.2	342.96	859.9	375.4	339.86
286	949.3	342.97	879.9	355.4	340.38
304.8	930.5	342.79	900.3	335	340.14
316.4	918.9	342.74	916	319.3	340.04
332.3	903	342.38	935.3	300	340.24

APPENDIX C: Detailed Cross Section Morphology

Cross-Section E-E'

Our cross-section E-E' data and plot indicates that the cross-section has experienced several different processes including erosion, deposition, and incision. When we plot our cross-section data with previous survey data (Figure 7), we see that the left bank has been eroded and the channel has moved towards the left since the 2005 survey. Erosion on the lower part of the left bank has occurred primarily between 349 ft. MSL and the thalweg. The channel did not widen since our data shows deposition on the right bank of the channel. Deposition on the lower part of the right bank occurred between 349 ft. MSL and the thalweg. The erosion on the left bank and deposition on the right bank suggests the channel is meandering towards the left bank. We can see from our data that the floodplain has experienced deposition near the channel banks with more on the right floodplain bank. Our data shows the deposition decreased further out onto the floodplain from the channel with little to no deposition occurring on the outer edges of the floodplain. Based on our data the thalweg incised as it moved towards the left bank. The degree of incision between surveys is uncertain due to our previously mentioned rationale. We were unable to visually confirm any signs of erosion, deposition, or incision since we were surveying in November after an entire summer's growth and over a year since any large storms. We did observe high water marks in the floodplain indicating the creek was laterally reconnected.

Cross-Section F-F'

Our cross-section F-F' data and plot compared to previous data (Figure 9) indicates that the channel undergoing aggradation with some erosion while the floodplain experiences both deposition and erosion. Our data clearly shows the channel bottom and the left bank aggrading since the 2005 survey. The right bank remained mostly unchanged with possible erosion, while the left bank primarily aggrading around 347 ft. MSL. The left bank had dense bulrushes growing (Figure 10.1) whose roots appeared to be stabilizing the upper bank and perhaps facilitating the aggradation measured in our data. Although it was not captured by the survey, the bank was beginning to undercut below the bulrush. The right bank had less vegetation growing on the edge of the bank (Figures 10.1 and 10.2) and thus didn't benefit from stabilization by roots. The channel bottom was composed of extremely fine, soft sediments, a finding that supports the aggradation seen in our data. Our data also suggest that sediment was deposited on the right floodplain near the channel bank, while the center of the left floodplain was eroded.

Cross-Section G-G'

Our data indicate that at G-G' the channel underwent significant aggradation and erosion, while deposition occurred on the floodplain (Figure 11). Our cross-section G-G' data may not represent exactly the same cross-section previously measured, but was nonetheless plotted with previous data for comparison. Figure 11 shows that almost the entire channel bottom aggraded, though 125 ft. from the left bank edge shows no change. The aggradation was nearly one foot at 115 ft. from the left bank edge. Our data shows there was some erosion of the bottom of the left and right banks. Some of the aggradation may be due to the shift in the right bank tie off point, but it is unlikely to account for all the aggradation seen in the data. The channel was heavily vegetated at the cross-section (Figure 12.1 and 12.2) and we believe the vegetation stabilized the channel bottom and reduced flow velocities, increasing aggradation. We observed during our survey that the channel was braided upstream and downstream of this cross-section with two of the braids actively conveying water. We noticed a third braid which would convey water during higher flows, but was not conveying water during our surveying. Previous reports and data do not mention any braiding, so we conclude that the braiding is a recent development that results from the in-channel vegetation and aggradation. Our data suggests that the channel is narrowing above 344 ft. MSL and widening some below 344 ft. MSL. Our data indicates the floodplain on both sides had deposition with the left floodplain receiving the most sediment. The left floodplain gained between one ft. at the channel/floodplain bank and less than 0.2 ft. towards the center of the left floodplain. The right floodplain only had about 0.5 ft. at maximum of sediment deposited on the channel/floodplain bank with less occurring further onto the right floodplain. The upper sides of the floodplain have negligible change between our survey and previous surveys.