Title

Post project appraisal of Green Valley Creek, Solano County, California : design and management review

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Post Project Appraisal of Green Valley Creek, Solano County, California: Design and Management Review

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Abstract

We assessed the success of Green Valley River Restoration Project, specifically assessing sedimentation and channel stability. The major objectives of the restoration were to provide flood control by constructing a two terraced channel, re-plant riparian corridor with native species, and mitigate for 1.89 acres of seasonal wetland lost to development. We attempted to compare project conditions after a major flow event in 1995 (second year after project completion) with those of the most recent (2002) surveys. Surveying methods were inconsistent from year to year making direct comparison of surveys difficult. In general, the two-terrace channel has remained relatively stable and successfully conveyed flood waters downstream. Erosion and deposition within the channel are less stable because of excessive sediment loading from upper watershed. Severe sedimentation along Hennessey Creek, a tributary to Green Valley Creek, caused damage to private property within the project reach during flood events. Litigation ensued and one of the outcomes was the development of new watershed scale management strategies. Some of these new strategies included improving farming techniques in the upper watershed to minimize sedimentation, conducting more scientific studies to assess sources of sediment, continuing monitoring creeks throughout the watershed, and consistently revising requirements developers must meet to build within the river corridor. Overall we see Greek Valley Creek as a successful project, one where the shortcomings of the project (sediment transport considerations) will provide useful learning tools for future management.

Introduction and Background Information

Green Valley Creek is one of the largest waterways in Solano County, California, and flows for 14 miles, from the Vaca Mountains to, and past, the town of Cordelia, where it becomes the Cordelia Slough; Figure 1 shows regional setting of project area. Green Valley Creek drains a total area of 22 square miles upstream of Interstate 80 and is controlled by Lakes Madigan and Frey Headwaters. Mean annual precipitation in the watershed is approximately 25in/yr area (Zentner and Zentner, 1998).

The creek is characterized by a relatively deep canyon in the upper reaches, before it enters a broad agricultural plain near the northern reach of the project. Active hill-slope, mass movement process, such as earth flows in the upper watershed, and bank instability (due to channel incision) in the lower watershed, contribute sediment to the system. Sediment deposits in areas where the elevation gradient is minimal. In the lower reaches of Green Valley Creek fine grained sediment has been continually dredge from the channel in order to maintain conveyance of flood waters over the past few decades (Zentner and Zentner, 1998).

Development in the floodplain was the initial motivation for restoring Green Valley Creek. Before developers could build housing subdivisions flood control provisions were required and wetland mitigation was needed to replace the 1.89 acres lost to housing. The project objectives were to: maintain and restore the riparian and wetland values of Green Valley creek; provide safe conveyance of flood waters; construct an open wooded channel for the redirected Hennessey Creek; and mitigate for 1.89 acres of seasonal wetland fill on adjacent pasture lands developed for housing.

The initial design plans described four specific methods to restore the creek and riparian corridor: preserve creek bed and existing riparian woodlands; plant riparian woodland 25 to 70 feet in width on both sides of the creek; construct an overflow terrace for flood waters consisting of native grasses and seasonal marsh 50 to 80 feet wide on the west side of the creek's riparian woodlands; and plant an oak woodland at least 10 to 15 feet wide on both the west and east banks.

During the construction of the two terrace channel of Green Valley Creek, Hennessey Creek was relocated. Hennessey Creek originally flowed south from Reservoir Lane, through Citation's property, to the westerly side of Green Valley Creek. On the south side of Reservoir Lane where Hennessey Creek crosses, an inlet structure was constructed with three 72" diameter pipes (each approximately 1700 feet long), which parallel Reservoir Lane to the westerly bank of Green Valley Creek. At this point, a concrete outlet structure was constructed at Green Valley Creek and three flap gates were installed on the ends of the storm drain pipes. The flap gates were installed to keep Green Valley Creek from flowing up the storm drain pipes during large flows (Beck, 1996).

The project goals were broken up into nine specific areas: sedimentation; geomorphology; bank stability; fisheries; plant vigor; species diversity; and mortality of riparian oak woodland. Performance standards for each of these project goals are provided in Table 1 (Zentner and Zentner, 1998).

Table 1 Green Valley Performance Standards

Design Goal	Performance Standard
Sedimentation	Habitat value not lost through deposition of sediment from on-site sources or normal watershed runoff over channel bottom gravels. Should watershed conditions change through fire, urbanization or other conditions, the city shall identify the sources of additional sediment, and propose remedial actions to the Army Corp of Engineers.
Geomorphology	Low flow channel and creek bottom to remain in position and retain at least 80% of the habitats and their extent as mapped in the Mitigation Plan.
Bank Stability	No erosion scares deeper than 12 inches to occur on the banks in the same location over successive years.
Fisheries	Species richness and populations equal to or greater than those measured by sampling prior to project.
Plant Vigor	Class 3 or better for shrubs, vines and oak woodland. Class 5 or better for riparian woodland trees.
Species Diversity	At least the same number of native species as provided in the planting plan.
Mortality	80% survival of all trees and shrubs
Cover	25% cover by native woody species in the oak woodland; 50% cover by native woody species in the riparian area.

Construction of the project began in 1992 and was completed in early 1994. The original consulting team consisted of four companies: Zentner and Zentner; MacKay and Somps Engineers; Phillip Williams and Associates; and Sycamore Associates. After the project was completed, a ten-year monitoring program was instituted. Zentner and Zentner conducted the first five years of monitoring and the last five years were contracted to ECORP Consulting, Inc. Both parties monitored channel stability, sedimentation, hydrology, geomorphology, vegetation, fisheries, and bird use. The monitoring program began in the fall of 1994 and continues until fall of 2004.

The goal of this paper is to compile, synthesize and evaluate monitoring conducted by Zentner and Zentner and ECORP and assess the overall success of Green Valley Creek restoration. To assess success, we considered data provided by monitoring reports as well as observational evidence collected during a site visit October 26, 2003. Although the consultants monitored all nine of the project goals, we did not focus our attention on hydrology, aquatic or terrestrial habitat. We assessed the sedimentation, geomorphology and channel stability of the project.

Methods

Zentner and Zentner established eight monitoring transects (Figure 2), which they surveyed bi-annually and photographed annually for five years (1994-1998) (Figure 3). ECORP conducted the monitoring for the next five years (1999-2004) and continued the channel surveys, identified points of interest (e.g. erosion scars, beaver dams), and took photos but not from the same locations as before. The consultants involved with the initial design and the first five years of monitoring identified five river sections within the project reach.

Sedimentation

To assess accumulation of sediment and other changes in channel structures, eight cross sections were surveyed once every two years. In theory, cross sections were monumented in the first year and included a fixed vertical datum so that successive surveys were taken at the same location and use the same sampling points. Baseline post-construction surveys were performed in fall of 1994 and were used for comparison.

Geomorphology

Geomorphic mapping of Green Valley and Hennessey Creeks in the project area was conducted at the same time as the channel survey to document changes in channel morphology and bank stability. As-built drawings documenting the creek conditions upon completion of construction were prepared by the City of Fairfield engineer.

Channel Stability

A survey of the channel banks was completed at the close of the wet season to document changes in channel morphology and bank stability problems. Any scars deeper than twelve inches were mapped in the field.

Results

This section summarizes project conditions after a major storm event and compares the conditions found after the first five years of monitoring (1998) to the most recent surveys (2002-2003).

Conditions after 100-yr flood in winter of 1995

Sedimentation

The City discovered problems with the silt flows in Hennessey Creek beginning on January 3, 1995. During this particular rainfall event, total suspended solids (TSS) at Green Valley Creek and Reservoir Lane (north of confluence with Hennessey Creek) was documented to be 9mg/L. At Hennessey Creek TSS concentration was 366 mg/L, and at the south end of the project was 109 mg/L (Beck, 1996). The difference between inflow and outflow TSS concentrations within the project reach shows sediment was transported from Hennessey Creek to Green Valley Creek and deposited along the project reach. These results indicate that the two-terrace design was appropriate and successful because most of the sediment was deposited in the upper terrace. Results of silt accumulation in Mangels Bridge baffles were recorded by Zentner & Zentner and are provided in Figure 4. Sediment accumulation in the baffles reached between 6 and 19 inches. Despite the success of the channel design, large amounts of sediment from Hennessey Creek were transported downstream to Suisun Marsh.

Channel Stability

Following the significant floods of 1995 (estimated at near 100-year storm levels by Zentner & Zentner), significant erosion occurred on the most downstream curve of the low-flow channel, at two locations where the low-flow channel entered the overflow terrace (due to silt fencing confining the flows) and at the upstream reach where Hennessey Creek enters the overflow terrace. A significant amount of sediment traveled down Hennessey Creek from upstream sources and plugged the three 72 inch storm drains (Figure 5). This drain clogging in turn caused Hennessey Creek waters to flow into the overflow terrace (Figure 6), cutting a channel around the pipe's head wall into Green Valley Creek (Zentner & Zentner, 1995).

Property surrounding Hennessey Creek was severely damaged during these floods particularly property owned by Citation (Figure 1). Property owners attributed the damage to the poor design of storm drains along Hennessey Creek and filed suit against the City of Fairfield that in turn filed a counter suit against McKay and Somps. This litigation led the City to develop best management practices (BMP) and new flood control priorities.

Best Management Practices and Adaptive Management

Within the Green Valley Creek watershed, the City of Fairfield requires developers to provide storm water detention for the difference between the 100-year developed and 100-year undeveloped flows to ensure there is not an increase in channel flow. The erosion and sedimentation control plans for subdivisions along Green Valley Creek include protecting storm drain inlets and other drainage areas to the storm drains and creeks by using silt fencing, hay bales, and temporary detention ponds (Beck, 1996).

After the storms in 1995 a report was issued by the Solano County Water Agency (SCWA) to address flood and sediment control within the district (Beck, 1996). They recommended:

- SCWA should continue to work with groups of property owners to provide technical assistance and to assist them in maintenance of unimproved creeks including use of California Conservation Corps/ California Department of Forestry workers as appropriate.
- SCWA staff should help form benefit assessment districts where requested.
- SCWA staff should better publicize it willingness to assist landowners in resolving flooding problems in cooperation with other public agencies having flood control or drainage functions.
- SCWA staff should work with cities and the County to make sure that FEMA maps accurately describe the flooding potential of various parts of the County so that existing and prospective property owners has a realistic picture of the potential for flooding.
- SCWA should work with the County Environmental Management Department to ensure that building permits for homes in flood susceptible areas are adequately protected from flooding.

A comprehensive countywide drainage and flood control program was initiated in 1996. Entire watersheds of problem areas were included in the study to ensure the program was comprehensive. The watershed approach was chosen to facilitate consideration of long-term comprehensive solutions and related problems such as siltation of Suisun Marsh. The first step in the watershed approach was to identify problem areas and their geographical distribution.

Recently, in 2002, SCWA received a Proposition 204 Grant from the State Water Resources Control Board to implement a Pilot BMP in the North Bay Aqueduct Watershed. Recently completed reports that evaluated the Barker Slough watershed made recommendations for potential water quality improvements through the installation of BMPs. The report presented feasibility, reliability and cost estimates for improving water quality through the implementation of BMPs to control non-point sources of total organic carbon, turbidity, and pathogens. The report recommended installation of cattle fencing along the main waterway of the watershed along with grazing management practices (SWCA, 2002).

Year five (1998) conditions compared to year nine (2002) conditions

Sedimentation

Upon the completion of Zentner and Zentner's 5th and final, year of monitoring, 6 cross-section surveys were provided out of the 8 routinely surveyed. ECORP surveyed the channel in July 2002. We surveyed some of the transects during our visit in October 26, 2003, however, some of the markers were unidentifiable due to vegetation encroachment. The transects we surveyed were very similar to ECORP's 2002 surveys.

Transect data collected by Zentner and Zentner in 1994 and 1996 used the same distance scale (stations) but in 1998 a different frame of reference was used (feet) (Figure 7). Not only can Zentner and Zentner data not be recreated (because there are no survey tabulations) to compare directly to ECORP's data, but also cannot be compared between 1998 and previous Zentner and Zentner surveys due to the change in transect format. Zentner and Zentner's survey graphs do not indicate water level any year, further arresting the comparison of low flow channel location and condition from year to year (Figure 8-12).

Ignoring the difference between datum and water surface profiles we have made some basic inferences as to how the channel has changed over time. Along transect 1 there has been slight aggradation along the east overflow terrace. The banks of the low flow channel have steepened. The channel may have migrated west since 1998 (Figure 8). Along transect 2 there might have been as much as 6ft of sedimentation along the east overflow terrace. Despite the apparent overall increase in elevation of the banks, the two terrace form is still present (Figure 9). Along transect 3 approximately 2ft of sediment has accumulated in the middle of the low flow channel, creating a small island during low flow periods. The west bank of transect 3 has eroded and the eastern bank has aggraded (Figure 10). Along transect 4 banks have steepened and the channel appears much narrower than it did in 1998. The low flow channel along this transect has migrated to the east (Figure 11). Along transect 5 both the eastern and western overflow terrace slopes have lessened due to sedimentation (Figure 12). Transect 6 was provided but runs through a wetland and not the low flow channel and is not included in this review.

Channel Stability

Beaver dams have been constructed in lower and upper most sections of the project since 1998. In 2002, ECORP recorded 1.5 -2 feet of fine sediment accumulated in one pool in reach 5. During our visit, we observed this beaver dam but did not measure sediment. In reach 4, the eastern banks of the river have been significantly undercut, potentially caused by a beaver dam built directly downstream (Figure 14). The dams are located in section 1 (three dams), section 2 (one dam), and section 5 (two dams) (Figure 13). ECORP recorded the largest dam in section 1, located just downstream of Business Center Drive at the staff gage. ECORP observed the cascade and plunge pool to see if salmon could advance past the dam. One fish attempted to swim up the cascade but was unsuccessful (ECORP, 2002).

Two sites within the river corridor are graded for commercial development north of Business Center Drive (Figure 15). These sites were observed by ECORP during a storm November 30 and December 1, 2001. ECORP found no indications of sediment transport from the graded sites to the restoration site. Both construction sites are bordered with waddles and silt fencing to protect the project site from soil erosion, deposition or construction waste. During those storms construction crews were maintaining the sediment structures during the peak of the storm on December 1, 2001. Since ECORP does not provide measurements of TSS before and after these sites during the storm, it is difficult to quantitatively determine the effect these sites actually have on sediment transport.

Recommendations

There is little valuable evidence documenting channel evolution during the first six years of monitoring. During the first six years major storms and sedimentation occurred yet there is no way to quantify how the channel changed in response to those conditions. The first recommendation would be to establish consistent monumented transects. Once monumented transects have been established, it would also be beneficial to geo-reference the monuments so they could be easily re-established in the event of flood or vandalism.

In addition to improving the quality of surveyingmethods employed, we would also recommend contracting monitoring physical characteristics of the stream to qualified personnel. Both Zentner and Zentner and ECORP are primarily ecology and biology specialists. Actual survey data of plants and animals were provided in each report unlike channel elevation or measured deposition and erosion. Zentner and Zentner concluded the vegetation and species diversity met their performance goals and hence that aspect of the project was successful. However, they cannot speak to the relative success or failure of channel stability and design because they have not demonstrated the ability to collect appropriate information to make that assessment. ECORP's surveys in 2002 were appropriate and hopefully will be comparable to the 2004 surveys.

The choice of contractors reflects a disconnection between initial project goals and monitoring goals. Conveyance of flood waters was the primary objective of this restoration, facilitated by the construction of a two terraced channel. The performance standards for sedimentation and geomorphology only refer to instream habitat. No maps were created to document changes in habitat from 1994-1998 so it is difficult to reach conclusions independent of Zentner and Zentner's brief summary stating habitats have remained stable (Zentner and Zentner, 1998). Channel stability standard was no scars deeper than 12 inches in the same location consecutive surveys. During our recent visit, we observed significant erosion in certain reaches (Figure 12) and sedimentation in others, yet there are no standards to quantify these changes. As the standards were established, the only characteristics that were quantified were the number of pools and riffles, not necessarily a direct way to measure sedimentation and geomorphology. The channel design is the foundation of the project, if the channel design fails, all other efforts to improve ecological habitat also fail. Based on this logic, the consultants should have placed equal if not greater emphasis on the channel stability compared to ecological functions of the project.

Fortunately, not all of the recommendations or assessments are made by the consultants. An independent scientific committee assembles annually to review scientific aspects of Solano County Natural Community Conservation Plan (NCCP)/Habitat Conservation Plan (HCP), prepared by the SCWA (Noss et. al, 2002). Every year independent advisors publish a Scientific Advisor report. The 2002 report makes the following recommendations for managing and monitoring erosion and water quality effects within the watershed:

- Future developments in urban and agricultural areas should be carried out in a way that minimizes changes in peak runoff, total runoff volume, and seasonality of runoff as a solution to reducing changes to the salinity regimes of tidal areas.
- Assessments should be done to determine appropriate dry season environmental flows especially in Suisun and Green Valley Creeks but also in Alamo and Ulatis Creeks. Developments should either maintain or enhance groundwater infiltration as one solution for maintenance of crucial dry season / dry year flows and as a contributing factor for maintenance of the riparian zone along creeks.
- A scientific study should be conducted to determine the relative magnitude and sources of non-point contaminants so that appropriate management techniques can be selected. Specifically, determine relative sediment supply from various sediment sources (hill

slopes, bank and bed erosion, faming, and urban runoff). Techniques to reduce non-point source pollution might include maximizing infiltration, grass swales, retention ponds, and levee setbacks.

- Measures should be taken immediately to improve farm management of sediment and contaminants. The current regime of minimum vegetation cover in rangeland, row crop, tree crop farming and vineyards is likely contributing to the supply of fine sediment to creek channels.
- Evaluate the use of constructed freshwater wetlands for wastewater treatment to eliminate or reduce the negative impacts of freshwater discharge into Suisun tidal sloughs.

In addition to supporting the recommendations made above, we recommend a watershed wide change in data management. Specifically, develop databases that can be used with GIS technologies. These technologies will help identify the geographical distribution of watershed problems. For example, the Sweetwater Duck club threatened to sue the City of Fairfield because the Duck Club assumed excessive sedimentation in Suisun Marsh was caused by development in the floodplain of Green Valley Creek. The city showed sediment was not generated at the site of development but further up in the catchment. Because upper watershed conditions affect many streams that may not be under the City or Fairfield's jurisdiction, an easily accessible uniform data base could prevent a repeat of studies within the same watershed conducted by another political entity faced with a similar problem.

Assuming monitoring programs are established to document how a particular location changes over time, site specific data consistently inputted into a GIS database throughout the life of a project would allow different year's data to be directly compared. Change maps could be generated and potentially change (i.e. channel elevation, FEMA, percent riparian cover, etc.) could be better quantified. Other data that could be collected and input to a GIS database include (but not limited to) land use maps, habitat use maps, water use maps, infiltration, precipitation, stream networks, geology, and topography. A geo-referenced database can also help maintain monitoring programs. If markers for monitoring have been vandalized, stolen or washed away, it would be possible to re-establish the same markers because the exact locations are referenced to a set of coordinates (UTM or Lat/Long) that does not change regardless of how the landscape changes.

Conclusions

In general, the project design has been successful with a few exceptions. The terraced channel has been effective in stabilizing channel migration and was able to provide safe conveyance of flood waters through the project reach. However, there have been major sedimentation problems during the course of this project, which in turn caused damage to surrounding properties. These sediments were not generated at the restoration site but further up in the watershed. In particular, during very wet winters such as in 1995 huge amounts of sediment were transported from Hennessey Creek to Suisun Marsh and silted in the marsh. As a result of heavy sedimentation and subsequent litigation, the city of Fairfield adopted long term management strategies including monitoring and BMP.

The major oversight and lesson to be learned from this project is to view the river restoration in the context of the entire watershed. During the planning stages no estimates were made regarding the sediment transport within the system. To understand sediment transport within the project reach it would have been crucial to identify potential sources and estimate amount and rate of sediment supplied. Other creeks close to Green Valley Creek such as Jameson Creek and American Canyon have documented histories of major sedimentation due to the geologically active uplift and mass flows in the upper watershed.

To avoid such oversights in the future careful planning and thoughtful consideration of the dynamics of a system is an obvious recommendation. Similar problems could also be avoided in the future if information or data previously collected were easily accessible at the watershed scale. Currently reports of studies such as Green Valley Creek River Restoration Project are only available in hard copy at the City of Fairfield's Office of Public Works. If studies like this were available in a digital format or available online, transfer of data would be much easier and hence planners and engineers could make better informed decisions and designs. If sedimentation data of neighboring creeks had been available to the planning team, sediment transport could have been taken into account when designing the project and possibly property damage and litigation could have been avoided.

Figures

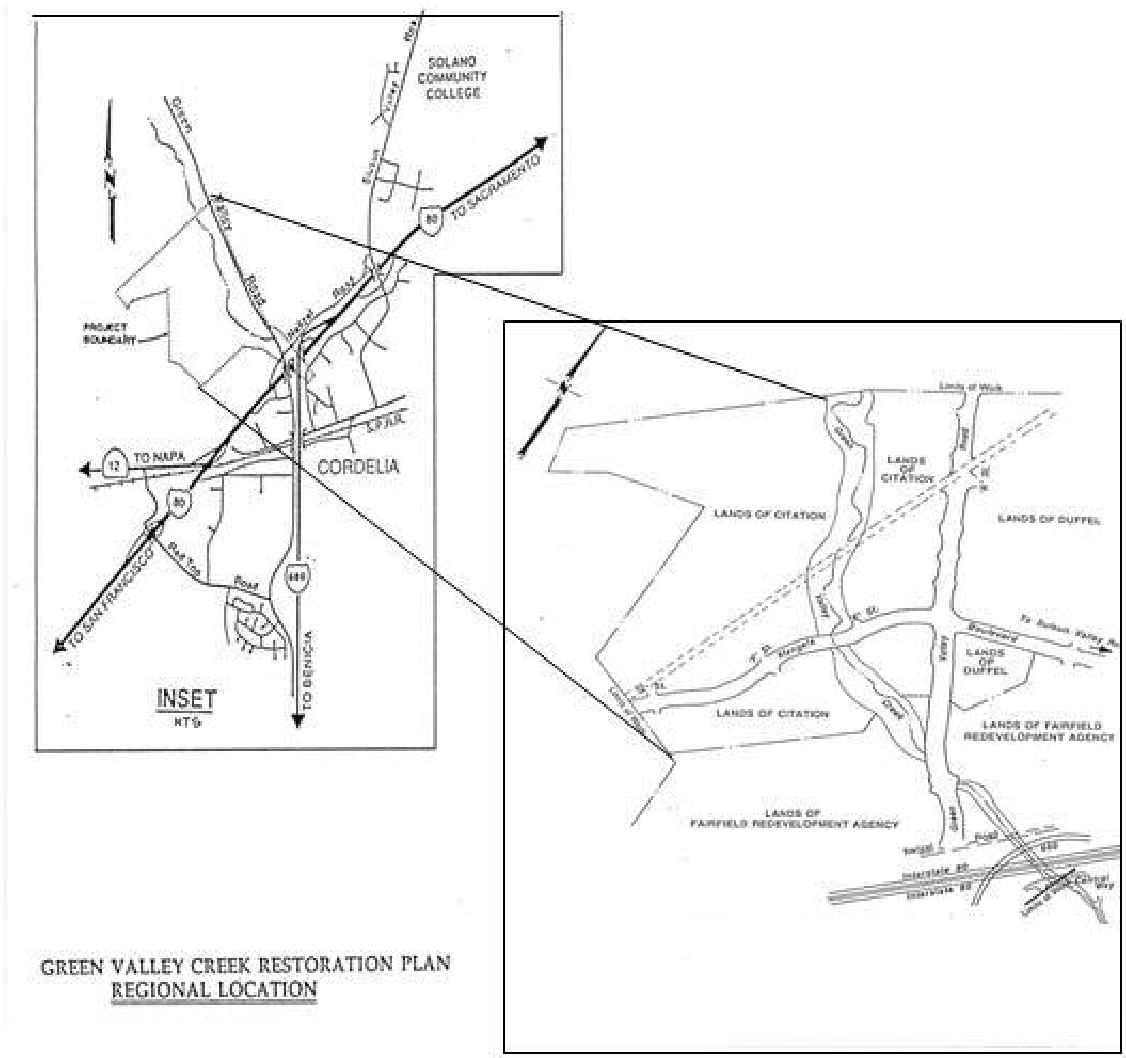


Figure 1. Regional Location of Green Valley Creek Restoration Project (Recreated from Zenitner & Zenitner)

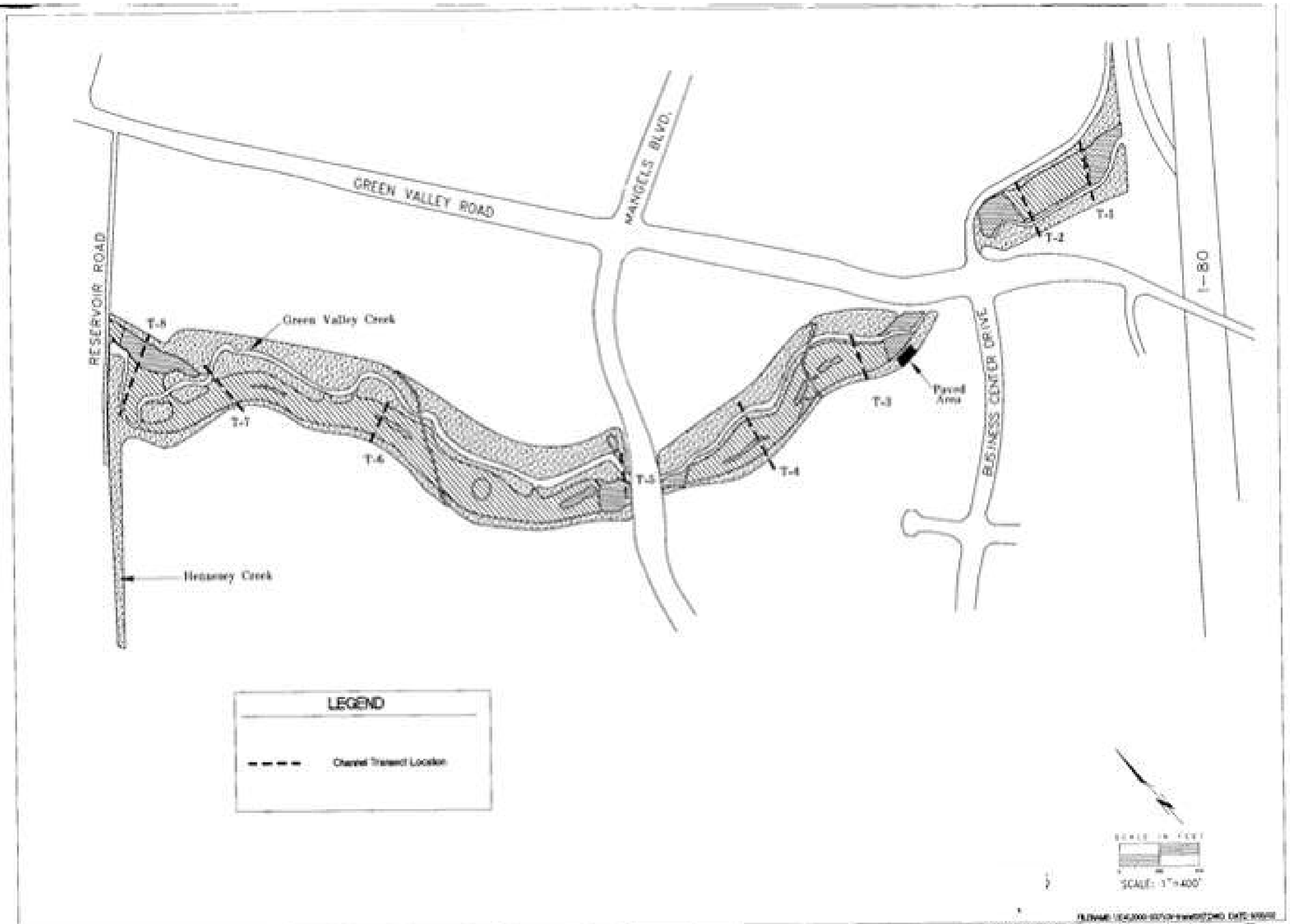


Figure 2. Survey transect locations

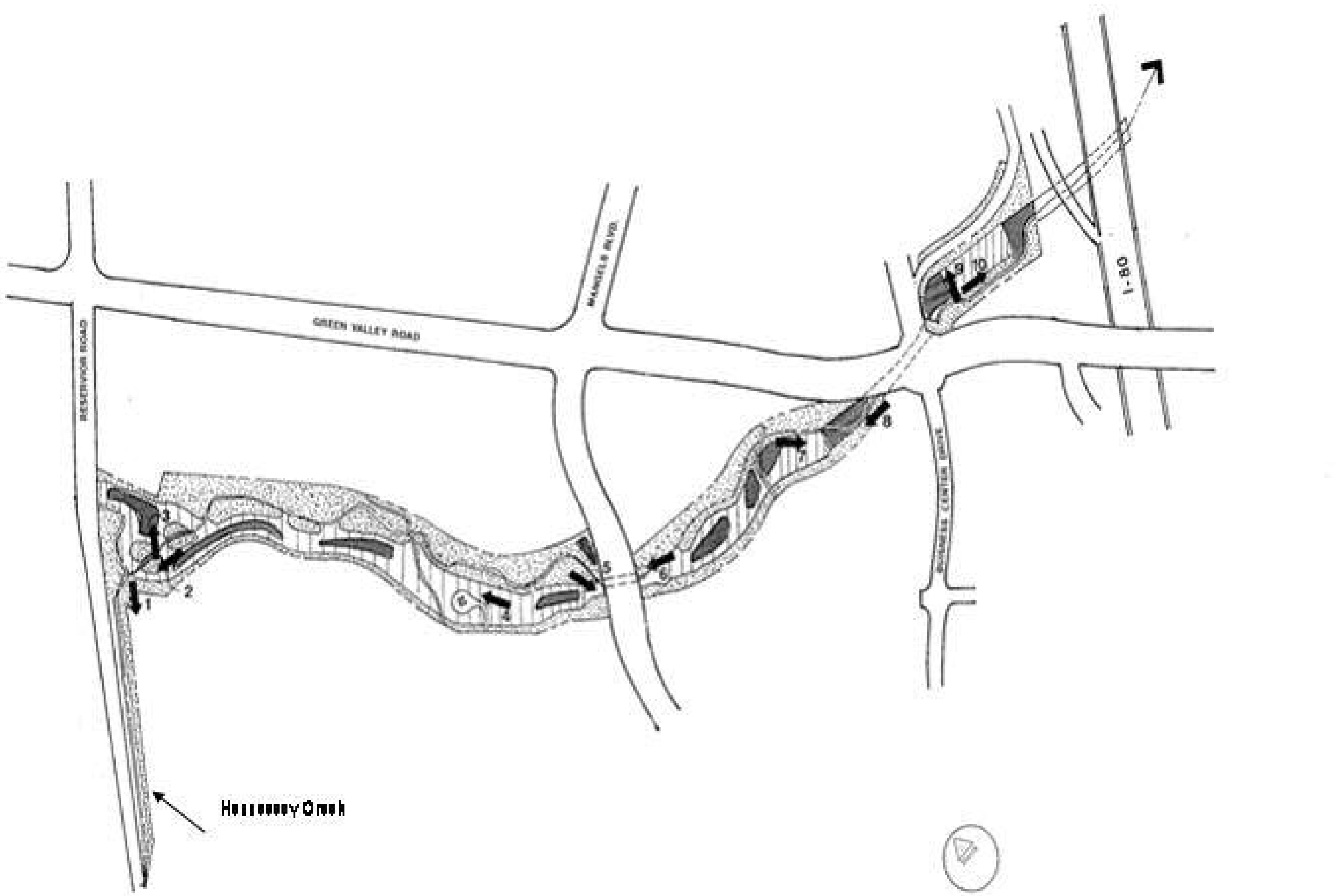


Figure 3. Photograph locations

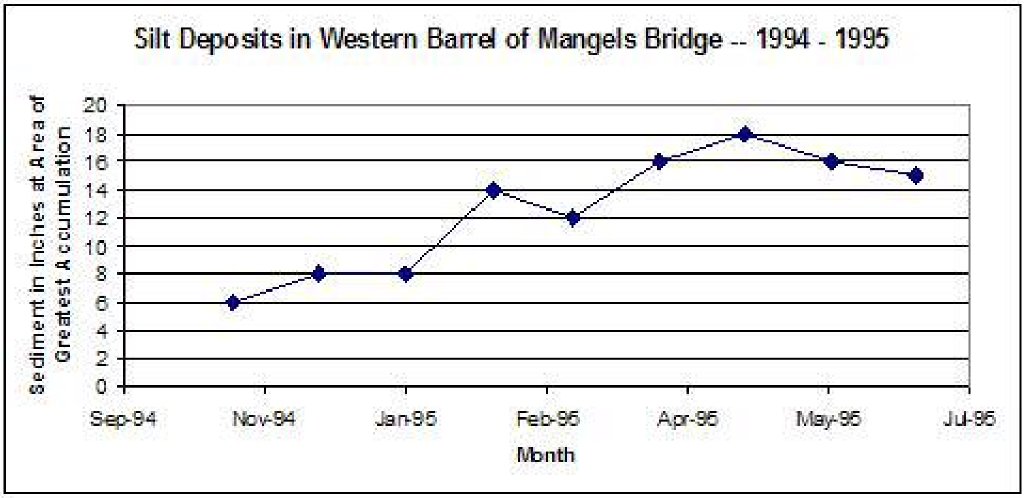


Figure 4. Recreation of Sediment Deposits on Baffles of Mangles Bridge after storms in 1995

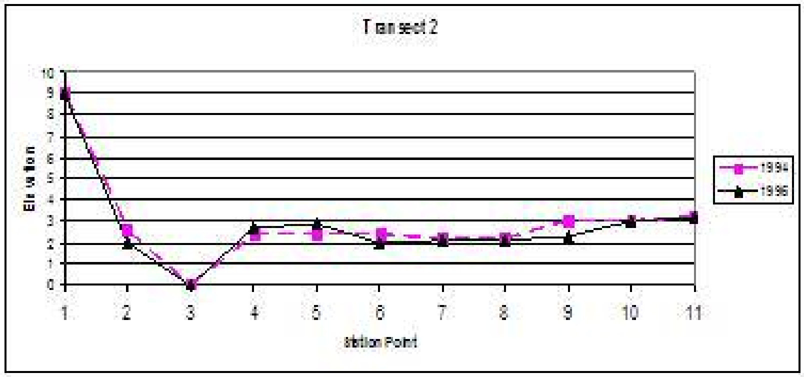
3/29/96 Silt deposits at pipe outfall at Green Valley Creek

Figure 5. Photographs of storm drains at confluence of Hennessey and Green Valley Creek after storms in the winter of 1995-1996

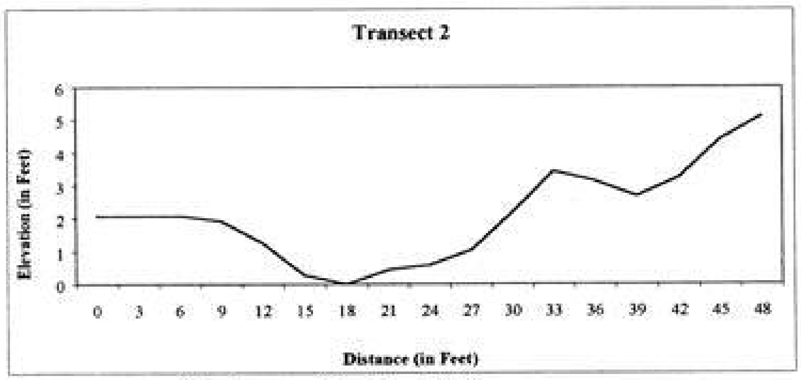
1-16-93 Hennessey Creek storm water flowing south over Reservoir Lane

Storm water flowing into inlet structure

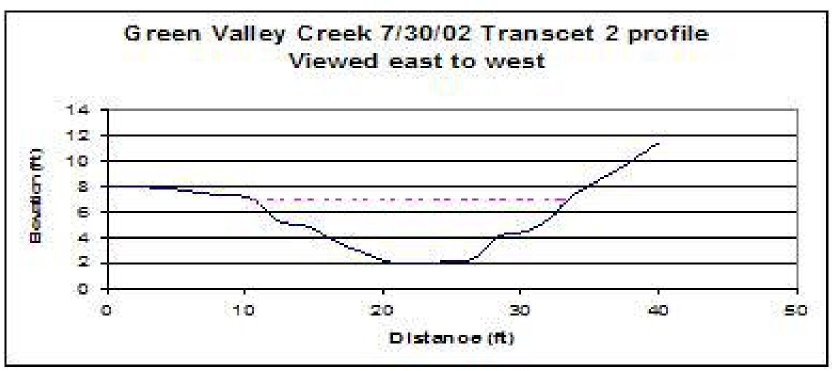
Figure 6. Photographs of Hennessey Creek flooding around storm drains, over Reservoir Rd., through the overflow terrace into Green Valley Creek during storm in winter of 1995-1996



Zentner and Zentner 1994 and 1996 surveys

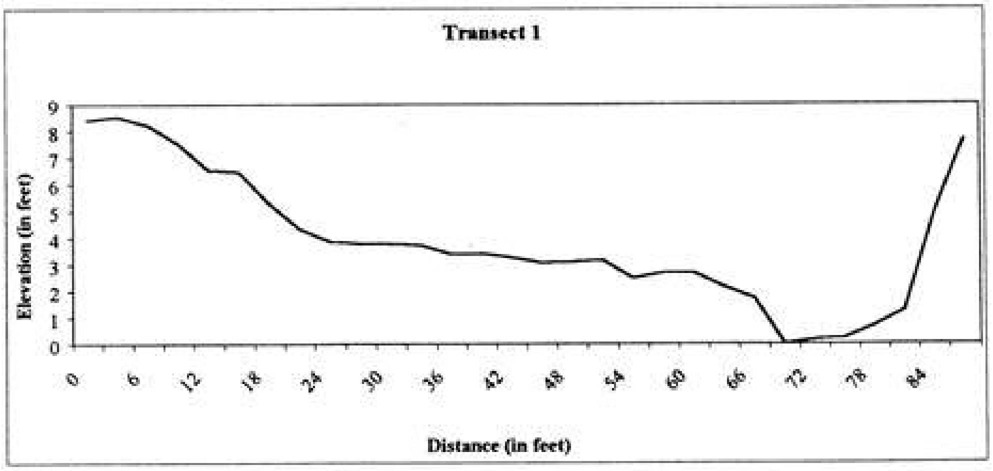


Zentner and Zentner 1998 survey

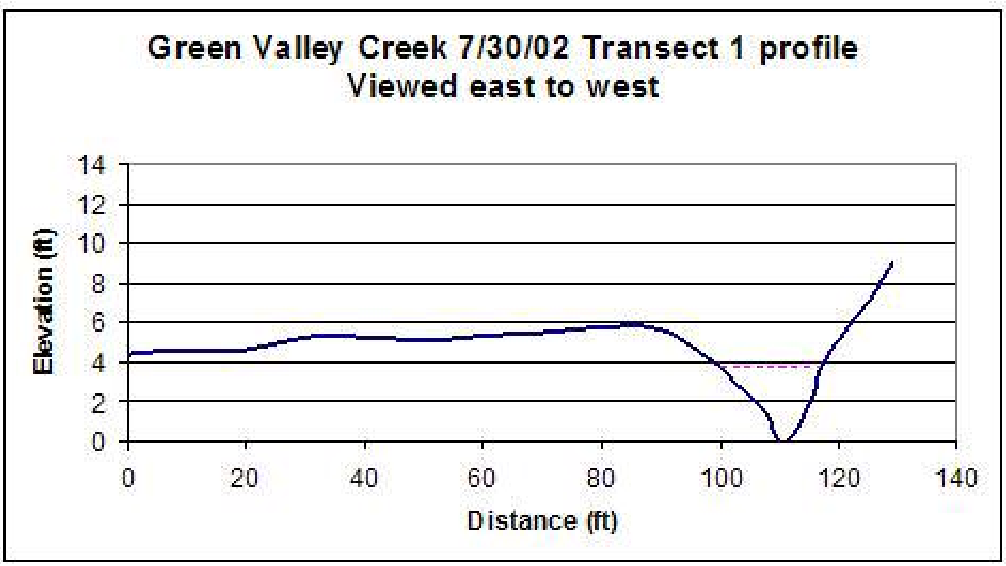


ECORP 2002 survey

Figure 7. Example of different datum used for same transect making direct compaison of surveys impossible

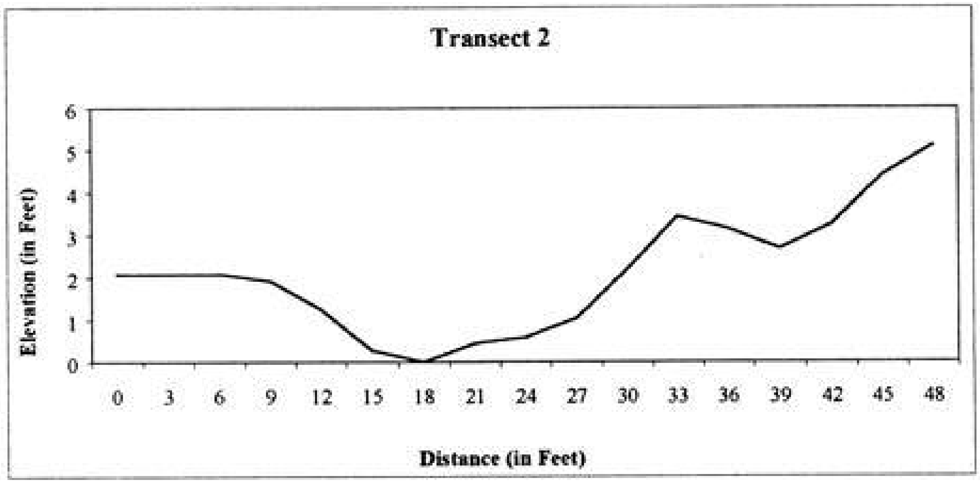


Zentner and Zentner 1998 survey

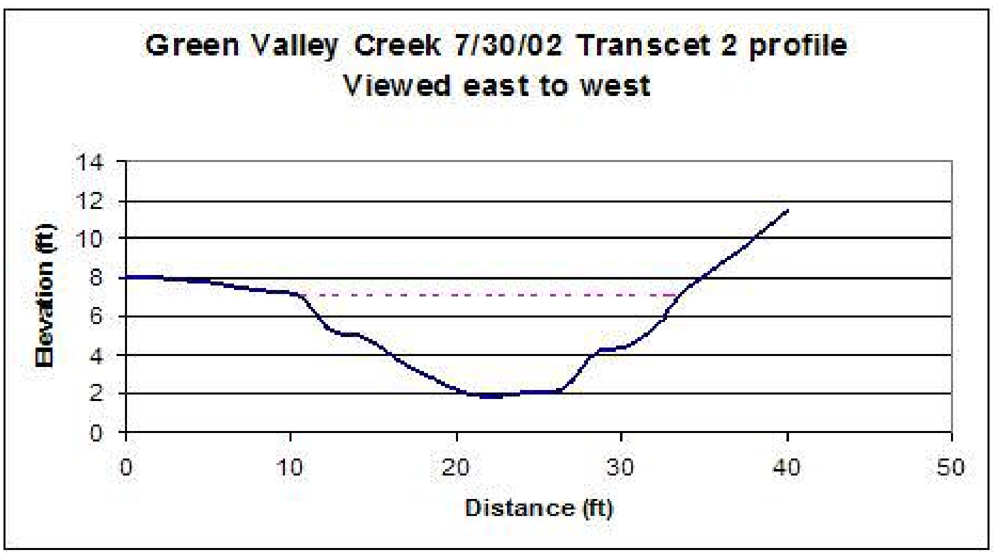


ECORP 2002 survey

Figure 8. Comparison of Zentner and Zenter's 1998 survey to ECORP's 2002 survey of transect 1

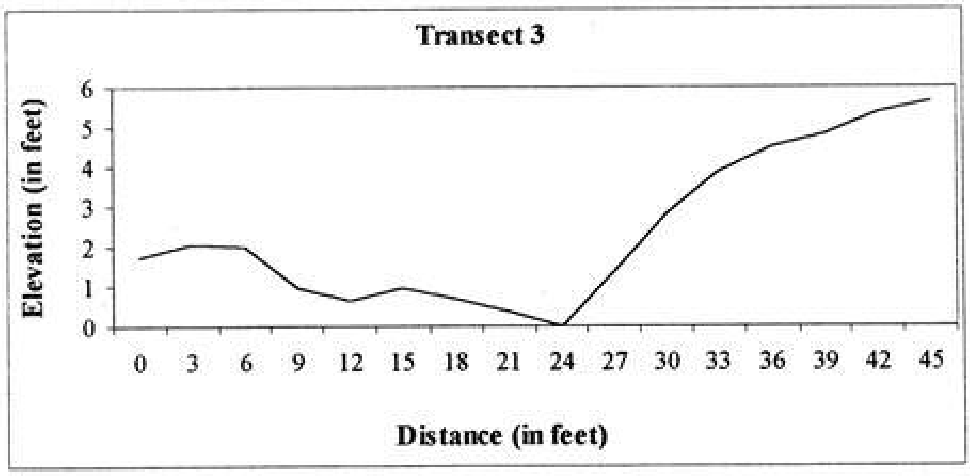


Zentner and Zentner 1998 survey

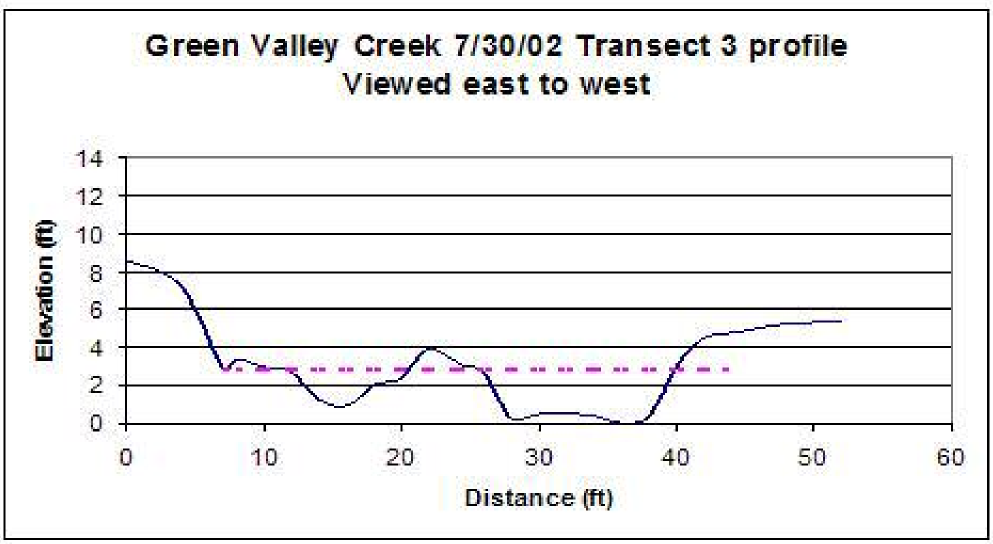


ECORP 2002 survey

Figure 9. Comparison of Zentner and Zenter's 1998 survey to ECORP's 2002 survey of transect 2

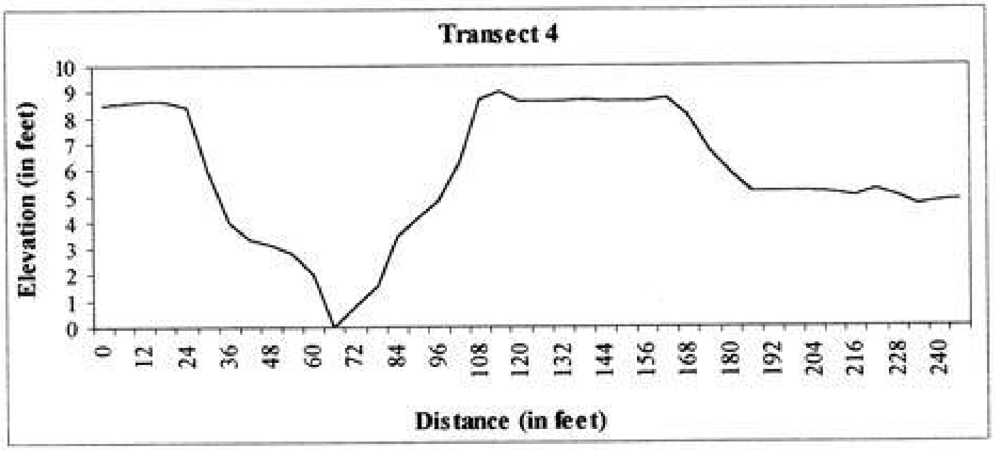


Zentner and Zentner 1998 survey

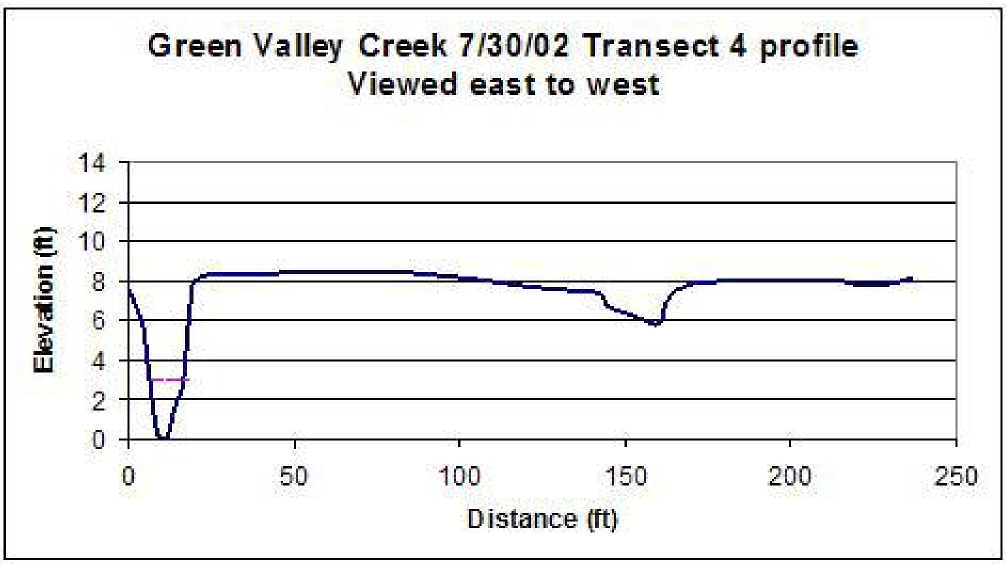


ECORP 2002 survey

Figure 10. Comparison of Zentner and Zenter's 1998 survey to ECORP's 2002 survey of transect 3

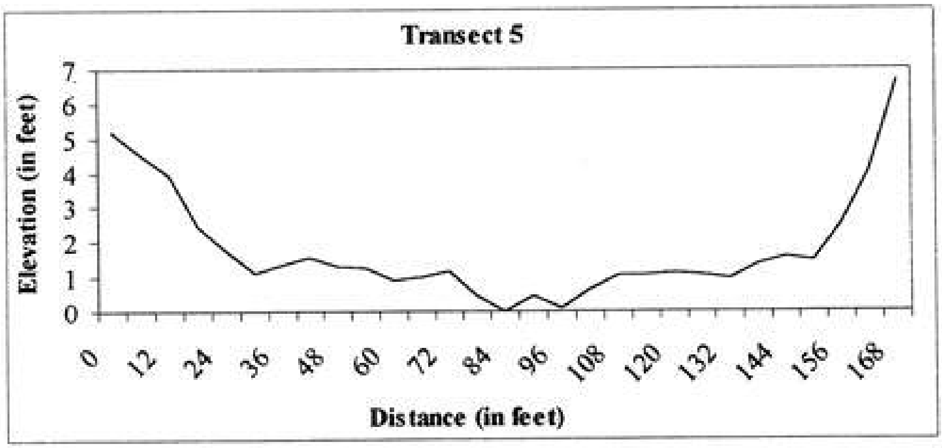


Zentner and Zentner 1998 survey

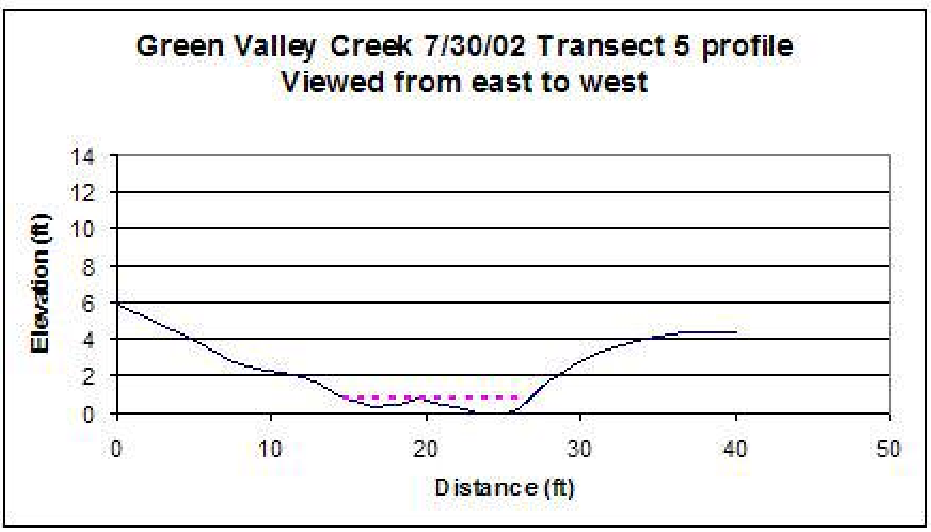


ECORP 2002 survey

Figure 11. Comparison of Zentner and Zenter's 1998 survey to ECORP's 2002 survey of transect 4



Zentner and Zentner 1998 survey



ECORP 2002 survey

Figure 12. Comparison of Zentner and Zenter's 1998 survey to ECORP's 2002 survey of transect 5

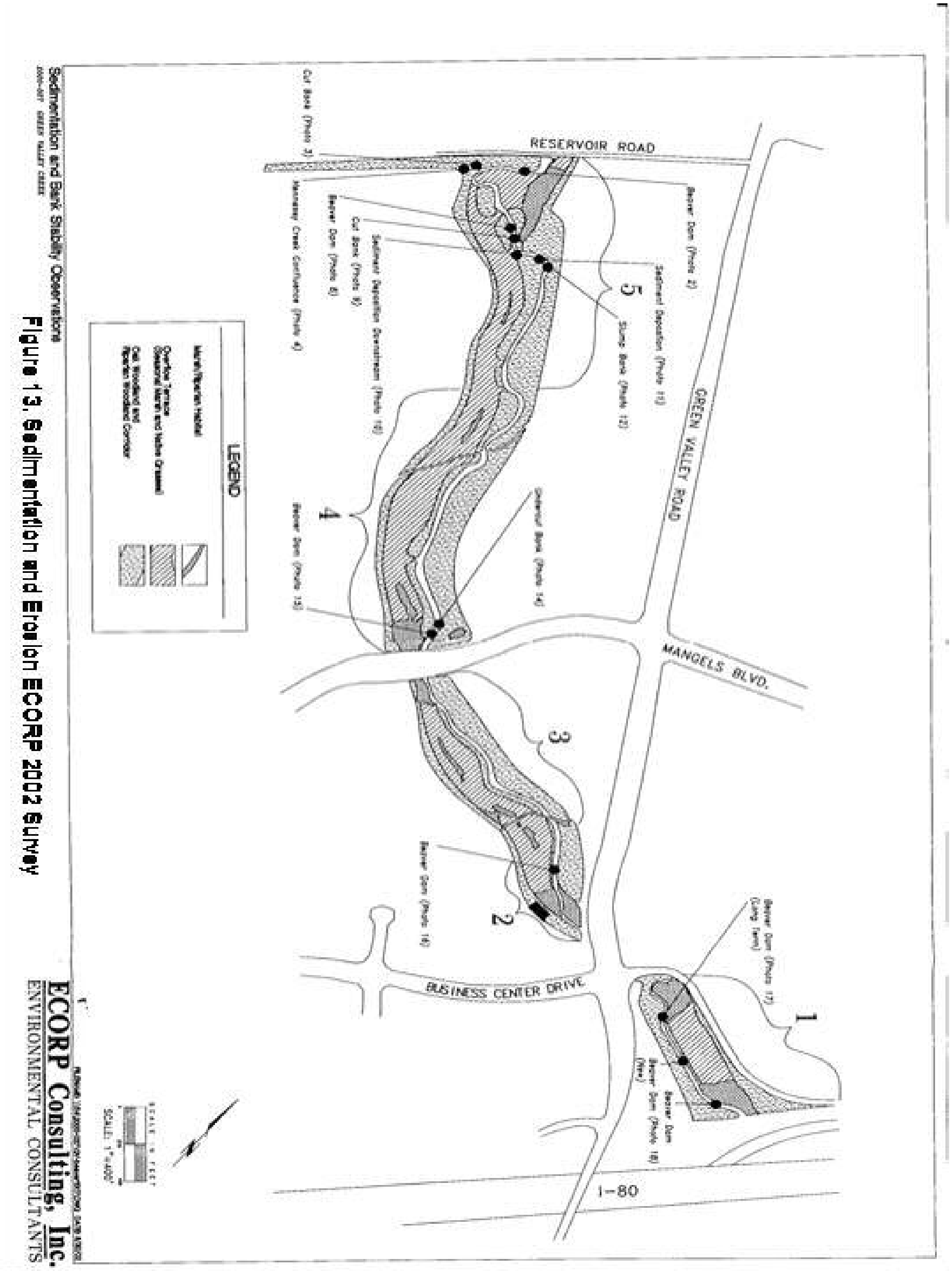


Figure 13. Sedimentation and Erosion ECORP 2002 Survey

Figure 14. Beaver dam in reach 5 and undercut eroding bank directly upstream from dam

Figure 15. Land graded by Redevelopment Agency of Fairfield for commercial development to the north of Business Center Drive.

References

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