The Implementation of the Lower Silver Creek Watershed Project

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Abstract
Lower Silver Creek in San Jose, California has been extremely altered by urbanization and is susceptible to major flood events. Multiple flood control projects have been proposed over the last thirty years and an environmentally conscious plan is currently under construction. The purpose of this study was to assess how the flood control plan of Lower Silver Creek evolved, to compare how well a built reach of the project (reach 1a) complied with the design documents, and to establish permanent benchmarks to assist future project monitoring. The first single-purpose plans for Lower Silver Creek recommended excavating the channel and lining it with concrete to prevent flooding. The most recent plan (1998) simultaneously addressed the flood problem using less concrete, introduced fish habitat, increased riparian vegetation, and attempted to return some geomorphic processes to the creek. Overall the earthen reach matched the design drawings; however the slope was an order of magnitude higher and the roughness was much lower because there was no vegetation at the time of the study. As a result the maximum velocity and shear stress were higher than designed and may result in substantial erosion. The establishment of vegetation prior to a major storm event is a major factor in the success of the project.

Introduction

Inundation of the floodplain during high flows is a natural process of rivers. However, people have ignored the potential of flooding and built homes and businesses on the floodplain in many urban areas. Traditionally, the threat of flooding was reduced by excavating the river and lining it with concrete. Recently, a number of river restoration plans have had multi-faceted goals; many projects have attempted to simultaneously solve the flood control problem and restore natural processes, such as sediment load and provision of habitat. Restoration of natural geomorphic processes is difficult in an urban river where the channel width is limited by development.

Lower Silver Creek is an example of an urbanized stream that threatens to flood developments on its floodplain. It drains 43 square miles in eastern San Jose and unincorporated Santa Clara County, California (Figure 1). The region has a Mediterranean-type climate and receives 80% of its 14 to 18 inches of mean annual precipitation between November and March.

The land-use of the Lower Silver Creek floodplain has changed several times over the last fifty years. In the early 1950's, portions of the creek were drained to reclaim wetland areas for agriculture. These drained areas were converted to residential and commercial use during the mid-1950's (United States Department of Agriculture/ Soil Conservation Service, USDA/SCS, 1983). The floodplain was subjected to continual development and was 95% urbanized as of 1998 (USDA/Natural Resources Conservation Service, USDA/NRCS, 1998).

Lower Silver Creek underwent numerous anthropogenic modifications after four significant floods during the 1950's and 60's (Santa Clara Valley Water District, SCVWD, 1975). Alterations included five enlargements of portions of the creek, the realignment of reaches of the channel, and the diversion of Upper Silver Creek to Coyote Creek (Table 1, USDA/SCS, 1983). Lake Cunningham was built as a detention basin and recreational area between 1978 and 1979 to store 590 acre-feet of water (USDA/SCS, 1983). Despite these modifications, the creek still had an insufficient flood carrying capacity. A large event, like the 100-year flood, had the potential to cause $37 million in damages (1998 dollars) and threaten the lives and homes of floodplain inhabitants (EIP Associates, 2000).

The original flood control plan, written in 1975, recommended lining most of the creek with concrete. Several other plans were proposed over the past three decades and a more environmentally sound project was under construction at the time of this study. The purpose of this study was to assess how the flood control plan of Lower Silver Creek has evolved, to compare how well a built reach of the project complies with the design documents, and to establish permanent benchmarks to assist future studies. The study focused on reach 1a, an excavated two-stage earthen channel upstream of the confluence of Coyote Creek (Figure 2).

Methods

Collection of Project Documents

We compiled flood control plans to assess the progression of the proposed modification of Lower Silver Creek. We reviewed project proposals from 1975, 1978, 1983, 1998, and 2000, summarized plan elements and compared design differences in a table. We obtained design drawings from 1998 and design alterations from 2001 for the project reach from M. Tompkins.

Photography

We conducted an initial field reconnaissance on October 4, 2003 to assess the progress of construction on the creek, to determine if the constructed reaches matched the design plans, and to take digital photographs along the entire project reach. We recorded the viewpoint, direction, and subject for all photographs, and located each viewpoint on a map. We transferred copies of the photographs to a CD.

Surveying: Cross Sections and Longitudinal Profile

On Oct. 19, 2003, we established benchmarks one and two with rebar and orange flagging on the south bank of reach 1a. We recorded the positions of the benchmarks using a GPS unit; they are located at N 37^{o}21.355’ W 121^{o}52.424’ and N 37^{o} 21.311’ W 121^{o}52.348’, respectively. We placed benchmark one south of the first storm drain outlet, near a large oak tree (Point 2, Figure 2), and benchmark two at the outside curve of the first bend in the river, near the fence (Point 4, Figure 2).

We established cross sections one and two using a 100-meter (m) measuring tape from benchmarks one and two, respectively, to the north side of bank, perpendicular to the flow of the river. We measured relative elevations at recorded points on the measuring tape with a rod and level and then drew detailed graphs of the cross sections using AutoCad 2002. We plotted a longitudinal profile of the reach using Excel and calculated the slope of the low-flow channel from the profile. We compared the surveying results and the dimensions given in the design drawings to assess potential changes in channel stability and bed-load sediment mobilization.

Results and Discussion

Comparison of Flood Control Plans

Repeated flooding along Lower Silver Creek and numerous failed flood control attempts led to several flood control plans. The first plan, by SCVWD in 1975, called for the excavation of the upper 1.7 miles of the creek to increase its flood carrying capacity from 600 cubic feet per second (cfs) to 1500 cfs. The lower portion of the creek already had the capacity to carry 1500 cfs, approximately a 32-year flood. In 1978, SCVWD wrote a second plan that proposed the excavation and reconstruction of 7.2 miles of Lower Silver Creek and 1.7 miles Thompson Creek, a tributary, to convey the 100-year flood. The plan called for a flood detention basin, Lake Cunningham, upstream of Cunningham Avenue, along with excavated earth channels, levees, concrete-lined channels, and concrete pipe (Table 2). While the SCVWD proposed channels were not built, Lake Cunningham was constructed in 1978.

A third plan, by the USDA and SCS in 1983, proposed the installation of 3.77 miles of concrete channel and 0.87 miles of earthen channel to prepare Lower Silver Creek for the 100-year flood. The plan was approved in 1983; however, objections to the project during the comment period required that the plan to be revised and resubmitted. USDA and NRCS prepared a revised plan in 1998 to increase the capacity of Lower Silver Creek to a maximum flow rate of 5,630 cfs during the 100-year flood. The 1998 plan reduced the amount of concrete channel to 0.82 miles, increased the amount of earth channel to 0.93 miles, and included 2.15 miles of vegetated block wall channel with earth over riprap. It incorporated additional acres of riparian vegetation and wetland installation, with modifications for fish habitat. One tall drop structure (5 feet) was replaced with two smaller drop structures (2 and 2.5 feet) at the confluence of Coyote Creek to allow fish passage. Other differences between the two plans are summarized in Table 3.
A negative declaration in the environmental impact statement, prepared by EIP Associates in 2000, allowed the implementation of the 1998 plan to proceed.

The flood control project on Lower Silver Creek evolved dramatically over the last thirty years (Figures 3 and 4). Flood capacity increased from a 32-year event to a 100-year event. Previous single-purpose plans were only concerned with the impacts of flooding on property and human life. The current plan simultaneously addressed environmental concerns, considered riparian habitat issues, and provided flood protection. The urban location of the creek has limited the restoration of natural geomorphic processes. However, the decreased use of concrete channelization has improved the visual quality of the creek and has allowed creation of wetlands and potential fish habitat.

Observations and Photographs

Construction began at the confluence of Coyote Creek and has been slowly progressing upstream. On October 4, 2003, construction workers were present in reaches 1a through 3a and the creek was dewatered. No construction had occurred upstream of 3a. Like many urban streams, houses, businesses and highways lined the creek. Upstream of 3a, the channel was narrow and overgrown with riparian vegetation; trash could be seen on the banks. The poor physical state of the stream was recorded in photographs 31-46, included on a CD with this report. The subject of each photograph is outlined in Table 4 and the location of each viewpoint is shown in Figures 2 and 5.

The major construction on reaches 1a through 2 was completed and water was returned to the creek by October 19, 2003. Riffles had already begun to form in portions of reach 1a (Photographs 51 and 56). The two proposed drop structures at the confluence of Coyote Creek had not been installed. However, small boulders were present in the bed just upstream of the confluence to dissipate the creek's energy. These will be removed in the future (M. Tompkins, University of California, personal communication, 2003). Irrigation pipes were already installed and vegetation planting was scheduled in reach 1a in mid-November, 2003. The channels in these reaches match the qualitative descriptions in the 1998 and 2000 reports with the exception of reach 1c (Table 2). This reach was constructed as a hybrid vegetated concrete block channel rather than as a trapezoidal concrete channel. This was unsurprising because the 2000 document noted that the channel type in this reach might be changed.

Comparison of Design Drawings and Constructed Reach

We compared the surveyed cross sections (Figures 6 and 7, Table 5) to the design drawings for reach 1a (Figure 4). The design drawings were not to scale and we were unable to obtain blueprints. As a result, we could not accurately overlay our cross sections with the designs. The majority of the available dimensions were approximately the same (Table 6). Dimensions from the 1998 and 2001 plans for the bottom width, low-flow channel depth, and right-of-way were similar to values measured in cross sections one and two. The surveyed banks were consistent with the planned slope of 0.5, except for the north bank of cross section one, where the slope was nearly 0.6. It may be difficult to establish vegetation on this steeper bank (M. Tompkins, University of California, personal communication, 2003).

The depth from the bottom of the channel to the top of the bank was designed to be approximately 18 feet. This dimension was consistent with actual measurements with the exception of the south bank of cross section one, which was only 10.2 feet high. This deviation should not affect the channel's ability to carry flood water due to its proximity to the confluence with Coyote Creek. During a large flood, Coyote Creek will inundate the area near the south bank of cross section one regardless of the height of the bank.

One major discrepancy between the designs and the surveyed cross sections was the width of the low-flow channel. The 1998 plans specified a low-flow channel that was 6 feet in width that would be held in place with willow fascines and a tri-lock block maintenance road. However, the actual width was approximately 24 feet in cross section one and 19.5 feet in cross section two. Alterations were made to the design drawings in 2001 and the low-flow channel was widened to carry channel-forming flows. The width of this sediment transport channel, unspecified in the 2001 Alteration Plans, is maintained by buried rock walls. A meandering low-flow channel with riffles and pools is expected to form 'freely' after a one- or two-year flood event and establishment of vegetation. The plan anticipates the formation of wetlands in the sediment channel, outside of the low-flow channel. This coupled with the riparian vegetation will decrease the velocity of water (M. Tompkins, University of California, personal communication, 2003).

The second difference between the designs and the survey measurements was the slope of the low-flow channel. We used the 500-foot longitudinal profile for the straight section of reach 1a (Figure 8) to determine the channel slope. The design slope was 0.0006 and the actual slope was 0.0055 to 0.0073, an order of magnitude steeper. The longitudinal profile shows a fairly constant slope until a sharp drop-off at the last measured data point. Small pools, corresponding to the last point, had formed behind the rocks at the confluence with Coyote Creek and may have exaggerated the slope at the end of the stream. The 0.0055 value is the slope of the profile calculated without including the last point. Possible explanations for the discrepancy between the design and actual slopes include poor design, local scouring at the confluence of Coyote Creek, and surveying error. The slope may decrease over time due to sediment deposition at the confluence of Coyote Creek and formation of the meandering low-flow channel within the sediment transport channel.

The lack of vegetation on the banks and in the channel was the third dissimilarity between the designs and the constructed reach. Native riparian trees and shrubs are planned for the bank slopes. Additionally, plans indicated that grass will be planted along the floodplain and willow wattles will be installed along the edges of the channel to provide channel stabilization and habitat. No vegetation had been planted at the time of this study. As a result of the lack of vegetation, the roughness in the earthen channel was lower than expected based on the design.

The combination of a higher channel bed slope and a lower roughness has multiple negative implications for this project. The maximum channel capacity, velocity, and shear stress will be significantly higher than planned, resulting in increased sediment transport and the mobilization of larger sediments. This erosion will lead to bank destabilization and could potentially wash out portions of the project. An example of erosion can be seen in photographs 58 through 61, which show the results of a burst one-inch irrigation pipe on an un-vegetated bank in reach 1a. Additional examples of erosion can be seen in photographs taken by M. Tompkins on November 9, 2003 during a rain event and by C. Keenan on November 16, 2003 after several small storms. The elevated flow during these rain events exposed the buried rock walls and caused a new channel to form around the rocks near the confluence of Coyote Creek (Photographs 63-71). It is evident from these photographs that erosion will be extensive if there is a large rain event before vegetation is planted or before vegetation is established.

Poor implementation, not poor design threatens the success of reach 1a. There were two major flaws in the project's execution. First, construction on the earthen reach was not initiated early enough for vegetation to establish itself prior to winter storms. Second, the irrigation pipes were installed in reach 1a but were never used to water the planted seeds. These two errors resulted in a lack of vegetation in the channel, which caused decreased roughness and increased erosion. Significant erosion in the earthen reaches may be averted if the winter is relatively dry and vegetation is established before a major storm.

Conclusions and Recommendations

The revised 1998 Lower Silver Creek Watershed Project plan with the 2001 Design Alterations was a vast improvement upon the 1983 plan due to its multi-purpose approach. It used far less concrete, increased riparian vegetation, introduced fish habitat, and improved the visual appearance of the channel while it addressed the threat of flooding. Allowing the low-flow channel to migrate within the sediment transport channel was an innovative attempt to restore geomorphic processes in the creek in a very urban environment. Overall, the constructed earthen channel matched the design drawings; however, the slope and roughness were significantly different. As a result, the maximum velocity and shear stress are higher than designed and may cause increased erosion and channel wash-out. The establishment of vegetation prior to a major storm event is imperative to the success of the project.

We recommend that a monitoring plan be continued for reach 1a of Lower Silver Creek. Monitoring could include resurveying cross sections one and two using the established benchmarks after large flows to assess potential changes in channel form. Other earthen reaches should also be surveyed to build a baseline data set to allow for comparison of changes in the future. Observations need to be made to evaluate the success of planned natural processes, such as the formation of pools and riffles and the establishment of a smaller channel form within the sediment channel. The establishment of vegetation and wetlands should be monitored. It is important that vegetation is well established on the banks and in the wetlands but does not encroach upon the low-flow channel. The evaluation of the project's successes and failures will allow others to improve the process of river restoration.

References

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United States Department of Agriculture/Natural Resources Conservation Service. December 1998. Lower Silver Creek Watershed Project Section 404(B)1 Alternatives Analysis & Plan Update. Davis, California. 26 pp, Appendices A-M.

United States Department of Agriculture/ Soil Conservation Service. July 1983. Lower Silver Creek, Final Watershed Plan and Environmental Impact Statement/Report. Davis, California. 113 pp, Appendices A-E.

Figure 1: Map of the Lower Silver Creek Watershed

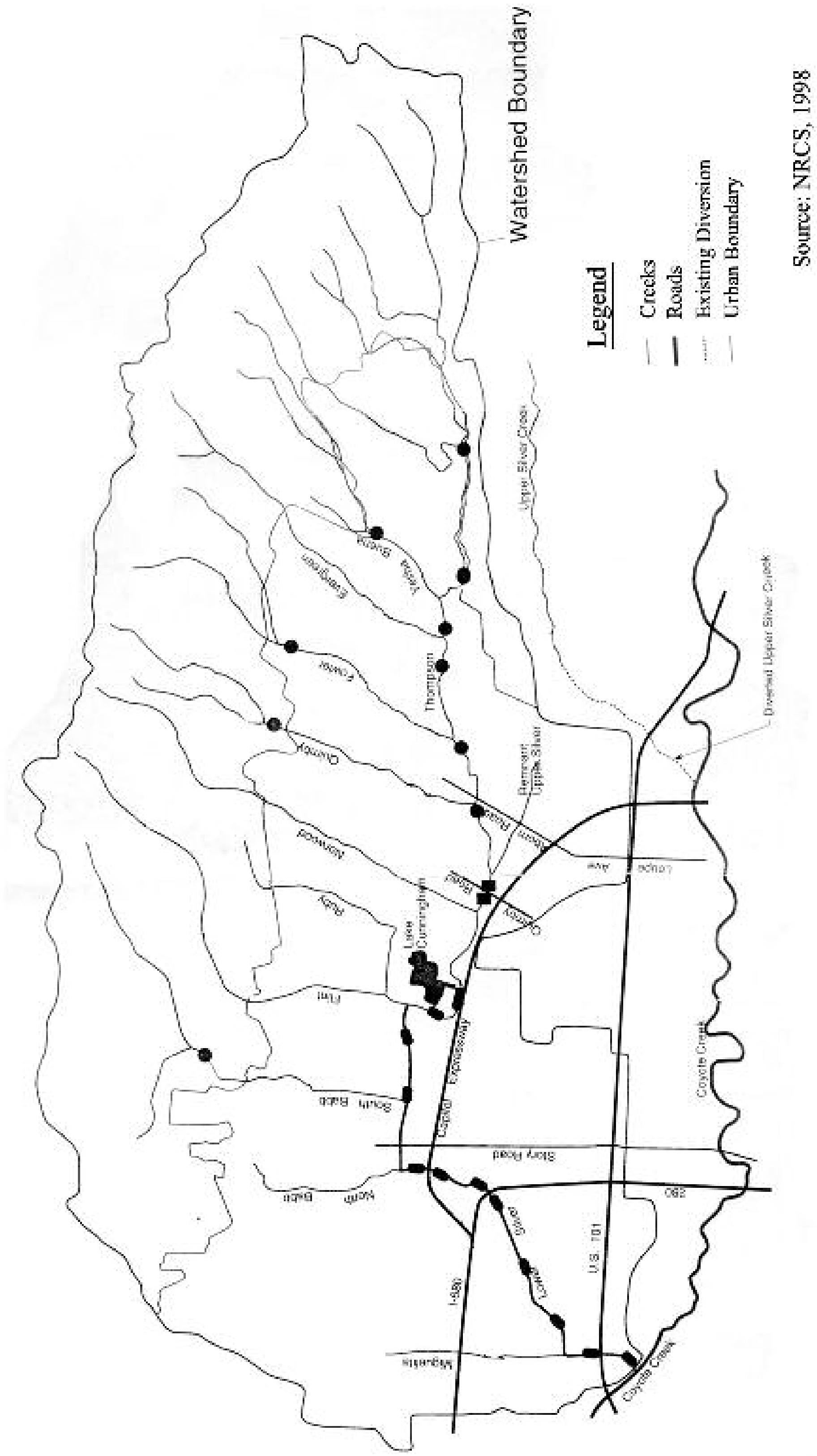


Figure 2: Location of photo stations from reach 1a–3f: Coyote Creek to I-680

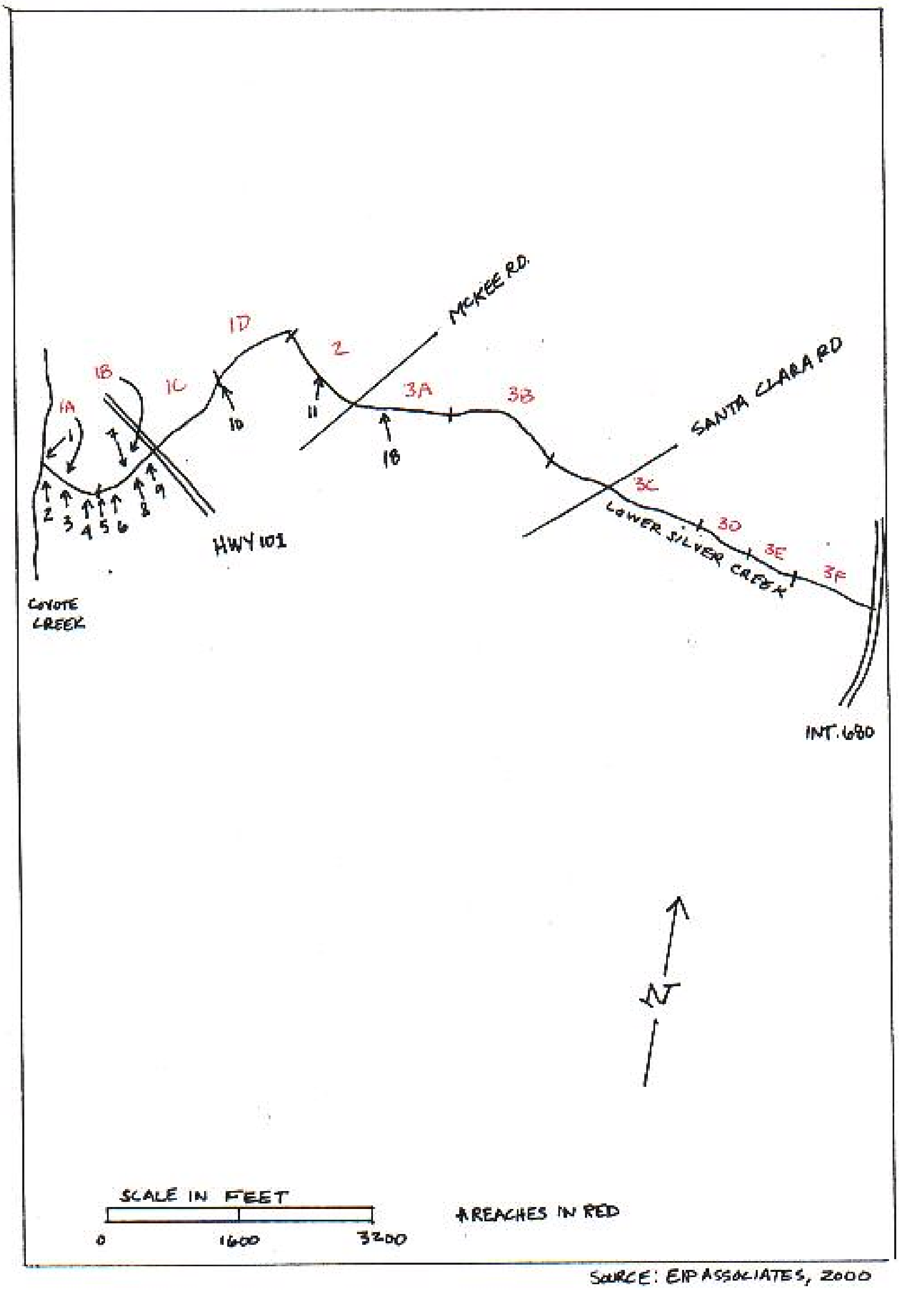


Figure 3: Evolution of the Lower Silver Creek flood control project

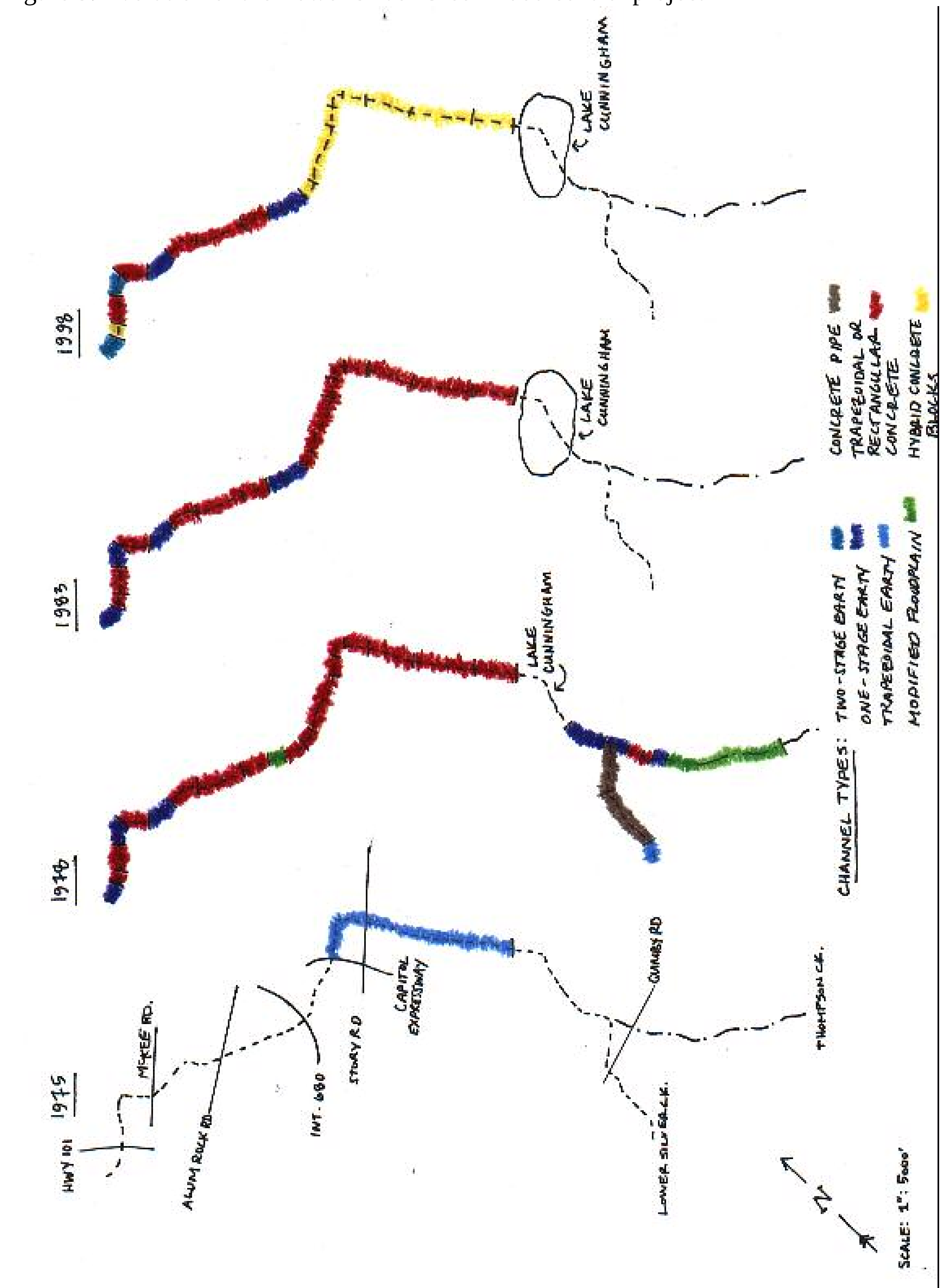
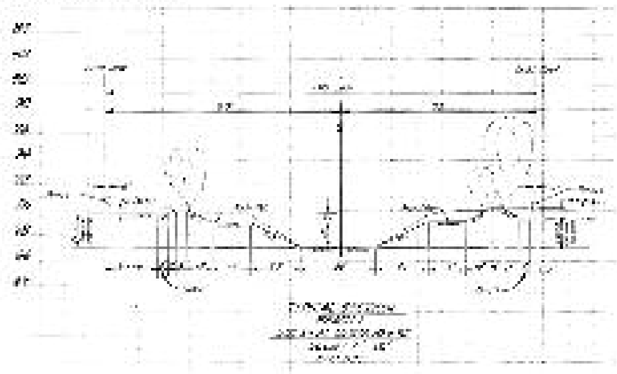


Figure 4: Evolution of reach 1a

1975: No action

1978: One-stage earthen channel

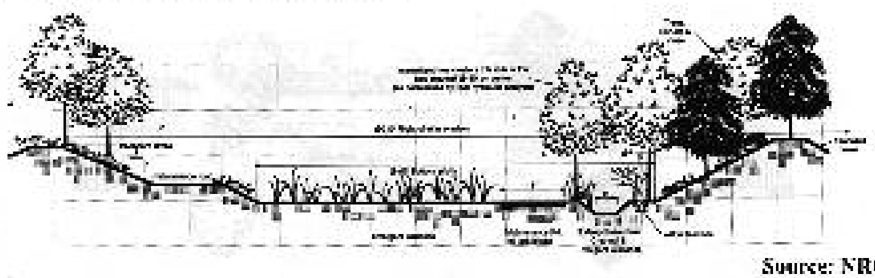


Source: SCVWD, 1978

1983: One-stage earthen channel

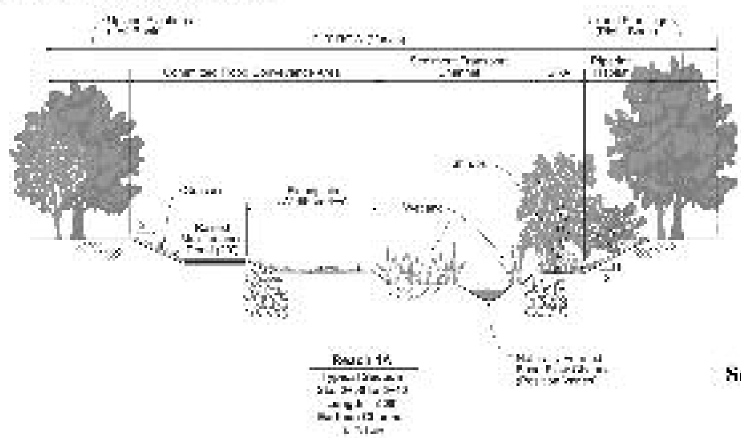
Source: SCS, 1983

1998: Multi-stage vegetated earthen channel



Source: NRCS, 1998

2001: Multi-stage vegetated earthen channel



Source: KIP, 2001

Figure 5: Location of photo stations from reach 4a–6b: I-680 to Lake Cunningham

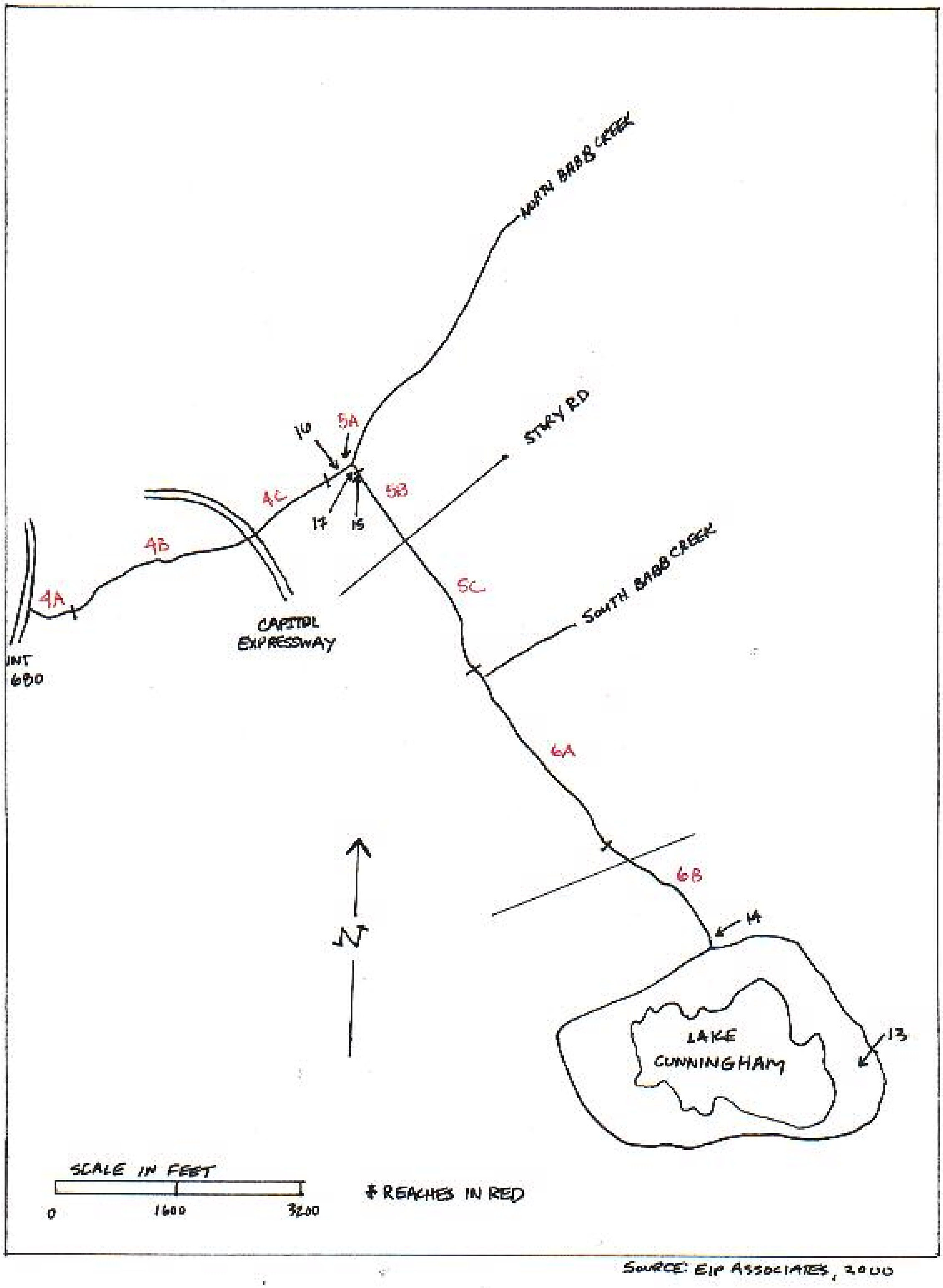


Figure 6: Cross Section One

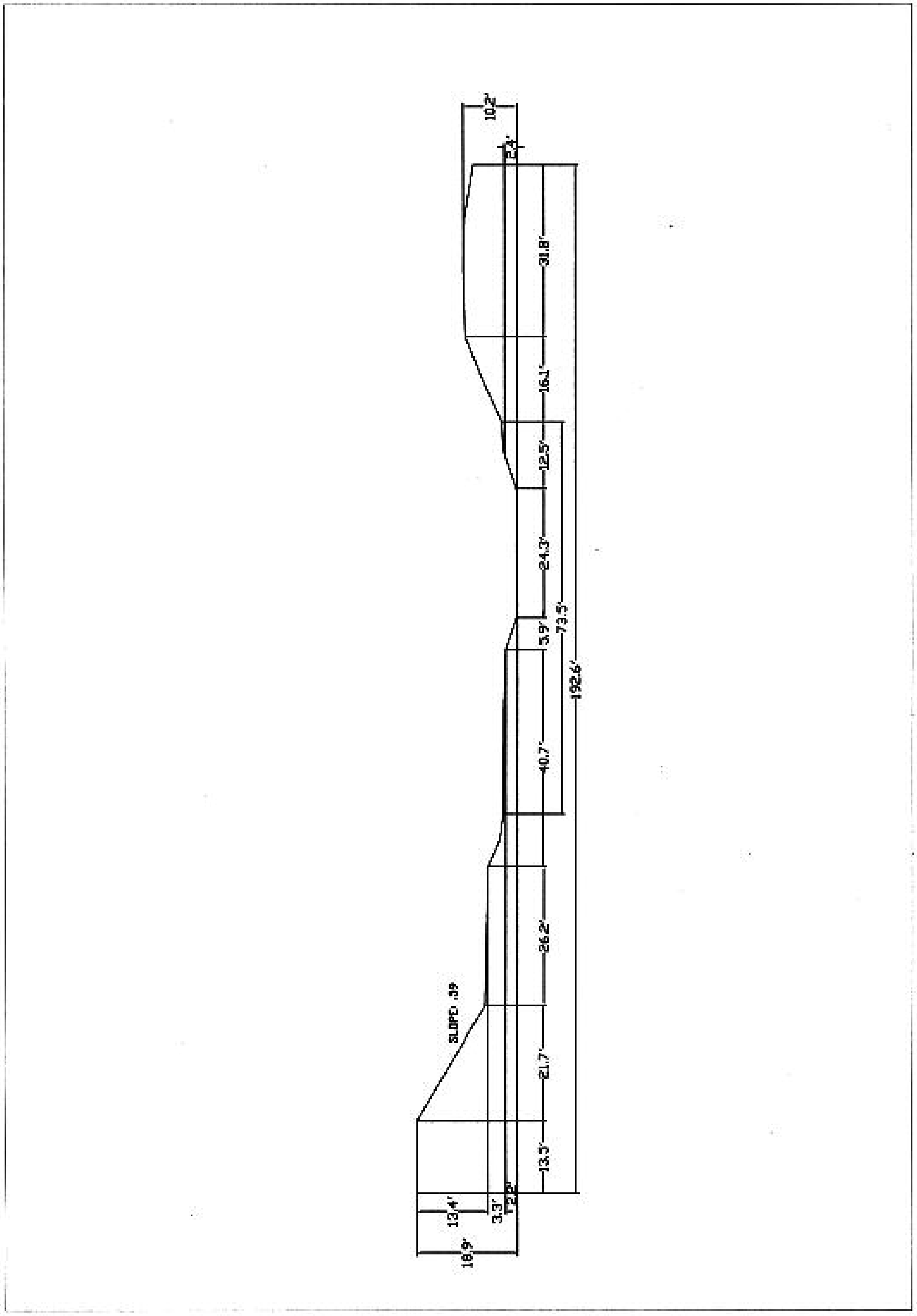


Figure 7: Cross Section Two

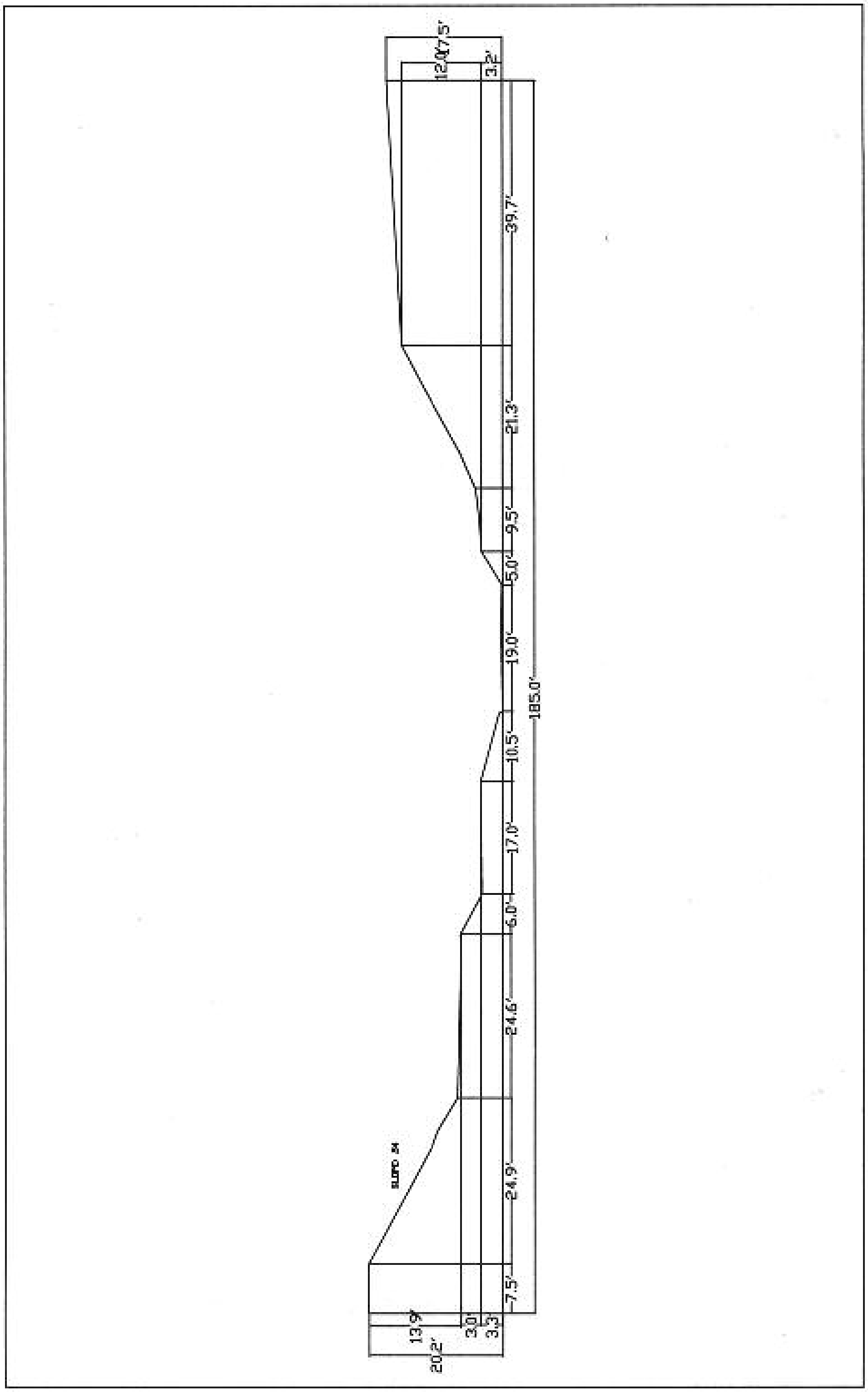
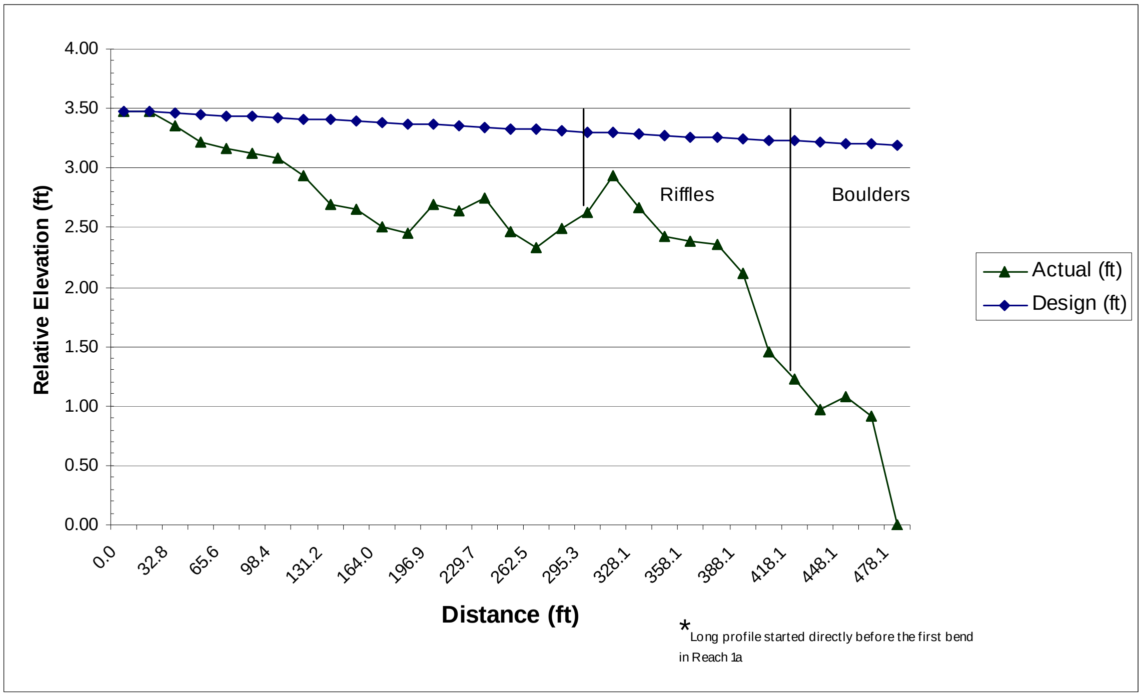


Figure 8: Longitudinal profile



Tables

Table 1: Timeline

Date	Event	Source
early 1950's	portions of LSC were diverted to reclaim wetland areas for agriculture	USDA/SCS, 1983
mid 1950's	agricultural land converted to residential and commerical uses	USDA/SCS, 1983
1952	LSC flooded	SCVWD, 1975
1955	channel enlarged from King Road to Coyote Creek	SCVWD, 1975
1955	LSC flooded	SCVWD, 1975
1956 -1958	channel enlarged from Capitol Expressway and Coyote Creek	USDA/SCS, 1983
1958	LSC flooded	SCVWD, 1975
1967	LSC flooded	SCVWD, 1975
1970 - 1972	channel enlarged from Thompson Creek to Capitol Expressway	SCVWD, 1975
1970	upper LSC diverted to Coyote Creek, channel realigned and enlarged between Capitol Expressway and King Road, Thompson Creek enlarged from Quimby Road to LSC	USDA/SCS, 1983
1975	Plan 1 written	SCVWD, 1975
1976	channel enlarged between Cunningham Ave. and Capitol Expressway	USDA/SCS, 1983
1978	Plan 2 written	SCVWD, 1978
1978 - 1979	Lake Cunningham built to store 590 acre feet, setback levees installed along Thompson Creek	USDA/SCS, 1983
1983	Plan 3 written	USDA/SCS, 1983
September 23, 1983	Original watershed agreement signed	USDA/NRCS, 1998
June, 1989	application by the Santa Clara Valley Water District for a U.S. Army Corps of Engineers Permit 404	USDA/NRCS, 1998
March, 1991	Corps public notice requesting comments issued	USDA/NRCS, 1998
April 5, 1991	objections to project by state and federal agencies, instructed to resolve concerns and resubmit application	USDA/NRCS, 1998
1998	Plan 4 written	USDA/NRCS, 1998
2001	Construction of 1998 plan began	EIP, 2000

Table 2: Comparison of reaches in the 1975, 1978, 1983 and 1998 flood control plans

Reach		Length (ft)	1975	1978	1983	1998	Condition in October, 2003
1	**a**	770	No action	Earth channel	Excavated trapezoidal earth channel	Earth channel	Constructed as planned, no vegetation
	b	530	No action	Trapezoidal concrete channel	Trapezoidal concrete channel	Hybrid concrete blocks w/topsoil over riprap	Constructed as planned, no vegetation
	c	1400	No action	Trapezoidal concrete channel	Trapezoidal concrete channel	Trapezoidal concrete channel	Constructed as hybrid block channel
	d	985	No action	Earth channel	Excavated trapezoidal earth channel	Earth channel w/floodwalls	Constructed as planned, no vegetation
2		1315	No action	Rectangular concrete channel	Rectangular concrete channel	Rectangular concrete channel	Constructed as planned
3	**a**	1600	No action	Earth channel	Excavated trapezoidal earth channel	Earth channel	Under construction as planned
	b	975	No action	Trapezoidal concrete channel	Trapezoidal concrete channel	Trapezoidal concrete channel	Pre-project state
	c	2095	No action	Trapezoidal concrete channel	Existing trapezoidal concrete channel w/floodwalls	Low flow retrofit of existing trapezoidal channel	Pre-project state
	d	655	No action	Trapezoidal concrete channel	Trapezoidal concrete channel	Trapezoidal concrete channel	Pre-project state
	e	655	No action	Modified floodplain	Excavated trapezoidal earth	Earth channel	Pre-project state
	f	900	No action	Trapezoidal and rectangular concrete channel	Excavated trapezoidal earth	Earth channel	Pre-project state
4	**a**	220	No action	Trapezoidal and rectangular concrete channel	Rectangular concrete channel	Hybrid concrete blocks w/topsoil over riprap	Pre-project state

	b	2300	No action	Trapezoidal and rectangular concrete channel	Trapezoidal concrete channel	Hybrid concrete blocks w/topsoil over riprap	Pre-project state
	c	1300	Excavated channel	Trapezoidal and rectangular concrete channel	Trapezoidal concrete channel	Hybrid concrete blocks w/topsoil over riprap	Pre-project state
5	**a**	240	Excavated channel	Trapezoidal and rectangular concrete channel	Rectangular concrete channel	Hybrid concrete blocks w/transition structure	Pre-project state
	b	860	Excavated channel	Trapezoidal and rectangular concrete channel	Trapezoidal concrete channel	Hybrid concrete blocks w/topsoil over riprap	Pre-project state
	c	1830	Excavated channel	Trapezoidal and rectangular concrete channel	Trapezoidal concrete channel	Hybrid concrete blocks w/topsoil over riprap	Pre-project state
6	**a**	1480	Excavated channel	Trapezoidal and rectangular concrete channel	Trapezoidal concrete channel	Hybrid concrete blocks w/topsoil over riprap	Pre-project state
	b	2540	Excavated channel	Trapezoidal and rectangular concrete channel	Trapezoidal concrete channel	Hybrid concrete block w/earth bottom	Pre-project state

Table 3: Comparison of elements of 1983 and 1998 plans

Factor	**1983**	**1998**
Length of Project	4.64	4.64
Flood Protection Provided (x-year flood)	100	100
Multi-stage vegetated earth channel (miles)	0.87	0.93
Vegetated block wall channel w/earth or earth-covered riprap bottom (miles)	0	2.15
New trapezoidal concrete channel (miles)	3	0.57
New rectangular concrete channel (miles)	0.5	0.25
Existing rectangular concrete channel w/ floodwalls (miles)	0.4	0.4
Installed riparian vegetation (acres)	6.6	14
Wetland area (acres)	8.9 (6.1 in concrete sections)	6
Fish structures	none	continual low-flow channel, resting pools, rock vortex wiers and riffle sections
Drop structure(s) near Coyote Creek	one (5 ft)	two (2.0 and 2.5 ft)
Right-of-way required (acres)	5.6	7
Flood flow channel capacity (cfs)	3,600 - 6,100	3,600 - 5,630

Table 4a: Photograph archive, October 4, 2003

Lower Silver Creek Photo Archive				
Entire Project Area				
October 4, 2003				
#	**Pt**	**Viewpoint**	**Dir**	**Picture**
1	1	Confluence of Coyote/Silver	US	Confluence of Coyote/Silver
2	1	Confluence of Coyote/Silver	US	Confluence of Coyote/Silver
3	1	Confluence of Coyote/Silver	-	Confluence of Coyote/Silver
4	1	Confluence of Coyote/Silver	DS	Confluence of Coyote/Silver
5	1	Coyote Creek	DS	DS of confluence
6	1	just US of confluence of Coyote Creek	US	1A
7	2	South side bank of 1A	DS	confluence
8	3	South side bank of 1A	US	Construction in 1A
9	4	South side bank of 1A	DS	1A
10	4	South side bank of 1A	DS	1A
11	5	South side bank of 1A	US	Wooster Br 1A/1B
12	5	South side bank of 1A	US	Wooster Br 1A/1B
13	5	South side bank of 1A	US	Hybrid Veg Blocks
14	6	Wooster Bridge	US	1B
15	6	Wooster Bridge	DS	Detail of Hybrid Veg Blocks
16	6	Wooster Bridge	DS	1A/1B
17	7	Railroad bridge in 1B	US	1B/Hwy 101
18	7	Railroad bridge in 1B	DS	1B/Wooster Br.
19	8	Below Railroad Bridge in 1B	-	Large Rocks
20	9	South bank between RR/101	US	1B/1C
21	9	South bank between RR/101		Constrution in 1B
22	10	N 33 St. intersects w/stream	DS	1C
23	10	N 33 St. intersects w/stream	US	1D
24	11	Bridge parallel to McKee	DS	2
25	11	Bridge parallel to McKee	US	2/McKee Rd
29	13	SE side of L. Cunningham		Lake
30	13	SE side of L. Cunningham		Lake
31	14	Cunningham Bridge	DS	6B
32	14	Cunningham Bridge		N sign
33	14	Cunningham Bridge	US	Confluence of creek/lake
34	14	Cunningham Bridge	US	Birds at confluence
35	14	Cunningham Bridge	US	Wetland below lake
36	14	Cunningham Bridge	US	Wetland below lake

37	14	Cunningham Bridge		S sign
38	14	Cunningham Bridge	DS	6B
39	15	Lyndale Bridge	DS	ducks in 5A
40	15	Lyndale Bridge	US	5A/5B
41	15	Lyndale Bridge	DS	Confluence 5A
42	16	Confluence of N.Babb/Silver	US	Confluence 5A
43	16	Confluence of N.Babb/Silver	DS	Silver Creek 5A/4C
44	17	Upstream of Confluence(43)	US	Lyndale Bridge
45	15	Lyndale Bridge	US	Trash in stream
46	15	Lyndale Bridge	US	Trash in stream
47	18	Bridge in Plata Arroyo Park	DS	3A
48	18	Bridge in Plata Arroyo Park	US	3A

Table 4b: Photograph archive, October 19, 2003

Lower Silver Creek Photo Archive				
Reach 1A				
October 19, 2003				
#	**Pt**	**Viewpoint**	**Dir**	**Picture**
49	1	Confluence of Coyote/Silver	DS	Confluence of Coyote/Silver
50	1	Confluence of Coyote/Silver	DS	Confluence of Coyote/Silver
51	2	South bank, US of Coyote	-	Riffles forming in bed of channel
53	2a	North bank, US of Coyote	-	Pipe draining nearby housing development in 1A
54	2a	North bank, US of Coyote		Same drainage pipe
56	2	South bank, US of Coyote	US	1A, transition from smooth bed to riffles
57	1	Confluence of Coyote/Silver	DS	Confluence of Coyote/Silver
58	3	South bank	DS	Blowout from an irrigation pipe
59	3	South bank	DS	Sediment from pipe blowout
60	3	South bank	US	Sediment from pipe blowout
61	3	South bank	US	Blowout from an irrigation pipe
62	1	Confluence of Coyote/Silver	DS	1A

Table 4c: Photograph archive, November 16, 2003

Lower Silver Creek Photo Archive				
Reach 1A				
November 16, 2003				
#	**Pt**	**Viewpoint**	**Dir**	**Picture**
63	3	South bank	US	1A, after 1 year event
66	3	South bank	-	Riffle formation
67	2	Confluence of Coyote/Silver	DS	New channel formation
68	2	Confluence of Coyote/Silver	DS	New channel formation
70	3	South bank	US	1A, after 1 year event
71	3	South bank	US	1A, after 1 year event

Table 5a: Cross section 1 looking downstream beginning on left bank

Cross section 1	
Station (ft)	**Relative elevation (ft)**
0.0	8.23
9.8	9.91
19.7	10.18
31.8	9.82
39.4	6.78
47.9	2.89
51.2	2.72
54.1	2.39
60.4	0.23
61.7	0
70.5	0.17
83.3	0.07
84.6	0.21
90.6	2.24
101.7	2.52
121.4	2.63
126.3	3.33
131.2	5.51
157.5	6.08
162.4	9.14
164.0	9.92
179.1	18.94
192.6	18.84

Table 5b: Cross section 2 looking downstream beginning on left bank

Cross-Section 2	
Station (ft)	**Relative elevation (ft)**
0.0	17.53
39.7	15.19
45.9	11.87
55.8	6.41
61.0	4.09
65.6	3.49
70.5	3.21
75.5	0.11
82.0	0.23
88.6	0.06
94.5	0.00
94.8	0.48
105.0	3.27
122.0	3.09
128.0	6.36
131.2	6.27
152.6	6.75
157.5	9.81
160.1	10.74
177.5	20.23
185.0	20.23

Table 5c: Longitudinal profile of straight portion of reach 1a beginning upstream

Long Profile	
Station (ft)	**Relative elevation (ft)**
0.0	3.48
16.4	3.48
32.8	3.35
49.2	3.22
65.6	3.16
82.0	3.13
98.4	3.09
114.8	2.94
131.2	2.70
147.6	2.65
164.0	2.50
180.4	2.45
196.9	2.70
213.3	2.64
229.7	2.75
246.1	2.47
262.5	2.33
278.9	2.49
295.3	2.62
311.7	2.94
328.1	2.66
343.1	2.42
358.1	2.38
373.1	2.36
388.1	2.11
403.1	1.45
418.1	1.23
433.1	0.97

Table 6: Comparison of design dimensions to measured dimensions

	Plan	**actual CS1**	**CS2**
Slope of low-flow channel	0.0006	0.0055 -.0073	0.055 - 0.0073
Right of way (ft)	210	192.6	195
Base (ft)	65	73.5	61
Manning's n	0.043	0.022	0.022
Depth to lowest bank (ft)	18.9	10.2	17.4
Depth to highest bank (ft)		18.7	20.2
Depth of low flow channel (ft)	3	2.3	3.3
Width of low flow channel (ft)	6	24.3	19.3
Slopes of channel bank	0.5	0.5937	0.5407