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STOECKER ECOLOGICAL
NATURAL RESOURCE ASSESSMENT AND RESTORATION SERVICES

July 31, 2008

To: Mary Larson
Senior Fisheries Biologist
California Department of Fish and Game

Subject: Horse Creek Post Dam Removal Monitoring Survey- 2008
PSMFC Contract No. A06-S2 / Grant Agreement No. P0610528

Dear Mary,

We have completed a post dam removal monitoring survey and establishment of long term monitoring benchmarks at the Horse Creek Dam Site. The findings are summarized in this document.

Our overall conclusion is that while demolition of the dam removed a significant impediment to fish passage, significant mobilization of the stored upstream sediment has yet to occur. Since demolition of the dam in October 2006, a small wedge of sediment has eroded and a kickpoint with a 3.7-foot drop has formed. The slower than expected channel incision is likely a result of the wide shallow upstream channel, naturally cemented channel substrate, stabilization of sediment from root networks, and increased sediment delivery from the watershed due to the 2006 wildfire in the Horse Creek basin.

At this time there remains a barrier to upstream migrating salmonids, but the knickpoint and associated drop should become more passable in time as additional material mobilizes and the headcut retreats upstream, reducing the channel gradient.

For your reference the project reach coordinates are listed in the report and are: Downstream (N 34° 50' 7.27" / W 120° 1 '5.94") and Upstream (N 34° 50' 21.92" / W 120° 1' 0.27")

It has been a pleasure working on this project.

Sincerely,

Antonio Llanos, P.E.
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Background

On October 20, 2006 a defunct dam located on Horse Creek, a tributary to the Sisquoc River within Santa Barbara County was demolished using explosives. The 4.5 foot tall and 60 foot wide dam was built in 1968 in the Los Padres National Forest (LPNF) on the edge of the San Rafael Wilderness Boundary. The following winter the region experienced a large flood event, estimated to have between a 10 and 25-year return period. Anecdotal and field evidence suggests that the basin behind the dam completely filled-in with sediment during the first few winters. Over time the downstream channel incised below the dam creating an overall drop of more than 8 feet over the dam face.

Horse Creek and the Sisquoc River are designated critical habitat for the Federally Endangered Southern Steelhead. The dam removal project was initiated as an effort to improve upstream passage for fish and other aquatic organisms.

In preparation for the dam removal, Stoecker Ecological (SE) and Michael Love & Associates (MLA) conducted a geomorphic assessment of the proposed dam removal project (MLA, September 7, 2005). As part of the study, the channel profile and cross sections were surveyed to document the pre-project condition of the stream channel and estimate the potential sediment delivery to the Sisquoc River. The pre-project survey found the small basin formed by the dam was filled-in completely with sediment. The sediment wedge from the dam extends over 1,000 feet upstream. The study estimated that roughly 15,400 cubic yards of sediment stored behind the dam would be released following dam removal, and the stored sediment would likely be mobilized relatively quickly during large flow events. In July 2006, shortly before the dam was demolished, a wildfire burned approximately 2,000 acres within the upper portions of the Horse Creek watershed (Per. Com., Kevin Copper, Forest Biologist, LPNF).

The final implemented project involved demolition of the dam using explosives and allowing natural sediment transport processes to regrade the upstream channel. On June 26th 2007, Stoecker Ecological conducted a post-project survey and determined that after the first winter, which experienced extremely low precipitation (only 7 inches fell at nearby Rancho Sisquoc) and no significant flow events, very little sediment behind the former dam was mobilized. In 2007 an incision measuring 7.5 feet wide and 4 feet deep extended 21 feet upstream. This represented mobilization of an estimated 19 cubic yards of stored material.

The second year following demolition (water year 2008) the Sisquoc River and its tributaries experienced several large flow events, as demonstrated by observed field evidence and recorded peak flows in other streams and rivers within the region.

This memorandum documents the follow-up survey conducted by SE and MLA in 2008 to quantify changes to the channel following the second winter since removal of the dam and establish benchmarks for future monitoring efforts.

Purpose of Geomorphic Monitoring

Continued monitoring of the channel's response to demolition of the dam is expected to provide information useful in planning for future dam removal projects. Some of the questions this geomorphic monitoring may assist in answering include:

- How accurate were the methods used to estimate the volume and rate of sediment mobilized and the resulting shape of the channel upstream of the dam?

- What is the nature of sediment release in drier hydrologic regimes? Much of the information currently available about sediment release from dam removal originates from areas with wetter hydrologic regimes. The Horse creek site represents one of the only studied dam removals in the drier southern California climate.

- Will the channel reestablish its historic location, and how long will it take?

- Was the decision to allow uncontrolled release of the stored sediments appropriate, or should other methods be used to address channel response? If stored material is left in place, but does not rapidly flush downstream, impacts to downstream habitat are limited but a passage impediment may still remain for an unknown duration of time.

- How should the effect of soil cementation and root structure be considered in the assessment of sediment removal?

A better understanding of these channel dynamics will help improve analysis and decision-making for future barrier removal projects.

Survey Methods

On April 17th and 18th, 2008 Matt Stoecker of SE and Antonio Llanos of MLA resurveyed the channel profile and cross sections established in 2004. The survey was conducted using the tape and level method. Previous benchmarks were relocated to overlay current and previous surveys. Rebar was installed at the ends of each of the six cross sections to provide permanent benchmarks for future surveys. The longitudinal profile of the channel extended 1,300 feet, from the confluence with the Sisquoc River to 460 feet upstream of the demolished Horse Creek Dam. All six cross sections were resurveyed.

Plots of the profile and cross sections and GPS coordinates of the cross section monuments are provided.

Measured Channel Changes

The sediment stored upstream of the demolished dam remains largely unchanged since the pre-project survey. Headward migrating incision of the channel extends about 40 feet upstream of the old dam face (Figure 1). The newly incised channel has an average slope of 7.5% and width of 14 feet. At the upstream end of this incising channel is a distinct knickpoint with a 3.7 foot vertical drop.

Figure 1 – New channel incised through the dam deposits. Photo was taken from approximately 20 feet from the old dam face. The knickpoint is characterized by a 3.7 feet drop and a 7.5 % channel slope for 45 feet.

Figure 2 – Newly exposed stratigraphy of sediments stored immediately upstream of the demolished Horse Creek Dam.

Calculated using the end-area method, an estimated 120 cubic yards of sediment has been released since the dam was demolished. This represents less than 1 percent of the estimated 15,400 cubic yards of stored sediment expected to be mobilized. Some of this material has been deposited immediately downstream but most of it appears to have been transported out of Horse Creek. The depositional area extends approximately 35 feet downstream of the demolished dam, filling in the plunge pool and forming a short section of braided channel.

Observations of the banks along the newly incised channel reveal the cemented nature of the material stored behind the dam and network of fine roots. The cementation is likely a result of the high mineral content of the water. The incision through the upstream sediment also revealed the vertical layering of the material as it deposited behind the dam (Figure 2). The bottom most layer is about 9 inch thick and consists of coarse relatively clean gravels. The elevation at the top of this layer is close to the elevation of the assumed pre-dam channel bed at this location, as shown in the pre-demolition report (MLA, 2005). The bottom layer is overlaid with a 15 inch thick layer of coarse cobbles and gravels mixed with fine sediment. This is presumed to be the initial material deposited after construction of the dam in 1968, and may have all been delivered during the single large flood event in January 1969 that followed the Wellman fire of 1966. On top of this layer is a 15 inch thick layer of fine sediment that may have been delivered shortly after the dam was constructed. It is overlaid by a 30 inch thick layer dominated by coarse gravels and cobbles. This stratification is common behind dams, as the larger material initially deposits at the upstream end of the basin and fines settle near the dam. As the basin fills in, larger material is more easily transported downstream to the dam site.

During the survey Red-legged and Pacific Tree frogs were both observed utilizing habitat at the former dam site.

Discussion

The Zaca Wildland Fire in July and August of 2007 burned a significant portion of the Sisquoc Basin, but none of the Horse Creek Watershed. While assessing the impacts of the fire was not a part of this study, the impacts to the mainstem Sisquoc River were noteworthy. The highly erosive soils of the basin have supplied large quantities of sediment to the mainstem as evidenced by the uniform channel bed, sand covered river bars, and infilling of pools with fine material along Manzana Creek and the Sisquoc River at Horse Creek.

Although Horse Creek experienced large flows during the winter of 2008, as clearly indicated by field evidence and USGS gage information for Sisquoc River, there was only limited channel adjustments and mobilization of the stored materials. There are several possible reasons for the lower than expected sediment mobilization.

The wide braided channel upstream of the dam site reduces stream power, limiting its ability to erode and transport sediment. The upstream channel is shallow and shows clear evidence of recent flow in side channels along both valley edges.

The surrounding hillslopes provided a high sediment load after the 2006 fire in the Horse Creek Basin, as evident by the veneer of fine grain material newly deposited over the coarse gravel bars upstream of the dam. Transport of these sediments may have exceeded the sediment transport capacity of the channel, reducing its ability to erode the channel bed.

Additionally, the cemented nature of the sediment upstream of the demolished dam, likely caused by high mineral content in the water, requires additional force to mobilize the streambed.

Future Monitoring Efforts

With benchmarks established at the ends of each cross section, future monitoring efforts will be able to quantify changes to the channel and volume of sediment mobilized. We recommend follow-up monitoring occur in the spring following significant storm events. Periodical reconnaissance of the site could also be a useful indicator for monitoring. Significant channel changes observed by US Forest Service, DFG, or others working in the area should serve as a trigger to mobilize a new survey.

Conclusions

Field observations and results from the survey suggest that it will take some time for the channel to readjust and mobilize the sediment stored behind the dam. At this time, the knickpoint at the head of the incision is still a barrier to migrating salmonids, but should become passable in time as the material mobilizes.

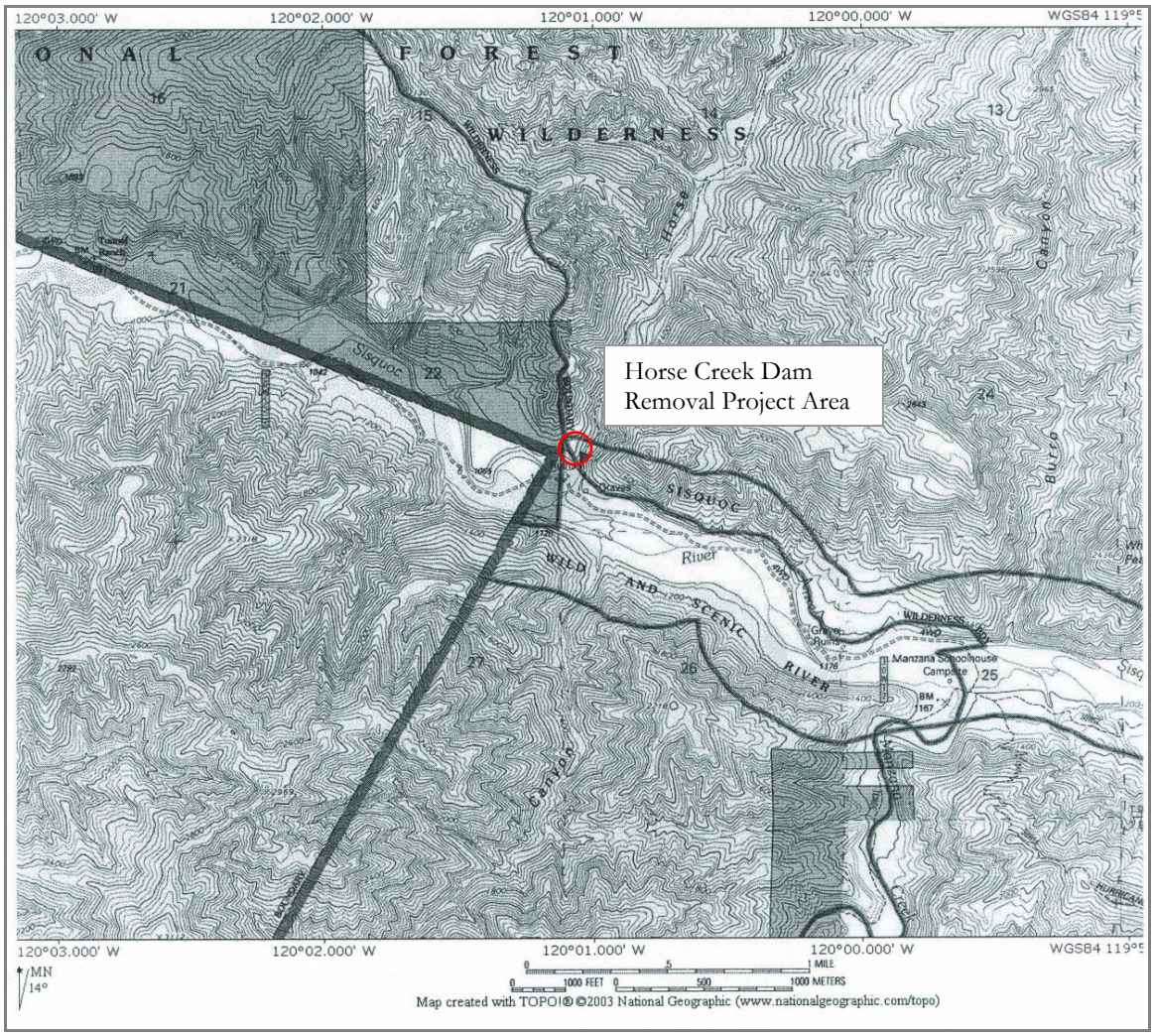
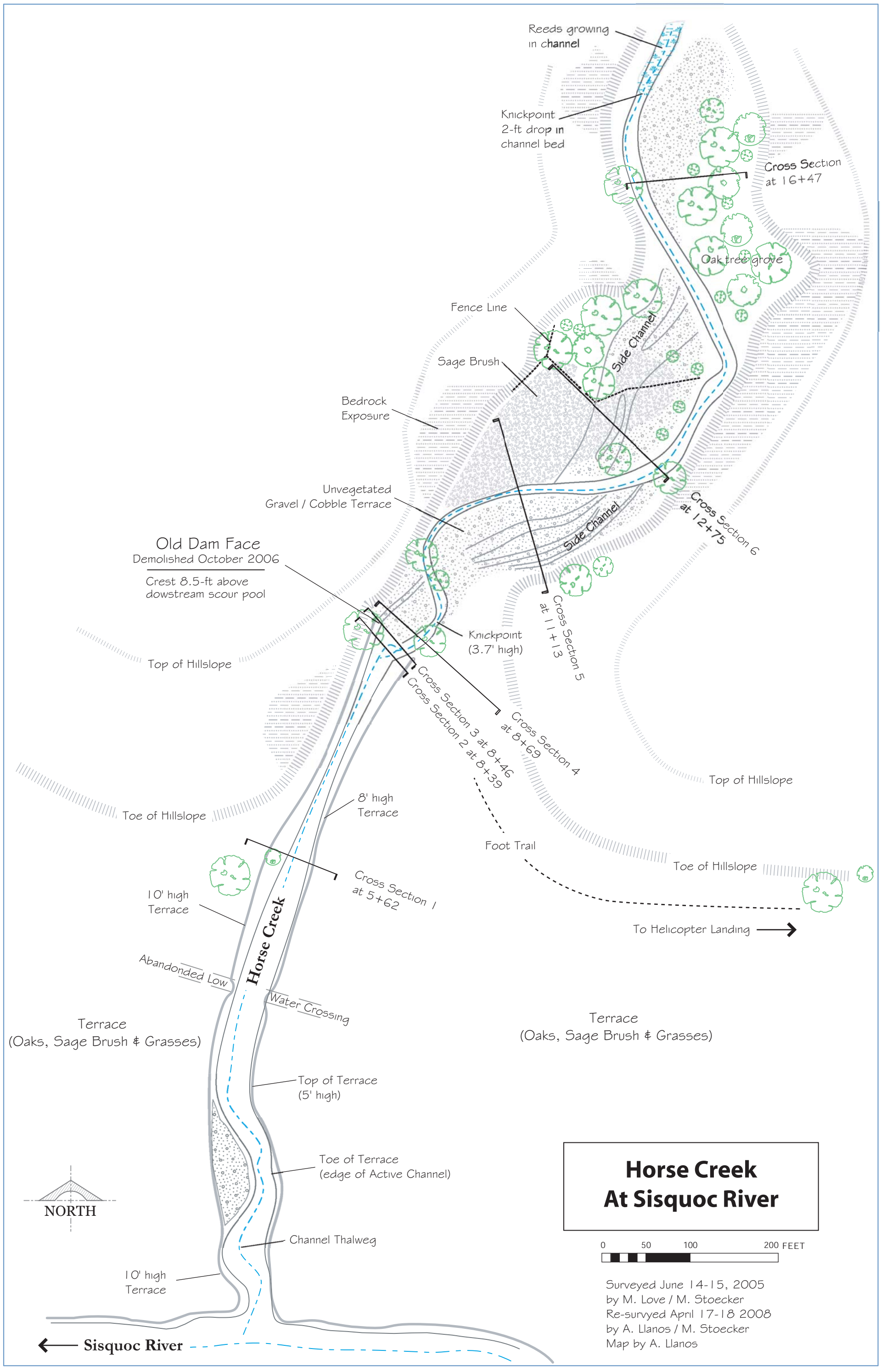
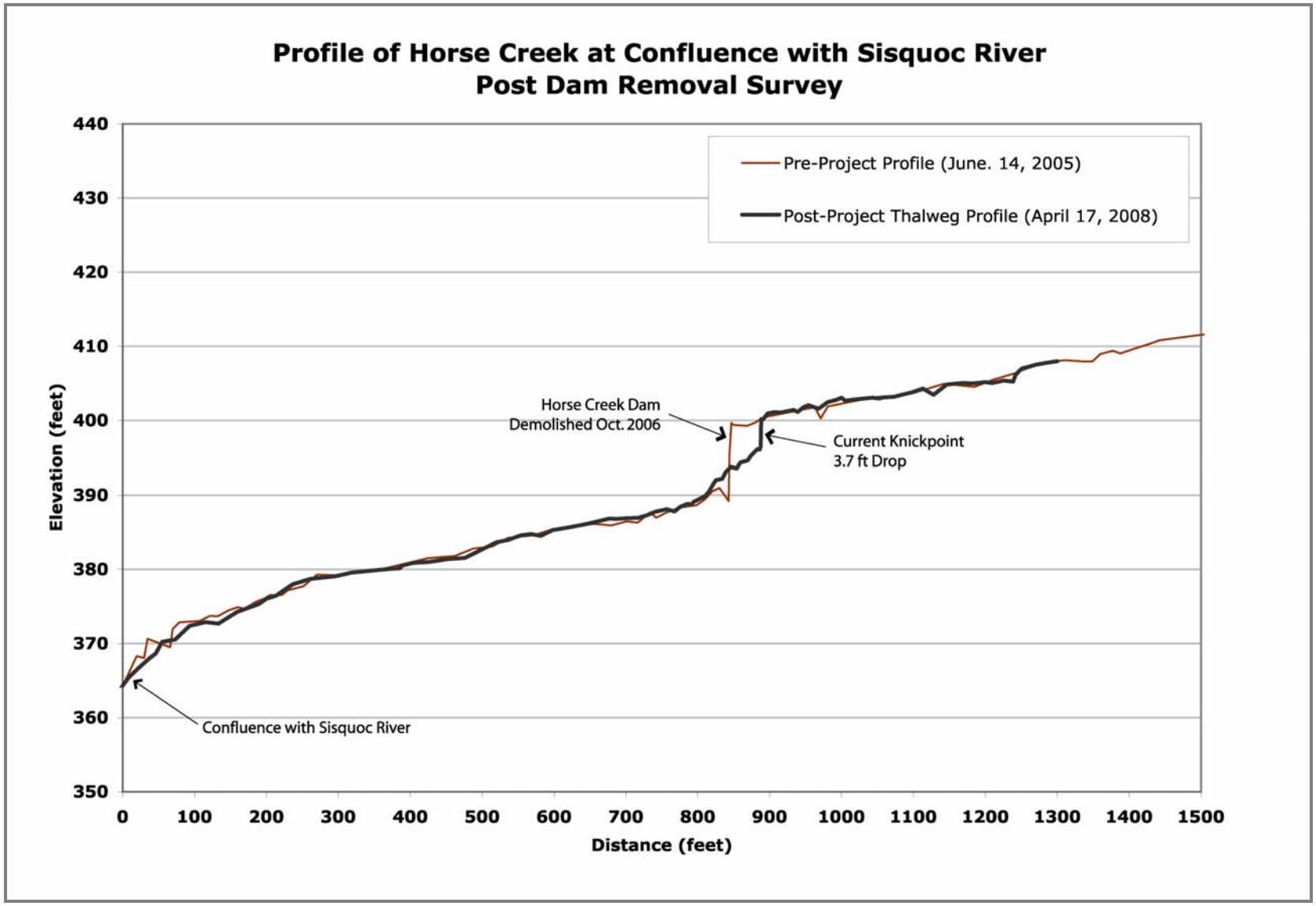


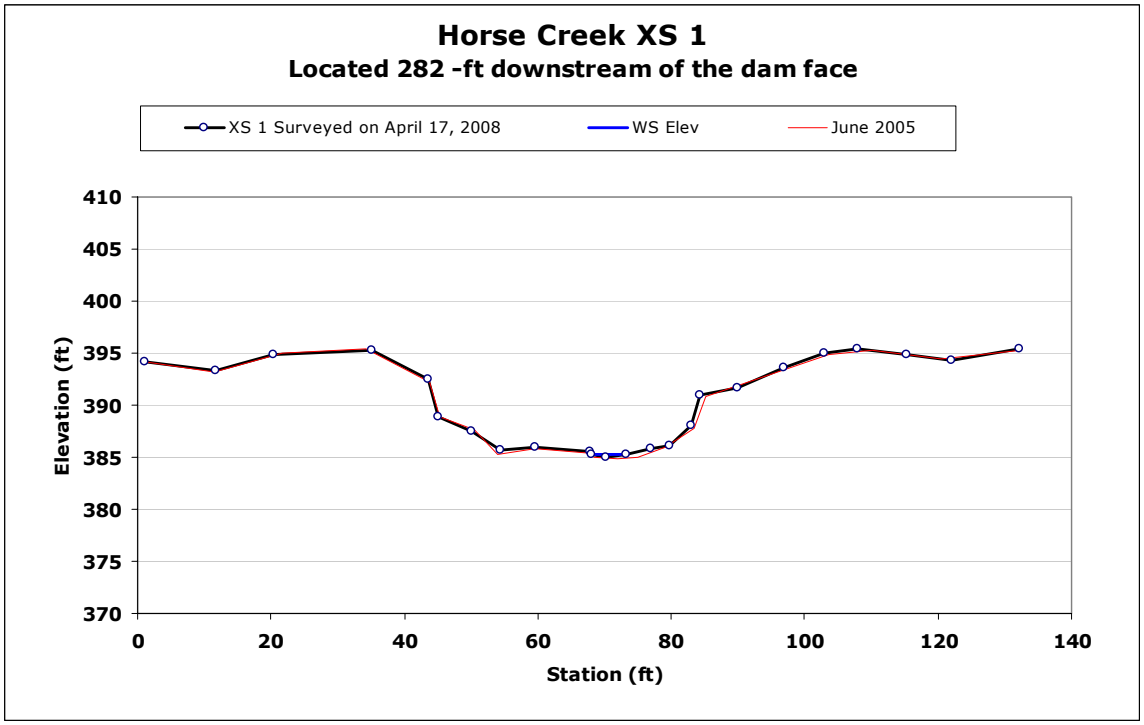
Figure – USGS Topographic map of Project Area

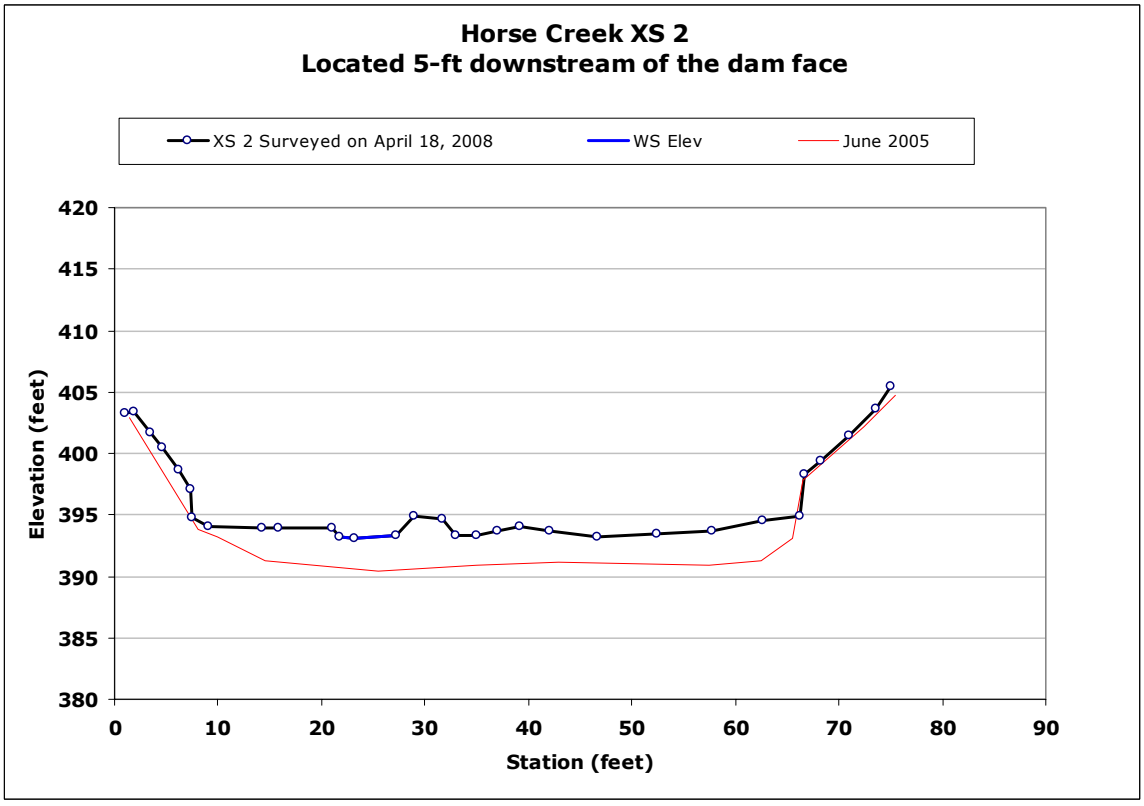

Reeds growing in channel
Knickpoint 2-ft drop in channel bed
Cross Section at 16+47
Oak tree grove
Fence Line
Side Channel
Sage Brush
Bedrock Exposure
Unvegetated Gravel / Cobble Terrace
Side Channel
Cross Section 6 at 12+75
Old Dam Face
Demolished October 2006
Crest 8.5-ft above dowstream scour pool
Cross Section 5 at 11+13
Knickpoint (3.7' high)
Top of Hillslope
Cross Section 3 at 8+46
Cross Section 2 at 8+39
Cross Section 4 at 8+69
Top of Hillslope
Toe of Hillslope
8' high Terrace
Foot Trail
Toe of Hillslope
Cross Section 1 at 5+62
10' high Terrace
To Helicopter Landing
Horse Creek
Abandonded Low Water Crossing
Terrace (Oaks, Sage Brush & Grasses)
Terrace (Oaks, Sage Brush & Grasses)
Top of Terrace (5' high)
Toe of Terrace (edge of Active Channel)
NORTH
Channel Thalweg
10' high Terrace
Sisquoc River
Horse Creek At Sisquoc River
0 50 100 200 FEET
Surveyed June 14-15, 2005
by M. Love / M. Stoecker
Re-survyed April 17-18 2008
by A. Llanos / M. Stoecker
Map by A. Llanos

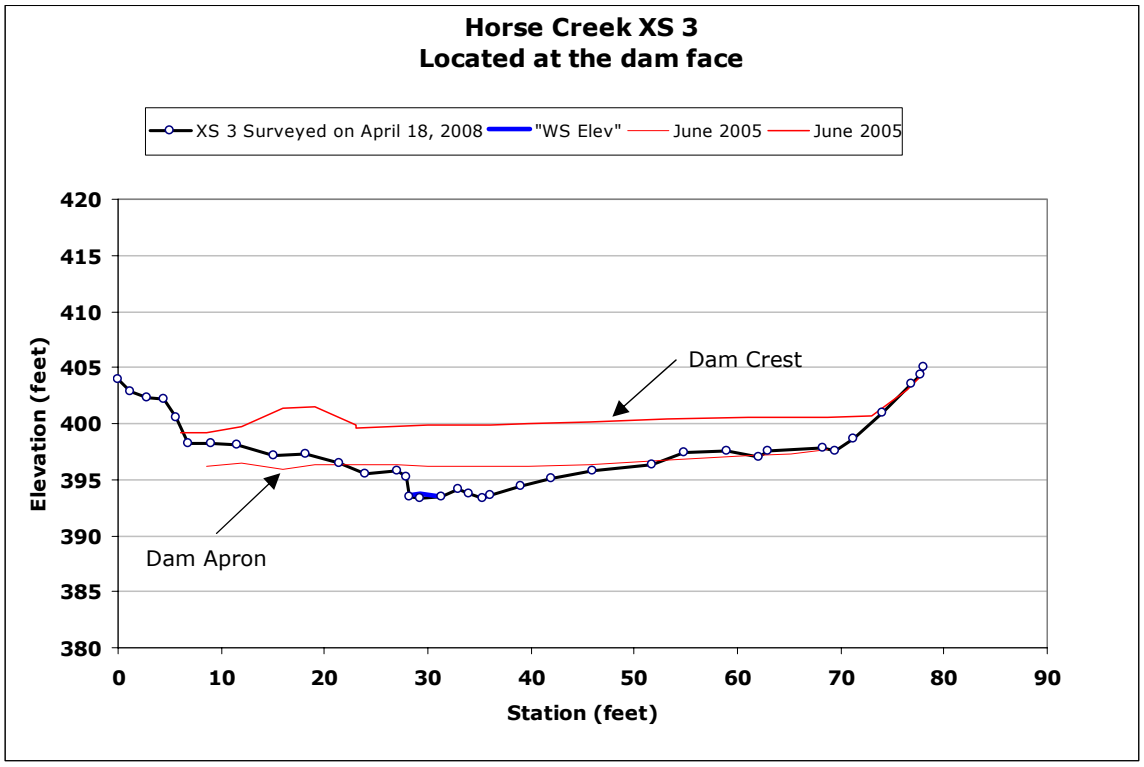

Profile of Horse Creek at Confluence with Sisquoc River
Post Dam Removal Survey
Pre-Project Profile (June. 14, 2005)
Post-Project Thalweg Profile (April 17, 2008)
Horse Creek Dam
Demolished Oct. 2006
Current Knickpoint
3.7 ft Drop
Confluence with Sisquoc River
Elevation (feet)
Distance (feet)
440
430
420
410
400
390
380
370
360
350
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500

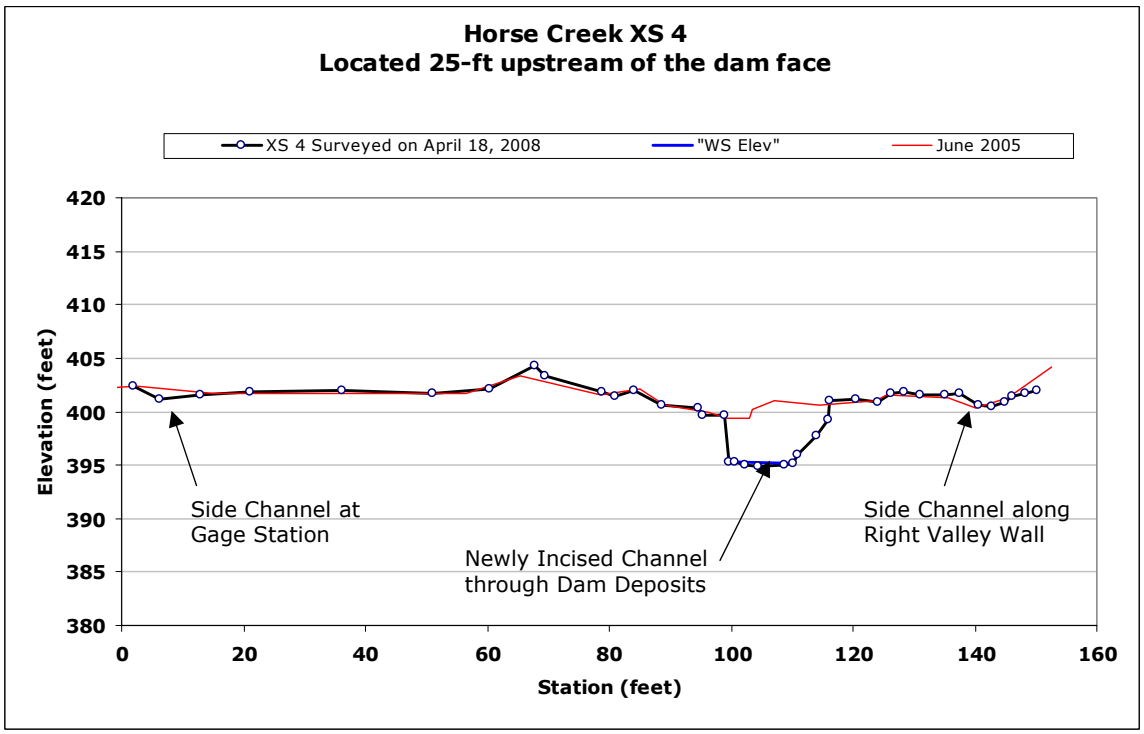
Post Dam Removal Survey Monumented Cross Sections

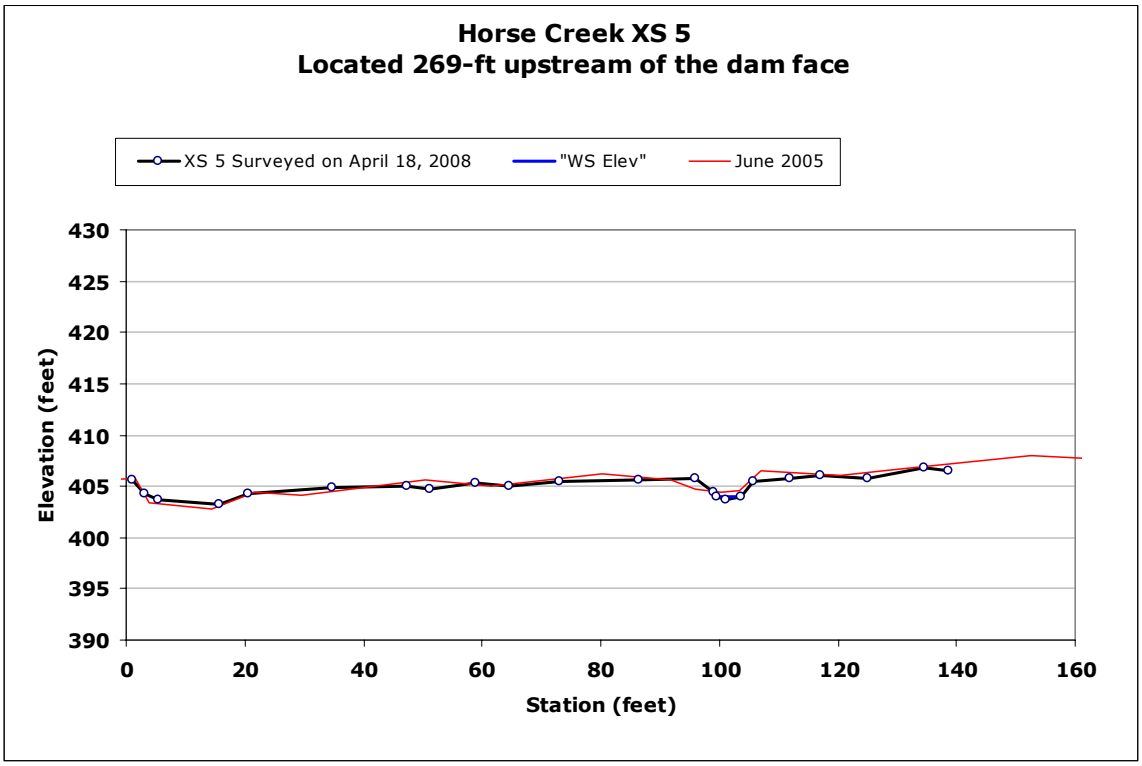
(All Cross Sections are Left to Right Bank as Looking Downstream)

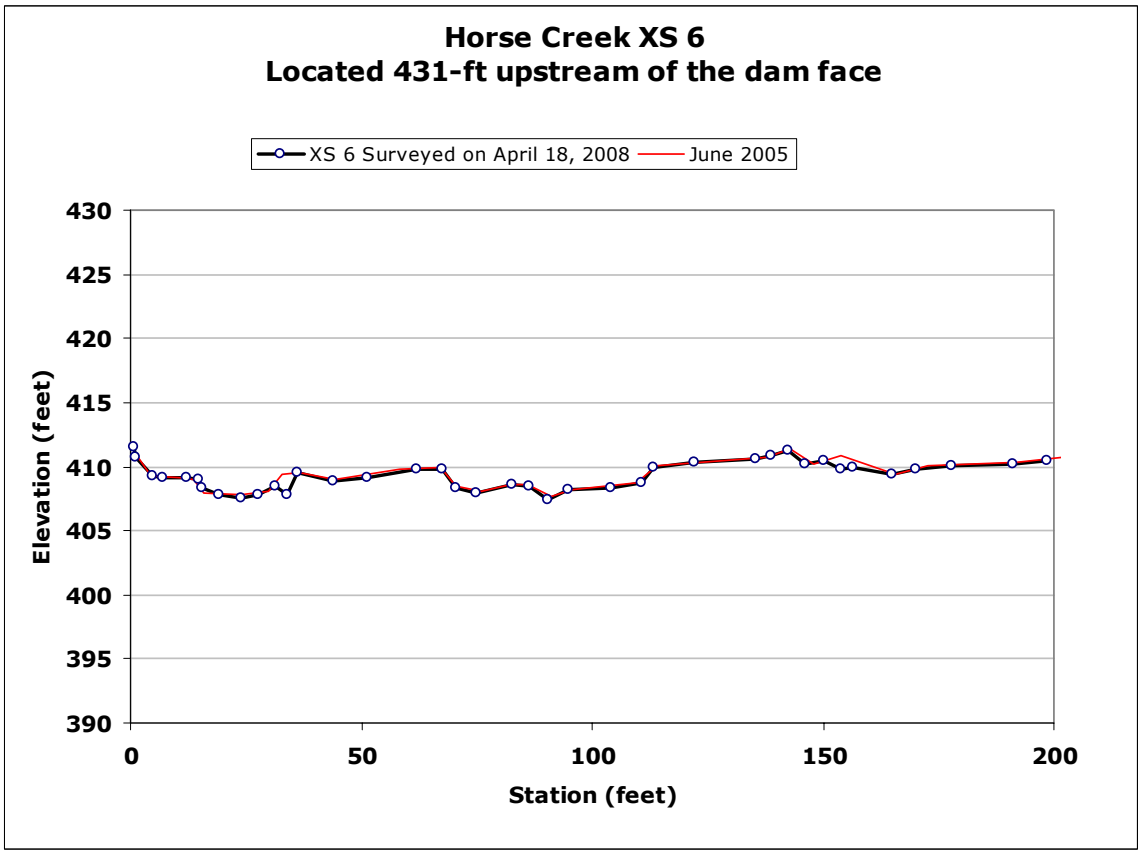





Horse Creek XS 3
Located at the dam face
XS 3 Surveyed on April 18, 2008
"WS Elev"
June 2005
June 2005
Elevation (feet)
Station (feet)
Dam Crest
Dam Apron


Horse Creek XS 4
Located 25-ft upstream of the dam face
XS 4 Surveyed on April 18, 2008
"WS Elev"
June 2005
Elevation (feet)
Station (feet)
Side Channel at
Gage Station
Newly Incised Channel
through Dam Deposits
Side Channel along
Right Valley Wall


Horse Creek XS 5
Located 269-ft upstream of the dam face
XS 5 Surveyed on April 18, 2008
"WS Elev"
June 2005
Elevation (feet)
430
425
420
415
410
405
400
395
390
0
20
40
60
80
100
120
140
160
Station (feet)


Horse Creek XS 6
Located 431-ft upstream of the dam face
XS 6 Surveyed on April 18, 2008
June 2005
Elevation (feet)
430
425
420
415
410
405
400
395
390
0
50
100
150
200
Station (feet)

Coordinates of Cross Section Rebar Monuments

Cross Section		Latitude	Longitude	Elevation	Bearing
XS 1	LB Pin	N 34° 50' 12.2"	W 120° 1' 3.6"	394.51	108°
	RB Pin	N 34° 50' 12.6"	W 120° 1' 5.1"	395.73	
XS 2	LB Pin			403.58	318°
	RB Pin	N 34° 50' 14.9"	W 120° 1' 3.0"	403.59	
XS 3	LB Pin	Wooden Stake		403.37	320°
	RB Pin	N 34° 50' 15.1"	W 120° 1' 3.0"	405.23	
XS 4	LB Pin	N 34° 50' 14.1"	W 120° 1' 1.5"	402.72	314°
	RB Pin	N 34° 50' 12.6"	W 120° 1' 5.1"	402.34	
XS 5	LB Pin	N 34° 50' 18.0"	W 120° 1' 1.9"	406.02	328°
	RB Pin	N 34° 50' 16.3"	W 120° 1' 2.0"	406.86	
XS 6	LB Pin	N 34° 50' 16.9"	W 120° 1' 0.1"	411.09	311°
	RB Pin	N 34° 50' 18.1"	W 120° 1' 0.4"	410.92	

Notes:
Pin = Rebar monument located at each edge of cross section
Bearing = compass bearing from left to right bank of cross section
LB / RB = Left Bank / Right Bank
All elevations on top of rebar pin

Up and Downstream Coordinates for Project Area

Project Reach Coordinates	Latitude	Longitude
Downstream	N 34° 50' 7.27"	W 120° 1 '5.94"
Upstream	N 34° 50' 21.92"	W 120° 1' 0.27"

Notes:
WGS84 Coordinate System