FEASIBILITY STUDY:

SIDE CHANNEL RECONNECTION AT

COYOTE TRAILS NATURE CENTER

OWEB Technical Assistance Grant, Project #213-2022

FINAL REPORT, February 2015

CONTENTS PAGES

INTRODUCTION AND BACKGROUND 2

METHODOLOGY AND RESULTS 7

TOPOGRAPHIC SURVEY

GROUNDWATER MONITORING

HEC-RAS MODELING

WETLAND DELINEATION

DISCUSSION AND SUMMARY 17

SUMMARY & RECOMMENDATIONS 19

LIST OF FIGURES

Figure 1. 1954 Aerial photo of Bear Creek 3

Figure 2. 1969 Aerial Photo of Bear Creek 3

Figure 3. DeYoung Side Channel 4

Figure 4. Gravel mining, Coyote Trails Nature Center, 1969 5

Figure 5. Two Alternative Side Channel Routes 6

Figure 6. Profile of Alternative Channel Routes 8

Figure 7. Location of Piezometer Nests and Thermographs 9

Figure 8. Graph Illustrating Temperature Fluctuation of Groundwater and Bear Cr. 10

Figure 9. Graph Comparing Relative Temperatures of Groundwater and Bear Cr. 11

Figure 10. Water Temperatures in Bear Cr. @ Upper and Lower Ends of Study Reach 12

Figure 11. Over widened Channel in Bear Creek 13

Figure 12. Plan View of Modeled Channel 14

Figure 13. Cross Sections and Profiles of Ordinary High Water Elevations 15

Figure 14. Preliminary Jurisdictional Wetland Map 17

Introduction

In 2013 the Oregon Watershed Enhancement Board (OWEB) funded a Technical Assistance (TA-1) grant to the Bear Creek Watershed Council to study the feasibility of opening a side channel of Bear Creek, a tributary of the Rogue River. The site is located at Coyote Trails Nature Center in the US Cellular Community Park on the south side of Medford, Oregon. The main goal in opening the channel is to improve rearing habitat for salmonids, however restoring the channel would also create diversity of land form and vegetation in the floodplain benefitting a variety of birds, mammals, amphibians, reptiles and fishes including Pacific lamprey,

Elements of the study included:

- Monitoring of Ground Water for presence and temperature.
- A temperature study of Bear Cr.
- A topographic survey & preliminary grading plan.
- HEC-RAS modeling for the proposed side channel.
- Wetland Delineation.

The project team consisted of K&C Environmental Services, Katalyst Inc., Northwest Biological Consulting, Kerbo Engineering, and KenCairn Landscape Architecture. This report presents the results of the study and is submitted by project manager Stephen Koskella, President of K&C Environmental Services Inc.

Background

Bear Creek is one of the most urbanized watersheds in Oregon. Air photography taken over a span of many years shows that Bear Creek was historically a braided channel and anecdotal information describes large runs of salmon and steelhead trout even in the early part of the 20th century. Flood control measures, gravel mining, and bank armoring have limited Bear Creek to a single thread for much of its course, drastically reducing rearing habitat.

The *Southern Oregon Northern California Coast Coho Recovery Plan* (September, 2014) produced by the NOAA Fisheries identifies the Upper Rogue subbasin in which Bear Creek lies as an area with a current status of a “Moderate Extinction Risk” for these species with Bear Creek having little recent documented use by coho. The *Recovery Plan* recommends the reconnection of off channel habitat as a way to improve stream structure for fish and rates it as a high priority activity for the recovery of this endangered species.

Figure 1. 1954 aerial photo showing Bear Creek south of Medford. Note location of road heading east from Hwy. 99 with circular driveway at entrance and bridge crossing Bear Cr.

Figure 2. 1969 Aerial photo of same area in Fig. 1. Road beginning with circular driveway is present, but bridge has washed out and road rerouted as Bear Cr has braided into multiple channels.

In 1998, K&C Environmental Services Inc. designed and created a successful side channel on Bear Creek that supports rearing salmonids at a gravel mining operation near Talent, Oregon. This channel intercepts hyporheic flows mixing shallow ground water with surface water to create thermal and high flow refuge while providing cover and producing food. Using this reach as a reference, the study looked at replicating this result by reopening a side channel at Coyote Trails that had been blocked at both ends by mining operations. The Coyote Trails channel was located approx. 6 miles downstream from the Talent reference site at the southern edge of Medford.

Side Channel Created By DeYoung Gravel Operation

Figure 3.

Ground reconnaissance at the Coyote Trails Nature Center revealed existence of two remnant side channels in the floodplain at the site. The channels are dry except during flood events as the upper end is blocked by fill material that includes broken concrete and asphalt, while the channel exits are blocked by fill from an old haul road. Historic air photography shows that this occurred during a 1969 gravel mining operation associated with the construction of Interstate 5. (See Figure 4.) The two channels have a common beginning and end, but take different routes through in their middle reaches. The most westerly route follows the toe of the bluff at the edge of the floodplain, while the easterly channel is closer to Bear Creek. (See Figure 5.)

Figure 4. Gravel mining, Coyote Trails Nature Center, 1969

Figure 5. Two alternative side channel routes.

Methodology and Results

As stated previously the purpose of the study was to determine the feasibility, benefits and risks of reconnecting one or both of these historic side channels. To this end, a topographic survey was done, flows were modeled, ground water and temperature monitored and a wetland delineation completed. A description of methods and summary of results follows. Complete reports of each study parameter are found in the appendices.

Topographic Survey

A professional topographic survey was conducted along both routes to determine baseline and relative elevations of Bear Creek and the side channel routes.

Results

The elevation of Bear Cr. channel bottom at the side channel entrance is 1408.50 ft. and the bank full elevation is 3.97 higher at 1411.78. The mainstem channel bottom drops 5.85 ft. to 1402.65 ft. at the channel exit 1275 ft. downstream for a slope of 0.46%. (Figure 6.)

Significant Findings of Topographic Survey

The elevations of land surface surveyed along the centerline of the potential side channel routes clearly show the plug that would need to be removed in the first 300 ft. of the combined channel route to allow water to flow into either side channel. Beyond that point (where the routes split), the land surface along the easterly route drops well below the bankfull elevations indicating water would find its way down that channel with no further excavation. Land surface elevations on the westerly route remain above the bankfull level and would require significantly more excavation to connect. The profile also shows that if 100 ft. of channel (below the point where the two alternative routes recombine) were excavated only 0.4 ft. the channel would be reconnected to Bear Creek at bankfull stage while 3 ft. of excavation would match the side channel exit with the Bear Creek channel bottom.

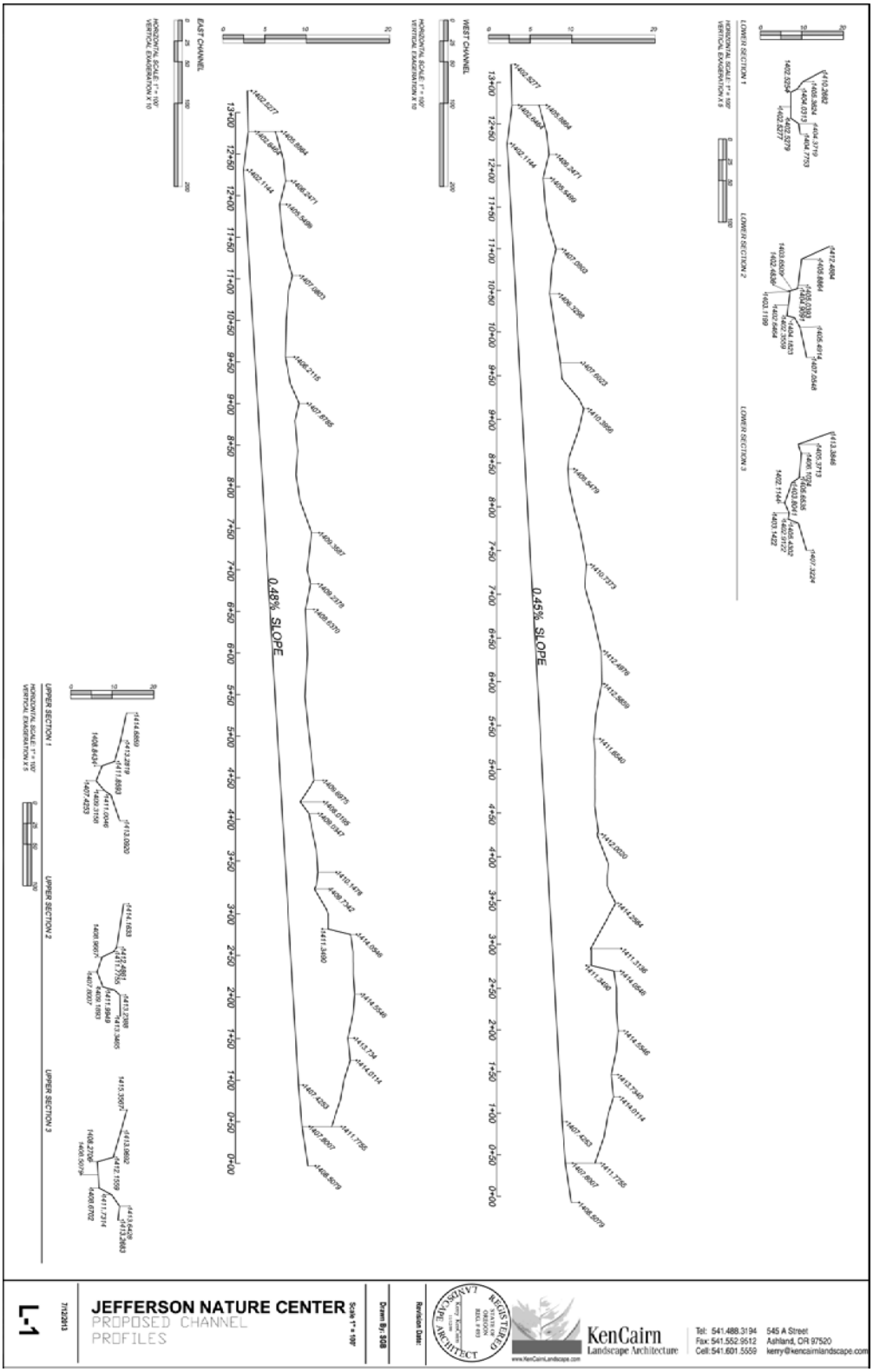


Figure 6. Profile of Alternative Channel Routes

Ground Water Monitoring

A ground water study was initiated by excavating five piezometer nests (small monitoring wells) along the two alternative channel routes to evaluate the static level and temperature of ground water that could potentially be intercepted by the proposed channels. Thermographs (temperature data loggers) were also placed at each piezometer nest (PN) and in the main channel of Bear Creek at the side channel entrance and exits. (See Figure 7.)

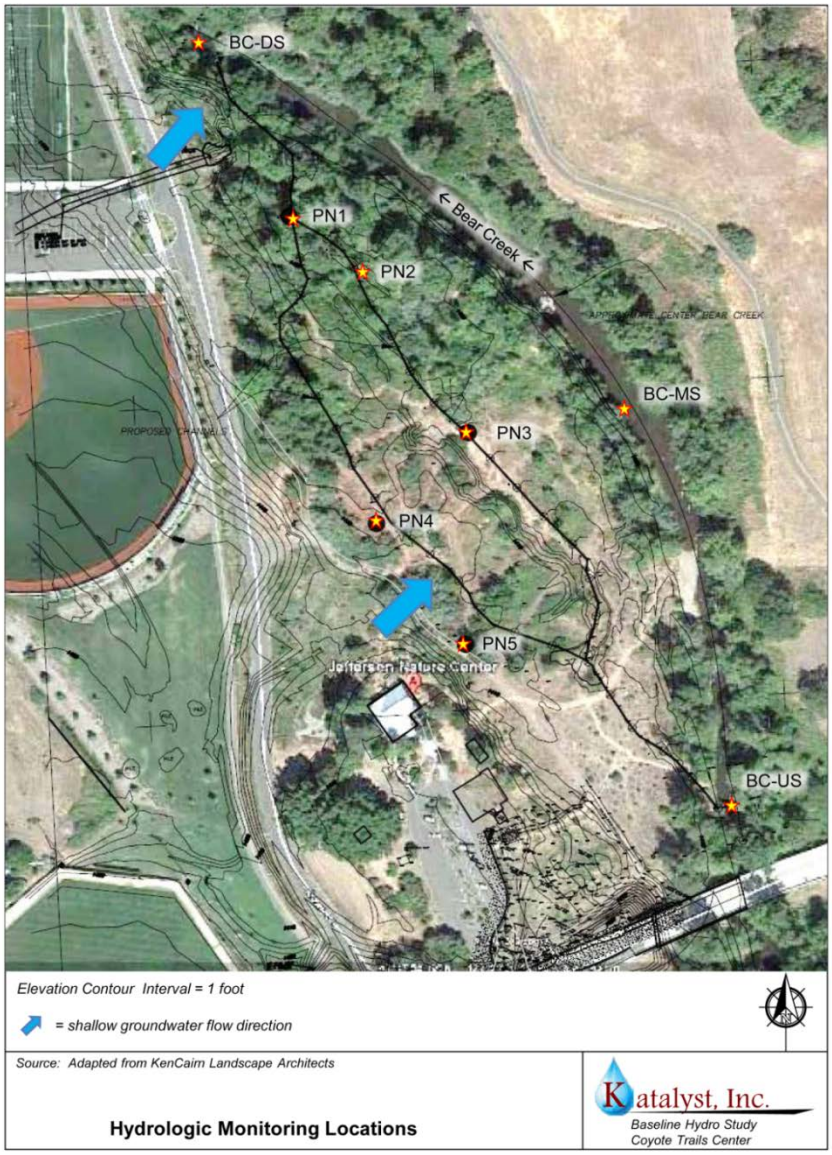


Figure 7 Location of Piezometer Nests and Thermographs

The sites were monitored from 4-25-2013 through 11-8-2013. Monitoring was performed weekly during the spring months, and reduced to one month intervals by the end of the season. Monitoring consisted of visual assessment of changes, and temperature spot checks and water level measurements at each piezometer as well as Bear Creek.

Results and Significant Findings of the Groundwater Survey

Water persisted in the piezometers at PN-1&2 until 6-14-2013, and continued to be measured in the deeper piezometer at PN1 (3.2 feet below ground surface) for the entire season. The Oregon Department of Environmental Quality (ODEQ) has set summer water quality standard in Bear Creek at 64.4 F., the upper temperature limit tolerated by salmonids. Although temperatures in Bear Creek exceeded the standard for the entire summer, the temperature of the alluvial groundwater at PN1 and PN2 never exceeded the standard. In contrast, PN3 had no ground water during the study period and temperatures at the bottom of the dry well that were consistently 5 to 7 degrees F higher than temperatures at PN1 and PN2, which are located in a shaded wetland area.

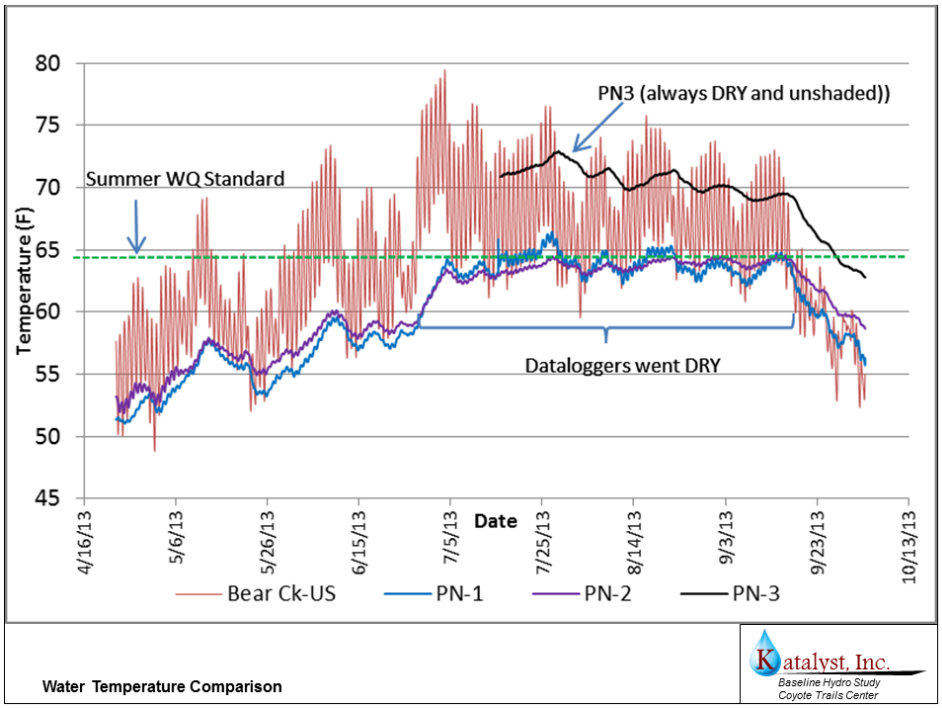


Figure 8. A graph comparing temperatures in piezometer nests 1,2 and 3 with Bear Cr. PN-1 and PN-2 maintained cool temperatures below the maximum TMDL standard set by DEQ, and PN-1 had ground water present during the entire season.

The following figure (Figure 9) compares the temperatures of Bear Creek and the alluvial groundwater at PN1 and PN5. PN5 was consistently about 5 degrees centigrade higher than the water temperatures at PN1 and PN2, and often exceeded the temperatures in Bear Creek. This came as a surprise since PN5 was the deepest groundwater encountered at the site. One possible explanation is that the ground water is within 10-20 ft. of a regional sewer line that flows through the area and may pick up heat through transference. Whatever the cause of this temperature differential, intercepting this ground water would be counter-productive to the goal of providing thermal refuge, and should be avoided.

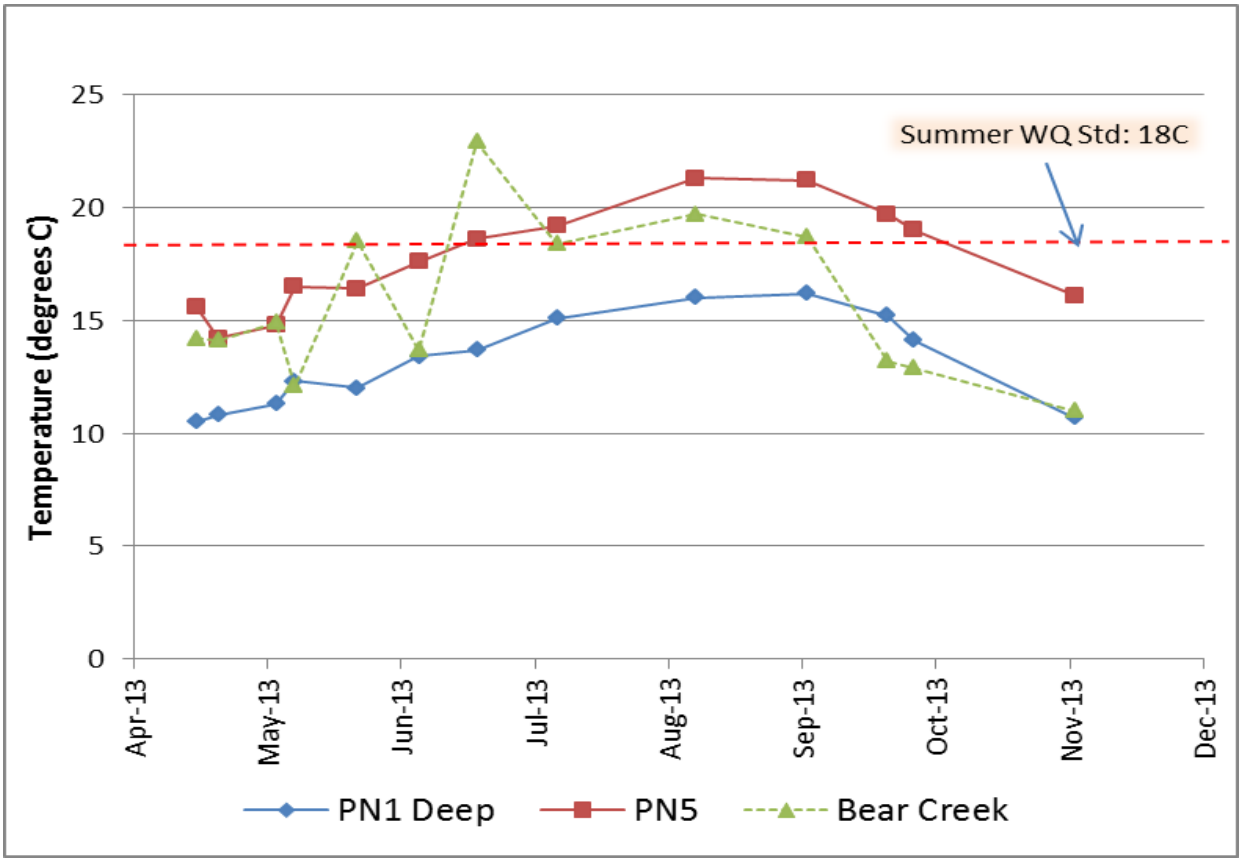


Figure 9. Comparison of Water Temperatures in Alluvial Groundwater and Bear Creek

A comparison of the water temperatures between the downstream station and the upstream station along Bear Creek at the site was also performed. Figure 10 shows a two-week subset of the temperature data from 6-1-2013 through 6-15-2015 as daily temperatures are rising. Downstream water temperatures are consistently higher (often more than 2°F) than upstream temperatures in the critical late afternoon period, peaking at about 1730 each day. This is apparently the result of shallow water flowing over the exposed bedrock during the sunny afternoons as the rock absorbs heat and transfers it back to the water in late afternoon. The

disparity is more prevalent as the reach heats up in the summer months. Apparently the broad, shallow bedrock areas along Bear Creek that were anthropogenically created by gravel mining during construction of the I-5 Corridor still act to increase water temperatures in Bear Creek in this reach.

Detailed data can be found in the ground water report in the appendix.

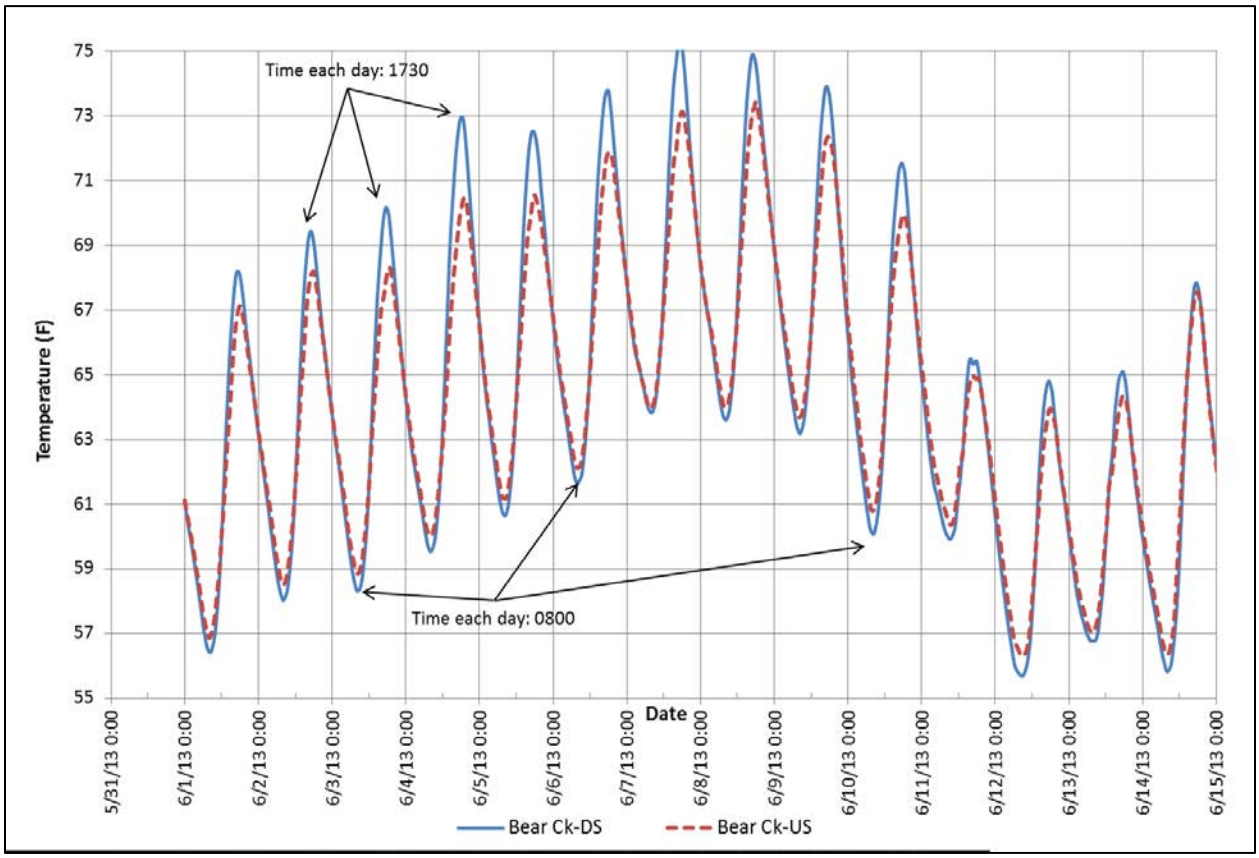


Figure 10. A Comparison of Water Temperatures in Bear Creek at Upper and Lower Ends of Study Reach.

Figure 11. Over-widened channel with exposed bedrock in mainstem of Bear Creek in study reach.

The shallow bedrock bottom observed in Bear Creek appears to be pervasive throughout the site, thereby limiting the thickness of the alluvial aquifer. The more upstream piezometer (PN-3) was dry for the entire study period indicating that hyporheic flows along Bear Creek are absent in this area. The static water levels in all of the piezometers was consistently higher than the water level measured in Bear Creek, indicating a "gaining" reach where water generally flows from the alluvial aquifer to the stream as base flow, rather than water flowing from the stream into the alluvium. This is significant in that the premise that hyporheic flows along Bear Creek may be intercepted and introduced into the side channel were not correct. In this reach alluvial ground water from off-site enters the side channel near the lower end only.

This alluvial groundwater down near PN1 and PN2 is consistently cooler than water in Bear Creek and never exceeded the ODEQ standard of 64.4 degrees. In contrast temperatures in Bear Creek exceeded the ODEQ water-quality standard for the entire summer.

HEC-RAS Modeling.

Hydrologic Engineering Centers-River Analysis System (HEC-RAS) modeling was performed to evaluate flow characteristics of the side channels under varying flow regimes. To run the model a preliminary channel design was assumed and laid out on the centerlines. The stream configuration type selected for the proposed side channel was the Rosgen C3 type with a 2 ft. wide channel bottom and side slopes of 3:1. It was also assumed that a flow control structure taking 10% of Bear Creek flows would be engineered at the channel entrance.

Because the ground water monitoring indicated that the ground water that would be intercepted would be warmer than Bear Creek, the original concept of watering the westerly channel was dropped, and modeling was done for the easterly location only. (See figure 11 Plan form.)

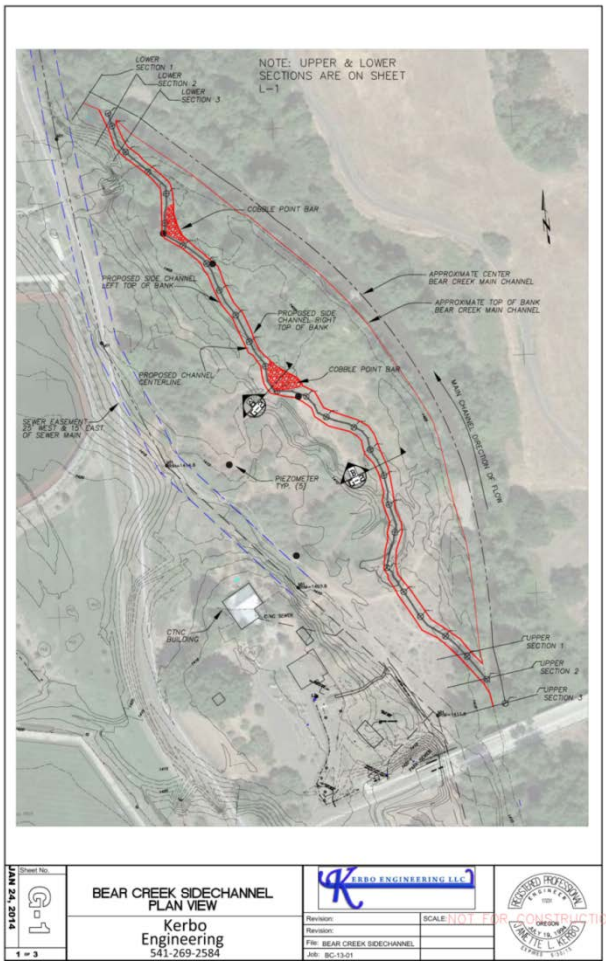


Figure 12. Plan View of Modeled Channel Location.

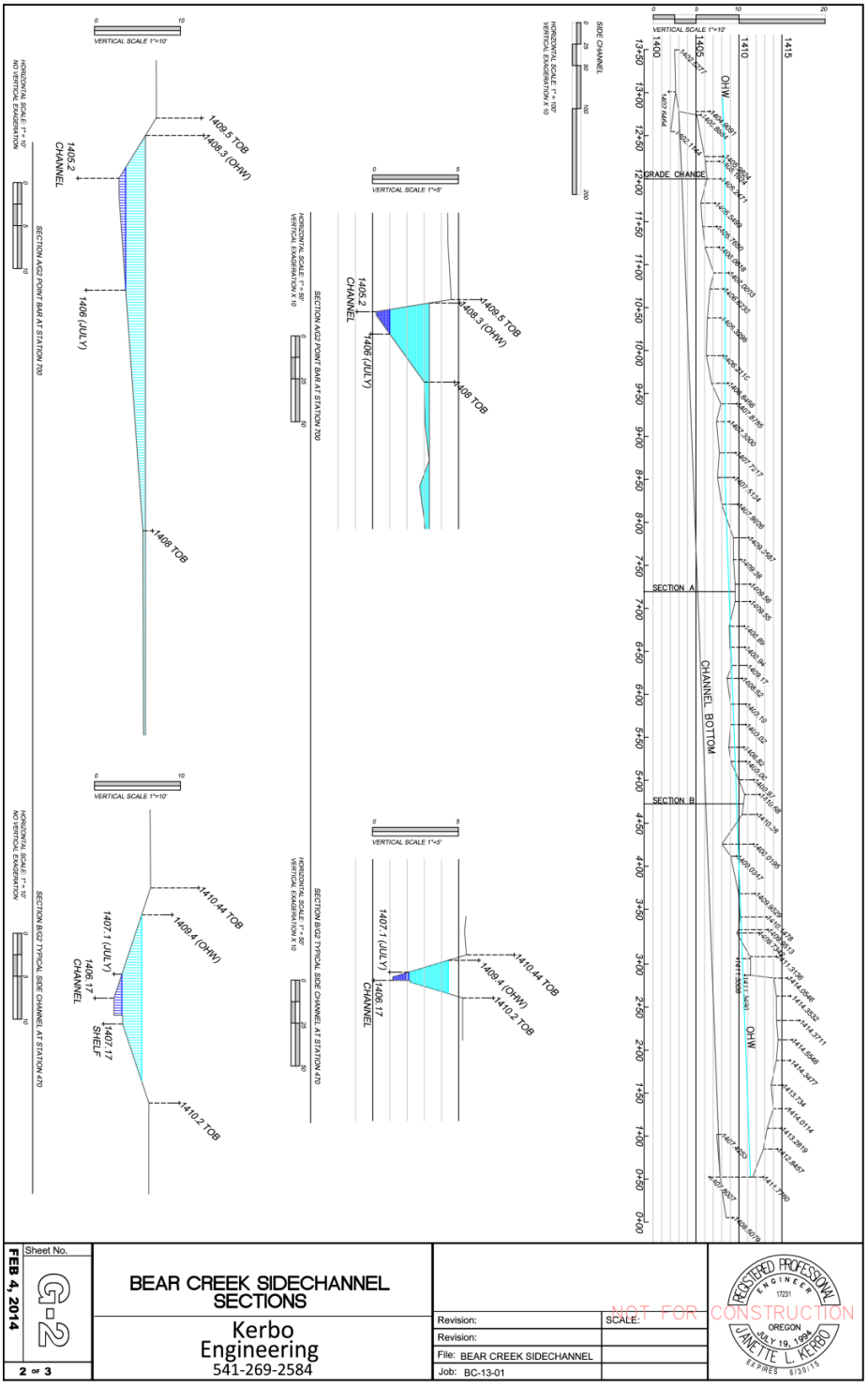


Figure 13 Cross Sections and Profile Showing OHW Elevations

The model showed that:

1. With an appropriate grade control structure at the entrance, water could be reintroduced to the side channel. Typical flows in July would be 1 ft. deep while OHW flows would be 3 ft. deep. (See Fig. 12)
2. During a 2 year flood event velocities in the side channel would range from 1.5 to 4 ft. /sec. while the main channel velocities are 7-9.5 ft. /sec.
3. During a 100 year flood event velocities in the side channel would range from 2.5 to 5.5 ft. /sec. while the main channel velocities are in the 13.5-18 ft. /sec. range.
4. A slight reverse grade in Bear Creek at the side channel exit indicates that flows will tend to recharge ground water at the lower end of the channel if it were open to the main stem of Bear Creek.

A more detailed discussion of modeling can be found in the appendix.

Wetlands

A wetland delineation was also performed using the standard Army Corps of Engineers methodology to locate jurisdictional wetlands so that potential interactions with the side channel and existing wetlands could be made. The delineation shows the upper 800 ft. of channel is outside of wetland areas while the lower 400 ft. in within jurisdictional wetland. To open the lower end of the channel a fill removal permit would be required from OR DSL, while excavation of the plug above OHW would not require a permit. The entire wetland delineation report can be found in the appendix.

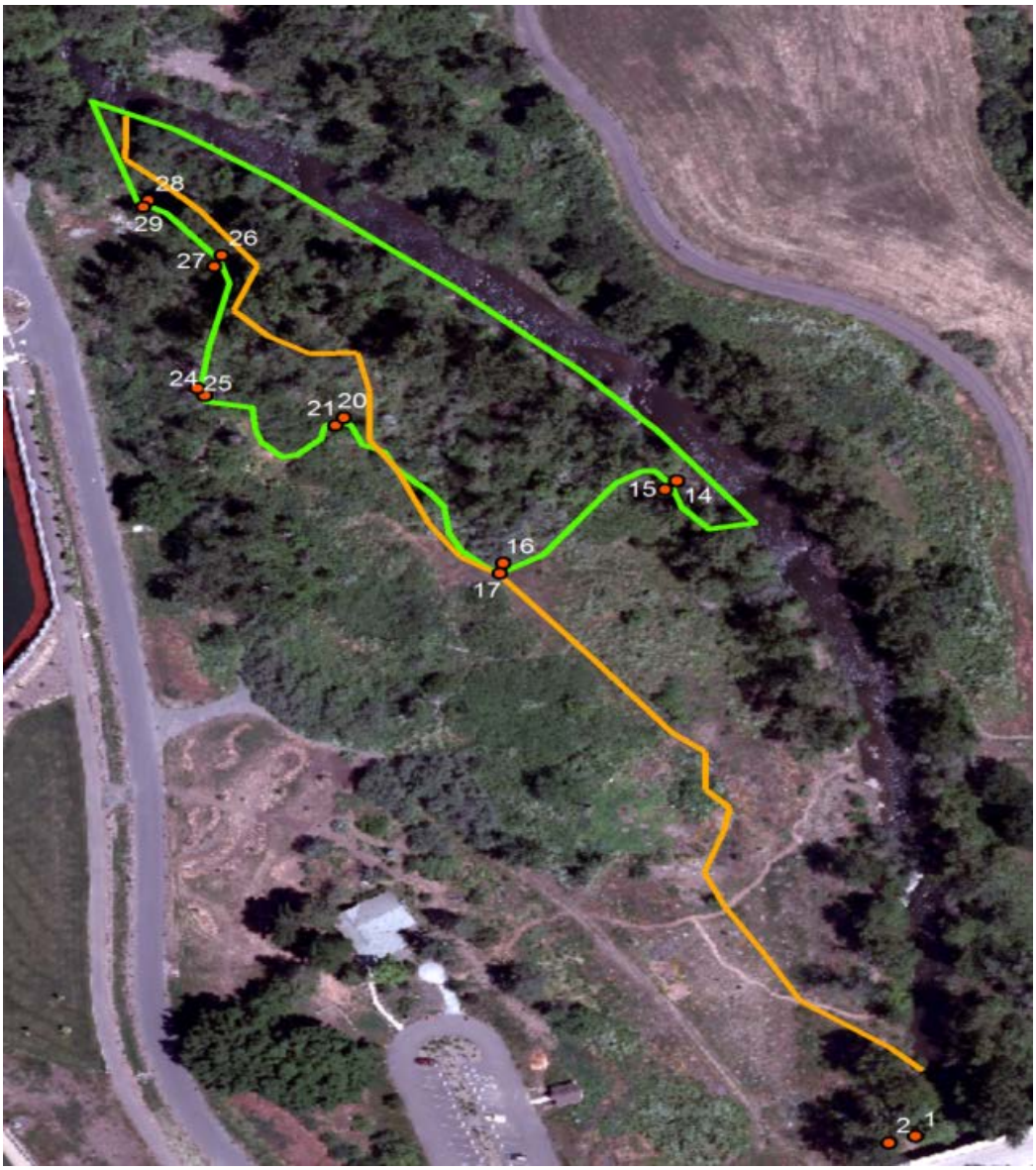


Figure 14. Preliminary Jurisdictional Wetland Boundaries

Discussion

The study has shown that a range of options for reconnecting Bear Creek to the floodplain exists for this site. Each option has its own unique set of risks and benefits as presented below.

1. **Reconnect the westerly channel with perennial flows.** Owing to the amount of excavation required, this would be the most costly option. It would also require a diversion structure at the entrance of the channel. On the plus side it would tend to spread water across the widest section of floodplain, providing the most ancillary

benefits to riparian wildlife. Previous owners report that this was the location of the main stem of Bear Creek in the past and the channel still receives water when Bear Creek is above 1500 cfs. Besides cost however, there are two risks to opening this channel. First is its proximity to the regional sewer line infrastructure. The engineer for Rogue Valley Sewer Services has said his preference is for the channel to be no closer than 40 ft. requiring the channel be moved laterally from our original plan. Secondly and possibly related to the sewer line is the fact that ground water in this area is warmer than expected and often exceeds the temperature of Bear Creek which negates the whole concept of creating thermal refuge. Because of these negative affects we do not recommend this option. Cost est. $275,000

2. **Reconnect the easterly channel with perennial flows.** This option has less risk than Option 1. Again it would require a diversion structure to send low flows from Bear Creek down the channel from the entrance as ground water is not present in the upper 800 ft. of channel during the summer months. The problem with this approach is that water introduced from the main stem of Bear Creek would be warmer than the ground water present in the lower end of the channel and tend to flush the cool water out into the warm waters of Bear Creek. This would lessen the thermal refuge offered by the ground water. In addition, removing flow from the main channel during hot summer months may exacerbate heating during this time.

   Another risk is building the control structure itself on bedrock. Considerable pinning of boulders may be required to create a stable structure, and this would not be a natural feature. These considerations indicate that a large effort would be required with marginal improvement of salmonid habitat with this option. Cost est. $180,000

3. **Removing the lower road prism to open the lower 100 ft. of side channel only.** This would be the least costly option and provide a solid habitat lift through creation of both cool water and high flow refugia. It also is very low risk as excavation could be accomplished by small excavator in less than 5 days, and a repository for spoils is present nearby outside of the riparian wetland area. The negative aspects of this option besides a minor temporary disturbance of vegetation is that it does nothing to improve conditions in the main channel of Bear Creek where lethal high temperatures may limit its usefulness. A more comprehensive approach would be to combine this action with channel improvements designed to provide shade in the main channel. Cost Est. $20,000

4. **No Action.** With no action, wetlands in the lower end of the study area will remain undisturbed and cool water subsurface flows will bleed into Bear Creek from them. However these flows will not be available as a concentration of cool water and potential refuge to any fishes including salmonids and lamprey. The main channel of Bear Creek which has shown no sign of recovering in the 45 years since gravel mining occurred will remain over widened and a source of summer heating. Cost $0.

5. **Cut a channel through the plug in the upper end of the side channel at bankfull elevation, and remove the road prism at the lower end of the channel.** This option makes sense if one looks at the main channel/side channel system as a whole. Excavating the plug at the upper end down to bank full elevation and removing the road prism at the lower end of the side channel, eliminates the unnatural elements from the flood plain without adding new ones. No control structure would be required, and flows down the side channel would occur only during bank full periods, allowing cool ground water to remain in the lower portion of the channel during summer months. It would also have a positive effect on Bear Cr. main stem by reducing pressure during high flows possibly allowing gravel accumulation and bank narrowing to occur. Cost est. $45,000

Summary & Recommendations

Ground reconnaissance showed that two possible side channel routes existed for improving salmonid habitat at the study site. Topographic surveys showed that both could feasibly be opened to carry flows. HEC-RAS modeling indicated channels would be 1ft. to 3 ft. deep depending on the flow of Bear Creek, and provide high velocity refuge during flood events. Ground water monitoring revealed that subsurface flows were not present in the upper portion of the eastern route, and were warm along the westerly route while cool ground water inflows are present in the lower 100 ft. of the channel. Water in the mainstem of Bear Creek warms up to 2 degrees C. in the 1200 ft. reach due to shallow water flowing over exposed bedrock in full sun.

When all of the above are considered, the best option for improving habitat appears to be "**Option 5**, ***Cutting through the plug at the upper end down to bank full elevation and opening the lower end of the channel to make the cool water inflows available*.**" This low risk solution makes cool water refuge available to salmonids and lamprey ammocoetes while creating an adjustment to the topography that would allow Bear Creek itself to create a braided channel

over time. Benefits of this action would be multiplied by narrowing Bear Creek main stem to the same width as the current main stem channel upstream and downstream of the study reach. Placing logs to capture sand, gravel, and cobble along the bank would be a possible solution. However feasibility and design of these structures goes beyond the scope of this study.

If the preferred option (Option 5) is to be constructed, it would require securing funding for the engineering, permitting and construction required to open the upper and lower ends of the side channel. In brief, this project would excavate 300 ft. at the upper end of the channel to the bank full elevation of Bear Creek and open the lower 100 ft. by excavating down to the channel bottom.

Furthermore, the temperature monitoring which shows that water temperatures rise as much as 2 degrees during critically hot summer afternoons, suggests that narrowing the cross section of Bear Creek would be a worthy endeavor. Placing and pinning large wood structures could be a solution, and it would be worthwhile to explore this concept further.

FEASIBILITY STUDY:

SIDE CHANNEL RECONNECTION AT

COYOTE TRAILS NATURE CENTER

OWEB Technical Assistance Grant, Project #213-2022

APPENDICES A-C

Includes:

A: Wetland Delineation

B: Hydrologic Assessment

C: HEC-RAS Modeling & Graphs, Maps

WETLAND DELINEATION / DETERMINATION REPORT COVER FORM

This form must be included with any wetland delineation report submitted to the Department of State Lands for review and approval. A wetland delineation report submittal is not "complete" unless the fully completed and signed report cover form and the required fee are submitted. Attach this form to the front of an unbound report or include a hard copy of the completed form with a CD/DVD that includes a single PDF file of the report cover form and report (minimum 300 dpi resolution) and submit to: **Oregon Department of State Lands, 775 Summer Street NE, Suite 100, Salem, OR 97301-1279.** A single PDF attachment of the completed cover from and report may be e-mailed to **Wetland_Delineation@dsl.state.or.us**. For submittal of PDF files larger than 10 MB, e-mail instructions on how to access the file from your ftp or other file sharing website. Fees can be paid by check or credit card. Make the check payable to the Oregon Department of State Lands. To pay the fee by credit card, call 503-986-5200.

x☐ Applicant ☐ Owner Name, Firm and Address: **Coyote Trails Nature Center, 2991 S. Pacific Hwy, Medford, Oregon 97501**	Business phone # 541-282-8577 Mobile phone # (optional) E-mail:
x☐ Authorized Legal Agent, Name and Address: **Scott English, Northwest Biological Consulting** **324 Terrace Street, Ashland, Oregon, 97520**	Business phone # **541-941-2042** Mobile phone # **Same as above** E-mail: **nwbiolog@gmail.com**

I either own the property described below or I have legal authority to allow access to the property. I authorize the Department to access the property for the purpose of confirming the information in the report, after prior notification to the primary contact.

Typed/Printed Name: **Scott English**_____ Signature: _____

Date: **September 30, 2013** Special instructions regarding site access: **Please Call**

Project and Site Information (using decimal degree format for lat/long.,enter centroid of site or start & end points of linear project)

Project Name: **Coyote Trails Side Channel Restoration**	Latitude: **42-17-56 N** Longitude: **122-50-28W**
Proposed Use: **Restore relic side channel of Bear Creek to provide critical habitat for ESA Coho salmon and enhance water quality**	Tax Map # **38-1-NE1/4 S 5**
Project Street Address (or other descriptive location): **2931 South Pacific Hwy, Medford, Oregon, 97501** City: **Medford** County: **Jackson**	Township **38S** Range **1W** Section **5** QQNE **1/4** Tax Lot(s) **100,106, & 200** Waterway: **Bear Creek** River Mile: **13.1** NWI Quad(s): **Medford East**

Wetland Delineation Information

Wetland Consultant Name, Firm and Address: **Scott English, NW Biological, 324 Terrace St, Ashland 97520**	Phone # **541-941-2042** Mobile phone # E-mail: **nwbiolog@gmail.com**

The information and conclusions on this form and in the attached report are true and correct to the best of my knowledge.

Consultant Signature: _____ Date: **Sept, 2013**

Primary Contact for report review and site access is x☐ Consultant ☐ Applicant/Owner x☐ Authorized Agent

Wetland/Waters Present? x☐ Yes ☐ No | Study Area size: **12.56 acres** Total Wetland Acreage: **1.83 Acres**

Check Box Below if Applicable:	**Fees:**
☐ R-F permit application submitted	x Fee payment submitted ~~$366~~ $388
☐ Mitigation bank site	☐ Fee ($100) for resubmittal of rejected report SE
☐ Wetland restoration/enhancement project (not mitigation)	☐ No fee for request for reissuance of an expired report
☐ Industrial Land Certification Program Site	
☐ Reissuance of a recently expired delineation Previous DSL # Expiration date _____	

Other Information:	Y	N	
Has previous delineation/application been made on parcel?	☐	x	If known, previous DSL #
Does LWI, if any, show wetland or waters on parcel?	x☐		

For Office Use Only

DSL Reviewer: _____ Fee Paid Date: _____ / _____ / _____ DSL WD # _____

Date Delineation Received: ____/ ___ / _____ DSL Project # _____ DSL Site # _____

Scanned: ☐ Final Scan: ☐ DSL WN # _____ DSL App. # _____

Form Updated 01/03/2013

NORTHWEST BIOLOGICAL CONSULTING

HABITAT RESTORATION – ENVIRONMENTAL PLANNING

Wetland Delineation Technical Report

Coyote Trails Nature Center Site

T38S, R1W, N.E. ¼ Sec. 5

Tax lots 100, 106, & 200

South Pacific Hwy, Medford, Oregon

Prepared For:

Bear Creek Watershed Council

and

Coyote Trails Nature Center,

2931 S Pacific Hwy, Medford, OR 97501
(541) 282-8577

Prepared By:

Northwest Biological Consulting,

324 Terrace St. Ashland, Oregon

Scott English, Isaac Skibinski, & Steve Koskella

OCTOBER, 2013

TABLE OF CONTENTS

WETLAND DELINEATION SUMMARY	**1**
INTRODUCTION	**2**
LANDSCAPE SETTING AND LAND USE	**3**
SITE ALTERATIONS	**3**
PRECIPITATION AND DATA ANALYSIS	**3**
METHODS	**5**
DEVIATION FROM NATIONAL WETLANDS INVENTORY	**8**
MAPPING METHOD	**8**
ADDITIONAL INFORMATION (FISHERIES)	**8**
RESULTS AND CONCLUSIONS	**8**
REQUIRED DISCLAIMER	**9**

TABLES

TABLE 1: PRECIPITATION FOR ONE YEAR PRIOR TO FIELD STUDY	**4**
TABLE 2: PRECIPITATION FOR TWO WEEKS PRIOR TO FIELD STUDY	**4**

APPENDICES

APPENDIX A: MAP FIGURES	**10**
FIGURE 1: LOCATION	
FIGURE 2A: TAXLOT	
FIGURE 2B: TAXLOTS	
FIGURE 3: NATIONAL WETLAND INVENTORY	
FIGURE 4: SOILS	
FIGURE 5: AERIAL PHOTOGRAPH	
FIGURE 6: WETLAND DELINEATION & SIDE CHANNEL MAP	
APPENDIX B: DATA FORMS & 2 GROUND-LEVEL PHOTOGRAPHS	**12**
APPENDIX C: LITERATURE CITED	**13**

WETLAND DELINEATION SUMMARY

PROJECT:	Coyote Trails Nature Center, Bear Creek Side Channel Restoration
LOCATION:	T38S, R1W, NE ¼ Section 5
LAT, LONG:	Centroid of Study Area = lat. 42.1756 long. 122.5028
CLIENT/OWNER:	City of Medford, Parks and Recreation Department
TAXLOTS:	TL 100,106, & 200
ACREAGE OF STUDY AREA:	Approximately **12.56** acres
METHOD:	1987 *Corps of Engineers Wetland Delineation Manual and Arid West Supplement Version 2.0*
STUDY PERIOD:	June 13, 2013
ELEVATION:	Approximately 1,250 feet above mean sea level (from Jackson County Smart-map data)
TOPOGRAPHIC FEATURES:	Floodplain of Bear Creek
WATERWAYS:	Adjacent to Bear Creek, RM 13.1
ESSENTIAL FISH HABITAT:	ESA listed coho salmon are present in this reach of Bear Creek and essential fish habitat supports coho and other anadromous fish species such as Chinook and steelhead trout. The intent of this project is to restore side channel habitat primarily for salmonid utilization and expand the riparian corridor along Bear Creek.
WETLAND TYPES:	PFO (Palustrine Forested) and PSS (Palustrine Scrub-Shrub)

NON-WETLAND WATERS: -The site of the side channel restoration is below Ordinary High Water Waters of the State would be impacted by the side channel restoration project

INTRODUCTION:

The channel restoration project is located in the Bear Creek floodplain at river mile 13.1 at the site of the Coyote Trails Nature Center, in the US Cellular Community Park. Property is owned by City of Medford Parks & Recreation Dept. The property site is managed by Coyote Trails School of Nature, an independent non-profit organization **(Figures 1, 2A, & 2B). Photograph 1** illustrates a good overview of the project site facing downstream and should be compared to **Figure 6** which depicts the proposed side channel in the same location as the photograph.

Project Description:

Historically, Bear Creek was a complex braided channel system which supported healthy salmonid spawning and rearing habitat. Currently, that habitat has been degraded by gravel mining and rearing habitat is very limited. The currently funded project will result in a conceptual solution to provide a hydologically connected side channel habitat and generate 30% level constructable, stamped technical plans and specifications for agency review to facilitate permitting. The goal of the work is to determine feasiblity and complete the preliminary steps to prepare for construction to open and restore a historic side channel on Bear Creek. Specific work will include: wetland delineation, an assessment of the groundwater/surface-water hydraulics to understand the subsurface flow regime, development of a plan to restore side channel areas, and 30% plans including cross sectional and slope drawings as well as landscape renderings of grading and planting plans. When constructed, the restored side channel and associated riparian habitat complex will add over 1000 lineal feet of channel which will include a rearing alcove at the downstream end which provides cover and cooler water for young salmonids as they outmigrate to the ocean.

Project Objectives & Expected Ecological Benefits:

The goal of the proposed project is to restore habitat complexity that was historically abundant on Bear Creek. Much of the fish habitat in Bear Creek has been modified or eliminated by land use practices, resulting in a single stem channel that is disconnected from the flood plain and typically exhibits higher flows and velocities than were present in the historic braided channel system. Due to the increased velocities, significant areas are now comprised of bedrock; gravels and other substrate are absent. This project would produce 30% level plans and design options for agency review. Cost estimates for construction to re-establish one side channel will also be developed. The side channel habitat will create refuge for juvenile salmonids during elevated spring and winter flows and from higher water temperatures during the summer. Gravels will also be sequestered in the restored side channels during high flow events, rather than being removed from the area. Planting of native riparian vegetation along the channel and in the flood-plain and removal of invasive species such as blackberries and reed canary grass are also part of the ecological benefits of the restoration project.

According to the Draft SONCC Coho Salmon Recovery plan, side channel restoration offers the best opportunity for bringing Coho salmon back from the verge of extinction. The plan states " …severely degraded conditions of the Upper Rogue River habitat, combined with the depressed coho salmon population size and distribution, significantly increases the risk of extinction of this

inland coho salmon population…" and "The greatest factor limiting recovery of coho salmon in the Upper Rogue River is the lack of suitable rearing habitat for juveniles."

The reconnected side channel would also offer a diverse habitat for a variety of native mammals, birds, reptiles, and amphibians. The project site is located at a nature center within a large urban park in Medford. Completion of the side channel would provide local residents of the Rogue Valley with educational opportunities to learn about the benefits of salmon restoration and recovery activities as well as recreational opportunities by improving the native habitat diversity. This project could also provide an example of the feasibility of restoring a braided system of side channels and backwaters on Bear Creek. It is expected that the project will benefit Coastal Chinook , Southern Oregon/Northern California Coho , as well as Steelhead and other trout.

LANDSCAPE SETTING AND LAND USE:

The channel restoration project is located within the City limits of Medford. The site is also situated within the Bear Creek floodplain at river mile 13.1 and is surrounded by urban parks and the Bear Creek Greenway. The site is bordered on the west by the US Cellular Sports- Park, the east boundary is Bear Creek and the Bear Creek Greenway, the north and south boundaries are undeveloped open space within the floodplain.

SITE ALTERATIONS:

The site has been severely impacted by a variety of past land use activities which included gravel mining and the filling in of historic Bear Creek channels and other channelization and flood control projects. The site contains disconnected relict channels that have been filled in. Artificial and out of place depressions and cobble berms are found throughout the site as evidence of past gravel mining activities. In addition, past flooding has altered the landscape. See previous discussion of project.

PRECIPITATION AND DATA ANALYSIS:

Climate:

The study area is situated in the Middle Rogue Watershed, which lies between the Coast Range, Klamath Mountains, and the Cascade Range in a subtle rain shadow. Summer months are generally warm and dry with infrequent rain and thunderstorms and occasional heat waves, while winter and spring months are generally cool and mild with moderate rainfall, occasional freezing temperatures, and infrequent snowfall. The growing season in Medford falls between April 30 and October 16 (169 days).

Precipitation

Monthly precipitation data was supplied by the National Weather Forecast Office Data Collection Station (MFO) in Medford for June 2012 through June 2013. Information from WSO

& WETS was used to compare the long-term monthly average precipitation to the observed precipitation for the year preceding the wetland delineation field surveys (Table 1).

Yearly average rainfall measured at the Medford WETS Station is 18.37 inches. To compare monthly rainfall for the water year 2012-2013, data collected by the Medford WFO was compared to the Medford WETS tables, which show that from 1971 to 2000, the Medford WSO averaged 18.37 inches of precipitation annually; primarily during winter and spring months. These data are shown in Table 1 under "30-Year Average". During the portion of the 2013 water year leading up to the field survey date--from October 1 2012 to June 13 2013--16.52 inches of precipitation were recorded in Medford, which is 90% of the 30-year average. However, during the three calendar months prior to sampling, only 2.29 inches of rain fell, which is 52% of the 30-year average of 4.37 inches for March through May.

Daily precipitation data for May 1 through June 13 2013 was supplied by Weather Underground and compared to the 30-year average rainfall for that period. The 30-year average precipitation for June is 0.76 inches. From this, a daily 30-year average precipitation of 0.025 inches was calculated, and subsequently the 30-year average precipitation for the 14-day period, 0.355 inches. (Table 2).

TABLE 1. OBSERVED AND 30-YEAR AVERAGE PRECIPITATION

	Jul 2012	Aug 2012	Sep 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2012	Feb 2013	Mar 2013	Apr 2013	May 2013	June 2013
Observed (inches)	0.07	0.00	0.00	1.96	5.13	5.66	0.96	0.49	0.56	1.04	0.69	0.39
30-Year Average (inches)	0.31	0.52	0.78	1.31	2.93	2.90	2.47	2.10	1.85	1.31	1.21	0.76
Percent of Average	23%	0%	0%	150%	175%	195%	39%	23%	30%	79%	57%	51%

As shown in Table 2, wetland delineation field conditions were drier than normal in the two weeks preceding and including the field survey on June 13, 2013.

TABLE 2. PRECIPITATION FOR ONE WEEK PRIOR TO FIELD SURVEY

Field Survey Date	Two Weeks Prior to and Including Field Survey Date	Observed Precipitation	Average Precipitation (Period 1971 – 2000)	Percent of Average (Observed Divided by Average)
May 9, 2013	May 31–July 13, 2013	0.01 in	0.355 in	3%

METHODS

Collection of Background Information:

Prior to conducting field surveys, a preliminary background investigation was undertaken to obtain the following information for the study area:

- Taxlot Information
- Regional Climate and Precipitation Information and Ordinary High Water (OHW) Data
- NWI & Local Wetlands
- Soils information
- Site History
- Aerial Photographs

Jackson County Spatial Data:

Tax-lot information, elevation data, local wetland inventories (**Figure 3**), NRCS-mapped soil boundaries (**Figure 4**) and aerial photographs (**Figure 5**) were acquired by accessing the Jackson County Geographic Information Services web page and downloading the corresponding GIS data.

Regional Climate and Precipitation Information:

Climate and monthly precipitation information for Jackson County was obtained from the National Oceanic and Atmospheric Administration (NOAA) National Weather Service Forecast Office website. USDA WETS data for Medford was downloaded from the NRCS Water and Climate Center FTP site Daily weather data was supplied by Weather Underground.

Soils Information:

Detailed soils descriptions for the mapped soils of the study area were obtained from the Soil Survey of Jackson County Area (Soil Conservation Service 1993). The soil survey map identifies three soil mapping units: 127A Medford Silty Clay Loam 0 to 3 percent slopes, 23 Camas-Newberg-Evans, 0 to 3 percent slope, and a small area of 154 Riverwash, 0 to 3 percent slopes.

The following map unit descriptions paraphrase the Soil Survey of Jackson County Area.

Map unit **127A** is very deep and moderately well-drained. It is on stream terraces. It is comprised of a 10-inch thick surface layer of very dark brown silty clay and a 31-inch thick layer of yellowish-brown silty-clay loam below that.

Map unit **23A** is very well drained soil found on flood- plains. It is comprised of a 10-inch thick surface layer of very dark brown gravelly sandy loam and a 60-inch thick layer of very dark grayish- brown extremely gravelly coarse sand below that.

Map unit **154** is Riverwash material that consists of deep excessively drained to very poorly drained, recently deposited alluvium in narrow, irregular strips along major streams and rivers. Most areas of Riverwash are very cobbly , extremely cobbly, or extremely gravelly sand to a depth of 60 inches or more. Riverwash is extremely prone to flooding and vegetation is sparce and not very well supported in this map unit. Riverwash was found in strips along the bank of Bear Creek within the project area.

Field Methods:

Paired, three-parameter wetland data plots were established to determine the wetland boundaries of the channel restoration site with data plots in the wetland and complementary data plots in the adjoining uplands. A total of 7 paired data plots were established throughout the site (**Figure 6).** Also, stream gauging data and other information was gathered to help determine OHW.

Vegetation

For each data plot, vegetative cover was visually estimated for each plant species within a 5-foot radius for herbaceous groundcover. Trees and shrubs were present in the data plots; therefore, a 10-foot radius for vegetative cover was visually estimated for these classes of vegetation. The wetland boundaries were well defined around the perimeter of the wetlands and 7 paired plots were used to determine upland and wetland conditions using the wetland indicator status in *Region 9 Plants Occurring in Wetlands and the Region 9 Supplemental Plants List (Reed Jr. 1988).* The wetland community was dominated by willows, cottonwoods, ash, and alders with an understory of ribes sp., reed canary grass, teasel, poison hemlock, tall fescue, juncus sp., and carex sp. The upland plant community consisted of black and white oaks, ponderosa pine, incense cedar, madrone, rose, snowberry, blackberry, scotch broom, and yellow star thistle.

All species listed on the data sheets were ranked (based on spatial cover for each vegetative layer) and the dominant species were selected and evaluated by using the dominance test on the Arid West Regional Supplement field form. Data plots with a Dominance Test having greater than fifty percent dominant species (OBL, FACW, or FAC) *(Reed Jr. 1988)* were considered to meet the criteria for wetland vegetation. In the event that vegetative cover did not meet the criteria for wetland vegetation based on the Dominance Test, the Prevalence Index Worksheet was used. Data plots with a Prevalence Index of 3.0 or less were considered to meet the criteria for wetland vegetation. A positive result in either test was sufficient for determining that a data plot met the criteria for wetland vegetation.

Hydric Soil Indicators

Soils and hydrology were evaluated at each data plot using a spade to excavate the upper part of the soil profile whenever possible, which in most cases was only 6 to 12 inches due to the presence of large cobble substrate. The soils both in wetland areas and adjacent uplands were problematic and consisted of highly disturbed soils that were excavated and graded when the area was mined for gravel many years ago.

Soils were examined in direct sunlight for hue, value, and chroma using Munsell color charts (Gretag/Macbeth 2000) for comparisons. All soil samples were moistened before determining hue, value, and chroma. Soil textures were determined using the methodology presented in *Field Indicators of Hydric Soils in the United States* (USDA Natural Resources Conservation Service 2006).

Soil characteristics and their depths were noted on the field forms and the criteria for making hydric soil determinations followed the guidance presented in the *Arid West Supplement* and *Field Indicators of Hydric Soils in the United States*.

Problematic soils were encountered in many of the data plots due to the nature of a highly disturbed site. Redox was indicated in some of the plots but very sandy soils in the Riverwash areas did not contain redox and were considered problem soils as per chapter 5 in the *Field Indicators of Hydric Soils in the United States.*

Hydrology Indiactors:

Photograph 2 was taken on December 1, 2012 and this photograph shows the upstream portion of the proposed side channel. As seen in the photograph the side channel is under water. Data from the USGS gauging station in Medford indicated that the peak flow on December 1, 2012 was 683 CFS and the average for the day was 443 CFS. If the two year flood event is more than 443 CFS and the side channel is inundated then the restoration project area could be considered as occurring below Ordinary High Water (OHW).

Many of the data plots indicate wetland hydrology due to the presence of water marks, sediment/drift deposits, and water stained leaves. The hydrology indicators are likely attributed to the December 1, 2012 two year flood event, an OHW benchmark.

DEVIATION FROM NATIONAL WETLANDS INVENTORY

There is a deviation from the NWI inventory. The NWI uses the Cowardin Classification System for classifying wetlands and the NWI map does not show any wetlands on the study site. The NWI map only shows a small sliver of PFO (Palustrine Forested) wetland across Bear Creek but not on the project site. Our investigation clearly shows both PFO and PSS (Palustrine Scrub-Shrub) wetland present in the northerly portion of the study site, adjacent to Bear Creek. **(Figures 5 and 6)**

MAPPING METHOD

The wetland boundaries and data plot locations were marked with pin-flagging and mapped with a sub-meter accurate GPS unit by Northwest Biological Consulting, who also prepared the wetland delineation/side channel map. **(Figure 6)**

ADDITIONAL INFORMATION (FISHERIES)

Please refer to the previous fisheries and habitat discussions presented on pages 2 and 3.

RESULTS AND CONCLUSIONS

The wetland delineation was performed in mid June during the growing season, and wetland vegetation was readily identifiable. Visible wetland hydrology in the data plots was easily found

due to the high water table in some of the plots and many of the plots indicated biotic crust, sediment deposits, water marks and debris trails, The soils were clearly hydric when redox was present but in some cases the Riverwash soils did not contain redox but were considered hydric as per chapter 5 in the *Field Indicators of Hydric Soils in the United States.*

Some wetland soils were described as having hue of 10YR or 7.5YR and had sufficient redox indicators to meet wetland criteria. Other wetland soils were problematic, due to the disturbed nature of past flood-plain mining activity. These soils were presumed to be hydric in data plots that had visible hydrologic indicators and a predominance of wetland vegetation along with a well-defined wetland boundary and were noted on the AWS data sheets **(Appendix B)** and **Figure 6.**

All wetland data plots exhibited a greater than 50 percent dominance of wetland vegetation or had a score of less-than or equal-to 3.0 using the prevalence indicator worksheet. The wetlands **totaled 1.83 acre**s and were considered a mosaic of PFO and PSS due to wetland hydrology, hydric soils and dominant wetland species which were primarily tree species: willow, ash, alder, and cottonwood with understory species of reed canary grass, ribes, carex, and juncus.

The channel restoration work would impact a small area of wetlands and any trees and shrubs and wetland vegetation impacted by the channel restoration work will be replaced by planting native riparian species along the banks of the restored side channel.

REQUIRED DISCLAIMER

This report is not a jurisdictional document until reviewed and confirmed by the DSL and/or the Corps (the Corps is currently only reviewing wetland delineations when accompanied by a permit application to fill a wetland). This report documents the investigation, best professional judgment, and conclusions of the investigator. It should be considered a preliminary Jurisdictional Determination and "used at your own risk" until it has been reviewed and approved by the DSL in accordance with Oregon Administrative Rules (OAR) 141-090-0005 through 141-090-0055.

APPENDIX A

MAP FIGURES

Figure 1: Location
Figure 2A: Tax Lots
Figure 2B: Tax Lots
Figure 3: National Wetlands Inventory
Figure 4: Jackson County Soil Survey
Figure 5: Aerial Photo
Figure 6: Wetland Delineation/OHW Map

Figure 1
Location

Data provided by Jackson County.

July 30, 2013

Northwest Biological Consulting
Habitat Restoration,
Environmental Planning
CA Engineering Contractor
OR General Contractor
324 Terrace St. P.O. Box 671 nwbiolog.com
Ashland, OR 97520 Ph/Fax (541) 488-1061

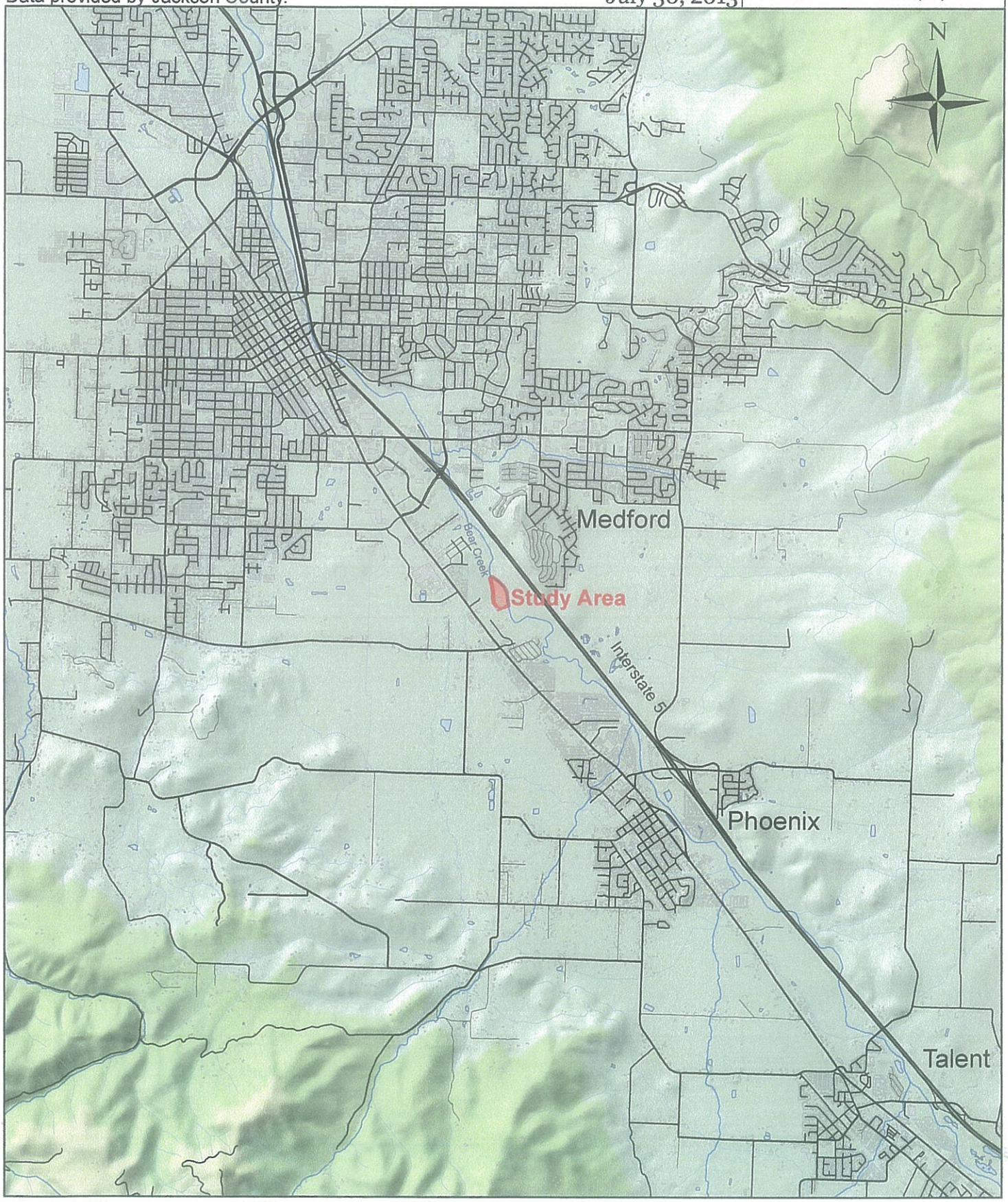
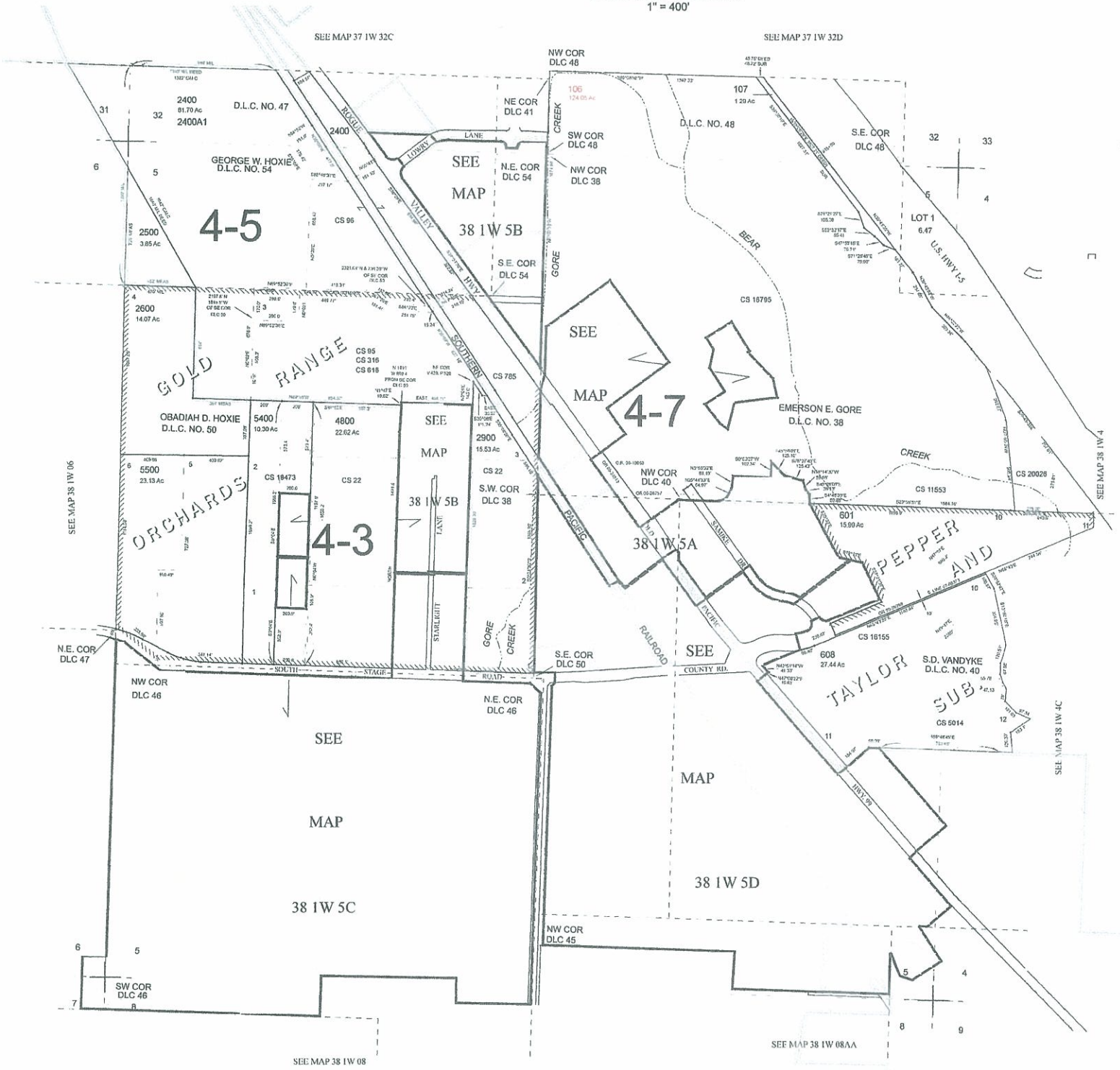


Figure 2A
Tax Lot 106

FOR ASSESSMENT AND TAXATION ONLY

SECTION 5, T.38S., R.1W., W.M.
JACKSON COUNTY
1" = 400'

38 1W 05
& INDEX
MEDFORD



CANCELLED TAX LOT NUMBERS:

100 THRU 105
108
200 THRU 600
2501
2502
2601 THRU 2800
3000 THRU 4700
4900 THRU 5300
5600
602 THRU 607
609 THRU 2300
6100 THRU 7600
7800

DATA
4/2010 7:44:56 AM : JohnsoWH

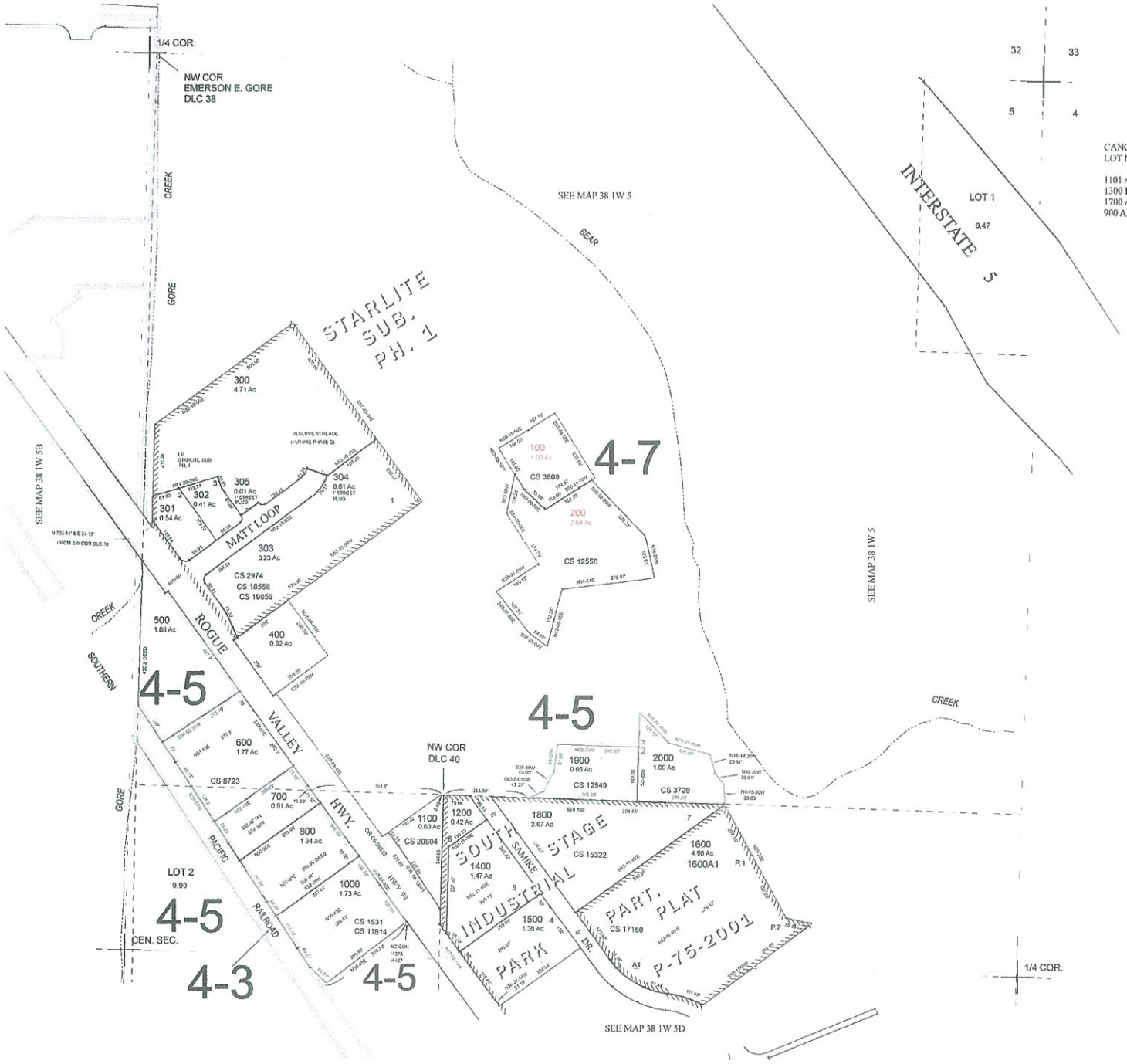
38 1W 05
& INDEX
MEDFORD
NEW MAP FEBRUARY 27, 2004

Figure 2B
Tax Lots 100 & 200

FOR ASSESSMENT AND TAXATION ONLY

N.E.1/4, SEC.5, T.38S., R.1W., W.M.
JACKSON COUNTY
1" = 200'

38 1W 05A
MEDFORD



CANCELLED TAX
LOT NUMBERS:

1101 ADDED TO 381W05 - 106
1300 KILLED TO STREET
1700 ADDED TO 1600
900 ADDED TO 800

38 1W 05A
MEDFORD

REV MARCH 01, 2004
REV JULY 13, 2010

GIS DATA
07/13/2010 8:06:52 AM : AlamoAJ

Figure 3
Wetland Inventory

Data provided by Jackson County.

July 30, 2013

Northwest Biological Consulting
Habitat Restoration,
Environmental Planning
CA Engineering Contractor
OR General Contractor
324 Terrace St. P.O. Box 671 nwbiolog.com
Ashland, OR 97520 Ph/Fax (541) 488-1061

Figure 4
Soils

Data provided by Jackson County.

July 30, 2013

Northwest Biological Consulting
Habitat Restoration,
Environmental Planning
CA Engineering Contractor
OR General Contractor
324 Terrace St. P.O. Box 671 nwbiolog.com
Ashland, OR 97520 Ph/Fax (541) 488-1061

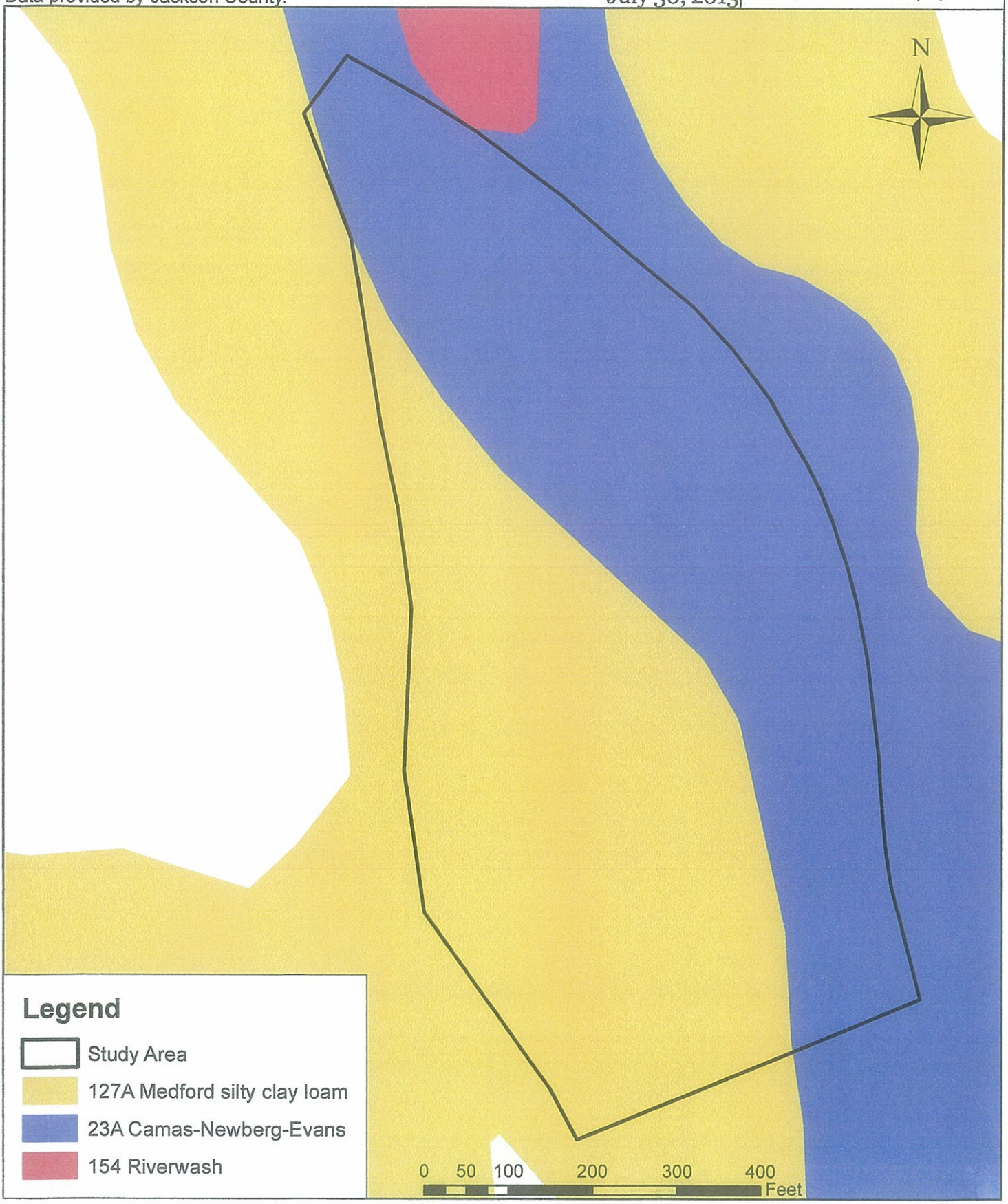


Figure 5
Aerial Photo

Photography provided by the city of Medford. Flown in 2009.

July 30, 2013

Northwest Biological Consulting
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Figure 6
Wetland Delineation

Mapped to submeter accuracy on the ground with a Trimble Geo XT.
River boundary estimated from aerial photo in Figure 5.

October 15, 2013

Northwest Biological Consulting
Habitat Restoration,
Environmental Planning
CA Engineering Contractor
OR General Contractor
324 Terrace St. P.O. Box 671 nwbiolog.com
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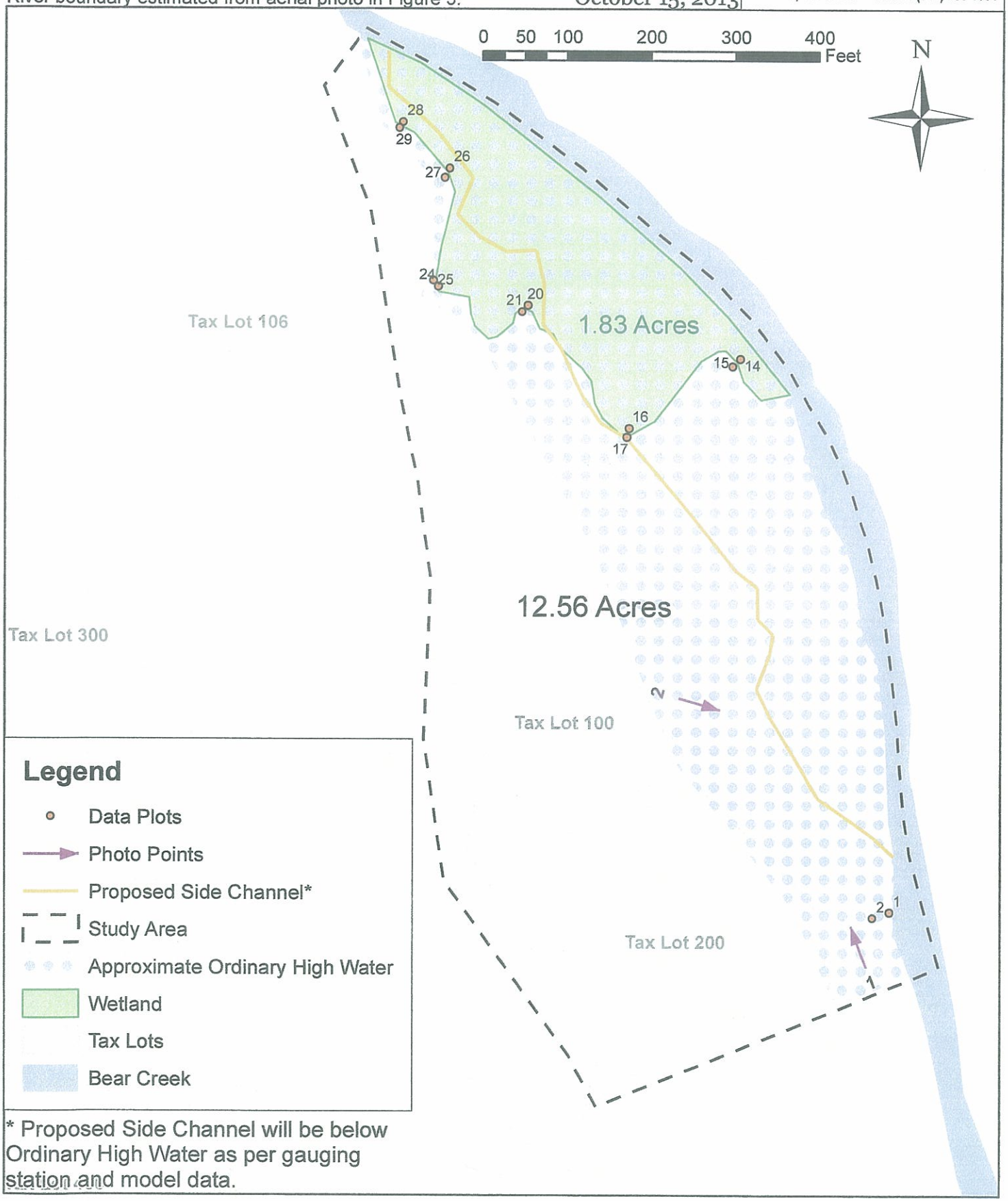


* Proposed Side Channel will be below Ordinary High Water as per gauging station and model data.

APPENDIX B

TWO GROUND-LEVEL COLOR PHOTOGRAPHS AND 14 DATA FORMS

Photograh # 2 Illustrates OHW on December 1, 2012 at the Upstream Location of Proposed Side Channel

Photograph # 1, Taken from Bear Cr. Bridge & Looking Downstream at Proposed Side Channel Area

APPENDIX B: Hydrological Assessment

B.1 Objectives

- Perform a limited baseline hydrologic assessment at the Site to better understand the sources of water contributing to the riparian area, and
- Determine potential hydrologic and hydraulic impacts to Bear Creek.

B.2 Field Program Installation

Preparation

Six HOBO Tidbit temperature data loggers were identified for use, and a calibration check was performed on each one with a temperature water bath in the lab. The data loggers were subsequently set to record temperature readings every 30 minutes beginning at midnight of 4-22-2013. Small, perforated PVC housings were constructed for data loggers to be discretely deployed in in Bear Creek (Photograph B1). Larger (longer) perforated PVC housings were constructed for data loggers to be deployed about one foot below ground surface (bgs) at selected piezometer nests in the wetland areas (Photograph B2). A HOBO waterproof shuttle was used to download the data loggers in the field. (Photograph B3.). The software, HOBOWarePro 3.4.0, was used to launch, download, and view the data.

Piezometers (a type of small monitoring well with a discrete screen depth) were constructed of PVC pipe with a 6-inch screened tip at the bottom (Photograph B4).

Static water levels were measured from each piezometer using a Solinst model 101 water level indicator, and spot-check water temperatures were measured with a National Institute of Standards and Technology (NIST)-calibrated thermometer (Photograph B5).

Field notes were collected in a field notebook and photographs were collected.

Field Work

Field work began on 4-22-2013. Five piezometer nests were installed and two stream stations were installed as shown in Figure B1. A small track hoe was used to advance test pits to inspect the soil horizon. Down on the flood terrace close to Bear Creek near PN3, soil was comprised of unsorted alluvial gravels, small cobbles and coarse sand (Photograph B6). A pervasive sandstone bedrock layer, also observed in Bear Creek (Photograph B7) was encountered very close to the land surface. In some areas, the bedrock layer was so close (less than 6 inches from the surface) that a piezometer could not be installed, and those areas were rejected (Photograph B8). Areas were

selected where the pervasive sandstone bedrock was covered by more than 1.25 (15 inches) feet of alluvium.

A shallow piezometer and a data logger were installed at PN3 (Photograph B6). Bedrock was encountered at 2.9 feet bgs at PN3. Therefore, a deep piezometer could not be installed. The piezometer tip was packed with fine, washed sand, and the alluvial material was repacked gently around the monitoring equipment (Photograph B9).

Piezometer nests PN1 and PN2 were installed further to the north in a thickly shaded wetland area. The bedrock layer at PN 2 was only 1.25 feet BGS, so a deep piezometer was not installed there (Photograph B10). The bedrock layer at PN1 was 3.25 feet bgs at PN1. Therefore a nest of a shallow piezometer, a deep piezometer, and a data logger were installed there (photographs B11 and B12). Both areas were in an inundated wetland at the time, and monitoring equipment was installed by hand.

Piezometer nests PN4 and PN5 were installed to the west further away from Bear Creek and further uphill on the flood terrace (Figure B1) (Photograph B13). The pervasive bedrock layer was encountered at 5.1 feet bgs at PN5, and a lens of groundwater was encountered above it. Therefore a deep piezometer was installed. However, no water was observed near the ground surface, so a shallow piezometer and shall data logger were not of use and not installed. Instead, plans were made to come out to the Site more often to collect spot-check temperature measurements. Bedrock was not encountered down to the vertical extent of the track hoe at approximately 6.5 feet bgs at PN4 (Photograph B14). Therefore the same set-up was installed at PN4 as that of PN5. One difference observed at PN4 was that the water bearing alluvial aquifer was comprised of a fairly well sorted oxidized medium to coarse sand, rather than the mixed cobbley gravelly sand observed at the other areas. This was overlain by a clayey fill material with bits of wire and broken glass observed during excavation.

Two data loggers were also deployed directly in Bear Creek; one upstream of the Site (BC-US) and one downstream of the Site (BC-DS). A metal “T” post was driven into the bank at BC-DS so that the stream stage could also be measured relative to the water levels measured at each piezometer nest. All of the stations were surveyed to real earth coordinates by Fred Frantz Engineering.

B.3 Monitoring

The sites were monitored from 4-25-2013 through 11-8-2013. Monitoring was performed weekly during the spring months to capture the changes as the standing water quickly infiltrated into the subsurface, and timing was extended slowly to one month intervals by the end of the season. Monitoring consisted of: visual assessment of changes, and temperature spot checks and water level measurements at each piezometer and Bear Creek.

All data loggers were pulled out on 10-9-2013.

Katalyst field staff noticed during monitoring that spot-check water temperatures at the downstream station along Bear Creek were often slightly higher than temperatures at the upstream station. This seemed more prevalent during the warm afternoons. The observation prompted further inspection and comparison of the two stations, discussed further in the following section.

Prior to beginning the monitoring work, on 12-2-2012 a significant high flow event occurred in the Rogue Valley including Bear Creek. The USGS rated the event as between a 2-year and a 5-year event. Fortunately, the Coyote Trails Center staff took photographs of the Site at the time. Photographs B15 and B16 show a comparison of the same area during the high flow event when Bear Creek was flowing at approximately 1500 cfs, and the more "normal" lower flow taken on 12-30-2013 when Bear Creek was flowing at only 25 cfs. This provides direct evidence that the flood terrace where the new channel modifications are proposed is inundated by overland flow from (at least) 2-year flood events.

B.4 Results

Monitoring results are summarized in Table B1. The standing surface water in the wetland observed at PN1 and PN2 had disappeared by the 5-13-2013 event, just two weeks after the stations were installed. However, shallow water persisted in the shallow piezometers at these two stations until 6-14-2013. Interestingly, water continued to be measured in the deeper piezometer at PN1 (3.2 feet bgs) for the entire season.

The static water levels in all of the piezometers was consistently higher than the water level measured in Bear Creek, indicating a "gaining" reach (water generally flows from the alluvial aquifer to the stream as base flow, rather than water flowing from the stream into the alluvium).

A comparison of water temperatures recorded by the data loggers during the 2013 season at selected locations is shown in Figure B2. The wide (typically about 8 degrees F) diurnal fluctuation in water temperature in Bear Creek is easily seen. In contrast, there is relatively little diurnal fluctuation in the alluvial groundwater at PN1 and PN2. Water temperatures were similar at stations PN1 and PN2, both located in the shaded wetland area. In addition, the time when the data loggers went dry at both PN1 and PN2 is also shown in Figure B2. A marked jump in temperature is evident when the data loggers went dry (around July 4th) and were exposed to soil atmosphere, followed by a subsequent decrease when the data loggers were again inundated in the fall (around September 23rd).

The Oregon Department of Environmental Quality (ODEQ) summer water quality standard in Bear Creek for Salmon and Trout rearing and migration (64.4 F) is also shown on Figure B2. Though temperatures in Bear Creek exceed the standard for the

entire summer, the temperature of the shallow alluvial groundwater at PN1 and PN2 never exceeds the standard.

One additional observation evident in Figure B2 is the comparison to the temperature of the soil atmosphere in PN1 and PN2 when they went dry, to that of PN3, which was always dry. Temperatures in PN3, located out in an unshaded part of the Site, are consistently 5 to 7 degrees F higher than temperatures at PN1 and PN2, which are located in a shaded wetland area.

A comparison of temperatures between Bear Creek and the alluvial groundwater at PN1 and PN5 is shown in Figure B3. There was a marked difference in water temperature at PN5, which was consistently about 5 degrees centigrade higher than the water temperatures at PN1 and PN2. In fact, the temperature at PN5 typically exceeded the temperatures in Bear Creek, which is counter-intuitive since the water at PN5 was the deepest groundwater encountered at the Site. Though the groundwater at PN5 is warmer than the groundwater at PN1, the seasonal trend between them is very similar.

A closer comparison of the water temperatures between the downstream station and the upstream station along Bear Creek at the Site was also performed. It is difficult to see the differences in the two lines for the entire season in Figure x.3, as they overlap considerably. However Figure B4 shows a two-week subset of the temperature data from 6-1-2013 through 6-15-2015 as daily temperatures are rising. Two trends are apparent. Downstream water temperatures are consistently higher (often more than 2°F) than upstream temperatures in the late afternoons, peaking at about 1730 each day. Conversely, downstream water temperatures are also consistently *lower* than upstream temperatures in the early morning, reaching a minimum at about 0800 each morning.

B.5 Discussion

- Shallow alluvial groundwater appears to be in direct hydrologic connection with Bear Creek. In addition, the bedrock bottom observed in Bear Creek appears to be pervasive throughout the Site, thereby limiting the thickness of the alluvial aquifer.

- The sources of water to the Site include: upstream flow from Bear Creek, overland flow from Bear Creek during high flow events, direct precipitation, seasonally stored water in the shallow alluvial aquifer as baseflow (limited by the underlying sandstone bedrock), and additional runoff from nearby bioswales. No signs of water contribution from springs or seeps (groundwater flowing naturally onto ground surface) were observed in the area.

- The alluvial groundwater down near PN1 and PN2 is consistently cooler than water in Bear Creek, and exhibits much less seasonal temperature fluctuation than Bear Creek. Though temperatures in Bear Creek exceed the ODEQ water-

quality standard for Salmon and Trout rearing and migration in Bear Creek for the entire summer, the temperature of the shallow alluvial groundwater at PN1 and PN2 never exceeded the standard.

- The shallow subsurface in shaded areas, such as near PN1 and PN2, is consistently cooler than the shallow subsurface in unshaded areas, such as PN3.

- The unusually high groundwater temperatures at PN5 were researched further. Review of Figure B5 and Photograph B17 shows that PN5 is very close (approximately 15-20 feet away) to the buried sewer line that runs through the area. It is possible that there is a heat transfer from the sewer effluent inside the line and nearby alluvial groundwater. That is, the relatively warmer effluent may be warming nearby alluvial groundwater along its entire length.

- The flood terrace where the proposed new channel modifications are proposed is inundated by overland flow from 2-year flood events.

- Daily water temperatures in Bear Creek fluctuate more as the water flows through the Site. That is, creek water gets slightly hotter at the downstream end each afternoon, yet slightly cooler downstream early each morning, relative to the upstream end just 1500 feet away (Figure B4). The disparity is more prevalent as the area heats up in the summer months. One possible explanation for this is that the broad, open expanse of shallow bedrock at the Site serves as a "temperature sink". As shallow water flows over the exposed bedrock that has been slowly warming in the sun during the day, the rock absorbs some of the heat during the warmest part of the day and transfers it back to the water for a few more hours in late afternoon. Likewise, as the entire riparian area cools off at night, the bedrock continues to cool the water that is beginning to warm up as the sun rises. If this explanation is correct, the broad, shallow bedrock areas along Bear Creek that were anthropogenically created by gravel mining (for example, during construction of the I-5 Corridor) may be increasing water temperatures in Bear Creek.

- While monitoring in the field, spawning Chinook were observed utilizing gravels to build two redds in the small accumulations of gravel substrate pockets on the bedrock channel of Bear Creek.

Table B1. Hydrologic Field Data Collection Results: 2013

Location ID	Total Depth	Survey Elev*	4-25-2013 at 1400			4-30-2013 at 1430			5-13-2013 at 1130			5-17-2013 at 1145			5-31-2013 at 1530			6-14-2013 at 1010		
			Depth	Elev.	Temp	Depth	Elev.	Temp	Depth	Elev.	Temp	Depth	Elev.	Temp	Depth	Elev.	Temp	Depth	Elev.	Temp
	(ft bgs)	(msl)	(ft toc)	(msl)	C	(ft toc)	(msl)	C	(ft toc)	(msl)	C	(ft toc)	(msl)	C	(ft toc)	(msl)	C	(ft toc)	(msl)	C
PN1-WLS	na		0.5	1406.4	10.9	0.67	1406.26	14.4	dry			dry			dry			dry		
PN1-Shallow	1.7	1406.89	0.5	1406.4	11	0.54	1406.35	12.8	0.82	1406.07	13.1	1.1	1405.79	13.3	1.14	1405.75	13.4	dry		
PN1-Deep	3.2	1406.93	0.5	1406.4	10.5	0.62	1406.31	10.8	0.85	1406.08	11.3	1.14	1405.79	12.3	1.22	1405.71	12.0	1.48	1405.5	13.4
PN2-WLS	na		0.45		19.2	0.69		18.0	dry			dry			dry			dry		
PN2-Shallow	1.2	1407.03	0.38	1406.7	11.8	0.58	1406.45	12.1	0.82	1406.21	14.5	1.15	1405.88	16.4	1.28	1405.75	16.3	dry		
PN3-Shallow	?	1408.98	1.89	1407.1	14.4	2.12	1406.86	14.5	2.45	1406.53	17.9	dry			dry			dry		
PN4-Deep	6.5	1412.95	5.57	1407.4	14.2	5.61	1407.34	12.3	5.90	1407.05	13.8	dry to probe, but wet below			6.14	1406.81	15.2	dry to probe, but wet below		
PN-5-Deep	5.1	1412.26	3.96	1408.3	15.6	4.12	1408.1	14.2	4.36	1407.9	14.8	4.57	1407.7	16.5	4.50	1407.8	16.4	4.72	1407.5	17.6
Bear Ck-US	na		na		15.2	na		14.1	na		15.2	na		12.2	na		18.5	na		13.2
Bear Ck-DS	na	1406.81	3.0	1403.8	14.2	3.15	1403.7	14.1	3.28	1403.5	14.9	3.27	1403.5	12.1	3.35	1403.5	18.5	3.50	1403.3	13.7

Table B1. Continued

Location ID	6-27-2013 at 1610			7-15-2013 at 1030			8-15-13 @1110			9-9-13 @ 1045			9-27-13 @ 1255			10-9-13@ 1300			11-8-2013 at 1400		
	Depth	Elev.	Temp	Depth	Elev.	Temp	Depth	Elev.	Temp	Depth	Elev.	Temp	Depth	Elev.	Temp	Depth	Elev.	Temp	Depth	Elev.	Temp
	(ft toc)	(msl)	C	(ft toc)	(msl)	C	(ft toc)	(msl)	C	(ft toc)	(msl)	C	(ft toc)	(msl)	C	(ft toc)	(msl)	C	(ft toc)	(msl)	C
PN1-WLS	dry			dry			dry			dry			dry			dry			dry		
PN1-Shallow	dry			dry			dry			dry			dry			0.89	1406.0	14.1	1.01	1405.88	10.9
PN1-Deep	1.69	1405.24	13.7	2.02	1404.9	15.1	1.91	1405.02	16	1.70	1405.2	16.2	1.50	1405.4	15.2	0.93	1406.0	14.2	1	1405.93	10.7
PN2-WLS	dry			dry			dry			dry			dry			dry			dry		
PN2-Shallow	dry			dry			dry			dry			dry			1.12	1405.9	14.9	1.09	1405.94	11.1
PN3-Shallow	dry			dry			dry			dry			dry			dry			dry		
PN4-Deep	dry			dry			dry			dry			dry			dry			dry		
PN-5-Deep	4.76	1407.5	18.6	4.90	1407.4	19.2	4.79	1407.5	21.3	4.82	1407.4	21.2	4.49	1407.8	19.7	4.02	1408.2	19	4.63	1407.6	16.1
Bear Ck-US	na		23.0	na		18.0	na		19.1	na		18.6	na		12.7	na		12.9	na		nm
Bear Ck-DS	3.43	1403.4	22.9	3.44	1403.4	18.4	3.52	1403.3	19.7	3.48	1403.3	18.7	3.48	1403.3	13.2	3.35	1403.5	12.9	3.53	1403.3	11

** Infrastructure surveyed by Fred Frantz Surveyor,*

bgs = below ground surface

toc = top of casing

msl = mean sea level

Elevation Contour Interval = 1 foot

= shallow groundwater flow direction

Source: Adapted from KenCairn Landscape Architects

Figure B1. Hydrologic Monitoring Locations

Katalyst, Inc.

Baseline Hydro Study
Coyote Trails Center

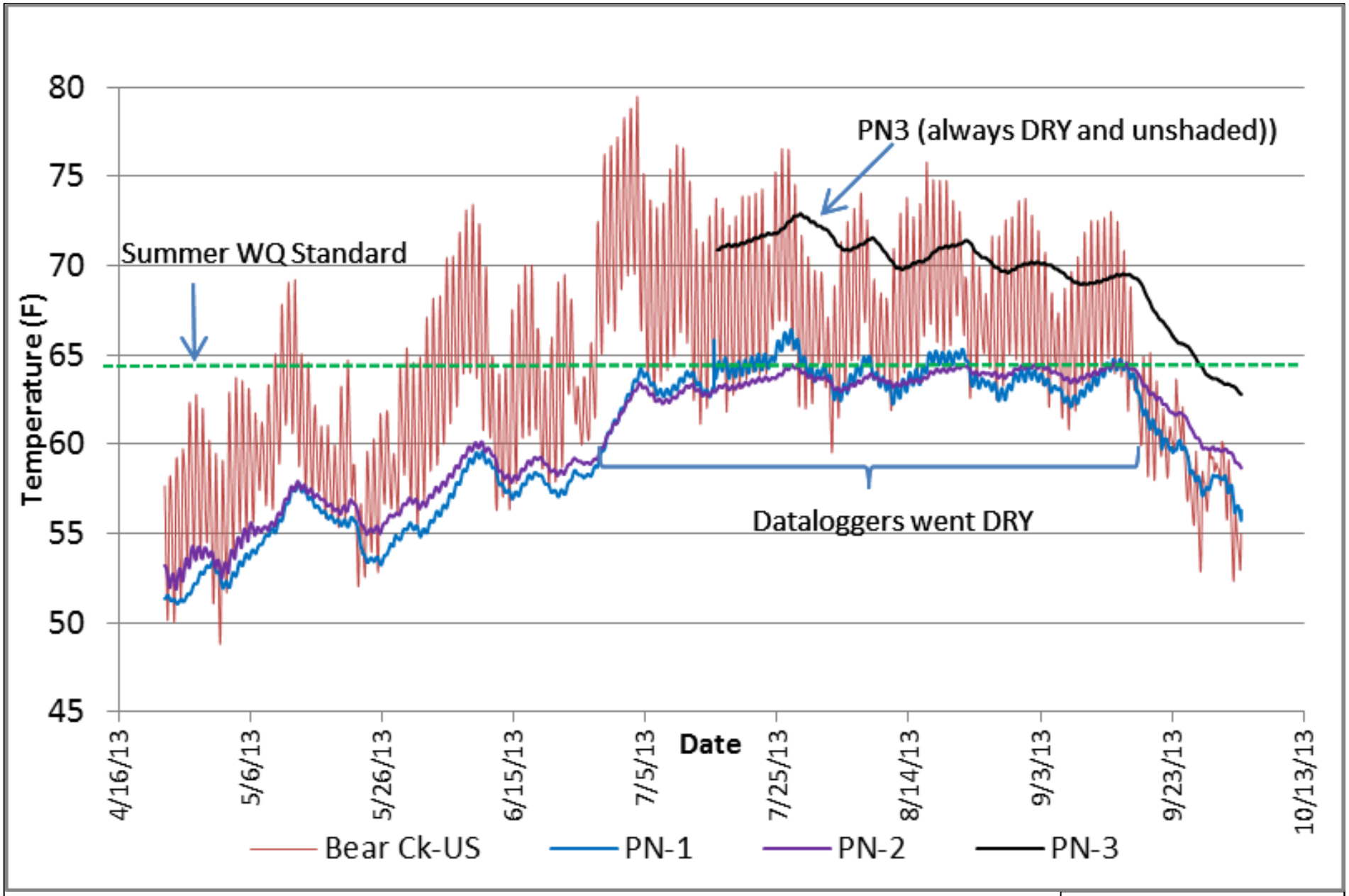


Figure B2. Water Temperature Comparison

Katalyst, Inc.
Baseline Hydro Study
Coyote Trails Center

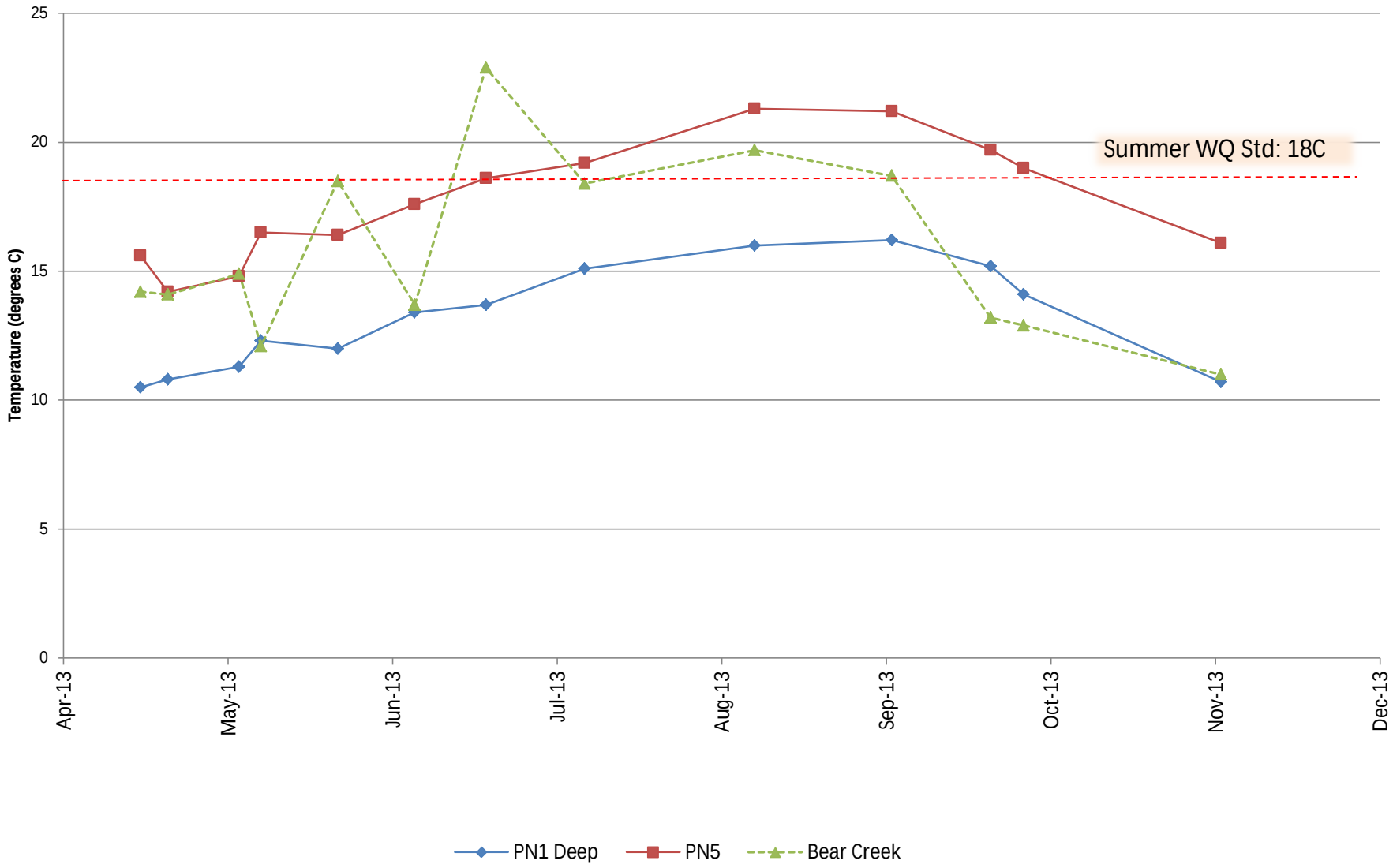


Figure B3. Temperature Comparison: Alluvial Groundwater and Bear Creek

Katalyst, Inc.
Baseline Hydro Study
Coyote Trails Center

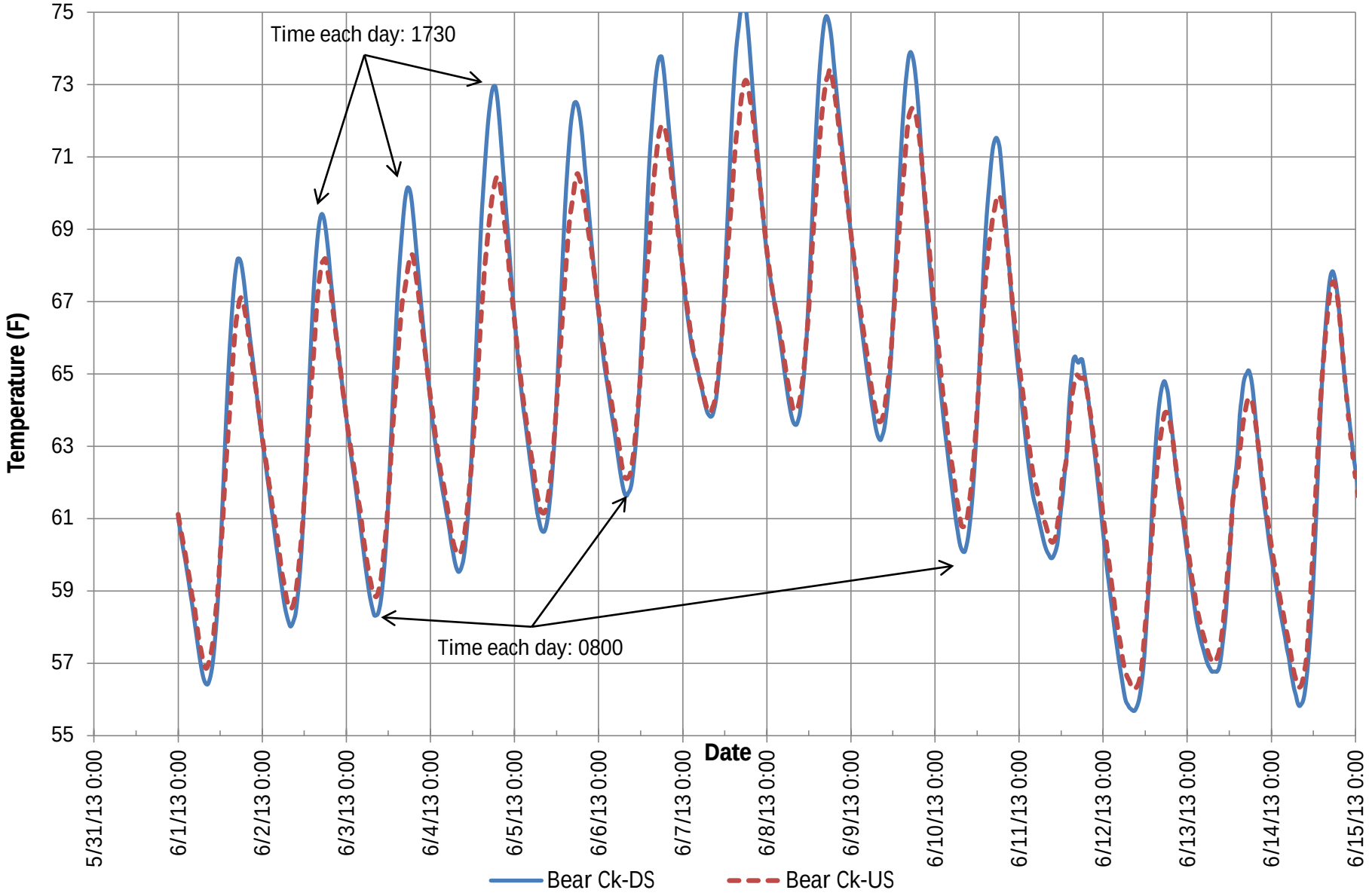
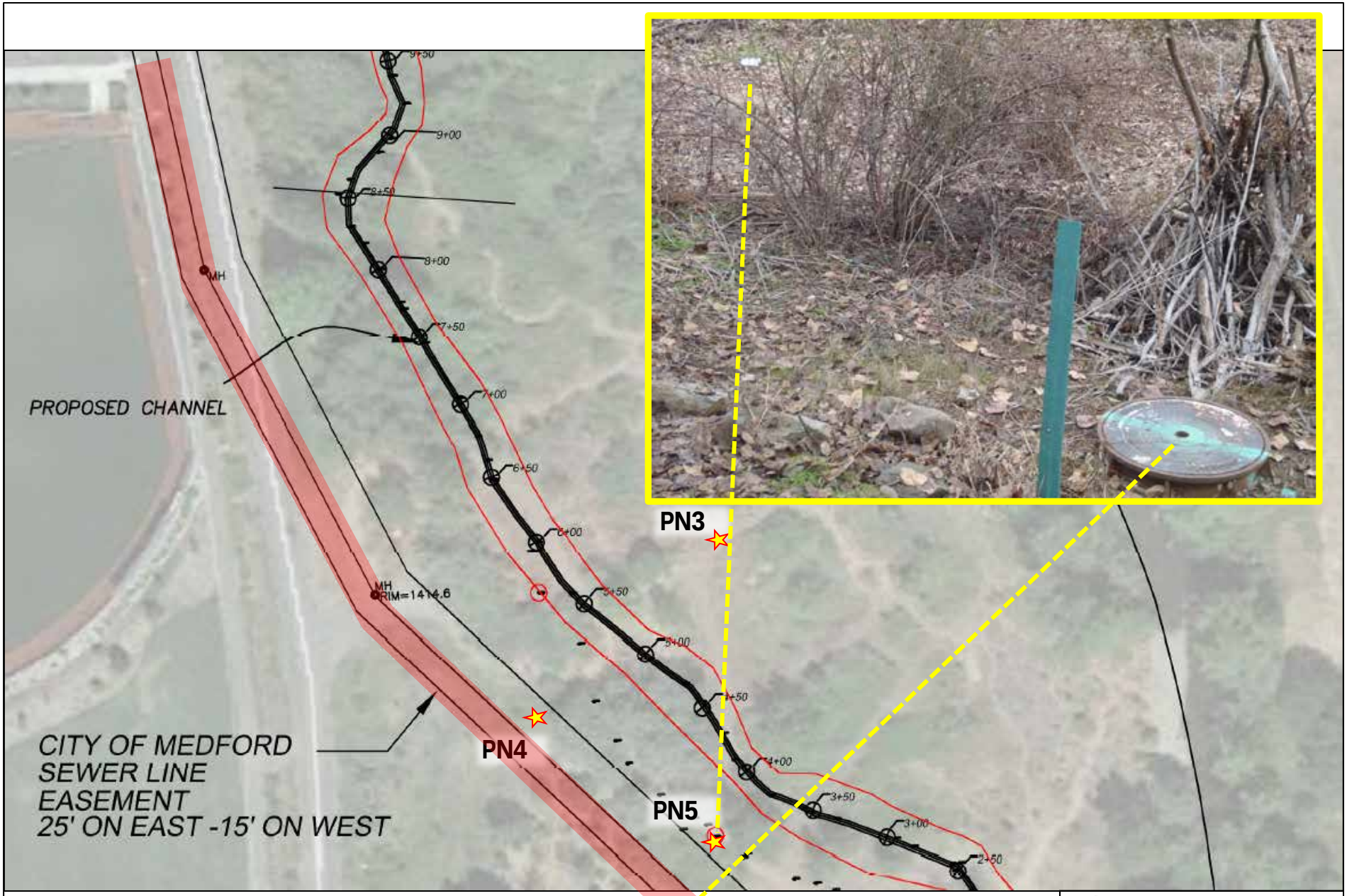


Figure B4. Temperature Comparison: Bear Creek, Downstream vs Upstream

Katalyst, Inc.
Baseline Hydro Study
Coyote Trails Center



Source: Adapted from Kerbo Engineering

Figure B5. Relative Location of Sewer Line to Site Features

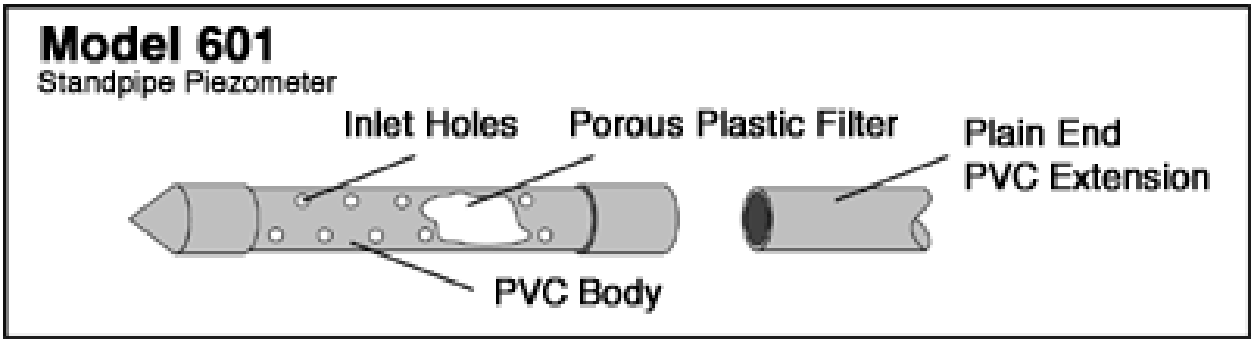
Katalyst, Inc.

Baseline Hydro Study
Coyote Trails Center

Photograph B1. Looking at the Tidbit data logger and protective housing used for deployment in Bear Creek. 4-22-2013.

Photograph B2. Looking at the recently removed 15-inch long housing containing the alluvial data loggers at each piezometer nest. The top of piezometer PN2 is shown to the left. 10-3-2013.

Photograph B3. A waterproof shuttle (upper left) was used to download the data loggers. 10-3-2013.



Photograph B4. Example of the piezometer type and construction used. Source: Solinst website.

PhotographB 5. Collection of the static water level (right) and spot water temperature (left) at PN2. 5-17-2013.

Photograph B6. Looking north at the alluvial soil (left) and shallow alluvial groundwater during placement of the data logger housing (center with hand) and the piezometer (right) at PN3. 4-22-2013.

Photograph B7. Looking east at the pervasive sandstone bedrock comprising the bottom of the channel in much of Bear Creek at the Site. 10-25-2013.

Photograph B8. Looking north at an area close to Bear Creek where the sandstone bedrock layer is > 6 inches from ground surface. 4-22-2013.

Photograph B9. Looking south at the recently completed station PN3. 4-22-2013.

Photograph B10. Looking east at PN2. 4-22-2013.

Photograph B11. Looking south at PN1 immediately after installation. 4-22-2013.

Photograph B12. Looking north at PN1 three weeks after installation. 5-8-2013.

Photograph B13. Looking north at the installation of PN4 higher up on the flood terrace, further from Bear Creek. 4-22-2013.

Photograph B14. Fill was encountered to about 5 feet bgs, underlain by natural coarse sand to a total depth of 6.5 feet bgs, the extent of the back hoe at PN4. The sandstone bedrock was not encountered, but thought to be slightly deeper than the total depth. 4-22-2013.

Photograph B15. Looking southeast from the Coyote Trails Center at the southern portion of the Site. Bear Creek (not visible was flowing at approximately 28 cfs. 12-30-2013.

Photograph B16. Looking southeast at the same area during an approximate 2-year storm event. Bear Creek was flowing at approximately 1500 cfs. 12-2-2012.

Photograph B17. Looking northeast at the sewer line (foreground left) that runs about 15 feet away from PN5 (white spot in background left). 12-30-2013.

APPENDIX C-1: HEC-RAS MODELING REPORT
Bear Creek Side Channel Restoration
HEC-RAS 4.1.0 Model Parameters
January 2014
Kerbo Engineering, LLC

PROJECT BACKGROUND

Bear Creek flows through five communities in southern Oregon, roughly following the path of Interstate Highway 5, before discharging into the Rogue River just above the Gold Ray dam. Historic photos show rock and gravel being mined from the creek bed and side channels in the 1960's for construction of the adjacent highway and deposition of fill from the highway construction along the creek. The highway construction resulted in the loss of much of the side channel braiding and channelization of the main stream.

Bear Creek passes through the Jefferson Nature Center (JNC) at river mile ** and the Bear Creek Watershed Council applied for an Oregon Watershed Enhancement Board grant in 2013 to study potential restoration of the historic Bear Creek side channel. The goals of the study were to determine if restoring the side channel would reduce the temperature of the Bear Creek main stem and if the side channel would provide suitable habitat for juvenile salmonids. Information on the HEC-RAS model developed for the study is presented below.

MODEL INPUTS

STREAM FLOW DATA

The Bear Creek stream gauge at the City of Medford was used for data, at station USGS 14357500. The gauge is located about 2 miles downstream of the project site. There are discharges into Bear Creek between the project site and the gauge, which were disregarded in the study as there was no gage data for the discharges. Crooked Creek, Lazy Creek and Larson Creek are all tributaries of Bear Creek between the project and the gauge. Bypassing of water from irrigation systems on these tributaries cause the flows to vary in the summer months.

Gauge data was tallied by month for 1980 through 2013 and the average stream flows for the data period were used. The project area was much less developed prior to 1980, so data before that period were discarded. Averaging the data is likely to result in modeling lower flows than use of the peak monthly flows, which is partly offset by using a data set that includes the flows from the lower tributaries. For the purposes of this study, which is to establish the feasibility of restoring the side channel, the flows used for the model will be within the range normally seen at the project site. Flows used in the model are presented in Table 1.

Table 1: Modeled Main Stem Flows

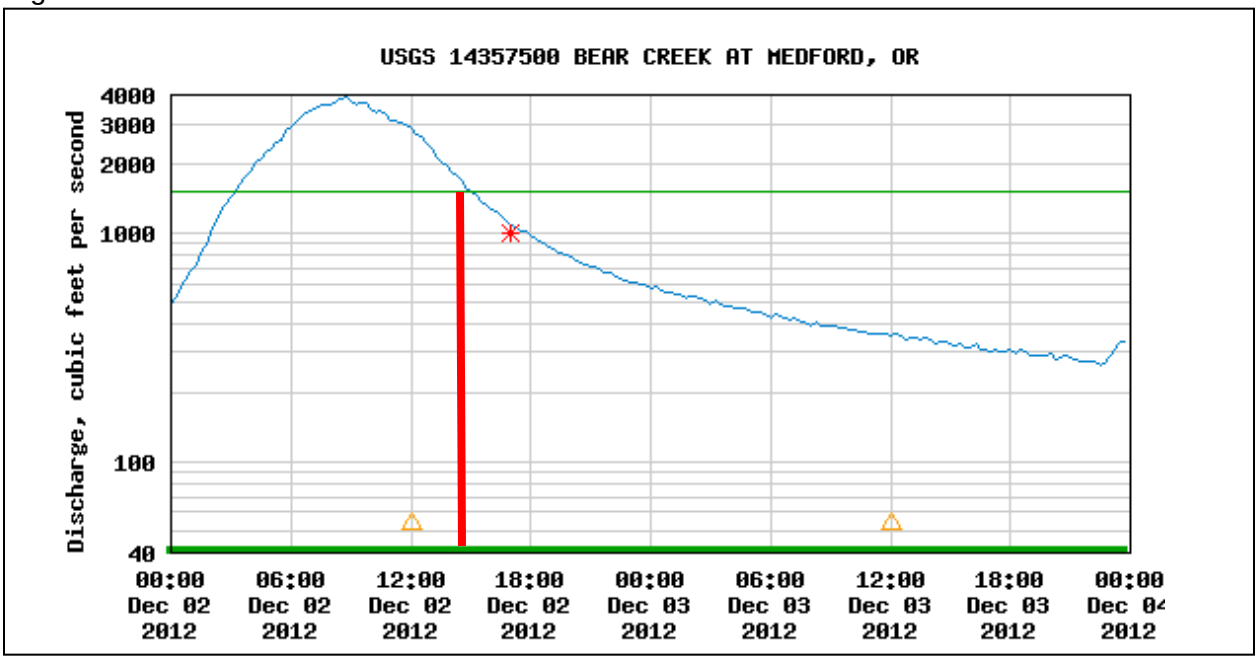
EVENT	MEAN FLOW (CFS)
January	132
April	195
May	114
July	46
October	37
OHW	1,500

Figure 1: Side channel flows 12/2/2012

1% Flood	18,430

The 50% (2-year) flood flows for this site were obtained from the USGS water data summary for the gauge station and used to model ordinary high water. Jefferson Nature Center staff provided photos and anecdotal references to a 2012 high water event that confirmed flooding of the proposed side channel area on December 2, 2012, with a corresponding gauge reading of 1,500 CFS (See Figures 1 & 2).

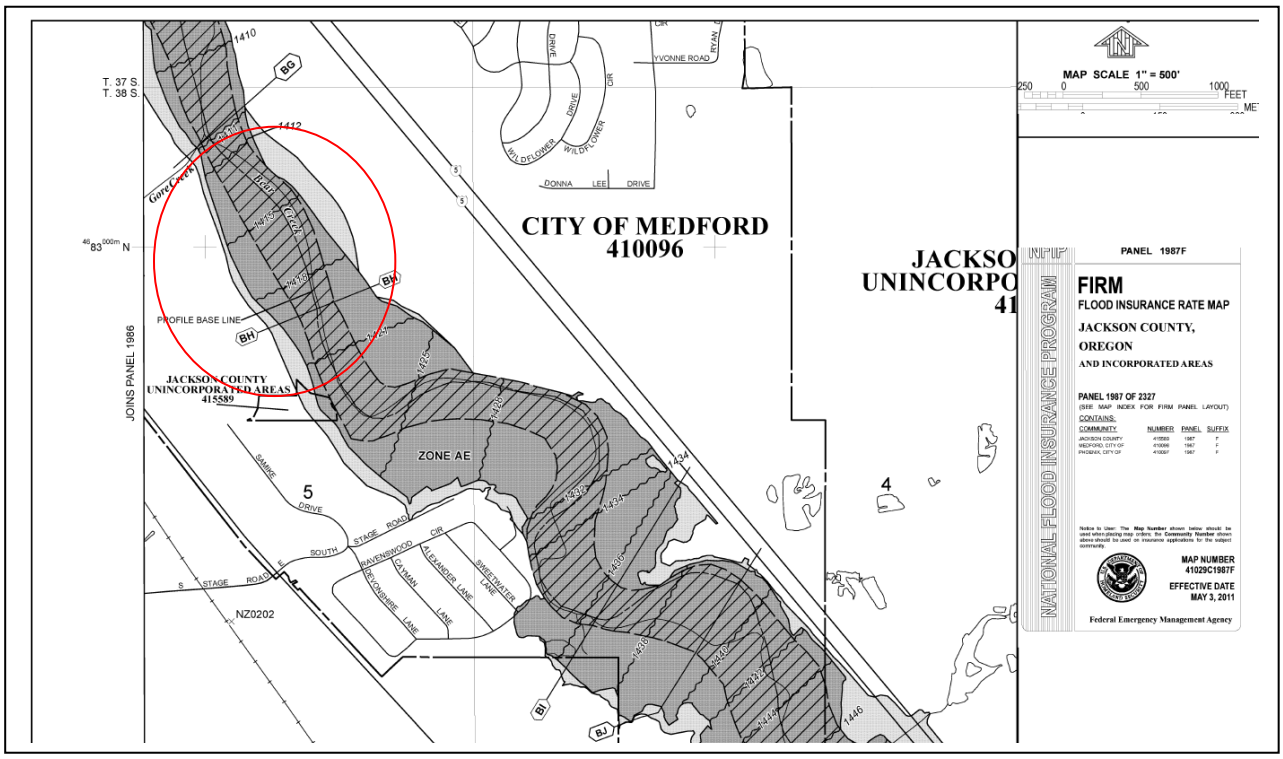
Figure 2: Bear Creek 2-Year Flood Data



The 1% (100-year) flood data was obtained from the May 2011 FEMA Flood Insurance Study for Jackson County. The flow of 18,430 CFS used is for Bear Creek near Coleman Creek, which is just above the project site. The FEMA flood map for the project area shows 100-year flood elevation at between 1421 and 1425 feet, which corresponds closely to the modeled elevation of 1424 to 1425 feet (See Figure 3).

The side channel flow was selected as 10% of the full flow of the main reach of Bear Creek at the upper junction. All flows were modeled as steady state flows.

Figure 3: FEMA Flood Map of Project Site



ELEVATIONS

Elevations were taken from on site survey data provided Fred Franz of TerraSurvey and by GPS measurements taken in the field by Steve Koskella and Northwest Biological Consulting as compiled by KenCairn Landscape Architecture LLC into an AutoCad model. The survey data show 5.15-feet of drop along the main reach of Bear Creek between the proposed upper and lower junctions with the side channel with an average slope of -0.42%. Sections of the main reach were surveyed at both junction points and 50 feet upstream and downstream of each junction. Main reach elevations for points between these sections were interpolated. Survey data was taken of the existing surface elevations along three potential side channel centerline paths. The hydrological data eliminated the westernmost path and the path to the east with the most sinuosity was selected for the model. Only data on the final path is incorporated in the model.

The center of the side channel elevation start and end points were assumed to match the toe of bank elevations of the Bear Creek main reach at the junction points, the point where the steeper banks made a slope transition to the channel bottom. As the channel bottom was bedrock or large boulders from the toe to the channel center, construction costs would be prohibitive to extend the side channel bottom to the center of the main stem. The actual channel path roughly follows the path the flow takes when Bear Creek flows exceed 1,500 CFS, the ordinary high water flow. The proposed location is presented separately in Sheet G-1.

A bedrock underlayment approximately 70 feet from the lower junction point determined the maximum depth of the side channel at that point and the modeled slope of the side channel was

set as a constant between that point and the upper junction at -0.39%. The slope of the last 70 feet was set at a constant -0.20%, which will allow for drainage during low flow conditions.

SIDE CHANNEL CONFIGURATION

The stream configuration type selected for the proposed side channel is a Rosgen C3. Type C streams have a low channel bed slope (less than 2%). “The primary morphological features of the "C" stream type are the sinuous, low relief channel, the well developed floodplains built by the river, and characteristic "point bars" within the active channel. (From: EPA Watershed Academy, http://www.epa.gov/watertrain/stream_class/index.htm)”

The side channel was laid out with a two-foot wide channel bottom and with the sides sloping at three-foot of run to one-foot of rise (3:1). A one-foot wide bench is located one foot above the bottom of the channel on the east side for the most of the channel length. The bench is to provide a shallow refuge for minnows. The model shows that the depth of water in the channel is below four-foot at the 2-year flood elevations. In areas where the existing surface elevation is more than four-foot above the bottom of the channel, the slope above the four foot line is increased to 2:1, to minimize the overall channel width and the resulting impact on adjacent areas. The assumption is made that the top of bank is equal to the surveyed elevation of the center of the proposed channel.

At two points, near stations 725 and 1035 where the channel sinuosity is highest, the channel was modeled with a cobble bank on the east with a 10:1 bank slope and no bench. The soils around the site are high in cobbles and it is anticipated that the lower slope and cobble armoring will help hold the channel configuration at these points while the vegetation takes hold. Cross sections taken at stations on the side channel path representative of both types of channel are presented separately in Sheet G-2.

Manning’s numbers for the proposed channel are 0.035 for the channel and 0.045 for the areas outside of the channel. Default coefficients of contraction are 0.1 and of expansion are 0.3.

MODEL RESULTS

EXISTING WATER SURFACE DATA SOURCE

The data available on existing Bear Creek elevations includes the May 2011 FEMA Flood Insurance Study estimates for the 1% flood event (100-year flood), the FEMA Flood Insurance Rate Map 41029C1987F, anecdotal records from flood events recorded by JNC staff, and stream height measurements taken by Katalyst, Inc. as part of the study.

100-YEAR FLOOD MODEL ELEVATIONS

The FEMA rate map shows a 100-year flood elevation of 1,423 feet at the upper end of the project for the main stem of Bear Creek and 1,413 at the downstream end of the project. The model projects 100-year flood elevations of 1,425 at the upper end of the project and 1,417 at the downstream end, which are slightly higher than those predicted by the model. The cross sections input into the HEC-RAS model extended only about 100-feet from the center of the creek channel. The model confines flows within the sections, causing the model to force the flows into a higher depth when flows exceed the capacity of the section since they can’t spread beyond the input section width. The flood elevations predicted by FEMA would inundated the surrounding area from I-5 to the JNC facility. The modeled flood elevations are about 20% higher than the FEMA map elevations, which is accurate enough for this portion of the study and in keeping with the limitations of the survey data.

2-YEAR FLOOD MODEL ELEVATIONS

The ordinary high water (2-Year Flood) for Bear Creek was modeled at 1,500 CFS per the USGS data for the downstream gauge. The model projected water surface elevations between 1,414 feet at the upper end of the project and 1,406 at the downstream end, which correlated closely with the photographs taken in 2012 of Bear Creek and the coincident downstream gauge data. The 2-year flood was within the boundaries of the survey data used to create the HEC-RAS model as reflected by the closer correlation between the modeled data and the actual conditions.

AVERAGE MONTH FLOOD MODEL ELEVATIONS

Katalyst, Inc. installed a reference station about 50 feet downstream of the convergence of the proposed side channel with the main channel of Bear Creek, which was surveyed and used to take measurements to the water surface of the main stream. The measurements were taken approximately every two weeks from April to September in 2013, with the time of measurement noted. The corresponding flows at the reference USGS gauge were paired with each measurement. The elevation versus flow for this data was compared to the modeled water elevations at the same point, with the result that the model elevations were about 0.5 feet lower than the actual field measurements for the corresponding flows.

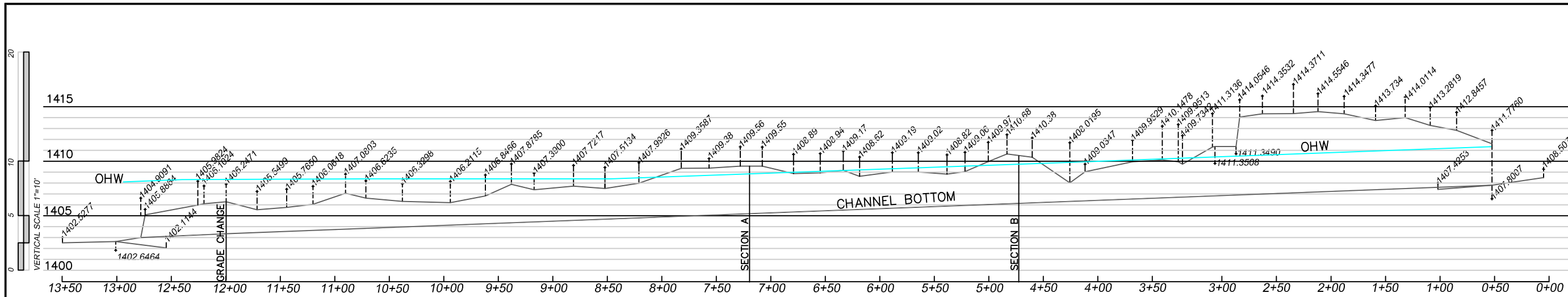
The reach of Bear Creek downstream of the gauge station was not surveyed, and downstream conditions may account for the higher measured elevations. The main channel centerline elevation does not continuously descend, which could cause the noted elevated water surface elevations upstream. However, the model does support that enough flow is present to support juvenile salmonids in the side channel and the slightly higher elevations of the field measurements document an even better water depth.

WATER VELOCITIES

Water velocities vary, both by flow and by location in each reach. The range of water velocities in the center of each channel is presented in Table 2. A plan view showing each of the named reaches is presented separately in Sheet M-1.

Table 2: Modeled Water Velocities Ft/S

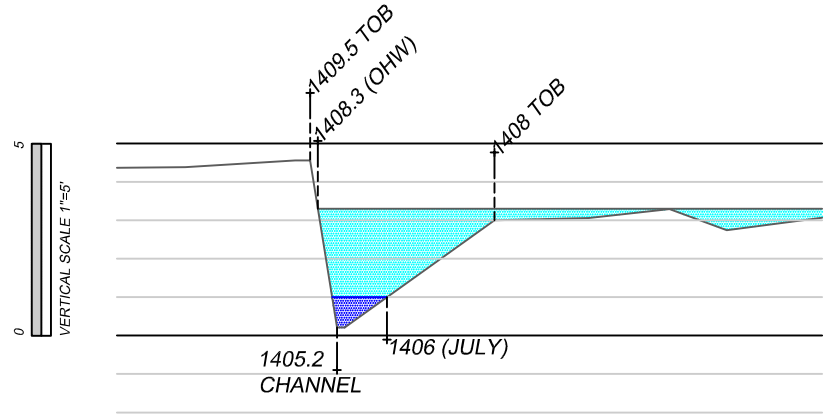
REACH	July	October	April	2-Year	100-Year
Main	2-3.5	2-3	3-5.5	7-9.5	13.5-18
Main A	1.5-3.5	1.5-3	2-5.5	4-8	8-13.5
Main B	2-3.5	1.5-3	3.5-5.5	7-9.5	10-23
Side	1-3	1-3	1.5-3	1.5-4	2.5-5.5



SIDE CHANNEL

0 25 50 100 200

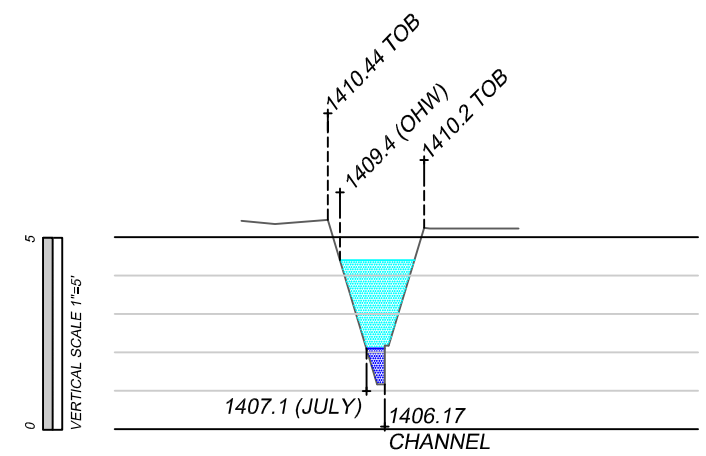
HORIZONTAL SCALE: 1" = 100'
VERTICAL EXAGERATION X 10



SECTION A/G2 POINT BAR AT STATION 700

HORIZONTAL SCALE: 1" = 50'
VERTICAL EXAGERATION X 10

0 25 50



SECTION B/G2 TYPICAL SIDE CHANNEL AT STATION 470

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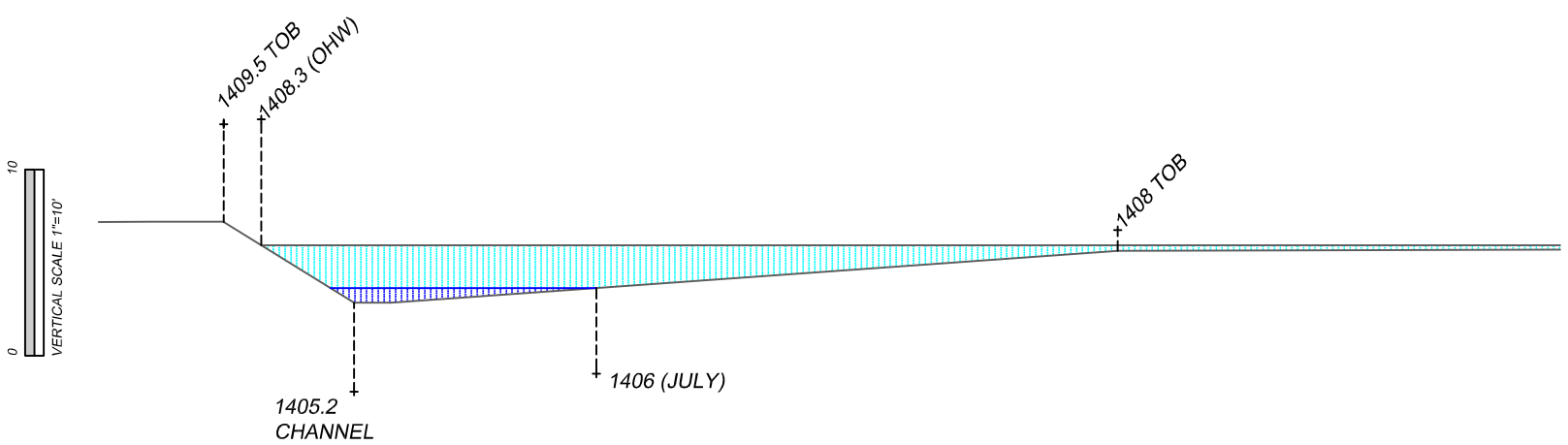
VERTICAL EXAGERATION X 10

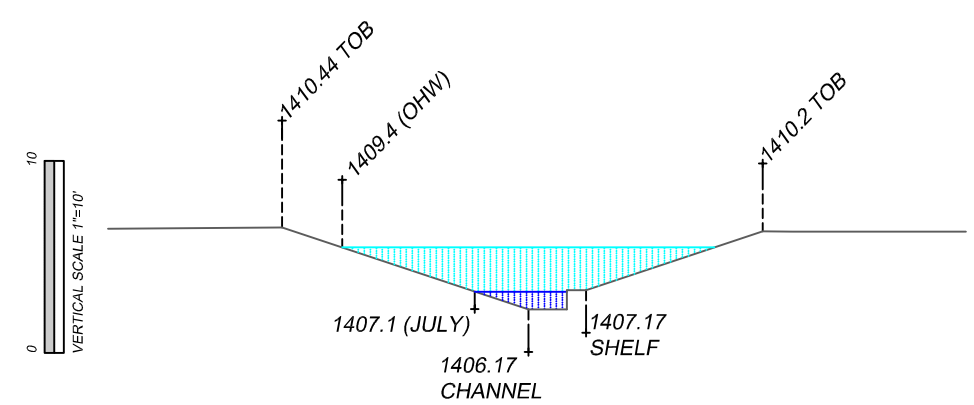
0 25 50



SECTION A/G2 POINT BAR AT STATION 700

HORIZONTAL SCALE: 1" = 10'
NO VERTICAL EXAGERATION

0 5 10



SECTION B/G2 TYPICAL SIDE CHANNEL AT STATION 470

HORIZONTAL SCALE: 1" = 10'
NO VERTICAL EXAGERATION

0 5 10

REGISTERED PROFESSIONAL ENGINEER
17231
OREGON
JULY 19, 1994
JANETTE L. KERBO
EXPIRES 6/30/15

NOT FOR CONSTRUCTION

SCALE:

Revision:

Revision:

File: BEAR CREEK SIDECHANNEL

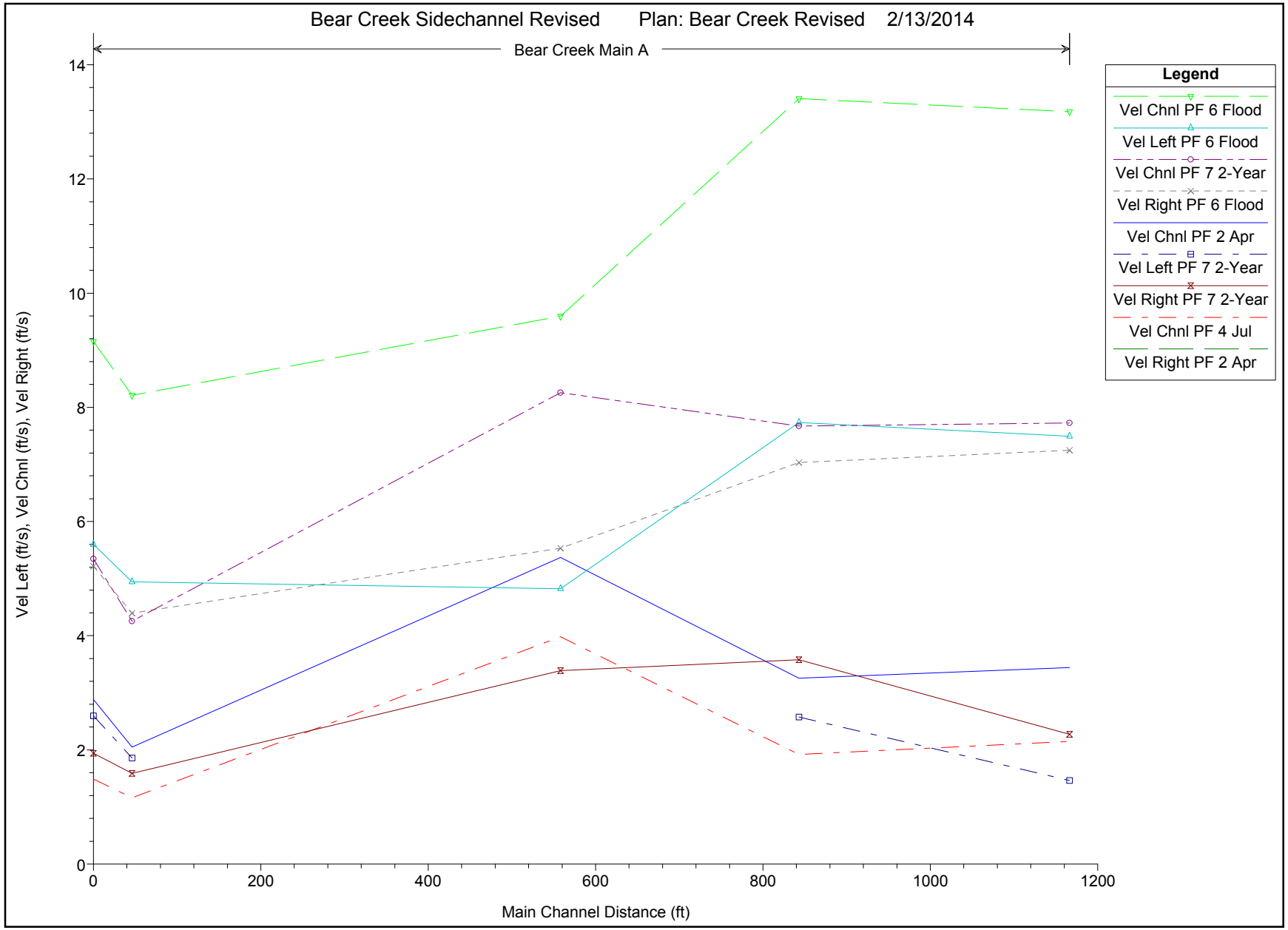
Job: BC-13-01

BEAR CREEK SIDECHANNEL SECTIONS

Kerbo Engineering
541-269-2584

Sheet No. G-2

FEB 4, 2014


Bear Creek Sidechannel Revised Plan: Bear Creek Revised 2/13/2014
Bear Creek Main A
Vel Left (ft/s), Vel Chnl (ft/s), Vel Right (ft/s)
Main Channel Distance (ft)
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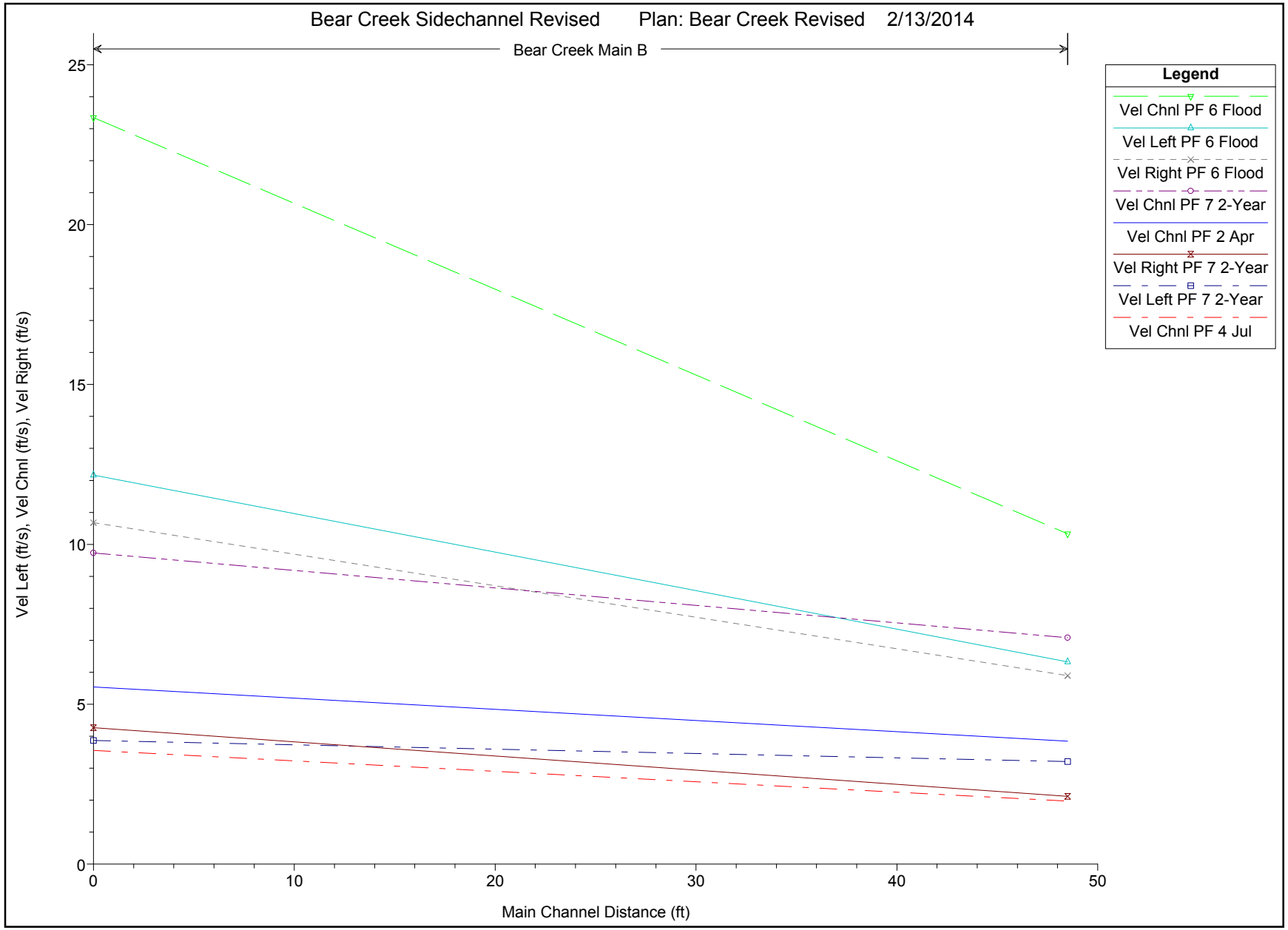
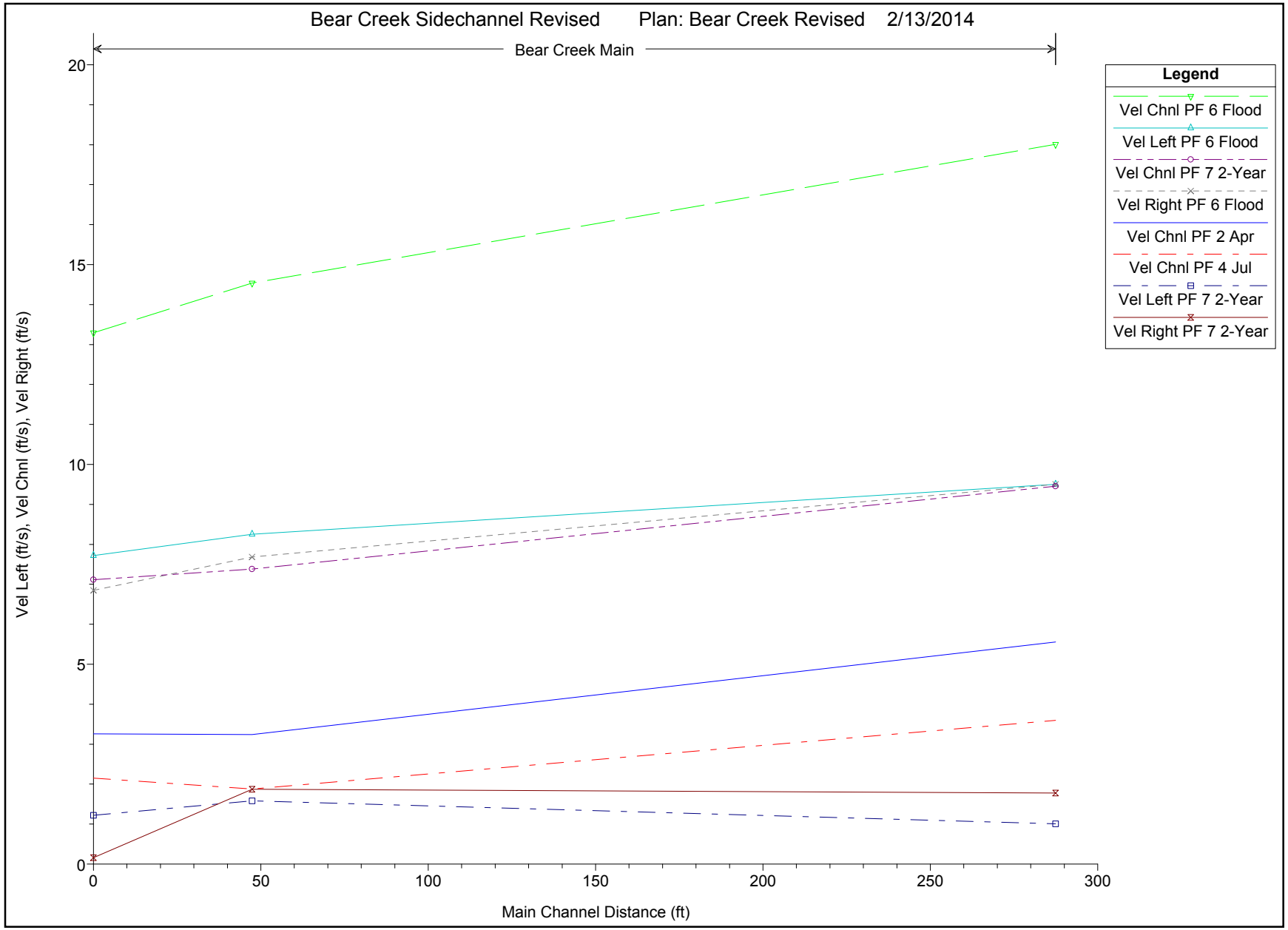
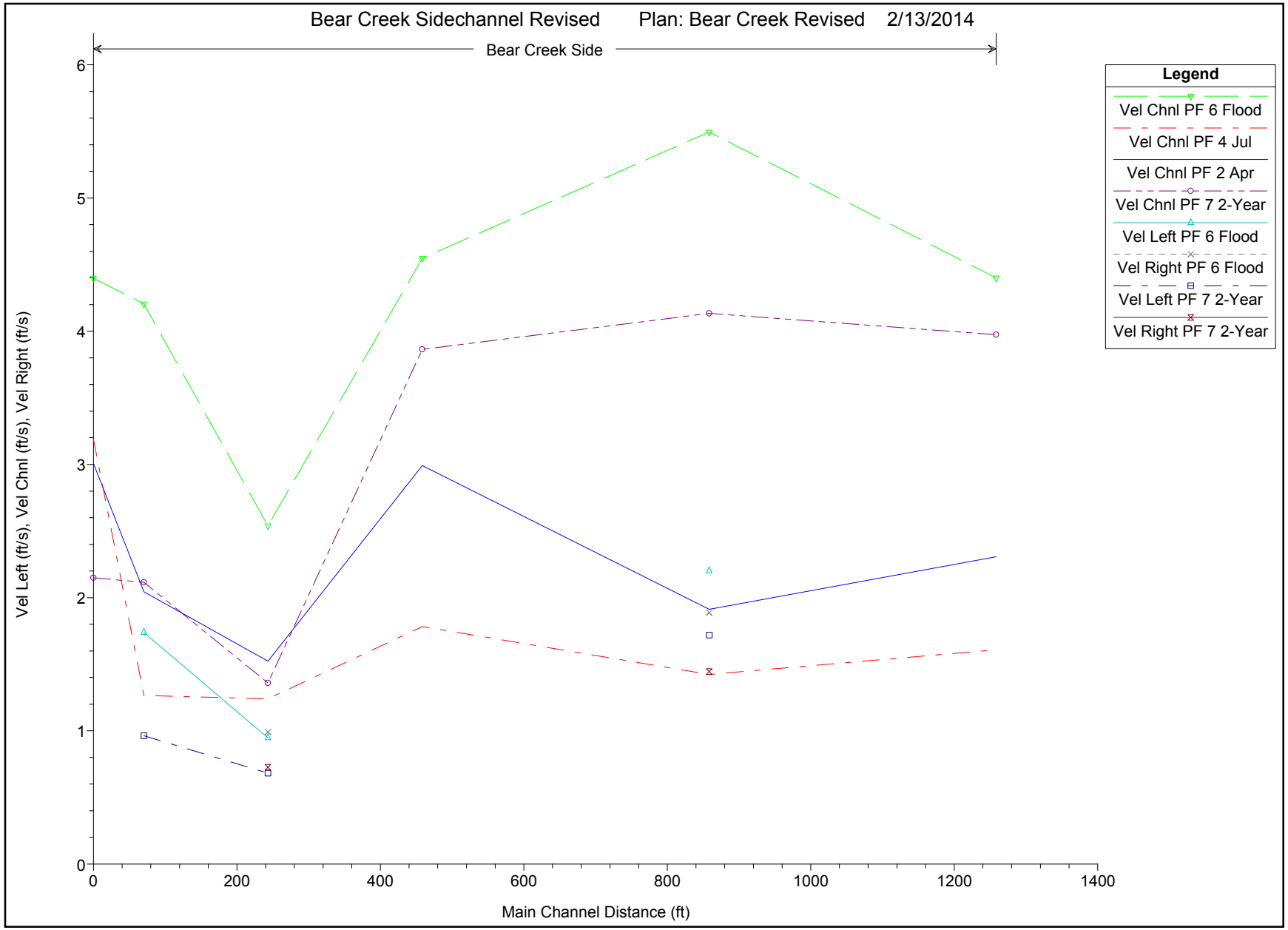
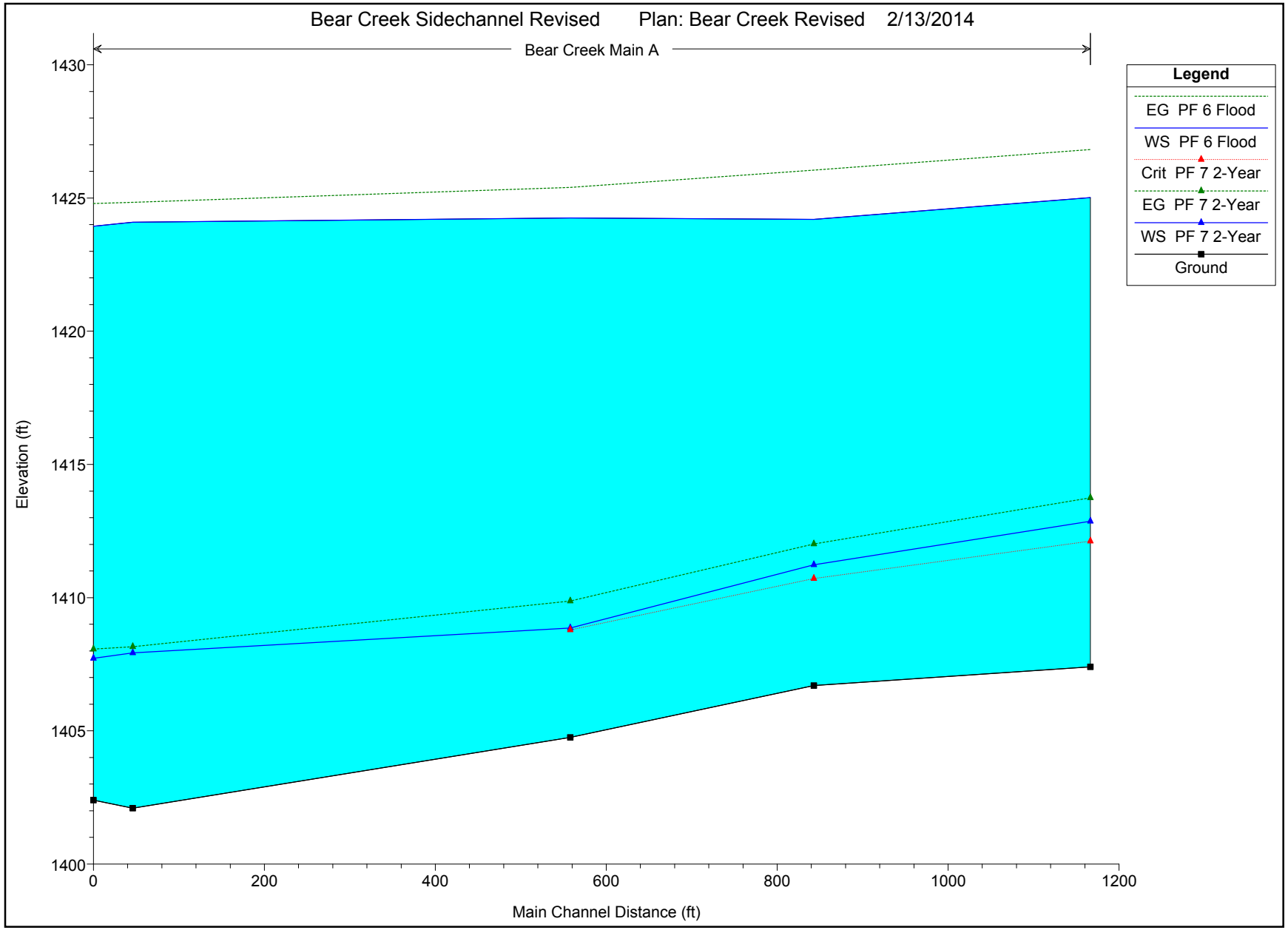
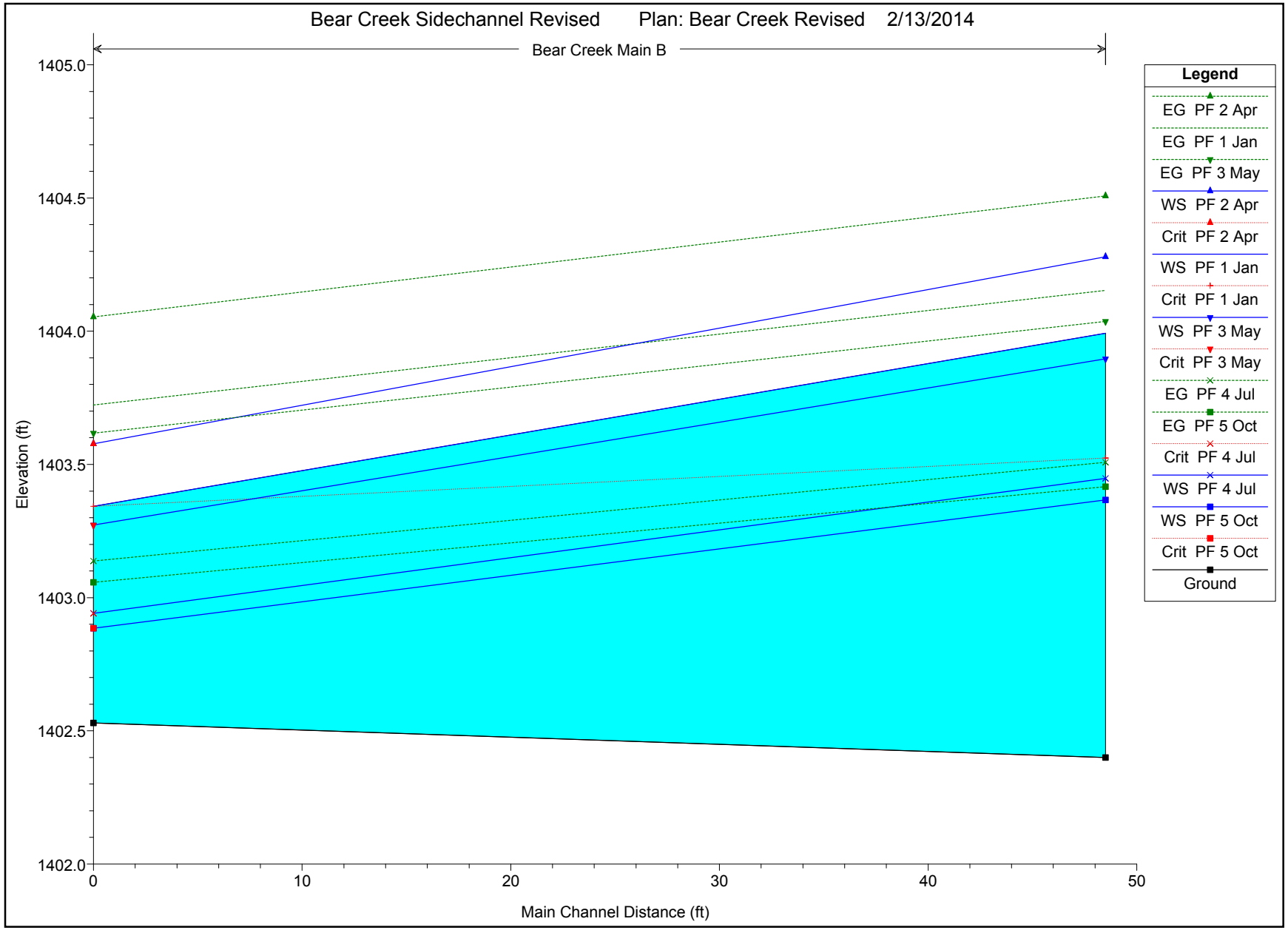
2
4
6
8
10
12
14
0
200
400
600
800
1000
1200
Legend
Vel Chnl PF 6 Flood
Vel Left PF 6 Flood
Vel Chnl PF 7 2-Year
Vel Right PF 6 Flood
Vel Chnl PF 2 Apr
Vel Left PF 7 2-Year
Vel Right PF 7 2-Year
Vel Chnl PF 4 Jul
Vel Right PF 2 Apr

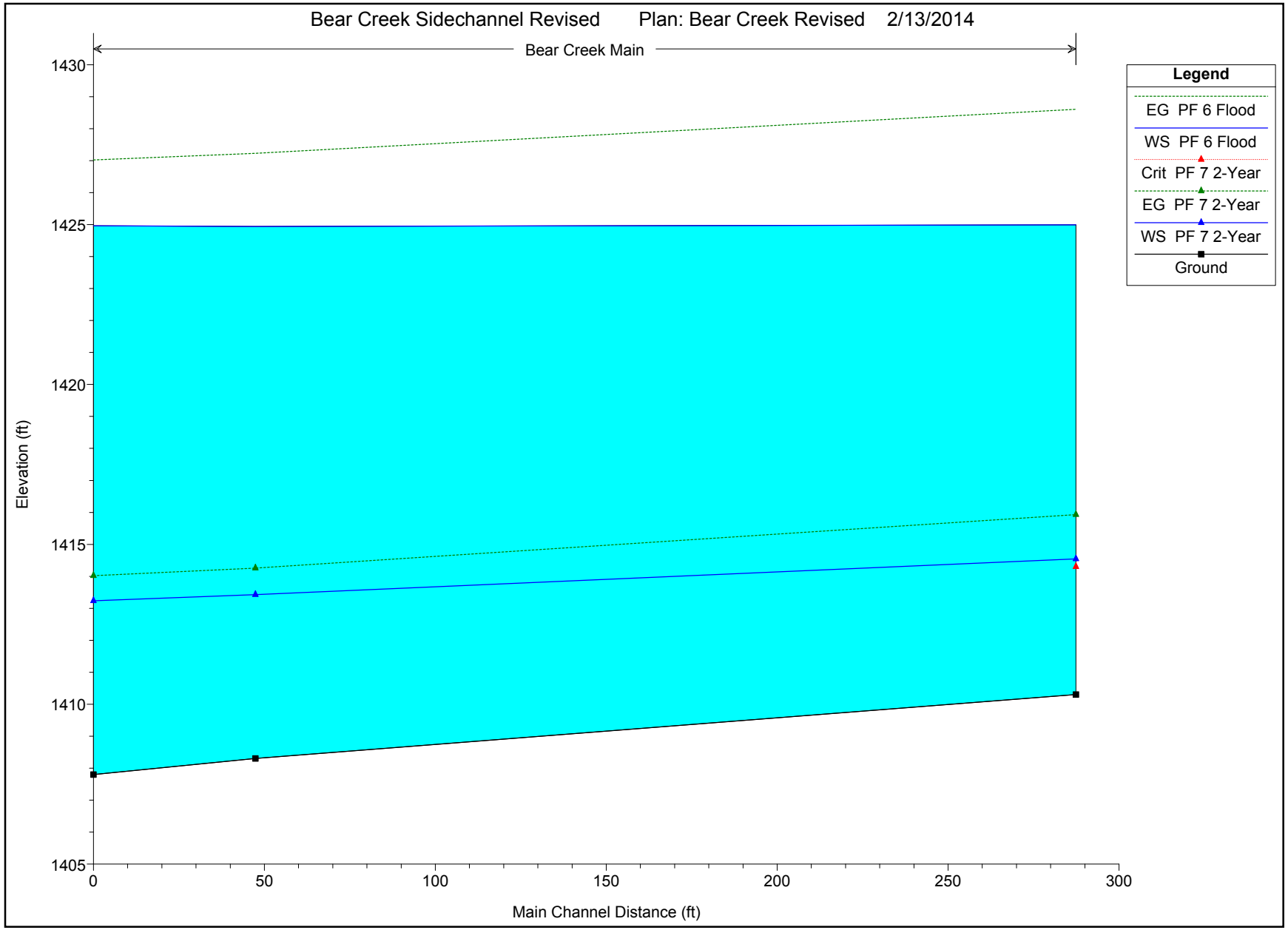

Bear Creek Sidechannel Revised Plan: Bear Creek Revised 2/13/2014
Bear Creek Main B
Legend
Vel Chnl PF 6 Flood
Vel Left PF 6 Flood
Vel Right PF 6 Flood
Vel Chnl PF 7 2-Year
Vel Chnl PF 2 Apr
Vel Right PF 7 2-Year
Vel Left PF 7 2-Year
Vel Chnl PF 4 Jul
Vel Left (ft/s), Vel Chnl (ft/s), Vel Right (ft/s)
Main Channel Distance (ft)
0
5
10
15
20
25
0
10
20
30
40
50

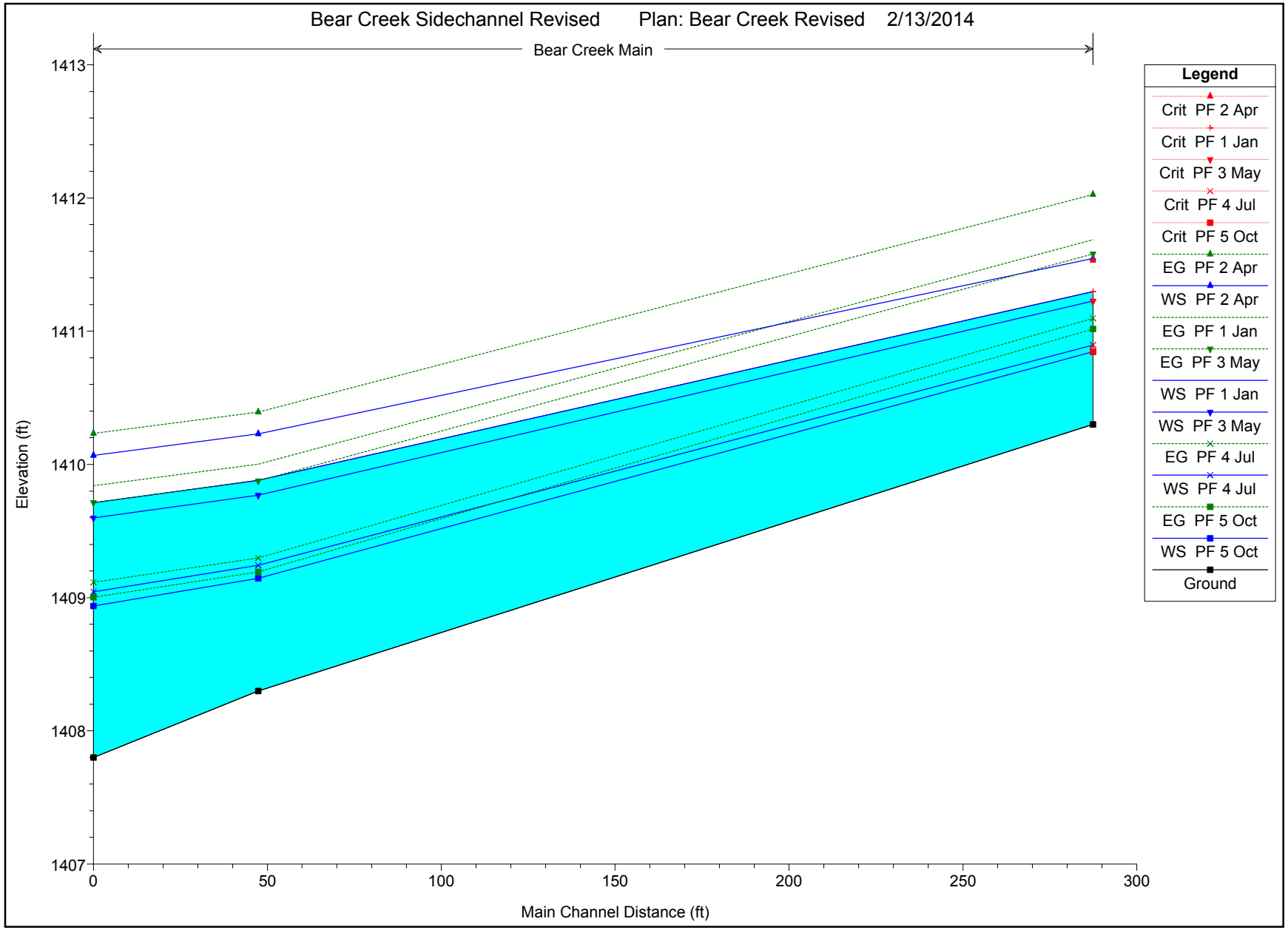

Bear Creek Sidechannel Revised Plan: Bear Creek Revised 2/13/2014
Bear Creek Main
Legend
Vel Chnl PF 6 Flood
Vel Left PF 6 Flood
Vel Chnl PF 7 2-Year
Vel Right PF 6 Flood
Vel Chnl PF 2 Apr
Vel Chnl PF 4 Jul
Vel Left PF 7 2-Year
Vel Right PF 7 2-Year
Vel Left (ft/s), Vel Chnl (ft/s), Vel Right (ft/s)
Main Channel Distance (ft)
0
5
10
15
20
0
50
100
150
200
250
300

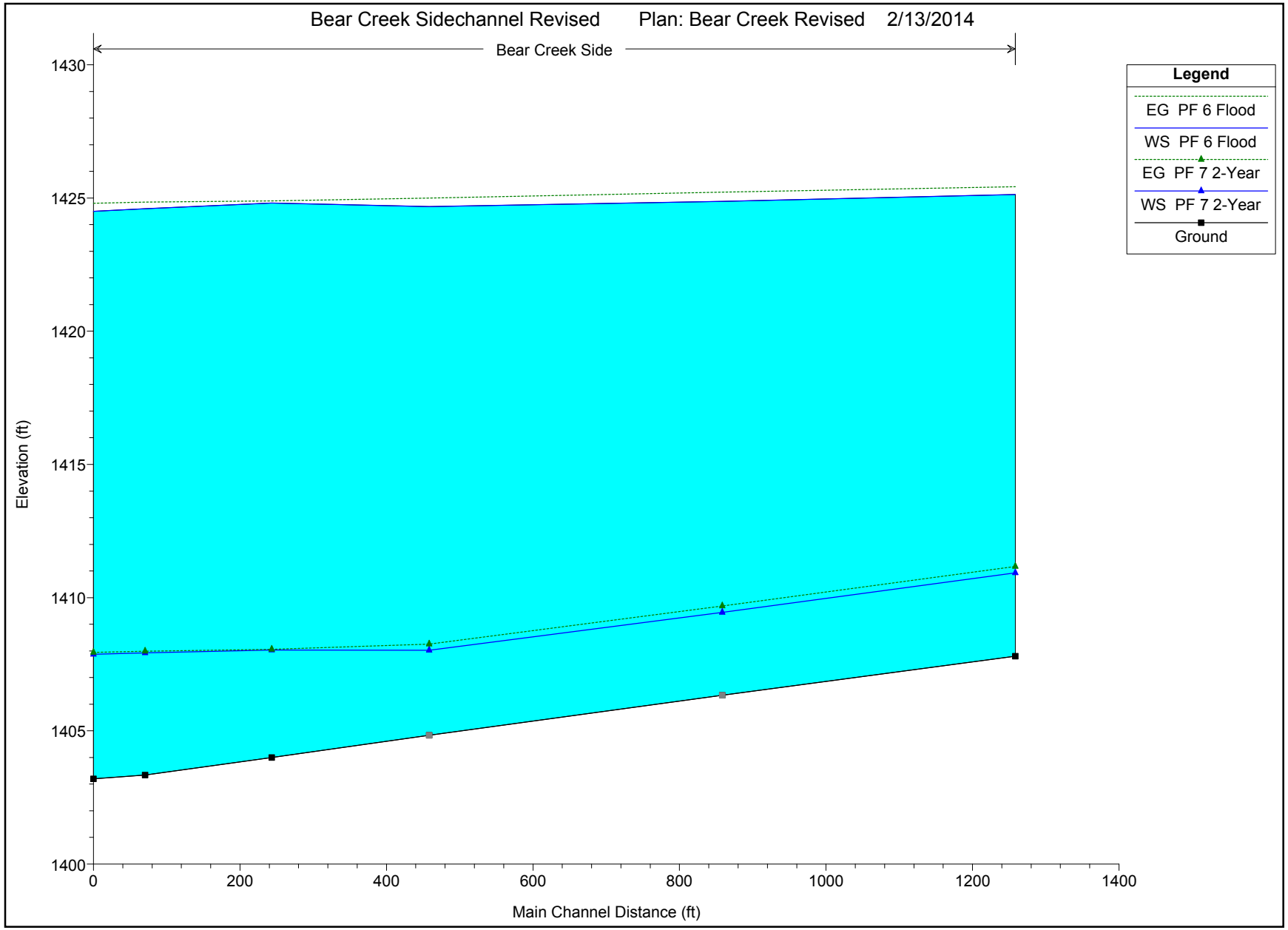

Bear Creek Sidechannel Revised
Plan: Bear Creek Revised
2/13/2014
Bear Creek Side
Legend
Vel Chnl PF 6 Flood
Vel Chnl PF 4 Jul
Vel Chnl PF 2 Apr
Vel Chnl PF 7 2-Year
Vel Left PF 6 Flood
Vel Right PF 6 Flood
Vel Left PF 7 2-Year
Vel Right PF 7 2-Year
Vel Left (ft/s), Vel Chnl (ft/s), Vel Right (ft/s)
Main Channel Distance (ft)
0
1
2
3
4
5
6
0
200
400
600
800
1000
1200
1400

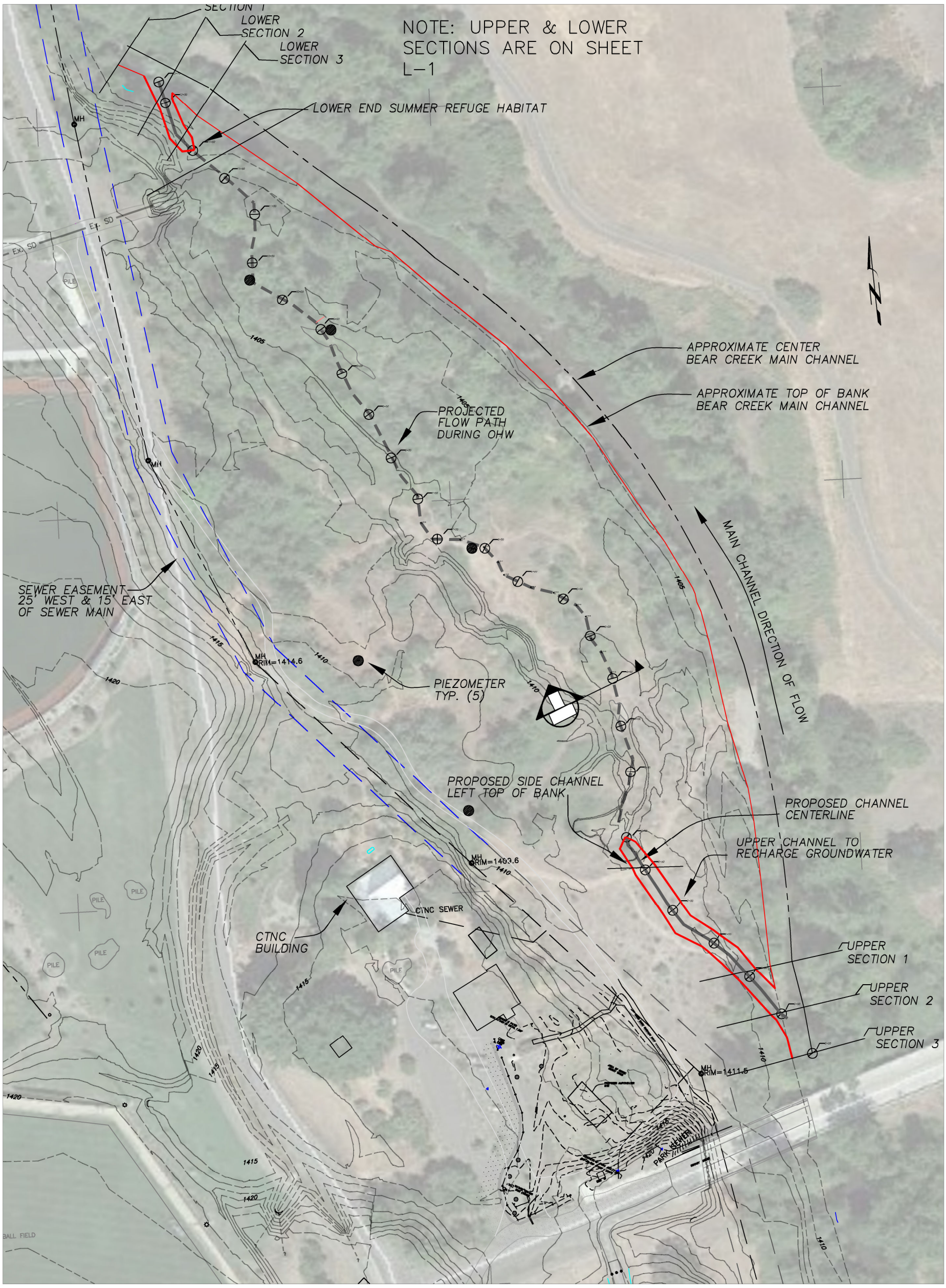

Bear Creek Sidechannel Revised Plan: Bear Creek Revised 2/13/2014
Bear Creek Main A
Legend
EG PF 6 Flood
WS PF 6 Flood
Crit PF 7 2-Year
EG PF 7 2-Year
WS PF 7 2-Year
Ground
Elevation (ft)
1430
1425
1420
1415
1410
1405
1400
0
200
400
600
800
1000
1200
Main Channel Distance (ft)


Bear Creek Sidechannel Revised Plan: Bear Creek Revised 2/13/2014
Bear Creek Main B
Elevation (ft)
1405.0
1404.5
1404.0
1403.5
1403.0
1402.5
1402.0
0
10
20
30
40
50
Main Channel Distance (ft)
Legend
EG PF 2 Apr
EG PF 1 Jan
EG PF 3 May
WS PF 2 Apr
Crit PF 2 Apr
WS PF 1 Jan
Crit PF 1 Jan
WS PF 3 May
Crit PF 3 May
EG PF 4 Jul
EG PF 5 Oct
Crit PF 4 Jul
WS PF 4 Jul
WS PF 5 Oct
Crit PF 5 Oct
Ground


Bear Creek Sidechannel Revised Plan: Bear Creek Revised 2/13/2014
Bear Creek Main
Legend
EG PF 6 Flood
WS PF 6 Flood
Crit PF 7 2-Year
EG PF 7 2-Year
WS PF 7 2-Year
Ground
Elevation (ft)
1430
1425
1420
1415
1410
1405
0
50
100
150
200
250
300
Main Channel Distance (ft)

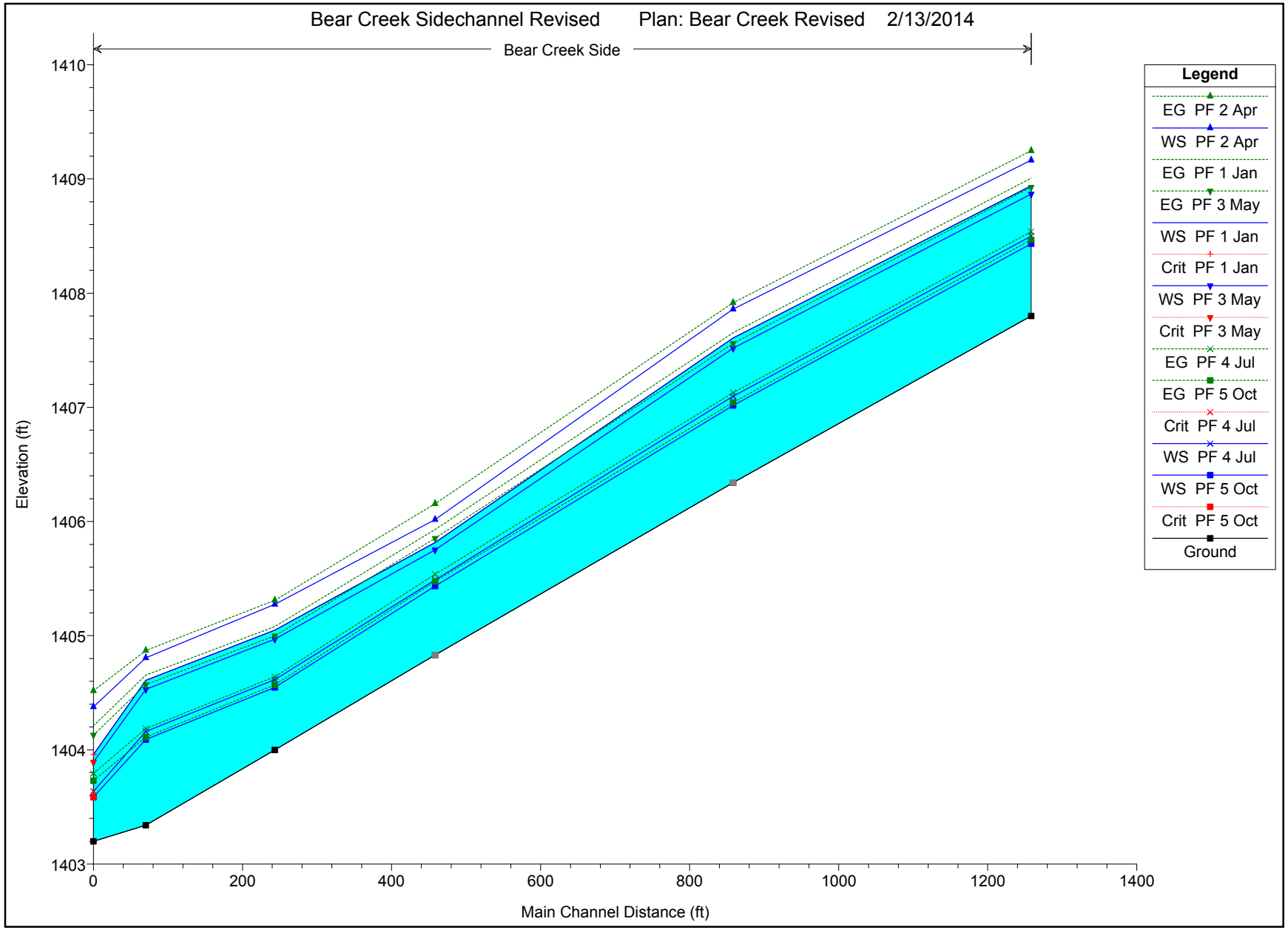

Bear Creek Sidechannel Revised Plan: Bear Creek Revised 2/13/2014
Bear Creek Main
Elevation (ft)
1413
1412
1411
1410
1409
1408
1407
0
50
100
150
200
250
300
Main Channel Distance (ft)
Legend
Crit PF 2 Apr
Crit PF 1 Jan
Crit PF 3 May
Crit PF 4 Jul
Crit PF 5 Oct
EG PF 2 Apr
WS PF 2 Apr
EG PF 1 Jan
EG PF 3 May
WS PF 1 Jan
WS PF 3 May
EG PF 4 Jul
WS PF 4 Jul
EG PF 5 Oct
WS PF 5 Oct
Ground


Bear Creek Sidechannel Revised Plan: Bear Creek Revised 2/13/2014
Bear Creek Side
Legend
EG PF 6 Flood
WS PF 6 Flood
EG PF 7 2-Year
WS PF 7 2-Year
Ground
Elevation (ft)
1430
1425
1420
1415
1410
1405
1400
0
200
400
600
800
1000
1200
1400
Main Channel Distance (ft)



MAY 30, 2014	Sheet No. G-1 A	BEAR CREEK SIDECHANNEL ALT 2 PLAN VIEW	KERBO ENGINEERING LLC
4 OF 4		Kerbo Engineering 541-269-2584	Revision: / SCALE: NOT FOR CONSTRUCTION
			Revision:
			File: BEAR CREEK SIDECHANNEL
			Job: BC-13-01

REGISTERED PROFESSIONAL ENGINEER 17231 OREGON JULY 19, 1994 JANETTE L. KERBO EXPIRES 6/30/15


Bear Creek Sidechannel Revised Plan: Bear Creek Revised 2/13/2014
Bear Creek Side
Elevation (ft)
1410
1409
1408
1407
1406
1405
1404
1403
0
200
400
600
800
1000
1200
1400
Main Channel Distance (ft)
Legend
EG PF 2 Apr
WS PF 2 Apr
EG PF 1 Jan
EG PF 3 May
WS PF 1 Jan
Crit PF 1 Jan
WS PF 3 May
Crit PF 3 May
EG PF 4 Jul
EG PF 5 Oct
Crit PF 4 Jul
WS PF 4 Jul
WS PF 5 Oct
Crit PF 5 Oct
Ground