Foster Meadow Restoration Design
February 17, 2015
Jim Wilcox, Plumas Corporation

Background:
The Foster Meadow Restoration Project encompasses 27 acres of meadow along the Middle Fork Cosumnes River on lands administered by the USDA- Forest Service, Amador Ranger District, El Dorado National Forest. Foster Meadow was identified as a target meadow for restoration in the Amador Calaveras Consensus Group (ACCG) Collaborative Forest Landscape Restoration Project (December, 2006). The ACCG CFLR Project is a multi-stakeholder, including National Forests, process to collaboratively address common natural resource concerns over a large geographic area. The project area is located approximately 40 miles east of Jackson, Ca., one mile north of State Highway 88, in the vicinity of the Peddler Hill maintenance station. The project is in El Dorado County. Amador Ranger District staff had expressed interest in having Plumas Corporation, a meadow restoration group in Plumas County, conduct data collection and design services for this meadow project. Plumas Corporation design work has been funded under a grant contract with the National Fish & Wildlife Foundation.

Design Approach:
The design approach utilized for the Foster Meadow project area applies the principles of fluvial geomorphology, the science of landscapes formed by flowing water, to understand the processes that have governed the development of the meadow through the Holocene period (last 10,000 years). This method also helps determine the possible mechanisms that have led to channel degradation and loss of floodplain connection/ecosystem function. The approach combines significant quantitative data with qualitative observation and historical overview of land uses, both onsite and watershed-wide.

Analysis Narratives:
Quantitative Analysis:
The 27-acre Foster Meadow Project area can be delineated into several reaches of work separated by reaches that are still functional. The functional reaches are at risk from headcuts moving upstream from the degraded reaches. The reaches are upstream to downstream. The culvert at the Forest Highway (FH) 54 crossing is a fish barrier and a risk for failure. There are three (3) distinct meadow sections, Pocket 1, Pocket 2 and Main Meadow downstream of the road crossing (see Appendix A). The drainage area to the road crossing is .55 mi^2, while the drainage area to the bottom of the three meadows is 1.6 mi^2.

Paired cross-sections of the native stream corridor and the FH 54 road surface were surveyed to determine the relationship of the current road/culvert configuration to the naturally evolved channel/ floodplain system. Additionally, paired profiles of the channel and floodplain through the influence zone of the crossing were surveyed to illustrate the current slope relationships of the crossing (see Appendix B).

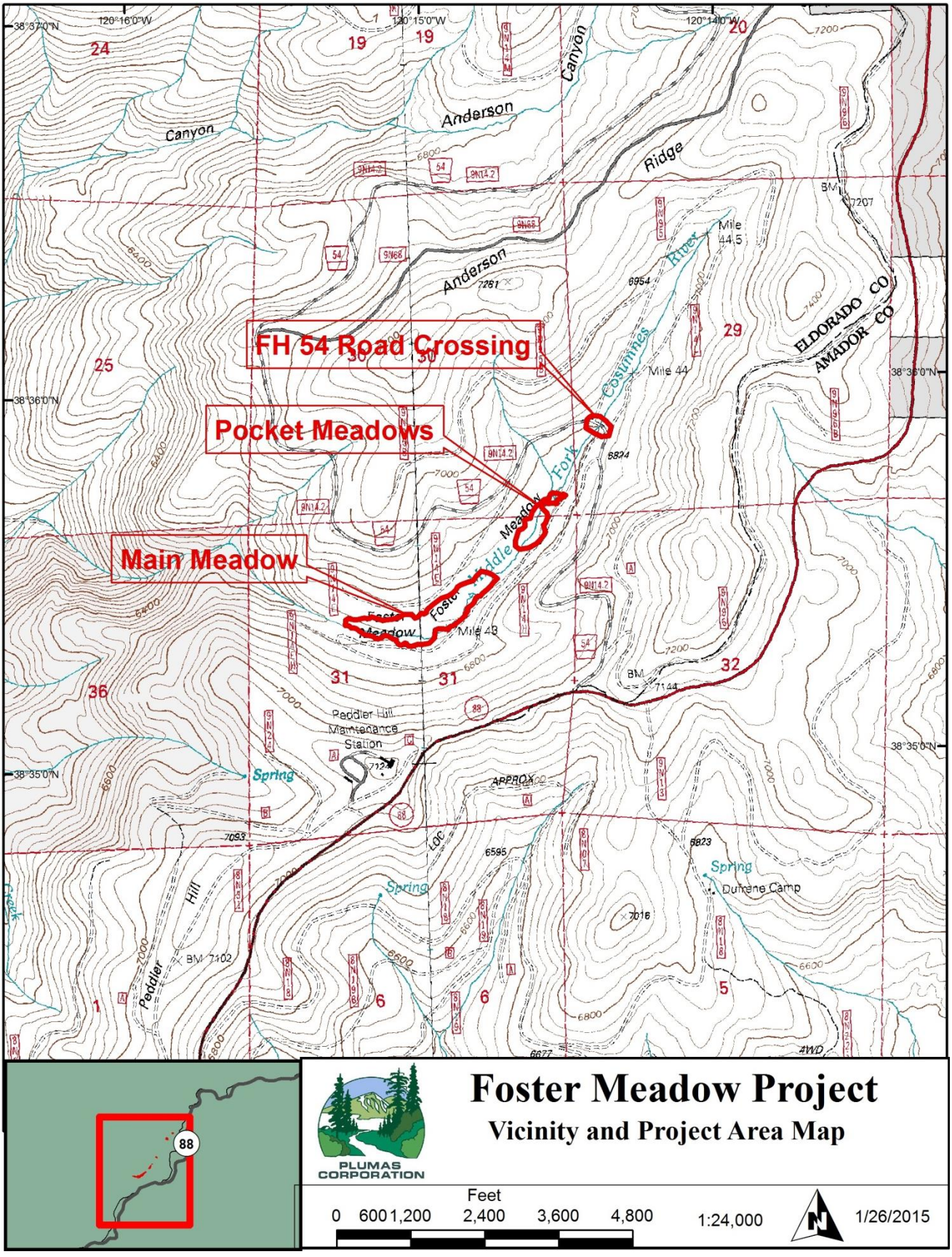
Fifteen (15) valley-wide cross-sections were surveyed perpendicular to the axis of Foster Meadow within the incised meadow sections. These cross-sections have been plotted, existing and proposed,

and appended to this report (see Appendix B). **All cross-sections are viewed with left and right looking downstream.** Longitudinal profiles were surveyed for all meadows.

All cross-sections have been analyzed for the morphological attributes of the principal features in the project area: width, depth and cross-sectional area of the gullies and the remnant channels as well as the effective floodplain widths. This data is summarized in Table 1. Erosion of the incised channel within the project areas has removed approximately 28,166 yds^3 of soil. It will require excavation and placement of approximately 22,533 yds^3 in the 7 total plugs to eliminate the existing gullies as a conduit for flow. The gully channel has average widths of between 54 ft. and 84 ft., with average depths between 4.2 ft. and 6 ft.. The average width of the historic Foster Meadow floodplain ranges from 110 ft. to 142 ft.

Table 1. Data Summary Values

FOSTER MEADOW CROSS-SECTION DATA SUMMARY- 2014							
X-section #	Gully A (sqft)	Gully W (ft)	Gully D (ft)	ReCh A (sqft)	ReCh W (ft)	ReCh D (ft)	Flpln W (ft)
Pocket 1 X-s#1	90	54	4	10	20	0.6	110
Pocket 1 X-s#2	105	68	4.5	10	23	0.75	130
Pocket 1 X-s#3	70	55	4	5	8	0.4	90
Pocket 1 Ave.	**88.3**	**59.0**	**4.2**	**8.3**	**17.0**	**0.6**	**110.0**
Pocket 2 X-s#1	215	32	7	7.5	22	1	80
Pocket 2 X-s#2	270	102	5	7.5	25	0.5	140
Pocket 2 X-s#3	380	119	6	N/A	N/A	N/A	150
Pocket 2 Ave.	**288.3**	**84.3**	**6.0**	**7.5**	**23.5**	**0.8**	**123.3**
Main Mdw X-s#1	N/A	N/A	N/A	5	4	1.25	135
Main Mdw X-s#2	N/A	N/A	N/A	15	25	2.5	80
Main Mdw X-s#3	55	55	2.5	5	32	0.25	315
Main Mdw X-s#4	90	38	4.5	6	18	1	180
Main Mdw X-s#5	85	50	4	7.5	17	1.5	130
Main Mdw X-s#6	420	62	8	7.5	12	2	60
Main Mdw X-s#7				7.5	22	0.5	80
Main Mdw X-s#8	150	76	4	N/A	N/A	N/A	100
Main Mdw X-s#9	45	45	2.5	N/A	N/A	N/A	200
Main Ave.	**140.8**	**54.3**	**4.3**	**7.6**	**18.6**	**1.3**	**142.2**
Reach	Length (ft)	Volume (sqft)	Void (cu. yds)	Plugs (Void*.80)			
Foster Pock #1	320	88.30	1,047	837			
Foster Pock #2	894	288.3	9,546	7,637			
Foster Main	3370	140.8	17,574	14,059			
			28,166	**22,533**			


FH 54 Road Crossing
Pocket Meadows
Main Meadow
Foster Meadow
Anderson Canyon
Anderson Ridge
Canyon
Cosumnes River
Middle Fork
Meadow
Peddler Hill Maintenance Station
Peddler Hill
Spring
Spring
Spring
Durnene Camp
APPROX
Mile 44.5
Mile 44
Mile 43
BM 7207
BM 7144
BM 7102
ELDORADO CO
AMADOR CO
88
Foster Meadow Project
Vicinity and Project Area Map
PLUMAS CORPORATION
Feet
0 600 1,200 2,400 3,600 4,800
1:24,000
1/26/2015

Qualitative:
The existing incised (downcut) channels are result of over 100 years of land use and natural events. The cumulative effects of these impacts can leave landscapes vulnerable to damage during major floods. The principal mechanisms that initiated this incision appear to be some channel modifications, past intensive livestock use and road building. This combination of cumulative effects is prevalent throughout the region. Once incision began to change the hydrology, the vigor and resilience of the vegetative community to livestock use was diminished.



Photo #1: Middle Fork Cosumnes River gully in Foster Meadow near X-section #8. Breached rock check dam in photo center.

Design Narrative:
The Amador Ranger District, El Dorado National Forest and project stakeholders are seeking to restore the natural hydrologic functions of the Foster Meadow system to provide improved water quality, timing of flows and enhanced aquatic and terrestrial habitats onsite and downstream. Attendant with that objective is to remove barriers to aquatic organism passage in this reach of the Middle Fork Cosumnes River. Plumas Corporation staff began surveying design-level cross-sections in the spring/early summer of 2014 in collaboration with the District staff.

Meadow Component- Ultimately, the design concept for degraded meadows in the Foster Meadow project areas is to implement near-complete gully fill. The fill material would be excavated from 4 small borrow ponds along the margins of the meadow and grading 4 areas of in-meadow terrace down to the design floodplain elevation. This design significantly reduces risk associated with frequent overland flow over plugs and into ponds. Given meadow slopes of 1% -3% and a gully near the center of the meadow, the more traditional pond and plug technique would have some risk.

The principal function if the borrow ponds are to provide native fill material for plug construction. Since the ponds will fill with groundwater and maintain ponded water year-round, habitat features and diversity are incorporated into the construction. These include varying water depths, islands, pennisulas, basking logs, etc., which are determined as fill needs are met. Topsoil is removed and stockpiled adjacent to the plug fill zone to top dress the completed plug. All plugs and borrow ponds are sited and configured to accommodate surface and subsurface through flow as well as adjacent hillslope-generated surface and groundwater inflows. Plugs are constructed with wheel loader(s) to provide wheel compaction of the fill. The compaction levels are intended to match the porosity/transmissivity of the native meadow soils. This allows moisture to move freely within the plug soil profile and support erosion resistant meadow vegetation for long term durability as well as preventing preferential pathways for subsurface flows either in the plug or the native material.

Design features specific to the Pocket Meadows #1 and #2 are as follows. All gully fill for Pocket Meadow #1 will be generated from the one borrow pond excavated into the timbered terrace to the south. Approximately 7 trees (red fir/lodgepole) will be incorporated into the plug fill surfaces and the remnant channel for velocity reduction. This borrow pond will provide an off-channel, in-forest, perennial surface water habitat feature. The majority of the earth fill for the gully in Pocket Meadow #2 will be generated from cutting terrace features down to floodplain elevation. This will provide more meadow area and floodplain extent, but not open water habitat. One borrow pond will be excavated into the forested terrace to the north. This will be an off-channel, in-forest, perennial surface water habitat feature. Approximately 4 red fir trees would be removed and used for habitat in the pond.

Design features specific to the Main Meadow include having the bulk of the gully fill being generated from terrace cut. This will reduce shear stresses on the remnant channel and increase the areal extent of wet meadow by approximately 4.9 acres. The lower end of the project will require using 9 rock riffles to raise the base level of the channel, in lieu of gully fill, in its existing alignment. This allows a seamless transition of the new meadow gradient to the existing channel at the downstream end of the project.

Upon completion, all plug surfaces are ripped to a depth of 12” to facilitate rainfall infiltration with, the recovered topsoil spread and seeded with native seed. All native vegetation recovered from fill and borrow sites will transplanted to plug edges, surfaces and key locations on the remnant channel. Additionally, 9 rock riffles will be installed in the existing channel, in lieu of plugs, to raise the base level at downstream end of the project where the channel is centered in the meadow with a narrow effective floodplain. All access for equipment and materials will be on existing open or closed roads and recent timber harvest skid trails and landings.

Aquatic Passage Component- The design for aquatic organism passage at the Forest Highway 54 crossing would use a rock/soil fill with vegetation transplants to raise both the channel and floodplain to match the existing culvert invert/floodplain elevation. This would require approximately 500 yds^3 of 2.0-foot minus rock and soil. To reduce the backwater effect of high flow in a single culvert, additional culverts set at floodplain elevation would be installed in the road crossing with invert elevations 1 foot above the invert elevation of the channel culvert. These floodplain culverts would be 'squash' type, 30-inch diameter set at as close an interval practicable across the floodplain. Ideally, no less than 3 additional culverts should be installed. All road prism/culvert modification work should be closely coordinated with, or engineered by, the Forest engineering staff. Examples of valley grade structures in Photos 4a, b, c, d below.



Photo #2a: FH 54 road crossing culvert inlet.



Photo #2b: FH 54 road crossing culvert outlet.



Photo 4a: Last Chance Creek- Alkali Flat, 2009



Photo 4b: Trout Creek, 2014



Photo 4c: Greenhorn Creek, 2015



Last Chance Creek- Ferris Flat, 2005

Hydrology:

Water Supply- Middle Fork Cosumnes River

The annual average runoff of 29 inches from the 992-acre portion of the Middle Fork Cosumnes River basin to the downstream end of the project produces 2,381 acre-feet (af) annually. The 27-acre project would likely require approximately 27 acre-feet of runoff to initially 'refill' the soils in the restored project, 1.1% of the annual average runoff. This refilling would generally occur in the winter with negligible effects on any downstream uses. Subsequent flows are throughflow until inflow to the project area ceases in late summer. At that point, some drainage, or recharge to the channel would occur from the upper 1-2 feet of meadow soils, until surface and subsurface inflows to the meadow resume in fall. Based on long term monitoring of similar restoration projects, it is highly unlikely the restored meadow would ever 'drain' out to its pre-project dewatered condition. Subsequent years would only require sufficient inflow/precipitation to recharge the upper 1-2 feet of meadow soil drained during the previous dry season, approximately 13 acre feet or 0.5% of the basin yield. The Foster Meadow project will have a negligible overall effect on water supply in the Cosumnes River basin

Design Hydrology:

The hydrology analysis entailed both a full regression analysis and basin area regressions were calculated for three nearby gages to provide comparison and to "bracket' the variability inherent in regression analyses. The full computations of the comparative analysis are included in Appendix C.

Table 2a. Summary of Regression Analyses- Foster Meadow Project- Middle Fork Cosumnes River

COMPARATIVE DISCHARGE CALCULATIONS (cfs)- FOSTER MEADOW PROJECT FH 54 xing (0.55 mi^2)										
Reach Name	Q2	Q5	Q10	Q25	Q50	Q100	Method			
MF Cosumnes	15	45	71	120	163	233	Full Regression			
	15	49	79	144	219	319	Area Reg.- NF Cosumnes.			
	15	38	59	90	120	157	Area Reg.- MF Cosumnes.			
Bankfull	N/A						Cross-section			

Table 2b. Summary of Regression Analyses- Foster Meadow Project- Middle Fork Cosumnes River

COMPARATIVE DISCHARGE CALCULATIONS (cfs)- FOSTER MEADOW PROJECT bottom (1.55 mi^2)										
Reach Name	Q2	Q5	Q10	Q25	Q50	Q100	Method			
MF Cosumnes	34	105	162	271	366	518	Full Regression			
	37	114	181	237	491	709	Area Reg.- NF Cosumnes.			
	36	89	136	204	270	350	Area Reg.- MF Cosumnes.			
Bankfull	23						Cross-section			

****Derived from Waananen & Crippen "Magnitude and Frequency of Floods in California", 1977**

Budget (construction only)

Equipment- all pieces 160 hrs ea.	$128,000.00
Trucks	$ 15,000.00
Labor- CCC or FS crew	$ 25,000.00
Materials- rock/culverts	$ 42,000.00
Project/Construction supervision	$ 44,000.00
Travel/lodging, etc.	$ 14,000.00
Total	**$268,000.00**

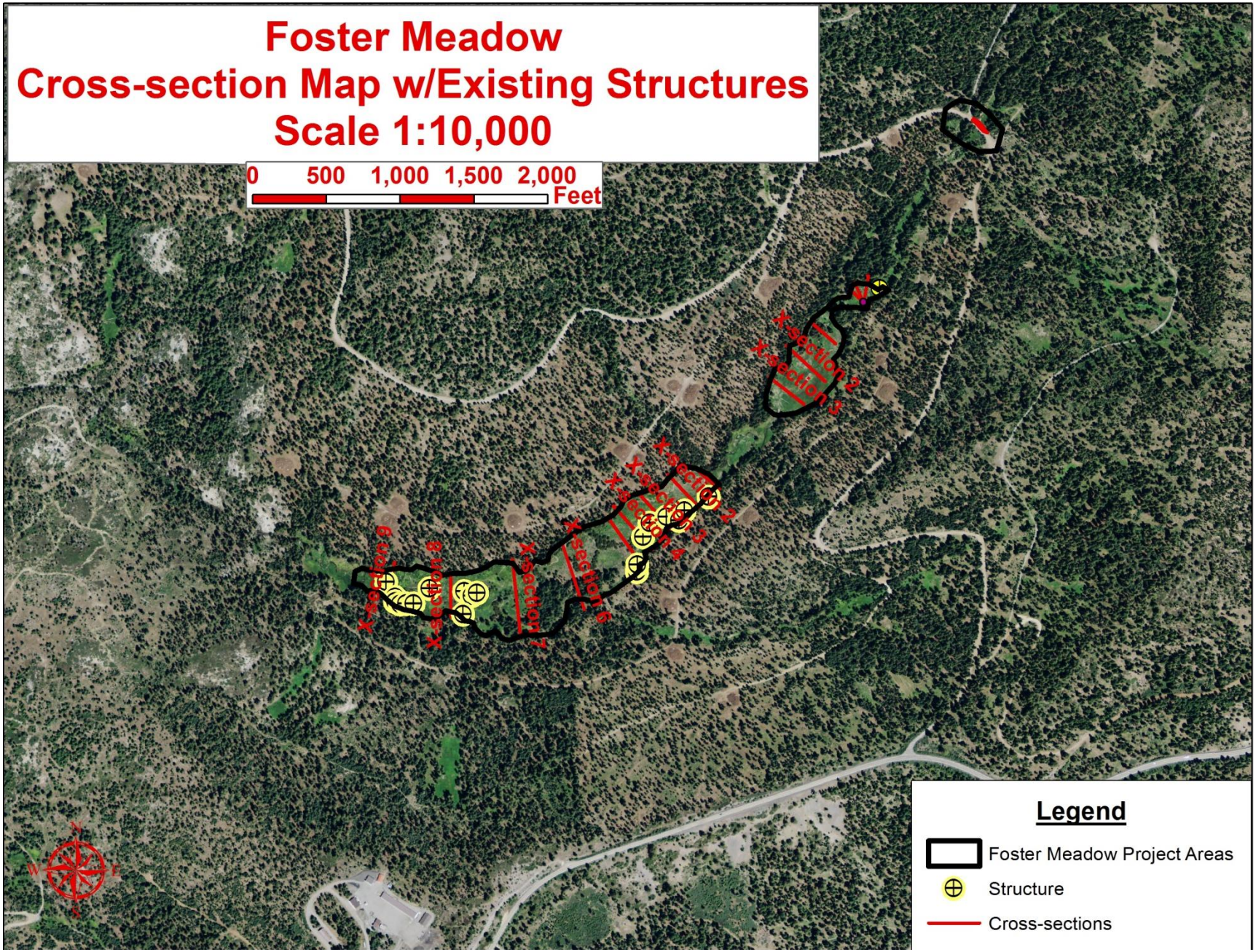
APPENDIX A

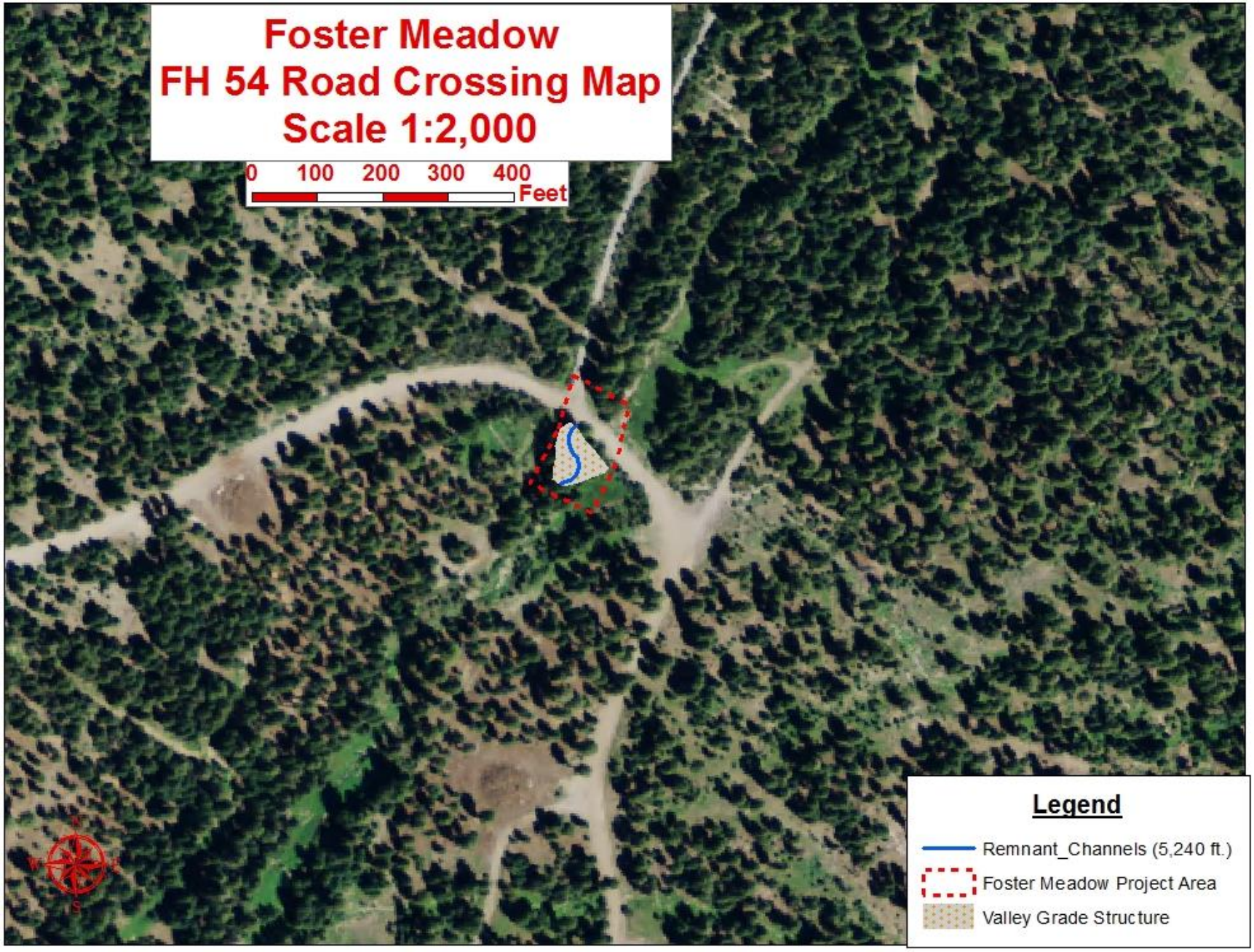
Foster Meadow Project Area with cross-sections and previous structures

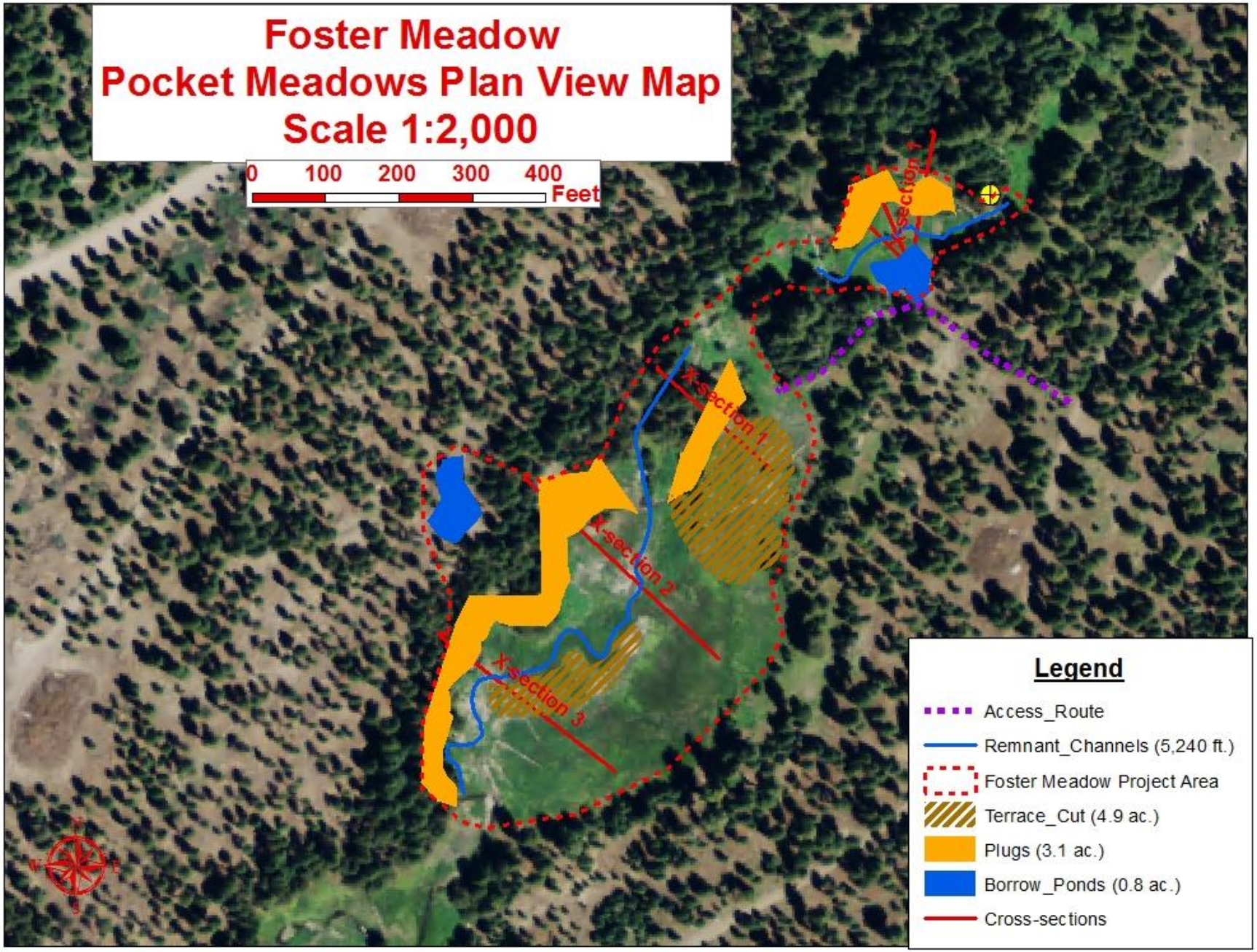
Plan View FH 54 Road Crossing

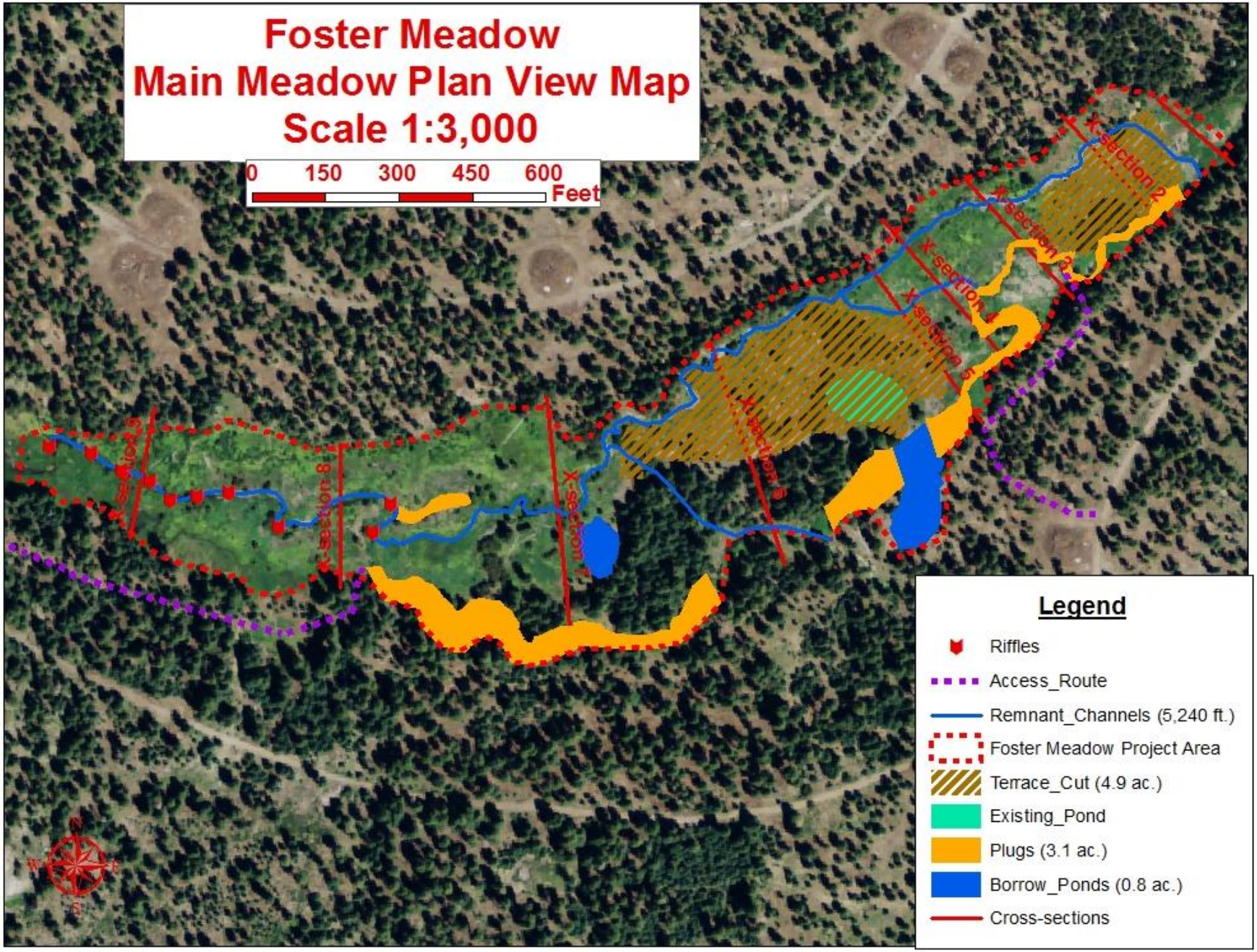
Plan View Pocket Meadows

Plan View Main Meadow


Foster Meadow
Cross-section Map w/Existing Structures
Scale 1:10,000
0 500 1,000 1,500 2,000
Feet
X-section 1
X-section 2
X-section 3
X-section 4
X-section 5
X-section 6
X-section 7
X-section 8
X-section 9
Legend
Foster Meadow Project Areas
Structure
Cross-sections


Foster Meadow
FH 54 Road Crossing Map
Scale 1:2,000
0 100 200 300 400
Feet
Legend
Remnant_Channels (5,240 ft.)
Foster Meadow Project Area
Valley Grade Structure


Foster Meadow
Pocket Meadows Plan View Map
Scale 1:2,000
0 100 200 300 400
Feet
X-section 1
X-section 2
X-section 3
X-section 4
Legend
Access_Route
Remnant_Channels (5,240 ft.)
Foster Meadow Project Area
Terrace_Cut (4.9 ac.)
Plugs (3.1 ac.)
Borrow_Ponds (0.8 ac.)
Cross-sections


Foster Meadow
Main Meadow Plan View Map
Scale 1:3,000
0 150 300 450 600
Feet
X-section 2
X-section 3
X-section 4
X-section 5
X-section 6
X-section 7
X-section 8
X-section 9
Legend
Riffles
Access_Route
Remnant_Channels (5,240 ft.)
Foster Meadow Project Area
Terrace_Cut (4.9 ac.)
Existing_Pond
Plugs (3.1 ac.)
Borrow_Ponds (0.8 ac.)
Cross-sections

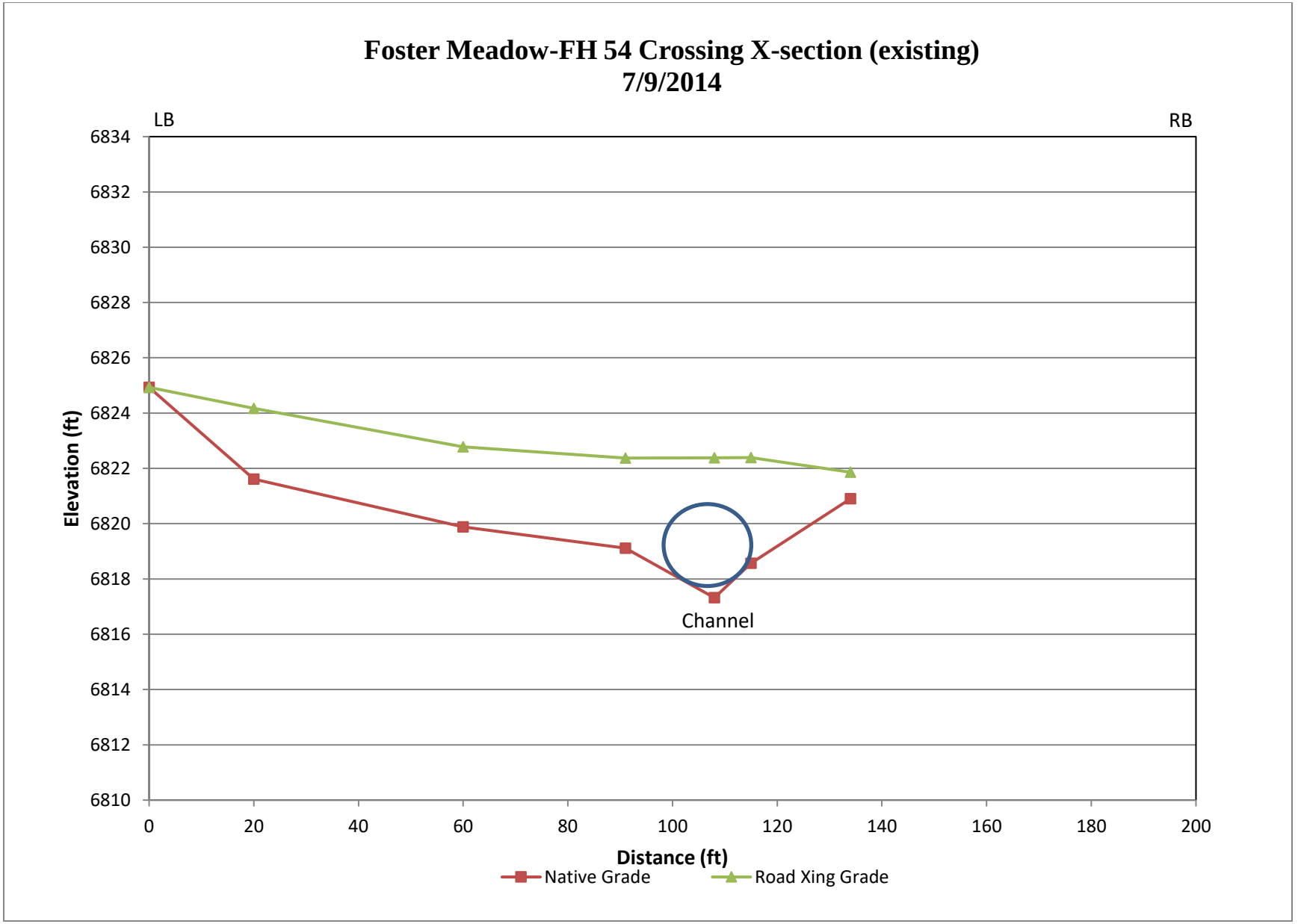
APPENDIX B

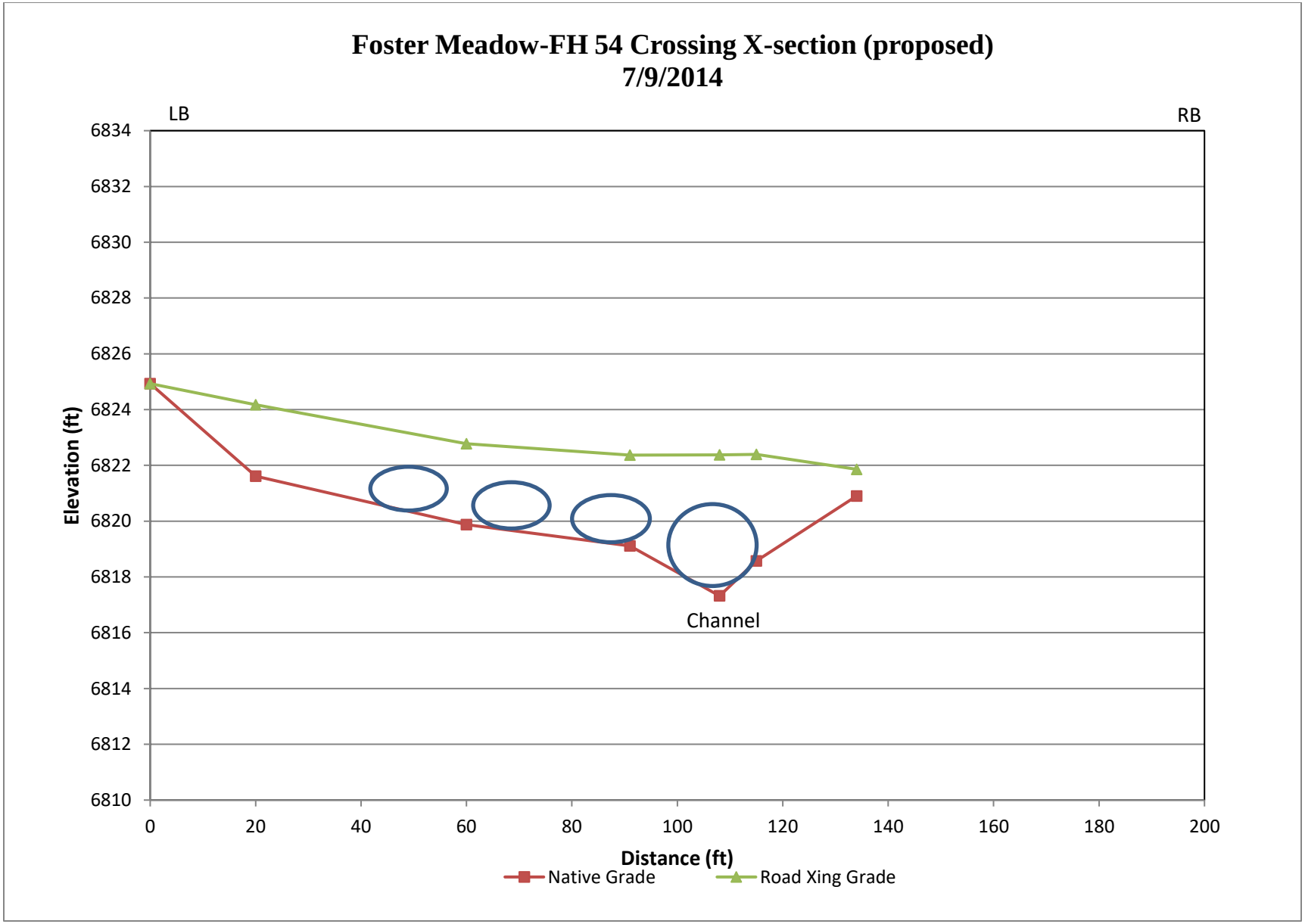
FH 54 Road Crossing Cross-sections- Paired existing and proposed
FH 54 Road Crossing Longitudinal Profiles- Paired existing and proposed

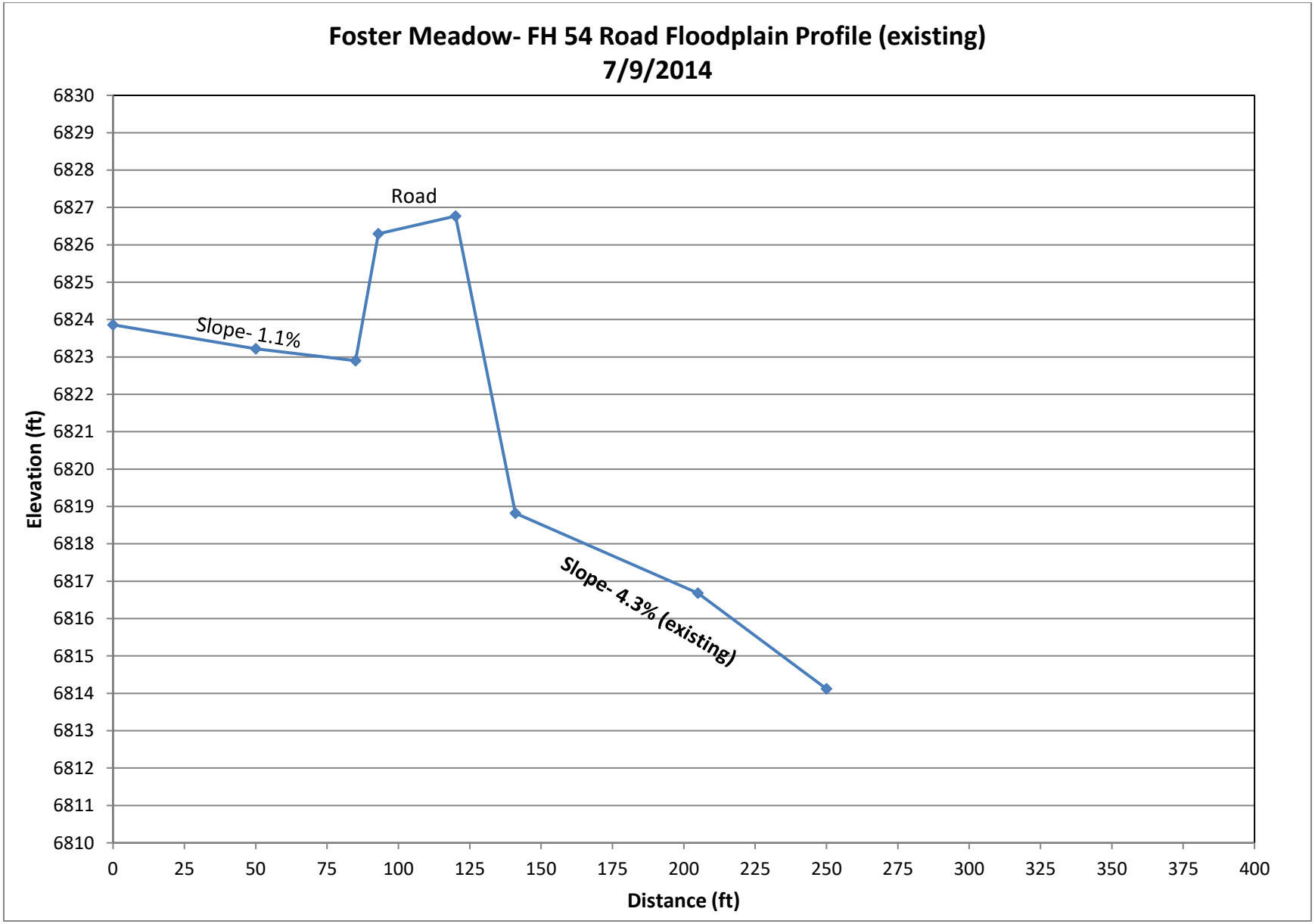
Pocket Meadow #1 Cross-sections- Paired existing and proposed
Longitudinal Profile- Pocket #1

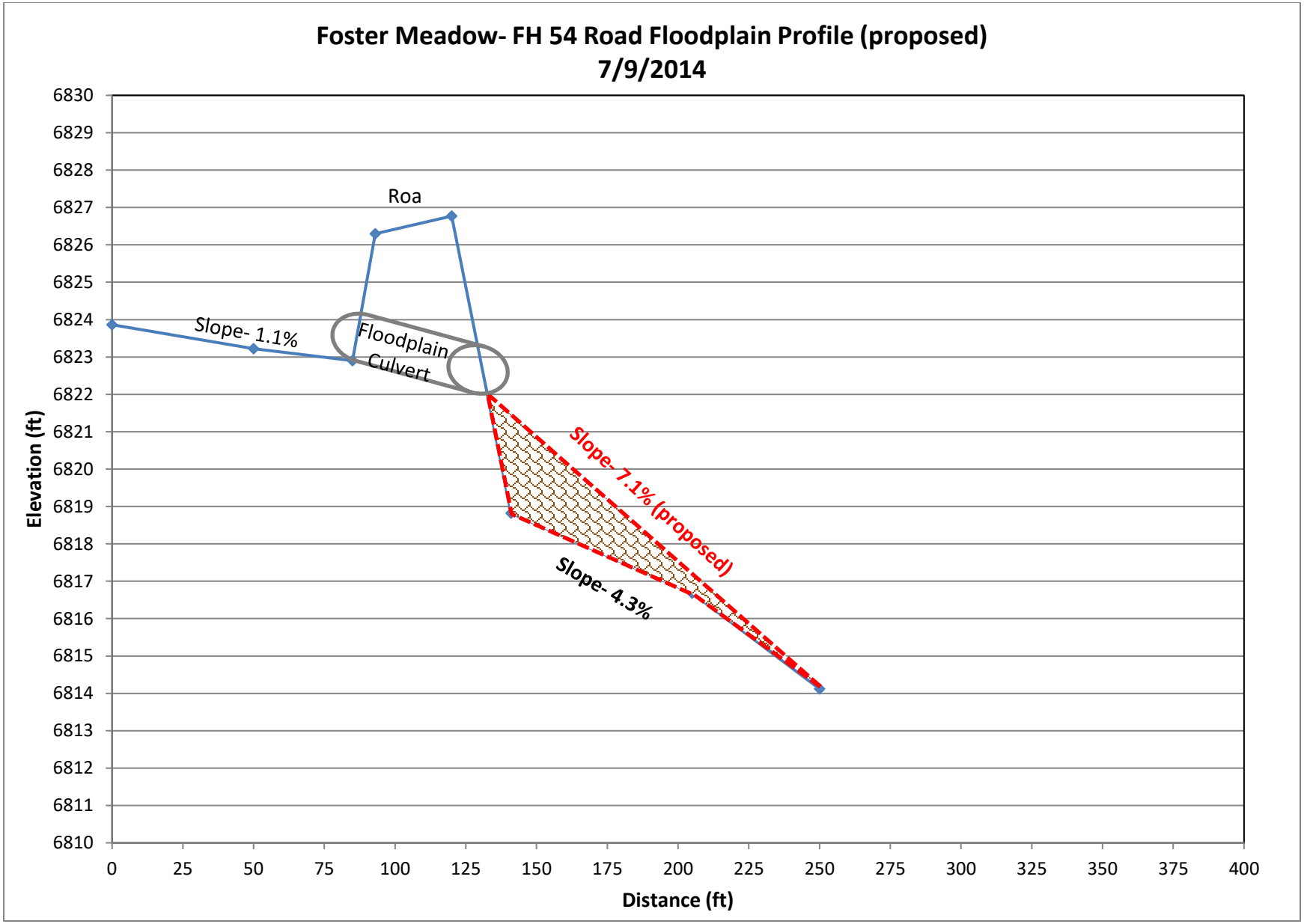
Pocket Meadow #2 Cross-sections- Paired existing and proposed
Longitudinal Profile- Pocket #2

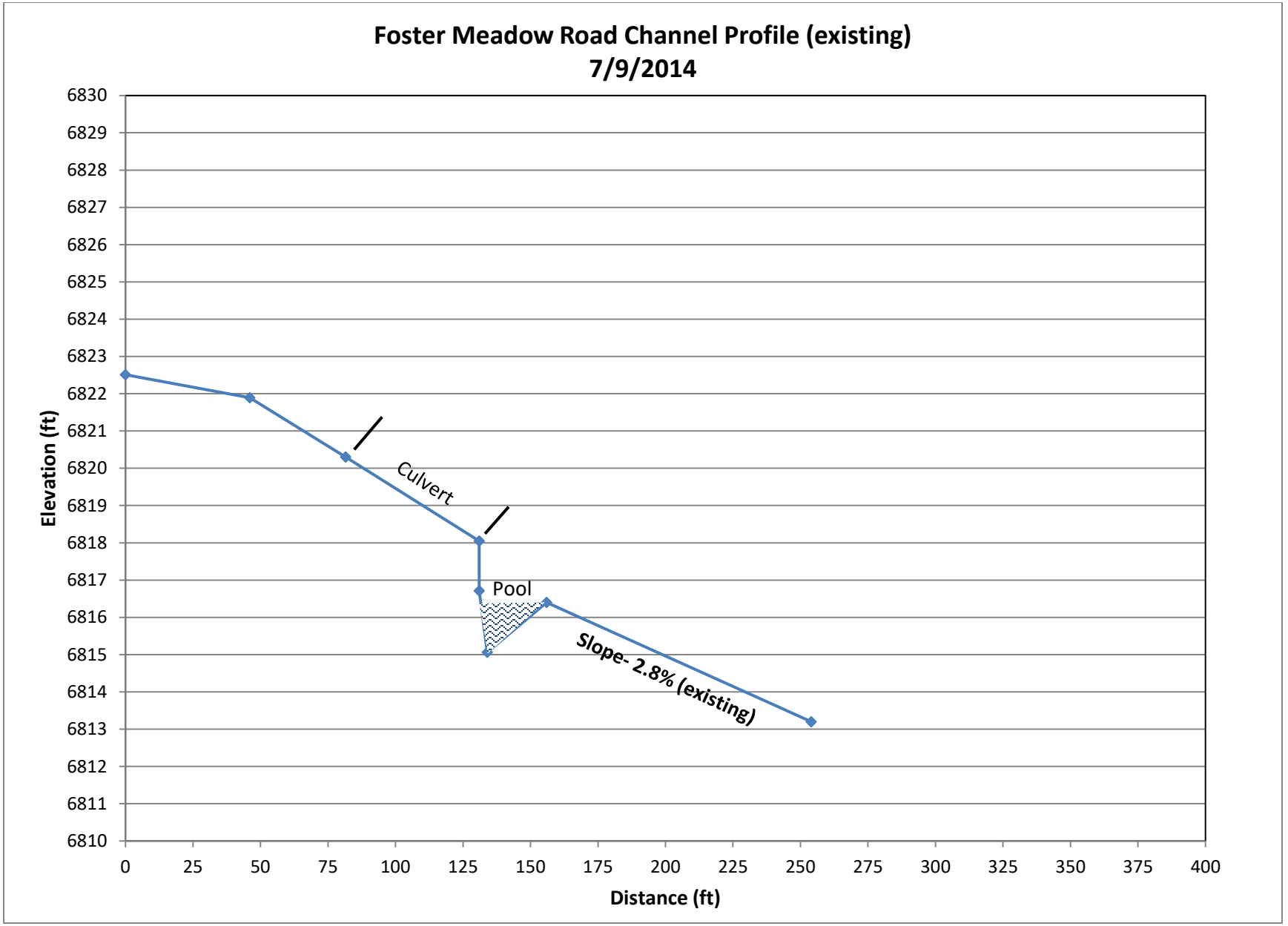
Main Meadow Cross-sections- Paired existing and proposed
Longitudinal Profile- Main Meadow

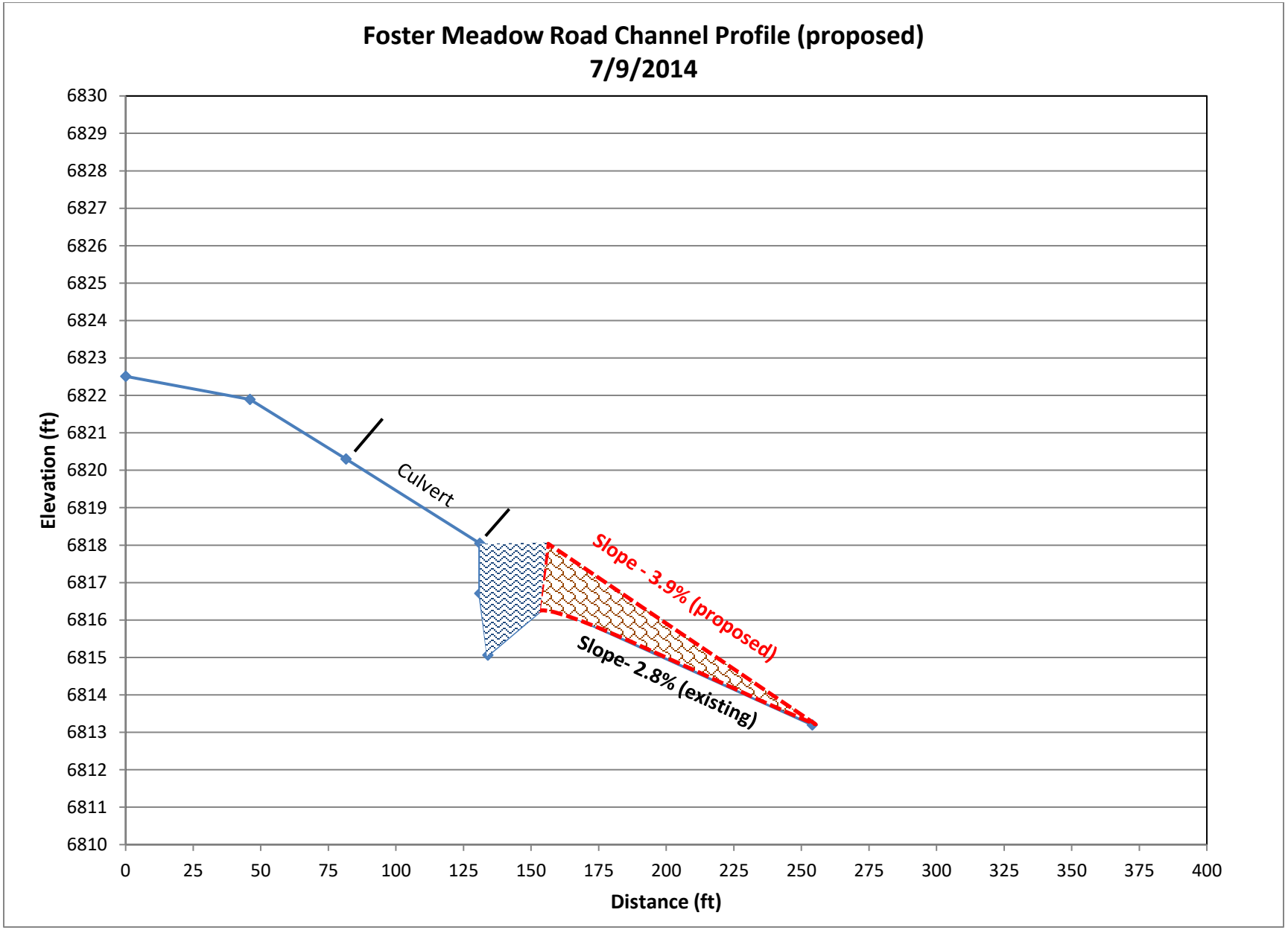

Foster Meadow-FH 54 Crossing X-section (existing)
7/9/2014
LB
RB
6834
6832
6830
6828
6826
6824
6822
6820
6818
6816
6814
6812
6810
Elevation (ft)
0
20
40
60
80
100
120
140
160
180
200
Distance (ft)
Channel
Native Grade
Road Xing Grade

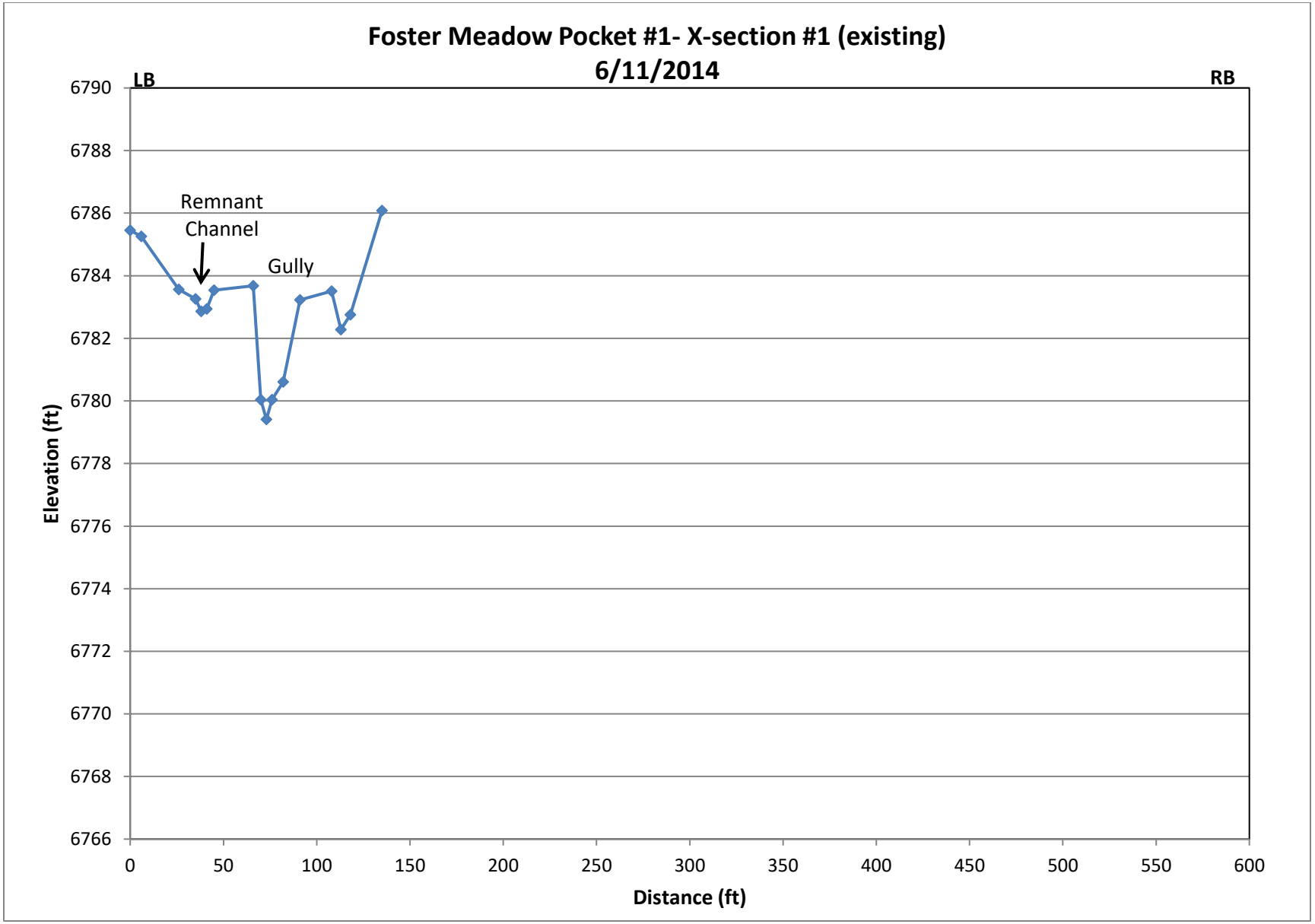

Foster Meadow-FH 54 Crossing X-section (proposed)
7/9/2014
LB
RB
6834
6832
6830
6828
6826
6824
6822
6820
6818
6816
6814
6812
6810
Elevation (ft)
0
20
40
60
80
100
120
140
160
180
200
Distance (ft)
Channel
Native Grade
Road Xing Grade

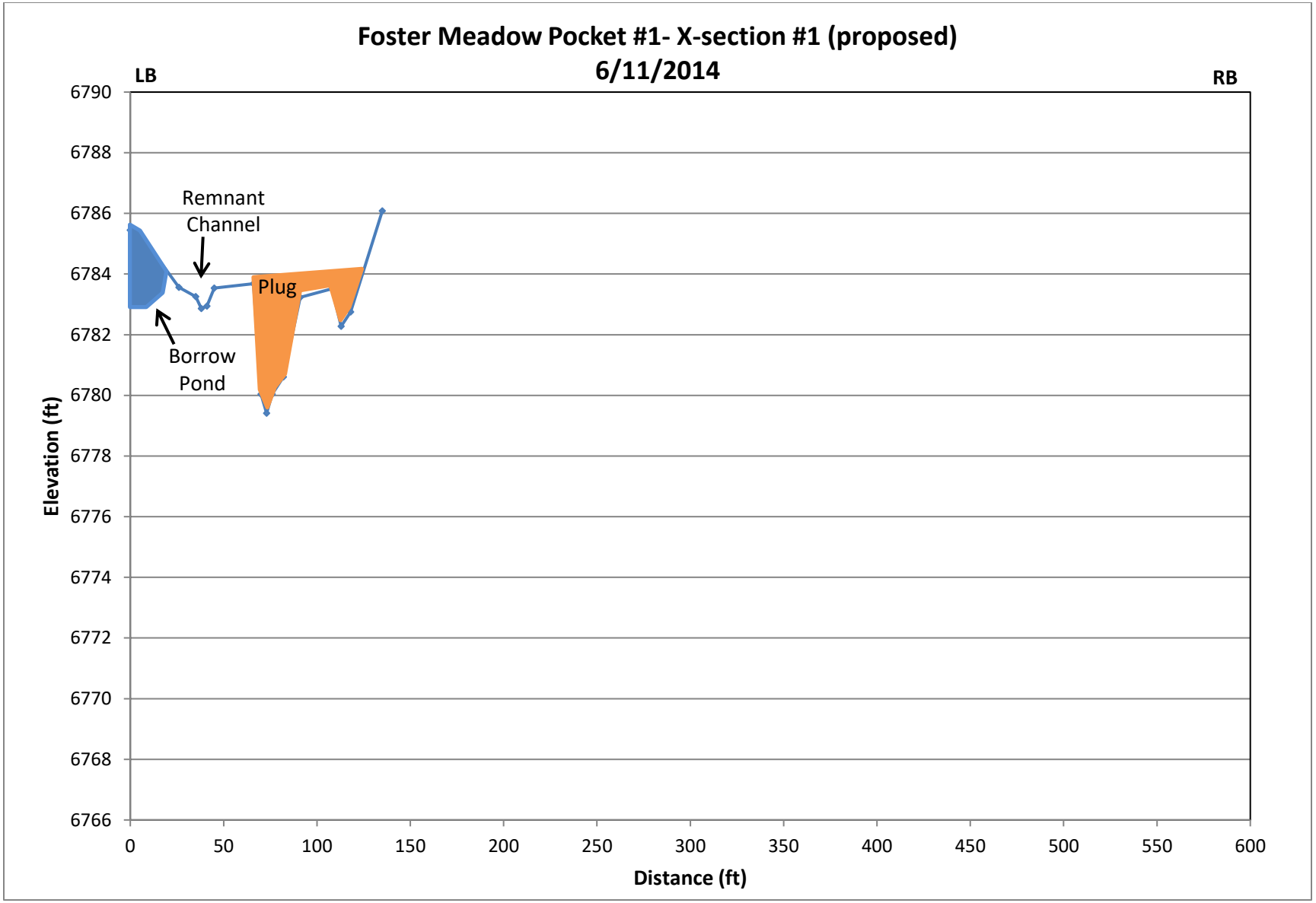

Foster Meadow- FH 54 Road Floodplain Profile (existing)
7/9/2014
Elevation (ft)
6830
6829
6828
6827
6826
6825
6824
6823
6822
6821
6820
6819
6818
6817
6816
6815
6814
6813
6812
6811
6810
Road
Slope- 1.1%
Slope- 4.3% (existing)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
Distance (ft)

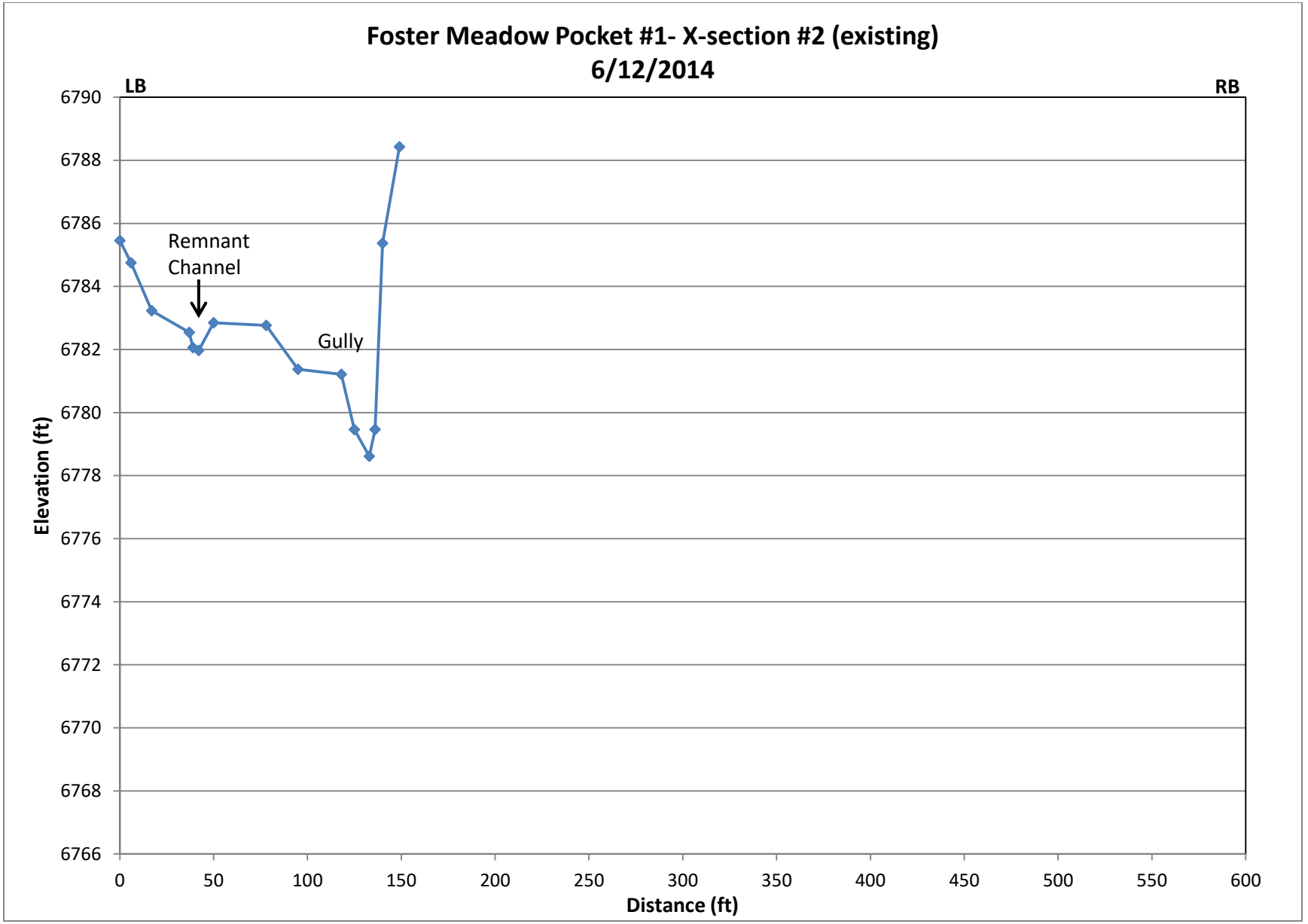

Foster Meadow- FH 54 Road Floodplain Profile (proposed)
7/9/2014
Elevation (ft)
6830
6829
6828
6827
6826
6825
6824
6823
6822
6821
6820
6819
6818
6817
6816
6815
6814
6813
6812
6811
6810
Roa
Slope- 1.1%
Floodplain
Culvert
Slope- 7.1% (proposed)
Slope- 4.3%
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
Distance (ft)

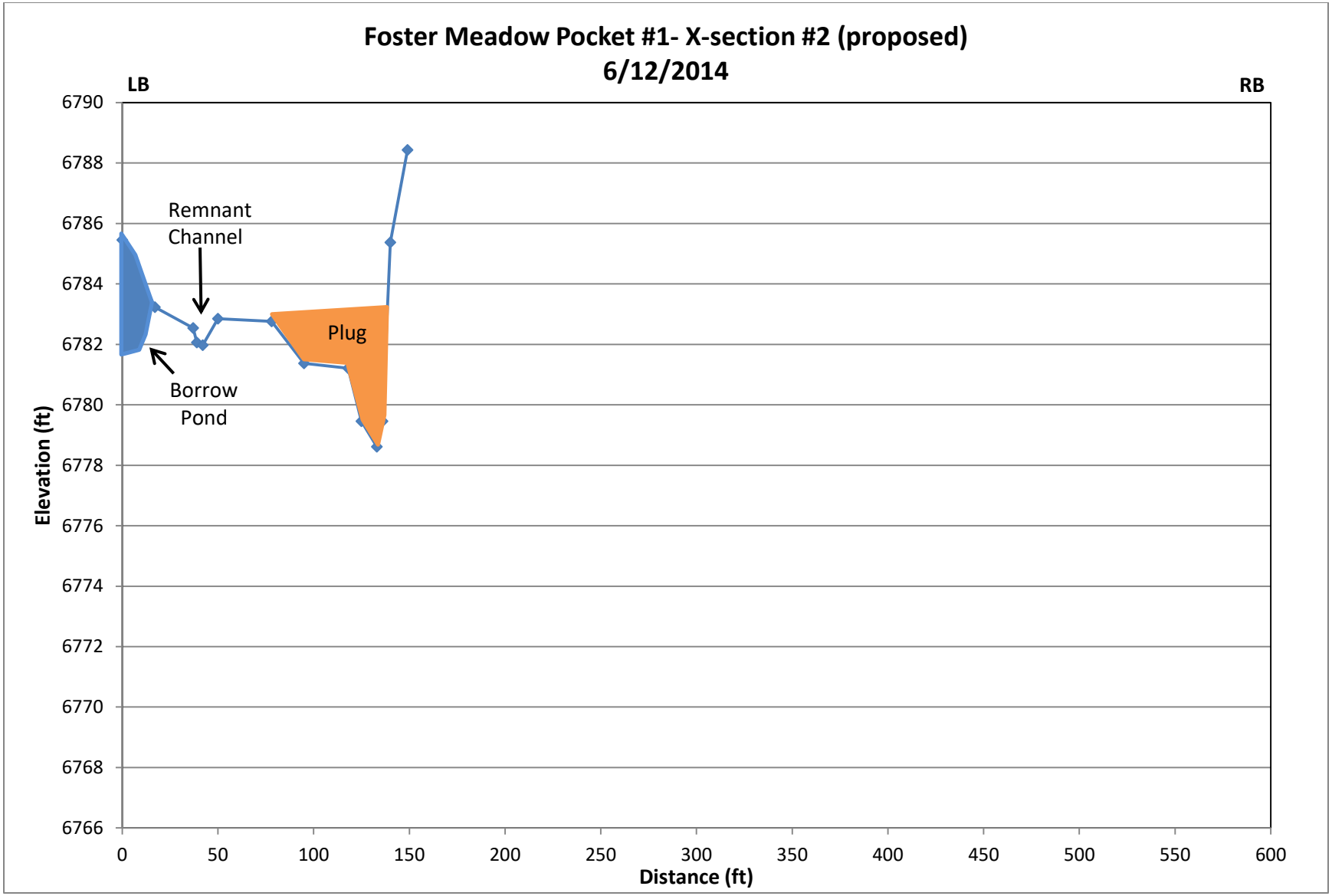

Foster Meadow Road Channel Profile (existing)
7/9/2014
Elevation (ft)
6830
6829
6828
6827
6826
6825
6824
6823
6822
6821
6820
6819
6818
6817
6816
6815
6814
6813
6812
6811
6810
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
Distance (ft)
Culvert
Pool
Slope- 2.8% (existing)

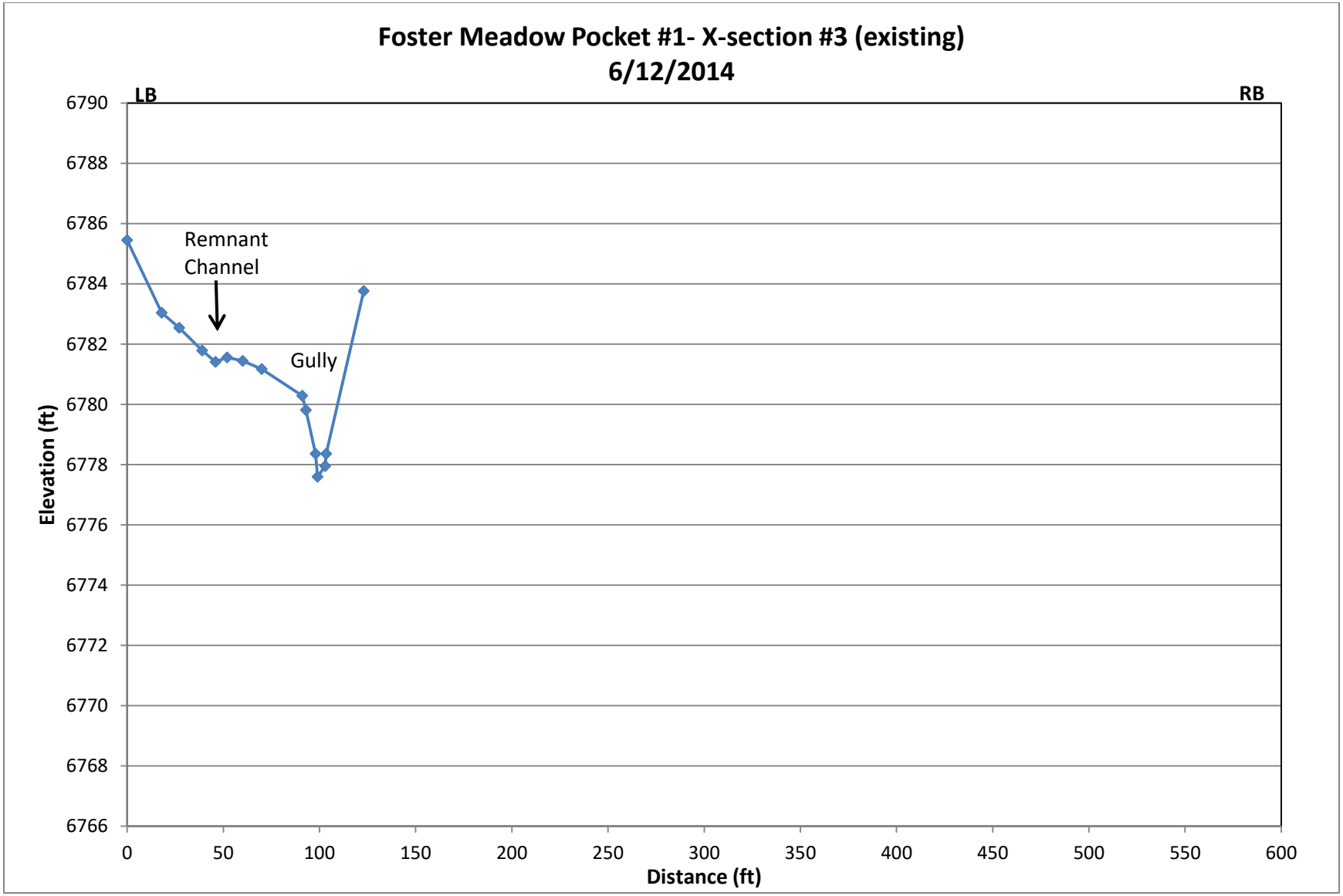

Foster Meadow Road Channel Profile (proposed)
7/9/2014
Elevation (ft)
6830
6829
6828
6827
6826
6825
6824
6823
6822
6821
6820
6819
6818
6817
6816
6815
6814
6813
6812
6811
6810
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
Distance (ft)
Culvert
Slope - 3.9% (proposed)
Slope- 2.8% (existing)

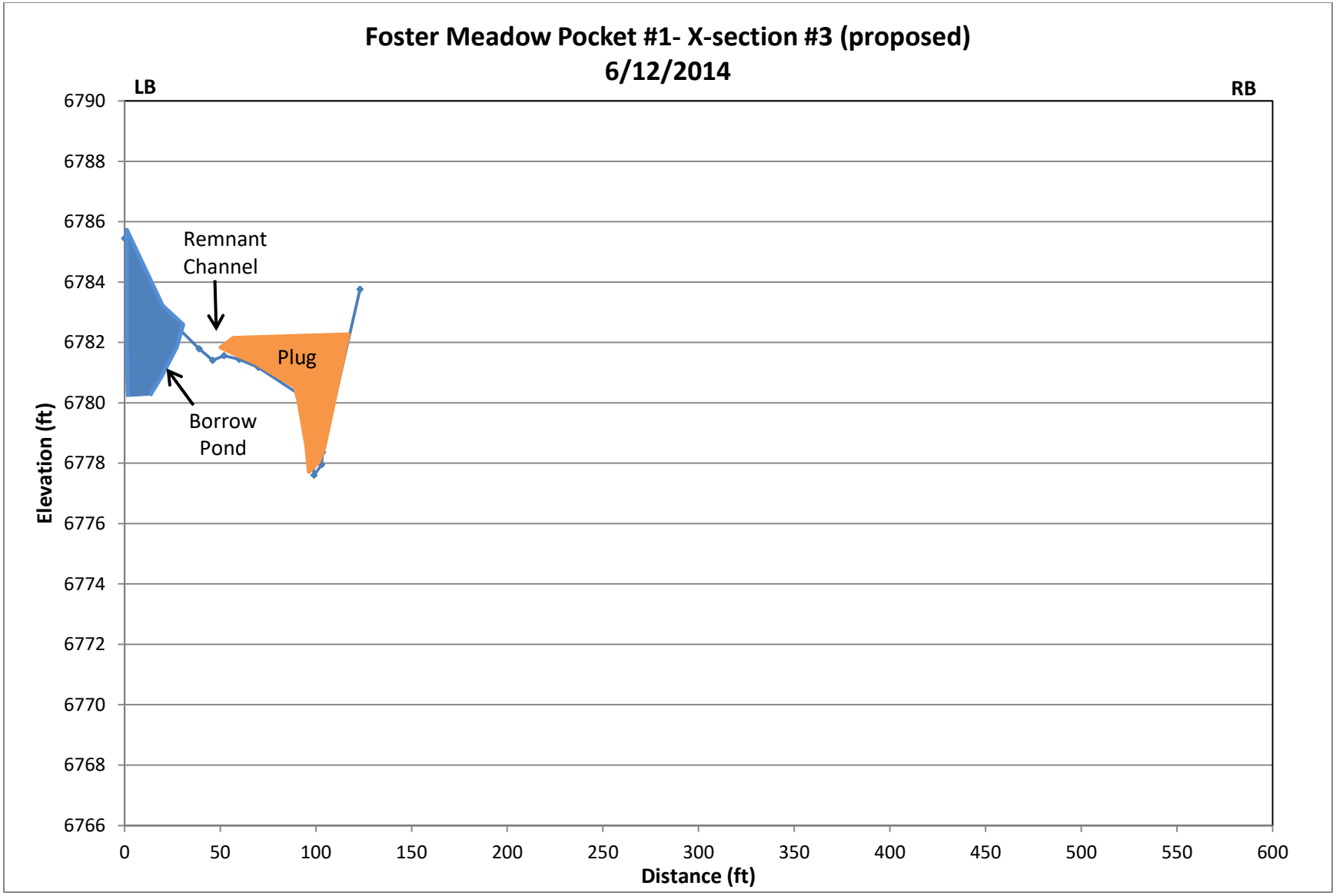

Foster Meadow Pocket #1- X-section #1 (existing)
6/11/2014
LB
RB
Remnant
Channel
Gully
Elevation (ft)
6790
6788
6786
6784
6782
6780
6778
6776
6774
6772
6770
6768
6766
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

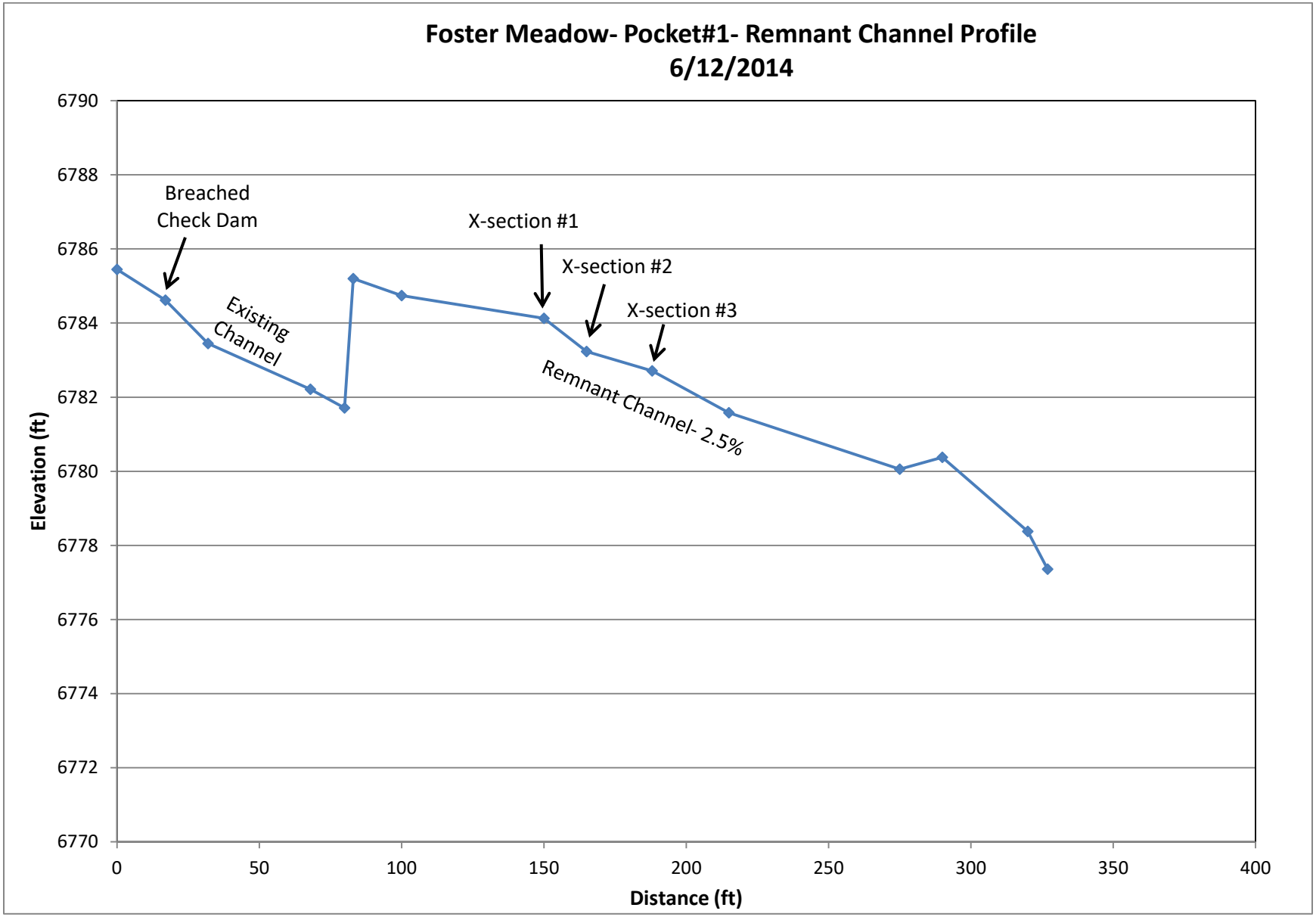

Foster Meadow Pocket #1- X-section #1 (proposed)
6/11/2014
LB
RB
Remnant Channel
Plug
Borrow Pond
Elevation (ft)
Distance (ft)
6790
6788
6786
6784
6782
6780
6778
6776
6774
6772
6770
6768
6766
0
50
100
150
200
250
300
350
400
450
500
550
600

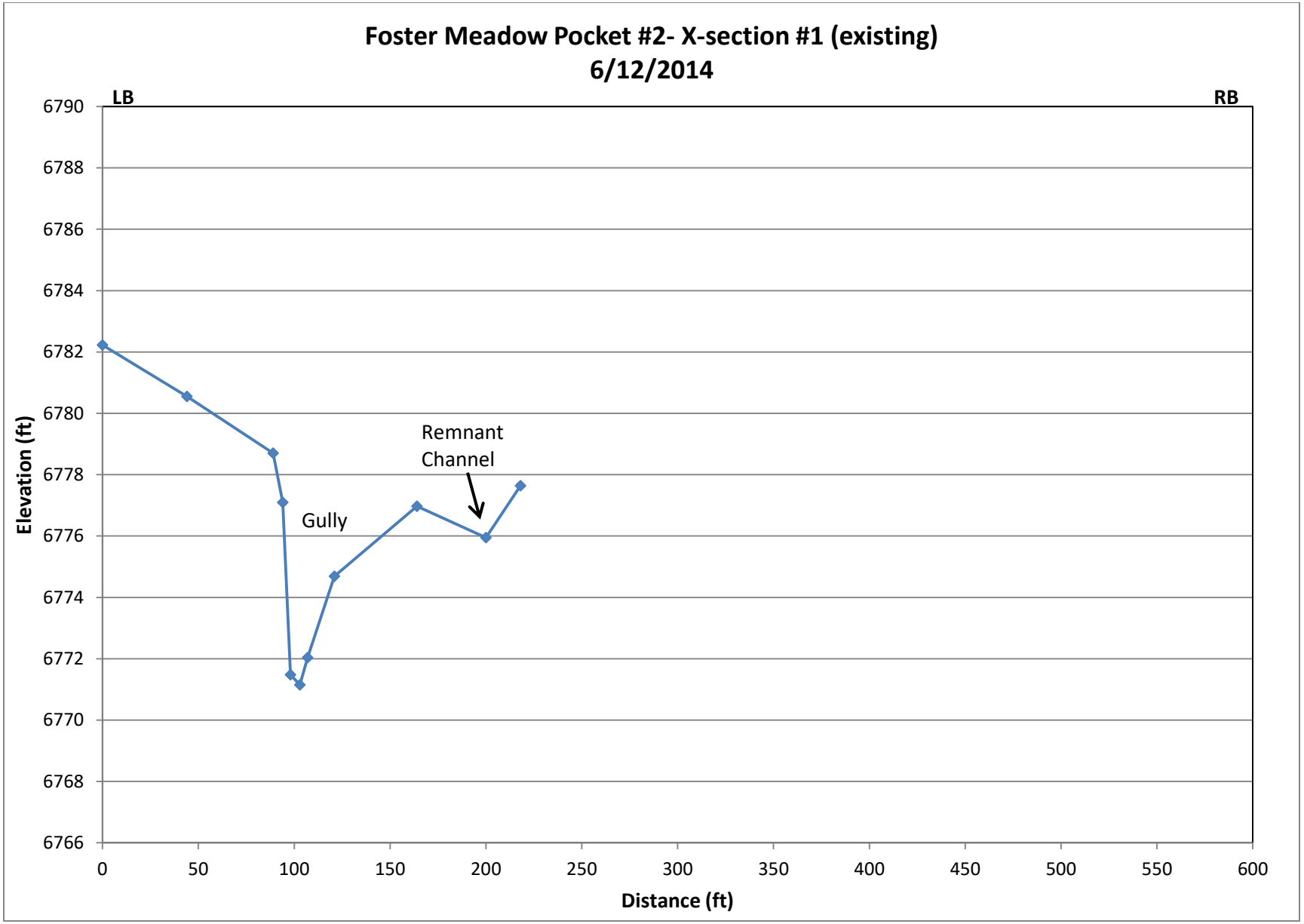

Foster Meadow Pocket #1- X-section #2 (existing)
6/12/2014
LB
RB
Remnant
Channel
Gully
Elevation (ft)
6790
6788
6786
6784
6782
6780
6778
6776
6774
6772
6770
6768
6766
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

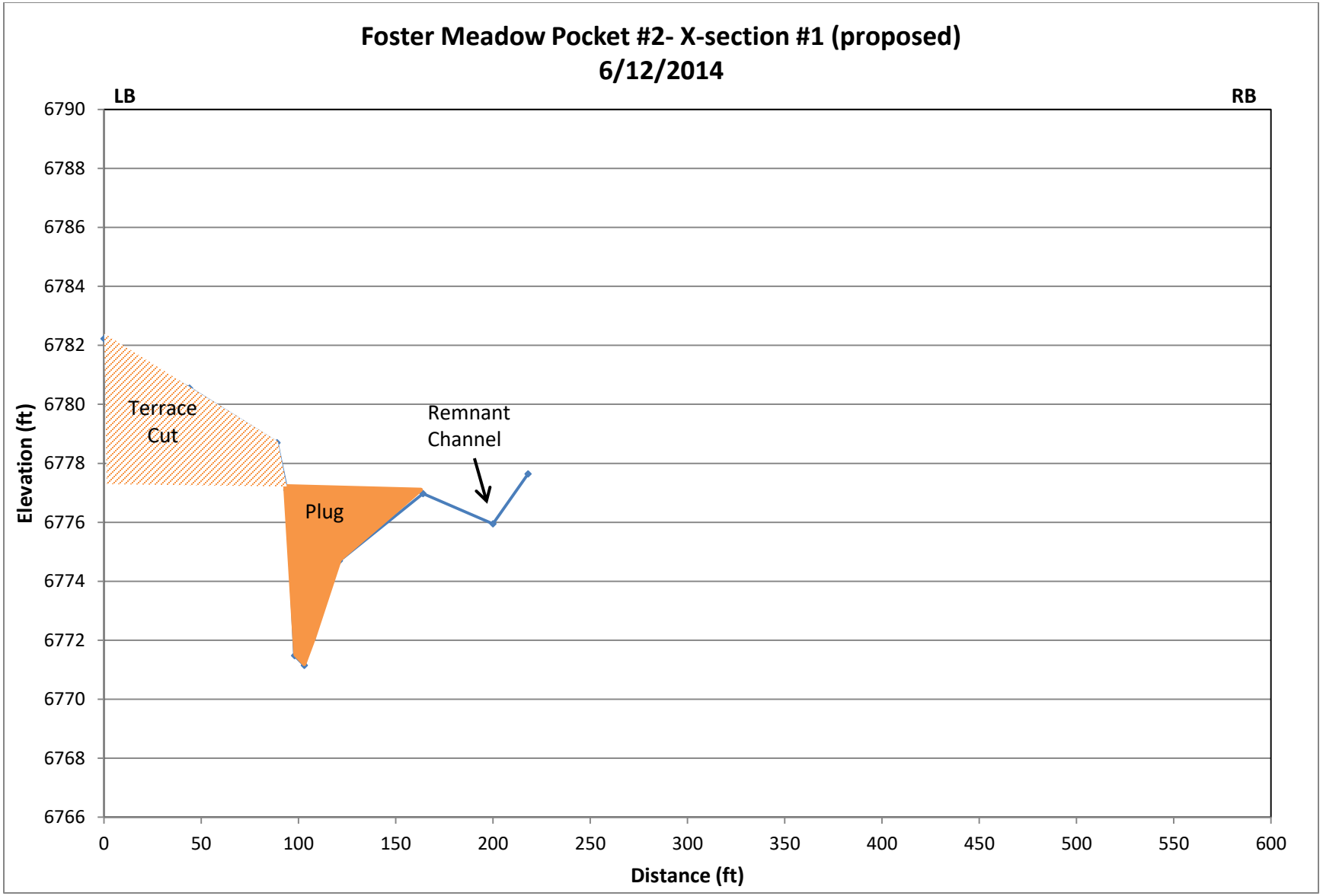

Foster Meadow Pocket #1- X-section #2 (proposed)
6/12/2014
LB
RB
Remnant
Channel
Plug
Borrow
Pond
Elevation (ft)
6790
6788
6786
6784
6782
6780
6778
6776
6774
6772
6770
6768
6766
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

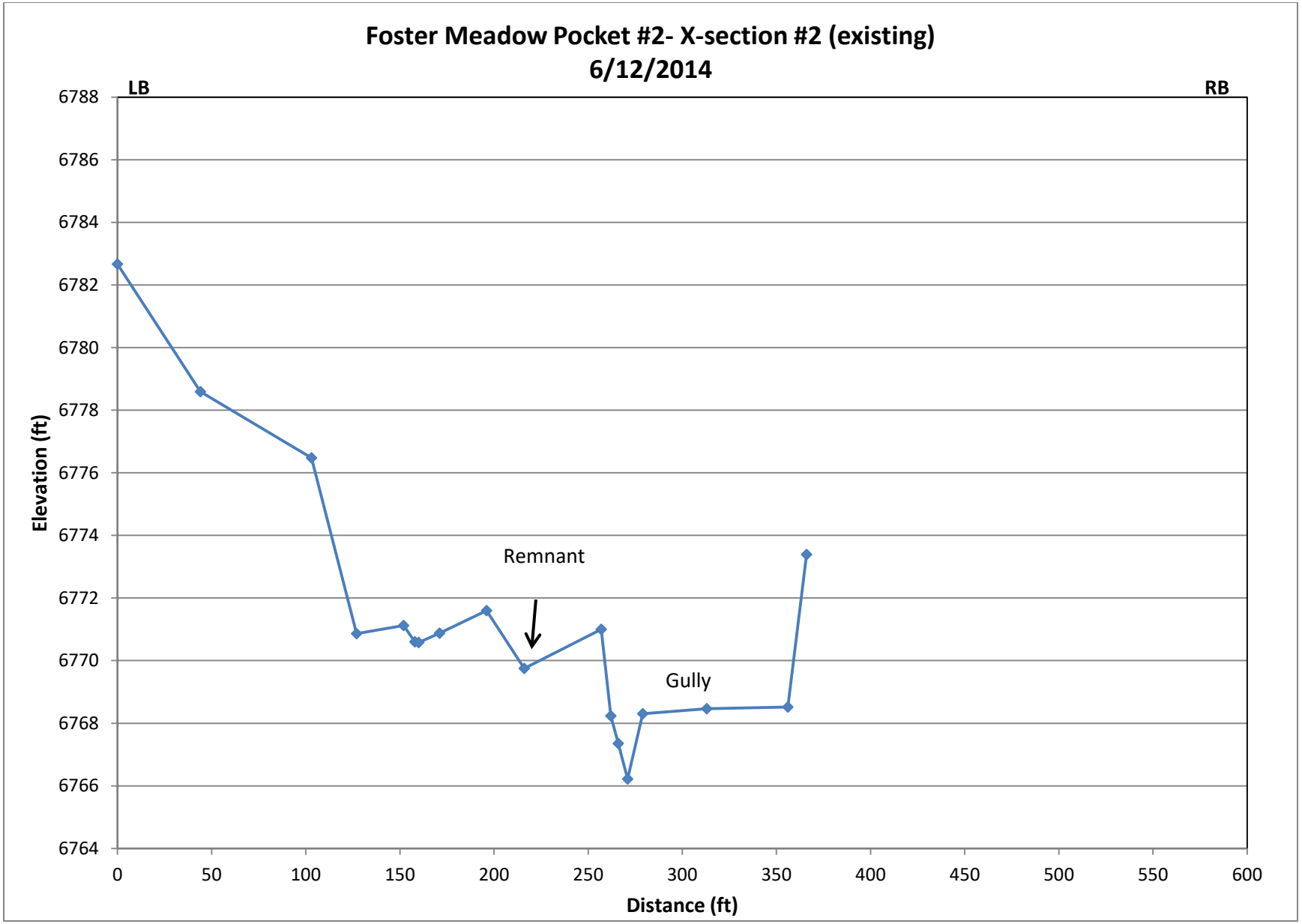

Foster Meadow Pocket #1- X-section #3 (existing)
6/12/2014
LB
RB
Remnant
Channel
Gully
Elevation (ft)
Distance (ft)
6790
6788
6786
6784
6782
6780
6778
6776
6774
6772
6770
6768
6766
0
50
100
150
200
250
300
350
400
450
500
550
600

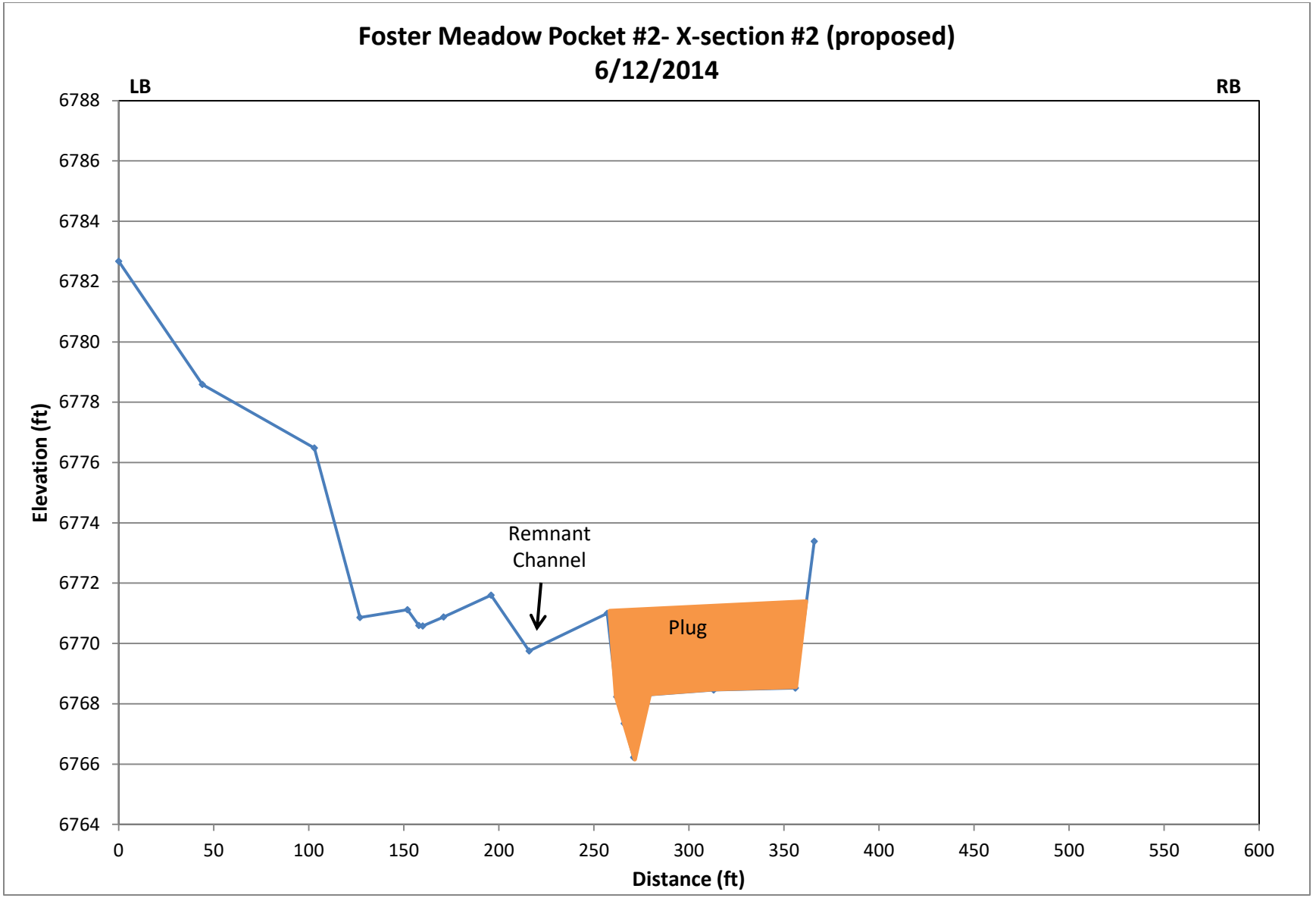

Foster Meadow Pocket #1- X-section #3 (proposed)
6/12/2014
LB
RB
Remnant Channel
Plug
Borrow Pond
Elevation (ft)
6790
6788
6786
6784
6782
6780
6778
6776
6774
6772
6770
6768
6766
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

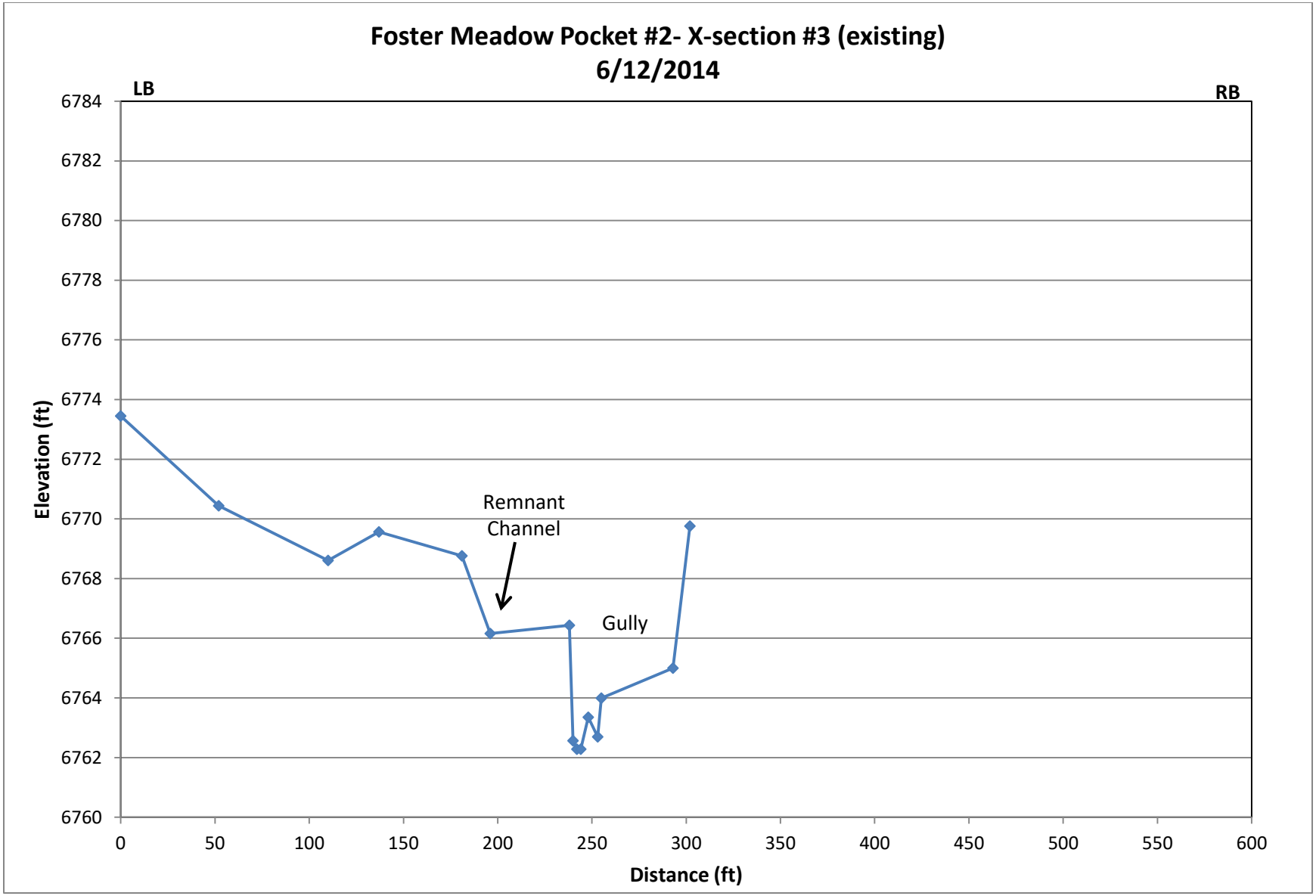

Foster Meadow- Pocket#1- Remnant Channel Profile
6/12/2014
Elevation (ft)
6790
6788
6786
6784
6782
6780
6778
6776
6774
6772
6770
0
50
100
150
200
250
300
350
400
Distance (ft)
Breached
Check Dam
X-section #1
X-section #2
X-section #3
Existing
Channel
Remnant Channel- 2.5%

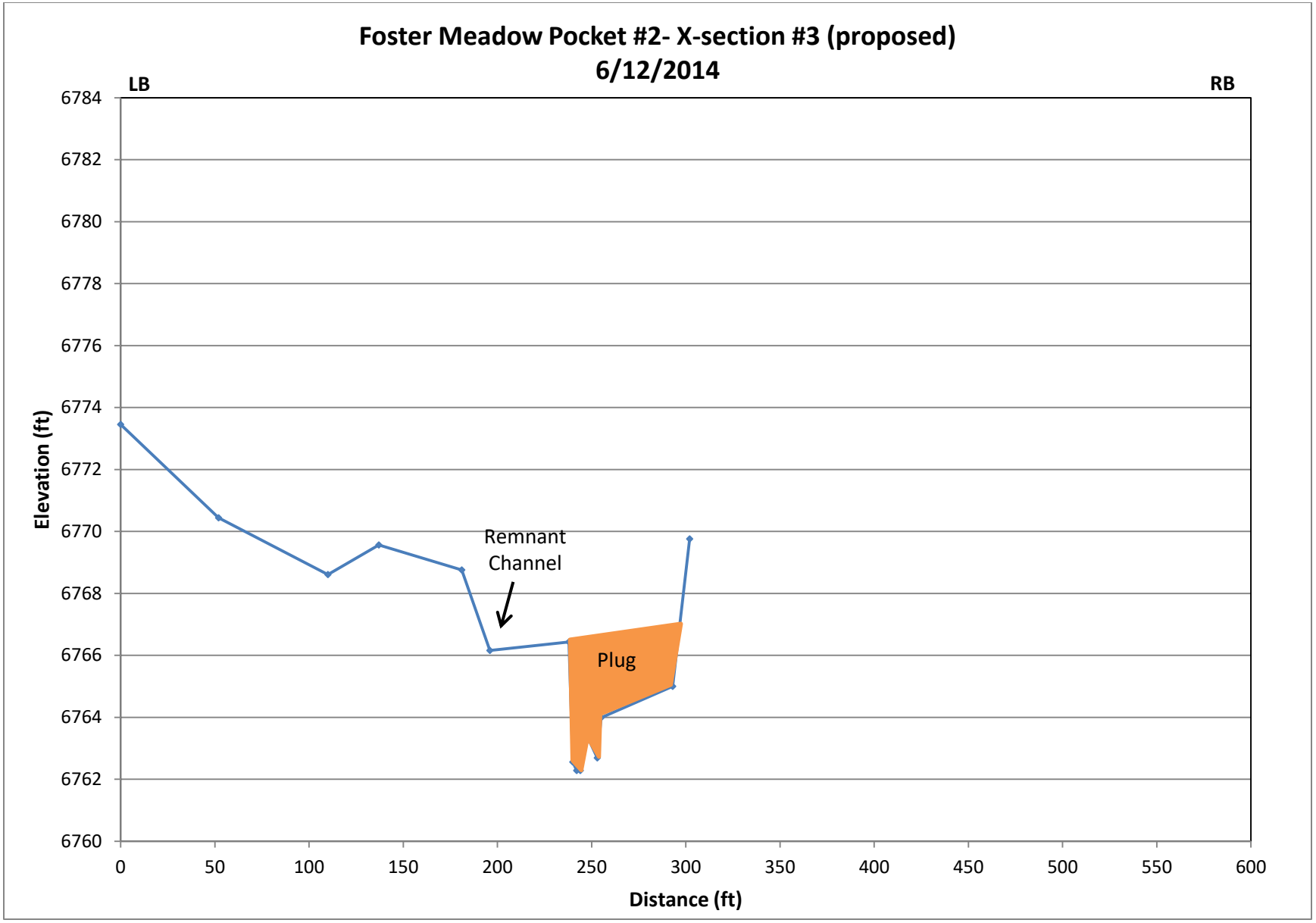

Foster Meadow Pocket #2- X-section #1 (existing)
6/12/2014
LB
RB
6790
6788
6786
6784
6782
6780
6778
6776
6774
6772
6770
6768
6766
Elevation (ft)
Remnant
Channel
Gully
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

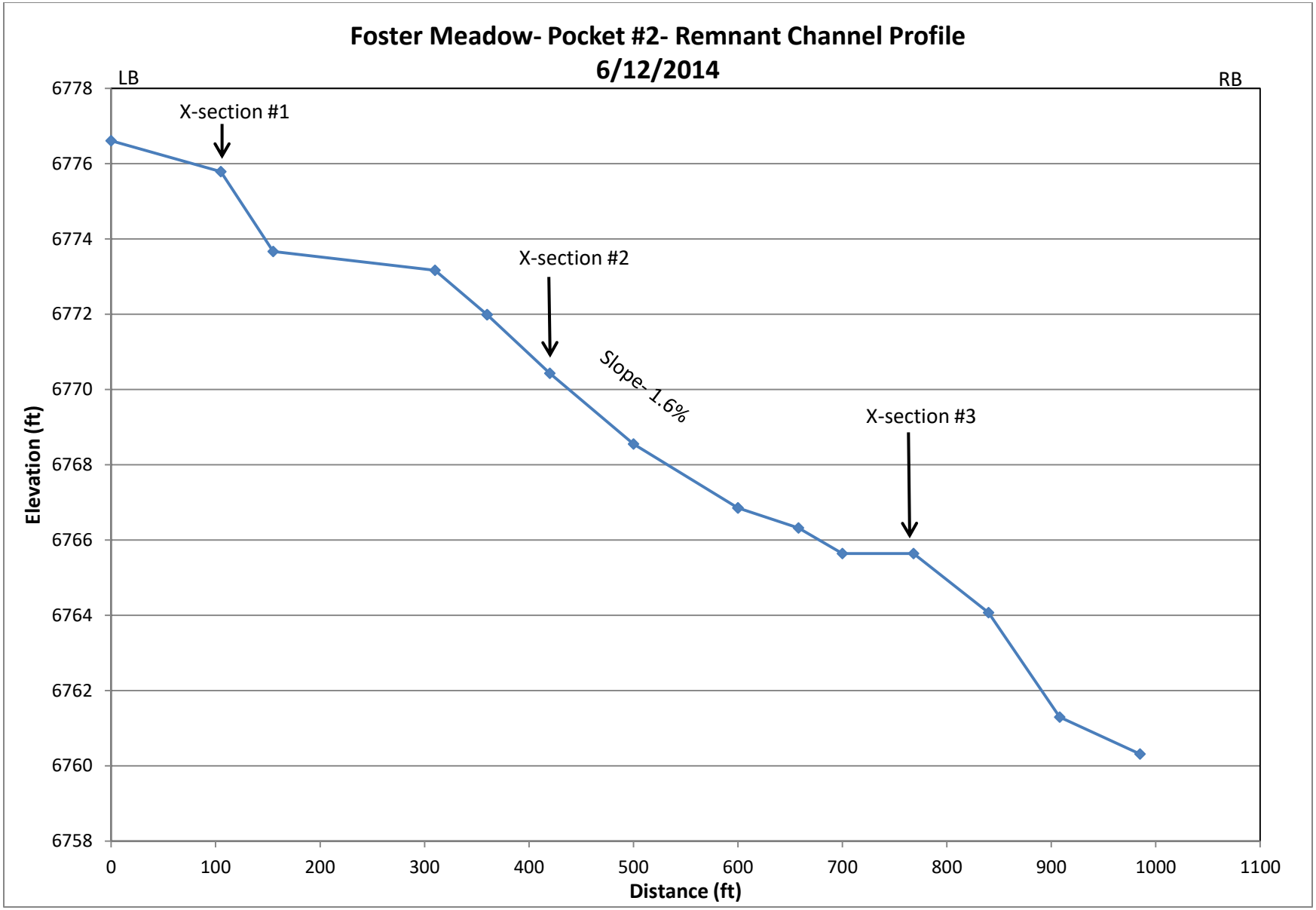

Foster Meadow Pocket #2- X-section #1 (proposed)
6/12/2014
LB
RB
6790
6788
6786
6784
6782
6780
6778
6776
6774
6772
6770
6768
6766
Elevation (ft)
Terrace Cut
Remnant Channel
Plug
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

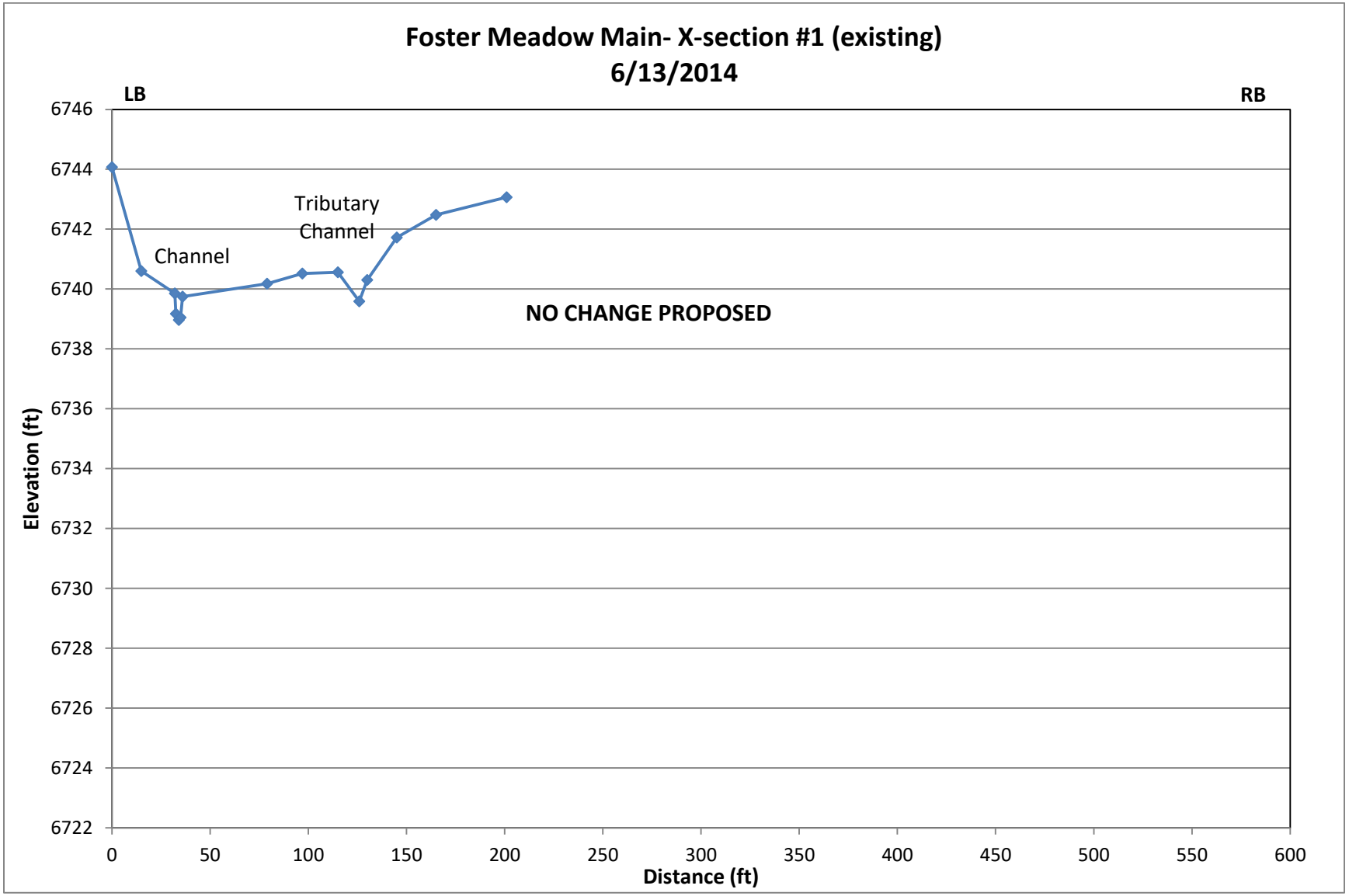

Foster Meadow Pocket #2- X-section #2 (existing)
6/12/2014
LB
RB
Elevation (ft)
6788
6786
6784
6782
6780
6778
6776
6774
6772
6770
6768
6766
6764
Remnant
Gully
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

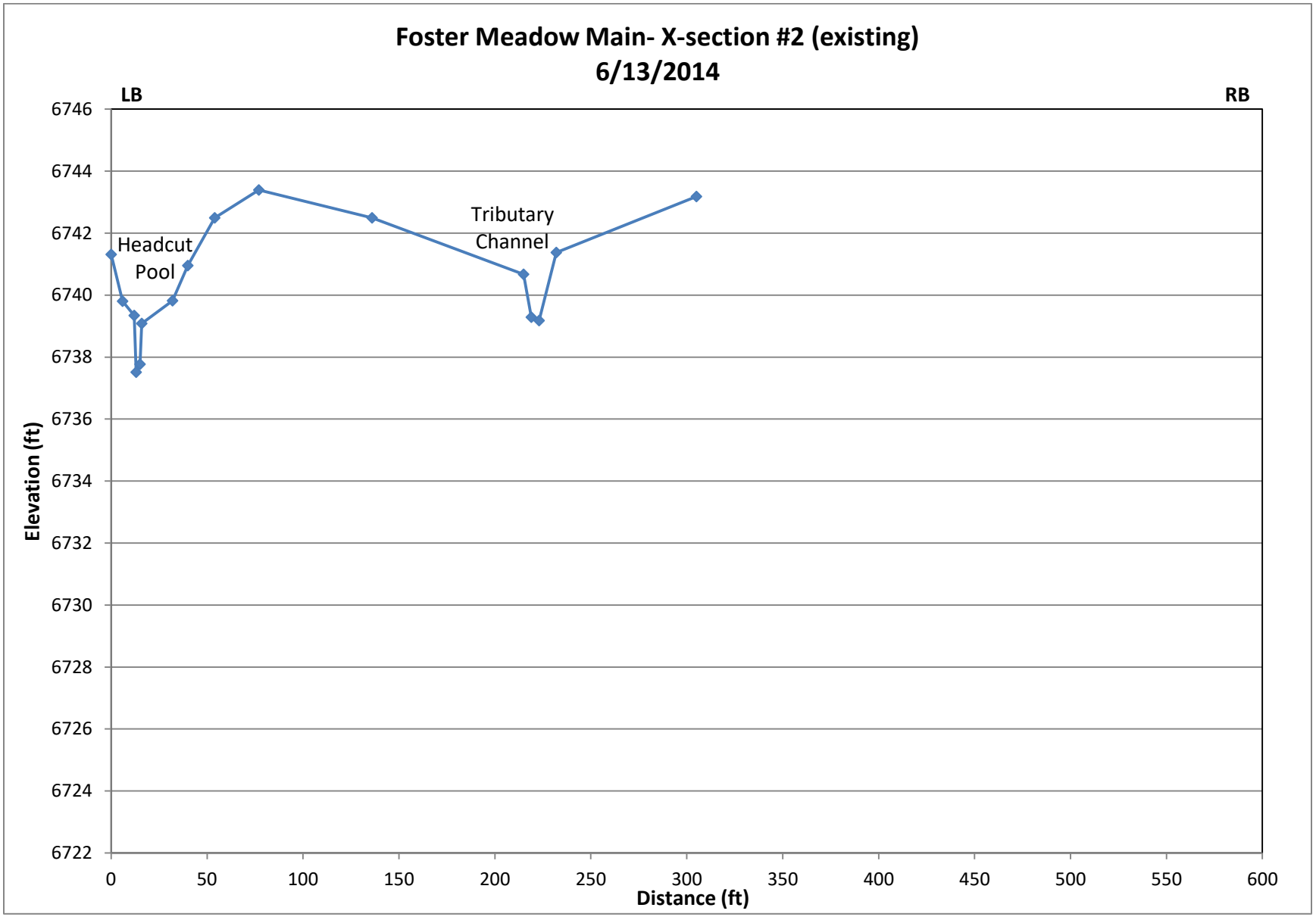

Foster Meadow Pocket #2- X-section #2 (proposed)
6/12/2014
LB
RB
6788
6786
6784
6782
6780
6778
6776
6774
6772
6770
6768
6766
6764
Elevation (ft)
Remnant
Channel
Plug
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

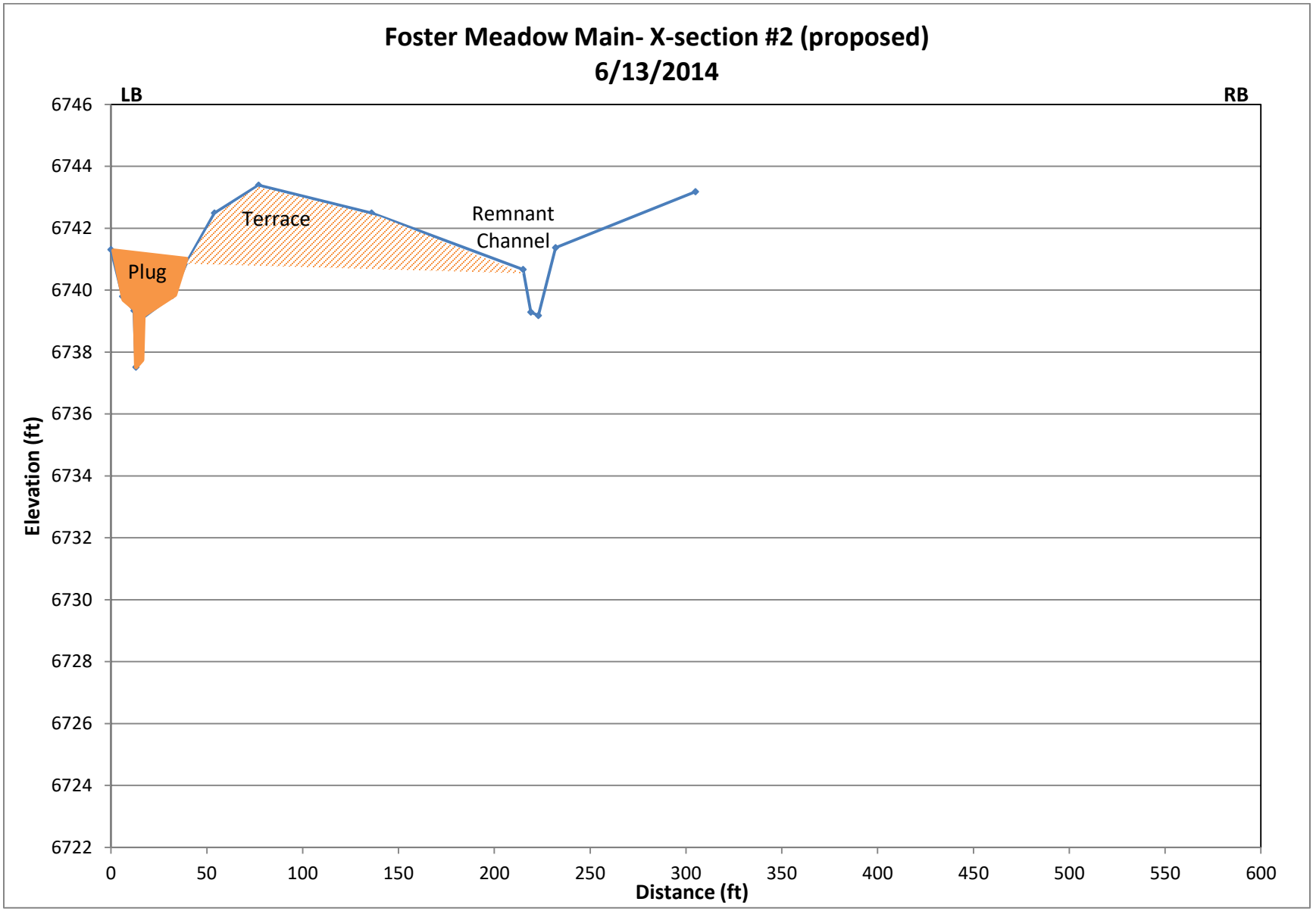

Foster Meadow Pocket #2- X-section #3 (existing)
6/12/2014
LB
RB
6784
6782
6780
6778
6776
6774
6772
6770
6768
6766
6764
6762
6760
Elevation (ft)
Remnant
Channel
Gully
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

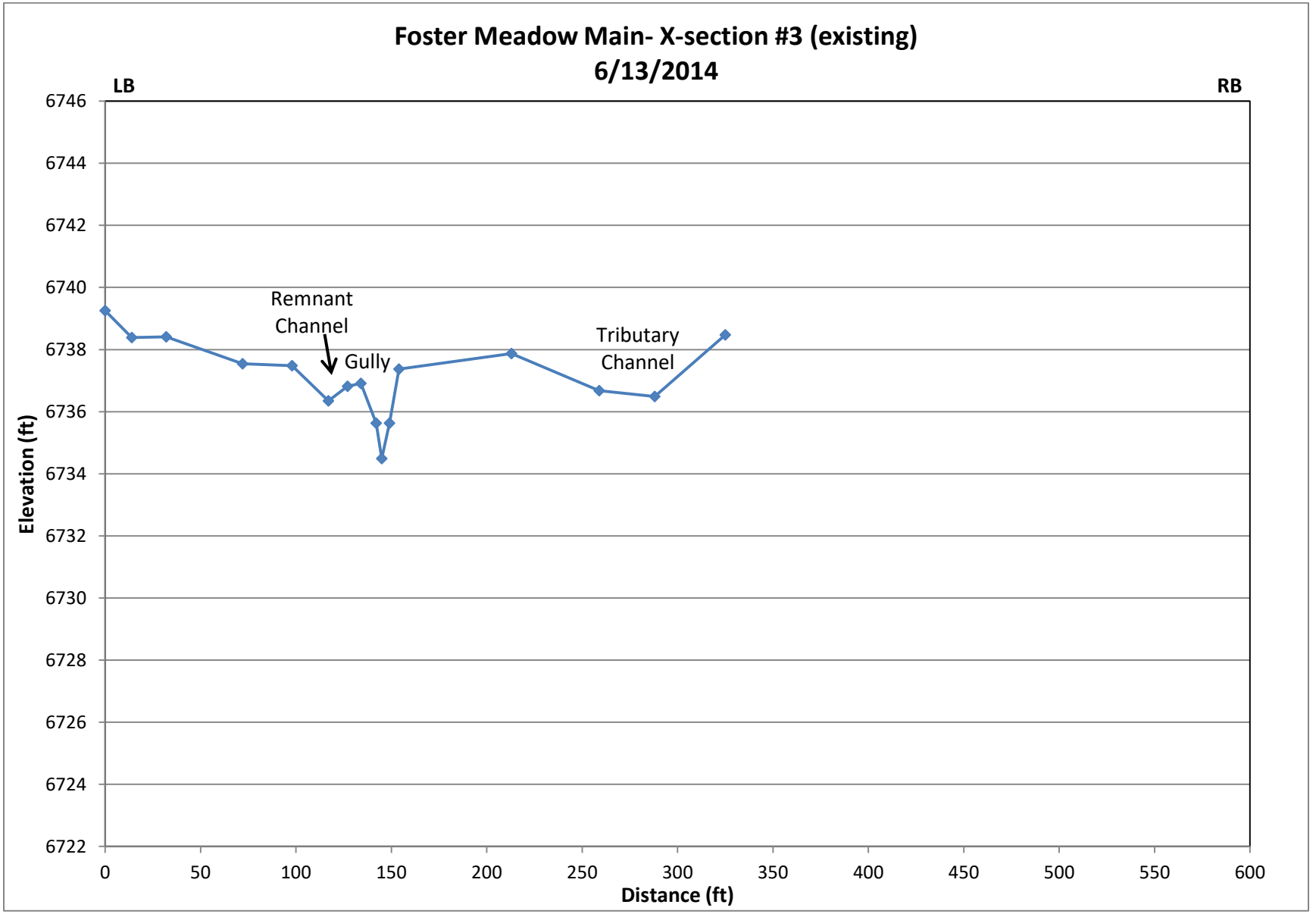

Foster Meadow Pocket #2- X-section #3 (proposed)
6/12/2014
LB
RB
6784
6782
6780
6778
6776
6774
6772
6770
6768
6766
6764
6762
6760
Elevation (ft)
Remnant
Channel
Plug
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

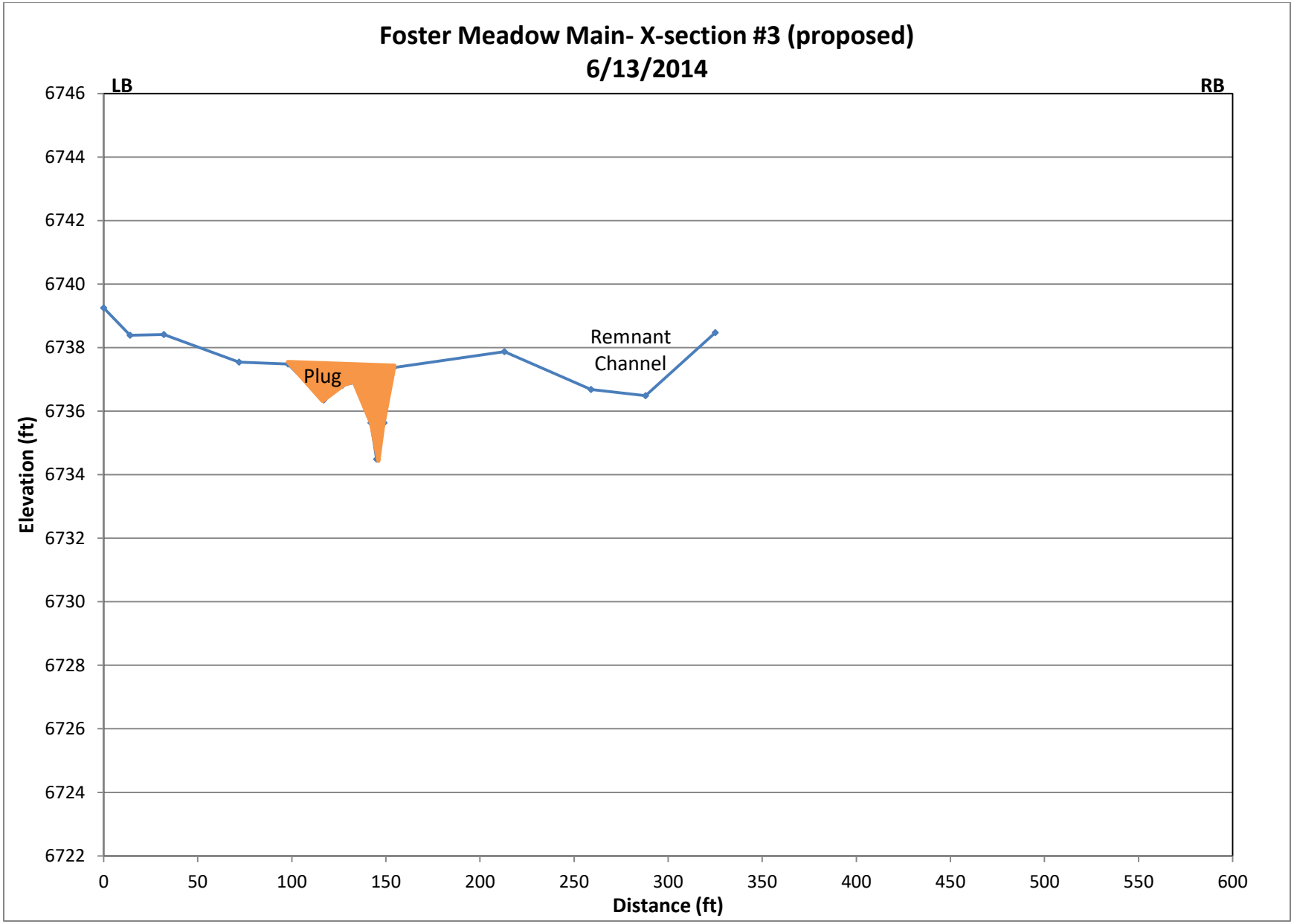

Foster Meadow- Pocket #2- Remnant Channel Profile
6/12/2014
LB
RB
X-section #1
X-section #2
X-section #3
Slope- 1.6%
Elevation (ft)
6778
6776
6774
6772
6770
6768
6766
6764
6762
6760
6758
0
100
200
300
400
500
600
700
800
900
1000
1100
Distance (ft)

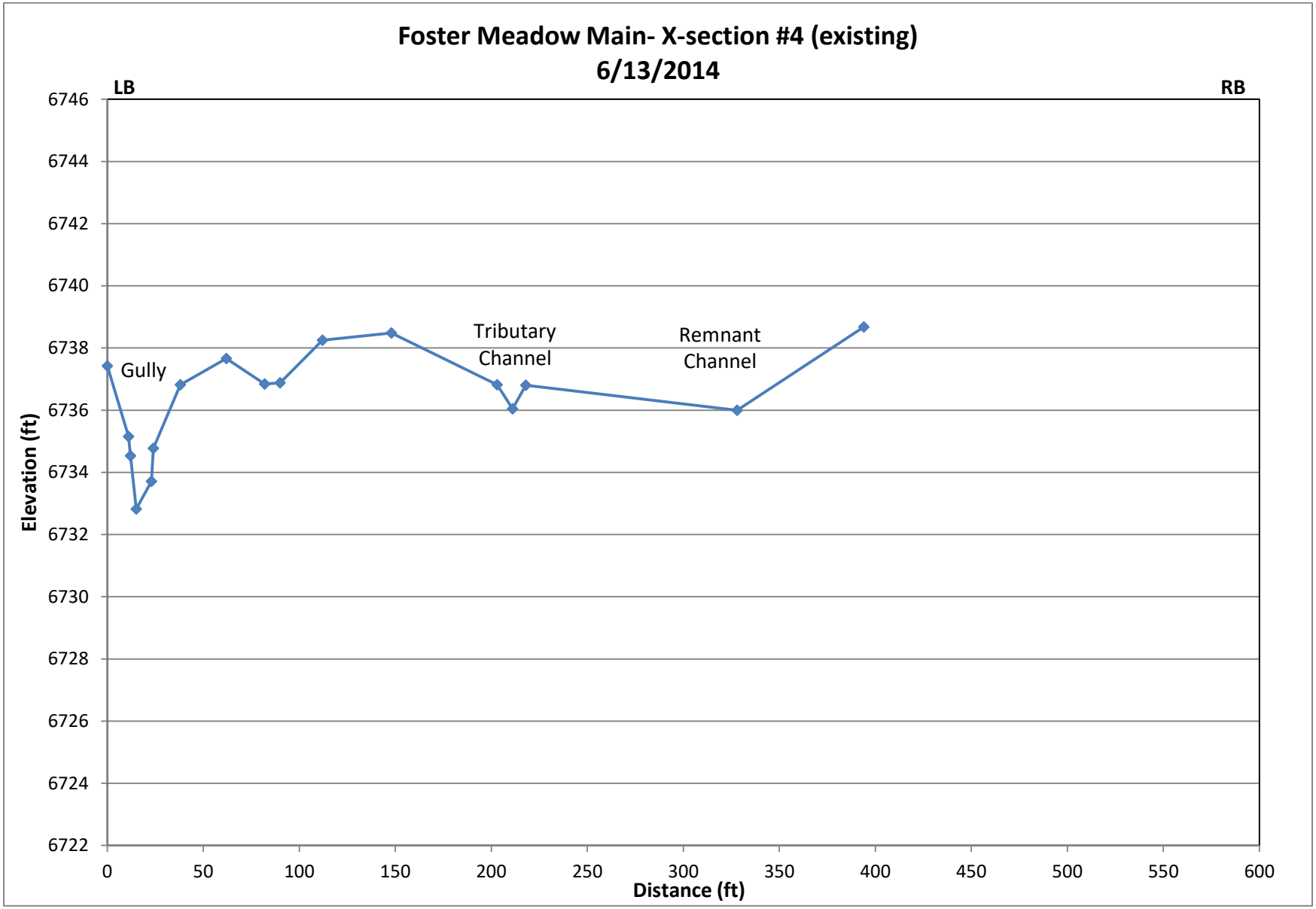

Foster Meadow Main- X-section #1 (existing)
6/13/2014
LB
RB
Tributary
Channel
Channel
NO CHANGE PROPOSED
Elevation (ft)
6746
6744
6742
6740
6738
6736
6734
6732
6730
6728
6726
6724
6722
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

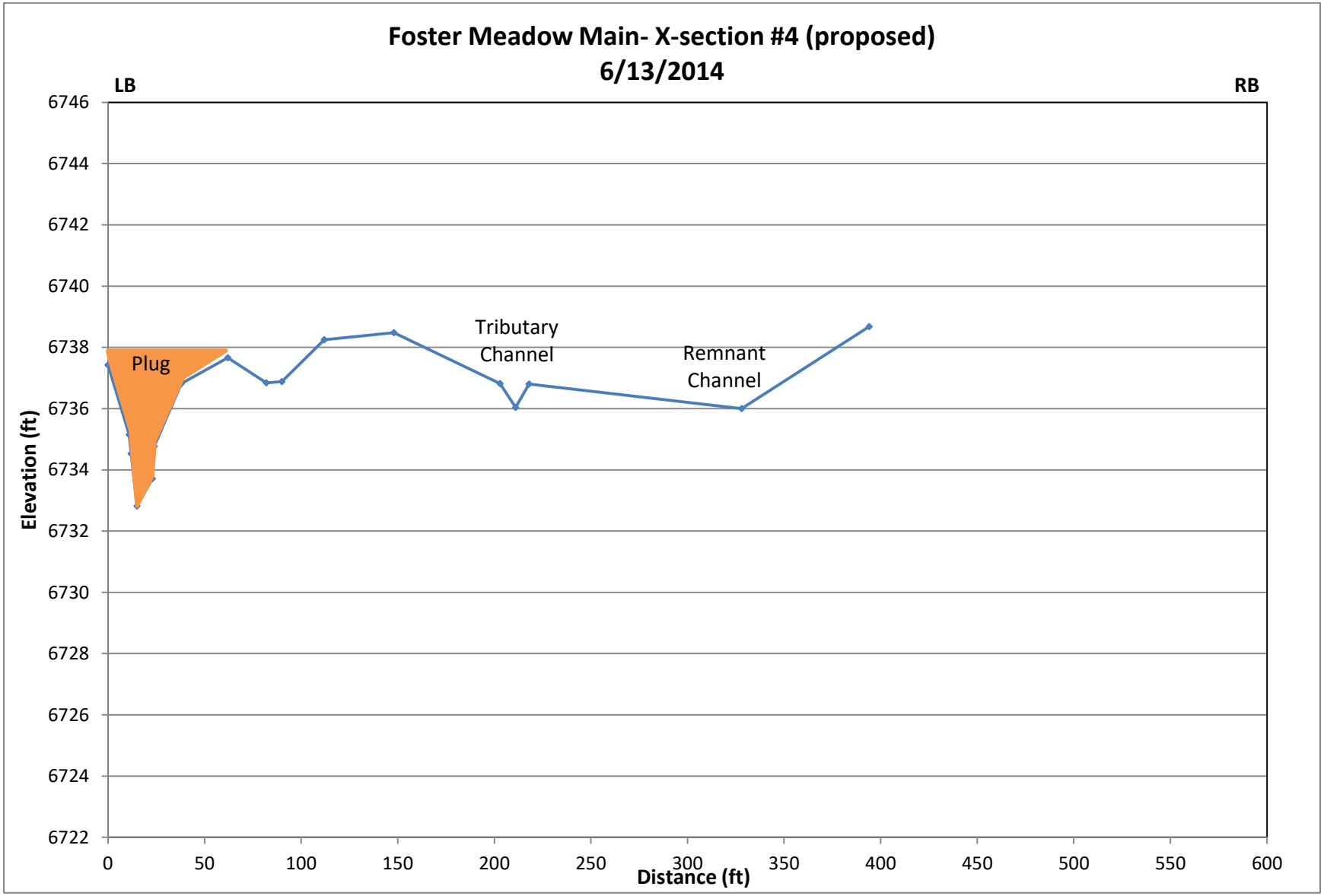

Foster Meadow Main- X-section #2 (existing)
6/13/2014
LB
RB
Headcut Pool
Tributary Channel
Elevation (ft)
6746
6744
6742
6740
6738
6736
6734
6732
6730
6728
6726
6724
6722
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

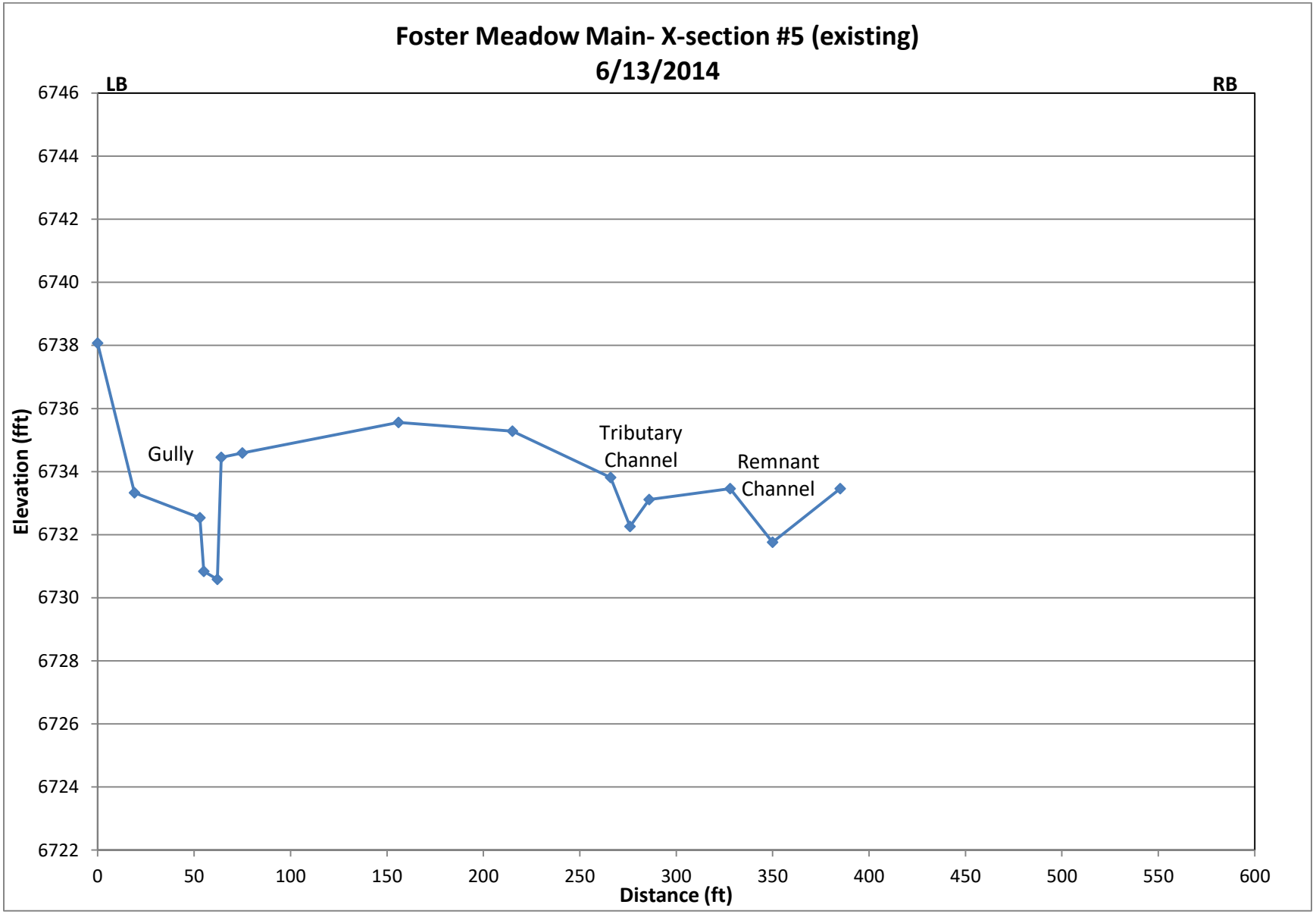

Foster Meadow Main- X-section #2 (proposed)
6/13/2014
LB
RB
Terrace
Remnant
Channel
Plug
Elevation (ft)
Distance (ft)
6746
6744
6742
6740
6738
6736
6734
6732
6730
6728
6726
6724
6722
0
50
100
150
200
250
300
350
400
450
500
550
600

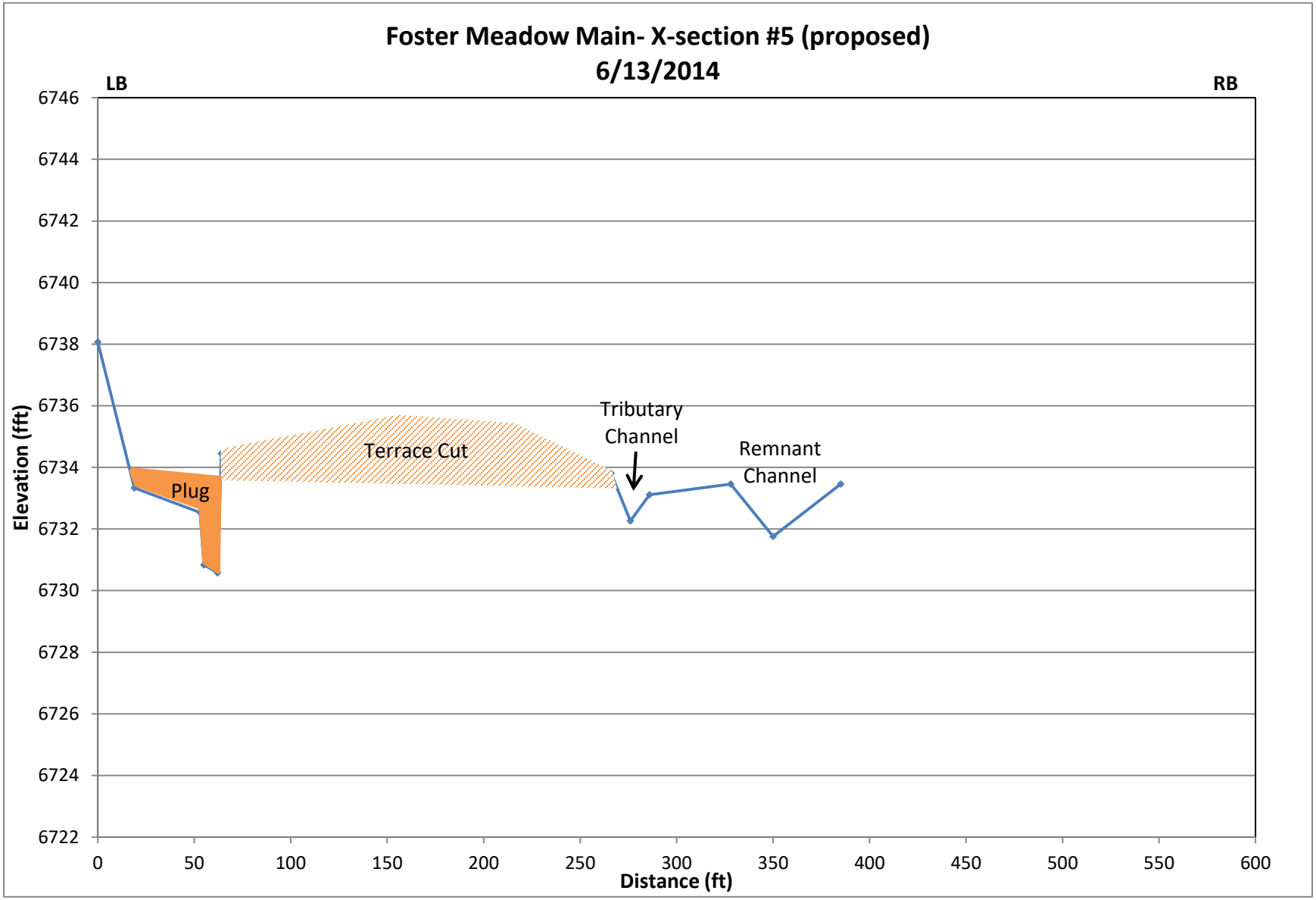

Foster Meadow Main- X-section #3 (existing)
6/13/2014
LB
RB
Remnant Channel
Gully
Tributary Channel
Elevation (ft)
Distance (ft)
6746
6744
6742
6740
6738
6736
6734
6732
6730
6728
6726
6724
6722
0
50
100
150
200
250
300
350
400
450
500
550
600

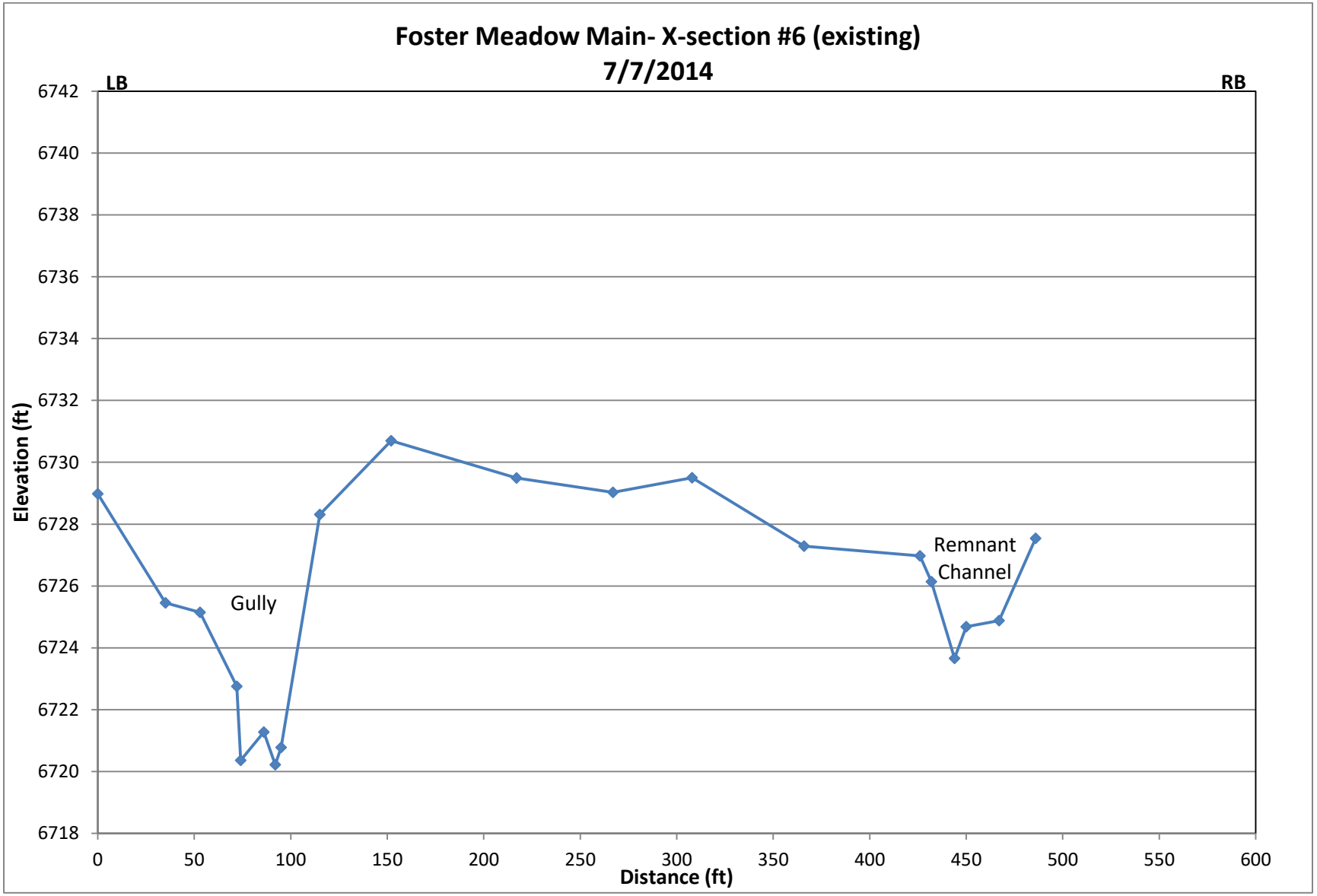

Foster Meadow Main- X-section #3 (proposed)
6/13/2014
LB
RB
Remnant
Channel
Plug
Elevation (ft)
6746
6744
6742
6740
6738
6736
6734
6732
6730
6728
6726
6724
6722
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

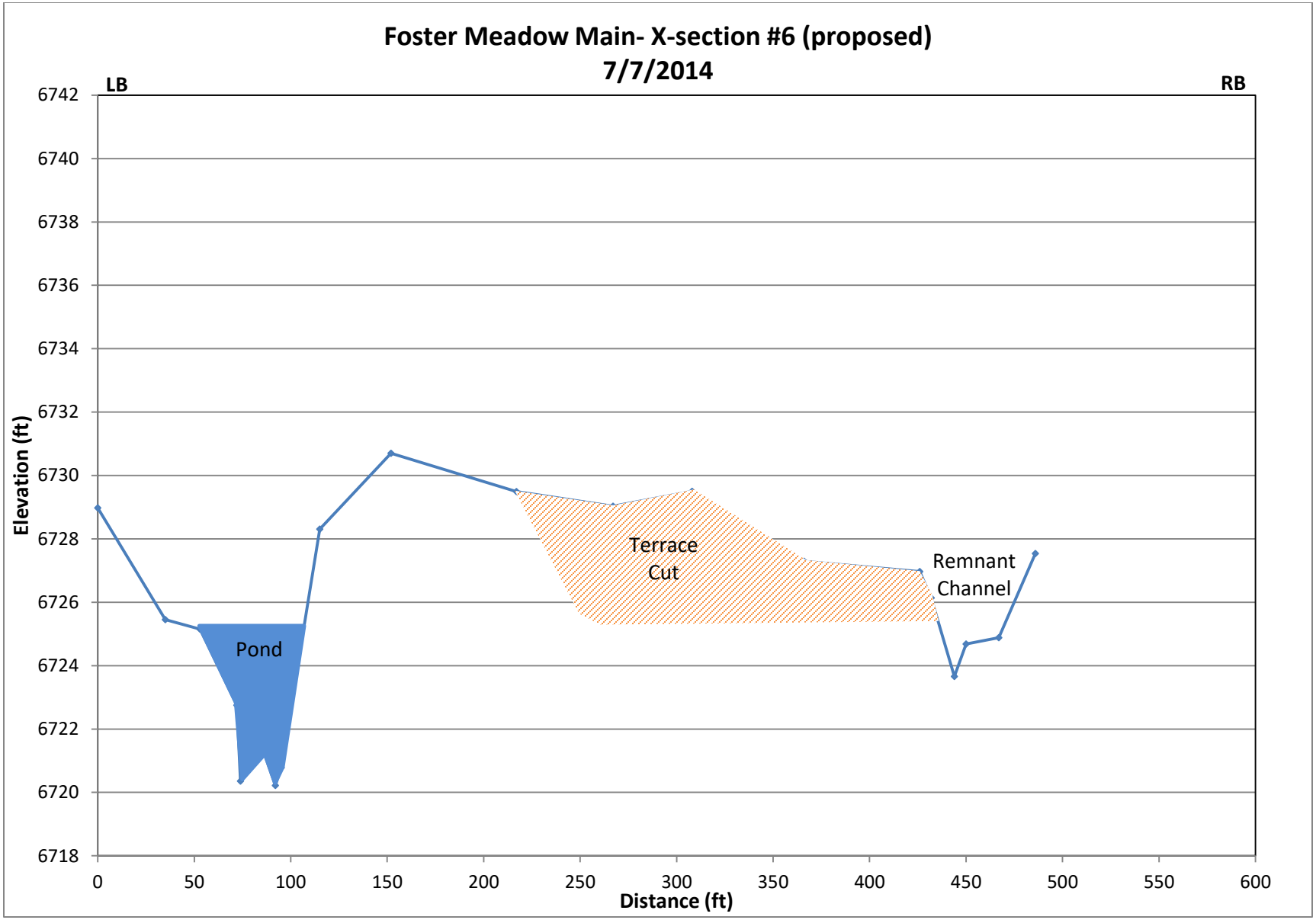

Foster Meadow Main- X-section #4 (existing)
6/13/2014
LB
RB
6746
6744
6742
6740
6738
6736
6734
6732
6730
6728
6726
6724
6722
Elevation (ft)
Gully
Tributary Channel
Remnant Channel
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

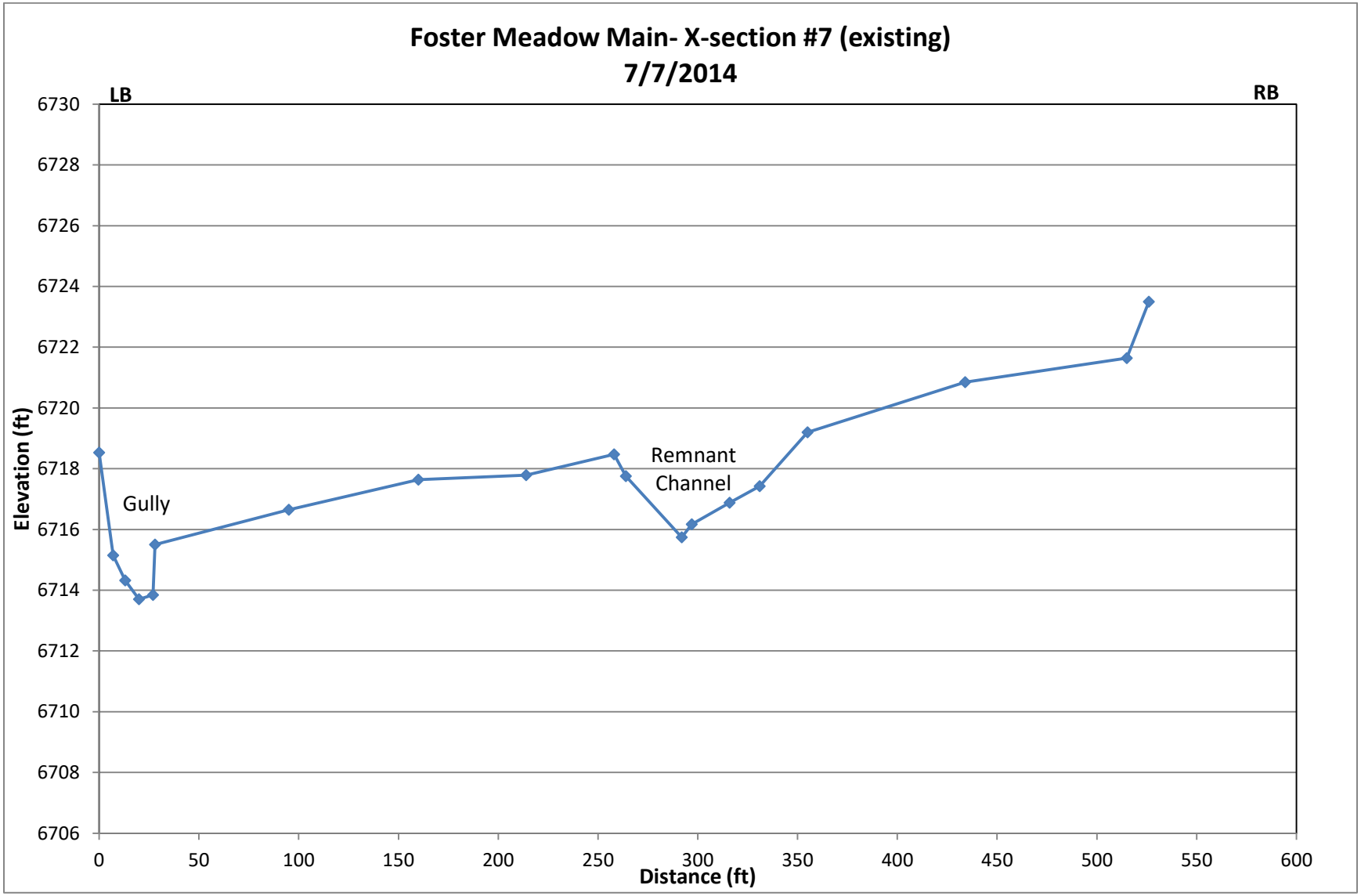

Foster Meadow Main- X-section #4 (proposed)
6/13/2014
LB
RB
6746
6744
6742
6740
6738
6736
6734
6732
6730
6728
6726
6724
6722
Elevation (ft)
Plug
Tributary Channel
Remnant Channel
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

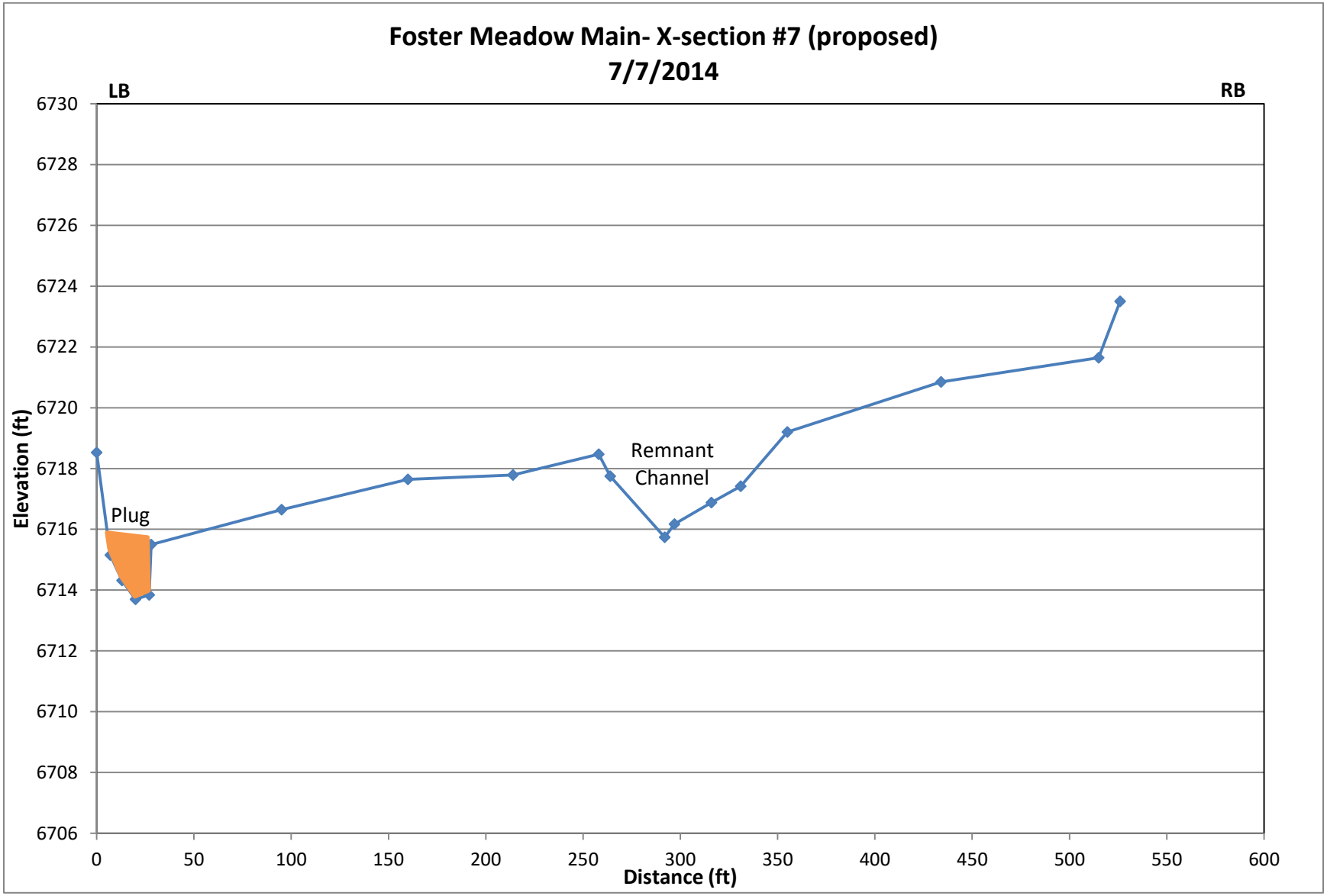

Foster Meadow Main- X-section #5 (existing)
6/13/2014
LB
RB
6746
6744
6742
6740
6738
6736
6734
6732
6730
6728
6726
6724
6722
Elevation (fft)
Gully
Tributary
Channel
Remnant
Channel
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

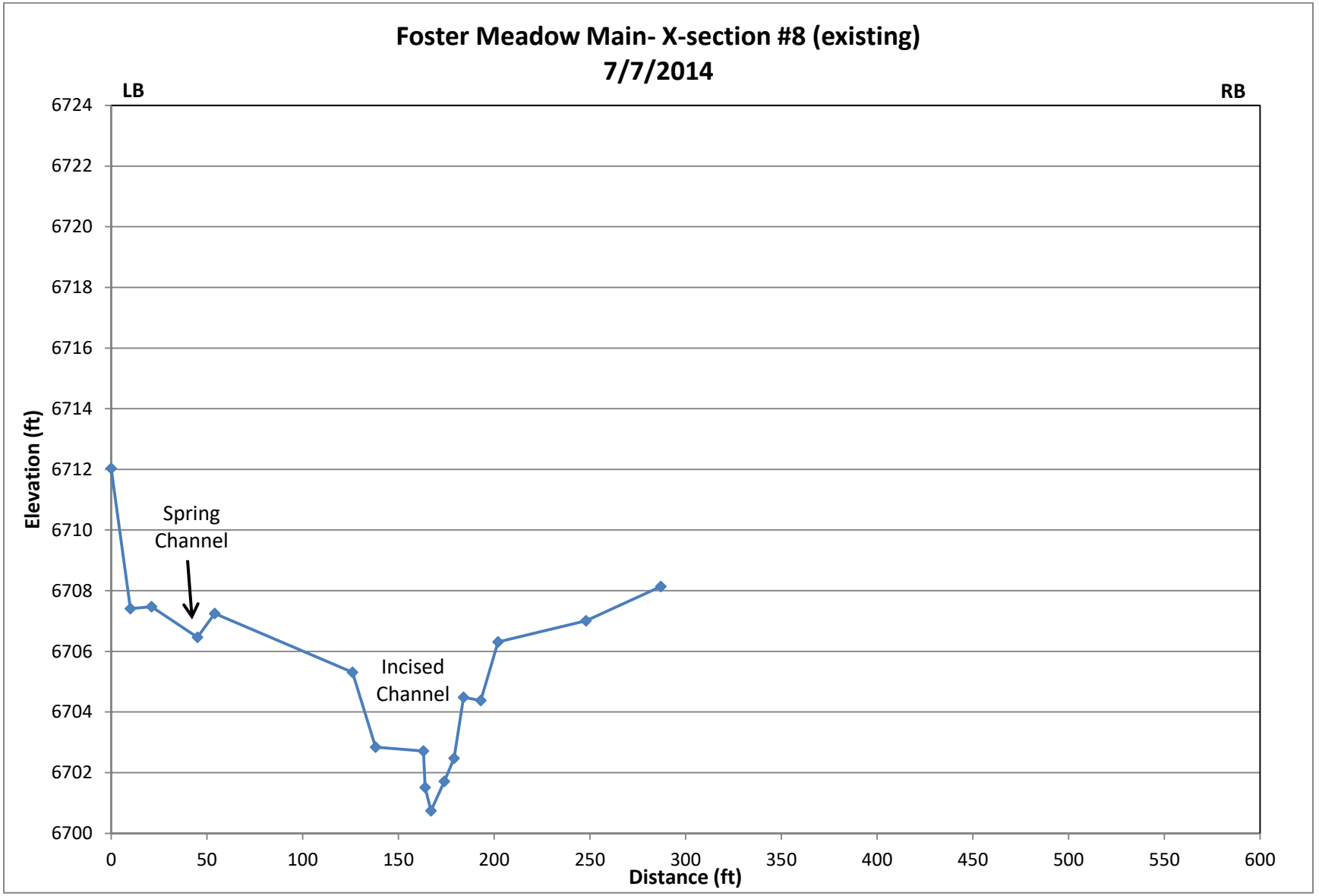

Foster Meadow Main- X-section #5 (proposed)
6/13/2014
LB
RB
6746
6744
6742
6740
6738
6736
6734
6732
6730
6728
6726
6724
6722
Elevation (fft)
Plug
Terrace Cut
Tributary
Channel
Remnant
Channel
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

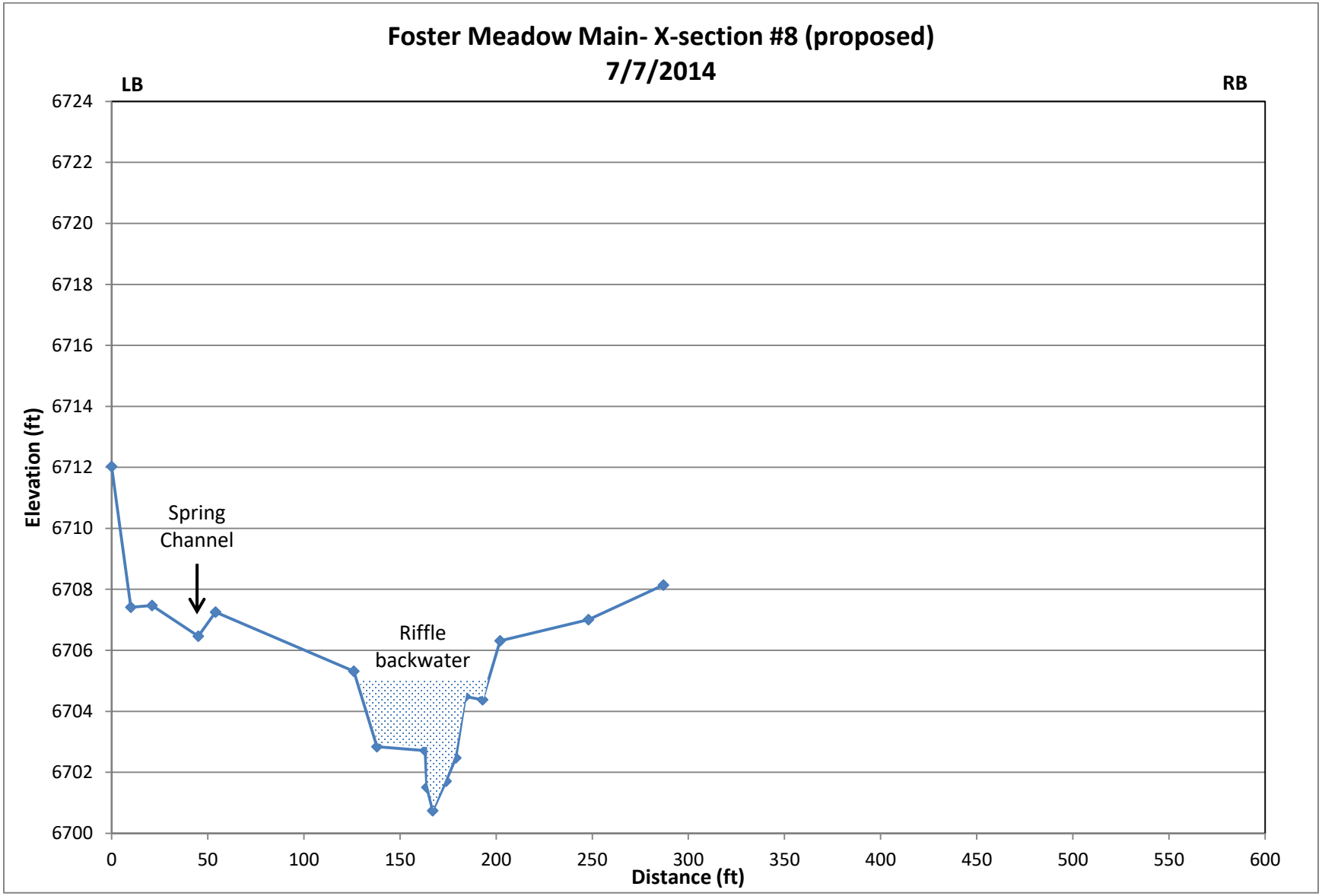

Foster Meadow Main- X-section #6 (existing)
7/7/2014
LB
RB
Elevation (ft)
6742
6740
6738
6736
6734
6732
6730
6728
6726
6724
6722
6720
6718
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)
Gully
Remnant
Channel

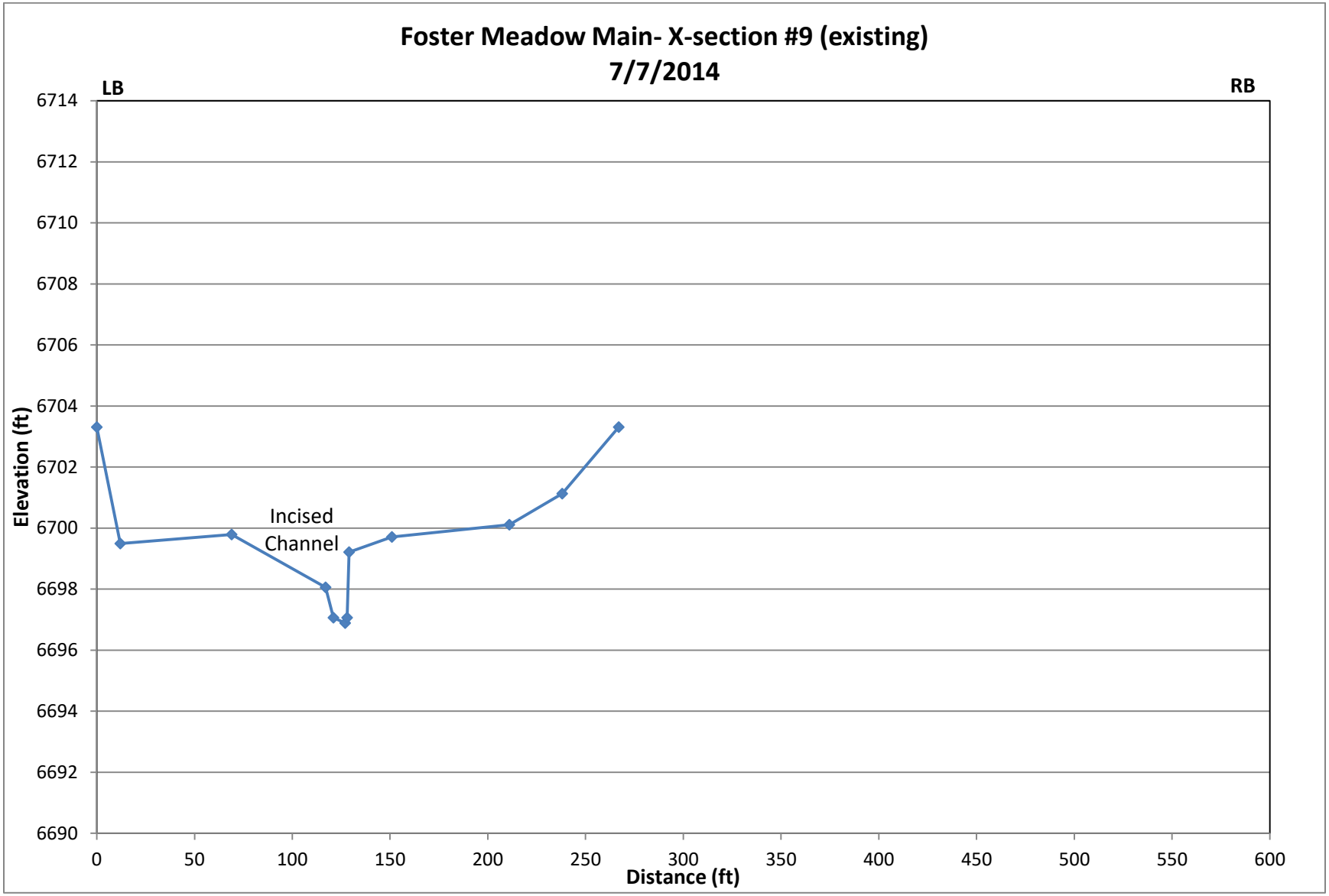

Foster Meadow Main- X-section #6 (proposed)
7/7/2014
LB
RB
Elevation (ft)
6742
6740
6738
6736
6734
6732
6730
6728
6726
6724
6722
6720
6718
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)
Pond
Terrace
Cut
Remnant
Channel

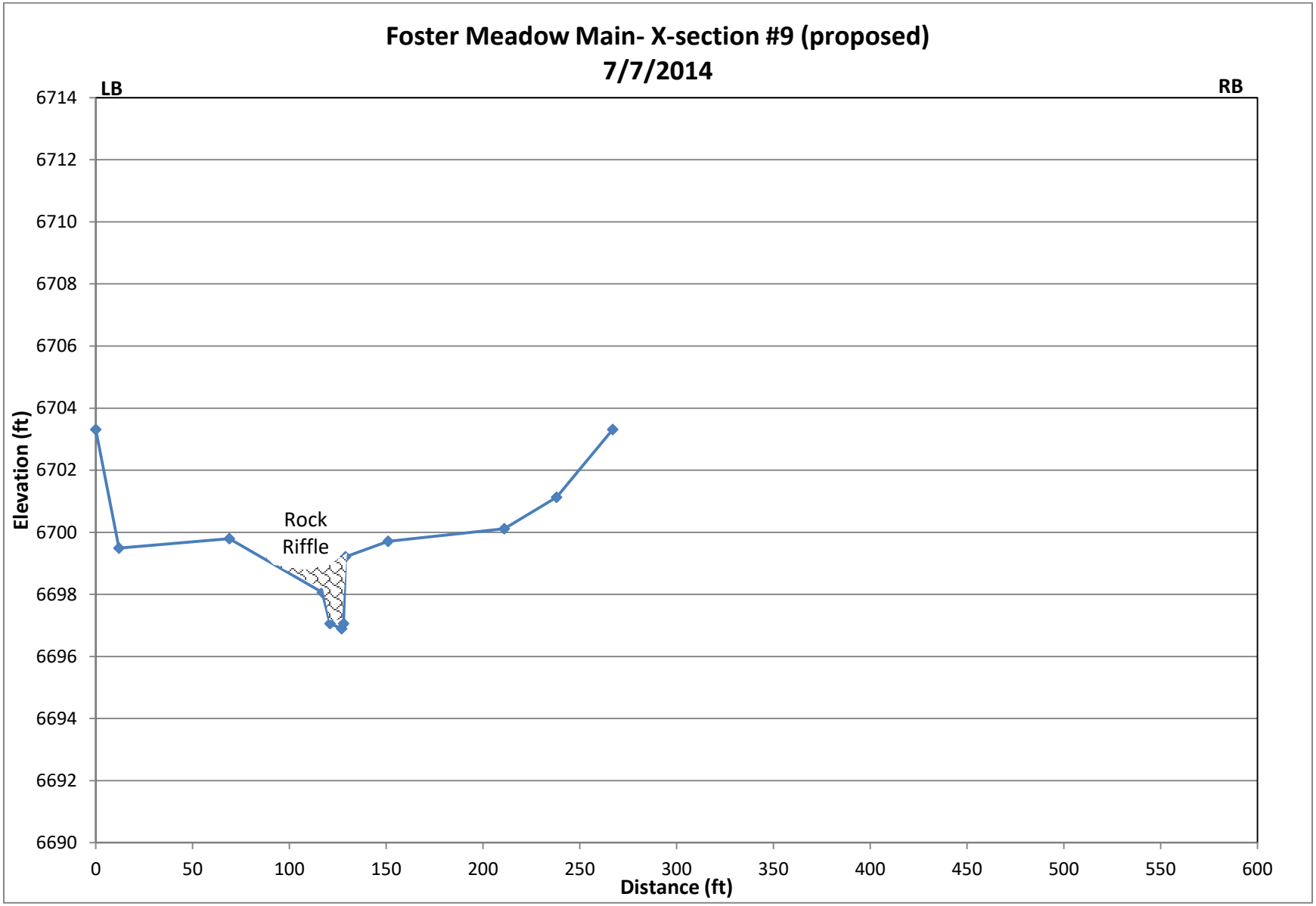

Foster Meadow Main- X-section #7 (existing)
7/7/2014
LB
RB
Elevation (ft)
6730
6728
6726
6724
6722
6720
6718
6716
6714
6712
6710
6708
6706
Gully
Remnant
Channel
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)

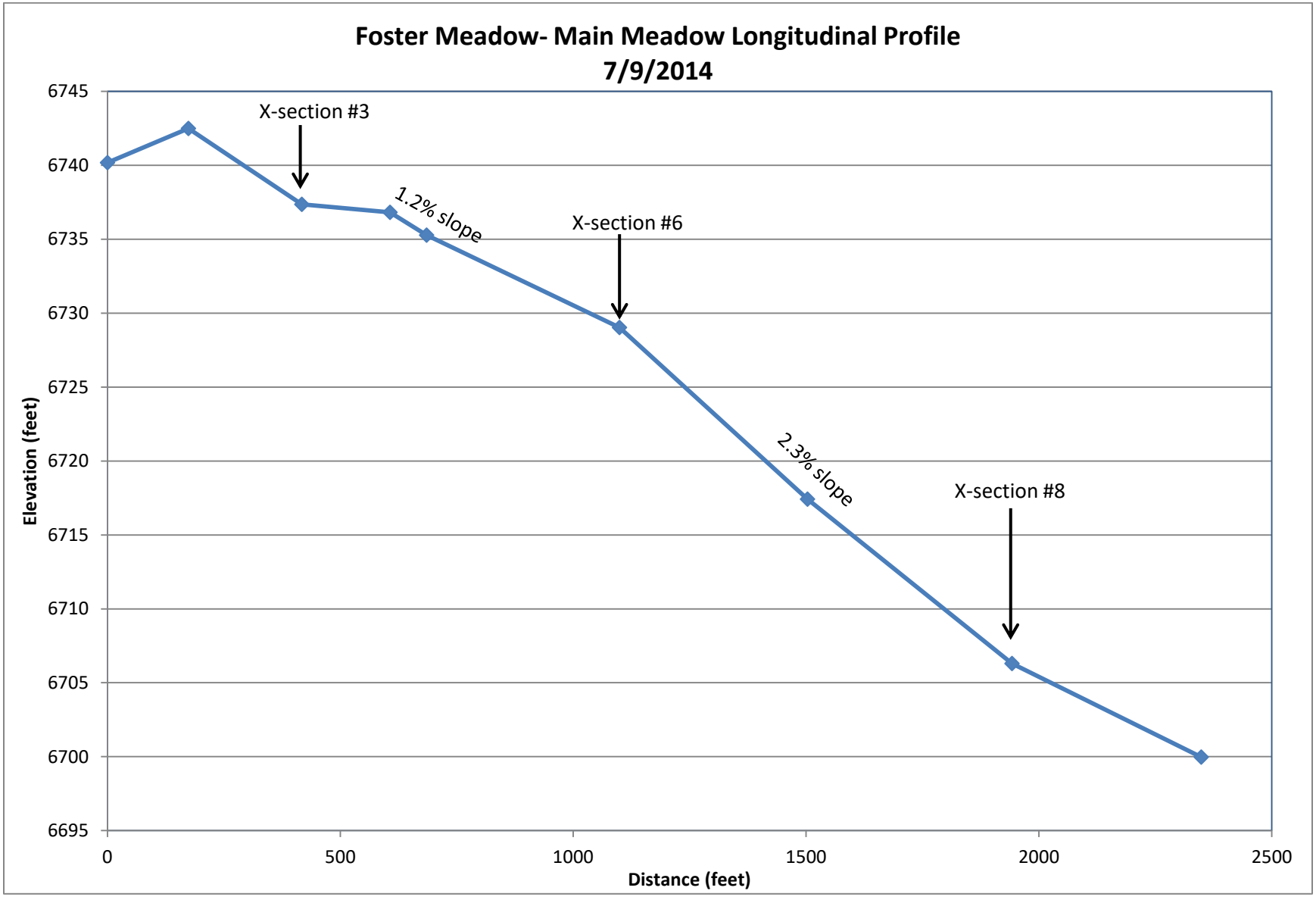

Foster Meadow Main- X-section #7 (proposed)
7/7/2014
LB
RB
Elevation (ft)
6730
6728
6726
6724
6722
6720
6718
6716
6714
6712
6710
6708
6706
Plug
Remnant
Channel
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)


Foster Meadow Main- X-section #8 (existing)
7/7/2014
LB
RB
6724
6722
6720
6718
6716
6714
6712
6710
6708
6706
6704
6702
6700
Elevation (ft)
Spring
Channel
Incised
Channel
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)


Foster Meadow Main- X-section #8 (proposed)
7/7/2014
LB
RB
Elevation (ft)
6724
6722
6720
6718
6716
6714
6712
6710
6708
6706
6704
6702
6700
Spring
Channel
Riffle
backwater
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)


Foster Meadow Main- X-section #9 (existing)
7/7/2014
LB
RB
6714
6712
6710
6708
6706
6704
6702
6700
6698
6696
6694
6692
6690
Elevation (ft)
Incised
Channel
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)


Foster Meadow Main- X-section #9 (proposed)
7/7/2014
LB
RB
Rock
Riffle
Elevation (ft)
Distance (ft)
6714
6712
6710
6708
6706
6704
6702
6700
6698
6696
6694
6692
6690
0
50
100
150
200
250
300
350
400
450
500
550
600


Foster Meadow- Main Meadow Longitudinal Profile
7/9/2014
6745
6740
6735
6730
6725
6720
6715
6710
6705
6700
6695
Elevation (feet)
X-section #3
1.2% slope
X-section #6
2.3% slope
X-section #8
0
500
1000
1500
2000
2500
Distance (feet)

APPENDIX C

Middle Fork Cosumnes River @ FH 54 Road Crossing Comparative Regression Analyses
Middle Fork Cosumnes River @ bottom of project Comparative Regression Analyses

Foster Meadow Key Construction Elevations

APPENDIX C

Middle Fork Cosumnes River (MCR) Hydrology Calculations

Comparative Watershed Method: @ FH 54 Road Crossing

Standard Formula: Qu = Qg(Au/Ag)b

Qu = discharge of ungaged stream — Qg = discharge of gaged stream
Au = watershed area of ungaged stream — Ag = watershed area of gaged stream
b = regional coefficient for area

MCR—Middle Fork (Somerset)-17yr record:		MCR—North Fork (El Dorado)- 57yr record:	
Q2 = 1520(.55/107).88 =	15 cfs	Q2 = 2770(.55/205).88 =	15 cfs
Q5 = 2870(.55/107).82 =	38 cfs	Q5 = 6290(.55/205).82 =	49 cfs
Q10 = 4030(.55/107).80 =	59 cfs	Q10 = 9020(.55/205).80 =	79 cfs
Q25 = 5800(.55/107).79 =	90 cfs	Q25 = 15500(.55/205).79 =	144 cfs
Q50 = 7360(.55/107).78 =	120 cfs	Q50 = 22200(.55/205).78 =	219 cfs
Q100 = 9120(.55/107).77 =	157 cfs	Q100 = 30500(.55/205).77 =	319 cfs

Multiple Regression Analysis:

Middle Fork Cosumnes River A = 0.55 mi^2. P = 50." annual precip. H = 6,900' mean elevation
**Standard coefficients derived by Waananen & Crippen from 249 stations Sierra-wide:

Q_2 = $.24(.55^{.88})(50.0^{1.58})(6.90^{-.80})$ = 15 cfs
Q_5 = $1.20(.55^{.82})(50.0^{1.37})(6.90^{-.64})$ = 45 cfs
Q_{10} = $2.63(.55^{.80})(50.0^{1.25})(6.90^{-.58})$ = 71 cfs
Q_{25} = $6.55(.55^{.79})(50.0^{1.12})(6.90^{-.52})$ = 120 cfs
Q_{50} = $10.40(.55^{.78})(50.0^{1.06})(6.90^{-.48})$ = 163 cfs
Q_{100} = $15.70(.55^{.77})(50.0^{1.02})(6.90^{-.43})$ = 233 cfs

Comparative Watershed Method: @ downstream end of Foster Meadow

Standard Formula: Qu = Qg(Au/Ag)b
Qu = discharge of ungaged stream — Qg = discharge of gaged stream
Au = watershed area of ungaged stream — Ag = watershed area of gaged stream
b = regional coefficient for area

MCR—Middle Fork (Somerset)-17yr record:		MCR—North Fork (El Dorado)- 57yr record:	
Q2 = 1520(1.55/107).88 =	36 cfs	Q2 = 2770(1.55/205).88 =	37 cfs
Q5 = 2870(1.55/107).82 =	89 cfs	Q5 = 6290(1.55/205).82 =	114 cfs
Q10 = 4030(1.55/107).80 =	136 cfs	Q10 = 9020(1.55/205).80 =	181 cfs
Q25 = 5800(1.55/107).79 =	204 cfs	Q25 = 15500(1.55/205).79 =	327 cfs
Q50 = 7360(1.55/107).78 =	270 cfs	Q50 = 22200(1.55/205).78 =	491 cfs
Q100 = 9120(1.55/107).77 =	350 cfs	Q100 = 30500(1.55/205).77 =	709 cfs

Slope/Area Method:

Channel Characteristics:
Bkf Width- 19.7' Bkf Depth- .9' Bkf Area- 7.8 ft^2 Bkf Wetted perimeter- 21.5.'
Slope- .020 ft/ft Hydraulic radius-.363

Velocity Calculations: Manning's Formula: V = 1.4/n(r)2/3(s)1/2

V= 1.4/.028(.363)2/3(.02)1/2 V= 1.4/.032(.363)2/3(.02)1/2 V= 1.4/.035(.363)2/3(.02)1/2
V= 1.4/.028(.507)(.1414) V= 1.4/.032(.507)(.1414) V= 1.4/.035(.507)(.1414)
V= 3.6 fps V= 3.1 fps V= 2.9 fps

Q = AV
Q = 7.5.7 X 3.1
Q = 23 cfs

Multiple Regression Analysis:

Middle Fork Cosumnes River A = 1.55 mi^2. P = 50." annual precip. H = 6,900' mean elevation
**Standard coefficients derived by Waananen & Crippen from 249 stations Sierra-wide:

Q_2 = $.24(1.55^{.88})(50.0^{1.58})(6.90^{-.80})$ = 34 cfs
Q_5 = $1.20(1.55^{.82})(50.0^{1.37})(6.90^{-.64})$ = 105 cfs
Q_{10} = $2.63(1.55^{.80})(50.0^{1.25})(6.90^{-.58})$ = 162 cfs
Q_{25} = $6.55(1.55^{.79})(50.0^{1.12})(6.90^{-.52})$ = 271 cfs
Q_{50} = $10.40(1.55^{.78})(50.0^{1.06})(6.90^{-.48})$ = 366 cfs
Q_{100} = $15.70(1.55^{.77})(50.0^{1.02})(6.90^{-.43})$ = 518 cfs

Discharge Summaries:

COMPARATIVE DISCHARGE CALCULATIONS (cfs)- FOSTER MEADOW PROJECT 9/16/2014										
Reach Name	Q2	Q5	Q10	Q25	Q50	Q100	Method			
MF Cosumnes	15	45	71	120	163	233	Full Regression			
	15	49	79	144	219	319	Area Reg.- NF Cosumnes.			
	15	38	59	90	120	157	Area Reg.- MF Cosumnes.			

COMPARATIVE DISCHARGE CALCULATIONS (cfs)- FOSTER MEADOW PROJECT 9/16/2014										
Reach Name	Q2	Q5	Q10	Q25	Q50	Q100	Method			
MF Cosumnes	34	105	162	271	366	518	Full Regression			
	37	114	181	237	491	709	Area Reg.- NF Cosumnes.			
	36	89	136	204	270	350	Area Reg.- MF Cosumnes.			
Bankfull	23						Cross-section			

Foster Meadow Key Construction Elevations

The key design elevations below are intended to be used for final constructed grade, and referenced to local project established benchmarks. The benchmarks are 1/2" galv pipe set flush to ground level flagged, painted and GPS'ed to sub meter horizontal accuracy.

Elevations were traversed using a Leica Rugby LR 100 laser from each reference BM with an assigned elevation.

Plug corners are referenced as upstream (URC) or downstream (DRC) right or left looking downstream.

Pocket Meadow #1

Plug #1

Feature	Elevation	Ref. BM	Elevation
URC	6785.35	LP Xs#1	6785.45
ULC	6784.65	LP Xs#1	6785.45
channel in	6783.95	LP Xs#1	6785.45
channel out	6778.85	LP Xs#1	6785.45
DRC	6780.55	LP Xs#1	6785.45
DLC	6779.75	LP Xs#1	6785.45

Pocket Meadow #2

Plug #1				Plug #2			
Feature	**Elevation**	**Ref. BM**	**Elevation**	**Feature**	**Elevation**	**Ref. BM**	**Elevation**
URC	6776.88	LP Xs#1	6782.23	URC	6774.18	LP Xs#1	6782.23
ULC	6777.38	LP Xs#1	6782.23	ULC	6773.68	LP Xs#1	6782.23
channel in	6776.18	LP Xs#1	6782.23	channel in	6772.62	LP Xs#1	6782.23
channel out	6772.62	LP Xs#1	6782.23	channel out	6759.25	LP Xs#3	6773.45
DRC	6774.78	LP Xs#1	6782.23	DRC	6761.15	LP Xs#3	6773.45
DLC	6774.18	LP Xs#1	6782.23	DLC	6760.25	LP Xs#3	6773.45

Main Meadow

Plug #1				Plug #2			
Feature	**Elevation**	**Ref. BM**	**Elevation**	**Feature**	**Elevation**	**Ref. BM**	**Elevation**
URC	6740.24	LP Xs#2	6738.54	URC	6730.29	LP Xs#5	6735.19
ULC	6740.24	LP Xs#2	6738.54	ULC	6730.99	LP Xs#5	6735.19
channel in	6739.04	LP Xs#2	6738.54	pond out	6729.49	LP Xs#5	6735.19
DRC	6731.99	LP Xs#5	6735.19	DRC	6725.44	LP Xs#6	6726.44
DLC	6731.99	LP Xs#5	6735.19	DLC	6729.04	LP Xs#6	6726.44

Plug #3				Plug #4			
Feature	**Elevation**	**Ref. BM**	**Elevation**	**Feature**	**Elevation**	**Ref. BM**	**Elevation**
URC	6722.24	LP Xs#6	6726.44	URC	6710.59	LP Xs#8	6709.49
ULC	6722.54	LP Xs#6	6726.44	ULC	6710.09	LP Xs#8	6709.49
pond out	6721.74	LP Xs#6	6726.44	DRC	6705.89	LP Xs#8	6709.49
DRC	6704.89	LP Xs#8	6709.49	DLC	6705.19	LP Xs#8	6709.49
DLC	6705.26	LP Xs#8	6709.49				

Main Meadow Riffles

Feature	Elevation	Length	Ref. BM	Elevation	Feature	Elevation	Length	Ref. BM	Elevation
Riffle #1 crest	6703.95	60'	LP Xs#8	6709.49	Riffle #5 tail	6696.95	20'	LP Xs#8	6709.49
Riffle #1 tail	6702.95	60'	LP Xs#8	6709.49	Riffle #6 crest	6696.95	20'	LP Xs#8	6709.49
Riffle #2 crest	6702.95	60'	LP Xs#8	6709.49	Riffle #6 tail	6695.95	20'	LP Xs#8	6709.49
Riffle #2 tail	6700.95	60'	LP Xs#8	6709.49	Riffle #7 crest	6695.95	20'	LP Xs#8	6709.49
Riffle #3 crest	6700.95	40'	LP Xs#8	6709.49	Riffle #7 tail	6694.95	20'	LP Xs#8	6709.49
Riffle #3 tail	6698.95	40'	LP Xs#8	6709.49	Riffle #8 crest	6694.95	20'	LP Xs#8	6709.49
Riffle #4 crest	6698.95	20'	LP Xs#8	6709.49	Riffle #8 tail	6693.95	20'	LP Xs#8	6709.49
Riffle #4 tail	6697.95	20'	LP Xs#8	6709.49	Riffle #9 crest	6693.95	20'	LP Xs#8	6709.49
Riffle #5 crest	6697.95	20'	LP Xs#8	6709.49	Riffle #9 tail	6692.95	20'	LP Xs#8	6709.49