Logan Springs & Bogard Meadow Conceptual Restoration Designs

February 26, 2018, Forest Creek Restoration, Inc.

Recent Studies Leading to These Locations

Pine Creek Geomorphic Assessment and Trend Analysis

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Prepared for: Pine Creek Coordinated Resource Management Planning group

September 1,2015

Pine Creek Watershed: Prioritization of Meadow Restoration Opportunities

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American Rivers Scope of Work

- Project Management
- Stakeholder Outreach
- Conceptual Restoration Designs
- Technical Restoration Designs
- Environmental Compliance and Permitting
- Reporting

Project Goals & Objectives

Goals

- Continue to build trust with project partners
- Continue to learn about meadows in our region
- Think about how we can make our Collaborative project unique and advance meadow restoration in the region
- Develop an understanding of the risks associated with implementing meadow restoration projects
- Return the meadows to a dynamic, more resilient fluvial system with increased aquatic, hydrologic, and riparian function

Objectives

- Learn something new about one of the project partners
- Ensure you understand the channel evolution model and can explain it to the someone not familiar with it
- Each person here has experience with meadows and our region - share your thoughts :)
- Convey your personal ideas about risk regarding meadow restoration

Geomorphic Assessments

Overview of geomorphic processes operating in the watershed:

- Geology and landforms (hydrogeomorphic types)
- Hydrology (spring fed, snow melt, limited precipitation)
- Sediment (erosion, supply, and transport)
- Meadow and riparian vegetation
- Fire, or lack thereof
- Wildlife (i.e. beaver, Belding's ground squirrels)

Questions:

1) What was the likely geomorphic condition of the stream/meadow prior to disturbance?

2) How did the creeks respond geomorphically to land use impacts?

3) What is the likely trend in channel geomorphic condition in the absence of further restoration efforts?

4) What opportunities and constraints exist for restoration efforts?

Important Points for Geomorphic Processes

- We have low sediment supply to our meadows due to the volcanic geology and low topographic relief
- Large-scale floods typically occur from rain on snow events in January and February; otherwise, each sites hydrology is unique and often based on how much snow fell during the winter
- Because most of our streams are intermittent, channel stability is more easily compromised, and beaver were not present within them (with caveats)
- Meadow and riparian vegetation are critical for channel and streambank stability, and most all of our meadows were heavily grazed 100 years ago
- Fire suppression and forest management has changed forest structure, which has affected aspen, and likely affected surface and groundwater hydrology for sites
- Beaver may have occurred in the upper portions of the watershed
- The Channel Evolution Model is an excellent tool for understanding processes responsible for degradation and opportunities for restoration

Hydrologic Conditions

There are a number of methods to conduct hydrologic analyses; we will discuss and review steps using the below:

- Use StreamStats to determine whether a gauging station is/was present on the stream; acquire watershed size and aquire annual precipitation values from StreamStats
- Flood frequency analysis conducted by two methods if there is no stream gauge on-site:
  1) Comparative watershed method;
  2) Multiple regression method

Why is this important?

- Give you some sense of system dynamism
- Provides estimates of bankfull flow and peak flows; bankfull can then be compared to what you have measured at the site for comparative purposes
- Can calculate shear stress and estimate size of particles that will be moved within the stream from various flow regimes

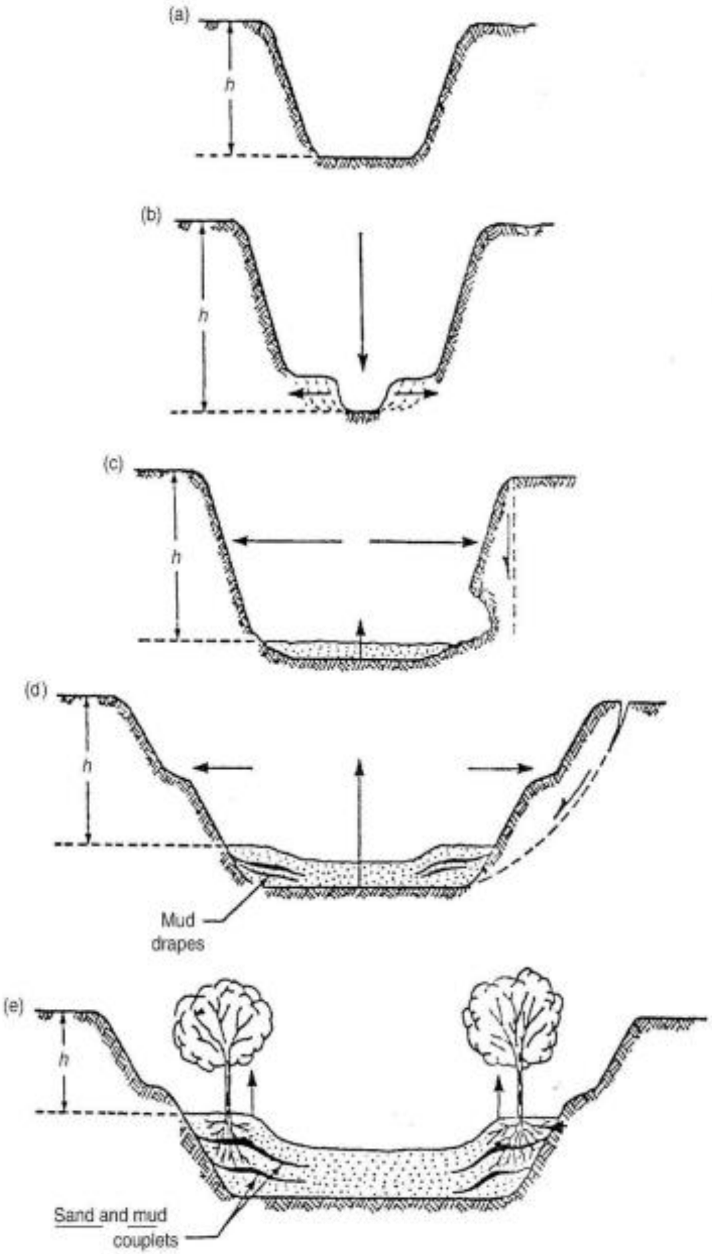

Figure 5.11 Evolution of incised channel from initial incision (a, b) and widening (c, d) to aggradation (c, d) and eventual stability (e) (modified from Schumm *et al.* 1984)

RIVER RESEARCH AND APPLICATIONS
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A STREAM EVOLUTION MODEL INTEGRATING HABITAT AND ECOSYSTEM BENEFITS

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ABSTRACT

For decades, Channel Evolution Models have provided useful templates for understanding morphological responses to disturbance associated with lowering base level, channelization or alterations to the flow and/or sediment regimes. In this paper, two well-established Channel Evolution Models are revisited and updated in light of recent research and practical experience. The proposed Stream Evolution Model includes a precursor stage, which recognizes that streams may naturally be multi-threaded prior to disturbance, and represents stream evolution as a cyclical, rather than linear, phenomenon, recognizing an *evolutionary cycle* within which streams advance through the common sequence, skip some stages entirely, recover to a previous stage or even repeat parts of the evolutionary cycle.

The hydrologic, hydraulic, morphological and vegetative attributes of the stream during each evolutionary stage provide varying ranges and qualities of habitat and ecosystem benefits. The authors' personal experience was combined with information gleaned from recent literature to construct a fluvial habitat scoring scheme that distinguishes the relative, and substantial differences in, ecological values of different evolutionary stages. Consideration of the links between stream evolution and ecosystem services leads to improved understanding of the ecological status of contemporary, managed rivers compared with their historical, unmanaged counterparts. The potential utility of the Stream Evolution Model, with its interpretation of habitat and ecosystem benefits includes improved river management decision making with respect to future capital investment not only in aquatic, riparian and floodplain conservation and restoration but also in interventions intended to promote species recovery. Copyright © 2013 John Wiley & Sons, Ltd.

KEY WORDS: Stream Evolution Model (SEM); channel evolution; freshwater ecology; habitat; conservation; river management; restoration; climate resilience

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INTRODUCTION

It is now generally accepted that river engineering and management that works with rather than against natural processes is more likely to attain and sustain the multi-functional goals (e.g. land drainage, flood risk management, fisheries, conservation, biodiversity, and recreation) demanded by local stakeholders and society more widely (Wohl *et al*., 2005; Thorne *et al*., 2010). This, coupled with growing recognition that the range and value of ecosystem services provided by rivers increase with the degree to which they are allowed to function naturally, fuels the drive for restoration of fluvial systems degraded by past management and engineering actions that have proven, in the long term, to be unsustainable (Palmer *et al*., 2005).

However, complete restoration of a river to some former condition is seldom possible, nor always desirable (Downs and Gregory, 2004), and deciding whether partial restoration, rehabilitation or environmental enhancement is the best way to treat a damaged stream raises fundamental questions for river managers responsible for achieving increased biodiversity or the protection and recovery of endangered species. Specifically, serious questions arise concerning the nature of the pre-disturbance condition to which a given river should be restored, the likely sequence (and habitat impacts) of channel adjustments associated with post-project evolution and the merits of restoring the river to some former condition rather than facilitating, or even enhancing, its progression to a configuration that is, first, better adjusted to the prevailing hydrological and sediment regimes and, second, more resilient to the unavoidable impacts of future climate change and/or land use.

In this paper, these questions are addressed by

1. revisiting well-established Channel Evolution Models (CEMs) for streams that respond to disturbance through incision,
2. updating these CEMs in light of recent research, including that on pre-disturbance channel forms in Europe and North America, to propose a more broadly based Stream Evolution Model (SEM),
3. linking the evolutionary stages of stream adjustment to indicators of habitat and lotic ecosystem benefits and

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Comparative Watershed Method

Uses flow estimates from a gauged stream and algebraically estimates flow for study stream using watershed size

Process

- Understand formula
- Acquire values from StreamStats
- Use more than one site with gauge data

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

Qu = discharge of ungaged stream

Qg = discharge of gaged stream

b = regional coefficient (drainage area) (NE) Waananen & Crippen

Au = watershed area of ungaged stream

Ag = watershed area of gaged stream

Values from StreamStats:

Watershed Area= 107.6 sq mi.

Hydro Calcs Document, Bogard & Logan: https://docs.google.com/spreadsheets/d/1paDUvPrJgisurIYYSiaLKpp0FeqGaYOXbZ8uTC8uCb4/edit#gid=1765290908

Example from one gaged site for Bogard:

	Whiskey Cr. near Thermo	**11 yr**	**10359510**
Q2 = 66(107.6/4.56)^.40			**233.7**
Q5 = 93(107.6/4.56)^.45			**385.7**
Q10 = 112(107.6/4.56)^.49			**527.1**
Q25 = 137(107.6/4.56)^.54			**755.2**
Q50 = 157(107.6/4.56)^.57			**951.5**
Q100 =178(107.6/4.56)^.59			**1149.2**

Multiple Regression Analysis Method

Multiple regression method allows you to use regional coefficients to estimate flows.

Formula: Q= K*(A^a)(P^b)(H^c)

K = Regional Coefficient

A = Drainage Area ~ a = Regional Drainage Area Coefficient

P = Mean Annual Precipitation ~ b = Regional Precipitation Coefficient

H = Altitude Index ~ c = Regional Altitude Coefficient

Values from StreamStats: Watershed Drainage Area = 107.6 sq. mi.

Note Precip & Altitude Coefficients are not available for N.E CA, excluded in formula below.

Hydro Calcs Doc., Bogard & Logan: https://docs.google.com/spreadsheets/d/1paDUvPrJgisurIYYSiaLKpp0FeqGaYOXbZ8uTC8uCb4/edit#gid=1765290908

Bogard:

Q2 = 22*(29^0.40)(39.8^1.58)(6.560^-.80)			**84.60**
Q5 = 46*(29^0.45)(39.8^1.37)(6.560^-.64)			**209.33**
Q10 = 61*(29^0.49)(39.8^1.25)(6.560^-.58)			**317.62**
Q25 = 84*(29^0.54)(39.8^1.12)(6.560^-.52)			**572.59**
Q50 = 103*(29^0.57)(39.8^1.06)(6.560^-.48)			**702.11**
Q100 = 125*(29^0.59)(39.8^1.02)(6.560^-.43)			**911.43**

Channel Capacity & Manning’s Equation

Manning's equation allows us to estimate the amount of flow a channel can contain. Elevation data collected from XS and profiles at the sites, and some assumed coefficients are used to calculate these estimates.

Discharge (Q)(ft3/sec) Calculated as velocity (V)(ft/sec) * cross section (XS) area (ft2)

Manning’s Equation: V = (1.49/n)((r)2/3(s)1/2))

1.49 is a conversion constant

"n" is roughness (small streams with veg and small particle size typically have values of **.032** (value derived from Rosgen (1996)).

"r" is hydraulic radius. Calculated as XS Area / Wetted Perimeter (WP). WP = bankfull width + 2 times bankfull depth. Channel width (22.5) + (channel depth (1.9)*(2)

Ex. from Bogard: WP = 22.5+(1.9*2) = 26.3 ~ r = 30.8/26.3 = **1.17**

"s" is slope of the primary channel. (Elev.upper/Elev. lower)/estimated distance from ArcMap)

Ex. from Bogard: Elev. at Ltb XS 2 5647.7 ~ Elev. at Ltb XS 3 5648.7
(5647.7/5648.7)/617.5= **0.0017**

(1.49/0.032)*(1.17^(2/3)*0.0017^(1/2))= **2.13 velocity**

Q = V * XS

2.13*30.8 = 65.6 cfs

Info. from Excel XS’s:
Channel Width = 22.5 ft.
Channel Depth = 1.9
Channel XS area = 30.8 sq. ft.

Hydro Calcs Doc., Bogard & Logan:
https://docs.google.com/spreadsheets/d/1paDUvPrJgisurIYYSiaLKpp0FeqGaYOXbZ8uTC8uCb4/edit#gid=1765290908

Logan Springs Meadow

All Photos:
https://photos.app.goo.gl/SAxp5HNFyKQysYxz2

Logan Meadow

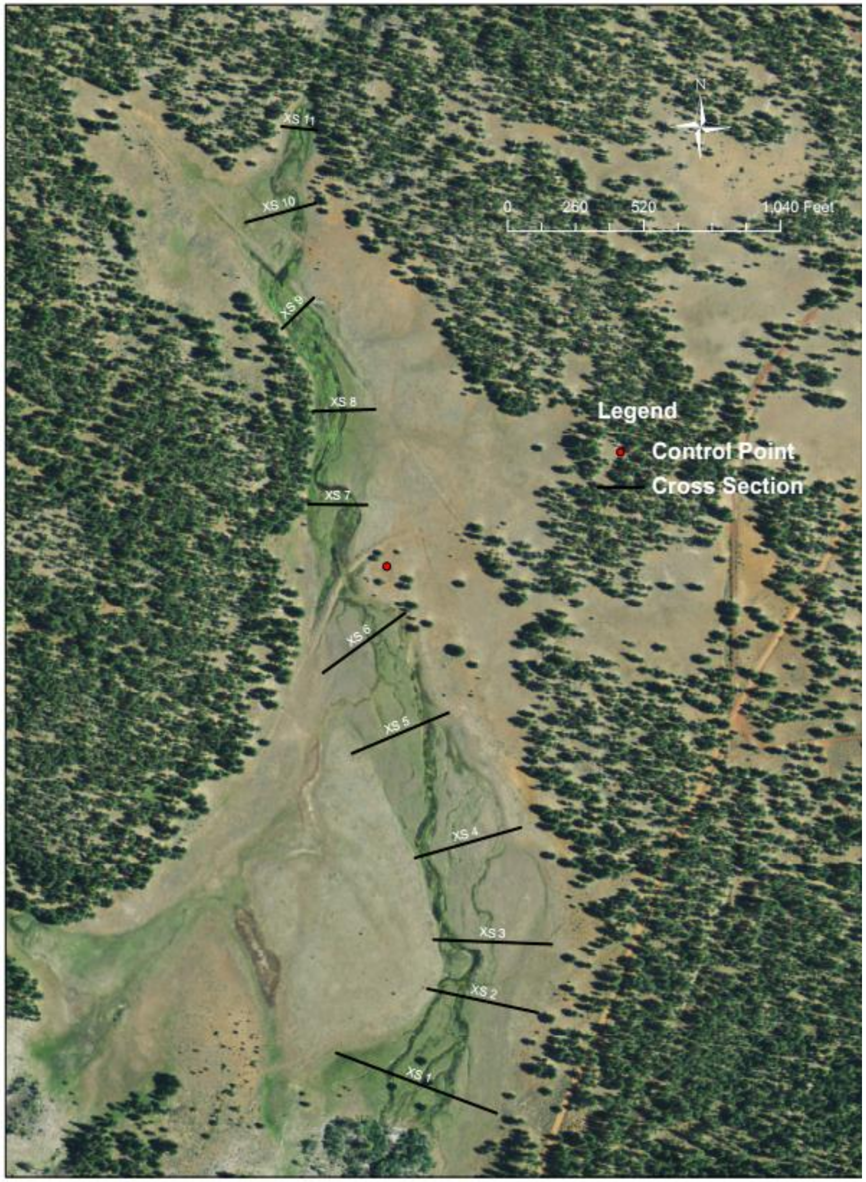
Site Characteristics & Conclusions

- Mostly a low gradient riparian hydrogeomorphic type
- Existing channel capacity is too large in the meadow,
- Historic remnant channel is present in some locations and this channel is within the valley low
- This remnant channel merges with the existing channel and is oversized again
- Floodplain narrows at lower meadow reach and numerous oversized channels present

Logan Flood Frequency Calcs

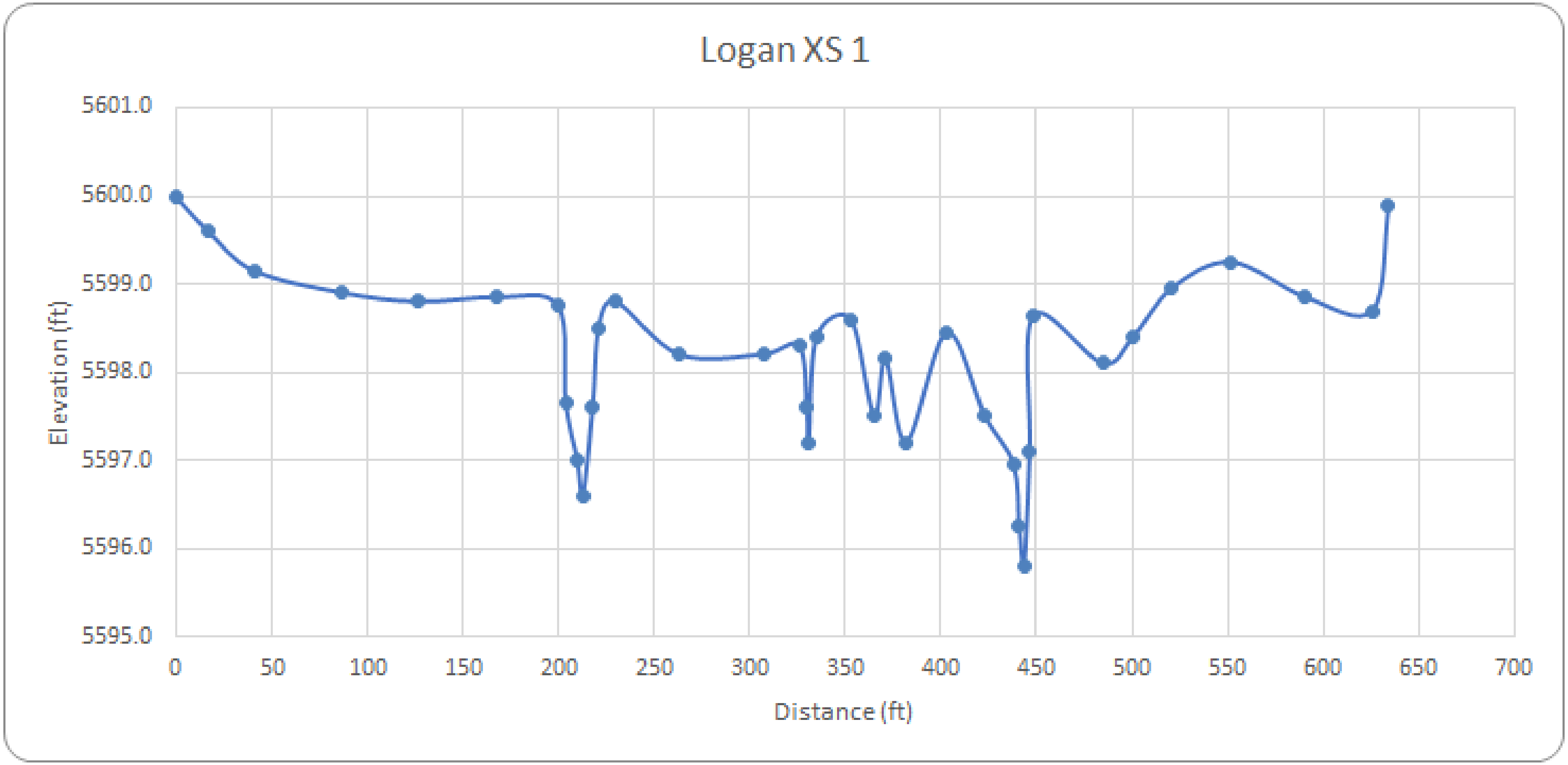
Return Intervals	Streamstats	Multiple Regression	Comparative Watershed
2	814	142	140
5	1,630	377	269
10	2,420	603	394
25	3,530	1,050	600
50	4,760	1,482	789
100	5,890	1,971	1,005

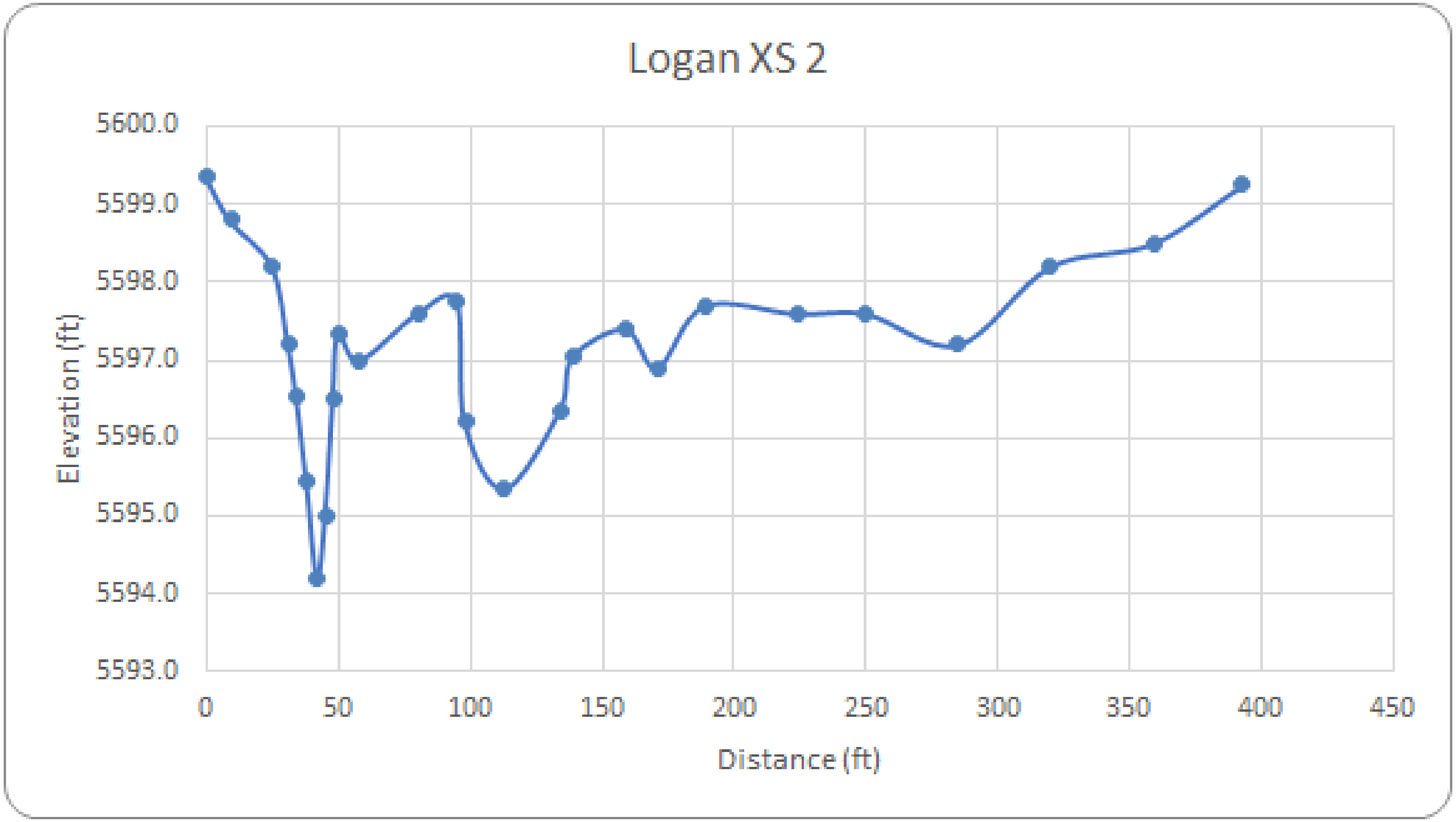
Cross Section & Longitudinal Profile

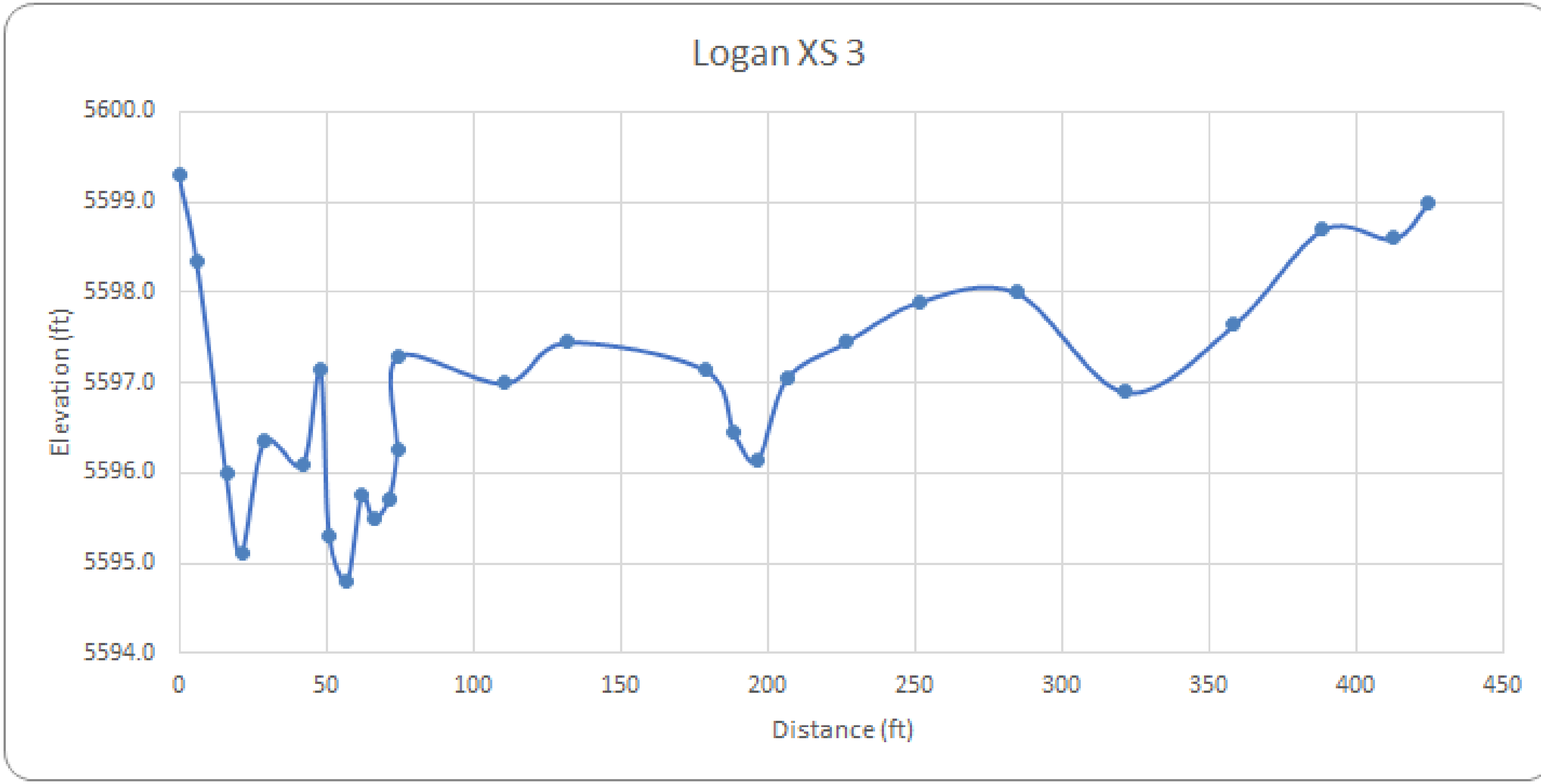


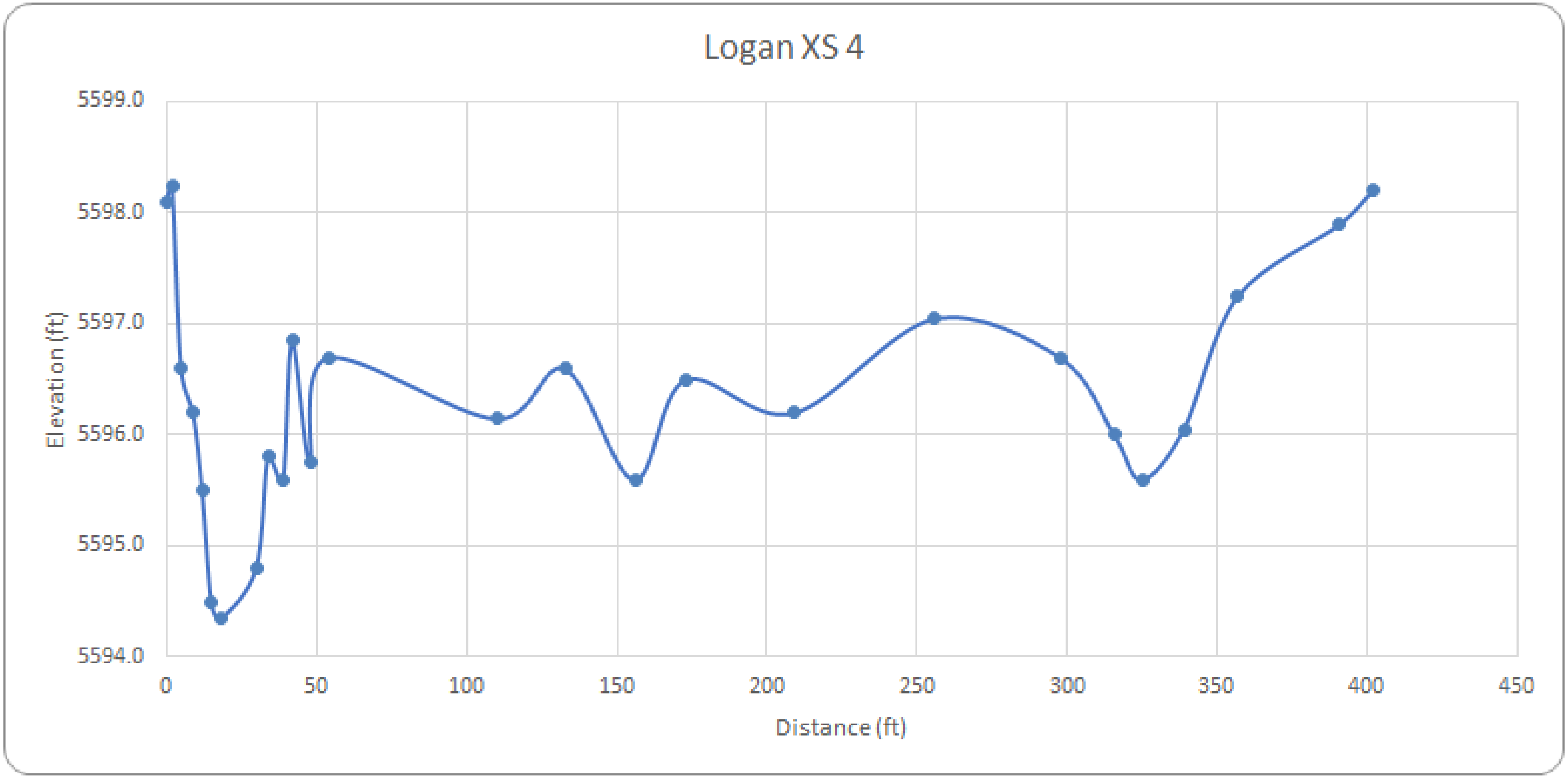
Cross Sections

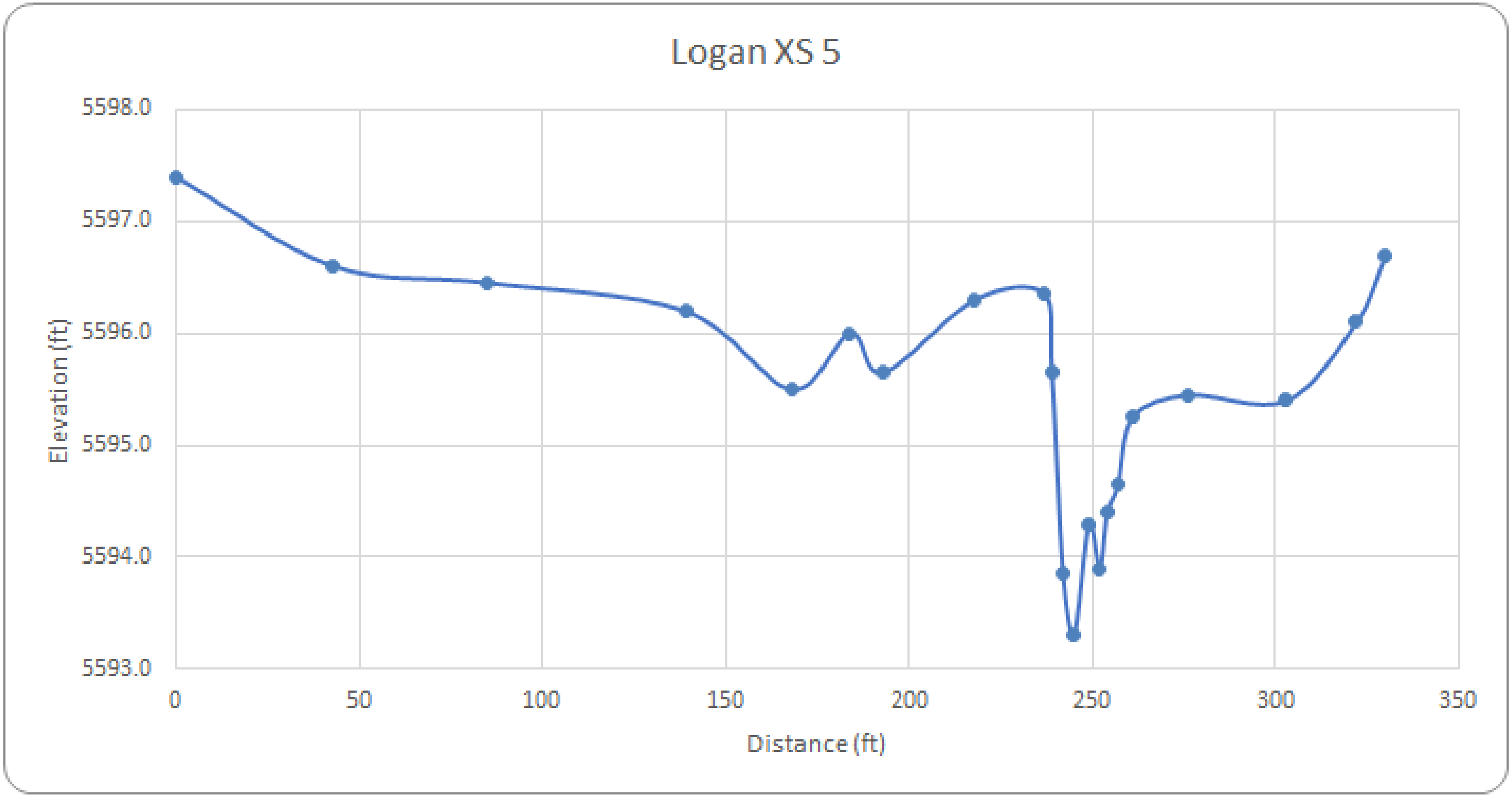
Plot distance vs. elevation from the Excel data



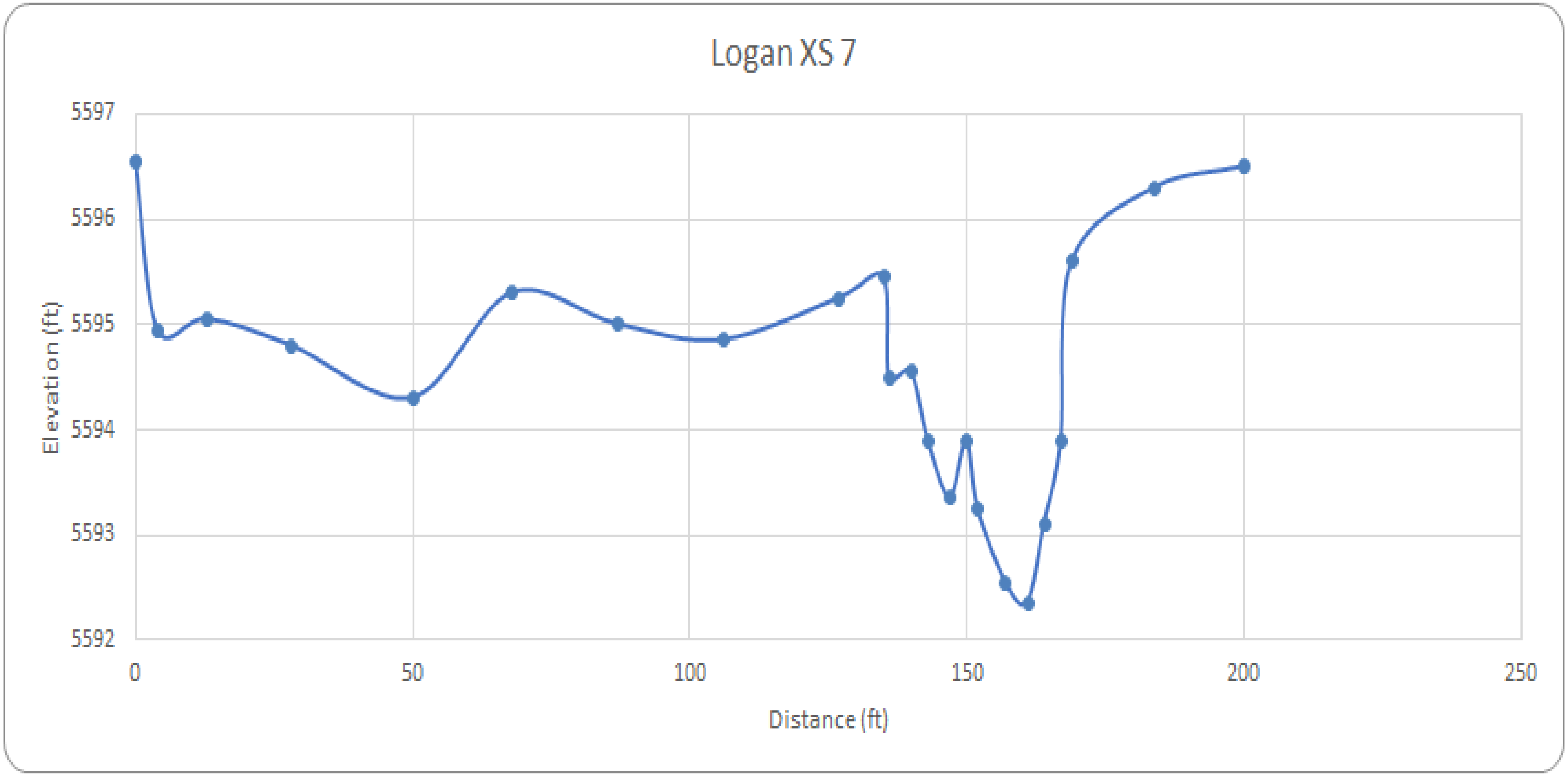

Logan XS 2
5600.0
5599.0
5598.0
5597.0
5596.0
5595.0
5594.0
5593.0
Elevation (ft)
0
50
100
150
200
250
300
350
400
450
Distance (ft)


Logan XS 3
5600.0
5599.0
5598.0
5597.0
5596.0
5595.0
5594.0
Elevation (ft)
0
50
100
150
200
250
300
350
400
450
Distance (ft)

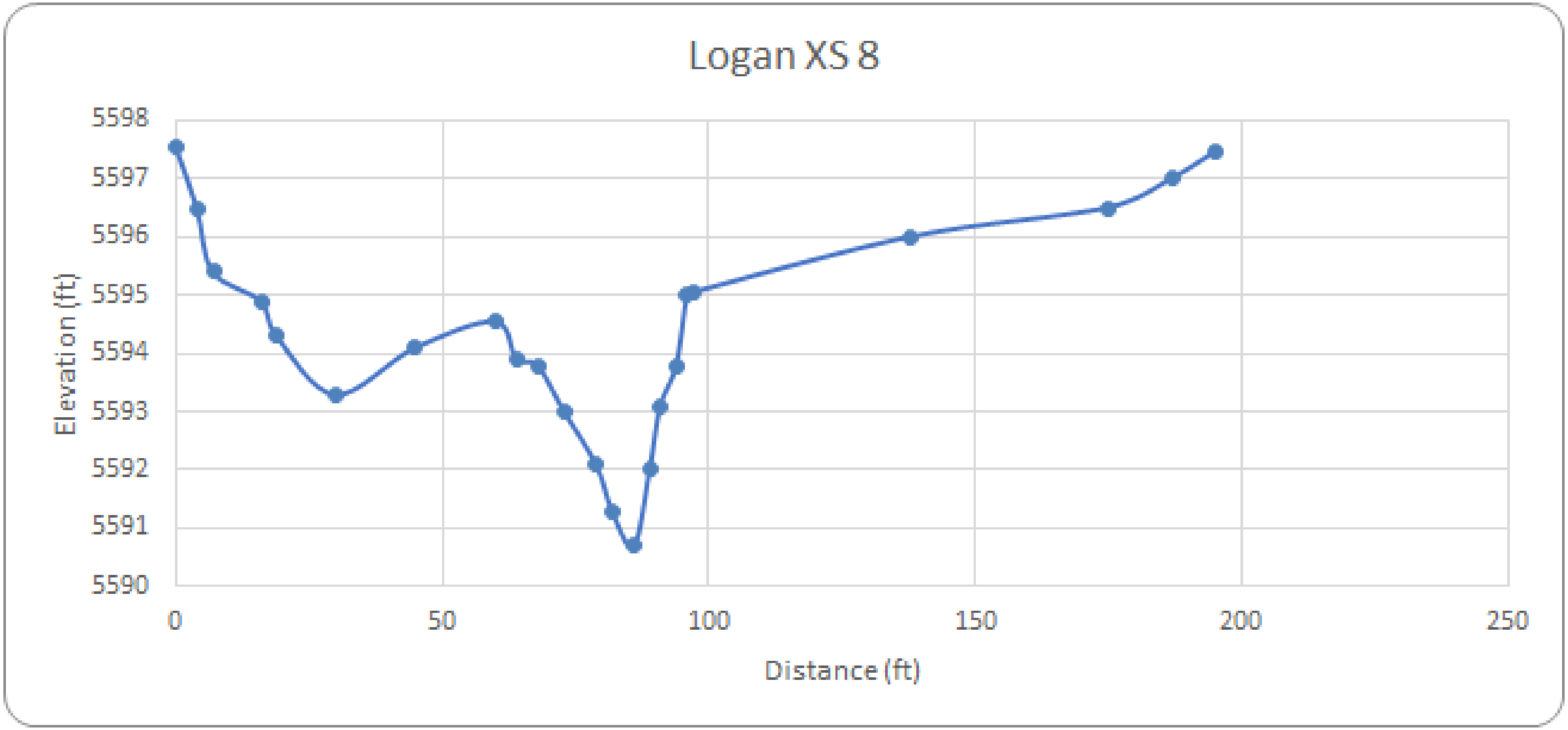

Logan XS 4
Elevation (ft)
5599.0
5598.0
5597.0
5596.0
5595.0
5594.0
0
50
100
150
200
250
300
350
400
450
Distance (ft)

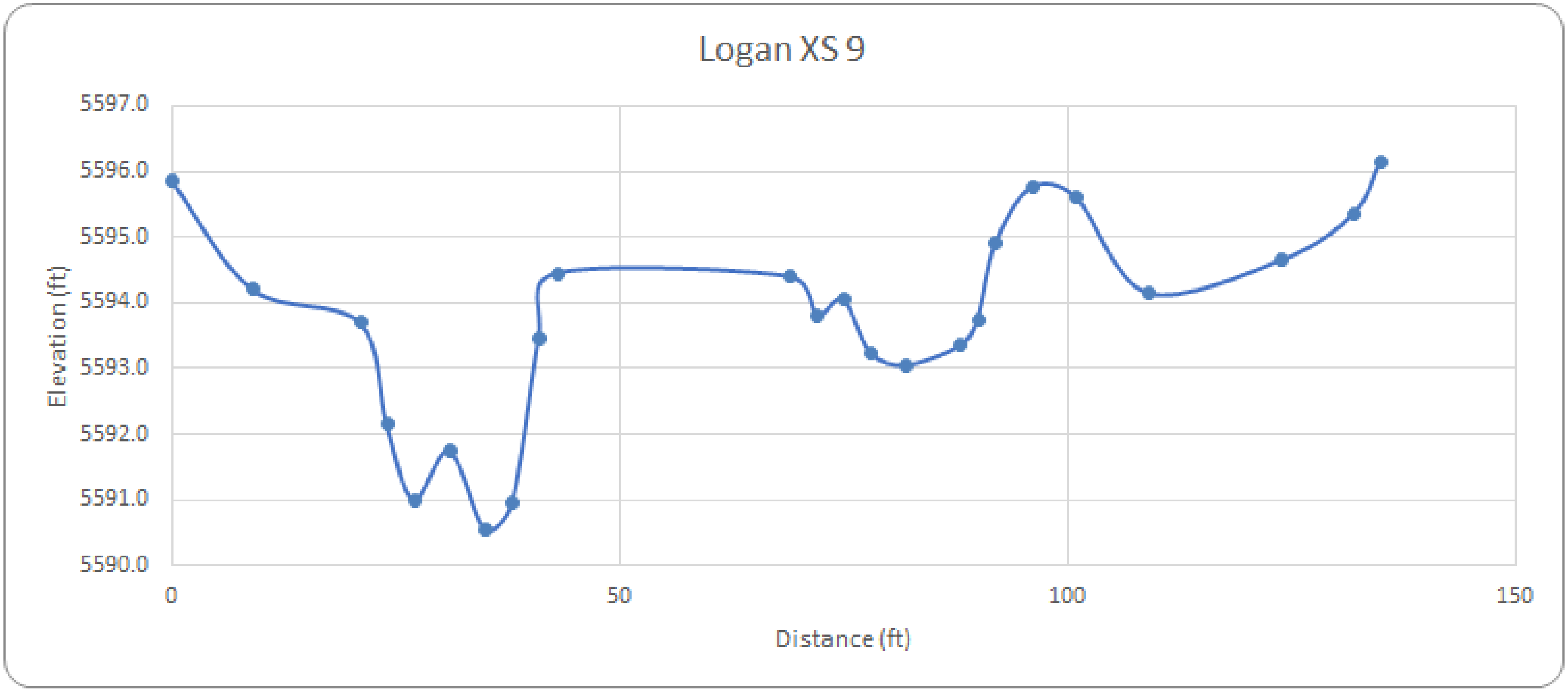

Logan XS 5
5598.0
5597.0
5596.0
5595.0
5594.0
5593.0
Elevation (ft)
0
50
100
150
200
250
300
350
Distance (ft)

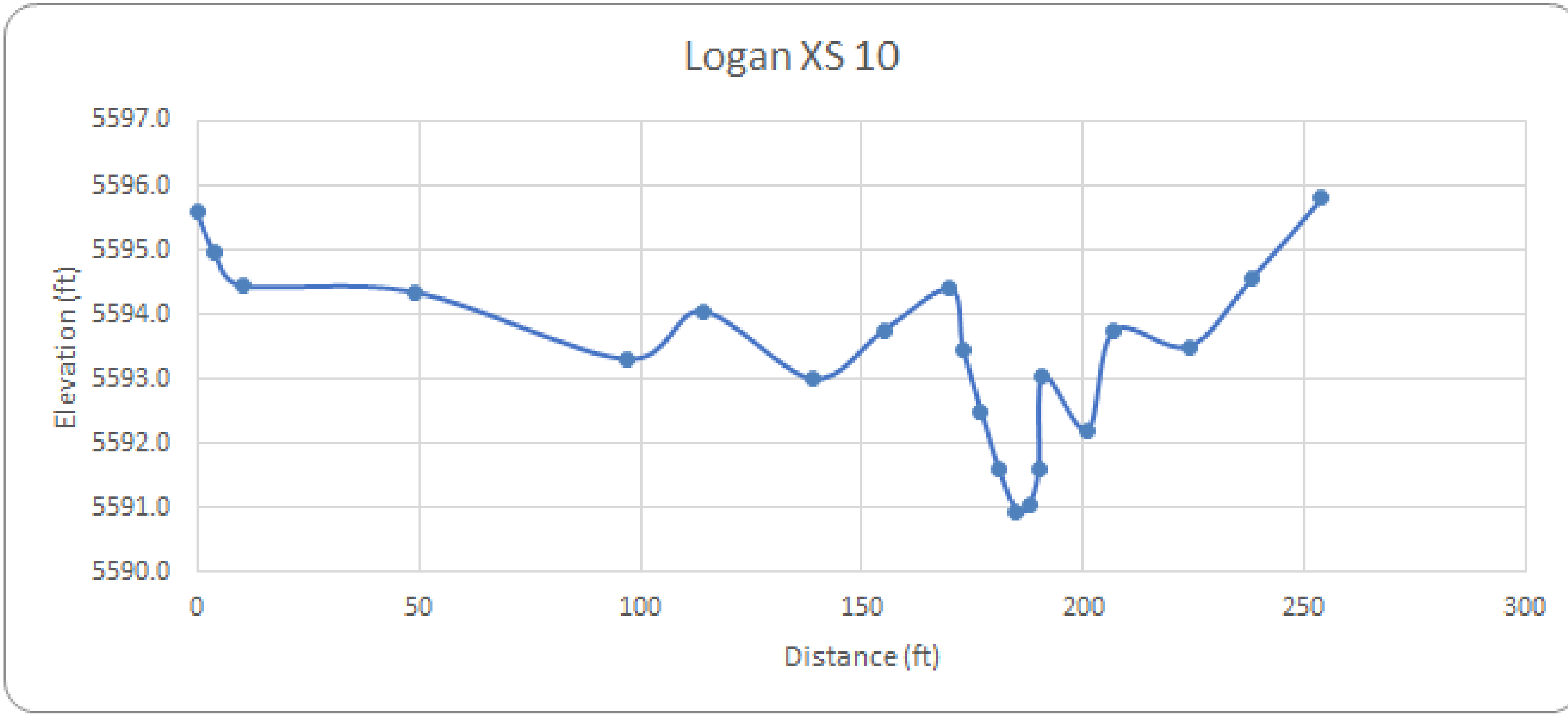

Logan XS 6
5597.0
5596.0
5595.0
5594.0
5593.0
Elevation (ft)
0
50
100
150
200
250
300
Distance (ft)

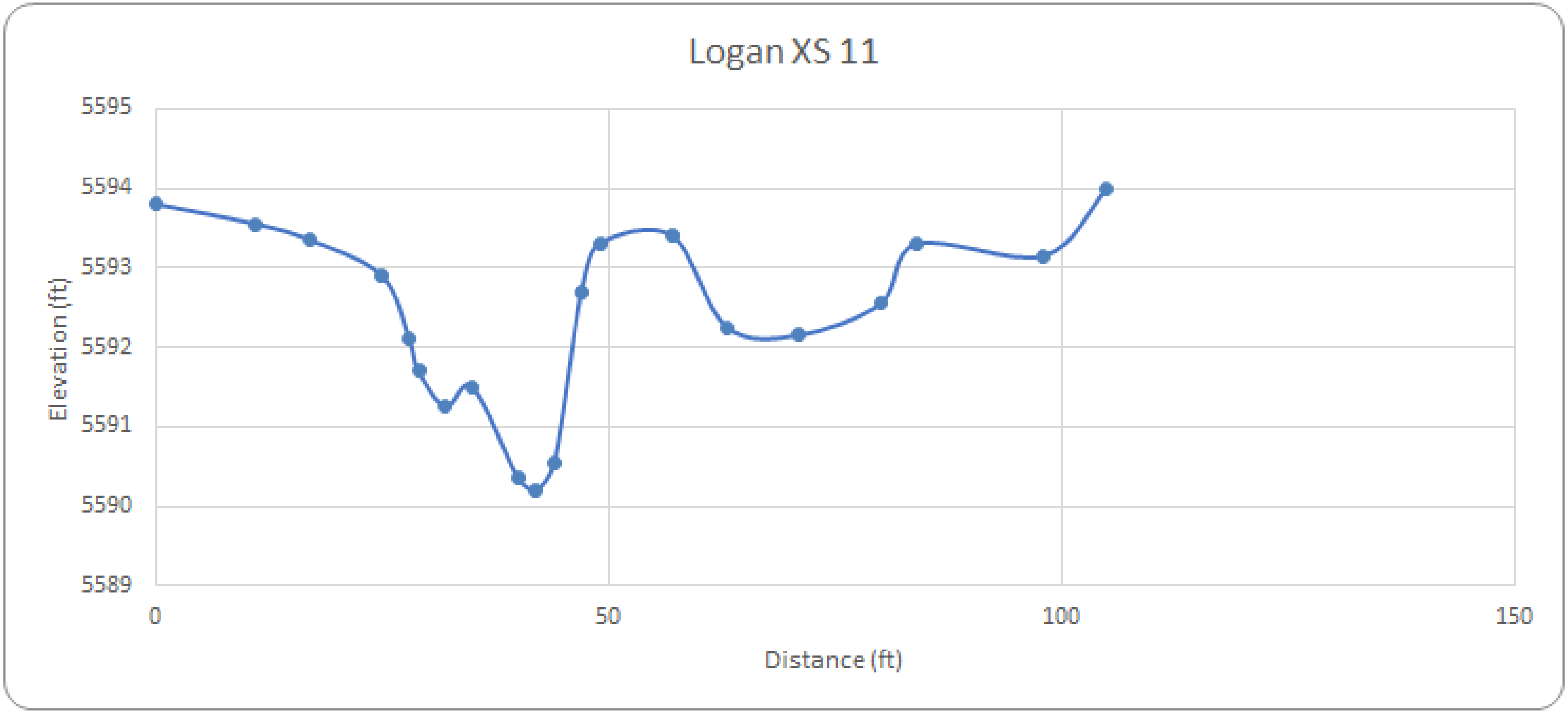


Logan XS 7
5597
5596
5595
5594
5593
5592
Elevation (ft)
0
50
100
150
200
250
Distance (ft)


Logan XS 8
Elevation (ft)
5598
5597
5596
5595
5594
5593
5592
5591
5590
0
50
100
150
200
250
Distance (ft)

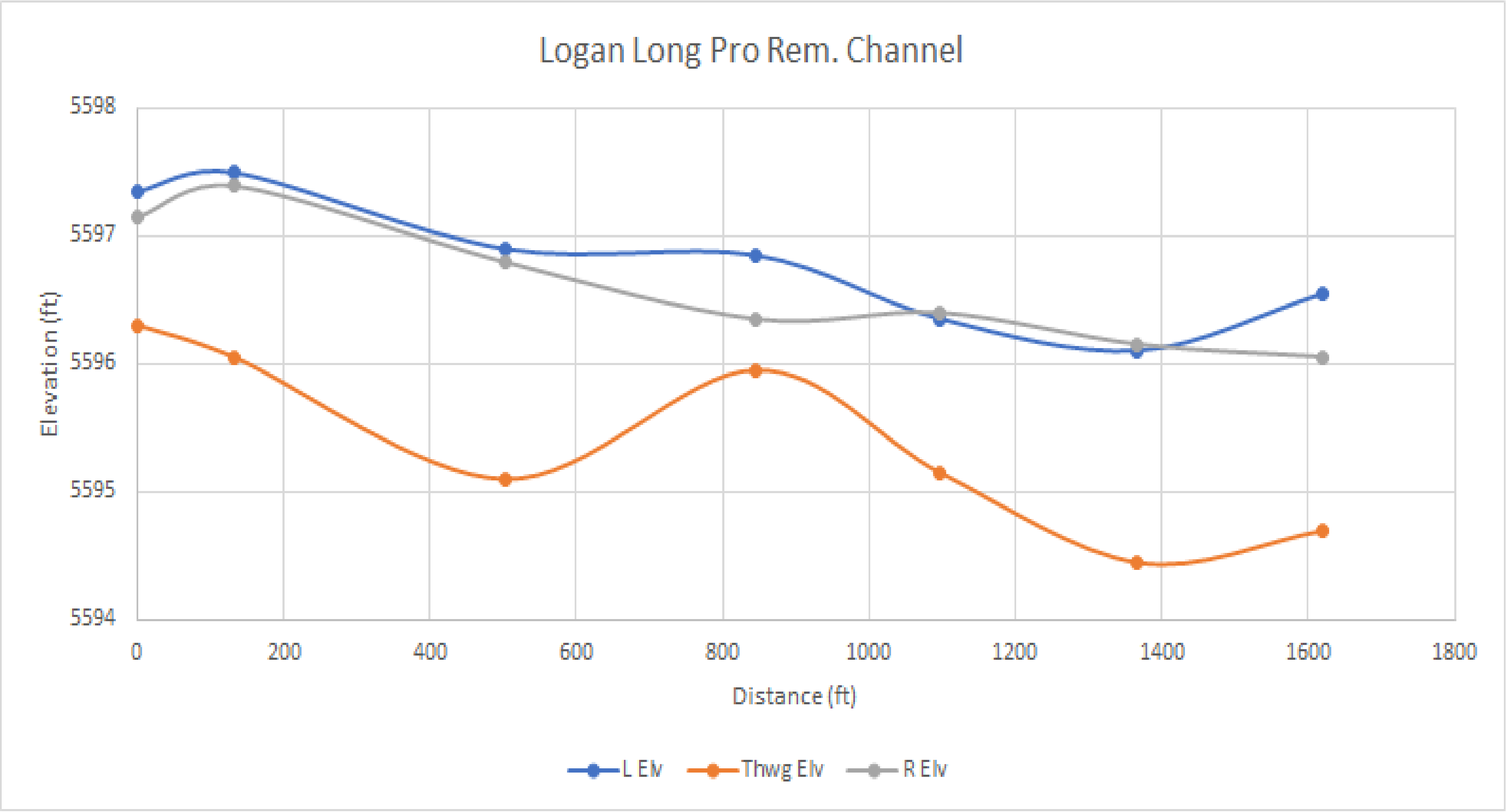

Logan XS 9
5597.0
5596.0
5595.0
5594.0
5593.0
5592.0
5591.0
5590.0
Elevation (ft)
0
50
100
150
Distance (ft)


Logan XS 10
5597.0
5596.0
5595.0
5594.0
5593.0
5592.0
5591.0
5590.0
Elevation (ft)
0
50
100
150
200
250
300
Distance (ft)


Logan XS 11
5595
5594
5593
5592
5591
5590
5589
Elevation (ft)
0
50
100
150
Distance (ft)

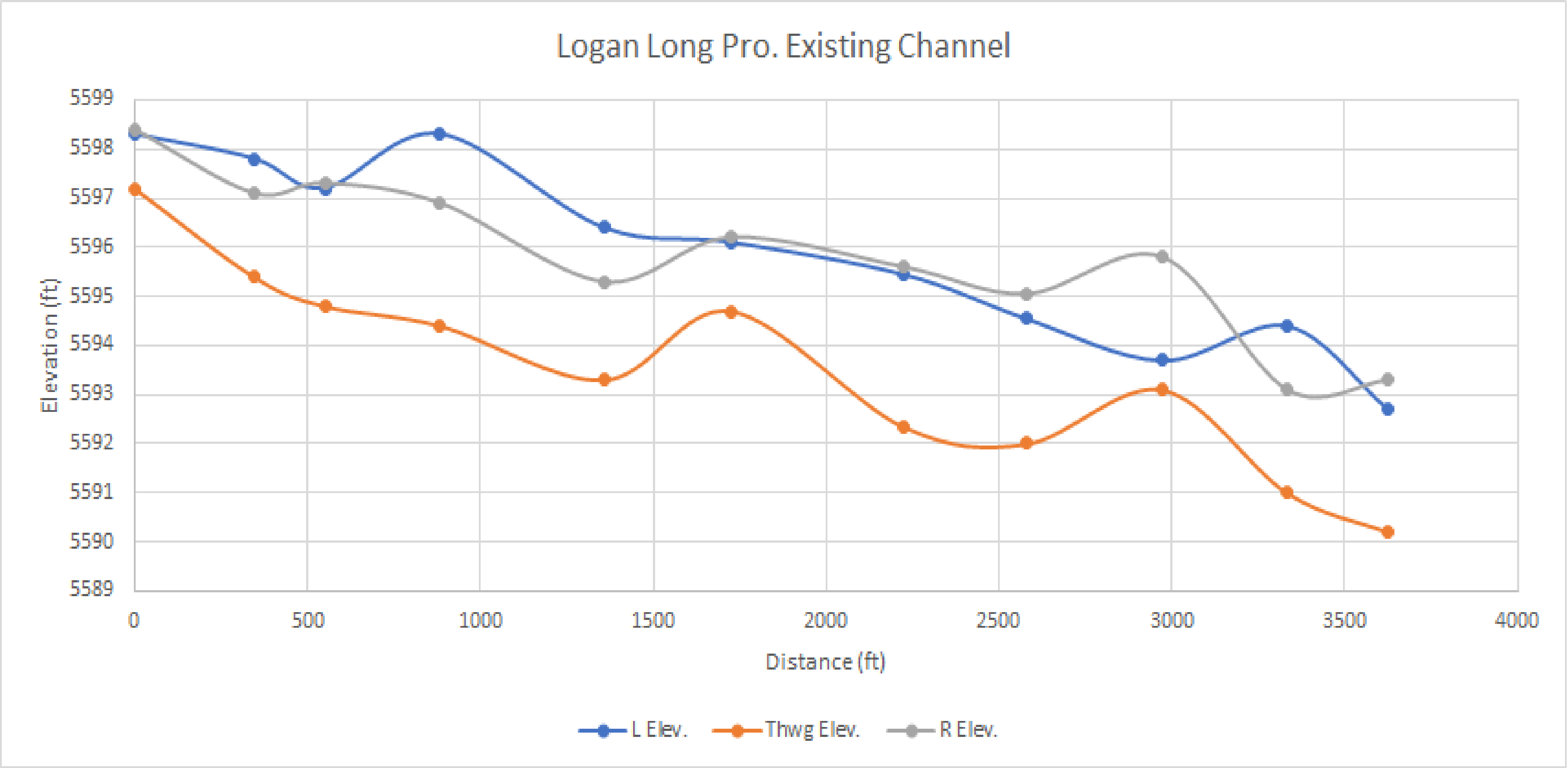
Longitudinal Profile
Rem. Channel

1. Elevations were taken at the left bank, thalweg, & right bank every 40 pases down the main channel.
2. Record data from ArcMap. Enter pole heights & distances between.



(thwg. elv. pt. 1 - thwg. Elv. pt. 31)/distance
(5596.3-5594.7)/1619.5 = **.0010 slope**

Longitudinal Profile
Existing Channel



(thwg. elv. pt. 1 - thwg. Elv. pt. 31)/distance
(5597.2-5590.2)/3626.5 = **.0019 slope**

Logan Springs Meadow

Design Considerations

- Highly modified floodplain; infrastructure (old railroad grades) affecting fluvial dynamics
- Low sediment supply
- Intermittent flow
- Limited remnant channel network
- Good Access
- Onsite rock present
- Adjacent terrace present to acquire fill if needed

Logan Springs Meadow

Options for Site

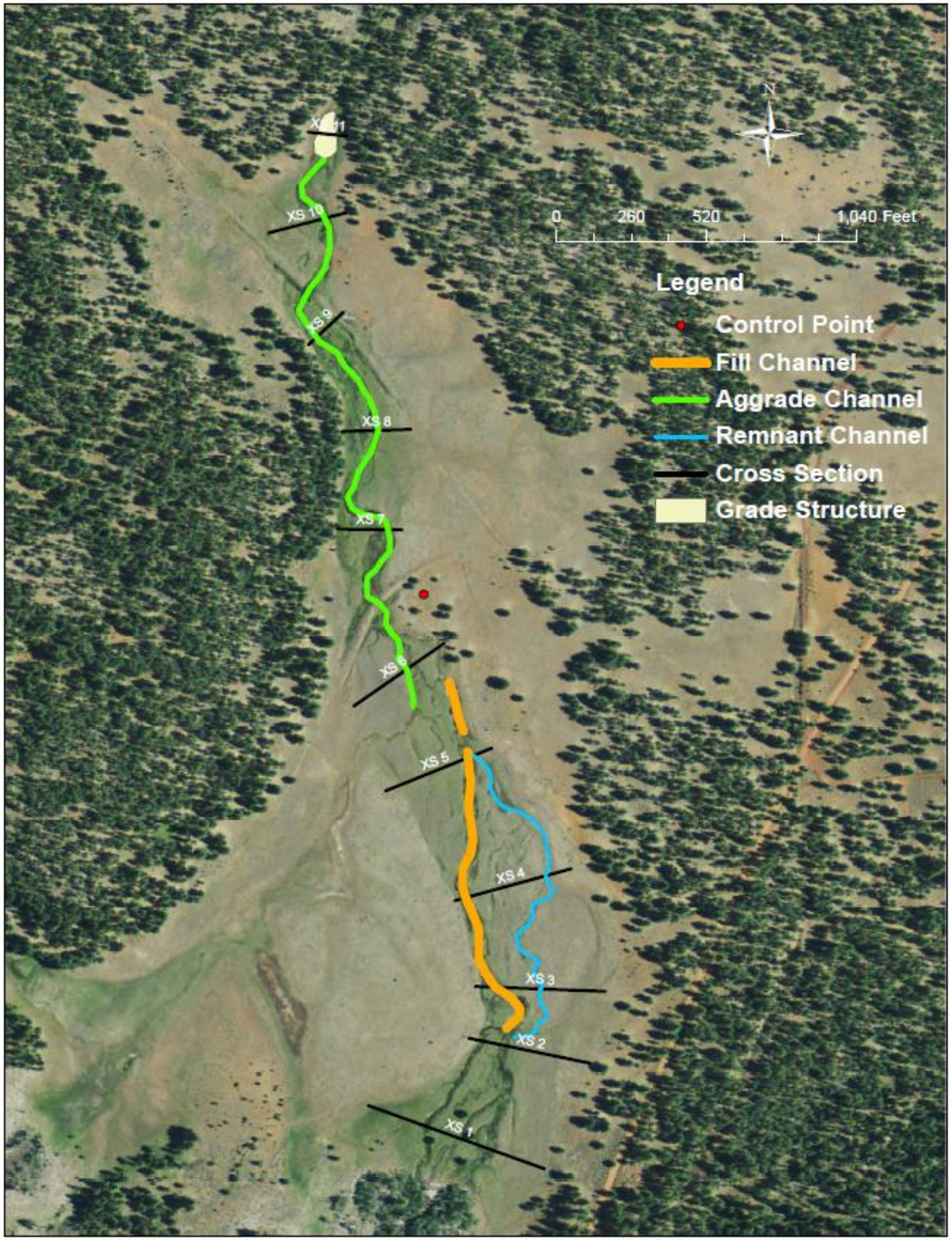
- Completely fill oversized channel areas; use remnant channels where present
- Reduce capacity of oversized channels; use remnant channels were present; no new construction of channels
- Stabilize eroding banks by resloping areas and planting vegetation
- Install grade control structures (e.g. rock/sod, to aggrade oversized channels
- Remove old railroad grades and spoils

Factors to Consider

- Costly to fill large channels; reduced risk if filled channels are not in valley low
- Aggrading existing oversized channels is tricky and requires a few years for sod and rock to stabilize
- Resloping areas and replanting is less risky but does not restore hydrologic function
- The lower portion of the meadow has a more confined floodplain and steeper slope; this section will likely require a few years to stabilize

Suggested Concept

- Insert earthen plug in oversized channel at above XS 3 and redirect low flow into remnant channel to the east
- Once remnant rejoins oversized channel, aggrade channel (using combination of rock and sod) for the remainder of the meadow
- Rebuild the floodplain with rock at the bottom end of the meadow (i.e. grade control structure)
- Remove railroad and levees
- Actions would restore physical processes (i.e. hydrology), and result in improved hydrologic, ecologic, and aquatic function



Bogard Meadow

Photos:
https://photos.app.goo.gl/otgHZ5IstS2jUiZj1

Bogard Meadow

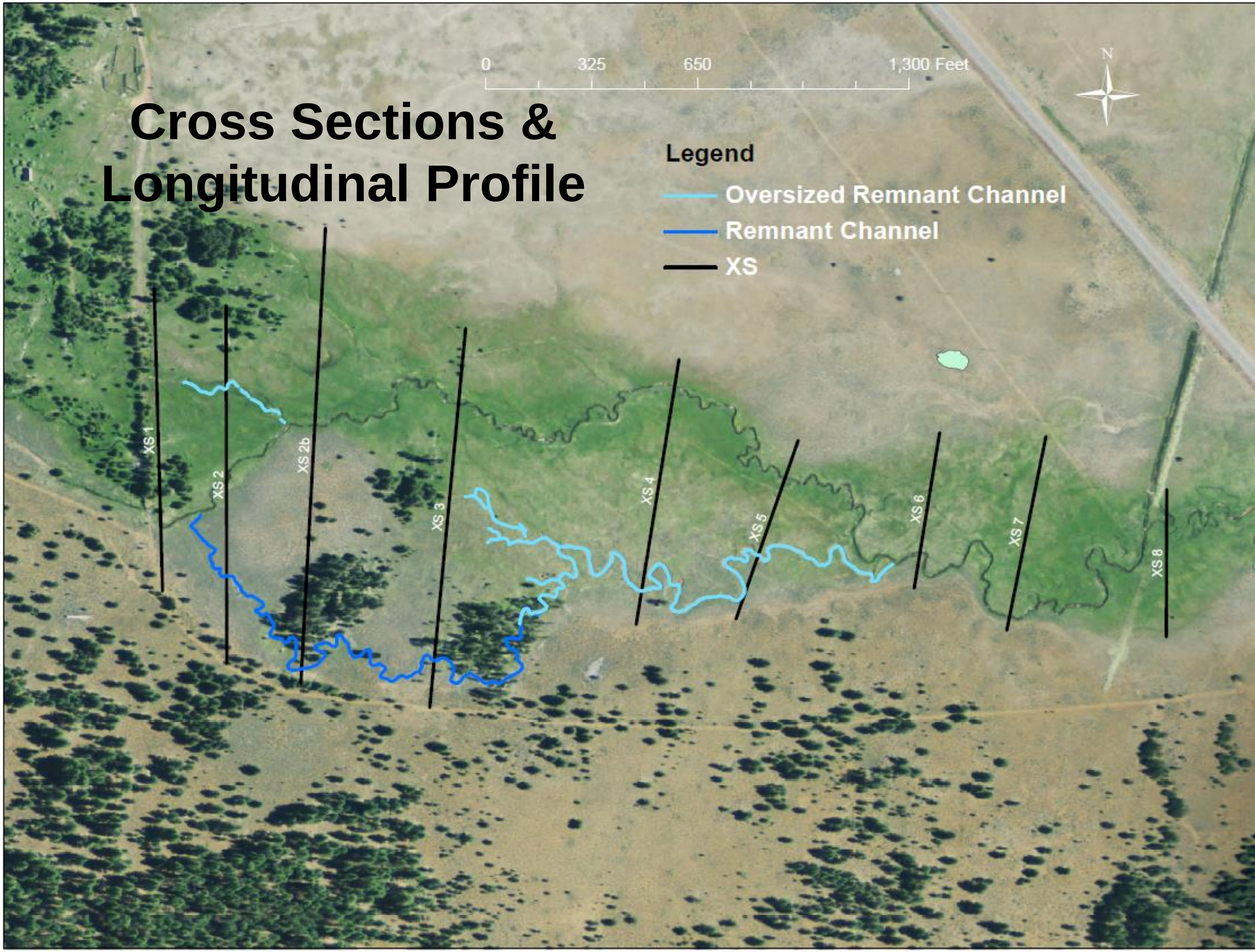
Site Characteristics & Conclusions

- Low gradient riparian hydrogeomorphic type
- Existing channel capacity is slightly larger than it should be; channel upstream of project area has roughly 30% less capacity
- Southern channel capacity is appropriate for several thousand feet until it becomes oversized quickly; It’s also roughly the same elevation as the existing channel
- This remnant channel merges with the existing channel and is oversized again
- Channel capacity becomes more appropriate below “splitter”

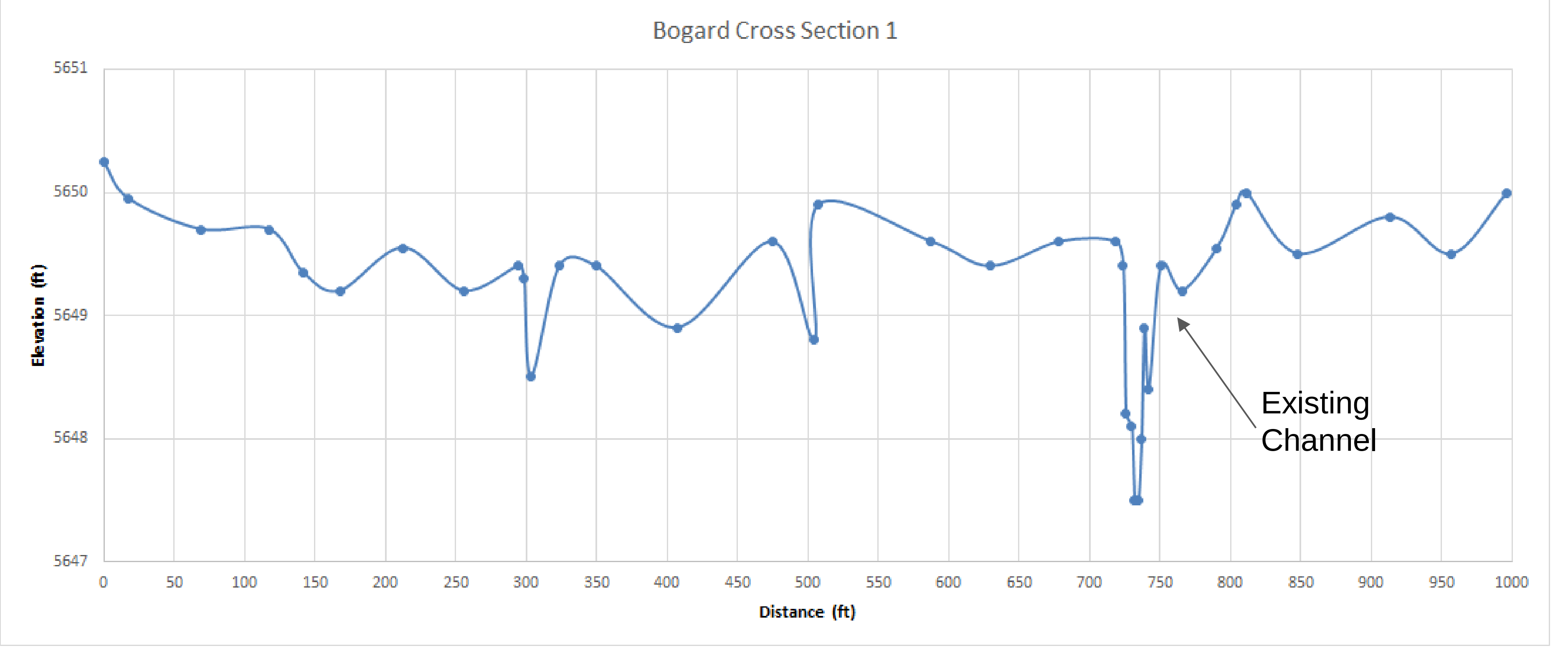
Bogard Flood Frequency Calcs

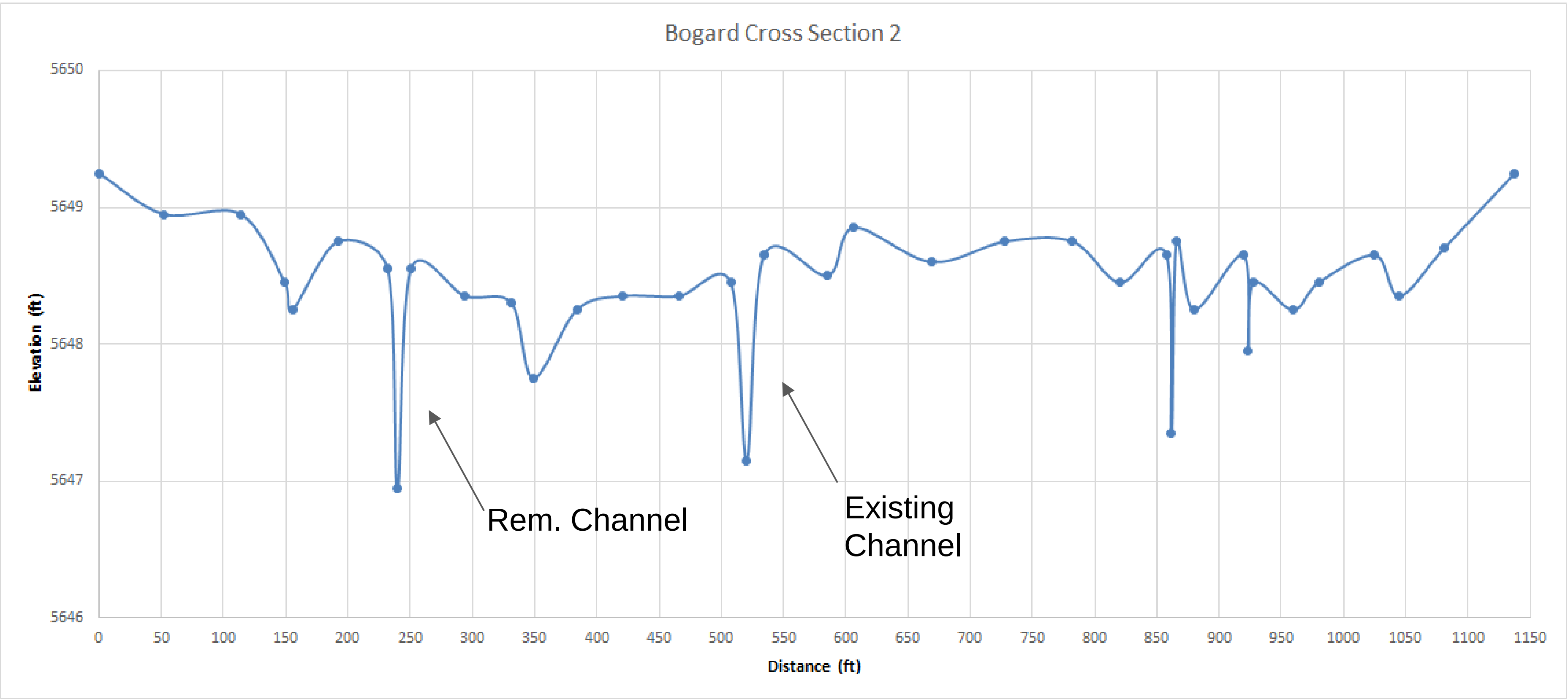
Return Intervals	Streamstats	Multiple Regression	Gaged Data Pine Creek near Westwood (10359250)
2 Yrs	361	84	78
5 Yrs	724	209	139
10 Yrs	1080	317	192
25 Yrs	1570	572	272
50 Yrs	2120	702	342
100 Yrs	2620	911	423

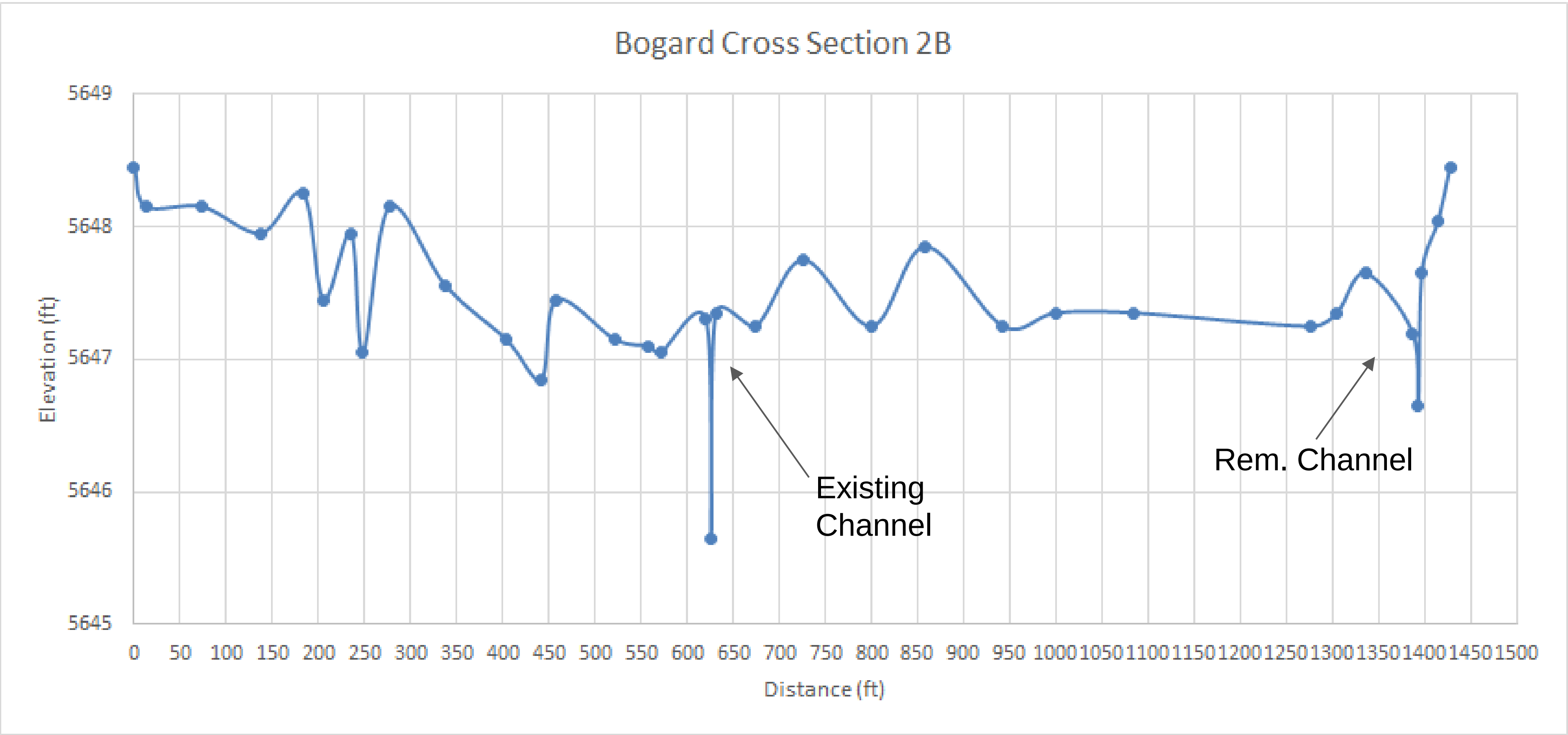
Cross Sections & Longitudinal Profile



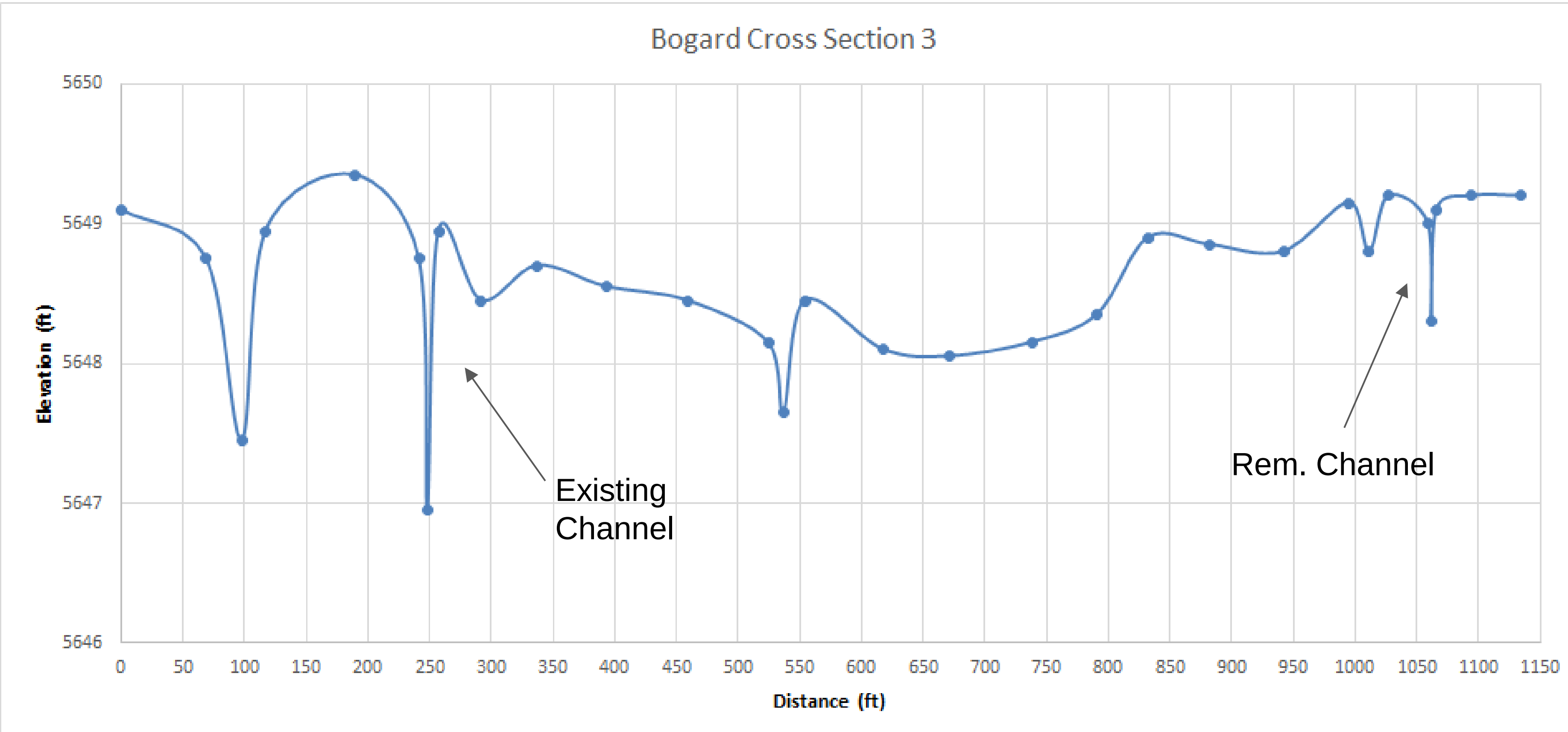
Cross Sections



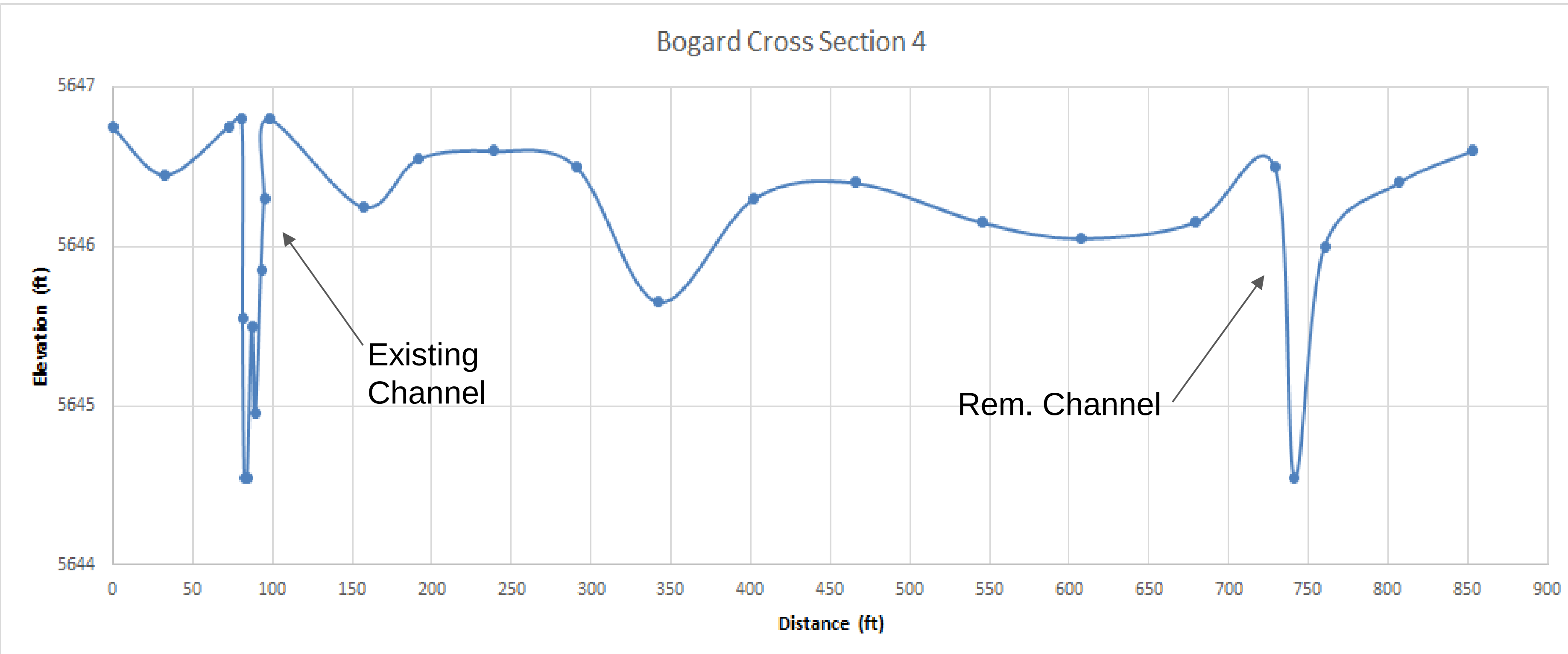

Bogard Cross Section 2
5650
5649
5648
5647
5646
Elevation (ft)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
Distance (ft)
Rem. Channel
Existing Channel



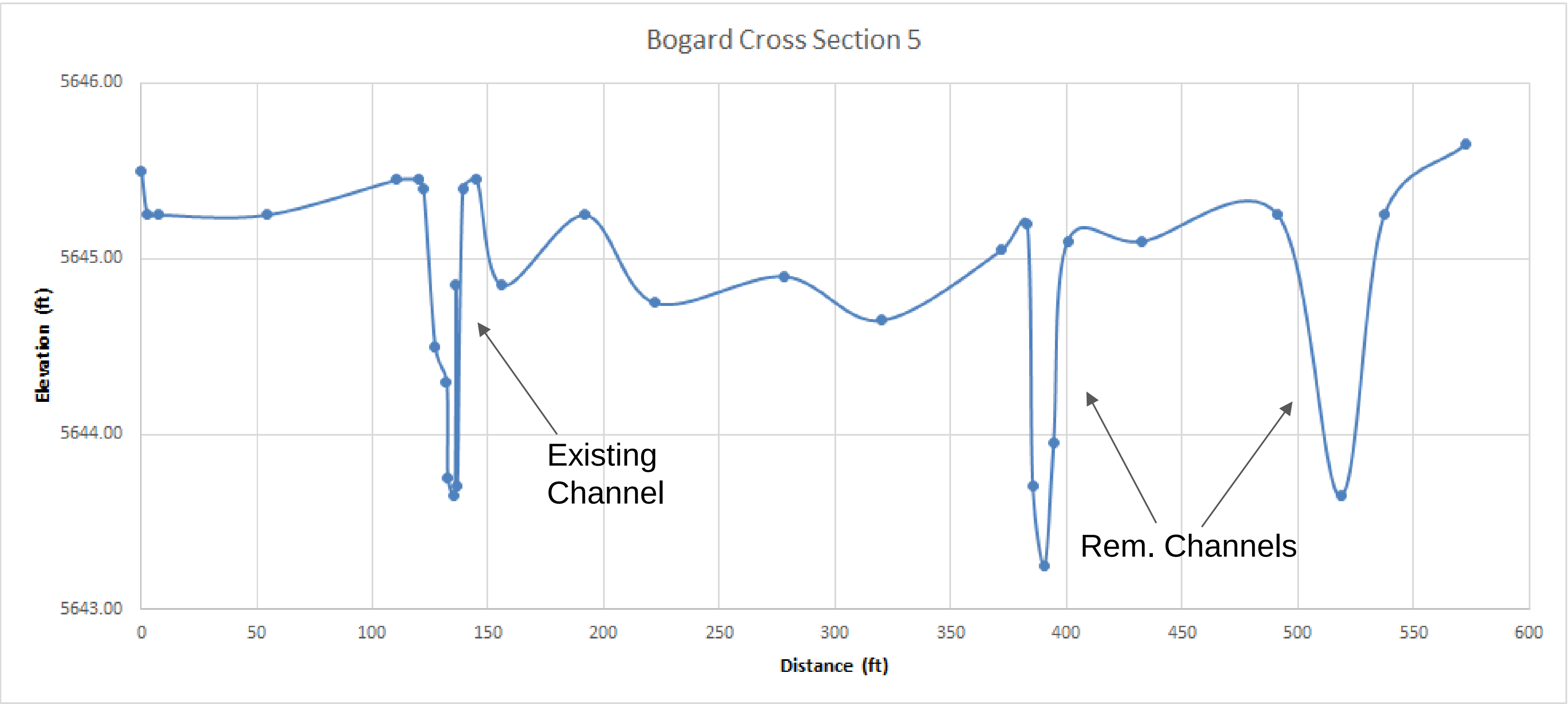
Bogard Cross Section 2B
5649
5648
5647
5646
5645
Elevation (ft)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500
Distance (ft)
Existing Channel
Rem. Channel

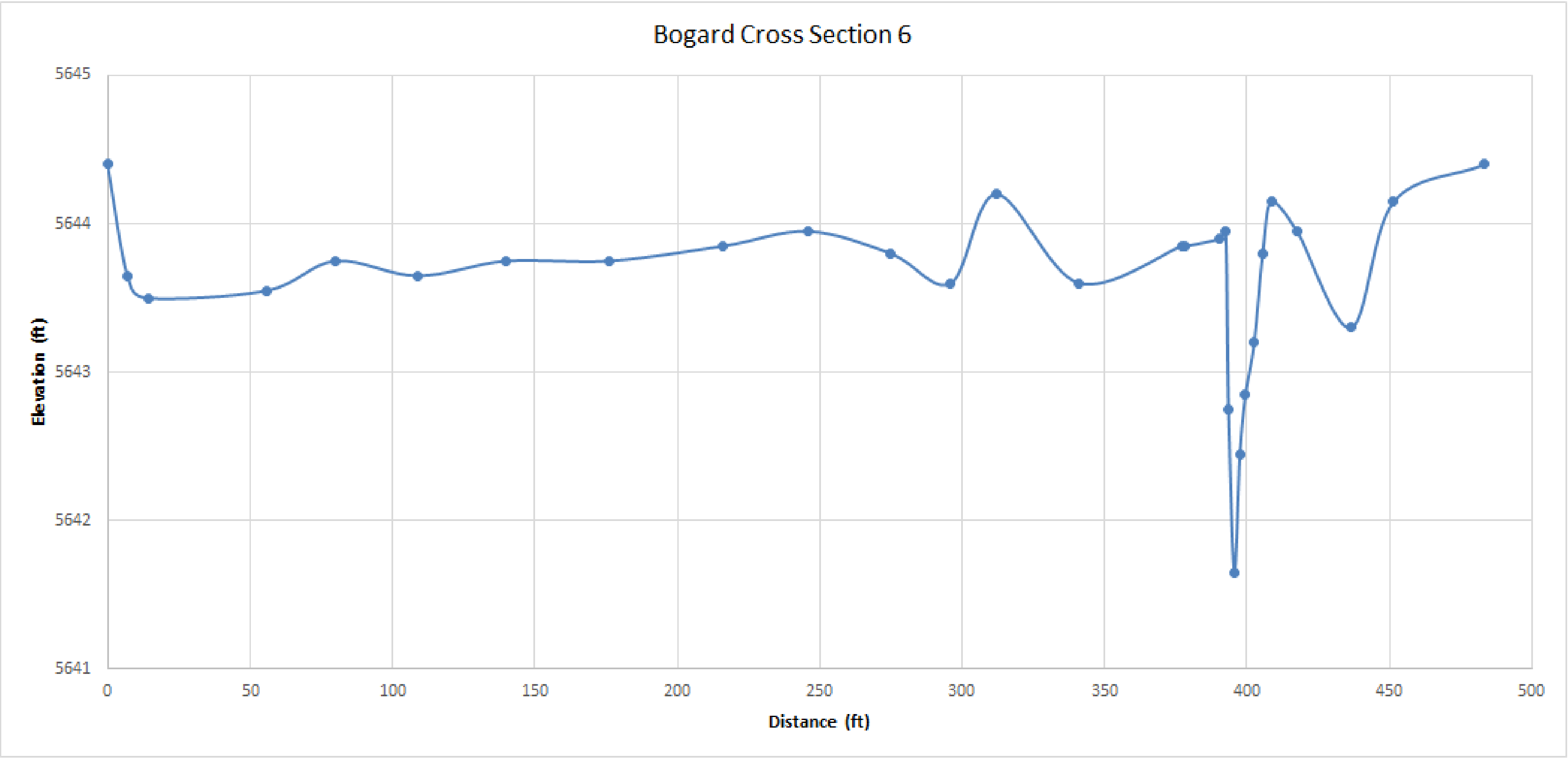


Bogard Cross Section 3
Elevation (ft)
5650
5649
5648
5647
5646
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
Distance (ft)
Existing Channel
Rem. Channel

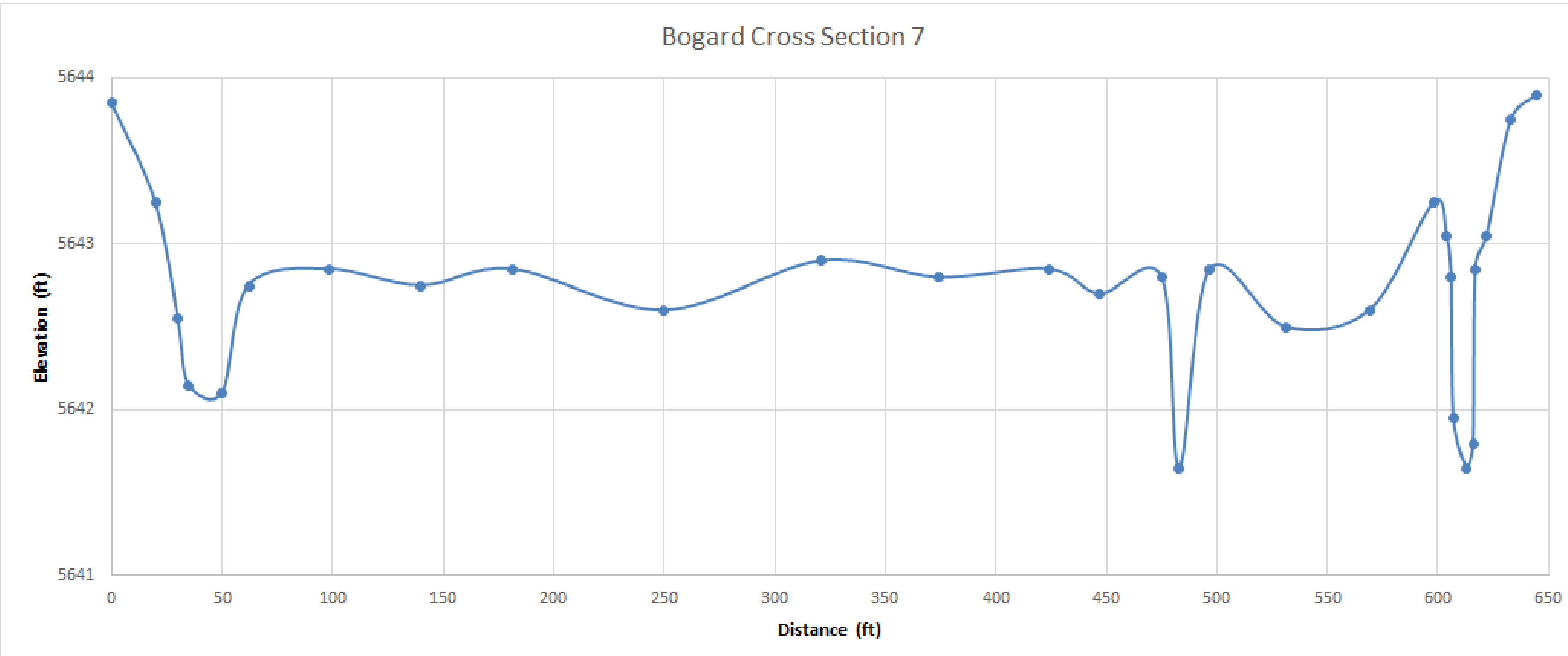


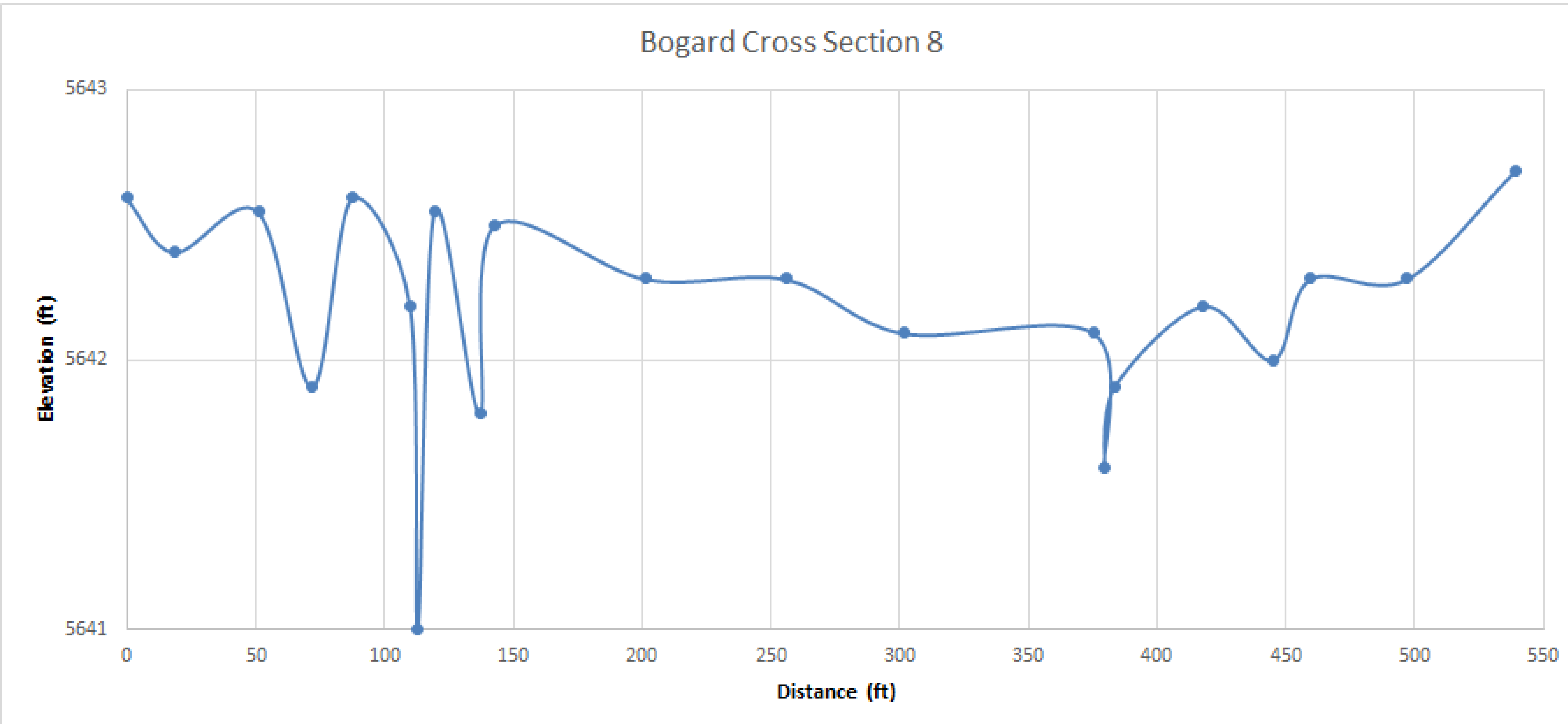
Bogard Cross Section 4
5647
5646
5645
5644
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
Elevation (ft)
Distance (ft)
Existing Channel
Rem. Channel


Bogard Cross Section 5
5646.00
5645.00
5644.00
5643.00
Elevation (ft)
0
50
100
150
200
250
300
350
400
450
500
550
600
Distance (ft)
Existing Channel
Rem. Channels



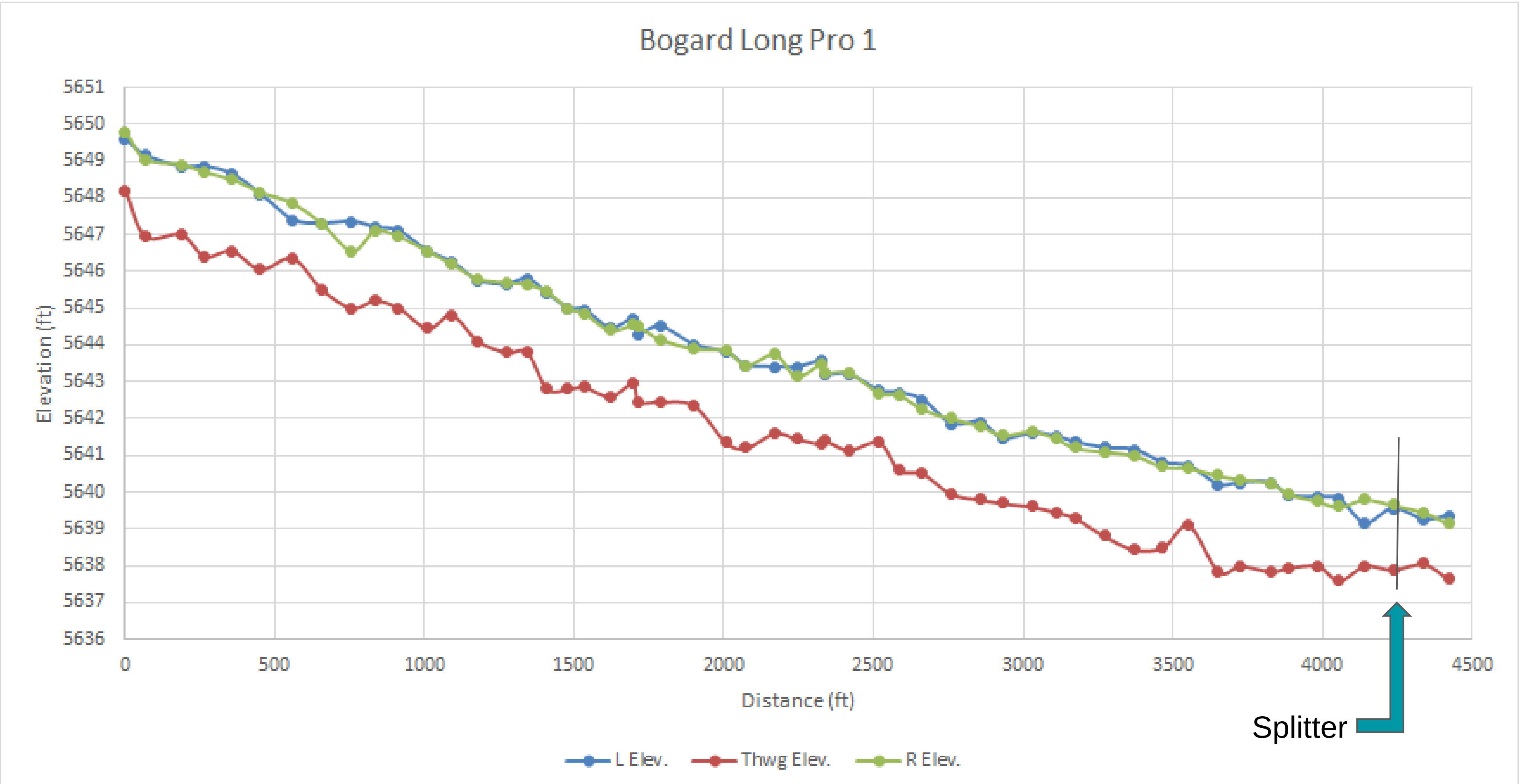
Bogard Cross Section 6
Elevation (ft)
5645
5644
5643
5642
5641
0
50
100
150
200
250
300
350
400
450
500
Distance (ft)


Bogard Cross Section 7
5644
5643
5642
5641
Elevation (ft)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
Distance (ft)


Bogard Cross Section 8
5643
5642
5641
Elevation (ft)
0
50
100
150
200
250
300
350
400
450
500
550
Distance (ft)

Longitudinal Profile

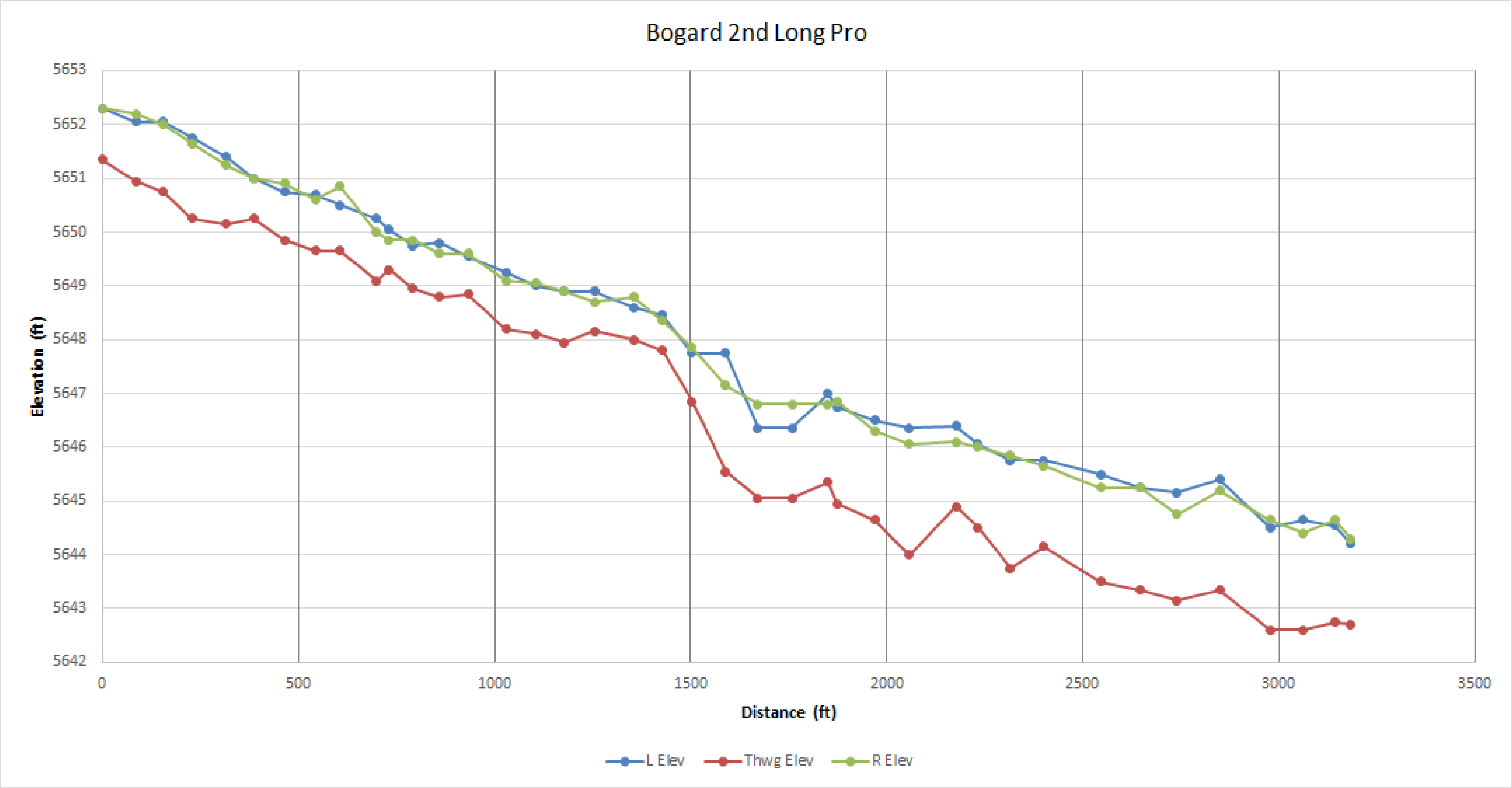
Existing Channel



(thwg. elv. pt. 1 - thwg. Elv. pt. 31)/distance
(5649.8-5639.15)/4421 = **.0024 slope**

Longitudinal Profile 2

Southern/Rem. Channel



(thwg. elv. pt. 1 - thwg. Elv. pt. 31)/distance
(5652.3-5644.3)/3183 = **.0025 slope**

Comparison of XS Area (Project area vs Upstream)

Mean (Outside of Project): **12.8**

Standard Deviation: **5.1**

Mean (Project Area): **18.6**

Standard Deviation: **5.4**

Difference: **5.8 sq. ft. or 32%**

Bogard Meadow

Design Considerations

- Minimal floodplain modification with the exception of old road immediately upstream
- Remnant channel present but degraded in areas
- Existing channel slightly incised
- Good access
- Limited onsite rock present
- Adjacent terrace present

Status & Next Steps

- Discuss design approaches
- Develop concept plan
- CWA has secured initial implementation funds that we can use in 2018/2019

Bogard Meadow

Options for Site

- Riffle augmentation for oversized channels; use remnant channels for a phased approach
- Riffle augmentation for existing channel; don’t phase
- Stabilize eroding banks by resloping areas and planting vegetation

Factors to Consider

- Many choices for riffle augmentation techniques (cobble size rock, alluvium similar size to present, sod clumps, sod burritos)
- Riffles need to have continuity throughout the reach, otherwise water will create nick points and headcut around them or in other low areas
- Potential to phase by aggrading south channel in fall 2018; then direct flow to it in 2019 and aggrade existing channel
- Think about what we might propose upstream for future fixes

Suggested Concept

- Aggrade southern channel in 2018
- Install earthen plug in fall 2019 to direct flow to south channel, then aggrade existing channel
- Remove earthen plug in 2020 and design so existing channel remains as the primary low flow path