Upper Eklutna River Survey

Preliminary
Fish Habitat Flow Assessment

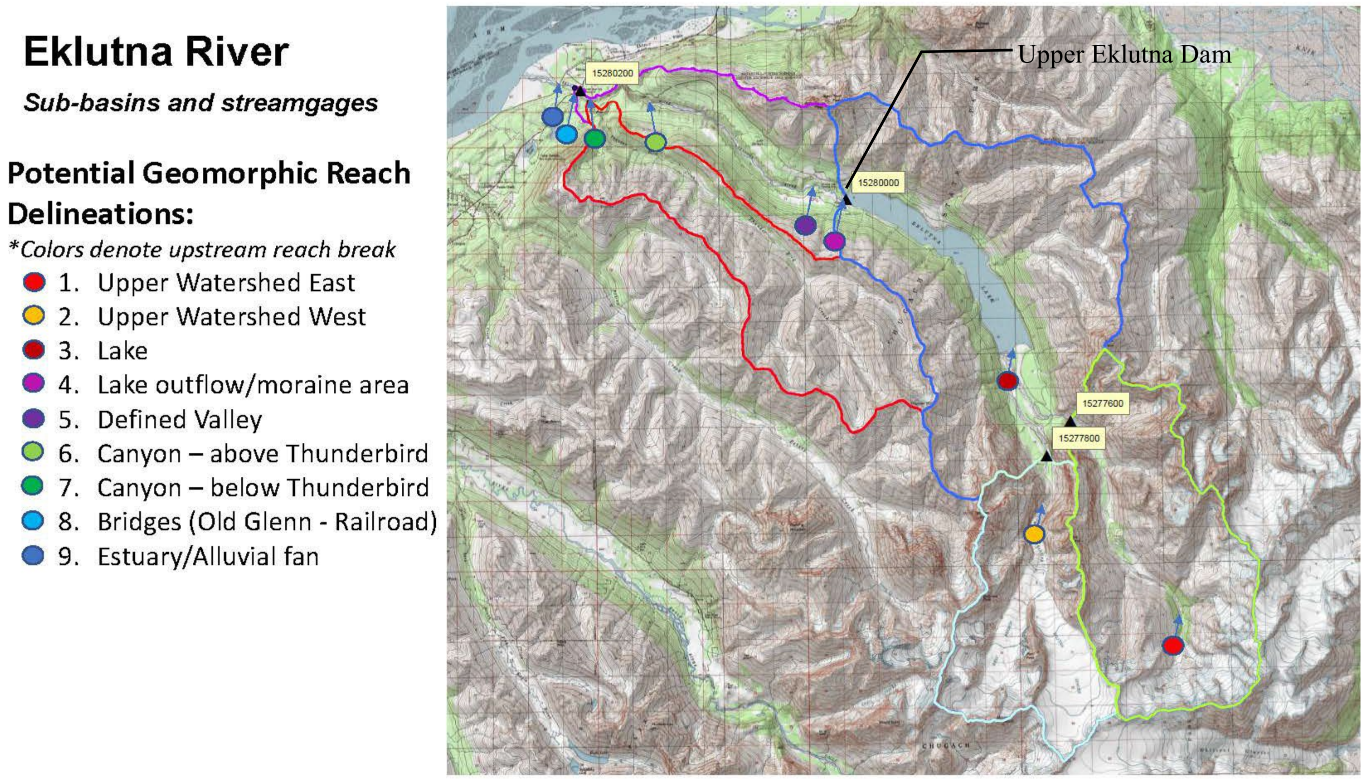
July 14, 2019

Prepared by:
Heather Hanson, P.E. Civil Engineer
U.S. Fish and Wildlife Service
Anchorage Fish and Wildlife Conservation Office
4700 BLM Road
Anchorage, AK 99507

1.0 Introduction

With the removal of the lower Eklutna Dam completed in 2018 the focus of restoration efforts for the Eklutna River has turned to the restoration of spawning and juvenile rearing habitat. Adequate flows would be required to provide spawning and rearing habitat for salmonids in the Eklutna River above the confluence with Thunderbird Creek. Currently, the flow above Thunderbird Falls in the Eklutna River is minimal due to the diversion of the flows at the Upper Eklutna Dam (Figure 1).

Figure 1. Map of the Eklutna Watershed (Prepared by Crane Johnson, NOAA, 2018).

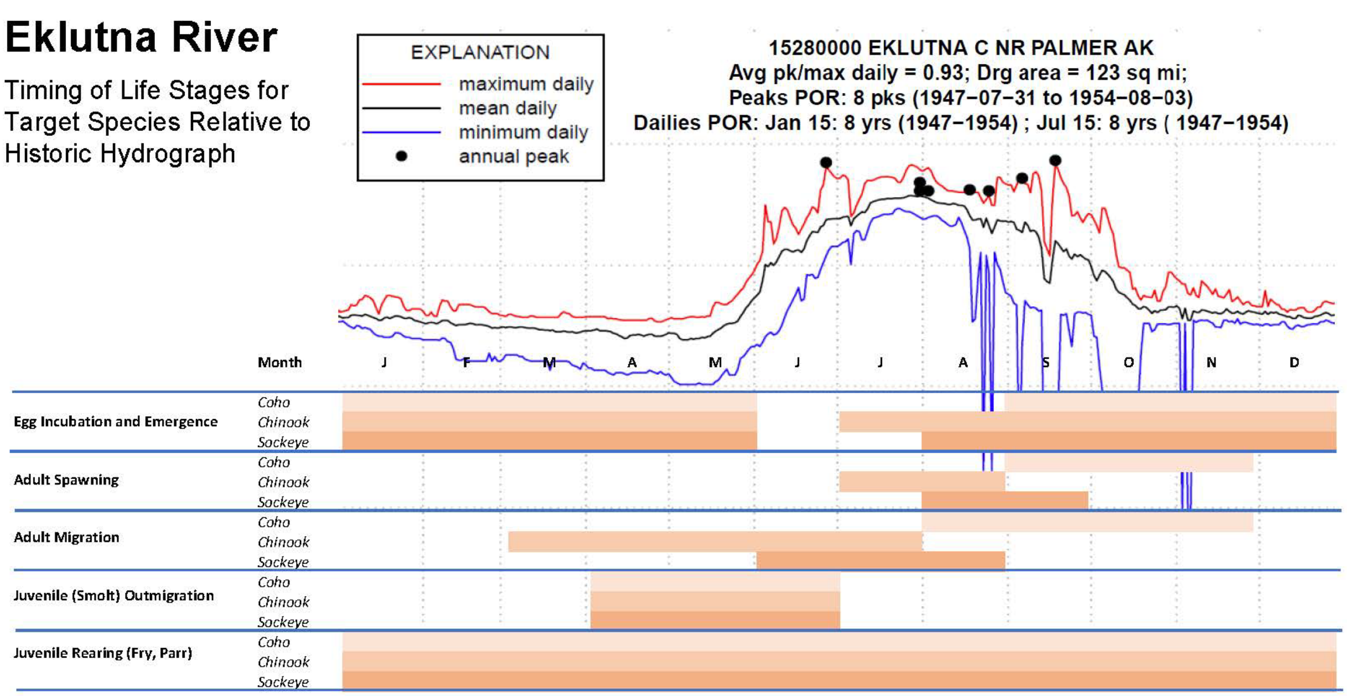


The goal of this assessment is to initiate the groundwork for a thorough survey, assessment and model of the available habitat in the Eklutna River watershed with restored instream flows. The preliminary flows presented in this document should not be construed as a final recommendation for flows needed to support salmon habitat in the Eklutna River. Study reach assessments were conducted between the upper and lower Eklutna Dams (Figure 3), in a preliminary effort to provide information that may guide future analysis of flow requirements for salmonids. As discussions move forward, a full hydraulic model (HEC-RAS or similar) should be developed for the full length of the Eklutna River as well as an overall habitat survey conducted prior to final recommendations concerning flow. Estes and Osborne (1986) present several methods for determining instream flow requirements and these methods should be evaluated and compared to this analysis to determine the most appropriate method for determining instream flow requirements in the Eklutna watershed.

The flows predicted by this assessment are based on projected channel characteristics given the current conditions in the study reach. In the long term, after flows are increased in the river, an adaptive management approach would best optimize the available habitat for salmonids in the Eklutna River watershed. An adaptive management framework was laid out in July 2018, at a three day restoration-focused workshop with participants from the Eklutna Tribal Conservation District (ETCD), the US Fish and Wildlife Service (USFWS), the National Oceanic and Atmospheric Administration (NOAA), the US Geological Service (USGS), the Alaska Department of Fish and Game (ADFG) and Trout Unlimited (TU).

This flow assessment uses the channel characteristics of the study reach just below the upper Eklutna Dam to estimate the discharge needed to provide fish habitat in the historical channel for salmonid spawning and incubation. Coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*Oncorynchus tshawytscha*) and sockeye salmon (*Oncorhynchus nerka*) were selected as the target species for restoration efforts. Figure 2 shows the life cycle timing for each species that was compiled based on the results of the 2018 restoration workshop. The design fish for this flow assessment has been conservatively selected as adult Chinook salmon as Chinook have the highest depth requirements for spawning and migration (Smith, 1973, Evans and Johnston, 1980).

Figure 2. Timing of Life Stage for Target Species Relative to Historic Hydrograph (Compiled by Eklutna Restoration Workshop, 2018)

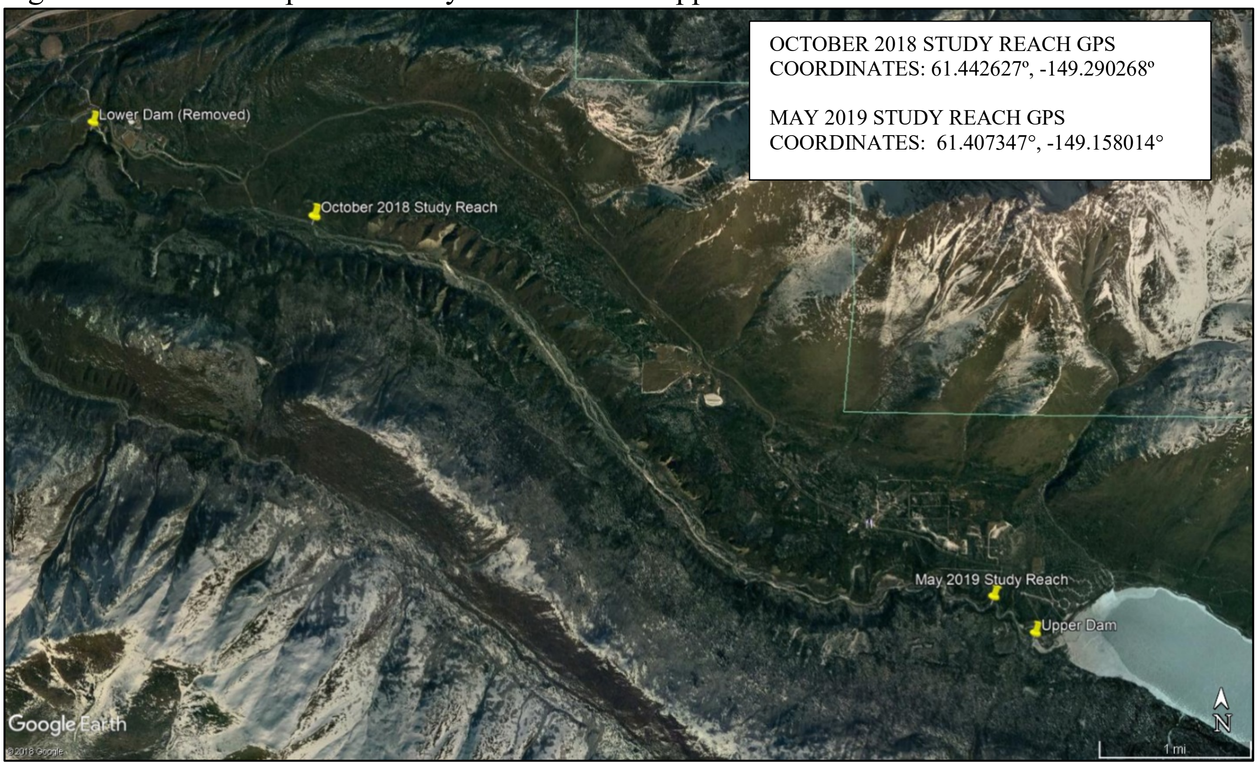


1.1 Survey Description

USFWS and ETCD collected data on an initial study reach 6.4 miles below the upper dam in October 2018 and a second study reach 0.5 mile below the upper dam in May 2019 (Figure

3). The October 2018 survey data showed that aggradation had occurred in the lower study reach. The flow estimated for the bankfull channel cross sections did not correlate well with the historical pre-dam records. The bankfull slope was significantly higher than the present day thalweg slope which also points to channel evolution and aggradation. Due to our observations at the initial October 2018 study reach, the investigators decided to conduct a second survey above the major sediment sources in order to analyze channel characteristics in an area of the river that would be less likely to be impacted by aggradation.

Figure 3. Location map of the study reaches on the upper Eklutna River



For the May 2019 survey, personnel from USFWS and ETCD completed five cross sections, pebble counts and a longitudinal profile. Three additional partial cross sections were surveyed that did not capture bankfull elevations and thus were not used in the analysis. The study reach was located approximately 0.5 mile downstream of the upper dam location. This site was selected for the purpose of estimating the discharge at various depths necessary for fish spawning and incubation habitat. This reach location was chosen because it is upstream of several alluvial fans which have contributed a large volume of sediment to the channel between the upper and lower dams (Figure 4). The data for the May 2019 survey is available in Appendix A. The remainder of this report will focus on the results from the May 2019 study reach.

1.2 Survey Observations

The reach surveyed was 2,000 feet long, and streambanks denoting historic bankfull elevations were visible in several locations along the reach (Figure 5). Portions of the channel in the study reach were completely dry during the survey so water surface elevations were not collected. The channel was impacted by a road embankment between station 1800 and station 2000 and bankfull features were not readily discernable in this area. Based on the data gathered, the study reach was classified as a Rosgen C3 stream type which equates to a cobble dominated alluvial channel characterized by point bars and a well-defined floodplain. The results of the survey indicate the historic channel had a bankfull slope of 0.008 ft/ft[1] in this reach.

Figure 4. One of several alluvial fans that contributes sediment to the Eklutna River.

Five full cross sections were collected, four different locations in riffles and one pool. Cross sections five and six were chosen as representative riffle cross sections for the purposes of estimating flow (Table 1). The upper part of the reach had several side channels and therefore did not provide a satisfactory single thread cross section for calculating bankfull flow. A sketch map of the study reach and graphical representation of all of the cross section elevations are available in Appendix A. Pebble counts were conducted at the cross sections in order to estimate the channel roughness and corresponding flows. For a pebble count the sieve size that will pass 84% of the material is known as the D84 size and has been shown to be one predictor of channel roughness and discharge (Rosgen, 2007).

[1] For non-entrenched streams, bankfull is the height on the streambanks where water flow fills the channel and begins to spread out onto the flood plain. The bankfull slope is the slope of the imaginary water surface along the longitudinal profile at the bankfull stage.

Table 1. Cross section channel geometry, pebble count, D84 and Manning's n

CROSS SECTION RESULTS	RIFFLE AT XS5	RIFFLE AT XS6
BANKFULL AREA (SF)	273	228
BANKFULL WIDTH (FT)	104	95
MEAN BANKFULL DEPTH (FT)	2.6	2.4
INCUBATION XS AREA (SF)	29	31
SPAWNING XS AREA (SF)	68	65
D84 (MILLIMETERS)	172	140
MANNING'S N (D84)	0.047	0.044
MANNING'S N BY STREAM TYPE	0.042	0.042

Figure 5. May 2019 study reach looking upstream.

1.3 Survey Analysis and Results

Analysis of the survey compared the geomorphology of the surveyed reach to existing flow records by cross-sectional analysis. Based on the eight years of pre-dam records from 1947-1954 at the upper Eklutna River gage (USGS ID 15280000), bankfull at a 1.5 to 2 year interval was estimated to be between 1527-1682 cfs in the predevelopment historical channel.[2] A 1.5 to 2 year flood interval was selected as this return interval correlates to the typical flow events where bankfull occurs in natural rivers. The bankfull discharge

[2]See Appendix B for the hydrologic analysis based on the unregulated flows in the upper Eklutna River.

calculated for the two cross sections surveyed ranged from 1222 to 1635 cfs. These values correlate well with the historical gage data. These bankfull flow values have been used to estimate future flushing flows needed to move sediment throughout the Eklutna river system as bankfull flows are generally responsible for the majority of sediment transport in a natural river system. However, additional flushing flows will likely be needed initially to move the large amount of sediment that has accumulated in the last 60-70 years. In the future, higher flushing flows to simulate larger flood events may be needed every few years to maintain habitat quality.

From the cross-sectional survey information gathered, Manning's equation was used to calculate estimated flow volumes at various depths. Cross sections five and six were taken in a riffle where flow vectors would typically be parallel to allow the application of Manning's equation to calculate uniform flow in an open channel. Manning's n was calculated based on both D84 and the stream type. Until instream flows are increased and sediment transport is reactivated in the channel, we do not have high confidence in the the Manning's n value determined from D84. For this reason, Manning's n was also estimated using the Rosgen stream type (Rosgen, 2007). This range of n values were used to calculate the range of minimum, maximum and average flows shown in Table 2. Actual Manning's n values should be calibrated with flow measurements after flow has been returned to river and sediment has been sufficiently flushed through the system.

Analysis was performed for a potential future flow scenario through the surveyed cross sections with a minimum water depth of 0.8 feet for spawning and 0.1 feet for incubation and rearing for Chinook salmon applied as determined by Moyle (2002), OSGC (1963), Thompson (1972), and DeVries (1997). Based on the life cycle chart in Figure 2, spawning flows were assumed to be required for 120 days and incubation flows for 214 days of the year. Flows were allowed to drop to a minimum low flow depth of 1.0 feet above the thalweg for adult salmon migration for one month of the year (Evans and Johnston, 1980). A flushing flow equivalent to the bankfull flow was assumed for 24 hours on an annual basis. As the channel was dry in some areas during the survey no contribution from groundwater was used for the flow calculation.

Using these assumptions and parameters, the values calculated are shown in Table 2 and provide a preliminary estimate of the range of flows needed in this reach to provide the depths noted above in potential spawning habitat.

Table 2. Estimated range of flow required for spawning and incubation

FLOW REGIME	SPAWNING (120 DAYS PER YEAR)	INCUBATION (214 DAYS PER YEAR)	MIGRATION (30 DAYS PER YEAR)	BANKFULL (1 DAY PER YEAR)	INSTREAM FLOW REQUIRED (MEAN DAILY VALUE)
	CFS	CFS	CFS	CFS	CFS
AVERAGE	206	61	24	1402	109
MAX	253	65	28	1635	128
MIN	181	58	20	1222	99

1.4 Future Needs

In order to determine the amount of flow that is needed to provide fish habitat along the length of the river, additional cross sections should be collected to represent all potential habitat and reach variations. If the channel width and slope changes along the length of the river, the amount of flow to maintain fish habitat may increase. In addition to these initial estimates, a sediment transport model should be constructed to ensure that the flow regime chosen provides sediments suitable for spawning. Lastly, a habitat survey should be conducted to estimate the available rearing habitat. The flow depths used in this assessment would only address spawning and incubation habitat for Chinook salmon and are likely not indicative of other salmonid species or rearing habitat needs.

References

DeVries, P. 1997. Riverine salmonid egg burial depths: review of published data and implications for scour studies. Can. J. Fish. Aquat. Sci. 54: 1685-1698.

DWR and USBR. 2000. Effects of the Central Valley Project and State Water Project on Steelhead and Spring-Run Chinook Salmon. California Department of Water Resources; U.S. Bureau of Reclamation.

Burner, C.J., 1951. Characteristics of spawning nests of Columbia River salmon. US Department of the Interior.

Evans, W.A., and B. Johnston. 1980. Fish migration and fish passage. USDA Forest Service, EM-7100-12, Washington D.C. 63 pp. plus appendices.

Estes, Christopher C. and Osborne, John F. 1986. Review and Analysis of Methods for Quantifying Instream Flow Requirements, Water Resources Bulletin, American Water Resources Association.

Moyle, P. B. 2002. Salmon and Trout, Salmonidae - Chinook Salmon, (Oncorhynchus tshawytscha) in Inland Fishes of California. Los Angeles, California: University of California Press, 251-263.

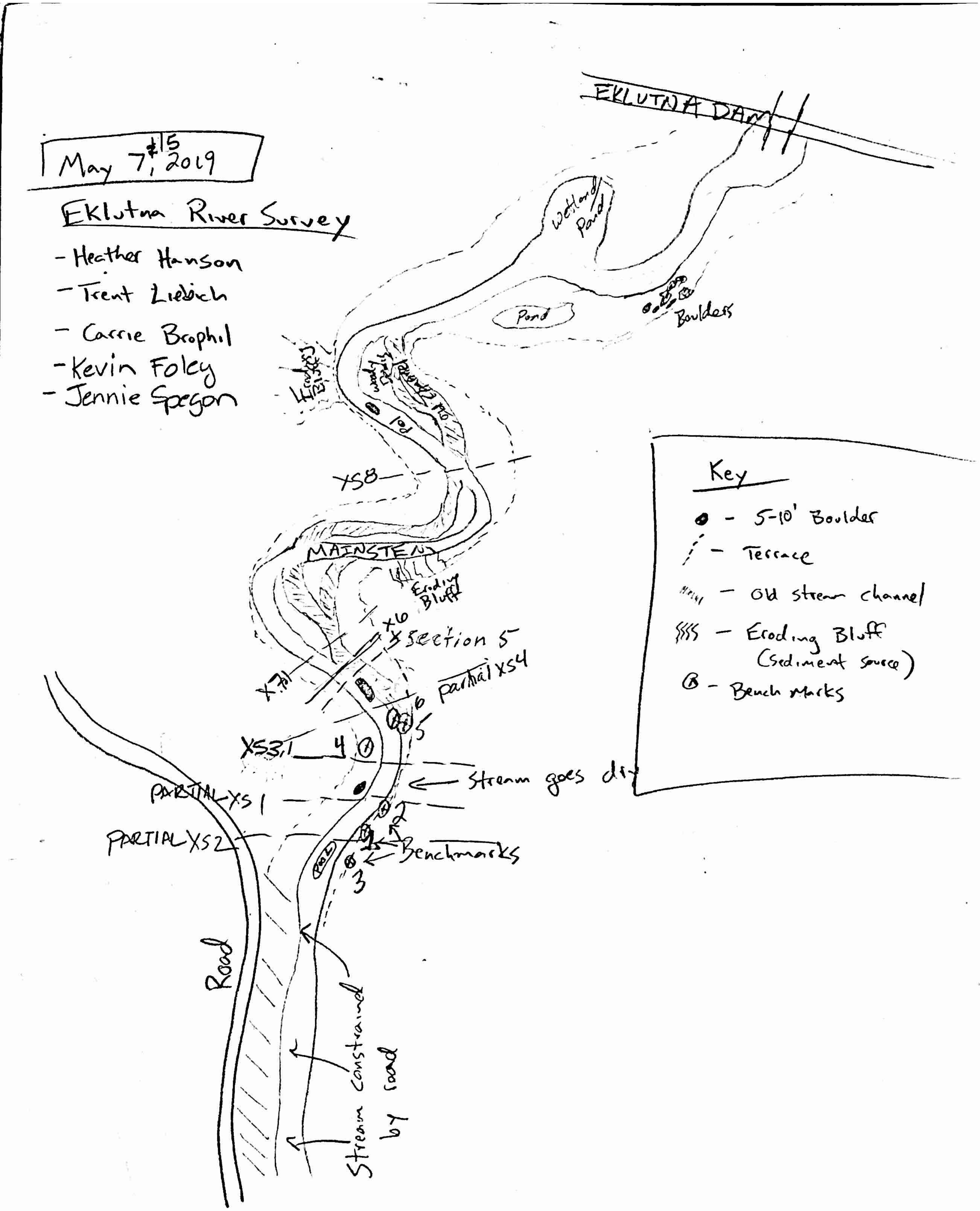
Oregon State Game Commission (OSGC). 1963. The fish and wildlife resources of the middle Willamette basin, Oregon, and their water use requirements. Report submitted to the State Water Resources Board, Portland. 27 p.

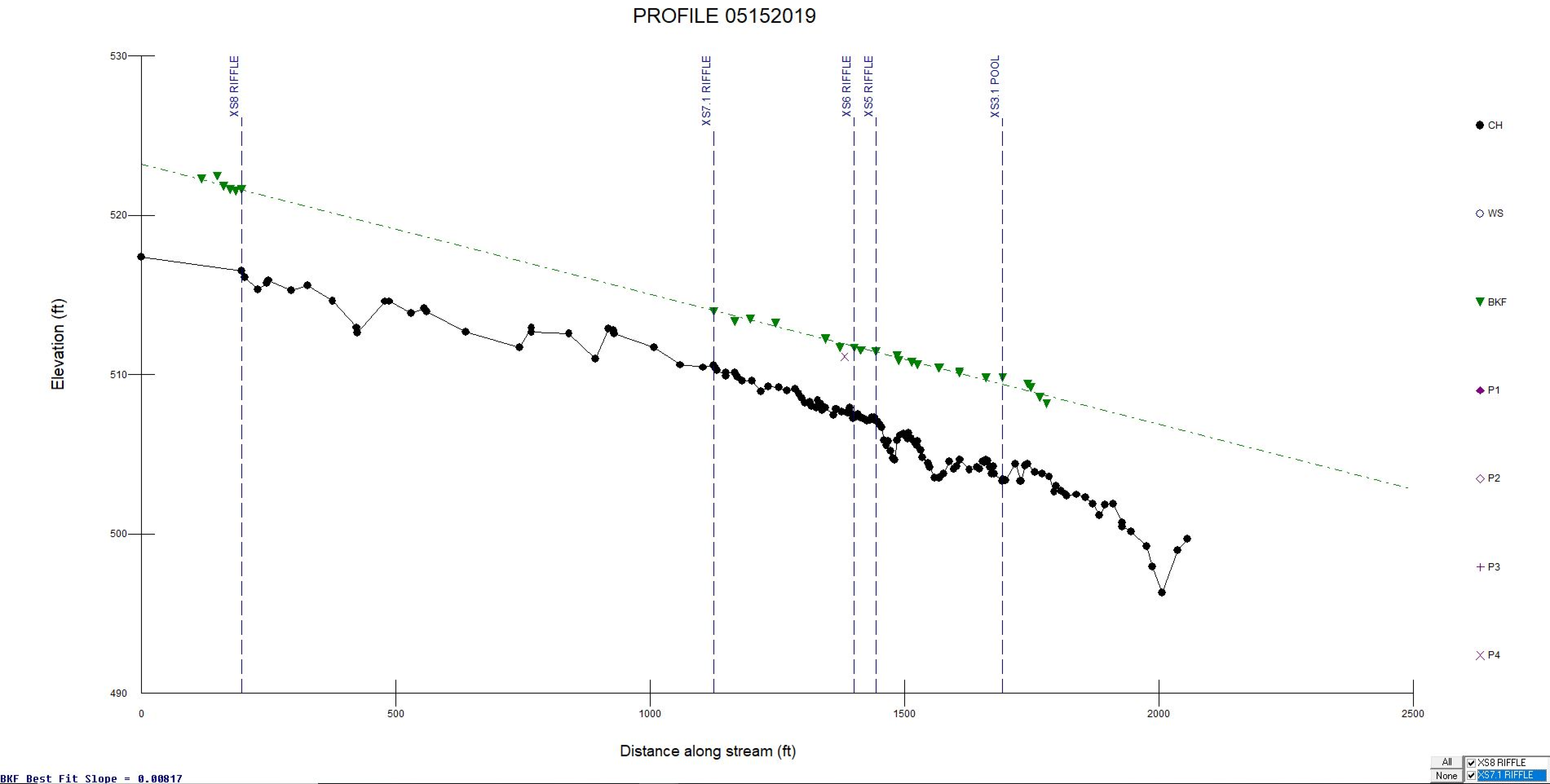
Rosgen, D.L. 2007. In Part 654 Stream Restoration Design National Engineering Handbook (210-VI-NEH), J. Bernard, J.F. Fripp & K.R. Robinson (Eds.). USDA Natural Resources Conservation Service, Washington, D.C. Retrieved from: https://wildlandhydrology.com/resources/

Thompson, K.E. 1972. Determining stream flows for fish life. Proceedings of the instream flow requirements workshop, Pacific Northwest River Basins Commission, Portland, Oregon, 31-50.

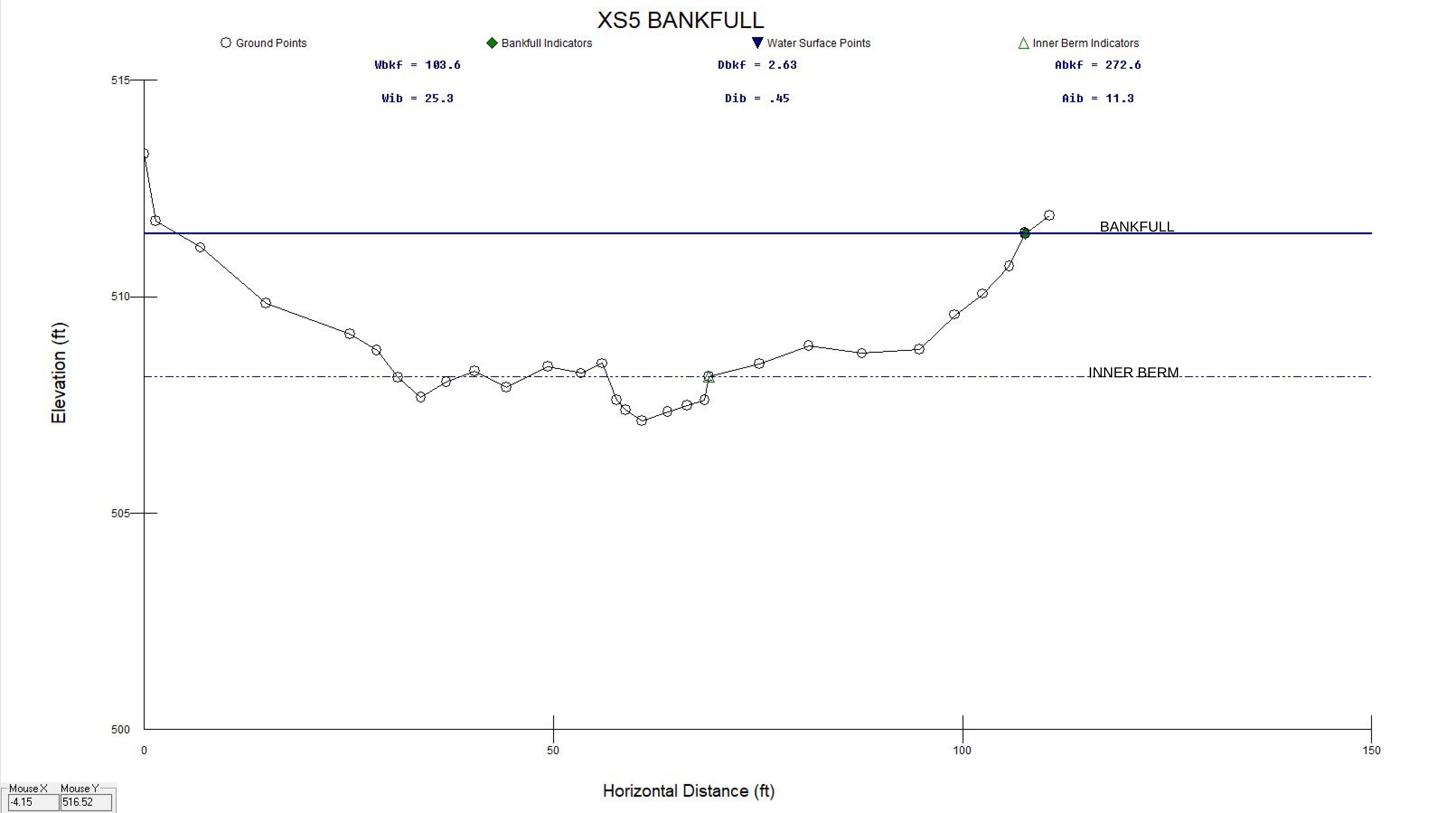
HDR, DRAFT Lower Eklutna Sediment Study, Revised November 2016

APPENDIX A

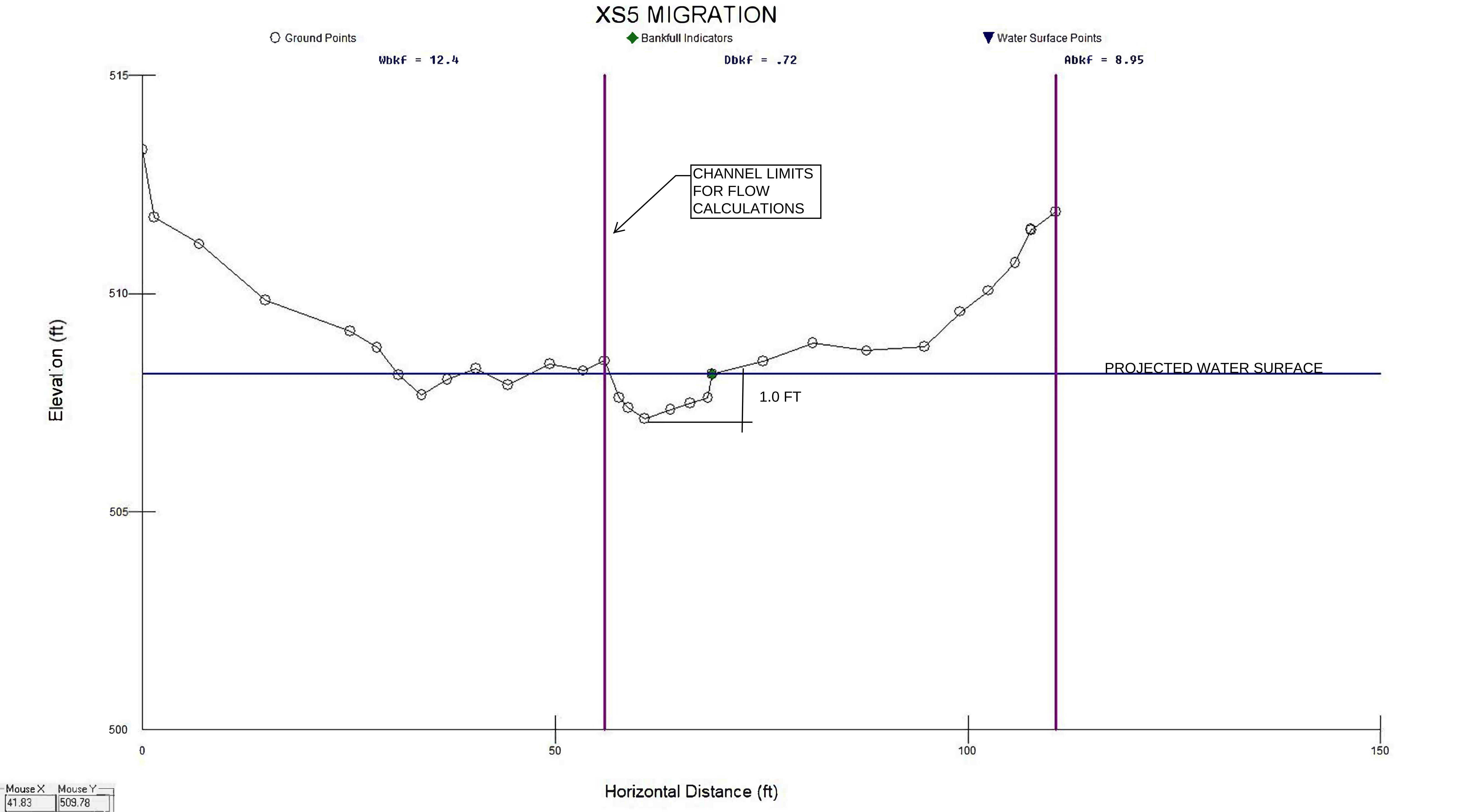


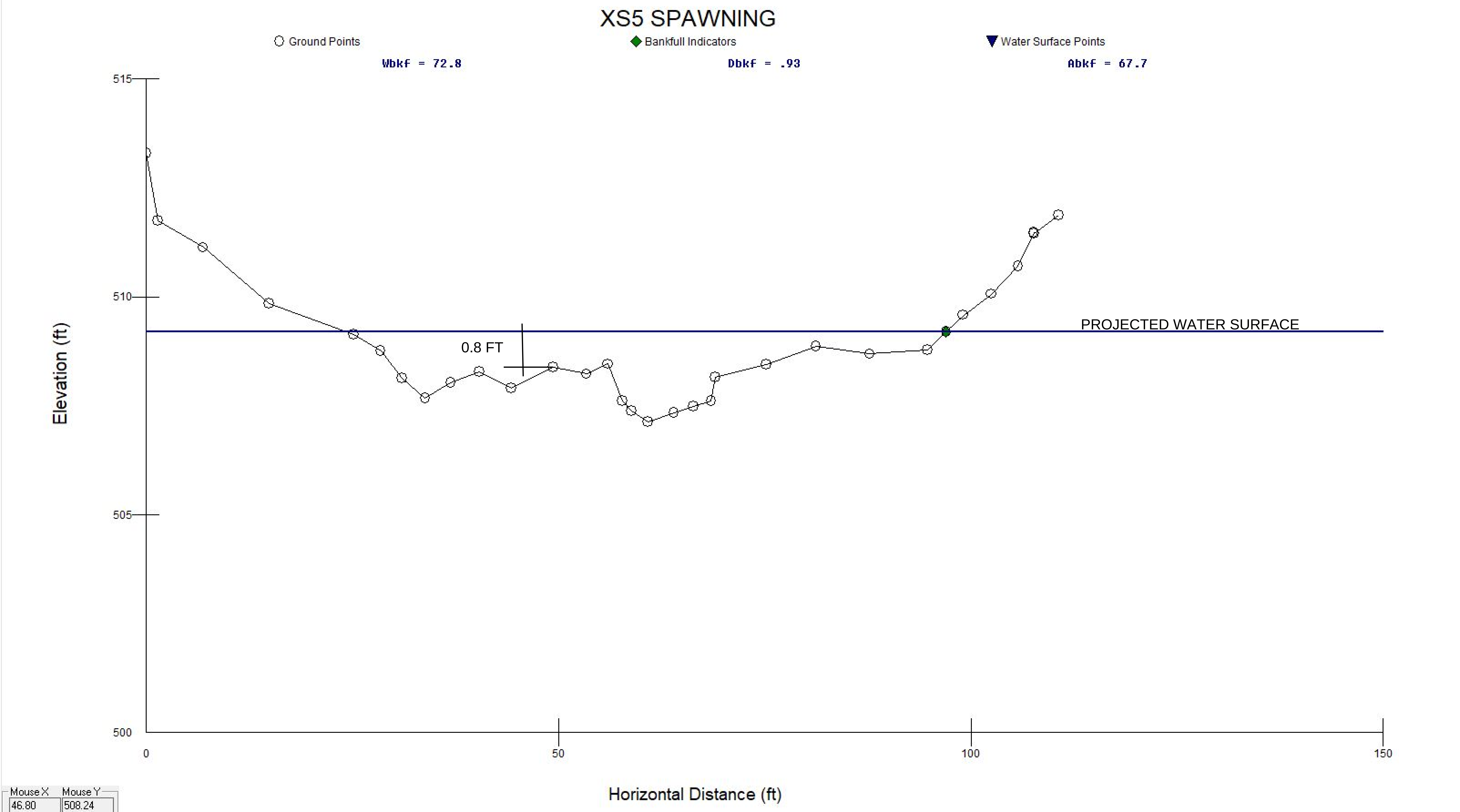


BKF Best Fit Slope = 0.00817

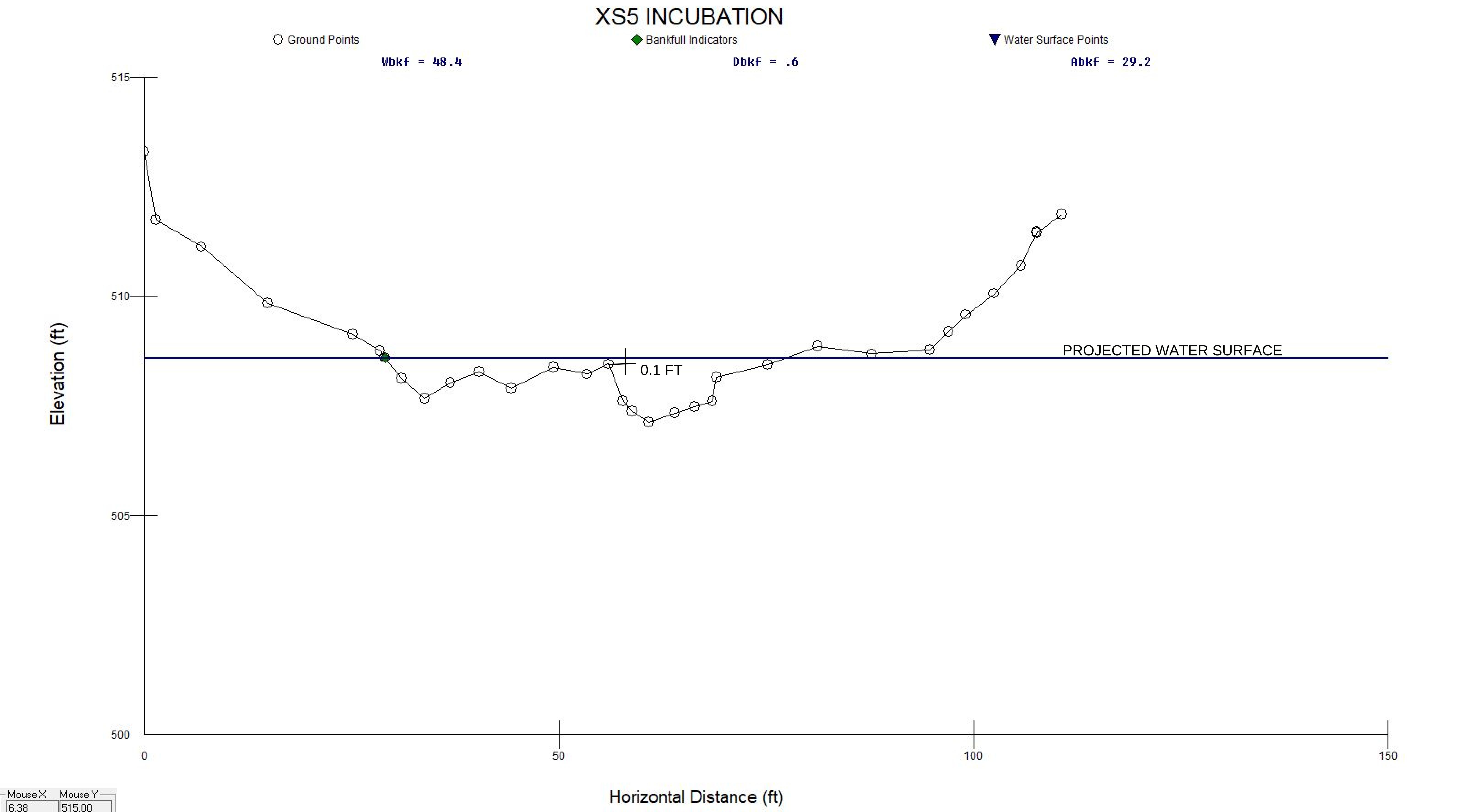


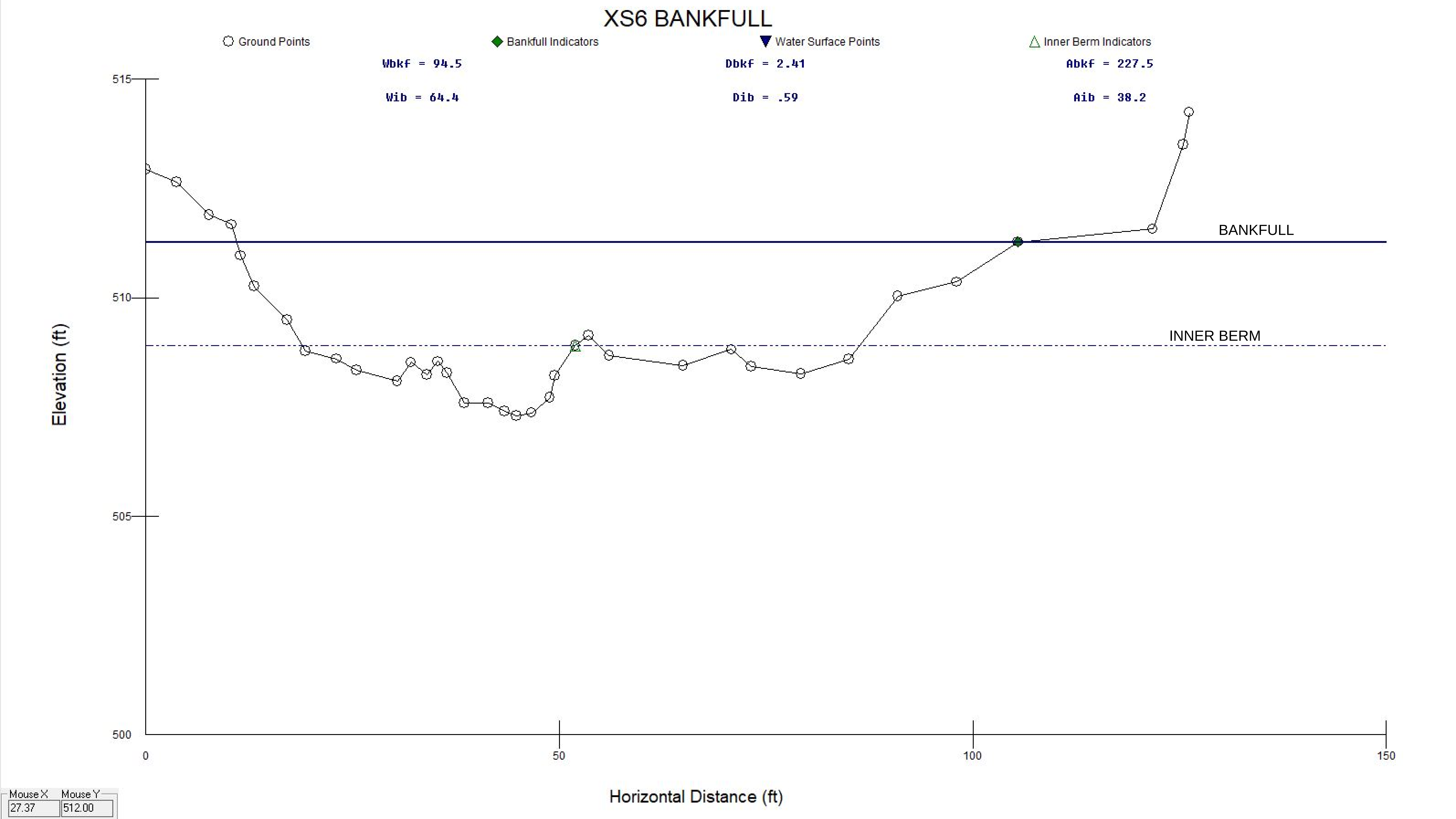
XS5 BANKFULL
Ground Points
Bankfull Indicators
Water Surface Points
Inner Berm Indicators
Wbkf = 103.6
Dbkf = 2.63
Abkf = 272.6
Wib = 25.3
Dib = .45
Aib = 11.3
515
510
505
500
Elevation (ft)
BANKFULL
INNER BERM
0
50
100
150
Horizontal Distance (ft)
Mouse X
-4.15
Mouse Y
516.52

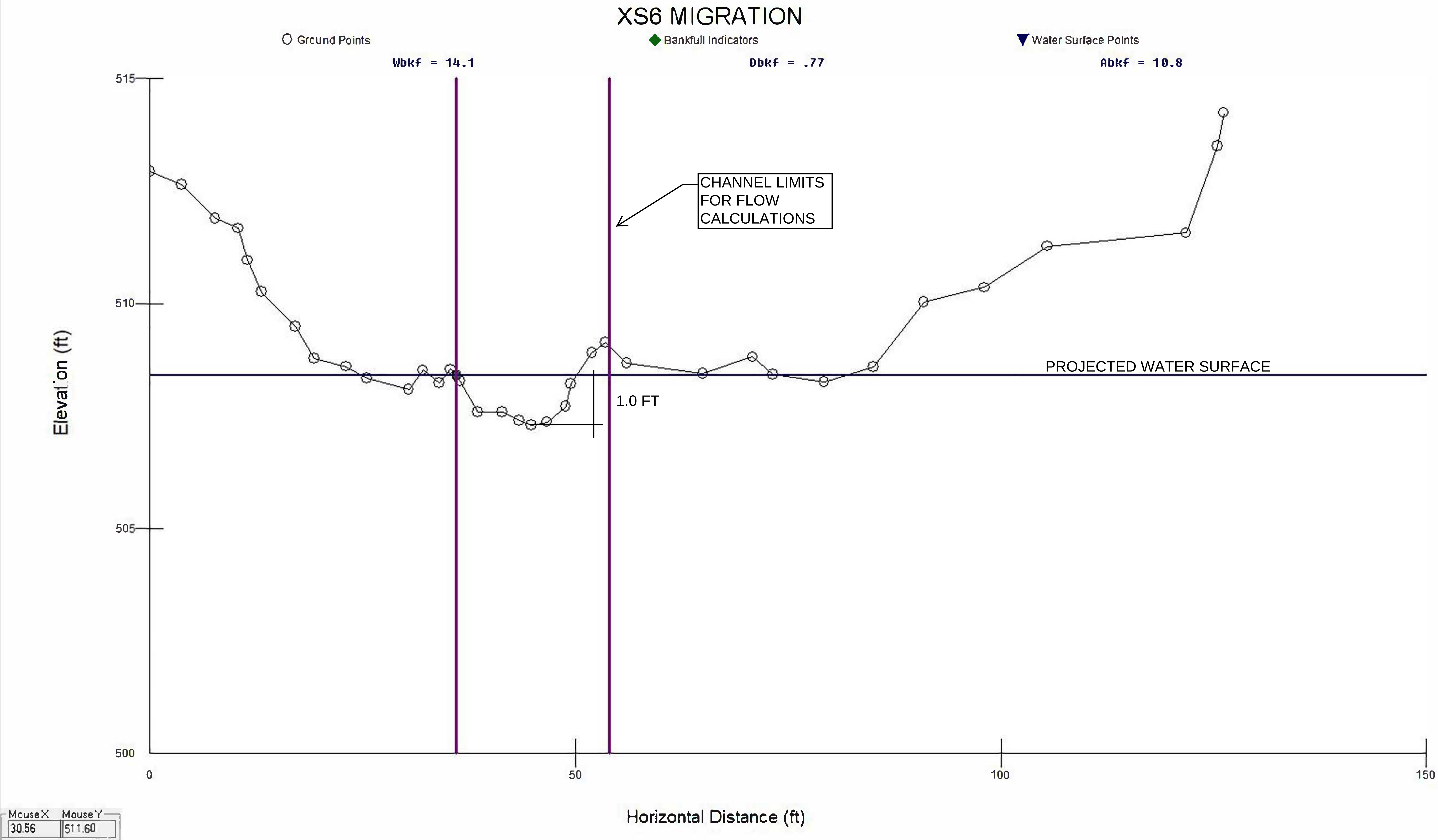

XS5 MIGRATION
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 12.4
Dbkf = .72
Abkf = 8.95
CHANNEL LIMITS
FOR FLOW
CALCULATIONS
PROJECTED WATER SURFACE
1.0 FT
515
510
505
500
0
50
100
150
Elevation (ft)
Horizontal Distance (ft)
Mouse X
41.83
Mouse Y
509.78

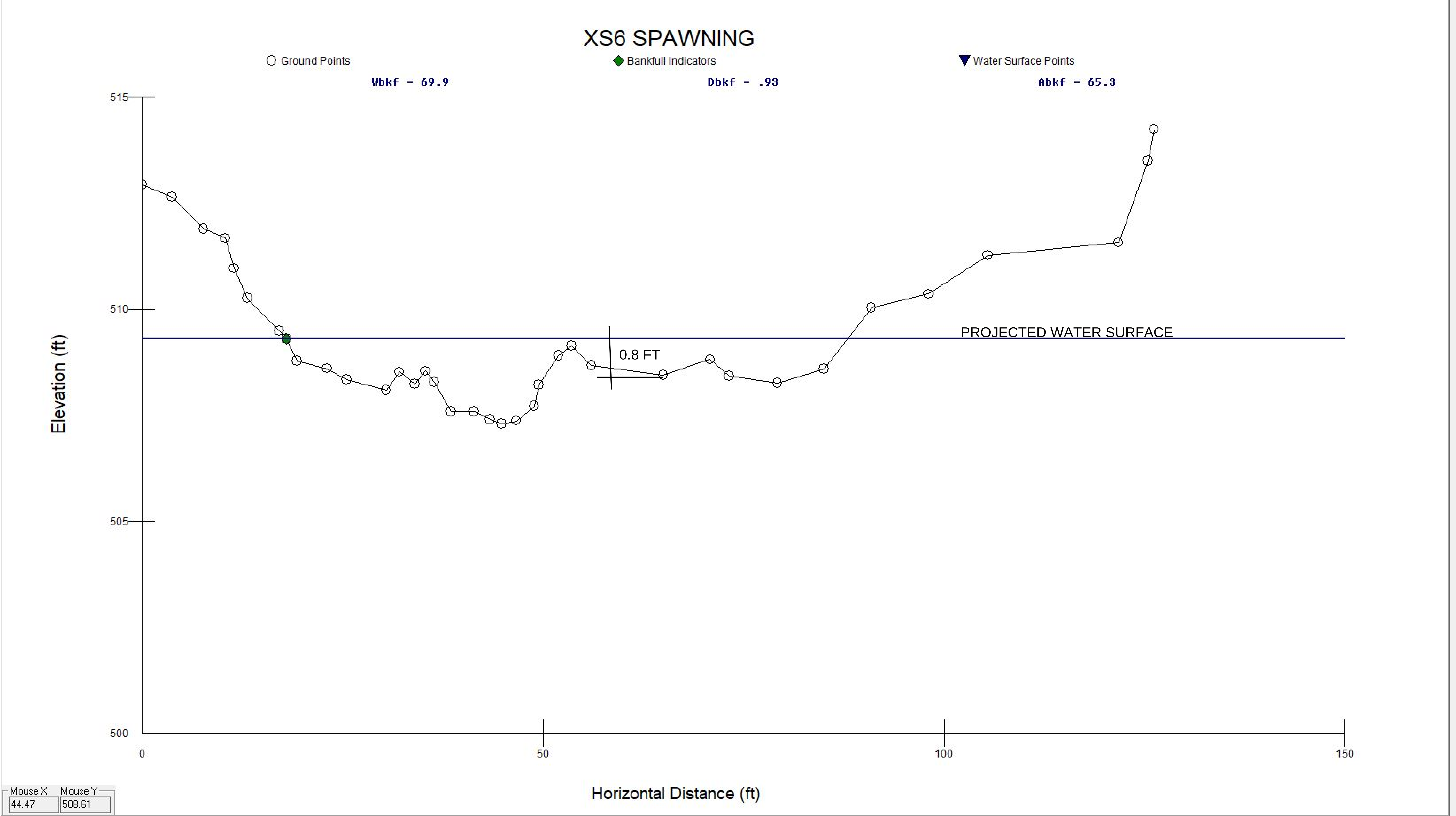


XS5 SPAWNING
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 72.8
Dbkf = .93
Abkf = 67.7
PROJECTED WATER SURFACE
0.8 FT
Elevation (ft)
515
510
505
500
0
50
100
150
Horizontal Distance (ft)
Mouse X
Mouse Y
46.80
508.24

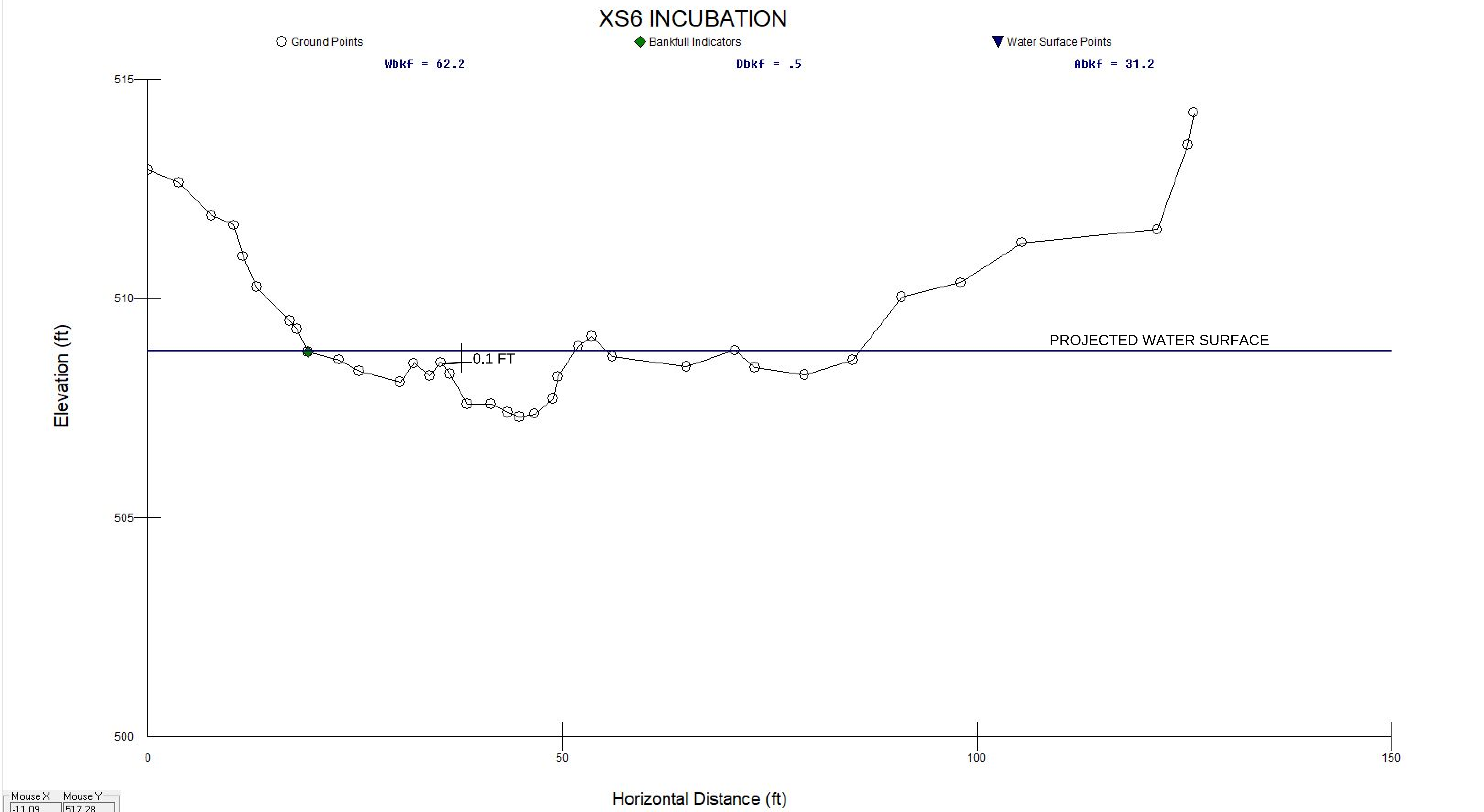

XS5 INCUBATION
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 48.4
Dbkf = .6
Abkf = 29.2
PROJECTED WATER SURFACE
0.1 FT
Elevation (ft)
515
510
505
500
0
50
100
150
Horizontal Distance (ft)
Mouse X
Mouse Y
6.38
515.00


XS6 BANKFULL
Ground Points
Bankfull Indicators
Water Surface Points
Inner Berm Indicators
Wbkf = 94.5
Dbkf = 2.41
Abkf = 227.5
Wib = 64.4
Dib = .59
Aib = 38.2
BANKFULL
INNER BERM
Elevation (ft)
515
510
505
500
0
50
100
150
Horizontal Distance (ft)
Mouse X
Mouse Y
27.37
512.00


XS6 MIGRATION
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 14.1
Dbkf = .77
Abkf = 10.8
CHANNEL LIMITS FOR FLOW CALCULATIONS
PROJECTED WATER SURFACE
1.0 FT
Elevation (ft)
515
510
505
500
0
50
100
150
Horizontal Distance (ft)
Mouse X
30.56
Mouse Y
511.60

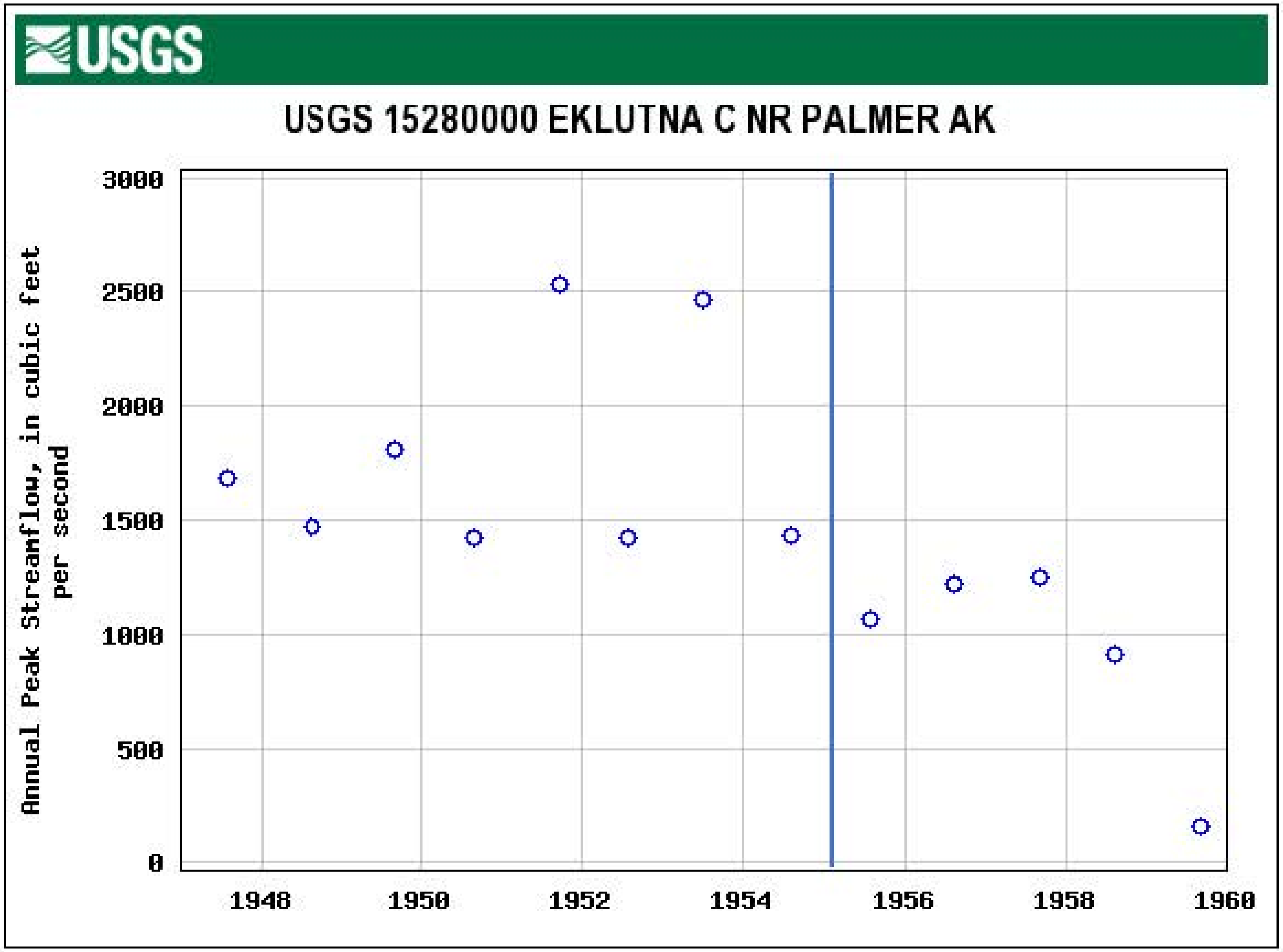


XS6 SPAWNING
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 69.9
Dbkf = .93
Abkf = 65.3
515
510
505
500
Elevation (ft)
PROJECTED WATER SURFACE
0.8 FT
0
50
100
150
Horizontal Distance (ft)
Mouse X
Mouse Y
44.47
508.61


XS6 INCUBATION
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 62.2
Dbkf = .5
Abkf = 31.2
515
510
505
500
Elevation (ft)
PROJECTED WATER SURFACE
0.1 FT
0
50
100
150
Horizontal Distance (ft)
Mouse X
Mouse Y
-11.09
517.28

Peak streamflow, Lake outlet

Peaks considered unregulated prior to 1955



APPENDIX B

Eklutna River Peak Flow Estimates – USGS Gage 15280000

July, 1947 – August, 1954

Franklin Dekker, USFWS Hydrologist
11/20/2018

Peak analysis included the 8 peak flow observations of Eklutna River prior to flow diversion to the Knik River began in December 1954. The gage record was analyzed with the USGS Bulletin 17B Log Pearson III technique for fitting the frequency distribution in USGS' PeakFQ software under various skew coefficients. A total of 5 skew coefficients were tested included station skew, generalized skew from USGS Bulletin 17B maps, a regional skew estimate from Curran et al. 2016 and 2 weighted average skew values.

The #5 estimate table below that used a skew value generated from the weighted average of a literature based regional skew and the station skew was chosen as the ideal flow estimates. The station skew estimates (#1) were not ideal because the peak flow record is less than 10 observations, which is outside the lower bound of the Bulletin 17B method for analysis and results in increased uncertainty. The generalized skew value used in #2 and #3 tables was derived from the Bulletin 17B skew map, however better estimates of skew are available from regional skew values in the literature (Curran et al. 2016). The #4 estimates used the skew value published in the literature (Curran et al. 20016). Ultimately the weighted regional skew result (#5) was selected as the preferred method because it used a weighted average between the station skew unique to the Eklutna River prior to flow diversion and a regional skew value from the literature. The regional skew valued was calculated from 75 gages in the central part of the Alaska that each had at least 25 peak flow observations (Curran et al. 2016).

1) Station Skew

Uses skew derived from the peak flow record.

Skew = 0.960

Recurrence Interval	Annual Exceedance Probability	Bull. 17B Estimate (cfs)	95% Confidence interval Lower (cfs)	95% Confidence interval Upper (cfs)
1.005	0.995	1146	789.4	1366
1.01	0.99	1169	815.9	1387
1.05	0.95	1252	915.5	1468
1.1	0.9	1313	989.3	1528
1.25	0.8	1407	1103	1624
1.5	0.6667	1518	1238	1748
2	0.5	1665	1408	1933
2.33	0.4292	1737	1486	2035
5	0.2	2081	1805	2622
10	0.1	2395	2043	3280
25	0.04	2833	2336	4354
50	0.02	3192	2556	5347
100	0.01	3580	2782	6526
200	0.005	4000	3016	7926
500	0.002	4612	3342	10180

2) Generalized Skew

Uses skew derived from the USGS Bulletin 17B skew map.

Skew= 0.700

Recurrence Interval	Annual Exceedance Probability	Bull. 17B Estimate (cfs)	95% Confidence interval Lower (cfs)	95% Confidence interval Upper (cfs)
1.005	0.995	1084	718.6	1308
1.01	0.99	1116	754.9	1337
1.05	0.95	1225	882.3	1441
1.1	0.9	1298	970.8	1513
1.25	0.8	1405	1101	1623
1.5	0.6667	1527	1249	1759
2	0.5	1682	1427	1957
2.33	0.4292	1756	1506	2063
5	0.2	2096	1817	2650
10	0.1	2391	2040	3271
25	0.04	2788	2307	4235
50	0.02	3102	2502	5088
100	0.01	3432	2697	6065
200	0.005	3781	2896	7183
500	0.002	4276	3165	8914

3) Weighted Skew

Uses the weighted average of the Bulletin 17B Map derived skew and station skew.

Skew = 0.780

Recurrence Interval	Annual Exceedance Probability	Bull. 17B Estimate (cfs)	95% Confidence Interval Lower (cfs)	95% Confidence Interval Upper (cfs)
1.005	0.995	1103	740.1	1325
1.01	0.99	1132	773.4	1353
1.05	0.95	1233	892.2	1449
1.1	0.9	1303	976.2	1517
1.25	0.8	1405	1102	1623
1.5	0.6667	1524	1245	1755
2	0.5	1677	1421	1949
2.33	0.4292	1750	1500	2054
5	0.2	2091	1813	2642
10	0.1	2392	2041	3275
25	0.04	2802	2316	4273
50	0.02	3130	2519	5168
100	0.01	3477	2723	6205
200	0.005	3848	2932	7405
500	0.002	4377	3219	9287

4) Regional Skew (Curran et al 2016)
Uses a regional skew value from Curran et al. 2016 (Regional Skew Area 1).
Skew = 0.54

Recurrence Interval	Annual Exceedance Probability	Bull. 17B Estimate (cfs)	95% Confidence Interval Lower (cfs)	95% Confidence Interval Upper (cfs)
1.005	0.995	1047	676.5	1272
1.01	0.99	1084	718.9	1308
1.05	0.95	1209	863.2	1425
1.1	0.9	1290	960.7	1505
1.25	0.8	1405	1101	1623
1.5	0.6667	1533	1256	1766
2	0.5	1693	1438	1971
2.33	0.4292	1768	1518	2080
5	0.2	2103	1823	2664
10	0.1	2386	2037	3261
25	0.04	2758	2287	4158
50	0.02	3045	2467	4928
100	0.01	3342	2645	5790
200	0.005	3650	2822	6754
500	0.002	4080	3060	8207

5) Weighted Regional Skew
Uses the weighted average of the Curran et al. 2016 Regional Skew 1 skew and station skew.
Skew = 0.707

Recurrence Interval	Annual Exceedance Probability	Bull. 17B Estimate (cfs)	95% Confidence Interval Lower (cfs)	95% Confidence Interval Upper (cfs)
1.005	0.995	1086	720.4	1309
1.01	0.99	1117	756.5	1339
1.05	0.95	1225	883.1	1441
1.1	0.9	1299	971.2	1513
1.25	0.8	1405	1101	1623
1.5	0.6667	1527	1248	1758
2	0.5	1682	1426	1956
2.33	0.4292	1756	1505	2062
5	0.2	2095	1816	2649
10	0.1	2391	2040	3272
25	0.04	2789	2307	4239
50	0.02	3104	2503	5095
100	0.01	3436	2699	6076
200	0.005	3787	2899	7201
500	0.002	4284	3170	8944

References
Curran, J.H., Barth, N.A., Veilleux, A.G., and Ourso, R.T., 2016, Estimating flood magnitude and frequency at gaged and ungaged sites on streams in Alaska and conterminous basins in Canada, based on data through water year