

MEMORANDUM OF REVIEW

Slope-area measurement of Rito de los Frijoles Creek in Bandelier National Monument, NM (Station Number 08313350) Flood of August 21, 2011

Peak discharge for flooding of the Frijoles Creek in Bandelier National Monument (Sta. No. 08313350) was computed by four-section slope-area analysis. The flood occurred August 21, 2011, and site surveying was conducted August 24-27, 2011 by personnel from the National Park Service, New Mexico Environment Department, and the USGS. The survey notes are not available for this review. Computation of the indirect measurement was done by Anne Tillery (USGS). The computed peak discharge was 6,775 cfs (gage height 11.44 feet; gage datum). Drainage area at the gage is 17.5 mi².

Nine cross sections were surveyed in the above and downstream of the gage; total reach length was 214 feet. High water mark (HWM) elevations were not available for this analysis, only the regression lines of the HWM. However, discussion of the HWMs is provided in the analysis. An average water-surface profile was drawn through regression line.

No mention is made in the analysis of how the cross-section locations were chosen – presumably based on the plotted HWM profile and channel conditions in the reach. The reach had adequate fall (3.77 feet) in the 234-ft reach. Weighted, composite roughness values were used for each cross section and varied from 0.054 to 0.083). Based on the photographs included in the folder, the magnitude of selected roughness values seems reasonable for the channel conditions.

All reaches were contracting except for sub-reach 20-19 was slightly expanding (Spread = 5%). Reach-length criteria were not satisfied, and total fall was adequate through the reach (greater than velocity head at all cross sections). Sub-reach discharges varied 1.9 to 9.9 percent from the accepted discharge, and Froude numbers indicate sub-critical flow throughout the reach (Froude Nos. ranged from 0.60 to 0.66).

The computational procedure, the computed discharge of 6,775 cfs, and a final quality rating of “fair” (+/-15 percent) appears reasonable.

D. Michael Roark, Surface-Water Specialist
March 12, 2012



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
NEW MEXICO WATER SCIENCE CENTER

Rito de los Frijoles in Bandelier National Monument, NM 08313350
Slope Area Computation
Flood of August 21, 2011

TYPE OF MEASUREMENT – Slope Area computation.

LOCATION OF GAGE – Original crest-stage gage was attached to the outside of the Los Alamos National Laboratory stream gage which was on the right just upstream of the Falls Trail trailhead and at a concrete weir. This gage was destroyed in the August 21 flood. On July 25, 2011 a second gage was installed on a tree on the left bank across from the original gage. This second gage survived the August 21 flood.

DRAINAGE AREA – 17.5 square miles (from adapts).

THEORETICAL DISCHARGES – Discharge: 6,775cfs, Gage height: 11.44 ft (gage datum)

SURVEY OF SITE -- The channel geometry and high water marks were surveyed by Ellen Soles of the National Park Service (NPS) and A. Tillery of the USGS with assistance from Mike Matusche (New Mexico Environment Department), Stephen Monroe (NPS – SCPN) Collin Haffey (NPS) and Stephen Brown (USGS) on August 24 - 27, 2011. The instruments used for the cross-section surveys were a Topcon GTS239 total station used by the NPS and Sokkia Set 3C total station used by the USGS. Both total stations were used with Recon dataloggers equipped with the SurveyPro software. Standard metric fiberglass survey rods and prisms were used. Whenever possible, backsights were established with a tripod and tribrach mounted prism to ensure precision.

Survey was initiated by the NPS and completed by the USGS. Survey set up was therefore according to NPS standards which call for total station data were collected in metric units. The earth curvature adjustment was set to “off” and the applied atmospheric correction (AC) was 60 ppm (based on local elevation and ambient temperature. An arbitrary survey grid was established with its origin set to X=50,000; y=50,000; z= 1,000. Initial processing of total station survey data collected along the Rito de los Frijoles floodplain in Bandelier National Monument

from 8/24/2011 to 8/26/2011 was completed using Terramodel (V. 10.4). Horizontal accuracy was roughly within 1-2 cm in most cases, but only within 0.25 m for points collected near the end the survey. The discrepancy is due to limited detail in field notes, therefore large differences between the early and final shots on 8/27/11 cannot be explained (or corrected).

As much of each transect, stream profile, and high water mark profile were surveyed as possible on each side of the channel from each setup. Due to limited visibility, some high water marks at the far right end of several transects were not surveyed therefore a plot of high water marks is not provided. Water surface elevation was interpolated for the area of missing high water marks using a regression of surveyed high water marks. A plot of the regressed high water mark profile is provided.

Cross sections not surveyed to the water surface edge were extended where necessary using LiDAR data. The total station survey was reported in a local arbitrary coordinate system and adjusted to UTM, NAD83 CORS 96 Geoid03 coordinates using high-resolution control points established with Promark-3 L1-GPS units. The total station data were transformed and rotated using three L1-GPS control points with Underhill Geomatics Copan Lite v11. The transformation RMS error was .057 m, and the angle of rotation was $-71^{\circ}37'19.62''$.

A correction factor of 847.345 m was added to the total station survey height data to convert it to orthometric height using Geoid03 datum (CorGeoid03). The correction factor was calculated by averaging the difference in height between two of the L1-GPS control points and the matching total station survey points. The height differences were less than 1cm between two of the control points. The third control point was excluded from the average height difference because the comparison of two-hour control blocks had inconsistent results, and the elevation of that point was inconsistent with the elevations of the two other control points.

A correction factor of 1.0 m was added to the orthometric height to adjust it to the 2010 LiDAR Tin elevation (G03Lid10El). The 1.0 m correction factor was determined by comparing the differences of a series of total station points taken in the parking lots around the visitor areas of Bandelier National Monument and averaging that difference. The average was 1.01 m, but we are using 1.0 m. Evaluation of total station survey data and corresponding LiDAR data for transects along the Rito de los Frijoles shows close agreement (Figure #).

NATURE OF FLOOD – The flood occurred between 4:00 and 7:00PM on the afternoon of August 21. The early rainfall covered the upper sections of the Frijoles Canyon water shed. The storm then tracked right down the length of Frijoles Canyon until it turned south west around 6:00PM. National Weather Service radar data show

intensities of 1.3 inches per hour and a storm total of 2.3 inches in the hardest hit areas of the canyon. A park service rain gage located on the north rim of the canyon just below the canyon narrows at Ponderosa Campground documented 2.7 inches of rainfall for this storm event.

FIELD CONDITIONS – The upstream end of the reach was near the Visitor's Center parking lot and the lower end was just downstream from the streamflow gaging station. This reach was selected because it is relatively straight and unobstructed and because of its proximity to the streamflow gaging station. The channel has a narrow trapezoidal geometry and is inset 4 to 6 feet below the floodplain. Channel substrate is sand and silt. Overbank areas are heavily vegetated with riparian woodlands (ponderosa, cottonwood, box elder and various shrubs and grasses). The high water marks and debris lines were clear and easy to locate however; surveying was complicated by the dense tree cover.

CROSS SECTIONS – Cross sections were numbered from 12 (downstream) to 20 (upstream). Cross section 15 was discarded as plan view documentation showed that it was heavily skewed with respect to the stream line. Cross sections were subdivided into multiple subareas for differences in roughness in the channel and overbank areas. Main-channel cross section bed material was composed of silt and sand. Photographs were taken of each cross section. Roughness coefficients were selected based on, channel morphology, channel substrate, and overbank vegetation and ranged from 0.02 to 0.15. Because the flow in the overbank area was deeper than 1/5 the depth of the channel in most places, the n values were weighted for each cross section. The weighted n values ranged from 0.054 to 0.083. The total distance of the reach modeled for the slope-area computation is 383 ft. A longer reach was not possible because the channel curved sharply just beyond the ends of this reach.

COMPUTATIONS – The U.S Army Corps of Engineers, Hydrologic Engineering Center HEC-RAS computer software was used by the NPS to compute flow consistent with water surface elevations. The slope for the computation was computed as (.0155 ft/ft). The stream gage is located at cross section 13. The USGS Slope Area Computation program was used by the USGS to compute flow consistent with the water surface elevations.

A visual examination of the plan view plot shows that the channel width decreases significantly downstream of cross section 16. Because of the abrupt channel constriction and possible flow regime change associated with this constriction, only cross sections 20-16 were used in the final analysis despite the sacrifice of a longer reach.

Final discharge obtained by using the 4 section formula. $Q = 6,775$

Reach	Q	Percent diff.	opening	spread
XS20 - XS19	6916	2.1	expanding	5
XS19 - XS18	6229	8.0	contracting	0
XS18 - XS17	6653	1.8	contracting	0
XS17 - XS16	7451	9.9	contracting	0

EVALUATION OF RESULTS. – Percent differences between reach computations and summary computation ranges from 1.8 percent to 9.9 percent. Length of entire reach is 234 feet. Total fall is 3.77 feet which exceeds the velocity head for each reach. Each two section reach falls exceeds the recommended fall of 0.5 ft.

Cross Section	Area	Top Width	Average Depth	Froude number
20	887	211	4.20	0.66
19	932	207	4.50	0.60
18	905	186	4.86	0.60
17	883	194	4.55	0.63
16	831	164	5.07	0.64
AVERAGE DEPTH			4.64	

Reach length (234 ft) is less than than $75 \times$ Average depth ($4.64 \times 75 = 348$).
Total reach XS20 – XS16 is slightly expanding (spread = 1).

PREVIOUS COMPUTATIONS

Date	Measurement type	Gage height	Discharge
07/05/1977	Slope Area	5.02	654
07/27/1977	Slope Area	3.88	397
08/29/2007	Slope-Conveyance	4.62	623

REMARKS – The highest percent difference between two section discharges and the total discharge was 9.9% for a fair rating but because of the short reach length the measurement should be rated as fair.

Prepared by: Anne C. Tillery Date: February 15, 2012

Checked by: Date:

Reviewed by:

Date:

SAC -USGS slope-area program Ver 97-01

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Echo input data file

5 section

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XS    XS16 349.94
GR    9.82,6060.03 10.96,6059.94 11.61,6059.93 12.35,6059.9 14.7,6059.61
GR    15.53,6059.45 15.95,6059.34 16.29,6059.16 18.05,6058.66 20.42,6058.47
GR    22.84,6058.35 24.11,6057.69 25.94,6057.26 27.53,6057.44 27.72,6057.45
GR    29.41,6057.15 29.49,6057.12 29.85,6057.21 30.72,6057.32 31.74,6057.34
GR    32.86,6057.36 33.27,6057.32 33.5,6057.32 34.73,6057.41 34.86,6057.42
GR    34.87,6057.42 34.88,6057.42 37.2,6057.55 37.93,6057.42 38.74,6057.44
GR    39.46,6057.3 40.62,6057.46 41.03,6057.54 41.48,6057.51 42.61,6057.49
GR    43.19,6057.54 43.61,6057.55 44.58,6057.43 45,6057.45 45.29,6057.43
GR    46.59,6057.53 47.41,6057.67 48.2,6057.66 48.38,6057.66 48.63,6057.64
GR    49.87,6057.49 51.05,6057.28 51.23,6057.25 51.52,6057.26 51.92,6057.25
GR    53.23,6057.37 54.13,6057.19 54.99,6057.32 60.82,6055.37 61.72,6054.76
GR    80.39,6051.79 92.44,6050.75 116.15,6049.97 121.15,6048.9
GR    125.49,6047.46 128.85,6047.05 134.89,6046.12 138.73,6044.93
GR    142.85,6044.99 145.39,6045.11 146.29,6045.71 147.98,6046.73
GR    151.14,6047.82 152.15,6048.22 158.71,6049.67 161.97,6049.36
GR    174.89,6049.54 183.22,6050.27 189.38,6051.63 204.31,6051.87
GR    206.1,6052.23 206.85,6052.21 207.26,6052.2 208.85,6052.27
GR    210.47,6052.39 211,6052.46 212.25,6052.52 212.62,6052.54
GR    215.04,6052.47 215.08,6052.46 215.09,6052.46 215.11,6052.46
GR    216.34,6052.21 217.36,6052.55 217.65,6052.53 218.26,6052.36
GR    218.98,6052.76 219.17,6052.85 219.96,6053.03 220.6,6053.19
GR    221.41,6053.38 221.67,6053.53 222.71,6054.22 224.33,6054.87
GR    224.88,6055.37 226.73,6055.86 227.41,6055.87 227.85,6056 228.19,6056.0
GR    228.78,6056.09 228.89,6056.09 235.8,6055.9 239.63,6056.06
GR    241.79,6056.15 242.13,6056.18 242.56,6056.23 243.36,6056.24
GR    243.84,6056.16 245.03,6056.28 245.59,6056.31 246.4,6056.25
GR    246.6,6056.26 247.54,6056.38 248.13,6056.46 249.51,6056.41
GR    249.64,6056.38 251.22,6056.24 252.36,6056.42 253.28,6056.65
GR    253.29,6056.65 253.35,6056.65 254.63,6056.54 255.17,6056.43
GR    256.45,6056.55 256.95,6056.59 257.48,6056.73 258.23,6056.85
GR    258.8,6056.9 260.02,6057.14 260.29,6057.18 260.58,6057.22
GR    260.78,6057.2 261.67,6057.23 262.1,6057.29
N      0.054767
HP    XS16 6055.37
XS    XS17 421.54
GR    0,6057.84 1.61,6057.77 2.32,6057.67 5.83,6057.86 6.51,6057.89
GR    6.91,6057.91 8,6057.71 9.25,6057.54 10.84,6057.34 12.35,6057.64
GR    13.25,6057.68 15.52,6057.76 16.3,6057.58 16.68,6057.56 17.87,6057.68
GR    18.3,6057.59 18.79,6057.75 19.2,6057.89 19.35,6057.88 21.81,6056.98
GR    22.25,6056.94 22.63,6057.02 23.31,6056.97 26.54,6056.6 27.11,6056.58
GR    27.53,6056.68 30.94,6057.54 31.79,6057.73 33.47,6057.75 35.63,6057.55
GR    38.36,6057.21 40.73,6057.61 51.33,6057 75.18,6057.12 78.45,6056.42
GR    88.44,6053.44 115.18,6050.81 135.18,6048.21 145.54,6047.25
GR    160.75,6048.52 170.54,6050.27 194.68,6051.48 202.79,6053.64
GR    235.58,6053.87 267.75,6054.63 272.3,6056.42 274.58,6057 276.16,6057.81
GR    276.88,6057.87 277.18,6058.1 278,6058.66 278.32,6058.76 281.05,6059.17
GR    284.88,6059.7 285.5,6059.69 286.05,6059.66 287.03,6059.72
GR    287.42,6059.7 288.3,6059.79 288.48,6059.81 288.68,6059.79
GR    289.46,6059.77 291.31,6059.97 291.35,6059.97 291.38,6059.98
GR    291.44,6059.98 291.86,6060.02
N      0.054
HP    XS17 6056.42
XS    XS18 482.72

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GR      26.33,6060.06 26.66,6059.98 26.78,6059.92 27.93,6059.74 28.34,6059.81
GR      28.59,6059.82 28.72,6059.77 29.58,6059.7 35.86,6059.01 38.9,6058.63
GR      39.58,6058.56 39.73,6058.55 40.06,6058.39 40.76,6058.18 41.58,6058.11
GR      41.6,6058.1 42.24,6058.01 42.94,6057.99 43.45,6058 44.15,6058.06
GR      44.25,6058.06 44.94,6057.91 45.25,6057.83 45.73,6057.74 46.79,6057.30
GR      47.06,6057.01 47.17,6056.95 47.25,6056.93 48.11,6057.07 48.52,6057.23
GR      48.83,6057.33 49.39,6057.42 50.54,6057.55 51.52,6057.19 73.46,6057.52
GR      90.89,6052.94 102.5,6051.8 111.63,6050.51 116.51,6049.35
GR      124.93,6047.88 126.19,6047.3 134.69,6047.72 135.57,6048.07
GR      138.87,6048.82 151.23,6049.97 174.94,6051.4 193.23,6052.63
GR      221.24,6054.47 235.82,6054.44 242.04,6056.75 250.61,6056.83
GR      250.69,6057.30 250.84,6057.73 255.39,6057.92 258.78,6058.31
GR      259.83,6058.6 260.62,6058.83 264.05,6059.43 267.01,6059.66
GR      268.66,6060.07 270.07,6060.4 270.65,6060.57
N      0.079
HP      XS18 6057.30
XS      XS19 536.96
GR      50.46,6061.47 51.32,6061.2 53.52,6060.23 55.39,6058.86 55.46,6058.83
GR      55.86,6058.66 59.88,6058.30 61.14,6057.79 83.95,6057.48 94.51,6051.95
GR      111.98,6050.75 122.15,6050.63 131.22,6048.67 132.26,6048.18
GR      135.33,6048.25 139.02,6049.35 143.47,6050.88 154.52,6052.44
GR      154.71,6052.45 174.52,6053.64 208.29,6054.08 223.77,6055.12
GR      251.91,6055.13 254.9,6056.68 262.79,6058.30 263.1,6058.05
GR      265.37,6058.19 267.89,6058.45 268.36,6058.6 268.58,6058.65
GR      268.82,6058.72 268.99,6058.76 269.47,6058.86 270.68,6059.08
GR      271.61,6059.38 272.7,6059.59 273.13,6059.8 273.57,6059.89
GR      274.35,6059.98 275.14,6060.13 276.74,6060.31 276.8,6060.31
GR      276.83,6060.31 276.95,6060.36 277.38,6060.57 277.44,6060.58
GR      278.53,6060.97 279.42,6061.29 280.27,6061.58 282.1,6062.13
N      0.083
HP      XS19 6058.30
XS      XS20 583.89
GR      47.76,6062.06 49.24,6061.83 50.33,6061.75 52.24,6061.13 54.89,6060.17
GR      55.82,6059.65 57.64,6059.32 59.79,6059.14 61.72,6058.19 85.69,6057.69
GR      97.63,6052.51 104.83,6051.74 108.22,6051.6 116.36,6050.23
GR      123.98,6050.55 133.67,6050.46 140.5,6053.34 150.73,6053.67
GR      165.2,6054.31 184.5,6054.9 196.9,6055.71 245.96,6056.29 269.31,6058.2
GR      270.54,6058.47 270.66,6059.14 271.46,6060.52 272.08,6060.92
GR      272.31,6061.03
N      0.061
HP      XS20 6059.14

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SAC -USGS slope-area program Ver 97-01

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5 section

RITO DE LOS FRIJOLES AT BANDELIER NATIONAL MONUMENT, NM STA 08313350
 FLOOD DATE: AUGUST 21, 2011 PEAK STAGE = 11.44 FT ABOVE GAGE DATUM
 4-SEC SA: N-VALUES OF 0.039-0.0633 (MAIN CH.) AND 0.02-0.15(O. BANK)

DISCHARGE COMPUTATIONS

	dh,fall (ft)	Reach length (ft)	Discharge (cfs)	Spread (%)	HF (ft)	CX	RC	RX	ER
XS20 - XS19	0.84	47.	6916.	5	0.885	0.973	0.000	-0.101	#
XS19 - XS18	1.00	54.	6229.	0	0.957	1.000	0.044	0.000	#
XS18 - XS17	0.88	61.	6653.	0	0.837	1.000	0.051	0.000	@#
XS17 - XS16	1.05	72.	7451.	0	0.907	1.000	0.158	0.000	#
XS20 - XS18	1.84	101.	6516.	2	1.834	0.989	0.025	-0.043	#
XS19 - XS17	1.88	116.	6417.	0	1.795	1.000	0.047	0.000	@#
XS18 - XS16	1.93	133.	7054.	0	1.754	1.000	0.100	0.000	@#
XS20 - XS17	2.72	162.	6560.	1	2.672	0.993	0.033	-0.030	#
XS19 - XS16	2.93	187.	6737.	0	2.719	1.000	0.077	0.000	@#
XS20 - XS16	3.77	234.	6775.	1	3.600	0.994	0.059	-0.024	#

Definitions:

Spread, the percent difference between discharge computed with no expansion loss (k=0) and discharge computed with full expansion loss (k=1.0), divided by the discharge computed with full expansion loss

HF, friction head- $HF = \text{sum of } Q^2 * L / (K1 * K2)$ over subreaches; Q, discharge; L, reach length; K1, upstream section conveyance; K2, downstream section conveyance

CX, the computed discharge divided by the discharge computed with no expansion loss (k=0)

RC, velocity head change in contracting section divided by friction head

RX, velocity head change in expanding section divided by friction head

ER, warnings, *-fall < 0.5ft, @-conveyance ratio exceeded, #-reach too short error, 1-negative or 0 fall

*****, terms that can not be computed because of strong expansion in reach

CROSS SECTION PROPERTIES

I.D. XS16		Velocity head	1.03ft	Discharge	6775.cfs
Ref.distance		Q/K	0.0106	Alpha	1.000
Sub	Water	Top	Wetted	Hydraulic	Conveyance
area	surface	n	Area	width	perimeter
no.	el.(ft)		(sq.ft)	(ft)	(ft)
1	6055.37	0.055	830.9	164.1	167.2
Total	6055.37	---	831.	164.	167.

radius	x 0.001	Vel.	F
(ft)	(cfs)	%	(fps)
4.97	65.847	100.	8.2
4.97	65.847	100.	8.2

Definitions:

n, Manning's coefficient of roughness Q/K = discharge/conveyance

F, Froude number $F = K1 * Q / (K * A \sqrt{g * (A1 / TW1)})$; Q, discharge; A, total cross-section area; g, acceleration of gravity; A1, sub-section area; TW1, sub-section top width

5 section

RITO DE LOS FRIJOLES AT BANDELIER NATIONAL MONUMENT, NM STA 08313350

FLOOD DATE: AUGUST 21, 2011 PEAK STAGE = 11.44 FT ABOVE GAGE DATUM

8-SEC SA: N-VALUES OF 0.039-0.0633 (MAIN CH.) AND 0.02-0.15(O. BANK)

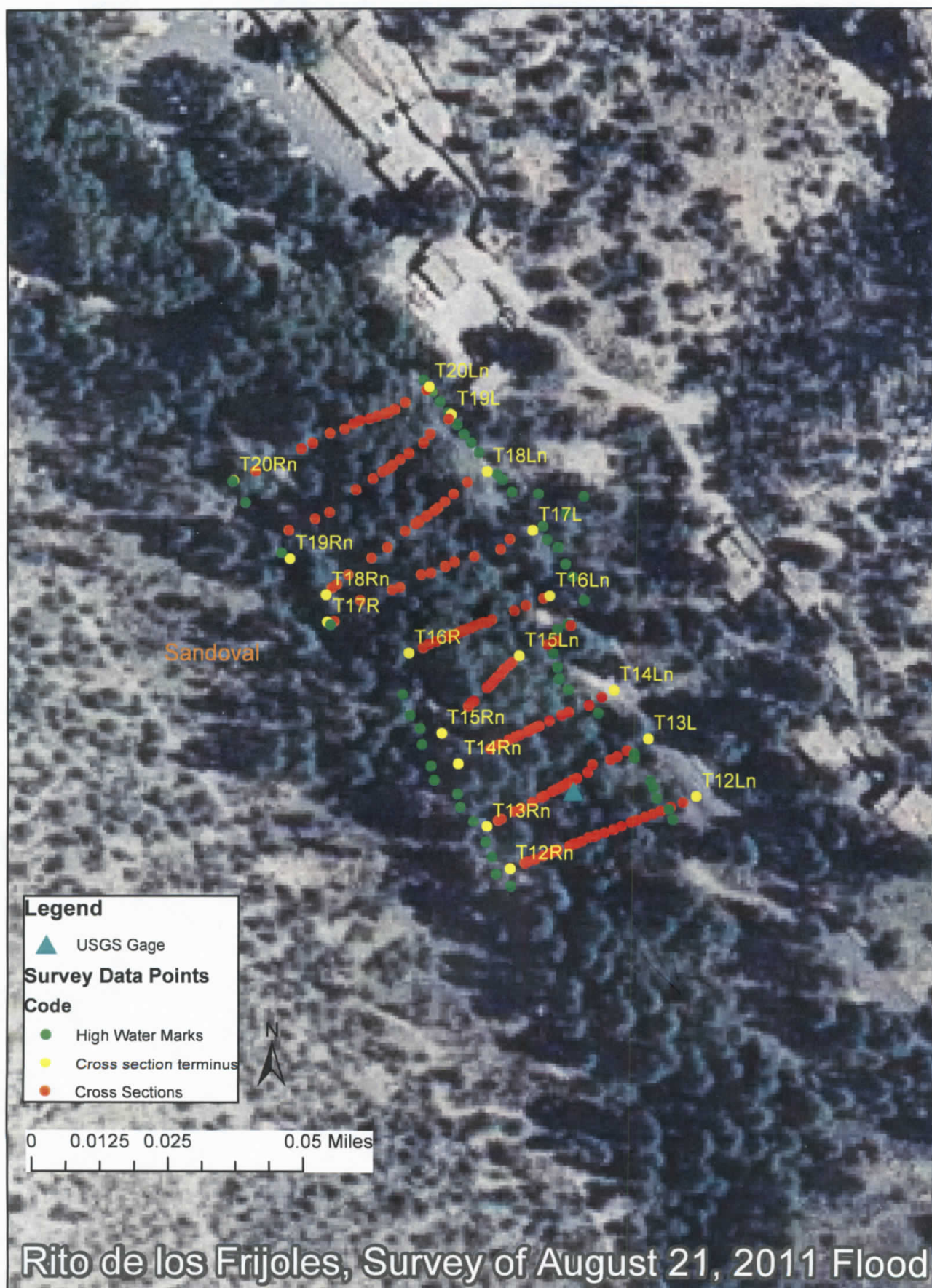
CROSS SECTION PROPERTIES

I.D. XS17		Velocity head		0.91ft	Discharge		6775.cfs	
Ref.distance		422.ft	Q/K		0.0104	Alpha		1.000
Sub	Water		Top	Wetted	Hydraulic	Conveyance		
area	surface	n	Area	width	perimeter	radius	x 0.001	Vel.
no.	el.(ft)		(sq.ft)	(ft)	(ft)	(ft)	(cfs)	%
1	6056.42	0.054	883.0	193.9	195.5	4.52	66.572	100.
Total	6056.42	---	883.	194.	195.	4.52	66.572	100.
I.D. XS18		Velocity head		0.87ft	Discharge		6775.cfs	
Ref.distance		483.ft	Q/K		0.0194	Alpha		1.000
Sub	Water		Top	Wetted	Hydraulic	Conveyance		
area	surface	n	Area	width	perimeter	radius	x 0.001	Vel.
no.	el.(ft)		(sq.ft)	(ft)	(ft)	(ft)	(cfs)	%
1	6057.30	0.079	905.1	185.9	188.4	4.80	48.600	100.
Total	6057.30	---	905.	186.	188.	4.80	48.600	100.
I.D. XS19		Velocity head		0.82ft	Discharge		6775.cfs	
Ref.distance		537.ft	Q/K		0.0224	Alpha		1.000
Sub	Water		Top	Wetted	Hydraulic	Conveyance		
area	surface	n	Area	width	perimeter	radius	x 0.001	Vel.
no.	el.(ft)		(sq.ft)	(ft)	(ft)	(ft)	(cfs)	%
1	6058.30	0.083	932.5	206.6	209.6	4.45	45.279	100.
Total	6058.30	---	932.	207.	210.	4.45	45.279	100.
I.D. XS20		Velocity head		0.91ft	Discharge		6775.cfs	
Ref.distance		584.ft	Q/K		0.0146	Alpha		1.000
Sub	Water		Top	Wetted	Hydraulic	Conveyance		
area	surface	n	Area	width	perimeter	radius	x 0.001	Vel.
no.	el.(ft)		(sq.ft)	(ft)	(ft)	(ft)	(cfs)	%
1	6059.14	0.061	887.1	210.9	213.6	4.15	55.979	100.
Total	6059.14	---	887.	211.	214.	4.15	55.979	100.

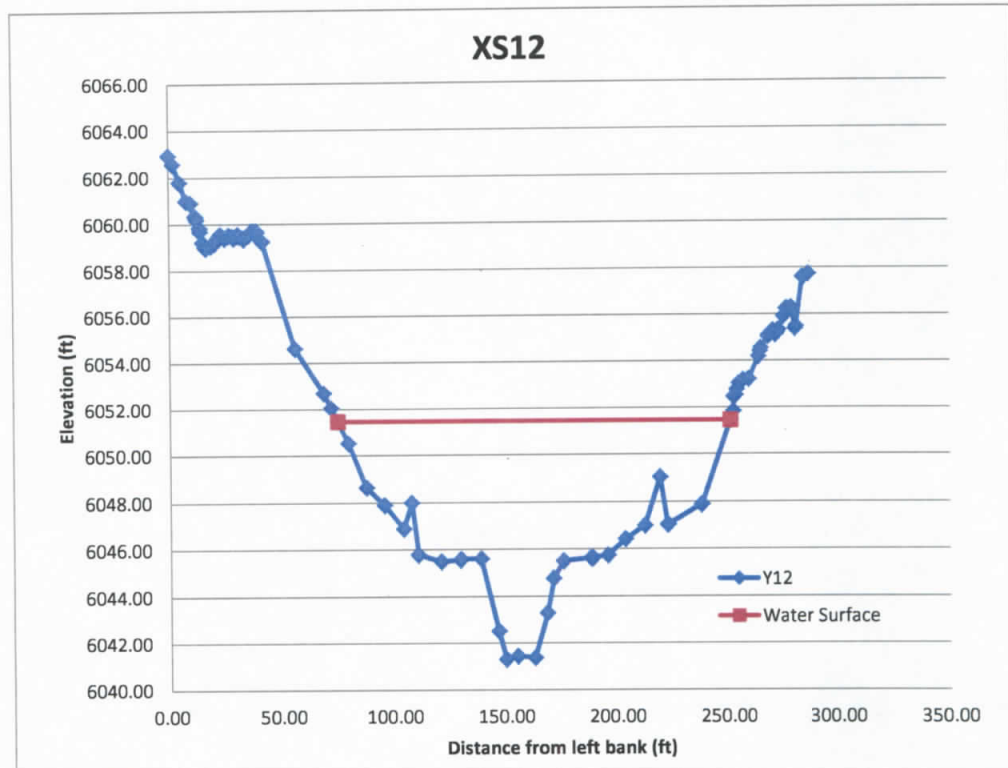
Definitions:

n, Manning's coefficient of roughness Q/K = discharge/conveyance

F, Froude number $F = Ki*Q/(K*A \sqrt{g*(Ai/TWi)})$; Q, discharge; A, total cross-section area; g, acceleration of gravity; Ai, sub-section area; TWi, sub-section top width



X12	Y12
0.00	6062.93
1.94	6062.57
4.87	6061.78
7.80	6060.98
9.69	6060.89
9.73	6060.88
11.73	6060.32
11.92	6060.28
12.38	6060.16
13.61	6059.83
13.78	6059.79
13.95	6059.65
15.01	6059.19
16.14	6058.99
16.30	6058.95
16.39	6058.96
16.73	6058.97
18.68	6059.05
19.00	6059.07
19.89	6059.15
20.39	6059.15
20.73	6059.20
21.13	6059.24
21.76	6059.37
22.63	6059.49
22.90	6059.54
23.89	6059.45
24.63	6059.39
25.01	6059.37
26.60	6059.47
26.87	6059.51
28.31	6059.46
29.04	6059.37
30.38	6059.47
30.88	6059.53
31.61	6059.46
32.94	6059.39
33.19	6059.36
33.53	6059.34
35.59	6059.51
35.64	6059.51
37.11	6059.67
37.16	6059.68
37.22	6059.69
38.84	6059.69
39.27	6059.61
41.11	6059.27
41.41	6059.25
41.59	6059.21
56.02	6054.59
68.82	6052.67
72.07	6052.03
75.02	6051.44
79.69	6050.51
87.75	6048.61
95.73	6047.86
104.40	6046.86

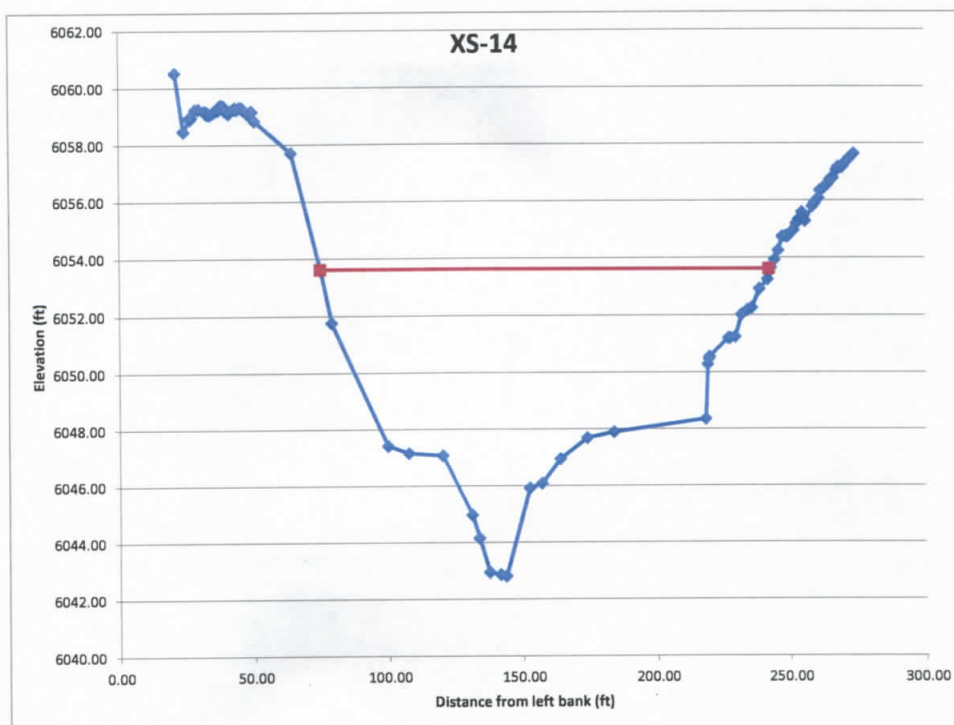


X12	Y12
108.02	6047.97
110.89	6045.76
121.13	6045.46
129.73	6045.53
130.10	6045.56
139.03	6045.57
146.85	6042.49
150.15	6041.28
155.26	6041.41
163.06	6041.35
168.67	6043.26
171.53	6044.74
176.10	6045.48
188.45	6045.60
189.29	6045.61
195.96	6045.72
203.91	6046.40
212.66	6046.97
219.51	6049.02
222.82	6047.01
223.10	6047.01
237.96	6047.85
238.25	6047.86
251.29	6051.44
252.72	6051.83
252.73	6051.83
252.79	6052.45
253.73	6052.52
254.20	6052.76
255.20	6053.03
257.21	6053.18
257.30	6053.18
257.37	6053.19
259.84	6053.22
259.87	6053.22
264.35	6054.18
264.94	6054.41
265.41	6054.54
268.75	6055.03
269.04	6055.10
269.35	6055.10
269.88	6055.14
271.10	6055.31
272.14	6055.11
272.58	6055.16
272.93	6055.23
273.64	6055.33
275.89	6055.90
276.99	6056.23
277.47	6056.25
278.43	6056.22
279.24	6056.26
279.31	6056.27
279.50	6056.27
279.55	6056.28
281.21	6055.37
281.54	6055.48
284.60	6057.59
285.19	6057.60
287.27	6057.73

X14	Y14	n value
0.00	6065.31	0.06
0.01	6065.31	
0.30	6065.25	
0.59	6065.24	
2.43	6065.05	
2.45	6065.05	
2.49	6065.04	
2.52	6065.04	
2.92	6065.06	
4.82	6065.16	
5.73	6065.17	
6.91	6065.17	
8.33	6065.21	
9.30	6065.13	
11.62	6064.63	
11.75	6064.60	
11.77	6064.60	
13.14	6064.43	
13.19	6064.42	
13.29	6064.39	
13.46	6064.28	
16.76	6062.19	
17.82	6061.97	
19.46	6061.30	
19.82	6061.14	

0.06

21.01	6060.51	
24.18	6058.46	
24.23	6058.45	
24.27	6058.45	
26.41	6058.94	
26.58	6058.88	
27.14	6058.94	
28.54	6059.22	
29.88	6059.24	
32.00	6059.16	
32.56	6059.14	
32.96	6059.06	
33.19	6059.11	
33.93	6059.04	
34.99	6059.10	
35.73	6059.16	
36.18	6059.20	
36.67	6059.24	
37.06	6059.20	
37.38	6059.33	
38.01	6059.37	
38.38	6059.37	
38.94	6059.35	
39.60	6059.19	
40.90	6059.08	
41.74	6059.17	
42.69	6059.23	
43.32	6059.27	
43.86	6059.23	
44.86	6059.29	
45.62	6059.29	
46.09	6059.25	
46.34	6059.22	
47.95	6059.09	
48.35	6059.09	
48.61	6059.10	
49.18	6059.15	
49.43	6059.17	
49.53	6059.15	
50.59	6058.82	
64.13	6057.68	

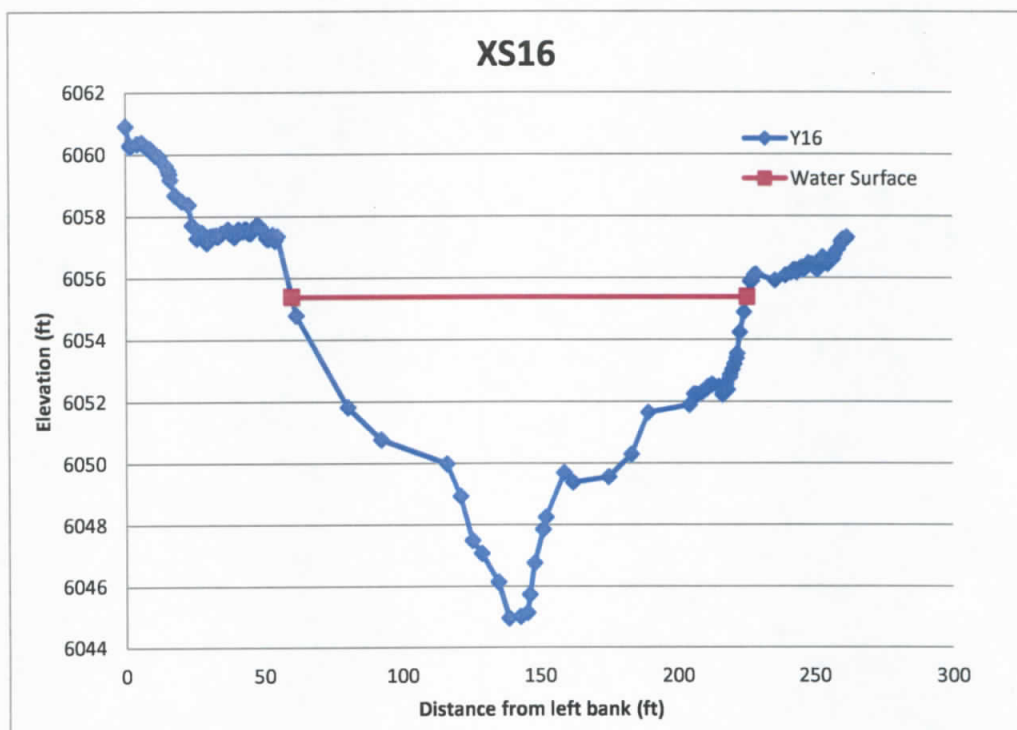


74.78	6053.60	WS	0.125	Area	Total Area
79.01	6051.76				0
99.81	6047.40				7.128435
107.52	6047.14				125.6971
120.20	6047.05	n	0.042		48.59445
131.18	6044.95				80.94452
133.75	6044.14				262.36454
137.55	6042.93				93.17346
141.69	6042.85				23.96138
143.73	6042.79	Thalweg			39.90142
152.70	6045.89				43.78199
157.26	6046.07	n	0.125		21.80579
					67.68251
					33.66518
					323.97173

HP=	6053.44						
n value	0.06	0.125	0.042	0.125	0.02	0.06	
distance	53.77	45.42	37.07	26.77	48.13	42.04	
n x distance	3.226012	5.677746	1.556762	3.34576	0.96255	2.522442	17.29127 Sum weighted
							253.19 total distance
							0.068294 weighted n

X14	Y14	n	n value	Area	0	323.9717	323.9717	157.1968	205.26	7.060517	
164.02	6046.94			43.96587	n x area	0	40.49647	13.60681	19.6496	4.10522	0.423631
174.05	6047.68			57.77953							78.28173
184.03	6047.88	n	0.02	55.4514	157.1968						1017.462
218.51	6048.35			175.4913							total area
219.34	6050.27			2.658799							0.076938
219.73	6050.47			1.139141							area weighted n
219.80	6050.50			0.199096							
219.96	6050.55			0.485976							
227.12	6051.20			16.04869							
227.89	6051.21			1.724896							
229.75	6051.24			4.087185							
232.16	6052.02	n	0.06	3.425934	205.26						
234.38	6052.18			2.805457							
236.09	6052.25			2.04739							
238.98	6052.90			1.559287							
242.01	6053.23			0.648384							
242.46	6053.60	WS		-0.07178	7.0605175						
242.57	6053.49										
243.36	6053.63										
244.60	6053.90										
246.07	6054.23										
247.59	6054.72										
248.87	6054.73										
249.40	6054.73										
249.92	6054.74										
251.35	6054.89										
251.88	6054.94										
252.83	6055.16										
253.70	6055.28										
253.88	6055.32										
254.04	6055.33										
254.97	6055.56										
255.42	6055.49										
256.17	6055.26										
258.93	6055.77										
259.62	6055.86										
259.85	6055.91										
261.07	6056.05										
261.21	6056.07										
261.79	6056.33										
262.58	6056.39										
263.00	6056.40										
264.31	6056.53										
264.40	6056.53										
264.54	6056.56										
265.49	6056.72										
266.13	6056.78										
266.50	6056.77										
267.91	6057.04										
268.01	6057.06										
268.04	6057.06										
268.41	6057.15										
269.25	6057.15										
269.70	6057.15										
270.02	6057.15										
270.28	6057.19										
271.66	6057.36										
272.57	6057.47										
272.79	6057.47										
274.15	6057.62										
274.20	6057.63										

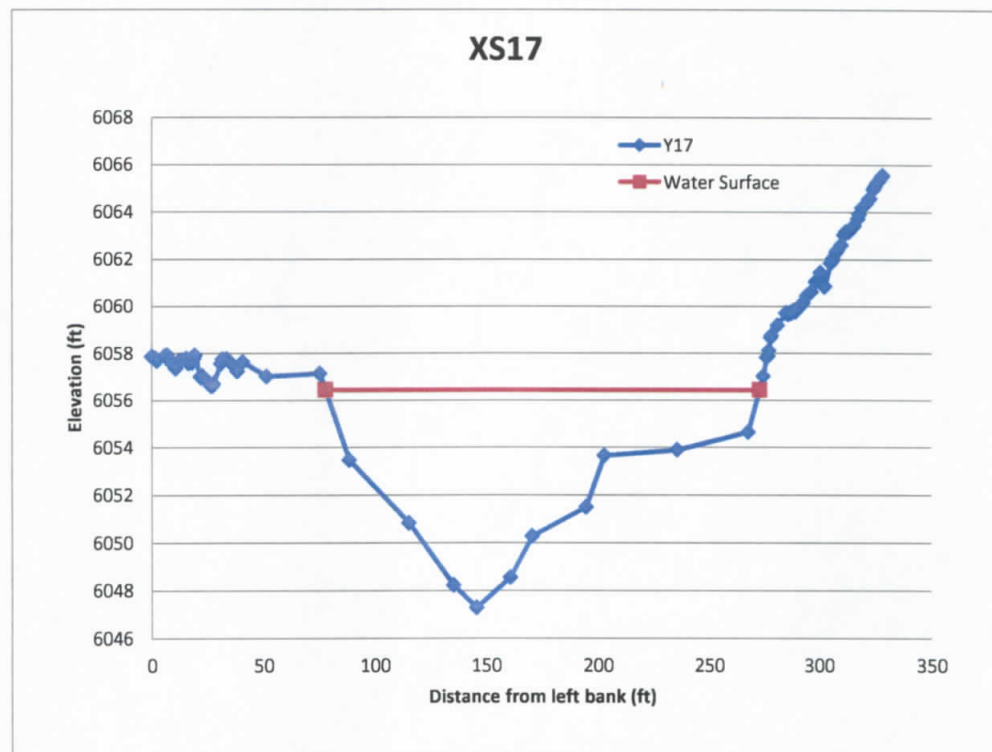
X16	Y16
0	6060.875
1.569653	6060.263
1.674124	6060.229
1.689072	6060.222
1.821963	6060.228
4.306284	6060.315
6.024625	6060.352
6.928144	6060.276
7.776734	6060.19
8.801101	6060.165
9.102675	6060.151
9.822107	6060.032
10.96118	6059.939
11.60927	6059.925
12.34828	6059.9
14.69751	6059.608
15.53282	6059.454
15.9515	6059.339
16.29474	6059.155
18.05071	6058.656
20.41809	6058.468
22.83719	6058.355
24.11092	6057.685
25.94192	6057.263
27.5342	6057.436
27.72453	6057.451
29.4072	6057.152
29.49469	6057.116
29.84862	6057.211
30.725	6057.32
31.73926	6057.34
32.85868	6057.36
33.27249	6057.324
33.50135	6057.321
34.72735	6057.406
34.86472	6057.416
34.86921	6057.416
34.87748	6057.415
37.19931	6057.546
37.9318	6057.416
38.7384	6057.442
39.45843	6057.299
40.61888	6057.463
41.02635	6057.539
41.47911	6057.506
42.61111	6057.494
43.19057	6057.543
43.60992	6057.554
44.57978	6057.434
45.00129	6057.451
45.29248	6057.43
46.59296	6057.533
47.40611	6057.668
48.19609	6057.662
48.37793	6057.66
48.63242	6057.636
49.86691	6057.491



X16	Y16
51.05082	6057.278
51.23451	6057.251
51.51761	6057.256
51.92007	6057.255
53.22996	6057.37
54.13184	6057.187
54.98775	6057.32
60.14543	6055.356
61.71734	6054.757
80.39413	6051.792
92.44467	6050.748
116.1533	6049.97
121.1529	6048.904
125.4916	6047.464
128.8485	6047.047
134.8903	6046.115
138.728	6044.931
142.8538	6044.987
145.3927	6045.112
146.286	6045.705
147.9756	6046.732
151.1384	6047.821
152.1532	6048.222
158.7131	6049.669
161.9658	6049.36
174.8885	6049.541
183.2169	6050.269
189.3811	6051.627
204.3149	6051.867
206.0953	6052.229
206.8523	6052.215
207.2648	6052.202
208.8469	6052.275
210.4738	6052.387
210.9951	6052.462
212.2515	6052.523
212.6211	6052.541
215.0397	6052.466
215.0757	6052.462
215.0889	6052.464
215.1098	6052.462
216.3385	6052.209
217.3611	6052.55
217.6494	6052.53
218.2553	6052.364
218.9831	6052.763
219.1652	6052.854
219.9607	6053.025
220.6013	6053.189
221.4145	6053.379
221.6711	6053.528
222.7105	6054.218
224.3338	6054.87
225.5062	6055.356
226.7346	6055.865
227.4091	6055.874
227.848	6056.004

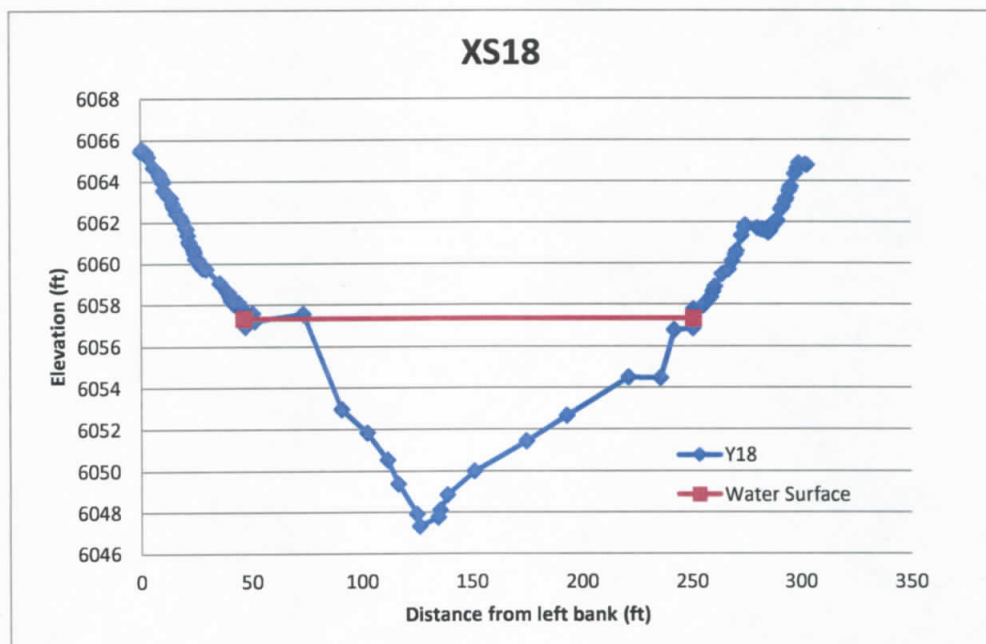
X16	Y16
228.1907	6056.072
228.7751	6056.088
228.8869	6056.093
235.8036	6055.897
239.6255	6056.06
241.7898	6056.154
242.1305	6056.183
242.5649	6056.228
243.362	6056.245
243.8362	6056.16
245.0278	6056.28
245.588	6056.315
246.404	6056.251
246.596	6056.261
247.5384	6056.383
248.1282	6056.461
249.5087	6056.415
249.6407	6056.378
251.218	6056.236
252.3627	6056.416
253.2753	6056.651
253.294	6056.654
253.3533	6056.653
254.6277	6056.542
255.1682	6056.43
256.4468	6056.545
256.9516	6056.591
257.4796	6056.73
258.2316	6056.851
258.7965	6056.905
260.0243	6057.145
260.2862	6057.178
260.5826	6057.218
260.779	6057.203
261.6673	6057.227
262.1049	6057.291

X17	Y17
0	6057.839
0.616323	6057.816
1.61232	6057.766
2.323047	6057.665
5.827537	6057.865
6.512167	6057.886
6.906815	6057.915
7.998516	6057.706
9.247657	6057.535
10.84079	6057.341
12.35434	6057.645
13.24558	6057.684
15.5242	6057.761
16.29647	6057.58
16.67723	6057.557
17.8676	6057.676
18.30182	6057.587
18.78792	6057.751
19.19891	6057.891
19.34569	6057.876
21.80934	6056.978
22.2538	6056.943
22.63168	6057.022
23.30718	6056.972
26.54388	6056.595
27.10897	6056.579
27.52963	6056.68
30.93897	6057.538
31.78564	6057.726
33.46724	6057.75
35.6261	6057.552
38.3587	6057.208
40.73053	6057.611
51.33185	6056.998
75.17578	6057.116
77.70818	6056.415
88.44226	6053.442
115.1785	6050.807
135.1784	6048.206
145.5386	6047.254
160.7546	6048.524
170.5389	6050.266
194.6842	6051.48
202.7858	6053.639
235.578	6053.874
267.7524	6054.629
272.8929	6056.415
274.5816	6057.001
276.1632	6057.815
276.8756	6057.869
277.178	6058.102
278.001	6058.658
278.321	6058.756
281.0542	6059.174
284.8777	6059.7
285.5026	6059.691
286.0469	6059.66
287.0319	6059.725
287.4229	6059.703
288.2968	6059.79



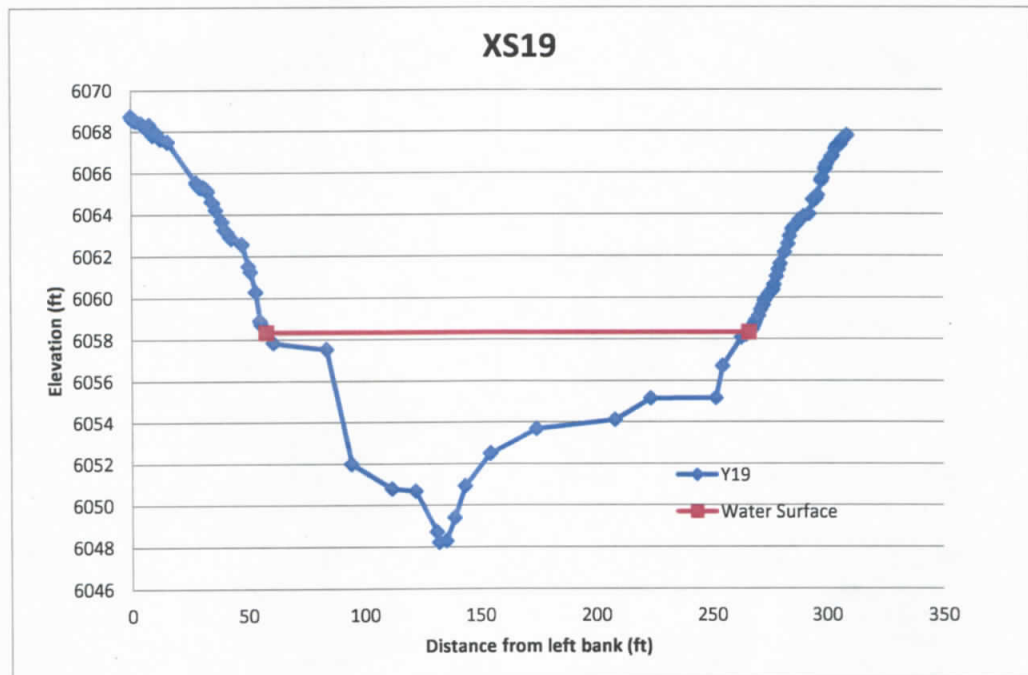
X17	Y17
288.4766	6059.813
288.6765	6059.786
289.4588	6059.768
291.3146	6059.972
291.352	6059.974
291.3813	6059.976
291.4389	6059.984
291.8578	6060.018
292.3082	6060.089
292.4321	6060.095
292.4821	6060.105
292.6934	6060.146
294.4413	6060.439
294.4986	6060.431
296.351	6060.59
296.3911	6060.601
296.4205	6060.602
298.4822	6061.02
298.5001	6061.024
298.6807	6061.057
300.5709	6061.403
300.6143	6061.411
300.629	6061.412
302.3874	6060.814
302.4634	6060.817
302.554	6060.83
305.1428	6061.808
305.8713	6061.915
306.2092	6062.013
307.68	6062.262
308.0386	6062.352
308.1949	6062.355
308.2494	6062.36
309.8744	6062.576
311.1923	6063.006
311.78	6063.056
312.089	6063.148
313.3242	6063.135
313.7499	6063.206
314.9021	6063.328
315.3639	6063.359
315.683	6063.407
317.3996	6063.696
317.9926	6063.888
319.1809	6064.168
320.2226	6064.256
320.907	6064.331
322.3138	6064.51
322.485	6064.554
324.3463	6064.935
324.7888	6065.046
325.7815	6065.201
326.8141	6065.326
327.8934	6065.466
328.315	6065.531

X18	Y18
0	6065.426
0.699887	6065.539
2.37774	6065.373
3.413698	6065.16
5.851016	6064.634
7.287494	6064.476
8.169651	6064.362
8.371212	6064.372
8.693651	6064.241
9.133175	6064.141
9.825944	6064.042
10.05979	6063.918
10.58809	6063.535
12.3878	6063.267
12.50919	6063.258
12.54754	6063.252
13.55052	6063.177
13.70767	6063.138
14.38793	6062.881
14.89909	6062.731
15.63858	6062.631
16.15301	6062.411
17.53702	6062.288
17.98118	6062.257
18.23326	6062.131
18.75196	6062.032
20.19783	6061.708
20.67049	6061.642
21.24915	6061.355
21.92116	6061.042
22.19226	6060.941
23.41667	6060.754
24.00862	6060.617
24.37722	6060.487
24.75476	6060.216
25.76862	6060.138
26.01414	6060.151
26.32767	6060.056
26.66414	6059.982
26.77929	6059.918
27.92599	6059.738
28.34116	6059.806
28.59109	6059.823
28.72436	6059.767
29.5833	6059.697
35.86231	6059.007
38.90312	6058.63
39.58018	6058.558
39.73174	6058.547
40.05665	6058.391
40.76445	6058.181
41.57653	6058.106
41.60392	6058.101
42.24238	6058.005
42.94202	6057.99
43.45177	6058.001
44.15411	6058.06



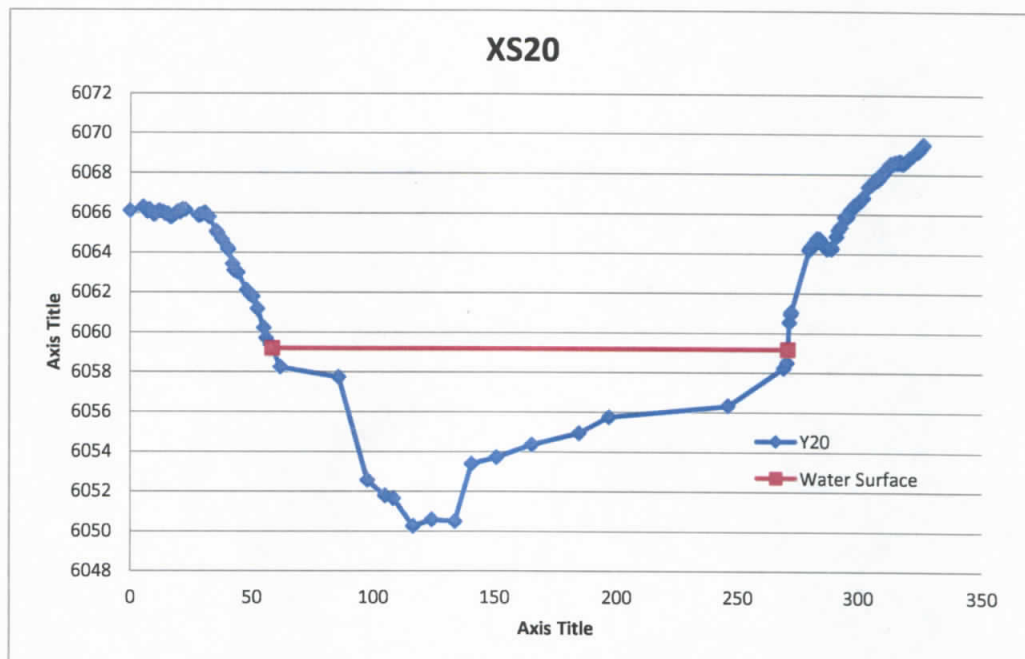
X18	Y18
44.25357	6058.058
44.93913	6057.907
45.24517	6057.833
45.72605	6057.74
46.53501	6057.297
47.06099	6057.01
47.1733	6056.945
47.24664	6056.932
48.11285	6057.067
48.51807	6057.229
48.82597	6057.334
49.39172	6057.422
50.53602	6057.548
51.5225	6057.195
73.45678	6057.52
90.89364	6052.94
102.5002	6051.798
111.6268	6050.508
116.5052	6049.351
124.9338	6047.881
126.1925	6047.296
134.6926	6047.72
135.5693	6048.074
138.8664	6048.815
151.2317	6049.967
174.9379	6051.404
193.2292	6052.628
221.2404	6054.465
235.8217	6054.442
242.0368	6056.745
250.6125	6056.834
250.73	6057.297
250.8399	6057.73
255.3931	6057.919
258.7769	6058.309
259.8318	6058.597
260.6193	6058.832
264.0489	6059.434
267.0143	6059.662
268.6555	6060.069
270.0653	6060.405
270.6473	6060.57
273.0308	6061.323
274.2515	6061.691
274.685	6061.825
280.4084	6061.691
282.0901	6061.628
282.6298	6061.626
283.0689	6061.635
284.2165	6061.564
285.3805	6061.465
285.9983	6061.516
286.6928	6061.677
286.882	6061.732
287.3043	6061.838
287.7873	6061.939
288.9438	6061.971

X19	Y19
0	6068.684
0.766007	6068.532
2.154211	6068.465
4.471346	6068.352
5.880983	6068.212
7.173317	6068.13
8.027749	6068.265
9.520792	6067.792
10.34492	6067.832
11.23983	6067.845
12.94863	6067.603
15.92451	6067.44
28.21855	6065.49
28.54063	6065.413
28.58566	6065.398
29.37894	6065.306
29.49542	6065.307
29.63715	6065.267
30.40647	6065.238
31.30153	6065.264
31.40353	6065.242
31.95099	6065.202
32.25343	6065.172
32.82169	6065.12
33.07675	6065.049
34.85364	6064.567
35.34554	6064.506
36.65849	6064.153
38.95699	6063.632
39.27444	6063.604
40.26538	6063.214
40.30416	6063.204
41.38356	6063.092
41.39056	6063.09
42.57531	6062.886
43.23084	6062.794
47.74592	6062.52
47.75934	6062.517
47.78623	6062.508
50.4604	6061.473
51.32101	6061.197
53.51758	6060.234
55.39171	6058.861
55.46153	6058.827
55.86445	6058.665
58.06816	6058.299
61.13937	6057.789
83.94875	6057.477
94.50981	6051.946
111.9798	6050.748
122.1529	6050.633
131.2186	6048.671
132.2575	6048.176
135.3342	6048.255
139.018	6049.354
143.4673	6050.879
154.5175	6052.444
154.708	6052.451
174.5229	6053.642
208.2929	6054.082



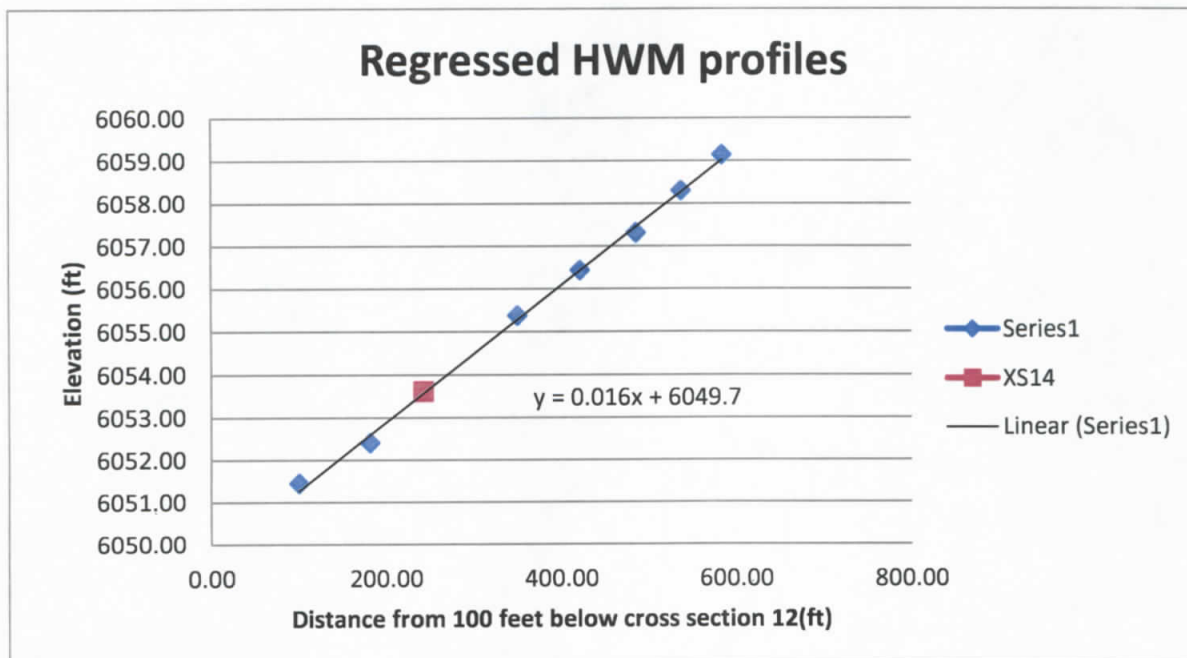
X19	Y19
223.7709	6055.121
251.9067	6055.134
254.8965	6056.677
263.0992	6058.048
265.3685	6058.188
266.4508	6058.299
267.8934	6058.447
268.3609	6058.596
268.5821	6058.648
268.8206	6058.719
268.9929	6058.76
269.4679	6058.861
270.6809	6059.081
271.6059	6059.384
272.7002	6059.593
273.1299	6059.797
273.5717	6059.893
274.3548	6059.984
275.1381	6060.131
276.7406	6060.31
276.7957	6060.309
276.8284	6060.312
276.953	6060.364
277.379	6060.567
277.4427	6060.58
278.5332	6060.97
279.4216	6061.289
280.2664	6061.576
282.0981	6062.128
283.6072	6062.533
284.3228	6062.877
285.4103	6063.225
286.4169	6063.363
287.5803	6063.49
288.6701	6063.656
290.5795	6063.836
292.8694	6063.963
294.525	6064.641
295.04	6064.594
295.6426	6064.681
296.1008	6064.698
296.5816	6064.854
298.193	6065.549
298.3249	6065.588
298.4385	6065.615
298.632	6065.701
299.8442	6066.122
299.9751	6066.2
300.5369	6066.365
302.5922	6066.675
302.8641	6066.719
302.9604	6066.739
303.1222	6066.778
304.488	6067.116
305.1946	6067.277
306.4894	6067.321
307.397	6067.504
307.5338	6067.569
309.2711	6067.735
309.4015	6067.749

X20	Y20
0	6066.059
5.268543	6066.231
5.478207	6066.235
6.084818	6066.143
6.995219	6066.011
7.295948	6066.084
8.152589	6066.098
9.527339	6065.876
9.762581	6065.85
10.14983	6065.883
10.44106	6065.905
11.8429	6066.032
12.26631	6066.036
13.75061	6065.971
14.15411	6065.929
14.72528	6065.894
15.62569	6065.884
16.69802	6065.733
17.20565	6065.74
18.46214	6065.882
18.72267	6065.912
19.22927	6065.971
19.5506	6065.999
20.65524	6065.976
20.79538	6066.009
20.99284	6066.077
21.40706	6066.102
21.5429	6066.12
22.73965	6066.096
28.07139	6065.817
28.51264	6065.824
29.44438	6065.86
30.35654	6065.928
30.66158	6065.947
32.24188	6065.752
32.27758	6065.747
35.49149	6065.009
35.62391	6064.98
35.84179	6064.913
37.67186	6064.598
40.0019	6064.188
40.23464	6064.108
41.98631	6063.38
42.62352	6063.043
44.17104	6062.95
47.75777	6062.06
49.24233	6061.83
50.33178	6061.752
52.23637	6061.125
54.89018	6060.168
55.82383	6059.652
57.63725	6059.321
58.30836	6059.135
61.72403	6058.189
85.68804	6057.69
97.62728	6052.506
104.8283	6051.739
108.2206	6051.601
116.357	6050.23
123.9791	6050.554

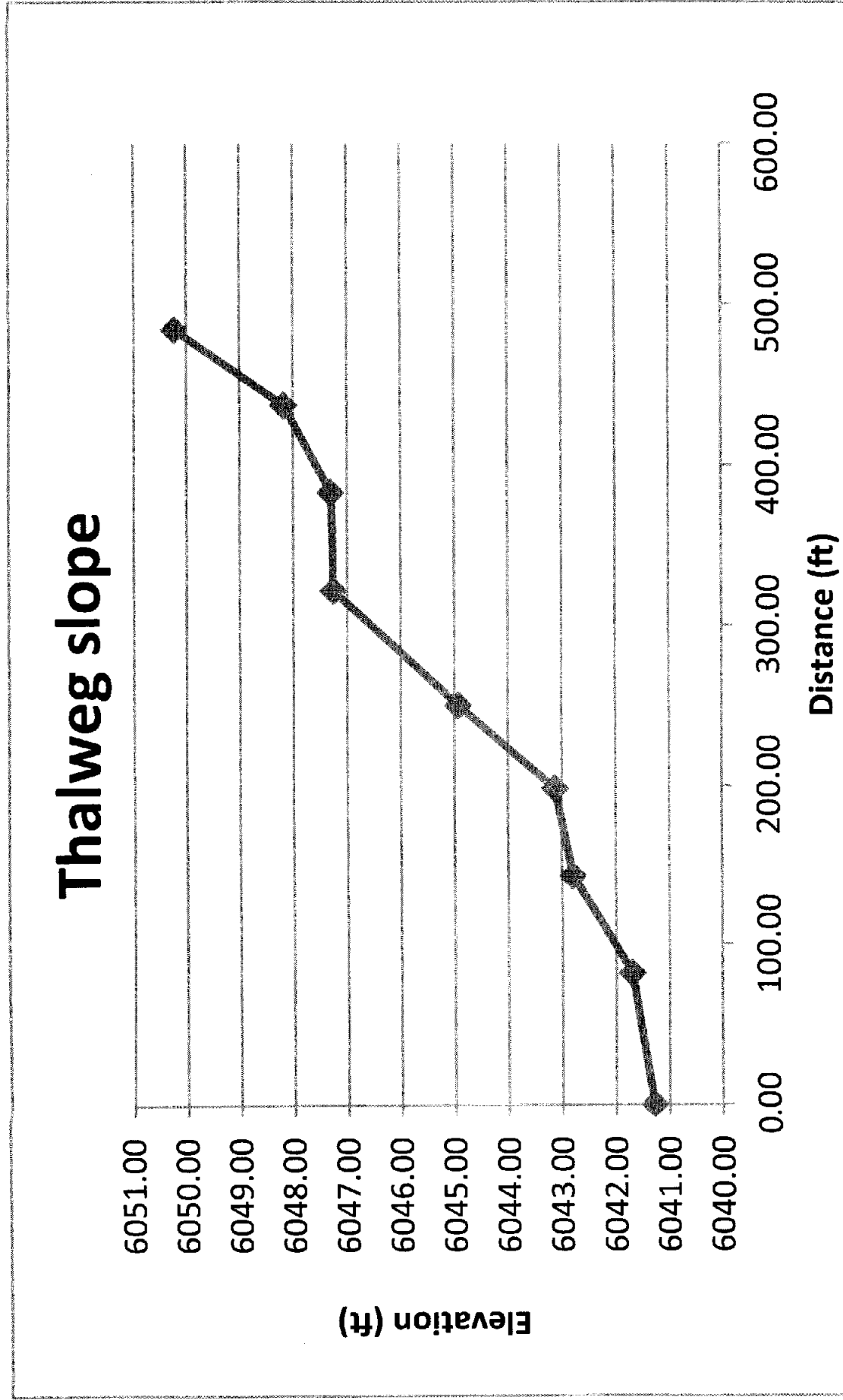


X20	Y20
133.6692	6050.463
140.5012	6053.34
150.7292	6053.668
165.2038	6054.314
184.5023	6054.898
196.8999	6055.712
245.9585	6056.289
269.3134	6058.195
270.5438	6058.468
270.8403	6059.135
271.4575	6060.524
272.0781	6060.922
272.3102	6061.033
279.6393	6064.15
279.7853	6064.162
279.8515	6064.198
280.4144	6064.331
281.6975	6064.416
281.961	6064.521
283.0084	6064.718
283.1614	6064.728
283.397	6064.711
284.2009	6064.702
284.4073	6064.631
285.9988	6064.355
286.9467	6064.268
287.0574	6064.225
287.3461	6064.266
288.8317	6064.216
289.0273	6064.211
289.1843	6064.26
291.0081	6064.836
291.7615	6065.156
292.6598	6065.328
292.702	6065.329
294.4164	6065.804
294.4419	6065.807
294.5808	6065.809
295.2529	6065.79
295.5091	6065.847
296.4777	6066.116
297.0727	6066.207
297.4147	6066.225
297.7042	6066.292
298.4353	6066.434
299.029	6066.45
299.711	6066.502
301.6226	6066.763
301.6393	6066.764
301.6457	6066.766
301.8335	6066.81
304.1392	6067.349
304.2129	6067.362
304.5125	6067.395
306.0327	6067.562
306.5137	6067.659
307.9657	6067.716
308.1933	6067.76
308.335	6067.802
309.1998	6067.981

XS	Station (ft)	Elevation (ft)	Distance from downstream XS	Elevation (ft)
12L	75.02	6051.44	100.00	6051.44
12R	251.29	6051.44		6051.44
13L	71.76	6052.39	182.00	6052.39
13R	238.77	6052.39		6052.39
14L*			243.00	6053.60
14R				
16L	60.15	6055.36	349.94	6055.36
16R	225.51	6055.36		6055.36
17L	77.71	6056.41	421.54	6056.41
17R	272.89	6056.41		6056.41
18L	46.54	6057.30	485.72	6057.30
18R	250.73	6057.30		6057.30
19L	58.07	6058.30	536.96	6058.30
19R	266.45	6058.30		6058.30
20L	58.31	6059.13	583.89	6059.13
20R	270.84	6059.13		6059.13



*Cross section 14 was used by USGS but not used by NPS



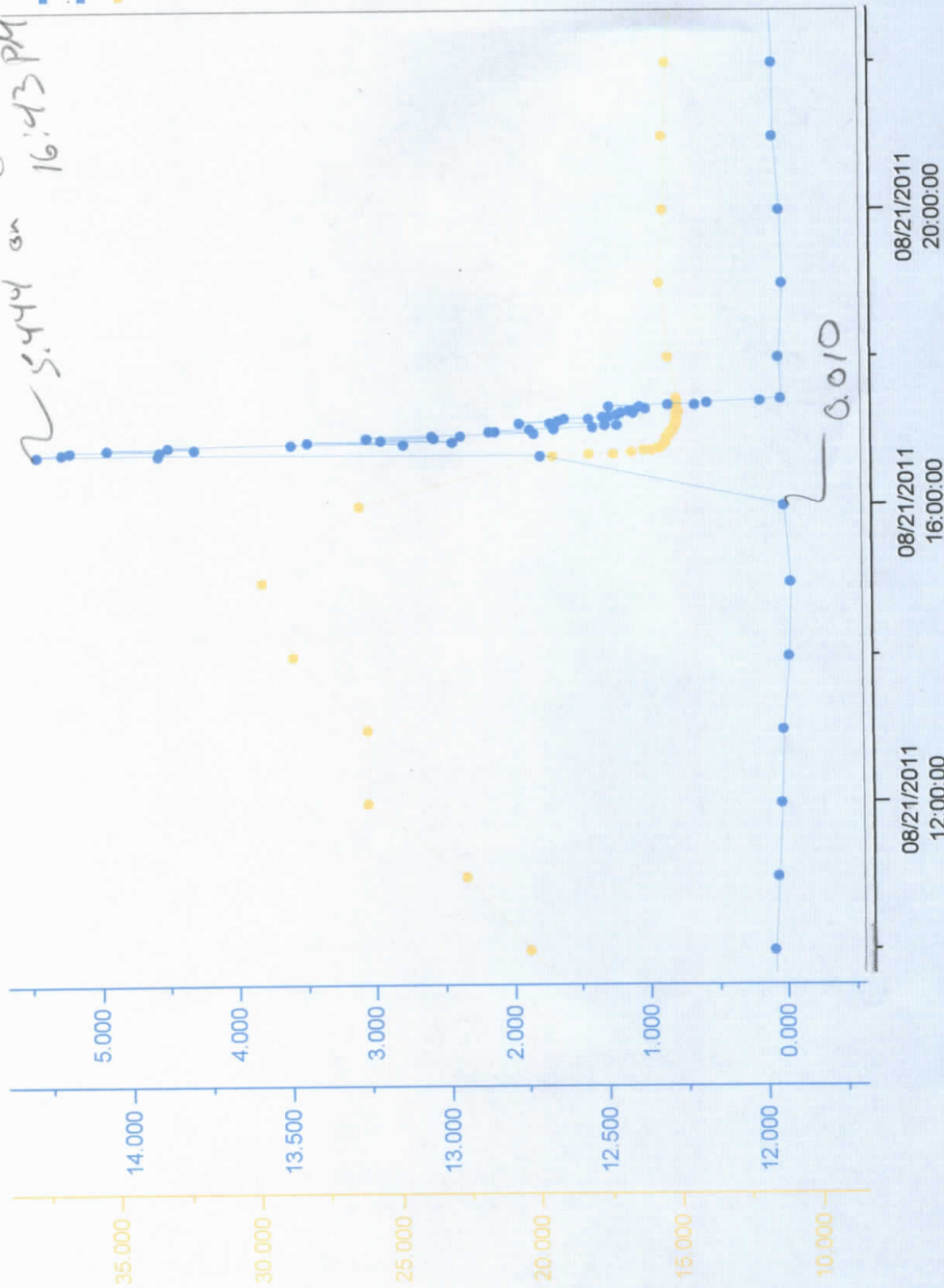
08313350_frijoles

②

11921-

16:43 PM

5.44 or



- Level Surface Elevation (ft)
- Pressure (PSI)
- Temperature (C)

544

0.01

2134

57

70

94

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11/11/21

11449
Gagg
big
H