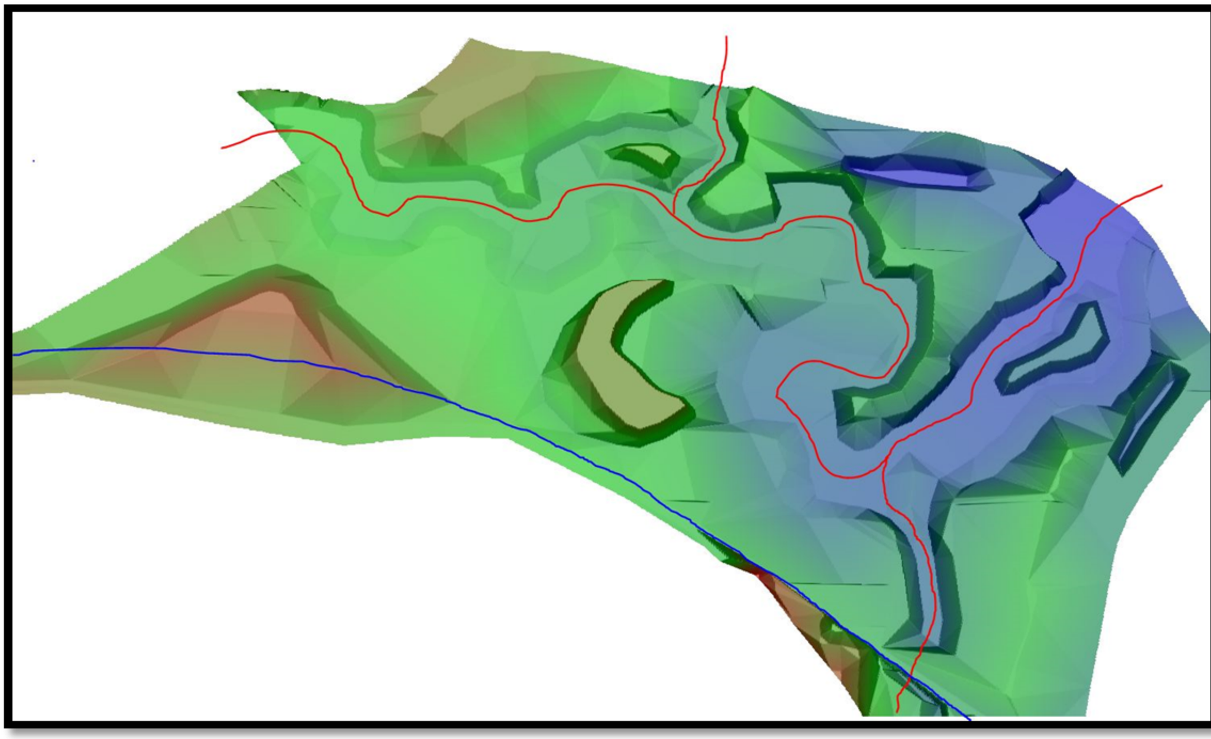
ATTACHMENT J-4

POSTMINE PAR 2I SFSC MAJOR CHANNEL DESIGN

Appendix J Volume 3 Attachment J-4 South Fork Spring Creek Design for PAR 2I (MR212)
August 10, 2015



Design Criteria
The goal of stream reclamation is to approximate the pre mine channel while meeting the rule requirement in ARM 17.24.634(1)(e) to safely pass the 100 year 6 hour storm event. Appendix J includes the post mine hydrology details for constructing stream channels. Section 3.5.2 states, "all channels will be constructed to Tables I-7, I-8, and I-9". This was meant to say tables J-7, J-8, and J-9. This section also says, "as necessary, the dimensions shown on Tables J-7 through J-9 may be adjusted to blend with adjacent native drainage basins and channel features".

Once the drainage area and slope are determined, these tables are routinely used for minor tributary design to determine the approximate **floodplain** width (also called "belt width" or "top width"). However, these tables were never intended to be used for designing major stream channels such as SFSC. Page J-15 states, "all major channel designs will be submitted to MDEQ for review and approval". The purpose of this letter is to satisfy this requirement.

Additionally, the range of drainage areas shown in these tables are too small to be used for the design of the major stream channels as the drainage area is limited to only 700 acres for stream channels with a slope between 0.5 – 2%. The SFSC has a slope of 1.1%, a stream centerline length of 1,536 feet, and a 5,626 acre drainage area at PAR 2I. Appendix J Vol. 2 Attachment #1 on page J-1-112 shows 5,625.86 acres SEDCAD structure #5 which is located within PAR 2I. The location of structure #5 is shown on Map 3. Because of this, Table J-9 was not used in the design of the SFSC major channel design. However, these tables were used for the flood plain design of the minor tributaries SF-6 and SF-8 as discussed below. SCC utilized premine cross sections and the HEC-RAS modeling for designing the SFSC channel floodplain as discussed below.

As is typically the method for stream channel construction, the SFSC drainage and minor tributaries will be constructed with a flat bottom width to allow the 2-yr 24 hour **pilot channel** width (also called the "bankfull width") to form naturally. Only the approximate floodplain width channel necessary for safely passing the 100-yr 6 hour event will be designed and constructed. The method of allowing the bankfull width to develop naturally is described on page J-26 of Appendix J Volume 1. In summary, only the 100-yr 6 hour storm event flows/analysis will be designed and constructed. Figure 1 below shows a typical stream channel cross section and channel dimension terms.

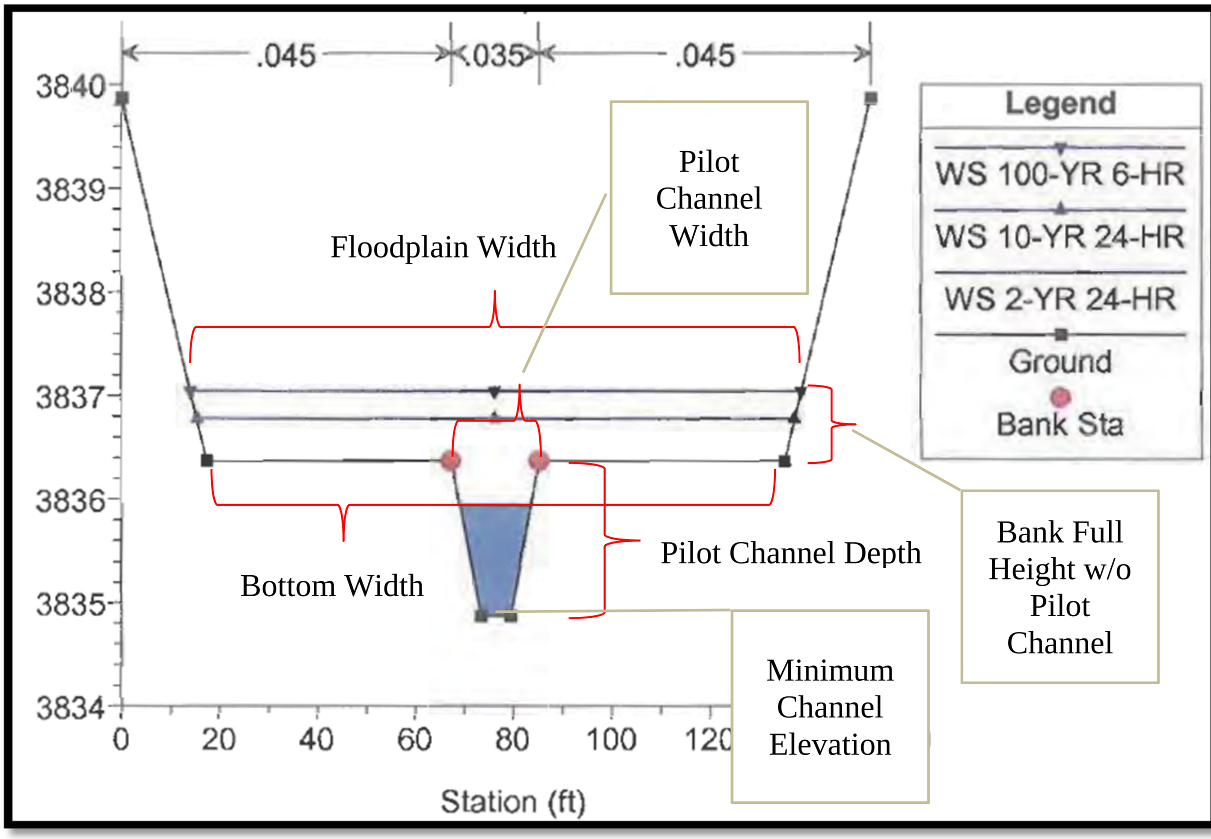


Figure 1. Stream Channel Cross Section Terms.

SFSC Design Results

Channel Sinuosity
As stated above the goal is to design the post mine channel to closely resemble and function as the pre mine channel. The approved stream centerline section of SFSC which crosses the PAR 2I area has large sweeping curves and consistent sinuosity as shown on Map 2. SCC utilized a premine stream centerline section of SFSC channel down stream of the PAR 2I reclamation area as a template to better approximate the pre mine channel sinuosity. The premine centerline channel length was adjusted to be consistent with the 1,536 feet of SFSC going through PAR 2I.

Concave Longitudinal
SCC conducted a detailed as built survey of the minor tributaries and SFSC drainage channel cross sections up and downstream of PAR 2I. This was done to ensure a concave longitudinal profile will be maintained through the PAR 2I area. Because the centerline channel stream length does not change, the SFSC will remain concave longitudinal.

Floodplain Area Determination
The post mine hydrology in Appendix J Vol. 2 Attachment J-2 shows the HEC-RAS modeling results for SFSC. Figure 1 below is from Appendix J Vol. 1 Plate J-4 and shows stations 66, 67, and 68 are within the PAR 2I area and 65 is located directly downstream. These stations represent the flow design criteria for PAR 2I.

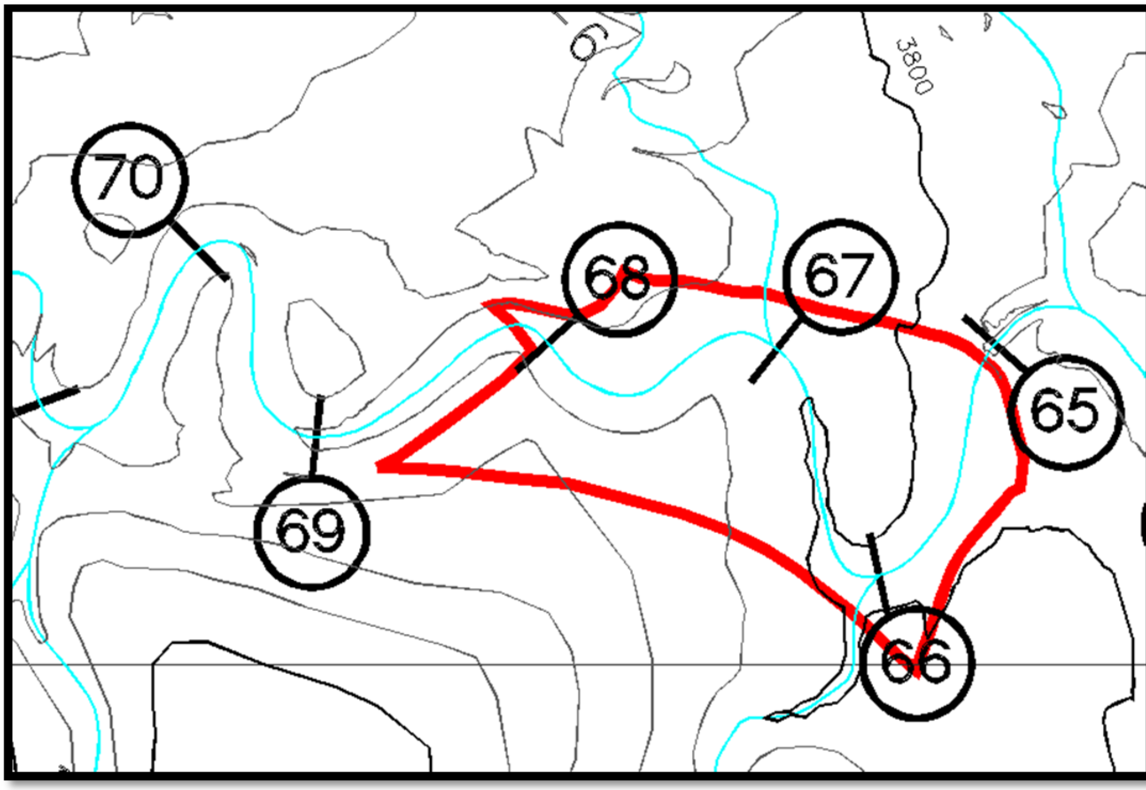


Figure 2. Plate J-4 with PAR 2I Boundary in Red.

Table 1 below summarizes the currently approved design flow data of the four stations from Appendix J Vol. 2, Attachment J-2 pages J-2-22 & 23.

Table 1. HEC-RAS Station Flow Data 100-yr 6-hr event

Station #	Flow Total (cfs)	Vel. (ft/s)	Flow Area (sq. ft)	Flood Plain (ft)	Froude # Chl	Water Surface Elev. (ft)	*Minimum Channel Elev. + 1.5' (ft)	Height of Bank Full w/o pilot channel (ft)
68	404.7	6.03	111.8	125.7	0.8	3808.1	3807.3	0.8
67	404.7	6.71	101.2	124.9	0.91	3802.9	3802.2	0.7
66	352.5	6.12	96.9	124.5	0.84	3797.3	3796.6	0.7
65	352.5	6.48	91.8	124.1	0.90	3791.5	3790.8	0.7
Average	378.6	6.34	**100.4**	124.8				0.73

*p. J-18 states SFSC the pilot channel is 1.5' deep. This depth was used for HEC-RAS analysis.

Table 1 above shows an average floodplain width of 125 feet with an average depth of only 0.7 feet. This section of SFSC indicates a fairly wide and shallow design whereas the pre mine channel was more entrenched. The average cross sectional area of **100** square feet was used as the targeted area necessary to safely pass the 100-yr 6 hour event.

Premine Channel Characteristics

As mentioned above, the native section of SFSC immediately upstream of PAR 2 reclamation was used as a guide to represent premine channel conditions. This area of the undisturbed channel was surveyed and a detailed topo of the area was drawn as shown on Map 1. After the cross section profiles were generated, an iterative process was used by drawing horizontal lines across the stream profile until the desired cross sectional area of approximately 100 square feet was attained. The profiles are shown on Map 1. The stream channel dimensions relative to a 100 square foot cross section flow event were then measured and recorded in Table 2 below. Because the 2-yr 24 hour pilot channel will not be constructed, the cross sectional area of the premine pilot channel was not included. The 2-yr 24 hour pilot channel is shown as blue and the 100-yr 6 hour area is shown in orange. Table 2 correlates with Map 1.

Table 2. Premine Cross Section Channel Characteristics

Station #	Area (sq. ft)	Total Perimeter (ft)	Flood-plain (ft)	Wetted Perimeter (ft)	Bottom Width (ft)	Height of Bank Full w/o pilot channel (ft)
1	98	239	*120	120	*28	2.7
2	109	150	73	78	29	2.4
3	98	215	108	108	44	1.6
4	114	200	100	100	92	2.0
Average	105		100	101	48	2.2

*The 100 sq feet of cross section is split between two areas for Cross Section #1.

Table 2 above shows an average floodplain width of 100 feet wide with an average depth of 2.2 feet. This indicates the premine section of SFSC is narrower (100' vs 125') and deeper (2.2' vs 0.7') compared to the PMT.

The cross section profiles of the native area on Map 1 show a general topographic trend of being steeper on the north side and flatter on the south side of SFSC. This general concept and the average stream channel characteristics from Table 2 above were used as guidelines for the PAR 2I topography design as shown on Map 2.

Postmine Channel Characteristics

Table 3 below shows the as designed cross section data for stations 66 through 68 as shown on Map 2. Station 65 was not included because it is already constructed. However, stations A (upstream) and stations B (downstream) are included for comparison purposes. Station B is adjacent to station 65 as shown on Map 2.

Table 3. As Designed Postmine Cross Section Channel Characteristics

Station	Area (sq. ft)	Perimeter (ft)	Floodplain (ft)	Wetted Perimeter (ft)	Bottom Width (ft)	Height of Bank Full w/o pilot channel (ft)
A *built*	98	162	81	81	49	1.4
68	109	166	83	83	52	1.6
67	107	135	67	67	37	2.0
66	101	151	75	76	56	1.6
B *built*	102	267	134	133	59	1.1
Average All	103		88	88	50	1.5

Table 3 shows average floodplain, wetted perimeter, bottom width, and bank full heights similar to the pre mine channel cross sections in Table 2. This revised SFSC design is more entrenched and more diverse compared to the uniform shallower drainage shown in Table 1 above.

Channel Stability

The HEC-RAS software was then used to ensure the revised channel design and change in sinuosity would safely pass the 100-yr 6 hour storm event. Table 4 below shows the results of the HEC-RAS modeling in comparison to the values shown in Appendix J Volume 2, Attachment #2.

Table 4. Comparison of HEC-RAS analysis for Stations 65 through 68.

Station		Q Total (cfs)	Min Ch. El (ft)	W.S. Elev. (ft)	Critical W.S. (ft)	E.G. Elev. (ft)	E.G. Slope (ft/ft)	Vel. Chnl (ft/s)	Flow Area (sq. ft)	Top Width (ft)	Froude # Chl
Approved	68	404.7	3805.8	3808.1	3808.1	3808.4	0.010	6.03	111.8	125.7	0.80
Designed	68	433.5	3806.3	3808.1	3807.6	3808.3	0.008	4.28	112.1	79.6	0.58
Approved	67	404.7	3800.7	3802.9		3803.3	0.013	6.71	101.2	124.9	0.91
Designed	67	433.5	3800.9	3802.6		3803.0	0.016	5.88	82.7	62.1	0.8
Approved	66	352.5	3795.1	3797.3	3797.3	3797.6	0.011	6.12	96.9	124.5	0.84
Designed	66	441.2	3795.1	3796.6	3796.3	3796.9	0.015	5.01	92.0	71.4	0.75
Approved	65	352.5	3789.3	3791.5	3791.5	3791.9	0.013	6.48	91.8	124.1	0.90
As Built	65	441.2	3787.5	3790.4	3790.4	3791.0	0.011	7.34	83.4	73.7	0.87

The approved flows are slightly lower compared to the designed flow rates. This is because the design model takes into account input changes resulting from the TR-1 major permit revision. The TR-1 revision resulted in small changes to the SFSC drainage area which resulted in slightly higher flows. Table 4 shows the post mine channel will be stable with a Froude number below 1.0 using the higher flows of the TR-1 revision.

Channel Function

The inherent risk in constructing a low slope stream channel with a wide flat bottom width is the stream channel can take the shortest route; which reduces the stream length. The flat bottom width has been pushed out near the drainage centerline in strategic areas to ensure the stream channel length will not be compromised as the pilot channel forms naturally. Two islands were also added to provide topographic diversity and to direct the stream channel. Additional upland swales and hill features were also added to improve topographic diversity. Figure 3 below shows a three dimensional rendering of the PAR 2I area with the stream centerline traced in red.

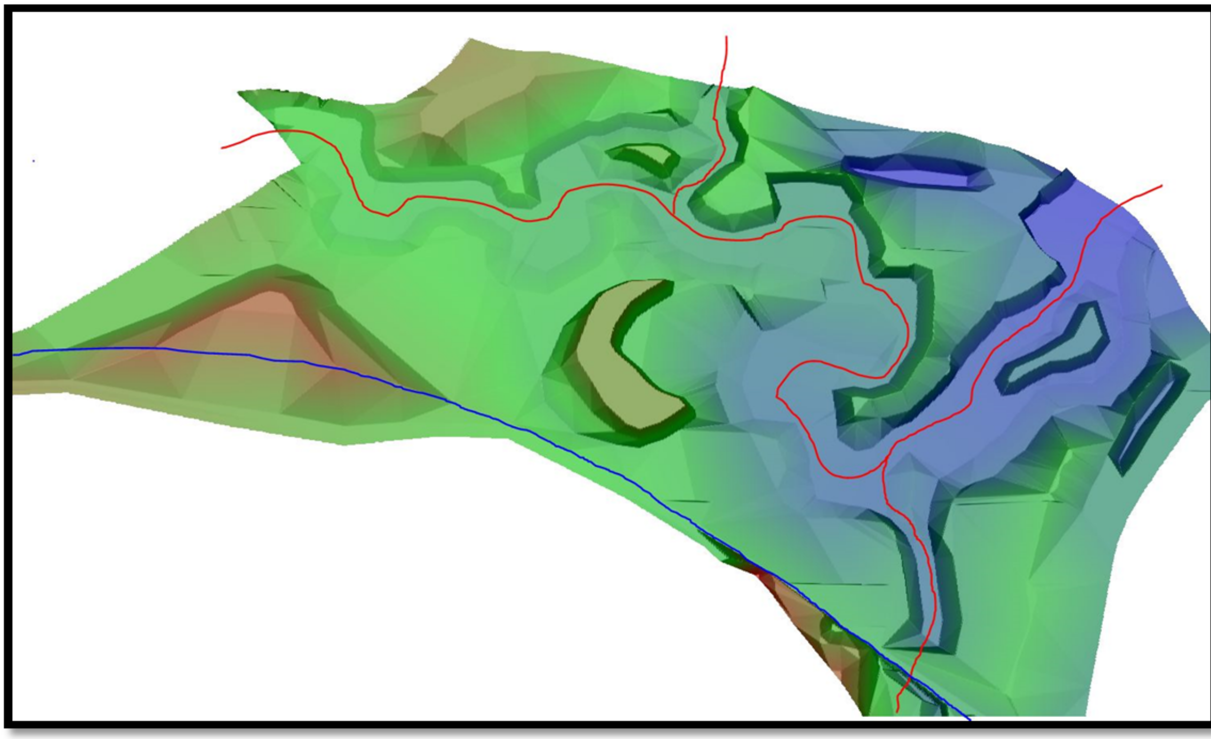


Figure 3. 3-D rendering, stream centerline in Red and PAR 2I southern boundary in Blue

Channel Construction
The SFSC channel has an approved typical cross section shown on Plate J-6 in Appendix J Volume 1. Figure 4 below shows this cross section which details two feet of alluvial topsoil placed in the drainage bottom. The alluvial A and B topsoil will be placed in the stream bottom as shown in Figure 3 below.

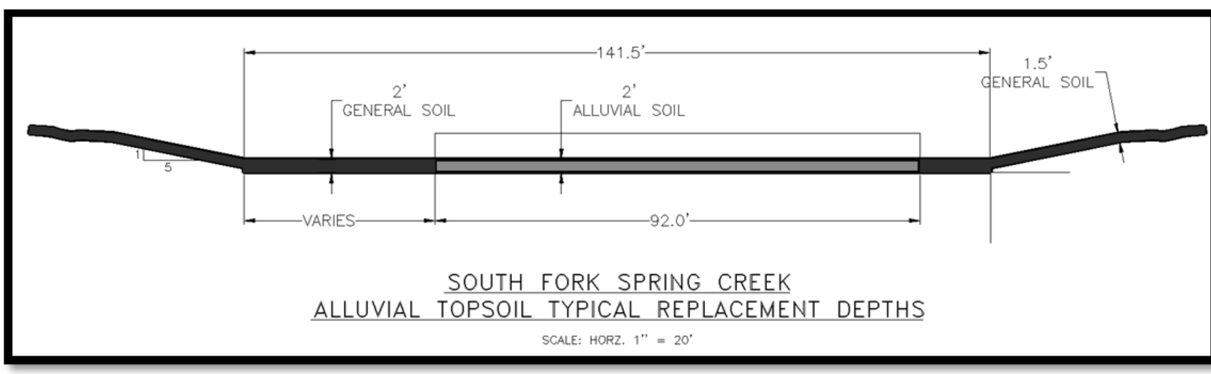
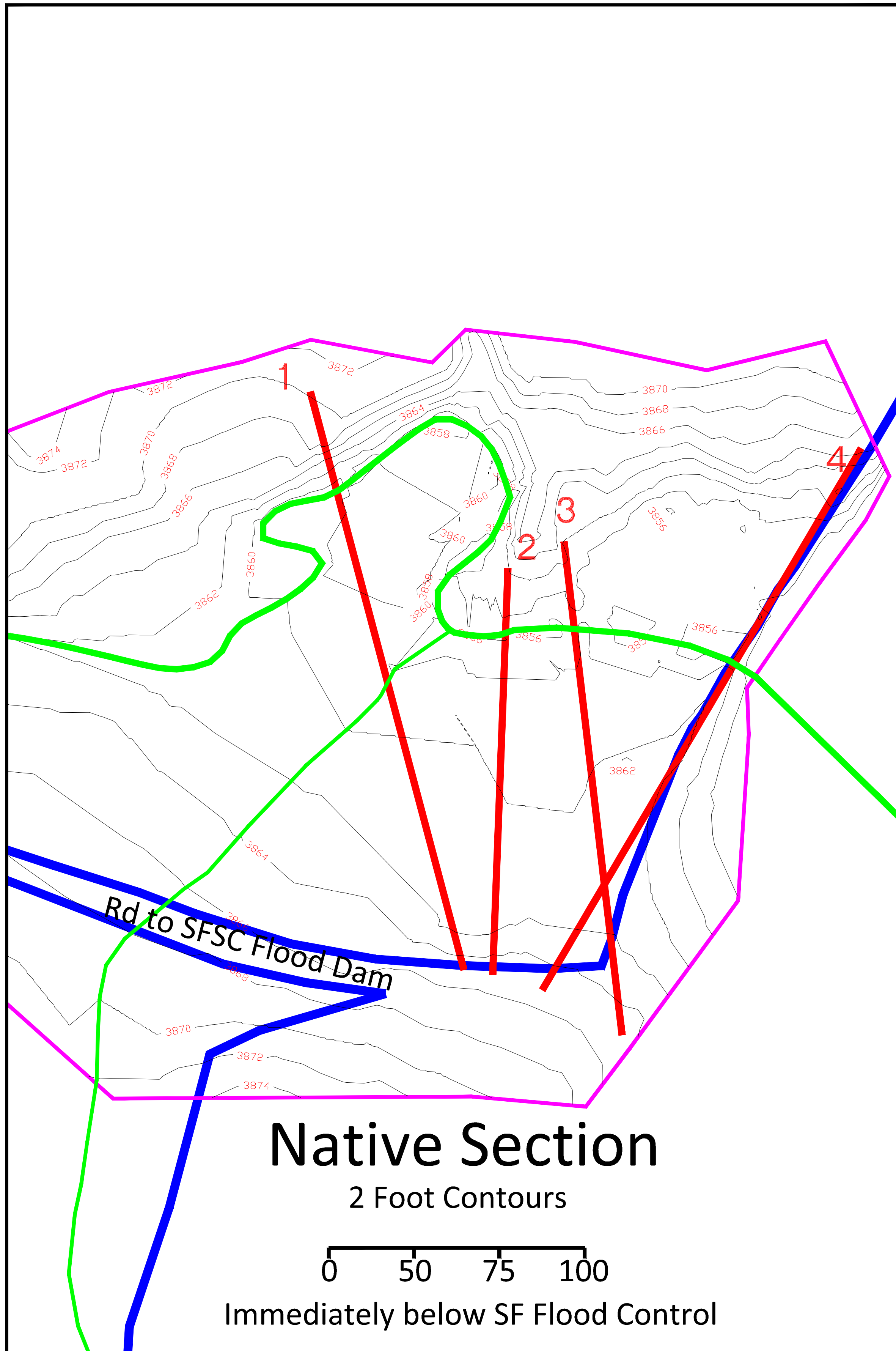
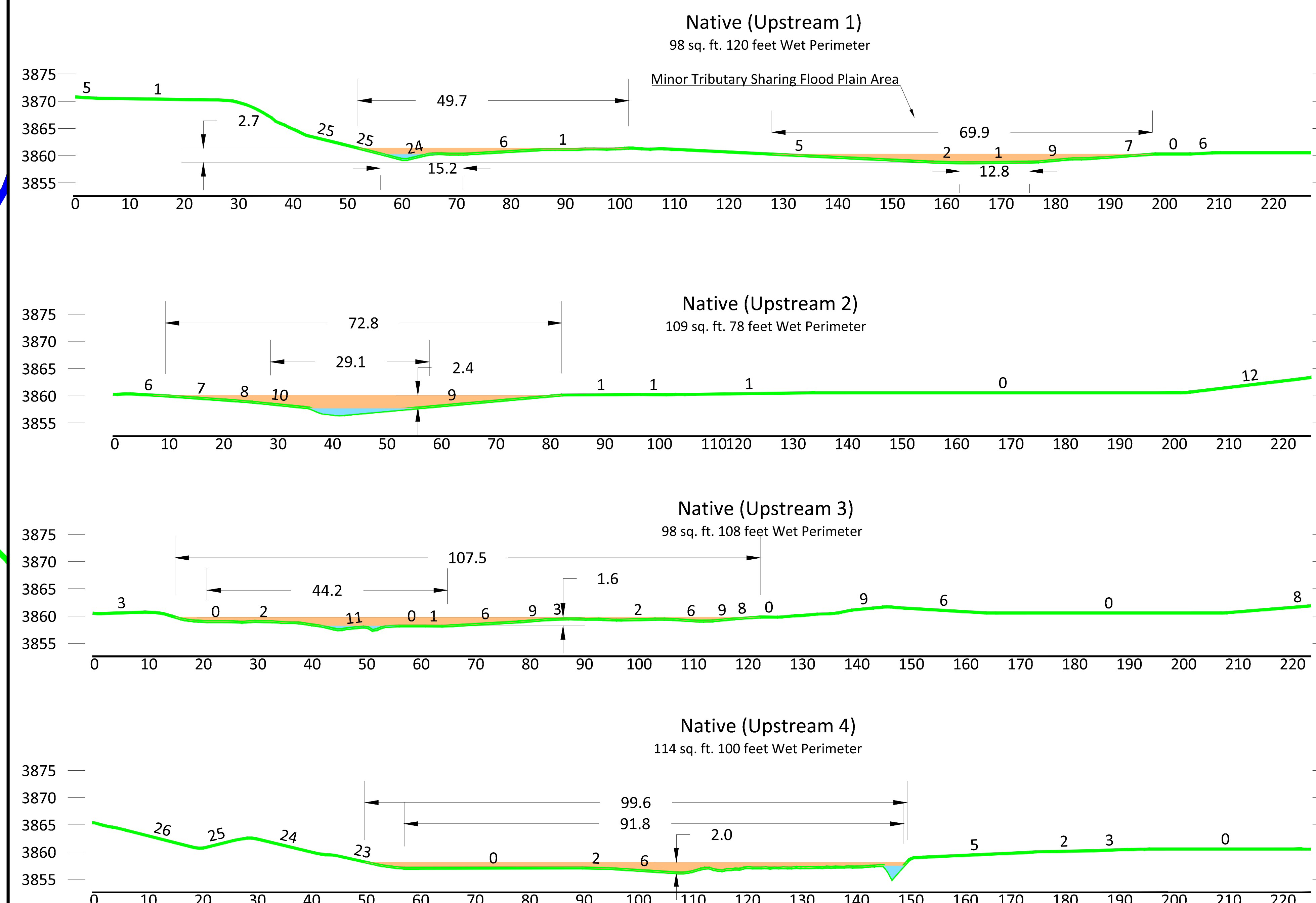


Figure 4. Appendix J Vol. 1 Plate J-6



Native Upstream Section Between SF Flood Control and West end of Pit #1



2 year 24 Hour Storm Event

100 year 6 Hour Storm Event

LEGEND

Current Disturbance Boundary

Premine Topo Boundary

Cross Section for PAR 2I Design

Drainage Centerline from PMT Map (Plate 4)

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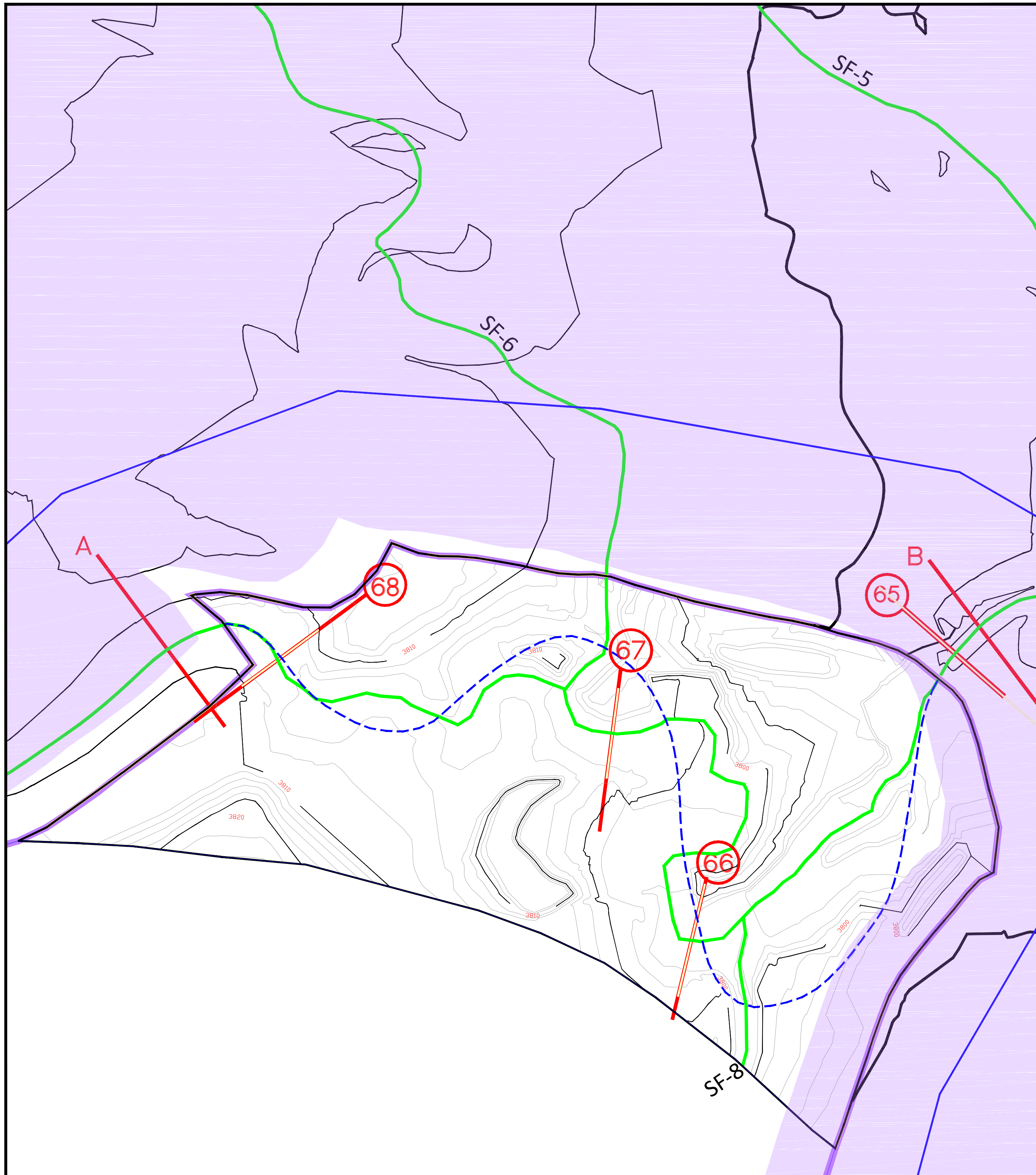
Map 1
PAR 2I South Fork
Pre Mine Channel

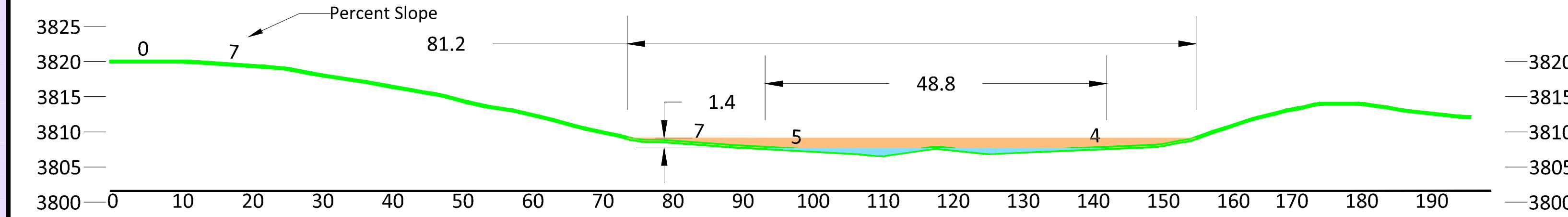
DATE	REVISION
BY	

DESIGN GLJ DRAWN GLJ DATE 4/22/2015 SHEET 1 OF 3

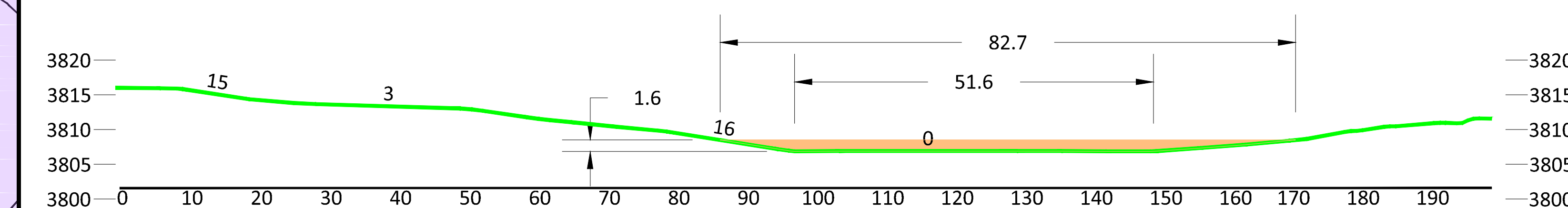
SCALE as shown CONTOUR INTERVAL 2 foot FILE NUMBER CF 10.3.2 2015 PAR 2I Design



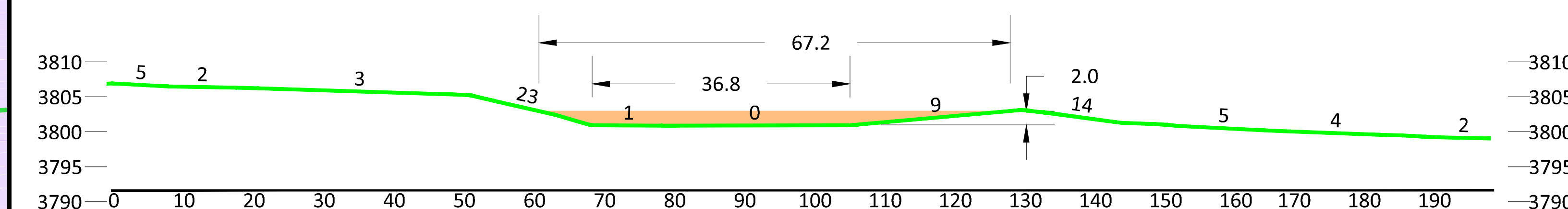
PAR 2I (Cross Section A Upstream)
98 sq. ft. 81 feet Wet Perimeter



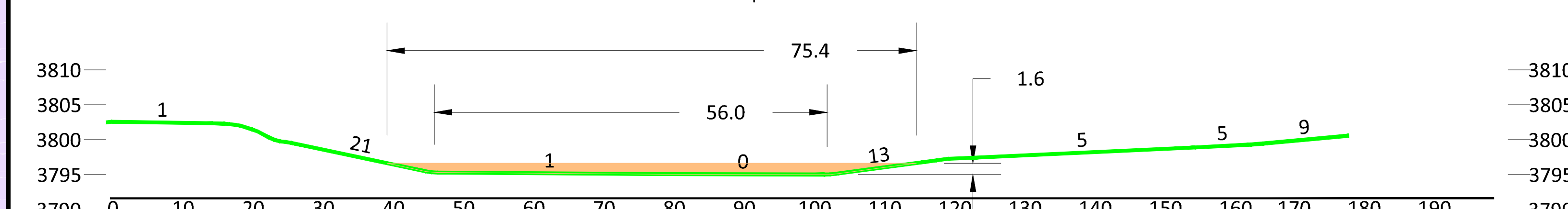
PAR 2I (Cross Section 68 HEC-RAS)
109 sq. ft. 83 feet Wet Perimeter



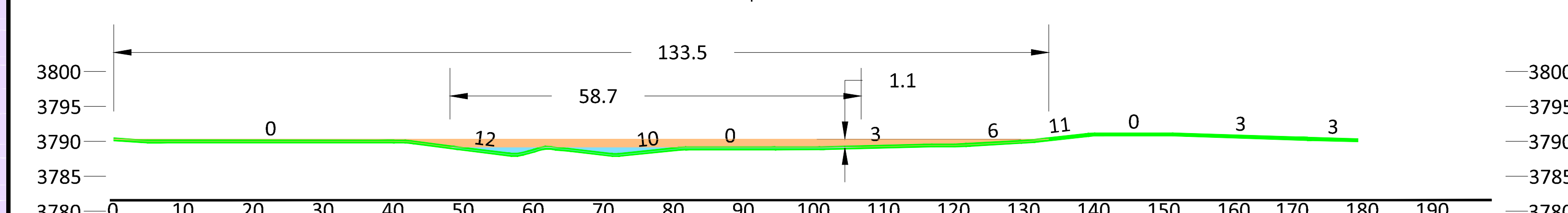
PAR 2I (Cross Section 67 HEC-RAS)
107 sq. ft. 68 feet Wet Perimeter



PAR 2I (Cross Section 66 HEC-RAS)
101 sq. ft. 76 feet Wet Perimeter



PAR 2I (Cross Section B Downstream)
102 sq. ft. 133 feet Wet Perimeter



2 year 24 Hour Storm Event

100 year 6 Hour Storm Event

LEGEND

68 HEC-RAS Cross Section Appendix J Vol 1 Plate J-4

Current Reclamation Boundary

PAR 2I Reclamation Boundary

Drainage Centerline

Drainage Centerline from PMT Plate 4

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DATE	REVISION
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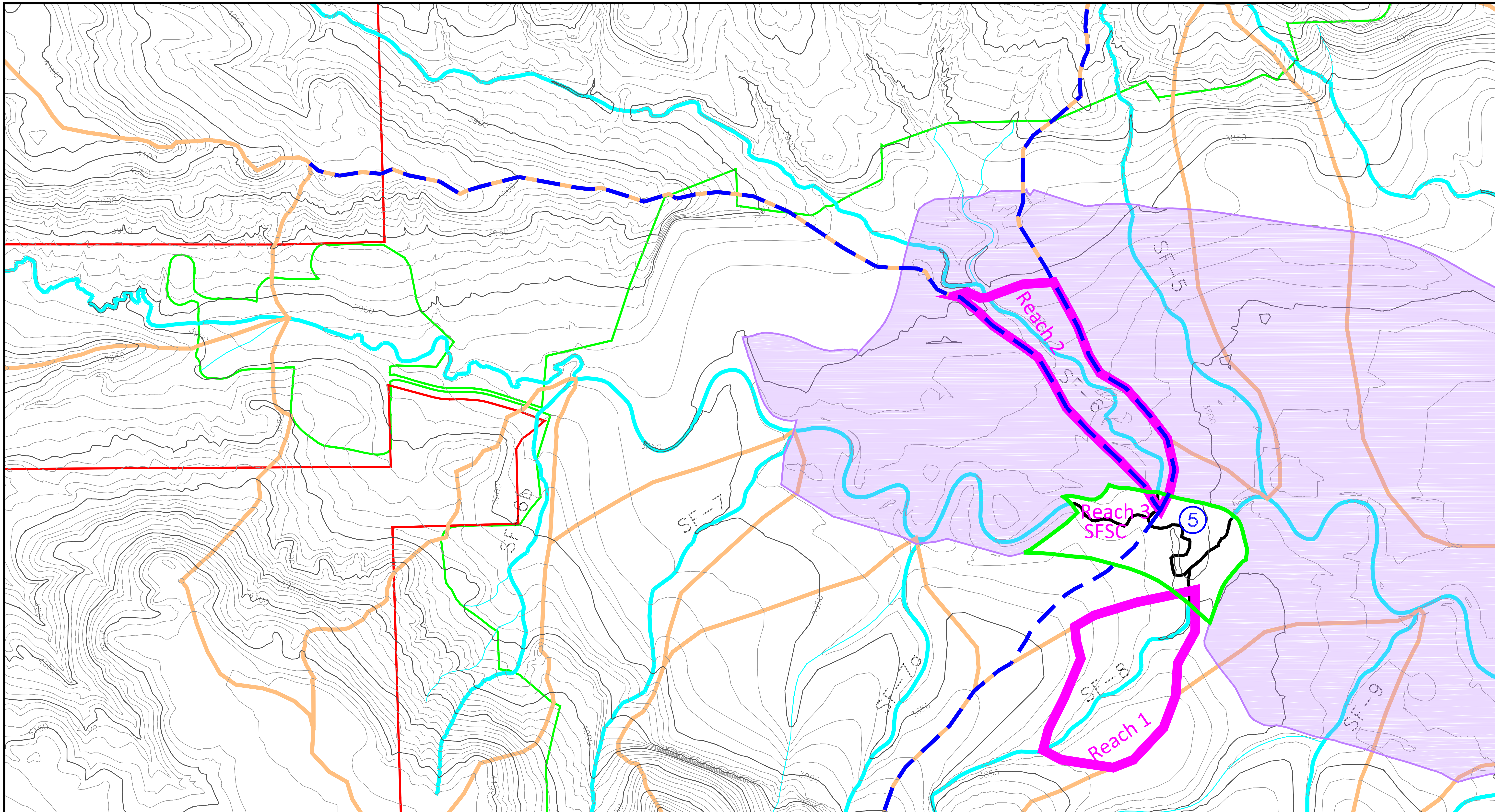
Map 2
PAR 2I South Fork
Drainage Design

DESIGN GLJ DRAWN GLJ DATE 4/22/2015 SHEET 2 OF 3
SCALE as shown CONTOUR INTERVAL 2-foot FILE NUMBER CF 10.3.2 2015_PAR 2I Design



LEGEND

5 SED-CAD Junction Appendix J Vol 1 Plate J-3

Reach Boundary

HEC-RAS Drainage Boundary

Current Reclamation Boundary

PAR 2I Reclamation Boundary

Mine Permit Boundary

Life of Mine Disturbance Boundary

Drainage Centerline Revised PAR 2I

Drainage Centerline Approved

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Map 3
PAR 2I South Fork
Drainage Area

DESIGN GLJ DRAWN GLJ DATE 4/22/2015 SHEET 3 OF 3

SCALE 1" = 500' CONTOUR INTERVAL 10 foot FILE NUMBER CF 10.3.2 2015..PAR 2I Design