APPENDIX B

Department of Conservation
California Geological Survey
Big River State Park- Watershed Restoration- Rd M2

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Date: May 5, 2014

Subject: Big River State Park – Watershed Restoration – Rd M2

County: Mendocino

Description: T17N, R17W, Sections 22, 26, 27 MDB&M.

Quadrangles: United States Geological Survey 7.5 minute Quadrangle Series (Topographic): Mendocino Peak, 1991 (39123C7)

Watershed: Super Planning Watershed: Mouth of Big River – 1113300403

References:

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4. Frizell, Kathleen H., James F. Ruff, and Subhendu Mishra, 1990, Simplified design guidelines for riprap subjected to overtopping flow, USBR, Hydraulics Laboratory Publication PAP-0790.
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Introduction

Mendocino Land Trust (MLT) working with California State Parks (CSP) is undertaking watershed restoration activities along the alignment of the M2 haul road (Project). The Project objective is to restore to the extent possible, hydrologic and hydraulic function to that part of the watershed traversed by the abandoned M2 haul road.

During the 21 April 2014 on-site meeting CSP, MLT, and CGS discussed project objectives and desired outcomes. The project will consist of pulling back outboard fill wherever possible, removal of all cross-drain culverts, and removal and stabilization of all water-course crossings. Spoil generated during road decommissioning will be managed on-site.

Due to administrative considerations, this project was placed upon a compressed schedule. Thus, the following design parameters are based on a reconnaissance level examination of haul road M2 and its appurtenant features rather than a more comprehensive evaluation typical of such projects at this point in the design process. As such, volumetric estimates are plus or minus 35 percent, at best.

Field Reconnaissance

CGS conducted a visual inspection of all project features. Basic hand-leveling and pace and compass traverses were conducted to generate approximate slope and grade data. In addition, basic measurements were obtained on the plan, pattern and profile of representative sections of the watercourses. In order to discern cross-drain culverts from actual water-course crossings each culvert location was evaluated up- and down-stream of the culvert to verify the presence of an actual channel, as opposed to a gully from concentrated runoff, and to collect data on the plan, pattern, and profile of any streams encountered.

Global Positioning System (GPS) data was also gathered to reference locations of Project features. These data were combined with existing CSP LIDAR topography data in a geographical information system (GIS) for use in subsequent analysis.

Project features consist of approximately 1.6 miles of former logging haul road with an average width of 22 feet with grades range from 2 to 16 percent.

Hydrologic features include seven water-course crossings, 7 ditch-relief or cross-drain culverts, one inline ditch culvert, one boggy area, and the hydrologic disconnection of road M2.5. This corresponds to the GIS files provided by CSP (Terra Fuller, personal communication 4-25-2014).

CGS also noted that the majority of the outboard fill was well vegetated and did not exhibit signs of stress[1]. For estimating purposes, a value of 2500 feet of outboard fill will be pulled back. This equates to an excavated volume of approximately 10,000 cubic yards.

Soils

Soils in the project area are predominately sandy, clay content running from 10 to 50 percent, and thus not resistant to erosion. Depth of soil ranges from slightly less than 3 feet to over 5 feet, depending on slope.

Table 1 is a summary of soil complexes and key properties occurring within the Project.

Soil Complex Name	Runoff Rating	Erodibility	Geomorphic Position
Shinglemill-Gibney	Very High	Moderate	Upper Slope
Quinliven-Ferncreek	High	High	Mid-Slope
Irmulco-Tramway	Moderate	High	Mid-Slope
Dehaven-Hotel	moderate	High	Lower slope

Source: USDA – Soil Web

Geology

The underlying regional geology is Franciscan Formation, a collection of terrains accreted during subduction of the Pacific Plate beneath the North-American Plate. The terrains in the Franciscan Formation consist of a series of northwest-southeast trending belts. The project lies within the coastal belt which consists of greywacke sandstone (mixed grain types), arkosic sandstone (quartz-feldspar), argillite (shale/slate), greenstone (metamorphosed submarine volcanic rocks), chert, vein quartz, and limestone, listed in decreasing order of abundance Jayco, et al, 2001. In the Project area the dominant bedrock is greywacke sandstone with lesser amounts of shale.

[1] E.g., tension cracking, slumping, leaning or pistol-butted trees.....

Hydrologic Analyses

CGS reviewed existing hydrologic data sets[2] for the largest drainage (0.88), estimating 2, 5, 10, 25, 50, and 100-year flows. Estimates of flow were used to derive general dimensions for rock armor.

Design Storm Flow

In keeping with general practice, the 100-year storm flow was used for estimating minimum channel dimensions and sizing rock armor. A design flow of 23 cubic feet per second (cfs) was used. A summary of the computations used to estimate the 100-year storm flow is attached.

Earthwork

It is anticipated that all earthwork can be accomplished by conventional means. Given the size and depth (reach) of several of the crossings, it is recommended that an excavator with an excavation reach of 20 feet or better[3] be utilized. Excavation volume (spoil) estimates were made based upon reconnaissance –level field measurements (see above) and include a 25 percent bulking or swell factor. Table 3 is a summary of earthwork volumes for hydrologic features.

Earthwork also includes "pulling back" the outboard fill on suitable segments of road. For estimating purposes, a value of 2500 linear feet of outboard fill will be pulled back. This equates to an excavated volume of approximately 10,000 cubic yards.

<u>Road Prism</u>

Road prism treatments will include out-sloping and "pulling back" the outboard fill portion of the road and placing it against the road cut. This is sometimes referred to as a partial re-contour. The objective is to remove potentially unstable outboard fill and place it as a compacted fill in a stable location, the cut portion of the road bed. Additional benefits include buttressing the road cut and decommissioning the inside ditch.

Drainage of remaining road prism will be accomplished through a combination of techniques. For road segments with grades of 8 percent or less the road surface will be out-sloped and dips constructed as needed or at least every 150 feet. For road segments with grades greater than 8 percent, drainage will be achieved through out-sloping in conjunction with water bars. Water bar spacing will be a function of road grade. Table 2 summarizes water-break spacing as a function of road grade for the soils anticipated to be encountered during the project.

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[2] *Goodridge, 2002, Compilation of Climatological Data for the California Department of Water Resources. USGS Water-Resources Investigation 77-21 for estimating flow (regression analyses),*

[3] Typically an excavator rated between 45,000 and 50,000 pounds (Caterpillar, 2014; John Deere, 2014)

Table 2: Water-Break Spacing As Function Of Road Grade

Road Grade (%)	Water Break Spacing (ft)
0 - 5	50
6 - 10	30
11 - 15	20
16 - 20	15

After Keller and Sherar, 2003

Spoil generated during out-sloping and dip construction will be used to decommission the inside ditch and buttress the cut slope.

Crossings

Crossing removal will generate sediment after construction from processes such as landsliding, channel incision, and bank erosion resulting from changes in channel base elevation (Madej, 2001; Switalski and others, 2004). Additional sources of post-removal sediment include soil disturbance from heavy equipment used in the construction, and large, bare slopes formerly covered by crossing fill (PWA, 2005).

Studies of road and crossing removals indicate that sediment production following construction ranges from 5 to 10 percent of the amount of excavated materials even when post-removal erosion control measures are present (Madej,2001; Harris and others, 2008; Keppeler and others, 2007; PWA, 2005).

Project values for generated sediment would then be on the order of 500 cubic yards (yd^3) for a crossing such as M2-0.88 and 40 yd^3 for a crossing like M2-0.48. These sediment yield estimates are for ideal conditions, when very rigorous erosion control measures are in place. If partial erosion control is utilized, sediment yields will be considerably higher.

Project crossing removal will entail removal and salvage of surficial organic debris, removal of anthropogenic fill and accumulated sediment associated with the crossing. Slopes will be graded to blend with native slopes. Channel dimensions and grade will be based upon conditions of minimally disturbed channel sections up- and down-stream of the crossing.

In order to inhibit erosion of newly disturbed materials, salvaged organic debris will be placed upon bare slopes and a combination of jute / coir logs and plantings as necessary. Reconstructed channels will be protected with a combination of jute netting, extensive willow planting, and rock armor Figure 2. The extent and location of armor will be based upon conditions encountered during crossing removal. For example, if during crossing removal original channel gravels are encountered and extend the length of the unearthed channel section, then the need for rock armor is greatly diminished. However, if channel deposits are not encountered and just deep, easily eroded soils, then a more robust application of rock armor will be required.

Any trees downed during the process of crossing removal will be retained and incorporated into the new channel as large woody debris (LWD). While these are essentially alpine streams, if a remnant flood plain is uncovered during excavation, the reconstruction effort will strive to reconnect the channel to that flood plain.

Figures 3 and 4 (attached) are typical drawings for crossing removal and channel restoration.

Figure 2: Typical Post-Removal Erosion Control (flow direction into page, note live willow stakes in voids within armor and anchoring jute netting)

Table 3: Estimates Of Restored Channel Footprint

Crossing Number	Length Existing Culvert (ft)	Length New Channel (ft)[1]
0.34	30	40
0.41	28	40
0.48	40	50
0.88	110	245
1.06	25	45
1.34	36	60
1.46	34	50

1-Based upon estimated footprint of crossing fill

<u>Cross Drains</u>

Cross drains or ditch-relief culverts will be removed and the excavation will be backfilled. Following backfilling, the cross-drain locality will be out-sloped and water breaks constructed as needed.

Table 4: Excavation and Backfill Volumes for Hydrologic Features

Feature ID	**Feature**	**Spoil**	**Backfill**
(road mileage**)**		yd^3	yd^3
0.08	Cross-drain		3
0.13	Cross-drain		3
0.16	Cross-drain		3
0.2	Cross-drain		3
0.24-0.26	Boggy Area		
0.29	Ditch culvert		3
0.32	Concentrated run-on		
0.36	Water Course Crossing	320	
0.41	Water Course Crossing	530	
0.45	Cross-drain		
0.48	Water Course Crossing	350	
0.74	M2.5 Hydrologic disconnection		200
0.88	Water Course Crossing	5,000	
0.91	Cross-drain		3
1.06	Water Course Crossing	75	
1.32	Cross-drain		3
1.34	Water Course Crossing	200	
1.46	Water Course Crossing	290	
	Bank Volumes	6,765	221
	Excavated Volume	8,456	

Spoil Management

During reconnaissance, CGS noted 16 potential spoil management locations. Potential spoil capacity was estimated using a foot-print from a LIDAR-based topographic map with a minimum five-foot setback and a maximum fill height of six feet.

Table 5: Capacities of Spoil Management Areas

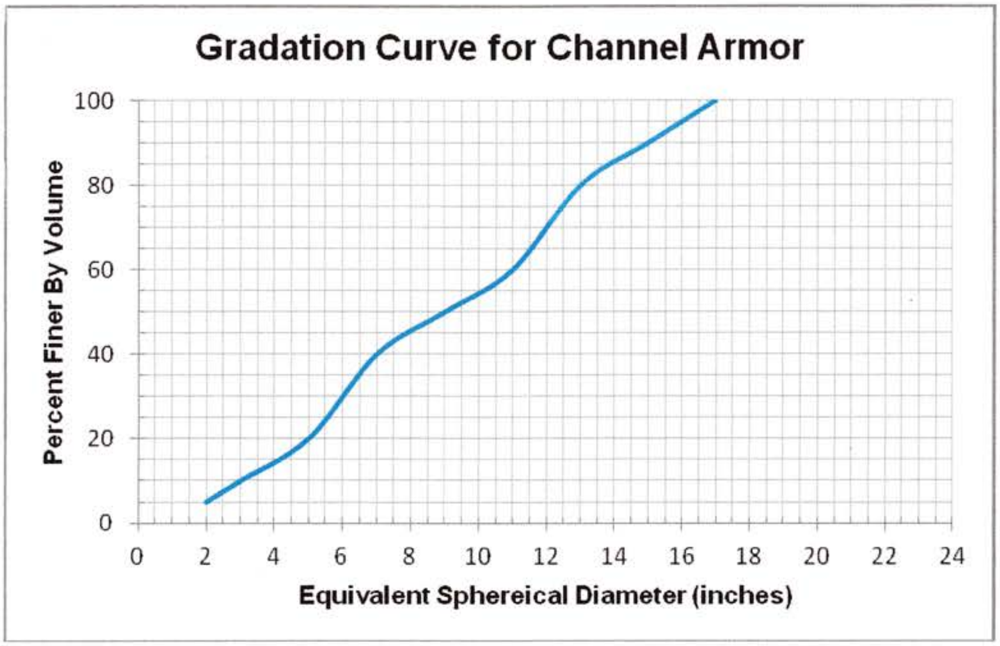
Feature ID	Feature	Spoil Area
(road mileage)		yd^3
0.07	Spoil Area	1160
0.39-0.40	Thru-cut / spoil area	380
0.44	Spoil Area	290
0.5	Spoil Area	2500
0.58	Spoil Area	1250
0.61	Spoil Area - M2.3	2600
0.64	Spoil Area	480
0.74 - 0.77	Spoil Area - M2.5	1060
1.02 - 1.04	Spoil Area	4850
1.11	Spoil Area	580
1.13	Spoil Area	290
1.17	Spoil Area	1060
1.24	Spoil Area	1160
1.28	Spoil Area	1650
1.36	Spoil Area	950
1.42	Spoil Area - M2.4	5800
	Total Volume (yd^3)	26,060

Spoil areas are located rather uniformly along the road alignment, with the largest corresponding to former logging landings. There is more than three times the spoil capacity as there is estimated spoil volume.

Rock Armor

Following USBR and Caltrans protocols an initial estimate of rock size was made for a storm flow of 26 cfs (M2-0.88). The 50th percentile rock (D_{50}) was estimated to be nine inches. Figure 2 is a graph of armor gradation. Standard specifications that are a close match for the armor gradation would be a **50-50 blend of Caltrans Backing Numbers 1 and 3.**

Figure 2: Armor Gradation



Estimates of rock armor requirements for removed water course crossings are provided in Table 3 below. Armor will not be used at cross-drain removal sites because the cross drain will be removed and backfilled with native material, the inside ditch feeding the former cross drain will be backfilled and the road out-sloped.

Table 6: Rock Armor Tonnage By Water Course Crossing

Crossing Designation	Tons (U.S.) Rock Armor
0.34	32
0.41	26
0.88	245
1.06	28
1.34	38
1.46	37

While not all the rock armor may be needed, given the potential for loss of heavy equipment access to the Project due to closure of road M1, it would best to be conservative in volumetric estimates.

The rock armor gradation is sufficiently robust to be used on other projects such as M1-7K culvert upgrades and Nelson Gulch fish Passage Improvement.

Original signed by
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Attachments: Location Map
Hydrologic Calculations
Typical Longitudinal Profile
Typical Cross Section with detail

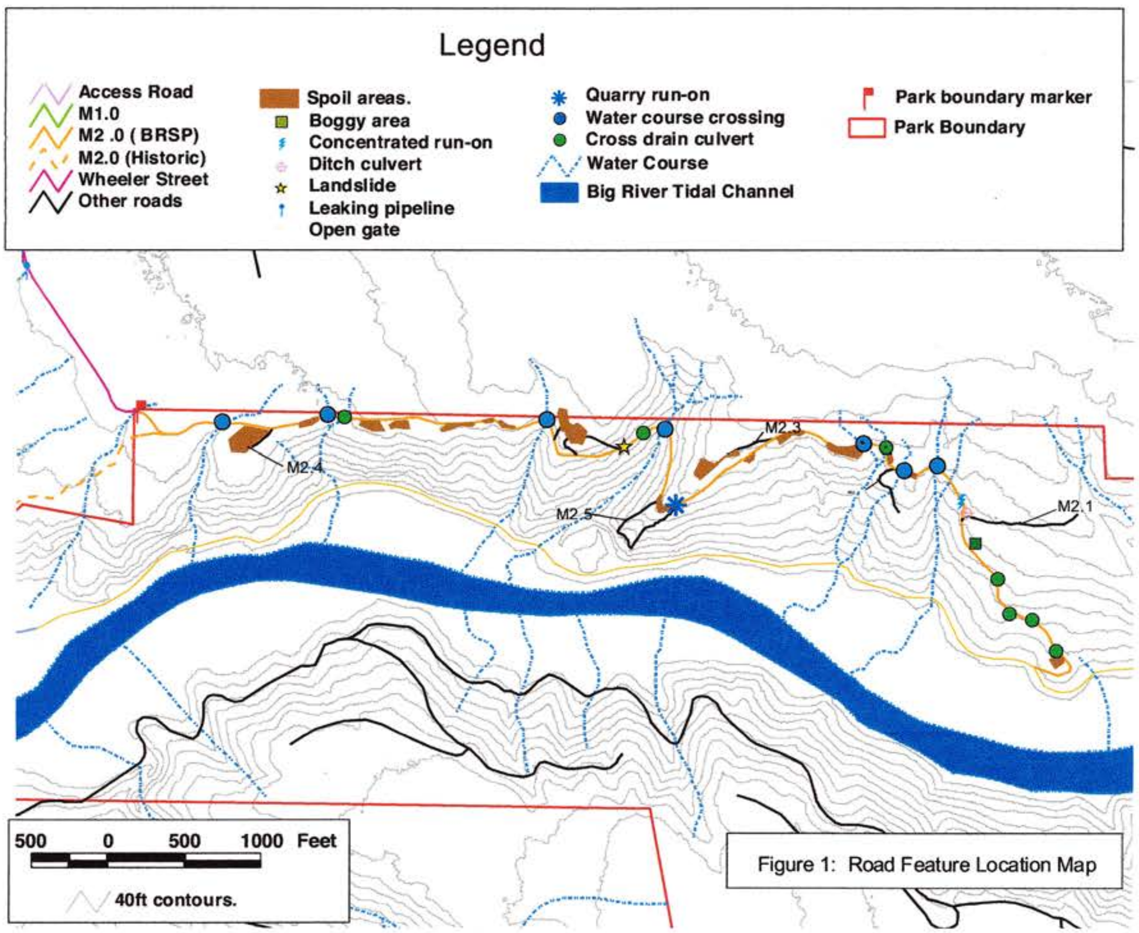

Figure 1: Road Feature Location Map

M2-0.88 Flow Estimates

Estimation of Storm Flows by Regression Method
$Qrp = C A^{e1} P^{e2} H^{e3}$

Return Period	A	P	H	C	e1	e2	e3				Q (cfs)
2.0	0.040	45.0	1.0	3.5200	0.90	0.89	-0.47	0.1	29.6	1.00000	6
5.0	0.040	45.0	1.0	5.0400	0.89	0.91	-0.35	0.1	31.9	1.00000	9
10.0	0.040	45.0	1.0	6.2100	0.88	0.93	-0.27	0.1	34.5	1.00000	13
25.0	0.040	45.0	1.0	7.6400	0.87	0.94	-0.17	0.1	35.8	1.00000	17
50.0	0.040	45.0	1.0	8.5700	0.87	0.96	-0.08	0.1	38.6	1.00000	20
100.0	0.040	45.0		9.2300	0.87	0.97		0.1	40.1		23

USGS WRI 77-21: A.O. Waananen & J.R. Crippen, Magnitude and Frequency of Floods in California

Estimation of 100-year Storm Flows by Rational Method
Tc = 60((11.9 x L3) / H) 0.385 with Q = CIA

Channel Length (miles) L	Elevation Difference (ft) H					Time of Concentration (minutes) Tc	Runoff Coefficient C	Precipitation (max 1 hr - in/hour) I	Drainage Area (acres) A	Q (cfs) Q
0.15	228.0	0.00	0.04	0.00	0.04	2.15	***0.2***	0.82	28	5
0.15	228.0	0.00	0.04	0.00	0.04	2.15	***0.4***	0.82	28	9
0.15	228.0	0.00	0.04	0.00	0.04	2.15	***0.6***	0.82	28	14

Estimated flow velocity by Manning's Equation
$v = R^{2/3} s^{1/2} / n$

A	s	R	Wp	n	R(2/3)	s(1/2)	v	Q(cfs)
3.50	0.20	0.70	5.00	0.055	0.79	0.45	6.40	22

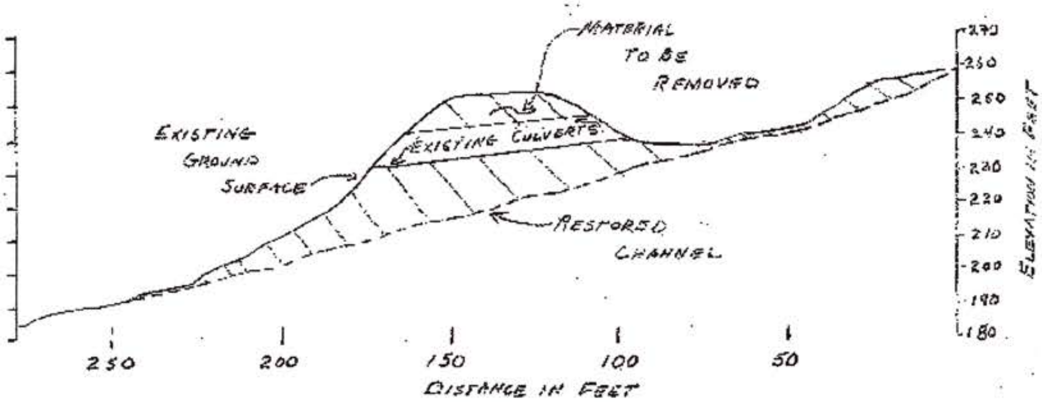

FIGURE 3: TYPICAL
LONGITUDINAL
PROFILE

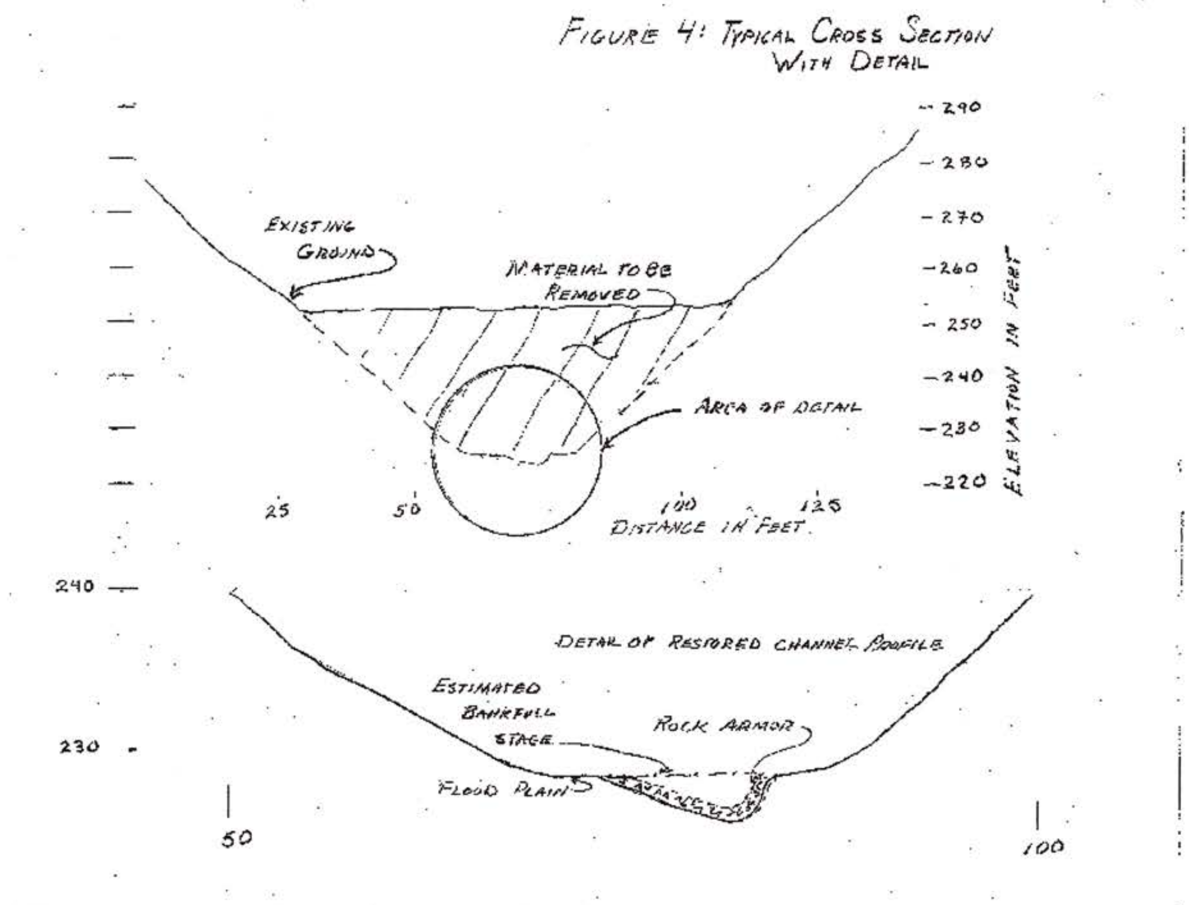
FIGURE 4: TYPICAL CROSS SECTION
WITH DETAIL
EXISTING
GROUND
MATERIAL TO BE
REMOVED
AREA OF DETAIL
290
280
270
260
250
240
230
220
ELEVATION IN FEET
25
50
100
125
DISTANCE IN FEET
240
230
DETAIL OF RESTORED CHANNEL PROFILE
ESTIMATED
BANKFULL
STAGE
ROCK ARMOR
FLOOD PLAIN
50
100