FINAL HYDRAULICS RECOMMENDATIONS

PINTO BASIN ROAD

JOSHUA TREE NATIONAL FOREST

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PROJECT INTRODUCTION

The Central Federal Lands Highway Division (CFLHD) of the Federal Highway Administration (FHWA), in cooperation with the Joshua Tree National Park Service are proposing improvements to restore and resurface (3R) Pinto Basin Road and associated parking areas in Joshua Tree National Park. The total length of restoration is approximately 19.25 miles.

The asphalt surface along the segment of Pinto Basin road received an average pavement condition rating (PCR) of 63 in the 2006 FHWA Road Inventory Program (RIP), which is only fair condition. The existing road alignment has numerous sharp curves, dips, and humps and restricted sight distances, which increases the chance of vehicles losing control. This report presents only the hydraulic recommendations for the project area and does not discuss any asphalt or alignment issues in detail. Other documents being prepared concurrent with this report focus in detail on the overall scope of the project.

HYDRAULIC AND HYDROLOGIC OVERVIEW OF PROJECT AREA

Joshua National Park consists of diverse terrain and multiple geological formations. Generally, the park has a series of mountain ranges that drain into surrounding desert valleys. Joshua National Park is classified as a desert and receives relatively low amounts of precipitation each year. Most of the precipitation occurs in August and September and can produce five to 10 inches of rain over a few hours. One or two storm events represent a large portion of the park's annual precipitation totals. Infrequent storm events fill the dry valleys and cause a large amount of runoff in a relatively short period of time. These storm events transport sediment from various formations and form the fluvial washes that are prevalent throughout the park. At low spots on Pinto Basin road, the roadway is overtopped during storm events and a substantial amount of sediment is deposited onto the road. The sediment has to be swept clean to allow for vehicular travel as part of regular maintenance by the park.

Within the project area there are three large fluvial washes and a series of low water crossings. There are many locations where drainage from the fluvial washes cross the roadway. The three main washes are:

- **Fried Liver Wash (Approximate Stations 790+00 to 930+00)**: The Fried Liver Wash is the largest wash in the project area with a contributing watershed of over 100 square miles. A ridge located west of the project area drains down into pleasant valley, which is mostly flat and located approximately 3,000 feet above the roadway. As drainage heads east through the valley it approaches erodible sections of the mountain range and creates deeply incised channels that characterize the wash. When water drains through these deeply incised channels it creates the Fried Liver Wash that crosses the roadway between Stations 790+00 to 930+00.
- **Porcupine Wash (Approximate Stations 480+00 to 530+00)**: The Porcupine Wash is considerably smaller than the Fried Liver Wash but drains in the same direction. Porcupine Wash has a contributing area of approximately 30 square miles and crosses the roadway between Stations 480+00 and 530+00.
- **Smoke Tree Wash (Approximate Stations 260+00 to 290+00)**: The Smoke Tree Wash is comparable in size to Porcupine Wash and crosses the roadway between 260+00 and

290+00. Smoke Tree Wash is the smallest wash of the three. However, at the location it crosses the roadway there is a more defined channel than the other two washes.

Figure 1 below presents an overview of the watershed delineation and locations of the three main fluvial washes as they cross the roadway.

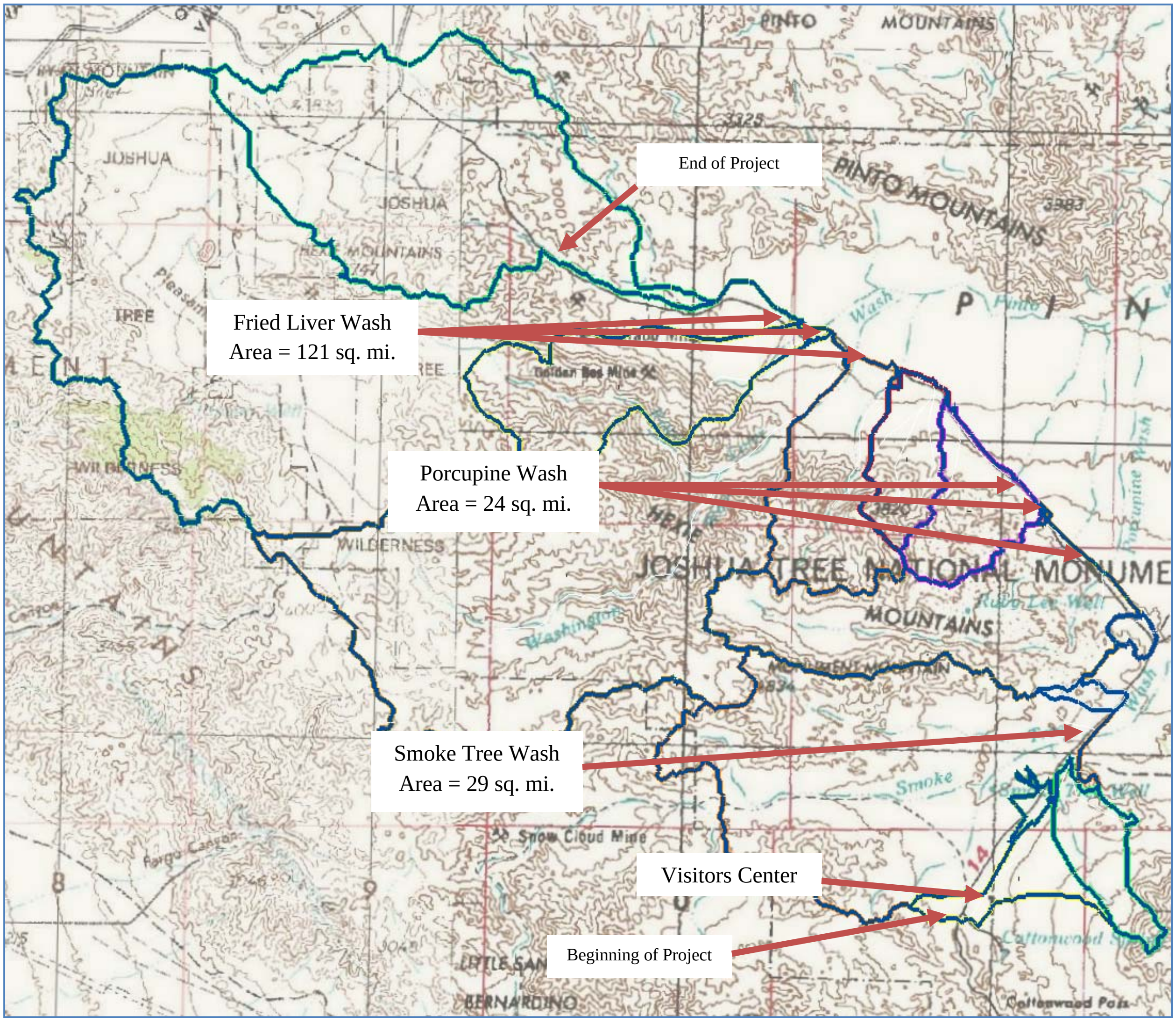

FIGURE 1 - WATERSHED DELINEATION OF PROJECT AREA AND THE THREE MAIN FLUVIAL WASHES

ESTIMATING PEAK FLOWS AT THE PROJECT SITE

Watershed delineation for selected roadway segments was performed within the Watershed Modeling System v8.3 (WMS) using a US Geological Survey (USGS) Digital Elevation Model (DEM) with 10 meter resolution. USGS regression equations are used to determine peak flows within the project area. A paper by Wannanen and Crippen (1977) contains regression equations for the South Lahontan-Colorado Desert Region (Region 10). These equations estimate peak flows with 2 to 100 year return periods and are related solely by the drainage basin area. Equations (1) and (2) below are used to estimate peak flows in Joshua National Park.

$$Q_{10} = 150 * A^{0.53} \quad (1)$$

$$Q_{25} = 410 * A^{0.63} \quad (2)$$

Where, Q_i is the peak flow rate for return period *i,* and *A* is the watershed area in square miles (sq. mi.).

DEVIATION FROM DESIGN STANDARDS

Chapter 7 of the Project Development and Design Manual (PDDM) discusses the design of low water crossings and requires that a low water crossing not be designed for any roadway segment with an average daily traffic (ADT) greater than 200. Pinto Basin road has an ADT of 387 that slightly exceeds the standard required by the PDDM. The following are items that support the use of low water crossings instead of culverts at Pinto Basin road even though the ADT value is higher than the standard:

- **Sediment Deposition:** The amount of sediment transported by storm events will likely clog the culverts within one or two years.
- **Stream Migration:** The dynamic process of sediment transport for each fluvial wash creates a highly mobile streambed within the valleys of Joshua National Park. A mobile streambed along with relatively flat terrain makes it difficult to determine the best culvert location that will not become unserviceable after the streambed migrates.
- **Increased Maintenance Costs:** Placing culverts that may clog easily or become unserviceable from stream migration will require additional maintenance and potentially burden the park with increased maintenance costs.

USEFULNESS OF SEDIMENT REDUCTION PRACTICES

Most sediment reduction practices associated with drainage runoff utilize topographic and erosion controls, grass buffers, water quality capture ponds, and also mechanical treatments. Research in this field is focused on stormwater quality inside urban areas and does not always apply to rural areas. Installation of any sediment reduction practices at Joshua National Park would likely require significant maintenance and a substantial increase in construction costs. The effectiveness of any sediment reduction practice would be minimal due to the lack of vegetation, high runoff potential, and an unusually large amount of sediment transport per storm event.

Erosion control measures can be applied to sections that are experiencing larger than normal erosion. It is recommended that erosion control mats (ECMs) that do not require vegetation growth be applied at highly eroded sections. It is recommended that the ECMs adhere to the properties presented in **Table 1** below.

TABLE 1 - RECOMMENDED PROPERTIES FOR ECMS AT PROJECT SITE

Property	Testing Method	Average Role Value	
Mass/Unit Area	ASTMD-6566	13.5	oz/yd2
Thickness	ASTM D-6525	0.4	in
Light Penetration	ASTM D-6567	10	%
Color Visual	-	Tan	
Tensile Strength (Grab)	ASTM D-6818	4000 x 3000	lb/ft
Elongation	ASTM D-6818	65	%
Resiliency	ASTM D-6524	80	%
Flexibility	ASTM D-6575	0.534	in-lb
UV Resistance @ 6000 hours	ASTM D-4355	90	%
Velocity	-	25	ft/sec
Shear Stress	-	15	lb/ft2
Manning's n	-	0.028	
Seedling Emergence	-	296	%
Roll Sizes	-	8.5 ft x 90 ft	

HYDRAULIC ANALYSIS BY ROADWAY STATIONING

Recommended improvements to stabilize roadway segments at the project site consist of unvented low water crossings. Unvented low water crossings are preferred because they handle the large sediment carrying capacity of the fluvial washes better than other alternatives. If culverts are constructed to aid the roadway drainage there is concern that the fluvial washes would quickly burry or clog the culverts, eventually leaving them in an unserviceable condition.

Tables 2 and **3** present the approximated overtopping depths for each low water crossing for the 25 and 10 year flood events, respectively. For large basins, the computed depth is much higher than will actually occur. This implies that the overtopping flow will likely spread beyond the low water crossing protection and further supports the need for additional toe protection from the boulders at these locations. For basins that have multiple low water crossings the flow rate is computed from the total area and then divided by the number of low water crossings.

TABLE 2 - LOW WATER CROSSING SUMMARY FOR THE 25 YEAR FLOOD

Station Start	Station End	Contributing Area (sq. mi.)	25 Year Peak Flow (cfs)	Crossing Length (ft)	Depth of Flow (ft)	Critical Velocity (ft/sec)
30+80	32+00	2.7	772	120	1.8	7.7
189+65	190+35	0.4	234	70	1.2	6.2
226+60	233+00	3.4	878	640	0.6	4.6
271+55	300+20	29.1	3430	2865	0.6	4.4
424+75	426+05	0.5	278	131	0.9	5.3
481+70	486+20	15.8	2330	450	1.6	7.1
722+20	723+70	4.8	1097	150	2.0	8.0
760+55	761+95	3.9	966	140	1.9	7.8
802+25	803+80	*8.1*	381	155	1.0	5.6
816+60	817+75		381	115	1.2	6.1
819+40	820+40		381	100	1.3	6.4
876+75	880+10		381	335	0.6	4.3
881+90	887+60	*43.6*	884	570	0.7	4.8
891+05	891+95		884	90	2.4	8.8
894+30	895+40		884	110	2.1	8.2
896+40	897+50		884	110	2.1	8.2
918+65	924+25		884	560	0.7	4.8
1031+10	1033+25	*28*	418	215	0.8	5.1
1050+55	1051+70		418	115	1.2	6.3
1054+60	1055+50		418	90	1.5	6.9
1097+45	1098+15		418	70	1.7	7.5
1146+60	1148+45		418	185	0.9	5.4
1156+80	1158+55		418	175	0.9	5.5
1173+50	1175+30		418	180	0.9	5.5
1198+85	1201+45		418	260	0.7	4.8

*RED CELLS INDICATE A COMPUTED OVERTOPPING DEPTH GREATER THAN 1.5 FEET

TABLE 3 - LOW WATER CROSSING SUMMARY FOR THE 10 YEAR FLOOD EVENT

Station Start	Station End	Contributing Area (sq. mi.)	10 Year Peak Flow (cfs)	Crossing Length (ft)	Depth of Flow (ft)	Critical Velocity (ft/sec)
30+80	32+00	2.7	255	120	0.9	5.3
189+65	190+35	0.4	94	70	0.6	4.5
226+60	233+00	3.4	285	640	0.3	3.1
271+55	300+20	29.1	896	2865	0.2	2.8
424+75	426+05	0.5	108	131	0.5	3.9
481+70	486+20	15.8	647	450	0.7	4.6
722+20	723+70	4.8	343	150	0.9	5.4
760+55	761+95	3.9	309	140	0.9	5.4
802+25	803+80	*8.1*	113	155	0.4	3.7
816+60	817+75		113	115	0.5	4.1
819+40	820+40		113	100	0.6	4.3
876+75	880+10		113	335	0.3	2.9
881+90	887+60	43.6	222	570	0.3	3.0
891+05	891+95		222	90	1.0	5.6
894+30	895+40		222	110	0.8	5.2
896+40	897+50		222	110	0.8	5.2
918+65	924+25		222	560	0.3	3.0
1031+10	1033+25	28	110	215	0.3	3.3
1050+55	1051+70		110	115	0.5	4.1
1054+60	1055+50		110	90	0.6	4.4
1097+45	1098+15		110	70	0.7	4.8
1146+60	1148+45		110	185	0.4	3.5
1156+80	1158+55		110	175	0.4	3.5
1173+50	1175+30		110	180	0.4	3.5
1198+85	1201+45		110	260	0.3	3.1

*RED CELLS INDICATE A COMPUTED OVERTOPPING DEPTH GREATER THAN 1.5 FEET

HYDRAULIC RECOMMENDATIONS BY ROADWAY STATION

Hydraulic recommendations for Pinto Basin Road in Joshua Tree National Park are designed to protect the roadway from erosion during overtopping flows from storm events. A high potential for heavy sediment deposition and frequent stream migration eliminates more common roadway hydraulic solutions, such as culverts and roadside ditches. Final recommendations deviate from the design standards and provide unvented low water crossings at 25 locations along the roadway alignment. Hydraulic recommendations for Pinto Basin road are presented in **Table 4** and discussed below:

- **Construct 25 low water crossings**: The location of each low water crossing is a result of field visits and topographic assessments. Some crossings require a larger degree of upstream and downstream toe protection than others. As such, each location presented in Table 4 requires a different degree of protection that includes,
  - Riprap Revetment: If revetment if called for in Table 4 then construct Class 2 riprap revetment protection according to CFLHD standards and specifications.
  - Gabion Baskets: If gabions are called for in Table 4 then place 3 foot by 3 foot rock gabion baskets at the edge of the sloped pavement.
  - Paved Ditches: Extend a layer of asphalt further down the shoulders of the roadway to serve as a cutoff wall and protect the road during overtopping events.
- **Place erosion control at above culvert at Station 14+00**: It is recommended to provide slope stability/erosion control above the culvert at Station 14+00. Placement of Class 2 Riprap or ECM properties similar to Table 1 may be used at this location.

TABLE 4 - LOW WATER CROSSING RECOMMENDATIONS BY ROADWAY STATION

LWC Number	Upstream Stations*				Downstream Stations				Recommendations
	Begin Taper	Begin Full Width	End Full Width	End Taper	Begin Taper	Begin Full Width	End Full Width	End Taper	
1					30+80	31+00	31+80	32+00	stacked gabions downstream only
2	189+65	189+85	190+15	190+35	189+65	189+85	190+15	190+35	paved ditches on both sides with gabions placed downstream
3	226+60	226+80	232+20	232+40	226+60	226+80	232+80	233+00	paved ditches both sides
4	269+90	270+10	300+00	300+20	271+55	271+75	300+00	300+20	paved ditches on both sides with revetment placed downstream
5					424+75	424+95	425+85	426+05	paved shoulder and revetment placed on downstream only
6	481+70	481+90	486+00	486+20	481+70	481+90	486+00	486+20	paved ditches both sides with gabion section placed downstream
7	722+20	722+40	723+50	723+70	722+20	722+40	723+50	723+70	paved ditch both sides with stacked gabions placed downstream
8	760+15	760+35	761+75	761+95	760+55	760+75	761+75	761+95	paved ditches on both sides with revetment placed downstream
9	802+25	802+45	803+60	803+80	802+25	802+45	803+60	803+80	paved ditches on both sides with revetment placed downstream
10	816+60	816+80	817+55	817+75	816+60	816+80	817+55	817+75	paved ditches on both sides with revetment placed downstream
11	819+40	819+60	820+20	820+40	819+40	819+60	820+20	820+40	paved ditches on both sides with revetment placed downstream
12					876+75	876+95	876+90	880+10	paved ditches and revetment placed downstream only
13					881+90	882+10	887+40	887+60	paved ditches and revetment placed downstream only
14					891+05	891+25	891+75	891+95	paved ditches and revetment placed downstream only
15					894+30	894+50	895+20	895+40	paved ditches and revetment placed downstream only

LWC Number	Upstream Stations*				Downstream Stations				Recommendations
	Begin Taper	Begin Full Width	End Full Width	End Taper	Begin Taper	Begin Full Width	End Full Width	End Taper	
16					896+40	896+60	897+30	897+50	paved ditches and revetment placed downstream only
17	918+65	918+85	924+05	924+25	918+65	918+85	924+05	924+25	paved ditches both sides and revetment placed downstream
18	1031+35	1031+55	1033+05	1033+25	1031+10	1031+30	1033+05	1033+25	paved ditches both sides with gabions placed downstream
19					1050+55	1050+75	1051+50	1051+70	paved ditches and gabions placed downstream only
20					1054+60	1054+80	1055+30	1055+50	paved ditches and gabions placed downstream only
21					1097+45	1097+65	1097+95	1098+15	paved ditches and gabions placed downstream only
22					1146+60	1146+80	1148+25	1148+45	paved ditches and gabions placed downstream only
23					1156+80	1157+00	1158+35	1158+55	paved ditches and gabions placed downstream only
24					1173+50	1173+70	1175+10	1175+30	paved ditches and gabions placed downstream only
25					1198+85	1199+05	1201+25	1201+45	paved ditches and gabions placed downstream only

*Where there is not stationing listed for the upstream side no treatment for the upstream portion of the low water crossing is recommended

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