Joshua Tree National Park,

CA PRA JOTR 11(3)

PAVEMENTS Report

Report # CA-02 10

Pavements Services Branch
July 2010

SIGNATURE SHEET

Report prepared by: _____

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Approved for distribution by: _____

Richard Duval P.E., Pavements Engineer

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Distribution
Project Management
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Pavements (2)
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I. INTRODUCTION

During the week of January 18th, 2010 a pavement and subgrade soil investigation was completed at Joshua Tree National Park for CA PRA JOTR 11(3) Pinto Basin Road.

This project will consist of the rehabilitation, restoration, and resurfacing (3R) of approximately 24.0 miles of Pinto Basin Road. This project will also include three 4R areas, the southern Visitor Center, Porcupine Wash and the Cholla Garden areas. Pinto Basin Road is the access road from the south entrance to the park to the northern attractions.

Along with the investigation of Pinto Basin Road three other roads within the park were also investigated, they are as follows:

- 49 Palms Canyon Road (Route 113) located on the north side of the park off Twentynine Palms Highway and is approximately 0.6 miles long including a parking lot at the end of the project.

- Indian Cove Road (Route 112) located on the north side of the park off Twentynine Palms Highway and is approximately 2.0 miles long.

- Black Rock Canyon Road (Route 221) located on the north side of the park off Twentynine Palms Highway and is approximately 0.2 miles long.

There currently exists a conditions and soils survey for the project location. The report: *Joshua Tree National Monument, California Conditions and Soils Survey, Borrow Sources, March 1985* contains detail information about the existing soil properties.

This soil investigation was conducted to confirm and support the results from 1985.

The project is located approximately 35 miles west of Palms Springs. From route 11 twenty-core holes were drilled and three samples were taken. From each of the three other locations two cores were drilled. See Tables 1 through 5 for a summary of layer thicknesses and soil description. Materials testing report and photos are attached.

Block cracking, fatigue cracking and longitudinal cracking is present the entire length of pavement. A few sections of the pavement have minor surface rutting. The outer edge of the pavement has erosion issues that are caused by high volume of runoff at the edge of pavement. (See photos in Appendix C).

II. CLIMATE AND THE EXISTING PAVEMENT, SOILS, & GEOLOGY

Climate

Days are typically clear with less than 25 percent humidity. Temperatures are most comfortable in the spring and fall, with an average high/low of 85 and 50°F (29 and 10°C) respectively. Winter brings cooler days, around 60°F (15°C), and freezing nights. It occasionally snows at higher elevations. Summers are hot, over 100°F (38°C) during the day and not cooling much below 85°F (29°C) until the early hours of the morning.

Existing Pavement

Route 11 consists of rehabilitating medium severity block cracking, low severity of fatigue cracking, low severity of rutting, and high severity of edge raveling caused by standing water and erosion. The current pavement section is 2-4 inches of asphalt pavement. There was no distinguishable base material.

Geology & Soils

Geologists believe the face of Joshua Tree modern landscape was born more than 100 million years ago. Molten liquid, heated by the continuous movement of earth's crust, oozed upward and cooled while still below the surface. These plutonic intrusions are a granitic rock called monzogranite.

The monzogranite developed a system of rectangular joints. One set, oriented roughly horizontally, resulted from the removal—by erosion—of the miles of overlying rock, called gneiss. Another set of joints are oriented vertically, roughly paralleling the contact of the monzogranite with its surrounding rocks. The third set is also vertical but cuts the second set at high angles. The resulting systems of joints tend to develop rectangular blocks.

III. EXPLORATION

On January 20, 2010 a two-person crew from the Federal Highway Administration (FHWA) Central Lands Highway Division (CFLHD) cut 20 cores in Route 11 and two cores in each of the other 3 locations. Subgrade samples were taken for from Route 11 for testing and comparison to the previous soil report. All samples were located and logged by FHWA personnel. The cores were taken to measure pavement thickness and each location was hand dug to identify base thickness. All cores were drilled within the roadway. Subgrade samples were sampled at the pavement edge by hand digging a trench 18 inches below the base. CFLHD staff completed visual identification of the soils and logged the cores and samples. Two samples were tested for R-value, gradation, and soil classification. At mile point 27.7 a sample large enough for gradation and soil classification testing was obtained. Table 5 is a summary of these three samples

Typical pavement distresses were recorded and photos were taken to further document the condition of the pavement. Laboratory test results are in Appendix B.

IV. TEST RESULTS

Table 1 provides a summary of the core locations and Figure 1 is a summary of the pavement thickness. Table 2 provides a summary of the soil properties evaluated on the three soil samples from route 11. The field data summary and the testing reports for both the 1985 report and this study are in Appendix B. Appendix E contains several charts, which provide layer depths of the existing pavement structural sections as measured in 1985 and 2010.

TABLE 1: Route 11 CA PRA JOTR 11(3)

Core	Location Mile Post (MP)	Pavement Width (feet)	Asphalt Thickness (inches)	Remarks
C-1	MP 10	23.0	2.5	Minor block cracking
C -2	MP 11	22.0	1.5	Surface raveling, transverse cracking
C -3	MP 12	19.5	4.0	Minor transverse cracking, outside of the wheel path cracking
C -5	MP 14	19.0	3.0	Transverse cracking
C -7	MP 16	19.0	3.25	Block cracking
C -9	MP 18	18.5	3.25	Edge cracking
C -10	MP 19	21.5	4.0	Minor surface rutting
C-12	MP 21	19.0	3.0	Minor surface rutting
C-14	MP 23	23.5	3.0	High severity block cracking and fatigue cracking
C-18	MP 28	19.0	3.5	Transverse cracking edge raveling, edge strip repair
	Average	**20.3**	**3.1**	

Due to inclement weather several cores locations were not measured (C-4, 6, 8, 11, 13, 15, 16, and 17).

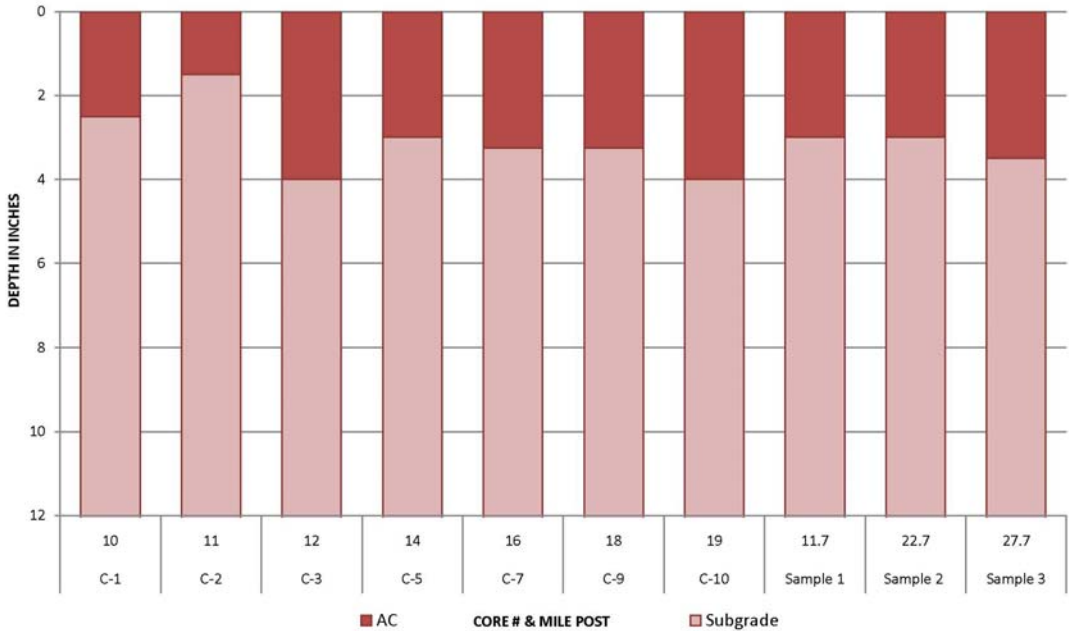


Figure 1 – Existing Pavement thickness

TABLE 2: Route 11 Soil Properties

Boring/ Milepost	Sample Depth	AASHTO Classification	R-Value
SP-1/11.7	2.5 ft	A-1-b	78
SP-2 /22.7	2 ft	A-1-b	77
SP-3 / 27.7	1 ft	A-1-b	-

The three samples tested did not verify the results from the 1985 report. This is most likely caused by the 1985 exploration obtaining samples at greater depths. The three new test samples were obtained by hand digging test pits to a depth of 18 inches below the bottom of pavement structure. In 1985 the sampling was done by auger to a depth of 5 feet.

The underlying subgrade material is classified as A-1-b (0) to A-2-4 the lowest R-value was 16 and the highest R-value was 78. Most of the samples were non-plastic and had no value for the Atterberg test. The test results are in Appendix B.

Most likely, a subase material exists under the road and the three news samples came from the subase not the subgrade. For the pavement structural section calculations, the 75^{th} percentile of the tested R-values of the 1985 test results are used. The 1985 tests provide an accurate representation of the existing subgrade material because of the greater sampling depth. For the calculation of the R-value only the eight 1985 R-values that fall within route 11 are used.

The subgrade soil design R-value is 21, which equates to a resilient soil modulus (M_r) of 5,100 psi, see Appendix D for calculations.

The required structural number (SN) is 2.18 based on AASHTO Guide for Design of Pavement Structures 1993 using Darwin to calculate, see appendix D.

V. PAVEMENT RECOMMENDATIONS AND DISCUSSION

The National Park Service (NPS) 2004 Traffic Data Report for Joshua Tree National Park contains traffic data for Route 11. Counter 08012 was set up to measure two-way traffic at just south of the intersection of Park Boulevard (route 12) and route 11 (map in appendix showing the location).

The two-way annual average daily traffic (AADT) measured in 2003 for the 2004 report is 380, see appendix. For this report, a growth rate of 2% from 2003 to 2010 is used to predict the current AADT.

The traffic was broken out into four classifications;

- Motorcycles (M)
- Passenger cars (PC)
- Recreational vehicles (RV)
- Vehicles/RV pulling Trailers (V+T)

For equivalent single axle loads (ESALs) calculations M and PC were combined to form class 2 with a factor ESAL of 0.0004 and RV and V+T were combined as class 5 with an ESAL factor of 0.5. A 2% an annual growth is used for both groups.

The calculated ESALs are 39,200 for 20 years, since this does not exceed the minimum design criteria, 50,000 ESALs was used for the pavement design calculations. Table 4 summarizes the traffic calculations.

Table 4: ESALs calculations

Traffic Volume		
Year	2003	2010
AADT	380	430

Calculation of 20 Year Design ESALs			
Vehicle Class	ESALs Factor	% of AADT	20 year Accumulated ESALs
Class 2	0.0004	96	**90**
Class 5	0.5	4	**38,300**
Total ESALs	39,200	**Design ESALs**	**50,000**

A pavement design analysis was performed in accordance with AASHTO 1993 Pavement Design Guide for the conditions that exist on this project.

The required structural number is 2.18 based on the design ESALs and the calculated modulus.

The Recommend Section is as follows:

- 6.5 inch CAB
- 3.0 inches of HACP
- Remove existing pavement approximately 3.5 inches
- Cost Estimate per mile = $599,338

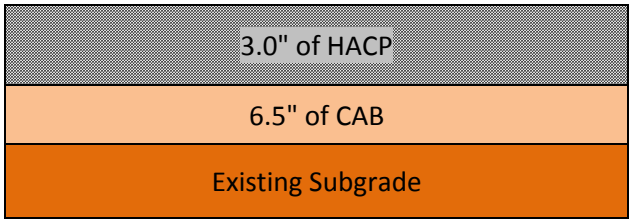


Figure 1 – Recommend Section

Option 1:

- Pulverize 4.0 inches deep
- Overlay with 4.0 inches of HACP
- Cost Estimate = $450,620

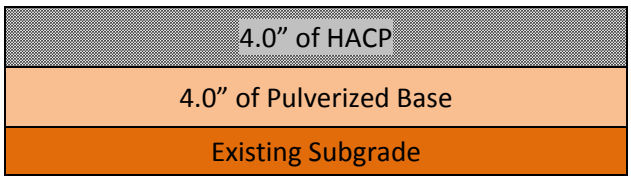


Figure 2 – Option 1

Option 2:

- Add 3.0 inches of CAB to existing pavement then pulverize 6.5 inches deep
- Overlay with 3.0 inches of HACP
- Cost Estimate = $494,870

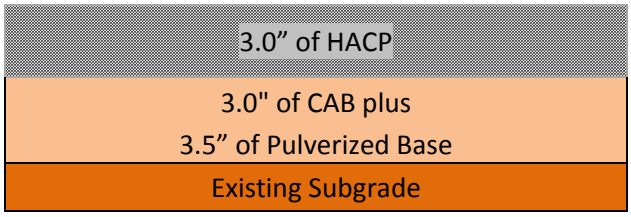


Figure 3 – Option 2

Notes:

The existing pavement can be used as CAB if it meets the requirements of SCR 303, this could be a significant cost savings for the recommended section.

Cost estimates are only for comparison and should not be used as an engineer’s estimate.

Pavement Materials Recommendations:

- The HACP should be Item 40201-4600 HVEEM Pavement, Class A, Grading C or E with Type IV Roughness level if the quantity is 4000 tons or more. If the quantity is less than 4000 tons, use Item 40301-0000 Hot Asphalt Concrete Pavement with Type IV Roughness level. The unit weight for either item can be estimated at 145 lb/ft^3.
- Antistrip additive, use Item 40205-3000 Antistrip Additive, Type 3 (Hydrated Lime) at 1% by weight of mix. Antistrip does not apply for Item 403
- The asphalt cement binder should be PG 70-10 which was also used on CA PRA JOTR 13(1). Quantity can be estimated at 6% by weight of mix.
- A 3- inch depth or greater of HACP shall be placed in two lifts.
- Item 41201-1000 Tack Coat Grade CSS-1, CSS-1h, SS-1, or SS-1h is required between lifts of HACP. Estimate the application rate at 0.10 gal/yd^2.

- Item 40920-1000 Fog Seal Grade CSS-1, CSS-1h, SS-1, or SS-1h should be included in the contract. Estimate the application rate at 0.10 gal/yd^2.
- Item 41101-0000 Prime Coat should be applied on the base material. For estimating purposes use an application rate of 0.33 gal/yd^2.
- Item 41105-0000 Blotter should be included in the contract. Estimate the application rate at 14.75 lb/yd^2.
- Removal of HACP 20303-1900, Disposal of waste 20441-0000
- Pulverization, 30306-3000
- Crushed Aggregate Base, 30101-0000 if greater then 5000 tons, 30802-2000 if less than 5000 tons. The unit weight for either item can be estimated at 138 lbs/ft^3

Drainage, Subexcavation, and other Issues

Low water crossing will be identified in the hydraulics report and designed as low water crossings. Other subexcavation locations could be identified during construction. A contingency quantity of 1000 tons of subexcavation should be put in the contract to be used at the discretion of the CO.

Typical subexcavation should be 2 feet of excavating; placement of a geotextile separation fabric, and placement of 2 feet of select borrow material on top of the fabric. Pavement structural section should then match the mainline typical section. A positive drainage system such as day lighting the select borrow out to the foreslope or an edge drain system should be included. The Pavements section or branch can be contacted for further details if subexcavating an area becomes necessary (720-963-3734).

APPENDICES

A – Location Map

B – Laboratory Test Results

C – Photographs

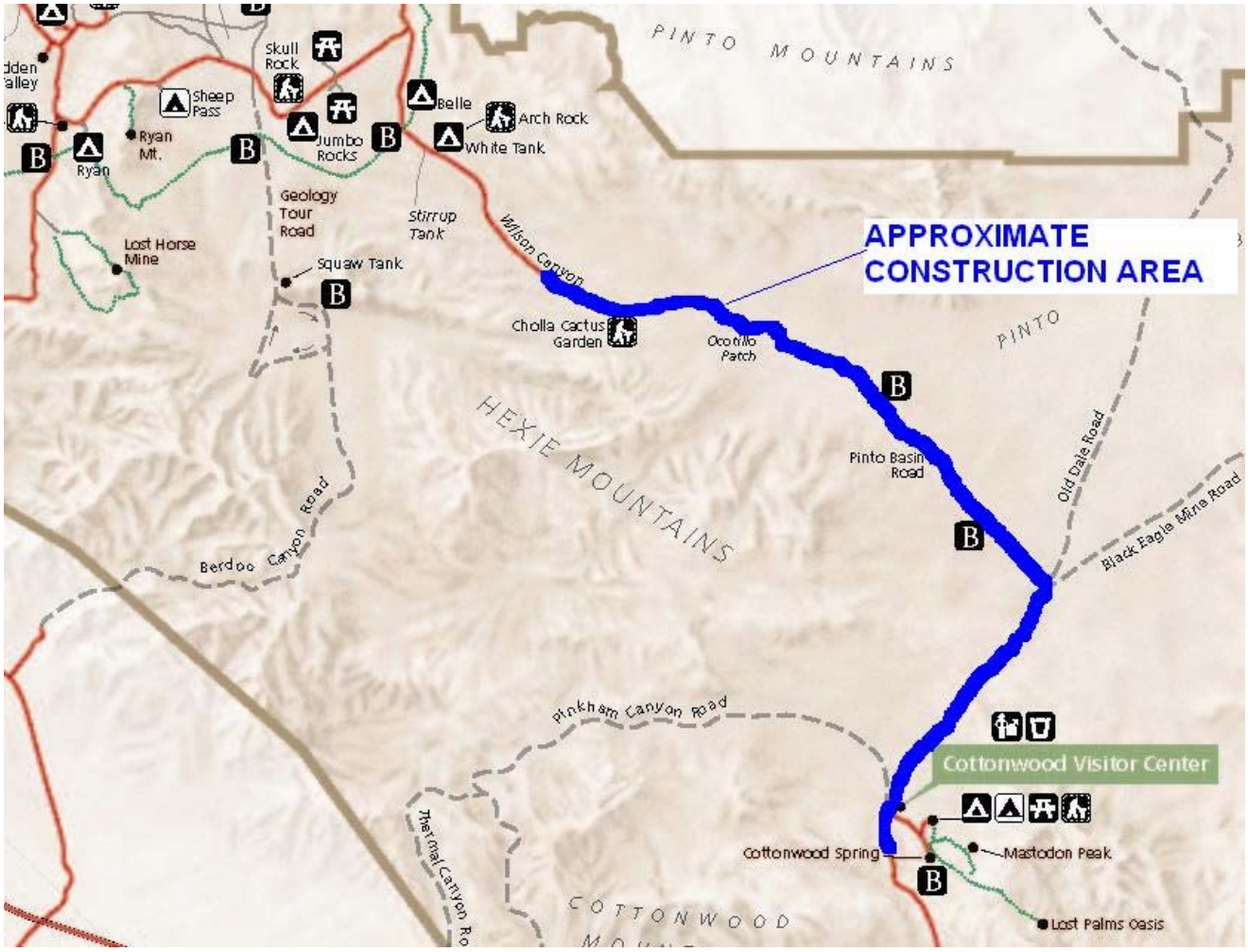
D – Pavement Design Calculations

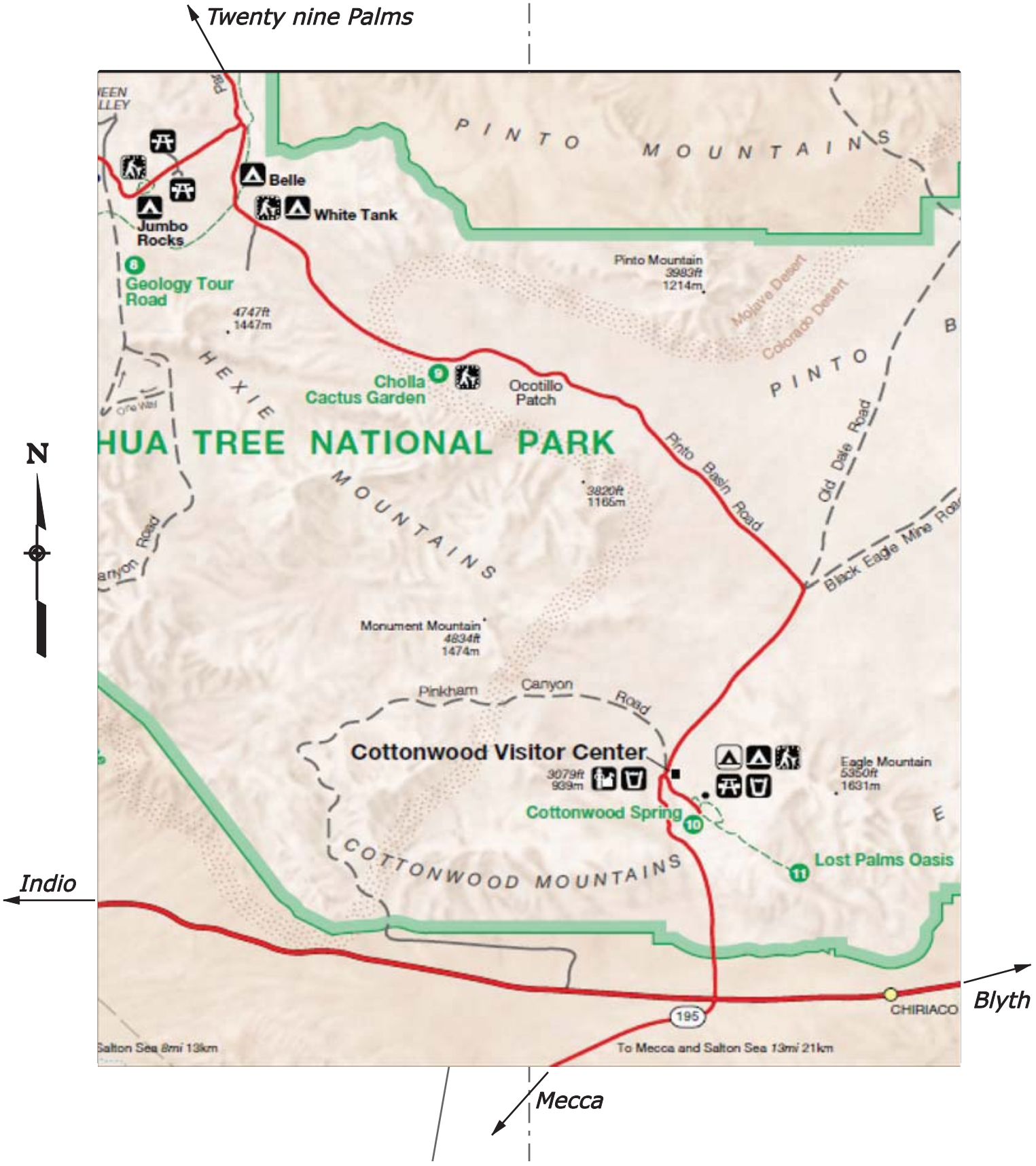
E – Field Data Summary

APPENDIX A

LOCATION MAP

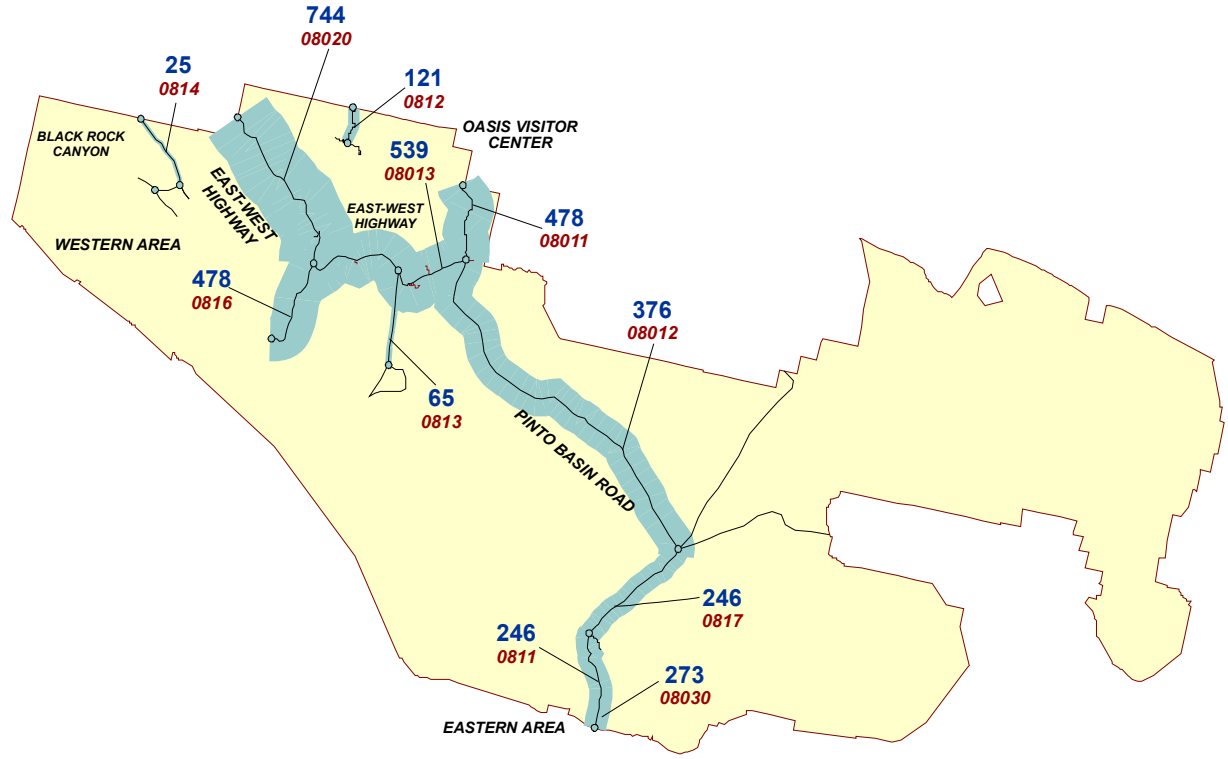
CA PRA JOTR 11(3), Joshua Tree National Park




Twenty nine Palms
PINTO MOUNTAINS
Belle
White Tank
Jumbo Rocks
8
Geology Tour Road
4747ft
1447m
Pinto Mountain
3993ft
1214m
Mojave Desert
Colorado Desert
HEXIE
Cholla Cactus Garden
9
Ocotillo Patch
PINTO
HUA TREE NATIONAL PARK
Pinto Basin Road
Old Dale Road
3820ft
1165m
MOUNTAINS
Black Eagle Mine Road
Monument Mountain
4834ft
1474m
Pinkham Canyon Road
Cottonwood Visitor Center
3079ft
939m
Eagle Mountain
5350ft
1631m
Cottonwood Spring
10
11
Lost Palms Oasis
COTTONWOOD MOUNTAINS
N
Indio
Blyth
CHIRIACO
195
To Mecca and Salton Sea 13mi 21km
Mecca

Joshua Tree National Park

California
U.S. Department of Interior
NATIONAL PARK SERVICE



2003 Traffic Counts

150
300
450
600
750

AADT Scale

Reference Station Number in ITALICS

8 0 8 Miles

APPENDIX B
APPROXIMATE CONSTRUCTION AREA LABORATORY TEST RESULTS

U.S. Department of Transportation
Federal Highway Administration

Central Federal Lands Highway Division Laboratory

An AASHTO and ISO Accredited Laboratory

AASHTO R18 ISO/IEC 17025

Report of Soil or Aggregate Tests

Project: California PRA JOTR 11 (3) Gold Point to Sand Hill

Submitted By: Eric Ross

Date Reported: 2/3/2010

Sample Number	Lab Number		10-56-RV	10-57-RV	10-58-SB		
	Field Number		B-1	B-2	B-3		
Sample Location	Location		Route 11 MP 11.7 Left Edge of Pavement	Entrance Road MP 22.7 Right Edge of Pavement	Entrance Road MP 27.7 Left Edge of Pavement		
	Depth	Inches	8-28	3-24	7-15		
AASHTO T 11, T 27 & T 88 Washed Sieve Analysis % Passing	3"	75.0 mm	100				
	1 1/2"	37.5 mm	93		100		
	1"	25.0 mm	88		99		
	3/4"	19.0 mm	85		99		
	1/2"	12.5 mm	79		98		
	3/8"	9.5 mm	76	100	98		
	#4	4.75 mm	69	98	98		
	#8	2.36 mm					
	#10	2.00 mm	55	81	82		
	#16	1.18 mm	42	63	64		
	#30	600 µm					
	#40	425 µm	18	34	37		
	#50	300 µm					
	#100	150 µm	6	19	23		
	#200	75 µm	2.9	13	18		
		20 µm					
		2 µm					
		1 µm					
AASHTO T 255	Moisture, %						
AASHTO T 89 & T 90	Liquid Limit		NV	NV	NV		
	Plasticity Index		NP	NP	NP		
Soil Classification	AASHTO M 145		A-1-b (0)	A-1-b (0)	A-1-b (0)		
	ASTM D 2487		SP	SM	SM		
AASHTO T 190	R –Value		78	77			
AASHTO T 288	Min. Resistivity, ohm-cm						
AASHTO T 289	pH						
AASHTO Method	Optimum Moisture, %						
	Maximum Dry Density, pcf						

Distribution:
Num. / Project File
Laboratory — Darrell Harding
Pavements — Eric Ross
Materials — 1 Copy

Remarks: These are subgrade samples.

Reported By:

Darrell Harding
Laboratory Manager

Form FHWA 1702 Rev. 01/10

Summary of 1985 Bore Hole Locations Used for This Study									
Route 11		**Route 11**		**Route 112**		**Route 113**		**Route 221**	
Mile Post	Bore Number	Mile Post	Bore Number	Mile Post	Bore Number	Mile Post	Bore Number	Mile Post	Bore Number
8.7	B-33	19.7	B-44	1	B-29	0.1	B-61	0.3	B-28
9.7	B-34	20.7	B-45	1.9	B-30				
10.7	B-35	21.7	B-46						
11.7	B-36	22.7	B-47						
12.7	B-37	23.7	B-48						
13.7	B-38	24.7	B-49						
14.7	B-39	25.7	B-50						
15.7	B-40	26.7	B-51						
16.7	B-41	27.7	B-52						
17.7	B-42	28.7	B-53						
18.7	B-43	29.7	B-54						

VA-16-226-A
9-28-83

F. of Highway Administration
Central Direct Federal Division

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DATE 1/28/85

SUMMARY OF SOIL OR AGGREGATE TESTS

PROJECT CALIFORNIA - JOSHUA TREE NATIONAL MONUMENT

SUBMITTED BY C.E. Martinez TESTED BY DH,KW,WK,JM REPORTED BY Alan Held

DISTRIBUTION: Project Engineer-1, CDFD File1, Materials Lab-3 Design Construction

NUMBER	Field No.	B-28	B-29	B-30	B-31	B-32	B-33	B-34
	Hole No.							
	Lab No.	85-52-S	85-53-S	85-54-S	85-55-S	85-56-S	85-57-S	85-58-S
LOCATION	Station or Location	Sec. 11 Route 221 Black Rock Road 800'S of Ent.	Sec. 10 Route 112 Indian Cove Road MP 1.0	Sec. 10 Route 112 Indian Cove Road MP 1.9	Sec. 10 Route 212 Indian Cove Road MP 2.9	Sec. 7 Route 11 N-S Hwy. MP 7.7	Sec. 7 Route 11 N-S Hwy. MP 8.7	Sec. 7 Route 11 N-S Hwy. MP 9.7
	Offset	Q Right Lane						→
	Depth	2½"-5'	3"-5'	2"-5'	2"-5'	3"-5'	2"-5' 3"-5'	
T-11, 27 8 88	3"					100		
	1 1/2"					93		
	1"					91		100
	3/4"	100				88		99
	1/2"	99				85		97
	3/8"	98	100	100	100	82	100	94
	# 4	95	96	98	97	72	96	83
	8							
	10	89	80	81	82	52	77	61
	#16	81	67	68	73	40	59	49
	#30							
	# 40	54	45	44	57	22	30	29
	# 50							
	#100	33	28	25	38	12	14	16
	#200	24.6	20.0	18.3	27.2	8.4	10.0	11.3
	0.05mm							
	002mm							
	0.002mm							
	0.001mm							
% Moist.								
ASHTO T-99, 0892	SL							
	LL	NV	NV	NV	NV	NV	NV	NV
	PI	NP	NP	NP	NP	NP	NP	NP
ASHTO M-145	Class	A-2-4	A-1-b	A-1-b	A-2-4	A-1-b	A-1-b	A-1-b
	GI							
ASHTO T-190	R	46			44	75		
	W(%)	9.1			9.3	7.5		
	γd(pcf)	127.6			124.6	131.6		
AS 99,	(%)							
	(pcf)							

REMARKS

VA-16-226-A
9-28-83

Federal Highway Administration
Central Direct Federal Division

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DATE 1/28/85

SUMMARY OF SOIL OR AGGREGATE TESTS

PROJECT CALIFORNIA - JOSHUA TREE NATIONAL MONUMENT

SUBMITTED BY C.E. Martinez TESTED BY DH,KW,WK,JM REPORTED BY Alan Held

DISTRIBUTION: Project Engineer-1, CDFD File1, Materials Lab-3 Design _____ Construction _____

NUMBER								
	Field No.	B-35	B-36	B-37	B-38	B-39	B-40	B-41
	Hole No.							
	Lab No.	85-59-S	85-60-S	85-61-S	85-62-S	85-63-S	85-64-S	85-65-S
LOCATION	Station or Location	Sec.7 Route 11 N-S Hwy. MP 10.7	MP 11.7	MP 12.7	MP 13.7	MP 14.7	MP 15.7	MP 16.7
	Offset	℄ Right Lane						
	Depth	3"-5'	3"-5'	2"-5'	3"-5'	2"-5'	5"-5'	3"-5'
T-11, 27 8 88	3"				100			100
	1 1/2"	100	100		92	100		98
	1"	99	98		87	98		95
	3/4"	98	97		84	95		92
	1/2"	95	94		81	89		88
	3/8"	94	91	100	79	86		84
	# 4	87	78	98	75	76		76
	#8							
	#10	72	59	91	71	61	Never	66
	#16	60	46	83	67	50	Received	57
	#30							
	#40	35	23	51	47	24		34
	#50							
	#100	18	11	18	18	8		19
	#200	12.0	7.1	10.7	10.8	5.2		13.4
	0.05mm							
	002mm							
	0.002mm							
	0.001mm							
% Moist.								
ASHTO T-99, 90 892	SL							
	LL	NV	NV	NV	NV	NV		NV
	PI	NP	NP	NP	NP	NP		NP
ASHTO M-145	Class	A-1-b	A-1-b	A-2-4	A-1-b	A-1-b		A-1-b
	GI							
ASHTO T-190	R		68					71
	W(%)		7.6					7.9
	γd(pcf)		126.1					129.6
AS T-99,	W(%)							
	γd(pcf)							

REMARK

WA-16-226-A
9-28-83

Federal Highway Administration
Central Direct Federal Division

SHEET 7 of 11

DATE 1/28/85

SUMMARY OF SOIL OR AGGREGATE TESTS

PROJECT CALIFORNIA - JOSHUA TREE NATIONAL MONUMENT

SUBMITTED BY C.E.Martinez TESTED BY DH,KW,WK,JM REPORTED BY Alan Held

DISTRIBUTION: Project Engineer-1, CDFD File1, Materials Lab--3 Design _____ Construction _____

NUMBER	Field No.	B-42	B-43	B-44	B-45	B-46	B-47	B-48
	Hole No.							
	Lab No.	85-66-S	85-67-S	85-68-S	85-69-S	85-70-S	85-71-S	85-72-S
LOCATION	Station or Location	Sec.7 Route 11 N-S Hwy. MP 17.7	Sec. 8 MP 18.7	MP 19.7	MP 20.7	MP 21.7	MP 22.7	MP 23.7
	Offset	℄ Right Lane						
	Depth	1½"-5'	3"-5'	3"-5'	2"-5'	4"-5'	2"-5'	2"-5'
T-11, 27 8 88	3"							
	1 1/2"							
	1"	100						
	3/4"	99						
	1/2"	98					100	
	3/8"	98	100	100	100	100	99	
	# 4	95	98	99	99	97	98	
	# 8							Never
	# 10	90	88	91	91	89	87	
	# 16	83	76	79	80	78	77	
	# 30							Received
	# 40	51	45	49	53	51	53	
	# 50							
	#100	26	25	29	34	30	35	
	#200	18.1	18.3	21.3	27.3	22.8	27.9	
	0.05mm							
	002mm							
	0.002mm							
	0.001mm							
	% Moist.							
SHTO -99, 892	SL							
	LL	NV	NV	NV	29	22	29	
	PI	NP	NP	NP	5	2	10	
SHTO -145	Class GI	A-2-4	A-1-b	A-1-b	A-2-4	A-2-4	A-2-4	
SHTO -190	R				28		17	
	W(%)				11.3		10.7	
	γ₀(pcf)				123.3		124.4	
SHTO [illegible] 9, 11	(%)							
	cf)							

YA-16-226-A
9-28-83

Fe l Highway Administration
Central Direct Federal Division

SHEET 8 of 11

DATE 1/28/85

SUMMARY OF SOIL OR AGGREGATE TESTS

PROJECT CALIFORNIA-JOSHUA TREE NATIONAL MONUMENT

SUBMITTED BY C.E. Martinez TESTED BY DH,KW,WK,JM REPORTED BY Alan Held

DISTRIBUTION: Project Engineer-1, CDFD File1, Materials Lab-3 Design _____ Construction _____

NUMBER	Field No.	B-49	B-50	B-51	B-52	B-53	B-54	B-55
	Hole No.							
	Lab No.	85-73-S	85-74-S	85-75-S	85-76-S	85-77-S	85-78-S	85-79-S
LOCATION	Station or Location	Sec. 8 Route 11 N-S Hwy. MP 24.7	MP 25.7	MP 26.7	MP 27.7	MP 28.7	MP 29.7	Sec. 1 → MP 30.7
	Offset	Q Right Lane						
	Depth	2"-5'	4"-5'	4"-5'	2"-5'	3"-5'	2"-5'	2"-5'
T-11, 27 8) 88	3"							
	1 1/2"							
	1"							
	3/4"							
	1/2"		100					
	3/8"		99	100	100	100	100	100
	# 4	100	92	99	98	99	97	92
	8							
	10	94	69	85	83	84	86	69
	# 16	85	58	74	71	71	75	57
	# 30							
	# 40	56	37	46	46	44	50	36
	# 50							
	#100	34	25	31	32	29	34	25
	#200	26.2	21.1	25.6	27.1	23.3	28.1	19.6
	0.05 mm							
	002 mm							
	0.002 mm							
	0.001 mm							
% Moist.								
ASHTO T-99, 0892	SL							
	LL	24	24	29	28	23	33	26
	PI	3	3	12	9	3	8	5
ASHTO M-145	Class GI	A-2-4	A-1-b	A-2-4	A-2-4	A-1-b	A-2-4	A-1-b
ASHTO T-190	R		52		16		21	
	W(%)		8.1		9.8		13.7	
	γ_0(pct)		131.6		125.5		114.4	
AS -99,	(%)							
	o(pct)							

REMARKS

A-16-226-A
9-28-83

DEPARTMENT OF ...
Fede . Highway Administration
Central Direct Federal Division

SHEET 10 of 11
DATE 1/28/85

SUMMARY OF SOIL OR AGGREGATE TESTS

PROJECT CALIFORNIA-JOSHUA TREE NATIONAL MONUMENT
SUBMITTED BY C.E.Martinez TESTED BY DH,KW,WK,JM REPORTED BY Alan Held
DISTRIBUTION: Project Engineer-1, CDFD File 1, Materials Lab-3 Design Construction

NUMBER	Field No.							
	Hole No.	B-61	B-62	B-63	B-64	B-65	B-66	B-67
	Lab No.	85-113-S	85-114-S	85-115-S	85-121-SB	85-116-S	85-117-S	85-122-SB
LOCATION	Station or Location	Sec. 10 Route 113 49 Palms Canyon Rd. MP 0.3	Sec. 11 Route 300 Geology Tour Rd. MP 1.0	MP 2.0	MP 3.0	MP 4.0	MP 5.0	MP 6.0
	Offset	Centerline						
	Depth	3"-4'	0-5'					
T-11, 27 & 88	3"							
	1 1/2"							
	1"							
	3/4"	100						
	1/2"	99						
	3/8"	98		100	100	100	100	100
	#4	90	100	98	99	99	99	98
	8							
	#10	72	97	93	93	85	89	81
	#16	58	91	87	84	72	75	67
	#30							
	#40	38	69	70	59	40	39	40
	#50							
	#100	25	38	46	33	19	17	21
	#200	18.3	25.5	34.6	24.5	12.4	11.0	14.8
	0.05mm							
	002mm							
	0.002mm							
	0.001mm							
% Moist.								
AASHTO T-99, 90 & 92	SL							
	LL	26	NV	33	NV	NV	NV	NV
	PI	5	NP	14	NP	NP	NP	NP
AASHTO M-145	Class GI	A-1-b	A-2-4	A-2-6	A-2-4	A-1-b	A-1-b	A-1-b
AASHTO T-190	R	46	43	10		68	68	
	W(%)	8.9	10.6	14.2		10.5	11.6	
	γ_d(pcf)	130.5	125.1	115.0		121.4	118.0	
AA... T-99, 100	W(%)							
	γ_d(pcf)							

REMARKS

APPENDIX C

PHOTOGRAPHS

Low severity transverse cracking Located near core 3

Loss of edge support and edge raveling located near core 6

Typical block cracking Located near core 7

Typical block cracking Located near core 8

Low severity surface rutting at core 10

Loss of edge support near Core 13

Near core 13 patch distresses

Core 14 cracking

Alligator cracking, patch repair and edge repair near core 14

Block cracking at core 15

Low severity rutting at core 15

Cracking at core 15

Drop off at edge of pavement and edge repair near core 16

Edge repair at core 16

Block cracking, fatigue cracking and edge failure at core 17

Water Crossing and edge erosion at mile point 10.4

Edge erosion at mile point 13.1

Edge erosion at mile point 19.2

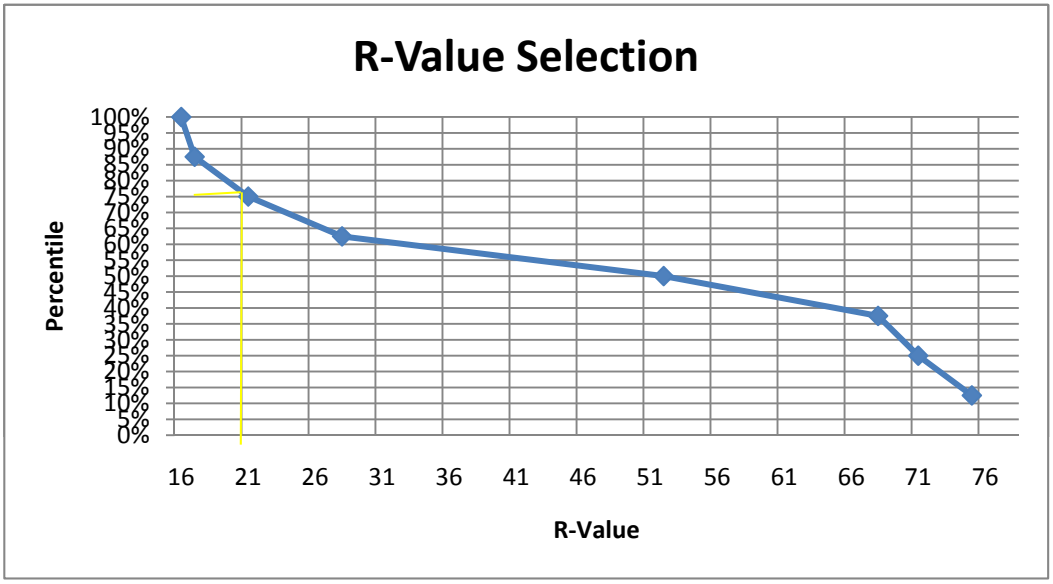
Water Crossing and ponding at mile post 23.2

APPENDIX D

PAVEMENT DESIGN CALCULATIONS

Selection of Design Subgrade Resistance Value

Number Greater Than or Equal To	Percent Equal to or Greater Than	Test Value in Desending Order	1985 Bore Hole
1	12.50%	75	BH-32
2	25.00%	71	BH-41
3	37.50%	68	BH-36
4	50.00%	52	BH-50
5	62.50%	28	BH-45
6	75.00%	21	BH-54
7	87.50%	17	BH-47
8	100.00%	16	BH-52



Design Percentile= 75

Design R-Value = 21

Moduls = 5104 Using the following Equation:

$$S_1 = \left[\frac{(R - Value\ - 5)}{11.29}\right] + 3 \qquad M_r = 10^{\left[\frac{(S_1 + 18.72)}{6.24}\right]}$$

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product
CFLHD

Flexible Structural Design Module

Additional Crushed Aggregate Base

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	50,000
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	5,103.7 psi
Stage Construction	1
Calculated Design Structural Number	2.18 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	432
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	60 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
2	96.6	2	0.0004	0	871
5	3.4	2	0.5	0	38,305
Total	100	-	-	-	39,175

Growth	Simple
Total Calculated Cumulative ESALs	39,175

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HACP	0.44	1	3	-	1.32
2	Pulverize	0.12	1	3.5	-	0.42
3	CAB	0.14	1	3.5	-	0.49
Total	-	-	-	10.00	-	2.23

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product
CFLHD

Flexible Structural Design Module

4R Construction areas

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	50,000
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	5,103.7 psi
Stage Construction	1
Calculated Design Structural Number	2.18 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	432
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	60 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
2	96.6	2	0.0004	0	871
5	3.4	2	0.5	0	38,305
Total	100	-	-	-	39,175

Growth	Simple
Total Calculated Cumulative ESALs	39,175

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HACP	0.44	1	3.5	-	1.54
2	Base Course	0.14	1	6	-	0.84
Total	-	-	-	9.50	-	2.38

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product
CFLHD

Flexible Structural Design Module

Pulverized Pavement

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	50,000
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	5,103.7 psi
Stage Construction	1
Calculated Design Structural Number	2.18 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	432
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	60 %

Vehicle Class	Percent of ADT	Annual % Growth	Average Initial Truck Factor (ESALs/ Truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
2	96.6	2	0.0004	0	871
5	3.4	2	0.5	0	38,305
Total	100	-	-	-	39,175

Growth	Simple
Total Calculated Cumulative ESALs	39,175

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HACP	0.44	1	4	-	1.76
2	Pulverize	0.12	1	4	-	0.48
Total	-	-	-	8.00	-	2.24

CA PRA JOTR 11(3) Joshua Tree National Park 2/10/2010

Paved width = 22
Route = 24

Option Items	inches convert to feet				length of route (ft)		width (ft)		unit weight		lbs to tons		tons or SQYD or CUYD		$/ton or $/SQYD or $/CUYD		
3.5" Pulverizing	3.5	x	0.0833	x	126720	x	22	x				=	309760	x $	5.4	=	$1,672,704
3.0" HACP	3	x	0.0833	x	126720	x	22	x	145	/	2000	=	50509	x $	125	=	$6,313,674
Lime	1%												505	x $	200	=	$101,019
4.0" HACP	4	x	0.0833	x	126720	x	22	x	145	/	2000	=	67346	x $	125	=	$8,418,231
Lime	1%												673	x $	200	=	$134,692
6.5" CAB	6.5	x	0.0833	x	126720	x	22	x	138	/	2000	=	104154	x $	38	=	$3,957,846
3.5" CAB	3.5	x	0.0833	x	126720	x	22	x	138	/	2000	=	56083	x $	38	=	$2,131,148
	square feet convert to square yards								**application rate**		**density**		**tons**		**$ / ton**		
Tack	126720	x	22	x	0.1111	=	309,729	x	0.1	/	241	=	129	x $	650	=	$83,537
Fog	126720	x	22	x	0.1111	=	309,729	x	0.1	/	241	=	129	x $	610	=	$78,396
Prime	126720	x	22	x	0.1111	=	309,729	x	0.33	/	253	=	404	x $	775	=	$313,096
Blotter	126720	x	22	x	0.1111	=	309,729	x	14.75	/	2000	=	2284	x $	50	=	$114,213
															SUBTOTAL		$589,241

Option #1 3.0" HACP + 3.5" CAB+3.5 pulverized base

$10,807,785 total cost
$450,324 per mile
130% $585,421.71

Option #2 3.0" HACP + 6.5" CAB

$10,961,780 total cost
$456,741 per mile
130% $593,763.06

Option #2 4" HACP + 3.5 Pulerized Base

$10,814,868 total cost
$450,620 per mile
130% $585,805.37

APPENDIX E

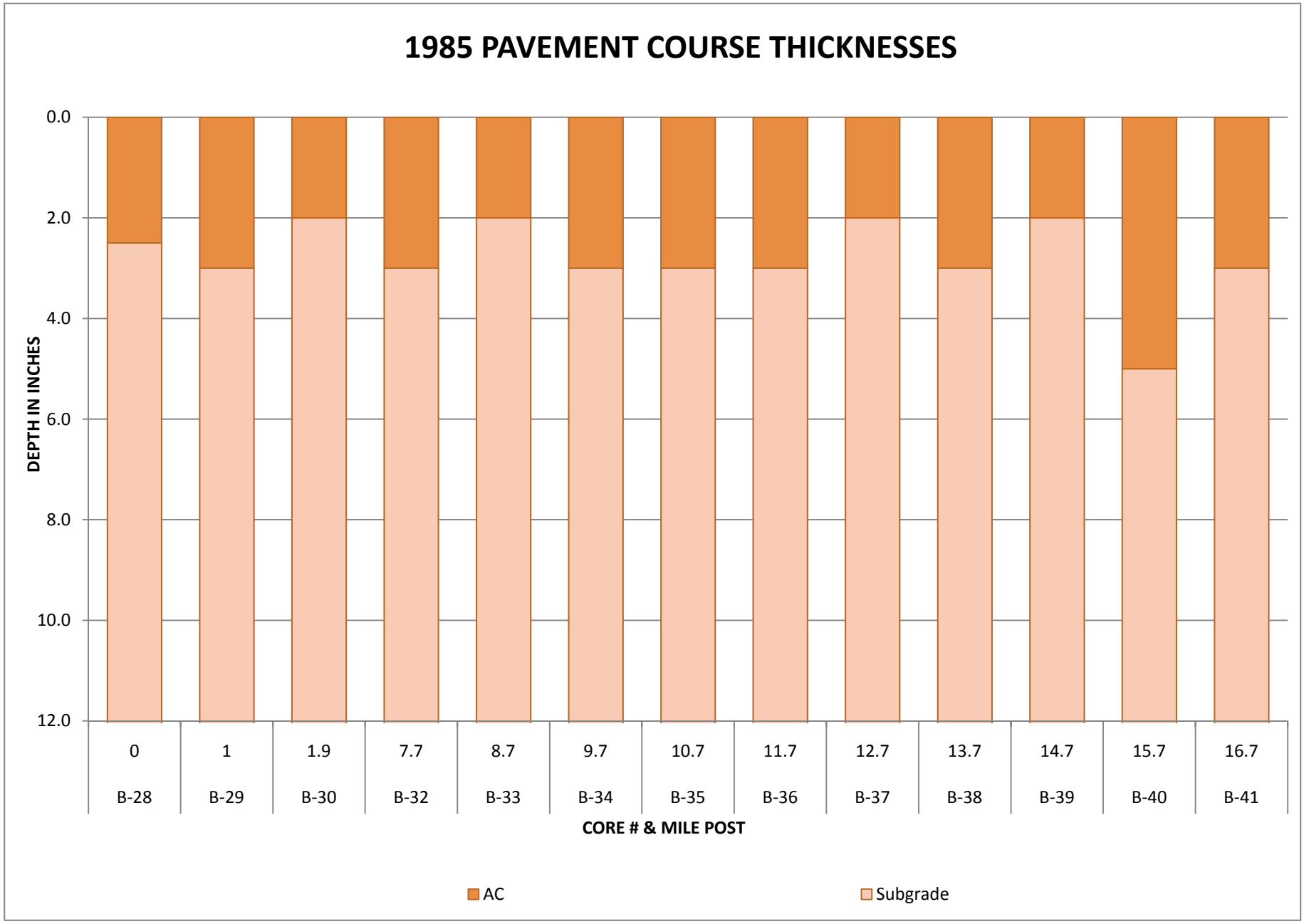
FIELD DATA SUMMARY

Route 11 Soil Properties as tested in 2010

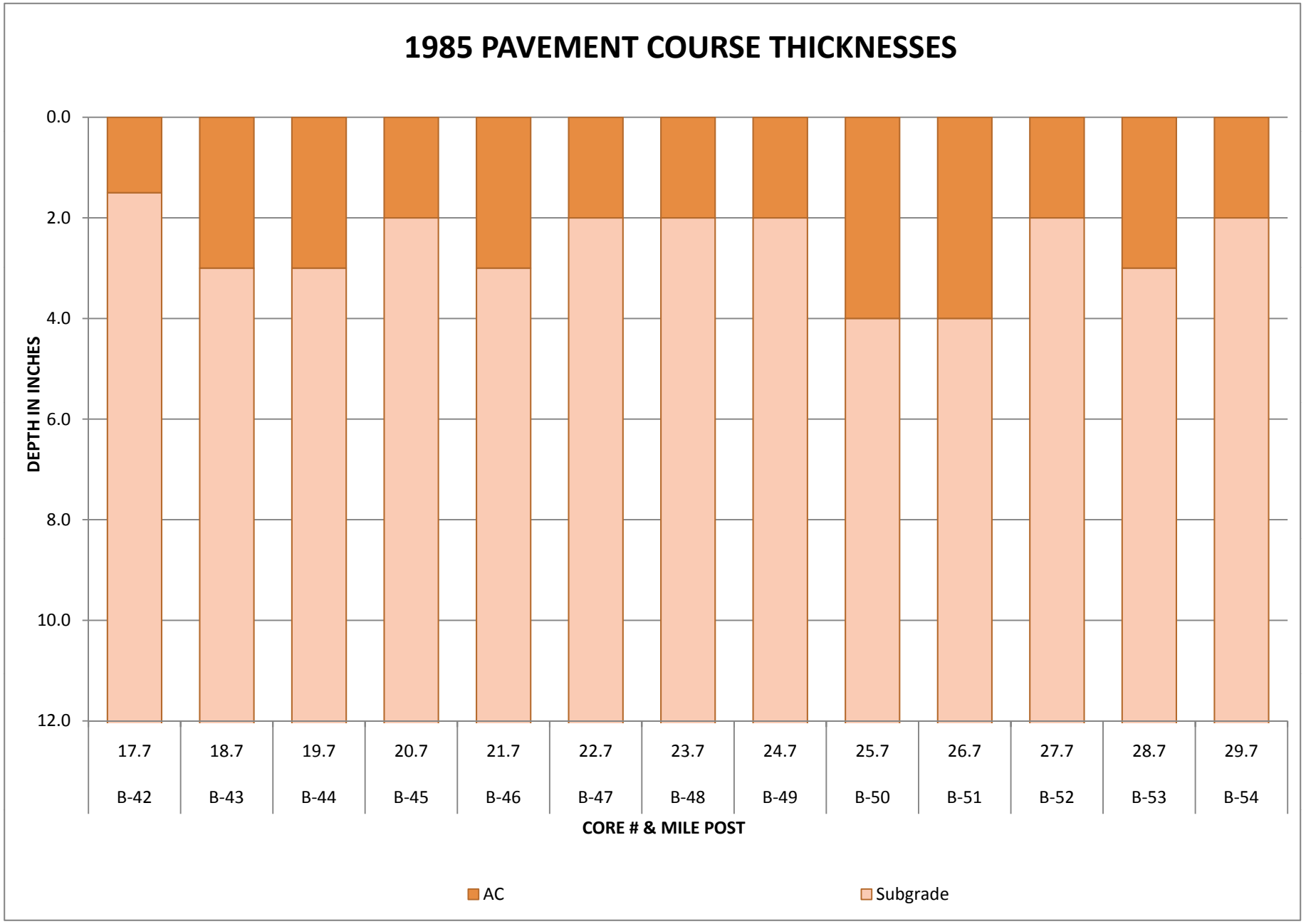
Sample #	Mile Post	Sample Depth (feet)	AASHTO Classification	R-Value	LL	PI
SP-1	11.7	2.5 ft	A-1-b	78	NV	NP
SP-2	22.7	2 ft	A-1-b	77	NV	NP
SP-3	27.7	1 ft	A-1-b		NV	NP

Soil Properties as tested in1985

Boring No.	Mile Post	Sample Depth (feet)	AASHTO Classification	R-Value	LL	PI
B-28		5	A-2-4	46	NV	NP
B-29	1	5	A-1-b		NV	NP
B-30	1.9	5	A-1-b		NV	NP
B-32	7.7	5	A-1-b	75	NV	NP
B-33	8.7	5	A-1-b		NV	NP
B-34	9.7	5	A-1-b		NV	NP
B-35	10.7	5	A-1-b		NV	NP
B-36	11.7	5	A-1-b	68	NV	NP
B-37	12.7	5	A-2-4		NV	NP
B-38	13.7	5	A-1-b		NV	NP
B-39	14.7	5	A-1-b		NV	NP
B-40	15.7	5				
B-41	16.7	5	A-1-b	71	NV	NP
B-42	17.7	5	A-2-4		NV	NP
B-43	18.7	5	A-1-b		NV	NP
B-44	19.7	5	A-1-b		NV	NP
B-45	20.7	5	A-2-4	28	29	5
B-46	21.7	5	A-2-4		22	2
B-47	22.7	5	A-2-4	17	29	10
B-48	23.7	5				
B-49	24.7	5	A-2-4		24	3
B-50	25.7	5	A-1-b	52	24	3
B-51	26.7	5	A-2-4		29	12
B-52	27.7	5	A-2-4	16	28	9
B-53	28.7	5	A-1-b		23	3
B-54	29.7	5	A-2-4	21	33	8
B-61	0.3	4	A-1-b	46	26	5


1985 PAVEMENT COURSE THICKNESSES
DEPTH IN INCHES
0.0
2.0
4.0
6.0
8.0
10.0
12.0
0
1
1.9
7.7
8.7
9.7
10.7
11.7
12.7
13.7
14.7
15.7
16.7
B-28
B-29
B-30
B-32
B-33
B-34
B-35
B-36
B-37
B-38
B-39
B-40
B-41
CORE # & MILE POST
AC
Subgrade

1985 PAVEMENT COURSE THICKNESSES



Boring No.	Location	Offset	Depth	Paved Width (Shoulder to Shoulder)	Material
B-22	Route 101 Keys View Rd. MP 4.0	℄ Rt. Lane	0-2" 2"-5'	19'21'	Chip seals & asphalt Slightly gravelly, silty sand NP A-2-4
B-23a	Route 101 Keys View Rd. MP 5.0	℄ Rt. Lane	0-4" 4"-5'	19'/21'	Chip seals & asphalt Slightly gravelly, silty sand, Some PI A-2-4
B-23b	Route 101 Keys View Rd. MP 5.5	℄ Rt. Lane	0-2" 2"-5'	19'/21'	Chip seals & asphalt Slightly gravelly, silty sand NP A-2-4
B-24	Route 12 E-W Hwy MP 16.0	℄ Rt. Lane	0-3" 3"-5'	20'/21'	Chip seals & asphalt Silty sand, NP A-2-4
B-25	Route 12 E-W Hwy. MP 17.0	℄ Rt. Lane	0-4" 4"-5'	20'/21'	Chip seals & asphalt Silty sand, NP A-1-b
B-26	Route 12 E-W Hwy. MP 18.0	℄ Rt. Lane	0-4" 4"-5'	20'/21'	Chip seals & asphalt Silty sand, NP A-2-4
-27	Route 12 E-W Hwy. MP 19.0	℄ Rt. Lane	0-2" 2"-5'	20'/21'	Chip seals & asphalt Silty sand, NP A-2-4
B-28	Route 221 Black Rock Rd. 800' S. of Entrance	℄ Rt. Lane	0-2½" 2½"-5'	11'	Chip seals & asphalt Silty sand, NP A-2-4
B-29	Route 112 Indian Cove Rd. MP 1.0	℄ Rt. Lane	0-3" 3"-5'	20'/20'	Chip seals & asphalt Silty sand, NP A-1-b
B-30	Route 112 Indian Cove Rd. MP 1.9	℄ Rt. Lane	0-2" 2"-5'	20'/20'	Chip seals & asphalt Silty sand, NP A-1-b
B-31	Route 212 Indian Cove Campground MP 2.9	℄ Rt. Lane	0-2" 2"-5'	16'/16'	Chip seals & asphalt Silty sand, NP A-2-4

FEDERAL HIGHWAY ADMINISTRATION
CENTRAL DIRECT FEDERAL DIVISION
MATERIALS DIVISION

Date: October, 1984

JOSHUA TREE NATIONAL MONUMENT

SOIL SURVEY
BORING LOGS

Boring No.	Location	Offset	Depth	Paved Width (Shoulder to Shoulder)	Material
B-32	Route 11 N-S Hwy. MP 7.7	℄ Rt. Lane	0-3" 3"-5'	18'/18'	Chip seals & asphalt Gravelly sand, NP A-1-b
B-33	Route 11 N-S Hwy. MP 8.7	℄ Rt. Lane	0-2" 2"-5'	19'/19'	Chip seals & asphalt Silty sand, NP A-1-b
B-34	Route 11 N-S Hwy. MP 9.7	℄ Rt. Lane	0-3" 3"-5'	20'/21'	Chip seals & asphalt Slightly silty, gravelly sand, NP A-1-b
B-35	Route 11 N-S Hwy. MP 10.7	℄ Rt. Lane	0-3" 3"-5'	20'/21'	Chip seals & asphalt Silty, gravelly sand, NP A-1-b
B-36	Route 11 N-S Hwy. MP 11.7	℄ Rt. Lane	0-3" 3"-5'	20'	Chip seals & asphalt Slightly silty, sandy gravel NP A-1-b
B-37	Route 11 N-S Hwy. MP 12.7	℄ Rt. Lane	0-2" 2"-5'	21'/21'	Chip seals & asphalt Silty sand, NP A-2-4
B-38	Route 11 N-S Hwy. MP 13.7	℄ Rt. Lane	0-3" 3"-5'	18'/19'	Chip seals & asphalt Silty, gravelly sand, NP A-1-b
B-39	Route 11 N-S Hwy MP 14.7	℄ Rt. Lane	0-2" 2"-5'	19'/20'	Chip seals & asphalt Slightly gravelly, silty sand, NP A-1-b
B-40	Route 11 N-S Hwy MP 15.7	℄ Rt. Lane	0-5" 5"-5'	19'/20'	Chip seals & asphalt Slightly silty, gravelly sand, NP A-1-b
B-41	Route 11 N-S Hwy MP 16.7	℄ Rt. Lane	0-3" 3"-5'	19'/20'	Chip seals & asphalt Silty, gravelly sand, NP A-1-b
B-42	Route 11 N-S Hwy. MP 17.7	℄ Rt. Lane	0-1½" 1½"-5'	19'/20'	Chip seals & asphalt Silty sand, NP A-2-4

FEDERAL HIGHWAY ADMINISTRATION
CENTRAL DIRECT FEDERAL DIVISION
MATERIALS DIVISION

Date: October, 1984

JOSHUA TREE NATIONAL MONUMENT

SOIL SURVEY
BORING LOGS

Boring No.	Location	Offset	Depth	Paved Width (Shoulder to Shoulder)	Material
B-43	Route 11 N-S Hwy. MP 18.7	℄ Rt. Lane	0-3" 3"-5'	20'/20'	Chip seals & asphalt Silty sand, NP A-1-b
B-44	Route 11 N-S Hwy.	℄ Rt. Lane	0-3" 3"-5'	20'/20'	Chip seals & asphalt Silty sand, NP A-1-b
B-45	Route 11 N-S Hwy. MP 20.7	℄ Rt. Lane	0-2" 2"-5'	20'/20'	Chip seals & asphalt Silty sand, some PI A-2-4
B-46	Route 11 N-S Hwy. MP 21.7	℄ Rt. Lane	0-3" 3"-5'	20'/20'	Chip seals & asphalt Silty sand, little PI A-2-4
B-47	Route 11 N-S Hwy. MP 22.7	℄ Rt. Lane	0-2"	20'/20'	Chip seals & asphalt Silty sand, some PI A-2-4
B-48	Route 11 N-S Hwy. MP 23.7	℄ Rt. Lane	0-2" 2"-5'	20'/22'	Chip seals & asphalt Very silty sand, little PI
B-49	Route 11 N-S Hwy. MP 24.7	℄ Rt. Lane	0-2" 2"-5'	20'/23'	Chip seals and asphalt Silty sand, little PI A-2-4
B-50	Route 11 N-S Hwy. MP 25.7	℄ Rt. Lane	0-4" 4"-5'	20'/22'	Chip seals and asphalt. Silty sand, little PI A-1-b
B-51	Route 11 N-S Hwy. MP 26.7	℄ Rt. Lane	0-4" 4"-5'	20'/26'	Chip seals and asphalt. Silty sand, some PI A-2-4
B-52	Route 11 N-S Hwy. MP 27.7	℄ Rt. Lane	0-2" 2"-5'	20'/24'	Chip seals and asphalt. Silty sand, some PI A-2-4
B-53	Route 11 N-S Hwy. MP 28.7	℄ Rt. Lane	0-3" 3"-5'	20'/22'	Chip seals and asphalt. Silty sand, little PI A-1-b

DERAL HIGHWAY ADMINISTRATION
NTRAL DIRECT FEDERAL DIVISION
MATERIALS DIVISION

Date: October, 1984

JOSHUA TREE NATIONAL MONUMENT

SOIL SURVEY
BORING LOGS

Boring No.	Location	Offset	Depth	Paved Width (Shoulder to Shoulder)	Material
B-54	Route 11 N-S Hwy. MP 29.7	℄ Rt. Lane	0-2" 2"-5'	20'/21'	Chip seals & asphalt Silty sand, some PI A-2-4
B-55	Route 11 N-S Hwy. MP 30.7	℄ Rt. Lane	0-2" 2"-5'	19'/20'	Chip seals & asphalt Silty sand, some PI A-1-b
B-56	Route 11 N-S Hwy. MP 31.7	℄ Rt. Lane	0-2" 2"-5'	19'/21'	Chip seals & asphalt Silty sand, little PI A-1-b
B-57	Route 11 N-S Hwy. MP 32.7	℄ Rt. Lane	0-7" 7"-5'	19'/22'	Chip seals & asphalt Silty sand, NP A-1-b
B-58	Route 11 N-S Hwy. MP 33.7	℄ Rt. Lane	0-3½" 3½"-5'	20'/21'	Chip seals & asphalt Silty sand, NP A-1-b
B-59	Route 11 N-S Hwy. MP 34.7	℄ Rt. Lane	0-6" 6"-5'	20½/22'	Chip seals & asphalt Silty sand, NP A-1-b
B-60	Route 11 N-S Hwy. MP 35.6	℄ Rt. Lane	0-4" 4"-5'	18'/20'	Chip seals & asphalt Silty sand, NP A-1-b
B-61	Route 113 49 Palms Canyon Rd. MP 0.3	℄	0-3" 3"-4'	20'/22'	Chip seals & asphalt Decomposed granite, some PI A-1-b
B-62	Route 300 Geology Tour Rd. MP 1.0	℄	0-'5		Silty sand, NP A-2-4
B-63	Route 300 Geology Tour Rd. MP 2.0	℄	0-5'		Clayey sand, PI A-2-6
B-64	Route 300 Geology Tour Rd. MP 3.0	℄	0-5'		Silty sand, NP A-2-4
B-65	Route 300 Geology Tour Rd. MP 4.0	℄	0-5'		Silty sand, NP A-1-b
B-66	Route 300 Geology Tour Rd. MP 5.0	℄	0-6'		Silty sand, NP A-1-b

DERAL HIGHWAY ADMINISTRATION
NTRAL DIRECT FEDERAL DIVISION
MATERIALS DIVISION

Date: October, 1984

JOSHUA TREE NATIONAL MONUMENT

SOIL SURVEY
BORING LOGS