U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: **AMENDED MEMORANDUM of MAY 19, 2006**
CO PRA ROMO 10(4) TRAIL RIDGE ROAD

Date: July 26, 2006

From: Steve Deppmeier, Pavements Engineer

To: Mark Meng, Project Manager
Wendy Hilgers, Lead Designer

A memo from me dated May 19, 2006 (attached) amended the original pavement report by providing two relatively equivalent pavement structural sections to insert into the project as different schedules/options.

Although Option 1 (foamed asphalt option) is structurally sufficient and meets CFL standards of a 20-year design, I understand the Park did not agree with the design and requested that one inch of asphalt be added to this option.

With this change the pavement structural section for Option 1 would now be:

Mill 75 mm (3 inches) existing pavement
75 mm (3 inches) HACP
150 mm (6 inches) FDR – Foamed Asphalt
SN = 2.22
Grade Raise = 0

CC: Mike Voth, Pavement Discipline Leader
Richard Duval, QA Materials Engineer
Kevin Black, COE

Attachment: May 19, 2006 Memorandum

ebrating 50 Years
1956 50th 2006
Eisenhower Interstate System

BUCKLE UP AMERICA

U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: **AMENDED PAVEMENT RECOMMENDATION**
CO PRA ROMO 10(4) TRAIL RIDGE ROAD

Date: May 19, 2006

From: Steve Deppmeier, Pavements Engineer

To: Mark Meng, Project Manager
Wendy Hilgers, Lead Designer

The Pavement Report 04-14, issued September 2004 recommended for Section D, Station 75+500 to 85+066 to mill 75 mm (3 inches), place 75 mm (3 inches) HACP on 150 mm (6 inches) FDR – Foamed Asphalt. The required Structural Number (SN) is 2.13. A desired feature was little or no grade raise from the existing pavement elevation. The upcoming project will actual begin near Station 72+000. The following discussion will pertain also for Station 72+000 to 85+066. The existing pavement averages 175 mm (7inches) in depth.

With construction cost spiraling upward the last two years, it is prudent to expand the potential number of bidders. The following typical pavement sections are generally equal in structural capacity, yet allow more contractors to bid. Additionally, having two options (schedules) will allow market conditions of material cost to influence prices. For instance, if HACP prices remain or go higher in price, Option 1 may be more economical. However, if foamed asphalt construction prices are high, Option 2 may be more economical.

Option 1:
Mill 50 mm (2 inches) existing pavement
50 mm (2 inches) HACP
175 mm (7 inches) FDR – Foamed Asphalt
SN = 2.14
Grade Raise = 0

Note: The depth of foamed asphalt is increased in order compensate for the thinner HACP mat and to roughly keep the same RAP to base ratio that foamed asphalt mix designs were performed on.

Option 2:
Mill 3 inches existing pavement
90 mm (3.5 inches) HACP
150 mm (6 inches) FDR – Pulverize the existing pavement & base course
SN = 2.26

Celebrating 50 Years 1956 2006 Eisenhower Interstate System

BUCKLE UP AMERICA

Grade Raise = 12.5 mm (0.5 inches)

Note: the 12.5 mm grade raise appears insignificant, but should be verified with the Park and CFT.

Both options will provide a 20-year plus design life assuming timely preventive maintenance is performed.

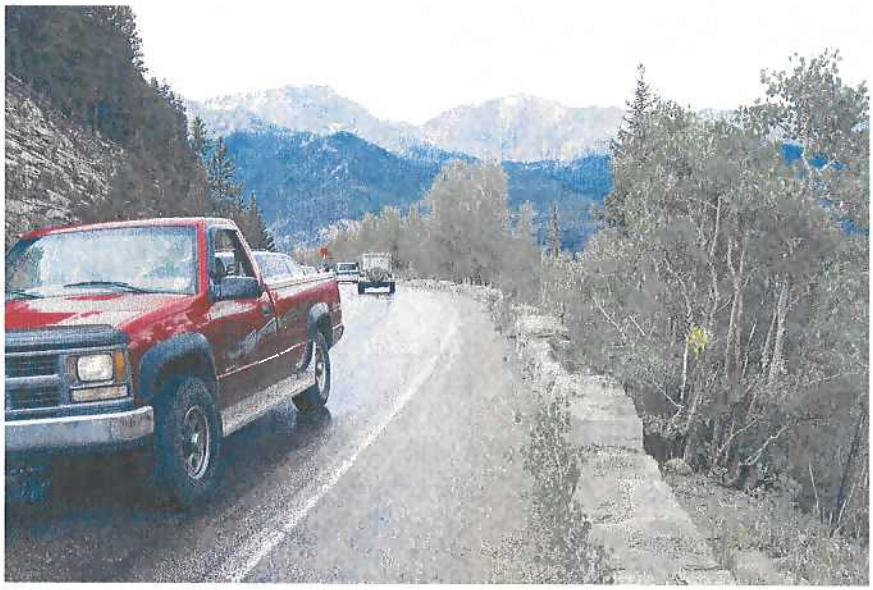
Option 1 could be placed in Schedule A with Options X, Y, & Z for the various geotechnical repairs further west of this work. Option 2 could be in Schedule B with the same Options X, Y, & Z.

Attachment: DARWin Pavement Calculations

CC: Mike Voth, Lead Pavements Engineer
Richard Duval, QA Materials Engineer
Kevin Black, COE

ROCKY MOUNTAIN NATIONAL PARK,

CO PRA ROMO 10(4) TRAIL RIDGE ROAD



PAVEMENT REPORT
SEPTEMBER 2004
REPORT 04-14

Report by:
Steve Deppmeier, Pavements Engineer

Technical Services Branch
Central Federal Lands Highway Division
Federal Highway Administration
Lakewood, Colorado

Distribution:
Project Development – (3) Wendy Hilgers
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Construction – (1) Kevin Black
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Approved for distribution by:

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Michael D. Voth, Lead Pavement Engineer

9-28-04
_____
DATE

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I. INTRODUCTION

On August 14, 2003 a pavement and subgrade soil investigation was completed in the Rocky Mountain National Park (RMNP). This investigation covers road conditions of Trail Ridge Road (U.S. Highway 34 outside of the National Park) from the National Park boundary at the west entrance to Deer Ridge Junction, intersection with U.S. Highway 36. Trail Ridge Road is the only significant transcontinental divide route between Interstates 70 & 80, although commercial traffic is prohibited from transversing the National Park.

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

Climate

Snow covers much of the park from mid-October through mid-June. Trail Ridge Road is usually closed late October through late May to early June. During years of heavy snowfall, the road may open significantly later. If weather permits, park road crews begin snowplowing in April. It generally takes 42 days to complete snowplowing operations.

Weather can be very warm in the summer down on the valley floor. Temperatures generally are 20 to 30 degrees Celsius (70's to 80's F) during daylight but can drop into the low single digits (40's F) at night. At the upper elevations, temperatures can be 10 degrees cooler. Afternoon thunderstorms and wind are normal with temperature drops of 10 to 15 degrees.

Winter is relatively mild down on the valley floor. At the upper elevations of Trail Ridge Road, arctic conditions prevail. Sudden blizzards, high winds, and deep snowpack are common. The west side of the park experiences more snow, less wind, and clear cold days during the winter months.

Estes Park receives approximately 330 mm (13 inches) of moisture every year while Grand Lake receives 505 mm (20 inches) of moisture every year.

Existing Pavement

In summer of 1984, Trail Ridge Road was rebuilt from the west entrance to the Colorado River Trailhead. Peter Kiewit Sons Company built this project. The pavement structural section was 100 mm of base course, 75 mm of hot asphalt concrete pavement (HACP) and an Open Graded Friction Course (OGFC).

1984 was a wet year. The spring had a high snow melt runoff level with a resulting high watertable, and the summer was extremely wet. The pavement had several structural section failures that had to be rebuilt in 1985. Since then the National Park Service (NPS) has had to repair sections with major cracks.

The OGFC was raveling two years ago (2001) from the park entrance to the Colorado River Trailhead when a chip seal was placed. At the time of this pavement investigation, the chip seal was in good condition and was masking the pavement distress of the underlying layers. Doug Buttrey, RMNP Road Foreman for the west side, stated that for the most part, cracking was limited to specific locations and was not too bad for the majority of the roadway from the park boundary to the Colorado River Trailhead. Frost heaves are a recurring problem and six areas are identified for subexcavating. See Appendix J for locations.

In 1982 & 1984 from the Colorado River Trailhead to Hidden Valley, Trail Ridge Road had the first cold in-place recycle and overlay projects that CFLHD performed. Flat Iron Paving Co. built the 1982 project. This project length was 14.8 kilometers (km) long (9.2 miles). Peter Kiewit Sons Company built the 1984 project, which was 5.2 km long (3.2 miles). The 1984 project was CFLHD's pilot project for contractor acceptance testing.

The proposed project(s) consist of rehabilitating Trail Ridge Road from the west park boundary to Deer Ridge Junction. Lava Cliffs Parking Area will be included within roadwork. Other pullouts will be included or slated for obliteration based on individual assessment by the RMNP.

RMNP has a complete maintenance road crew that performs their own chip sealing operations. A chip seal was placed during the summer of 2003 from Milner Pass to the Alpine Visitor Center.

The total length of proposed roadwork is approximately 61.7 km (38.3 miles). The following pavement conditions were recorded from an odometer and then converted to approximate project stationing.

Table 1: Pavement Condition of Trail Ridge Road, Rocky Mountain National Park

Station	Road Width	Pavement Thickness (Average)	No. of Cores Indicating Stripping	Pavement Conditions
23+395 to 32+800	8.80 m	103 mm	16 of 22	Chip seal masking cracks. High severity edge cracking leading beneath the chip seal. Chip seal has pop-outs and patches present.
32+800 to 38+000	8.96 m	100 mm	4 of 11	Rough surface. Chip seal masking any cracks.
38+000 to 40+800	9.66 m	103 mm	No recorded Stripping	No visible cracks beneath chip seal.

Station	Road Width	Pavement Thickness (Average)	No. of Cores Indicating Stripping	Pavement Conditions
40+800 to 42+400	7.65 m	170 mm	3 of 5	Pop outs in old chip seal, consistent problem with water pooling. No cracks visible.
42+400 to 47+600	7.97 m	155 mm	4 of 11	Old chip seal, no visible cracks.
47+600 to 50+400	7.45 m	165 mm	3 of 7	Uniform HACP thickness, no visible cracks. One patch area present.
50+400 to 57+200	7.58 m	215 mm	7 of 17	HACP varied from 150 mm to 265 mm. Any cracks masked by new chip seal.
57+200 to 59+000	7.92 m	168 mm	2 of 5	Pavement settlement area studied by CFLHD Geotech Section and portion recommended for reconstruction.
59+000 to 64+800	9.68 m	156 mm	5 of 16	Couple settlement areas studied by CFLHD Geotech Section. Patches present, moderate edge and transverse cracking present.
64+800 to 68+400	8.06 m	154 mm	5 of 9	No cracks visible. CFLHD Geotech Section settlement studied areas and other patches but otherwise HACP was good for most part.
68+400 to 73+600	7.83 m	151 mm	9 of 13	No visible cracks.
73+600 to 79+200	8.56 m	160 mm	4 of 15	Moderate transverse cracking. One location had rutting and shoving and another had localized high severity alligator cracking between C95 & C96.
79+200 to 80+900	8.99 m	155 mm	No recorded stripping	Moderate to high transverse cracking and moderate longitudinal cracking.
80+900 to 85+066	7.98 m	197 mm	6 of 11	Moderate transverse & longitudinal cracking. Low to high rutting with some shoving.

Soils

Subgrade soils consisted of material generally classified by AASHTO M 145 as A-1-b (0) to A-2-4 (0), silty sand or clayey sand under ASTM D 2487. Only one sample had a Plasticity Index (PI) above 6. All other samples were non-plastic or had a PI of 6 or less. In-situ moisture content (MC) ranged from 1.9% to 7.9%. Average moisture content was 5%.

Soil properties from previous investigations were incorporated into this report. The reports were: Soils Survey and Materials Source Investigation March 1979 by Larry W. Wolf and Robert J. Blenk, the Materials Investigation (Maintenance Project) November 1981 by Bob Blenk and Wayne Folkman, and the CO PRA 10(3) Trail Ridge Road Report# CO-PX-ROMO-01-01 by Khamis Y. Haramy. Laboratory test results from these reports were copied and place in Appendix B of this report. Laboratory results were consistent among the reports thereby reducing the amount of field investigation in 2003.

Geology: *From Geotechnical Report CO-PX-ROMO-01-01 by Khamis Haramy.*

Trail Ridge Road is located in the heart of Rocky Mountain National Park, which rises to impressive heights ranging from 238 to 4350 m (7,800 to 14,255 ft) and includes Longs Peak, one of Colorado's highest points. These mountains are part of the northern Front Range that lies within the geologic province known as the Southern Rocky Mountains. These north-south trending mountains are characterized as broad-backed uplift, along whose crest erosion has laid bare wide areas of Precambrian rocks. These Precambrian rocks consist of granites, granitic gneisses, and biotitic schists that have been sculpted by several episodes of glaciations. These glacial features are present today as U-shaped valleys, hanging valleys, cirques, cirque lakes, and huge lateral moraines. The soils consist mainly of glacial deposits and residual soils derived from weathering of the granite basement rocks.

III. EXPLORATION

The investigation used a truck mounted drill rig to auger through the existing pavement and to continue into the subgrade from 0.3 m to 1.5 m (1 ft. to 5 ft.) in depth. Pavement thicknesses were recorded, as were the soil descriptions. Samples were labeled from '-32C' to 'C-120'. Samples in pullouts or on the shoulders were labeled for example as C-81b to correspond with the sample in the mainline, C-81. Sampling was generally every 400 m (0.25 miles) on the main Park Road. Mileposts (MP) were recorded for sample locations and converted to project stationing.

Three samples were taken at the Lava Cliffs Parking Area and labeled C-60A, C-60B, and C-60C.

On August 11, 12, 13, & 14, 2003 a two-person crew from GDI Drilling, Inc. completed 31 auger borings greater than 0.450 m in depth and 125 auger borings of 0.300 m in depth to check the pavement thickness and to obtain subgrade samples at selected locations. GDI used a CME 75 truck-mounted drill rig. Northern Colorado Traffic

Control, Inc. provided traffic control. Auger refusal was encountered in 7 borings. All borings were drilled within the roadway or in the paved parking areas. CFLHD staff completed visual identification of the soils and logged the borings. Ten samples were tested for soil classification and in-situ moisture content. Four samples were tested for R-Values.

In addition, five test pits were excavated to collect material for a preliminary full-depth reclamation mix design. Approximately 100 kg of asphalt and base course were collected at each site. GDI used a 400 mm diameter cookie cutter bit to obtain the samples. Two to four corings were required at each site to obtain enough material.

Typical pavement distresses were recorded and photos were taken to further document the condition of the pavement. Laboratory test results, boring logs, and photographs of the boring locations are provided in the appendices in the back of this report.

IV. FOAMED ASPHALT & FWD TEST RESULTS

Foamed asphalt is a Full-Depth Reclamation (FDR) process where existing Hot Asphalt Concrete Pavement (HACP), base and/or subgrade is pulverized through the use of a road reclaimer. As the material is being pulverized, hot asphalt and water is injected through nozzles. The resulting foaming action of the asphalt coats the fine particles of the pulverized material. The course particles are embedded in the coated fine particles and act as a brick & mortar type asphalt treated base course. A riding surface of HACP then caps the foamed asphalt section. Generally the amount of asphalt binder required for foamed asphalt is 2% to 4% (based on the unit weight of the reclaimed material).

Four small roadway sections have been constructed in RMNP with the foamed asphalt FDR process. Prior to the above drilling exploration, Ground Engineering Consultants mobilized a 2003 JILS Falling Weight Deflectometer (FWD) to determine the structural capacity of these four pavement sections. An FWD is a trailer-mounted unit that uses dynamic impulse loads and the subsequent measurement of the deflection basin to estimate the modulus of pavement layers. The purpose of the FWD was to test the durability and strength of foamed asphalt. Though these sections have only been in-place since 1999 and 2001, RMNP has been pleased with the results and asked FHWA to consider the use of foamed asphalt for the upcoming 62 km of road rehabilitation.

Since RMNP experiences extreme climate conditions and that any pavement recommendation for 62 km is a significant investment, it was prudent to determine how well the existing foamed asphalt sections were performing.

The foamed asphalt placed in RMNP was not designed, tested, or constructed to the standards of FHWA projects. Soter Construction, of Quebec, Canada, constructed three foamed asphalt sections in 1999. Soter used a Caterpillar RM-350 Road Reclaimer to pulverize the existing pavement and to mix in the hot asphalt and water to form the foamed asphalt base. The fourth section was constructed in 2001 by Son-Haul, Inc. of Fort Morgan, CO. Son-Haul used a Wirtgen WR2500 Recycler/Stabilizer.

Foamed asphalt was injected to a depth of to 150 mm (6inch) on the projects. A 37 mm (1.5inch) HACP overlay then topped the pavement structural section. Fall River Road, one of the sections built by Soter, received approximately 50 mm to 75 mm (2 inch to 3 inch) overlay. During the pavement investigation in the summer of 2003, no distresses were noted in any of the four pavement sections.

Cores of the pavement structural section, both HACP & foamed asphalt portions were taken from the roadway few days after the FWD testing to calibrate the FWD data. Pictures of the cores are in Appendix C. Field pictures of cores show the HACP portion being dry while the foamed asphalt portion of the core is wet due to the lower asphalt content and resulting voids.

Cores of the Moraine Park area and Trail Ridge Road were good. Cores from the Fall River Road did not retain any portion of the foamed asphalt beneath the HACP overlay. The foamed asphalt portions of the cores from Moraine Park and Trail Ridge Road appear as course HACP cores though with more voids than HACP cores.

The full FWD report by Ground Engineering Consultants is in Appendix G. To quickly summarize, the foamed asphalt section provided resilient modulus values similar to that of HACP. The moisture susceptibility of the foamed asphalt portions of the roadway cores was somewhat disappointing, as the wet tensile strengths would not meet FP-03 specifications.

Earth Engineering, Inc (EEC) performed four preliminary foamed asphalt mix designs. EEC's report is in Appendix H. Two of the mix designs were acceptable. The third mix design represents an area that has been eliminated from the 10(4) project. The fourth mix design was run at two portland cement contents.

The following table contains application rate recommendations for the foamed asphalt base stabilization based upon EEC's test results. The asphalt cement should be graded as AC-10.

Table 2: Foamed Asphalt Recommended Application Rates

STATIONING	AC-10	PORTLAND CEMENT
SECTION A: 23+050 to 40+845	3%	2%
SECTION B: 40+800 to 50+400 & 59+160 to 75+500	4%	1%
SECTION C: 50+400 to 57+000	3%	1%
SECTION D: 75+500 to 85+066	3%	1%

For estimating purposes, use AC-10 applied at the above percent of the unit weight of the existing pavement structure assuming 2275 kg/m^3 (142.0 lb/ft^3) and the portland cement applied at the above percent of the unit weight of the existing pavement.

V. TEST RESULTS

Table 3 provides a summary of the soil properties evaluated on 10 soil samples from this investigation. Appendix B contains the full laboratory report. In Appendix E are several Charts, which provide layer depths of the existing pavement structural sections. Core locations were taken from an odometer and converted to approximate stationing. Also, in Appendix B are reports with historical R-Value and soil property information for Trail Ridge Road.

Table 3: Main Road and its spur roads Soil Properties

Milepost/ Location/ Boring	Sample Depth	AASHTO Classification	R-Value	Moisture (%) (in-situ)
C-7 @ 39+800	0.100 – 1.5m	A-1-b (0)	41	5.1
C-18 @ 44+200	0.175 – 1.2m	A-1-b (0)	-	1.9
C-28 @ 48+200	0.165 – 1.5m	A-1-b (0)	-	3.4
C-36 @ 51+400	0.225 – 1.5m	A-2-6 (0)	-	5.9
C-40 @ 53+000	0.165 -1.5m	A-1-b (0)	-	3.8
C-56 @ 59+300	0.165 –1.5m	A-1-b (0)	39	6.4
C-60D @ 60+870	0.170 – 1.5m	A-2-4 (0)	24	4.5
C-80 @ 69+000	0.165 – 1.5m	A-1-b (0)	-	7.9
C-111 @ 81+350	0.200 – 1.5m	A-1-b (0)	70	5.0
C-117 @ 83+800	0.225 – 1.5m	A-1-b (0)	-	4.6

Auger refusal occurred at the following depths and locations. These depths would not affect a pulverizing operation but the contractor should be made aware of the depths as sampling was performed every 400 meters and variations could occur within this distance.

Table 4: Auger Refusal

Milepost/ Location/ Boring	Depth from Pavement Surface
C-6	318 mm
C-40	1065 mm
C-84	420 mm
C-86	405 mm
C-88	470 mm
C-89	470 mm
C-91	610 mm

VI. PAVEMENT RECOMMENDATIONS AND DISCUSSION

Traffic counts were obtained from the FHWA Geotechnical Report CO-PX-ROMO-01-01. The ADT was 2825. The projected 18-kip ESALs for 20 years were 617,765. Subgrade soil support was good. The average R-Values were 50 to 60; which correlates to 13,000 to 17,000 psi soil resilient modulus. Calculated Pavement Structural Numbers (SN) were 2.13 and 2.24.

HACP average thickness trends lend themselves to be grouped into five different pavement structural sections. HACP averaged 100 mm to 212 mm between four sections. The fifth section is a reconstruction section based upon the CO-ROMO-01-01 Geotechnical Report.

Major concerns were to minimize the amount of grade raise, and be able to construct the project with the amount of traffic and the afternoon thunderstorms within the short summer season.

Trail Ridge Road:

Section A: Average Existing HACP thickness 100 mm (4 inches)
23+395 to 40+800
Needed SN: 2.13

Option 1:
90 mm (3.5 inches) HACP
125 mm (5 inches) Road Reconditioning / Pulverizing.
(Bid item 303)
SN = 2.14
Grade Raise: 90 mm
Cost estimate: $162,000/kilometer

Option 2: Recommended Section
75 mm (3 inches) HACP
125 mm (5 inches) Full-depth Reclamation
(Foamed asphalt or other type, bid item 418).
SN = 2.32
Grade Raise: 75 mm
Cost estimate: $ 159,000/kilometer

Section B: Average existing HACP thickness 165 mm (6.5 inches) & 160 mm (6.25 inches) respectfully for the following sections:
40+800 to 50+400 & 59+160 to 75+500
Needed SN: 2.24

Option 1: Recommended Structural Section
Mill 75 mm (3 inches)
75 mm (3 inches) HACP
150 mm (6 inches) Full-depth Reclamation
(Foamed asphalt or other type, bid item 418).
SN = 2.22
Grade Raise: 0.00
Cost estimate: $ 159,000/kilometer

Section C: Average existing HACP thickness 210 mm (8.25 inches)
50+400 to 57+600
Needed SN: 2.24

Option 1:
Mill 75 mm (3 inches)
65 mm (2.5 inches) HACP
200 mm (8 inches) Full-depth Reclamation
(Foamed asphalt or other type, bid item 418).
SN = 2.30
Grade Raise: -12mm (-0.5 inches)
Cost estimate: $156,000/kilometer

Option 2: Recommended Structural Section
Mill 100 mm (4 inches)
75 mm (3 inches) HACP
150 mm (6 inches) Full-depth Reclamation
(Foamed asphalt or other type, bid item 418).
SN= 2.22
Grade Raise: -25 mm (-1.0 inches)
Cost estimate: $161,000/kilometer

Section D: Average existing HACP thickness 175 mm (7 inches)
75+500 to 85+066
Needed SN: 2.13

Option 1: Recommended Structural Section
Mill 75 mm (3 inches)
75 mm (3 inches) HACP
150 mm (6 inches) Full-depth Reclamation
(Foamed asphalt or other type, bid item 418).
SN= 2.22
Grade Raise: 0.00
Cost estimate: $157,000/kilometer

Section E: Reconstruction
57+600 to 59+160
Needed SN: 2.24

Option 1: Recommended Structural Section
75 mm (3 inches) HACP
175 mm (7 inches) Base Course (bid item 308).
SN= 2.30
Grade Raise: As set by Reconstruction of subgrade elevation following Geotechnical report CO-ROMO-01-01.
Cost estimate: $248,000/kilometer

Lava Cliffs Parking Area:

Due to its poor condition, Lava Cliffs will be reconstructed. HACP thickness in the roadway one station prior to Lava Cliffs, at Lava Cliffs, and just past Lava Cliffs were 292 mm, 172 mm, and 216 mm respectively. Three HACP thicknesses in the parking area were 70 mm, 75 mm, and 200 mm. An R-Value from the roadway with 172 mm of HACP was 24 with in-situ MC of 4.5. The reconstructed structural section will be 75 mm HACP and 175 mm base course.

Pullouts:

In general, parking areas and pullouts will not be rehabilitated. If parking areas and pullouts are added to the project, they shall be rehabilitated and paved as the adjoining paved traveled way. Parking areas with concrete curb & gutter require tapering the Full-depth Reclamation and the new pavement surface to match existing grade elevations. Positive drainage of the parking areas needs to be maintained. For Full-depth Reclamation, the road reclaimer needs to pulverize at least 25 mm below the HACP depth.

Pavement Materials:

•The HACP should be Item 401 Superpave, 12.5 mm grading with a Type II smoothness level. The unit weight can be estimated at 2325 kg/m^3 (145 lb/ft^3).
•Hydrated lime (Type III), at 1%, will be the antistrip additive.
•The asphalt cement should be a PG 58-40. Quantity can be estimated at 6% by weight of mix.
•The 75 mm depth HACP shall be placed in two lifts.
•Tack coat at 0.45 L/m^2 (0.10 gal/yd^2) is required between lifts and should either be a CSS-1, CSS-1h, SS-1, or SS-1h emulsion. A tack coat will be required between the foamed asphalt and the bottom HACP mat.
•A fog seal, bid Item 409 should be included in the contract. For determining quantities use an application rate of 0.45 L/m^2 (0.10 gal/yd^2). The emulsion type can be a CSS-1, CSS-1h, SS-1, or SS-1h.
•The foamed asphalt stabilized base specification; Item 418 SCR should be used. For estimating purposes see Part IV of this report.

Drainage, Subexcavation, and other Issues:

On May 19, 2004, when collecting the additional sample for the preliminary foamed asphalt mix design, NPS maintenance personnel made a point of escorting a FHWA representative to approximately Station 34+000, the Coyote Valley Trail turn-out. The maintenance personnel said for whatever reason, water pools up at this point and the pavement pops out. See Photo 7 in Appendix C. This roughly 60 m stretch is their worst continuous headache. This area should be subexcavated to 900 mm depth and backfilled, daylighting out to the foreslope. If millings are not available or are not allowed by the NPS for use as backfill, then select borrow should be specified as the backfill material.

Frost Heave:

RMNP suffers from frost heaves in the spring.

Table 5: Frost Heaves

Location
24+200 to 24+420
30+390 to 30+470
30+580 to 30+630
31+860 to 31+920
37+180 to 37+260

All the sections listed in Table 3 will be subexcavated and backfilled with millings or select borrow as above. Additionally, a section from Station 34+020 to 34+080 should be subexcavated. This is an area that has experienced a subgrade failure.

Beyond the planned quantities of subexcavation, an additional 1000 cubic meters should be put into the contract to be used at the discretion of the CO.

APPENDICES

A – Location Map

B – Laboratory Test Results

C – Photographs

D – Pavement Design Calculations

E – Asphalt Pavement Thickness Charts

F – Field Data Summary

G – Falling Weight Deflectometer Report –
Ground Engineering Consultants, Inc.

H – Preliminary Foamed Asphalt Mix Design –
Earth Engineering Consultants, Inc.

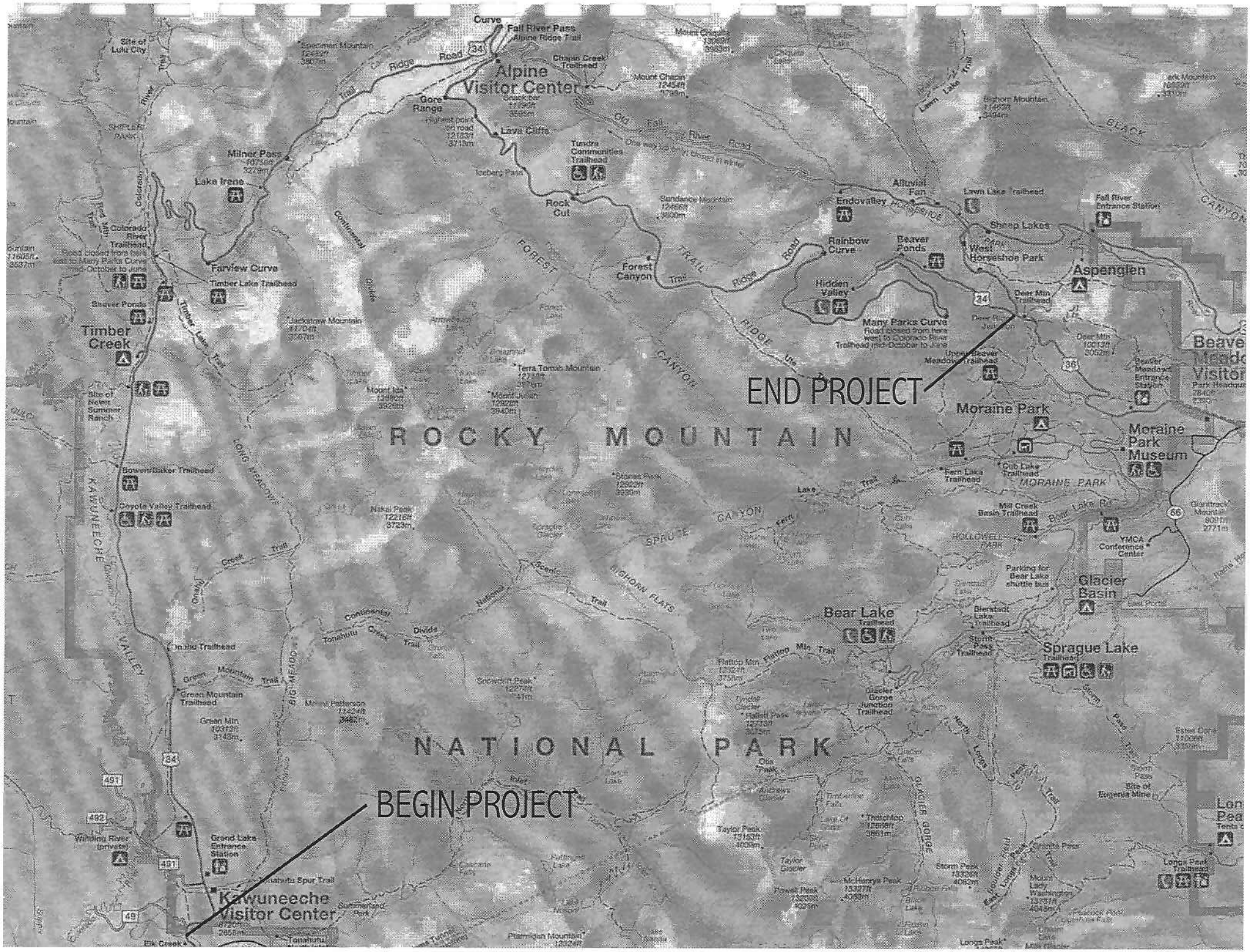
I – NPS Foamed Asphalt Data

J – Frost Heave Locations

K – Historical Memos

APPENDIX A

LOCATION MAP


END PROJECT
BEGIN PROJECT
ROCKY MOUNTAIN
NATIONAL PARK
Alpine Visitor Center
Fall River Pass
Alpine Ridge Trail
Chapin Creek Trailhead
Gore Range
Lava Cliffs
Tundra Communities Trailhead
Rock Cut
Milner Pass
Lake Irene
Farview Curve
Timber Lake Trailhead
Timber Creek
Forest Canyon
Rainbow Curve
Beaver Ponds
Hidden Valley
Many Parks Curve
Endovalley
Alluvial Fan
Lawn Lake Trailhead
Sheep Lakes
West Horseshoe Park
Fall River Entrance Station
Aspenglen
Deer Mtn Trailhead
Upper Beaver Meadows Trailhead
Beaver Meadows Entrance Station
Moraine Park
Moraine Park Museum
Fern Lake Trailhead
Cub Lake Trailhead
Mill Creek Basin Trailhead
YMCA Conference Center
Glacier Basin
Bear Lake Trailhead
Bierstadt Lake Trailhead
Storm Pass Trailhead
Sprague Lake Trailhead
Glacier Gorge Junction Trailhead
Longs Peak Trailhead
Bowen/Baker Trailhead
Coyote Valley Trailhead
Green Mountain Trailhead
Grand Lake Entrance Station
Kawuneeche Visitor Center
Winding River (private)
Site of Lulu City
Site of Eugenia Mine
Longs Peak
Mount Chapin
Mount Ida
Specimen Mountain
Sundance Mountain
Terra Tomah Mountain
Mount Julian
Nakai Peak
Stones Peak
Snowdrift Peak
Mount Patterson
Green Mtn
Flattop Mtn
Otis Peak
Taylor Peak
Stettson Mountain
Lark Mountain
Deer Mtn
Gianttrack Mountain
Storm Peak
McHenrys Peak
Powell Peak
Mount Lady Washington
Ptarmigan Mountain
Tonahutu Spur Trail
Tonahutu Creek Trail
Continental Divide Trail
Colorado River Trailhead
Road closed from here west to Many Parks Curve mid-October to June
Road closed from here west to Colorado River Trailhead mid-October to June
One way up or vehicles closed in winter
Highest point on road 12183ft 3713m
Old Fall River Road
Trail Ridge Road
Forest Canyon Trail
Ridge Trail
Lawn Lake Trail
Black Canyon
Sprucetree Trail
Bighorn Flats Trail
Long Meadows
Big Meadow
Kawuneeche Valley
Glacier Gorge
North Longs Peak Trail
East Longs Peak Trail
Storm Pass Trail
Bear Lake Road
Moraine Park Road
Fall River Road
Colorado River
Tonahutu Creek
Onahu Creek
Green Mountain Trail
Continental Divide Trail
Tonahutu Creek Trail
Elk Creek
Tonahutu
Summerland Park
Cascade Falls
Pitkin Lake
Inlet
Alluvial Fan
Horseshoe Park
Beaver Meadows
Moraine Park
Hollowell Park
Parking for Bear Lake shuttle bus
Glacier Gorge
Longs Peak
Tents

APPENDIX B

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: Colorado PRA ROMO 10 (4) Trail Ridge Road

Submitted By: Steve Deppmeier

Date Reported: 9/2/2003

Sample Number	Lab Number		03-864-RV	03-865-S	03-866-S	03-867-S	03-868-S
	Hole Number						
	Field Number		C-7	C-18	C-28	C-36	C-40
Sample Location	Station or Location		39+800	44+200	48+200	51+400	53+000
	Offset						
	Depth		4"-5'	7"-4'	6.5"-5'	9"-5'	6.5"-3.5'
AASHTO T 11, T 27 & T 88 Washed Sieve Analysis % Passing	3"	75.0 mm					
	1 1/2"	37.5 mm	100	100	100		100
	1"	25.0 mm	99	99	99	100	99
	3/4"	19.0 mm	97	98	96	99	95
	1/2"	12.5 mm	92	93	89	95	89
	3/8"	9.5 mm	88	88	84	91	83
	#4	4.75 mm	77	75	69	79	67
	#8	2.36 mm					
	#10	2.00 mm	63	60	56	64	52
	#16	1.18 mm	56	51	49	55	45
	#30	600 µm					
	#40	425 µm	40	36	37	39	32
	#50	300 µm					
	#100	150 µm	25	22	23	27	20
	#200	75 µm	18	16	17	21	15
		20 µm					
		2 µm					
		1 µm					
AASHTO T 255	Moisture, %		5.1	1.9	3.4	5.9	3.8
AASHTO T 89 & T 90	Liquid Limit		24	NV	NV	35	25
	Plasticity Index		2	NP	NP	11	3
Soil Classification	AASHTO M 145		A-1-b (0)	A-1-b (0)	A-1-b (0)	A-2-6 (0)	A-1-b (0)
	ASTM D 2487		SM	SM	SM	SC	SM
AASHTO T 190	R –Value		41				
AASHTO T 288	Min. Resistivity, ohm-cm						
AASHTO T 289	pH						
AASHTO Method	Optimum Moisture, %						
	Maximum Dry Density, pcf						

Distribution:

Laboratory	Num. / Project File
	Darrell Harding
Pavements	Steve Deppmeier
Materials	1 Copy

Remarks:
The moisture samples were taken from sealed plastic bags.

Reported By:

For

Darrell Harding

Form FHWA 1702 Rev. 12/01

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: Colorado PRA ROMO 10 (4) Trail Ridge Road

Submitted By: Steve Deppmeier

Date Reported: 9/2/2003

Sample Number	Lab Number		03-869-RV	03-870-RV	03-871-S	03-872-RV	03-873-S
	Hole Number						
	Field Number		C-56	C-60D	C-80	C-111	C-117
Sample Location	Station or Location		59+300	60+870	69+000	81+350	83+800
	Offset						
	Depth		6.5"-5'	6.75"-5'	6.5"-5'	8"-5'	9"-5'
AASHTO T 11, T 27 & T 88 Washed Sieve Analysis % Passing	3"	75.0 mm					*
	1 1/2"	37.5 mm					100
	1"	25.0 mm	100	100	100		98
	3/4"	19.0 mm	99	99	99	100	95
	1/2"	12.5 mm	93	97	98	96	91
	3/8"	9.5 mm	89	96	96	93	88
	#4	4.75 mm	74	89	91	86	83
	#8	2.36 mm					
	#10	2.00 mm	57	79	81	74	69
	#16	1.18 mm	48	70	70	64	55
	#30	600 µm					
	#40	425 µm	33	53	45	42	24
	#50	300 µm					
	#100	150 µm	22	36	30	25	7
	#200	75 µm	17	27	24	18	3.1
		20 µm					
		2 µm					
		1 µm					
AASHTO T 255	Moisture, %		6.4	4.5	7.9	5.0	4.6
AASHTO T 89 & T 90	Liquid Limit		28	26	25	NV	NV
	Plasticity Index		4	6	2	NP	NP
Soil Classification	AASHTO M 145		A-1-b (0)	A-2-4 (0)	A-1-b (0)	A-1-b (0)	A-1-b (0)
	ASTM D 2487		SM	SC-SM	SM	SM	SP
AASHTO T 190	R –Value		39	24		70	
AASHTO T 288	Min. Resistivity, ohm-cm						
AASHTO T 289	pH						
AASHTO Method	Optimum Moisture, %						
	Maximum Dry Density, pcf						

Distribution:

Laboratory	Num. / Project File
	Darrell Harding
Pavements	Steve Deppmeier
Materials	1 Copy

Remarks:
The moisture samples were taken from sealed plastic bags.

* This sample's +#4 material contains 31% asphalt by weight. Due to the asphaltic nature of the material, a dry -#4 gradation was performed

Reported By:

For Darrell Harding

Form FHWA 1702 Rev. 12/01

Form-8-226-A
Rev. 4-76

DEPARTMENT OF TRANSPORTATION - REGION 8

SUMMARY OF SOIL OR AGGREGATE TESTS

DATE 9/10/81
SHEET 1 of 1

PROJECT COLORADO-ROCKY MOUNTAIN NATIONAL PARK, TRAIL RIDGE ROAD

SUBMITTED BY Bob Blenk TESTED BY DH, KW, KR REPORTED BY ALAN HELD

DISTRIBUTION: Project Engineer -1, Region -1, Materials Lab. 32 CDFD

amH

SAMPLE NUMBER								
	Field No.							
	Hole No.	B-23	B-31	B-32	B-39	B-41	B-41	B-52
	Lab No.	81-1331-SB	81-1332-SB	81-1333-SB	81-1334-SB	81-1335-SB	81-1336-SB	81-1337-SB
SAMPLE LOCATION	Station or Location	Mile 8.85	Mile 12.18	Mile 13.15	Mile 17.25	Mile 18.50	Mile 18.50	Mile 22.40
	Offset	Rt.Shl.	Rt.Shl.	Rt.Shl.	Rt.Shl.	Rt.Shl.	Rt.Shl.	Rt.Shl.
	Depth	5-9'	3-5'	10-13'	3.5-4'	2.5-6'	6-9'	12-14'
AASHTO T-11, 27 & 88	3"+							
	3"							
	1-1/2"	100		100				100
	3/4"	99		89	100		100	97
	1/2"	92		78	98		99	89
	3/8"	89		71	98	100	98	84
	#4	81	100	60	97	98	95	75
	#8							
	#10	70	96	49	96	92	88	67
	#16	58	91	42	95	87	83	62
	#30							
	#40	37	82	30	91	74	71	49
	#50							
	#100	26	63	23	80	57	51	33
	#200	22.3	46.6	20.1	73.6	46.5	40.8	27.5
	0.05 mm							
	0.02 mm							
	0.002mm							
	0.001mm							
% Moist.		16.9	14.9	12.1	26.8	28.9	36.1	15.2
AASHTO T-89, 90 & 92	SL							
	LL	47	38	25	67	41	41	34
	PI	9	13	4	40	13	10	9
AASHTO M-145	Class	A-2-4	A-7-6	A-1-b	A-7-6	A-7-6	A-5	A-2-4
	GI		(3)		(31)	(3)	(1)	
AASHTO T-190	R							
	W(%)							
	γ_d(pcf)							
AASHTO T-99,180	W(%)							
	γ_d(pcf)							

REMARKS

Form-8-226-A
Rev 4-76

US DEPARTMENT OF TRANSPORTATION - REGION 8

SUMMARY OF SOIL OR AGGREGATE TESTS

DATE
SHEET 1 of 1

PROJECT COLORADO - ROCKY MOUNTAIN NATIONAL PARK, TRAIL RIDGE ROAD

SUBMITTED BY R. BLENK TESTED BY DH,KR REPORTED BY A. HELD

DISTRIBUTION: Project Engineer -1, Region -1, Materials Lab. -2 CDFD 3

BY: GNP

SAMPLE NUMBER	Field No.								
	Hole No.	B-25							
	Lab No.	81-1303-S							
SAMPLE LOCATION	Station or Location	Mile 9.60							
	Offset	Rt. Should.							
	Depth	7" - 2½'							
AASHTO T-11, 27 & 88	3" +								
	3"								
	1-1/2"	100							
	3/4"	96							
	1/2"	90							
	3/8"	85							
	#4	74							
	#8								
	#10	63							
	#16	56							
	#30								
	#40	42							
	#50								
	#100	29							
	#200	27.3							
	0.05 mm								
	0.02 mm								
	0.002mm								
	0.001mm								
% Moist.									
AASHTO T-99, 90 & 92	SL								
	LL	33							
	PI	2							
AASHTO M-145	Class	-2-4							
	GI								
AASHTO T-190	R								
	W(%)								
	γ_d(pcf)								
AASHTO T-99,180	W(%)								
	γ_d(pcf)								

REMARKS

The above subgrade soil was blended as 20% of total mix with existing asphalt pavement of the same location for Hveem stability determination.

4-76

DEPARTMENT OF TRANSPORTATION REGION 8

SUMMARY OF SOIL OR AGGREGATE TESTS

DATE: [illegible]
SHEET 1 of 3

PROJECT: ROCKY MOUNTAIN NATIONAL PARK - TRAIL RIDGE ROAD

SUBMITTED BY: Robert Blenk TESTED BY: DH, KW, KR, LB REPORTED BY: A.M. Held

DISTRIBUTION: Project Engineer -1, Region -1, Materials Lab.-2

amh

SAMPLE NUMBER								
	Field No.	BK-1	BK-2	BK-4	BK-5	BK-6	BK-8	BK-10
	Hole No.							
	Lab. No.	78-1163-S	78-1164-S	78-1166-S	78-1167-S	78-1169-S	78-1170-S	78-1172-S

SAMPLE LOCATION								
	METRES Station or Location	5+80	11+06	23+00	28+60	32+00	43+82	55+80
	METRES Offset	6.86 RT	3.66 RT	3.76 R	6.40 R	3.05 R	5.18 R	8.69 R
	Depth	0.1-0.69	0.1-0.97	0.1-0.69	0.1-0.99	0.1-1.02	0.1-0.86	0.1-0.53

AASHTO T-11, 27 & 88								
	75mm+							
	75mm	97	93	97		100	100	100
	37.5mm	85	78	85	100	92	89	88
	19.0mm	73	66	71	95	75	80	77
	12.5mm	65	61	64	90	68	73	71
	9.5mm	60	57	59	87	63	69	66
	4.75mm	49	48	49	82	52	57	55
	2.36mm							
	2.00mm	39	37	38	74	41	46	44
	1.18mm	32	31	31	69	33	39	38
	0.600mm							
	0.425mm	17	15	16	59	16	22	24
	0.300mm							
	0.150mm	8	6	7	43	6	9	14
	0.075mm	6.2	4.3	4.9	35.1	3.9	6.5	11.2
	0.05mm							
	0.02mm							
	0.002mm							
	0.001mm							
% Moist.								

AASHTO T-89, 90 & 92								
	SL							
	LL	NV	NV	NV	NV	NV	NV	NV
	PI	NP	NP	NP	NP	NP	NP	NP

AASHTO M-145								
	Class	A-1-a	A-1-a	A-1-a	A-4	A-1-a	A-1-a	A-1-a
	GI				(0)			

AASHTO T-190								
	R	70	72	75	70	64	72	65
	W(%)	6.5	8.6	8.4	9.2	8.3	7.8	8.5
	γ_d(kg/m^3)	2066	2028	2012	2028	2002	2087	2142

AASHTO T-99								
	W(%)	7.9		7.8			6.4	
	γ_d(kg/m^3)	2156		2156			2119	

REMARKS

All holes were taken on the shoulder and represent the subbase material directly beneath the 10-13 cm (4-5 inches) thickness of the pavement structure.

4-76

U.S. DEPARTMENT OF TRANSPORTATION - REGION 8

SUMMARY OF SOIL OR AGGREGATE TESTS

DATE: 2/24/79
SHEET 2 of 3

PROJECT: ROCKY MOUNTAIN NATIONAL PARK - TRAIL RIDGE ROAD

SUBMITTED BY: Wayne Folkman TESTED BY: DH, KW, KR, PB REPORTED BY: A. Held

DISTRIBUTION: Project Engineer -1, Region -1, Materials Lab.-2

SAMPLE NUMBER								
Field No.	BK-11	BK-12	BK-13	BK-14	BK-15	BK-16	BK-17
Hole No.							
Lab. No.	78-1173-S	78-1174-S	78-1175-S	78-1176-S	78-1177-S	78-1178-S	78-1179-S
SAMPLE LOCATION METRES Station or Location	62+40	68+40	75+00	77+93	81+20	87+80	94+20
METRES Offset	Centerline	5.94 R	3.12 R	Centerline	Centerline	2.44 R	3.96 R
Depth	0.53-1.02	0.1-0.41	0.1-0.43	0.1-0.61	0.1-1.02	0.1-0.28	0.1-0.36
AASHTO T-11, 27 & 88 75mm+							
75mm	82	89	94		100	100	100
37.5mm	63	82	90	100	99	92	94
19.0mm	53	74	85	97	98	73	87
12.5mm	49	71	81	96	97	71	76
9.5mm	47	68	77	95	96	65	68
4.75mm	42	62	70	91	95	55	53
2.36mm							
2.00mm	37	55	62	85	90	41	42
1.18mm	32	52	58	77	38	34	36
0.600mm							
0.425mm	23	43	46	44	31	20	25
0.300mm							
0.150mm	17	33	31	20	68	11	16
0.075mm	14.2	27.6	23.5	14.5	57.4	8.5	13.5
0.05mm							
0.02mm							
0.002mm							
0.001mm							
% Moist.							
AASHTO T-89, 90 & 92 SL							
LL	NV	NV	NV	NV	38	NV	27
PI	NP	NP	NP	NP	10	NP	4
AASHTO M-145 Class	A-1-a	A-2-4	A-1-b	A-1-b	A-4	A-1-a	A-1-a
GI					(4)		
AASHTO T-190 R	62	48	64	58	39	69	62
W(%)	9.0	10.5	9.3	12.7	19.9	7.2	9.2
γ_d (kg/m^3)	2094	2002	1994	1866	1695	2164	2092
AASHTO T-99 W(%)		8.8					
γ_d (kg/m^3)		2001					

REMARKS

GPO 835-472

SUMMARY OF SOIL OR AGGREGATE TESTS

DATE:
SHEET 3 of 3

PROJECT: ROCKY MOUNTAIN NATIONAL PARK - TRAIL RIDGE ROAD

SUBMITTED BY: Robert Blenk TESTED BY: DH, KR, KW, LB REPORTED BY: A. Held

DISTRIBUTION: Project Engineer -1, Region -1, Materials Lab.-2

SAMPLE NUMBER	Field No.	BK-18	BK -19	BK-20	BK-22	BK-26	BK-28	
	Hole No.							
	Lab. No.	78-1180-S	78-1181-S	78-1182-S	78-1184-S	78-1188-S	78-1190-S	
SAMPLE LOCATION	METRES Station or Location	100+00	110+69	116+20	130+00 Approx.	156+64	176+00 Approx.	
	METRES Offset	5.28 R	3.66 L	3.5 R	RT. SHLDR	3.6 R	RT. SHLDR	
	Depth	0.1-0.61	0.1-0.25	0.1-0.46	0.1-0.30	0.1-0.28	0.1-0.41	
AASHTO T-11, 27 & 88	75mm+							
	75mm	92	100	91	100	100	96	
	37.5mm	81	99	79	98	86	81	
	19.0mm	71	90	68	88	80	69	
	12.5mm	63	83	62	80	76	64	
	9.5mm	57	77	57	74	72	59	
	4.75mm	47	64	47	61	62	50	
	2.36mm							
	2.00mm	38	54	39	47	52	42	
	1.18mm	32	48	34	40	46	37	
	0.600mm							
	0.425mm	20	35	25	27	32	24	
	0.300mm							
	0.150mm	11	24	17	17	20	13	
	0.075mm	8.6	18.7	13.9	13.7	15.3	9.1	
	0.05mm							
	0.02mm							
	0.002mm							
	0.001mm							
% Moist.								
AASHTO T-89, 90 & 92	SL							
	LL	NV	NV	NV	NV	25	NV	
	PI	NP	NP	NP	NP	3	NP	
AASHTO M-145	Class GI	A-1-a	A-1-b	A-1-a	A-1-a	A-1-a	A-1-a	
AASHTO T-190	R	74	71	72	68	60	75	
	W(%)	7.7	8.4	7.9	8.5	8.9	7.5	
	γ_d (kg/m^3)	2118	1998	2220	2103	2116	2169	
AASHTO T-99	W(%)							
	γ_d (kg/m^3)							

REMARKS

Form-8-226-A
Rev 4-76

DEPARTMENT OF TRANSPORTATION - REGION 8

SUMMARY OF SOIL OR AGGREGATE TESTS

DATE 9/15/81
SHEET 1 of 2

PROJECT COLORADO-ROCKY MOUNTAIN NATIONAL PARK, TRAIL RIDGE ROAD

SUBMITTED BY Bob Blenk TESTED BY DH,BB,KW,KR,RB,GH REPORTED BY Al Held

DISTRIBUTION: Project Engineer -1, Region -1, Materials Lab. -2 CDFD-1 3

SAMPLE NUMBER	Field No.							
	Hole No.	B-3	B-9	B-11*	B-16	B-23	B-26	B-31
	Lab No.	81-1286-S	81-1290-S	81-1292-S	81-1295-S	81-1301-S	81-1304-S	81-1306-S
SAMPLE LOCATION	Station or Location	Mile 0.90	Mile 3.40	Mile 4.15	Mile 6.15	Mile 8.85	Mile 9.98	Mile 12.18
	Offset	Rt.Shl.	Rt.Shl.	Rt.Shl.	Rt.Shl.	Rt.Shl.	Rt.Shl.	Rt.Shl.
	Depth	4"-3'6"	6"-4'	6½"-4'	3"-4'	6"-3½'	3-3/4"-5'	5"-2½'
AASHTO T-11, 27 & 88	3" +							
	3"				100			
	1-1/2"	100		100	99	100	100	100
	3/4"	99	100	99	96	99	94	94
	1/2"	94	99	96	90	96	85	87
	3/8"	90	98	93	86	93	79	82
	#4	79	90	85	77	83	66	71
	#8							
	#10	67	73	70	64	69	55	58
	#16	57	59	59	54	58	47	52
	#30							
	#40	36	40	39	31	37	34	40
	#50							
	#100	22	30	26	20	24	23	28
	#200	17.6	25.5	20.9	16.5	19.0	18.3	24.2
	0.05 mm							
	0.02 mm							
	0.002mm							
	0.001mm							
% Moist.								
AASHTO T-89, 90 & 92	SL							
	LL	NV	NV	31	NV	NV	31	NV
	PI	NP	NP	2	NP	NP	2	NP
AASHTO M-145	Class	A-1-b	A-2-4	A-1-b	A-1-b	A-1-b	A-1-b	A-1-b
	GI							
AASHTO T-190	R	69	69	57	66	61	64	66
	W(%)	8.1	9.2	10.6	7.6	8.0	8.6	9.5
	γ_d(pcf)	129.7	125.4	122.1	132.8	127.7	128.6	129.3
AASHTO T-99, 180	W(%)							
	γ_d(pcf)							

REMARKS

*Note that the sample from B-11 contained a substantial amount of wood fragments.

Rev 4-76

SUMMARY OF SOIL OR AGGREGATE TESTS

SHEET 2 of 2

PROJECT COLORADO ROCKY MOUNTAIN NATIONAL PARK, TRAIL RIDGE ROAD

SUBMITTED BY Bob Blenk TESTED BY DH,BB,KW,KR,RB,GH REPORTED BY Al Held

DISTRIBUTION: Project Engineer -1, Region -1, Materials Lab. -2 CDFD-1 3

SAMPLE NUMBER	Field No.							
	Hole No.	B-34	B-37	B-38	B-44	B-49	B-52	B-57
	Lab No.	81-1308-S	81-1311-S	81-1312-S	81-1318-S	81-1322-S	81-1325-S	81-1328-S
SAMPLE LOCATION	Station or Location	Mile 15.30	Mile 16.50	Mile 16.90	Mile 19.70	Mile 21.65	Mile 22.40	Mile 24.00
	Offset	Rt.Shl.	Rt.Shl.	Rt.Shl.	Rt.Shl.	Rt.Shl.	Rt.Shl.	Rt.Shl.
	Depth	3½"-4'	2½"-4'	3"-4'	5"-4'	3"-4'	5½"-4'	3"-13'6"
AASHTO T-11, 27 & 88	3" +							
	3"							
	1-1/2"	100	100	100	100	100	100	100
	3/4"	97	98	99	97	94	95	97
	1/2"	93	94	97	91	85	86	90
	3/8"	90	89	94	85	77	79	84
	#4	79	76	85	69	63	64	71
	#8							
	#10	67	61	74	54	52	51	59
	#16	61	54	67	46	44	44	52
	#30							
	#40	47	41	53	35	32	32	41
	#50							
	#100	31	28	36	23	21	22	29
	#200	24.0	22.0	28.0	18.1	17.8	17.3	23.6
	0.05 mm							
	0.02 mm							
	0.002mm							
	0.001mm							
% Moist.								
AASHTO T-89, 90 & 92	SL							
	LL	NV	NV	NV	NV	26	26	23
	PI	NP	NP	NP	NP	6	4	3
AASHTO M-145	Class	A-1-b	A-1-b	A-2-4	A-1-b	A-1-b	A-1-b	A-1-b
	GI							
AASHTO T-190	R	53	52	58	57	51	32	51
	W(%)	8.9	8.9	9.1	7.0	7.2	7.7	7.4
	γ_d(pcf)	132.6	135.6	124.9	136.8	136.0	136.2	139.4
AASHTO T-99,180	W(%)							
	γ_d(pcf)							

REMARKS

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 Foamed Asphalt Mixture Tests

Project: Colorado PRA ROMO 10(4) Trail Ridge Road **Submitted By:** Steve Deppmeier **Date Reported:** 8/14/2003

Lab Number						03-709-C	03-710-C	03-711-C	03-713-C	03-714-C
Field Number										
Sample Location	Station					*MP-1	*MP-5	*MP-9	*MP-20	*MP-26
Item: Class:	Sieve Size		Gr. , Spec.	T.V.	(D)					
AASHTO T 30 Sieve Analysis, % Passing	1"	25.0mm								
	3/4"	19.0mm								
	1/2"	12.5mm								
	3/8"	9.5mm								
	#4	4.75mm								
	#8	2.36mm								
	#10	2.00mm								
	#16	1.18mm								
	#30	600µm								
	#40	425µm								
	#50	300µm								
	#100	150µm								
	#200	75µm								
AASHTO T 308 Asphalt Content, % by Total Mix Weight										
Foamed Asphalt Field Cores	AASHTO T 166 Density, pcf					133.1	135.7	130.6	131.5	136.1
	Compaction, %									
	AASHTO T 269 Air Voids, %									
	ASTM D 3549 Thickness, inches					4.90	4.35	5.65	4.45	3.20
Loose Asphalt Mixture Received From Field	Immersion Compression AASHTO T 165	Wet Strength, psi								
		Dry Strength, psi								
		Retained Strength, %								
		Air Voids, %								
	Maximum Density, AASHTO T 209, pcf									
	Hveem Specimen AASHTO T 246	Stabilometer value								
		Density, pcf								
		Air Voids, %								

Distribution:

Num. / Project File	
Laboratory	Darrell Harding
Pavements	Steve Deppmeier
Materials	1 copy

Remarks:

* Moraine Park from Museum Entrance to north on Bear Lake Road. Only the foamed asphalt portions of the cores were tested.

"(D)" indicates the allowable deviation from the target value.

Reported By:

Darrell Harding

Form FHWA 1713 Rev. 12/01

U.S. Department of Transportation
Federal Highway Administration

Central Federal Lands Highway Division Laboratory

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Report of Foamed Asphalt Mixture Tests

Project: Colorado PRA ROMO 10(4) Trail Ridge Road **Submitted By:** Steve Deppmeier **Date Reported:** 8/14/2003

Lab Number						03-715-C	03-718-C	03-719-C	03-720-C	03-721-C
Field Number										
Sample Location		Station				*MP-28	**TR-5	**TR-9	**TR-13	**TR-17
Item:	Class:	Sieve Size		Gr. , Spec.	T.V.	(D)				
AASHTO T 30 Sieve Analysis, % Passing		1"	25.0mm							
		3/4"	19.0mm							
		1/2"	12.5mm							
		3/8"	9.5mm							
		#4	4.75mm							
		#8	2.36mm							
		#10	2.00mm							
		#16	1.18mm							
		#30	600µm							
		#40	425µm							
		#50	300µm							
		#100	150µm							
		#200	75µm							
AASHTO T 308 Asphalt Content, % by Total Mix Weight										
Foamed Asphalt Field Cores	AASHTO T 166 Density, pcf						134.3	128.4	126.8	128.0	130.4
	Compaction, %										
	AASHTO T 269 Air Voids, %										
	ASTM D 3549 Thickness, inches						3.85	4.65	5.80	4.30	3.60
Loose Asphalt Mixture Received From Field	Immersion Compression AASHTO T 165	Wet Strength, psi									
		Dry Strength, psi									
		Retained Strength, %									
		Air Voids, %									
	Maximum Density, AASHTO T 209, pcf										
	Hveem Specimen AASHTO T 246	Stabilometer value									
		Density, pcf									
		Air Voids, %									

Distribution:
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Steve Deppmeier
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Remarks:

* Moraine Park from Museum Entrance to north on Bear Lake Road.
** Trail Ridge RC from Bear Lake Junction to 3M.
Only the foamed asphalt portions of the cores were tested.

"(D)" indicates the allowable deviation from the target value.

Reported By:

Darrell Harding

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Report of Foamed Asphalt Mixture Tests

Project: Colorado PRA ROMO 10(4) Trail Ridge Road **Submitted By:** Steve Deppmeier **Date Reported:** 8/14/2003

Lab Number				03-722-C	03-723-C	03-724-C	03-725-C	03-726-C
Field Number							TR-33	TR-39
Sample Location		Station		**TR-21	**TR-25	***TR-29	***@ 3M pullout	***@ rock outcrop
Item:	Class:	Sieve Size	Gr. , Spec.	T.V.	(D)			
AASHTO T 30 Sieve Analysis, % Passing	1"	25.0mm						
	3/4"	19.0mm						
	1/2"	12.5mm						
	3/8"	9.5mm						
	#4	4.75mm						
	#8	2.36mm						
	#10	2.00mm						
	#16	1.18mm						
	#30	600µm						
	#40	425µm						
	#50	300µm						
	#100	150µm						
	#200	75µm						
AASHTO T 308 Asphalt Content, % by Total Mix Weight								
Foamed Asphalt Field Cores	AASHTO T 166 Density, pcf					132.0	126.6	131.8	136.9	131.0
	Compaction, %									
	AASHTO T 269 Air Voids, %									
	ASTM D 3549 Thickness, inches					6.65	4.70	2.20	1.55	4.45
Loose Asphalt Mixture Received From Field	Immersion Compression AASHTO T 165	Wet Strength, psi								
		Dry Strength, psi								
		Retained Strength, %								
		Air Voids, %								
	Maximum Density, AASHTO T 209, pcf									
	Hveem Specimen AASHTO T 246	Stabilometer value								
		Density, pcf								
		Air Voids, %								

Distribution:
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Darrell Harding
Steve Deppmeier
1 Copy

Remarks:

** Trail Ridge RC from Bear Lake Junction to 3M.
*** Trail Ridge Road from 3M to Deer Ridge Junction.
Only the foamed asphalt portions of the cores were tested.

"(D)" indicates the allowable deviation from the target value.

Reported By:

Darrell Harding

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AASHTO R18 ISO/IEC 17025

Report of Foamed Asphalt Mixture Tests

Project: Colorado PRA ROMO 10(4) Trail Ridge Road **Submitted By:** Steve Deppmeier **Date Reported:** 8/14/2003

Lab Number						03-729-C	03-730-C	03-731-C	03-733-C	03-734-C
Field Number										
Sample Location	Station					****RT-6	****RT-10	****RT-14	*****RT-22	*****RT-26
Item: Class:	Sieve Size		Gr. , Spec.	T.V.	(D)					
AASHTO T 30 Sieve Analysis, % Passing	1"	25.0mm								
	3/4"	19.0mm								
	1/2"	12.5mm								
	3/8"	9.5mm								
	#4	4.75mm								
	#8	2.36mm								
	#10	2.00mm								
	#16	1.18mm								
	#30	600µm								
	#40	425µm								
	#50	300µm								
	#100	150µm								
	#200	75µm								
AASHTO T 308 Asphalt Content, % by Total Mix Weight										
Foamed Asphalt Field Cores	AASHTO T 166 Density, pcf					133.3	134.5	129.9	124.8	125.3
	Compaction, %									
	AASHTO T 269 Air Voids, %									
	ASTM D 3549 Thickness, inches					4.40	4.35	2.70	2.60	4.40
Loose Asphalt Mixture Received From Field	Immersion Compression AASHTO T 165	Wet Strength, psi								
		Dry Strength, psi								
		Retained Strength, %								
		Air Voids, %								
	Maximum Density, AASHTO T 209, pcf									
	Hveem Specimen AASHTO T 246	Stabilometer value								
		Density, pcf								
		Air Voids, %								

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Steve Deppmeier
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Remarks:

**** Trail Ridge Road from Deer Ridge Junction to 3M.
***** Trail Ridge Road form 3M to Bear Lake Junction.
Only the foamed asphalt portions of the cores were tested.

"(D)" indicates the allowable deviation from the target value.

Reported By:

Darrell Harding

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Federal Highway Administration

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Report of Foamed Asphalt Mixture Tests

Project: Colorado PRA ROMO 10(4) Trail Ridge Road **Submitted By:** Steve Deppmeier **Date Reported:** 8/14/2003

Lab Number						03-735-C	03-737-C			
Field Number										
Sample Location		Station				*****RT-30	*****RT-42			
Item:	Class:	Sieve Size		Gr. , Spec.	T.V.	(D)				
AASHTO T 30 Sieve Analysis, % Passing		1"	25.0mm							
		3/4"	19.0mm							
		1/2"	12.5mm							
		3/8"	9.5mm							
		#4	4.75mm							
		#8	2.36mm							
		#10	2.00mm							
		#16	1.18mm							
		#30	600µm							
		#40	425µm							
		#50	300µm							
		#100	150µm							
		#200	75µm							
AASHTO T 308 Asphalt Content, % by Total Mix Weight										
Foamed Asphalt Field Cores	AASHTO T 166 Density, pcf						128.2	128.0		
	Compaction, %									
	AASHTO T 269 Air Voids, %									
	ASTM D 3549 Thickness, inches						4.40	4.85		
Loose Asphalt Mixture Received From Field	Immersion Compression AASHTO T 165	Wet Strength, psi								
		Dry Strength, psi								
		Retained Strength, %								
		Air Voids, %								
	Maximum Density, AASHTO T 209, pcf									
	Hveem Specimen AASHTO T 246	Stabilometer value								
		Density, pcf								
		Air Voids, %								

Distribution:
Laboratory — Num. / Project File
Pavements — Darrell Harding
Materials — Steve Deppmeier
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Remarks:

***** Trail Ridge Road form 3M to Bear Lake Junction.
Only the foamed asphalt portions of the cores were tested.

"(D)" indicates the allowable deviation from the target value.

Reported By:

Darrell Harding

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Report of Foamed Asphalt Mixture Tests

Project: Colorado PRA ROMO 10(4) Trail Ridge Road **Submitted By:** Steve Deppmeier **Date Reported:** 9/5/2003

Lab Number						03-709-C	03-710-C	03-714-C	03-715-C	03-718-C
Field Number										
Sample Location		Station				*MP-1	*MP-5	*MP-26	*MP-28	**TR-5
Item: 401	Nominal Maximum Size:									
AASHTO T 30 Sieve Analysis, % Passing	Sieve Size		Specification	T.V.	(D)					
	1 1/2"	37.5mm								
	1"	25.0mm								
	3/4"	19.0mm								
	1/2"	12.5mm								
	3/8"	9.5mm								
	#4	4.75mm								
	#8	2.36mm								
	#16	1.18mm								
	#30	600µm								
	#50	300µm								
	#100	150µm								
	#200	75µm								
AASHTO T 308 Asphalt Content, % by Total Mix Weight										
Loose Asphalt Mixture Received From Field	Field Cores				Specs.					
		AASHTO T166 Density, pcf				135.3	137.4	137.3	136.4	129.7
		Compaction, %								
		Air Voids, %								
	Moisture Induced Damaged AASHTO T 283	Conditioned Strength, psi				10.2		10.9		30.7
		Dry Strength, psi					26.4		73.8	
		Tensile Strength Ratio, %								
		Air Voids, %								
	Maximum Density, AASHTO T 209, pcf									
	Hveem Specimen AASHTO T 246	Stabilometer value								
		Density, pcf								
		Air Voids, %								

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Remarks:
* Moraine Park from Museum Entrance to north on Bear Lake Road.
** Trail Ridge RC from Bear Lake Junction to 3M.
Maximum Density, AASHTO T209, could not be performed due to the high amounts of uncoated aggregate present in the foamed asphalt cores.

"(D)" indicates the allowable deviation from the target value.

Reported By:

Darrell Harding

Form FHWA 1716 Rev. 12/01

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 Foamed Asphalt Mixture Tests

Project: Colorado PRA ROMO 10(4) Trail Ridge Road **Submitted By:** Steve Deppmeier **Date Reported:** 9/5/2003

Lab Number						03-719-C	03-719-C	03-720-C	03-722-C	03-722-C
Field Number						Top	Bottom		Top	Bottom
Sample Location	Station					**TR-9	**TR-9	**TR-13	**TR-21	**TR-21
Item: 401	Nominal Maximum Size:									
AASHTO T 30 Sieve Analysis, % Passing	Sieve Size		Specification	T.V.	(D)					
	1 1/2"	37.5mm								
	1"	25.0mm								
	3/4"	19.0mm								
	1/2"	12.5mm								
	3/8"	9.5mm								
	#4	4.75mm								
	#8	2.36mm								
	#16	1.18mm								
	#30	600µm								
	#50	300µm								
	#100	150µm								
	#200	75µm								
AASHTO T 308 Asphalt Content, % by Total Mix Weight										
Loose Asphalt Mixture Received From Field					Specs.					
	Field Cores	AASHTO T166 Density, pcf				127.5	125.5	129.0	134.9	128.9
		Compaction, %								
		Air Voids, %								
	Moisture Induced Damaged AASHTO T 283	Conditioned Strength, psi							59.6	30.8
		Dry Strength, psi				27.1	19.0	26.5		
		Tensile Strength Ratio, %								
		Air Voids, %								
	Maximum Density, AASHTO T 209, pcf									
	Hveem Specimen AASHTO T 246	Stabilometer value								
		Density, pcf								
		Air Voids, %								

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Steve Deppmeier
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Remarks:
** Trail Ridge RC from Bear Lake Junction to 3M.
Maximum Density, AASHTO T209, could not be performed due to the high amounts of uncoated aggregate present in the foamed asphalt cores.

"(D)" indicates the allowable deviation from the target value.

Reported By:

Darrell Harding

Form FHWA 1716 Rev. 12/01

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 Foamed Asphalt Mixture Tests

Project: Colorado PRA ROMO 10(4) Trail Ridge Road **Submitted By:** Steve Deppmeier **Date Reported:** 9/5/2003

Lab Number					03-723-C	03-735-C	03-737-C		
Field Number									
Sample Location	Station				**TR-25	***RT-30	***RT-42		
Item: 401	Nominal Maximum Size:								
AASHTO T 30 Sieve Analysis, % Passing	Sieve Size		Specification	T.V.	(D)				
	1 1/2"	37.5mm							
	1"	25.0mm							
	3/4"	19.0mm							
	1/2"	12.5mm							
	3/8"	9.5mm							
	#4	4.75mm							
	#8	2.36mm							
	#16	1.18mm							
	#30	600µm							
	#50	300µm							
	#100	150µm							
	#200	75µm							
AASHTO T 308 Asphalt Content, % by Total Mix Weight									
Loose Asphalt Mixture Received From Field				Specs.					
	Field Cores	AASHTO T166 Density, pcf			128.4	129.7	128.7		
		Compaction, %							
		Air Voids, %							
	Moisture Induced Damaged AASHTO T 283	Conditioned Strength, psi				16.4			
		Dry Strength, psi			27.4		19.1		
		Tensile Strength Ratio, %							
		Air Voids, %							
	Maximum Density, AASHTO T 209, pcf								
	Hveem Specimen AASHTO T 246	Stabilometer value							
		Density, pcf							
		Air Voids, %							

Distribution:
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Pavements
Materials

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Darrell Harding
Steve Deppmeier
4 copies

Remarks:
** Trail Ridge RC from Bear Lake Junction to 3M.
*** Trail Ridge Road from 3M to Dear Ridge Junction.
Maximum Density, AASHTO T209, could not be performed due to the high amounts of uncoated aggregate present in the foamed asphalt cores.

"(D)" indicates the allowable deviation from the target value.

Reported By:

Darrell Harding

Form FHWA 1716 Rev. 12/01

September 2, 2003

Subject: Laboratory Testing on Delivered Asphalt Cores.

Job No. 03-3235

Central Federal Lands
Highway Division
Attn: Steve Deppmeier
Denver Federal Center
Building 52
Denver CO 80225

Dear Mr. Deppmeier,

As requested Marshall Stability and Flow testing has been completed on the cores delivered to our office by your representative. The testing was done in general accordance with ASTM D 1559. The results are summarized in the table below.

Location	LAB ID	Stability (lbs)	Flow (in.)
MP-9 (top)	03-711-C	2193	20
MP-9 (bottom)	03-711-C	940	20
MP-20	03-713-C	2071	19
TR-17	03-721-C	972	18
RT-6	03-729-C	1734	19
RT-26	03-734-C	860	24

Upon review, if you have any questions, please contact our office.

Sincerely,
Ground Engineering Consultants, Inc.

Michael J. Quinn

Reviewed by James B. Kowalsky, P.E.

GROUND
ENGINEERING CONSULTANTS

41 Inverness Drive East, Englewood, CO 80112-5412
North Office: 7393 Dahlia Street, Commerce City, CO 80022-1834

Phone (303) 289-1989
www.groundeng.com

Fax (303) 289-1686
Fax (303) 289-6742

APPENDIX C

PHOTOGRAPHS

Photo 1: 82+200 Drop Inlet

Photo 2: 79+000 Overlay & Masonry Wall

Photo 3: 77+400 Edge Drain

Photo 4: 73+400 Failed Wall Area

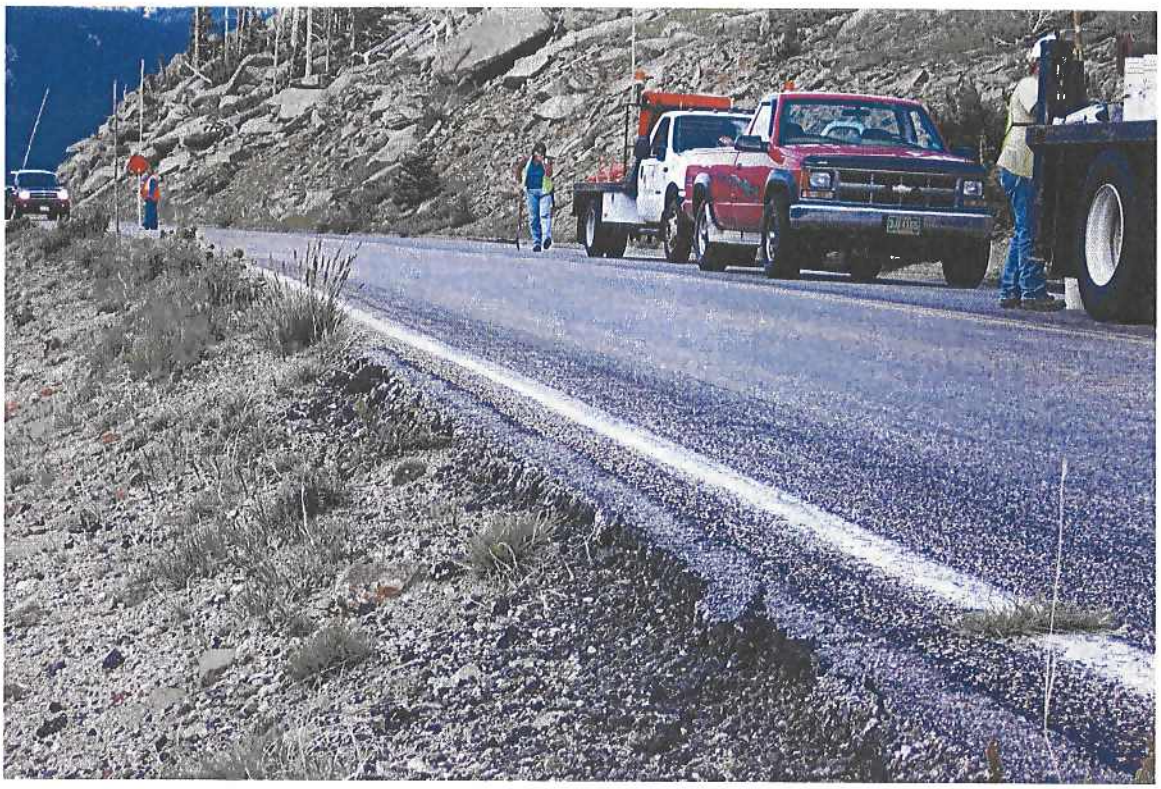


Photo 5: 71+400 Shoulder Drop Off

Photo 6: 36+200 HACP Distress

Photo 7: 34+000 Chip Seal Failing

Photo 8: 30+200 Reflective Cracking

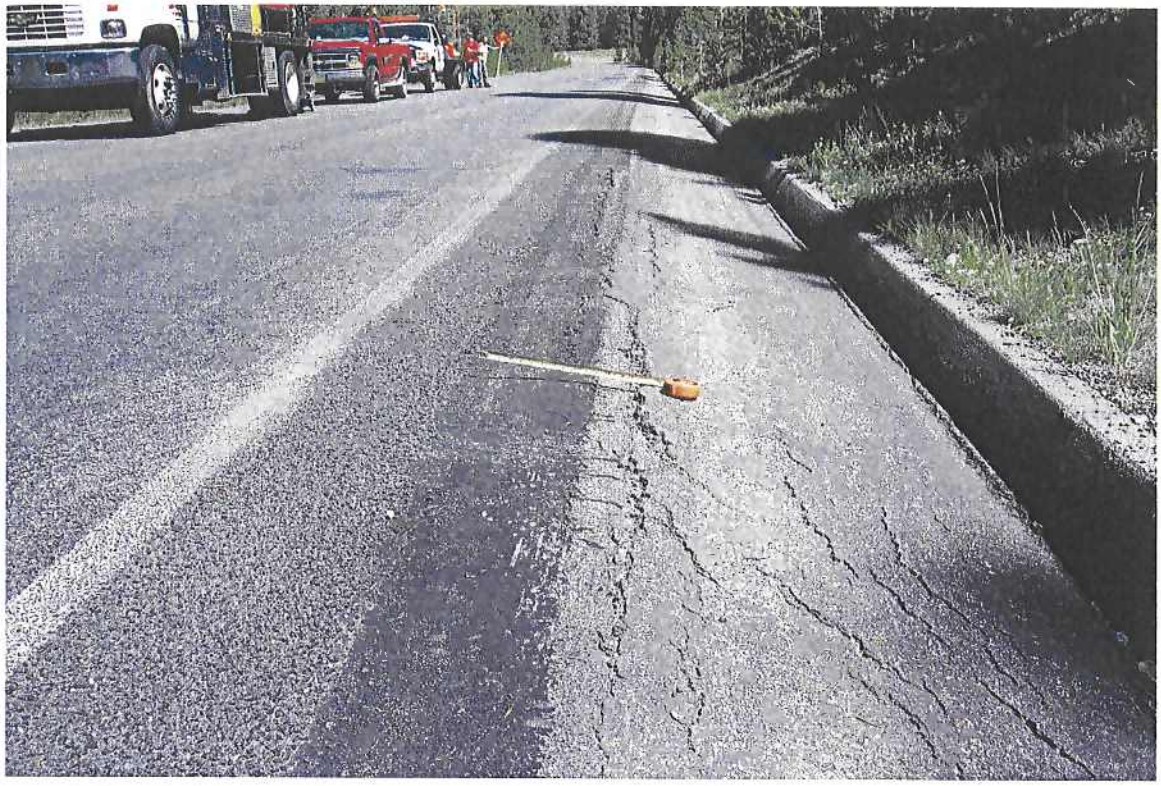


Photo 9: 25+800 Cracking & 2" Uplifting

Photo 10: 25+400 Reflective Cracking

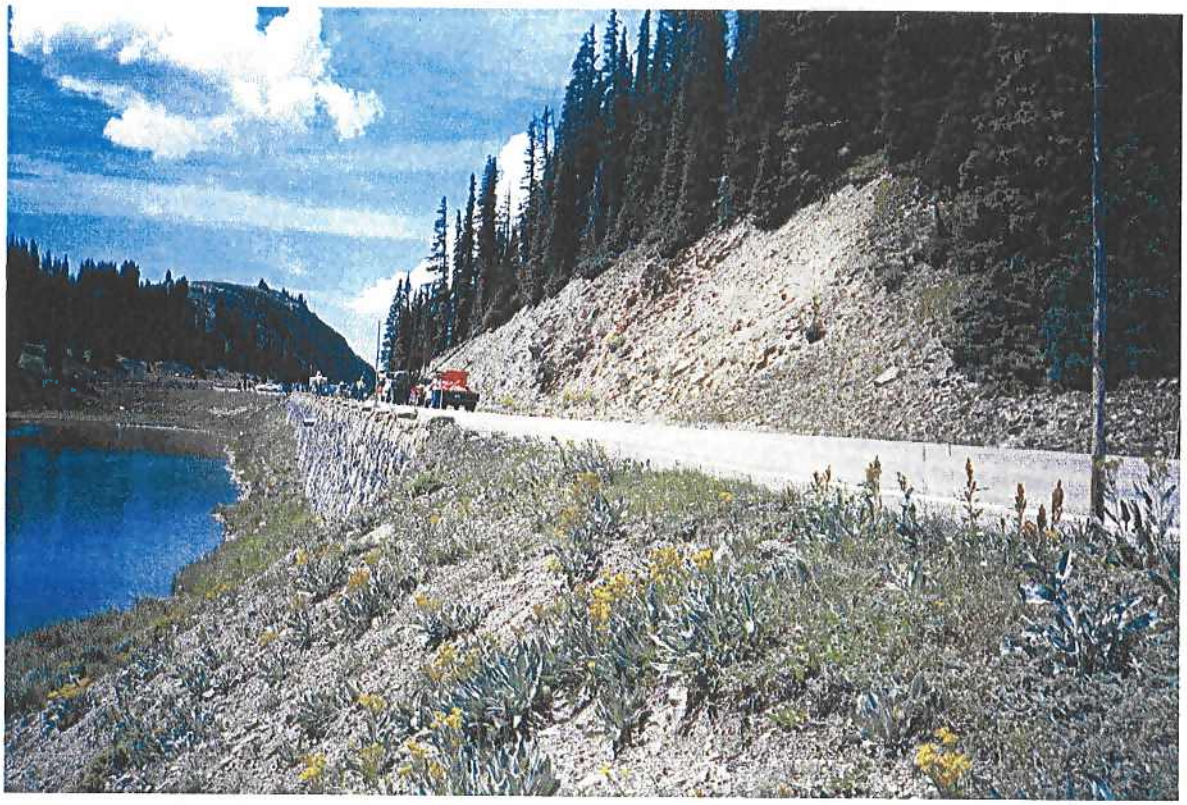


Photo 11: 51+000 Milner Pass Area

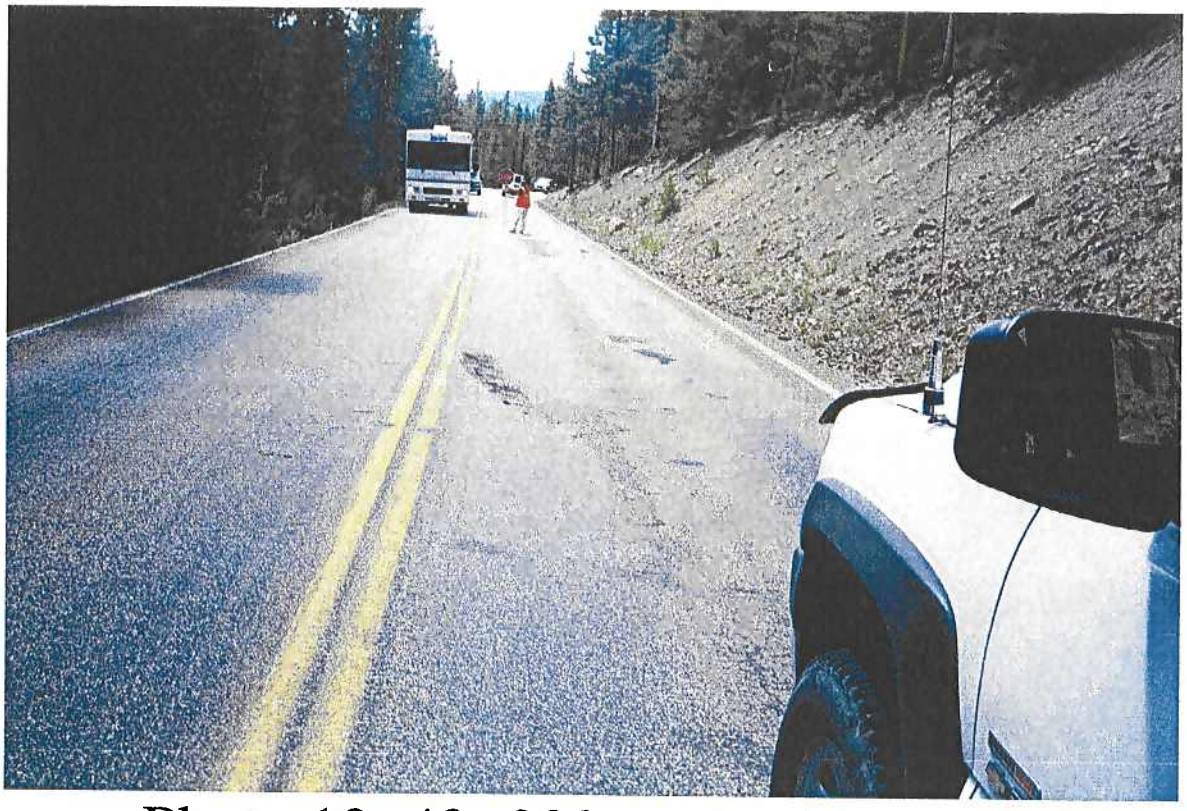


Photo 12: 49+000 HACP Distress

Photo 13: 46+600 Edge Drain

Photo 14: 74+600 Shoulder Drop Off

CO PRA ROMO 10(4) TRAIL RIDGE ROAD

PHOTO 15: 81+000

PHOTO 16: 34+600

CO PRA ROMO 10(4) TRAIL RIDGE ROAD

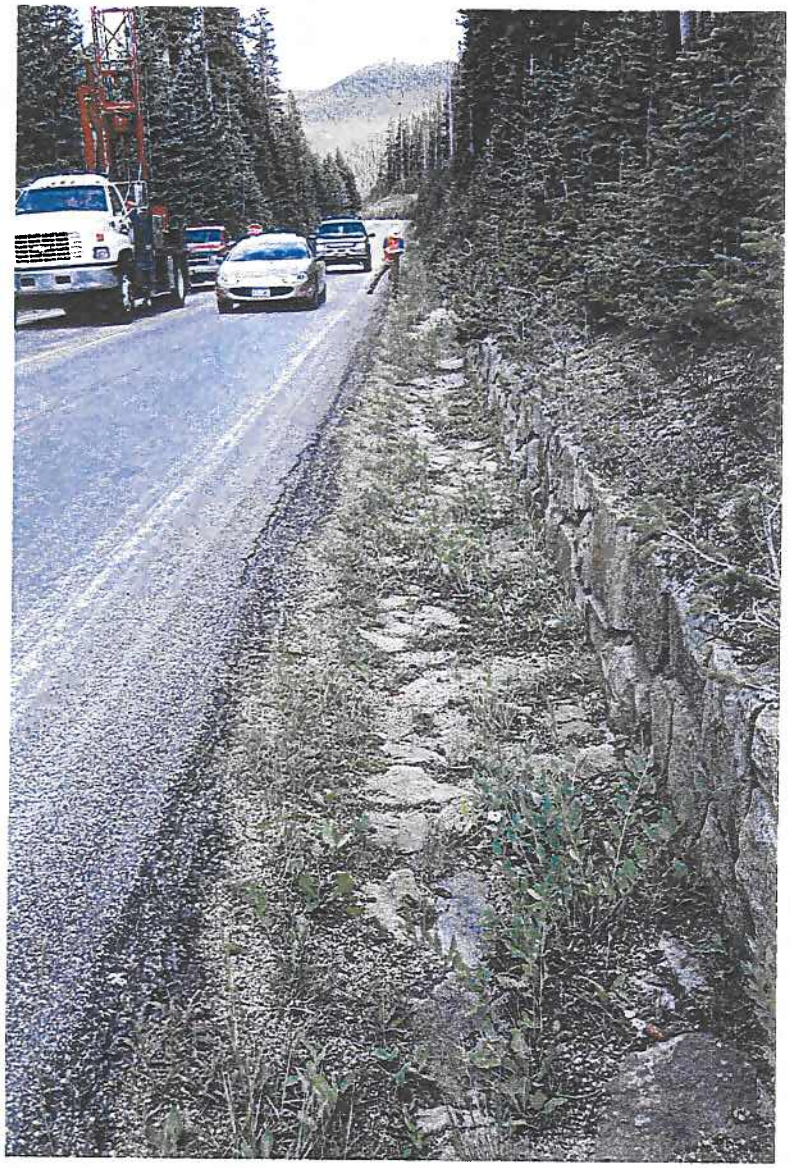


PHOTO 17: 74+200

Photo 18: 47+400

Photo 19: Test Pit 3 60+200

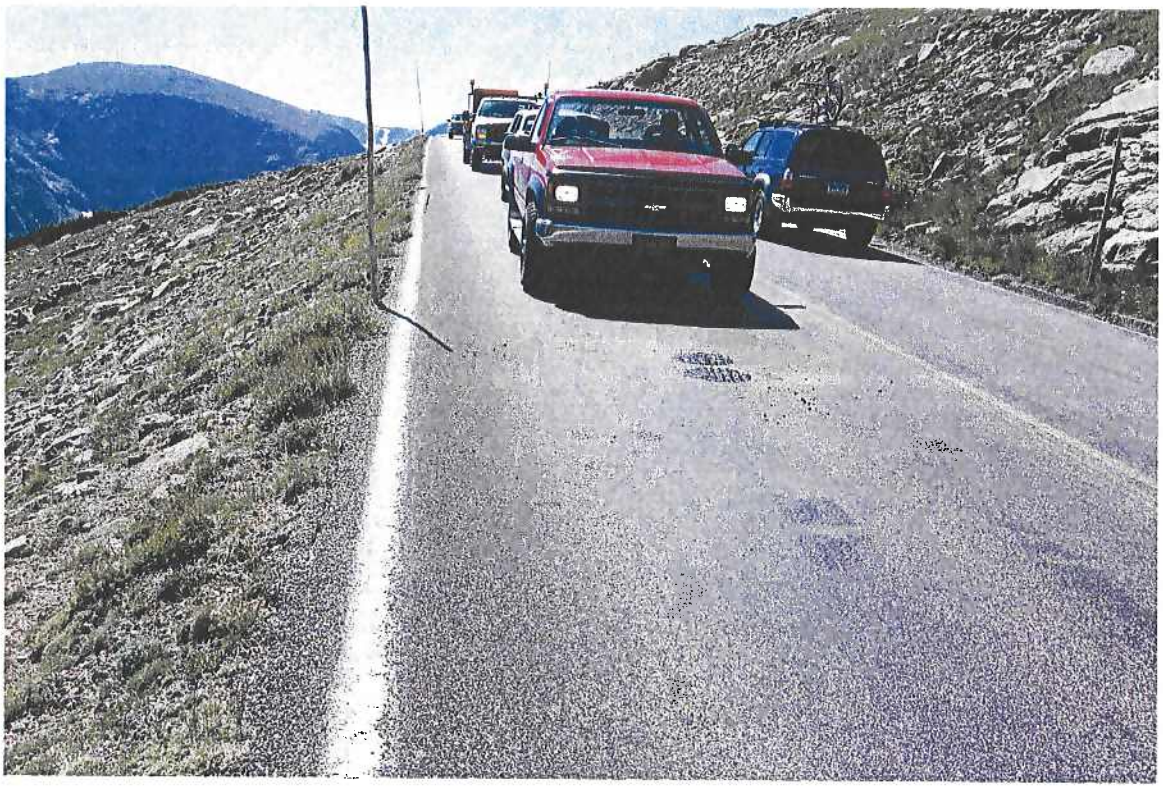


Photo 20: 68+400 Test Pit 4 68+400

Photo 21: Erosion from Thunder Shower

Photo 22: FWD Testing Park Foamed Asphalt

Photo 23: Cored Foamed Asphalt post FWD

Photo 24: Dried HACP, Wet Foamed Asphalt

Photo 25: Dried HACP, Wet Foamed Asphalt

Photo 26: Dried HACP, Wet Foamed Asphalt

Photo 27: Dried HACP, Wet Foamed Asphalt

Photo 28: Dried HACP, Wet Foamed Asphalt

Photo 29: Full Core of Foamed Asphalt

Photo 30: Base & Subgrade

APPENDIX D

PAVEMENT DESIGN CALCULTATIONS

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Flexible Structural Design Module

Section A 23+395 to 40+800
Existing Ave 4"
3.5"HACP & 5" Pulverize

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	617,765
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	17,000 psi
Stage Construction	1
Calculated Design Structural Number	2.13 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,825
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	84	1.81	0.0008	0	9,751
4	0.5	1.81	0.88	0	63,849
5	15	1.81	0.2	0	435,332
6	0.5	1.81	1.5	0	108,833
Total	100	-	-	-	617,765

Growth	Simple
Total Calculated Cumulative ESALs	617,765

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

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
2	Pulverize/Recycle	0.12	1	5	-	0.60
Total	-	-	-	8.50	-	2.14

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Flexible Structural Design Module

Section A 23+395 to 40+800
Existing Ave 4";
3"HACP & 5" FDR

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	617,765
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	17,000 psi
Stage Construction	1
Calculated Design Structural Number	2.13 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,825
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	84	1.81	0.0008	0	9,751
4	0.5	1.81	0.88	0	63,849
5	15	1.81	0.2	0	435,332
6	0.5	1.81	1.5	0	108,833
Total	100	-	-	-	617,765

Growth	Simple
Total Calculated Cumulative ESALs	617,765

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	FDR	0.2	1	5	-	1.00

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
Total	-	-	-	8.00	-	2.32

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Flexible Structural Design Module

Section B
40+800 to 50+400 & 59+160 to 75+500
Existing Ave 6.25";
Mill 3" Place 3" HACP & 6" FDR

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	617,765
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	15,000 psi
Stage Construction	1
Calculated Design Structural Number	2.24 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,825
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	84	1.81	0.0008	0	9,751
4	0.5	1.81	0.88	0	63,849
5	15	1.81	0.2	0	435,332
6	0.5	1.81	1.5	0	108,833
Total	100	-	-	-	617,765

Growth	Simple
Total Calculated Cumulative ESALs	617,765

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	FDR	0.15	1	6	-	0.90
Total	-	-	-	9.00	-	2.22

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Flexible Structural Design Module

Section C
50+400 to 57+600
Existing Ave 8.25"
Mill 3 & Pave 2.5 & 8 FDR

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	617,765
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	15,000 psi
Stage Construction	1
Calculated Design Structural Number	2.24 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,825
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	84	1.81	0.0008	0	9,751
4	0.5	1.81	0.88	0	63,849
5	15	1.81	0.2	0	435,332
6	0.5	1.81	1.5	0	108,833
Total	100	-	-	-	617,765

Growth	Simple
Total Calculated Cumulative ESALs	617,765

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	2.5	-	1.10
2	FDR	0.15	1	8	-	1.20
Total	-	-	-	10.50	-	2.30

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Flexible Structural Design Module

Section C
50+400 to 57+600
Existing Ave 8.25"
Mill 4 & Pave 3 & 6 FDR

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	617,765
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	15,000 psi
Stage Construction	1
Calculated Design Structural Number	2.24 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,825
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	84	1.81	0.0008	0	9,751
4	0.5	1.81	0.88	0	63,849
5	15	1.81	0.2	0	435,332
6	0.5	1.81	1.5	0	108,833
Total	100	-	-	-	617,765

Growth	Simple
Total Calculated Cumulative ESALs	617,765

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	FDR	0.15	1	6	-	0.90
Total	-	-	-	9.00	-	2.22

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Flexible Structural Design Module

Section D
75+500 to 85+066
Existing Ave 7"
Mill 3 & Pave 3 & 6 FDR

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	617,765
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	17,000 psi
Stage Construction	1
Calculated Design Structural Number	2.13 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,825
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	84	1.81	0.0008	0	9,751
4	0.5	1.81	0.88	0	63,849
5	15	1.81	0.2	0	435,332
6	0.5	1.81	1.5	0	108,833
Total	100	-	-	-	617,765

Growth	Simple
Total Calculated Cumulative ESALs	617,765

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	FDR	0.15	1	6	-	0.90
Total	-	-	-	9.00	-	2.22

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Flexible Structural Design Module

Section E
57+600 to 59+160
Reconstruct

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	617,765
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability Level	75 %
Overall Standard Deviation	0.49
Roadbed Soil Resilient Modulus	15,000 psi
Stage Construction	1
Calculated Design Structural Number	2.24 in

Rigorous ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	2,825
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	84	1.81	0.0008	0	9,751
4	0.5	1.81	0.88	0	63,849
5	15	1.81	0.2	0	435,332
6	0.5	1.81	1.5	0	108,833
Total	100	-	-	-	617,765

Growth	Simple
Total Calculated Cumulative ESALs	617,765

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	Base Course	0.14	1	7	-	0.98
Total	-	-	-	10.00	-	2.30

General	A=3 km	B=14 km	C=23 km
State	CO	CO	CO
Station ID	0053496	0053500	0050183
County/District	grand	grand	boulder
Weather Station	grand lake 1 nw	grand lake 6 ssw	allenspark 2 nnw
Elevation, m	2658	2526	2535
Latitude, Longitude	40.27 , 105.83	40.18 , 105.87	40.22 , 105.53
Last Year Data Available	1996	1995	1993

Air Temperature	Mean [Std, N]	Mean [Std, N]	Mean [Std, N]
Average 7-day High Temp	27.0 (1.4, 32)	25.9 (0.9, 44)	27.1 (1.2, 12)
Low Temperature	-33.3 (3.8, 33)	-34.7 (3.5, 44)	-27.1 (3.1, 15)
Low Temperature Drop	24.4 (4.2, 32)	24.9 (4.8, 43)	23.4 (5.9, 15)
Degree Days Above 30 C	1 (2, 32)	0 (0, 44)	0 (0, 12)

Pavement Temp. and PG	High Low Rel.	High Low Rel.	High Low Rel.
=50% Rel. Pavement Temp.	46.3 -23.3 (50,50)	45.5 -24.3 (50,50)	46.4 -18.8 (50,50)
>50% Rel. PG (High, Low Rel.)	52 -28 (96,91)	46 -28 (57,87)	52 -22 (96,85)
	52 -34 (96,98)	52 -28 (98,87)	52 -28 (96,98)
	58 -34 (98,98)	52 -34 (98,98)	58 -28 (98,98)

Close | PG Chart | Print | Save | Help

State/Province: CO

Weather Station: GRAND LAKE 1 NW

Depth from Pavement Surface to Top of Layer, mm: 0

Station ID	0053496	Latitude	40.27
County / District	GRAND	Longitude	105.83
Last Year Data Avail.	1996	Elevation, m	2658

Air Temperature	Mean	Std Dev.	Min	Max	Years
High 7-day Air Temp., Deg. C	27.0	1.4	24.8	30.3	32
Low Air Temperature, Deg. C	-33.3	3.8	-41.7	-27.8	33
Low Air Temp. Drop, Deg. C	24.4	4.2	17.2	33.3	32
Degree Days over 30 Deg. C	1	2	0	7	32

Pavement Temperature and PG	HIGH	LOW	High Rel	Low Rel
50% Reliability Pvt Temp., C	46.3	-23.3	50	50
>50% Reliability PG	52	-28	96	91
	52	-34	96	98
	58	-34	98	98

Close | PG Chart | PG Distribution | Print | Save | Help

State/Province: CO

Weather Station: ESTES PARK

Depth from Pavement Surface to Top of Layer, mm: 0

Station ID	0052759
County / District	LARIMER
Last Year Data Avail	1993

Latitude	40.38
Longitude	105.52
Elevation, m	2293

Air Temperature	Mean	Std Dev.	Min	Max	Years
High 7-day Air Temp., Deg. C	28.6	1.3	25.6	32.4	34
Low Air Temperature, Deg. C	-29.2	4.4	-39.4	-22.8	36
Low Air Temp. Drop, Deg. C	23.7	4.7	15.0	33.9	36
Degree Days over 30 Deg. C	3	6	0	31	34

Pavement Temperature and PG	HIGH	LOW	High Rel	Low Rel
50% Reliability Pvt Temp., C	47.5	-20.4	50	50
>50% Reliability PG	52	-22	92	66
	52	-28	92	97
	58	-28	98	97
	58	-34	98	98

Close | PG Chart | PG Distribution | Print | Save | Help

General	A=1 km	B=18 km	C=27 km
State	CO	CO	CO
Station ID	0052759	0050183	0058839
County/District	larimer	boulder	larimer
Weather Station	estes park	allenspark 2 nnw	waterdale
Elevation, m	2293	2535	1594
Latitude, Longitude	40.38 , 105.52	40.22 , 105.53	40.43 , 105.20
Last Year Data Available	1993	1993	1996

Air Temperature	Mean (Std, N)	Mean (Std, N)	Mean (Std, N)
Average 7-day High Temp.	28.6 (1.3, 34)	27.1 (1.2, 12)	33.8 (1.2, 38)
Low Temperature	-29.2 (4.4, 36)	-27.1 (3.1, 15)	-27.2 (3.5, 38)
Low Temperature Drop	23.7 (4.7, 36)	23.4 (5.9, 15)	22.4 (7.0, 36)
Degree Days Above 30 C	3 (6, 34)	0 (0, 12)	122 (45, 38)

Pavement Temp. and PG	High Low Rel.	High Low Rel.	High Low Rel.
=50% Rel. Pavement Temp.	47.5 -20.4 (50,50)	46.4 -18.8 (50,50)	51.6 -18.9 (50,50)
>50% Rel. PG (High, Low Rel.)	52 -22 (92,66)	52 -22 (96,85)	52 -22 (55,82)
	52 -28 (92,97)	52 -28 (96,98)	58 -22 (97,82)
	58 -28 (98,97)	58 -28 (98,98)	58 -28 (97,98)
	58 -34 (98,98)		64 -28 (98,98)

Close | PG Chart | Print | Save | Help

CO PRA ROMO 10(4) TRAIL RIDGE ROAD

SECTION A: 23+395 to 40+800

Option 1:

3.5" hacp	Asphalt	2325	kg/m^3	8.5	m	1000 m	0.09	m	1000 m	=	1780 tons	*	$	50 per ton	=	90,000	$161,500/kilometer
5" pulverize	AC	0.06	percent							=	107 tons	*	$	400 per ton	=	43,000	
	Lime	0.01	percent							=	18 tons	*	$	130 per ton	=	2500	
	Prime Coat	0.0015	t/m^2	8.5	m	1000 m				=	13 tons	*	$	360 per ton	=	5000	
	Tack Coat	0.00045	t/m^2	8.5	m	1000 m				=	4 tons	*	$	375 per ton	=	1500	
	Blotter	8	kg/m^2	8.5	m	1000 m				=	68 tons	*	$	25 per ton	=	2000	
	Pulverize			8.5	m	1000 m				=	8500 m^2	*	$	1.88 per m^2	=	16,000	
	Fog Seal - HACP	0.00045	t/m^2	8.5	m	1000 m				=	4 tons	*	$	375 per ton	=	1,500	

Option 2:

3" hacp	Asphalt	2325	kg/m^3	8.5	m	1000 m	0.075	m	1000 m	=	1285 tons	*	$	50 per ton	=	75,000	$159,000/kilometer
5" FDR	AC	0.06	percent							=	78 tons	*	$	400 per ton	=	36,000	
	Lime	0.01	percent							=	13 tons	*	$	130 per ton	=	2000	
	Tack Coat	0.00045	t/m^2	8.5	m	1000 m				=	4 tons	*	$	375 per ton	=	1,500	
	FDR			8.5	m	1000 m				=	8500 m^2	*	$	2.25 per m^2	=	19,000	
	Asphalt B.3%	2275	kg/m^3	8.5	m	1000 m	0.125	m	0.03 %	=	73 tons	*	$	250 per ton	=	19,000	
	Cement 1%	2225	kg/m^3	8.5	m	1000 m	0.125	m	0.01 %	=	24 tons	*	$	130 per ton	=	3500	
	Fog Seal - FDR	0.00045	t/m^2	8.5	m	1000 m				=	4 tons	*	$	375 per ton	=	1500	
	Fog Seal - HACP	0.00045	t/m^2	8.5	m	1000 m				=	4 tons	*	$	375 per ton	=	1,500	

Option 3:

2.5" hacp	Asphalt	2325	kg/m^3	8.5	m	1000 m	0.065	m	1000 m	=	1285 tons	*	$	50 per ton	=	65,000	$159,000/kilometer
4" CIPR	AC	0.06	percent							=	78 tons	*	$	400 per ton	=	31,000	
	Lime	0.01	percent							=	13 tons	*	$	130 per ton	=	2000	
	Tack Coat	0.00045	t/m^2	8.5	m	1000 m				=	4 tons	*	$	375 per ton	=	1,500	
	CIPR									=			$	20,000 per 1000m	=	20,000	
	Emulsions	2225	kg/m^3	8.5	m		0.1	m		=	76 tons	*	$	500 per ton	=	38,000	
	Fog Seal - HACP	0.00045	t/m^2	8.5	m	1000 m				=	4 tons	*	$	375 per ton	=	1,500	

CO PRA ROMO 10(4) TRAIL RIDGE ROAD

SECTION B: 40+800 to 50+400 & 59+160 to 75+500

Option 1:

3" Mill	Mill									7300	m^2	* $	2.5	per m^2	=	18,000	
3" hacp	Asphalt	2325	kg/m^3	7.3	m	1000 m	0.075	m	1000 m =	1275	tons	* $	50	per ton	=	64,000	$159,000/kilometer
6" FDR	AC	0.06	percent						=	77	tons	* $	400	per ton	=	31,000	
	Lime	0.01	percent						=	13	tons	* $	130	per ton	=	2000	
	Tack Coat	0.00045	t/m^2	7.3	m	1000 m			=	4	tons	* $	375	per ton	=	1,500	
	FDR			7.3	m	1000 m			=	7300	m^2	* $	2.25	per m^2	=	17,000	
	Cement	2225	kg/m^3	7.3	m		0.150	m	0.01 % =	25	tons	* $	130	per ton	=	3500	
	Asphalt B.3%	2275	kg/m^3	7.3	m	1000 m	0.150	m	0.03 % =	75	tons	* $	250	per ton	=	19000	
	Fog Seal - FDR	0.00045	t/m^2	7.3	m	1000 m			=	4	tons	* $	375	per ton	=	1500	
	Fog Seal - HACP	0.00045	t/m^2	7.3	m	1000 m			=	4	tons	* $	375	per ton	=	1500	

SECTION C: 50+400 to 57+600

Option 1:

3" Mill	Mill									7350	m^2	* $	2.5	per m^2	=	18,500	
2.5" hacp	Asphalt	2325	kg/m^3	7.35	m	1000 m	0.075	m	1000 m =	1115	tons	* $	50	per ton	=	56,000	$156,000/kilometer
8" FDR	AC	0.06	percent						=	67	tons	* $	400	per ton	=	27,000	
	Lime	0.01	percent						=	12	tons	* $	130	per ton	=	1500	
	Tack Coat	0.00045	t/m^2	7.35	m	1000 m			=	4	tons	* $	375	per ton	=	1,500	
	FDR			7.35	m	1000 m			=	7350	m^2	* $	2.5	per m^2	=	18,500	
	Cement	2225	kg/m^3	7.35	m		0.200	m	0.01 % =	33	tons	* $	130	per ton	=	4,000	
	Asphalt B.3%	2275	kg/m^3	7.35	m	1000 m	0.200	m	0.03 % =	101	tons	* $	250	per ton	=	26000	
	Fog Seal - FDR	0.00045	t/m^2	7.35	m	1000 m			=	4	tons	* $	375	per ton	=	1500	
	Fog Seal - HACP	0.00045	t/m^2	7.35	m	1000 m			=	4	tons	* $	375	per ton	=	1,500	

Option 2:

4" Mill	Mill									7350	m^2	* $	2.5	per m^2	=	18,500	
3" hacp	Asphalt	2325	kg/m^3	7.35	m	1000 m	0.075	m	1000 m =	1285	tons	* $	50	per ton	=	64,000	$161,000/kilometer
6" FDR	AC	0.06	percent						=	78	tons	* $	400	per ton	=	31,000	
	Lime	0.01	percent						=	13	tons	* $	130	per ton	=	2000	
	Tack Coat	0.00045	t/m^2	7.35	m	1000 m			=	4	tons	* $	375	per ton	=	1,500	
	FDR			7.35	m	1000 m			=	8500	m^2	* $	2.25	per m^2	=	19,000	
	Cement	2225	kg/m^3	7.35	m		0.150	m	0.01 % =	25	tons	* $	130	per ton	=	3000	
	Asphalt B.3%	2275	kg/m^3	7.35	m	1000 m	0.150	m	0.03 % =	76	tons	* $	250	per ton	=	19000	
	Fog Seal - FDR	0.00045	t/m^2	7.35	m	1000 m			=	4	tons	* $	375	per ton	=	1500	
	Fog Seal - HACP	0.00045	t/m^2	7.35	m	1000 m			=	4	tons	* $	375	per ton	=	1,500	

CO PRA ROMO 10(4) TRAIL RIDGE ROAD

SECTION D: 75+500 to 85+066

Option 1:

3" Mill	Mill										7200	m^2	*	$	2.5	per m^2	=	18,000	
3" hacp	Asphalt	2325	kg/m^3	7.2	m	1000 m	0.075	m	1000 m	=	1260	tons	*	$	50	per ton	=	63,000	$156,500/kilometer
6" FDR	AC	0.06	percent							=	76	tons	*	$	400	per ton	=	30,500	
	Lime	0.01	percent							=	13	tons	*	$	130	per ton	=	2000	
	Tack Coat	0.00045	t/m^2	7.2	m	1000 m				=	4	tons	*	$	375	per ton	=	1,500	
	FDR			7.2	m	1000 m				=	7200	m^2	*	$	1.88	per m^2	=	17,000	
	Cement	2225	kg/m^3	7.2	m		0.150	m	0.01 %	=	24	tons	*	$	130	per ton	=	3000	
	Asphalt B.3%	2275	kg/m^3	7.2	m	1000 m	0.150	m	0.03 %	=	74	tons	*	$	250	per ton	=	18500	
	Fog Seal - FDR	0.00045	t/m^2	7.2	m	1000 m				=	4	tons	*	$	375	per ton	=	1500	
	Fog Seal - HACP	0.00045	t/m^2	7.2	m	1000 m				=	4	tons	*	$	375	per ton	=	1,500	

SECTION E: 57+600 to 59+160

Option 1:

3" hacp	Asphalt	2325	kg/m^3	8.0	m	1000 m	0.075	m	1000 m	=	1395	tons	*	$	50	per ton	=	70,000	$247,500/kilometer
7" Base	AC	0.06	percent							=	84	tons	*	$	400	per ton	=	34,000	
	Lime	0.01	percent							=	14	tons	*	$	130	per ton	=	2000	
	Tack Coat	0.0045	t/m^2	8.0	m	1000 m				=	36	tons	*	$	375	per ton	=	13,500	
	Prime Coat	0.0015	t/m^2	8.0	m	1000 m				=	12	m^2	*	$	360	per m^2	=	4,500	
	Blotter	8	kg/m^2	8.0	m					=	64	tons	*	$	25	per ton	=	2,000	
	Agg Base	2225	kg/m^3	8.1	m	1000 m	0.175	m		=	3155	tons	*	$	38	per ton	=	120,000	
	Fog Seal - HACP	0.00045	t/m^2	8.0	m	1000 m				=	4	tons	*	$	375	per ton	=	1,500	

APPENDIX E

ASPHALT MAT THICKNESS CHARTS

CHART 1

TRAIL RIDGE ROAD 23+395 TO 28+000: Existing Structural Section

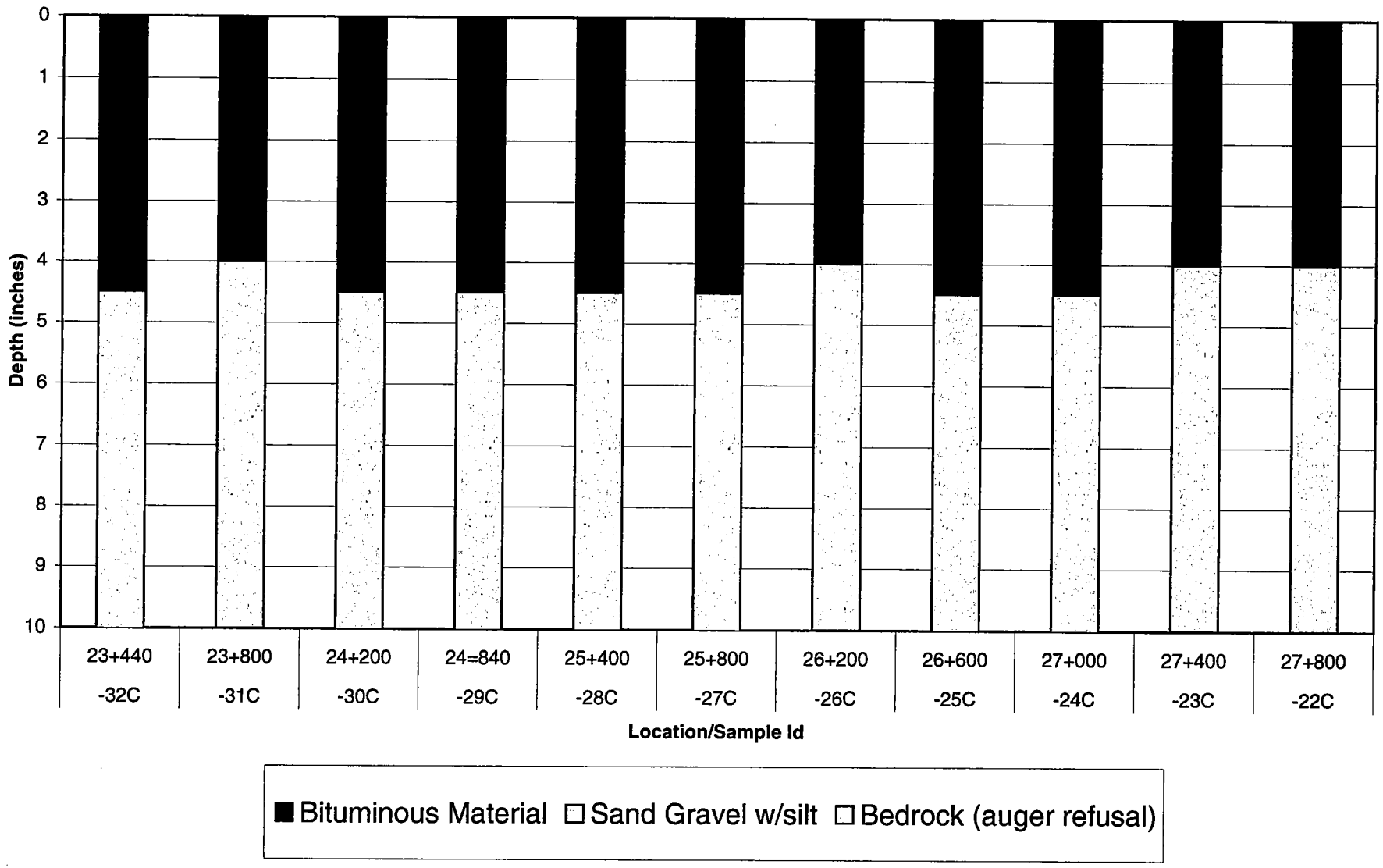


CHART 2

TRAIL RIDGE ROAD 28+000 TO 32+400: Existing Structural Section

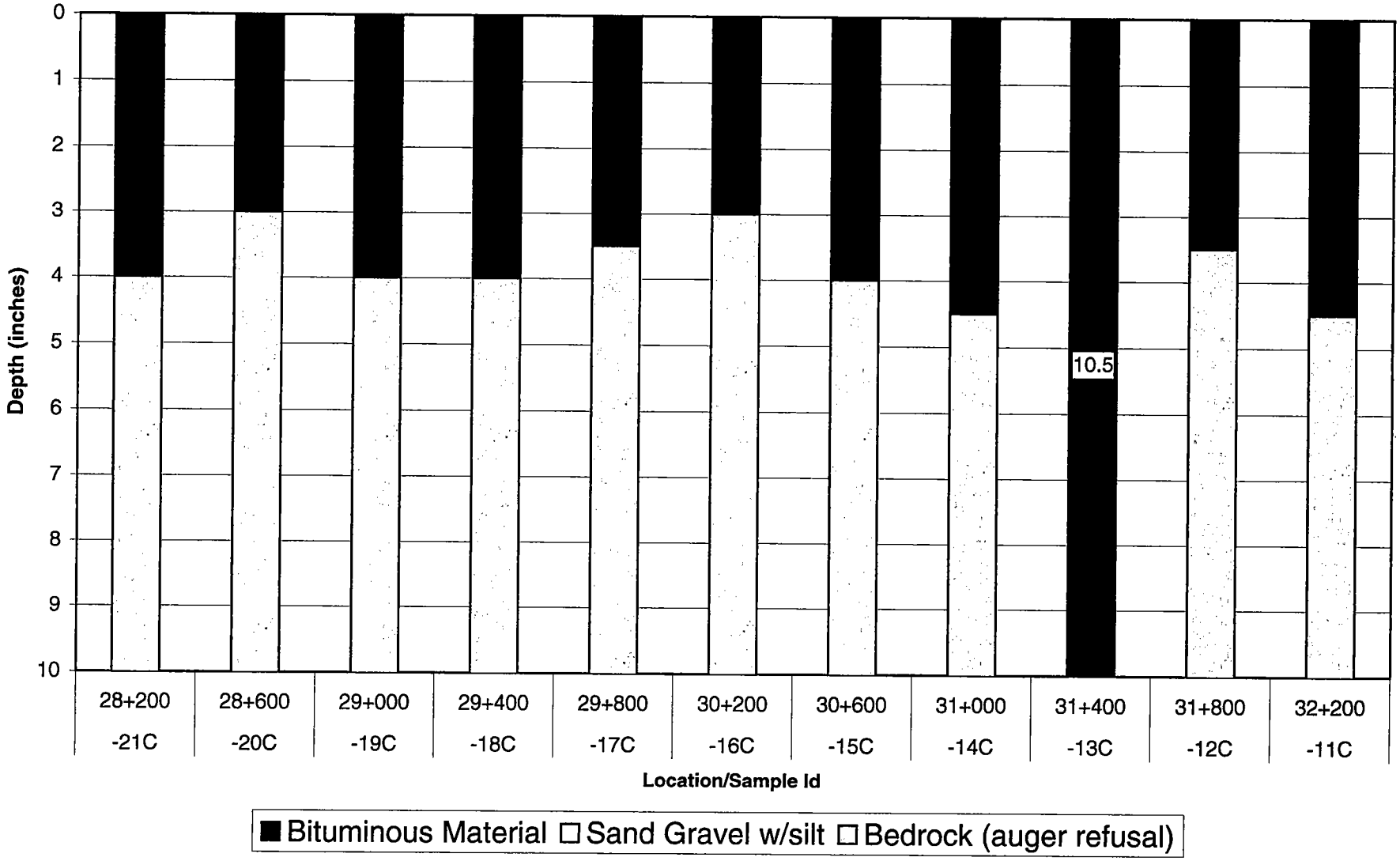


CHART 3

TRAIL RIDGE ROAD 32+400 TO 36+800: Existing Structural Section

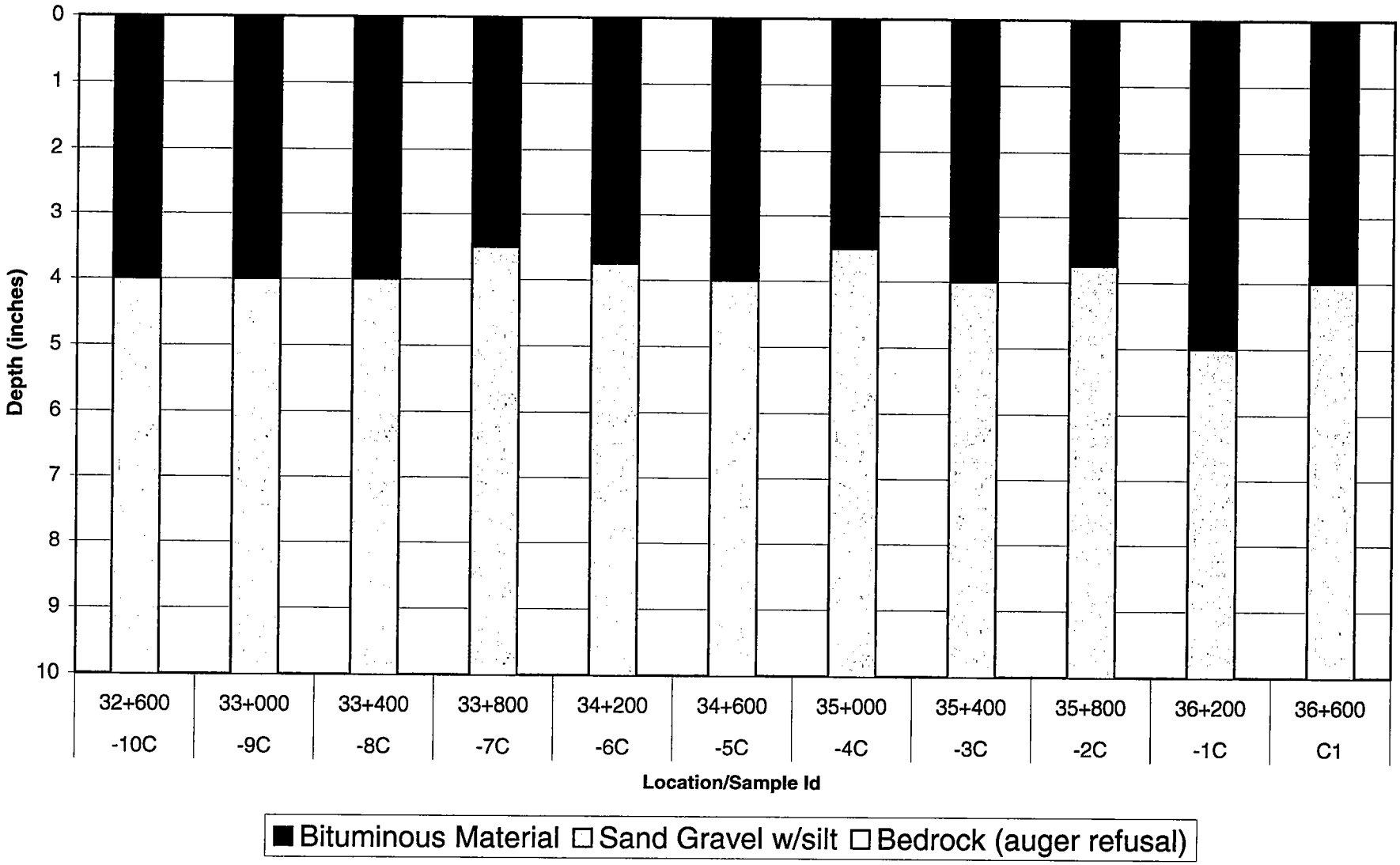
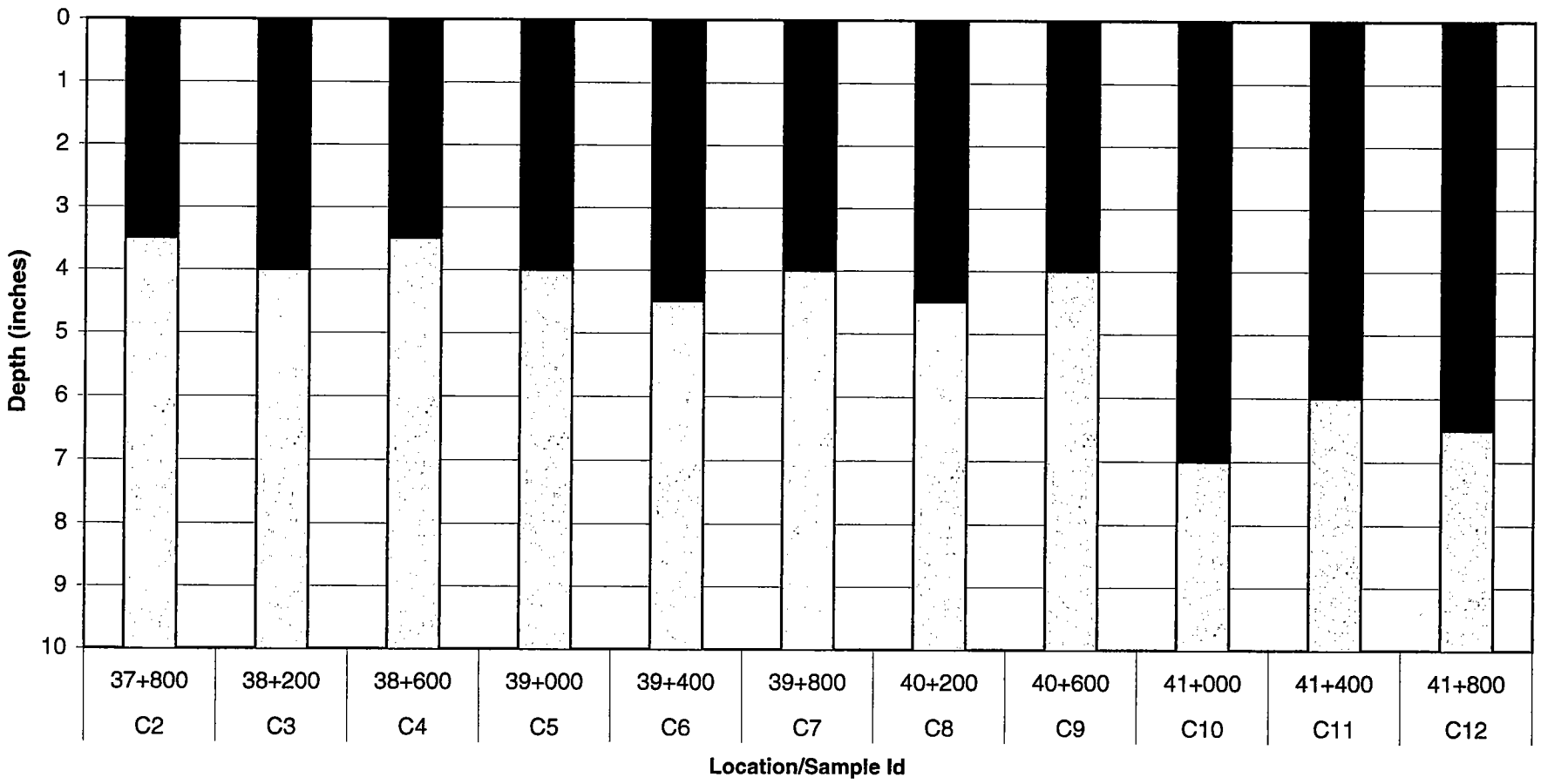


CHART 4

TRAIL RIDGE ROAD 37+600 TO 42+000: Existing Structural Section



■ Bituminous Material □ Sand Gravel w/silt □ Bedrock (auger refusal)

CHART 5

TRAIL RIDGE ROAD 42+000 TO 46+400: Existing Structural Section

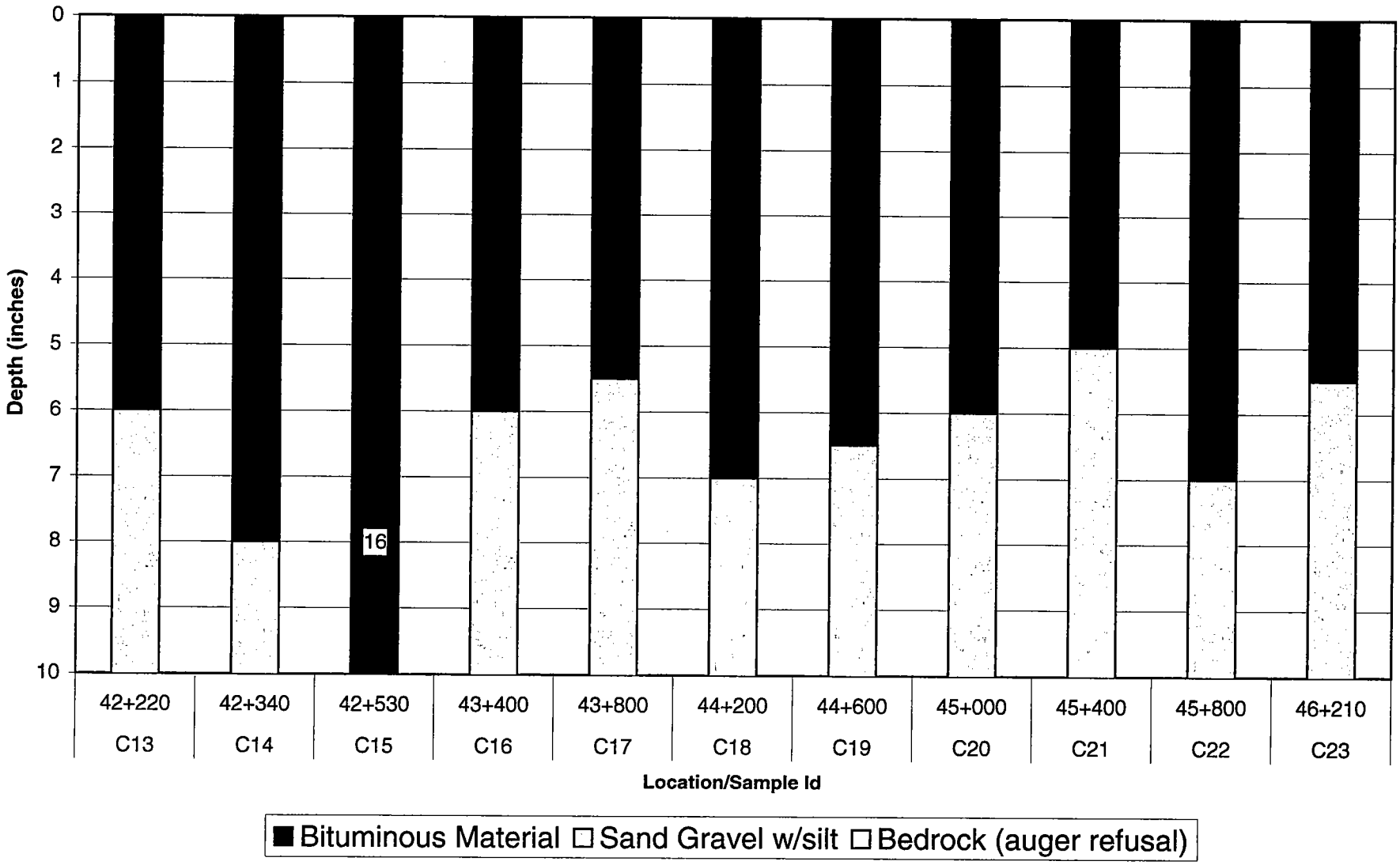


CHART 6

TRAIL RIDGE ROAD 46+400 TO 50+800: Existing Structural Section

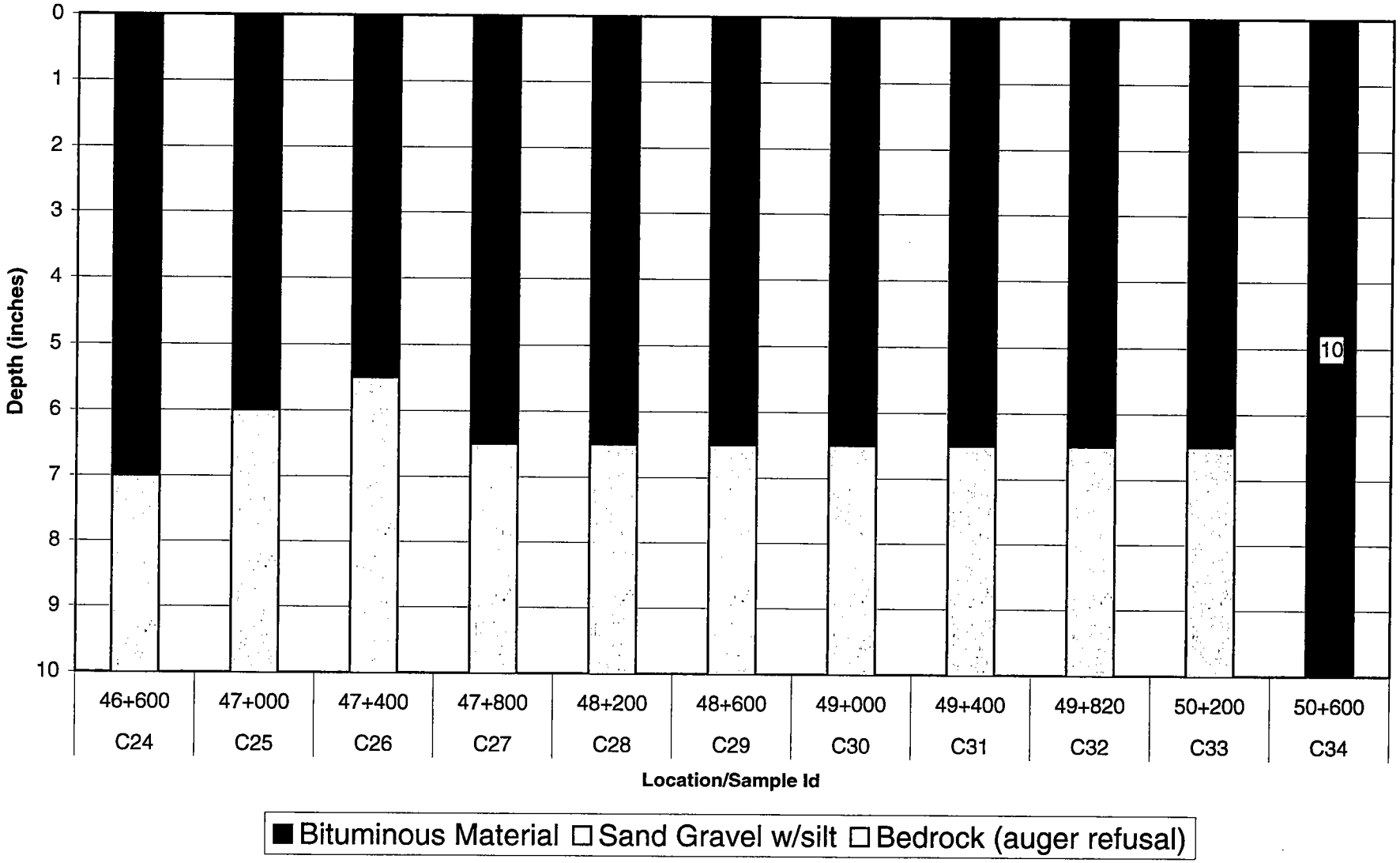


CHART 7

TRAIL RIDGE ROAD 50+800 TO 55+200: Existing Structural Section

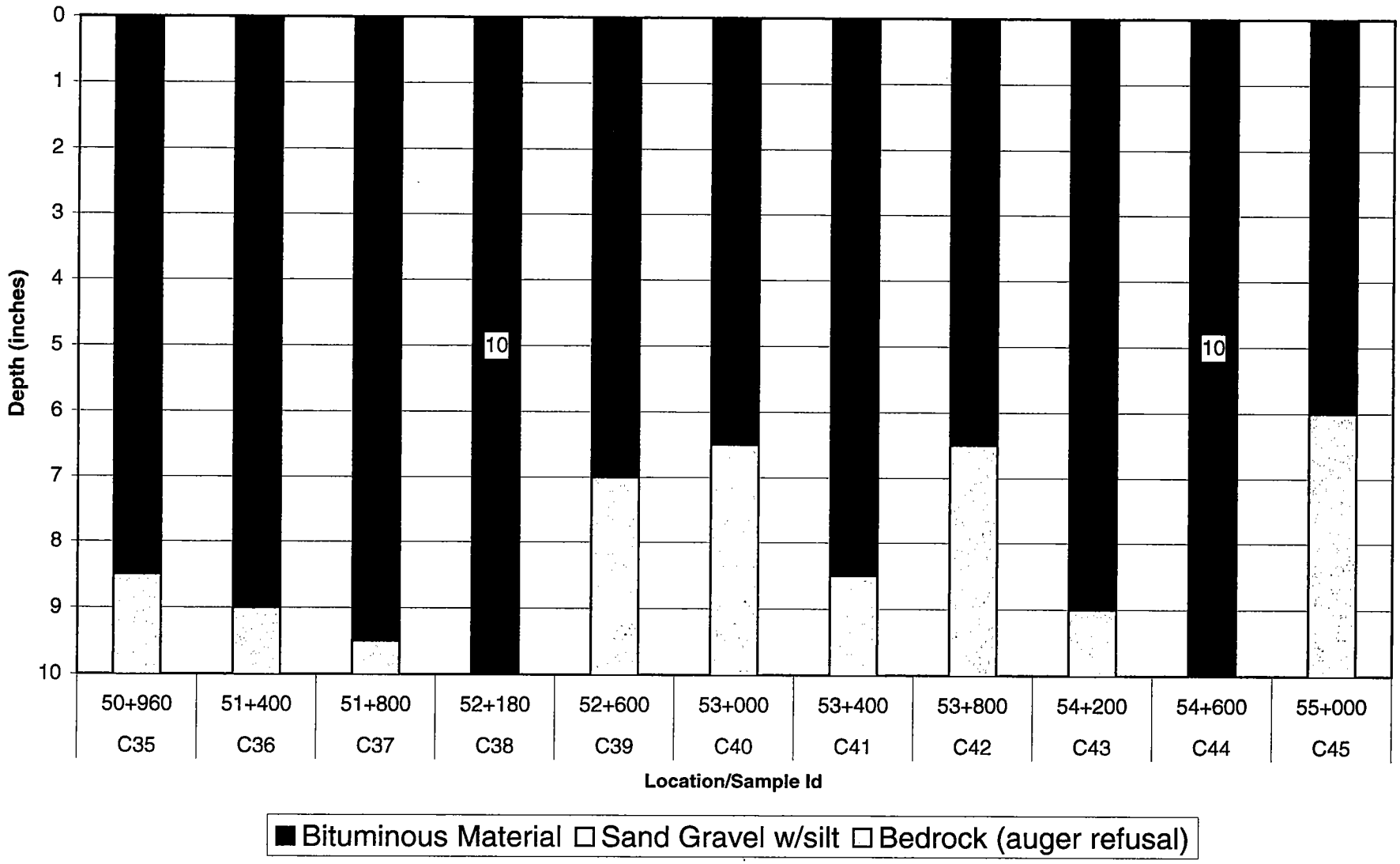


CHART 8

TRAIL RIDGE ROAD 55+200 TO 59+500: Existing Structural Section

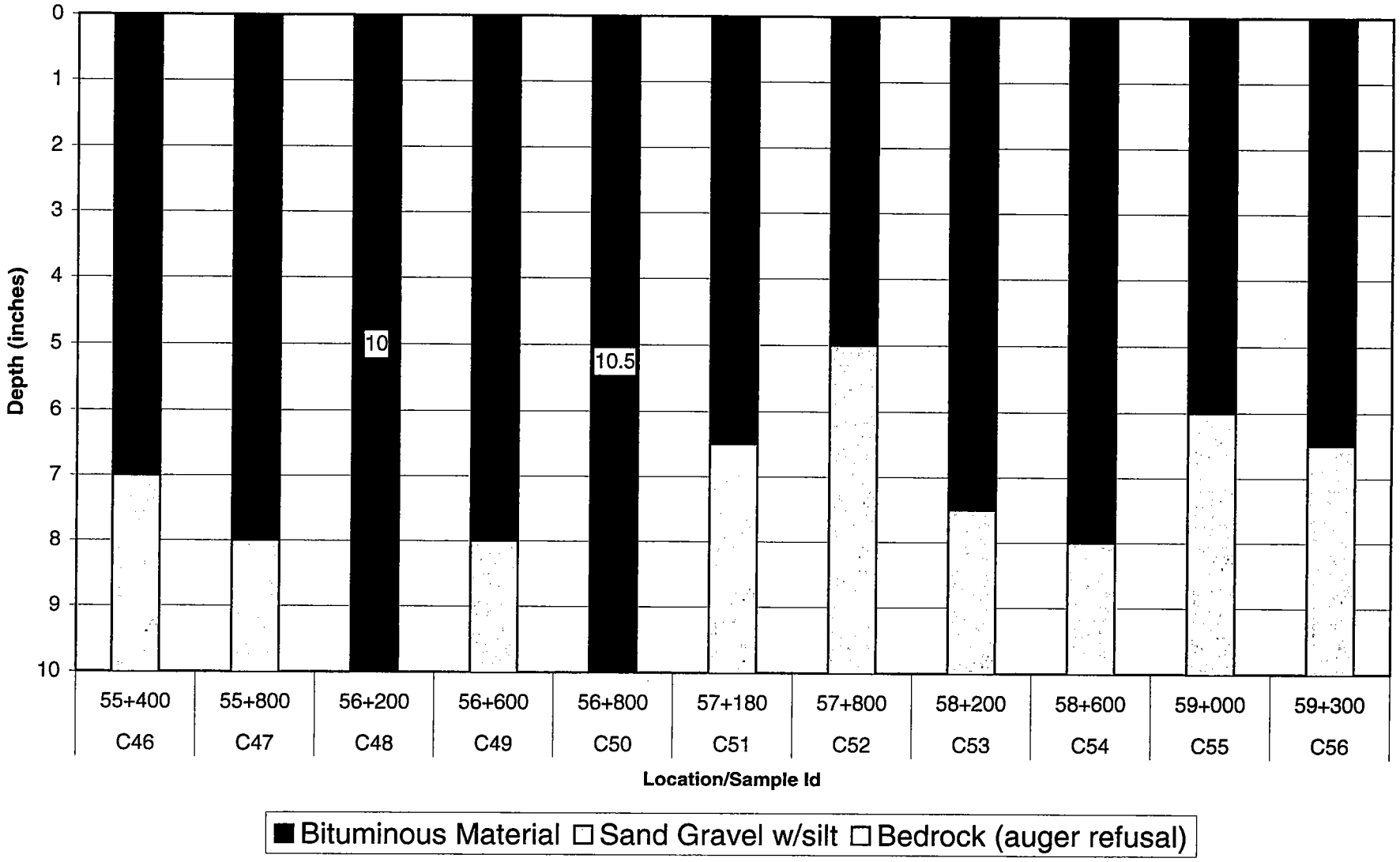


CHART 9

TRAIL RIDGE ROAD 59+600 TO 62+300: Existing Structural Section

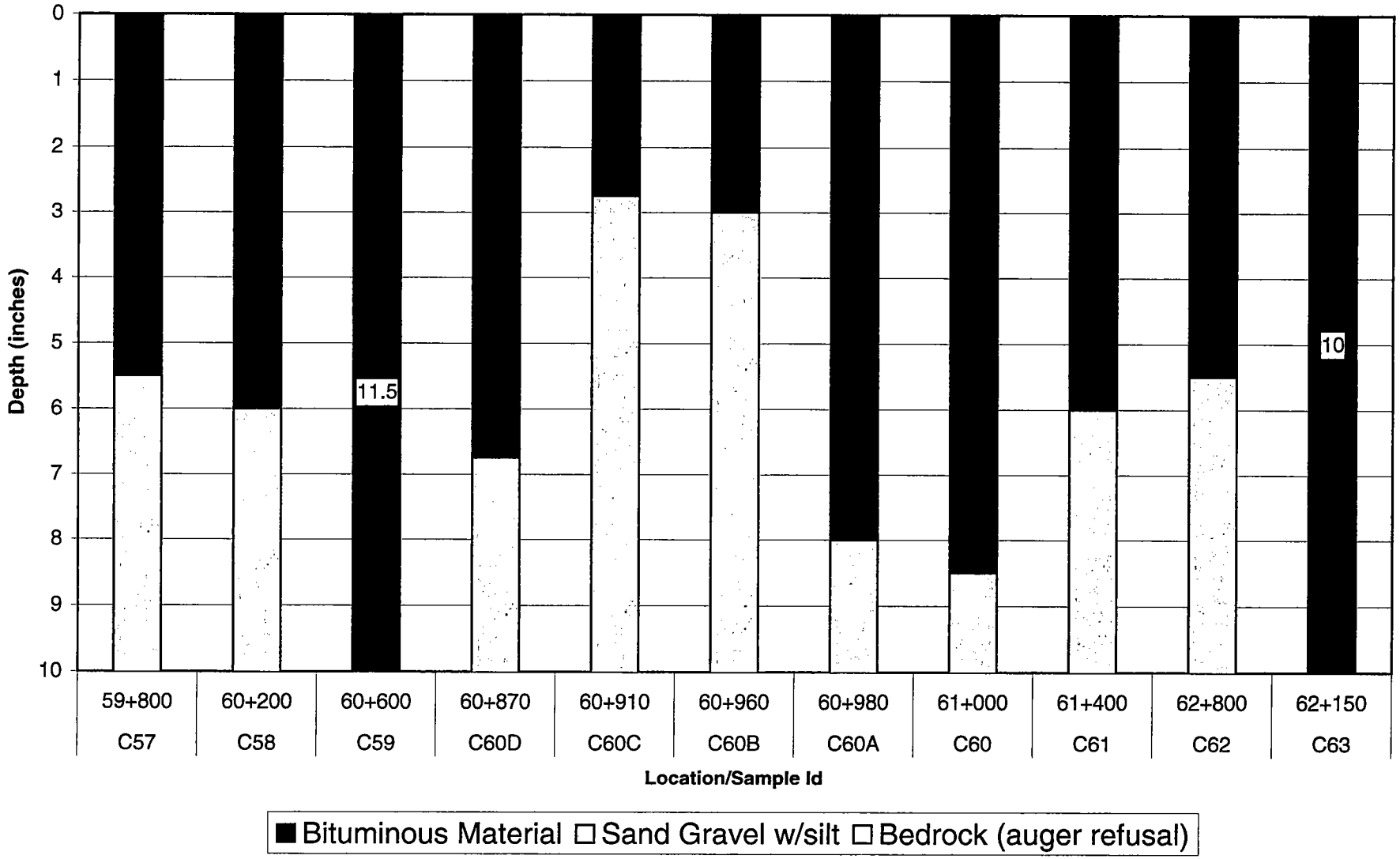


CHART 10

TRAIL RIDGE ROAD 62+300 TO 66+400: Existing Structural Section

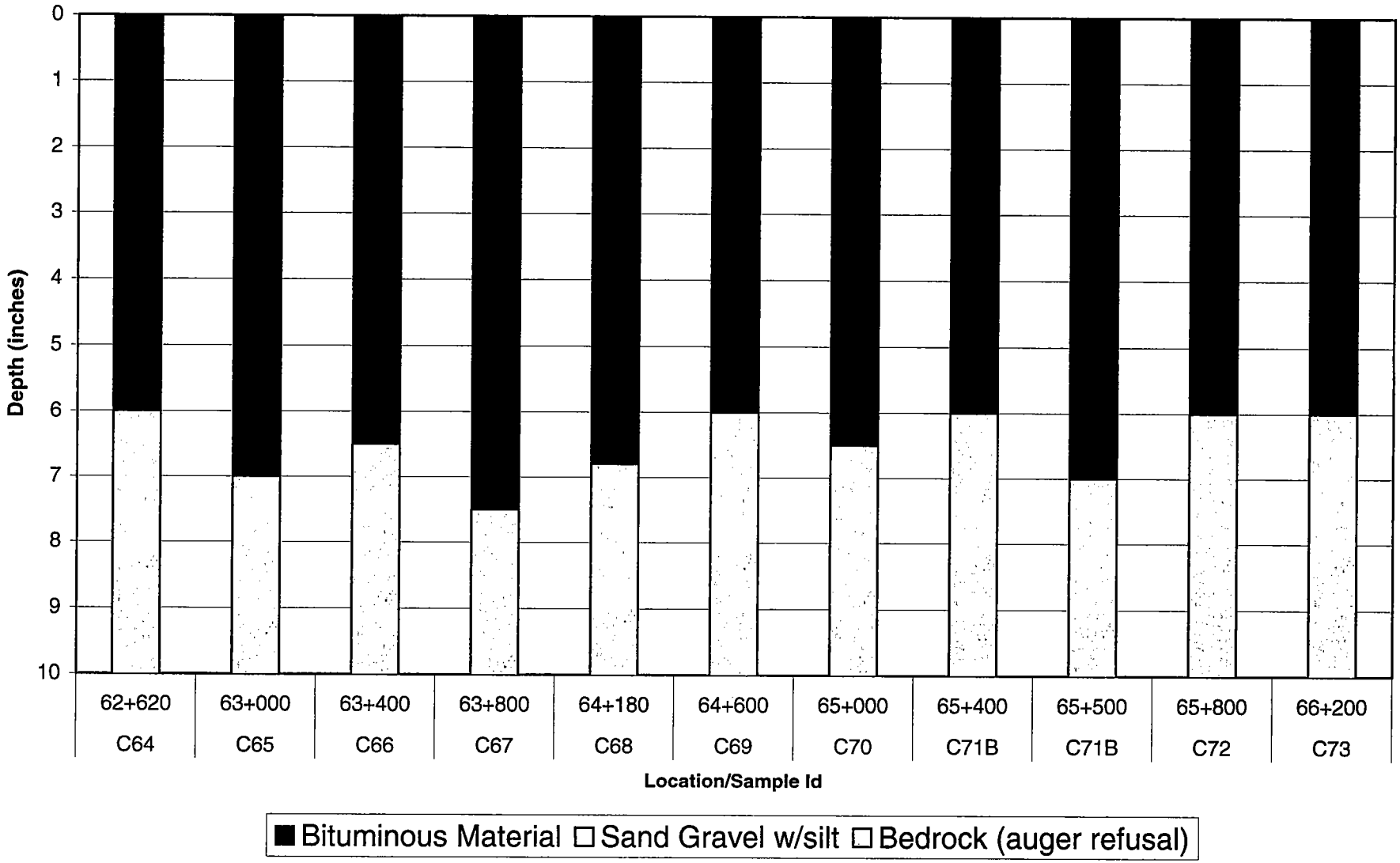


CHART 11

TRAIL RIDGE ROAD 66+400 TO 70+400: Existing Structural Section

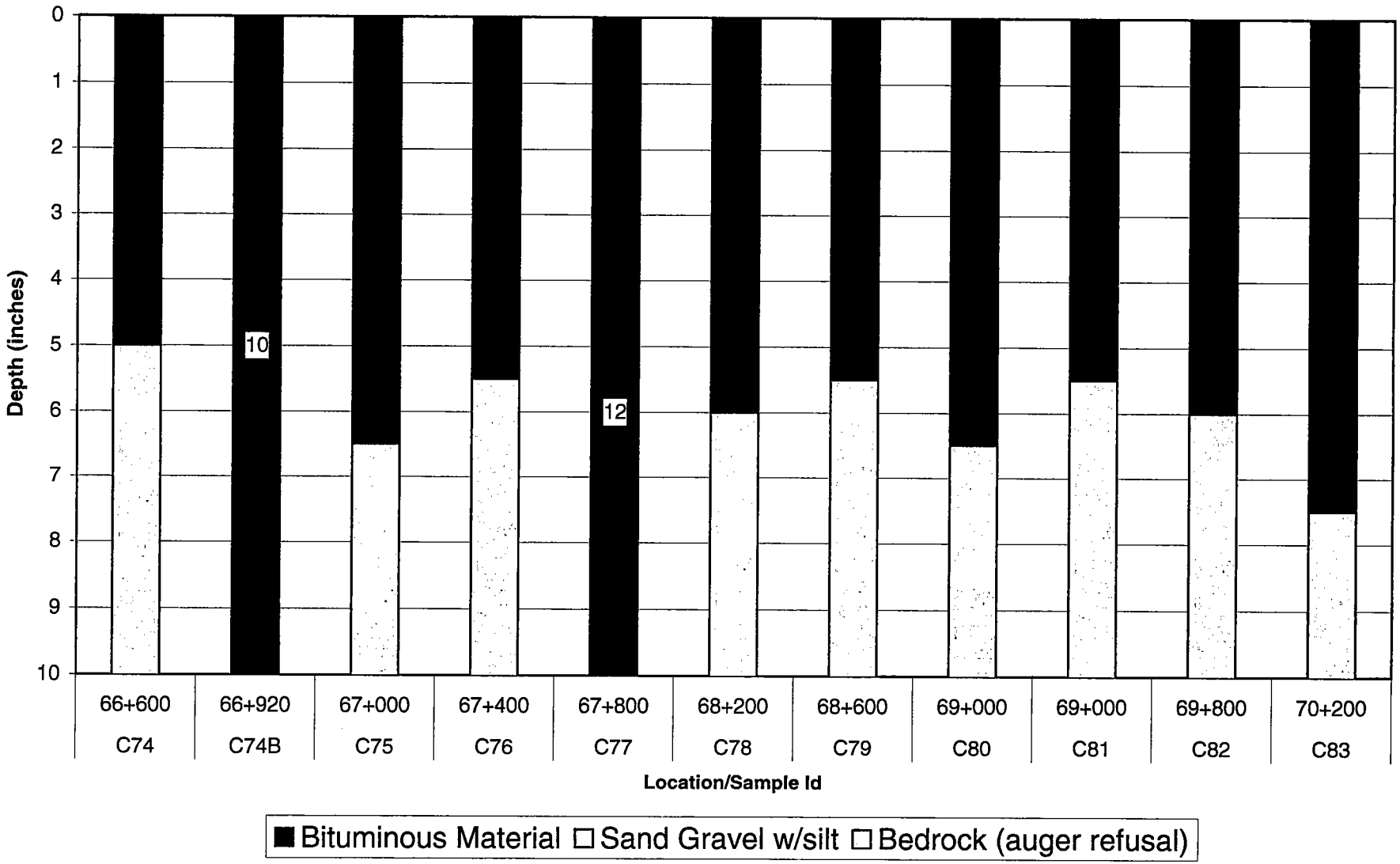


CHART 12

TRAIL RIDGE ROAD 70+400 TO 74+700: Existing Structural Section

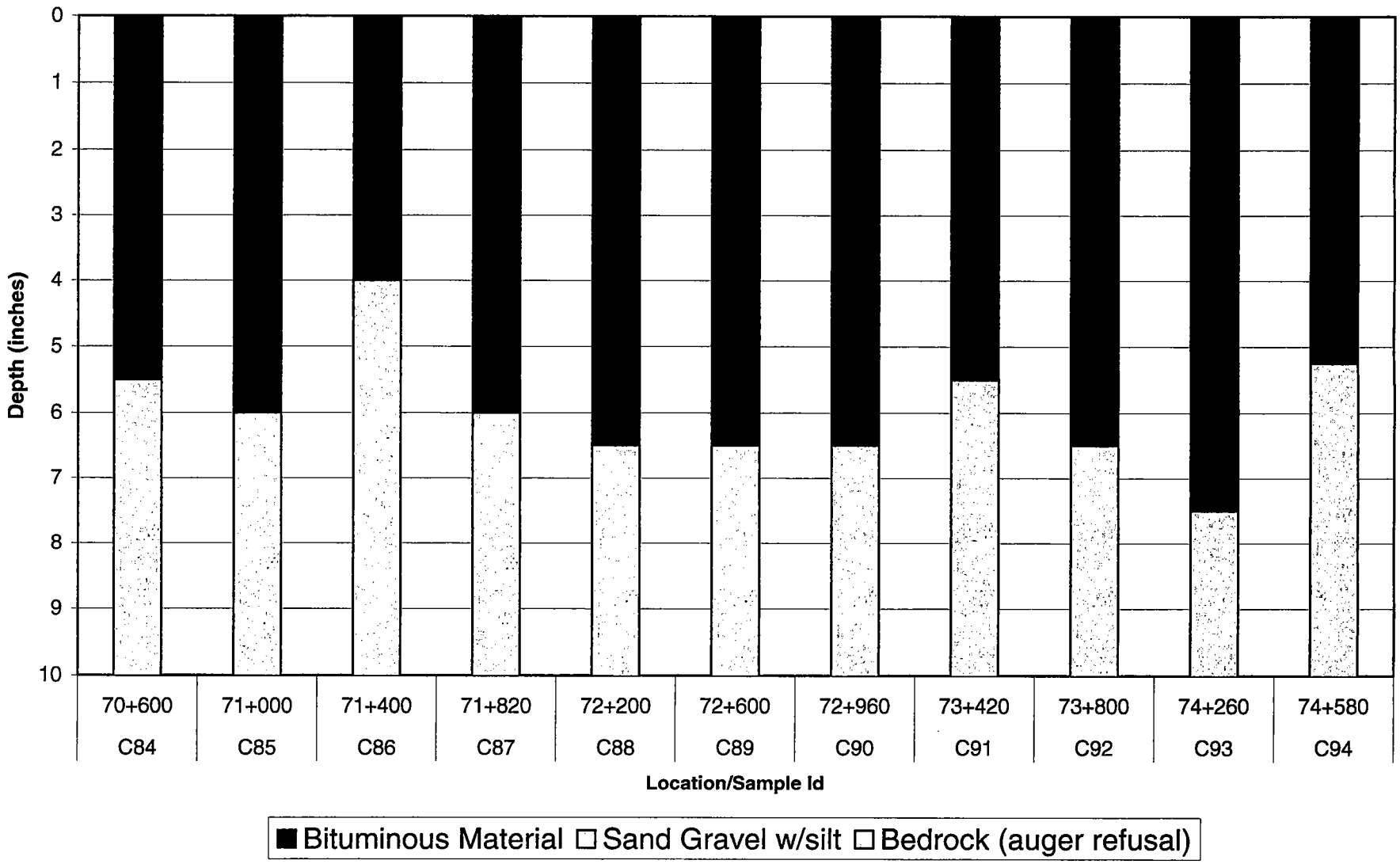


CHART 13

TRAIL RIDGE ROAD 74+700 TO 78+700: Existing Structural Section

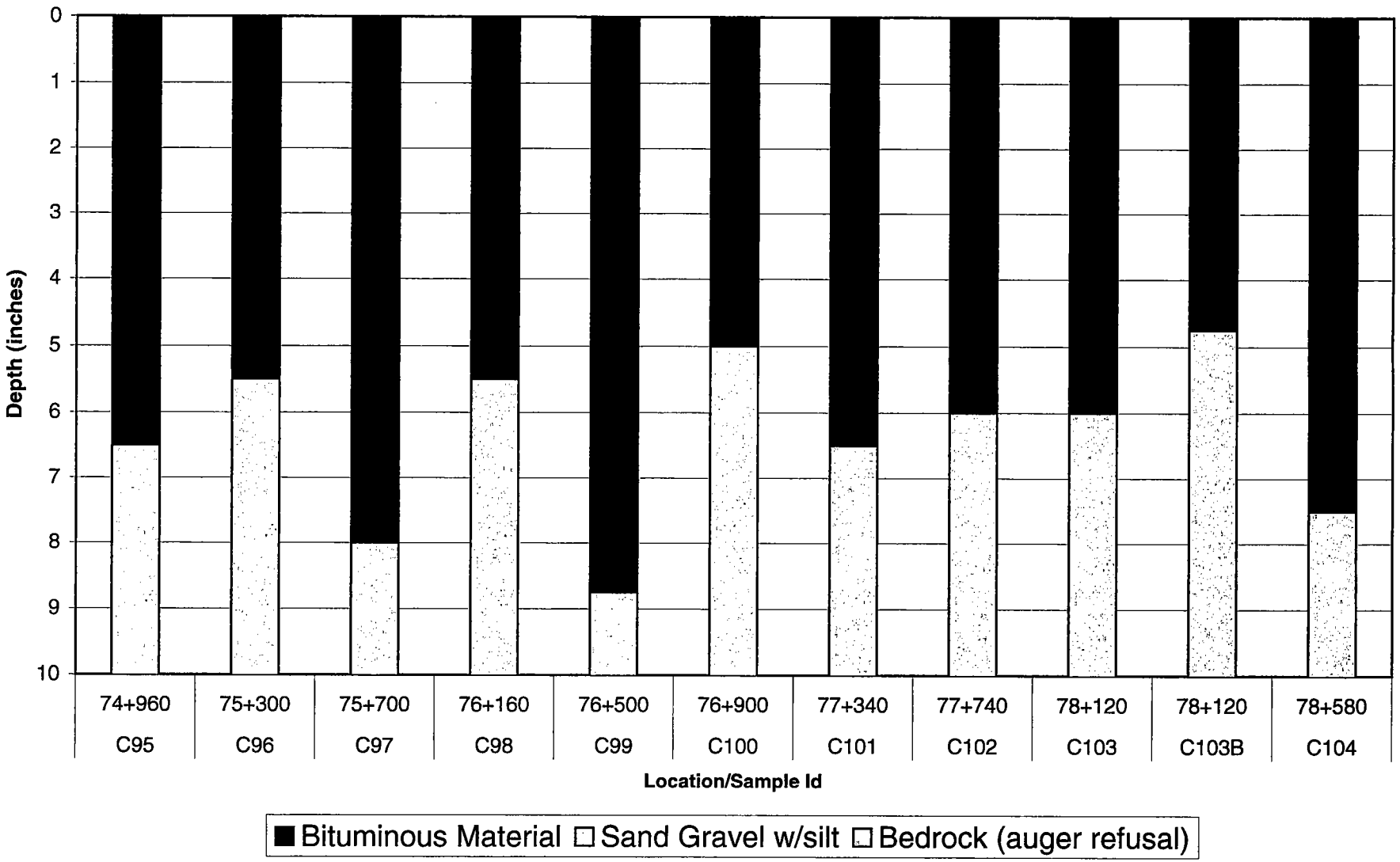


CHART 14

TRAIL RIDGE ROAD 78+700 TO 83+200: Existing Structural Section

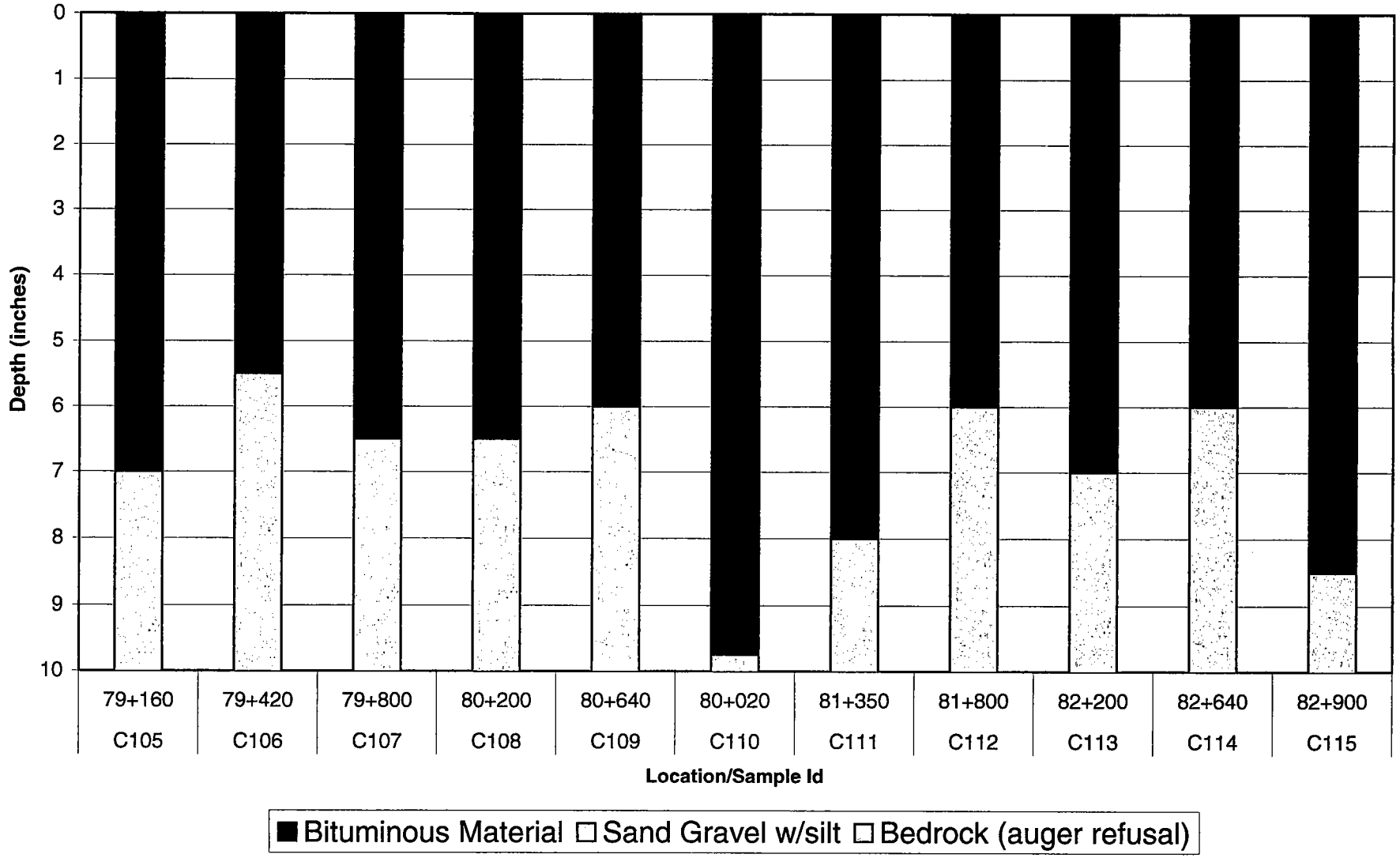
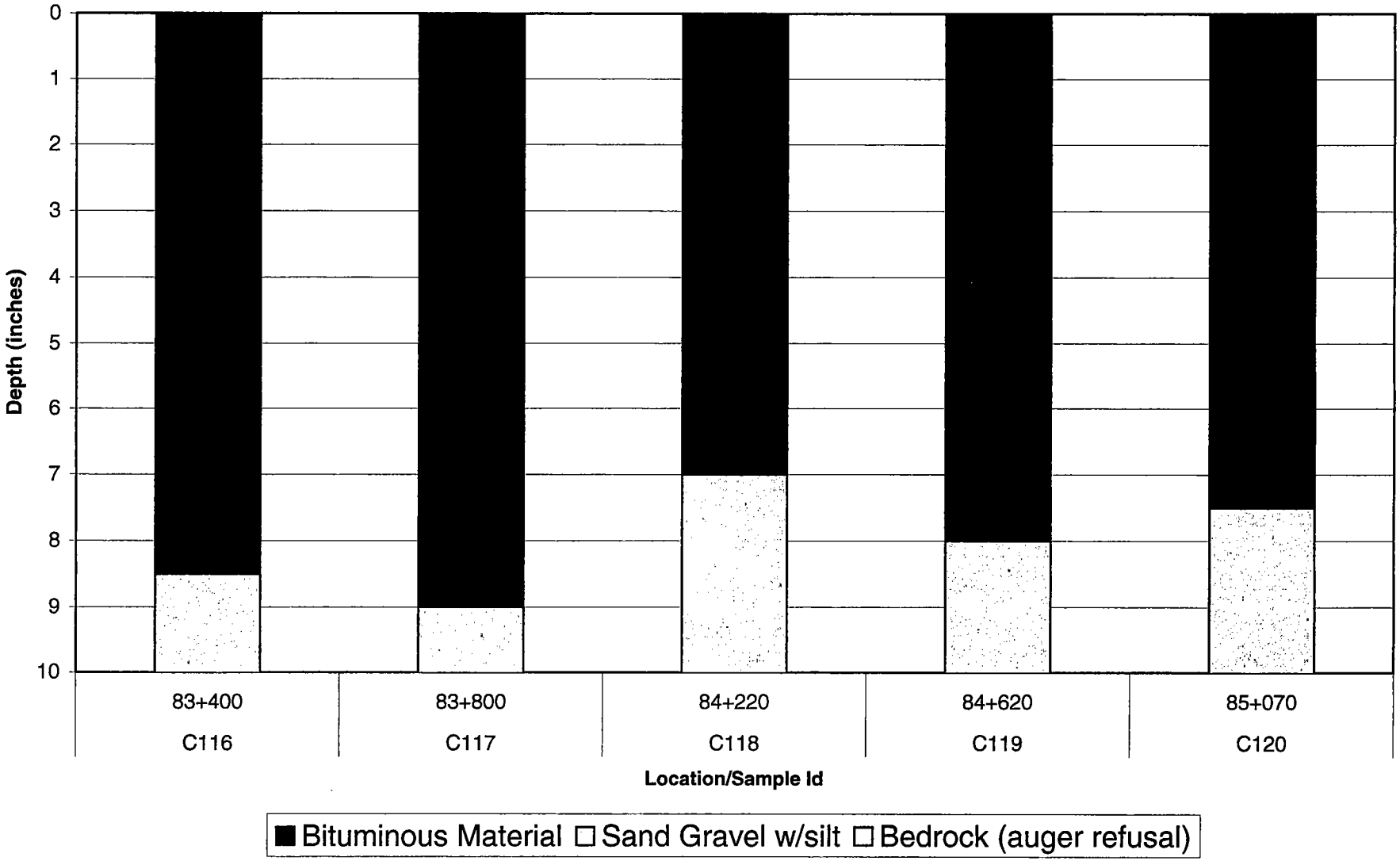


CHART 15

TRAIL RIDGE ROAD 83+200 TO 85+066: Existing Structural Section



APPENDIX F

FIELD DATA SUMMARY

ROMO

BORING	STATION	MP	ASPHALT THICKNESS	asphalt condition	ROAD WIDTH	LEFT SHLDER TYPE	RIGHT SHLDER TYPE	NOTES	MATERIAL TYPE
-32C	23+440		4.5"	poor	30'	pullout	pullout	Chip seal popping out hollow sound	Sand Gravel w/silt
-31C	23+800		4"	poor	29.4			curve to right, low side	Sand Gravel w/silt
-30C	24+200		4.5"	bottom 1" stripping	45.5'	20' to curb	25.5'	0.25 miles short of Kawunchee	Sand Gravel w/silt
-29C	24+840		4.5"	incompetent	27.6'	13.8'	13.8'	0.1 miles short of toll booth	Sand Gravel w/silt
			@least two chip seals but some cracking evident beneath, uplifting rather than open space.						
-28C	25+400		4.5"	bottom 2" stripping	28.5'	13.7'	14.8'	cracks hid by chip seals	Sand Gravel w/silt
-27C	25+800		4.5"	bottom 1.5" stripping	32.8'	15.2'	17.6'	photo of measuring tape @edge & gutter uplifting 2"	Sand Gravel w/silt
-26C	26+200		4"	bottom 1" stripping	28.1'	14.5'	14.6'	cracks now evident beneath chip seals	Sand Gravel w/silt
-25C	26+600		4.5"	bottom 1" stripping	29.6'	14.3'	15.3'	Lt edge, old hacp shows lots of edge cracking that	Sand Gravel w/silt appears to go beneath chip sea
-24C	27+000		4.5"	poor	27.8'	13.8'	14'	high side of curve	Sand Gravel w/silt
-23C	27+400		4"	poor	28'				Sand Gravel w/silt
-22C	27+800		4"	bottom 0.5" stripping	27.6'	14' w/ 1' paved slope	13.6'		Sand Gravel w/silt
-21C	28+200		4"	Stripping 0.5" bot & 1.5" top	29.3'	fill slope	fill slope	no visible cracks	Sand Gravel w/silt

-20C	28+600	3"	bottom 1.5" stripping	29.1'	14.8' level ground out	14.3' c&g, rock cut gutter 3.3'	chip seal - hollow sound	Sand Gravel w/silt
-19C	29+000	4"	stripping 1" top & bottom each	28.5'	15'+1' paved slope	13.5'+5' gutter	crumbly beneath chip seal hollow sound	Sand Gravel w/silt
-18C	29+400	4"	begin strippi @bottom	29.7'	15.8'	13.9'	hollow sound	Sand Gravel w/silt
-17C	29+800	3.5"	poor	29.0'	15'	14'		Sand Gravel w/silt
-16C	30+200	3"	bottom 0.5" stripping	26.8'	11.3'+2' paved slope	13.5'+ 4' gutter & curb	cracks hid by chip seal	Sand Gravel w/silt -2" cobbles
-15C	30+600	4"	bottom 1.5" stripping	29.7'			couple of patches of chip no cracks	Sand Gravel w/silt
-14C	31+000	4.5"	bottom 0.5" stripping	30'			chip seal-hollow sound rt edge-old hacp w/ high severity edge cracking	Sand Gravel w/silt
-13C	31+400	**10.5"**	photos of rut & alligator	28.0'	ground cut up	rock cut up 3.5' gutter/curb	HACP-first 3" incompetent next 2" better, then good hacp	Sand Gravel w/silt
-12C	31+800	3.5"	stripping not very good	30.0'			small pop outs of chip seal	Sand Gravel w/silt
-11C	32+200	4.5"	bottom 1" stripping	28.0'	pullout	3.5' gutter/curb	@lt edge-two chips & old hacp- not smooth	Sand Gravel w/silt
-10C	32+600	4"	begin stripping	28.0'	level ground out	level ground out	chip seal-hollow sound	Sand Gravel w/silt
-9C	33+000	4"	bottom 1" stripping	34'	16'	13'+5' gutter		Sand Gravel w/silt
-8C	33+400	4"		28'			no real distress rough surface - high side of curve	Sand Gravel w/silt
-7C	33+800	3.5"	begin stripping	32.2'	EO, then down	16.7' c&g then up	real distress is uneven road surface	Sand Gravel w/silt

-6C	34+200	3.75"	bottom .25" stripping	30.0'	15.5' EO then down	14.5'+3.5 gutter /curb then up	no visible cracks	Sand Gravel w/silt
-5C	34+600	4"	bottom 1.5" stripping	28.0'		3.5' gutter/curb	photos of old distress & edges	Sand Gravel w/silt
-4C	35+000	3.5"	begin stripping	29.0'			no cracks - uneven surfaces	sandy gravel w/silt/clay still good material
-3C	35+400	4"		29.5'			darker material - petroleum smell 8" below hacp	lighter sandy gravel w/silt
-2C	35+800	3.75"		28.0'	level ground out	EO, 3' then slope		Sand Gravel w/silt
-1C	36+200	5"	high sever edge cracking	28.5'		3' paved gutter /curb	Old hacp beneath c.s. very cracked - Rt gutter running water from spring	
C1	36+600	4"		28.0'	pullout		rough surface - chip seal hid distress	
C2	37+800	3.5"		28.0'			minor rutting	
C3	38+200	4"		37.5'		widening for campground		Sand Gravel w/silt
C4	38+600	3.5"		28.5'	5' dirt pullout	4.8' paved ditch /curb		Sand Gravel w/silt
C5	39+000	4"		28.5'				Sand Gravel w/silt
C6	39+400	4.5"		28.5'	4' gutter	4' gutter/curb	8" below hacp, auger refusal fog/chip seal - no visible cracks	Sand Gravel w/silt
C7	39+800	4"		28.7'		4' gutter/curb		Sand Gravel w/silt
C8	40+200	4.5"		28.5'			moist 6" below hacp & then	Sand Gravel w/silt

							dried up	
C9	40+600	4"		42'		4' gutter/curb	widening for parking Colorado River Trailhead	Sand Gravel w/silt
LOGICAL BREAK FOR PROJECT								
C10	41+000	7"		26.0'	fill	fill	going up mountain old surface - no cracks	tan sandy gravel w/ more silt powder dry
C11	41+400	6"	bottom 1" stripping	25.7'	fill	fill	old chip seal - no cracks some pop outs	
C12	41+800	6.5"	bottom 1" stripping	25.0'		upslope	old chip seal - no cracks	
C13	42+220	6"		23.7	pullout		no cracks - pop outs snowplow?	sandy Gravel w/silt
C14	42+340	8"	bottom 1" stripping		stonewall	3' paved slope		sandy Gravel w/silt
C15	42+530	**16" KHAMIS**	bottom 4" stripping	26.0'	upslope	stonewall	Geotech Slide Area	sandy Gravel w/silt
C16	43+400	6"		27.0'	3' paved ditch then up	stonewall then down	8" below hacp, auger refusal photo of rock wall slide	sandy Gravel w/silt
C17	43+800	5.5"	bottom 1.5" stripping	24.5'	3' paved slope then up	downslope	dangerous switchback no cracks	sandy Gravel w/silt
C18	44+200	7"	bottom 2.5" stripping	24.5'	3' paved ditch	stonewall	Auger refusal @ 4' photo of rocks in ditch	sandy Gravel w/Silt dirtier material & drier
C19	44+600	6.5"			13.2' + 2' paved ditch & then up	18.0' stonewall then down	no cracks	sandy Gravel w/Silt dirtier material & drier
C20	45+000	6"	poor surface of hacp drilled soft - like no oil, crumbly	26.7'			chip seal on top of patch? high side of curve	

C21	45+400	5"		24.5'	11.5', 4" drop to shld & then down	3' paved ditch stonewall then up		sandy Gravel w/silt
C22	45+800	7"	bottom 2" stripping	24.5'	18" paved ditch then up	downslope	@ rock outcrop	sandy Gravel w/silt
C23	46+210	5.5"		33.8'				sandy Gravel w/silt
C24	46+600	7"		25.0'	6.5' paved ditch to stonewall		photo of drop inlet	sandy Gravel w/silt
C25	47+000	6"		24.0'				sandy Gravel w/silt
C26	47+400	5.5"		27.0'	18" paved ditch then up	stonewall	photo rockcut & stonewall	sandy Gravel w/silt
C27	47+800	6.5"		24.5"				sandy Gravel w/silt more fines - sand & silt
C28	48+200	6.5"		24.5'	3.5' paved ditch then upslope	EO, 1', dropoff	no real cracks	lighter brown sandy Gravel w/silt
C29	48+600	6.5"	bottom 2.5" stripping	24.5'	upslope	6" drop to shlder then dropoff	patch area, not normal hacp drilling just rocks	dry gravel w/silt
C30	49+000	6.5"		25.3'		stonewall	mica present	sandy Gravel w/silt
C31	49+400	6.5"	bottom 1" stripping	24.2'	4' paved ditch drop inlet	EO is drop off 6" drop to shlder		sandy Gravel w/silt
C32	49+820	6.5"		24.0'	4' paved ditch very minor cut area	pullout		sandy Gravel w/silt
C33	50+200	6.5"	bottom 1" stripping	24.0'	3' paved ditch minor cuts on both sides	5' paved ditch		sandy Gravel w/silt
C34	50+600	10"	bottom 4"	23.0'	18" paved ditch		high edge cracking	Sandy Gravel w/silt/clay

			stripping		then upslope			
C35	50+960	**8.5"**		26.7'	rock cut	stonewall 20' drop to pond	Milner Pass Area	Sandy Gravel w/silt
C36	51+400	**9"**		25.3'	Fill above marsh/pond; 7" drop to shlder material steep slope down 7'			Sandy Gravel w/clay slightly moist to moist
C37	51+800	**9.5"**	rt hillside has spring	24.5'	EO, 5' drop off	7.8' paved ditch then cut	pavement warming, left screw imprints in hacp	New Material - Sandy Gravel w/clay/silt-clayballs
C38	52+180	**10"**	bottom 3" stripping	24.5'	EO, 1' shlder then drop off	5" drop to shld mat 1' shld, then drop	pavement warmer, can shave it w/chisel	
C39	52+600	7"	bottom 1.5" stripping	24.5'	EO, down slope	3' paved ditch cut, upslope	pavement cool, stiff&brittle but otherwise like on top TR	
C40	53+000	6.5"		24.5'	EO, 1' shlder then drop off	3.5' paved ditch cut, rockface	auger refusal @ 3.5'	sandy Gravel w/silt
C41	53+400	**8.5"**	bottom 2.5" stripping	29.0'			fill area bridging a creek and culvert	
C42	53+800	6.5"		24.0'	EO is drop off	3.5' paved ditch minor cut, upslope		
C43	54+200	**9"**		24.5'	EO is drop off 5" drop to shld	4' paved ditch cut upslope		
C44	54+600	**10"**		24.5'	EO, 1' shlder drop off	4.5' paved gutter stonewall, upslope		
C45	55+000	6"		25.2'	EO, 1' shlder drop off	pullout	really tough scrapping below hacp this side of AVC	
C46	55+400	7"	bottom 0.5" stripping	24.5'	EO, 1' shlder drop off	5' paved ditch then upslope	spring between C47 & C46	
C47	55+800	**8"**		24.0'	EO is drop off	6.5' paved ditch then upslope		

C48	56+200	**10"**	bottom 2" strpping	25.0'	EO is drop off	7' paved ditch minor cut, upslope		
C49	56+600	**8"**	bottom 2.5" stripping	24.0'	EO is drop off	minor cut upslope	any cracks masked by new chip seal, switchback	sandy Gravel w/silt
C50	56+800	**10.5"**		curve widening			any cracks masked by new chip seal, switchback	sandy Gravel w/silt
C51	57180	6.5"		24.6'	minor cut upslope	EO is drop off	brand new chip seal so any cracks masked	Brown Sandy Gravel w/silt
Alpine Visitor Center								
C52	57+800	5"	bottom 3" stripping	26.4'	curb	EO, slopes away	@ snowgate high severity tranverse crk	
C53	58+200	7.5" **KHAMIS**		27.9'	curb, cut upslope	drop off	high severity transverse crk long - med; settlement	
C54	58+600	**8"**		24.0'	stonewall	drop off	settlement area surface seal popouts, patches	Sandy Gravel w/silt
C55	59+000	6"	bottom 1.5" stripping	27.0'			edge crk high, 30 " into mat trans crk - 25'	Sandy Gravel w/silt/clay
C56	59+300	6.5"	bottom 3.5" stripping	26.6'	curb	EO is drop off	patches, high trans, cl cracking	new color gravel Sandy Gravel w/silt
C57	59+800	5.5" **just passed KHAMIS**		26.8'	curb		settled area - trans crk	imported road mix; has ffaces
C58	60+200	6"	bottom 2" stripping	25.8'	4" drop to shld then drop off	curb, cut, upslope	high edge & trans crk	
C59	60+600	**11.5"**	bottom 3" stripping	30.9'	curb, cut upslope	12" drop to shld then drop off	high edge & trans crk; mica present	hard hacp
C60D	60+870	6.75"					Lava Cliffs Roadway	

								soft hacp - no cracks
C60C	60+910	2.75"					Lava Cliffs Parking Area	
C60B	60+960	3"					Lava Cliffs Parking Area mica present	Sandy Gravel w/silt soft hacp - trans crk
C60A	60+980	**8"**	patches & patches	28.2'		curb	start Lava Cliffs Parking Area	Sandy Gravel w/silt
C60	61+000	**8.5"**		31.4'	EO is tundra	3.4' gutter	just before Lava Cliffs	dark Sandy Gravel w/silt soft hacp - begin trans & cl crk
C61	61+400	6"		31.6'	4' gutter/curb		just before switchback	soft hacp
C62	62+800	5.5"	bottom 2" stripping	38.0'	stonewall	curb	high side of switchback	Gravelly Sand w/silt
C63	62+150	**10"**		27.7'	tundra	stone lined ditch		lt brown Sandy Silt w/small grav soft hacp
C64	62+620	6"		26.5'	EO, small ditch tundra	tundra	no real cracks the next 4 or 5 miles	Sandy Gravel w/silt
C65	63+000	7"		26.5'	3.7' gutter/curb	EO is drop off		soft hacp
C66	63+400	6.5"		30.5'	6' fill	6' fill	fill area - road mix med trans & low long crk	cobbles @ 2' soft hacp
C67	63+800	7.5"		32.4'	curb	stonewall	very fine & tender mix shaving w/chisel	Sandy Gravel w/silt
C68	64+180	6.8"					Rest Area low trans crk here & there	Sandy Gravel w/silt
C69	64+600	6.0"	bottom 1.5" stripping	29.8'	curb	EO is drop off	just past Rock Cut	Sandy Gravel w/silt

C70	65+000	6.5"		28.2'	2' fill above tundra			Sandy Gravel w/silt
C71B	65+400	6"	bottom 1' stripping	24.8'	4' gutter/curb	pullout hacp is 2"	correct stationing	darker Sandy Gravel w/silt
C71A	65+500	7"	bottom 3" stripping	28.5'	ditch		Patch Area	
C72	65+800	6"		28.5'	3.4' gutter/curb	EO is drop off		darker Sandy Gravel w/silt
C73	66+200	6"	bottom 1" stripping	27.7'	2.7' gutter/curb	EO is drop off	break in material at 2.5' depth lighter color & less clay/silt	Sandy Gravek w/silt
C74	66+600	5.0"		30.0'	5' gutter/curb		just before dip	
C74B	66+920	**10"**	bottom 2" stripping	27.4'	4.6' gutter/curb	EO is drop off	just past dip	silty Sand w/gravel a little clay in the silt
C75	67+000	6.5" **KHAMIS**		23.4'	2.8' gutter/curb	EO is drop off to tundra	just past settled area	darker brown silty(clayey) Sand w/small gravel
C76	67+400	5.5"		23.0'	18" paved slope to tundra	EO is drop off 4' to tundra	past Khamis settled area	
C77	67+800	**12"**	top 1" crumbly	26.0'	2' guttercurb	EO is drop off 4' to tundra		
C78	68+200	6"	bottom 1.5" stripping	23.4'	2.8' gutter/curb	EO is drop off		
C79	68+600	5.5"	bottom 1.5" stripping	22.0'	3.5' gutter/curb	1' paved slope 1' drop off	Switched-cross the ridge line med trans cracking	
C80	69+000	6.5"	bottom 1" stripping	25.0'	paved 1' slope to tundra	paved 4' slope to tundra	Ute Trail oil stained	darker silty sand w/small gravel @2.5' to 5' cobbles
C81	69+400	5.5"	bottom 1" stripping	24.5'	pullout - 2" hacp	6' gutter/curb		silty sand w/gravel

C82	69+800	6"	bottom 2" stripping	28.7'	EO is drop off	4' gutter/curb	no real cracks super - high side	silty sand w/small gravel
C83	70+200	7.5"	bottom 1" stripping	24.2'	EO is drop off	curb	no real cracks patching - snowplow damage?	silty sand w/gravel
C84	70+600	5.5"	bottom 2" stripping	24.7'	EO is drop off	minor cut, upslope	auger refusal @ 11'	silty sand w/gravel
C85	71+000	6"		25.0'	EO is drop off	EO is drop off	low cl,trans,edge crk	silty sand w/gravel
C86	71+400	4"	bottom 1" stripping	25.7'	EO is drop off	curb	auger refusal @ 1' photo 14 - drop off	Material change - fill brown gravelly base
C87	71+820	6"		25.9'	stonewall	curb, upslope big boulders	tremendous boulder area	fill - brown gravelly base
C88	72+200	6.5"	bottom 1" stripping		major overlook	c & g, rock face	Rainbow Curve auger refusal @ 1.5'	
C89	72+600	6.5"	bottom 1" strippping	26.0'	stonewall	short gutter/curb major rock cut	auger refusal @ 1.5'	
C90	72+960	6.5"		27.0'	EO, 2.5' shlder then drop off	gutter/curb cut upslope		Gravelly silt w/sand very dry
C91	73+420	5.5"		29.5'	stonewall, drop	gutter/curb cut rock face	auger refusal @ 2' photo 13 - failed wall area	hacp is 1' @ wall failure
C92	73+800	6.5"		28.6'	4' shld - drop off	gutter/curb cut uphill	fairly moist gravelly @ 11"	
C93	74+260	7.5"	high rutting shoving	24.9'	2' shld - drop off	4.4' stone gutter 20" stone retaining w	Above Hidden Valley photo 12	more moist - cobbles @ 2.5'
C94	74+580	5.25"		27.6'	3.5' shldr then drop off	curb, cut upslope	photo 11 - pavement drop off	
C95	74+960	6.5"		25.6'	stonewall	c & g	moisture damage between	drier silty sand w/gravel

						then cut upslope	C95 & C96	
C96	75+300	5.5"		28.9'	5' shldr then drop off	gutter/stonewall to begin curb	new wall, probably had a slide	more moist, gravelly sand w/silt
C97	75+700	**8"**	bottom 1" stripping	27.0'	pullout		pullout is 4" hacp w/orginal 2.5" hacp	more moist, gravelly sand w/silt silt not sticky together too well
C98	76+160	5.5"		27.1'	4' shldr then drop off	gutter/curb cut upslope		very dry - silty sand w/1.5" gravel
C99	76+500	**8.75"**		28.1'	5' shldr then drop off	cut upslope	med trans cracks	silty sand w/gravel cobbles @ 20"
C100	76+900	5"		27.0'	3' shldr then drop off	gutter/curb cut upslope	road in pretty good shape here @ least one overlay	silty sand w/ fine gravel moisture varying last 2/3 miles
C101	77+340	6.5"	bottom 3" stripping	27.8'	6' shldr then drop off	upslope	photo 10 edge drain	darker silty sand w/fine gravel but on a crack
C102	77+740	6"	bottom 1" stripping	27.8'	2.5' shldr then drop off	c & g cut upslope		dry silty sand w/small gravel
C103	78+120	6"		34.7'	pullout/stonewall	curb/rock face		silty sand w/gravel
C103B	78+120	4.75"	bottom 2" sever stripped				Pullout	silty sand w/gravel
C104	78+580	7.5"		27'	gutter/curb	2' shldr then drop off	@ Snowgate photo 8 - Many Parks wall	silty sand w/gravel
C105	79+160	7"		31'			just past Many Parks photo 7 - overlay & wall	silty sand
C106	79+420	5.5"		31.3'				
C107	79+800	6.5"		27.7'				

C108	80+200	6.5"		27.7'	
C109	80+640	6"		31.1'	
C110	80+020	**9.75"**	bottom 3.5" stripped	26.5'	
C111	81+350	**8"**	bottom 4.5" stripped	26.7'	shoving @ high sever trans crk
C112	81+800	6"		26.5'	
C113	82+200	7"	bottom 3" stripped	26.5'	
C114	82+640	6"		25.7'	
C115	82+900	**8.5"**	bottom 2" stripped	24.7'	
C116	83+400	**8.5"**	bottom 2" stripped	26.5'	
C117	83+800	**9"**		25.6'	
C118	84+220	7"	**bottom 5" stripped**	27.7'	
C119	84+620	**8"**		27.5'	high rutting & trans crk
C120	85+070	7.5"		24.0'	

ROMO ASPHALT THICKNESS FOR THE LAST SECTION OF THE FWD TESTING
8/11/2003

FHWA LOCATION #	MP from Deer Ridge Junc.	Asphalt Mat Thickness	
C120	0.1	7.5"	
C119	0.35	8"	
C118	0.6	7"	
C117	0.85	9"	
C116	1.1	8.5"	bottom 2" stripping
C115	1.35	8.5"	bottom 2" stripping
C114	1.6	6"	
C113	1.85	7"	bottom 3" stripping
C112	30' past FWD 36	6"	
	2.1		
C111	opposite lane to FWD 40	8"	bottom 4 to 5" stripping
	2.35		
C110	@FWD 42	9.75"	bottom 3 to 4" stripping
	2.6		
C109	2.85	6"	
C108	3.1	6.5"	
C107	3.35	6.5"	
C106	3.6	5.5"	
C105	3.85	7"	
C104	4.1	7.5"	
	@snowgate of Many Parks		

Base course was all a native silty sand with gravel. Very consistent, just the amount of silt or the size of the grav

CO PR ROMO 10(3) TRAIL RIDGE ROAD

Haramy/ Martinez 2000 *Three Slump Areas*

00P-101	1.6 miles east of Alpine Visitor Center 3.0m R	0-0.2 m HACP	0.2-2.5m Gray brown silty Sand and rock fragments
00P-102	1.48 miles east of Alpine Visitor Center 2.9m R	0-0.5m HACP	0.5-2.5m Brown silty Sand and rock fragments
00P-103	1.45 miles east of Alpine Visitor Center 3.0m R	0-0.5m HACP	0.5-4.25m Brown silty Sand and gravel -size rock fragments
00P-104	1.48 miles east of Alpine Visitor Center 2.5m R	0-0.5m HACP	0.5-4.8m Brown silty Sand and rock fragments
00P-105	0.45 miles east of Alpine Visitor Center 3.0m R	0-0.125m HACP	0.125-4.0 yellow brown silty Sand and rock fragments
00P-106	04 miles east of Alpine Visitor Center 4.0m R	0-0.275m HACP & base course	0.275-4.5 Yellow brown silty Sand and rock fragments
00P-107	0.3 miles east of Alpine Visitor Center 3.8m R	0-0.30m HACP & base course	0.30-2.0m yellow brown silty Sand and rock fragments
00P-108	5.85 miles east of Alpine Visitor Center 2.0m L	0-0.25m HACP & base course	0.25-6.45m Yellow brown silty Sand and rock fragments
00P-109	5.85 miles east of Alpine Visitor Center 2.0 R	0-0.25m HACP & base course	0.25-4.95 Yellow brown silty Sand and rock fragments

Blenk/Folkman 1981 *23 miles beginning 0.3 miles west of Hidden Valley Ski Area for 25 miles, with one 2-mile section skipped, 12.45 to 14.45 miles*

	Boring	Milepost	R	Class	PI	LL	MC	
4	B-3 #1	0.9	69	A-1-b	NP	NV	8.1	
4½	B-9 #2	3.4	69	A-2-4	NP	NV	9.2	
6½	B-11	4.15	57	A-1-b	2	31	10.6	had substantial amount of wood fragments
3	B-16 #3	6.15	66	A-1-b	NP	NV	7.6	
6	B-23 #4	8.85	61	A-1-b	NP	NV	8	
3½	B-26	9.98	64	A-1-b	2	31	8.6	
—	B-31 #5	12.18	66	A-1-b	NP	NV	9.5	
3	B-34	15.3	53	A-1-b	NP	NV	8.9	
2	B-37	16.5	52	A-1-b	NP	NV	8.9	
2½	B-38	16.9	58	A-2-4	NP	NV	9.1	
4½	B-44	19.7	57	A-1-b	NP	NV	7	
2½	B-49	21.65	51	A-1-b	6	26	7.2	
4½	B-52	22.4	32	A-1-b	4	26	7.7	
2½	B-57	24	51	A-1-b	3	23	7.4	

Used 'R' of 60 for MP 0.0 to 12.45

Used 'R' of 50 for MP 14.45 to ~~18.75~~ 25.15

Ave HACP	4"	5"	3"	4½"	4"	4"	3"	3½"	2½"
Area A:	Sect. 1	Sect 2	Sect 3	Sect 4	Sect 5	Sect 6	Area B: Sect 7	Sect 8	Sect 9
Required depth	3½"	4½"	2½"	4"	3½"	3½"	Existing Pavement 3"	3½"	2½"
Overlay req'd	2¼"	2"	2¾"	2"	2¼"	2¼"	Overlay 2½"	2"	3"
	5¾	6½	5"	6"	5¾"	5¾"	5½"	5½"	5½"

Wolf/Blenk 1979 *17.7 kilometers beginning at Grand Lake entrance and extends to 177+28.476*

Used 'R' of 60

Test Pit	Station	R	Class	PI	LL	MC
BK-1	5+80	70	A-1-a	NP	NV	6.5
BK-2	11+06	70	A-1-a	NP	NV	8.6
BK-4	23+00	75	A-1-a	NP	NV	8.4
BK-5	28+60	70	A-4	NP	NV	9.2
BK-6	32+00	64	A-1-a	NP	NV	8.3
BK-8	43+82	72	A-1-a	NP	NV	7.8
BK-10	55+80	65	A-1-a	NP	NV	8.5
BK-11	62+40	62	A-1-a	NP	NV	9
BK-12	68+40	48	A-2-4	NP	NV	10.5
BK-13	75+00	64	A-1-b	NP	NV	9.3
BK-14	77+93	58	A-1-b	NP	NV	12.7
BK-15	81+20	39	A-4	10	38	19.9
BK-16	87+80	69	A-1-a	NP	NV	7.2
BK-17	94+20	62	A-1-a	4	27	9.2
BK-18	100+00	74	A-1-a	NP	NV	7.7
BK-19	110+69	71	A-1-b	NP	NV	8.4
BK-20	116+20	72	A-1-a	NP	NV	7.9
BK-22	130+00	68	A-1-a	NP	NV	8.5
BK-26	156+64	60	A-1-a	3	25	8.9
BK-28	176+00	75	A-1-a	NP	NV	7.5

Deer Ridge - 'R' of 67
A-1-b (0)
NP
NV

CO PR ROMO 10(3) TRAIL RIDGE ROAD

Haramy/ Martinez 2000 *Three Slump Areas*

20+400	00P-101	1.6 miles east of Alpine Visitor Center 3.0m R	0-0.2 m HACP	0.2-2.5m Gray brown silty Sand and rock fragments
20+200	00P-102	1.48 miles east of Alpine Visitor Center 2.9m R	0-0.5m HACP	0.5-2.5m Brown silty Sand and rock fragments
20+165	00P-103	1.45 miles east of Alpine Visitor Center 3.0m R	0-0.5m HACP	0.5-4.25m Brown silty Sand and gravel -size rock fragments
20+200	00P-104	1.48 miles east of Alpine Visitor Center 2.5m R	0-0.5m HACP	0.5-4.8m Brown silty Sand and rock fragments
58+560	00P-105	0.45 miles east of Alpine Visitor Center 3.0m R	0-0.125m HACP	0.125-4.0 yellow brown silty Sand and rock fragments
58+475	00P-106	04 miles east of Alpine Visitor Center 4.0m R	0-0.275m HACP & base course	0.275-4.5 Yellow brown silty Sand and rock fragments
58+310	00P-107	0.3 miles east of Alpine Visitor Center 3.8m R	0-0.30m HACP & base course	0.30-2.0m yellow brown silty Sand and rock fragments
27+245	00P-108	5.85 miles east of Alpine Visitor Center 2.0m L	0-0.25m HACP & base course	0.25-6.45m Yellow brown silty Sand and rock fragments
27+245	00P-109	5.85 miles east of Alpine Visitor Center 2.0 R	0-0.25m HACP & base course	0.25-4.95 Yellow brown silty Sand and rock fragments

Blenk/Folkman 1981 80+840 *23 miles beginning 0.3 miles west of Hidden Valley Ski Area for 25 miles, with one 2-mile section skipped, 12.45 to 14.45 miles*

	Boring	Milepost	R	Class	PI	LL	MC	
79+390	B-3	0.9	69	A-1-b	NP	NV	8.1	
75+370	B-9	3.4	69	A-2-4	NP	NV	9.2	
74+160	B-11	4.15	57	A-1-b	2	31	10.6	had substantial amount of wood fragments
70+940	B-16	6.15	66	A-1-b	NP	NV	7.6	
66+600	B-23	8.85	61	A-1-b	NP	NV	8	
64+780	B-26	9.98	64	A-1-b	2	31	8.6	
61+240	B-31	12.18	66	A-1-b	NP	NV	9.5	
56+220	B-34	15.3	53	A-1-b	NP	NV	8.9	
54+290	B-37	16.5	52	A-1-b	NP	NV	8.9	
53+640	B-38	16.9	58	A-2-4	NP	NV	9.1	
49+140	B-44	19.7	57	A-1-b	NP	NV	7	
46+000	B-49	21.65	51	A-1-b	6	26	7.2	
44+790	B-52	22.4	32	A-1-b	4	26	7.7	
42+220	B-57	24	51	A-1-b	3	23	7.4	

15.25 57+590

17.25 60+810

Wolf/Blenk 1979 *17.7 kilometers beginning at Grand Lake entrance and extends to 177+28.476*

	Test Pit	Station	R	Class	PI	LL	MC
23+975	BK-1	5+80	70	A-1-a	NP	NV	6.5
24+501	BK-2	11+06	70	A-1-a	NP	NV	8.6
25+695	BK-4	23+00	75	A-1-a	NP	NV	8.4
26+255	BK-5	28+60	70	A-4	NP	NV	9.2
26+595	BK-6	32+00	64	A-1-a	NP	NV	8.3
27+777	BK-8	43+82	72	A-1-a	NP	NV	7.8
28+975	BK-10	55+80	65	A-1-a	NP	NV	8.5
29+635	BK-11	62+40	62	A-1-a	NP	NV	9
30+235	BK-12	68+40	48	A-2-4	NP	NV	10.5
30+895	BK-13	75+00	64	A-1-b	NP	NV	9.3
31+189	BK-14	77+93	58	A-1-b	NP	NV	12.7
31+575	BK-15	81+20	39	A-4	10	38	19.9
32+175	BK-16	87+80	69	A-1-a	NP	NV	7.2
32+815	BK-17	94+20	62	A-1-a	4	27	9.2
33+395	BK-18	100+00	74	A-1-a	NP	NV	7.7
34+464	BK-19	110+69	71	A-1-b	NP	NV	8.4
35+015	BK-20	116+20	72	A-1-a	NP	NV	7.9
36+395	BK-22	130+00	68	A-1-a	NP	NV	8.5
39+059	BK-26	156+64	60	A-1-a	3	25	8.9
40+995	BK-28	176+00	75	A-1-a	NP	NV	7.5
39+800			41	A-1-b	2	24	5.1

APPENDIX G

FALLING WEIGHT DEFLECTOMETER – GROUND ENGINEERING CONSULTANTS, INC.

CO PRA ROMO 10(3) Trail Ridge Road

Nondestructive Deflection Testing and Pavement Evaluation
Rocky Mountain National Park
Trail Ridge Road, Bear Lake Road, Fall River Road
Larimer County, Colorado

Prepared for:

Federal Highway Administration
Central Federal Lands Highway Department
Denver Federal Center, Building 52
Lakewood, Colorado 80225

Attention: Mr. Michael Voth

Job Number 03-3235 **September 15, 2003**

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Average Resilient Modulus Calculations	Appendix B

SUMMARY

GROUND Engineering Consultants, Inc. (GROUND) has completed the nondestructive deflection testing (NDT) program for the requested portions of **Trail Ridge Road, Bear Lake Road, and Fall River Road**, located within the Rocky Mountain National Park in Larimer County, Colorado.

Four (4) roadway segments, totaling approximately 6.9 miles (11.1 km) were evaluated using a 2003 JILS Falling Weight Deflection machine.

A detailed discussion of the testing program, analysis, and specific information for various segments of the roadway alignment that was analyzed is presented herein.

PURPOSE AND SCOPE OF STUDY

This report presents the results of a nondestructive deflection testing program and pavement evaluation for 4 roadway segments totaling approximately 6.9 miles of Trail Ridge Road (or adjacent roadways) within Rocky Mountain National Park. The purpose of this testing was to evaluate the moduli and deflection data of several foamed sections that were constructed within the last few years, as well to complete an FWD survey on an approximate 5-mile section where historical R-value data does not exist.

Nondestructive deflection testing (NDT) through the use of a 2003 JILS Falling Weight Deflectometer (FWD) was performed along the requested segments of roadway alignments. In accordance with the project documents, a NDT evaluation of the pavement condition was performed at a minimum frequency of approximately one test location for every 100 meters.

This report has been prepared to summarize the data obtained and to present our conclusions and recommendations based on the data obtained from the NDT program and the information provided by the Central Federal Lands Highway Department.

PROJECT LIMITS/EXISTING PAVEMENT SECTIONS

The limits of this evaluation consist of the following:

- Bear Lake Road, from the Moraine Museum Entrance North approximately 1 km.
- Bear Lake Junction North to 3M approximately 4.2 km.

- Deer Ridge Junction to Horseshoe Overlook approximately 1.2 km.
- Deer Ridge Junction to 3M approximately 4.7 km.

The existing pavement sections along with (visual) subsurface data to a depth of approximately 0.5 meters were provided by the Central Federal Lands Highway Division. We understand that the majority of the existing pavement sections were originally constructed approximately 70 years ago, with occasional maintenance consisting of patching, crack sealing, overlays and replacement performed on an as-needed basis.

The surface of the pavement sections observed were in variable condition, ranging from new-looking pavement to pavement with minor to moderate rutting and/or shoving.

NONDESTRUCTIVE DEFLECTION TESTING

A nondestructive deflection testing (NDT) program was performed using a 2003 JILS Falling Weight Deflectometer (FWD). Evaluation of the pavement sections' effective structural capacity can be performed through the use of dynamic impulse loads and the subsequent measurement of the deflection basin. Using the measured deflection basin, the resilient modulus values of the in-situ base course and subgrade materials, as well as the effective pavement layers are estimated. The Falling Weight Deflectometer (FWD) has the capability of adjustable loads ranging from approximately 6,000 pounds to 40,000 pounds. For this testing, it was specified that each test point is to be subjected to dynamic impulse loads of 6,000 pounds, 9,000 pounds, and 12,000 pounds. The actual loading was increased to include 15,000 pounds because negligible to no readings were obtained at the outer sensors under lesser loadings (likely the result of periodic rock formations near the surface under portions of the roadway alignments). The individual load was transmitted to the pavement through a set of springs and a 12-inch diameter rigid plate. Seven geophones were used to measure the deflection basin at offsets of 0, 8, 12, 18, 24, 36 and 60 inches.

The deflection tests were performed along the roadway segments at a spacing of no greater than 100 meters for each lane. Areas that yielded high deflections or other variable results were tested more frequently, generally on 25 or 50 meter centers. The deflection tests were generally performed in the outer wheel path of each travel lane evaluated.

During the deflection testing, a calibration sequence was performed periodically to maintain the desired "target" loads. As pavement temperatures increase, a reduction in

the pavement section stiffness is observed and the actual force imposed on the pavement decreases. This necessitates the use of periodic calibration throughout the day.

Pavement temperature was determined automatically at each test location, with the pavement temperatures input directly into the data file by the JILS computer software. Ambient temperatures and general directional bearings were recorded in the general notes at each test location.

In addition, the loadings and deflection basins were shown graphically "real time" during the testing. Occasionally, anomalies or discontinuities were observed in the test data and retesting was performed.

ANALYSIS

When the deflection testing was completed, the raw data was converted to both an .FWD file and .PDDX file format for additional analysis and modulus determination. The computer software, DAPS 1.5.1 (Deflection Analysis of Pavement Structures), designed by Abatech, Inc., was used for back calculation of the effective modulus of the asphalt (including the foamed asphalt section), granular base, and subgrade. The DAPS program requires that the thickness, density, and void ratio is input for each of the pavement section layers. A correction factor is applied to correct the results to a mean temperature of 68 degrees Fahrenheit. A detailed discussion of the inputs used is included in Appendix A.

The DAPS program calculates the modulus of each pavement layer, as well as the percentage of error for each deflection basin. The percentage of error is calculated as the Root Mean Square error divided by the maximum deflection. Errors of less than 4 percent indicate that the data obtained resulted from a satisfactory deflection basin, (an accurate test). As shown in the data for this project, 2 of the 255 tests contained errors of 4.55 and 4.56 percent; all others had errors less than 4 percent, with the average error of less than 1.0 percent. This information is presented in Appendix E: Summary of Test Results and Calculated Modulus Values.

The results of the modulus calculations generated by the computer software were exported to Microsoft Excel™ for further manipulation. The modulus for the asphalt, base course, and subgrade were converted from Metric to English units and separated by location. For this purpose, the data was analyzed for each roadway segment. The average modulus for the pavement, base course, and subgrade was evaluated at the

15,000 pound target loading in each lane of analysis. Typically, a comparison would made for each test location between the four individual loads of 6,000 pounds, 9,000 pounds, 12,000 pounds and 15,000 pounds, and the average percent deviation was also calculated. However, the variability of the asphalt sections and the "0" deflection results at the outer sensors (because of the stiff subgrade) did not allow for a complete comparison (the majority of the tests at lower loading yielded "0" deflections in the sixth and seventh sensor which did not allow for complete calculation). In addition, there was significant variability in the pavement sections. Calculation of every loading cycle for the variable core results would require significant additional analysis, and based on the variable pavement section, does not yield additional useful information (this was attempted for one of the smaller analyzed sections).

The foamed asphalt exhibited a modulus similar to that of pavement, and distinguishing between the two was not possible during the analysis. As shown, the modulus values obtained are consistent with conventional asphalt.

The average resilient modulus of the base material was often lower than that of the subgrade. Many times, the modulus of the subgrade exceeded one million psi. This is likely due to rock cuts and dense cobbles/rock fragments which compose the subgrade throughout many of the roadway alignments. In addition, it may be the result of the gradual contamination of the base course with fine material that has propagated upward.

During the analysis, the calculated modulus values of the asphalt and foamed asphalt (which were treated as one section) are sensitive to the assumed asphalt thickness. Based on the variability of the pavement sections (as exhibited in the core data provided by CFLHD), it is not possible to ensure that all calculated modulus values are perfectly accurate since the pavement section changes frequently. During one trial of the analysis, the deflection data was analyzed using the same pavement section for each test point, the procedure was repeated for every different pavement section. The resulting modulus data from each assumed pavement section were then compared to the one another. General trends and general ranges of results were identified and some judgment was exercised in selecting the modulus used in the final analysis. For example, although a test may be near an area where the asphalt core was 8.5-inches, but the modulus values appear much more reasonable using an assumed asphalt thickness of 9.5 inches, then the modulus values used were the more reasonable ones. Based on the variability of the pavement sections, this approach appears reasonable and resulted in more consistent modulus data.

RESULTS AND CONCLUSIONS

The following table presents the general structural characteristics of the pavement sections and underlying subgrade materials determined for the subject roadway alignments that were evaluated using nondestructive testing:

Section	Average Asphalt Modulus *(psi)*	Average Base Course Modulus *(psi)*	Average Subgrade Modulus *(psi)*
Moraine Museum N. on Bear Lake Road	498,592	25,486	998,923
Deer Ridge Junction to Horseshoe Overlook on Fall River Road	230,752	8,521	81,684
Bear Lake Junction to 3M on Trail Ridge Road	389,083	9,345	59,891
Deer Junction to 3M on Trail Ridge Road	269,149	24,232	60,684

As shown, the average modulus varies significantly from one section of roadway to another. The subgrade modulus of the first section (Bear Lake Road from Moraine Museum Entrance North) is extremely high, likely the result of the rock cuts that underlie the roadway alignment. It is possible that these shallow rock formations also influenced the modulus values calculated for the asphalt/foamed asphalt section, as the modulus for the asphalt at this location was very high.

This report only addresses the structural capacity of the pavement sections at the areas tested. With the high frequency of testing, it is assumed that general trends have been identified with respect to the pavement section structural characteristics, however, it is possible that additional areas exist that will exhibit different characteristics that have not been identified in this report.

Additional Considerations: The performance of the pavement throughout the remaining life will be influenced by changes in the subgrade moisture content and the traffic loads,

especially at areas where heavy trucks perform sharp turning motions. As in most mountainous regions, excessive runoff may occur from snowmelt or rain. This may result in soft and yielding subgrade areas and may require additional maintenance throughout the design life, especially if some of the seasons are subjected to more precipitation than usual. It is important that routine maintenance is performed to seal cracks, repair distressed areas and thin overlays may be required throughout the remaining life of this pavement structure in order to maintain acceptable performance of the pavement. Additionally, care should be taken during the proposed construction so that excessive turning motions of the construction equipment does not negatively impact the pavement.

LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical and pavement engineering practices in this area for use by the client for design purposes. The conclusions and recommendations submitted in this report are based upon the data obtained from the NDT test results, our on-site observations and the information provided by the client. If the referenced data used in the analysis appears to be inconsistent with the subject project, this office should be advised at once so that reevaluation of the conclusions may be made.

Sincerely,

GROUND ENGINEERING CONSULTANTS, INC.

ANDREW SUEDKAMP, P.E.

Reviewed by Richard J. Suedkamp, P.E.

Appendix A

Input Parameters

The Deflection Analysis of Pavement Structures (DAPS) computer software, version 1.5.1, by Abatech, Inc. is a Windows-based software package specifically designed to provide back-calculation of the stiffness moduli (resilient modulus) of the layers within a pavement system.

Prior to the back-calculation procedure, the user must input information for each pavement layer. For this project, the following data was used:

Material Layer	Void Ratio	Density (kn/mcu)
Asphalt	0.3	24
Base Course	0.4	22
Subgrade	0.45*	20**

* This value was adjusted from 0.4 to 0.45 with only negligible changes to the resulting asphalt, base course, and subgrade modulus values.
** This value was adjusted from 20 to 22 kn/mcu with only negligible changes to the resulting asphalt, base course, and subgrade modulus values.

In addition, the user is allowed to change specific thicknesses from one pavement segment to the next, by selecting specific stations that were recorded during the testing. For example, the user can input that from station 0.0 km to 1.6 km the pavement thickness is 150 mm, the granular base is 230 mm and the subgrade is a thickness of 3 meters (underlain by bedrock), and then the section changes from station 1.6 km to 3.2 km to consist of 160 mm of asphalt, 200 mm of granular base, and 5 meters of subgrade (underlain by bedrock).

The layer thickness information was adjusted according to the information provided by CFLHD in the summary report prepared for this project. In order to account for possible deviations in the asphalt, base, and subgrade thickness, the back-calculation was performed using various combinations of each that were within 5 to 10 percent of the thickness information provided in the summary of the borings performed by CFLHD. This was performed to incorporate an additional Factor of Safety. The depth to bedrock (subgrade thickness) was adjusted from 1 meter below the existing pavement surface to over 10 meters below the existing pavement surface. The resulting modulus values using various combinations of thicknesses outlined above were not observed to change by more than 1 to 2 percent.

The pavement temperature was corrected to 68 degrees Fahrenheit for the analysis, which incorporated a correction factor of approximately 1.0 to 2.0 (for pavement temperatures over 120 degrees Fahrenheit, the correction of 2.0 was applied in the analysis).

Appendix B

Asphalt, Base Course and Subgrade Resilient Modulus Calculations

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DEFLECTION DATA

Project Location: From Entrance to Moraine Park Museum, North on Bear Lake Road

Location or Comments	Station (km)	Test Number	Press Mpa	Force lbs.	Deflection (Microns) d1	d2	d3	d4	d5	d6	d7	E1 Mpa	E1 psi	E2 Mpa	E2 psi	E3 Mpa	E3 psi	Error (%-RMS)
Museum Entrance	0.000	1	0.729	11959	332	287	250	206	169	114	79	3841	557,099	7	1,036	11300	1,638,952	0.55
heading North	0.040	2	0.726	11909	260	231	206	175	148	107	77	6239	904,905	8	1,124	34500	5,003,880	0.43
72 Degrees	0.060	3	0.721	11827	323	263	228	188	156	110	80	3262	473,120	25	3,582	340	49,314	0.48
	0.124	4	0.736	12073	266	221	189	150	119	77	54	3969	575,664	10	1,450	15000	2,175,600	0.56
	0.240	5	0.724	11877	225	163	125	90	65	34	22	4136	599,885	55	8,006	554	80,352	1.41
	0.342	6	0.738	12106	198	123	89	60	45	28	22	2406	348,966	245	35,535	658	95,436	0.75
77 degrees	0.350	6	0.721	11827	267	176	127	87	64	37	26	2187	317,202	120	17,405	465	67,444	1.00
	0.370	7	0.738	12106	166	102	75	54	41	25	16	2710	393,058	431	62,512	744	107,910	1.38
	0.550	8	0.721	11827	157	126	99	72	53	30	19	4769	691,696	18	2,640	53900	7,817,656	0.74
	0.665	9	0.749	12287	130	92	73	56	44	30	23	4063	589,298	166	24,077	866	125,605	0.48
	0.770	10	0.732	12008	188	138	109	76	53	27	19	3334	483,563	19	2,770	42500	6,164,200	1.12
81 degrees	0.866	11	0.905	14846	194	143	111	80	62	39	25	3066	444,693	46	6,672	715	103,704	0.79
84 degrees	0.953	12	0.9	14764	259	182	140	96	67	34	20	2871	416,410	35	5,076	601	87,169	1.55
	0.970	13	0.903	14813	306	226	181	129	90	49	31	2865	415,540	25	3,611	470	68,169	1.07
	0.991	14	0.908	14895	278	200	145	90	63	33	21	2484	360,279	27	3,873	791	114,727	0.85
	1.005	15	0.921	15108	210	141	114	79	56	32	22	3086	447,593	88	12,807	578	83,833	1.79
	1.024	16	0.883	14485	380	321	271	213	165	103	69	3981	577,404	7	965	41800	6,062,672	0.41
Heading Back, South	0.000	17	0.907	14878	242	194	156	117	89	54	36	4541	658,627	23	3,278	701	101,673	0.63
Toward Moraine Museum	0.021	18	0.9	14764	271	200	164	122	91	51	33	3295	477,907	50	7,252	362	52,504	1.46
	0.037	19	0.915	15010	294	202	152	107	79	47	34	2284	331,271	117	16,970	367	53,230	0.80
	0.131	20	0.911	14944	159	120	101	80	63	40	27	4667	676,902	65	9,413	625	90,650	0.82
	0.229	21	0.908	14895	206	150	122	91	69	42	28	3030	439,471	46	6,730	599	86,879	0.98
	0.341	22	0.91	14928	172	131	108	82	65	41	29	4242	615,260	33	4,743	1110	160,994	0.73
	0.443	23	0.939	15403	218	151	115	78	55	29	20	3113	451,510	53	7,687	682	98,917	1.35
	0.545	24	0.913	14977	188	112	82	53	37	19	16	2445	354,623	104	15,084	956	138,658	1.94
	0.648	25	0.889	14583	259	203	169	129	99	58	36	4298	623,382	34	4,989	378	54,825	0.96
	0.747	26	0.914	14993	216	164	134	97	71	37	24	4653	674,871	26	3,728	814	118,063	1.16
	0.851	27	0.899	14747	350	281	232	178	134	75	43	3532	512,281	15	2,103	364	52,795	0.87
	0.957	28	0.917	15042	281	225	187	151	121	85	62	3781	548,396	80	11,661	310	44,962	0.56
	0.999	29	0.893	14649	342	264	215	170	133	89	61	2626	380,875	110	15,954	233	33,794	0.53
84 degrees	1.016	30	0.902	14796	378	231	195	154	121	79	57	788	114,292	3360	487,334	221	32,054	0.45
											average		498,582		25,486		998,923	0.92

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DEFLECTION DATA

Project Location: Fall River Road - Deer Ridge Junction to Horseshoe Overlook

Location or Comments	Station	Test Number	Press Mpa	Force lbs.	Deflection (Microns) d1	d2	d3	d4	d5	d6	d7	E1 Mpa	E1 psi	E2 Mpa	E2 psi	E3 Mpa	E3 psi	Error (%-RMS)
Fall River Road, Heading North	0.000	1	0.724	11877	498	294	178	97	60	30	21	694	205,342	30	4,380	964	139,819	1.46
83 degrees	0.005	2	0.903	14813	450	233	142	84	61	39	29	612	181,080	81	11,690	582	84,413	0.8
	0.100	3	0.911	14944	396	220	144	101	88	72	56	710	210,076	136	19,725	642	93,116	1.25
	0.200	4	0.900	14764	534	332	223	137	89	43	29	743	219,840	29	4,250	465	67,444	0.87
	0.301	5	0.899	14747	395	230	147	85	54	27	20	876	259,192	46	6,686	778	112,841	0.91
	0.401	6	0.903	14813	486	318	223	152	113	70	54	878	259,784	40	5,860	414	60,047	1.02
88 degrees	0.499	7	0.886	14534	686	418	273	184	132	74	51	516	152,675	46	6,614	236	34,229	1.28
	0.600	8	0.914	14993	576	397	299	209	150	80	53	908	268,660	26	3,757	262	38,000	0.6
	0.701	9	0.918	15059	457	289	199	128	89	45	29	887	262,447	43	6,164	396	57,436	0.95
	0.800	10	0.891	14616	683	407	279	186	134	83	62	514	152,083	46	6,614	264	38,291	0.69
	0.900	11	0.900	14764	608	403	297	223	180	126	93	671	198,537	89	12,967	200	29,008	0.91
	1.000	12	0.927	15207	531	338	246	171	124	70	52	779	230,492	55	8,006	260	37,710	0.62
	1.143	13	0.910	14928	514	308	207	132	93	53	39	692	204,750	49	7,107	383	55,550	0.89
End Point	1.143	14	0.923	15141	440	281	196	135	102	62	46	899	265,998	65	9,370	358	51,924	1.07
Off of Foam	1.165	15	0.905	14846	465	283	203	140	103	62	45	786	232,563	87	12,618	300	43,512	0.56
Foam	1.188	16	0.907	14878	459	275	199	136	101	61	48	788	233,155	84	12,154	330	47,863	0.52
Heading South	0.000	17	0.923	15141	355	219	135	67	35	27	0	1037	306,829	34	4,859	1820	263,973	2.57
	0.006	18	0.911	14944	555	353	237	158	110	61	41	713	210,964	38	5,541	325	47,138	1.2
	0.039	19	0.914	14993	449	267	185	118	82	46	34	805	238,185	59	8,499	409	59,321	0.48
	0.067	20	0.938	15387	418	236	157	104	75	43	33	750	221,911	100	14,460	407	59,031	0.77
	0.149	21	0.894	14665	631	390	246	148	96	50	33	591	174,866	26	3,699	468	67,879	1.47
	0.252	22	0.923	15141	453	255	153	86	54	27	25	714	211,259	39	5,599	1120	162,445	1.13
	0.276	23	0.907	14878	455	247	144	79	48	24	28	675	199,720	38	5,439	2180	316,187	1.13
	0.349	24	0.923	15141	466	279	197	137	103	64	48	741	219,248	104	15,084	301	43,657	0.64
	0.456	25	0.903	14813	534	340	246	169	124	73	54	770	227,829	52	7,470	280	40,611	0.58
86 degrees	0.550	26	0.900	14764	534	347	249	175	129	72	47	789	233,451	60	8,688	229	33,214	0.84
	0.650	27	0.893	14649	588	384	272	192	142	87	63	715	211,555	44	6,411	260	37,710	0.99
	0.749	28	0.905	14846	537	371	280	213	166	103	71	890	263,335	84	12,198	183	26,542	0.92
	0.854	29	0.939	15403	404	262	183	127	93	52	36	1025	303,279	65	9,471	355	51,489	1.09
	0.955	30	0.928	15223	350	197	127	78	51	25	21	936	276,945	68	9,906	703	101,963	0.83
	1.050	31	0.913	14977	450	253	168	100	63	28	22	755	223,391	46	6,730	585	84,848	0.53
	1.151	32	0.910	14928	398	231	151	96	68	37	28	841	248,836	73	10,530	496	71,940	0.93
	1.209	33	0.917	15042	301	163	101	50	27	24	0	1036	306,533	60	8,659	1630	236,415	2.07
											average		230,752		8,521		81,684	0.99

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DEFLECTION DATA

Project Location: Trail Ridge Road - Bear Lake Junction to 3M

Location or Comments	Station	Test Number	Press Mpa	Force lbs.	Deflection (Microns) d1	d2	d3	d4	d5	d6	d7	E1 Mpa	E1 psi	E2 Mpa	E2 psi	E3 Mpa	E3 psi	Error (%-RMS)
Trail Ridge Road, at Bear Lake Junction,	0.000	1	0.734	12041	234	165	128	93	72	41	25	2571	372,898	64	9,326	478	69,329	0.73
Heading to 3 M	0.100	2	0.721	11827	220	171	141	108	82	48	32	4084	592,343	19	2,785	1110	160,994	0.46
89 degrees	0.204	3	0.731	11991	298	221	178	132	97	51	31	2532	367,241	23	3,336	449	65,123	0.33
	0.300	4	0.741	12155	235	178	138	100	72	40	27	3166	459,197	20	2,843	1360	197,254	0.97
85 degrees	0.408	5	0.719	11794	416	328	269	209	160	96	61	3599	521,999	105	15,229	171	24,802	1.50
	0.500	6	0.722	11844	295	222	177	130	96	53	34	4558	661,092	56	8,064	331	48,008	2.30
	0.600	7	0.718	11778	433	364	310	252	201	130	88	2480	359,699	60	8,702	129	18,710	1.62
	0.703	8	0.741	12155	271	208	172	130	98	56	33	3117	452,090	29	4,163	373	54,100	0.65
	0.801	9	0.724	11877	265	196	156	117	89	54	35	2595	376,379	50	7,267	394	57,146	0.56
	0.902	10	0.725	11893	312	216	164	113	77	35	20	3614	524,175	31	4,540	517	74,986	0.49
	1.004	11	0.744	12205	366	257	203	153	118	77	55	1813	262,958	490	71,070	244	35,390	0.36
	1.102	12	0.716	11745	488	370	289	212	156	89	62	2612	378,844	38	5,439	202	29,298	0.89
	1.204	13	0.738	12106	341	246	188	126	84	33	15	3900	565,656	17	2,422	687	99,642	1.62
	1.303	14	0.746	12237	327	263	219	167	124	65	36	6218	901,859	19	2,814	317	45,978	0.91
	1.402	15	0.718	11778	572	450	353	260	190	105	69	2632	381,745	19	2,683	187	27,122	1.32
	1.502	16	0.736	12073	362	261	206	150	108	56	32	3443	499,373	40	5,802	303	43,947	0.42
	1.600	17	0.728	11942	388	271	201	136	92	45	29	2594	376,234	34	4,873	364	52,795	0.93
	1.700	18	0.729	11959	374	289	236	181	136	77	48	4055	588,137	58	8,398	218	31,619	0.51
	1.800	19	0.739	12123	297	202	149	107	81	52	39	2322	336,783	206	29,878	366	53,085	0.88
94 degrees	1.901	20	0.729	11959	490	359	270	188	132	67	41	2307	334,607	28	4,047	243	35,245	4.55
	2.002	21	0.729	11959	234	190	158	121	90	49	30	4388	636,436	11	1,537	1660	240,766	1.14
	2.102	22	0.724	11877	396	305	246	182	132	67	38	4114	596,695	22	3,191	273	39,596	0.66
	2.199	23	0.729	11959	326	224	165	113	79	40	25	2842	412,204	51	7,455	411	59,611	0.74
	2.302	24	0.735	12057	308	201	152	108	80	46	30	2063	299,218	236	34,229	346	50,184	0.41
	2.401	25	0.747	12254	256	181	141	101	74	41	26	2387	346,210	47	6,831	473	68,604	0.41
	2.504	26	0.704	11548	970	809	639	474	351	203	122	1757	254,835	14	2,074	81.1	11,763	2.51
	2.602	27	0.721	11827	446	345	279	213	163	98	63	2849	413,219	143	20,741	164	23,787	0.63
	2.700	28	0.725	11893	459	375	312	245	187	111	68	4412	639,916	23	3,379	183	26,542	0.87
Area Reconstructed In 1998	2.752	29	0.736	12073	423	283	212	144	100	47	26	2179	316,042	38	5,497	326	47,283	0.49
	2.849	30	0.71	11647	494	412	343	265	203	119	72	1379	200,010	134	19,435	57.9	8,398	4.56
	2.955	31	0.714	11712	419	326	267	200	148	75	37	2171	314,882	9	1,342	414	60,047	0.46
	3.053	32	0.728	11942	321	250	201	152	117	70	45	2593	376,089	19	2,683	467	67,734	0.96
	3.160	33	0.738	12106	236	168	129	91	66	38	26	2531	367,096	51	7,339	530	76,871	0.63
	3.251	34	0.725	11893	298	227	183	143	114	73	48	2436	353,317	80	11,661	280	40,611	0.73
	3.352	35	0.722	11844	494	401	335	260	194	93	49	4531	657,176	10	1,429	221	32,054	1.27
	3.453	36	0.732	12008	294	212	169	121	88	48	29	2279	330,546	32	4,685	413	59,902	0.33
	3.551	37	0.725	11893	375	272	216	163	124	70	43	2636	382,325	181	26,252	224	32,489	0.58
	3.651	38	0.732	12008	455	345	274	200	144	75	47	3109	450,929	27	3,931	225	32,634	0.70
	3.751	39	0.741	12155	386	308	247	181	134	72	41	2244	325,470	9	1,355	693	100,513	1.29
	3.851	40	0.749	12287	211	161	134	102	77	44	26	4052	587,702	36	5,236	495	71,795	0.22
	3.951	41	0.747	12254	199	143	115	83	60	31	19	3104	450,204	22	3,234	1400	203,056	0.21
	4.051	42	0.744	12205	352	230	162	96	60	28	28	2359	342,149	28	4,076	791	114,727	1.10
End of 1998 Section	4.051	43	0.728	11942	494	366	279	192	135	68	42	2478	359,409	23	3,292	249	36,115	0.94
	4.095	44	0.738	12106	427	265	174	97	60	32	24	1536	222,781	33	4,830	534	77,451	1.84
	4.112	45	0.725	11893	459	333	255	172	119	59	39	2499	362,455	26	3,713	281	40,756	0.79
Deer Ridge to 3 M	0.000	46	0.716	11745	506	388	316	232	163	76	40	3289	477,037	14	2,002	238	34,520	0.67
1998 Section, East End, Just off Paint	0.068	47	0.701	11499	629	476	355	244	173	94	60	1909	276,881	19	2,683	198	28,718	1.04
	0.089	48	0.701	11499	689	514	376	255	173	80	44	1728	250,629	13	1,929	206	29,878	1.06
50 m East of Test 42 (opposite direction)	0.154	49	0.722	11844	156	107	82	56	41	22	21	3781	548,396	37	5,323	2170	314,737	0.66
	0.254	50	0.731	11991	331	257	208	149	106	50	26	5158	748,116	17	2,451	437	63,382	1.01

Location	Station	Test Number	Press Mpa	Force lbs.	Deflection (Microns) d1	d2	d3	d4	d5	d6	d7	E1 Mpa	E1 psi	E2 Mpa	E2 psi	E3 Mpa	E3 psi	Error (%-RMS)
	0.351	51	0.741	12155	134	89	67	45	31	18	0	4568	662,543	36	5,279	3490	506,190	2.79
	0.455	52	0.713	11696	340	274	234	191	154	102	69	3137	454,990	20	2,944	317	45,978	3.44
	0.552	53	0.722	11844	431	341	279	206	152	77	45	1379	200,010	140	20,306	91.5	13,271	0.81
	0.664	54	0.721	11827	356	270	222	168	127	70	46	2341	339,539	16	2,306	430	62,367	0.40
Marked Section	0.754	55	0.735	12057	279	196	152	113	88	56	40	1969	285,584	97	14,098	375	54,390	0.67
	0.880	56	0.705	11565	794	610	467	323	217	99	52	1801	261,217	9	1,233	183	26,542	0.58
	0.953	57	0.729	11959	573	458	372	280	209	113	65	3072	445,563	19	2,727	153	22,191	0.98
3 M	1.051	58	0.735	12057	522	343	238	152	99	44	26	1561	226,407	26	3,713	338	49,024	1.00
3 M to Bear Lake, 1998 Section Cont'd	1.149	59	0.724	11877	421	310	238	161	109	49	28	3092	448,464	18	2,567	382	55,405	0.94
89 degrees	1.268	60	0.724	11877	283	204	164	125	98	63	46	2190	317,638	92	13,358	342	49,604	0.41
	1.356	61	0.725	11893	546	419	337	246	180	98	61	2628	381,165	28	4,119	167	24,222	0.73
New Section at 1.394 km	1.409	62	0.721	11827	481	386	324	254	197	120	76	3762	545,640	52	7,499	148	21,466	0.49
	1.508	63	0.743	12188	347	249	187	132	96	55	37	2791	404,807	78	11,241	303	43,947	1.37
	1.602	64	0.749	12287	345	235	175	128	96	58	37	1435	208,132	86	12,401	301	43,657	0.80
	1.700	65	0.728	11942	379	273	210	151	108	54	31	1740	252,370	20	2,959	371	53,810	0.64
87 degrees	1.801	66	0.725	11893	403	294	241	192	155	104	73	1396	202,476	106	15,374	202	29,298	0.52
	1.898	67	0.735	12057	343	228	176	129	97	57	38	1312	190,292	69	9,964	308	44,672	0.43
	2.000	68	0.731	11991	506	381	300	214	150	73	44	2777	402,776	19	2,683	235	34,084	0.79
	2.102	69	0.732	12008	433	336	268	207	161	105	77	2909	421,921	98	14,228	201	29,153	0.91
	2.199	70	0.743	12188	338	240	188	138	102	59	37	2759	400,165	146	21,176	273	39,596	0.43
	2.373	71	0.724	11877	263	179	141	105	81	53	41	1798	260,782	70	10,080	489	70,925	0.40
	2.399	72	0.729	11959	623	469	368	266	186	91	54	2247	325,905	16	2,364	181	26,252	3.46
	2.500	73	0.732	12008	240	162	127	97	78	52	38	1824	264,553	185	26,832	424	61,497	0.46
	2.607	74	0.732	12008	251	163	123	86	63	36	25	1902	275,866	79	11,473	515	74,696	0.34
	2.695	75	0.735	12057	438	313	244	173	121	59	35	2711	393,203	29	4,235	275	39,886	0.39
	2.795	76	0.732	12008	569	417	338	252	184	92	50	2485	360,424	24	3,495	174	25,237	0.49
	2.894	77	0.734	12041	527	377	287	205	145	72	43	2115	306,760	30	4,293	217	31,474	0.70
	2.997	78	0.708	11614	629	476	358	255	186	97	58	1943	281,813	24	3,466	166	24,077	2.33
	3.096	79	0.735	12057	547	408	322	243	182	111	78	1939	281,233	107	15,519	153	22,191	0.67
	3.197	80	0.743	12188	353	228	167	122	94	60	44	1185	171,872	124	17,985	327	47,428	0.74
	3.297	81	0.713	11696	659	478	365	268	197	105	60	1613	233,950	43	6,251	143	20,741	0.87
	3.399	82	0.756	12401	307	197	152	106	77	41	26	1581	229,308	58	8,441	428	62,077	0.61
89 degrees	3.499	83	0.735	12057	446	322	243	177	131	73	47	2178	315,897	78	11,284	216	31,329	0.96
	3.600	84	0.697	11434	888	690	539	388	273	131	76	1709	247,873	9	1,376	127	18,420	1.61
	3.700	85	0.722	11844	606	450	347	257	189	104	67	1863	270,210	52	7,513	146	21,176	0.88
	3.800	86	0.752	12336	221	138	107	80	63	44	32	1602	232,354	383	55,550	484	70,199	0.29
	3.902	87	0.749	12287	360	231	168	121	89	53	35	1501	217,705	264	38,291	300	43,512	0.71
	4.108	88	0.732	12008	482	345	264	194	144	81	53	1887	273,690	110	15,954	188	27,268	0.79
	4.113	89	0.738	12106	297	207	156	110	81	44	26	3147	456,441	81	11,748	383	55,550	0.76
Just Off Foamed Section	4.173	90	0.749	12287	277	206	166	119	89	50	33	4556	660,802	72	10,399	349	50,619	0.96
	4.218	91	0.746	12237	289	221	175	125	93	53	37	4706	682,558	43	6,179	397	57,581	1.30
											average		389,083		9,345		59,891	0.99

GROUND
ENGINEERING CONSULTANTS

DEFLECTION DATA

Project Location: Trail Ridge Road - Deer Junction to 3 M

Location or Comments	Station	Test Number	Press Mpa	Force lbs.	Deflection (Microns) d1	d2	d3	d4	d5	d6	d7	E1 Mpa	E1 psi	E2 Mpa	E2 psi	E3 Mpa	E3 psi	Error (%-RMS)
Trail Ridge Road Heading West	0.001	1	0.89	14600	605	416	300	193	124	54	29	1093	158,529	18	2,596	332	48,153	0.67
	0.104	2	0.913	14977	439	291	210	143	95	42	23	1415	205,232	32	4,685	398	57,726	1.24
	0.199	3	0.936	15354	247	138	96	58	37	17	25	1713	248,454	77	11,110	1390	201,606	1.45
	0.211	4	0.928	15223	272	179	132	83	53	22	15	2330	337,943	39	5,686	927	134,452	0.75
	0.255	5	0.913	14977	436	301	219	143	95	47	30	1485	215,384	31	4,438	384	55,695	0.56
	0.302	6	0.903	14813	270	155	112	82	61	35	24	1211	175,643	280	40,611	477	69,184	1.18
94 degrees	0.407	7	0.91	14928	324	212	164	121	86	42	23	1944	281,958	73	10,559	383	55,550	1.94
	0.500	8	0.93	15256	294	184	136	103	77	42	25	1471	213,354	257	37,275	377	54,680	1.64
	0.601	9	0.902	14796	378	265	203	145	100	53	31	1905	276,301	42	6,135	338	49,024	0.80
Shoving and Rutting of the Asphalt	0.701	10	0.905	14846	424	279	212	149	104	53	30	1439	208,713	52	7,586	306	44,382	1.23
from this point forward	0.801	11	0.907	14878	373	277	230	177	134	73	42	2627	381,020	47	6,759	240	34,810	1.16
(throughout)	0.900	12	0.917	15042	436	322	263	206	158	95	63	1710	248,018	182	26,397	167	24,222	0.82
	1.000	13	0.93	15256	153	122	108	94	80	57	43	5325	772,338	2890	419,166	389	56,421	0.88
	1.102	14	0.918	15059	265	138	90	66	51	34	27	1002	145,330	422	61,207	609	88,329	0.77
	1.201	15	0.89	14600	569	403	281	205	157	96	68	1018	147,651	54	7,789	214	31,039	1.62
	1.303	16	0.927	15207	280	182	133	98	77	48	32	1551	224,957	339	49,169	366	53,085	0.84
	1.400	17	0.921	15108	247	138	104	79	61	37	26	1157	167,811	713	103,414	465	67,444	0.97
	1.514	18	0.917	15042	412	279	194	131	94	53	38	1346	195,224	55	7,992	349	50,619	1.11
	1.602	19	0.913	14977	331	193	136	95	68	38	26	1133	164,330	179	25,962	415	60,192	1.01
89 degrees	1.703	20	0.918	15059	172	97	70	49	37	24	19	1847	267,889	408	59,176	831	120,528	0.59
	1.805	21	0.911	14944	313	180	126	91	69	43	31	1038	150,552	347	50,329	401	58,161	0.64
	1.901	22	0.92	15092	368	204	150	105	76	42	29	894	129,666	247	35,825	357	51,779	1.22
	2.000	23	0.924	15157	255	139	95	61	42	22	17	1424	206,537	147	21,321	747	108,345	1.21
84 degrees	2.101	24	0.91	14928	297	181	130	89	64	35	24	1486	215,529	134	19,435	471	68,314	0.93
	2.201	25	0.918	15059	403	304	249	190	141	78	49	2364	342,875	45	6,541	220	31,909	0.80
75 degrees	2.301	26	0.88	14436	787	542	386	287	218	138	101	619	89,780	114	16,535	115	16,680	1.53
	2.400	27	0.92	15092	512	302	195	137	100	54	36	722	104,719	104	15,084	279	40,466	1.40
	2.501	28	0.921	15108	413	272	203	154	120	80	59	1082	156,933	237	34,374	255	36,985	0.64
	2.600	29	0.9	14764	571	386	288	221	172	107	73	821	119,078	211	30,603	158	22,916	0.93
	2.706	30	0.923	15141	559	384	288	209	154	84	53	1078	156,353	65	9,442	183	26,542	0.90
	2.800	31	0.874	14337	853	549	388	298	233	153	108	429	62,222	225	32,634	107	15,519	1.51
	2.900	32	0.938	15387	268	192	162	129	103	69	48	2098	304,294	507	73,535	270	39,161	0.76
	3.002	33	0.936	15354	403	290	221	155	113	65	44	1780	258,171	45	6,527	307	44,527	0.52
77 degrees	3.100	34	0.924	15157	469	340	257	185	141	88	59	1447	209,873	63	9,167	223	32,344	0.80
	3.201	35	0.897	14714	641	466	329	237	184	122	92	995	144,315	31	4,525	247	35,825	1.65
	3.300	36	0.9	14764	689	447	298	178	117	64	46	745	108,055	22	3,191	350	50,764	0.97
	3.402	37	0.897	14714	789	489	331	244	192	141	110	499	72,375	65	9,486	213	30,894	1.12
More Severe shoving and rutting	3.502	38	0.921	15108	516	294	176	104	69	39	31	715	103,704	52	7,470	451	65,413	1.11
from this point forward	3.603	39	0.907	14878	645	356	211	128	86	46	32	536	77,741	49	7,165	333	48,298	1.14
	3.702	40	0.908	14895	573	386	285	206	157	97	70	911	132,131	91	13,228	189	27,413	0.71
	3.803	41	0.913	14977	647	405	240	138	89	46	34	690	100,078	24	3,495	485	70,344	1.76
	3.903	42	0.933	15305	376	252	175	118	82	46	32	1446	209,728	62	9,007	379	54,970	0.98
	4.004	43	0.938	15387	227	157	126	97	73	42	28	2872	416,555	225	32,634	407	59,031	1.30
rutting and shoving pavement	4.102	44	0.928	15223	333	200	130	92	72	47	35	1105	160,269	162	23,496	464	67,299	1.27
less severe from this point forward	4.203	45	0.914	14993	359	208	129	81	57	34	27	1047	151,857	87	12,618	563	81,658	1.02
	4.304	46	0.914	14993	136	70	45	25	17	0	0	Not Reliable Data - No Reading on Sensor 5 or 6						--
	4.400	47	0.914	14993	329	232	177	122	86	47	34	2132	309,225	45	6,512	457	66,283	0.44
	4.501	48	0.91	14928	440	315	246	184	143	92	67	1466	212,629	118	17,115	216	31,329	0.54
85 degrees	4.602	49	0.923	15141	297	225	178	128	92	51	40	3182	461,517	22	3,133	1440	208,858	0.35
	4.691	50	0.903	14813	377	266	205	144	102	57	45	1915	277,752	37	5,424	422	61,207	0.53

Location	Station	Test Number	Press Mpa	Force lbs.	Deflection (Microns) d1	d2	d3	d4	d5	d6	d7	E1 Mpa	E1 psi	E2 Mpa	E2 psi	E3 Mpa	E3 psi	Error (%-RMS)
Heading East	4.668	51	0.92	15092	281	210	169	129	100	62	42	2880	417,715	127	18,420	311	45,107	0.61
	4.600	52	0.926	15190	354	267	201	141	103	61	44	2294	332,722	25	3,641	583	84,558	2.84
73 degrees	4.550	53	0.91	14928	396	285	220	158	114	65	44	1845	267,599	50	7,252	291	42,207	0.43
	4.450	54	0.913	14977	400	277	203	137	97	56	36	1545	224,087	51	7,412	331	48,008	0.63
Rutting and Shoving Observed	4.349	55	0.928	15223	279	213	170	123	89	51	35	3446	499,808	27	3,945	756	109,650	0.40
Throughout	4.243	56	0.921	15108	407	317	245	176	128	72	52	2347	340,409	16	2,350	762	110,520	0.96
	4.150	57	0.908	14895	367	268	215	166	130	84	58	1883	273,110	191	27,703	225	32,634	0.65
	4.045	58	0.914	14993	369	253	187	138	107	68	47	1441	209,003	160	23,206	278	40,321	0.90
	3.949	59	0.915	15010	380	268	204	153	119	77	54	1557	225,827	156	22,626	253	36,695	0.72
	3.850	60	0.917	15042	352	228	165	113	80	43	28	1504	218,140	78	11,299	386	55,985	0.91
	3.748	61	0.928	15223	263	160	107	79	62	42	33	1377	199,720	245	35,535	563	81,658	1.36
	3.642	62	0.911	14944	501	333	233	154	103	53	38	1104	160,124	40	5,729	305	44,237	0.82
	3.542	63	0.853	13993	451	396	272	176	117	65	43	1528	221,621	43	6,237	1104	160,124	2.92
	3.531	64	0.908	14895	659	423	281	167	102	46	32	783	113,566	22	3,133	356	51,634	0.83
	3.438	65	0.936	15354	358	203	131	89	70	48	34	910	131,986	179	25,962	451	65,413	0.97
	3.349	66	0.93	15256	331	210	150	104	76	46	32	1386	201,025	139	20,161	375	54,390	0.65
	3.251	67	0.89	14600	691	435	280	179	126	74	54	650	94,276	36	5,178	265	38,436	1.24
	3.150	68	0.945	15502	321	227	180	138	108	66	41	1762	255,560	167	24,222	261	37,855	0.78
	3.046	69	0.926	15190	361	241	170	111	77	44	31	1530	221,911	55	7,977	440	63,818	0.72
	2.949	70	0.913	14977	412	290	216	168	137	94	66	1244	180,430	239	34,665	236	34,229	1.15
	2.848	71	0.897	14714	649	451	327	244	191	128	91	846	122,704	73	10,588	176	25,527	1.15
56 degrees	2.748	72	0.899	14747	536	312	171	112	81	48	35	659	95,581	57	8,296	417	60,482	2.14
	2.649	73	0.91	14928	703	480	356	240	170	98	66	859	124,589	32	4,699	183	26,542	0.43
	2.546	74	0.902	14796	646	462	359	264	198	120	82	1041	150,987	59	8,586	148	21,466	0.54
	2.450	75	0.948	15551	272	189	144	105	78	44	27	2406	348,966	103	14,939	404	58,596	0.91
	2.343	76	0.938	15387	256	180	139	106	82	52	36	2226	322,859	340	49,314	340	49,314	0.67
	2.245	77	0.899	14747	489	342	247	184	146	109	86	1134	164,475	63	9,181	330	47,863	1.21
	2.149	78	0.913	14977	277	175	130	94	69	40	27	1667	241,782	205	29,733	418	60,627	1.03
	2.042	79	0.915	15010	184	96	70	52	40	27	21	1340	194,354	1070	155,193	733	106,314	0.51
	1.950	80	0.942	15453	192	131	103	71	51	29	21	3501	507,785	103	14,939	681	98,772	0.66
	1.849	81	0.928	15223	195	124	97	70	51	29	21	2594	376,234	250	36,260	599	86,879	1.29
	1.748	82	0.905	14846	253	204	172	136	107	69	50	4963	719,834	36	5,250	510	73,970	0.47
	1.643	83	0.926	15190	218	164	135	104	79	45	29	4427	642,092	86	12,444	417	60,482	0.84
	1.546	84	0.915	15010	181	118	90	69	54	34	24	2295	332,867	487	70,634	548	79,482	0.83
62 degrees - Heavy Rain	1.451	85	0.921	15108	228	162	130	101	82	54	41	2410	349,546	287	41,626	401	58,161	0.65
	1.349	86	0.927	15207	196	138	112	85	66	41	32	3042	441,212	154	22,336	537	77,886	0.81
	1.247	87	0.857	14058	413	285	191	130	96	56	39	1329	192,758	53	7,702	367	53,230	1.69
	1.148	88	0.92	15092	562	416	318	232	174	107	74	1351	195,949	35	5,105	207	30,023	0.76
	1.050	89	0.927	15207	401	301	246	189	144	83	53	2190	317,638	80	11,647	198	28,718	0.72
	0.949	90	0.938	15387	233	186	155	122	96	60	39	4902	710,986	71	10,312	365	52,940	0.51
	0.849	91	0.897	14714	517	400	321	245	185	108	70	1867	270,790	30	4,395	190	27,558	0.63
	0.750	92	0.935	15338	184	151	127	101	81	51	34	7216	1,046,609	60	8,630	508	73,680	0.66
	0.650	93	0.907	14878	243	152	120	88	66	37	23	1886	273,545	319	46,268	440	63,818	1.61
	0.541	94	0.911	14944	399	252	198	139	90	44	28	1487	215,674	53	7,644	352	51,054	1.68
	0.448	95	0.914	14993	350	260	204	145	102	48	31	2568	372,463	24	3,524	467	67,734	0.63
	0.347	96	0.918	15059	244	197	164	127	95	56	36	5366	778,285	19	2,698	1460	211,758	0.32
	0.248	97	0.91	14928	204	159	132	102	80	49	30	5146	746,376	101	14,649	398	57,726	0.53
	0.151	98	0.896	14698	459	374	312	239	180	104	67	2906	421,486	97	14,069	313	45,398	0.40
	0.048	99	0.907	14878	406	323	274	227	188	134	97	2357	341,859	272	39,451	174	25,237	0.51
	0.005	100	0.902	14796	521	425	344	255	184	89	42	2456	356,218	101	14,649	542	78,612	0.69
											average		269,149		24,232		60,684	0.97

Appendix C

Summary of Field Deflection Results

Appendix C

Summary of Field Deflection Results -

Moraine Park Museum North on Bear Lake Road

M3
Date-Time: 7-17-2003 7:42: 2
Sensors: CHOP CHOP Chop Chop Chop Chop Chop
Weight/spring: 2
Location: Rocky Mount Natl Park
Temp: 93.18
Operator: ajs
Comments: FHWA Testing
1 1 0.000 1 6.32 6.73 5.83 5.12 4.23 3.49 2.36 1.68 83.5
1 1 0.000 1 9.11 10.13 8.78 7.70 6.35 5.19 3.46 2.47 83.5
1 1 0.000 1 11.96 13.61 11.77 10.23 8.44 6.92 4.66 3.23 83.5
GPS: Quality : GPS Fi Latitude = 40°21.541302 N Longitude = 105°35.185957 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: morraine park musem start heading west
2 1 0.040 1 6.15 5.40 4.87 4.42 3.78 3.22 2.33 1.76 83.9
2 1 0.040 1 8.91 7.74 6.91 6.13 5.21 4.39 3.10 2.24 83.9
2 1 0.040 1 11.91 10.60 9.45 8.39 7.14 6.03 4.35 3.15 83.9
GPS: Quality : GPS Fi Latitude = 40°21.549186 N Longitude = 105°35.212651 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: 72 degrees
3 1 0.060 1 5.96 6.32 5.31 4.67 3.91 3.30 2.37 1.80 83.9
3 1 0.060 1 8.81 9.55 7.79 6.75 5.57 4.59 3.20 2.32 83.9
3 1 0.060 1 11.82 13.09 10.66 9.24 7.63 6.32 4.47 3.25 83.9
GPS: Quality : GPS Fi Latitude = 40°21.552633 N Longitude = 105°35.222060 W PDOP = 2.50
GPS: State Plane Coordinates:
Note: 72 degrees
4 1 0.124 1 6.25 5.52 4.59 3.95 3.13 2.49 1.58 1.15 84.6
4 1 0.124 1 9.13 8.20 6.79 5.83 4.60 3.63 2.29 1.66 84.6
4 1 0.124 1 12.08 11.03 9.17 7.82 6.20 4.92 3.17 2.22 84.6
GPS: Quality : GPS Fi Latitude = 40°21.557555 N Longitude = 105°35.262810 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: 72 degrees
5 1 0.240 1 6.05 4.36 3.25 2.50 1.78 1.27 0.00 0.00 90.5
5 1 0.240 1 9.11 6.85 5.00 3.85 2.75 1.98 1.04 0.00 90.5
5 1 0.240 1 11.87 9.15 6.62 5.10 3.65 2.64 1.40 0.91 90.5
GPS: Quality : GPS Fi Latitude = 40°21.547045 N Longitude = 105°35.350524 W PDOP = 3.10
GPS: State Plane Coordinates:
Note: 72 degrees
6 1 0.342 1 5.98 3.78 2.44 1.76 0.00 0.90 0.00 0.00 82.8
6 1 0.342 1 9.13 6.04 3.82 2.74 1.87 1.39 0.92 0.00 82.8
6 1 0.342 1 12.11 8.23 5.12 3.69 2.51 1.87 1.17 0.93 82.8
GPS: Quality : GPS Fi Latitude = 40°21.550796 N Longitude = 105°35.422052 W PDOP = 4.00
GPS: State Plane Coordinates:
Note: 74 degrees
6 1 0.350 1 6.05 5.08 3.46 2.47 1.76 1.25 0.00 0.00 83.9
6 1 0.350 1 8.98 7.95 5.25 3.77 2.59 1.91 1.12 0.82 83.9
6 1 0.350 1 11.82 10.83 7.12 5.13 3.53 2.60 1.51 1.07 83.9
GPS: Quality : GPS Fi Latitude = 40°21.551647 N Longitude = 105°35.423561 W PDOP = 2.60
GPS: State Plane Coordinates:
Note: 77 degrees
7 1 0.370 1 6.01 3.19 2.05 1.51 0.00 0.81 0.00 0.00 79.5
7 1 0.370 1 9.03 5.06 3.14 2.30 1.65 1.26 0.75 0.00 79.5
7 1 0.370 1 12.11 6.88 4.24 3.11 2.25 1.72 1.05 0.67 79.5
GPS: Quality : GPS Fi Latitude = 40°21.611095 N Longitude = 105°35.437235 W PDOP = 2.20
GPS: State Plane Coordinates:
Note: 75 degrees
8 1 0.550 1 6.15 3.10 2.53 1.95 1.43 1.05 0.00 0.00 97.4
8 1 0.550 1 8.96 4.75 3.84 3.01 2.18 1.61 0.89 0.61 97.4
8 1 0.550 1 11.82 6.38 5.11 4.03 2.93 2.16 1.22 0.75 97.4
GPS: Quality : GPS Fi Latitude = 40°21.635258 N Longitude = 105°35.367701 W PDOP

= 3.50
GPS: State Plane Coordinates:
Note: 76 degrees
9 1 0.665 1 6.08 2.52 1.78 1.49 0.00 0.88 0.00 0.00 91.9
9 1 0.665 1 8.98 3.81 2.68 2.14 1.64 1.31 0.89 0.69 91.9
9 1 0.665 1 12.28 5.49 3.88 3.09 2.35 1.87 1.26 0.95 91.9
GPS: Quality : GPS Fi Latitude = 40°21.632057 N Longitude = 105°35.286786 W PDOP
= 2.40
GPS: State Plane Coordinates:
Note: 79 degrees
10 1 0.770 1 6.32 4.08 3.02 2.37 1.63 1.12 0.00 0.00 90.1
10 1 0.770 1 9.03 5.90 4.35 3.40 2.35 1.65 0.88 0.00 90.1
10 1 0.770 1 12.01 7.76 5.68 4.47 3.12 2.19 1.13 0.79 90.1
GPS: Quality : GPS Fi Latitude = 40°21.611684 N Longitude = 105°35.217320 W PDOP
= 2.70
GPS: State Plane Coordinates:
Note: 77 degrees
11 1 0.866 1 8.86 5.91 4.38 3.42 2.46 1.89 1.18 0.81 94.5
11 1 0.866 1 11.74 7.88 5.83 4.52 3.30 2.53 1.56 1.03 94.5
11 1 0.866 1 14.84 9.85 7.27 5.64 4.09 3.17 1.97 1.27 94.5
GPS: Quality : GPS Fi Latitude = 40°21.601311 N Longitude = 105°35.150485 W PDOP
= 2.60
GPS: State Plane Coordinates:
Note: 81 degrees
12 1 0.953 1 8.91 8.16 5.81 4.46 3.06 2.14 1.06 0.66 91.9
12 1 0.953 1 11.77 10.69 7.58 5.82 4.00 2.80 1.39 0.87 91.9
12 1 0.953 1 14.77 13.09 9.21 7.07 4.86 3.41 1.72 1.02 91.9
GPS: Quality : GPS Fi Latitude = 40°21.597635 N Longitude = 105°35.088373 W PDOP
= 2.40
GPS: State Plane Coordinates:
Note: 84 degrees
13 1 0.970 1 8.98 9.50 7.21 5.74 4.05 2.84 1.46 1.00 93.4
13 1 0.970 1 11.87 12.62 9.49 7.53 5.36 3.75 1.93 1.29 93.4
13 1 0.970 1 14.82 15.55 11.48 9.17 6.54 4.59 2.47 1.58 93.4
GPS: Quality : GPS Fi Latitude = 40°21.597025 N Longitude = 105°35.078675 W PDOP
= 2.90
GPS: State Plane Coordinates:
Note: Off Foamed Section, 84 degrees
14 1 0.991 1 9.13 8.68 6.31 4.58 2.82 1.97 0.99 0.70 94.8
14 1 0.991 1 11.99 11.63 8.43 6.11 3.81 2.66 1.37 0.86 94.8
14 1 0.991 1 14.89 14.19 10.23 7.41 4.61 3.23 1.68 1.05 94.8
GPS: Quality : GPS Fi Latitude = 40°21.596549 N Longitude = 105°35.066663 W PDOP
= 2.60
GPS: State Plane Coordinates:
Note: 84 degrees
15 1 1.005 1 8.91 6.76 4.50 3.65 2.52 1.75 1.01 0.76 96.3
15 1 1.005 1 11.94 8.95 5.97 4.80 3.33 2.36 1.33 0.97 96.3
15 1 1.005 1 15.11 10.89 7.28 5.88 4.09 2.92 1.68 1.16 96.3
GPS: Quality : GPS Fi Latitude = 40°21.595697 N Longitude = 105°35.057027 W PDOP
= 2.30
GPS: State Plane Coordinates:
Note: 84 degrees, end
16 1 1.024 1 8.84 11.65 9.83 8.38 6.54 5.03 3.04 2.10 93.8
16 1 1.024 1 11.87 15.57 13.24 11.18 8.78 6.75 4.16 2.79 93.8
16 1 1.024 1 14.48 18.88 15.92 13.45 10.58 8.18 5.10 3.40 93.8
GPS: Quality : GPS Fi Latitude = 40°21.595781 N Longitude = 105°35.043234 W PDOP
= 3.50
GPS: State Plane Coordinates:
Note: Heading Back to Morraine Museum, 84 degrees
17 1 0.000 1 9.03 7.53 6.13 4.92 3.62 2.71 1.62 1.18 90.8
17 1 0.000 1 11.99 10.09 8.22 6.56 4.88 3.72 2.22 1.54 90.8
17 1 0.000 1 14.87 12.34 9.89 7.96 5.95 4.56 2.76 1.85 90.8
GPS: Quality : GPS Fi Latitude = 40°21.596881 N Longitude = 105°35.069476 W PDOP
= 2.40
GPS: State Plane Coordinates:
Note: 82 degrees
18 1 0.021 1 8.94 8.79 6.51 5.37 4.01 2.97 1.62 1.09 87.2
18 1 0.021 1 12.04 11.48 8.53 7.00 5.22 3.87 2.09 1.40 87.2

18 1 0.021 1 14.77 13.71 10.13 8.29 6.18 4.59 2.57 1.65 87.2
GPS: Quality : GPS Fi Latitude = 40°21.597542 N Longitude = 105°35.084592 W PDOP = 2.30
GPS: State Plane Coordinates:
Note: 84 degrees
19 1 0.037 1 8.91 9.31 6.58 4.95 3.49 2.54 1.51 1.13 87.9
19 1 0.037 1 12.11 12.37 8.63 6.53 4.57 3.36 1.96 1.46 87.9
19 1 0.037 1 15.01 15.13 10.39 7.82 5.50 4.04 2.40 1.77 87.9
GPS: Quality : GPS Fi Latitude = 40°21.597681 N Longitude = 105°35.095161 W PDOP = 2.30
GPS: State Plane Coordinates:
Note: 83 degrees
20 1 0.131 1 9.11 4.90 3.72 3.14 2.47 1.94 1.20 0.89 90.8
20 1 0.131 1 11.99 6.54 4.97 4.18 3.31 2.59 1.63 1.13 90.8
20 1 0.131 1 14.94 8.12 6.17 5.16 4.08 3.23 2.04 1.38 90.8
GPS: Quality : GPS Fi Latitude = 40°21.602268 N Longitude = 105°35.162296 W PDOP = 3.00
GPS: State Plane Coordinates:
Note: 84 degrees
21 1 0.229 1 8.76 6.21 4.51 3.68 2.75 2.10 1.27 0.91 89.7
21 1 0.229 1 12.04 8.56 6.23 5.08 3.76 2.87 1.77 1.21 89.7
21 1 0.229 1 14.89 10.51 7.64 6.23 4.62 3.53 2.16 1.44 89.7
GPS: Quality : GPS Fi Latitude = 40°21.616118 N Longitude = 105°35.231206 W PDOP = 2.20
GPS: State Plane Coordinates:
Note: 84 degrees
22 1 0.341 1 8.86 4.86 3.76 3.09 2.40 1.83 1.20 0.85 91.9
22 1 0.341 1 11.82 6.89 5.25 4.35 3.32 2.59 1.63 1.18 91.9
22 1 0.341 1 14.92 8.78 6.68 5.50 4.19 3.31 2.07 1.48 91.9
GPS: Quality : GPS Fi Latitude = 40°21.633245 N Longitude = 105°35.297058 W PDOP = 2.70
GPS: State Plane Coordinates:
Note: 84 degrees, Near Test 9
23 1 0.443 1 9.11 6.78 4.79 3.63 2.46 1.73 0.90 0.00 92.3
23 1 0.443 1 12.28 9.28 6.51 4.93 3.34 2.36 1.21 0.88 92.3
23 1 0.443 1 15.41 11.49 7.95 6.05 4.10 2.92 1.53 1.07 92.3
GPS: Quality : GPS Fi Latitude = 40°21.634302 N Longitude = 105°35.375636 W PDOP = 2.70
GPS: State Plane Coordinates:
Note: 80 degrees
24 1 0.545 1 9.11 5.83 3.48 2.49 1.63 1.11 0.00 0.00 78.0
24 1 0.545 1 11.96 7.74 4.67 3.35 2.17 1.49 0.81 0.00 78.0
24 1 0.545 1 14.97 9.67 5.76 4.19 2.72 1.90 0.97 0.80 78.0
GPS: Quality : GPS Fi Latitude = 40°21.609146 N Longitude = 105°35.441037 W PDOP = 2.70
GPS: State Plane Coordinates:
Note: 81 degrees
25 1 0.648 1 8.81 7.66 6.11 5.03 3.82 2.91 1.68 1.10 83.5
25 1 0.648 1 11.72 10.28 8.17 6.75 5.14 3.93 2.32 1.45 83.5
25 1 0.648 1 14.58 12.94 10.17 8.43 6.44 4.95 2.90 1.80 83.5
GPS: Quality : GPS Fi Latitude = 40°21.553900 N Longitude = 105°35.432503 W PDOP = 4.00
GPS: State Plane Coordinates:
Note: 84 degrees
26 1 0.747 1 8.98 6.65 5.05 4.06 2.91 2.05 1.07 0.00 89.7
26 1 0.747 1 11.94 9.01 6.89 5.56 4.01 2.87 1.46 0.98 89.7
26 1 0.747 1 14.99 11.10 8.41 6.86 4.99 3.63 1.91 1.25 89.7
GPS: Quality : GPS Fi Latitude = 40°21.541436 N Longitude = 105°35.363361 W PDOP = 2.60
GPS: State Plane Coordinates:
Note: 84 degrees
27 1 0.851 1 8.84 10.49 8.49 7.09 5.45 4.14 2.31 1.38 94.8
27 1 0.851 1 11.84 14.13 11.40 9.47 7.26 5.52 3.11 1.81 94.8
27 1 0.851 1 14.75 17.68 14.20 11.72 8.98 6.79 3.81 2.17 94.8
GPS: Quality : GPS Fi Latitude = 40°21.554694 N Longitude = 105°35.291816 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: 86 degrees

28 1 0.957 1 9.01 8.70 6.90 5.80 4.66 3.71 2.55 1.92 94.8
28 1 0.957 1 12.28 12.13 9.71 8.14 6.62 5.34 3.76 2.80 94.8
28 1 0.957 1 15.04 14.51 11.58 9.62 7.80 6.23 4.36 3.17 94.8
GPS: Quality : GPS Fi Latitude = 40°21.548753 N Longitude = 105°35.217140 W PDOP = 2.60
GPS: State Plane Coordinates:
Note: 84 degrees
29 1 0.999 1 8.94 10.40 8.12 6.69 5.25 4.13 2.67 1.93 92.7
29 1 0.999 1 11.79 13.89 10.83 8.88 6.99 5.50 3.61 2.52 92.7
29 1 0.999 1 14.65 17.16 13.25 10.82 8.54 6.70 4.45 3.05 92.7
GPS: Quality : GPS Fi Latitude = 40°21.540477 N Longitude = 105°35.188641 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: 84 degrees
30 1 1.016 1 8.86 12.78 7.46 6.32 4.90 3.81 2.45 1.77 92.3
30 1 1.016 1 11.79 16.27 9.64 8.21 6.43 5.01 3.23 2.36 92.3
30 1 1.016 1 14.79 19.17 11.69 9.91 7.82 6.11 4.01 2.87 92.3
GPS: Quality : GPS Fi Latitude = 40°21.536352 N Longitude = 105°35.179059 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: 84 degrees Off Foamed Section
31 1 1.035 1 8.69 19.36 13.80 9.72 6.11 4.03 2.38 1.81 94.8
31 1 1.035 1 11.62 26.28 18.32 12.83 8.04 5.31 3.12 2.35 94.8
31 1 1.035 1 14.23 32.20 21.86 15.37 9.61 6.36 3.70 2.84 94.8
GPS: Quality : GPS Fi Latitude = 40°21.530504 N Longitude = 105°35.167848 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: 85 degrees, Off foamed Section

Appendix C

Summary of Field Deflection Results -

Trail Ridge Road – Bear Lake Junction to 3M

M3
Date-Time: 7-17-2003 9:20:25
Sensors: CHOP CHOP Chop Chop Chop Chop Chop
Weight/spring: 2
Location: Rocky Mount Natl Park
Temp: 115.83
Operator: ajs
Comments: FHWA Testing
1 1 0.008 1 6.15 4.62 3.32 2.55 1.86 1.41 0.81 0.00 100.0
1 1 0.008 1 9.03 7.19 5.09 3.92 2.86 2.17 1.23 0.79 100.0
1 1 0.008 1 12.04 9.64 6.83 5.29 3.84 2.95 1.67 1.05 100.0
GPS: Quality : GPS Fi Latitude = 40°22.002588 N Longitude = 105°35.238349 W PDOP = 1.80
GPS: State Plane Coordinates:
Note: Bear Lake Junction to 3M, 89 Degrees
2 1 0.100 1 6.03 4.15 3.27 2.69 2.06 1.56 0.94 0.00 102.2
2 1 0.100 1 8.91 6.50 5.07 4.17 3.19 2.42 1.40 0.98 102.2
2 1 0.100 1 11.82 8.92 6.94 5.71 4.37 3.31 1.95 1.30 102.2
GPS: Quality : GPS Fi Latitude = 40°22.024378 N Longitude = 105°35.300509 W PDOP = 1.70
GPS: State Plane Coordinates:
Note:
3 1 0.204 1 6.10 5.90 4.40 3.56 2.62 1.94 1.03 0.00 103.6
3 1 0.204 1 8.86 9.03 6.71 5.42 3.99 2.93 1.51 0.98 103.6
3 1 0.204 1 11.99 12.25 9.07 7.32 5.41 3.97 2.11 1.27 103.6
GPS: Quality : GPS Fi Latitude = 40°22.047811 N Longitude = 105°35.371113 W PDOP = 1.50
GPS: State Plane Coordinates:
Note:
4 1 0.300 1 6.10 4.82 3.75 2.96 2.11 1.55 0.85 0.00 100.7
4 1 0.300 1 8.94 7.38 5.61 4.39 3.15 2.30 1.24 0.84 100.7
4 1 0.300 1 12.16 9.79 7.40 5.75 4.15 3.02 1.66 1.11 100.7
GPS: Quality : GPS Fi Latitude = 40°22.069784 N Longitude = 105°35.436251 W PDOP = 2.70
GPS: State Plane Coordinates:
Note:
5 1 0.408 1 5.93 7.90 6.34 5.29 4.07 3.15 1.91 1.26 102.5
5 1 0.408 1 8.74 12.33 9.78 8.05 6.21 4.79 2.83 1.85 102.5
5 1 0.408 1 11.79 16.83 13.27 10.89 8.43 6.47 3.88 2.45 102.5
GPS: Quality : GPS Fi Latitude = 40°22.094809 N Longitude = 105°35.509039 W PDOP = 1.80
GPS: State Plane Coordinates:
Note: 85 degrees
6 1 0.500 1 5.93 5.79 4.51 3.59 2.66 1.96 1.09 0.00 107.3
6 1 0.500 1 8.96 9.05 6.88 5.49 4.07 3.00 1.63 1.10 107.3
6 1 0.500 1 11.84 11.98 9.03 7.18 5.29 3.89 2.15 1.37 107.3
GPS: Quality : GPS Fi Latitude = 40°22.132302 N Longitude = 105°35.551151 W PDOP = 1.80
GPS: State Plane Coordinates:
Note:
7 1 0.600 1 5.96 8.33 7.05 6.08 4.90 3.91 2.51 1.73 105.8
7 1 0.600 1 8.94 13.18 11.13 9.52 7.70 6.17 3.92 2.68 105.8
7 1 0.600 1 11.77 17.48 14.69 12.51 10.18 8.11 5.26 3.55 105.8
GPS: Quality : GPS Fi Latitude = 40°22.179557 N Longitude = 105°35.520888 W PDOP = 1.80
GPS: State Plane Coordinates:
Note:
8 1 0.703 1 6.10 5.27 4.15 3.44 2.63 1.99 1.11 0.00 107.7
8 1 0.703 1 9.06 8.36 6.49 5.36 4.07 3.07 1.71 1.06 107.7
8 1 0.703 1 12.16 11.28 8.69 7.15 5.43 4.09 2.32 1.37 107.7
GPS: Quality : GPS Fi Latitude = 40°22.203187 N Longitude = 105°35.452325 W PDOP = 1.90
GPS: State Plane Coordinates:
Note:
9 1 0.801 1 6.23 5.08 3.82 3.04 2.26 1.71 1.06 0.00 76.5
9 1 0.801 1 9.06 8.07 6.01 4.77 3.53 2.70 1.60 1.12 76.5
9 1 0.801 1 11.87 10.77 7.97 6.35 4.74 3.61 2.20 1.43 76.5
GPS: Quality : GPS Fi Latitude = 40°22.220777 N Longitude = 105°35.384241 W PDOP

= 2.50
GPS: State Plane Coordinates:
Note:
10 1 0.902 1 6.08 5.98 4.20 3.20 2.18 1.46 0.00 0.00 103.3
10 1 0.902 1 9.06 9.57 6.64 5.06 3.46 2.34 1.03 0.00 103.3
10 1 0.902 1 11.89 12.70 8.81 6.67 4.60 3.12 1.42 0.82 103.3
GPS: Quality : GPS Fi Latitude = 40°22.219209 N Longitude = 105°35.302265 W PDOP
= 1.80
GPS: State Plane Coordinates:
Note:
11 1 1.004 1 5.96 6.83 4.80 3.80 2.87 2.20 1.44 1.09 105.5
11 1 1.004 1 9.11 11.25 7.91 6.25 4.70 3.61 2.33 1.71 105.5
11 1 1.004 1 12.21 15.33 10.77 8.51 6.41 4.94 3.24 2.31 105.5
GPS: Quality : GPS Fi Latitude = 40°22.197433 N Longitude = 105°35.232867 W PDOP
= 1.80
GPS: State Plane Coordinates:
Note:
12 1 1.102 1 6.13 9.27 7.10 5.58 4.01 2.94 1.69 1.18 106.6
12 1 1.102 1 8.98 14.96 11.36 8.95 6.56 4.84 2.83 2.00 106.6
12 1 1.102 1 11.74 19.64 14.88 11.65 8.54 6.28 3.57 2.49 106.6
GPS: Quality : GPS Fi Latitude = 40°22.212260 N Longitude = 105°35.171227 W PDOP
= 1.80
GPS: State Plane Coordinates:
Note:
13 1 1.204 1 6.05 6.79 5.01 3.84 2.60 1.72 0.69 0.00 107.7
13 1 1.204 1 9.20 10.76 7.82 5.98 4.02 2.63 1.03 0.00 107.7
13 1 1.204 1 12.11 14.14 10.22 7.79 5.24 3.47 1.35 0.60 107.7
GPS: Quality : GPS Fi Latitude = 40°22.261155 N Longitude = 105°35.213183 W PDOP
= 1.90
GPS: State Plane Coordinates:
Note:
14 1 1.303 1 6.03 6.02 4.84 4.08 3.09 2.30 1.21 0.00 106.6
14 1 1.303 1 8.81 9.64 7.74 6.47 4.92 3.64 1.88 1.06 106.6
14 1 1.303 1 12.23 13.72 11.03 9.17 6.99 5.19 2.72 1.49 106.6
GPS: Quality : GPS Fi Latitude = 40°22.271713 N Longitude = 105°35.284745 W PDOP
= 1.80
GPS: State Plane Coordinates:
Note:
15 1 1.402 1 5.93 10.36 8.25 6.57 4.83 3.58 2.03 1.34 111.3
15 1 1.402 1 9.01 16.87 13.27 10.50 7.71 5.64 3.12 2.08 111.3
15 1 1.402 1 11.77 23.08 18.17 14.26 10.48 7.67 4.24 2.77 111.3
GPS: Quality : GPS Fi Latitude = 40°22.295717 N Longitude = 105°35.349468 W PDOP
= 1.80
GPS: State Plane Coordinates:
Note:
16 1 1.502 1 5.96 6.79 4.92 3.91 2.81 2.05 1.07 0.00 104.7
16 1 1.502 1 8.96 10.98 7.94 6.29 4.55 3.29 1.65 1.00 104.7
16 1 1.502 1 12.08 14.98 10.82 8.55 6.23 4.49 2.30 1.31 104.7
GPS: Quality : GPS Fi Latitude = 40°22.322200 N Longitude = 105°35.414363 W PDOP
= 2.20
GPS: State Plane Coordinates:
Note:
17 1 1.600 1 5.91 6.86 4.84 3.60 2.41 1.66 0.85 0.00 98.9
17 1 1.600 1 8.96 11.58 8.07 5.98 4.00 2.73 1.31 0.00 98.9
17 1 1.600 1 11.94 15.88 11.11 8.22 5.55 3.77 1.86 1.19 98.9
GPS: Quality : GPS Fi Latitude = 40°22.354717 N Longitude = 105°35.472839 W PDOP
= 1.80
GPS: State Plane Coordinates:
Note:
18 1 1.700 1 5.98 6.74 5.21 4.30 3.29 2.47 1.43 0.00 108.8
18 1 1.700 1 8.89 10.92 8.46 6.91 5.31 3.97 2.27 1.45 108.8
18 1 1.700 1 11.96 15.32 11.86 9.66 7.40 5.56 3.16 1.96 108.8
GPS: Quality : GPS Fi Latitude = 40°22.396991 N Longitude = 105°35.520905 W PDOP
= 1.90
GPS: State Plane Coordinates:
Note:
19 1 1.800 1 6.10 5.58 3.87 2.81 2.03 1.53 1.03 0.00 103.6
19 1 1.800 1 9.06 9.03 6.14 4.49 3.20 2.42 1.55 1.21 103.6

```
19 1   1.800 1 12.13 12.36  8.42  6.21  4.43  3.35  2.16  1.62 103.6
GPS: Quality : GPS Fi   Latitude = 40°22.442984  N   Longitude = 105°35.563669   W   PDOP
= 2.20
GPS: State Plane Coordinates:
Note:
20 1   1.901 1  5.86  9.17  6.79  5.15  3.56  2.50  1.26  0.00 105.8
20 1   1.901 1  9.01 14.96 10.90  8.25  5.70  4.00  1.96  1.25 105.8
20 1   1.901 1 11.96 20.09 14.70 11.05  7.69  5.40  2.74  1.69 105.8
GPS: Quality : GPS Fi   Latitude = 40°22.481998  N   Longitude = 105°35.617706   W   PDOP
= 2.30
GPS: State Plane Coordinates:
Note: 94 degrees
21 1   2.002 1  5.98  4.16  3.41  2.84  2.15  1.60  0.91  0.00 109.9
21 1   2.002 1  9.06  6.83  5.55  4.62  3.51  2.62  1.45  0.91 109.9
21 1   2.002 1 11.96  9.59  7.79  6.47  4.95  3.68  2.02  1.24 109.9
GPS: Quality : GPS Fi   Latitude = 40°22.515033  N   Longitude = 105°35.678103   W   PDOP
= 2.30
GPS: State Plane Coordinates:
Note:
22 1   2.102 1  6.05  7.61  5.87  4.79  3.50  2.53  1.28  0.00 108.0
22 1   2.102 1  9.06 11.99  9.22  7.47  5.47  3.97  1.95  1.15 108.0
22 1   2.102 1 11.87 16.11 12.42 10.02  7.42  5.38  2.74  1.56 108.0
GPS: Quality : GPS Fi   Latitude = 40°22.547116  N   Longitude = 105°35.738501   W   PDOP
= 2.30
GPS: State Plane Coordinates:
Note:
23 1   2.199 1  6.20  6.11  4.27  3.13  2.12  1.47  0.00  0.00 111.7
23 1   2.199 1  8.96  9.68  6.66  4.92  3.34  2.33  1.19  0.00 111.7
23 1   2.199 1 11.96 13.38  9.17  6.78  4.64  3.23  1.65  1.04 111.7
GPS: Quality : GPS Fi   Latitude = 40°22.584569  N   Longitude = 105°35.789083   W   PDOP
= 1.90
GPS: State Plane Coordinates:
Note:
24 1   2.302 1  5.98  5.56  3.58  2.70  1.94  1.42  0.85  0.00  97.8
24 1   2.302 1  9.13  9.41  5.93  4.48  3.22  2.37  1.37  0.98  97.8
24 1   2.302 1 12.06 12.73  8.32  6.29  4.47  3.29  1.91  1.25  97.8
GPS: Quality : GPS Fi   Latitude = 40°22.636503  N   Longitude = 105°35.823463   W   PDOP
= 5.20
GPS: State Plane Coordinates:
Note:
25 1   2.401 1  5.98  4.57  3.29  2.55  1.89  1.34  0.00  0.00 108.0
25 1   2.401 1  8.94  7.54  5.35  4.16  3.01  2.20  1.21  0.87 108.0
25 1   2.401 1 12.26 10.75  7.59  5.92  4.26  3.12  1.74  1.11 108.0
GPS: Quality : GPS Fi   Latitude = 40°22.687411  N   Longitude = 105°35.853902   W   PDOP
= 2.50
GPS: State Plane Coordinates:
Note:
26 1   2.504 1  5.79 18.46 15.62 12.67  9.34  6.95  4.03  2.77 100.3
26 1   2.504 1  8.67 28.66 23.80 19.10 14.11 10.42  6.02  3.90 100.3
26 1   2.504 1 11.55 38.40 32.03 25.29 18.77 13.91  8.04  4.84 100.3
GPS: Quality : GPS Fi   Latitude = 40°22.736171  N   Longitude = 105°35.893421   W   PDOP
= 1.90
GPS: State Plane Coordinates:
Note:
27 1   2.602 1  5.96  8.21  6.45  5.22  3.98  3.07  1.86  1.26  96.7
27 1   2.602 1  9.03 13.32 10.35  8.35  6.35  4.87  2.91  1.91  96.7
27 1   2.602 1 11.82 18.07 13.96 11.29  8.64  6.59  3.96  2.55  96.7
GPS: Quality : GPS Fi   Latitude = 40°22.773018  N   Longitude = 105°35.946768   W   PDOP
= 1.60
GPS: State Plane Coordinates:
Note:
28 1   2.700 1  6.01  8.48  7.01  5.89  4.61  3.56  2.12  1.39 110.6
28 1   2.700 1  8.89 13.76 11.32  9.51  7.47  5.79  3.49  2.24 110.6
28 1   2.700 1 11.89 18.71 15.29 12.73  9.97  7.63  4.53  2.78 110.6
GPS: Quality : GPS Fi   Latitude = 40°22.818379  N   Longitude = 105°35.985684   W   PDOP
= 1.70
GPS: State Plane Coordinates:
Note:
```

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29 1   2.752 1  6.03  8.63  5.98  4.50  3.07  2.14  1.02  0.00 105.8
29 1   2.752 1  9.01 13.32  9.04  6.79  4.62  3.19  1.52  0.83 105.8
29 1   2.752 1 12.08 17.52 11.73  8.79  5.97  4.14  1.96  1.08 105.8
GPS: Quality : GPS Fi   Latitude = 40°22.843357  N   Longitude = 105°36.004480   W   PDOP
= 2.50
GPS: State Plane Coordinates:
Note: Estimated Start of Area (re)constructed in 1998
30 1   2.849 1  5.96 10.05  8.51  7.25  5.62  4.32  2.54  1.60 106.9
30 1   2.849 1  9.06 15.48 12.92 10.82  8.35  6.38  3.70  2.23 106.9
30 1   2.849 1 11.65 19.73 16.44 13.70 10.60  8.12  4.76  2.89 106.9
GPS: Quality : GPS Fi   Latitude = 40°22.891052  N   Longitude = 105°36.041443   W   PDOP
= 2.50
GPS: State Plane Coordinates:
Note: 1998 Section
31 1   2.955 1  5.98  8.40  6.69  5.55  4.18  3.10  1.57  0.82 108.4
31 1   2.955 1  8.81 12.74  9.96  8.22  6.18  4.55  2.29  1.14 108.4
31 1   2.955 1 11.72 16.84 13.08 10.73  8.05  5.94  3.01  1.47 108.4
GPS: Quality : GPS Fi   Latitude = 40°22.899958  N   Longitude = 105°36.108733   W   PDOP
= 2.30
GPS: State Plane Coordinates:
Note: 1998 Section
32 1   3.053 1  5.98  6.29  4.93  3.98  2.98  2.28  1.38  0.92 107.3
32 1   3.053 1  9.33 10.06  7.85  6.27  4.74  3.62  2.14  1.42 107.3
32 1   3.053 1 11.94 13.14 10.24  8.21  6.21  4.77  2.85  1.83 107.3
GPS: Quality : GPS Fi   Latitude = 40°22.861105  N   Longitude = 105°36.163991   W   PDOP
= 1.90
GPS: State Plane Coordinates:
Note: 1998 Section
33 1   3.160 1  6.05  4.48  3.23  2.51  1.79  1.29  0.00  0.00 111.7
33 1   3.160 1  9.01  7.09  5.06  3.92  2.76  2.02  1.15  0.80 111.7
33 1   3.160 1 12.11  9.78  6.96  5.36  3.77  2.75  1.59  1.06 111.7
GPS: Quality : GPS Fi   Latitude = 40°22.839788  N   Longitude = 105°36.234329   W   PDOP
= 1.90
GPS: State Plane Coordinates:
Note: 1998 Section
34 1   3.251 1  5.96  5.66  4.41  3.59  2.81  2.26  1.48  1.01 106.2
34 1   3.251 1  8.98  9.04  6.95  5.61  4.38  3.50  2.23  1.53 106.2
34 1   3.251 1 11.89 12.14  9.24  7.44  5.81  4.63  2.97  1.97 106.2
GPS: Quality : GPS Fi   Latitude = 40°22.868081  N   Longitude = 105°36.287321   W   PDOP
= 1.60
GPS: State Plane Coordinates:
Note: 1998 Section
35 1   3.352 1  6.05  9.94  8.19  6.92  5.33  3.99  1.90  1.06  80.6
35 1   3.352 1  8.91 15.33 12.50 10.50  8.13  6.04  2.84  1.54  80.6
35 1   3.352 1 11.84 20.04 16.26 13.60 10.56  7.87  3.76  2.00  80.6
GPS: Quality : GPS Fi   Latitude = 40°22.923224  N   Longitude = 105°36.292827   W   PDOP
= 1.60
GPS: State Plane Coordinates:
Note: 1998 Section
36 1   3.453 1  6.03  5.62  4.05  3.23  2.35  1.71  0.94  0.00 105.8
36 1   3.453 1  9.16  8.97  6.48  5.18  3.75  2.71  1.45  0.94 105.8
36 1   3.453 1 12.01 12.09  8.72  6.94  4.99  3.64  1.99  1.20 105.8
GPS: Quality : GPS Fi   Latitude = 40°22.969826  N   Longitude = 105°36.329651   W   PDOP
= 1.80
GPS: State Plane Coordinates:
Note: 1998 Section
37 1   3.551 1  6.01  7.36  5.47  4.38  3.28  2.48  1.41  0.00 113.9
37 1   3.551 1  8.86 11.47  8.40  6.67  5.04  3.79  2.12  1.31 113.9
37 1   3.551 1 11.89 15.28 11.10  8.81  6.66  5.04  2.86  1.74 113.9
GPS: Quality : GPS Fi   Latitude = 40°23.018656  N   Longitude = 105°36.356523   W   PDOP
= 2.60
GPS: State Plane Coordinates:
Note: 1998 Section
38 1   3.651 1  5.88  8.92  6.91  5.53  4.04  2.88  1.51  0.93 106.6
38 1   3.651 1  8.96 13.86 10.59  8.45  6.14  4.42  2.31  1.41 106.6
38 1   3.651 1 12.01 18.73 14.22 11.29  8.23  5.93  3.08  1.92 106.6
GPS: Quality : GPS Fi   Latitude = 40°23.070772  N   Longitude = 105°36.332173   W   PDOP
= 1.80
```

GPS: State Plane Coordinates:
Note: 1998 Section
39 1 3.751 1 6.08 7.78 6.30 5.12 3.78 2.80 1.47 0.87 107.3
39 1 3.751 1 9.08 12.29 9.82 7.93 5.82 4.31 2.26 1.31 107.3
39 1 3.751 1 12.16 16.10 12.86 10.28 7.55 5.57 2.99 1.70 107.3
GPS: Quality : GPS Fi Latitude = 40°23.121289 N Longitude = 105°36.354330 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: 1998 Section
40 1 3.851 1 6.15 4.12 3.17 2.65 2.01 1.51 0.88 0.00 108.8
40 1 3.851 1 9.11 6.43 4.92 4.12 3.12 2.36 1.34 0.83 108.8
40 1 3.851 1 12.28 8.87 6.77 5.63 4.28 3.25 1.86 1.10 108.8
GPS: Quality : GPS Fi Latitude = 40°23.154996 N Longitude = 105°36.412659 W PDOP = 2.60
GPS: State Plane Coordinates:
Note: 1998 Section
41 1 3.951 1 6.23 3.71 2.68 2.17 1.59 1.12 0.00 0.00 115.0
41 1 3.951 1 9.08 5.90 4.26 3.44 2.47 1.78 0.91 0.00 115.0
41 1 3.951 1 12.26 8.35 6.02 4.85 3.50 2.52 1.31 0.78 115.0
GPS: Quality : GPS Fi Latitude = 40°23.172768 N Longitude = 105°36.481533 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: 1998 Section
42 1 4.051 1 6.18 7.56 4.87 3.34 1.93 1.15 0.00 0.00 113.9
42 1 4.051 1 9.16 11.38 7.38 5.12 2.95 1.81 0.85 0.00 113.9
42 1 4.051 1 12.21 14.73 9.62 6.80 4.02 2.52 1.16 1.18 113.9
GPS: Quality : GPS Fi Latitude = 40°23.194281 N Longitude = 105°36.546628 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: 1998 Section
43 1 4.051 1 6.08 10.39 7.90 6.06 4.06 2.78 1.38 0.80 107.7
43 1 4.051 1 8.91 15.27 11.41 8.75 5.98 4.14 2.10 1.24 107.7
43 1 4.051 1 11.94 20.21 15.00 11.43 7.87 5.53 2.80 1.71 107.7
GPS: Quality : GPS Fi Latitude = 40°23.200732 N Longitude = 105°36.561393 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: End of 1998 Section
44 1 4.095 1 6.18 9.09 5.81 3.83 2.10 1.29 0.00 0.00 113.5
44 1 4.095 1 9.03 13.57 8.43 5.56 3.08 1.88 1.02 0.68 113.5
44 1 4.095 1 12.11 17.74 11.00 7.22 4.01 2.48 1.31 0.99 113.5
GPS: Quality : GPS Fi Latitude = 40°23.212678 N Longitude = 105°36.588894 W PDOP = 1.70
GPS: State Plane Coordinates:
Note:
45 1 4.112 1 6.08 9.43 6.90 5.33 3.56 2.41 1.22 0.82 110.2
45 1 4.112 1 9.08 14.35 10.43 7.99 5.37 3.68 1.87 1.22 110.2
45 1 4.112 1 11.89 18.72 13.57 10.39 7.03 4.83 2.41 1.60 110.2
GPS: Quality : GPS Fi Latitude = 40°23.216604 N Longitude = 105°36.600251 W PDOP = 1.70
GPS: State Plane Coordinates:
Note:
46 1 0.000 1 6.03 9.89 7.68 6.28 4.58 3.22 1.53 0.83 117.9
46 1 0.000 1 8.89 15.30 11.71 9.57 6.99 4.90 2.30 1.20 117.9
46 1 0.000 1 11.74 20.35 15.61 12.70 9.32 6.57 3.07 1.59 117.9
GPS: Quality : DGPS Fix Latitude = 40°23.214445 N Longitude = 105°36.616407 W PDOP = 1.70
GPS: State Plane Coordinates:
Note: Deer Ridge to 3M, 94 degrees, 1998, east end, just off paint
47 1 0.068 1 6.05 13.16 9.80 7.42 5.05 3.56 1.95 1.24 124.5
47 1 0.068 1 8.74 19.04 14.16 10.69 7.30 5.11 2.81 1.78 124.5
47 1 0.068 1 11.50 24.79 18.75 14.01 9.63 6.80 3.72 2.36 124.5
GPS: Quality : GPS Fi Latitude = 40°23.199555 N Longitude = 105°36.568384 W PDOP = 2.00
GPS: State Plane Coordinates:
Note: Deer Ridge to 3M, 94 degrees, heading east, 1998, east end,
48 1 0.089 1 5.93 13.99 10.48 7.87 5.33 3.59 1.68 0.93 121.2
48 1 0.089 1 8.91 21.55 15.95 11.88 8.01 5.43 2.51 1.41 121.2
48 1 0.089 1 11.50 27.18 20.26 14.81 10.05 6.82 3.17 1.72 121.2

GPS: Quality : GPS Fi Latitude = 40°23.194503 N Longitude = 105°36.555101 W PDOP = 2.00
GPS: State Plane Coordinates:
Note: Deer Ridge to 3M, 94 degrees, heading east, 1998, east end just indside foamed area
49 1 0.154 1 6.23 3.08 2.14 1.65 0.00 0.82 0.00 0.00 121.2
49 1 0.154 1 9.30 4.83 3.33 2.53 1.77 1.26 0.72 0.00 121.2
49 1 0.154 1 11.84 6.32 4.35 3.32 2.29 1.66 0.90 0.87 121.2
GPS: Quality : GPS Fi Latitude = 40°23.178829 N Longitude = 105°36.511792 W PDOP = 2.00
GPS: State Plane Coordinates:
Note: Deer Ridge to 3M, 95 degrees, heading east, 1998, 50m east of test 42
50 1 0.254 1 6.23 6.84 5.47 4.44 3.15 2.25 1.04 0.00 120.5
50 1 0.254 1 8.96 10.23 8.03 6.51 4.67 3.33 1.53 0.82 120.5
50 1 0.254 1 11.99 13.61 10.57 8.54 6.12 4.35 2.04 1.08 120.5
GPS: Quality : GPS Fi Latitude = 40°23.161775 N Longitude = 105°36.440617 W PDOP = 2.60
GPS: State Plane Coordinates:
Note: Deer Ridge to 3M, 94 degrees, heading east, 1998 Section
51 1 0.351 1 6.32 2.78 1.87 1.44 0.00 0.68 0.00 0.00 120.5
51 1 0.351 1 9.11 4.23 2.82 2.13 1.50 0.99 0.00 0.00 120.5
51 1 0.351 1 12.16 5.59 3.71 2.81 1.88 1.31 0.73 0.00 120.5
GPS: Quality : GPS Fi Latitude = 40°23.135282 N Longitude = 105°36.378149 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: Deer Ridge to 3M, 94 degrees, heading east, 1998 Section
52 1 0.455 1 6.01 6.69 5.41 4.67 3.76 3.02 1.97 1.37 116.5
52 1 0.455 1 8.74 10.40 8.46 7.30 5.97 4.84 3.26 2.30 116.5
52 1 0.455 1 11.69 13.62 11.00 9.39 7.64 6.16 4.08 2.77 116.5
GPS: Quality : GPS Fi Latitude = 40°23.089338 N Longitude = 105°36.333716 W PDOP = 2.60
GPS: State Plane Coordinates:
Note: Deer Ridge to 3M, 94 degrees, heading east, 1998 Section
53 1 0.552 1 6.20 8.44 6.56 5.41 3.99 2.92 1.52 0.88 116.8
53 1 0.552 1 8.89 12.68 9.96 8.15 6.04 4.41 2.25 1.29 116.8
53 1 0.552 1 11.84 17.49 13.83 11.31 8.36 6.16 3.13 1.81 116.8
GPS: Quality : GPS Fi Latitude = 40°23.036298 N Longitude = 105°36.353062 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: Deer Ridge to 3M, 94 degrees, heading east, 1998 Section
54 1 0.664 1 6.25 6.81 5.08 4.17 3.17 2.39 1.36 0.00 120.8
54 1 0.664 1 9.13 10.71 8.10 6.64 5.02 3.78 2.08 1.39 120.8
54 1 0.664 1 11.82 14.42 10.93 8.98 6.79 5.14 2.85 1.85 120.8
GPS: Quality : GPS Fi Latitude = 40°22.977807 N Longitude = 105°36.342109 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: Deer Ridge to 3M, 94 degrees, heading east, 1998 section
55 1 0.754 1 6.23 5.30 3.75 2.91 2.24 1.71 1.12 0.00 119.4
55 1 0.754 1 9.06 8.28 5.83 4.52 3.39 2.66 1.71 1.25 119.4
55 1 0.754 1 12.06 11.53 8.12 6.28 4.69 3.65 2.33 1.66 119.4
GPS: Quality : GPS Fi Latitude = 40°22.939857 N Longitude = 105°36.299199 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: Deer Ridge to 3M, 94 degrees, heading east, 1998 section, marked section
56 1 0.880 1 6.10 15.80 12.08 9.34 6.36 4.28 1.97 1.08 119.8
56 1 0.880 1 8.72 23.13 17.65 13.62 9.38 6.27 2.85 1.54 119.8
56 1 0.880 1 11.57 31.50 24.21 18.51 12.80 8.62 3.92 2.06 119.8
GPS: Quality : GPS Fi Latitude = 40°22.882738 N Longitude = 105°36.297846 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: Deer Ridge to 3M, 94 degrees, heading east, 1998 section, marked section
57 1 0.953 1 6.25 11.98 9.66 7.87 5.90 4.40 2.38 1.39 116.1
57 1 0.953 1 9.08 17.80 14.26 11.59 8.70 6.47 3.47 2.02 116.1
57 1 0.953 1 11.96 23.50 18.77 15.24 11.49 8.58 4.62 2.66 116.1
GPS: Quality : GPS Fi Latitude = 40°22.842439 N Longitude = 105°36.253761 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: Deer Ridge to 3M, 94 degrees, heading east, 1998 section, marked section
58 1 1.051 1 6.30 11.10 7.44 5.14 3.24 2.08 0.95 0.00 118.3

58 1 1.051 1 9.08 16.19 10.76 7.47 4.73 3.05 1.37 0.80 118.3
58 1 1.051 1 12.06 21.60 14.17 9.86 6.30 4.08 1.82 1.08 118.3
GPS: Quality : GPS Fi Latitude = 40°22.846679 N Longitude = 105°36.184417 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: 3M, 93 degrees, heading east, 1998 section
59 1 1.149 1 6.35 9.07 6.57 5.02 3.36 2.26 1.00 0.00 123.4
59 1 1.149 1 8.94 13.24 9.72 7.40 5.00 3.37 1.49 0.84 123.4
59 1 1.149 1 11.87 17.13 12.60 9.69 6.56 4.45 1.99 1.12 123.4
GPS: Quality : GPS Fi Latitude = 40°22.883375 N Longitude = 105°36.131130 W PDOP = 2.60
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 89 degrees, heading east, 1998 section
60 1 1.268 1 6.32 5.60 4.08 3.31 2.54 1.99 1.30 0.97 121.9
60 1 1.268 1 9.01 8.49 6.13 4.95 3.76 2.95 1.92 1.37 121.9
60 1 1.268 1 11.87 11.50 8.29 6.68 5.07 3.98 2.55 1.85 121.9
GPS: Quality : GPS Fi Latitude = 40°22.896057 N Longitude = 105°36.053808 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 89 degrees, heading east, 1998 section
61 1 1.356 1 6.25 11.52 9.02 7.27 5.34 3.91 2.16 1.31 115.4
61 1 1.356 1 9.06 16.99 13.12 10.59 7.72 5.64 3.05 1.88 115.4
61 1 1.356 1 11.89 22.26 17.09 13.72 10.03 7.33 3.99 2.50 115.4
GPS: Quality : GPS Fi Latitude = 40°22.854885 N Longitude = 105°36.016930 W PDOP = 2.60
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 89 degrees, heading east, 1998 section
62 1 1.409 1 6.49 10.14 8.21 6.94 5.41 4.16 2.49 1.63 117.9
62 1 1.409 1 9.11 14.95 12.04 10.15 7.96 6.13 3.68 2.38 117.9
62 1 1.409 1 11.82 19.48 15.65 13.13 10.31 7.97 4.86 3.08 117.9
GPS: Quality : GPS Fi Latitude = 40°22.829279 N Longitude = 105°35.997861 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 89 degrees, heading east, 2002 section new section at 1.394 km
63 1 1.508 1 6.64 7.16 5.26 3.94 2.78 2.00 1.19 0.00 122.3
63 1 1.508 1 9.06 10.32 7.46 5.59 3.93 2.85 1.62 1.16 122.3
63 1 1.508 1 12.18 14.47 10.41 7.79 5.53 4.00 2.29 1.56 122.3
GPS: Quality : GPS Fi Latitude = 40°22.781165 N Longitude = 105°35.957000 W PDOP = 2.50
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 89 degrees, heading east, 2002 section, 50 m past test 28
64 1 1.602 1 6.67 7.05 4.82 3.61 2.60 1.97 1.21 0.00 117.6
64 1 1.602 1 9.08 10.36 7.08 5.27 3.83 2.92 1.75 1.14 117.6
64 1 1.602 1 12.28 14.52 9.89 7.38 5.37 4.06 2.45 1.56 117.6
GPS: Quality : GPS Fi Latitude = 40°22.744044 N Longitude = 105°35.907619 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 89 degrees, heading east, 2002 section
65 1 1.700 1 6.08 7.28 5.26 4.05 2.87 2.05 1.03 0.00 117.2
65 1 1.700 1 8.86 11.33 8.15 6.31 4.48 3.19 1.56 0.98 117.2
65 1 1.700 1 11.94 15.50 11.17 8.61 6.17 4.41 2.20 1.25 117.2
GPS: Quality : GPS Fi Latitude = 40°22.699860 N Longitude = 105°35.864445 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 89 degrees, heading east, 2002 section
66 1 1.801 1 6.08 7.45 5.39 4.50 3.63 2.94 1.99 1.44 120.8
66 1 1.801 1 8.91 12.03 8.74 7.22 5.75 4.68 3.09 2.20 120.8
66 1 1.801 1 11.89 16.43 11.98 9.82 7.82 6.33 4.23 2.97 120.8
GPS: Quality : GPS Fi Latitude = 40°22.648997 N Longitude = 105°35.833308 W PDOP = 4.20
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 89 degrees, heading east, 2002 section
67 1 1.898 1 5.98 6.34 4.17 3.24 2.41 1.79 1.10 0.00 122.7
67 1 1.898 1 9.01 10.28 6.77 5.25 3.82 2.89 1.70 1.14 122.7
67 1 1.898 1 12.06 14.17 9.43 7.29 5.35 3.99 2.37 1.56 122.7
GPS: Quality : GPS Fi Latitude = 40°22.598907 N Longitude = 105°35.803011 W PDOP = 5.40
GPS: State Plane Coordinates:

Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section
68 1 2.000 1 5.98 9.72 7.45 5.90 4.20 2.97 1.47 0.94 123.0
68 1 2.000 1 9.08 15.59 11.85 9.38 6.65 4.68 2.29 1.41 123.0
68 1 2.000 1 11.99 20.80 15.66 12.34 8.78 6.16 3.01 1.80 123.0
GPS: Quality : GPS Fi Latitude = 40°22.554421 N Longitude = 105°35.755389 W PDOP = 2.00
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section
69 1 2.102 1 6.15 7.97 6.31 5.04 3.92 3.10 2.06 1.61 123.4
69 1 2.102 1 9.18 12.98 10.10 8.05 6.17 4.76 3.06 2.26 123.4
69 1 2.102 1 12.01 17.82 13.83 11.03 8.51 6.62 4.34 3.16 123.4
GPS: Quality : GPS Fi Latitude = 40°22.520857 N Longitude = 105°35.694619 W PDOP = 2.40
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section
70 1 2.199 1 6.03 6.35 4.59 3.62 2.66 2.00 1.16 0.00 123.0
70 1 2.199 1 9.01 10.20 7.27 5.73 4.17 3.10 1.78 1.17 123.0
70 1 2.199 1 12.18 14.12 10.02 7.85 5.76 4.27 2.46 1.55 123.0
GPS: Quality : GPS Fi Latitude = 40°22.488518 N Longitude = 105°35.636218 W PDOP = 2.00
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section
71 1 2.373 1 6.15 5.02 3.41 2.71 2.08 1.62 1.10 0.00 121.6
71 1 2.373 1 9.13 7.89 5.32 4.18 3.14 2.43 1.59 1.27 121.6
71 1 2.373 1 11.87 10.72 7.27 5.73 4.28 3.31 2.16 1.67 121.6
GPS: Quality : GPS Fi Latitude = 40°22.451340 N Longitude = 105°35.577966 W PDOP = 2.30
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section
72 1 2.399 1 6.03 11.72 8.80 7.01 5.03 3.51 1.72 1.08 124.5
72 1 2.399 1 8.91 18.72 14.03 11.10 7.97 5.57 2.68 1.62 124.5
72 1 2.399 1 11.96 25.54 19.24 15.07 10.90 7.62 3.73 2.23 124.5
GPS: Quality : GPS Fi Latitude = 40°22.406490 N Longitude = 105°35.534515 W PDOP = 2.00
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section
73 1 2.500 1 6.15 4.58 3.09 2.45 1.95 1.52 1.07 0.00 124.5
73 1 2.500 1 8.94 7.14 4.79 3.76 2.88 2.28 1.55 1.20 124.5
73 1 2.500 1 12.01 9.89 6.67 5.23 4.00 3.19 2.15 1.58 124.5
GPS: Quality : GPS Fi Latitude = 40°22.361898 N Longitude = 105°35.488115 W PDOP = 2.00
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section
74 1 2.607 1 6.18 4.85 3.14 2.39 1.71 1.22 0.00 0.00 122.7
74 1 2.607 1 9.25 7.69 4.98 3.77 2.64 1.91 1.10 0.80 122.7
74 1 2.607 1 12.01 10.33 6.72 5.08 3.55 2.58 1.48 1.01 122.7
GPS: Quality : GPS Fi Latitude = 40°22.324308 N Longitude = 105°35.426099 W PDOP = 2.00
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section
75 1 2.695 1 5.91 8.05 5.79 4.55 3.21 2.26 1.13 0.00 121.2
75 1 2.695 1 9.03 13.21 9.40 7.37 5.20 3.64 1.76 1.07 121.2
75 1 2.695 1 12.06 18.12 12.93 10.09 7.15 5.02 2.44 1.45 121.2
GPS: Quality : GPS Fi Latitude = 40°22.300239 N Longitude = 105°35.368948 W PDOP = 2.00
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section
76 1 2.795 1 6.03 10.75 7.78 6.40 4.74 3.46 1.77 0.00 121.9
76 1 2.795 1 8.98 17.17 12.50 10.20 7.57 5.49 2.72 1.53 121.9
76 1 2.795 1 12.01 23.41 17.15 13.91 10.39 7.57 3.80 2.04 121.9
GPS: Quality : GPS Fi Latitude = 40°22.274373 N Longitude = 105°35.303049 W PDOP = 2.00
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section
77 1 2.894 1 6.18 10.09 7.31 5.63 4.02 2.83 1.40 0.00 125.6
77 1 2.894 1 8.96 15.79 11.29 8.69 6.21 4.36 2.14 1.28 125.6
77 1 2.894 1 12.04 21.75 15.55 11.85 8.48 5.99 2.97 1.76 125.6
GPS: Quality : GPS Fi Latitude = 40°22.260361 N Longitude = 105°35.232673 W PDOP

= 2.00
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section
78 1 2.997 1 5.96 11.63 9.16 6.81 4.80 3.48 1.86 1.10 119.0
78 1 2.997 1 8.76 18.79 14.50 10.80 7.64 5.51 2.90 1.70 119.0
78 1 2.997 1 11.62 25.06 18.97 14.25 10.15 7.39 3.87 2.29 119.0
GPS: Quality : GPS Fi Latitude = 40°22.232525 N Longitude = 105°35.172255 W PDOP
= 2.00
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section
79 1 3.096 1 5.96 10.47 7.88 6.33 4.76 3.62 2.20 1.60 117.6
79 1 3.096 1 8.74 16.07 11.95 9.48 7.08 5.27 3.08 2.16 117.6
79 1 3.096 1 12.06 22.61 16.87 13.31 10.03 7.52 4.57 3.23 117.6
GPS: Quality : GPS Fi Latitude = 40°22.194649 N Longitude = 105°35.212239 W PDOP
= 2.00
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section
80 1 3.197 1 6.03 6.79 4.47 3.30 2.43 1.86 1.22 0.00 119.4
80 1 3.197 1 9.30 11.14 7.23 5.33 3.86 2.97 1.89 1.44 119.4
80 1 3.197 1 12.18 14.72 9.50 6.99 5.08 3.92 2.50 1.82 119.4
GPS: Quality : GPS Fi Latitude = 40°22.215375 N Longitude = 105°35.281976 W PDOP
= 2.30
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section
81 1 3.297 1 5.86 12.85 9.57 7.51 5.52 4.09 2.25 1.32 119.0
81 1 3.297 1 8.86 19.85 14.44 11.20 8.21 6.04 3.25 1.85 119.0
81 1 3.297 1 11.69 26.41 19.14 14.61 10.73 7.89 4.19 2.39 119.0
GPS: Quality : GPS Fi Latitude = 40°22.224035 N Longitude = 105°35.354585 W PDOP
= 1.90
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 88 degrees, heading east, 2002 section
82 1 3.399 1 6.08 6.30 4.08 3.15 2.25 1.61 0.89 0.00 119.8
82 1 3.399 1 9.25 9.82 6.29 4.85 3.42 2.46 1.33 0.88 119.8
82 1 3.399 1 12.40 13.07 8.38 6.44 4.50 3.26 1.73 1.10 119.8
GPS: Quality : GPS Fi Latitude = 40°22.212281 N Longitude = 105°35.427521 W PDOP
= 1.90
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 89 degrees, heading east, 2002 section
83 1 3.499 1 6.10 8.91 6.55 5.02 3.66 2.69 1.50 1.00 119.8
83 1 3.499 1 9.13 14.07 10.18 7.76 5.61 4.14 2.29 1.50 119.8
83 1 3.499 1 12.06 18.44 13.30 10.04 7.31 5.40 3.00 1.93 119.8
GPS: Quality : GPS Fi Latitude = 40°22.189971 N Longitude = 105°35.495285 W PDOP
= 1.90
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 89 degrees, heading east, 2002 section,
84 1 3.600 1 5.86 16.56 12.90 10.21 7.25 5.06 2.44 1.45 121.6
84 1 3.600 1 8.79 26.32 20.51 16.02 11.48 8.04 3.84 2.23 121.6
84 1 3.600 1 11.43 34.78 27.02 21.12 15.21 10.68 5.15 2.96 121.6
GPS: Quality : GPS Fi Latitude = 40°22.155447 N Longitude = 105°35.551464 W PDOP
= 1.90
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 89 degrees, heading east, 2002 section
85 1 3.700 1 5.96 11.69 8.56 6.77 4.97 3.64 1.99 1.30 125.2
85 1 3.700 1 9.03 18.74 13.66 10.71 7.90 5.75 3.13 2.01 125.2
85 1 3.700 1 11.84 24.58 18.25 14.09 10.45 7.68 4.22 2.71 125.2
GPS: Quality : GPS Fi Latitude = 40°22.104083 N Longitude = 105°35.535637 W PDOP
= 1.90
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 88 degrees, heading east, 2002 section
86 1 3.800 1 6.10 4.38 2.71 2.13 0.00 1.23 0.86 0.00 121.9
86 1 3.800 1 9.28 6.86 4.27 3.30 2.47 1.96 1.33 1.03 121.9
86 1 3.800 1 12.33 9.35 5.83 4.51 3.40 2.68 1.84 1.35 121.9
GPS: Quality : GPS Fi Latitude = 40°22.078530 N Longitude = 105°35.470134 W PDOP
= 2.20
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 88 degrees, heading east, 2002 section
87 1 3.902 1 6.18 7.06 4.65 3.43 2.51 1.83 1.07 0.00 121.9
87 1 3.902 1 9.01 11.04 7.14 5.23 3.77 2.77 1.62 1.12 121.9

87 1 3.902 1 12.28 15.17 9.73 7.08 5.09 3.76 2.22 1.47 121.9
GPS: Quality : GPS Fi Latitude = 40°22.055121 N Longitude = 105°35.401260 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 89 degrees, heading east, 2002 section
88 1 4.108 1 6.13 9.51 6.98 5.40 3.96 2.94 1.68 1.12 85.3
88 1 4.108 1 9.13 14.85 10.69 8.16 5.99 4.45 2.53 1.63 85.3
88 1 4.108 1 12.01 19.86 14.22 10.88 7.98 5.94 3.34 2.18 85.3
GPS: Quality : GPS Fi Latitude = 40°22.033025 N Longitude = 105°35.335424 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 89 degrees, heading east, 2002 section
89 1 4.113 1 6.05 5.54 3.86 2.92 2.08 1.49 0.83 0.00 80.6
89 1 4.113 1 9.18 8.99 6.21 4.67 3.33 2.44 1.32 0.85 80.6
89 1 4.113 1 12.11 12.33 8.59 6.46 4.57 3.35 1.82 1.08 80.6
GPS: Quality : GPS Fi Latitude = 40°22.008277 N Longitude = 105°35.258338 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section, east end, just on foam section
90 1 4.173 1 6.25 5.81 4.30 3.41 2.41 1.77 1.02 0.00 117.9
90 1 4.173 1 9.01 8.66 6.45 5.09 3.63 2.68 1.52 1.03 117.9
90 1 4.173 1 12.28 11.65 8.69 6.97 4.99 3.75 2.11 1.39 117.9
GPS: Quality : GPS Fi Latitude = 40°21.992569 N Longitude = 105°35.219482 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section, east end, just outside foam section
91 1 4.218 1 6.23 6.46 4.88 3.84 2.68 1.92 1.08 0.75 119.8
91 1 4.218 1 9.20 9.51 7.29 5.71 4.05 2.99 1.73 1.21 119.8
91 1 4.218 1 12.23 12.12 9.27 7.33 5.22 3.89 2.20 1.55 119.8
GPS: Quality : GPS Fi Latitude = 40°21.980896 N Longitude = 105°35.190090 W PDOP = 1.80
GPS: State Plane Coordinates:
Note: 3M to Bear Lake, 87 degrees, heading east, 2002 section, east end, just outside foam section

Appendix C

Summary of Field Deflection Results -

Deer Ridge Junction to Horseshoe Overlook

M3
Date-Time: 7-17-2003 12: 0:39
Sensors: CHOP CHOP Chop Chop Chop Chop Chop
Weight/spring: 2
Location: Rocky Mount Natl Park
Temp: 118.07
Operator: ajs
Comments: FHWA Testing

1	1	0.000	1	6.03	11.12	6.35	3.82	2.08	1.22	0.00	0.00	117.9
1	1	0.000	1	6.03	11.12	6.35	3.82	2.08	1.22	0.00	0.00	117.9
1	1	0.000	1	9.16	16.31	9.40	5.70	3.06	1.83	0.94	0.75	117.9
1	1	0.000	1	11.87	10.12	5.99	3.62	1.98	1.22	0.61	0.43	117.9

GPS: Quality : GPS Fi Latitude = 40°23.234836 N Longitude = 105°36.645660 W PDOP = 1.60
GPS: State Plane Coordinates:
Note: Fall River Road, 83 degrees, heading north,start

2	1	0.005	1	6.05	9.67	5.05	3.01	0.00	1.25	0.00	0.00	117.9
2	1	0.005	1	9.01	14.71	7.52	4.54	2.65	1.85	1.18	0.92	117.9
2	1	0.005	1	11.82	18.91	9.66	5.91	3.46	2.49	1.56	1.21	117.9
2	1	0.005	1	14.82	11.42	5.92	3.61	2.14	1.54	0.98	0.75	117.9

GPS: Quality : GPS Fi Latitude = 40°23.234833 N Longitude = 105°36.645689 W PDOP = 1.60
GPS: State Plane Coordinates:
Note: Fall River Road, 87 degrees, heading north,start

3	1	0.100	1	6.20	7.90	4.59	3.00	2.10	1.75	1.40	1.10	131.8
3	1	0.100	1	8.86	11.79	6.73	4.39	3.09	2.61	2.07	1.61	131.8
3	1	0.100	1	12.08	16.15	9.12	5.97	4.16	3.60	2.92	2.27	131.8
3	1	0.100	1	14.94	10.19	5.85	3.68	2.58	2.25	1.84	1.44	131.8

GPS: Quality : GPS Fi Latitude = 40°23.284573 N Longitude = 105°36.673305 W PDOP = 5.10
GPS: State Plane Coordinates:
Note: Fall River Road, 88 degrees, heading north

4	1	0.200	1	6.03	10.27	6.50	4.42	2.70	1.69	0.00	0.00	134.4
4	1	0.200	1	8.69	15.52	9.82	6.70	4.09	2.56	1.24	0.00	134.4
4	1	0.200	1	11.65	21.28	13.36	9.05	5.54	3.55	1.71	1.13	134.4
4	1	0.200	1	14.77	27.06	16.83	11.31	6.95	4.49	2.15	1.46	134.4

GPS: Quality : GPS Fi Latitude = 40°23.340177 N Longitude = 105°36.691174 W PDOP = 1.80
GPS: State Plane Coordinates:
Note: Fall River Road, 87 degrees, heading north

5	1	0.301	1	6.05	7.93	4.83	3.17	1.87	1.16	0.00	0.00	134.8
5	1	0.301	1	8.94	12.11	7.25	4.69	2.75	1.70	0.82	0.00	134.8
5	1	0.301	1	12.01	16.30	9.53	6.16	3.62	2.25	1.12	0.77	134.8
5	1	0.301	1	14.75	19.98	11.64	7.41	4.29	2.71	1.36	0.99	134.8

GPS: Quality : GPS Fi Latitude = 40°23.391439 N Longitude = 105°36.725584 W PDOP = 1.80
GPS: State Plane Coordinates:
Note: Fall River Road, 87 degrees, heading north

6	1	0.401	1	6.01	9.39	6.11	4.48	3.11	2.28	1.44	1.08	137.3
6	1	0.401	1	8.64	14.33	9.33	6.73	4.61	3.38	2.13	1.62	137.3
6	1	0.401	1	11.69	19.53	12.80	9.12	6.22	4.60	2.87	2.19	137.3
6	1	0.401	1	14.82	24.70	16.17	11.35	7.74	5.72	3.57	2.74	137.3

GPS: Quality : GPS Fi Latitude = 40°23.436834 N Longitude = 105°36.770086 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: Fall River Road, 88 degrees, heading north

7	1	0.499	1	5.88	12.22	7.54	5.11	3.49	2.47	1.38	0.00	139.5
7	1	0.499	1	8.79	19.78	12.06	8.15	5.49	3.90	2.18	1.44	139.5
7	1	0.499	1	11.72	27.18	16.49	11.02	7.44	5.33	2.98	2.02	139.5
7	1	0.499	1	14.53	34.19	20.81	13.58	9.16	6.59	3.68	2.52	139.5

GPS: Quality : GPS Fi Latitude = 40°23.489902 N Longitude = 105°36.789041 W PDOP = 1.80
GPS: State Plane Coordinates:
Note: Fall River Road, 88 degrees, heading north

8	1	0.600	1	5.96	10.79	7.64	5.83	4.12	2.95	1.62	1.08	138.8
8	1	0.600	1	8.94	17.35	12.19	9.27	6.47	4.62	2.49	1.61	138.8
8	1	0.600	1	11.87	23.31	16.33	12.29	8.63	6.18	3.31	2.17	138.8
8	1	0.600	1	14.99	29.60	20.41	15.34	10.76	7.70	4.13	2.70	138.8

GPS: Quality : GPS Fi Latitude = 40°23.543000 N Longitude = 105°36.814141 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading north

9	1	0.701	1	5.86	8.42	5.47	3.81	2.44	1.66	0.00	0.00	136.2
9	1	0.701	1	8.94	13.49	8.73	6.10	3.88	2.64	1.36	0.00	136.2
9	1	0.701	1	12.13	18.86	12.03	8.36	5.36	3.69	1.88	1.18	136.2
9	1	0.701	1	15.06	23.62	14.93	10.25	6.59	4.61	2.31	1.51	136.2

GPS: Quality : GPS Fi Latitude = 40°23.585798 N Longitude = 105°36.865081 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading north

10	1	0.800	1	5.93	11.29	7.05	4.93	3.40	2.49	1.63	1.27	139.9
10	1	0.800	1	8.64	18.02	11.30	7.81	5.25	3.80	2.43	1.87	139.9
10	1	0.800	1	11.69	25.44	15.97	11.04	7.38	5.37	3.38	2.56	139.9
10	1	0.800	1	14.62	34.22	20.42	14.00	9.31	6.73	4.15	3.11	139.9

GPS: Quality : GPS Fi Latitude = 40°23.627827 N Longitude = 105°36.914018 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading north

11	1	0.900	1	5.96	11.62	8.01	6.13	4.68	3.84	2.67	1.95	137.0
11	1	0.900	1	8.96	18.01	12.31	9.28	7.05	5.74	4.09	3.04	137.0
11	1	0.900	1	11.91	24.37	16.43	12.15	9.16	7.36	5.16	3.82	137.0
11	1	0.900	1	14.77	30.80	20.39	15.04	11.28	9.11	6.39	4.69	137.0

GPS: Quality : GPS Fi Latitude = 40°23.675961 N Longitude = 105°36.952968 W PDOP = 1.80
GPS: State Plane Coordinates:
Note: Fall River Road, 88 degrees, heading north

12	1	1.000	1	5.91	10.71	6.96	5.23	3.65	2.60	1.47	1.01	136.2
12	1	1.000	1	9.18	16.92	10.86	8.07	5.59	3.97	2.22	1.53	136.2
12	1	1.000	1	12.13	22.36	14.43	10.57	7.33	5.28	2.96	2.16	136.2
12	1	1.000	1	15.21	27.69	17.62	12.82	8.92	6.47	3.67	2.69	136.2

GPS: Quality : GPS Fi Latitude = 40°23.717712 N Longitude = 105°37.002533 W PDOP = 2.20
GPS: State Plane Coordinates:
Note: Fall River Road, 88 degrees, heading north

13	1	1.143	1	6.08	9.63	6.02	4.16	2.71	1.87	1.09	0.00	141.7
13	1	1.143	1	8.91	14.88	9.16	6.29	4.02	2.86	1.64	1.15	141.7
13	1	1.143	1	12.18	21.06	12.70	8.62	5.51	3.91	2.22	1.60	141.7
13	1	1.143	1	14.92	26.28	15.74	10.58	6.74	4.78	2.70	1.97	141.7

GPS: Quality : GPS Fi Latitude = 40°23.746186 N Longitude = 105°37.068204 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: Fall River Road, 89 degrees, heading north

14	1	1.143	1	6.08	8.86	5.99	4.19	2.90	2.14	1.32	0.00	133.7
14	1	1.143	1	9.06	13.48	9.00	6.23	4.26	3.17	1.94	1.39	133.7
14	1	1.143	1	12.13	18.36	12.15	8.33	5.75	4.31	2.63	1.94	133.7
14	1	1.143	1	15.14	22.86	14.61	10.15	6.99	5.29	3.23	2.36	133.7

GPS: Quality : GPS Fi Latitude = 40°23.756727 N Longitude = 105°37.094872 W PDOP = 2.20
GPS: State Plane Coordinates:
Note: Fall River Road, 89 degrees, heading north, end point

15	1	1.165	1	6.03	8.81	5.52	4.07	2.89	2.09	1.28	0.00	140.6
15	1	1.165	1	9.06	13.80	8.55	6.21	4.34	3.17	1.93	1.36	140.6
15	1	1.165	1	11.99	19.01	11.61	8.40	5.85	4.28	2.58	1.88	140.6
15	1	1.165	1	14.84	23.64	14.39	10.31	7.11	5.26	3.13	2.31	140.6

GPS: Quality : GPS Fi Latitude = 40°23.762054 N Longitude = 105°37.109145 W PDOP = 1.80
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading north, off of foam

16	1	1.188	1	6.03	9.41	5.86	4.35	2.99	2.21	1.34	0.97	141.4
16	1	1.188	1	8.98	14.23	8.74	6.42	4.39	3.23	1.98	1.49	141.4
16	1	1.188	1	12.01	19.11	11.53	8.40	5.77	4.26	2.56	2.00	141.4
16	1	1.188	1	14.87	23.40	14.04	10.13	6.92	5.16	3.12	2.46	141.4

GPS: Quality : GPS Fi Latitude = 40°23.767683 N Longitude = 105°37.124177 W PDOP = 1.80
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading north, foam

```
17 1   0.000 1  6.03  6.68  4.34  2.71  0.00  0.78  0.00  0.00 141.0
17 1   0.000 1  8.96 10.59  6.72  4.17  2.11  1.11  0.00  0.00 141.0
17 1   0.000 1 12.18 14.84  9.25  5.70  2.82  1.49  0.00  0.00 141.0
17 1   0.000 1 15.14 18.41 11.35  7.01  3.48  1.81  1.38  0.00 141.0
GPS: Quality : GPS Fi   Latitude = 40°23.770834  N   Longitude = 105°37.135848   W   PDOP
= 2.10
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading south, foam
18 1   0.006 1  6.13  9.91  6.51  4.49  3.06  2.15  1.24  0.49 138.1
18 1   0.006 1  8.84 15.40  9.99  6.81  4.59  3.23  1.87  1.24 138.1
18 1   0.006 1 11.91 21.86 14.15  9.58  6.40  4.47  2.50  1.68 138.1
18 1   0.006 1 14.94 28.44 18.10 12.16  8.07  5.65  3.12  2.08 138.1
GPS: Quality : GPS Fi   Latitude = 40°23.770019  N   Longitude = 105°37.133547   W   PDOP
= 1.50
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading south, foam
19 1   0.039 1  6.08  8.88  5.63  3.95  2.65  1.79  1.00  0.00 143.2
19 1   0.039 1  8.98 13.69  8.48  5.92  3.86  2.63  1.46  1.04 143.2
19 1   0.039 1 12.04 18.49 11.17  7.77  5.02  3.46  1.94  1.39 143.2
19 1   0.039 1 14.99 23.09 13.74  9.52  6.08  4.22  2.37  1.75 143.2
GPS: Quality : GPS Fi   Latitude = 40°23.761754  N   Longitude = 105°37.112225   W   PDOP
= 1.50
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading south, foam
20 1   0.067 1  5.96  7.94  4.89  3.37  2.28  1.64  1.19  0.00 145.4
20 1   0.067 1  9.01 12.85  7.58  5.19  3.48  2.51  1.48  1.06 145.4
20 1   0.067 1 12.01 17.38  9.84  6.66  4.45  3.21  1.85  1.38 145.4
20 1   0.067 1 15.38 22.04 12.44  8.27  5.49  3.96  2.26  1.73 145.4
GPS: Quality : GPS Fi   Latitude = 40°23.754536  N   Longitude = 105°37.093982   W   PDOP
= 1.70
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading south, foam
21 1   0.149 1  5.91 10.98  6.96  4.69  2.86  1.86  1.02  0.00 146.9
21 1   0.149 1  9.01 17.81 11.02  7.33  4.39  2.85  1.53  1.01 146.9
21 1   0.149 1 11.72 24.54 15.07  9.84  5.92  3.82  2.06  1.34 146.9
21 1   0.149 1 14.67 31.74 19.62 12.38  7.42  4.84  2.53  1.64 146.9
GPS: Quality : GPS Fi   Latitude = 40°23.734062  N   Longitude = 105°37.041048   W   PDOP
= 2.00
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading south, foam
22 1   0.252 1  6.15  8.90  5.18  3.26  1.93  1.19  0.00  0.00 135.5
22 1   0.252 1  8.98 13.67  7.83  4.87  2.81  1.74  0.88  0.00 135.5
22 1   0.252 1 12.18 18.97 10.68  6.52  3.76  2.32  1.14  1.45 135.5
22 1   0.252 1 15.14 23.51 13.22  7.94  4.48  2.80  1.38  1.27 135.5
GPS: Quality : GPS Fi   Latitude = 40°23.698959  N   Longitude = 105°36.979563   W   PDOP
= 1.70
GPS: State Plane Coordinates:
Note: Fall River Road, 86 degrees, heading south, foam
23 1   0.276 1  6.15  8.59  4.84  2.93  1.65  1.01  0.00  0.00 135.9
23 1   0.276 1  9.03 13.68  7.50  4.49  2.50  1.53  0.00  0.00 135.9
23 1   0.276 1 12.08 18.64 10.08  5.96  3.33  2.03  1.03  0.00 135.9
23 1   0.276 1 14.87 23.22 12.59  7.32  4.04  2.47  1.20  1.40 135.9
GPS: Quality : GPS Fi   Latitude = 40°23.688805  N   Longitude = 105°36.967976   W   PDOP
= 1.80
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading south, foam
24 1   0.349 1  5.98  9.27  5.65  3.99  2.75  1.95  1.20  1.32 131.5
24 1   0.349 1  8.96 14.30  8.71  6.17  4.27  3.10  1.91  1.40 131.5
24 1   0.349 1 12.13 19.48 11.73  8.33  5.80  4.31  2.64  1.99 131.5
24 1   0.349 1 15.14 24.20 14.48 10.21  7.13  5.35  3.32  2.50 131.5
GPS: Quality : GPS Fi   Latitude = 40°23.654959  N   Longitude = 105°36.940239   W   PDOP
= 1.80
GPS: State Plane Coordinates:
Note: Fall River Road, 86 degrees, heading south, foam
25 1   0.456 1  6.10  9.87  6.31  4.60  3.24  2.35  1.45  1.04 126.0
25 1   0.456 1  8.91 15.54  9.94  7.19  4.99  3.61  2.20  1.58 126.0
25 1   0.456 1 12.16 22.00 14.03 10.15  7.02  5.10  3.08  2.21 126.0
25 1   0.456 1 14.82 27.13 17.26 12.52  8.58  6.31  3.73  2.76 126.0
```

GPS: Quality : GPS Fi Latitude = 40°23.605984 N Longitude = 105°36.894140 W PDOP = 1.70
GPS: State Plane Coordinates:
Note: Fall River Road, 86 degrees, heading south, foam
26 1 0.550 1 5.93 9.85 6.54 4.81 3.38 2.45 1.34 0.00 126.0
26 1 0.550 1 8.96 15.64 10.28 7.52 5.29 3.86 2.15 1.36 126.0
26 1 0.550 1 11.91 21.46 13.98 10.13 7.18 5.26 2.90 1.89 126.0
26 1 0.550 1 14.77 27.03 17.55 12.61 8.87 6.52 3.64 2.36 126.0
GPS: Quality : GPS Fi Latitude = 40°23.568568 N Longitude = 105°36.844366 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading south, foam
27 1 0.650 1 5.81 10.79 7.17 5.22 3.70 2.69 1.64 1.17 124.1
27 1 0.650 1 8.81 17.18 11.38 8.12 5.72 4.18 2.56 1.81 124.1
27 1 0.650 1 11.72 23.65 15.58 11.04 7.77 5.74 3.51 2.53 124.1
27 1 0.650 1 14.65 29.51 19.29 13.65 9.63 7.12 4.38 3.16 124.1
GPS: Quality : GPS Fi Latitude = 40°23.521756 N Longitude = 105°36.804072 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading south, foam
28 1 0.749 1 6.10 10.91 7.71 5.94 4.46 3.37 2.07 1.41 125.6
28 1 0.749 1 9.13 16.60 11.59 8.87 6.63 5.09 3.14 2.12 125.6
28 1 0.749 1 12.08 22.31 15.50 11.74 8.91 6.89 4.26 2.92 125.6
28 1 0.749 1 14.84 27.32 18.89 14.25 10.82 8.45 5.23 3.61 125.6
GPS: Quality : GPS Fi Latitude = 40°23.466596 N Longitude = 105°36.788718 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading south, foam
29 1 0.854 1 6.32 8.03 5.39 3.83 2.67 1.90 1.06 0.00 126.7
29 1 0.854 1 8.98 12.20 8.12 5.75 3.98 2.88 1.61 1.09 126.7
29 1 0.854 1 12.35 17.07 11.22 7.86 5.46 3.99 2.23 1.55 126.7
29 1 0.854 1 15.41 21.36 13.84 9.65 6.71 4.91 2.75 1.91 126.7
GPS: Quality : GPS Fi Latitude = 40°23.415753 N Longitude = 105°36.753073 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading south, foam
30 1 0.955 1 5.98 6.96 4.14 2.72 1.69 1.09 0.00 0.00 123.8
30 1 0.955 1 9.13 11.04 6.40 4.15 2.53 1.66 0.82 0.00 123.8
30 1 0.955 1 12.33 14.74 8.42 5.42 3.33 2.17 1.09 0.87 123.8
30 1 0.955 1 15.23 18.29 10.31 6.61 4.05 2.66 1.28 1.08 123.8
GPS: Quality : GPS Fi Latitude = 40°23.368392 N Longitude = 105°36.712261 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading south, foam
31 1 1.050 1 6.03 8.89 5.29 3.60 2.22 1.39 0.00 0.00 121.6
31 1 1.050 1 9.03 13.86 8.04 5.43 3.27 2.05 0.97 0.00 121.6
31 1 1.050 1 11.87 18.21 10.43 6.96 4.17 2.63 1.25 0.81 121.6
31 1 1.050 1 14.97 23.07 12.98 8.60 5.11 3.21 1.44 1.15 121.6
GPS: Quality : GPS Fi Latitude = 40°23.318211 N Longitude = 105°36.687783 W PDOP = 2.40
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading south, foam
32 1 1.151 1 6.05 8.51 5.01 3.38 2.19 1.51 0.81 0.00 125.6
32 1 1.151 1 9.28 12.94 7.48 5.03 3.24 2.26 1.23 0.86 125.6
32 1 1.151 1 12.38 17.06 9.74 6.56 4.20 2.95 1.61 1.19 125.6
32 1 1.151 1 14.92 20.35 11.81 7.71 4.91 3.49 1.90 1.45 125.6
GPS: Quality : GPS Fi Latitude = 40°23.264456 N Longitude = 105°36.663081 W PDOP = 2.40
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading south, foam
33 1 1.209 1 6.15 6.67 3.70 2.32 0.00 0.00 0.00 0.00 123.0
33 1 1.209 1 9.30 10.08 5.51 3.44 1.78 0.94 0.00 0.00 123.0
33 1 1.209 1 12.21 12.99 7.07 4.38 2.18 1.16 0.00 0.00 123.0
33 1 1.209 1 15.04 15.52 8.40 5.19 2.57 1.39 1.21 0.00 123.0
GPS: Quality : GPS Fi Latitude = 40°23.233512 N Longitude = 105°36.650466 W PDOP = 1.90
GPS: State Plane Coordinates:
Note: Fall River Road, 85 degrees, heading south, foam, end

Appendix C

Summary of Field Deflection Results -

Trail Ridge Road – Deer Junction to 3M

M3
Date-Time: 7-17-2003 13:29:14
Sensors: CHOP CHOP Chop Chop Chop Chop Chop
Weight/spring: 2
Location: Rocky Mount Natl Park
Temp: 122.19
Operator: ajs
Comments: FHWA Testing

1	1	0.001	1	6.01	11.30	8.01	5.94	3.87	2.54	1.15	0.00	112.8
1	1	0.001	1	8.91	18.11	12.50	9.21	5.97	3.86	1.75	0.97	112.8
1	1	0.001	1	11.87	24.59	16.96	12.29	7.93	5.12	2.25	1.24	112.8
1	1	0.001	1	14.60	30.27	20.82	15.02	9.66	6.21	2.72	1.47	112.8

GPS: Quality : GPS Fi Latitude = 40°23.228265 N Longitude = 105°36.662432 W PDOP = 3.10
GPS: State Plane Coordinates:
Note: trail ridge road heading west

2	1	0.104	1	6.05	8.84	5.89	4.32	2.91	1.94	0.86	0.00	108.4
2	1	0.104	1	9.11	13.83	9.08	6.63	4.50	2.99	1.31	0.00	108.4
2	1	0.104	1	12.11	18.51	12.10	8.80	6.01	3.99	1.76	0.96	108.4
2	1	0.104	1	14.97	22.51	14.92	10.77	7.33	4.89	2.17	1.17	108.4

GPS: Quality : GPS Fi Latitude = 40°23.232127 N Longitude = 105°36.738018 W PDOP = 4.60
GPS: State Plane Coordinates:
Note: trail ridge road heading west

3	1	0.199	1	6.08	5.61	3.23	2.19	0.00	0.79	0.00	0.00	106.6
3	1	0.199	1	9.23	8.45	4.72	3.24	1.94	1.19	0.00	0.00	106.6
3	1	0.199	1	12.26	10.89	6.04	4.17	2.51	1.59	0.77	0.00	106.6
3	1	0.199	1	15.36	12.98	7.28	5.06	3.05	1.94	0.90	1.31	106.6

GPS: Quality : GPS Fi Latitude = 40°23.244153 N Longitude = 105°36.806013 W PDOP = 4.50
GPS: State Plane Coordinates:
Note: trail ridge road heading west

4	1	0.211	1	6.13	6.29	4.32	3.25	2.06	1.29	0.00	0.00	109.5
4	1	0.211	1	9.03	9.01	6.03	4.50	2.87	1.80	0.74	0.00	109.5
4	1	0.211	1	12.33	11.76	7.72	5.76	3.68	2.33	0.93	0.66	109.5
4	1	0.211	1	15.23	14.18	9.33	6.87	4.35	2.78	1.13	0.76	109.5

GPS: Quality : GPS Fi Latitude = 40°23.246623 N Longitude = 105°36.814495 W PDOP = 4.50
GPS: State Plane Coordinates:
Note: trail ridge road heading west

5	1	0.255	1	6.15	8.21	5.61	4.11	2.63	1.74	0.89	0.00	110.2
5	1	0.255	1	9.06	13.05	8.91	6.52	4.19	2.77	1.37	0.95	110.2
5	1	0.255	1	12.04	17.98	12.36	9.00	5.85	3.87	1.89	1.28	110.2
5	1	0.255	1	14.97	22.39	15.47	11.26	7.34	4.88	2.43	1.53	110.2

GPS: Quality : GPS Fi Latitude = 40°23.256375 N Longitude = 105°36.843585 W PDOP = 4.40
GPS: State Plane Coordinates:
Note: trail ridge road heading west

6	1	0.302	1	6.23	5.29	2.98	2.09	0.00	1.10	0.00	0.00	108.0
6	1	0.302	1	9.11	8.31	4.70	3.35	2.42	1.78	1.05	0.00	108.0
6	1	0.302	1	12.01	11.11	6.33	4.55	3.32	2.46	1.42	1.01	108.0
6	1	0.302	1	14.82	13.71	7.88	5.67	4.17	3.10	1.79	1.20	108.0

GPS: Quality : GPS Fi Latitude = 40°23.267483 N Longitude = 105°36.875335 W PDOP = 4.40
GPS: State Plane Coordinates:
Note: trail ridge road heading west

7	1	0.407	1	6.05	6.17	4.24	3.26	2.38	1.67	0.83	0.00	106.9
7	1	0.407	1	8.89	9.79	6.62	5.09	3.72	2.64	1.27	0.00	106.9
7	1	0.407	1	12.06	13.39	8.93	6.87	5.05	3.60	1.73	0.98	106.9
7	1	0.407	1	14.92	16.57	10.86	8.40	6.19	4.41	2.15	1.19	106.9

GPS: Quality : GPS Fi Latitude = 40°23.290285 N Longitude = 105°36.945640 W PDOP = 4.30
GPS: State Plane Coordinates:
Note: trail ridge road heading west 94 degrees

8	1	0.500	1	6.13	5.95	3.87	2.83	2.12	1.58	0.86	0.00	104.0
8	1	0.500	1	9.06	9.13	5.85	4.31	3.23	2.41	1.30	0.83	104.0
8	1	0.500	1	12.13	12.28	7.77	5.71	4.32	3.23	1.75	1.07	104.0
8	1	0.500	1	15.26	15.39	9.63	7.10	5.37	4.01	2.18	1.32	104.0

GPS: Quality : GPS Fi Latitude = 40°23.315764 N Longitude = 105°37.005528 W PDOP = 4.20
GPS: State Plane Coordinates:
Note: trail ridge road heading west 94 degrees

9	1	0.601	1	6.18	7.46	5.26	3.98	2.80	1.90	0.99	0.00	104.4
9	1	0.601	1	8.94	11.62	8.12	6.20	4.39	2.98	1.53	0.98	104.4
9	1	0.601	1	11.99	15.74	10.96	8.42	5.98	4.11	2.13	1.29	104.4
9	1	0.601	1	14.79	19.19	13.44	10.28	7.34	5.09	2.66	1.57	104.4

GPS: Quality : GPS Fi Latitude = 40°23.338001 N Longitude = 105°37.074080 W PDOP = 3.00
GPS: State Plane Coordinates:
Note: trail ridge road heading west 94 degrees

10	1	0.701	1	6.08	8.12	5.51	4.20	2.95	2.06	1.06	0.00	99.2
10	1	0.701	1	8.76	12.60	8.47	6.45	4.53	3.16	1.60	0.97	99.2
10	1	0.701	1	11.87	17.39	11.56	8.79	6.18	4.29	2.17	1.27	99.2
10	1	0.701	1	14.84	21.55	14.17	10.80	7.57	5.28	2.68	1.53	99.2

GPS: Quality : GPS Fi Latitude = 40°23.366393 N Longitude = 105°37.136530 W PDOP = 2.70
GPS: State Plane Coordinates:
Note: trail ridge road heading west 94 degrees, rutting and shoving from last test forward

11	1	0.801	1	6.10	7.17	5.40	4.53	3.49	2.64	1.45	0.00	97.4
11	1	0.801	1	9.03	11.32	8.49	7.09	5.47	4.13	2.24	1.34	97.4
11	1	0.801	1	11.87	15.11	11.28	9.40	7.21	5.47	3.00	1.73	97.4
11	1	0.801	1	14.87	18.99	14.11	11.73	9.02	6.82	3.72	2.16	97.4

GPS: Quality : GPS Fi Latitude = 40°23.409266 N Longitude = 105°37.184500 W PDOP = 3.00
GPS: State Plane Coordinates:
Note: trail ridge road heading west 94 degrees, rutting and shoving

12	1	0.900	1	5.98	8.96	6.51	5.40	4.20	3.19	1.90	1.28	101.8
12	1	0.900	1	9.08	13.80	10.10	8.35	6.50	4.94	2.91	1.96	101.8
12	1	0.900	1	12.01	18.16	13.35	11.01	8.63	6.58	3.96	2.62	101.8
12	1	0.900	1	15.04	22.46	16.60	13.54	10.62	8.14	4.92	3.26	101.8

GPS: Quality : GPS Fi Latitude = 40°23.451130 N Longitude = 105°37.233044 W PDOP = 2.90
GPS: State Plane Coordinates:
Note: trail ridge road heading west 94 degrees, rutting and shoving from last test forward

13	1	1.000	1	6.13	2.96	2.40	2.19	0.00	1.59	1.17	0.00	96.3
13	1	1.000	1	9.13	4.62	3.70	3.32	2.86	2.41	1.75	1.34	96.3
13	1	1.000	1	12.28	6.44	5.14	4.59	3.96	3.35	2.42	1.81	96.3
13	1	1.000	1	15.26	7.99	6.37	5.67	4.89	4.17	3.00	2.24	96.3

GPS: Quality : GPS Fi Latitude = 40°23.483466 N Longitude = 105°37.294089 W PDOP = 2.90
GPS: State Plane Coordinates:
Note: trail ridge road heading west 94 degrees, rutting and shoving

14	1	1.102	1	6.13	4.90	2.66	1.69	0.00	0.95	0.00	0.00	90.5
14	1	1.102	1	8.98	7.84	4.14	2.65	1.95	1.49	1.06	0.00	90.5
14	1	1.102	1	11.96	10.68	5.62	3.61	2.61	2.00	1.34	1.15	90.5
14	1	1.102	1	15.06	13.66	7.12	4.65	3.38	2.61	1.75	1.38	90.5

GPS: Quality : GPS Fi Latitude = 40°23.517568 N Longitude = 105°37.355669 W PDOP = 2.90
GPS: State Plane Coordinates:
Note: trail ridge road heading west 94 degrees, rutting and shoving

15	1	1.201	1	5.91	11.52	8.44	5.95	4.28	3.26	1.98	1.37	95.6
15	1	1.201	1	8.89	17.50	12.60	8.83	6.38	4.85	2.90	2.03	95.6
15	1	1.201	1	11.87	23.58	16.83	11.78	8.56	6.55	3.97	2.79	95.6
15	1	1.201	1	14.60	28.48	20.17	14.08	10.28	7.88	4.81	3.39	95.6

GPS: Quality : GPS Fi Latitude = 40°23.552009 N Longitude = 105°37.413626 W PDOP = 3.80
GPS: State Plane Coordinates:
Note: trail ridge road heading west 94 degrees, rutting and shoving

16	1	1.303	1	6.13	6.15	4.10	2.97	2.21	1.67	1.04	0.00	98.5
16	1	1.303	1	9.18	9.22	6.05	4.40	3.23	2.50	1.56	1.12	98.5
16	1	1.303	1	12.30	12.13	7.87	5.77	4.25	3.32	2.06	1.43	98.5
16	1	1.303	1	15.21	14.61	9.49	6.95	5.11	4.03	2.50	1.67	98.5

GPS: Quality : GPS Fi Latitude = 40°23.566592 N Longitude = 105°37.483938 W PDOP = 3.70
GPS: State Plane Coordinates:
Note: trail ridge road heading west 94 degrees, rutting and shoving

```
17 1   1.400 1  6.10  5.38  3.13  2.38  1.77  1.35  0.82  0.00  91.9
17 1   1.400 1  8.94  8.05  4.55  3.44  2.55  1.98  1.21  0.86  91.9
17 1   1.400 1 12.23 10.78  6.00  4.56  3.41  2.64  1.58  1.13  91.9
17 1   1.400 1 15.11 12.80  7.16  5.41  4.07  3.18  1.90  1.32  91.9
GPS: Quality : GPS Fi   Latitude = 40°23.583588  N   Longitude = 105°37.552346   W   PDOP
= 2.90
GPS: State Plane Coordinates:
Note: trail ridge road heading west 94 degrees, rutting and shoving
18 1   1.514 1  6.03  9.11  6.34  4.31  2.91  2.04  1.16  0.82  91.6
18 1   1.514 1  8.94 13.57  9.27  6.32  4.26  3.01  1.72  1.21  91.6
18 1   1.514 1 11.96 17.53 11.92  8.21  5.56  3.93  2.24  1.58  91.6
18 1   1.514 1 15.04 21.22 14.39  9.99  6.77  4.83  2.73  1.94  91.6
GPS: Quality : GPS Fi   Latitude = 40°23.617520  N   Longitude = 105°37.622711   W   PDOP
= 2.90
GPS: State Plane Coordinates:
Note: trail ridge road heading west 94 degrees, rutting and shoving
19 1   1.602 1  6.10  6.92  4.15  2.93  2.05  1.46  0.84  0.00  86.8
19 1   1.602 1  9.11 10.55  6.32  4.42  3.07  2.22  1.25  0.88  86.8
19 1   1.602 1 11.91 13.77  8.18  5.73  4.00  2.87  1.60  1.15  86.8
19 1   1.602 1 14.97 16.99  9.89  6.96  4.85  3.51  1.97  1.35  86.8
GPS: Quality : GPS Fi   Latitude = 40°23.634470  N   Longitude = 105°37.683429   W   PDOP
= 2.80
GPS: State Plane Coordinates:
Note: trail ridge road heading west 89 degrees, rutting and shoving
20 1   1.703 1  6.03  3.37  1.88  0.00  0.00  0.00  0.00  0.00  83.9
20 1   1.703 1  8.94  5.26  2.93  2.12  1.59  1.09  0.00  0.00  83.9
20 1   1.703 1 12.08  7.22  4.05  2.93  2.06  1.54  0.99  0.79  83.9
20 1   1.703 1 15.06  8.86  5.00  3.63  2.53  1.91  1.23  0.97  83.9
GPS: Quality : GPS Fi   Latitude = 40°23.647589  N   Longitude = 105°37.756522   W   PDOP
= 3.50
GPS: State Plane Coordinates:
Note: trail ridge road heading west 89 degrees, rutting and shoving
21 1   1.805 1  6.08  6.29  3.67  2.57  1.87  1.37  0.89  0.00  80.6
21 1   1.805 1  8.96  9.85  5.64  3.97  2.84  2.14  1.38  1.01  80.6
21 1   1.805 1 12.06 13.19  7.51  5.31  3.83  2.88  1.79  1.33  80.6
21 1   1.805 1 14.94 16.04  9.22  6.47  4.66  3.52  2.20  1.59  80.6
GPS: Quality : GPS Fi   Latitude = 40°23.663775  N   Longitude = 105°37.828405   W   PDOP
= 3.50
GPS: State Plane Coordinates:
Note: trail ridge road heading west 86 degrees, rutting and shoving f
22 1   1.901 1  6.03  7.11  4.41  3.20  2.24  1.59  0.91  0.00  80.6
22 1   1.901 1  8.91 11.36  6.52  4.83  3.38  2.42  1.38  0.96  80.6
22 1   1.901 1 12.04 15.40  8.50  6.32  4.41  3.19  1.76  1.25  80.6
22 1   1.901 1 15.09 19.06 10.57  7.76  5.42  3.94  2.16  1.49  80.6
GPS: Quality : GPS Fi   Latitude = 40°23.688678  N   Longitude = 105°37.890560   W   PDOP
= 2.80
GPS: State Plane Coordinates:
Note: trail ridge road heading west 85 degrees, rutting and shoving
23 1   2.000 1  6.01  5.31  3.32  2.22  1.40  0.92  0.00  0.00  78.0
23 1   2.000 1  9.03  8.22  4.75  3.20  2.05  1.37  0.78  0.00  78.0
23 1   2.000 1 12.01 10.70  5.97  4.07  2.62  1.80  0.93  0.78  78.0
23 1   2.000 1 15.16 13.23  7.22  4.94  3.19  2.19  1.12  0.87  78.0
GPS: Quality : GPS Fi   Latitude = 40°23.724551  N   Longitude = 105°37.945841   W   PDOP
= 2.80
GPS: State Plane Coordinates:
Note: trail ridge road heading west 84 degrees, rutting and shoving
24 1   2.101 1  6.05  5.83  3.76  2.69  1.86  1.28  0.00  0.00  78.0
24 1   2.101 1  9.01  9.18  5.74  4.13  2.81  1.98  1.11  0.78  78.0
24 1   2.101 1 12.16 12.49  7.65  5.49  3.75  2.65  1.44  1.04  78.0
24 1   2.101 1 14.92 15.20  9.26  6.64  4.54  3.25  1.79  1.25  78.0
GPS: Quality : GPS Fi   Latitude = 40°23.764818  N   Longitude = 105°37.999002   W   PDOP
= 2.70
GPS: State Plane Coordinates:
Note: trail ridge road heading west 84 degrees, rutting and shoving
25 1   2.201 1  5.98  8.19  6.30  5.27  4.01  2.97  1.61  1.11  79.5
25 1   2.201 1  8.98 12.72  9.67  8.04  6.14  4.55  2.45  1.65  79.5
25 1   2.201 1 11.99 16.69 12.72 10.48  8.00  5.95  3.25  2.15  79.5
25 1   2.201 1 15.06 20.81 15.67 12.88  9.79  7.30  4.01  2.55  79.5
```

GPS: Quality : GPS Fi Latitude = 40°23.793993 N Longitude = 105°38.061174 W PDOP = 2.70
GPS: State Plane Coordinates:
Note: trail ridge road heading west 81 degrees, rutting and shoving
26 1 2.301 1 5.91 15.16 10.14 7.56 5.68 4.32 2.76 2.06 76.5
26 1 2.301 1 8.84 23.60 15.76 11.51 8.54 6.38 4.00 2.98 76.5
26 1 2.301 1 11.52 31.13 21.13 15.26 11.38 8.56 5.40 3.94 76.5
26 1 2.301 1 14.43 38.94 26.79 19.11 14.20 10.77 6.82 4.99 76.5
GPS: Quality : GPS Fi Latitude = 40°23.799979 N Longitude = 105°38.133727 W PDOP = 2.50
GPS: State Plane Coordinates:
Note: trail ridge road heading west 75 degrees, rutting and shoving
27 1 2.400 1 6.01 10.55 6.25 3.88 2.71 1.93 1.05 0.00 77.3
27 1 2.400 1 9.08 16.53 9.59 6.08 4.26 3.10 1.68 1.14 77.3
27 1 2.400 1 12.08 21.98 12.76 8.14 5.77 4.17 2.22 1.52 77.3
27 1 2.400 1 15.09 26.47 15.62 10.07 7.11 5.19 2.79 1.86 77.3
GPS: Quality : GPS Fi Latitude = 40°23.807863 N Longitude = 105°38.210116 W PDOP = 3.30
GPS: State Plane Coordinates:
Note: trail ridge road heading west 75 degrees, rutting and shoving
28 1 2.501 1 5.98 8.32 5.45 4.10 3.12 2.41 1.63 1.23 77.6
28 1 2.501 1 9.06 13.02 8.51 6.36 4.79 3.74 2.52 1.92 77.6
28 1 2.501 1 12.33 17.77 11.56 8.67 6.53 5.05 3.36 2.56 77.6
28 1 2.501 1 15.11 21.42 14.08 10.54 7.95 6.19 4.16 3.07 77.6
GPS: Quality : GPS Fi Latitude = 40°23.831464 N Longitude = 105°38.277990 W PDOP = 2.50
GPS: State Plane Coordinates:
Note: trail ridge road heading west 75 degrees, rutting and shoving
29 1 2.600 1 5.93 11.87 7.92 6.01 4.58 3.57 2.19 1.49 77.3
29 1 2.600 1 8.84 18.21 12.03 9.06 6.91 5.34 3.24 2.22 77.3
29 1 2.600 1 11.82 23.90 15.75 11.83 9.05 7.03 4.30 2.93 77.3
29 1 2.600 1 14.77 28.91 19.53 14.59 11.19 8.72 5.42 3.68 77.3
GPS: Quality : GPS Fi Latitude = 40°23.870057 N Longitude = 105°38.326466 W PDOP = 3.30
GPS: State Plane Coordinates:
Note: trail ridge road heading west 75 degrees, rutting and shoving
30 1 2.706 1 6.05 11.46 8.03 6.02 4.30 3.15 1.68 1.09 77.3
30 1 2.706 1 8.98 17.65 12.21 9.10 6.57 4.79 2.54 1.63 77.3
30 1 2.706 1 12.04 23.69 16.33 12.19 8.82 6.46 3.46 2.21 77.3
30 1 2.706 1 15.14 29.04 19.95 14.96 10.85 8.00 4.38 2.74 77.3
GPS: Quality : GPS Fi Latitude = 40°23.915228 N Longitude = 105°38.370588 W PDOP = 2.60
GPS: State Plane Coordinates:
Note: trail ridge road heading west 75 degrees, rutting and shoving
31 1 2.800 1 5.83 18.00 11.63 7.99 5.99 4.65 3.05 2.20 77.3
31 1 2.800 1 8.94 26.65 17.30 11.90 8.98 6.94 4.54 3.27 77.3
31 1 2.800 1 11.89 35.41 22.79 15.88 12.13 9.42 6.18 4.42 77.3
31 1 2.800 1 14.33 41.91 26.98 19.08 14.63 11.43 7.51 5.30 77.3
GPS: Quality : GPS Fi Latitude = 40°23.933381 N Longitude = 105°38.435981 W PDOP = 2.70
GPS: State Plane Coordinates:
Note: trail ridge road heading west 75 degrees, rutting and shoving
32 1 2.900 1 6.30 5.54 4.14 3.51 2.81 2.23 1.47 1.04 82.4
32 1 2.900 1 9.33 8.38 6.21 5.24 4.18 3.33 2.19 1.56 82.4
32 1 2.900 1 12.40 11.48 8.34 7.03 5.57 4.47 2.94 2.07 82.4
32 1 2.900 1 15.38 14.13 10.14 8.56 6.79 5.45 3.62 2.54 82.4
GPS: Quality : GPS Fi Latitude = 40°23.952326 N Longitude = 105°38.505329 W PDOP = 2.60
GPS: State Plane Coordinates:
Note: trail ridge road heading west 75 degrees, rutting and shoving
33 1 3.002 1 6.15 7.95 5.78 4.44 3.09 2.25 1.31 0.78 86.4
33 1 3.002 1 9.25 12.45 8.96 6.88 4.78 3.46 1.98 1.43 86.4
33 1 3.002 1 12.30 16.96 12.22 9.34 6.53 4.75 2.73 1.87 86.4
33 1 3.002 1 15.36 21.23 15.26 11.66 8.15 5.96 3.42 2.33 86.4
GPS: Quality : GPS Fi Latitude = 40°23.972366 N Longitude = 105°38.575835 W PDOP = 2.40
GPS: State Plane Coordinates:
Note: trail ridge road heading west 77 degrees, rutting and shoving

34 1 3.100 1 6.13 10.18 7.23 5.42 3.80 2.85 1.77 1.23 89.0
34 1 3.100 1 8.89 14.99 10.78 8.07 5.69 4.28 2.62 1.83 89.0
34 1 3.100 1 12.28 20.23 14.75 11.03 7.89 5.96 3.66 2.54 89.0
34 1 3.100 1 15.16 24.38 17.68 13.36 9.63 7.33 4.58 3.04 89.0
GPS: Quality : GPS Fi Latitude = 40°23.987603 N Longitude = 105°38.645445 W PDOP = 2.40
GPS: State Plane Coordinates:
Note: trail ridge road heading west 77 degrees, rutting and shoving
35 1 3.201 1 6.08 13.77 10.13 7.17 5.05 3.85 2.52 1.90 94.5
35 1 3.201 1 8.74 20.39 14.92 10.53 7.46 5.72 3.76 2.89 94.5
35 1 3.201 1 12.04 27.13 19.81 13.90 9.95 7.64 5.01 3.77 94.5
35 1 3.201 1 14.72 32.34 23.54 16.60 11.97 9.29 6.16 4.66 94.5
GPS: Quality : GPS Fi Latitude = 40°23.974749 N Longitude = 105°38.716506 W PDOP = 2.40
GPS: State Plane Coordinates:
Note: trail ridge road heading west 79 degrees, rutting and shoving
36 1 3.300 1 5.98 14.40 9.80 6.45 3.77 2.42 1.33 0.00 93.0
36 1 3.300 1 8.86 21.79 14.53 9.50 5.64 3.65 2.00 1.45 93.0
36 1 3.300 1 12.04 28.52 19.21 12.39 7.39 4.81 2.65 1.92 93.0
36 1 3.300 1 14.77 34.88 22.61 15.08 9.03 5.91 3.25 2.35 93.0
GPS: Quality : GPS Fi Latitude = 40°23.942644 N Longitude = 105°38.775900 W PDOP = 6.50
GPS: State Plane Coordinates:
Note: trail ridge road heading west 80 degrees, rutting and shoving
37 1 3.402 1 5.96 16.06 10.30 7.15 5.18 3.98 2.84 2.23 94.1
37 1 3.402 1 8.64 24.00 15.04 10.42 7.56 5.86 4.23 3.31 94.1
37 1 3.402 1 11.77 32.92 19.98 13.73 10.07 7.91 5.81 4.56 94.1
37 1 3.402 1 14.72 39.81 24.68 16.68 12.29 9.68 7.13 5.57 94.1
GPS: Quality : GPS Fi Latitude = 40°23.908203 N Longitude = 105°38.836743 W PDOP = 6.10
GPS: State Plane Coordinates:
Note: trail ridge road heading west 80 degrees, rutting and shoving
38 1 3.502 1 6.23 10.57 5.99 3.44 2.06 1.36 0.00 0.00 96.7
38 1 3.502 1 9.13 16.46 9.37 5.47 3.21 2.09 1.29 0.92 96.7
38 1 3.502 1 12.26 21.71 12.34 7.28 4.29 2.84 1.65 1.26 96.7
38 1 3.502 1 15.11 26.73 15.21 9.10 5.41 3.58 2.02 1.58 96.7
GPS: Quality : GPS Fi Latitude = 40°23.877803 N Longitude = 105°38.898492 W PDOP = 5.70
GPS: State Plane Coordinates:
Note: trail ridge road heading west 80 degrees, more severe rutting and shoving from last test forward
39 1 3.603 1 6.03 12.27 7.05 4.07 2.49 1.65 0.00 0.00 94.8
39 1 3.603 1 8.94 18.86 10.83 6.31 3.78 2.56 1.44 0.98 94.8
39 1 3.603 1 11.87 26.10 14.87 8.70 5.25 3.54 1.91 1.35 94.8
39 1 3.603 1 14.87 32.90 18.17 10.75 6.51 4.39 2.32 1.64 94.8
GPS: Quality : GPS Fi Latitude = 40°23.852803 N Longitude = 105°38.964803 W PDOP = 5.30
GPS: State Plane Coordinates:
Note: trail ridge road heading west 80 degrees, more severe rutting and shoving
40 1 3.702 1 6.03 11.83 7.94 5.86 4.20 3.14 1.99 1.42 96.7
40 1 3.702 1 9.16 18.37 12.24 9.04 6.48 4.83 2.99 2.16 96.7
40 1 3.702 1 11.99 23.74 15.91 11.75 8.46 6.34 3.93 2.83 96.7
40 1 3.702 1 14.89 29.25 19.69 14.57 10.54 7.99 4.96 3.59 96.7
GPS: Quality : GPS Fi Latitude = 40°23.831315 N Longitude = 105°39.031010 W PDOP = 5.10
GPS: State Plane Coordinates:
Note: trail ridge road heading west 80 degrees, more severe rutting and shoving
41 1 3.803 1 6.05 12.58 7.51 4.50 2.59 1.68 0.00 0.00 96.3
41 1 3.803 1 8.98 19.74 12.01 7.14 4.04 2.60 1.46 1.06 96.3
41 1 3.803 1 12.06 26.66 16.41 9.78 5.57 3.58 1.88 1.41 96.3
41 1 3.803 1 14.97 33.22 20.81 12.34 7.06 4.57 2.36 1.74 96.3
GPS: Quality : GPS Fi Latitude = 40°23.806321 N Longitude = 105°38.988789 W PDOP = 5.00
GPS: State Plane Coordinates:
Note: trail ridge road heading west 80 degrees, more severe rutting and shoving
42 1 3.903 1 6.18 6.48 4.56 3.32 2.31 1.59 0.00 0.00 90.5
42 1 3.903 1 9.08 10.78 7.38 5.26 3.55 2.47 1.45 1.04 90.5
42 1 3.903 1 12.04 15.26 10.19 7.19 4.87 3.38 1.90 1.37 90.5

42 1 3.903 1 15.31 19.72 13.21 9.18 6.21 4.32 2.43 1.68 90.5
GPS: Quality : GPS Fi Latitude = 40°23.816818 N Longitude = 105°38.916654 W PDOP = 4.80
GPS: State Plane Coordinates:
Note: trail ridge road heading west 80 degrees, more severe rutting and shoving
43 1 4.004 1 6.30 4.42 3.10 2.51 1.95 1.40 0.00 0.00 93.4
43 1 4.004 1 9.16 7.00 4.87 3.95 3.00 2.23 1.27 0.92 93.4
43 1 4.004 1 12.26 9.42 6.54 5.27 4.04 3.00 1.71 1.19 93.4
43 1 4.004 1 15.38 11.95 8.27 6.65 5.11 3.83 2.22 1.46 93.4
GPS: Quality : GPS Fi Latitude = 40°23.829812 N Longitude = 105°38.844641 W PDOP = 4.60
GPS: State Plane Coordinates:
Note: trail ridge road heading west 82 degrees, more severe rutting and shoving
44 1 4.102 1 6.10 6.67 4.14 2.65 1.85 1.45 0.99 0.00 94.5
44 1 4.102 1 9.06 10.33 6.26 4.04 2.81 2.19 1.46 1.14 94.5
44 1 4.102 1 12.21 14.06 8.48 5.49 3.84 3.00 1.98 1.45 94.5
44 1 4.102 1 15.23 17.39 10.46 6.80 4.78 3.74 2.45 1.83 94.5
GPS: Quality : GPS Fi Latitude = 40°23.861975 N Longitude = 105°38.786723 W PDOP = 4.50
GPS: State Plane Coordinates:
Note: trail ridge road heading west 82 degrees, rutting and shoving
45 1 4.203 1 6.13 7.21 4.24 2.63 0.00 1.14 0.00 0.00 96.7
45 1 4.203 1 9.11 11.39 6.57 4.09 2.54 1.74 1.10 0.00 96.7
45 1 4.203 1 12.16 15.00 8.63 5.39 3.35 2.33 1.42 1.11 96.7
45 1 4.203 1 14.99 18.43 10.67 6.64 4.14 2.91 1.75 1.36 96.7
GPS: Quality : GPS Fi Latitude = 40°23.896392 N Longitude = 105°38.726298 W PDOP = 4.20
GPS: State Plane Coordinates:
Note: trail ridge road heading west 85 degrees, rutting and shoving
46 1 4.304 1 6.03 2.76 1.53 0.00 0.00 0.00 0.00 0.00 96.7
46 1 4.304 1 9.08 4.30 2.29 1.46 0.00 0.00 0.00 0.00 96.7
46 1 4.304 1 12.08 5.68 2.97 1.92 0.00 0.70 0.00 0.00 96.7
46 1 4.304 1 14.99 6.98 3.62 2.29 1.30 0.85 0.00 0.00 96.7
GPS: Quality : GPS Fi Latitude = 40°23.915154 N Longitude = 105°38.658111 W PDOP = 4.10
GPS: State Plane Coordinates:
Note: trail ridge road heading west 85 degrees, rutting and shoving
47 1 4.400 1 6.25 7.34 5.35 4.06 2.77 1.94 1.06 0.65 94.1
47 1 4.400 1 9.11 10.90 7.80 5.94 4.07 2.85 1.58 1.10 94.1
47 1 4.400 1 12.04 14.06 9.98 7.57 5.22 3.67 2.01 1.46 94.1
47 1 4.400 1 14.99 16.92 11.90 9.07 6.25 4.42 2.43 1.74 94.1
GPS: Quality : GPS Fi Latitude = 40°23.891555 N Longitude = 105°38.595766 W PDOP = 2.50
GPS: State Plane Coordinates:
Note: trail ridge road heading west 85 degrees, rutting and shoving, rock cut from test 46 to 47
48 1 4.501 1 5.98 8.81 6.59 5.17 3.78 2.86 1.83 1.30 90.8
48 1 4.501 1 8.96 13.78 10.05 7.90 5.81 4.46 2.84 2.02 90.8
48 1 4.501 1 11.91 18.32 13.33 10.36 7.71 5.97 3.80 2.74 90.8
48 1 4.501 1 14.92 22.49 16.09 12.57 9.42 7.31 4.72 3.40 90.8
GPS: Quality : GPS Fi Latitude = 40°23.855002 N Longitude = 105°38.539608 W PDOP = 2.50
GPS: State Plane Coordinates:
Note: trail ridge road heading west 85 degrees, rutting and shoving
49 1 4.602 1 6.05 6.13 4.84 3.92 2.79 2.02 1.17 0.91 92.7
49 1 4.602 1 9.01 9.31 7.17 5.74 4.12 2.97 1.72 1.33 92.7
49 1 4.602 1 12.01 12.37 9.43 7.50 5.38 3.88 2.20 1.70 92.7
49 1 4.602 1 15.14 15.41 11.70 9.25 6.62 4.78 2.65 2.06 92.7
GPS: Quality : GPS Fi Latitude = 40°23.829298 N Longitude = 105°38.472954 W PDOP = 2.50
GPS: State Plane Coordinates:
Note: trail ridge road heading west 85 degrees, rutting and shoving
50 1 4.691 1 5.96 7.67 5.55 4.27 2.94 2.02 1.20 0.75 87.5
50 1 4.691 1 8.86 11.69 8.37 6.48 4.47 3.14 1.82 1.37 87.5
50 1 4.691 1 11.96 15.69 11.12 8.60 6.00 4.23 2.38 1.83 87.5
50 1 4.691 1 14.82 19.14 13.49 10.42 7.29 5.19 2.88 2.26 87.5
GPS: Quality : GPS Fi Latitude = 40°23.793083 N Longitude = 105°38.430527 W PDOP = 2.80

GPS: State Plane Coordinates:
Note: trail ridge road heading west 85 degrees, rutting and shoving
51 1 4.668 1 6.13 5.47 4.17 3.38 2.55 1.93 1.18 0.00 90.1
51 1 4.668 1 9.25 8.64 6.55 5.26 3.99 3.06 1.86 1.34 90.1
51 1 4.668 1 12.28 11.77 8.89 7.13 5.47 4.21 2.61 1.88 90.1
51 1 4.668 1 15.09 14.56 10.87 8.74 6.68 5.19 3.22 2.19 90.1
GPS: Quality : GPS Fi Latitude = 40°23.811594 N Longitude = 105°38.437544 W PDOP = 4.20
GPS: State Plane Coordinates:
Note: trail ridge road heading west 85 degrees, rutting and shoving
52 1 4.600 1 5.98 6.80 5.44 4.13 2.92 2.11 1.27 0.00 89.4
52 1 4.600 1 9.06 10.63 8.27 6.27 4.38 3.14 1.85 1.36 89.4
52 1 4.600 1 12.06 14.68 11.34 8.49 5.96 4.32 2.49 1.86 89.4
52 1 4.600 1 15.19 18.42 13.91 10.44 7.33 5.34 3.17 2.31 89.4
GPS: Quality : GPS Fi Latitude = 40°23.835521 N Longitude = 105°38.475928 W PDOP = 3.30
GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving
53 1 4.550 1 6.18 7.70 5.60 4.38 3.12 2.27 1.33 0.92 89.4
53 1 4.550 1 8.98 11.86 8.62 6.66 4.73 3.39 1.90 1.37 89.4
53 1 4.550 1 12.06 16.35 11.92 9.19 6.58 4.75 2.70 1.89 89.4
53 1 4.550 1 14.92 20.25 14.57 11.26 8.06 5.81 3.34 2.26 89.4
GPS: Quality : GPS Fi Latitude = 40°23.846423 N Longitude = 105°38.508927 W PDOP = 3.30
GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving
54 1 4.450 1 6.10 7.55 5.49 4.14 2.80 2.00 1.16 0.98 90.1
54 1 4.450 1 9.03 11.92 8.48 6.26 4.24 3.01 1.67 1.15 90.1
54 1 4.450 1 11.89 16.07 11.35 8.35 5.65 4.00 2.28 1.54 90.1
54 1 4.450 1 14.97 20.53 14.23 10.43 7.01 4.98 2.85 1.87 90.1
GPS: Quality : GPS Fi Latitude = 40°23.879458 N Longitude = 105°38.570008 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving
55 1 4.349 1 6.18 6.00 4.55 3.60 2.54 1.78 1.02 0.00 91.9
55 1 4.349 1 8.94 9.03 6.89 5.45 3.86 2.73 1.54 1.10 91.9
55 1 4.349 1 12.11 12.00 9.23 7.30 5.24 3.75 2.10 1.51 91.9
55 1 4.349 1 15.23 14.55 11.14 8.87 6.40 4.65 2.64 1.85 91.9
GPS: Quality : GPS Fi Latitude = 40°23.913990 N Longitude = 105°38.629649 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving
56 1 4.243 1 6.05 8.51 6.73 5.37 3.81 2.71 1.53 1.07 92.3
56 1 4.243 1 8.89 12.76 9.97 7.83 5.57 3.94 2.19 1.57 92.3
56 1 4.243 1 12.18 17.28 13.40 10.54 7.52 5.39 3.01 2.15 92.3
56 1 4.243 1 15.11 21.08 16.44 12.68 9.13 6.62 3.74 2.70 92.3
GPS: Quality : GPS Fi Latitude = 40°23.907576 N Longitude = 105°38.704567 W PDOP = 2.70
GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving
57 1 4.150 1 6.15 7.26 5.48 4.46 3.48 2.71 1.78 1.29 92.7
57 1 4.150 1 8.86 11.12 8.25 6.64 5.13 4.01 2.57 1.82 92.7
57 1 4.150 1 12.11 15.23 11.27 9.01 6.96 5.43 3.49 2.44 92.7
57 1 4.150 1 14.89 18.74 13.68 10.95 8.49 6.64 4.28 2.97 92.7
GPS: Quality : GPS Fi Latitude = 40°23.879600 N Longitude = 105°38.763806 W PDOP = 2.70
GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving
58 1 4.045 1 6.15 6.85 4.86 3.63 2.69 2.08 1.35 1.00 91.6
58 1 4.045 1 8.96 10.93 7.62 5.66 4.17 3.26 2.08 1.48 91.6
58 1 4.045 1 11.99 15.15 10.53 7.74 5.72 4.44 2.82 1.95 91.6
58 1 4.045 1 14.99 18.94 13.02 9.62 7.08 5.51 3.49 2.41 91.6
GPS: Quality : GPS Fi Latitude = 40°23.841091 N Longitude = 105°38.823737 W PDOP = 2.70
GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving
59 1 3.949 1 6.01 7.09 5.15 3.89 2.96 2.27 1.54 1.14 88.6
59 1 3.949 1 9.06 11.50 8.22 6.21 4.63 3.61 2.36 1.73 88.6

59 1 3.949 1 11.74 15.33 10.92 8.24 6.14 4.78 3.14 2.23 88.6
59 1 3.949 1 15.01 19.53 13.80 10.50 7.85 6.11 3.98 2.76 88.6
GPS: Quality : GPS Fi Latitude = 40°23.822062 N Longitude = 105°38.890105 W PDOP = 2.60
GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving
60 1 3.850 1 6.05 6.59 4.20 3.07 2.12 1.49 0.00 0.00 81.7
60 1 3.850 1 9.13 10.78 6.92 5.03 3.45 2.43 1.31 0.93 81.7
60 1 3.850 1 12.06 14.60 9.47 6.85 4.70 3.32 1.76 1.16 81.7
60 1 3.850 1 15.04 18.15 11.76 8.49 5.85 4.13 2.22 1.43 81.7
GPS: Quality : GPS Fi Latitude = 40°23.811979 N Longitude = 105°38.962102 W PDOP = 2.60
GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving from last test forward
61 1 3.748 1 6.08 5.44 3.30 2.22 0.00 1.25 0.00 0.00 81.7
61 1 3.748 1 9.08 8.39 5.11 3.36 2.51 1.91 1.32 1.06 81.7
61 1 3.748 1 12.01 11.04 6.75 4.48 3.31 2.58 1.74 1.41 81.7
61 1 3.748 1 15.23 13.73 8.36 5.57 4.14 3.24 2.17 1.72 81.7
GPS: Quality : GPS Fi Latitude = 40°23.815718 N Longitude = 105°39.032309 W PDOP = 2.60
GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving
62 1 3.642 1 5.96 10.15 6.48 4.42 2.82 1.89 0.93 0.00 78.0
62 1 3.642 1 9.03 15.96 10.28 7.13 4.55 3.01 1.57 1.14 78.0
62 1 3.642 1 11.84 20.89 13.66 9.54 6.23 4.17 2.17 1.56 78.0
62 1 3.642 1 14.94 25.66 17.03 11.91 7.89 5.29 2.72 1.93 78.0
GPS: Quality : GPS Fi Latitude = 40°23.847006 N Longitude = 105°38.975780 W PDOP = 2.60
GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving
63 1 3.542 1 5.57 9.45 6.12 4.25 2.69 1.81 0.00 0.00 69.6
63 1 3.542 1 8.33 16.63 10.66 7.37 4.68 3.08 1.70 1.11 69.6
63 1 3.542 1 11.43 24.63 15.07 10.43 6.67 4.42 2.48 1.62 69.6
63 1 3.542 1 13.99 21.62 18.98 13.06 8.43 5.61 3.12 2.04 69.6
GPS: Quality : GPS Fi Latitude = 40°23.871617 N Longitude = 105°38.907992 W PDOP = 2.50
GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving
64 1 3.531 1 6.15 11.82 7.58 5.05 2.91 1.78 0.00 0.00 67.4
64 1 3.531 1 9.11 19.65 12.57 8.34 4.82 2.93 1.46 0.96 67.4
64 1 3.531 1 12.30 27.87 17.82 11.88 6.95 4.23 1.92 1.34 67.4
64 1 3.531 1 14.89 33.65 21.59 14.35 8.50 5.21 2.35 1.62 67.4
GPS: Quality : DGPS Fix Latitude = 40°23.875117 N Longitude = 105°38.900744 W PDOP = 2.50
GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving
65 1 3.438 1 6.05 6.32 3.74 2.43 0.00 1.34 0.00 0.00 67.0
65 1 3.438 1 9.01 10.36 6.13 3.85 2.68 2.06 1.45 1.06 67.0
65 1 3.438 1 12.40 15.03 8.67 5.47 3.74 2.92 2.01 1.46 67.0
65 1 3.438 1 15.36 18.86 10.68 6.90 4.70 3.69 2.54 1.78 67.0
GPS: Quality : GPS Fi Latitude = 40°23.902266 N Longitude = 105°38.841960 W PDOP = 2.50
GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving
66 1 3.349 1 6.18 6.49 4.05 2.88 2.04 1.48 0.00 0.00 62.3
66 1 3.349 1 9.28 10.46 6.59 4.69 3.25 2.40 1.45 1.08 62.3
66 1 3.349 1 12.50 14.30 9.09 6.46 4.50 3.28 1.96 1.42 62.3
66 1 3.349 1 15.26 17.30 10.99 7.84 5.43 3.97 2.38 1.66 62.3
GPS: Quality : GPS Fi Latitude = 40°23.930732 N Longitude = 105°38.788468 W PDOP = 2.50
GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving
67 1 3.251 1 6.13 13.08 8.25 5.33 3.43 2.42 1.49 0.00 65.9
67 1 3.251 1 9.01 21.17 13.24 8.53 5.43 3.84 2.30 1.69 65.9
67 1 3.251 1 12.08 28.50 17.79 11.45 7.28 5.14 2.99 2.24 65.9
67 1 3.251 1 14.60 34.57 21.76 14.02 8.96 6.29 3.70 2.68 65.9
GPS: Quality : GPS Fi Latitude = 40°23.963392 N Longitude = 105°38.730151 W PDOP = 2.30

GPS: State Plane Coordinates:
Note: trail ridge road heading east 73 degrees, rutting and shoving
68 1 3.150 1 6.27 6.64 4.71 3.79 2.94 2.29 1.42 0.93 66.3
68 1 3.150 1 9.18 10.23 7.21 5.79 4.45 3.46 2.11 1.38 66.3
68 1 3.150 1 12.38 13.90 9.79 7.80 6.01 4.68 2.87 1.81 66.3
68 1 3.150 1 15.50 17.04 12.07 9.56 7.35 5.72 3.51 2.17 66.3
GPS: Quality : GPS Fi Latitude = 40°23.983672 N Longitude = 105°38.661386 W PDOP = 2.30
GPS: State Plane Coordinates:
Note: trail ridge road heading east 763degrees, rutting and shoving
69 1 3.046 1 6.30 7.56 5.06 3.55 2.29 1.57 0.94 0.00 64.5
69 1 3.046 1 9.18 11.50 7.72 5.40 3.45 2.40 1.39 1.05 64.5
69 1 3.046 1 12.28 15.41 10.33 7.25 4.69 3.26 1.80 1.36 64.5
69 1 3.046 1 15.19 18.81 12.55 8.86 5.76 4.01 2.27 1.61 64.5
GPS: Quality : GPS Fi Latitude = 40°23.971682 N Longitude = 105°38.586061 W PDOP = 5.50
GPS: State Plane Coordinates:
Note: trail ridge road heading east 763degrees, rutting and shoving
70 1 2.949 1 6.15 8.01 5.61 4.25 3.34 2.74 1.92 1.39 62.6
70 1 2.949 1 9.03 12.36 8.59 6.47 5.03 4.13 2.84 2.04 62.6
70 1 2.949 1 12.08 17.04 11.88 8.91 6.96 5.65 3.90 2.73 62.6
70 1 2.949 1 14.97 21.16 14.86 11.08 8.63 7.01 4.83 3.37 62.6
GPS: Quality : GPS Fi Latitude = 40°23.953019 N Longitude = 105°38.517936 W PDOP = 5.30
GPS: State Plane Coordinates:
Note: trail ridge road heading east 763degrees, rutting and shoving
71 1 2.848 1 6.03 13.29 9.37 6.91 5.17 4.06 2.68 1.91 61.2
71 1 2.848 1 8.91 20.33 14.20 10.37 7.74 6.04 3.97 2.84 61.2
71 1 2.848 1 12.11 27.46 19.17 13.85 10.34 8.11 5.37 3.88 61.2
71 1 2.848 1 14.72 32.74 22.78 16.51 12.32 9.66 6.44 4.59 61.2
GPS: Quality : GPS Fi Latitude = 40°23.932513 N Longitude = 105°38.448671 W PDOP = 5.80
GPS: State Plane Coordinates:
Note: trail ridge road heading east 763degrees, rutting and shoving
72 1 2.748 1 5.83 9.89 5.75 3.39 2.16 1.52 0.00 0.00 61.5
72 1 2.748 1 8.79 17.60 9.34 5.29 3.40 2.40 1.45 1.02 61.5
72 1 2.748 1 11.77 23.98 12.86 7.14 4.61 3.33 2.02 1.49 61.5
72 1 2.748 1 14.75 27.12 15.80 8.66 5.66 4.09 2.43 1.79 61.5
GPS: Quality : GPS Fi Latitude = 40°23.912752 N Longitude = 105°38.379263 W PDOP = 8.00
GPS: State Plane Coordinates:
Note: trail ridge road heading east 56 degrees, rutting and shoving
73 1 2.649 1 6.08 13.29 9.39 7.09 4.76 3.39 1.96 1.38 61.5
73 1 2.649 1 8.84 20.65 14.50 10.81 7.25 5.13 2.90 2.03 61.5
73 1 2.649 1 12.13 29.07 20.09 14.94 10.04 7.06 3.97 2.74 61.5
73 1 2.649 1 14.92 35.95 24.57 18.21 12.28 8.71 4.99 3.36 61.5
GPS: Quality : GPS Fi Latitude = 40°23.875650 N Longitude = 105°38.329471 W PDOP = 3.60
GPS: State Plane Coordinates:
Note: trail ridge road heading east 56 degrees, rutting and shoving
74 1 2.546 1 5.86 11.44 8.59 6.70 4.83 3.53 2.10 1.47 63.4
74 1 2.546 1 8.91 19.30 14.30 11.05 8.02 5.90 3.51 2.38 63.4
74 1 2.546 1 11.99 26.69 19.36 14.95 10.94 8.14 4.87 3.35 63.4
74 1 2.546 1 14.79 32.76 23.45 18.20 13.39 10.04 6.06 4.16 63.4
GPS: Quality : Fix not valid Latitude = 40°23.830725 N Longitude = 105°38.283229 W PDOP = 3.60
GPS: State Plane Coordinates:
Note: trail ridge road heading east 56 degrees, rutting and shoving
75 1 2.450 1 6.30 5.54 3.92 3.03 2.22 1.62 0.92 0.00 64.5
75 1 2.450 1 9.13 8.37 5.87 4.50 3.24 2.39 1.34 0.89 64.5
75 1 2.450 1 12.38 11.57 8.12 6.21 4.49 3.34 1.89 1.21 64.5
75 1 2.450 1 15.55 14.49 10.06 7.69 5.58 4.14 2.36 1.43 64.5
GPS: Quality : DGPS Fix Latitude = 40°23.809873 N Longitude = 105°38.218707 W PDOP = 2.70
GPS: State Plane Coordinates:
Note: trail ridge road heading east 56 degrees, rutting and shoving
76 1 2.343 1 6.45 5.18 3.79 2.93 2.27 1.75 1.13 0.00 63.4
76 1 2.343 1 9.28 7.92 5.75 4.42 3.34 2.61 1.65 1.18 63.4

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76 1   2.343 1 12.45 10.93  7.82  6.00  4.57  3.56  2.26  1.55  63.4
76 1   2.343 1 15.38 13.50  9.51  7.34  5.57  4.34  2.76  1.88  63.4
GPS: Quality : GPS Fi   Latitude = 40°23.798862  N   Longitude = 105°38.140483   W   PDOP
= 2.90
GPS: State Plane Coordinates:
Note: trail ridge road heading east 56 degrees, rutting and shoving
77 1   2.245 1  6.15  9.85  6.79  4.99  3.66  2.81  2.04  1.64  64.5
77 1   2.245 1  8.81 15.26 10.65  7.86  5.84  4.64  3.41  2.73  64.5
77 1   2.245 1 12.16 20.81 14.52 10.55  7.85  6.24  4.61  3.64  64.5
77 1   2.245 1 14.75 24.72 17.29 12.48  9.32  7.40  5.50  4.35  64.5
GPS: Quality : GPS Fi   Latitude = 40°23.794075  N   Longitude = 105°38.068389   W   PDOP
= 2.70
GPS: State Plane Coordinates:
Note: trail ridge road heading east 56 degrees, rutting and shoving
78 1   2.149 1  5.98  4.58  3.23  2.47  0.00  1.31  0.00  0.00  63.4
78 1   2.149 1  9.03  7.81  5.22  3.94  2.85  2.09  1.18  0.00  63.4
78 1   2.149 1 12.13 11.16  7.21  5.37  3.89  2.84  1.60  1.12  63.4
78 1   2.149 1 14.97 14.21  8.99  6.65  4.83  3.55  2.05  1.36  63.4
GPS: Quality : GPS Fi   Latitude = 40°23.769065  N   Longitude = 105°38.006023   W   PDOP
= 2.70
GPS: State Plane Coordinates:
Note: trail ridge road heading east 56 degrees, rutting and shoving
79 1   2.042 1  6.05  2.84  0.00  0.00  0.00  0.00  0.00  0.00  61.5
79 1   2.042 1  8.98  4.87  2.73  2.08  0.00  1.15  0.00  0.00  61.5
79 1   2.042 1 12.16  7.28  3.93  2.84  2.16  1.63  1.12  0.88  61.5
79 1   2.042 1 15.01  9.49  4.93  3.60  2.66  2.06  1.38  1.10  61.5
GPS: Quality : GPS Fi   Latitude = 40°23.727676  N   Longitude = 105°37.949890   W   PDOP
= 10.20
GPS: State Plane Coordinates:
Note: trail ridge road heading east 56 degrees, rutting and shoving
80 1   1.950 1  6.30  4.26  2.98  2.33  1.64  1.11  0.00  0.00  63.4
80 1   1.950 1  9.23  6.31  4.40  3.42  2.34  1.65  0.94  0.00  63.4
80 1   1.950 1 12.28  8.29  5.76  4.50  3.11  2.20  1.21  0.87  63.4
80 1   1.950 1 15.45 10.15  6.94  5.46  3.78  2.71  1.51  1.09  63.4
GPS: Quality : GPS Fi   Latitude = 40°23.692885  N   Longitude = 105°37.898842   W   PDOP
= 3.90
GPS: State Plane Coordinates:
Note: trail ridge road heading east 56 degrees, rutting and shoving
81 1   1.849 1  6.18  4.14  2.70  2.10  0.00  1.05  0.00  0.00  63.4
81 1   1.849 1  9.03  6.19  4.03  3.12  2.19  1.58  0.92  0.00  63.4
81 1   1.849 1 12.21  8.33  5.42  4.20  3.01  2.19  1.22  0.91  63.4
81 1   1.849 1 15.23 10.17  6.45  5.05  3.64  2.66  1.51  1.12  63.4
GPS: Quality : GPS Fi   Latitude = 40°23.663851  N   Longitude = 105°37.834303   W   PDOP
= 2.70
GPS: State Plane Coordinates:
Note: trail ridge road heading east 56 degrees, rutting and shoving
82 1   1.748 1  5.93  5.03  4.08  3.50  2.77  2.15  1.38  1.01  64.8
82 1   1.748 1  8.91  7.79  6.35  5.39  4.22  3.30  2.11  1.52  64.8
82 1   1.748 1 11.94 10.46  8.48  7.16  5.66  4.46  2.83  2.07  64.8
82 1   1.748 1 14.84 12.87 10.39  8.74  6.93  5.46  3.51  2.55  64.8
GPS: Quality : GPS Fi   Latitude = 40°23.648888  N   Longitude = 105°37.761709   W   PDOP
= 2.50
GPS: State Plane Coordinates:
Note: trail ridge road heading east 56 degrees, rutting and shoving
83 1   1.643 1  6.18  4.67  3.66  3.04  2.35  1.78  1.02  0.00  63.0
83 1   1.643 1  8.89  6.77  5.24  4.35  3.33  2.53  1.42  0.99  63.0
83 1   1.643 1 12.08  9.13  6.98  5.79  4.46  3.37  1.90  1.26  63.0
83 1   1.643 1 15.19 11.34  8.55  7.05  5.42  4.11  2.35  1.53  63.0
GPS: Quality : GPS Fi   Latitude = 40°23.633626  N   Longitude = 105°37.686076   W   PDOP
= 2.50
GPS: State Plane Coordinates:
Note: trail ridge road heading east 56 degrees, rutting and shoving
84 1   1.546 1  5.74  3.15  2.30  0.00  0.00  1.04  0.00  0.00  65.6
84 1   1.546 1  8.86  5.37  3.68  2.81  2.18  1.68  1.05  0.00  65.6
84 1   1.546 1 12.11  7.49  4.94  3.80  2.91  2.26  1.43  1.04  65.6
84 1   1.546 1 15.01  9.32  6.08  4.64  3.54  2.80  1.75  1.24  65.6
GPS: Quality : GPS Fi   Latitude = 40°23.614562  N   Longitude = 105°37.619240   W   PDOP
= 2.70
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GPS: State Plane Coordinates:
Note: trail ridge road heading east 56 degrees, rutting and shoving
85 1 1.451 1 5.76 4.53 3.26 2.67 2.05 1.64 1.10 0.00 63.4
85 1 1.451 1 8.98 7.15 5.14 4.15 3.22 2.56 1.72 1.31 63.4
85 1 1.451 1 12.23 9.54 6.86 5.52 4.31 3.44 2.28 1.75 63.4
85 1 1.451 1 15.11 11.80 8.39 6.73 5.25 4.23 2.82 2.13 63.4
GPS: Quality : GPS Fi Latitude = 40°23.584416 N Longitude = 105°37.560662 W PDOP = 2.40
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving
86 1 1.349 1 5.93 3.98 3.00 2.39 0.00 1.38 0.00 0.00 64.5
86 1 1.349 1 8.96 6.34 4.69 3.78 2.87 2.15 1.37 1.01 64.5
86 1 1.349 1 11.99 8.32 5.98 4.81 3.64 2.79 1.75 1.34 64.5
86 1 1.349 1 15.21 10.20 7.21 5.82 4.41 3.43 2.14 1.65 64.5
GPS: Quality : GPS Fi Latitude = 40°23.563672 N Longitude = 105°37.490783 W PDOP = 2.40
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving
87 1 1.247 1 6.42 8.66 6.10 4.03 2.68 1.96 1.16 0.00 64.5
87 1 1.247 1 8.91 12.52 8.70 5.78 3.88 2.83 1.66 1.22 64.5
87 1 1.247 1 11.79 16.72 11.51 7.71 5.23 3.82 2.19 1.55 64.5
87 1 1.247 1 14.06 19.92 13.75 9.19 6.28 4.62 2.70 1.89 64.5
GPS: Quality : GPS Fi Latitude = 40°23.551637 N Longitude = 105°37.417982 W PDOP = 2.50
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving
88 1 1.148 1 6.25 11.33 8.37 6.39 4.62 3.44 2.13 1.52 61.9
88 1 1.148 1 9.08 17.59 12.94 9.90 7.15 5.31 3.18 2.30 61.9
88 1 1.148 1 11.99 23.32 17.19 13.18 9.62 7.17 4.33 3.08 61.9
88 1 1.148 1 15.09 29.08 21.51 16.44 12.02 8.99 5.52 3.85 61.9
GPS: Quality : GPS Fi Latitude = 40°23.517790 N Longitude = 105°37.360583 W PDOP = 5.90
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving
89 1 1.050 1 6.23 8.76 6.72 5.53 4.16 3.14 1.79 1.15 65.2
89 1 1.050 1 9.16 13.10 9.87 8.12 6.14 4.64 2.63 1.70 65.2
89 1 1.050 1 12.26 17.25 12.98 10.63 8.13 6.15 3.55 2.22 65.2
89 1 1.050 1 15.21 20.91 15.70 12.83 9.84 7.49 4.35 2.74 65.2
GPS: Quality : GPS Fi Latitude = 40°23.486594 N Longitude = 105°37.302706 W PDOP = 2.70
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving
90 1 0.949 1 6.23 5.04 4.08 3.43 2.68 2.09 1.29 0.00 66.7
90 1 0.949 1 9.18 7.53 6.07 5.08 3.99 3.13 1.89 1.31 66.7
90 1 0.949 1 12.23 10.01 8.04 6.71 5.27 4.12 2.55 1.74 66.7
90 1 0.949 1 15.38 12.31 9.81 8.17 6.42 5.05 3.15 2.06 66.7
GPS: Quality : GPS Fi Latitude = 40°23.455171 N Longitude = 105°37.240719 W PDOP = 5.50
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving
91 1 0.849 1 6.18 11.16 8.74 7.06 5.20 3.86 2.15 1.39 64.5
91 1 0.849 1 8.91 16.73 12.94 10.39 7.78 5.78 3.24 2.12 64.5
91 1 0.849 1 12.08 22.07 17.05 13.71 10.36 7.78 4.43 2.92 64.5
91 1 0.849 1 14.72 26.07 20.20 16.22 12.35 9.34 5.46 3.55 64.5
GPS: Quality : GPS Fi Latitude = 40°23.414367 N Longitude = 105°37.190032 W PDOP = 5.20
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving
92 1 0.750 1 6.27 3.72 3.09 2.59 2.08 1.64 1.03 0.00 65.6
92 1 0.750 1 9.25 5.77 4.76 3.97 3.15 2.53 1.55 1.07 65.6
92 1 0.750 1 12.18 7.73 6.38 5.30 4.24 3.38 2.11 1.42 65.6
92 1 0.750 1 15.33 9.67 7.92 6.65 5.32 4.27 2.67 1.76 65.6
GPS: Quality : GPS Fi Latitude = 40°23.371588 N Longitude = 105°37.142554 W PDOP = 2.70
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving
93 1 0.650 1 6.18 4.77 2.93 2.34 0.00 1.26 0.00 0.00 65.9
93 1 0.650 1 9.18 7.48 4.67 3.67 2.68 2.00 1.12 0.00 65.9

93 1 0.650 1 12.33 10.23 6.39 5.02 3.69 2.75 1.54 1.01 65.9
93 1 0.650 1 14.87 12.37 7.74 6.10 4.50 3.35 1.90 1.17 65.9
GPS: Quality : GPS Fi Latitude = 40°23.338328 N Longitude = 105°37.084770 W PDOP = 2.20
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving
94 1 0.541 1 5.96 6.94 4.62 3.59 2.54 1.58 0.00 0.00 68.8
94 1 0.541 1 8.74 11.39 7.60 5.89 4.12 2.58 1.28 0.00 68.8
94 1 0.541 1 12.01 16.36 10.64 8.29 5.79 3.72 1.81 1.20 68.8
94 1 0.541 1 14.94 20.43 12.91 10.13 7.11 4.59 2.27 1.45 68.8
GPS: Quality : GPS Fi Latitude = 40°23.316447 N Longitude = 105°37.009923 W PDOP = 4.80
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving
95 1 0.448 1 6.13 6.94 5.14 4.04 2.82 1.98 0.98 0.00 68.5
95 1 0.448 1 9.03 10.80 8.07 6.29 4.41 3.07 1.44 1.02 68.5
95 1 0.448 1 11.94 14.40 10.82 8.44 5.98 4.19 1.95 1.31 68.5
95 1 0.448 1 14.99 17.97 13.35 10.46 7.47 5.25 2.49 1.58 68.5
GPS: Quality : GPS Fi Latitude = 40°23.290848 N Longitude = 105°36.949361 W PDOP = 4.50
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving
96 1 0.347 1 6.13 4.60 3.73 3.14 2.44 1.80 1.06 0.00 67.0
96 1 0.347 1 9.08 7.32 5.92 4.97 3.79 2.86 1.65 1.10 67.0
96 1 0.347 1 12.23 10.02 8.13 6.79 5.24 3.94 2.29 1.46 67.0
96 1 0.347 1 15.06 12.59 10.19 8.49 6.54 4.92 2.89 1.85 67.0
GPS: Quality : GPS Fi Latitude = 40°23.268686 N Longitude = 105°36.880747 W PDOP = 4.20
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving
97 1 0.248 1 6.20 3.98 3.09 2.55 1.95 1.49 0.93 0.00 68.8
97 1 0.248 1 8.89 6.10 4.74 3.89 2.99 2.32 1.40 0.96 68.8
97 1 0.248 1 11.96 8.44 6.60 5.45 4.21 3.28 1.99 1.27 68.8
97 1 0.248 1 14.92 10.45 8.15 6.76 5.23 4.10 2.49 1.54 68.8
GPS: Quality : DGPS Fix Latitude = 40°23.245223 N Longitude = 105°36.814969 W PDOP = 5.30
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving
98 1 0.151 1 5.96 9.18 7.48 6.18 4.62 3.41 1.94 1.28 69.2
98 1 0.151 1 8.98 14.37 11.74 9.69 7.27 5.36 3.01 1.96 69.2
98 1 0.151 1 11.79 18.78 15.41 12.76 9.71 7.27 4.10 2.65 69.2
98 1 0.151 1 14.70 23.15 18.87 15.72 12.03 9.08 5.25 3.37 69.2
GPS: Quality : GPS Fi Latitude = 40°23.230289 N Longitude = 105°36.747376 W PDOP = 2.10
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving
99 1 0.048 1 6.10 8.76 7.06 6.01 4.89 4.01 2.78 2.07 70.3
99 1 0.048 1 8.86 13.03 10.53 8.95 7.29 6.05 4.20 3.08 70.3
99 1 0.048 1 12.04 17.04 13.77 11.64 9.58 7.88 5.55 3.98 70.3
99 1 0.048 1 14.87 20.68 16.49 13.97 11.57 9.57 6.83 4.93 70.3
GPS: Quality : GPS Fi Latitude = 40°23.224182 N Longitude = 105°36.670952 W PDOP = 2.50
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving
100 1 0.005 1 6.05 10.24 8.30 6.92 5.06 3.64 1.76 0.90 69.2
100 1 0.005 1 8.94 15.96 12.96 10.65 7.84 5.63 2.67 1.28 69.2
100 1 0.005 1 11.72 21.11 16.98 14.05 10.38 7.49 3.56 1.70 69.2
100 1 0.005 1 14.79 26.41 21.53 17.44 12.91 9.31 4.49 2.11 69.2
GPS: Quality : GPS Fi Latitude = 40°23.219465 N Longitude = 105°36.640599 W PDOP = 2.50
GPS: State Plane Coordinates:
Note: trail ridge road heading east 62 degrees, rutting and shoving

APPENDIX H

PRELIMINARY FOAMED ASPHALT MIX DESIGN – EARTH ENGINEERING CONSULTANTS, INC.

March 1, 2004

EARTH ENGINEERING
CONSULTANTS, INC.

FHWA-CFLHD
555 Zang Street, Room 259
Lakewood, Colorado 80228

Attn: Mr. Steve Deppmeier

Re: Foamed Bitumen Mix Designs
Trail Ridge Road
CO PRA ROMO 10(4)
Estes Park, Colorado
EEC Project Number: 1044009

Mr. Deppmeier:

Earth Engineering Consultants, Inc. (EEC) personnel have completed the foamed bitumen mix designs you requested for the above referenced project. A Wirtgen® WLB 10 foam laboratory was used for designing the mixes. Results of the completed mix designs are included with this report.

Foaming Characteristics

A sample of AC-10 obtained from the Frontier Oil Refinery in Cheyenne, Wyoming was evaluated to determine foaming characteristics. The sample was obtained on January 7, 2004 from tank 1-52. In general, the AC-10 graded asphalt exhibited favorable foaming characteristics and was used in the mix design. The Frontier asphalt was evaluated at 160, 170 and 180° C to develop expansion ratio and half-life information.

Foaming characteristics are determined by adjusting the percent of water utilized to produce the foaming reaction and recording the foam expansion ratio and half-life. The expansion ratio indicates how many times the asphalt foam expands from its original volume. The half-life is the amount of time it takes for the foam to reach 50% of its maximum expanded volume. Results of foam characteristics testing are outlined on the attached summary. The optimum percent injection water occurs when the maximum amount of foam is produced and maintained in the foam state for the greatest amount of time. Maximizing foaming will aid in dispersing the bitumen throughout the recycled

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materials. Maximizing half-life will allow for the dispersion process to occur for the greatest amount of time.

In general, the higher the asphalt temperature, the more energy is available to produce asphaltic cement foam. However, based on past experience, essential volatile components are burned off more quickly at higher asphalt temperatures and higher asphalt temperatures are difficult to maintain in the field. A minimum expansion ratio of 15 and half-life of 12 is preferred for use in the mix design. However, we understand those values were derived from the increased expansion ratios and half-lives that can be produced with the higher nozzle pressures developed utilizing Wirtgen® equipment in the field. Difficulty obtaining the outlined expansion ratio and half-life values in the laboratory has been encountered in the past and was the case in this evaluation. It has been our experience, and recommended by A.A. Louden and Partners, that sufficient foaming characteristics are developed with laboratory values as low as an expansion ratio of 9 and half-life of 6 seconds.

Based on the results of laboratory testing, we recommend 2.5% injection water be added to induce foaming and a minimum asphalt temperature of 160°C be maintained in the field. For the provided mix designs, a minimum asphalt temperature of 160°C and 2.5% injection water was utilized.

Sampling and Sample Preparation

Samples of the asphaltic concrete surfacing and aggregate base from the proposed reconstruction area were sent to our laboratory for use in the preliminary mix designs. A gradation analysis was completed on each proportionately blended sample of aggregate base and RAP prior to cement addition to develop grain size distribution information. In addition, Atterberg limits and modified Proctor tests were completed on each aggregate blend. Results of the outlined testing are outlined on the attached summary sheets.

Samples of the asphalt pavement were softened by heating and broken down to obtain material representing recycled asphaltic concrete. The RAP and aggregate base materials were blended in proportion to the recommended layer thicknesses and assumed in-situ densities as outlined below in Table I.

TABLE I – Proportioning Summary

Section A

Material	Weight Per Square Meter (kg)	Per 10 kg Sample (g)
Asphaltic Concrete (100 mm @ 2403 kg/m^3)	240.3 kg (82.19%)	8219 g
Aggregate Base (25 mm @ 2083 kg/m^3)	52.1 kg (17.81%)	1781 g
Total Blend	292.4 kg	10,000 g

Section B

Material	Weight Per Square Meter (kg)	Per 10 kg Sample (g)
Asphaltic Concrete (85 mm @ 2403 kg/m^3)	204.3 kg (60.14%)	6014 g
Aggregate Base (65 mm @ 2083 kg/m^3)	135.4 kg (39.86%)	3986 g
Total Blend	339.7 kg	10,000 g

Section C

Material	Weight Per Square Meter (kg)	Per 10 kg Sample (g)
Asphaltic Concrete (110 mm @ 2403 kg/m^3)	264.3 kg (76.04%)	7604 g
Aggregate Base (40 mm @ 2083 kg/m^3)	83.3 kg (23.96%)	2396 g
Total Blend	347.6 kg	10,000 g

Section D

Material	Weight Per Square Meter (kg)	Per 10 kg Sample (g)
Asphaltic Concrete (100 mm @ 2403 kg/m^3)	240.3 kg (69.77%)	6977 g
Aggregate Base (50 mm @ 2083 kg/m^3)	104.1 kg (30.23%)	3023 g
Total Blend	344.4 kg	10,000 g

Atterberg limits tests indicated the proportioned materials were non-plastic. Based on the results of completed Atterberg Limits tests, the addition of lime was not explored. One percent (1%) Portland cement by unit weight was added to the blend to supplement fine content and add cementatious qualities to the blend. Augmenting the fine content is necessary to provide a sufficient amount of material for development of asphalt foam mortar. Limiting the Portland cement addition to 1% is preferred to reduce the potential for development of a more brittle material susceptible to cracking. The compaction moisture added to the blends was 1.25% for Section A, 2.25% for section B and 2.00% for Sections C and D prior to treatment with foamed bitumen.

Foamed Bitumen was added to the proportioned blends for Sections A, C and D at 2.0, 2.5, 3.0, 3.5 and 4.0% based on the sample dry unit weight. Foamed Bitumen was added to the proportioned blend for Section B at 2.5, 3.0, 3.5 4.0 and 4.5% based on the sample dry unit weight. The treated samples were then compacted into 4-inch diameter specimens using 75-blow Marshall compactive effort. The molded specimens were cured at 104°F for 3 days. The cured samples were tested for indirect tensile strength under treated and untreated conditions. Untreated conditions consist of allowing samples to remain at room temperature for 24 hours after curing. Treated conditions consist of soaking the samples in room temperature water for 24 hours after curing.

Results

A summary of the completed indirect tensile strength test results are outlined below in Table II. Graphic representations of the percent foam versus soaked and unsoaked strengths for sections A through D are included with this report.

TABLE II – ITS Testing Summary

Section A

% Foamed Asphalt Added	2.0	2.5	3.0	3.5	4.0
Additives & %	1% Portland cement	1% Portland cement	1% Portland cement	1% Portland cement	1% Portland cement
Molded Density (kg/m^3)	1974	1954	1961	1932	1962
ITS Dry (kPa)	295	348	277	293	288
ITS Soaked (kPa)	239	253	255	261	248
Retained Strength (%)	81%	73%	92%	89%	86%

Section B

% Foamed Asphalt Added	2.5	3.0	3.5	4.0	4.5
Additives & %	1% Portland cement	1% Portland cement	1% Portland cement	1% Portland cement	1% Portland cement
Molded Density (kg/m^3)	2052	2052	2049	2051	2025
ITS Dry (kPa)	316	359	364	357	319
ITS Soaked (kPa)	253	266	290	326	268
Retained Strength (%)	80%	74%	80%	91%	84%

TABLE II Contd.

Section C

% Foamed Asphalt Added	2.0	2.5	3.0	3.5	4.0
Additives & %	1% Portland cement	1% Portland cement	1% Portland cement	1% Portland cement	1% Portland cement
Molded Density (kg/m^3)	2017	2017	1991	2003	1994
ITS Dry (kPa)	446	435	474	428	439
ITS Soaked (kPa)	407	381	407	384	343
Retained Strength (%)	91%	88%	86%	90%	78%

Section D

% Foamed Asphalt Added	2.0	2.5	3.0	3.5	4.0
Additives & %	1% Portland cement	1% Portland cement	1% Portland cement	1% Portland cement	1% Portland cement
Molded Density (kg/m^3)	2110	2095	2150	2127	2127
ITS Dry (kPa)	395	406	443	420	415
ITS Soaked (kPa)	312	362	361	370	355
Retained Strength (%)	79%	89%	81%	88%	86%

An additional mixing device has been employed in the mix design processes completed for this project. The dough hook mixing procedure is now followed by a wire whip mixing operation. In our opinion, much better mixing and dispersing of the asphalt foam is achieved which more closely represents the degree of mixing achieved in the field utilizing industrial recycling equipment. As a result, it is our opinion that increases in wet strengths and resulting retained strengths can be obtained in the laboratory.

Recommendations

The recommended foam and Portland cement addition rates are outlined below in Table III. The blended materials should be compacted to be at least 95% of modified Proctor maximum dry density.

Table III - Recommendations

	Section A	Section B	Section C	Section D
Foam Addition	2.5%±0.3%	3.5±0.3%	3.0%±0.3%	3.0%±0.3%
Additives	1% Portland Cement	1% Portland Cement	1% Portland Cement	1% Portland Cement

We appreciate the opportunity to work with you on this project. If you have any questions concerning the enclosed information, or if we can be of further service to you in any other way, please do not hesitate to contact us.

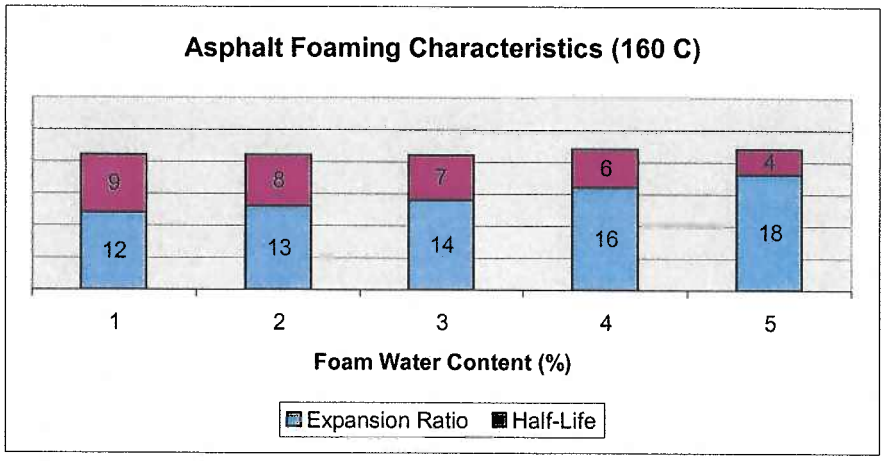
Very truly yours,
Earth Engineering Consultants, Inc.

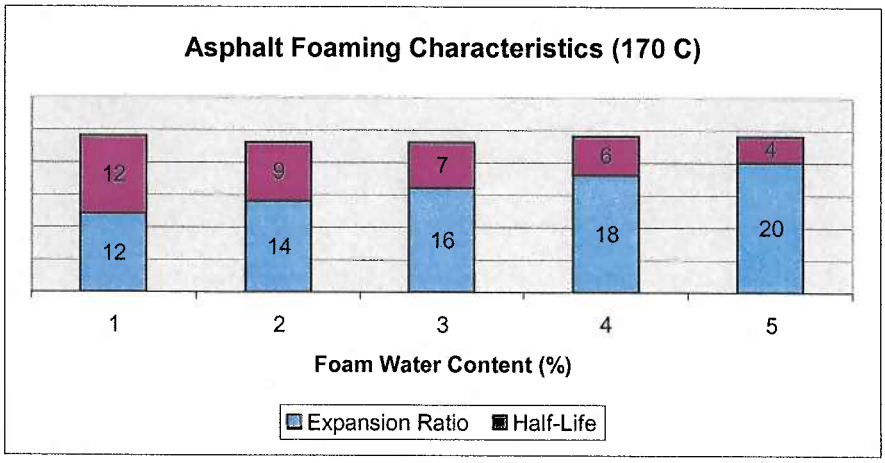
Reviewed by:

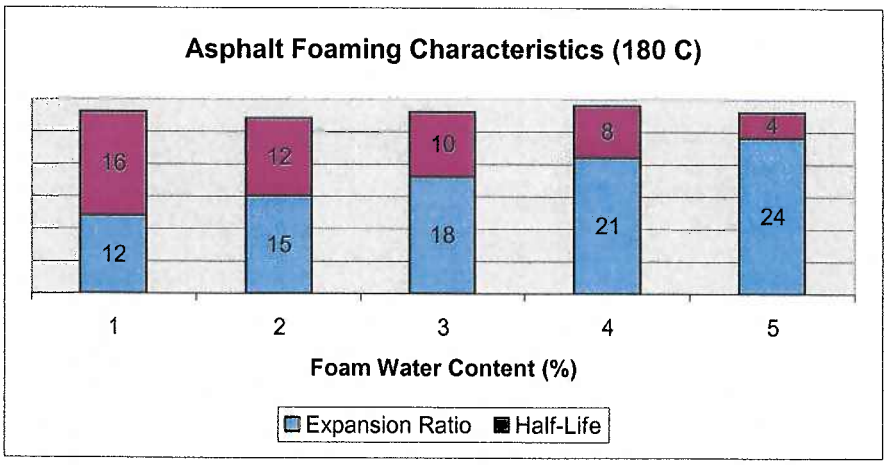
Wolfram von Carlowitz, P.E.
Senior Project Engineer

Lester L. Litton, P.E.
Principal Engineer

FOAM SUMMARY

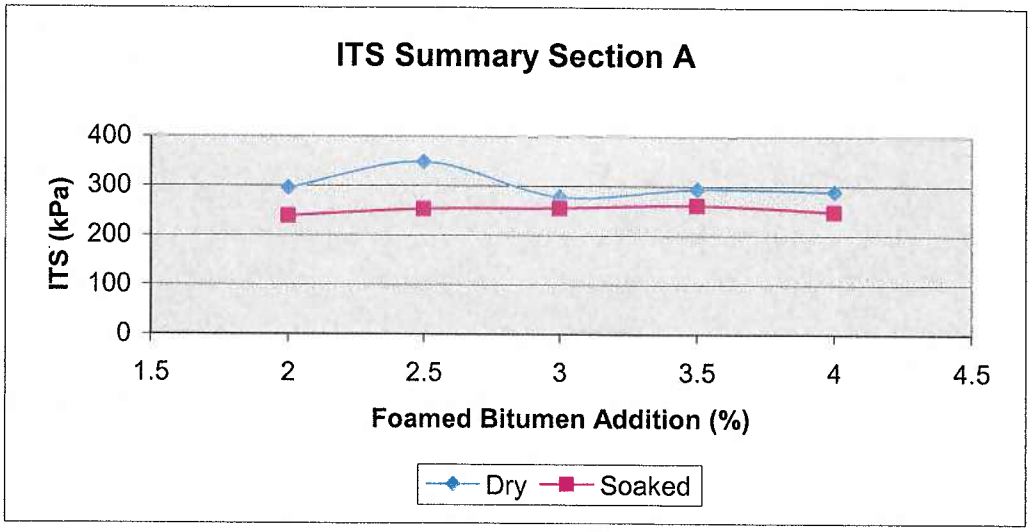


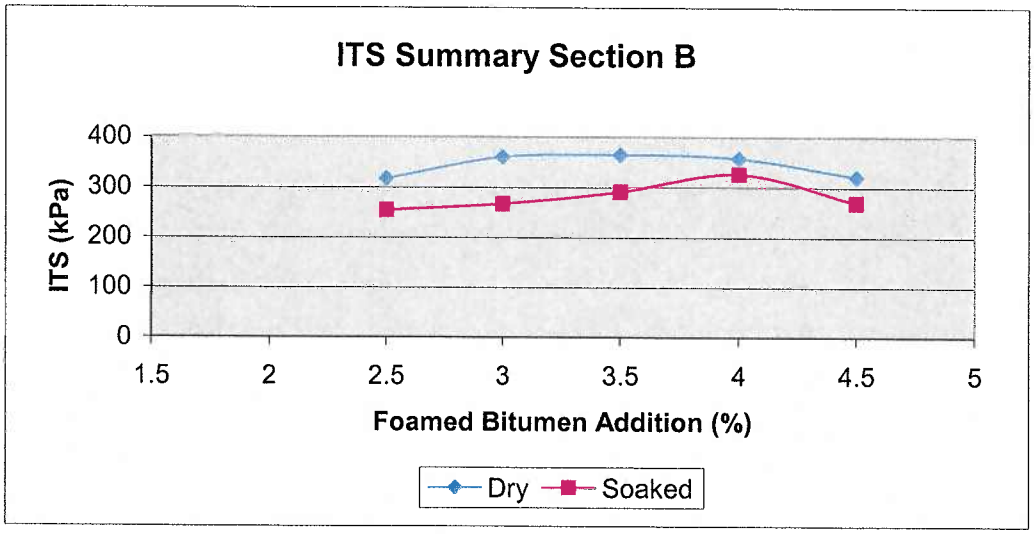




Project: Trail Ridge Road
Estes Park, Colorado
Project No.: 1044009
Date: February 2004

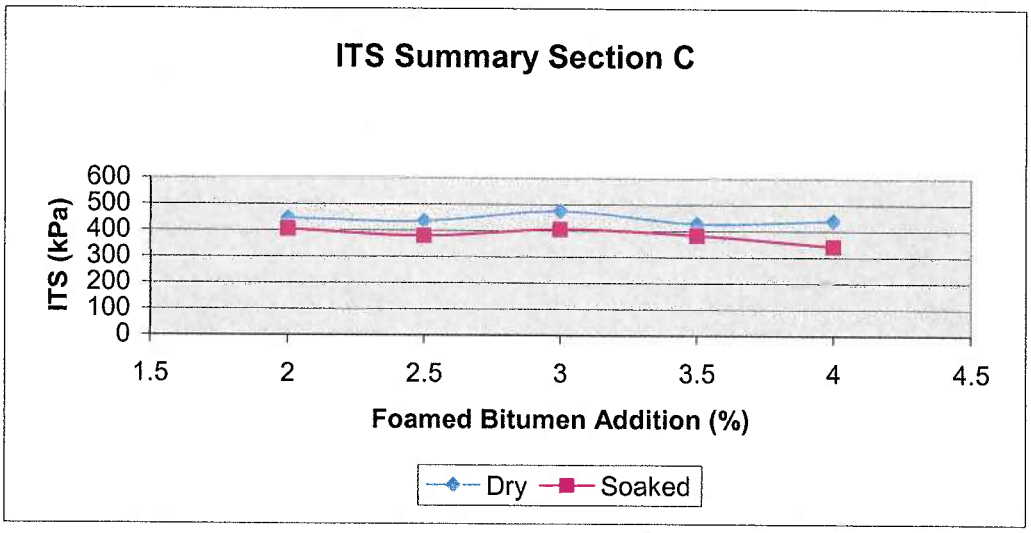
SUMMARY OF ITS TESTING

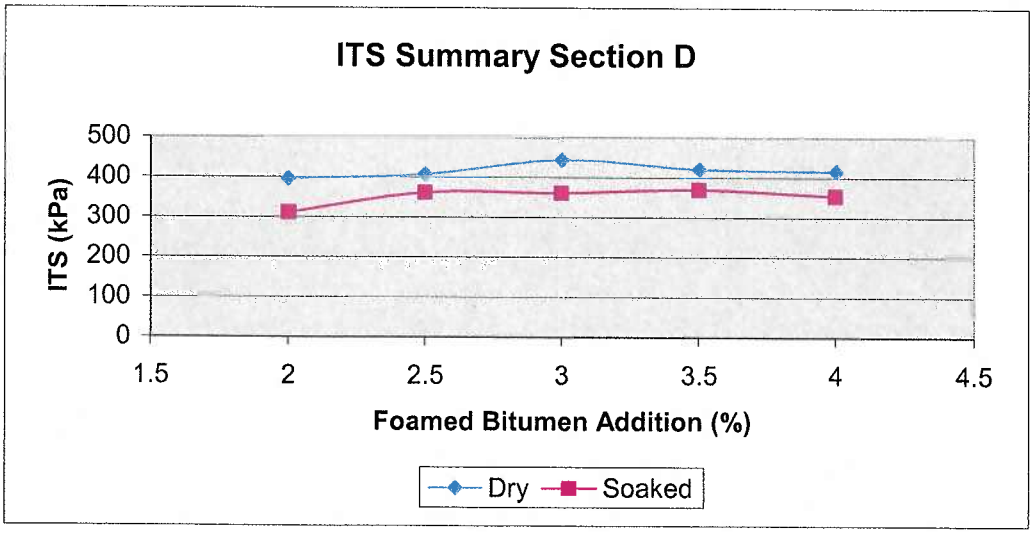




Project:	Trail Ridge Road Estes Park, Colorado
Project No.:	1044009
Date	February 2004

SUMMARY OF ITS TESTING

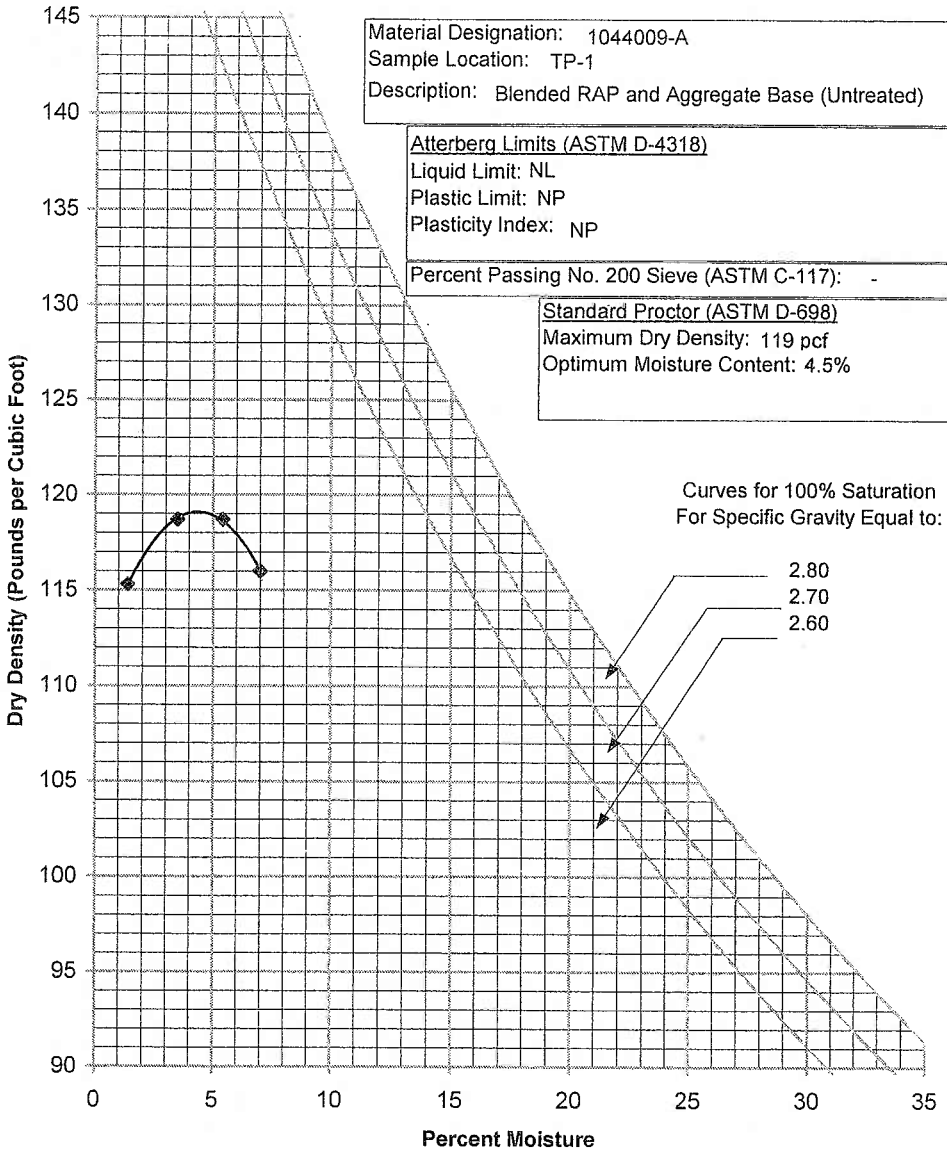




Project:	Trail Ridge Road Estes Park, Colorado
Project No.:	1044009
Date	February 2004

Earth Engineering Consultants, Inc.

Summary of Laboratory Classification/ Moisture-Density Relationship



Project: Trail Ridge Road
Estes Park, Colorado
Project No: 1044009
Date February 2004

EARTH ENGINEERING CONSULTANTS, INC.

SUMMARY OF GRADATION TEST RESULTS

SAMPLE I.D.: Section A

GRADATION OF AGGREGATE (AASHTO T-11, T-27)	
SIEVE SIZE	PERCENT PASSING
4"	100%
3"	100%
2"	100%
1 1/2"	100%
1"	100%
3/4"	100%
1/2"	77%
3/8"	59%
No. 4	33%
No. 8	19%
No. 16	11%
No. 30	6%
No. 50	4%
No. 100	2%
No. 200	1.6%

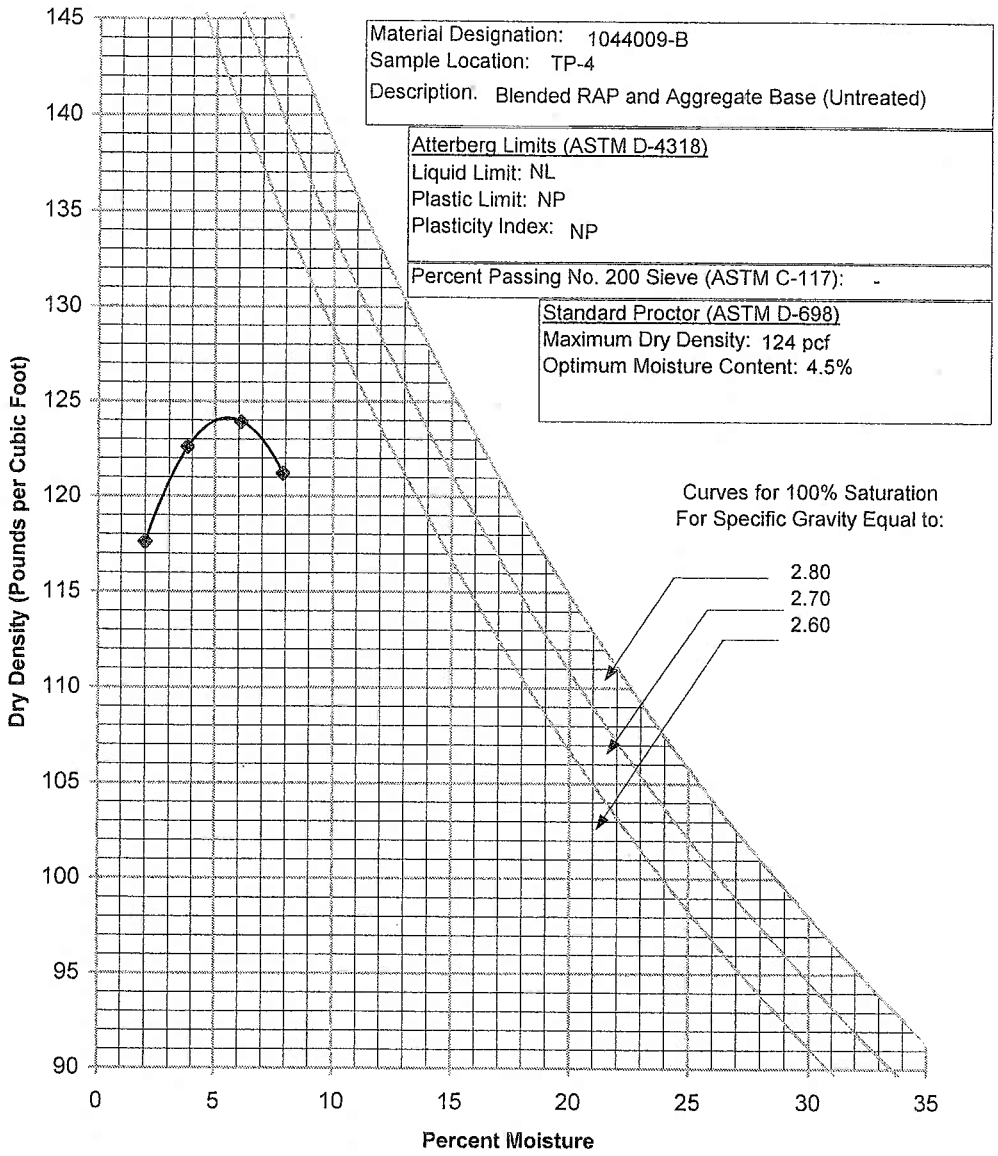
PROJECT: Trail Ridge Road
Estes Park, Colorado

EEC PROJECT NO 1044009

DATE: February 2004

Earth Engineering Consultants, Inc.

Summary of Laboratory Classification/ Moisture-Density Relationship



Project: Trail Ridge Road
Estes Park, Colorado
Project No: 1044009
Date February 2004

EARTH ENGINEERING CONSULTANTS, INC.

SUMMARY OF GRADATION TEST RESULTS

SAMPLE I.D.: Section B

GRADATION OF AGGREGATE (AASHTO T-11, T-27)	
SIEVE SIZE	PERCENT PASSING
4"	100%
3"	100%
2"	100%
1 1/2"	100%
1"	100%
3/4"	100%
1/2"	85%
3/8"	73%
No. 4	55%
No. 8	41%
No. 16	28%
No. 30	19%
No. 50	12%
No. 100	8%
No. 200	5.5%

PROJECT: Trail Ridge Road
Estes Park, Colorado

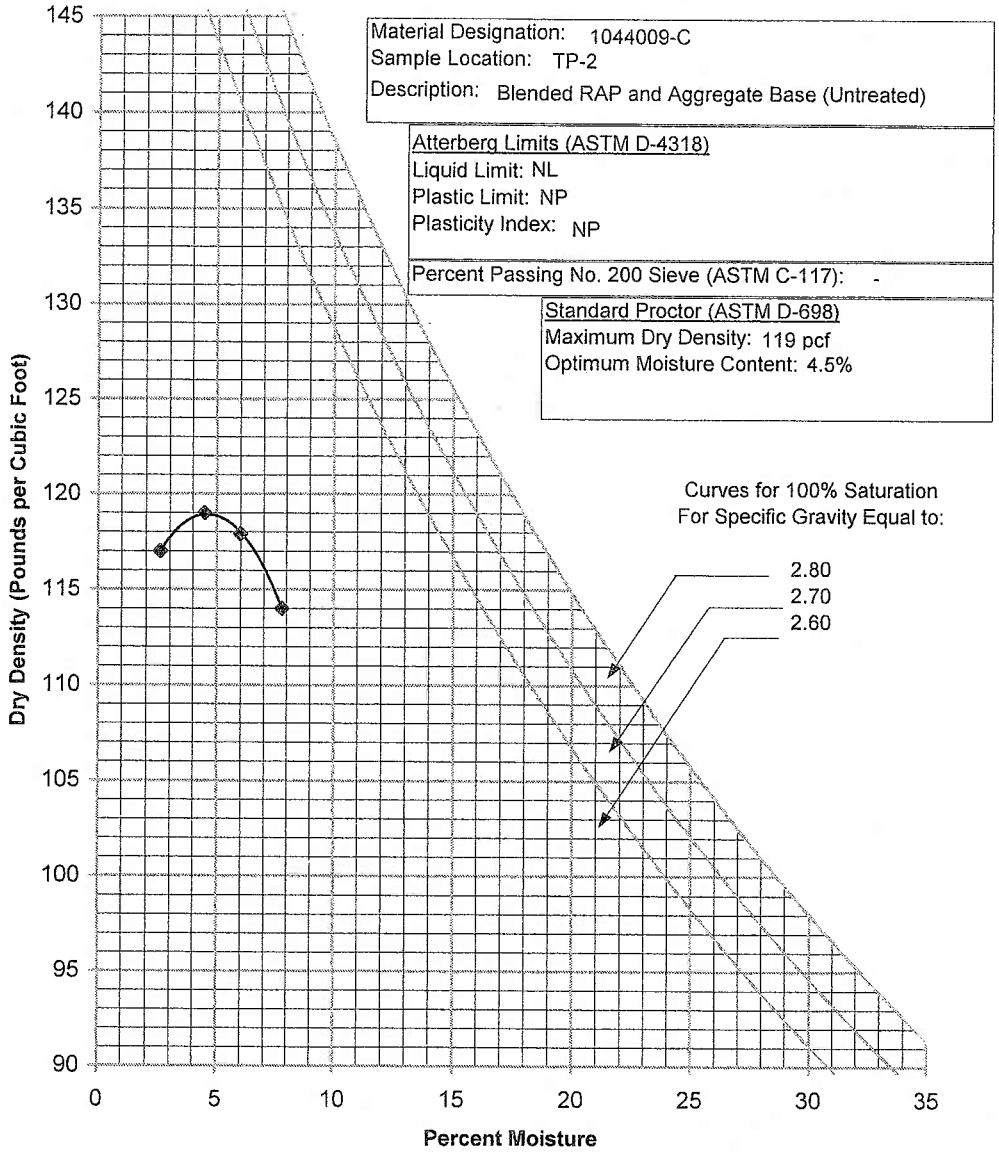
EEC PROJECT NO 1044009

DATE: February 2004

EEC

Earth Engineering Consultants, Inc.

Summary of Laboratory Classification/ Moisture-Density Relationship



Project: Trail Ridge Road
Estes Park, Colorado
Project No: 1044009
Date February 2004

EARTH ENGINEERING CONSULTANTS, INC.

SUMMARY OF GRADATION TEST RESULTS

SAMPLE I.D.: Section C

GRADATION OF AGGREGATE (AASHTO T-11, T-27)	
SIEVE SIZE	PERCENT PASSING
4"	100%
3"	100%
2"	100%
1 1/2"	100%
1"	100%
3/4"	99%
1/2"	72%
3/8"	55%
No. 4	35%
No. 8	23%
No. 16	15%
No. 30	9%
No. 50	6%
No. 100	4%
No. 200	2.8%

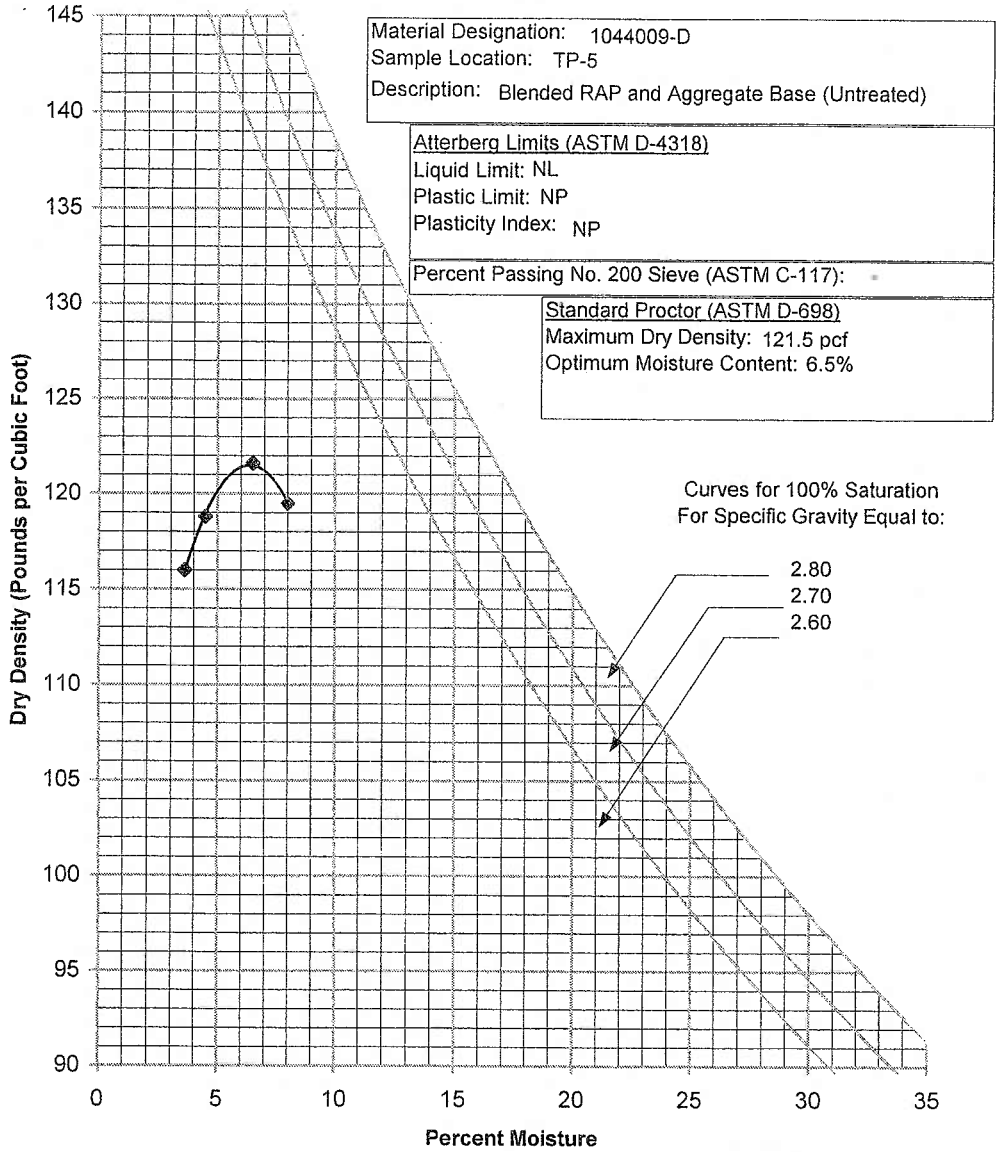
PROJECT: Trail Ridge Road
Estes Park, Colorado

EEC PROJECT NO 1044009

DATE: February 2004

Earth Engineering Consultants, Inc.

Summary of Laboratory Classification/ Moisture-Density Relationship



Project: Trail Ridge Road
Estes Park, Colorado
Project No: 1044009
Date February 2004

EARTH ENGINEERING CONSULTANTS, INC.

SUMMARY OF GRADATION TEST RESULTS

SAMPLE I.D.: Section D

GRADATION OF AGGREGATE (AASHTO T-11, T-27)	
SIEVE SIZE	PERCENT PASSING
4"	100%
3"	100%
2"	100%
1 1/2"	100%
1"	100%
3/4"	99%
1/2"	81%
3/8"	67%
No. 4	47%
No. 8	33%
No. 16	22%
No. 30	14%
No. 50	8%
No. 100	5%
No. 200	3.5%

PROJECT: Trail Ridge Road
Estes Park, Colorado

EEC PROJECT NO 1044009

DATE: February 2004

EARTH ENGINEERING
CONSULTANTS, INC.

March 24, 2004

FHWA-CFLHD
555 Zang Street, Room 259
Lakewood, Colorado 80228

Attn: Mr. Steve Deppmeier

Re: Supplemental Design Information
Trail Ridge Road
CO PRA ROMO 10(4)
Estes Park, Colorado
EEC Project Number: 1044009

Mr. Deppmeier:

Earth Engineering Consultants, Inc. (EEC) personnel submitted four (4) foamed bitumen mix designs to your attention in a report dated March 1, 2004. At this time we have been asked to provide clarification of the sample identification scheme and provide input concerning the mixing procedures utilized in the laboratory. That information is provided in the following report. Suggestions concerning foamed asphalt section design and possible project specifications are also included.

Samples of existing roadway materials for the referenced project were sent to our Fort Collins laboratory for use in completing four (4) foamed asphalt mix designs. Those materials were labeled utilizing test pit and stationing numbers with each test pit identified as representing different roadway sections. A summary of the test pit to section correlation scheme is outlined below.

Test Pit 1 (Sta. 28+300) = Section A
Test Pit 4 (Sta. 68+375) = Section B
Test Pit 2 (Sta. 50+830) = Section C
Test Pit 5 (Sta. 77+870) = Section D

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Concerning the laboratory testing procedures, an added mixing step was employed in the laboratory utilizing a wire whip. It is our opinion that the wire whip allows the laboratory mixing process to more closely approach the degree of mixing achieved in the field utilizing the commercial recycling equipment. Even with the added wire whip mixing, we believe the degree of mixing and related strengths developed using production equipment in the field is higher than that which can be simulated in the laboratory. Slightly higher wet and dry strengths should be expected in the field than can be developed utilizing current laboratory design procedures.

Concerning the indirect tensile strength (ITS) information, the minimum design requirements which were set out for the completed mix designs include a minimum wet ITS of 350 kPa and minimum retained strength of 70%. The mix designs we recommended for Sections A and B showed results of wet ITS of 253 kPa and 290 kPa respectively for what, in our opinion, was the optimum foam content. Dry strengths at the optimum oil content were 348 kPa and 364 kPa with retained strengths of 73 and 80 percent respectively.

Based on the requested proportioning scheme, Section A was a relatively coarse graded mix while Section B contained more aggregate base materials and was more finely graded. Significantly higher strengths were achieved in Sections C and D where there was an optimum proportion of recycled asphalt pavement and reclaimed aggregate base. In our opinion, the lower strengths obtained in Section A were due to the gap graded characteristics of the material. Sufficient mortar pockets and contact areas could not be developed in the molded specimens which was evident by the amount of observable voids. Conversely, the lower strengths observed in the Section B mix were, in our opinion, a result of excess sand sized materials. The finer graded materials, in our opinion did not benefit from the aggregate interlock that develops with more well graded blends.

In our opinion, the strengths obtained in the mix designs completed for sections A and B are reflective of the in place materials at the proposed mixing depths. A.A. Louden and partners have developed correlation data concerning material types, indirect tensile

strengths and design structural numbers. The information was developed utilizing Wirtgen® equipment and various pavement analysis programs and will be published in the new Wirtgen® manual. With their permission, I have attached a copy of the table and summary of the correlation data. In general, a range of structural number equivalents are produced with dry ITS values ranging from 100 to 500 kPa. As can be seen, dry ITS strengths of approximately 300 kPa would result in a structural number of approximately 0.26. Dry ITS strengths of 500 kPa would result in a structural number of 0.35.

Instead of setting a strength requirement and either accepting or dismissing the potential for foam stabilization based on strength alone, flexibility in the design process would allow the preliminary designs to develop information about what can be achieved in the field utilizing what materials are in place. After establishing the potential strength of the recycled materials, the design thickness could be adjusted to obtain the structural number required for the pavement design. With that approach, the in place materials that are present in the field can be reconstituted to the strengths proven in the mix design and that homogeneous section adjusted in thickness and incorporated into the pavement section design resulting in a much greater range of potential applications. In our opinion, a minimum soaked ITS of 100 kPa should be specified for all projects only because it implies that materials of lesser quality would be a problem where saturation of the pavement is expected.

Concerning the slightly lower strengths obtained in the mix designs completed for sections A and B, various design approaches could be pursued. As outlined above, the section thickness could be increased slightly to account for the slightly lower ITS results without completing an additional mix design. Alternately, an additional mix design could be completed utilizing a slightly different blend of materials to maximize strengths. For section A, the recycling thickness could be increased 1 inch which would supplement finer graded materials and allow for a more densely graded mix with fewer voids. The mix design completed by increasing the aggregate base materials by 1 inch in section A would be identical to the mix completed for section D which results in significant strength increases. With this 2nd approach, higher strengths and an increased foam section would result. Both of those benefits may not be required to meet the required

design. Concerning section B, the coarse material content could be supplemented by adding aggregate to the pavement surface prior to recycling in order to increase strength. Or, as outlined above, the mix design strength numbers could be used and the pavement section augmented slightly to obtain a slightly thicker but structurally equivalent section.

Additional cement could be added to increase strengths. However, for RAP and aggregate base blends, it is typically recommended that the cement addition be limited to 1% to reduce the potential for development of brittle materials. One of the most important characteristics of foam stabilized materials is their ability to remain flexible. Maintaining flexibility in the stabilized section will reduce reflective cracking. ITS strengths, in our opinion, are secondary to the durability characteristics produced by limiting cement addition and maintaining flexibility.

Although retaining 70% of dry strength in a saturated test was not a problem with the type materials utilized for these mix designs, some new information concerning retained strength requirements based on environmental conditions is being developed. As discussed with A.A. Louden and Partners, soaked strengths control the structural coefficient that can be used in the pavement design only in areas where saturation of the pavement is expected (rainfall >1000mm/annum). Specifying wet ITS indicates that lesser values may pose a problem only in areas where saturation of the pavement will occur. Up to this point, minimum soaked strength values are what have been specified when completing mix designs. While we understand the need to incorporate some conservative estimates in the pavement designs, wet ITS values, in our opinion, do not represent realistic conditions for a majority of the central and western states. In our opinion, structural number equivalents for the dry strengths could be used for design while requiring a certain minimum retained strength under soaked conditions. A minimum wet strength could be specified but would eliminate any requirement for a retained strength percentage. Typically, in the hot mix asphalt community, a minimum dry strength is specified with a minimum required retained strength. We understand that the retained strength recommendations from AA Louden and Wirtgen personnel published in the new Wirtgen manual will resemble those outlined below.

Suggested Retained Strength Specifications

Terrain Type and Drainage	Dry (Rainfall <600mm per annum)	Moderate (Rainfall between 600 and 1000mm per annum)	Wet (Rainfall >1000mm per annum)
Rolling – well drained	50%	60%	70%
Flat – Poorly Drained	60%	65%	75%

We appreciate the opportunity to assist you with the required mix designs and look forward to exploring further possibilities with the foam stabilization technology. We would welcome the opportunity to discuss possible design and construction approaches to insure a high quality product is delivered in the field. If you have any questions or concerns, please feel free to contact us at any time. We value our relationship and the continued open dialogue.

Very truly yours,
Earth Engineering Consultants, Inc.

Reviewed by:

COLORADO REGISTERED WOLFRAM VON CARLOWITZ 36746 PROFESSIONAL ENGINEER

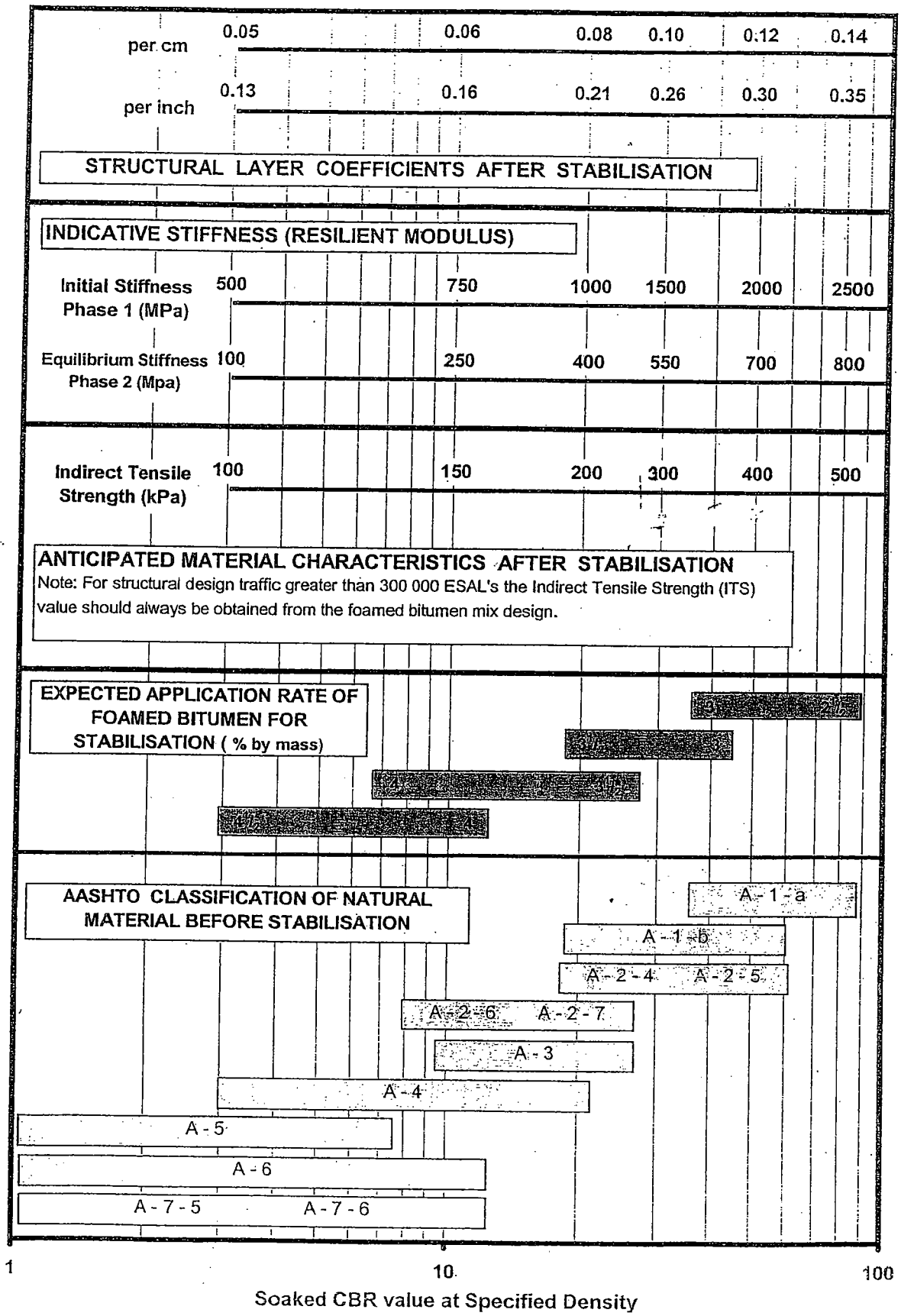
Wolfram von Carlowitz, P.E.
Senior Project Engineer

COLORADO REGISTERED LESTER L. LITTON 28957 PROFESSIONAL ENGINEER

Lester L. Litton, P.E.
Principal Engineer

cc: Michael Voth – FHWA
Richard Duval - FHWA

SUGGESTED STRUCTURAL LAYER COEFFICIENTS FOR FOAMED BITUMEN STABILISED MATERIAL



Notes

1. All materials classified as A - 4 or lower to be pretreated with hydrated lime
2. Cement at nominal 1% to be added to all materials with P <10 and CBR <45
3. Where required, non-plastic fine material to be added to increase the percentage passing the 0.075mm sieve to achieve a minimum of 5%.

ESTIMATION OF STRUCTURAL LAYER COEFFICIENTS

The method used to derive the structural coefficients was based on the comparison of two layered systems using the elastic layer method (ELSYM5 – Analysis of elastic layered systems under normal wheel loads) and Pavement Analysis Software (PAS5 based on the 1993 AASHTO - Guide for the Design of Pavement Structures).

The elastic layer method was used to simulate stresses, strains and deformations within a pavement comprising a foamed bitumen stabilised layer and subgrade support. The foamed bitumen stabilised layer was evaluated at various elastic (resilient) moduli values. The subgrade support was kept constant in all cases. The critical stresses and strains determined for each elastic modulus were then used to estimate the number of load applications to failure.

This information was then used as input in the AASHTO based design method, which utilises structural numbers. As with the elastic layer method, the subgrade support was maintained at the same constant condition. For each comparison, the thickness of the foamed bitumen stabilised layer was kept the same as that used in the elastic layer method. The structural number required with respect to the number of load applications to failure for each evaluation was determined. With the thickness of the foamed bitumen stabilised layer known and moderate drainage assumed, the structural coefficient was determined for each relevant elastic modulus.

The derivation of resilient modulus from ITS measurements is based on guidelines from the "GEMS – The design and use of granular emulsion mixes" Manual 14 issued by the South African Bitumen and Tar Association (SABITA) and testing carried out to date.

The foamed bitumen application rates are merely guidelines based on experience to date and should only be used for the purposes of estimation. The determination of the optimum foam bitumen content during construction is essential for optimisation of the material characteristics of the stabilised layer and related cost savings.

June 17, 2004

FHWA-CFLHD
12300 West Dakota Avenue
Suite 210
Lakewood, Colorado 80228-2683

Attn: Mr. Steve Deppmeier

Re: Supplementary Testing
Trail Ridge Road
CO PRA ROMO 10(4)
Estes Park, Colorado
EEC Project Number: 1044009

Mr. Deppmeier:

Earth Engineering Consultants, Inc. (EEC) personnel have completed the additional testing you requested for the above referenced project. A Wirtgen® WLB 10 foam laboratory was used for developing the additional mix design information. Results of the completed laboratory testing are included with this report.

Foaming Characteristics

In order to remain consistent with the mix designs completed for the referenced project submitted to your attention on March 1, 2004, a sample of AC-10 obtained from the Frontier Oil Refinery in Cheyenne, Wyoming was used in treating the delivered samples. Based on the results of a previously completed foam evaluation, 2.5% injection water was utilized at a temperature of 160°C.

Sampling and Sample Preparation

Samples of the asphaltic concrete surfacing and aggregate base from the proposed reconstruction area were delivered to our laboratory for use in developing the supplemental mix design information. As requested, a moisture content test was

CENTRE FOR ADVANCED TECHNOLOGY
2301 RESEARCH BOULEVARD, SUITE 104
FORT COLLINS, COLORADO 80526
(970) 224-1522 (FAX) 224-4564

completed on a sample of the delivered aggregate base. The moisture content of the base was measured at 3.7%. Samples of the asphalt pavement were softened by heating and broken down to obtain material representing recycled asphaltic concrete. The RAP and aggregate base materials were blended in proportion to the recommended layer thicknesses and assumed in-situ densities as outlined below in Table I.

TABLE I – Proportioning Summary

Section A

Material	Weight Per Square Meter (kg)	Per 10 kg Sample (g)
Asphaltic Concrete (100 mm @ 2403 kg/m^3)	240.3 kg (82.19%)	8219 g
Aggregate Base (25 mm @ 2083 kg/m^3)	52.1 kg (17.81%)	1781 g
Total Blend	292.4 kg	10,000 g

Two percent (2%) compaction moisture was added to the blend for section A prior to treatment with foamed bitumen. As requested, foamed bitumen was added to the proportioned blends for Section A at 2.5 and 3.0% based on the sample dry unit weight. For each of the bitumen addition percentages, 1.5% and 2% cement was added to the blend. The treated samples were then compacted into 4-inch diameter specimens using 75-blow Marshall compactive effort. The molded specimens were cured at 104°F for 3 days. The cured samples were tested for indirect tensile strength under treated and untreated conditions. Untreated conditions consist of allowing samples to remain at room temperature for 24 hours after curing. Treated conditions consist of soaking the samples in room temperature water for 24 hours after curing.

We appreciate the opportunity to work with you on this project. If you have any questions concerning the enclosed information, or if we can be of further service to you in any other way, please do not hesitate to contact us.

Very truly yours,
Earth Engineering Consultants, Inc.

Reviewed by:

COLORADO REGISTERED PROFESSIONAL ENGINEER WOLFRAM VON CARLOWITZ 36746

COLORADO REGISTERED PROFESSIONAL ENGINEER LESTER L. LITTON 23957

Wolfram von Carlowitz, P.E.
Senior Project Engineer

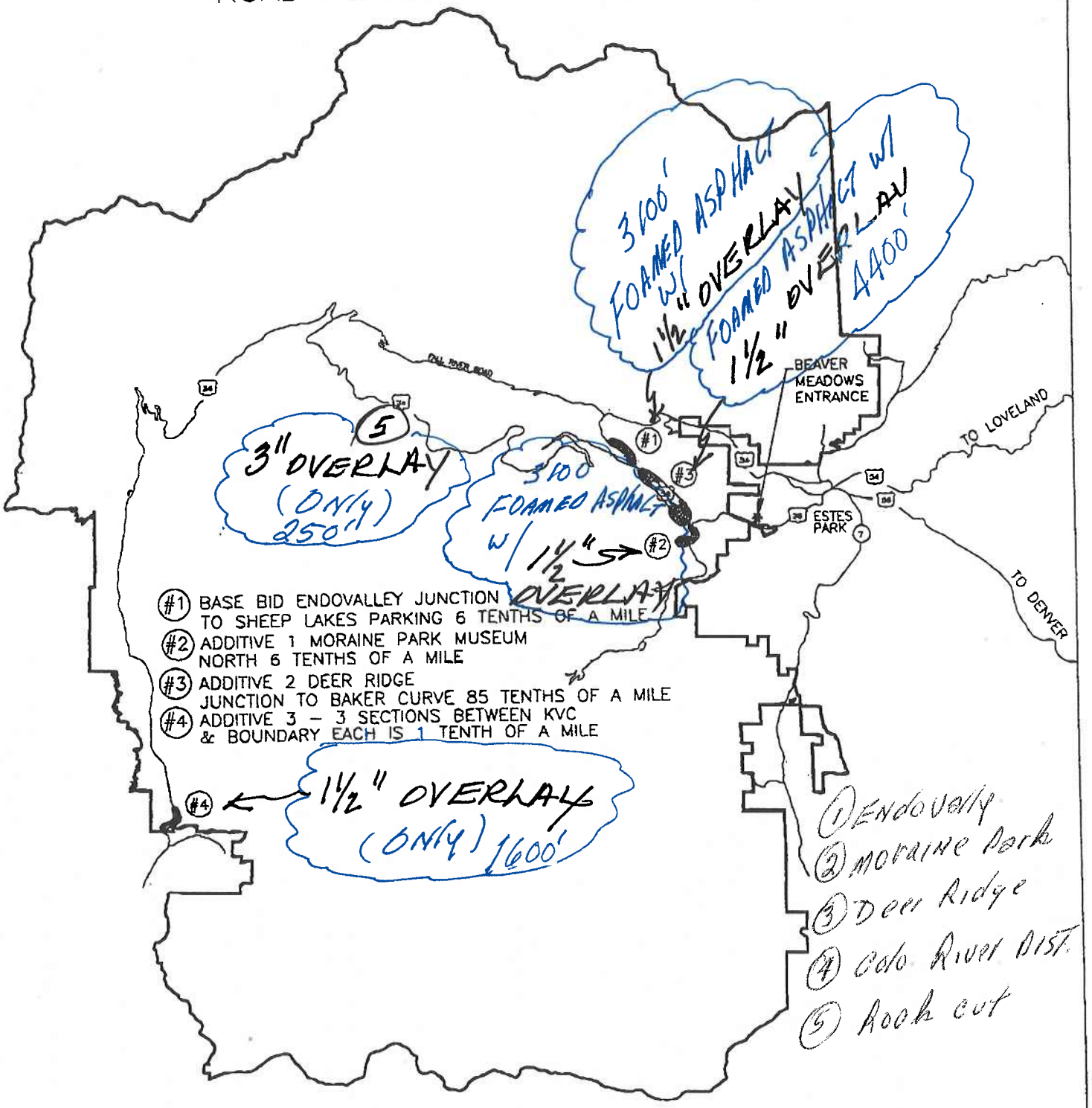
Lester L. Litton, P.E.
Principal Engineer

APPENDIX I

NPS FOAMED ASPHALT DATA

3039692605
2063

ROCKY MOUNTAIN NATIONAL PARK
ROAD REHABILITATION LOCATIONS



FACILITY MANAGEMENT SAFETY SLEUTH

"Safety comes first, each time, every time, all the time."

CONRAD KLEIN

Conrad was nominated for his efforts in wearing his safety vest while picking up roadside trash AND not taking it off until the end of his shift.

JESSE ASSMUSSEN

CRD trails awards Jesse for taking the lead on packing in hard hats for trail work on the North Inlet trail. This work involved the Continental Trail Alliance crew. According to the peers nominating Jesse, most of this crew intended to leave their hard hats in their backpacks until he spoke up, pulled his hard hat out of his pack and took the lead to ensure the rest of the crew followed his lead. He also gave safety talks how to prevent blisters from forming on hiker's feet by addressing proper footwear.

KELLY CONFER

Kelly was recognized for taking the initiative to bring up the need and to follow through to order earplugs, goggles and safety glasses. Also he is recognized for his willingness to tactfully bring up the needs in a morning meeting.

BRIAN SMITH

Brian was nominated for taking the initiative to come in on his day off to attend ergonomic and SAFE training with the Buildings crew.

BILL BROWN

Utilities (east) recognize Bill for his safety lectures to seasonal employees on "How to work in utility line ditches and work around heavy equipment".

Congratulations to all of you for being nominated by your peers for your acts in promoting safety.

Don't be surprised if sometime, somewhere, someone steps up to you and says "Smile, the Safety Sleuth recognizes your safe work ethics"

APPENDIX J

FROST HEAVE LOCATIONS

1985 Station	Nearest Landmark (in 1985 stationing)		Distance to Nearest Landmark	Nearest Landmark (in 2003 stationing)	2003 Station
57+80	Green Mountain TH	63+00	520 m	29+400	28+880
61+40	Green Mountain TH	63+00	160 m	29+400	29+240
85+50	Onahu Creek TH	73+00	-1250 m	30+300	31+550
89+00	Onahu Creek TH	73+00	-1600 m	30+300	31+900
129+60	Holzwarth Historic Site	140+80	1120 m	37+300	36+180
149+66	Holzwarth Historic Site	140+80	-886 m	37+300	38+186
169+90 to 171+20	Timber Lake TH	172+66	276 m to 146 m	40+300	40+024 to 40+154

Frost Heave Areas noted by Joe Arnold
24+200 to 24+420
30+390 to 30+470
30+580 to 30+630
31+860 to 31+920
34+020 to 34+080
37+180 to 37+260

Note:

1. Stationing shown is approximate.
2. It appears that there is only one current frost heave area that was also a subgrade failure in 1985 (this is the shaded frost heave area).

APPENDIX K

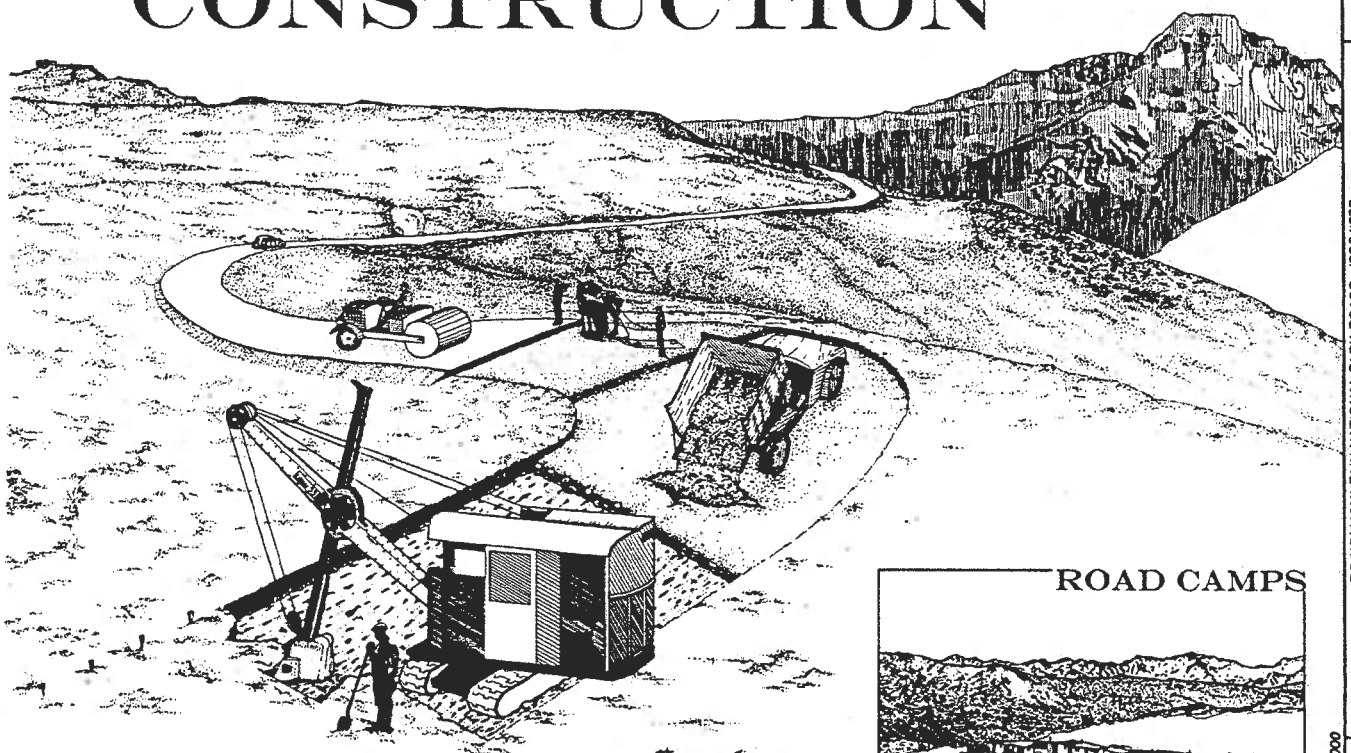
HISTORICAL MEMOS

HIGH-ALTITUDE CONSTRUCTION

More than eight miles of Trail Ridge Road lie at least 11,000' above sea level; three miles are above 12,000'. Above treeline, the road crosses an open tundra landscape underlain by perpetually frozen soil called permafrost usually only encountered north of the Arctic Circle. In contrast to the tortuous climb up from the valleys below, the high elevation sections were designed with easy slopes and gentle curves sweeping across the landscape, offering spectacular views down Forest Canyon and the Fall River Valley. Close at hand on either side are many of the highest peaks of the northern Rockies.

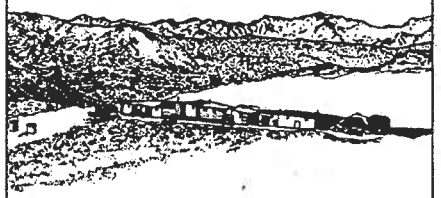
Construction of the road through this harsh and ecologically sensitive landscape presented challenges rarely encountered in traditional roadway construction. Construction crews working in this section were routinely confronted by harsh weather conditions. Road-obliterating landslides and heavy snowdrifts hampered the work. Violent electrical storms and hurricane-force winds often forced crews down the mountain. Freezing temperatures and blinding snowstorms could occur at any time, even in the summer months. Compounding these problems was the lack of oxygen at the higher altitudes, making the hard work even more difficult.

One of the greatest challenges was constructing the roadway across the alpine tundra and permafrost, an extremely delicate ecosystem that develops at a rate of about an inch every hundred years. Normal drills would not penetrate the frozen material, and special equipment had to be designed. The thinner areas could be stripped away like sod or melted by exposure, but where it was deep, disturbance had to be minimized. The deeper parts below the surface could not be allowed to melt, or the area would turn into a permanent quagmire. Here the upper sections were carefully removed, then a prepared roadbed was constructed on rock fill resting directly atop the frozen soil. The tundra sod that had been salvaged was then used to cover the roadbanks scarred during construction.



ROAD AND TUNDRA SECTION

ROAD CAMPS



To avoid further scarring the tundra, rolling road camps were located right on the road. This kept the crews close to the work sites and off the fragile vegetation.

DELINEATED BY: *Christopher A. Boldt, 2000*

NPS PARK ROADS RECORDING PROGRAM

ROCKY MOUNTAIN NATIONAL PARK ROADS - 1920/1932

LARIMER COUNTY COLORADO

ESTES PARK VICINITY

SHEET 3 OF 8

HISTORIC AMERICAN ENGINEERING RECORD CO-78

IF REPRODUCED, PLEASE CREDIT: HISTORIC AMERICAN ENGINEERING RECORD, NATIONAL PARK SERVICE, NAME OF DELINEATOR, DATE OF THE DRAWING

U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: Colorado-Rocky Mountain National Park 1-D(1)
Trail Ridge Road, Grand Lake-Phantom Valley

Date: June 8, 1982

From: Chief, Materials Division
Central Direct Federal Division

Reply to Attn. of: HFM (Folkman)

To: Mr. Robert Warren
HFP Chief, Preconstruction Division
Central Direct Federal Division
Denver, Colorado

On May 20, 1982 a review of the above project was made by Wayne Folkman of the Materials Division. The main purpose of this trip was to try and locate a borrow and aggregate source for the project, and to look at two areas for proposed retaining walls.

All known possible sources of borrow and aggregate were looked at in company with Ted Rex, NPS Maintenance Foreman, West Unit. At this time a source hasn't been obtained. We are presently working on some possible sources with the Forest Service and private owners. The possible source that was sampled in 1979 has been mostly depleted and does not have the quantity of material we need for the project; also the County is trying to close the pit.

We have made an agreement to sample a possible source belonging to R. W. Busse Excavating, which is located about one mile from the beginning of the project. He has agreed to let us sample the area but will not sell the quantities of material needed at the present time and will not sign an option. He has indicated that he would prefer to deal with the contractors.

We will continue to pursue this matter and will advise as to our progress.

Another item we would like to bring to your attention is the large amount of borrow your present design requires. When we conducted our materials investigation in August, 1978 the quantity of borrow needed was a maximum of 30,000 cubic yards and we were told that the project would probably be balanced. On May 23, 1979 we were told that the project would require 75,000 to 100,000 cubic yards of borrow. At the present design stage the requirements are 135,000 cubic yards.

When reviewing the project on May 20, 1982 it was noted that the present projected centerline follows the existing roadway to the left side (west) which amounts to filling throughout most of the project with only about 35,000 cubic yards of unclassified excavation.

It was noted that there are several swampy areas throughout the project. All of these were noted on the plans (copy attached) and will require subexcavation of from one to three feet before embankment can be placed.

In fact, this will increase the present planned borrow quantities considerably. Also, filling throughout the project, especially in wet areas, will increase the chance of roadway failures.

Since trees are growing up to the shoulder of the road throughout the project (in fact there are more and larger trees on the fill side), there would probably be less environmental impact by cutting. Consideration should be given to redesigning the project to balance the earthwork.

There are several rock walls about 4 feet high in existing cuts. These areas were reviewed and we feel that they could be taken out in all cases except the one at station 106. This cutslope is unstable and we recommend not cutting and installing the planned retaining wall. The retaining wall footing will be in a swampy area but appears to be underlain by clean, alluvial gravel. Subexcavation should be included to excavate any muck down to clean gravel estimated to be 2 to 6 feet. Footing elevations should be 4 to 6 feet below the bottom of the stream channel to prevent frost action and stream scour.

The planned retaining wall at station 84 does not appear to be necessary. The alignment could be shifted right to avoid the planned wall. This would also help to decrease borrow quantities.

During our original survey of August 1979 pavement recycling was not considered. In August 1981 additional pavement samples were taken for testing for consideration of recycling. This testing is being conducted now and results will be forwarded when complete. We do not feel that recycling will be economically justified for this project.

Since the existing grade and alignment will be changed considerably, the only way to use the existing 2 inches of pavement would be to pick up and haul to the contractor's hot plant. We cannot be sure where the contractor will have his hot plant located but it could be as far away as Granby and it would not be practical to haul the old pavement that far. Removing of the existing pavement may also cause additional problems with traffic control.

An error was noted in our report of March, 1979 on page 4 where we showed existing depths of pavement and road mix. This should be changed to pavement and base course. The average depth of pavement is 2-inches with an average of 4-inches of base course.

After reviewing the project this spring, and noting the considerable amount of water, we recommend that the proposed structural section be changed from our original recommendation (3 inches hot bituminous pavement and 4 inches crushed aggregate base) to the following:

2 inches - hot bituminous pavement
4 inches - crushed aggregate base
6 inches - subbase

An overlay of 1½ inches will probably be needed in the future. Adequate width should be provided to allow for a future overlay.

Joseph H. Clem

Attachments

FHWA 8-417
Rev. 7/19/73

U. S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration
Region 8, Denver, Colorado

DESIGN
FLEXIBLE PAVEMENT STRUCTURE

Project CO Rocky Mountain Nat'l Pk.1-D(1)6 Trail Ridge Road

Date June 7, 1982
By Wayne Folkman

Regional Factor

Precipitation 18 " = 1.0
Avg. Elevation 9000' = 1.0
Drainage poor = 1.0
Total R.F. 3.0

Traffic Factor

880 + 2200/2 x 0.6 = 924 Avg. V.P.D. one way, 20 yr. project.
924 x 0.01 = 9.24 18^k single axle loads/day.
(924 - 9) x .0002 = .18 Eq. 18^k single axle loads/day.
Total 9.42 Use 10

Soil Class	R Value	Soil Support Value G.I.	Soil Support Value R	Wt. Structural Number G.I.	Wt. Structural Number R	Inches G.I.	Subbase R
	60		7.73		1.59		

RECOMMENDED ULTIMATE DESIGN

Pavement Component	Structural Coef. Range	Depth	Cost Coef. Range	Coef. for CN	Coef. for SN	Cost No.	Structural Number
Seal Coat							
Plant Mix Surf (future)	.25 - .30	1½ "	4.00 - 6.00		.40		.60 future
Plant Mix Surf.	.35 - .45	2 "	3.75 - 5.75		.40		.80
Road Mix Surf.	.20 - .25		3.25 - 5.25				
Stab. Base P.M.	.25 - .30		3.50 - 5.50				
Stab. Base R.M.	.15 - .20		3.25 - 5.25				
Stab. Base, SS-1	.12 - .17		1.90 - 2.80				
Cement T-Base	.12 - .17		2.10 - 3.00				
Ca $(OH)_2$ T-Base	.12 - .17		2.10 - 3.00				
Crushed Agg. Base	.10 - .15	4"	1.10 - 2.00		.12		.48
Gravel Base	.07 - .12		1.10 - 2.00				
Subbase	.07 - .12	6"	1.00		.10		.60
Select Borrow	.05 - .10		0.5 - 1.00				

Total Depth 12"
Future 13½"

Total SN 1.88
Future 2.48

U.S. Department of Transportation
Federal Highway Administration

RECEIVED
JUN 30 '82
MAT'L. DIV. (HFM-16)

Memorandum

Subject: Rocky Mountain National Park 1-D(1)
(Your June 8, 1982 Memorandum)

Date: June 28, 1982

From: Chief, Preconstruction Division
Central Direct Federal Division
Denver, Colorado 80225

Reply to Attn. of: HFP-16

To: Mr. Joseph H. Clem
HFM-16 Chief, Materials Division
Central Direct Federal Division
Denver, Colorado

This is in reference to your memorandum of June 8, 1982, in which you discussed a series of materials related problems on the Rocky Mountain National Park project from Grand Lake to Phantom Valley.

We are aware of the borrow problem and the fact that material is difficult to find in the Grand Lake area particularly close to the National Park. At the next field design review we hope to pursuade the National Park Service to allow some alignment and design changes to reduce the large amount of borrow. At this time I am not too optimistic that we can reduce it below 100,000 cubic yards; however, we will try. The National Park Service has insisted since inception of the project that we minimize the impact on the existing cut slopes and that we leave the existing rock walls in place. As you know, this placed a very tight limitation on the number of design options.

Your recommendation that the structural section be changed comes at an inopertune time. Three years of design and location work have been based on your original recommendation. To change now could result in the following:

1. Considerable redesign including changing of centerline in the tight areas.

2. The probability that we would not have the project ready for advertising in early 1983 as promised.

3. An overrun in project cost. This office has previously prepared a cost estimate for the project which the National Park Service has used in Congressional hearings.

Therefore I have concluded that it is too late in the process to change the structural section.

Robert J. Warren

Robert J. Warren

Rocky Mountain National Park 1-D(1)
(Colorado) Trail Ridge Rd.
Grand Lake-Phantom Valley

July 21, 1982

Chief, Materials Division
Central Direct Federal Division

HFM (Folkman)

Mr. Bob Warren
HFP Chief, Preconstruction Division
Central Direct Federal Division
Denver, Colorado

This memorandum documents a July 9 meeting held in response to your June 28 memo concerning our request that the structural section originally recommended for the subject project be increased. We agree that the recommendation to increase the structural section was untimely and can understand your reluctance to change the design. However, we do feel that because of the adverse conditions (heavy snow, flat grades and shallow ditches) encountered at the project site that, as a minimum, the base course thickness should be increased to 6 inches. Wayne Folkman discussed this recommendation with you on July 9, 1982 and it is our understanding that you concur.

Joseph H. Clemens

gc: Circ
yc: File
wc: Subject/Reading HFM
WFOLKMAN/JCLEM:mj:7/21/82

J. L. Buckley

SEP 9 1982

D30 (DSC-TMW)

Memorandum

To: Assistant Manager, Midwest/Rocky Mountain Team, DSC

From: Federal Highway Administration Coordinator, Midwest/Rocky Mountain Team, DSC

Reference: Rocky Mountain National Park, Package No. 106, West Unit, Trail Ridge Road - Grand Lake to Phantom Valley, P.T. 07

Subject: Trip Report - August 23, 1982

PURPOSE

The purpose of the field inspection was to review two proposed horizontal alignment changes at Kawauneechee Curve (Sta. 81+00 to 84+00) and at Deadman's Curve (Sta. 105+00 to 107+00). The typical road cross-section, and road widening by cut vs. fill and material sources were to be determined.

DISCUSSION & FINDINGS

Those present for the discussion/inspection were:

Chester Brooks, Superintendent, ROMO
Jim Godbolt, Assistant Superintendent, ROMO
Larry Reed, West Unit Manager, ROMO
Ron Cotten, Chief, Division of Maintenance, ROMO
Ed Menning, Resource Management Specialist, ROMO
Don McLane, Chief, Branch of Roads & Trails, RMR
Joe Clem, Chief, Materials Division, FHWA
Wayne Folkman, Field Exploration Supervisor, Materials Div., FHWA
Larry Sellon, Construction Operations Engineer, Construction Div., FHWA
Walter Langlitz, Area Design Engineer, Preconstruction Div., FHWA
John Ronscavage, Chief, Landscape Architect, Midwest/Rocky Mountain Team, DSC
Jim Ellis, Geotechnical Engineer, Transportation Br., DSC
Christine Turk, Ecologist/Compliance Specialist, Midwest/Rocky Mountain Team, DSC
Leon Clifford, FHWA Coordinator, Midwest/Rocky Mountain Team, DSC

The field trip began with a discussion at the West Unit Headquarters followed by a field review. The following decisions were made and agreements reached:

An "urban" typical cross-section was chosen due to less site disturbance during construction and ease of ditch maintenance (see enclosure). Full depth base (6") and pavement (3") will be utilized throughout. Slotted inlets will be used in the paved ditch section where appropriate.

The Park agreed to the use of an existing borrow pit located approximately 1/4 mile left of Sta. 4 1+13. In the opinion of the FHWA Material Division representatives, this pit would serve their needs for all base and bituminous aggregate necessary for project construction. Permission was also given by the Park for the contractor to set up a batch plant and crusher at this location. This pit can also be used for surfacing material for other road projects on the west side of Trail Ridge Road. The FHWA will conduct additional materials investigations of the existing pit and will map the area for preparation of a reclamation plan to be prepared by DSC. The plan will reshape existing slopes and cleanup existing debris for total site rehabilitation. The pit is to be regraded, seeded and planted. The NPS will prepare the environmental documentation necessary to clear the use of the pit.

The alternate alignments for Kawauneechee Curve were reviewed (Sta. 74+00 to 87+00). It was agreed that alternate F-2 was acceptable. This line cuts into the rock knob at Sta. 84+00 and eliminates the need and cost of a retaining wall at this location. Rock slopes can be graded at 1/4:1 to 1/2:1 and are to be left rough and irregular. The intention is to provide pockets or seams in the rock, topsoil the pockets, and encourage vegetation to re-establish itself in the slope, thus detracting from the cut. Should drilling and blasting be necessary for rock slope construction, drill marks should be obliterated. This alignment also permits extending the box culvert at Sta. 75+80 on the right side only. The existing stone masonry head wall is to be removed and placed on the new extension. During construction, the DSC representative will be available to help the project supervisor on all site matters. ?

The alternative alignments at Deadman's Curve were also reviewed (Sta. 101+00 to 108+00). It was agreed that the FHWA should restudy the F-2 alignment at this curve due to the extensive cut at Sta. 105+00. The FHWA will restudy the section using 35, 40 and 45 mph alignments and the following criterias:

a) The river at Sta. 105+90L would be used as a control but avoided entirely.

b) The ponded water between Sta. 106+00 and 107+00L could be encroached upon. A rock fill will be constructed to an elevation above high water level and the horse trail benched into the fill slope. Rock from the excavation at Sta. 84+00 will be used in this fill.

c) Preserve as much as possible of the existing masonry retaining wall on the right side, however, it should not be a limiting factor.

d) Minimize environmental impacts in the area.

Road widening by filling versus widening by balancing cut/fill was discussed. The original concept of obtaining the required road width by filling and minimizing cuts is still the objective. This objective can now be accomplished much more economically by use of the borrow source discussed above. There are some areas where cutting is preferable to preserve existing tree screens or to permit better sight distance or alignment.

Revegetation of all disturbed areas with native plant material is a primary concern. Native seed collection is recommended. This revegetation should be accomplished by the Day Labor portion of the project. Topsoil will be placed on all cut slopes of 1½:1 or flatter as a first priority. Fill slopes will receive topsoil if available. It appears that a minimum of 6 inches of topsoil is available within the project limits. Additional topsoil is available outside these limits. All topsoil will be stripped and stockpiled for later use in revegetation. Additional required topsoil can be imported if money is available. Disturbed slopes will be left rough following construction to encourage water collection and enhance revegetation efforts. Slope benching or serrating will not be used.

The following station by station comments and agreements were made by the inspection party:

Sta. 2+00 - the intersection of Columbine and Trail Ridge Road is acceptable. An acceleration lane to the west is not necessary.

Sta. 4+60 ± - move the snowplow turnaround to the west approximately 20 meters.

Sta. 17+20 - lay the slope back on the right to 2:1. Spread topsoil for good revegetation. The existing overhead power and telephone lines should be placed underground prior to project construction. This will be accomplished in the Day Labor portion of the project. DSC will coordinate the work and set aside funds for the Park.

Sta. 15+28 - an existing 1" conduit is located in the culvert pipe. Determine from the park what the conduit is for.

Sta. 21+00 to 22+00 - the FHWA Material Division will core the entrance station area to determine the existing surfacing depth. If adequate, only an overlay may be required. The curbing around the middle kiosk will be removed by the Park prior to construction. This will facilitate conversion of the kiosk to a portable structure for removal during snow plowing operations. Funds to be transferred to the Park for this work.

Sta. 26+50R - avoid cutting the backslope as much as possible.

Sta. 32+50L - move the Harbison Meadows parking area to the northwest approximately 100 meters and depress the grade if feasible.

Sta. 54+00 to 56+20R - avoid cutting as much as possible.

Sta. 58+75 to 62+15L - avoid filling to preserve the existing tree screen at the housing area.

Sta. 58+76 to 62+15R - lower grade and move into hill.

Sta. 62+25L - provide planted berm to provide buffer by Day Labor.

Sta. 62+50 to 63+50L - wet fill slope. Subexcavate and provide fill foundation.

St. 65+00 - lower grade to provide increased sight distance with cut on right.

Sta. 73+00R - it was agreed that the oversize vehicle parking for Onahu Creek Trailhead be shifted to the east 8-10 meters to preserve the tree buffer to the west.

Sta. 75+00 to 80+00 - Vista clearing.

Sta. 100+35 - the Jennings Bridge parking area shall be paved. The vault toilet shall be handicap accessible. The Park has requested that a representative of ROMO be present during construction of the handicap fishing trail.

Sta. 109+00L - revise the note on the drawing to obliterate the south access to the inholding off Trail Ridge Road. The south access is to remain and the north access obliterated due to poor sight distance at the intersection.

Sta. 138+00 - it was agreed that the parking area at Holzwarth Homestead should be restudied. Shift the parking toward the meadow approximately 5 to 7 meters and lower the grade. Adjust the entrance intersections as necessary to provide a grade not to exceed 8 percent. Additional clearing is no limitation. Provide turn lanes.

Sta. 140+00L - tree clearing was approved by the park to eliminate an excess of cut on the right side of the roadway.

Sta. 147+25 to 149+50 - widening through this section should be accomplished by slope excavation to avoid removal of the tree buffer on the fill side of the roadway.

Sta. 149+48 - the left turn lane and acceleration lane were approved at the intersection of Trail Ridge and Timber Creek Campground approach road.

Sta. 168+00 - replace the existing concrete box culvert with an adequate CMP. Salvage the masonry headwall and replace around the CMP.

Sta. 172+67R - provide a left turn lane to Timberlake Trailhead parking area.

Sta. 174+00L - a deceleration lane was approved for delineation to the West Picnic Access Road.

Sta. 175+00 to 177+00R - backslope shall be 11/2:1.

RECOMMENDATIONS

It was determined that the present scheduling for this project could still be kept which calls for a plan in hand inspection in October and a contract advertising date in May, 1983. It is still the intention of the FHWA to pre-show this contract this calendar year so that construction can begin as soon as possible following the contract award.

If funds do not permit construction of the entire roadway length, the Superintendent recommends that work at the park entrance is the highest priority.

Signed

Leon Clifford

Approved for Distribution:

(Sgd.) C. W. Blackstone SEP 9 1982

Chief, Branch of Design, Midwest/Rocky Mountain Team, DSC Date

cc:
Reg. Dir., Rocky Mountain Region
Supt., Rocky Mountain National Park
Mr. J.L. Budwig
Division Engineer
Central Direct Federal Division
P.O. Box 25246
Denver, CO 80225

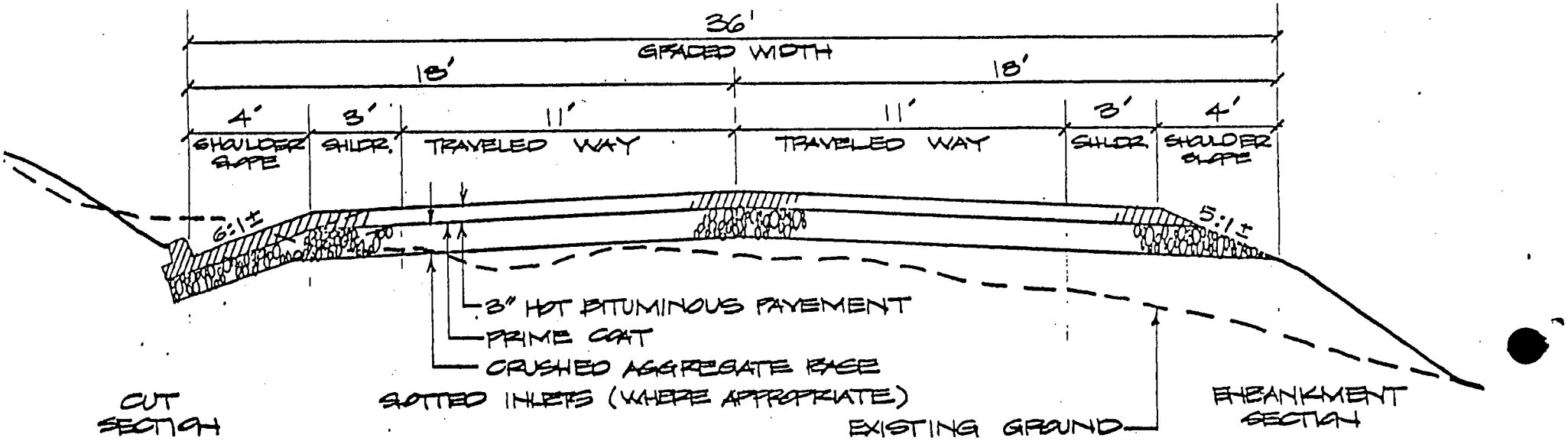
TYPICAL SECTION

ROCKY MOUNTAIN NATIONAL PARK

PACKAGE* 166

TRAIL RIDGE ROAD - WEST ENTRANCE TO PHANTOM VALLEY

AUGUST 1982



* NOTE: DIMENSIONS INDICATED CHANGED FROM METRIC TO ENGLISH

J. Clem
PROJECT FILE

United States Department of the Interior

NATIONAL PARK SERVICE
DENVER SERVICE CENTER
755 Parfet Street
P.O. Box 25287
Denver, Colorado 80225

IN REPLY REFER TO:

MAY 21 1985

D30 (DSC-TMW)

Mr. Jerry L. Budwig
Division Engineer
Central Direct Federal Division
Federal Highway Administration
P.O. Box 25246
Denver, Colorado 80225

MAY 23 '85

Dear ~~Mr. Budwig~~ JERRY:

Reference: Rocky Mountain National Park, Package No. 106, West Unit, Grade and Pave 10.6 Miles of Trail Ridge Road-Grand Lake to Phantom Valley, Type: 12

Subject: Road Deterioration and Surface Riding Quality

Recent field reviews by our staffs have substantiated the existence of four problems that have developed along portions of the referenced project. Those problems are longitudinal cracking, "alligator cracking", roadway patching due to wet subgrade and poor riding characteristics.

We request that your office make an independent evaluation of the causes of these problems and provide us with engineering alternatives to correct the cited problems. Those alternatives should reflect accompanying costs, reflect unfinished contract items and assess construction impacts to park visitors.

Upon receiving your written response, we would like to meet with members of your staff to discuss the corrective actions to be taken. We hope that work can commence promptly.

Sincerely,

John W. Bright FASLA
Assistant Manager
Midwest/Rocky Mountain Team

Materials

June 5, 1985

JUN 7 - '85

HFB-16

Mr. John W. Bright
Assistant Manager
Midwest/Rocky Mountain Team
Denver Service Center
National Park Service
PO Box 25287
Denver, Colorado 80225

Dear Mr. Bright:

Subject: Rocky Mountain National Park Project 1-C(1) & 1-D(1)
(Your Letter Dated May 21, 1985)

Your recent letter expressed concern over items your staff has identified as problem areas in need of corrective action. These included the longitudinal cracking that appears in the winter and spring of the year, the "alligator cracking", the roadway patching, and rideability. We are aware of what you have described and, as with other unfinished items of work in the contract, it is our intent to address these matters with the contractor and resolve them within the provisions of the contract prior to final acceptance.

We take this opportunity to assure or reassure you, as the case may be, that it is our intent to complete the project in accordance with the contract to everyone's satisfaction, to the extent available funding will permit.

As you are no doubt aware, when a project is designed and constructed to address Park values with a low profile grade line, the presence of a high water table and high surface runoff, particularly in the spring of the year, combines to create an unstable foundation condition. The summer of 1984 during the peak of construction activity was extremely wet in Rocky Mountain National Park. This combined with construction traffic and high visitor traffic volumes resulted in less than ideal construction conditions as all of us associated with the project will attest.

The "alligator cracking" and the patched areas are the result of constructing a facility under the adverse weather and traffic conditions described above. We prefer that it were otherwise but the options available to us at the time made our chosen course of action the most practical. The rough patches are the result of poor workmanship by the contractor and he/we have yet to decide how to best correct them so as to achieve acceptable riding quality following the application of the open-graded asphalt friction course. The

areas beneath these patches and beneath the "alligator cracking" were saturated in late 1984 but do not appear to be wet at this time. The pavement that has failed by cracking due to subgrade failure was all identified last year and will be removed and replaced at an estimated cost of about $6,000. We have observed these areas carefully this year after the water level has dropped and even though they have been subjected to numerous heavy but legal loads, no additional information has been noted. We plan no subsurface work in any of these areas unless we discover a need for some type of corrective work after the existing pavement has been removed.

Work is already underway to seal the longitudinal cracks prior to placing the open-graded asphalt friction course. These cracks are occurring in the winter and in the same location where they appeared in the old road and are caused by frost and freeze/thaw action. We attribute these to the presence of excessive moisture near the roadway surface in areas where the old roadway likely contains organic material. Ordinarily the presence of organic material in the subgrade is undesirable; however, in this instance the material is capable of providing the required structural support. While we agree the presence of these longitudinal cracks are undesirable, the roadway is stable and the cost to correct them far outweighs the maintenance effort required to seal them occasionally.

We are sealing these cracks with the asphalt-rubber joint sealing compound included in the contract under that bid item and related specifications. We might also add that the intent of the contract was to seal these same cracks in the old existing pavement prior to constructing the remainder of the roadway section but construction and visitor traffic caused the old surface to deteriorate making the crack sealing impractical. While we agree the presence of these cracks is aesthetically undesirable, we view it as impractical to reconstruct these areas unless the roadway profile is raised out of the water table. Neither funding nor adequate material is presently available to accomplish the work that would be required to hopefully eliminate the possibility of future cracking. We would discourage an undertaking of this magnitude and expense without some serious reconsideration of design philosophies in locations where excessive moisture is present and likely to jeopardize the integrity of the roadway.

If you have further questions about the action we are taking in these matters or would like to meet and discuss them further, please do not hesitate to contact us. We are available to meet with your staff next week.

Sincerely yours,

CHARLES R. HOUSER

Jerry L. Budwig
Division Engineer

cc: L. Sellon
E. Reusch
Materials
Reading File
yc: Pl File
gc: Circ LDSELLON:rc:6/5/85

TRAIL RIDGE ROAD
RMNP [illegible] 1-C(1) & 1-D(1)

Summary of Actions

1. Seal longitudinal cracks 1/4-inch and widen.
   Cost - $20,000 with contract items.

2. Remove and replace rough patches or blade smooth with Motor Patrol. Additional asphalt mix may be required to obtain acceptable rideability.
   Cost - $5,000 (To be shared by the Contractor.)

3. Overlay with 1 inch asphalt to obtain roadway smoothness in the following areas:

   Stations 57+80
   61+40
   85+50
   89+00
   129+60
   149+66

   This is a section of significant patching last season and is structurally stable and adequate.
   Cost - $40,000

4. Station 169+90 tO Station 171+20 remove area of alligator cracking, repair subgrade and base if necessary and repave with 3 inches asphalt.
   Cost - $6,000