Geotechnical Investigation and Pavement Design Report
Crosby Avenue Improvements
City of Grand Junction, Colorado
RockSol Project No. 599.81
July 14, 2023

Prepared for:

City of Grand Junction
Public Works Department
333 West Avenue, Building D
Grand Junction, Colorado 81501

Attention: William Comerer, PE, CFM, Project Engineer

Prepared by:

RockSol Consulting Group, Inc.
566 W Crete Circle, Unit 2
Grand Junction, Colorado 81505
(970) 822-4350

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ATTACHMENTS

1.0 PROJECT OBJECTIVE AND DESCRIPTION

This report documents the geotechnical engineering investigation and pavement design performed by RockSol Consulting Group, Inc. (RockSol) for the Crosby Avenue Improvements Project in the City of Grand Junction, Colorado (see Figure 1, *Project Site Location Map*).

Figure 1 – Project Site Location Map (Google Earth)

The proposed improvements to Crosby Avenue from Base Rock Road to Main Street include roadway widening with bike lane additions, a detached multi-modal path, upgraded storm sewer, piping of existing irrigation and street lighting, and sound walls to protect the El Poso neighborhood to the northwest of Crosby Avenue from traffic noise from West Gunnison Avenue to Broadway.

The geotechnical investigation was conducted by RockSol for the City of Grand Junction. The scope of work for this geotechnical investigation included:

- Preparing a drilling/sampling program to perform a subsurface investigation and implementing the program to collect soil samples for laboratory testing.
- Performing laboratory tests and analyzing the data.
- Preparing a report that presents subsurface conditions encountered, the results of the laboratory testing, pavement design recommendations, sound wall foundation recommendations, and earthwork/subgrade recommendations.

Surface and groundwater hydrology, hydraulic engineering, and environmental evaluation of site soils and groundwater for possible contaminant characterization were not included in RockSol's geotechnical scope of work.

Unless otherwise specified, all recommendations presented in this report are based on the Colorado Department of Transportation (CDOT) 2022 Standard Specifications for Road and Bridge Construction; the City of Grand Junction Standard Specifications for Road and Bridge Construction; and the City of Grand Junction Transportation Engineering Design Standards.

2.0 PROJECT SITE CONDITIONS

A combination of commercial and residential land borders the project limits to the north and east. The railway lines servicing Grand Junction border the project site to the southwest (See Figure 1). Currently, Crosby Avenue consists of one travel lane in each direction within the project limits. Crosby Avenue turns into Base Rock Road north of the intersection with West Gunnison Avenue where it consists of on travel lane in each direction with a center median lane at the north end of the project limits and a bike lane adjacent to the southbound travel lane. The existing lanes are approximately 11 feet wide south of West Gunnison Avenue and 12 feet wide north of West Gunnison Avenue and surfaced with asphalt pavement throughout the project vicinity.

Topography throughout the project limits of consist of nearly flat slopes with mild slopes falling to the southwest towards the Colorado River. A low spot has been noted near the business access on the northeast side of Crosby Avenue approximately 350 feet southeast of W Gunnison Avenue where water ponds during storm events. Drainage improvements to eliminate the ponding will be incorporated into this project.

3.0 GEOLOGICAL CONDITIONS

Based on information presented in the United States Geological Survey (USGS) Geologic Map (See Figure 2, *Site Geology Map*) of the Grand Junction Quadrangle, Mesa County, Colorado, by Roger B. Scott, Paul E. Carrara, William C. Hood, and Kyle E. Murray, dated 2002, the project site is predominantly underlain by alluvium deposited by the Colorado River (Holocene and latest Pleistocene) (Qalc2) north of Broadway. The project site is underlain by alluvium and colluvium (Qac) south of Broadway. Younger alluvium deposits (Qalc1) are mapped directly to the southeast of the project site. Alluvium generally consists of silt, sand, and gravel. The colluvium generally consists of sandy silt, silty to clayey sand, and sandy clay. Artificial fill associated with railroad construction and construction of the Broadway bridge over the Colorado River are mapped directly adjacent to and crossing the project site. The materials identified by the USGS mapping were consistent with native soils encountered during our geotechnical investigation. Mancos Shale bedrock (Km) is mapped at or near the surface to the west and southeast of the project site, however, no bedrock was encountered during this investigation.

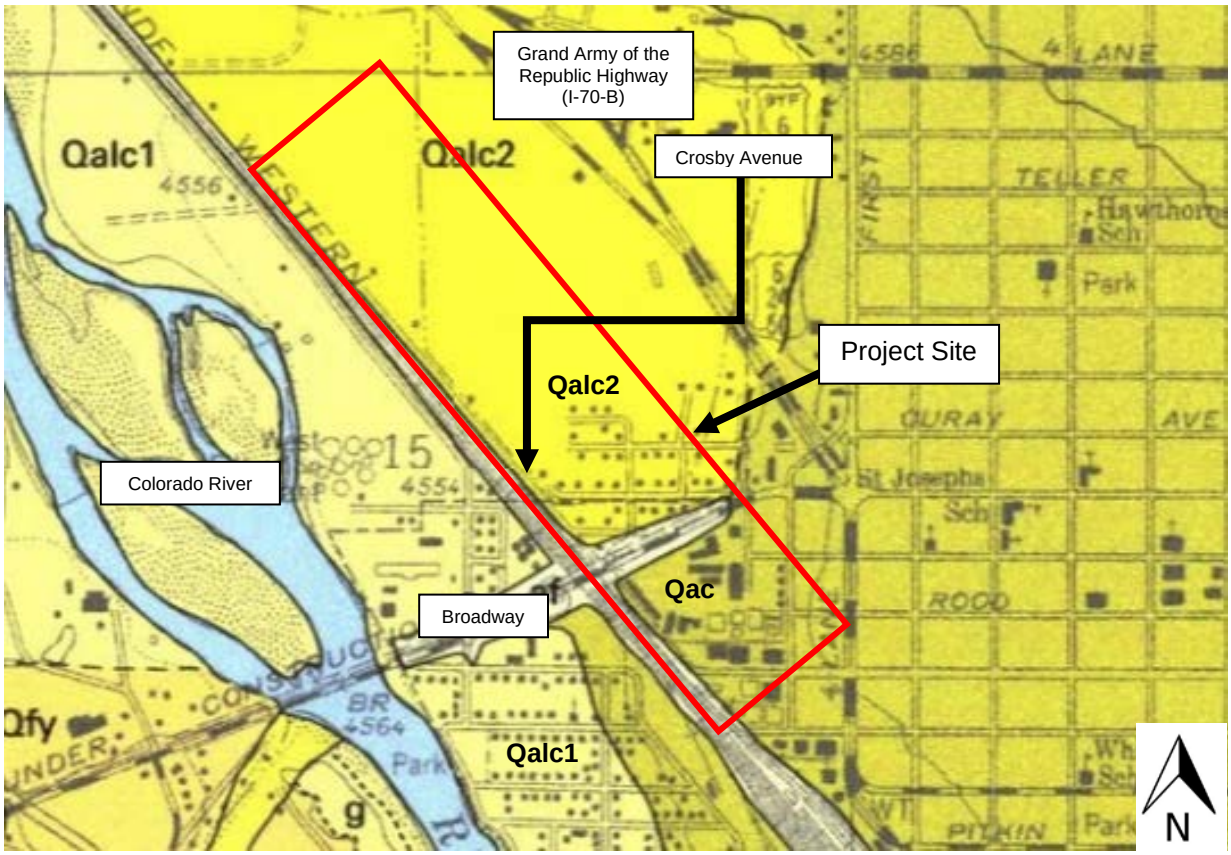


Figure 2 – Site Geology Map (Grand Junction, Mesa County, Colorado 2002)

4.0 SUBSURFACE EXPLORATION

For this investigation, RockSol completed a total of 8 boreholes identified as BH-1 through BH-8, shown in Figure 3 and Appendix A. All boreholes were drilled for the purpose of soil investigation for pavement design of the proposed roadway improvements and sound wall. Boreholes extended to an approximate depth of 10 to 15.5 feet below existing grade.

The locations of the geotechnical investigation boreholes are summarized below in Table 1 and shown in Figure 3 – Borehole Location Plan. The boreholes were drilled on May 30, 2023.

Table 1 – Borehole Location Summary

Borehole ID	Borehole Location
BH-1	Crosby Avenue, ~300' S of American Way
BH-2	Crosby Avenue, ~400' N of Gunnison Avenue
BH-3	NB Crosby Avenue, ~200' S of Gunnison Avenue
BH-4	Crosby Avenue, ~550' S of Gunnison Avenue
BH-5	~15' E of irrigation ditch E of Crosby Avenue
BH-6	Crosby Avenue, ~200' NW of Broadway
BH-7	NB Crosby Avenue, ~100' S of Broadway
BH-8	SB Crosby Avenue, ~200' N of Main Street

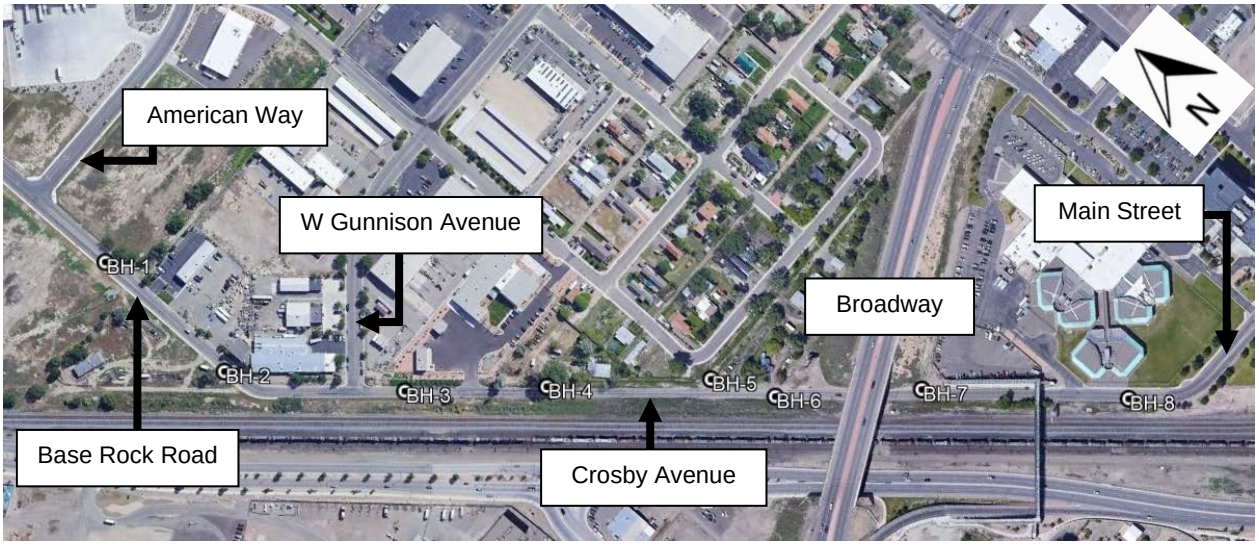


Figure 3 – Borehole Location Plan (Google Earth)

The boreholes were advanced with a truck mounted Simco 2800 drill rig using 4.25-inch outside diameter solid stem auger. The boreholes were logged in the field by a representative of RockSol with the depth to groundwater, if encountered, noted at the time of drilling. Borehole BH-5 was covered but left open to monitor groundwater levels. A temporary piezometer was installed at Borehole BH-7 to monitor groundwater levels. All other boreholes were backfilled at the completion of drilling and groundwater level checks and patched with surface asphalt patch mix when drilled within existing pavement.

Subsurface materials were sampled and resistance of the soil to penetration of the sampler was performed using modified California barrel and standard split spoon samplers. Penetration Tests were performed using an automatic lift system with a hammer weighing 140 pounds falling 30 inches. The modified California barrel sampler has an outside diameter of approximately 2.5 inches and an inside diameter of 2 inches. The standard split spoon sampler used had an outside diameter of 2 inches and an inside diameter of 1⅜-inches. Brass tube liners were used with the modified California barrel sampler. Brass tube liners are not used with the standard split spoon sampler. The standard split spoon sampling method is the Standard Penetration Test (SPT) described by ASTM Method D-1586. The modified California Barrel sampling method is similar to the SPT test with the difference being the sampler dimensions and the number of 6-inch intervals driven with the hammer per ASTM D3550. It is RockSol's experience that blow counts obtained with the modified California sampler tend to be slightly greater than a standard split spoon sampler. Soils were logged in the field per ASTM D2488.

Penetration resistance values (blow counts) were recorded for each sampling event. Blow counts, when properly evaluated, indicate the relative density or consistency of the soils. Depths at which the samples were taken, the type of sampler used, and the blow counts that were obtained are shown on the Borehole Logs (See Appendix B).

5.0 SURFACE AND SUBSURFACE CONDITIONS

The surface and subsurface materials encountered by RockSol at our borehole locations included asphaltic pavement, fill soils, and native soils. A brief description of the materials encountered is presented below.

5.1 Existing Asphalt Pavement Sections

Asphalt pavement was encountered in Boreholes BH-1, BH-2, BH-3, BH-6, and BH-8 and in the pavement core adjacent to BH-4. Asphalt pavement ranged in thickness from 2 to 5 inches and was underlain by 13 - 21 inches of a granular fill material. The granular fill material was likely placed during construction as a road base. A summary of existing pavement section thickness encountered at each borehole location is presented in Table 2. Existing pavement section thicknesses are also shown on the individual borehole logs found in Appendix B. Pavement cores were taken at or near Boreholes BH-1, BH-2, BH-3, BH-4, BH-6, and BH-8. The pavement core log report can be found in Appendix D.

Table 2 – Existing Pavement Sections

Borehole ID	HMA Pavement Thickness (in)	Granular Fill Material Thickness (in)
BH-1	5.5	13.0
BH-2	5.5	13.0
BH-3	3.0	21.0
BH-4 (Note 1)	3.0	--
BH-6	1.8	16.0
BH-8	4.5	13.0

HMA = Hot Mix Asphalt
Note 1: Borehole BH-4 was drilled off-shoulder, a pavement core was obtained in the adjacent drive lane. The material below the pavement core was not measured.

A visual pavement distress evaluation was performed by RockSol on June 27, 2023. The visual evaluation found severe fatigue cracking as shown in Figure 4 along with severe lane/shoulder separation with low to moderate transverse and block cracking throughout project limits. The pavement evaluation can be found in Appendix E.

Figure 4 – Severe Fatigue Cracking Distress on Crosby Avenue

5.2 Native Subgrade Soils

Native soils were encountered below existing pavement and subbase materials and extended to maximum depths drilled at all borehole locations. Native soils encountered generally consisted of very soft to very stiff, slightly moist to wet, brown, sandy to silty clay and very loose to very dense, moist to wet, silty to gravelly sand. The native soils encountered by RockSol are generally consistent with the alluvium and colluvium materials identified on the USGS Geological Map (See Figure 3*)* found in Section 3.0 of this report. Please review the individual logs in Appendix B for specific soil descriptions at each borehole location.

5.3 Sedimentary Bedrock

Sedimentary Bedrock was not encountered to the total depths drilled during drilling operations.

5.4 Groundwater

Groundwater was encountered during drilling/sampling activities at all boreholes except BH-8 at approximate depths ranging from 3 feet to 8.4 feet below existing grades at the time of drilling operations. A temporary piezometer was installed at borehole BH-7 and Borehole BH-5 was left open temporarily to monitor short term groundwater fluctuation. A summary of short-term ground water levels can be found in Table 3. Depth to groundwater where encountered is presented on individual borehole logs in Appendix B.

Table 3 – Short-Term Groundwater Monitoring Summary (BH-5 and BH-7 Only)

Date Sampled	BH-5 Depth to Groundwater (ft)	BH-5 Groundwater Elevation (ft)	BH-7 Depth to Groundwater (ft)	BH-7 Groundwater Elevation (ft)
5/30/2023	5.8	4,549.4	7.4	4,551.2
5/31/2023	5.0	4,550.2	6.7	4,551.9
6/01/2023	5.0	4,550.2	6.7	4,551.9
6/12/2023	5.0	4,550.2	6.6	4,552.0
6/23/2023	5.1	4,550.1	6.5	4,552.1

Depth to groundwater is subject to change depending on climatic conditions, water flows in the Colorado River or nearby drainage channels, local irrigation practices, changes in local topography, and changes in surface storm water management. Long-term monitoring of groundwater elevations is required to establish groundwater fluctuations.

6.0 LABORATORY TESTING

Soil samples retrieved from the borehole locations were examined by the project geotechnical engineer in the RockSol laboratory. Selected samples were tested and classified per American Association of State Highway and Transportation Officials (AASHTO) and Unified Soil Classification System (USCS) methods. The following laboratory tests were performed in accordance with the American Society for Testing and Materials (ASTM), American Association of State Highway and Transportation Officials (AASHTO), and current local practices:

- Percent Passing No. 200 Sieve (ASTM D1140)
- Liquid and Plastic Limits (AASHTO T-89/T-90)
- Gradation (ASTM D6913)
- Water-Soluble Sulfates (CDOT CP-L 2103)

- Soil Classification (AASHTO M-145, ASTM D2487)
- Swell Test (Denver Swell Test, modified from ASTM D-4546)
- Resistance Value (AASHTO T-190)

R-Values (Resistance Values) were tested by CMT Technical Services. All other laboratory tests were performed by RockSol. Laboratory test results are presented in Appendix C and are also summarized on the Borehole Logs presented in Appendix B.

7.0 SUBGRADE CHARACTERIZATION

Laboratory test results were used to characterize the engineering properties of the subsurface material encountered. For soil classification, RockSol conducted sieve analyses and Atterberg Limits tests. Lab testing was also performed on selected samples to determine the water-soluble sulfate content of subsurface materials to assist with cement type recommendations. A summary of physical and chemical test results is included in Appendix C.

7.1 Roadway Subgrade Soil Classification

Subgrade bulk samples of existing roadway grades were obtained at various depths from each pavement borehole location and were tested for AASHTO soil classification. The native subgrade soils tested were classified as A-1-a through A-6 AASHTO soil types. The tested granular fill soils classified as A-1-b AASHTO soil types. A summary of the roadway subgrade soil classifications is presented in Table 4.

Table 4 – Roadway Subgrade Soil Classifications

Borehole Location	Depth (feet)	AASHTO Classification
BH-1	1.5 - 4	A-4 (0)
BH-1	4 – 10	A-2-4 (0)
BH-2	4 – 9	A-1-b (0)
BH-2	9	A-1-a (0)
BH-3	4	A-1-a (0)
BH-3	7 – 9	A-1-b (0)
BH-3	9	A-1-b (0)
BH-4	0.67 – 2	A-4 (0)
BH-4	2 – 4	A-4 (0)
BH-4	4 – 9	A-4 (0)
BH-5	9	A-1-b (0)
BH-6	0.17	A-1-b (0)
BH-6	5 – 9	A-4 (0)
BH-6	9	A-1-a (0)
BH-7	3 – 9	A-4 (3)
BH-8	0.38	A-1-b (0)
BH-8	1.46 – 9	A-6 (8)

7.2 Water-Soluble Sulfate Content

Cementitious material requirements for concrete in contact with soils or groundwater are based on the percentage of water-soluble sulfate. Mix design requirements for concrete exposed to water-soluble sulfates in soils or water is considered by the Colorado Department of Transportation (CDOT) as shown in Table 5 and in the 2022 CDOT Standard Specifications for Road and Bridge Construction. Water-soluble Sulfate Testing Results are summarized in Table 6.

Table 5 – Requirements to Protect Against Damage to Concrete by Sulfate Attack from External Sources of Sulfate

Water-Soluble Sulfate (SO_4) in dry soil, percent	Water-Soluble Sulfate (SO_4) in water, ppm	Cementitious Material Requirements
0.00 to 0.10	0 to 150	Class 0
0.11 to 0.20	151 to 1,500	Class 1
0.21 to 2.0	1,501 to 10,000	Class 2
2.01 or greater	10,001 or greater	Class 3

Table 6 – Water-Soluble Sulfate Testing Summary

Borehole I.D.	Sample Depth (Feet)	Water-Soluble Sulfate (SO_4) in dry soil, percent	Cementitious Material Requirements
BH-1	1.5 – 4	0.18	Class 1
BH-4	2 – 4	0.08	Class 0
BH-5	5	0.14	Class 1
BH-7	3 – 9	0.27	Class 2

The concentration of water-soluble sulfates measured in soil samples obtained from RockSol's exploratory boreholes ranged from 0.08 percent to 0.27 percent by weight (See Appendices B and C). Based on the results of the water-soluble sulfate testing, Exposure Class 2 may be considered for concrete in contact with subgrade materials along Crosby Avenue. Refer to CDOT's current Specifications in Section 601 for concrete mixtures that satisfy appropriate sulfate exposure Class 2 requirements.

7.3 Subgrade Support Test Results (R-Value)

To test the subgrade support characteristics of soils representative of the project site, two R-Value laboratory tests were performed on bulk samples obtained from Borehole BH-1 from a depth of 4 to 9 feet below existing grade and at Borehole BH-7 from a depth of 3 to 9 feet below existing grade. R-Value test results of 42 and 32 were obtained from these samples, respectively. The Colorado Department of Transportation (CDOT) Pavement Design Manual equation 4-1 was used to determine the resilient modulus of 9,621 psi and 8,927 psi, respectively. Due to potential variations in subsurface soil conditions, RockSol used an R-Value of 20 for pavement design purposes.

7.4 Expansive Soils Discussion

Based on the field and laboratory test data, the subgrade soils encountered within 4 feet of the surface exhibit low swell potential (0.4 percent under 200 pounds per square foot (psf) surcharge pressure) with low consolidation/settlement potential (-0.2 percent under 200-psf surcharge pressure). Based on the test results and soil classifications, special requirements to mitigate expansive soils are not required for this project.

8.0 PAVEMENT DESIGN RECOMMENDATIONS

Crosby Avenue and Base Rock Road are classified as major collectors by the City of Grand Junction. The roadway classifications for this project were found on the website for the City of Grand Junction's Transportation Map as shown in Figure 5.

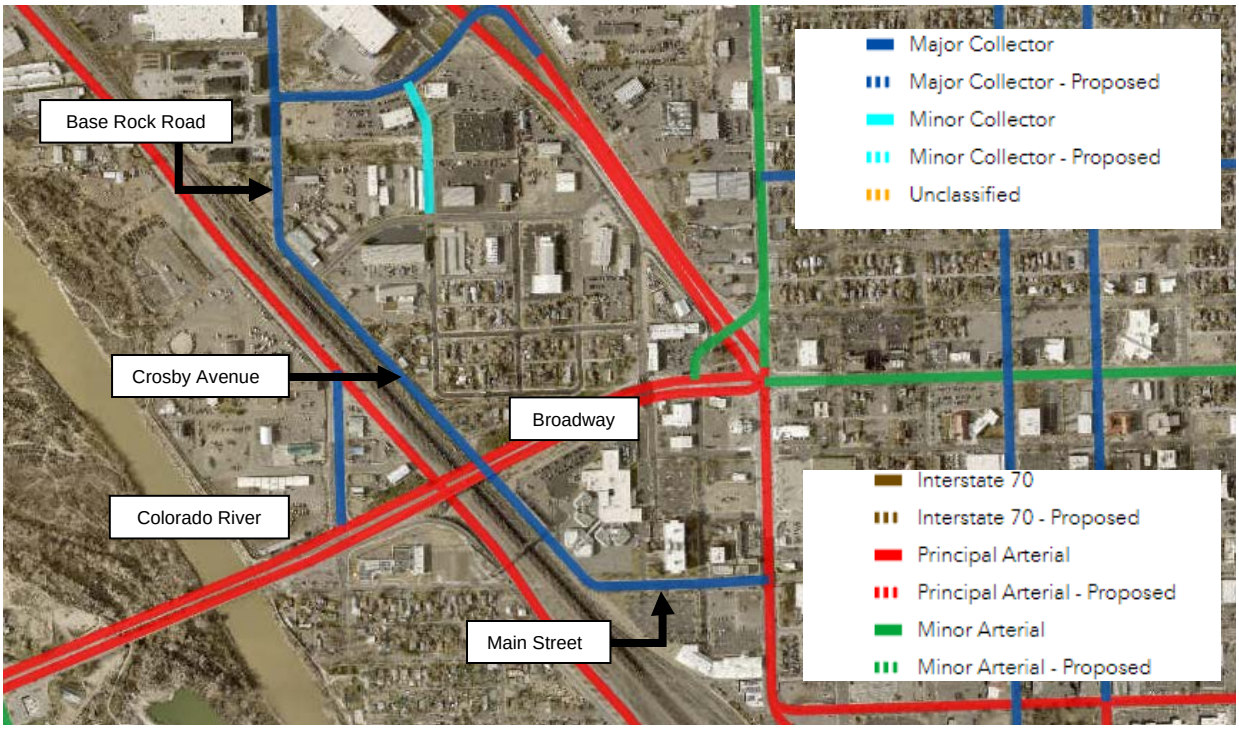


Figure 5 – Roadway Classifications (City of Grand Junction Transportation Map)

Based on the severity and amount of fatigue cracking in Crosby Avenue, full reconstruction is recommended by RockSol. In this report Hot Mix Asphalt (HMA) pavement is identified as flexible pavement. Portland Cement Concrete (PCC) pavement is identified as rigid pavement.

Pavement thickness evaluation for the development of flexible and rigid pavement design recommendations within the City of Grand Junction right of way were performed in accordance with CDOT's 2021 M-E Pavement Design Manual as modified in 2022 which uses Version 2.3.1 of AASHTO's Pavement Mechanistic-Empirical Design (PMED) software, *Subsection 29.32 – Pavements and Truck Routes* in the City of Grand Junction Municipal Code as passed in Ordinance 5136 on March 15, 2023, and a spreadsheet developed by RockSol to replicate the 1993 AASHTO flexible pavement design as recommended in 29.32.040(a).

8.1 Traffic Loading

Traffic loading was estimated for a 20 and 30-year flexible pavement design life and 30-year rigid pavement design life in accordance with the City of Grand Junction Municipal Code (Subsection 29.32.030). The 20-year design life is consistent with CDOT's Pavement Design Manual for reconstruction projects. The average daily traffic (ADT) was taken from current data supplied by the City's Transportation Engineer and the City of Grand Junction's Transportation Map (Traffic Counts). Based on discussions with the City's Transportation Engineer, it was decided to use the highest traffic count in the pavement designs with a compound growth rate of 2.0 percent.

RockSol was supplied traffic data dated July 12, 2021, from Grand Junction staff indicating the average daily traffic (ADT) was 2,558 and shown in Appendix F. RockSol compared the ADT in 2021, to the ADT from nearest traffic station on Base Rock Road North of Crosby Avenue (Station ID 3944). The ADT from the Base Rock Road North of Crosby ranged from a low of 3,917 in 2011 to a high of 4,307 in 2019. Using the highest ADT of 4,307 in 2019 and the

compound growth rate of 2 percent, the 2024 ADT used for the pavement design for Crosby Avenue is 4,755.

The Average Annual Daily Truck Traffic (AADTT) has a significant effect on the predicted pavement performance as compared to cars and pick-up trucks. For this project, predominately Class 5 vehicles when using the Federal Highway vehicle type classification system were noted in the 2019 and 2021 data. From the supplied traffic data, an average of 14 percent truck traffic will be used to determine the AADTT for this project. Therefore, the 2024 AADTT to be used for this project is 670. The calculated 20-year 18,000-pound equivalent single axle loads (18k ESAL's) derived from the PMED software were 2,070,000 and the 30-year 18k ESALs were 3,450,000 for the flexible design. The 18k ESAL's were 4,460,000 for the 30-year design life of rigid pavement. Based on CDOT's Pavement Design Manual, Cluster 1 truck percentages will be used to model the truck traffic in the PMED software.

8.2 Pavement Subgrade Characterization

Based on R-Value testing, a conservative R-Value of 20 with a corresponding subgrade resilient modulus value of 7,844 psi was used by RockSol as the design R-value for evaluation of new pavement constructed on the existing soils for this project.

To provide an appropriate structural layer for Hot Mix Asphalt (HMA), RockSol recommends 8 inches of a subbase layer of non-stabilized CDOT Class 2 Aggregate Base Course (ABC) material be included as part of the pavement design section in addition to 8 inches of CDOT Class 6 ABC directly underlying the pavement. A structural coefficient of 0.12 was used for Class 6 Aggregate Base Course (ABC), 0.11 for Class 2 ABC, and 0.44 for HMA. The Class 2 material must have an R-Value of at least 40 and the Class 6 material must have an R-Value of at least 78 when tested in accordance with AASHTO T 190. Class 1 ABC may be used instead of Class 2 ABC as road base. Class 1 ABC will have the same structural coefficient and R-Value requirements as the Class 2 ABC.

8.3 Pavement Section Recommendations,

Three pavement thickness design procedures were used for the design of new flexible and rigid pavements. The first procedure used for flexible and rigid pavement design was performed in accordance with the 2021 Colorado Department of Transportation M-E Pavement Design Manual as modified in 2022 and the PMED software, Version 2.3.1. The second procedure used a spreadsheet developed by RockSol to replicate the 1993 AASHTO flexible pavement design since the AASHTOWare DARWin version 3.1 Pavement Design and Analysis System recommended in subsection 29.32.040 (a) of the City of Grand Junction Transportation Engineering Design Standards is no longer available. The third procedure used the 1998 version of the AASHTO Guide for the Design of Pavement Structures in accordance with subsection 29.32.040 (b) of the City of Grand Junction Transportation Engineering Design Standards.

8.3.1 Flexible ME-Pavement Design Recommendations

A summary of the PMED minimum pavement section thickness using a 20 and 30-year design life for flexible pavement is presented in Table 8 and the pavement design output sheets are included in Appendices F.

Table 8 – Flexible Pavement Section Minimum Thickness Recommendations (PMED)

Pavement Location	Material Type	20-Year Design Life Pavement Thickness (inches)	30-Year Design Life Pavement Thickness (inches)
Crosby Avenue	HMA SX(75) PG 64-22	2.0	2.0
	HMA S or SX(75) PG 64-22	2.5	3.0
	ABC Class 6	8.0	8.0
	ABC Class 2	8.0	8.0

HMA = Hot Mix Asphalt; ABC = Aggregate Base Course

8.3.2 Rigid ME-Pavement Design Recommendations

A summary of the PMED minimum pavement section thickness for the 30-year design life of rigid pavement is presented in Table 9 and the pavement design output sheets are included in Appendices G.

Table 9 – Rigid Pavement Section Minimum Thickness Recommendations (PMED)

Pavement Location	Material Type	Thickness (inches)
Crosby Avenue	PCC	9.0
	ABC Class 6	8.0

PCC = Portland Cement Concrete; ABC = Aggregate Base Course

8.3.3 AASHTO 1993 Flexible Pavement Design

A summary of the AASHTO 1993 minimum pavement section thickness for the 20 and 30-year design life of flexible pavement is presented in Table 10. The pavement design output sheets are included in Appendix I.

Table 10 – Flexible Pavement Section Minimum Thickness Recommendations (AASHTO 1993)

Pavement Location	Material Type	20-Year Design Life Pavement Thickness (inches)	30-Year Design Life Pavement Thickness (inches)
Crosby Avenue	HMA SX(75) PG 64-22	2.0	2.0
	HMA S or SX(75) PG 64-22	2.0	2.5
	ABC Class 6	8.0	8.0
	ABC Class 2	8.0	8.0

HMA = Hot Mix Asphalt; ABC = Aggregate Base Course

8.3.4 AASHTO 1998 Rigid Pavement Recommendations

A summary of the AASHTO 1998 minimum pavement section thickness for the 30-year design life of rigid pavement is presented in Table 11 and the pavement design output sheets are included in Appendix J.

Table 11 – Rigid Pavement Section Minimum Thickness Recommendations (AASHTO 1998)

Pavement Location	Material Type	Thickness (inches)
Crosby Avenue	PCC	8.5
	ABC Class 6	8.0

PCC = Portland Cement Concrete; ABC = Aggregate Base Course

8.4 RockSol Pavement Section Recommendations

After reviewing the various designs, the recommended typical section by RockSol for the reconstruction of Crosby Avenue is the PMED 20-year design life using 4.5 inches of HMA since the PMED software accounts for site specific variables that AASHTO 1993 does not account for and that the adjacent pavement consists of HMA. The 20-year design life is recommended since the top layer of most HMA pavements will require rehabilitation within 20 years after construction that should remove the top-down fatigue cracking along with other surface defects and there is no significant difference between the 20 and 30-year design lives for the predicted rutting, thermal cracking, and bottom-up fatigue cracking. The top 2 inches of HMA should be a CDOT Grading SX with 75 gyrations using a performance graded (PG) binder of 64-22. The lower layer should be a 2.5-inch-thick lift, using either a CDOT Grading S or SX with 75 gyrations and a PG 64-22. The top 8-inch layer of ABC should consist of material meeting CDOT Class 6 Aggregate Base Course and the bottom 8-inch layer of ABC should consist of material meeting CDOT Class 2 Aggregate Base Course per CDOT 703.03.

8.5 Subgrade Preparation (Prior to Pavement Construction)

Prior to construction of new pavements on subgrade soils, the underlying subgrade should be properly prepared by removal of all organic matter (topsoil), debris, loose material, and any deleterious material identified by the Project Engineer followed by scarification, moisture conditioning and re-compaction. The minimum depth of scarification, moisture conditioning and re-compaction in all cases shall be 6 inches. Based on the results of our field and laboratory tests, A-1-b and A-4 soils are anticipated to be encountered at existing pavement subgrade elevations within the project limits.

Materials classified as AASHTO A-1, A-2-4, A-2-5, and A-3 soils shall be compacted at plus or minus 2 percent of Optimum Moisture Content (OMC) and to at least 95 percent of maximum dry density determined in accordance with AASHTO T 180 as modified by CDOT CP 23. All other soil types shall be compacted to 95 percent of the maximum dry density determined in accordance with AASHTO T 99 as modified by CDOT CP 23. Soils with 35 percent fines or less shall be compacted at plus or minus 2 percent of OMC. Soils with greater than 35 percent fines shall be compacted at a moisture content equal to or above OMC to achieve stability of the compacted lift. Stability is defined as the absence of rutting or pumping as observed and documented by the Contractor's Process Control Representative and as approved by the Project Engineer. If the soils cannot be compacted and prove to be unstable at a moisture content equal to or above OMC, then the required moisture content for compaction may be reduced below OMC if approved by the Engineer.

Prior to pavement section construction, subgrade proof rolling with pneumatic tire equipment shall be performed using a minimum axle load of 18 kips per axle after specified subgrade compaction has been obtained. Areas found to be weak and those areas which exhibit soft spots, non-uniform deflection or excessive deflection as determined by the project engineer

shall be ripped, scarified, wetted, or dried if necessary, and re-compacted to the requirements for density and moisture. Complete coverage of the proof roller will be required.

Where areas of unstable subgrade soils remain after proof rolling, it is recommended that a maximum of 12 inches of the unstable material be removed and a woven geotextile material such as Solmax Mirafi® HP570 or similar product be placed along with 12 inches of a CDOT Class 3 ABC meeting the following requirements:

- Maximum Particle Dimension: 6-inches
- Minus 200 Screen Size: 20% max.
- Liquid Limit (LL): 35 max.

If the area remains unstable after proof rolling the Class 3 ABC, it is recommended that another layer a woven geotextile material such as Mirafi® HP570 or similar product be placed prior to placing the Class 2 ABC.

9.0 SOUND WALL DESIGN PARAMETERS

The proposed sound wall will be installed on the northeast border of Crosby Road and is intended to protect the El Poso neighborhood from traffic noise. Approximate extents of the proposed sound wall system can be found in Figure 6. Sound wall engineering properties were based on subsurface conditions encountered in Boreholes BH-4, BH-5, and BH-6. If the sound wall design requires heights greater than 6 feet above ground level, additional geotechnical investigation is recommended.

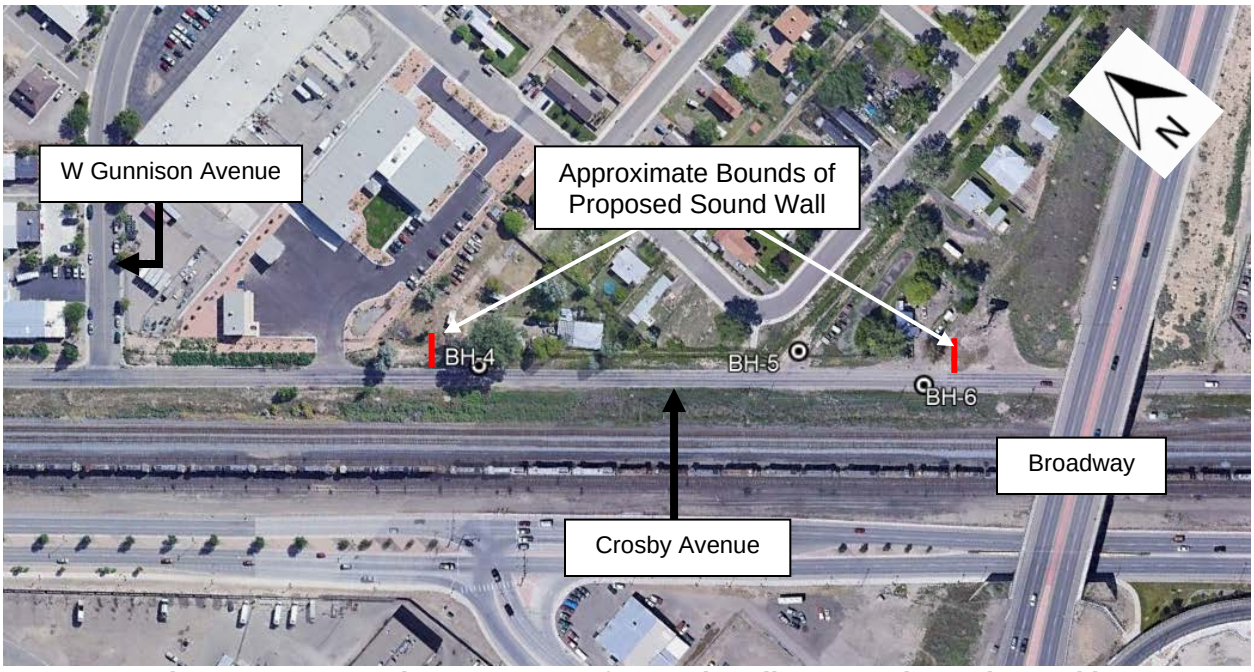


Figure 6 – Approximate Extent of Sound Wall System (Google Earth)

9.1 Surface and Subsurface Descriptions (BH-4 – BH-6)

Surface Material

Approximately 6 inches of sandy topsoil with moderate vegetation was encountered at the ground surface at Borehole BH-5. Borehole BH-4 had approximately 8 inches of gravelly sand driveway surfacing material. Borehole BH-6 was drilled in the roadway which was surfaced with approximately 2 inches of asphalt pavement.

Fill Soils

Fill soils were encountered in Borehole BH-6 directly below the asphalt pavement and consisted of a gravelly sand with clay granular fill, likely placed as a form of road base. Fill soils were not encountered in Boreholes BH-4 or BH-5.

Native Soils

Native soils extended to total depths drilled in each of the borings. The upper native soils consisted of medium stiff to stiff, moist to wet silty to sandy clay with gravel to an approximate average elevation of 4,549 feet. A layer of very loose to medium dense, wet, silty to clayey sand ranged from approximate elevation 4,545 feet to 4,549 feet. Dense, wet, gravelly sand and sandy gravel was encountered below the silty to clayey sand layer to total depths drilled.

Bedrock

Bedrock was not encountered in any of the boreholes to the maximum depths explored.

Groundwater

Groundwater was encountered in Boreholes BH-4, BH-5, and BH-6 at a depth of 3.0 feet (Elev. 4,550.2), 5.8 feet (Elev. 4,549.4), and 5.0 feet (Elev. 4,550.7) at the time of drilling, respectively. Short-term groundwater monitoring from the temporary piezometer installed at Borehole BH-5 indicated the groundwater in the piezometer stabilized at 5.1 feet below existing grade (Elev. 4,550.1).

9.2 Engineering Properties for Drilled Shaft Design

Drilled shafts (caissons) are the recommended foundation system for the proposed sound wall structure. Drilled shafts will provide support by embedment into overburden soils. Based on the subsurface conditions encountered, it is anticipated that dense granular soils will be encountered at an approximate elevation of 4,545 feet. RockSol recommends a minimum embedment of two times the design wall height.

Based on our evaluation, recommended nominal (unfactored) base resistance and nominal (unfactored) side resistance values for the overburden soils and bedrock material are presented in Table 13 for use with Load and Resistance Factor Design (LRFD) methods.

Table 13—LRFD Base and Side Resistance Values for Drilled Shafts

Material Type	Material Elevation (feet)	Ultimate (Nominal)		Service	
		Base (ksf)	Side (ksf)	Bearing (ksf)	Side (ksf)
Silty to Sandy CLAY	≥4,549	N/A	N/A	N/A	N/A
Very Loose to Dense Clayey SAND	4,545-4,549	N/A	0.6	N/A	0.25
Dense gravelly SAND	<4,545	10	1.0	4.0	0.4

The side resistance is applicable to the portion of the shaft embedded in overburden soil and bedrock. When evaluating the side resistance of the drilled shaft, the upper 5 feet of soil embedment should be ignored. For LRFD strength limit state evaluation, a resistance factor of 0.50 is recommended for base/ tip resistance and a resistance factor of 0.50 is recommended for side resistance evaluation for single shafts.

Drilled shaft diameters shall be sufficient to satisfy axial, bending, and lateral load resistance requirements. In addition, the shaft diameters shall be sufficient to allow for use of casing, if required, and placement of reinforcement with adequate concrete cover.

Based on our evaluation, recommended lateral resistance parameters for the subsurface materials are presented in Table 14 for use with Load and Resistance Factor Design (LRFD) methods.

Table 14—Drilled Shaft Lateral Resistance Parameters

Borehole Material (Approximate Elevation Range[1])	L-Pile Soil Type	Undrained Shear Strength (psf)	Angle of Internal Friction (degrees)	Effective Subgrade Reaction Coefficient (pci)	Strain Factor ε_{50} (%)	Unit Weight (pcf)
(Native) CLAY, silty to sandy, above water table (Above 4,549 ft)	Stiff clay (#3)	250	12	30	0.020	125 (Total)
(Native) SAND, slightly silty to clayey, below water table (4,545 ft – 4,549 ft)	Sand (#4)	0	22	20	--	60 (Submerged)
(Native) SAND, gravelly, below water table (Below 4,545 ft)	Sand (#4)	0	35	125	--	65 (Submerged)

Note[1]: Elevations listed in this table are approximate averages. Variations in elevation may exist between borings. See Appendix B for localized elevation and soil data.

Additional design and construction considerations for drilled shafts are presented below.

(a) The construction of the drilled shafts should follow the guidelines specified in the "CDOT Standard Specifications for Road and Bridge Construction (SSRBC), Section 503, 2022."

(b) During construction of drilled shafts, casing or slurry methods may be required to support the excavation where holes are unstable due to soil and groundwater conditions. Groundwater was encountered at Boreholes BH-4, BH-5, and BH-6 and ranged in elevation from 4945.4 feet to 4550.7 feet.

(c) Prior to the placement of the concrete, the drilled shaft excavation, including the bottom, should be cleaned of all loose material. For wet conditions (more than two inches of water), concrete placement by "tremie" methods should be used.

10.0 EARTHWORK

To accommodate any potential widening, new embankment may be required along the roadway alignments. At some locations minor cuts may be required. Materials used to construct embankments, roadway side slopes, structure backfill, and aggregate base course materials should meet the material and moisture density control requirements specified Section 8.5 of this report.

At a minimum, the ground surface underlying all embankment fills should be carefully prepared by removing all organic matter (topsoil), scarification to a minimum depth of 6 inches and recompacting to the requirements for maximum dry density/compaction and moisture content presented in Section 8.5 of this report prior to fill placement.

Where fill material is to be placed on existing slopes steeper than 4 (H):1 (V), benching must be performed to tie the new fill into the existing slope. Benching into the existing slopes shall allow sufficient bench width to accommodate placing and compaction equipment to operate in a horizontal orientation.

Broken concrete, broken asphalt, or other solid materials more than 6 inches in greatest dimension shall not be placed within embankment areas supporting the roadway shoulders and pavement structure. Claystone/shale materials shall not be used for construction of new embankment. Imported fill material used for embankment construction shall be compatible with designed side slopes. Material excavated from utility trenches may be used for backfilling provided it does not contain unsuitable material. Unsuitable material includes, but is limited to, topsoil, vegetation, brush, sod, trash, and other deleterious substances. All imported embankment material must meet a minimum R-Value of 20.

11.0 OTHER DESIGN AND CONSTRUCTION CONSIDERATIONS

Proper construction practices, in accordance with the Colorado Department of Transportation (CDOT) 2022 Standard Specifications for Road and Bridge Construction; the City of Grand Junction Standard Specifications for Road and Bridge Construction; and the City of Grand Junction Transportation Engineering Design Standards, should be followed during site preparation, earthwork, excavations, roadway and bridge construction, and embankment and retaining wall construction for the suitable long-term performance of the proposed improvements. Excavation support should be provided to maintain onsite safety and the stability of excavations and slopes. Excavations shall be constructed in accordance with local, state, and federal regulations including OSHA guidelines. The contractor must provide a competent person to determine compliance with OSHA excavation requirements. For preliminary planning, existing fill material and native soils may be considered as OSHA Type C soils.

Surface drainage patterns may be altered during construction and local landscape irrigation (if any) must be controlled to prevent excessive moisture infiltration into the subgrade soils during and after construction.

Environmentally contaminated material, if encountered, should be characterized, and removed under the direction of the project environmental consultant. Design and construction plans should be reviewed, and onsite construction should be observed by the professional engineers.

All utility trenching, including storm drainage, should follow City of Grand Junction Standards details GU-03 and GU-04, and Section 103 of the Standard Specifications for Construction of Underground Utilities – Waterlines, Sanitary Sewers, Storm Drains, Underdrains, and Irrigation Systems. The maximum size of rock or clod allowed within 6" of any plastic pipe shall be one (1) inch. The maximum size of rock or clod allowed within 6" of a rigid pipe or structure shall be three (3) inches. Bedding and backfill material requirements are listed below.

Bedding material must meet the following requirements:

- % Passing 1-inch Sieve: 100%
- % Passing #4 Sieve: 20% maximum

Pit run backfill material must meet the following requirements:

- Percent Passing No. 4 Sieve: 20% min.
- Percent Passing No. 200 Sieve: 20% max.
- Plasticity Index (PI): 7 max.

12.0 LIMITATIONS

This geotechnical investigation was conducted in general accordance with the scope of the work. RockSol's geotechnical practices are similar to those used in Colorado with similar soil conditions and based on our understanding of the proposed work. This report has been prepared for use by the City of Grand Junction for the project described in this report. The report is based on our exploratory boreholes and does not consider variations in the subsurface conditions that may exist between boreholes. Additional investigation is required to address such variation. If during construction activities, materials or water conditions appear to be different from those described herein, RockSol should be advised of at once so that a re-evaluation of the recommendations presented in this report can be made. RockSol is not responsible for liability associated with interpretation of subsurface data by others.

APPENDIX A

BOREHOLE LOCATION PLAN (GOOGLE EARTH)

Appendix A – Borehole Location Plan (Google Earth)

APPENDIX B

LEGEND AND INDIVIDUAL SOIL BOREHOLE LOGS

LEGEND

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction
PROJECT NAME Crosby Avenue Improvements Project
PROJECT NUMBER 599.81
PROJECT LOCATION Grand Junction, Colorado

LITHOLOGY

- Asphalt Pavement
- Fill - SAND, gravelly
- Native - SAND, silty
- Native - SAND, clayey
- Native - CLAY, silty
- Native - SILT, sandy
- Fill - CLAY, sandy
- TOPSOIL
- Native - SAND, gravelly
- Native - CLAY
- Native - CLAY, sandy
- Native - GRAVEL, silty

SAMPLE TYPE

- Auger Cuttings
- MODIFIED CALIFORNIA SAMPLER 2.5" O.D. AND 2" I.D. WITH BRASS LINERS INCLUDED
- SPLIT SPOON SAMPLER 2" O.D. AND 1 3/8" I.D. NO LINERS

Fines Content indicates amount of material, by weight, passing the US No 200 Sieve (%)

15/12 Indicates 15 blows of a 140 pound hammer falling 30 inches was required to drive the sampler 12 inches.

50/11 Indicates 50 blows of a 140 pound hammer falling 30 inches was required to drive the sampler 11 inches.

5,5,5 Indicates 5 blows, 5 blows, 5 blows of a 140 pound hammer falling 30 inches was required to drive the sampler 18 inches.

- GROUND WATER LEVEL 1ST DEPTH
- GROUND WATER LEVEL 2ND DEPTH
- GROUND WATER LEVEL 3RD DEPTH

Borehole Location – BH-1

Photograph Taken Looking North

RockSol Consulting Group, Inc.

BORING : BH-1

CLIENT City of Grand Junction
PROJECT NAME Crosby Avenue Improvements Project
PROJECT NUMBER 599.81
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 5/30/23 **COMPLETED** 5/30/23
GROUND ELEVATION 4552.7 ft **STATION NO.**
DRILLING CONTRACTOR Colorado Drilling and Sampling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"
BORING LOCATION: NB Crosby Avenue, ~300' S of American Way
LOGGED BY R. Lepro/T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS:
NOTES
WATER DEPTH 4.0 ft on 5/30/23

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
4552.7	0.0		Asphalt pavement, approximately 5.5 inches thick										
			(Fill) SAND, gravelly with clay, slightly moist, medium dense to dense	SS	9/7/4								24.4
			(Native) SAND, silty, moist, brown, medium dense										
4550.2	2.5		**Approximate Bulk Depth 1.5-4** Liquid Limit= NP Plastic Limit= NP Plasticity Index= NP Fines Content= 37.5 Sulfate= 0.18	B BULK			0.18			NP	NP	NP	37.5
			(Native) SAND, gravelly, wet, loose to dense	MC	7/12			93.9	25.2				
4547.7	5.0		**Approximate Bulk Depth 4-9** Liquid Limit= NP Plastic Limit= NP Plasticity Index= NP Fines Content= 34.3	B BULK						NP	NP	NP	34.3
4545.2	7.5												
4542.7	10.0			SS	13/30/18								13.3
			Bottom of hole at 10.5 feet.										

Borehole Location – BH-2

Photograph Taken Looking North

RockSol Consulting Group, Inc.

BORING : BH-2

CLIENT City of Grand Junction
PROJECT NAME Crosby Avenue Improvements Project
PROJECT NUMBER 599.81
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 5/30/23 **COMPLETED** 5/30/23
GROUND ELEVATION 4553.6 ft **STATION NO.**
DRILLING CONTRACTOR Colorado Drilling and Sampling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"
BORING LOCATION: SB Crosby Avenue, ~400' N of Gunnison Avenue
LOGGED BY T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS:
NOTES On White Edge Line
WATER DEPTH 8.4 ft on 5/30/23

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
4553.6	0.0		Asphalt pavement, approximately 5.5 inches thick										
			(Fill) SAND, gravelly with clay, slightly moist, medium dense to dense	SS	16/18/14					NP	NP	NP	
			(Native) SAND, gravelly, moist, dense, up to 1-inch diameter gravel										
4551.1	2.5		**Approximate Bulk Depth 2-4** Fines Content= 33.3	B BULK									33.3
			(Native) SAND, gravelly to silty, moist to wet, brown, medium dense to dense	SS	5/7/15								
4548.6	5.0		**Approximate Bulk Depth 4-9** Liquid Limit= NP Plastic Limit= NP Plasticity Index= NP Fines Content= 24.2	B BULK						NP	NP	NP	24.2
4546.1	7.5												
4543.6	10.0			SS	17/17/15					NP	NP	NP	5.4
			Bottom of hole at 10.5 feet.										

Borehole Location – BH-3

Photograph Taken Looking Northwest

RockSol Consulting Group, Inc.

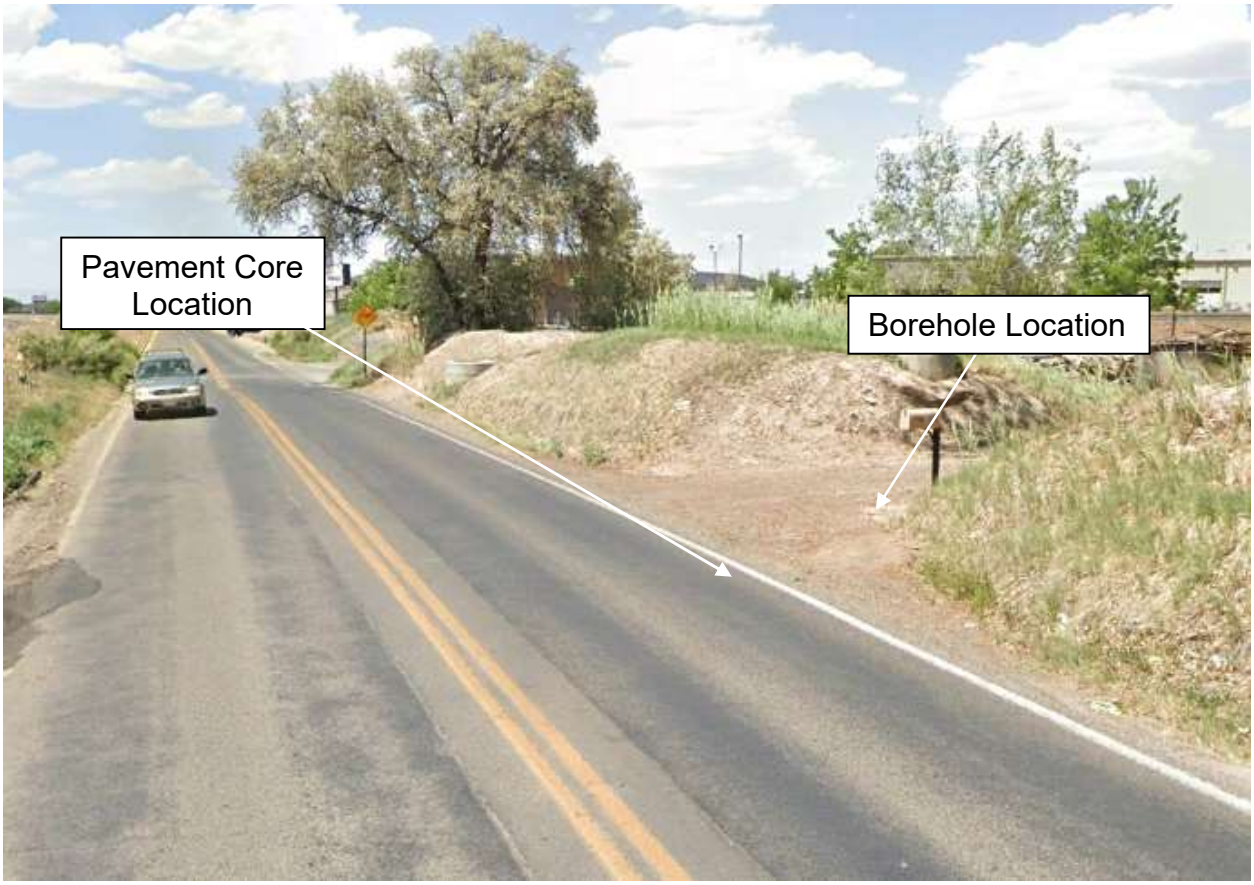
BORING : BH-3

CLIENT City of Grand Junction
PROJECT NAME Crosby Avenue Improvements Project
PROJECT NUMBER 599.81
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 5/30/23 **COMPLETED** 5/30/23
GROUND ELEVATION 4552.1 ft **STATION NO.**
DRILLING CONTRACTOR Colorado Drilling and Sampling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"
BORING LOCATION: NB Crosby Avenue, ~200' S of Gunnison Avenue
LOGGED BY T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS:
NOTES Right Wheel Path
WATER DEPTH 4.8 ft on 5/30/23

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
4552.1	0.0		Asphalt pavement, approximately 3 inches thick										
			(Fill) SAND, gravelly with clay, slightly moist, medium dense to dense										
4549.6	2.5		(Native) SAND, gravelly to silty, moist to wet, dense to very dense	SS B BULK	10/16/17								10.5
4547.1	5.0			SS B BULK	29/29/36					NP	NP	NP	11.6
4544.6	7.5		**Approximate Bulk Depth 7-9** Liquid Limit= 14 Plastic Limit= 15 Plasticity Index= NP Fines Content= 21.8	B BULK						14	15	NP	21.8
4542.1	10.0			SS	19/29/35					NP	NP	NP	10.6
			Bottom of hole at 10.5 feet.										

LOG - STANDARD 599.81_CROSBY AVE GEOTECH AND PAVEMENT DESIGN.GPJ 7/11/23

Borehole Location – BH-4
(Google Earth)



Photograph Taken Looking Northwest

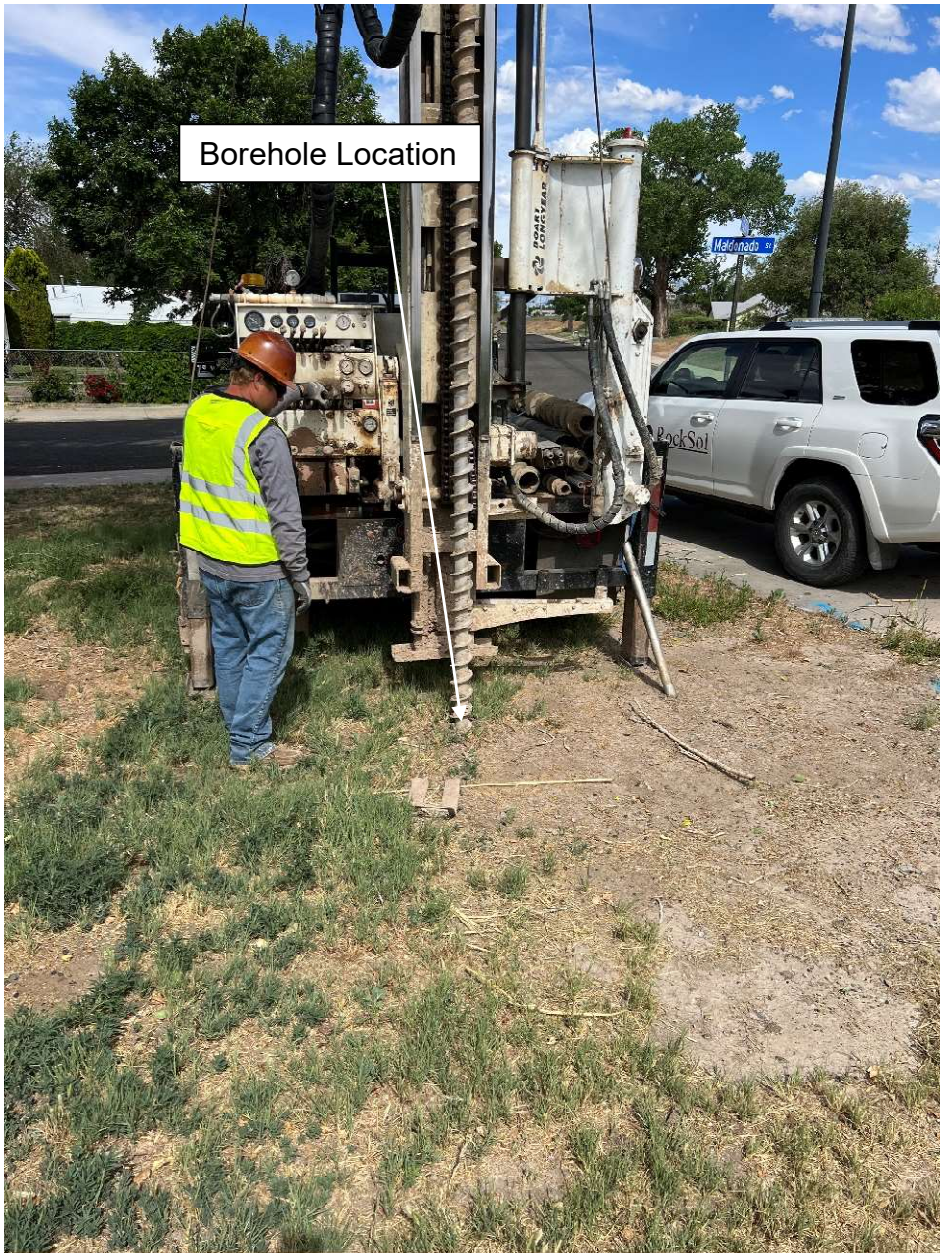
RockSol Consulting Group, Inc.

BORING : BH-4

CLIENT City of Grand Junction
PROJECT NAME Crosby Avenue Improvements Project
PROJECT NUMBER 599.81
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 5/30/23 **COMPLETED** 5/30/23
GROUND ELEVATION 4553.2 ft **STATION NO.**
DRILLING CONTRACTOR Colorado Drilling and Sampling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"
BORING LOCATION: Crosby Avenue, ~550' S of Gunnison Avenue
LOGGED BY T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS:
NOTES Off Shoulder, ~10' E of Pavement Edge
WATER DEPTH 3.0 ft on 5/30/23

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
4553.2	0.0		(Fill) SAND, gravelly, unpaved residence driveway material, approximately 8 inches thick										
			(Native) CLAY, silty to sandy with gravel, brown, stiff **Approximate Bulk Depth 0.67-2** Liquid Limit= 19 Plastic Limit= 15 Plasticity Index= 4 Fines Content= 69.9	BULK						19	15	4	69.9
4550.7	2.5		(Native) SILT, sandy, moist to wet, medium stiff to stiff **Approximate Bulk Depth 2-4** Liquid Limit= NP Plastic Limit= NP Plasticity Index= NP Fines Content= 52.5 Sulfate= 0.08	MC	10/12	-0.2		102.9	19.7				
				BULK			0.08			NP	NP	NP	52.5
4548.2	5.0		(Native) SAND, silty, wet, tan-gray, loose to dense	MC	5/12			97.3	25.3				
			Approximate Bulk Depth 4-9 Liquid Limit= NP Plastic Limit= NP Plasticity Index= NP Fines Content= 37.2	BULK						NP	NP	NP	37.2
4545.7	7.5												
4543.2	10.0			SS	14/11/20								
			Bottom of hole at 10.5 feet.										

Borehole Location – BH-5



Photograph Taken Looking East

RockSol Consulting Group, Inc.

BORING : BH-5

CLIENT City of Grand Junction
PROJECT NAME Crosby Avenue Improvements Project
PROJECT NUMBER 599.81
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 5/30/23 **COMPLETED** 5/30/23
EXISTING ELEVATION 4555.2 ft **STATION NO.**
DRILLING CONTRACTOR Colorado Drilling and Sampling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"
BORING LOCATION: ~15' E of irrigation ditch E of Crosby Avenue
LOGGED BY T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS: ▼ **1ST DEPTH** 5.8 ft on 5/30/23
NOTES Temporary Piezometer Installed
▼ **2ND DEPTH** 5.0 ft on 5/31/23 ▼ **3RD DEPTH** 5.1 ft on 6/23/23

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
4555.2	0.0		(Topsoil) SAND, clayey, supporting moderate vegetation										
			(Native) CLAY, silty, moist to very moist, medium stiff										
4552.7	2.5			MC	6/12	-0.2		111.0	13.5				
			(Native) SAND, silty to clayey, wet, very loose										
4550.2	5.0			MC	2/12		0.14	92.5	31.1				39.4
				B) BULK									
4547.7	7.5		(Native) SAND, gravelly, wet, dense to very dense										
4545.2	10.0			SS	11/14/18					NP	NP	NP	11.2
4542.7	12.5												
4540.2	15.0			MC	65/12			148.8	7.0				
			Bottom of hole at 15.0 feet.										

LOG - STANDARD - 2 H20 599.81_CROSBY AVE GEOTECH AND PAVEMENT DESIGN.GPJ 7/11/23

Borehole Location – BH-6

Photograph Taken Looking North

RockSol Consulting Group, Inc.

BORING : BH-6

CLIENT City of Grand Junction
PROJECT NAME Crosby Avenue Improvements Project
PROJECT NUMBER 599.81
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 5/30/23 **COMPLETED** 5/30/23
GROUND ELEVATION 4555.7 ft **STATION NO.**
DRILLING CONTRACTOR Colorado Drilling and Sampling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"
BORING LOCATION: Crosby Avenue, ~200' NW of Broadway
LOGGED BY R. Lepro/T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS:
NOTES Center of Lane
WATER DEPTH 5.0 ft on 5/30/23

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
4555.7	0.0		Asphalt pavment, approximately 2 inches thick										
			(Fill) SAND, gravelly with clay, slightly moist, medium dense to dense										
			(Native) CLAY, slightly silty, moist, brown, soft to very stiff	SS	19/15/16					NP	NP	NP	19.2
4553.2	2.5												
				MC	3/12								
4550.7	5.0		(Native) GRAVEL, sandy to silty, wet, brown, dense										
			Approximate Bulk Depth 5-9 Liquid Limit= NP Plastic Limit= NP Plasticity Index= NP Fines Content= 37.0	8 BULK						NP	NP	NP	37.0
4548.2	7.5												
				SS	18/23/24					NP	NP	NP	10.2
4545.7	10.0		Bottom of hole at 10.5 feet.										

LOG - STANDARD 599.81_CROSBY AVE GEOTECH AND PAVEMENT DESIGN.GPJ 7/11/23

Borehole Location – BH-7

Photograph Taken Looking South

RockSol Consulting Group, Inc.

BORING : BH-7

CLIENT City of Grand Junction
PROJECT NAME Crosby Avenue Improvements Project
PROJECT NUMBER 599.81
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 5/30/23 **COMPLETED** 5/30/23
EXISTING ELEVATION 4558.6 ft **STATION NO.**
DRILLING CONTRACTOR Colorado Drilling and Sampling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"
BORING LOCATION: NB Crosby Avenue, ~100' S of Broadway
LOGGED BY R. Lepro/T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS: ▼ **1ST DEPTH** 7.4 ft on 5/30/23
NOTES
▼ **2ND DEPTH** 6.7 ft on 5/31/23 ▼ **3RD DEPTH** 6.5 ft on 6/23/23

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
4558.6	0.0		(Fill) SAND, slightly silty to gravelly with cobbles										
4556.1	2.5		(Native) CLAY, with sand to sandy, moist to very moist, brown, stiff, minor calcareous deposits	MC	12/12	0.4		118.1	19.2				
4553.6	5.0		**Approximate Bulk Depth 3-9** Liquid Limit= 29 Plastic Limit= 23 Plasticity Index= 6 Fines Content= 70.7 Sulfate= 0.27	B BULK			0.27			29	23	6	70.7
4551.1	7.5												
4548.6	10.0		(Native) SAND, clayey with gravel to slightly silty to gravelly, wet, brown to gray-brown, medium dense to dense	MC	10/12								
4546.1	12.5												
4543.6	15.0			SS	33/23/19								8.2
			Bottom of hole at 15.5 feet.										

LOG - STANDARD - 2 H20 599.81_CROSBY AVE GEOTECH AND PAVEMENT DESIGN.GPJ 7/11/23

Borehole Location – BH-8

Photograph Taken Looking Southeast

RockSol Consulting Group, Inc.

BORING : BH-8

CLIENT City of Grand Junction
PROJECT NAME Crosby Avenue Improvements Project
PROJECT NUMBER 599.81
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 5/30/23 **COMPLETED** 5/30/23
GROUND ELEVATION 4566.7 ft **STATION NO.**
DRILLING CONTRACTOR Colorado Drilling and Sampling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"
BORING LOCATION: SB Crosby Avenue, ~200' N of Main Street
LOGGED BY R. Lepro/T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS:
NOTES Center of Lane
WATER DEPTH None Encountered on 5/30/23

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
4566.7	0.0		Asphalt pavement, approximately 4.5 inches thick										
			(Fill) SAND, gravelly with clay, slightly moist, medium dense to dense	SS	13/14/7					NP	NP	NP	14.6
4564.2	2.5		(Fill) CLAY, sandy, moist, brown, medium stiff to stiff										
			(Native) CLAY, sandy, moist to very moist, brown, medium stiff to stiff	MC	5/12			101.4	23.5				
4561.7	5.0		**Approximate Bulk Depth 1.46-9** Liquid Limit= 25 Plastic Limit= 14 Plasticity Index= 11 Fines Content= 93.5	B BULK						25	14	11	93.5
4559.2	7.5												
				MC	8/12			93.2	24.5				
4556.7	10.0		Bottom of hole at 10.0 feet.										

LOG - STANDARD 599.81_CROSBY AVE GEOTECH AND PAVEMENT DESIGN.GPJ 7/11/23

APPENDIX C

LABORATORY TEST RESULT SUMMARY

AND

TEST RESULT SHEETS

RockSol Consulting Group, Inc.

SUMMARY OF PHYSICAL & CHEMICAL TEST RESULTS

CLIENT City of Grand Junction

PROJECT NAME Crosby Avenue Improvements Project

PROJECT NUMBER 599.81

PROJECT LOCATION Grand Junction, Colorado

Borehole	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	Swell Potential (%)	%<#200 Sieve	Classification		Water Content (%)	Dry Density (pcf)	Unconfined Compressive Strength (psi)	Sulfate (%)	Resistivity (ohm-cm)	pH	Chlorides (%)	Proctor S=Standard M=Modified		
							USCS	AASHTO								MDD	OMC	S/M
BH-1	0.46					24												
BH-1	1.5-4	NP	NP	NP		37	SM	A-4 (0)				0.18						
BH-1	4-9	NP	NP	NP		34	SM	A-2-4 (0)										
BH-1	4.01								25.2	93.9								
BH-1	9					13												
BH-2	0.46	NP	NP	NP														
BH-2	2-4					33												
BH-2	4-9	NP	NP	NP		24	SM	A-1-b (0)										
BH-2	4.01																	
BH-2	9	NP	NP	NP		5	SP-SM	A-1-a (0)										
BH-3	2-4																	
BH-3	2.01					10												
BH-3	4-7																	
BH-3	4.01	NP	NP	NP		12	SW-SM	A-1-a (0)										
BH-3	7-9	14	15	NP		22	SM	A-1-b (0)										
BH-3	9	NP	NP	NP		11	GP-GM	A-1-b (0)										
BH-4	0.67-2	19	15	4		70	CL-ML	A-4 (0)										
BH-4	2-4	NP	NP	NP		52	ML	A-4 (0)				0.08						
BH-4	2.01				-0.2				19.7	102.9								
BH-4	4-9	NP	NP	NP		37	SM	A-4 (0)										
BH-4	4.01								25.3	97.3								
BH-4	9																	
BH-5	2				-0.2				13.5	111.0								
BH-5	4-9																	
BH-5	5					39			31.1	92.5		0.14						
BH-5	9	NP	NP	NP		11	SP-SM	A-1-b (0)										
BH-5	14								7.0	148.8								
BH-6	0.17	NP	NP	NP		19	SM	A-1-b (0)										
BH-6	4																	
BH-6	5-9	NP	NP	NP		37	SM	A-4 (0)								118.2	12.1	S

RockSol Consulting Group, Inc.

SUMMARY OF PHYSICAL & CHEMICAL TEST RESULTS

CLIENT City of Grand Junction

PROJECT NAME Crosby Avenue Improvements Project

PROJECT NUMBER 599.81

PROJECT LOCATION Grand Junction, Colorado

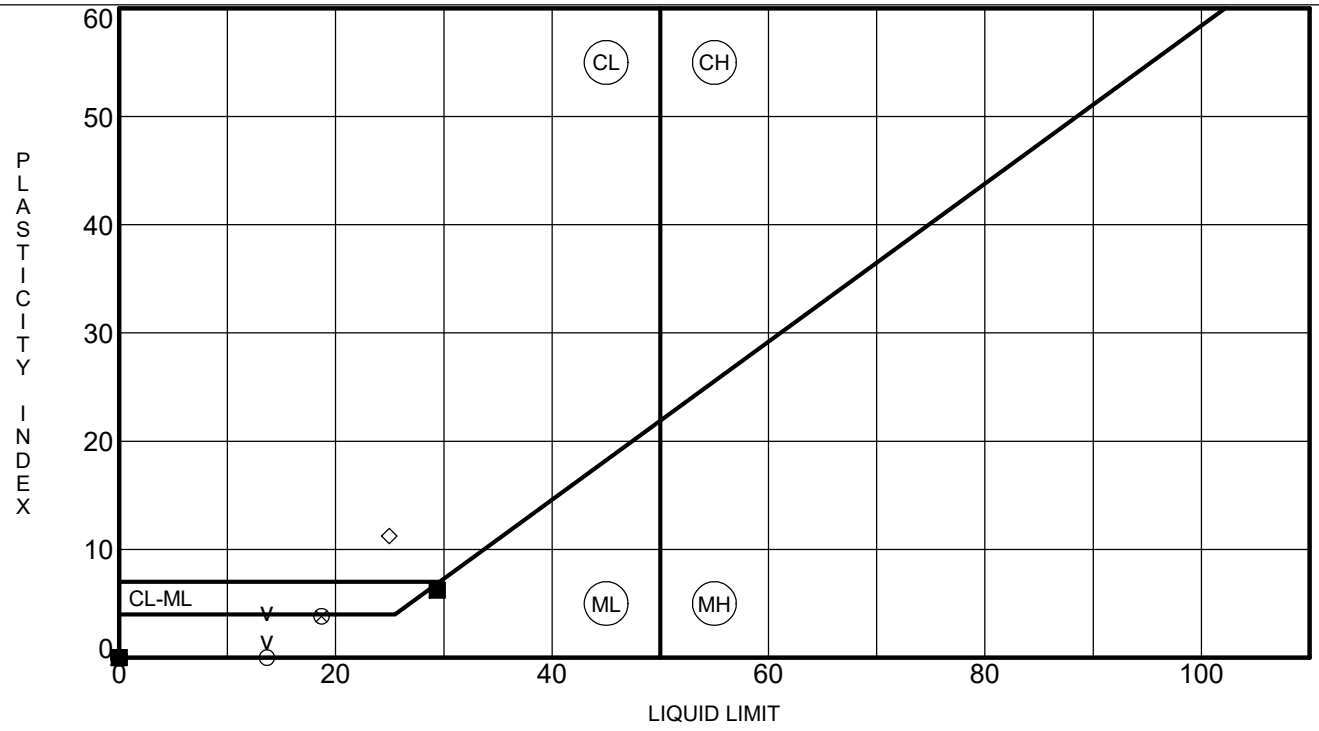
Borehole	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	Swell Potential (%)	%<#200 Sieve	Classification		Water Content (%)	Dry Density (pcf)	Unconfined Compressive Strength (psi)	Sulfate (%)	Resistivity (ohm-cm)	pH	Chlorides (%)	Proctor S=Standard M=Modified		
							USCS	AASHTO								MDD	OMC	S/M
BH-6	9	NP	NP	NP		10		A-1-a (0)										
BH-7	3-9	29	23	6		71	ML	A-4 (3)				0.27						
BH-7	4				0.4				19.2	118.1								
BH-7	9																	
BH-7	14					8												
BH-8	0.375	NP	NP	NP		15	SM	A-1-b (0)										
BH-8	1.46-9	25	14	11		93	CL	A-6 (8)										
BH-8	4								23.5	101.4								
BH-8	9								24.5	93.2								

RockSol Consulting Group, Inc.

ATTERBERG LIMITS RESULTS
AASHTO T89 Method A/T90

CLIENT City of Grand Junction **PROJECT NAME** Crosby Avenue Improvements Project

PROJECT NUMBER 599.81 **PROJECT LOCATION** Grand Junction, Colorado



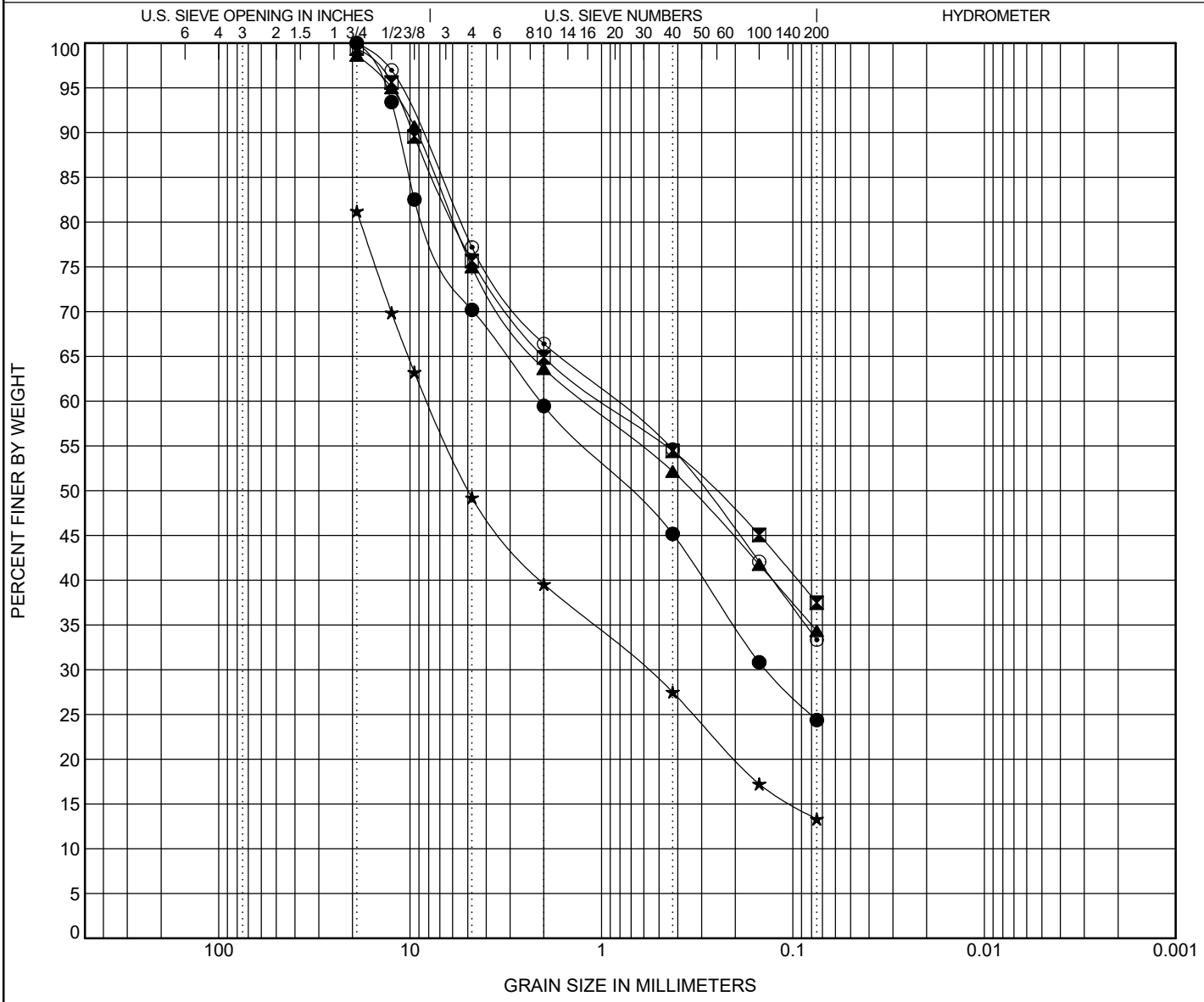
	Specimen Identification		LL	PL	PI	Fines	Classification
●	BH-1	1.5-4.0	NP	NP	NP	37.5	SILTY SAND with GRAVEL (SM) (A-4)
⊠	BH-1	4.0-10.0	NP	NP	NP	34.3	SILTY SAND with GRAVEL (SM) (A-2-4)
▲	BH-2	0.5	NP	NP	NP		GRAVELLY SAND with CLAY
★	BH-2	4.0-9.0	NP	NP	NP	24.2	SILTY SAND with GRAVEL (SM) (A-1-b)
⊙	BH-2	9.0	NP	NP	NP	5.4	POORLY GRADED SAND with SILT and GRAVEL (SP-SM) (A-1-a)
✿	BH-3	4.0	NP	NP	NP	11.6	WELL-GRADED SAND with SILT and GRAVEL (SW-SM) (A-1-a)
○	BH-3	7.0-9.0	14	15	NP	21.8	SILTY SAND with GRAVEL (SM) (A-1-b)
△	BH-3	9.0	NP	NP	NP	10.6	POORLY GRADED GRAVEL with SILT and SAND (GP-GM) (A-1-b)
⊗	BH-4	0.7-2.0	19	15	4	69.9	SANDY SILTY CLAY (CL-ML) (A-4)
⊕	BH-4	2.0-4.0	NP	NP	NP	52.5	SANDY SILT (ML) (A-4)
□	BH-4	4.0-9.0	NP	NP	NP	37.2	SILTY SAND (SM) (A-4)
⊛	BH-5	9.0	NP	NP	NP	11.2	POORLY GRADED SAND with SILT and GRAVEL (SP-SM) (A-1-b)
◕	BH-6	0.2	NP	NP	NP	19.2	SILTY SAND with GRAVEL (SM) (A-1-b)
☆	BH-6	5.0-9.0	NP	NP	NP	37.0	SILTY SAND (SM) (A-4)
⊠	BH-6	9.0	NP	NP	NP	10.2	SANDY GRAVEL with CLAY (A-1-a)
■	BH-7	3.0-9.0	29	23	6	70.7	SILT with SAND (ML) (A-4)
◆	BH-8	0.4	NP	NP	NP	14.6	SILTY SAND with GRAVEL (SM) (A-1-b)
◇	BH-8	1.5-9.0	25	14	11	93.5	LEAN CLAY (CL) (A-6)

GRAIN SIZE DISTRIBUTION

RockSol

CLIENT City of Grand Junction **PROJECT NAME** Crosby Avenue Improvements Project

PROJECT NUMBER 599.81 **PROJECT LOCATION** Grand Junction, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	BH-1	0.5	SANDY GRAVEL with CLAY					
⊠	BH-1	1.5-4.0	SILTY SAND with GRAVEL (SM) (A-4)	NP	NP	NP		
▲	BH-1	4.0-10.0	SILTY SAND with GRAVEL (SM) (A-2-4)	NP	NP	NP		
★	BH-1	9.0	SILTY SAND with GRAVEL					
⊙	BH-2	2.0-4.0	GRAVELLY SAND					

Specimen Identification			D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
●	BH-1	0.5	19	2.089	0.137		40.5	14.3	20.8	24.4	
⊠	BH-1	1.5-4.0	19	0.969			34.5	10.4	17.0	37.5	
▲	BH-1	4.0-10.0	19	1.226			35.0	11.5	17.8	34.3	
★	BH-1	9.0	19	8.095	0.586		41.7	12.0	14.2	13.3	
⊙	BH-2	2.0-4.0	19	0.861			33.6	11.8	21.3	33.3	

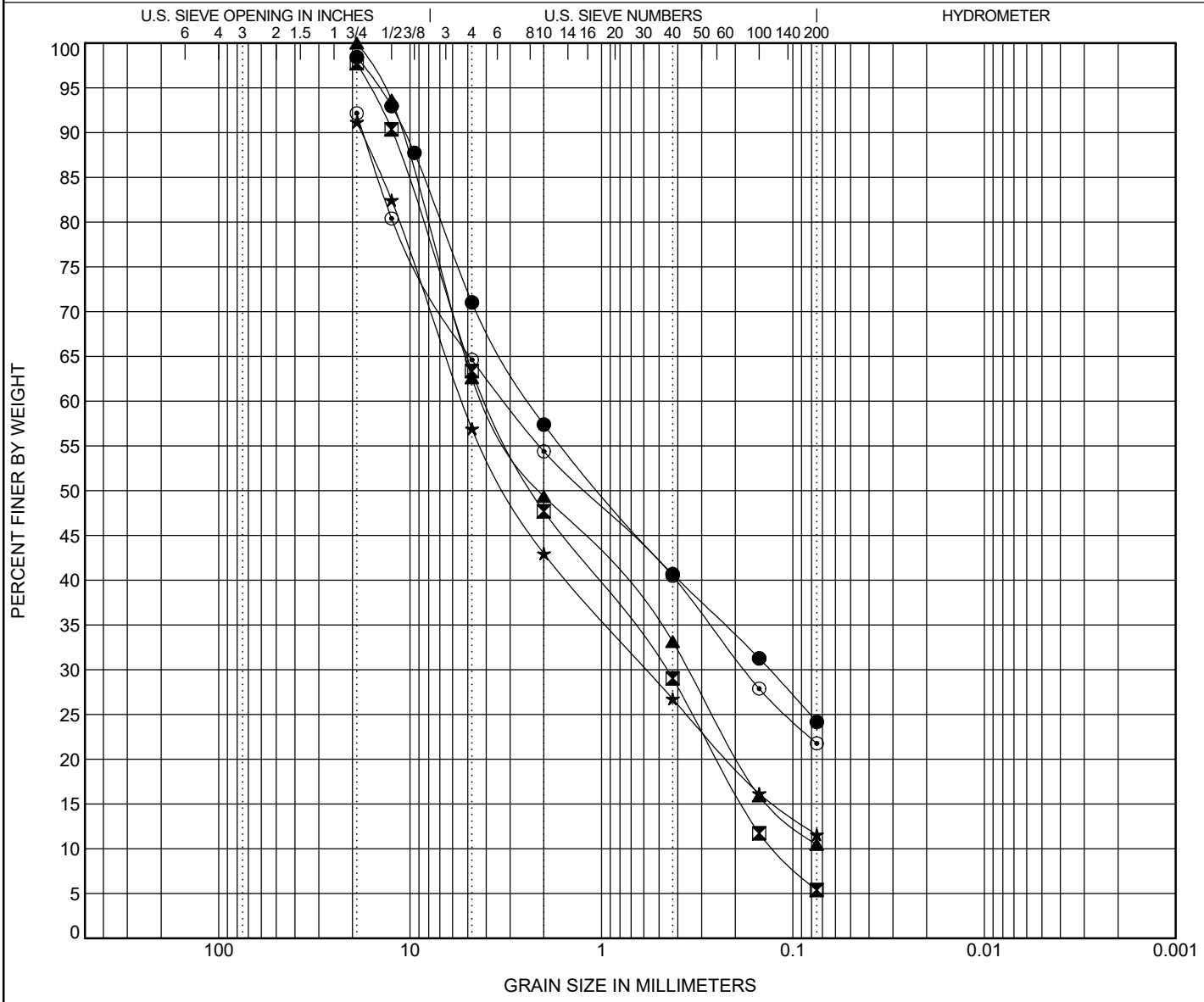
GRADATION - STANDARD 599.81_CROSBY AVE GEOTECH AND PAVEMENT DESIGN.GPJ ROCKSOL TEMPLATE.GDT 7/3/23

GRAIN SIZE DISTRIBUTION

RockSol

CLIENT City of Grand Junction **PROJECT NAME** Crosby Avenue Improvements Project

PROJECT NUMBER 599.81 **PROJECT LOCATION** Grand Junction, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	BH-2	4.0-9.0	SILTY SAND with GRAVEL (SM) (A-1-b)	NP	NP	NP		
⊠	BH-2	9.0	POORLY GRADED SAND with SILT and GRAVEL (SP-SM) (A-1-a)	NP	NP	NP	0.43	31.80
▲	BH-3	2.0	SILTY SAND with GRAVEL				0.44	56.72
★	BH-3	4.0	WELL-GRADED SAND with SILT and GRAVEL (SW-SM) (A-1-a)	NP	NP	NP	1.06	89.96
⊙	BH-3	7.0-9.0	SILTY SAND with GRAVEL (SM) (A-1-b)	14	15	NP		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
●	BH-2	4.0-9.0	19	2.361	0.133		41.0	16.7	16.5	24.2	
⊠	BH-2	9.0	19	3.947	0.461	0.124	50.1	18.7	23.6	5.4	
▲	BH-3	2.0	19	4.01	0.351		50.6	16.2	22.7	10.5	
★	BH-3	4.0	19	5.34	0.58		48.2	16.2	15.2	11.6	
⊙	BH-3	7.0-9.0	19	3.215	0.179		37.8	13.9	18.7	21.8	

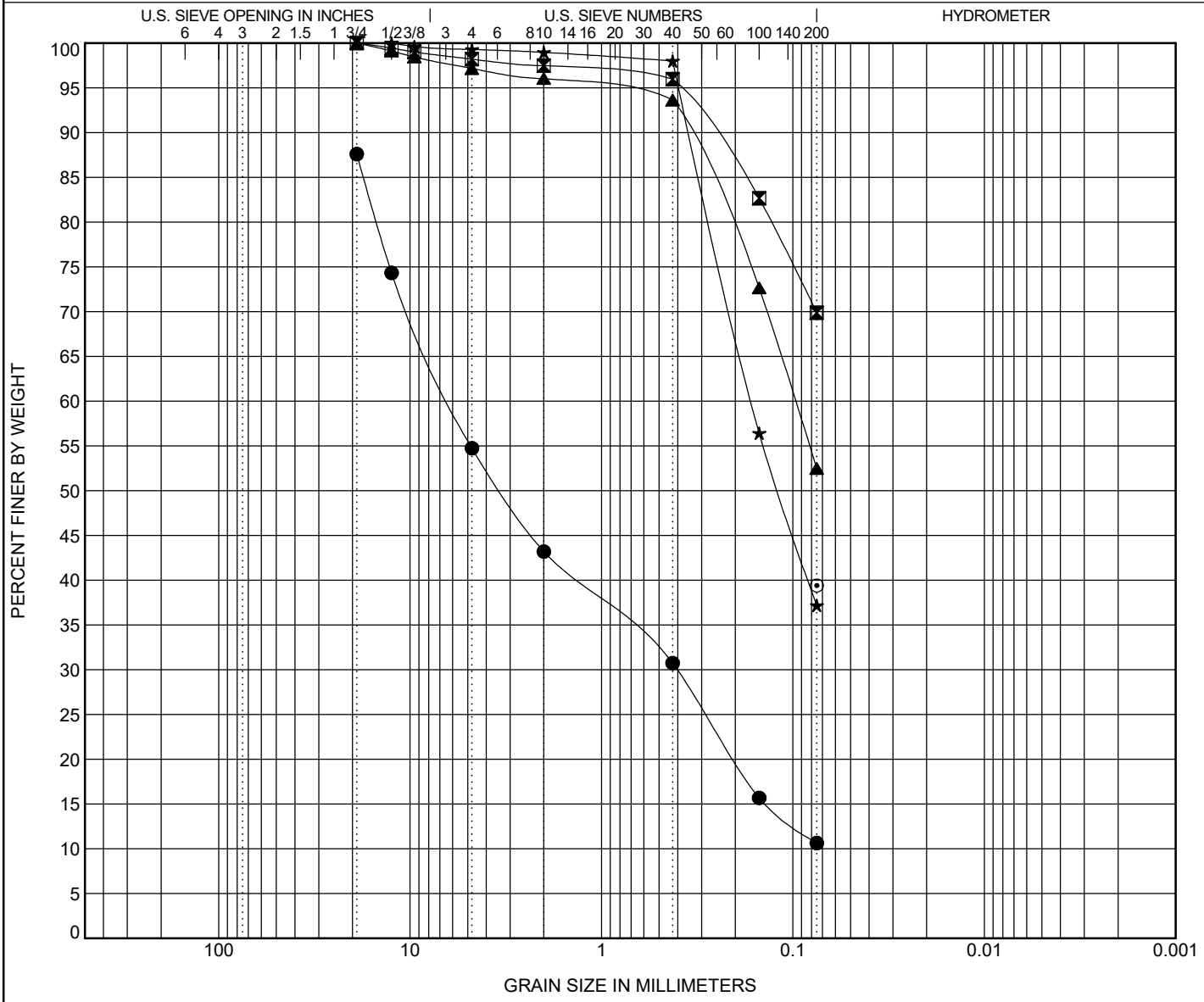
GRADATION - STANDARD 599.81_CROSBY AVE GEOTECH AND PAVEMENT DESIGN.GPJ ROCKSOL TEMPLATE.GDT 7/3/23

GRAIN SIZE DISTRIBUTION

RockSol

CLIENT City of Grand Junction **PROJECT NAME** Crosby Avenue Improvements Project

PROJECT NUMBER 599.81 **PROJECT LOCATION** Grand Junction, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	BH-3	9.0	POORLY GRADED GRAVEL with SILT and SAND (GP-GM) (A-1-b)	NP	NP	NP	0.39	89.63
⊠	BH-4	0.7-2.0	SANDY SILTY CLAY (CL-ML) (A-4)	19	15	4		
▲	BH-4	2.0-4.0	SANDY SILT (ML) (A-4)	NP	NP	NP		
★	BH-4	4.0-9.0	SILTY SAND (SM) (A-4)	NP	NP	NP		
⊙	BH-5	5.0	CLAYEY SAND					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
●	BH-3	9.0	19	6.158	0.404		44.4	12.5	20.1	10.6	
⊠	BH-4	0.7-2.0	19				2.5	1.5	26.1	69.9	
▲	BH-4	2.0-4.0	19	0.097			4.0	2.4	41.2	52.5	
★	BH-4	4.0-9.0	12.5	0.164			1.0	1.0	60.8	37.2	
⊙	BH-5	5.0	0.075							39.4	

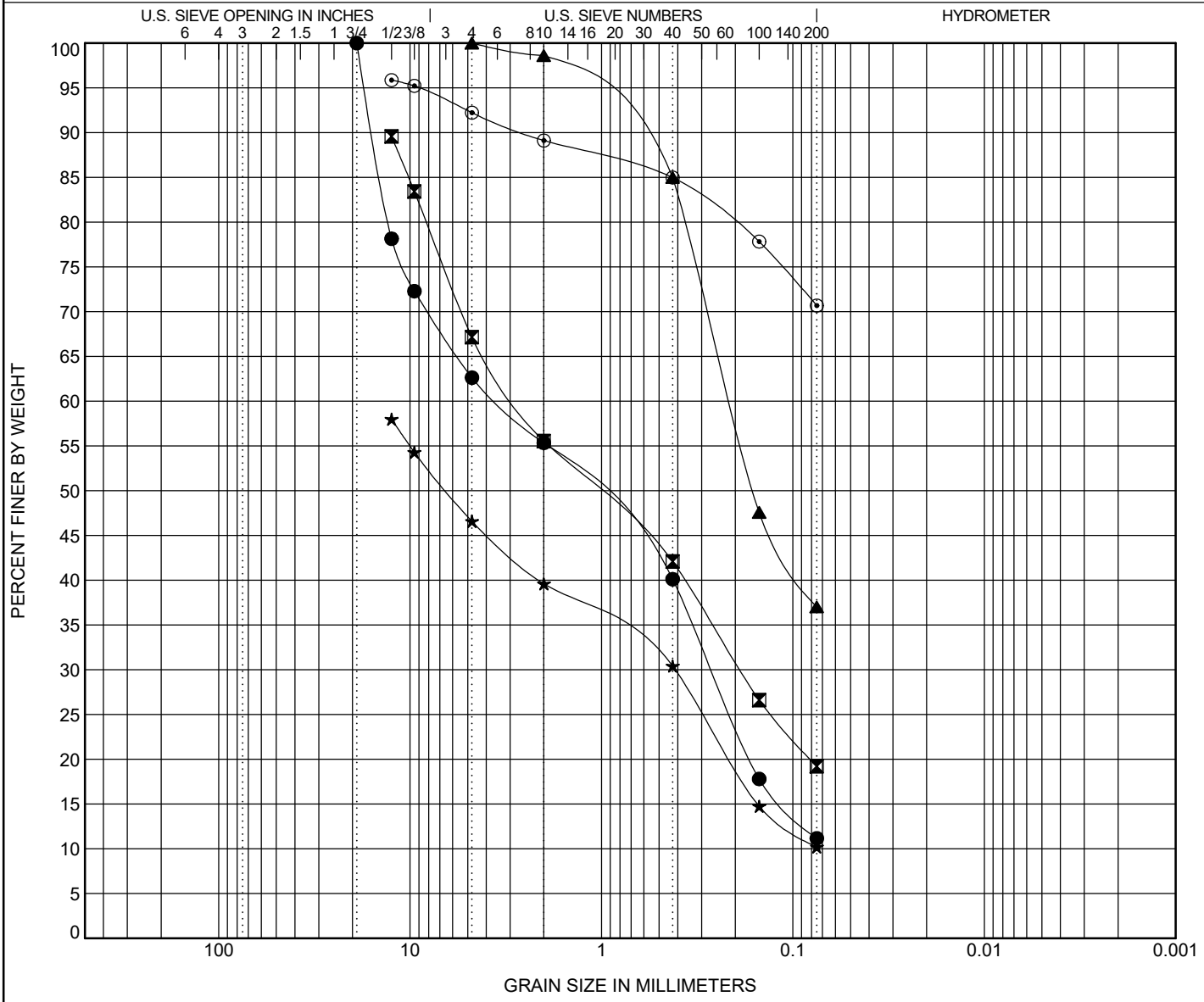
GRADATION - STANDARD 599.81_CROSBY AVE GEOTECH AND PAVEMENT DESIGN.GPJ ROCKSOL TEMPLATE.GDT 7/3/23

GRAIN SIZE DISTRIBUTION

RockSol

CLIENT City of Grand Junction **PROJECT NAME** Crosby Avenue Improvements Project

PROJECT NUMBER 599.81 **PROJECT LOCATION** Grand Junction, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	BH-5	9.0	POORLY GRADED SAND with SILT and GRAVEL (SP-SM) (A-1-b)	NP	NP	NP	0.30	52.36
⊠	BH-6	0.2	SILTY SAND with GRAVEL (SM) (A-1-b)	NP	NP	NP		
▲	BH-6	5.0-9.0	SILTY SAND (SM) (A-4)	NP	NP	NP		
★	BH-6	9.0	SANDY GRAVEL with CLAY (A-1-a)	NP	NP	NP		
⊙	BH-7	3.0-9.0	SILT with SAND (ML) (A-4)	29	23	6		

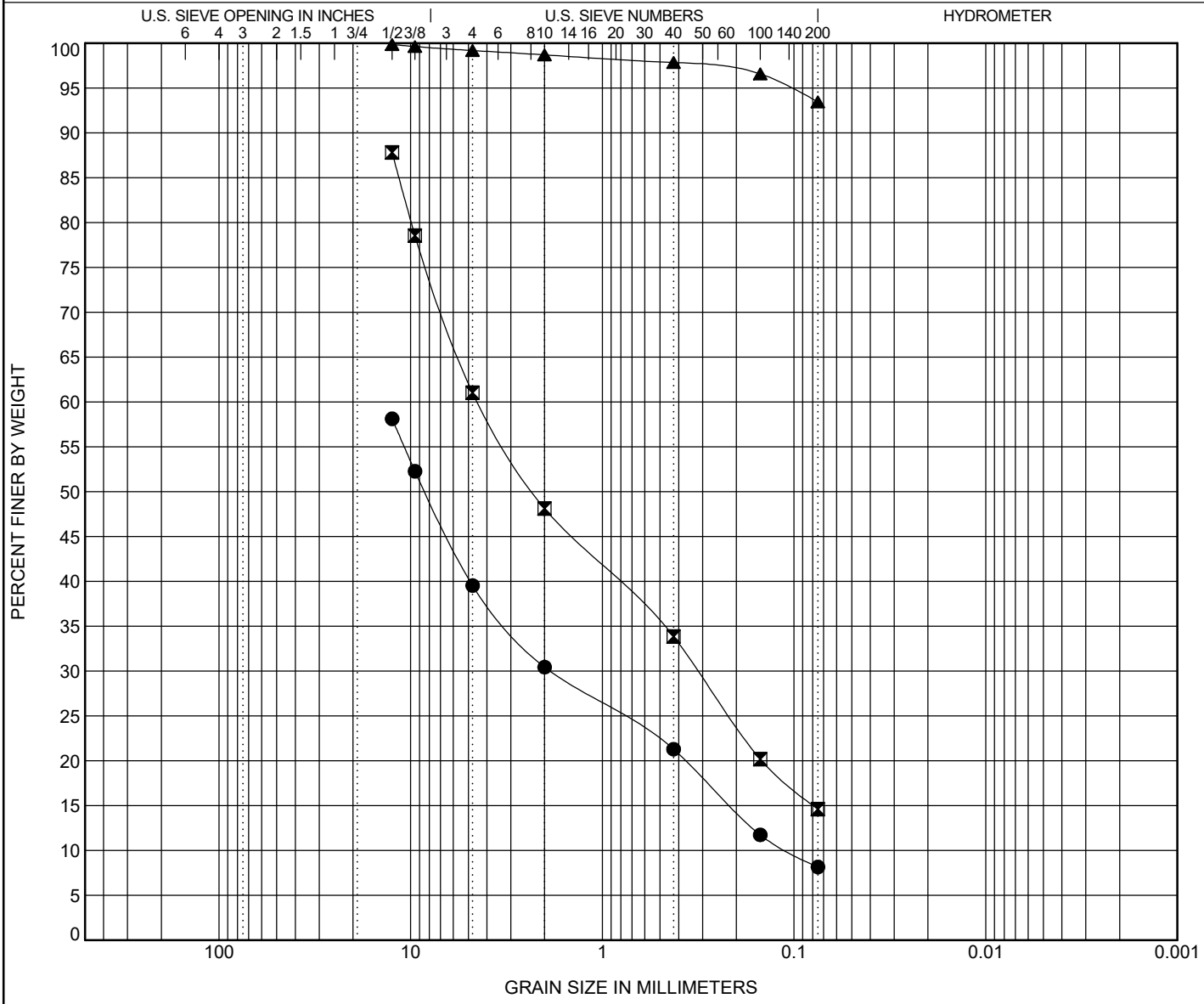
Specimen Identification			D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
●	BH-5	9.0	19	3.477	0.265		44.7	15.2	28.9	11.2	
⊠	BH-6	0.2	12.5	2.788	0.188		34.0	13.5	22.9	19.2	
▲	BH-6	5.0-9.0	4.75	0.212			1.4	13.6	48.0	37.0	
★	BH-6	9.0	12.5		0.413		18.4	9.2	20.2	10.2	
⊙	BH-7	3.0-9.0	12.5				6.8	4.1	14.3	70.7	

GRAIN SIZE DISTRIBUTION

RockSol

CLIENT City of Grand Junction **PROJECT NAME** Crosby Avenue Improvements Project

PROJECT NUMBER 599.81 **PROJECT LOCATION** Grand Junction, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	BH-7	14.0	CLAYEY SAND with GRAVEL					
⊠	BH-8	0.4	SILTY SAND with GRAVEL (SM) (A-1-b)	NP	NP	NP		
▲	BH-8	1.5-9.0	LEAN CLAY (CL) (A-6)	25	14	11		

Specimen Identification			D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
●	BH-7	14.0	12.5		1.86	0.107	27.7	9.1	13.1	8.2	
⊠	BH-8	0.4	12.5	4.437	0.317		39.7	14.2	19.3	14.6	
▲	BH-8	1.5-9.0	12.5				1.2	0.9	4.4	93.5	

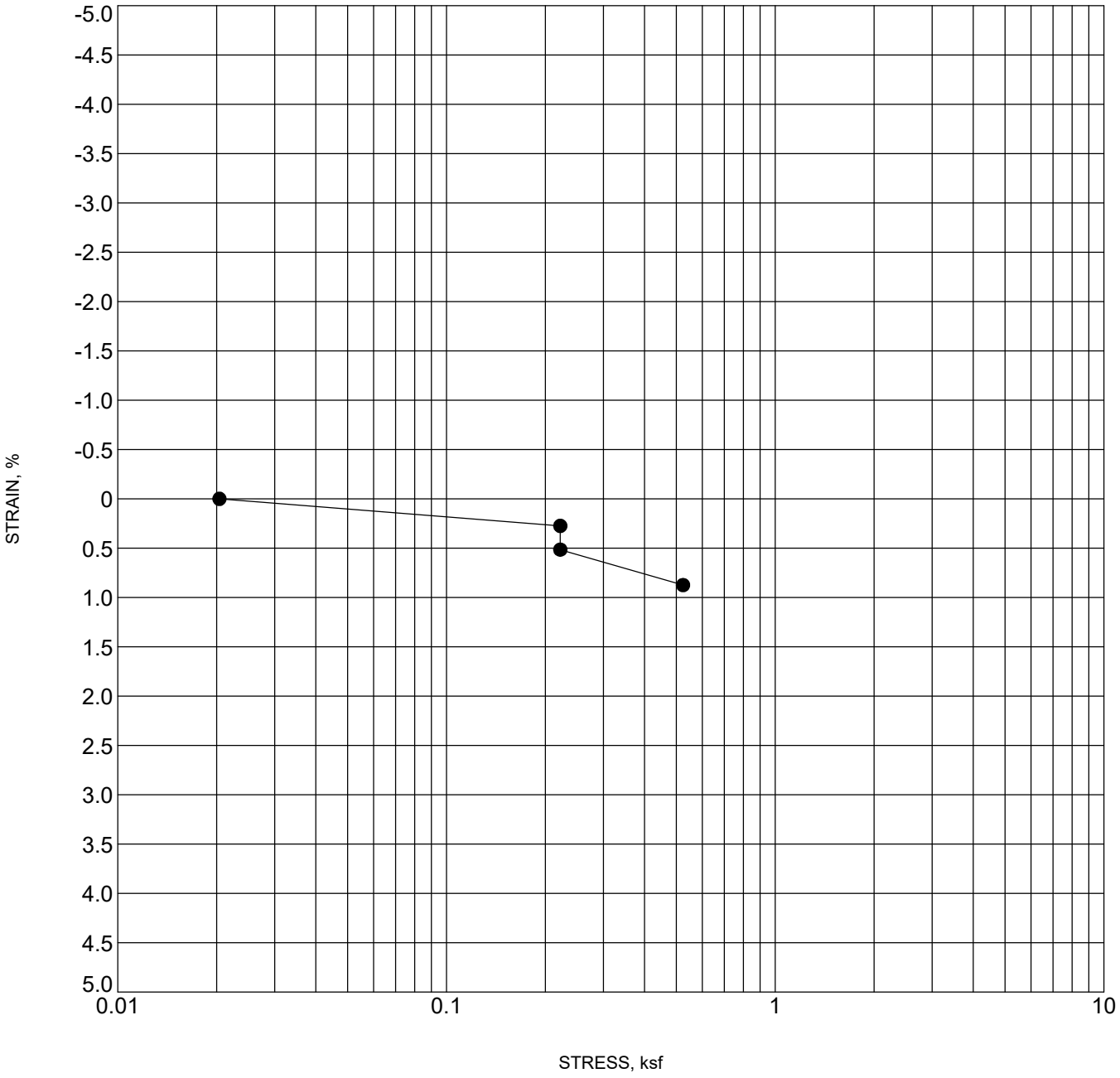
GRADATION - STANDARD 599.81_CROSBY AVE GEOTECH AND PAVEMENT DESIGN.GPJ ROCKSOL TEMPLATE.GDT 7/3/23

SWELL - CONSOLIDATION TEST

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction **PROJECT NAME** Crosby Avenue Improvements Project

PROJECT NUMBER 599.81 **PROJECT LOCATION** Grand Junction, Colorado



Specimen Identification	Classification	Swell/Consol. (%)	γ_d (pcf)	MC%
● **BH-4 2**	**SILTY to SANDY CLAY with GRAVEL**	**-0.2**	**102.9**	**19.7**

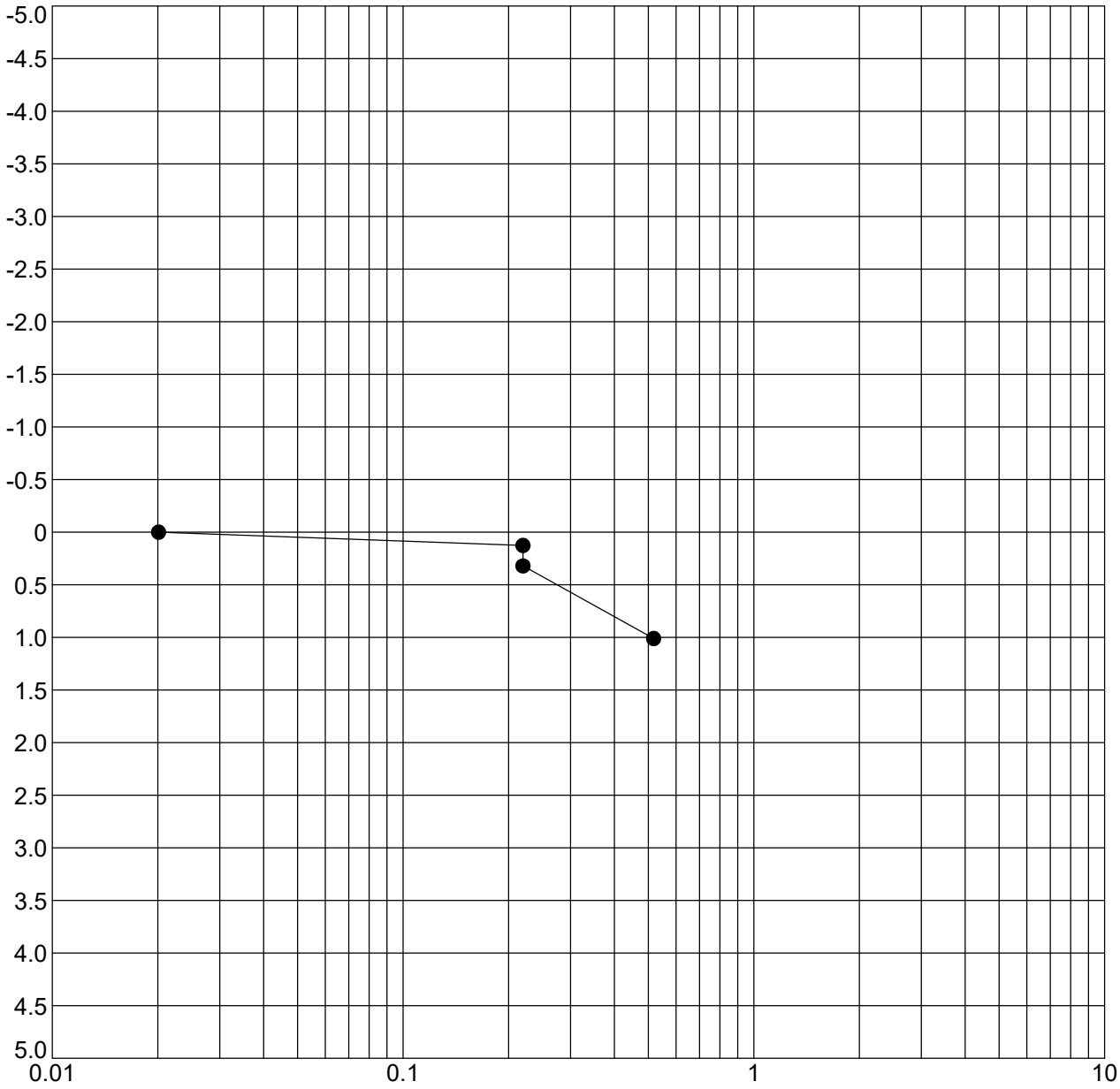
SWELL - STANDARD 599.81_CROSBY AVE GEOTECH AND PAVEMENT DESIGN.GPJ ROCKSOL TEMPLATE.GDT 7/3/23

SWELL - CONSOLIDATION TEST

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction **PROJECT NAME** Crosby Avenue Improvements Project

PROJECT NUMBER 599.81 **PROJECT LOCATION** Grand Junction, Colorado



Specimen Identification	Classification	Swell/Consol. (%)	γ_d (pcf)	MC%
● **BH-5 2**	**SILTY CLAY**	**-0.2**	**111.0**	**13.5**

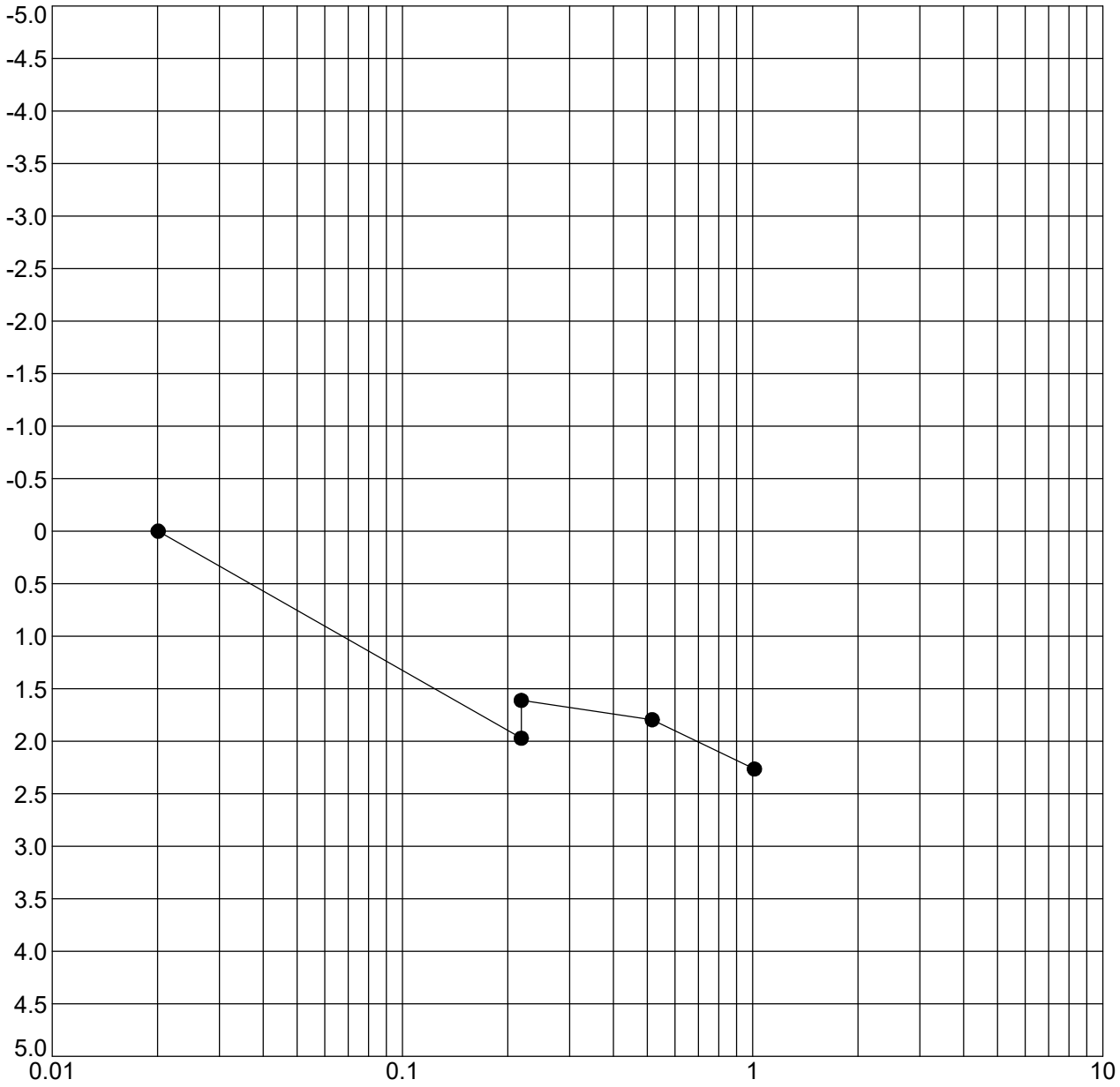
SWELL - STANDARD 599.81_CROSBY AVE GEOTECH AND PAVEMENT DESIGN.GPJ ROCKSOL TEMPLATE.GDT 7/3/23

SWELL - CONSOLIDATION TEST

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction **PROJECT NAME** Crosby Avenue Improvements Project

PROJECT NUMBER 599.81 **PROJECT LOCATION** Grand Junction, Colorado



Specimen Identification	Classification	Swell/Consol. (%)	γ_d (pcf)	MC%
● **BH-7 4**	**SANDY CLAY**	**0.4**	**118.1**	**19.2**

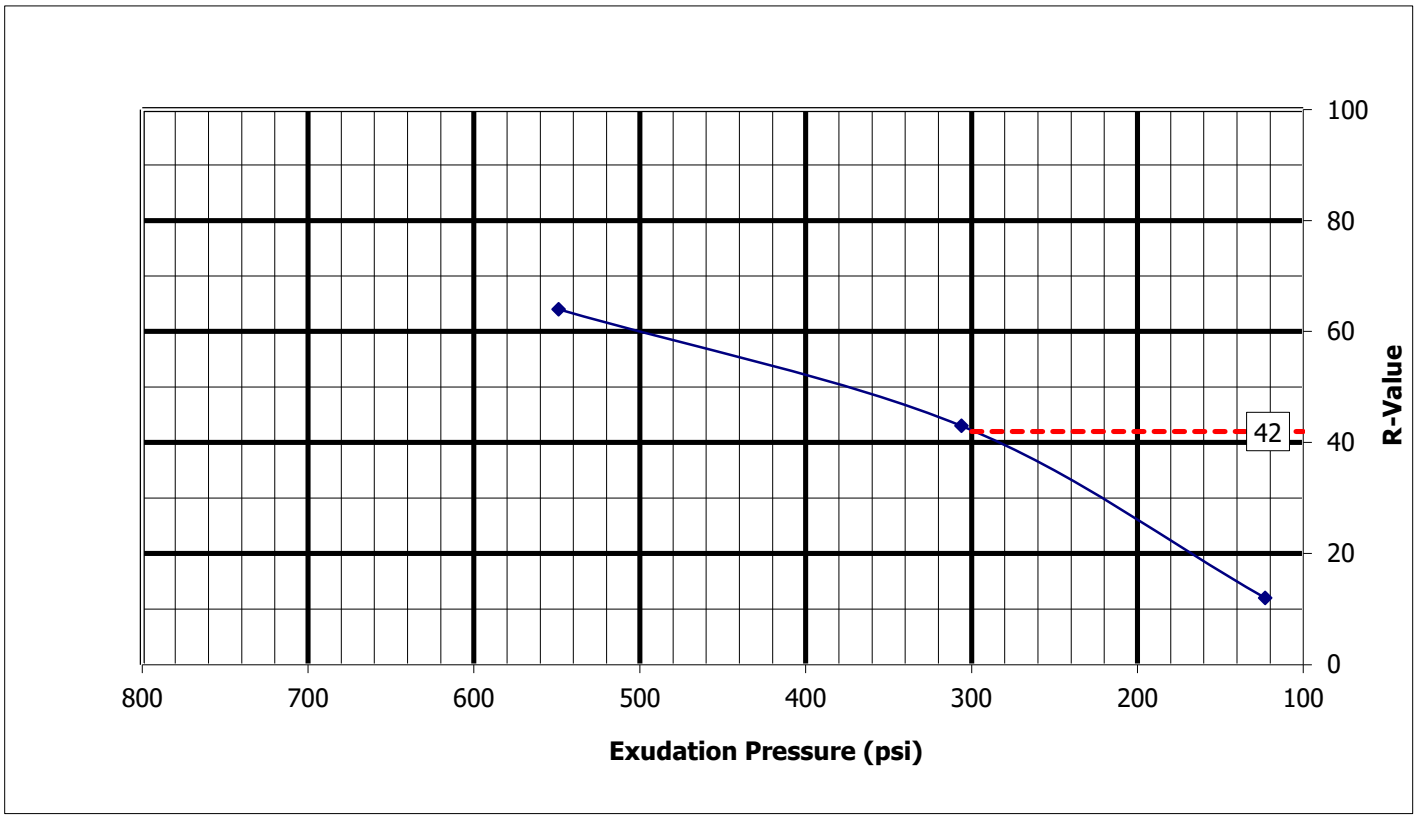
SWELL - STANDARD 599.81_CROSBY AVE GEOTECH AND PAVEMENT DESIGN.GPJ ROCKSOL TEMPLATE.GDT 7/3/23

CMT TECHNICAL SERVICES

AASHTO ACCREDITED

R-VALUE TEST GRAPH (AASHTO T190)

Project Number:	23.022, RockSol Consulting	Date:	03/07/23
Project Name:	City of GJ Crosby (RockSol Project No. 599.81)	Technician:	J. De Los Santos 232489
Lab ID Number:	Reviewer: G. Hoyos North bound turn lane approximately 400 feet from American Way - newer		
Sample Location:	roadway (BH-1 at 4 to 9 fee		
Visual Description:	SAND, gravelly, with silt, brown		



R-Value @ Exudation Pressure 300 psi: 42

Specification:

CDOT Pavement Design Manual, 2011.
Eq. 2.1 & 2.2, page 2-3.

$S_1 = [(R-5)/11.29]+3$ **S_1= 6.28**

$M_R = 10^{[(S_1+18.72)/6.24]}$ **M_R= 10,138**

M_R = Resilient Modulus, psi

S_1 = the Soil Support Value

R = the R-Value obtained

Test Specimen:	1	2	3
Moisture Content, %:	8.1	8.6	10.1
Expansion Pressure, psi:	0.12	0.03	-0.09
Dry Density, pcf:	132.3	131.8	127.9
R-Value:	64	43	12
Exudation Pressure, psi:	549	306	123

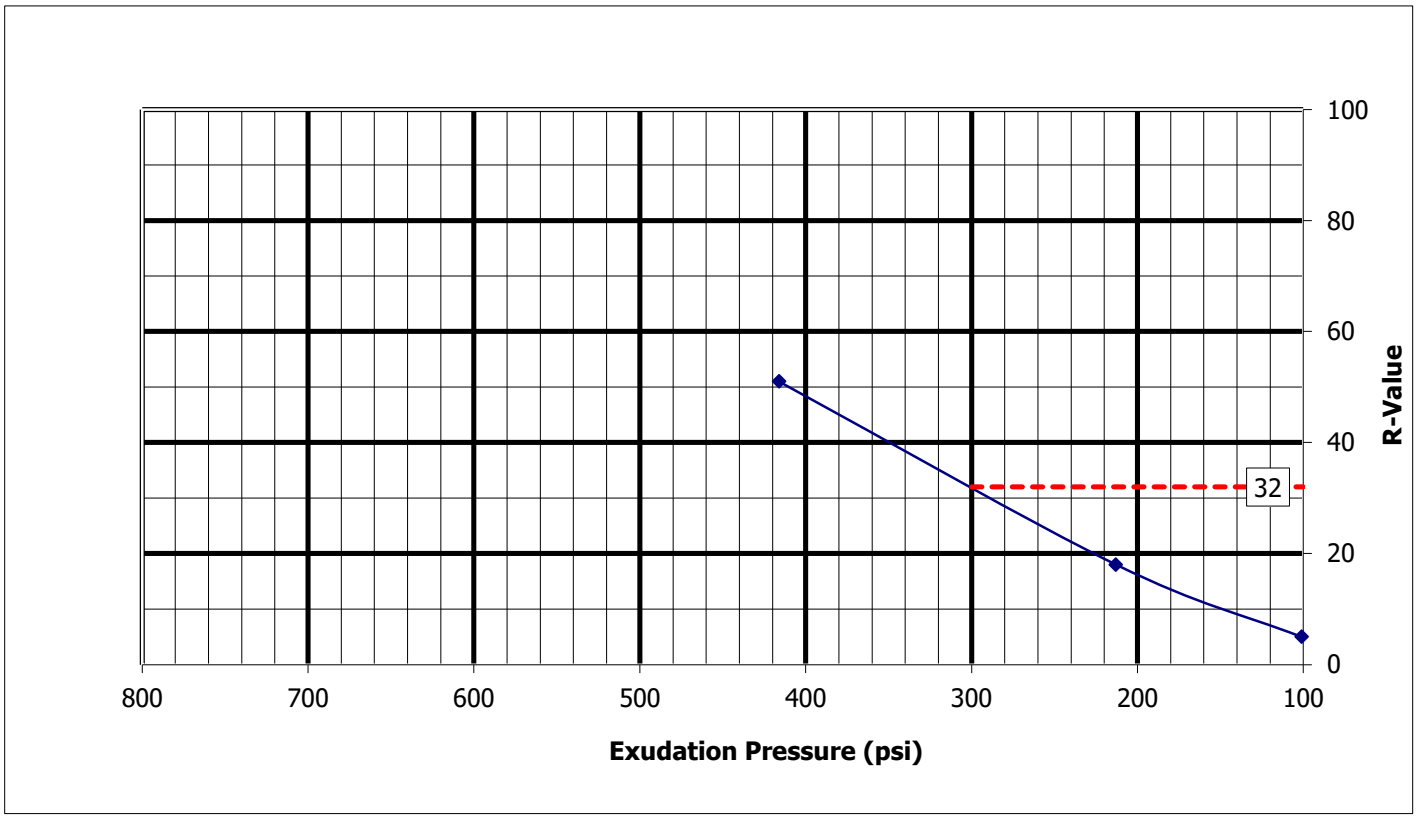
Note: The R-Value is measured; the M_R is an approximation from correlation formulas.

CMT TECHNICAL SERVICES

AASHTO ACCREDITED

R-VALUE TEST GRAPH (AASHTO T190)

Project Number:	23.022, RockSol Consulting	Date:	06/07/23
Project Name:	City of GJ Crosby (RockSol Project No. 599.81)	Technician:	J. De Los Santos 232490
Lab ID Number:	Reviewer: G. Hoyos Approximately 4 feet East of Edge Oil. 100 feet South of Broadway (BH-7 at 3		
Sample Location:	to 9 feet)		
Visual Description:	SAND, silty, brown		



R-Value @ Exudation Pressure 300 psi: **32**

Specification:

CDOT Pavement Design Manual, 2011.
Eq. 2.1 & 2.2, page 2-3.

$S_1 = [(R-5)/11.29]+3$ **S_1= 5.39**

$M_R = 10^{[(S_1+18.72)/6.24]}$ **M_R= 7,312**

M_R = Resilient Modulus, psi

S_1 = the Soil Support Value

R = the R-Value obtained

Test Specimen:	1	2	3
Moisture Content, %:	12.8	15.1	17.6
Expansion Pressure, psi:	0.21	0.17	-0.09
Dry Density, pcf:	119.0	116.3	111.3
R-Value:	51	18	5
Exudation Pressure, psi:	416	213	101

Note: The R-Value is measured; the M_R is an approximation from correlation formulas.

APPENDIX D

PAVEMENT CORE LOG REPORT

Existing Pavement Core Log Summary

Note 1: Total pavement thickness was measured in the field at the core hole and in the RockSol office. Where core material was lost during coring operations, the core measurements are based on core hole measurements.

Borehole ID: C-1

General Location: NB Crosby Avenue, ~ 300' S of American Way

Lane Location: On White Edge Line

Description:

Thickness of Asphalt Pavement: 5.50 inches

Thickness of Concrete Pavement: Not Present

Thickness of Aggregate Base Course: 13 inches

Condition of Asphalt: Good

Condition of Concrete: N/A

Diameter of Core: 4 inches

Date Core Obtained: 5/3/2023

Notes:

Photo taken looking South

Borehole ID: C-2

General Location: SB Crosby Avenue, ~400' N of Gunnison Avenue

Lane Location: Shoulder Pavement

Description:

Thickness of Asphalt Pavement: 5.50 inches

Thickness of Concrete Pavement: Not Present

Thickness of Aggregate Base Course: 13 inches

Condition of Asphalt: Good

Condition of Concrete: N/A

Diameter of Core: 4 inches

Date Core Obtained: 5/30/2023

Notes:

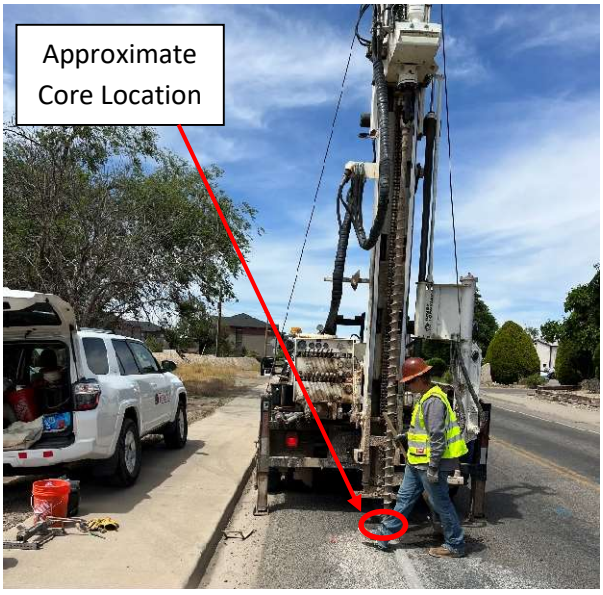
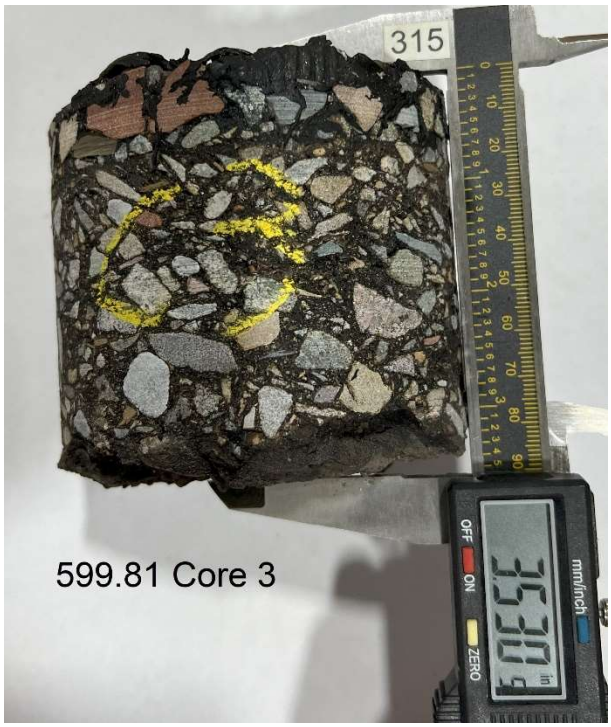


Photo taken looking North

Borehole ID: C-3

General Location: NB Crosby Avenue, ~200' S of Gunnison Avenue

Lane Location: Right Wheel Path



Description:

Thickness of Asphalt Pavement: 3.50 inches

Thickness of Concrete Pavement: Not Present

Thickness of Aggregate Base Course: 21 inches

Condition of Asphalt: Good

Condition of Concrete: N/A

Diameter of Core: 4 inches

Date Core Obtained: 5/30/2023

Notes:

Photo taken looking North

Borehole ID: C-4

General Location: NB Crosby Avenue, ~550' S of Gunnison Avenue

Lane Location: N/A

Description:

Thickness of Asphalt Pavement: 3.00 inches

Thickness of Concrete Pavement: Not Present

Thickness of Aggregate Base Course: Not Measured

Condition of Asphalt: Fair-Good

Condition of Concrete: N/A

Diameter of Core: 4 inches

Date Core Obtained: 5/30/2023

Notes:

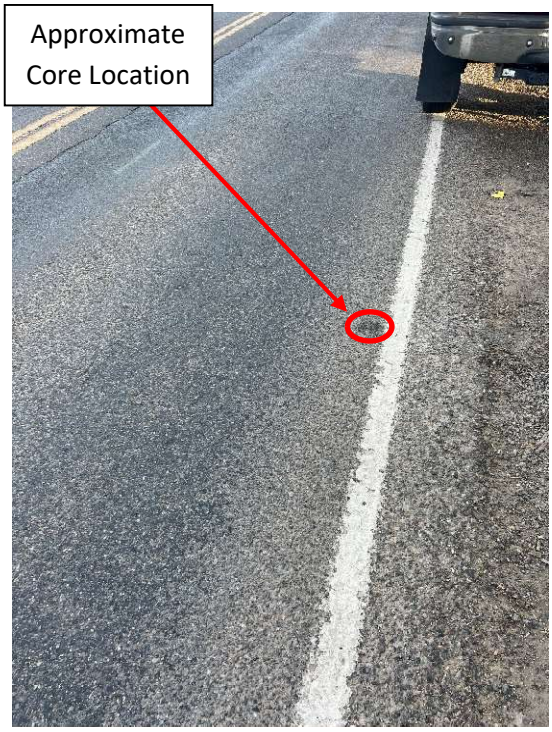


Photo taken looking North

Borehole ID: C-6

General Location: NB Crosby Avenue, ~200' NW of Broadway

Lane Location: Right Wheel Path

Description:

Thickness of Asphalt Pavement: 1.75 inches

Thickness of Concrete Pavement: Not Present

Thickness of Aggregate Base Course: 16 inches

Condition of Asphalt: Fair

Condition of Concrete: N/A

Diameter of Core: 4 inches

Date Core Obtained: 5/30/2023

Notes:

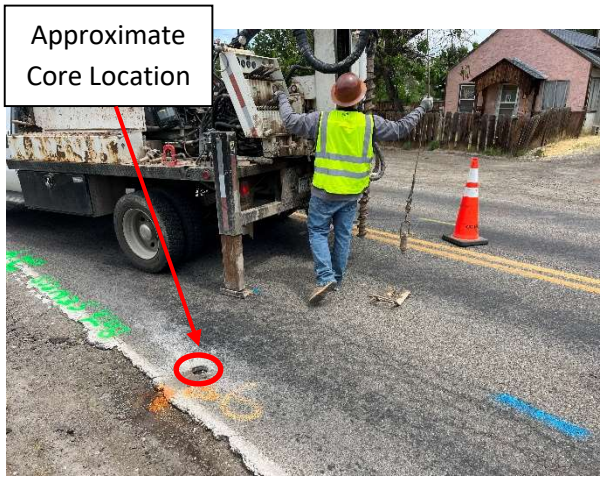


Photo taken looking South

Borehole ID: C-8

General Location: SB Crosby Avenue, ~200' N of Main Street

Lane Location: Center of Lane

Description:

Thickness of Asphalt Pavement: 4.50 inches

Thickness of Concrete Pavement: Not Present

Thickness of Aggregate Base Course: 13 inches

Condition of Asphalt: Good

Condition of Concrete: N/A

Diameter of Core: 4 inches

Date Core Obtained: 5/30/2023

Notes:

Photo taken looking North

APPENDIX E

PAVEMENT EVALUATION CHECKLIST

PAVEMENT EVALUATION CHECKLIST (FLEXIBLE)

PROJECT NO.: 599.81
PROJECT CODE (SA #): City of GJ
DATE: 6/27/23

LOCATION: Crosby Avenue
DIRECTION: MP 1st Street to MP American Way
BY: Wade Coniff (support from Dave Eller)
TITLE: Materials Tech Intern

DISTRESS EVALUATION SURVEY

Type	Distress Severity*	Distress Amount*
Alligator (Fatigue) Cracking	Severe	~30% shows allegator
Bleeding	low	less than 5% (chipseal)
Block Cracking	Moderate	Cracking approx 0.25"
Corrugation	low	
Depression	low	
Joint Reflection Cracking (from PCC Slab)	n/a	
Lane/Shoulder Joint Separation	Severe	Shoulder breaking away
Longitudinal Cracking	Moderate	
Transverse Cracking	low	
Patch Deterioration	Moderate	
Polished Aggregate		
Potholes	Moderate	
Raveling/Weathering		
Rutting	low	
Slippage Cracking		
OTHER		

Many portions of the Roadway which seemed to be bleeding appear to have been chip-sealed, and that is believed to be the root cause for the bleeding.
The roadway had very severe damage to the shoulder, patchwork appeared to be attempted but hasn't held up the greatest.
The roadway had multiple utility patches which were experiencing cracking along the joints with the existing road.
Measurements of the rutting showed rutting no greater than 1/4 inch.

APPENDIX F

GRAND JUNCTION TRAFFIC DATA

Daily Vehicle Volume Report

Study Date: Wednesday, 05/12/2021
Unit ID: H-2
Location: CROSBY AVE SOUTH OF W GUNNISON AVE

	Northbound Volume	Southbound Volume	Total Volume
00:00 - 00:59	2	0	**2**
01:00 - 01:59	0	0	**0**
02:00 - 02:59	3	1	**4**
03:00 - 03:59	3	2	**5**
04:00 - 04:59	10	2	**12**
05:00 - 05:59	15	8	**23**
06:00 - 06:59	26	28	**54**
07:00 - 07:59	28	59	**87**
08:00 - 08:59	42	74	**116**
09:00 - 09:59	46	74	**120**
10:00 - 10:59	60	113	**173**
11:00 - 11:59	61	158	**219**
12:00 - 12:59	61	154	**215**
13:00 - 13:59	56	186	**242**
14:00 - 14:59	34	149	**183**
15:00 - 15:59	50	168	**218**
16:00 - 16:59	46	168	**214**
17:00 - 17:59	54	164	**218**
18:00 - 18:59	38	119	**157**
19:00 - 19:59	16	94	**110**
20:00 - 20:59	11	66	**77**
21:00 - 21:59	11	56	**67**
22:00 - 22:59	5	27	**32**
23:00 - 23:59	0	10	**10**
Totals	**678**	**1880**	**2558**
AM Peak Time	**10:13 - 11:12**	**10:55 - 11:54**	**11:00 - 11:59**
AM Peak Volume	**64**	**161**	**219**
PM Peak Time	**16:11 - 17:10**	**12:57 - 13:56**	**12:56 - 13:55**
PM Peak Volume	**70**	**189**	**245**

Daily Northbound Classes Report

Study Date: Wednesday, 05/12/2021
Unit ID: H-2
Location: CROSBY AVE SOUTH OF W GUNNISON AVE

	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	Total
00:00 - 00:59	0	1	1	0	0	0	0	0	0	0	0	0	0	**2**
01:00 - 01:59	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
02:00 - 02:59	0	3	0	0	0	0	0	0	0	0	0	0	0	**3**
03:00 - 03:59	0	3	0	0	0	0	0	0	0	0	0	0	0	**3**
04:00 - 04:59	0	6	2	0	2	0	0	0	0	0	0	0	0	**10**
05:00 - 05:59	0	12	2	0	1	0	0	0	0	0	0	0	0	**15**
06:00 - 06:59	0	18	2	0	6	0	0	0	0	0	0	0	0	**26**
07:00 - 07:59	0	17	8	0	3	0	0	0	0	0	0	0	0	**28**
08:00 - 08:59	0	21	9	0	10	1	0	0	1	0	0	0	0	**42**
09:00 - 09:59	0	31	7	0	7	0	0	0	1	0	0	0	0	**46**
10:00 - 10:59	0	44	7	1	8	0	0	0	0	0	0	0	0	**60**
11:00 - 11:59	0	38	6	1	13	2	0	1	0	0	0	0	0	**61**
12:00 - 12:59	0	47	6	0	8	0	0	0	0	0	0	0	0	**61**
13:00 - 13:59	0	45	7	0	4	0	0	0	0	0	0	0	0	**56**
14:00 - 14:59	0	22	4	1	7	0	0	0	0	0	0	0	0	**34**
15:00 - 15:59	0	39	7	0	4	0	0	0	0	0	0	0	0	**50**
16:00 - 16:59	0	33	8	0	5	0	0	0	0	0	0	0	0	**46**
17:00 - 17:59	0	42	7	0	5	0	0	0	0	0	0	0	0	**54**
18:00 - 18:59	0	28	4	0	5	0	0	1	0	0	0	0	0	**38**
19:00 - 19:59	0	11	4	0	1	0	0	0	0	0	0	0	0	**16**
20:00 - 20:59	0	8	2	0	1	0	0	0	0	0	0	0	0	**11**
21:00 - 21:59	0	10	1	0	0	0	0	0	0	0	0	0	0	**11**
22:00 - 22:59	0	3	1	0	1	0	0	0	0	0	0	0	0	**5**
23:00 - 23:59	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Totals	**0**	**482**	**95**	**3**	**91**	**3**	**0**	**2**	**2**	**0**	**0**	**0**	**0**	**678**
Percent of Total	**0.0**	**71.1**	**14.0**	**0.4**	**13.4**	**0.4**	**0.0**	**0.3**	**0.3**	**0.0**	**0.0**	**0.0**	**0.0**	**100**
Percent of AM	**0.0**	**65.5**	**14.9**	**0.7**	**16.9**	**1.0**	**0.0**	**0.3**	**0.7**	**0.0**	**0.0**	**0.0**	**0.0**	**100**
Percent of PM	**0.0**	**75.4**	**13.4**	**0.3**	**10.7**	**0.0**	**0.0**	**0.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**100**

Truck Summary:

Total Trucks: 101 % Trucks: 14.9 AM % Trucks: 19.6 PM % Trucks: 11.3

Classification Scheme: FHWA (ID: 1)

#1 Motorcycles - 2 Axles
#2 Passenger Cars - 2 Axles
#3 Pickup Trucks, Vans - 2 Axles
#4 Buses
#5 Single Unit - 2 Axles, 6 Tires
#6 Single Unit Truck - 3 Axles
#7 Single Unit - 4 Axles
#8 Single Unit - 4 Axles or Less
#9 Double Unit - 5 Axles
#10 Double Unit - 6 Axles or More
#11 Multi-Unit - 5 Axles or Less
#12 Multi-Unit - 6 Axles
#13 Multi-Unit - 7 Axles or More

Daily Southbound Classes Report

Study Date: Wednesday, 05/12/2021
Unit ID: H-2
Location: CROSBY AVE SOUTH OF W GUNNISON AVE

	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	Total
00:00 - 00:59	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
01:00 - 01:59	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
02:00 - 02:59	0	1	0	0	0	0	0	0	0	0	0	0	0	**1**
03:00 - 03:59	0	1	0	0	1	0	0	0	0	0	0	0	0	**2**
04:00 - 04:59	0	2	0	0	0	0	0	0	0	0	0	0	0	**2**
05:00 - 05:59	0	2	2	0	3	1	0	0	0	0	0	0	0	**8**
06:00 - 06:59	0	16	7	0	5	0	0	0	0	0	0	0	0	**28**
07:00 - 07:59	0	42	7	1	9	0	0	0	0	0	0	0	0	**59**
08:00 - 08:59	0	46	11	0	15	1	0	0	1	0	0	0	0	**74**
09:00 - 09:59	0	44	11	0	18	1	0	0	0	0	0	0	0	**74**
10:00 - 10:59	0	83	11	0	19	0	0	0	0	0	0	0	0	**113**
11:00 - 11:59	1	108	21	0	27	0	0	1	0	0	0	0	0	**158**
12:00 - 12:59	1	105	26	0	21	0	0	0	1	0	0	0	0	**154**
13:00 - 13:59	0	143	25	1	17	0	0	0	0	0	0	0	0	**186**
14:00 - 14:59	0	113	19	0	17	0	0	0	0	0	0	0	0	**149**
15:00 - 15:59	0	129	18	0	21	0	0	0	0	0	0	0	0	**168**
16:00 - 16:59	0	129	17	0	21	0	0	1	0	0	0	0	0	**168**
17:00 - 17:59	2	113	30	0	19	0	0	0	0	0	0	0	0	**164**
18:00 - 18:59	1	83	19	0	16	0	0	0	0	0	0	0	0	**119**
19:00 - 19:59	0	73	12	0	9	0	0	0	0	0	0	0	0	**94**
20:00 - 20:59	0	55	4	0	7	0	0	0	0	0	0	0	0	**66**
21:00 - 21:59	0	45	4	0	7	0	0	0	0	0	0	0	0	**56**
22:00 - 22:59	0	23	2	0	2	0	0	0	0	0	0	0	0	**27**
23:00 - 23:59	0	6	2	0	2	0	0	0	0	0	0	0	0	**10**
Totals	**5**	**1362**	**248**	**2**	**256**	**3**	**0**	**2**	**2**	**0**	**0**	**0**	**0**	**1880**
Percent of Total	**0.3**	**72.4**	**13.2**	**0.1**	**13.6**	**0.2**	**0.0**	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**100**
Percent of AM	**0.2**	**66.5**	**13.5**	**0.2**	**18.7**	**0.6**	**0.0**	**0.2**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**	**100**
Percent of PM	**0.3**	**74.7**	**13.1**	**0.1**	**11.7**	**0.0**	**0.0**	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**100**

Truck Summary:

Total Trucks: 265 % Trucks: 14.1 AM % Trucks: 19.8 PM % Trucks: 11.9

Classification Scheme: FHWA (ID: 1)

#1 Motorcycles - 2 Axles
#2 Passenger Cars - 2 Axles
#3 Pickup Trucks, Vans - 2 Axles
#4 Buses
#5 Single Unit - 2 Axles, 6 Tires
#6 Single Unit Truck - 3 Axles
#7 Single Unit - 4 Axles
#8 Single Unit - 4 Axles or Less
#9 Double Unit - 5 Axles
#10 Double Unit - 6 Axles or More
#11 Multi-Unit - 5 Axles or Less
#12 Multi-Unit - 6 Axles
#13 Multi-Unit - 7 Axles or More

Daily Total Classes Report

Study Date: Wednesday, 05/12/2021
Unit ID: H-2
Location: CROSBY AVE SOUTH OF W GUNNISON AVE

	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	Total
00:00 - 00:59	0	1	1	0	0	0	0	0	0	0	0	0	0	**2**
01:00 - 01:59	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
02:00 - 02:59	0	4	0	0	0	0	0	0	0	0	0	0	0	**4**
03:00 - 03:59	0	4	0	0	1	0	0	0	0	0	0	0	0	**5**
04:00 - 04:59	0	8	2	0	2	0	0	0	0	0	0	0	0	**12**
05:00 - 05:59	0	14	4	0	4	1	0	0	0	0	0	0	0	**23**
06:00 - 06:59	0	34	9	0	11	0	0	0	0	0	0	0	0	**54**
07:00 - 07:59	0	59	15	1	12	0	0	0	0	0	0	0	0	**87**
08:00 - 08:59	0	67	20	0	25	2	0	0	2	0	0	0	0	**116**
09:00 - 09:59	0	75	18	0	25	1	0	0	1	0	0	0	0	**120**
10:00 - 10:59	0	127	18	1	27	0	0	0	0	0	0	0	0	**173**
11:00 - 11:59	1	146	27	1	40	2	0	2	0	0	0	0	0	**219**
12:00 - 12:59	1	152	32	0	29	0	0	0	1	0	0	0	0	**215**
13:00 - 13:59	0	188	32	1	21	0	0	0	0	0	0	0	0	**242**
14:00 - 14:59	0	135	23	1	24	0	0	0	0	0	0	0	0	**183**
15:00 - 15:59	0	168	25	0	25	0	0	0	0	0	0	0	0	**218**
16:00 - 16:59	0	162	25	0	26	0	0	1	0	0	0	0	0	**214**
17:00 - 17:59	2	155	37	0	24	0	0	0	0	0	0	0	0	**218**
18:00 - 18:59	1	111	23	0	21	0	0	1	0	0	0	0	0	**157**
19:00 - 19:59	0	84	16	0	10	0	0	0	0	0	0	0	0	**110**
20:00 - 20:59	0	63	6	0	8	0	0	0	0	0	0	0	0	**77**
21:00 - 21:59	0	55	5	0	7	0	0	0	0	0	0	0	0	**67**
22:00 - 22:59	0	26	3	0	3	0	0	0	0	0	0	0	0	**32**
23:00 - 23:59	0	6	2	0	2	0	0	0	0	0	0	0	0	**10**
Totals	**5**	**1844**	**343**	**5**	**347**	**6**	**0**	**4**	**4**	**0**	**0**	**0**	**0**	**2558**
Percent of Total	**0.2**	**72.1**	**13.4**	**0.2**	**13.6**	**0.2**	**0.0**	**0.2**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**	**100**
Percent of AM	**0.1**	**66.1**	**14.0**	**0.4**	**18.0**	**0.7**	**0.0**	**0.2**	**0.4**	**0.0**	**0.0**	**0.0**	**0.0**	**100**
Percent of PM	**0.2**	**74.9**	**13.1**	**0.1**	**11.5**	**0.0**	**0.0**	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**100**

Truck Summary:

Total Trucks: 366 % Trucks: 14.3 AM % Trucks: 19.8 PM % Trucks: 11.8

Classification Scheme: FHWA (ID: 1)

#1 Motorcycles - 2 Axles
#2 Passenger Cars - 2 Axles
#3 Pickup Trucks, Vans - 2 Axles
#4 Buses
#5 Single Unit - 2 Axles, 6 Tires
#6 Single Unit Truck - 3 Axles
#7 Single Unit - 4 Axles
#8 Single Unit - 4 Axles or Less
#9 Double Unit - 5 Axles
#10 Double Unit - 6 Axles or More
#11 Multi-Unit - 5 Axles or Less
#12 Multi-Unit - 6 Axles
#13 Multi-Unit - 7 Axles or More

Daily Northbound Speeds (MPH)

Study Date: Wednesday, 05/12/2021
Unit ID: H-2
Location: CROSBY AVE SOUTH OF W GUNNISON AVE
Posted Speed: 30

	5-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-99	Total
00:00 - 00:59	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	**2**
01:00 - 01:59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
02:00 - 02:59	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	**3**
03:00 - 03:59	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	**3**
04:00 - 04:59	0	0	1	0	4	0	2	2	0	1	0	0	0	0	0	**10**
05:00 - 05:59	0	0	0	1	8	4	2	0	0	0	0	0	0	0	0	**15**
06:00 - 06:59	0	0	2	3	7	7	5	2	0	0	0	0	0	0	0	**26**
07:00 - 07:59	0	0	0	1	6	12	6	1	1	1	0	0	0	0	0	**28**
08:00 - 08:59	0	0	1	2	14	19	4	2	0	0	0	0	0	0	0	**42**
09:00 - 09:59	0	0	0	3	21	14	7	0	0	1	0	0	0	0	0	**46**
10:00 - 10:59	0	0	1	8	23	20	6	2	0	0	0	0	0	0	0	**60**
11:00 - 11:59	0	0	3	7	18	21	9	2	0	0	0	0	0	0	1	**61**
12:00 - 12:59	0	1	0	7	14	25	12	1	1	0	0	0	0	0	0	**61**
13:00 - 13:59	0	1	0	5	17	21	9	2	1	0	0	0	0	0	0	**56**
14:00 - 14:59	0	0	0	1	13	10	8	2	0	0	0	0	0	0	0	**34**
15:00 - 15:59	0	0	0	8	18	15	8	1	0	0	0	0	0	0	0	**50**
16:00 - 16:59	0	0	0	5	12	19	8	2	0	0	0	0	0	0	0	**46**
17:00 - 17:59	0	0	0	3	20	18	6	4	2	0	0	0	0	0	0	**53**
18:00 - 18:59	1	0	2	3	7	16	8	1	0	0	0	0	0	0	0	**38**
19:00 - 19:59	0	0	0	2	8	3	1	2	0	0	0	0	0	0	0	**16**
20:00 - 20:59	0	1	1	4	3	2	0	0	0	0	0	0	0	0	0	**11**
21:00 - 21:59	0	0	0	0	4	6	1	0	0	0	0	0	0	0	0	**11**
22:00 - 22:59	0	0	0	0	1	3	1	0	0	0	0	0	0	0	0	**5**
23:00 - 23:59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Totals	**1**	**4**	**11**	**63**	**223**	**237**	**103**	**26**	**5**	**3**	**0**	**0**	**0**	**0**	**1**	**677**
Percent of Total	**0.1**	**0.6**	**1.6**	**9.3**	**32.9**	**35.0**	**15.2**	**3.8**	**0.7**	**0.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**100**
Percent of AM	**0.0**	**0.3**	**2.7**	**8.4**	**35.8**	**33.4**	**13.9**	**3.7**	**0.3**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.3**	**100**
Percent of PM	**0.3**	**0.8**	**0.8**	**10.0**	**30.7**	**36.2**	**16.3**	**3.9**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**100**

Standard Deviation: 6.3 MPH
Mean Speed: 35.9 MPH
Median Speed: 35.8 MPH
Modal Speed: 37.5 MPH

Ten Mile Pace: 30 to 39 MPH
Percent in Ten Mile Pace: 67.9%

85th Percentile: 41.7 MPH
15th Percentile: 30.5 MPH
90th Percentile: 43.4 MPH
95th Percentile: 45.1 MPH

Daily Southbound Speeds (MPH)

Study Date: Wednesday, 05/12/2021
Unit ID: H-2
Location: CROSBY AVE SOUTH OF W GUNNISON AVE
Posted Speed: 30

	5-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-99	Total
00:00 - 00:59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
01:00 - 01:59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
02:00 - 02:59	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**
03:00 - 03:59	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	**2**
04:00 - 04:59	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	**2**
05:00 - 05:59	0	0	1	0	4	3	0	0	0	0	0	0	0	0	0	**8**
06:00 - 06:59	0	0	0	7	15	4	2	0	0	0	0	0	0	0	0	**28**
07:00 - 07:59	0	2	1	6	24	20	6	0	0	0	0	0	0	0	0	**59**
08:00 - 08:59	0	0	1	15	32	23	3	0	0	0	0	0	0	0	0	**74**
09:00 - 09:59	0	0	3	20	29	14	6	1	0	1	0	0	0	0	0	**74**
10:00 - 10:59	0	0	4	27	50	27	5	0	0	0	0	0	0	0	0	**113**
11:00 - 11:59	0	1	3	45	70	30	5	2	1	0	1	0	0	0	0	**158**
12:00 - 12:59	0	0	8	35	76	27	7	0	0	0	0	1	0	0	0	**154**
13:00 - 13:59	0	0	2	32	90	50	10	1	1	0	0	0	0	0	0	**186**
14:00 - 14:59	0	0	2	20	83	34	8	1	1	0	0	0	0	0	0	**149**
15:00 - 15:59	0	0	2	43	75	37	8	2	1	0	0	0	0	0	0	**168**
16:00 - 16:59	0	1	0	24	83	52	8	0	0	0	0	0	0	0	0	**168**
17:00 - 17:59	0	0	3	34	66	49	11	0	0	0	1	0	0	0	0	**164**
18:00 - 18:59	0	0	1	17	49	43	9	0	0	0	0	0	0	0	0	**119**
19:00 - 19:59	0	0	1	15	52	19	6	1	0	0	0	0	0	0	0	**94**
20:00 - 20:59	0	1	3	25	26	9	1	1	0	0	0	0	0	0	0	**66**
21:00 - 21:59	1	2	4	10	15	15	7	1	1	0	0	0	0	0	0	**56**
22:00 - 22:59	0	0	3	3	12	7	2	0	0	0	0	0	0	0	0	**27**
23:00 - 23:59	0	0	0	3	3	3	1	0	0	0	0	0	0	0	0	**10**
Totals	**1**	**7**	**43**	**384**	**854**	**467**	**105**	**10**	**5**	**1**	**2**	**1**	**0**	**0**	**0**	**1880**
Percent of Total	**0.1**	**0.4**	**2.3**	**20.4**	**45.4**	**24.8**	**5.6**	**0.5**	**0.3**	**0.1**	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**	**100**
Percent of AM	**0.0**	**0.6**	**2.7**	**23.7**	**43.2**	**23.5**	**5.2**	**0.6**	**0.2**	**0.2**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**	**100**
Percent of PM	**0.1**	**0.3**	**2.1**	**19.2**	**46.3**	**25.3**	**5.7**	**0.5**	**0.3**	**0.0**	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**	**100**

Standard Deviation: 5.1 MPH
Mean Speed: 33.2 MPH
Median Speed: 33.0 MPH
Modal Speed: 32.5 MPH

Ten Mile Pace: 30 to 39 MPH
Percent in Ten Mile Pace: 70.3%

85th Percentile: 38.3 MPH
15th Percentile: 28.0 MPH
90th Percentile: 39.3 MPH
95th Percentile: 41.4 MPH

Daily Total Speeds (MPH)

Study Date: Wednesday, 05/12/2021
Unit ID: H-2
Location: CROSBY AVE SOUTH OF W GUNNISON AVE
Posted Speed: 30

	5-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-99	Total
00:00 - 00:59	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	**2**
01:00 - 01:59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
02:00 - 02:59	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	**4**
03:00 - 03:59	0	0	0	2	2	1	0	0	0	0	0	0	0	0	0	**5**
04:00 - 04:59	0	0	1	1	4	1	2	2	0	1	0	0	0	0	0	**12**
05:00 - 05:59	0	0	1	1	12	7	2	0	0	0	0	0	0	0	0	**23**
06:00 - 06:59	0	0	2	10	22	11	7	2	0	0	0	0	0	0	0	**54**
07:00 - 07:59	0	2	1	7	30	32	12	1	1	1	0	0	0	0	0	**87**
08:00 - 08:59	0	0	2	17	46	42	7	2	0	0	0	0	0	0	0	**116**
09:00 - 09:59	0	0	3	23	50	28	13	1	0	2	0	0	0	0	0	**120**
10:00 - 10:59	0	0	5	35	73	47	11	2	0	0	0	0	0	0	0	**173**
11:00 - 11:59	0	1	6	52	88	51	14	4	1	0	1	0	0	0	1	**219**
12:00 - 12:59	0	1	8	42	90	52	19	1	1	0	0	1	0	0	0	**215**
13:00 - 13:59	0	1	2	37	107	71	19	3	2	0	0	0	0	0	0	**242**
14:00 - 14:59	0	0	2	21	96	44	16	3	1	0	0	0	0	0	0	**183**
15:00 - 15:59	0	0	2	51	93	52	16	3	1	0	0	0	0	0	0	**218**
16:00 - 16:59	0	1	0	29	95	71	16	2	0	0	0	0	0	0	0	**214**
17:00 - 17:59	0	0	3	37	86	67	17	4	2	0	1	0	0	0	0	**217**
18:00 - 18:59	1	0	3	20	56	59	17	1	0	0	0	0	0	0	0	**157**
19:00 - 19:59	0	0	1	17	60	22	7	3	0	0	0	0	0	0	0	**110**
20:00 - 20:59	0	2	4	29	29	11	1	1	0	0	0	0	0	0	0	**77**
21:00 - 21:59	1	2	4	10	19	21	8	1	1	0	0	0	0	0	0	**67**
22:00 - 22:59	0	0	3	3	13	10	3	0	0	0	0	0	0	0	0	**32**
23:00 - 23:59	0	0	0	3	3	3	1	0	0	0	0	0	0	0	0	**10**
Totals	**2**	**11**	**54**	**447**	**1077**	**704**	**208**	**36**	**10**	**4**	**2**	**1**	**0**	**0**	**1**	**2557**
Percent of Total	**0.1**	**0.4**	**2.1**	**17.5**	**42.1**	**27.5**	**8.1**	**1.4**	**0.4**	**0.2**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**100**
Percent of AM	**0.0**	**0.5**	**2.7**	**18.2**	**40.5**	**27.1**	**8.3**	**1.7**	**0.2**	**0.5**	**0.1**	**0.0**	**0.0**	**0.0**	**0.1**	**100**
Percent of PM	**0.1**	**0.4**	**1.8**	**17.2**	**42.9**	**27.7**	**8.0**	**1.3**	**0.5**	**0.0**	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**	**100**

Standard Deviation: 5.6 MPH
Mean Speed: 33.9 MPH
Median Speed: 33.5 MPH
Modal Speed: 32.5 MPH

Ten Mile Pace: 30 to 39 MPH
Percent in Ten Mile Pace: 69.7%

85th Percentile: 39.1 MPH
15th Percentile: 28.5 MPH
90th Percentile: 40.1 MPH
95th Percentile: 43.2 MPH

Weekly Volumes

Unit ID: H-2

Location: CROSBY AVE SOUTH OF W GUNNISON AVE

Week of 05/12/2021

Start Time	05/12 Wednesday		05/13 Thursday		05/14 Friday		05/15 Saturday		05/16 Sunday		05/17 Monday		05/18 Tuesday		Daily Average	
	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB
00:00	2	0	-	-	-	-	-	-	-	-	-	-	-	-	2	0
01:00	0	0	-	-	-	-	-	-	-	-	-	-	-	-	0	0
02:00	3	1	-	-	-	-	-	-	-	-	-	-	-	-	3	1
03:00	3	2	-	-	-	-	-	-	-	-	-	-	-	-	3	2
04:00	10	2	-	-	-	-	-	-	-	-	-	-	-	-	10	2
05:00	15	8	-	-	-	-	-	-	-	-	-	-	-	-	15	8
06:00	26	28	-	-	-	-	-	-	-	-	-	-	-	-	26	28
07:00	28	59	-	-	-	-	-	-	-	-	-	-	-	-	28	59
08:00	42	74	-	-	-	-	-	-	-	-	-	-	-	-	42	74
09:00	46	74	-	-	-	-	-	-	-	-	-	-	-	-	46	74
10:00	60	113	-	-	-	-	-	-	-	-	-	-	-	-	60	113
11:00	61	158	-	-	-	-	-	-	-	-	-	-	-	-	61	158
12:00	61	154	-	-	-	-	-	-	-	-	-	-	-	-	61	154
13:00	56	186	-	-	-	-	-	-	-	-	-	-	-	-	56	186
14:00	34	149	-	-	-	-	-	-	-	-	-	-	-	-	34	149
15:00	50	168	-	-	-	-	-	-	-	-	-	-	-	-	50	168
16:00	46	168	-	-	-	-	-	-	-	-	-	-	-	-	46	168
17:00	54	164	-	-	-	-	-	-	-	-	-	-	-	-	54	164
18:00	38	119	-	-	-	-	-	-	-	-	-	-	-	-	38	119
19:00	16	94	-	-	-	-	-	-	-	-	-	-	-	-	16	94
20:00	11	66	-	-	-	-	-	-	-	-	-	-	-	-	11	66
21:00	11	56	-	-	-	-	-	-	-	-	-	-	-	-	11	56
22:00	5	27	-	-	-	-	-	-	-	-	-	-	-	-	5	27
23:00	0	10	-	-	-	-	-	-	-	-	-	-	-	-	0	10
Lane Total	678	1880	-	-	-	-	-	-	-	-	-	-	-	-	678	1880
Day Total		2558		-		-		-		-		-		-		2558
AM Peak	10:13	10:55	-	-	-	-	-	-	-	-	-	-	-	-	11:00	11:00
AM Count	64	161	-	-	-	-	-	-	-	-	-	-	-	-	61	158
PM Peak	16:11	12:57	-	-	-	-	-	-	-	-	-	-	-	-	12:00	13:00
PM Count	70	189	-	-	-	-	-	-	-	-	-	-	-	-	61	186

APPENDIX G

CROSBY AVENUE FLEXIBLE PMED OUTPUT SHEETS

Crosby Avenue HMA (64-22) 20-year Design

File Name: C:\Users\goldbaum\Documents\My PMED Designs\My ME Design\Projects\Crosby Avenue\Crosby Avenue HMA (64-22) 20-year Design.dgpx

Design Inputs

Design Life: 20 years
Design Type: FLEXIBLE

Base construction: May, 2024
Pavement construction: July, 2024
Traffic opening: September, 2024

Climate Data Sources (Lat/Lon): 39.134, -108.538

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	R2 Level 1 SX(75) PG 64-22	4.5
NonStabilized	Crushed gravel	8.0
NonStabilized	CDOT Class 2 ABC	8.0
Subgrade	A-4	6.0
Subgrade	A-4	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	11.8
Air voids (%)	6.9

Traffic

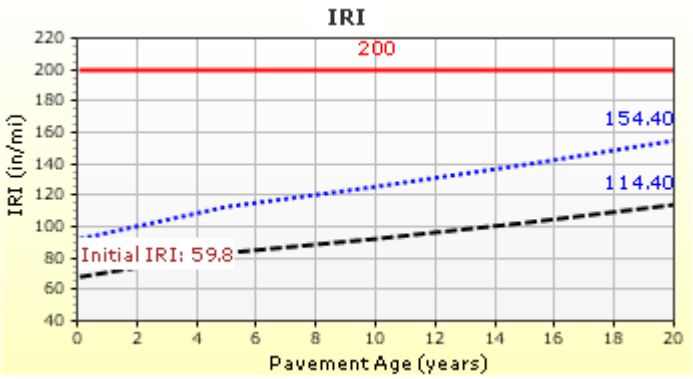
Age (year)	Heavy Trucks (cumulative)
2024 (initial)	670
2034 (10 years)	1,446,980
2044 (20 years)	3,210,840

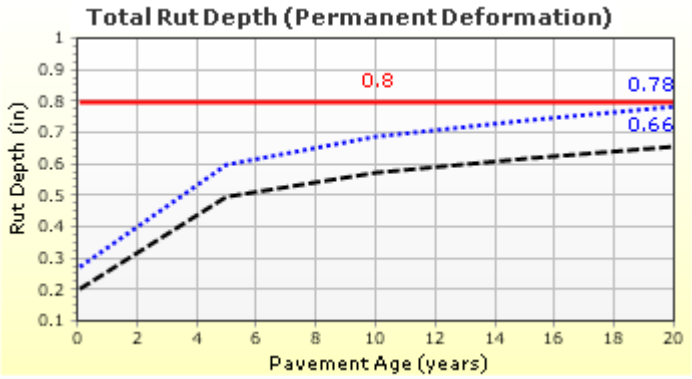
Design Outputs

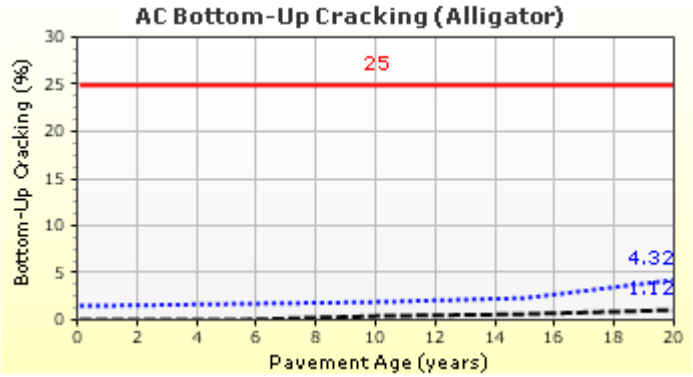
Distress Prediction Summary

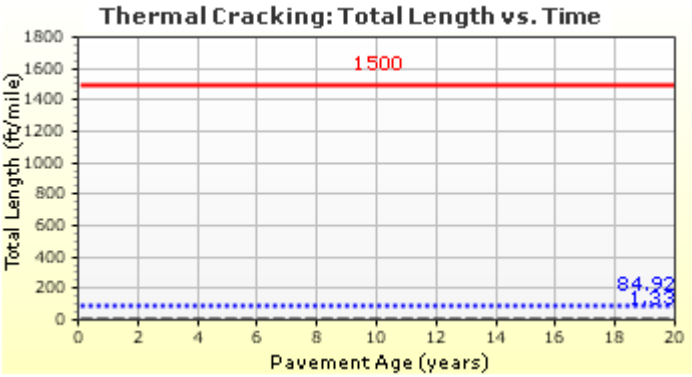
Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	200.00	154.40	90.00	99.69	Pass
Permanent deformation - total pavement (in)	0.80	0.78	90.00	92.67	Pass
AC bottom-up fatigue cracking (% lane area)	25.00	4.32	90.00	100.00	Pass
AC thermal cracking (ft/mile)	1500.00	84.92	90.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	3000.00	701.58	90.00	100.00	Pass
Permanent deformation - AC only (in)	0.65	0.07	90.00	100.00	Pass

Distress Charts





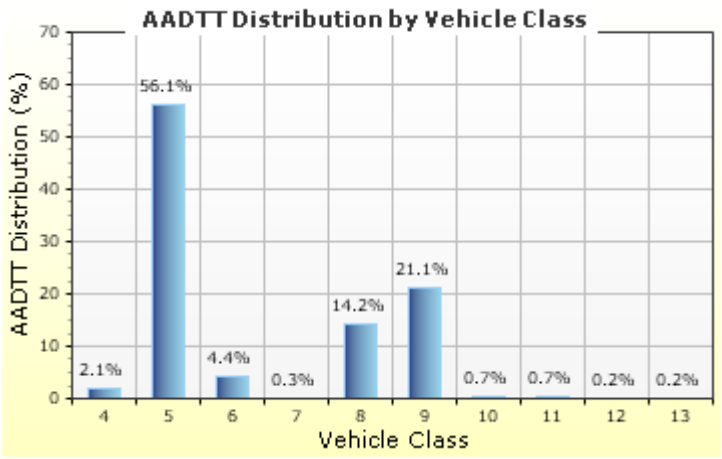


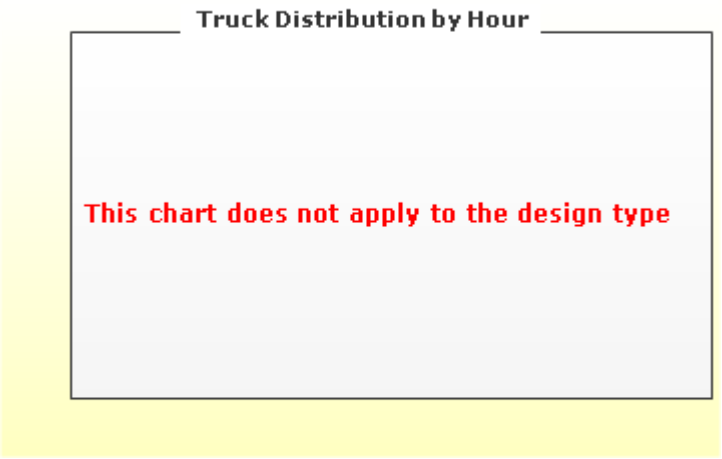


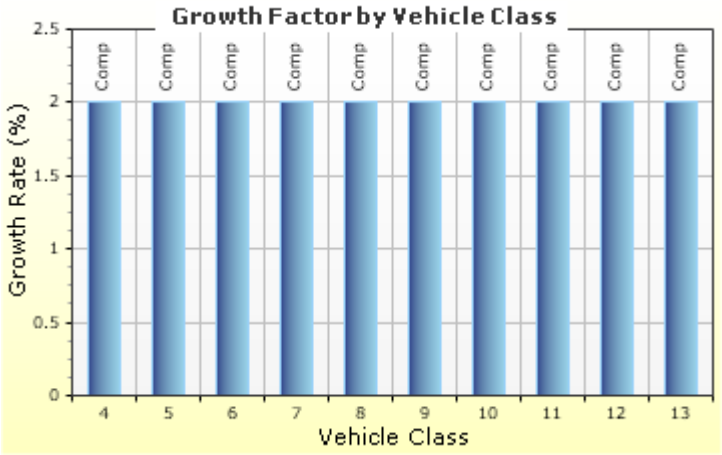
Traffic Inputs

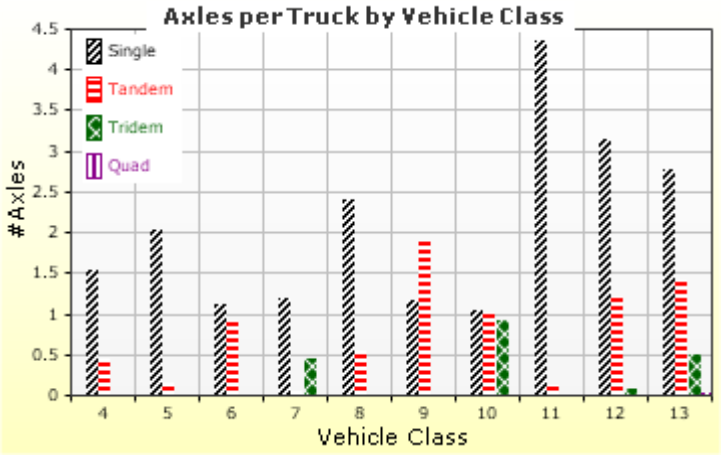
Graphical Representation of Traffic Inputs

Initial two-way AADTT:	670	Percent of trucks in design direction (%):	60.0
Number of lanes in design direction:	1	Percent of trucks in design lane (%):	90.0
		Operational speed (mph)	35.0

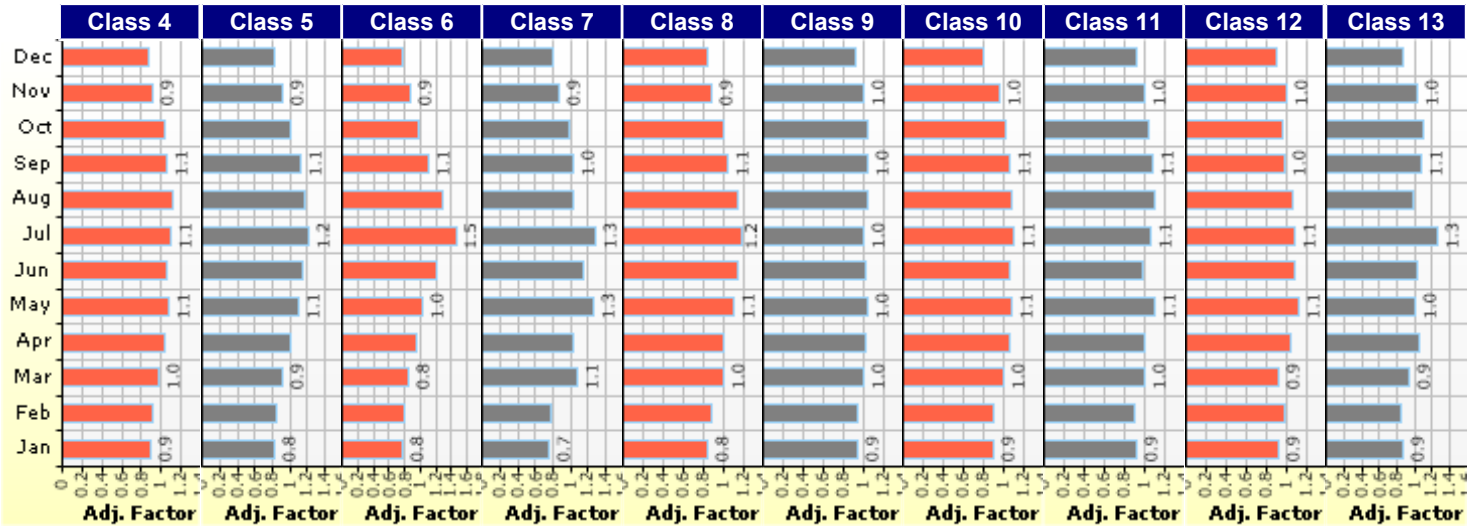








Traffic Volume Monthly Adjustment Factors



Tabular Representation of Traffic Inputs

Volume Monthly Adjustment Factors

Level 3: Default MAF

Month	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
January	0.9	0.8	0.8	0.7	0.8	0.9	0.9	0.9	0.9	0.9
February	0.9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	0.8
March	1.0	0.9	0.8	1.1	1.0	1.0	1.0	1.0	0.9	0.9
April	1.0	1.0	0.9	1.0	1.0	1.0	1.1	1.0	1.0	1.1
May	1.1	1.1	1.0	1.3	1.1	1.0	1.1	1.1	1.1	1.0
June	1.1	1.1	1.2	1.1	1.1	1.0	1.1	1.0	1.1	1.0
July	1.1	1.2	1.5	1.3	1.2	1.0	1.1	1.1	1.1	1.3
August	1.1	1.2	1.3	1.0	1.1	1.0	1.1	1.1	1.1	1.0
September	1.1	1.1	1.1	1.0	1.1	1.0	1.1	1.1	1.0	1.1
October	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.1
November	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0
December	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.9	0.9	0.9

Distributions by Vehicle Class

Truck Distribution by Hour does not apply

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	2.1%	2%	Compound
Class 5	56.1%	2%	Compound
Class 6	4.4%	2%	Compound
Class 7	0.3%	2%	Compound
Class 8	14.2%	2%	Compound
Class 9	21.1%	2%	Compound
Class 10	0.7%	2%	Compound
Class 11	0.7%	2%	Compound
Class 12	0.2%	2%	Compound
Class 13	0.2%	2%	Compound

Axle Configuration

Traffic Wander	
Mean wheel location (in)	18.0
Traffic wander standard deviation (in)	10.0
Design lane width (ft)	12.0

Axle Configuration	
Average axle width (ft)	8.5
Dual tire spacing (in)	12.0
Tire pressure (psi)	120.0

Average Axle Spacing	
Tandem axle spacing (in)	51.6
Tridem axle spacing (in)	49.2
Quad axle spacing (in)	49.2

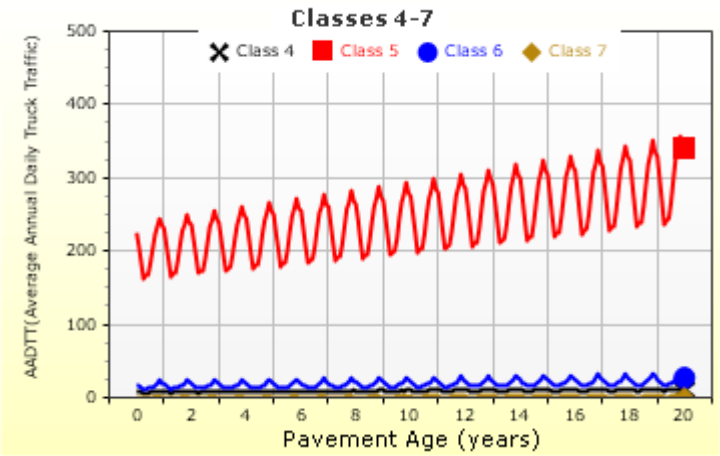
Wheelbase does not apply

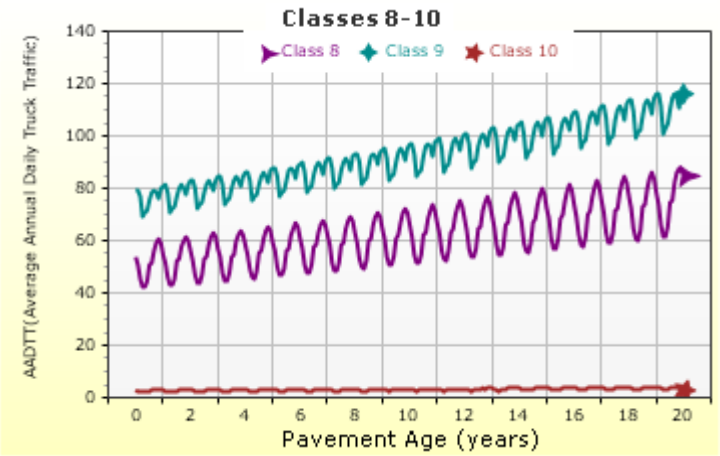
Number of Axles per Truck

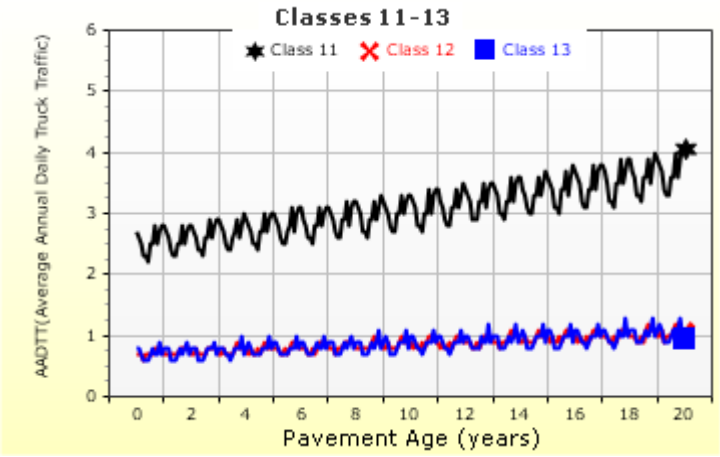
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.53	0.45	0	0
Class 5	2.02	0.16	0.02	0
Class 6	1.12	0.93	0	0
Class 7	1.19	0.07	0.45	0.02
Class 8	2.41	0.56	0.02	0
Class 9	1.16	1.88	0.01	0
Class 10	1.05	1.01	0.93	0.02
Class 11	4.35	0.13	0	0
Class 12	3.15	1.22	0.09	0
Class 13	2.77	1.4	0.51	0.04

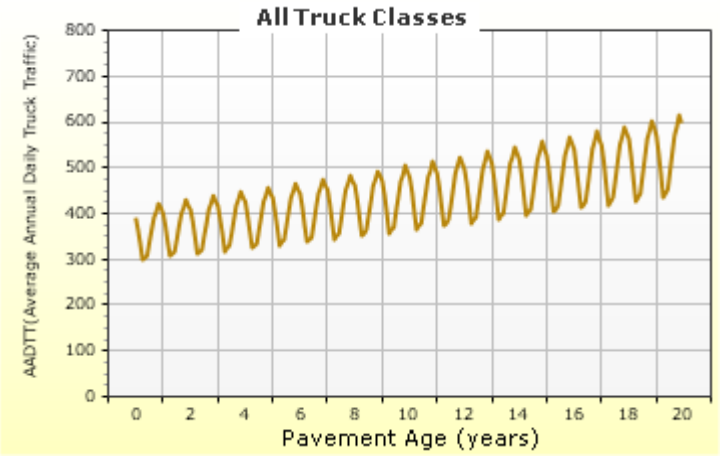
AADTT (Average Annual Daily Truck Traffic) Growth

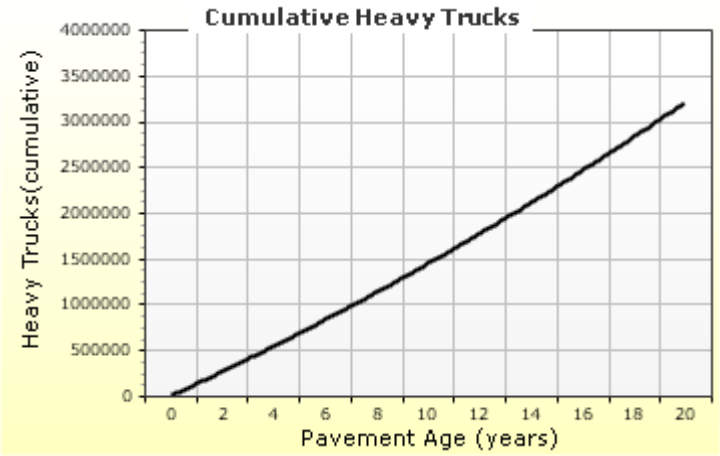
*** Traffic cap is not enforced**







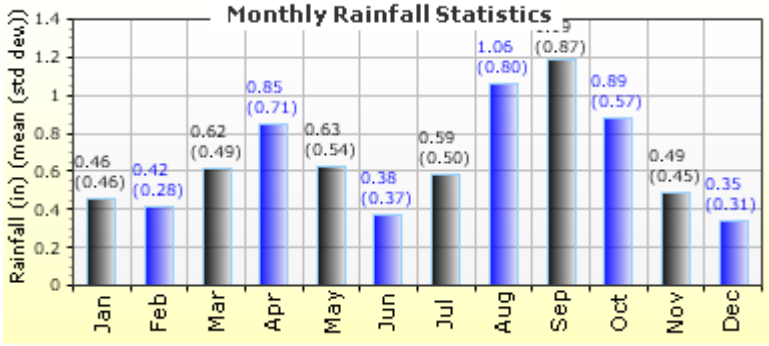




Climate Inputs

Climate Data Sources:

Climate Station Cities:	Location (lat lon elevation(ft))
GRAND JUNCTION, CO	39.13400 -108.53800 4839

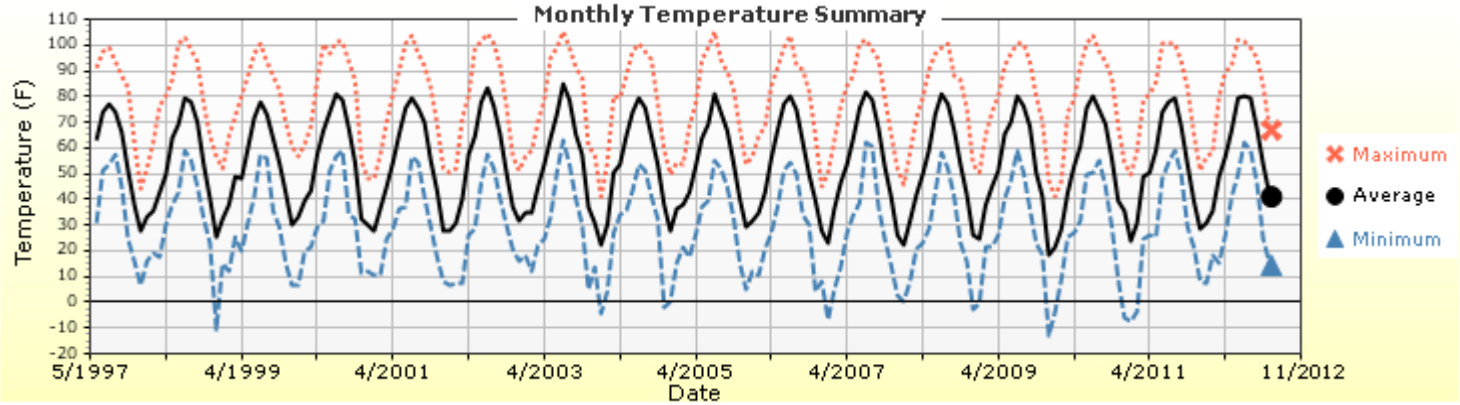


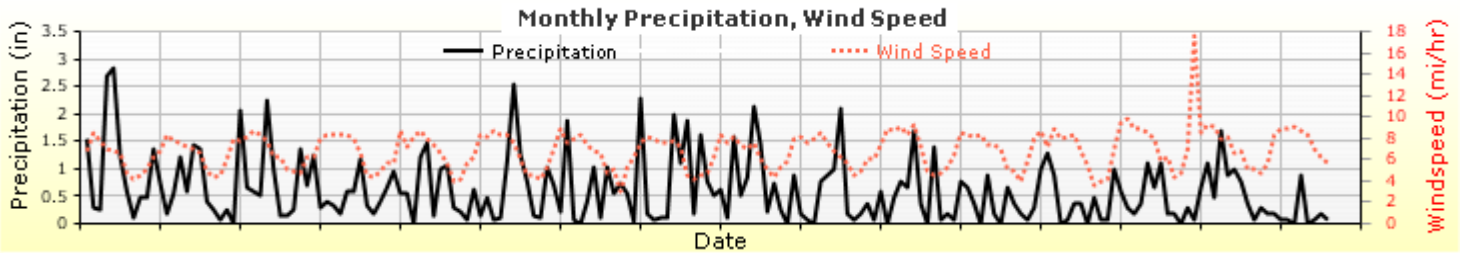
Annual Statistics:

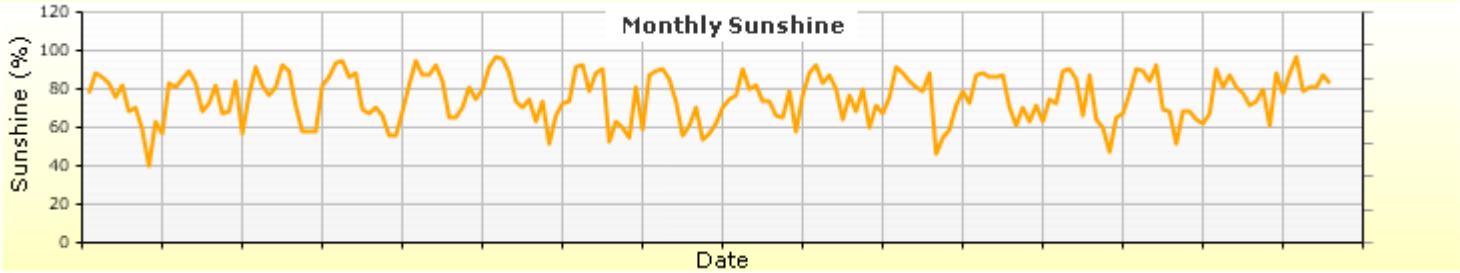
Mean annual air temperature (ºF)	53.75
Mean annual precipitation (in)	7.96
Freezing index (ºF - days)	360.58
Average annual number of freeze/thaw cycles:	111.77

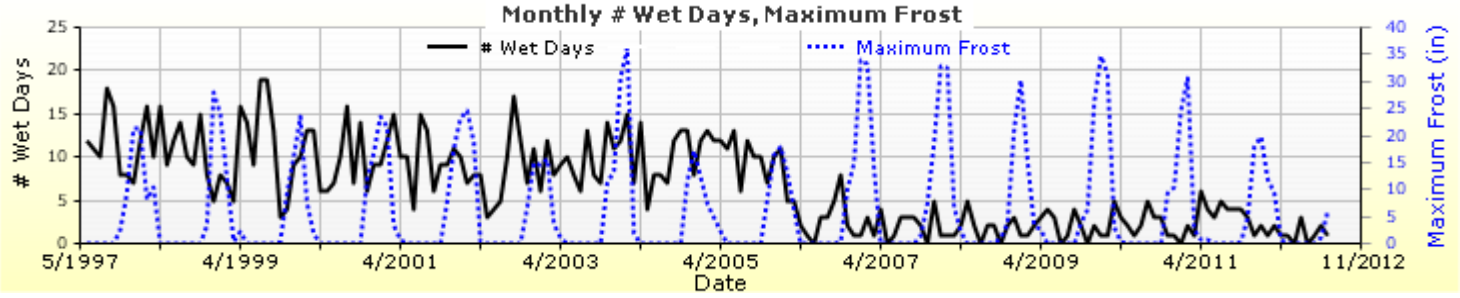
Water table depth (ft)	4.00

Monthly Climate Summary:

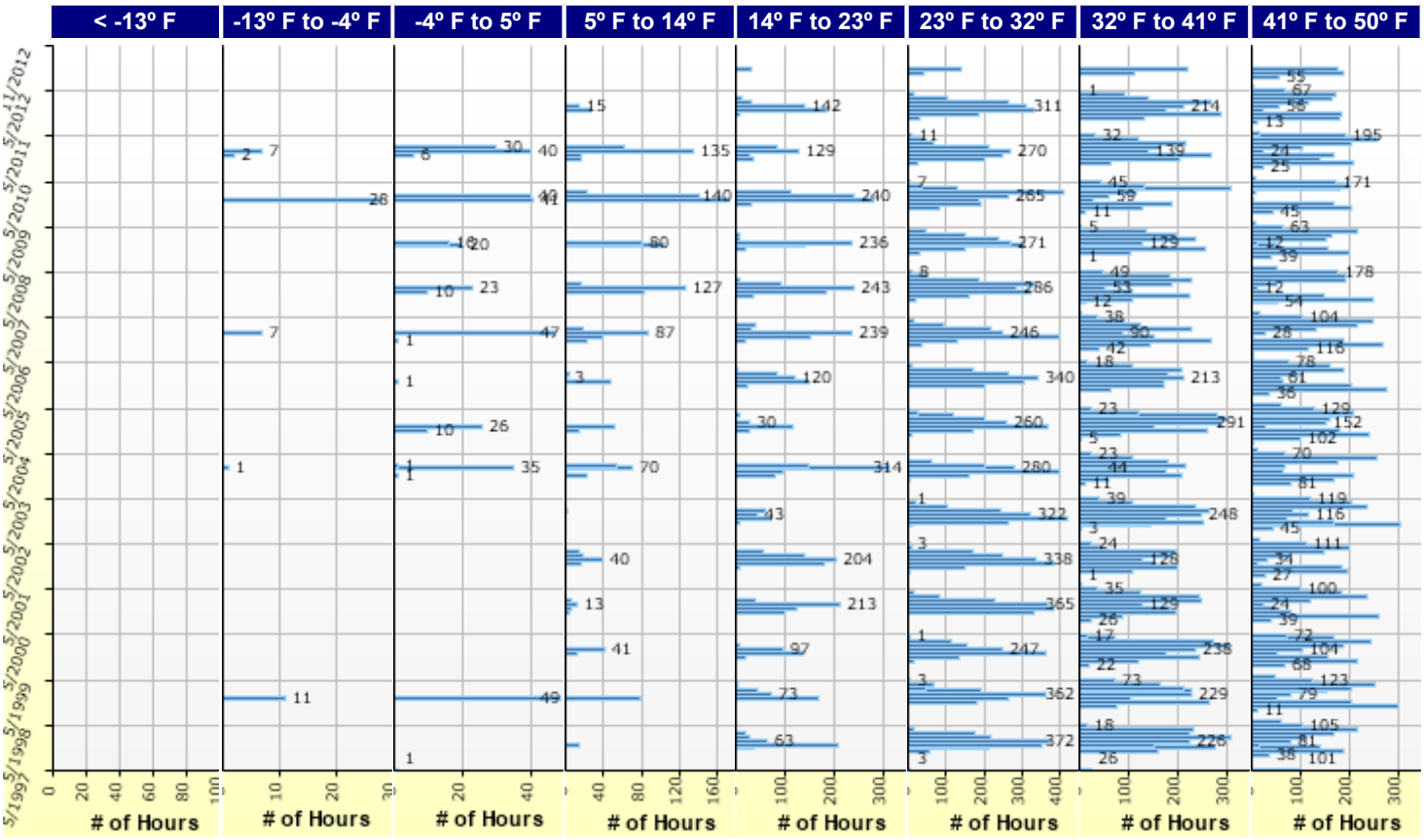


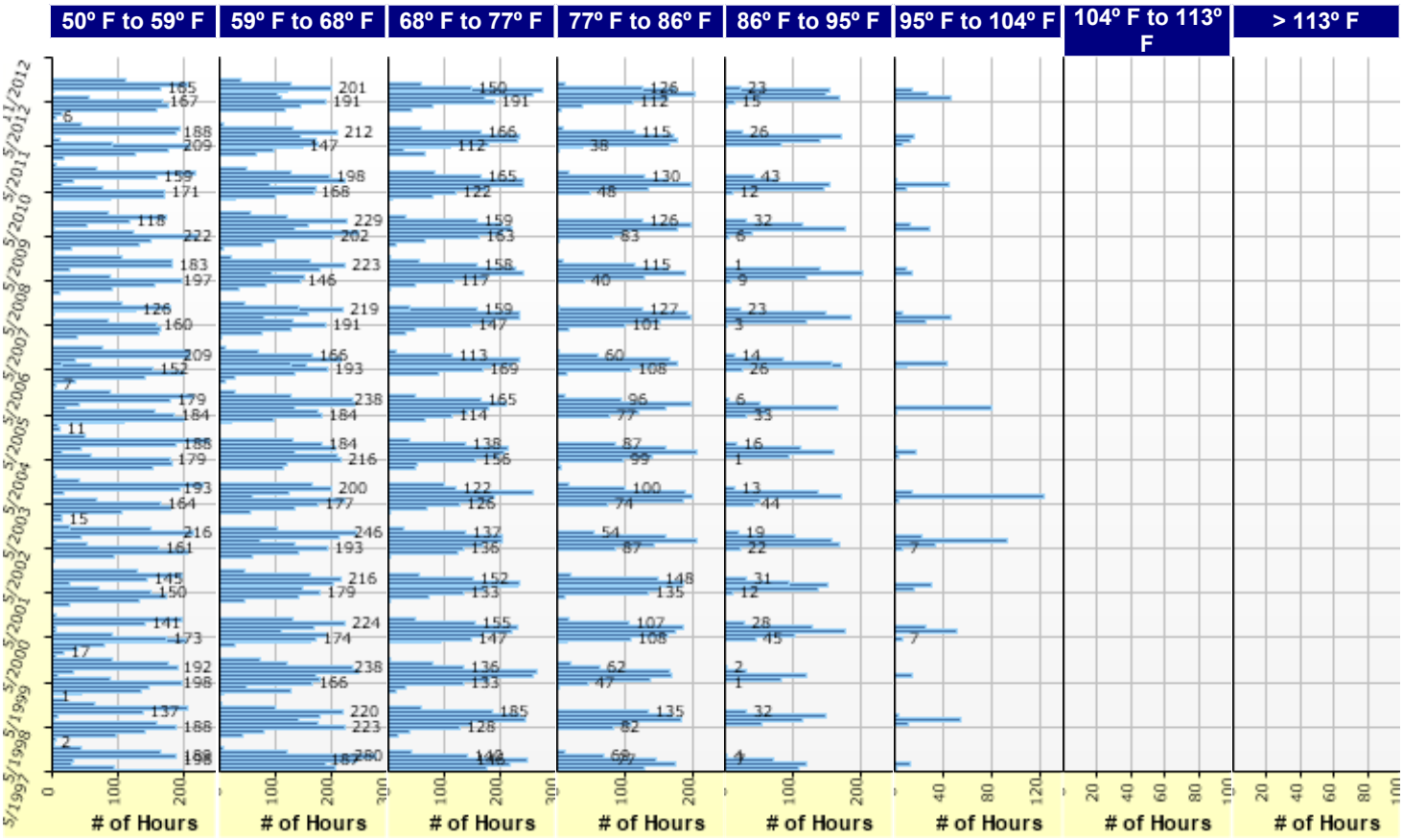






Hourly Air Temperature Distribution by Month:





Design Properties

HMA Design Properties

Use Multilayer Rutting Model	False
Using G* based model (not nationally calibrated)	False
Is NCHRP 1-37A HMA Rutting Model Coefficients	True
Endurance Limit	-
Use Reflective Cracking	True

Structure - ICM Properties	
AC surface shortwave absorptivity	0.85

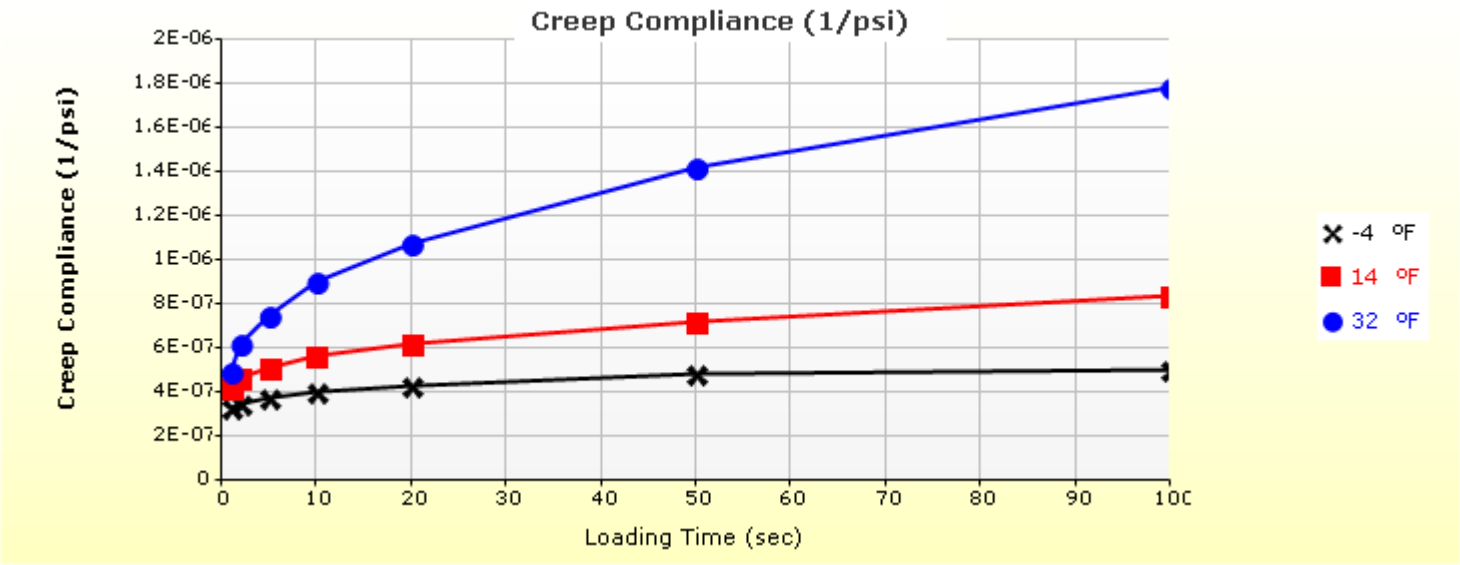
Layer Name	Layer Type	Interface Friction
Layer 1 Flexible : R2 Level 1 SX (75) PG 64-22	Flexible (1)	1.00
Layer 2 Non-stabilized Base : Crushed gravel	Non-stabilized Base (4)	1.00
Layer 3 Non-stabilized Base : CDOT Class 2 ABC	Non-stabilized Base (4)	1.00
Layer 4 Subgrade : A-4	Subgrade (5)	1.00
Layer 5 Subgrade : A-4	Subgrade (5)	-

Thermal Cracking (Input Level: 1)

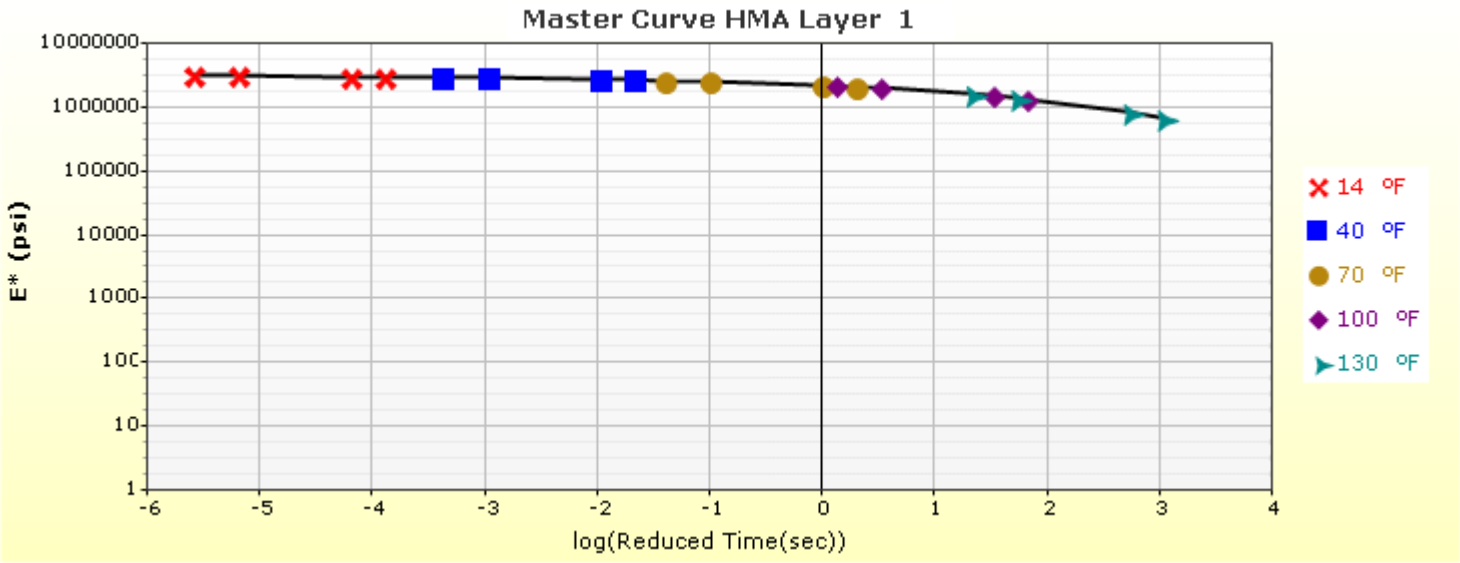
Indirect tensile strength at 14 °F (psi)	451.00

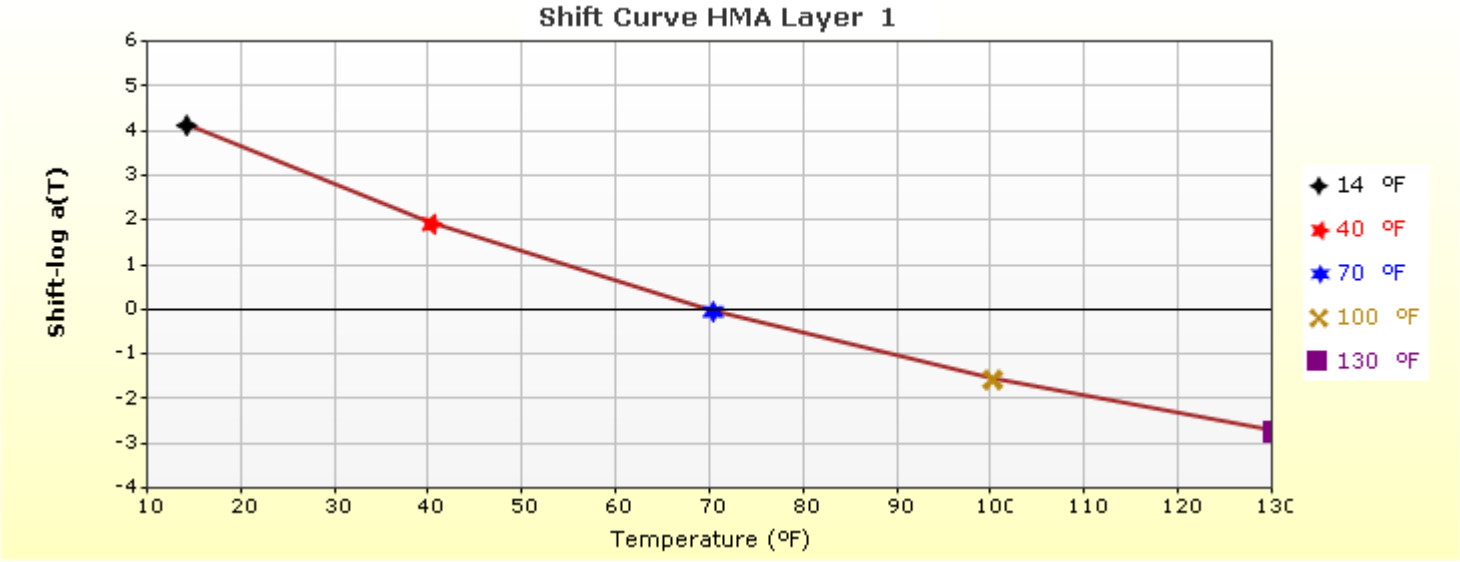
Thermal Contraction	
Is thermal contraction calculated?	True
Mix coefficient of thermal contraction (in/in/°F)	-
Aggregate coefficient of thermal contraction (in/in/°F)	5.0e-006
Voids in Mineral Aggregate (%)	18.7

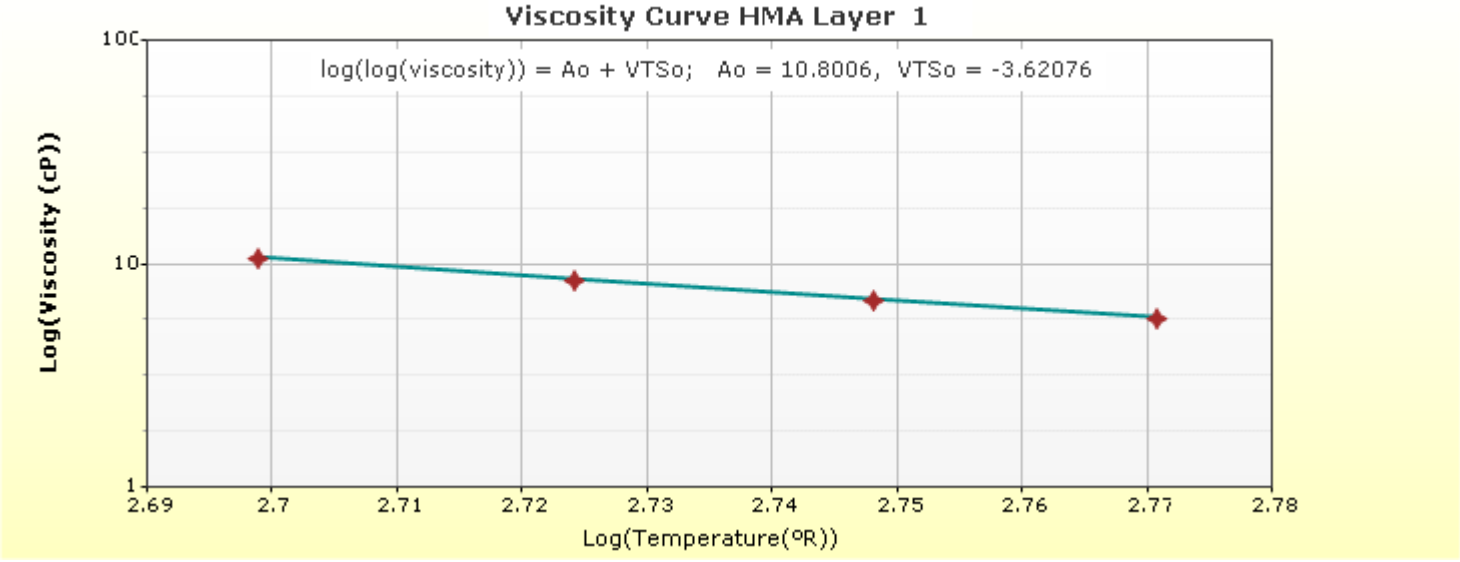
	Creep Compliance (1/psi)		
Loading time (sec)	-4 °F	14 °F	32 °F
1	3.34e-007	4.19e-007	4.99e-007
2	3.53e-007	4.64e-007	6.19e-007
5	3.79e-007	5.15e-007	7.49e-007
10	4.05e-007	5.70e-007	9.08e-007
20	4.31e-007	6.26e-007	1.08e-006
50	4.87e-007	7.27e-007	1.43e-006
100	5.05e-007	8.41e-007	1.79e-006



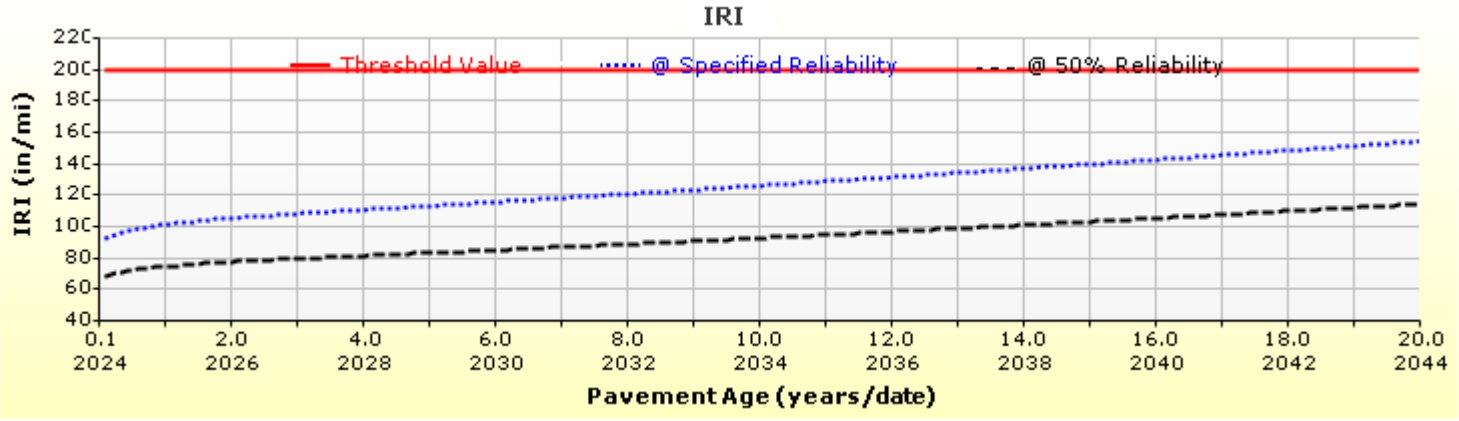
HMA Layer 1: Layer 1 Flexible : R2 Level 1 SX(75) PG 64-22

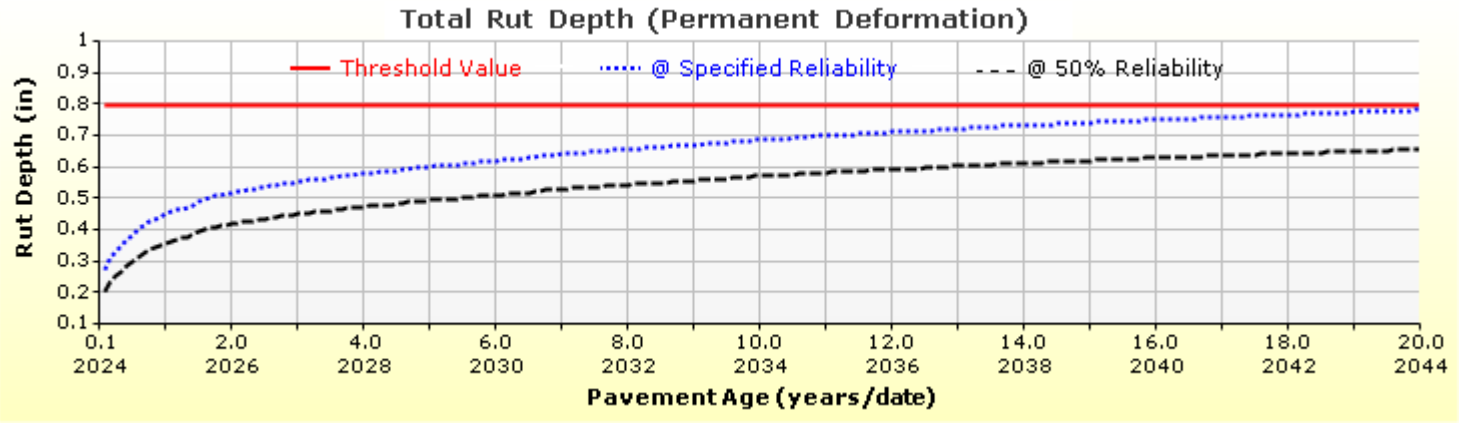


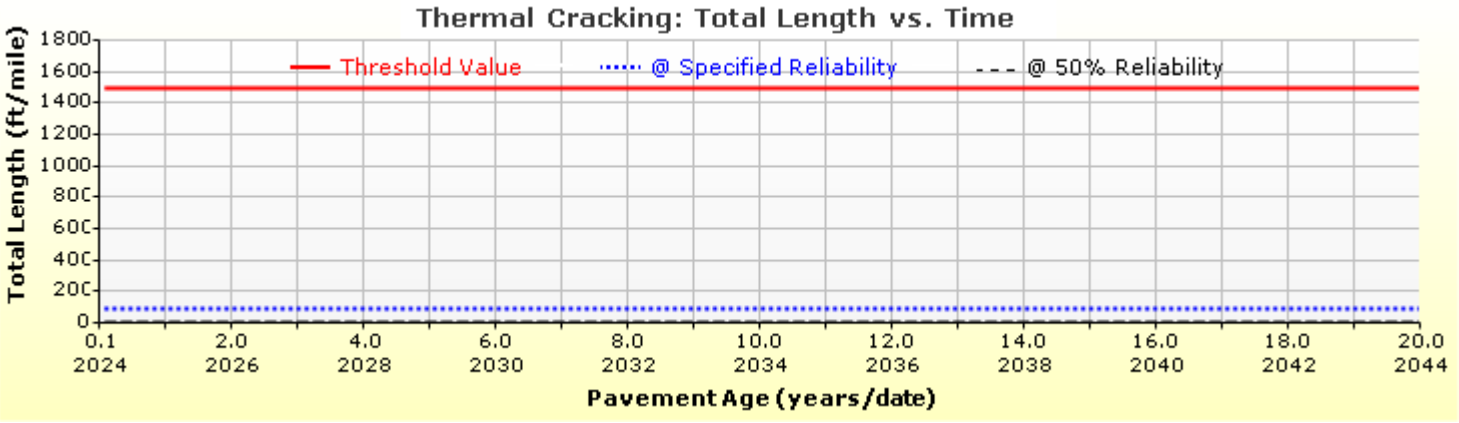


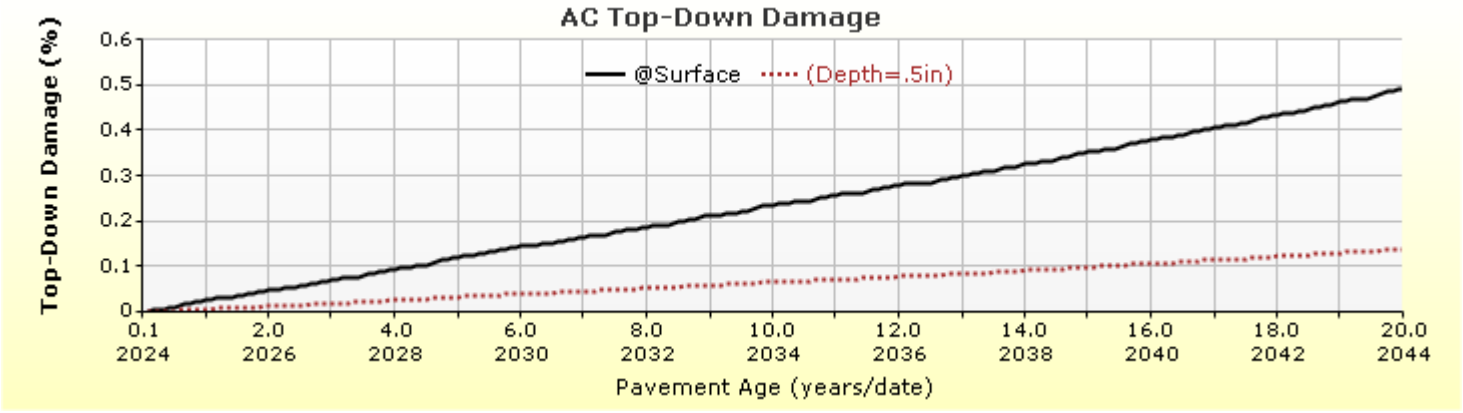


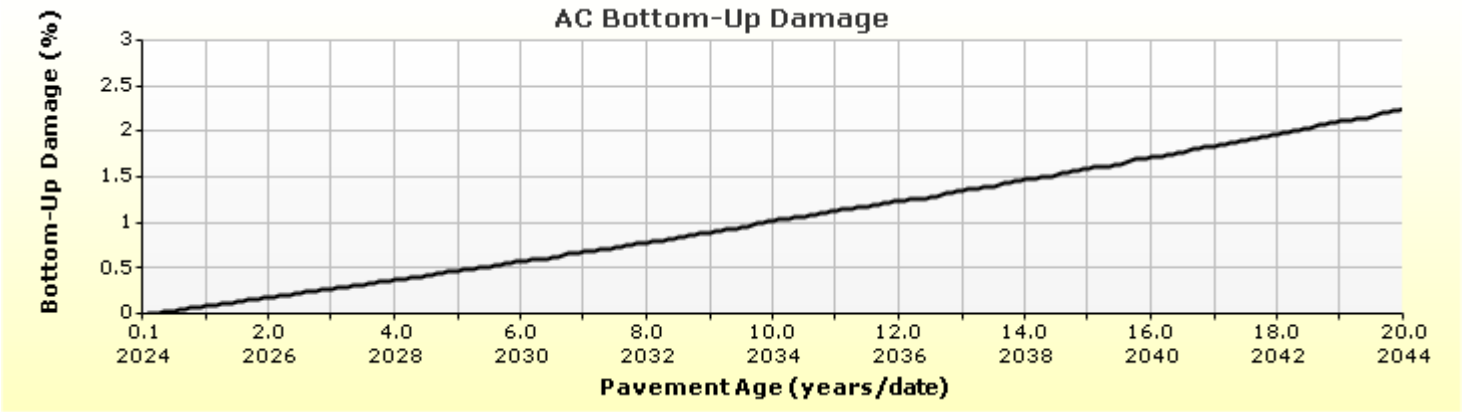
Analysis Output Charts

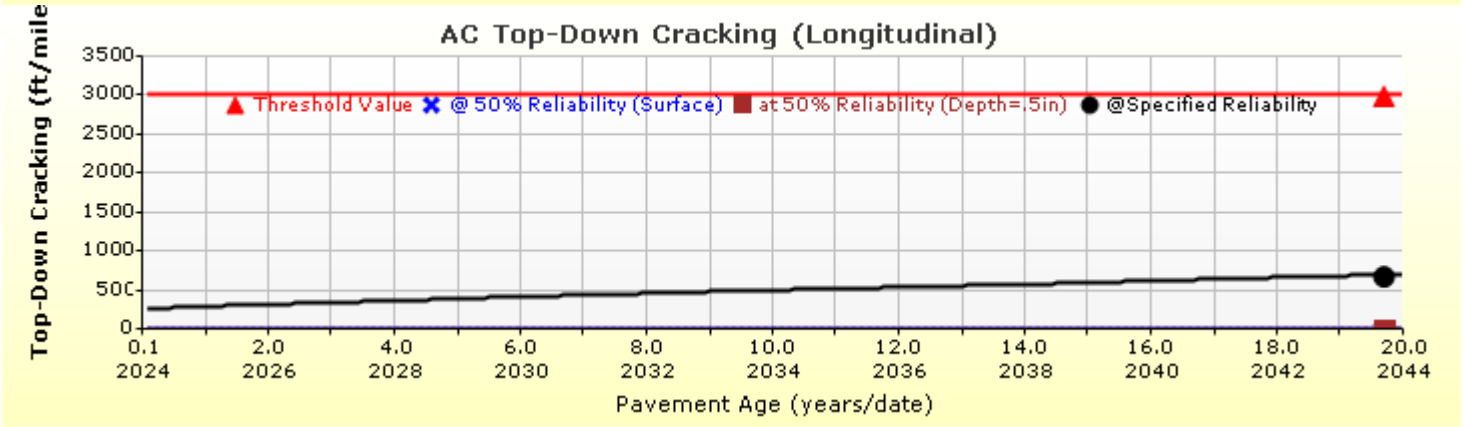


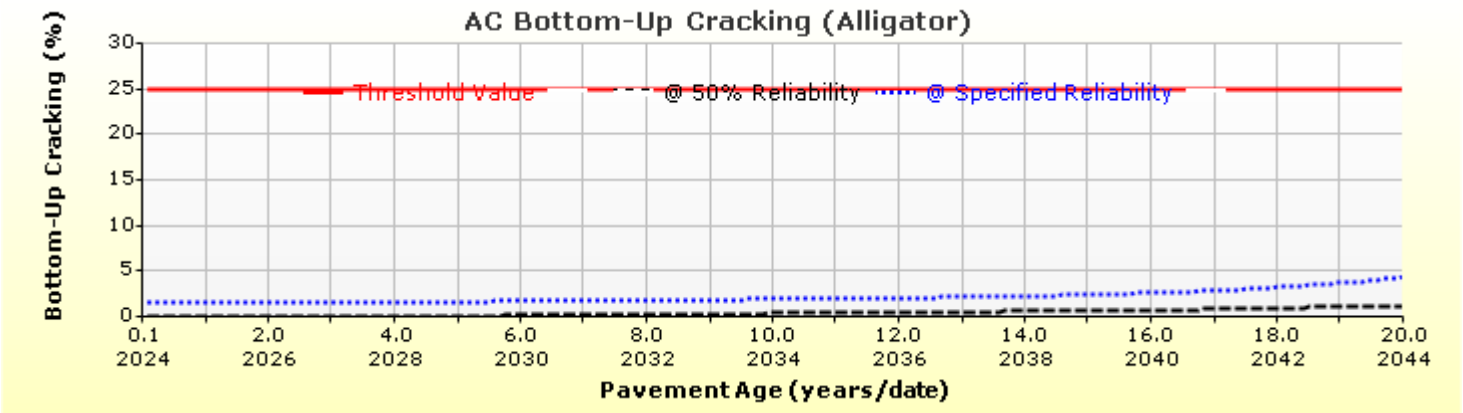


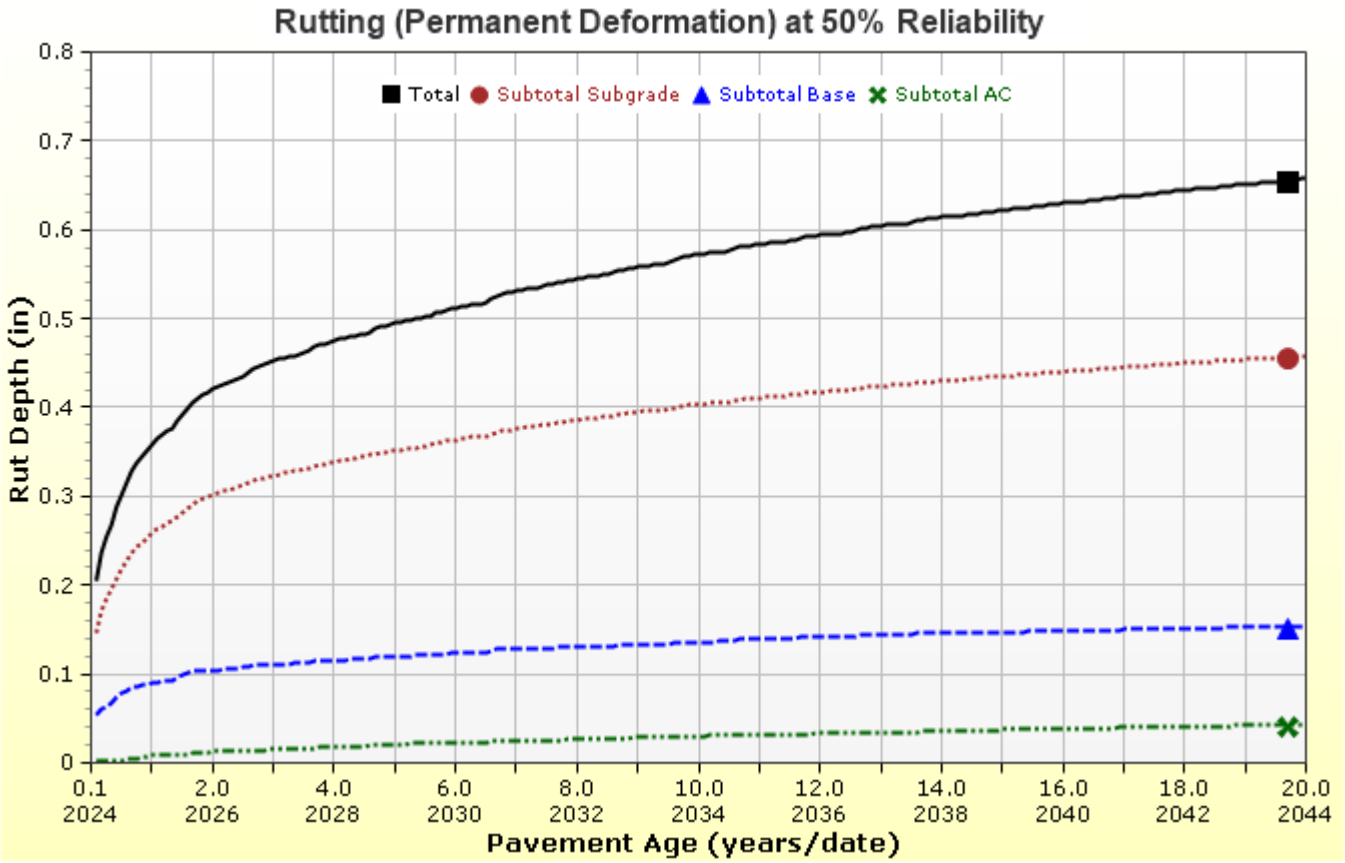


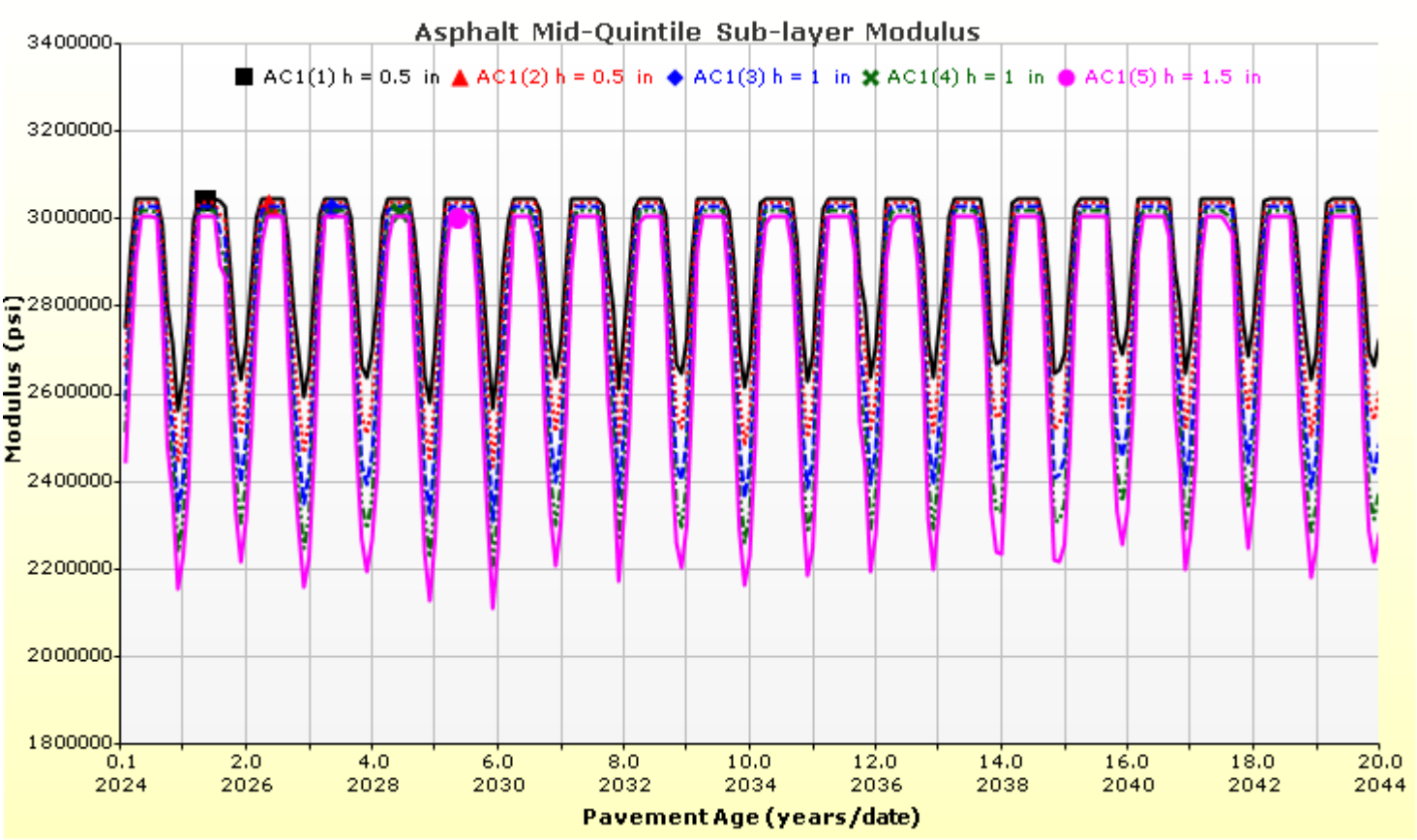

AC Top-Down Damage
Top-Down Damage (%)
@Surface
(Depth=.5in)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.1 2024
2.0 2026
4.0 2028
6.0 2030
8.0 2032
10.0 2034
12.0 2036
14.0 2038
16.0 2040
18.0 2042
20.0 2044
Pavement Age (years/date)

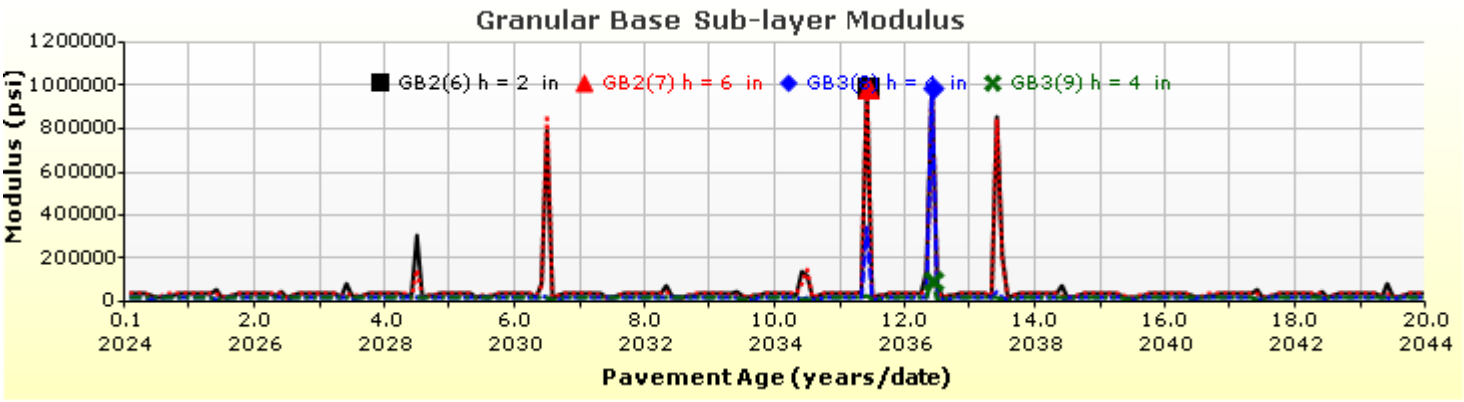

AC Bottom-Up Damage
Bottom-Up Damage (%)
0
0.5
1
1.5
2
2.5
3
0.1 2024
2.0 2026
4.0 2028
6.0 2030
8.0 2032
10.0 2034
12.0 2036
14.0 2038
16.0 2040
18.0 2042
20.0 2044
Pavement Age (years/date)

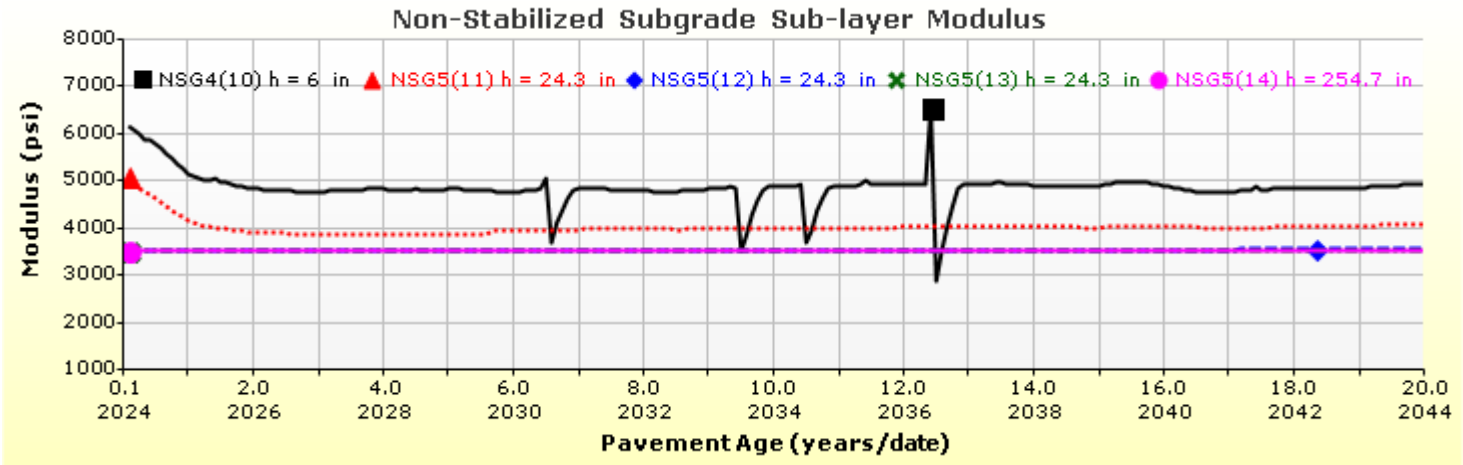

AC Top-Down Cracking (Longitudinal)
Top-Down Cracking (ft/mile
Threshold Value
@ 50% Reliability (Surface)
at 50% Reliability (Depth=.5in)
@Specified Reliability
0
500
1000
1500
2000
2500
3000
3500
0.1 2024
2.0 2026
4.0 2028
6.0 2030
8.0 2032
10.0 2034
12.0 2036
14.0 2038
16.0 2040
18.0 2042
20.0 2044
Pavement Age (years/date)


AC Bottom-Up Cracking (Alligator)
Bottom-Up Cracking (%)
Threshold Value
@ 50% Reliability
@ Specified Reliability
0
5
10
15
20
25
30
0.1 2024
2.0 2026
4.0 2028
6.0 2030
8.0 2032
10.0 2034
12.0 2036
14.0 2038
16.0 2040
18.0 2042
20.0 2044
Pavement Age (years/date)


Rutting (Permanent Deformation) at 50% Reliability
Total
Subtotal Subgrade
Subtotal Base
Subtotal AC
Rut Depth (in)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
2024
2.0
2026
4.0
2028
6.0
2030
8.0
2032
10.0
2034
12.0
2036
14.0
2038
16.0
2040
18.0
2042
20.0
2044
Pavement Age (years/date)


Asphalt Mid-Quintile Sub-layer Modulus
AC1(1) h = 0.5 in
AC1(2) h = 0.5 in
AC1(3) h = 1 in
AC1(4) h = 1 in
AC1(5) h = 1.5 in
Modulus (psi)
3400000
3200000
3000000
2800000
2600000
2400000
2200000
2000000
1800000
0.1
2024
2.0
2026
4.0
2028
6.0
2030
8.0
2032
10.0
2034
12.0
2036
14.0
2038
16.0
2040
18.0
2042
20.0
2044
Pavement Age (years/date)


Granular Base Sub-layer Modulus
GB2(6) h = 2 in
GB2(7) h = 6 in
GB3(8) h = 4 in
GB3(9) h = 4 in
Modulus (psi)
1200000
1000000
800000
600000
400000
200000
0
0.1
2024
2.0
2026
4.0
2028
6.0
2030
8.0
2032
10.0
2034
12.0
2036
14.0
2038
16.0
2040
18.0
2042
20.0
2044
Pavement Age (years/date)


Non-Stabilized Subgrade Sub-layer Modulus
NSG4(10) h = 6 in
NSG5(11) h = 24.3 in
NSG5(12) h = 24.3 in
NSG5(13) h = 24.3 in
NSG5(14) h = 254.7 in
Modulus (psi)
8000
7000
6000
5000
4000
3000
2000
1000
0.1
2024
2.0
2026
4.0
2028
6.0
2030
8.0
2032
10.0
2034
12.0
2036
14.0
2038
16.0
2040
18.0
2042
20.0
2044
Pavement Age (years/date)

Layer Information

Layer 1 Flexible : R2 Level 1 SX(75) PG 64-22

Asphalt		
Thickness (in)	4.5	
Unit weight (pcf)	140.5	
Poisson's ratio	Is Calculated?	True
	Ratio	-
	Parameter A	-1.63
	Parameter B	3.84E-06

Asphalt Dynamic Modulus (Input Level: 1)

T (ºF)	0.5 Hz	1 Hz	10 Hz	25 Hz
14	2910500	2947100	3034800	3058600
40	2620500	2695700	2882400	2934800
70	2057300	2190500	2549800	2658300
100	1334300	1500400	2017600	2195500
130	697600	836500	1365200	1584000

Asphalt Binder

Temperature (ºF)	Binder Gstar (Pa)	Phase angle (deg)
168.8	451	85
147.2	1857	81.6
158	889	83.1

General Info

Name	Value
Reference temperature (ºF)	70
Effective binder content (%)	11.8
Air voids (%)	6.9
Thermal conductivity (BTU/hr-ft-ºF)	0.67
Heat capacity (BTU/lb-ºF)	0.23

Identifiers

Field	Value
Display name/identifier	R2 Level 1 SX(75) PG 64-22
Description of object	Mix ID # 19127A
Author	CDOT
Date Created	4/3/2013 12:00:00 AM
Approver	CDOT
Date approved	4/3/2013 12:00:00 AM
State	Colorado
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	SX
User defined field 2	
User defined field 3	
Revision Number	0

Layer 2 Non-stabilized Base : Crushed gravel

Unbound	
Layer thickness (in)	8.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
25000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Crushed gravel
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	42

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.7
Saturated hydraulic conductivity (ft/hr)	False	5.054e-02
Specific gravity of solids	False	2.7
Water Content (%)	False	7.4

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	7.2555
bf	1.3328
cf	0.8242
hr	117.4000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20.0
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8-in.	57.2
1/2-in.	63.1
3/4-in.	72.7
1-in.	78.8
1 1/2-in.	85.8
2-in.	91.6
2 1/2-in.	
3-in.	
3 1/2-in.	97.6

Layer 3 Non-stabilized Base : CDOT Class 2 ABC

Unbound	
Layer thickness (in)	8.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
12000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	CDOT Class 2 ABC
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.7
Saturated hydraulic conductivity (ft/hr)	False	5.054e-02
Specific gravity of solids	False	2.7
Water Content (%)	False	7.4

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	7.2555
bf	1.3328
cf	0.8242
hr	117.4000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20.0
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8-in.	57.2
1/2-in.	63.1
3/4-in.	72.7
1-in.	78.8
1 1/2-in.	85.8
2-in.	91.6
2 1/2-in.	
3-in.	
3 1/2-in.	97.6

Layer 4 Subgrade : A-4

Unbound	
Layer thickness (in)	6.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
7844.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	A-4
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	21.0
Plasticity Index	5.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	119
Saturated hydraulic conductivity (ft/hr)	False	7.589e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	11.8

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	68.8377
bf	0.9983
cf	0.4757
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	60.6
#100	
#80	73.9
#60	
#50	
#40	82.7
#30	
#20	
#16	
#10	89.9
#8	
#4	93.0
3/8-in.	95.6
1/2-in.	96.7
3/4-in.	98.0
1-in.	98.7
1 1/2-in.	99.4
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.8

Layer 5 Subgrade : A-4

Unbound	
Layer thickness (in)	Semi-infinite
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
7844.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	A-4
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	21.0
Plasticity Index	5.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	118.4
Saturated hydraulic conductivity (ft/hr)	False	8.325e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	11.8

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	68.8377
bf	0.9983
cf	0.4757
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	60.6
#100	
#80	73.9
#60	
#50	
#40	82.7
#30	
#20	
#16	
#10	89.9
#8	
#4	93.0
3/8-in.	95.6
1/2-in.	96.7
3/4-in.	98.0
1-in.	98.7
1 1/2-in.	99.4
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.8

Calibration Coefficients

AC Fatigue

$$N_f = 0.00432 * C * \beta_{f1} k_1 \left(\frac{1}{\varepsilon_1}\right)^{k_2\beta_{f2}} \left(\frac{1}{E}\right)^{k_3\beta_{f3}}$$

$$C = 10^M$$

$$M = 4.84\left(\frac{V_b}{V_a + V_b} - 0.69\right)$$

k1: 0.007566	
k2: 3.9492	
k3: 1.281	
Bf1: 1	
Bf2: 1	
Bf3: 1	

AC Rutting

$$\frac{\varepsilon_p}{\varepsilon_r} = k_z \beta_{r1} 10^{k_1} T^{k_2\beta_{r2}} N^{k_3\beta_{r3}}$$

$$k_z = (C_1 + C_2 * depth) * 0.328196^{depth}$$

$$C_1 = -0.1039 * H_\alpha^2 + 2.4868 * H_\alpha - 17.342$$

$$C_2 = 0.0172 * H_\alpha^2 - 1.7331 * H_\alpha + 27.428$$

Where:

$H_{ac} = total\ AC\ thickness(in)$

$\varepsilon_p = plastic\ strain\left(^{in}/_{in}\right)$
$\varepsilon_r = resilient\ strain\left(^{in}/_{in}\right)$
$T = layer\ temperature(^{\circ}F)$
$N = number\ of\ load\ repetitions$

AC Rutting Standard Deviation	0.24 * Pow(RUT,0.8026) + 0.001	
AC Layer	K1:-3.35412 K2:1.5606 K3:0.4791	Br1:1 Br2:1 Br3:1

Thermal Fracture

$$C_f = 400 * N\left(\frac{\log C / h_{ac}}{\sigma}\right)$$

$$\Delta C = (k * \beta t)^{n+1} * A * \Delta K^n$$

$$A = 10^{(4.389 - 2.52 * \log(E * \sigma_m * n))}$$

$C_f = observed\ amount\ of\ thermal\ cracking(ft/500ft)$
$k = refression\ coefficient\ determined\ through\ field\ calibration$
$N() = standard\ normal\ distribution\ evaluated\ at()$
$\sigma = standard\ deviation\ of\ the\ \log\ of\ the\ depth\ of\ cracks\ in\ the\ pavments$
$C = crack\ depth(in)$
$h_{ac} = thickness\ of\ asphalt\ layer(in)$
$\Delta C = Change\ in\ the\ crack\ depth\ due\ to\ a\ cooling\ cycle$
$\Delta K = Change\ in\ the\ stress\ intensity\ factor\ due\ to\ a\ cooling\ cycle$
$A, n = Fracture\ parameters\ for\ the\ asphalt\ mixture$
$E = mixture\ stiffness$
$\sigma_M = Undamaged\ mixture\ tensile\ strength$
$\beta_t = Calibration\ parameter$

Level 1 K: 1.5	Level 1 Standard Deviation: 0.1468 * THERMAL + 65.027
Level 2 K: 0.5	Level 2 Standard Deviation: 0.2841 * THERMAL + 55.462
Level 3 K: 1.5	Level 3 Standard Deviation: 0.3972 * THERMAL + 20.422

CSM Fatigue

$$N_f = 10^{\left(\frac{k_1 \beta_{c1} \left(\frac{\sigma_s}{M_r}\right)}{k_2 \beta_{c2}}\right)}$$

$N_f = number\ of\ repetitions\ to\ fatigue\ cracking$
$\sigma_s = Tensile\ stress(psi)$
$M_r = modulus\ of\ rupture(psi)$

k1: 1	k2: 1	Bc1: 0.75	Bc2:1.1

Subgrade Rutting

$$\delta_a(N) = \beta_{s_1} k_1 \varepsilon_v h \left(\frac{\varepsilon_0}{\varepsilon_r}\right) \left| e^{-\left(\frac{\rho}{N}\right)^{\beta}} \right|$$

$\delta_a = permanent\ deformation\ for\ the\ layer$
$N = number\ of\ repetitions$
$\varepsilon_v = average\ veritcal\ strain(in/in)$
$\varepsilon_0, \beta, \rho = material\ properties$
$\varepsilon_r = resilient\ strain(in/in)$

Granular		Fine	
k1: 2.03	Bs1: 1	k1: 1.35	Bs1: 1
Standard Deviation (BASERUT) 0.1477 * Pow(BASERUT,0.6711) + 0.001		Standard Deviation (BASERUT) 0.1235 * Pow(SUBRUT,0.5012) + 0.001	

AC Cracking

AC Top Down Cracking

$$FC_{top} = \left(\frac{C_4}{1 + e^{(C_1 - C_2 * log_{10}(Damage))}}\right) * 10.56$$

c1: 7	c2: 3.5	c3: 0	c4: 1000

AC Cracking Top Standard Deviation

200 + 2300/(1+exp(1.072-2.1654*LOG10 (TOP+0.0001)))

AC Bottom Up Cracking

$$FC = \left(\frac{6000}{1 + e^{(C_1 * C_1' + C_2 * C_2' log_{10}(D * 100))}}\right) * \left(\frac{1}{60}\right)$$

$$C_2' = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$$

$$C_1' = -2 * C_2'$$

c1: 1	c2: 1	c3: 6000

AC Cracking Bottom Standard Deviation

1.13 + 13/(1+exp(7.57-15.5*LOG10 (BOTTOM+0.0001)))

CSM Cracking

$$FC_{ctb} = C_1 + \frac{C_2}{1 + e^{C_3 - C_4(Damage)}}$$

C1: 0	C2: 75	C3: 5	C4: 3

CSM Standard Deviation

CTB*1

IRI Flexible Pavements

C1 - Rutting
C2 - Fatigue Crack
C3 - Transverse Crack
C4 - Site Factors

C1: 40	C2: 0.4	C3: 0.008	C4: 0.015

Crosby Avenue HMA (64-22) 30-year Design

File Name: C:\Users\goldbaum\Documents\My PMED Designs\My ME Design\Projects\Crosby Avenue\Crosby Avenue HMA (64-22) 30-year Design.dgpx

Design Inputs

Design Life: 30 years
Design Type: FLEXIBLE

Base construction: May, 2024
Pavement construction: July, 2024
Traffic opening: September, 2024

Climate Data Sources (Lat/Lon): 39.134, -108.538

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	R2 Level 1 SX(75) PG 64-22	5.0
NonStabilized	Crushed gravel	8.0
NonStabilized	CDOT Class 2 ABC	8.0
Subgrade	A-4	6.0
Subgrade	A-4	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	11.8
Air voids (%)	6.9

Traffic

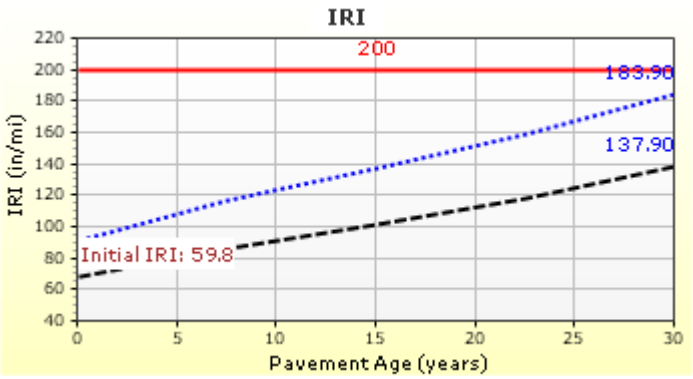
Age (year)	Heavy Trucks (cumulative)
2024 (initial)	670
2039 (15 years)	2,285,280
2054 (30 years)	5,360,970

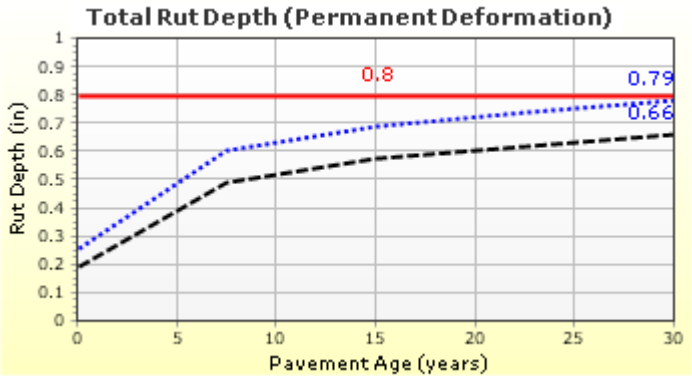
Design Outputs

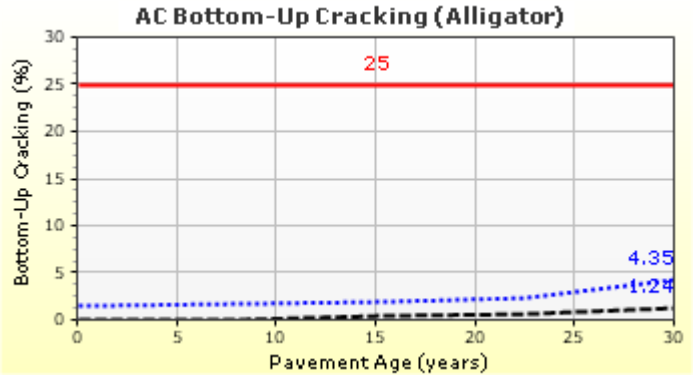
Distress Prediction Summary

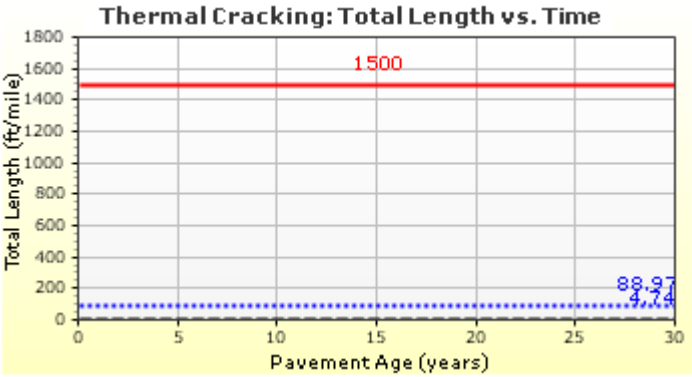
Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	200.00	183.93	90.00	95.81	Pass
Permanent deformation - total pavement (in)	0.80	0.79	90.00	92.38	Pass
AC bottom-up fatigue cracking (% lane area)	25.00	4.35	90.00	100.00	Pass
AC thermal cracking (ft/mile)	1500.00	88.97	90.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	3000.00	424.81	90.00	100.00	Pass
Permanent deformation - AC only (in)	0.65	0.07	90.00	100.00	Pass

Distress Charts





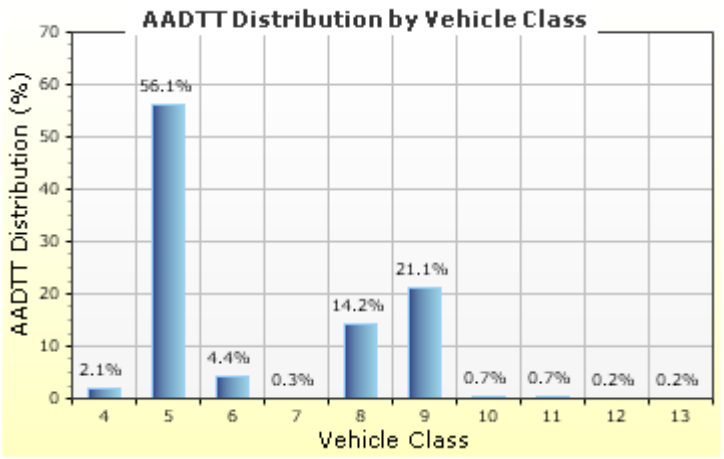


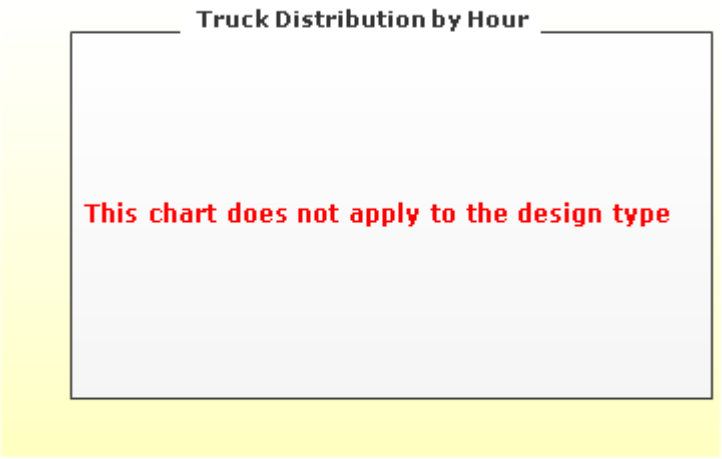


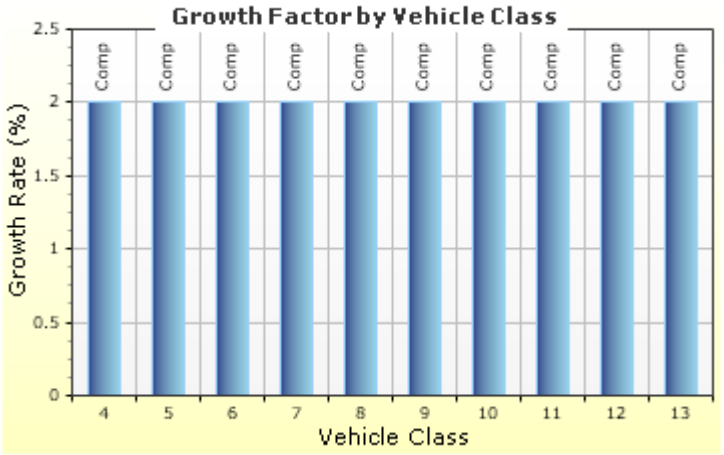
Traffic Inputs

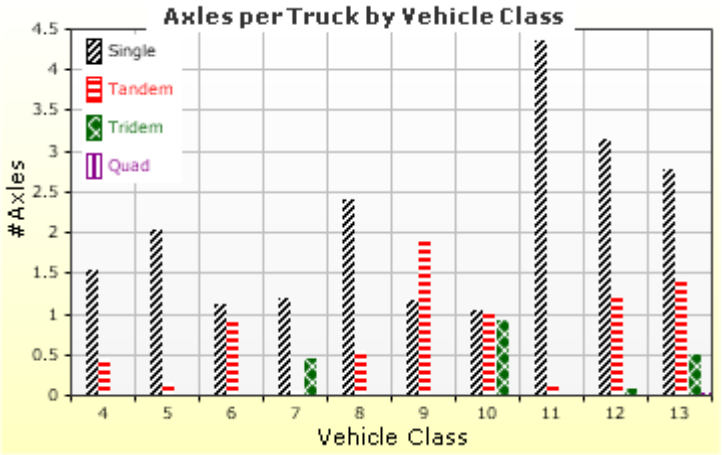
Graphical Representation of Traffic Inputs

Initial two-way AADTT:	670	Percent of trucks in design direction (%):	60.0
Number of lanes in design direction:	1	Percent of trucks in design lane (%):	90.0
		Operational speed (mph)	35.0

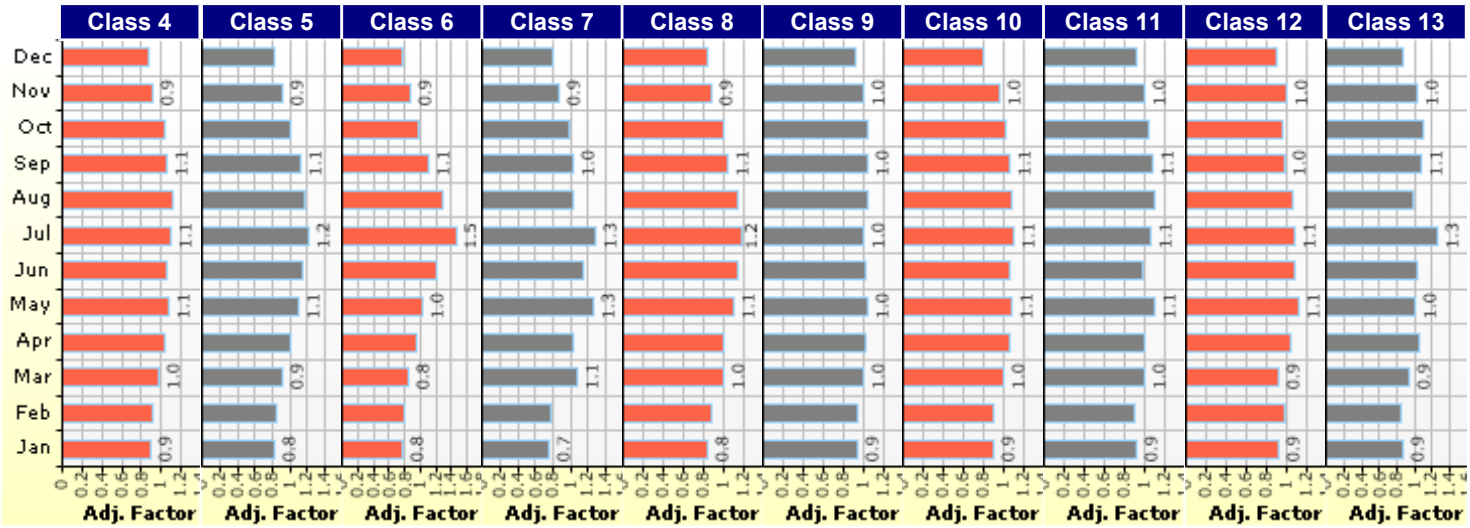








Traffic Volume Monthly Adjustment Factors



Tabular Representation of Traffic Inputs

Volume Monthly Adjustment Factors

Level 3: Default MAF

Month	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
January	0.9	0.8	0.8	0.7	0.8	0.9	0.9	0.9	0.9	0.9
February	0.9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	0.8
March	1.0	0.9	0.8	1.1	1.0	1.0	1.0	1.0	0.9	0.9
April	1.0	1.0	0.9	1.0	1.0	1.0	1.1	1.0	1.0	1.1
May	1.1	1.1	1.0	1.3	1.1	1.0	1.1	1.1	1.1	1.0
June	1.1	1.1	1.2	1.1	1.1	1.0	1.1	1.0	1.1	1.0
July	1.1	1.2	1.5	1.3	1.2	1.0	1.1	1.1	1.1	1.3
August	1.1	1.2	1.3	1.0	1.1	1.0	1.1	1.1	1.1	1.0
September	1.1	1.1	1.1	1.0	1.1	1.0	1.1	1.1	1.0	1.1
October	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.1
November	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0
December	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.9	0.9	0.9

Distributions by Vehicle Class

Truck Distribution by Hour does not apply

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	2.1%	2%	Compound
Class 5	56.1%	2%	Compound
Class 6	4.4%	2%	Compound
Class 7	0.3%	2%	Compound
Class 8	14.2%	2%	Compound
Class 9	21.1%	2%	Compound
Class 10	0.7%	2%	Compound
Class 11	0.7%	2%	Compound
Class 12	0.2%	2%	Compound
Class 13	0.2%	2%	Compound

Axle Configuration

Traffic Wander	
Mean wheel location (in)	18.0
Traffic wander standard deviation (in)	10.0
Design lane width (ft)	12.0

Axle Configuration	
Average axle width (ft)	8.5
Dual tire spacing (in)	12.0
Tire pressure (psi)	120.0

Average Axle Spacing	
Tandem axle spacing (in)	51.6
Tridem axle spacing (in)	49.2
Quad axle spacing (in)	49.2

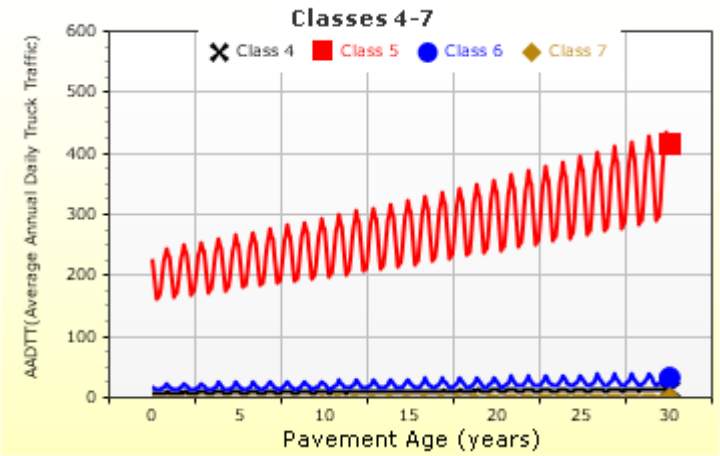
Wheelbase does not apply

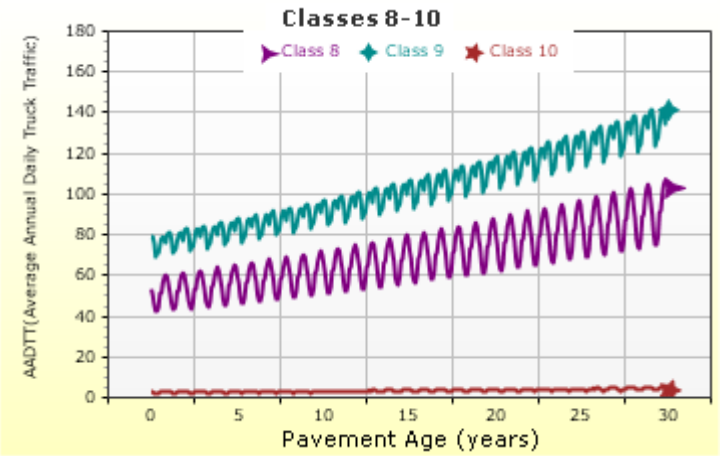
Number of Axles per Truck

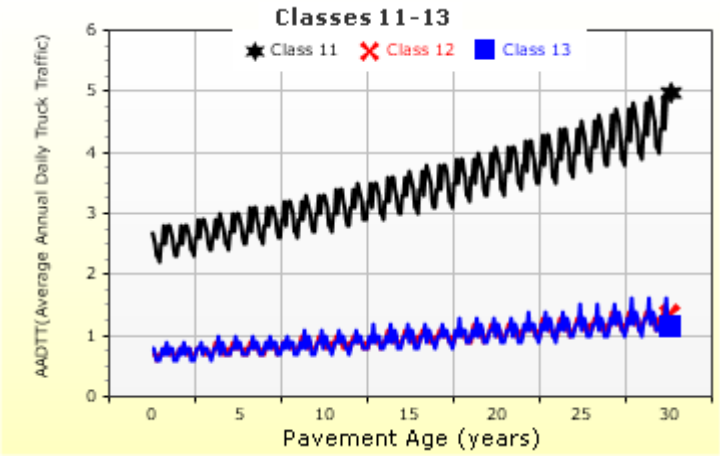
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.53	0.45	0	0
Class 5	2.02	0.16	0.02	0
Class 6	1.12	0.93	0	0
Class 7	1.19	0.07	0.45	0.02
Class 8	2.41	0.56	0.02	0
Class 9	1.16	1.88	0.01	0
Class 10	1.05	1.01	0.93	0.02
Class 11	4.35	0.13	0	0
Class 12	3.15	1.22	0.09	0
Class 13	2.77	1.4	0.51	0.04

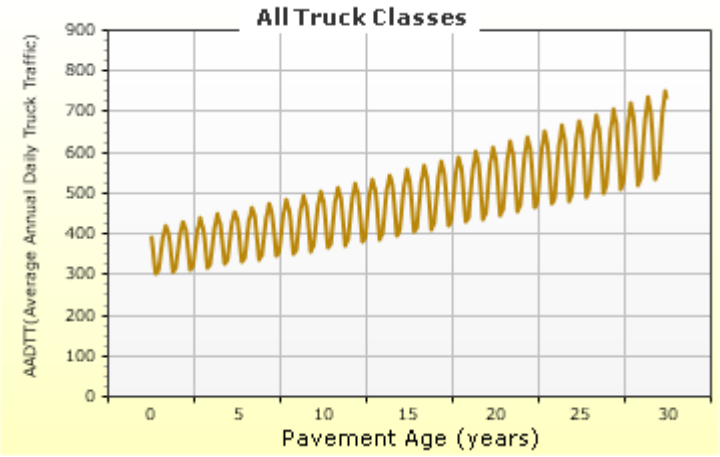
AADTT (Average Annual Daily Truck Traffic) Growth

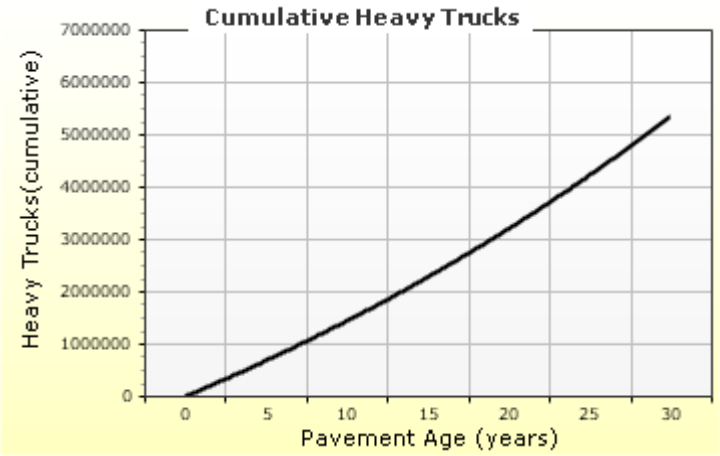
*** Traffic cap is not enforced**







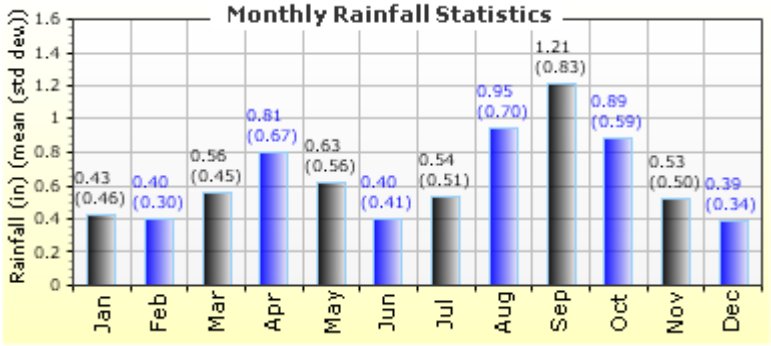




Climate Inputs

Climate Data Sources:

Climate Station Cities:	Location (lat lon elevation(ft))
GRAND JUNCTION, CO	39.13400 -108.53800 4839

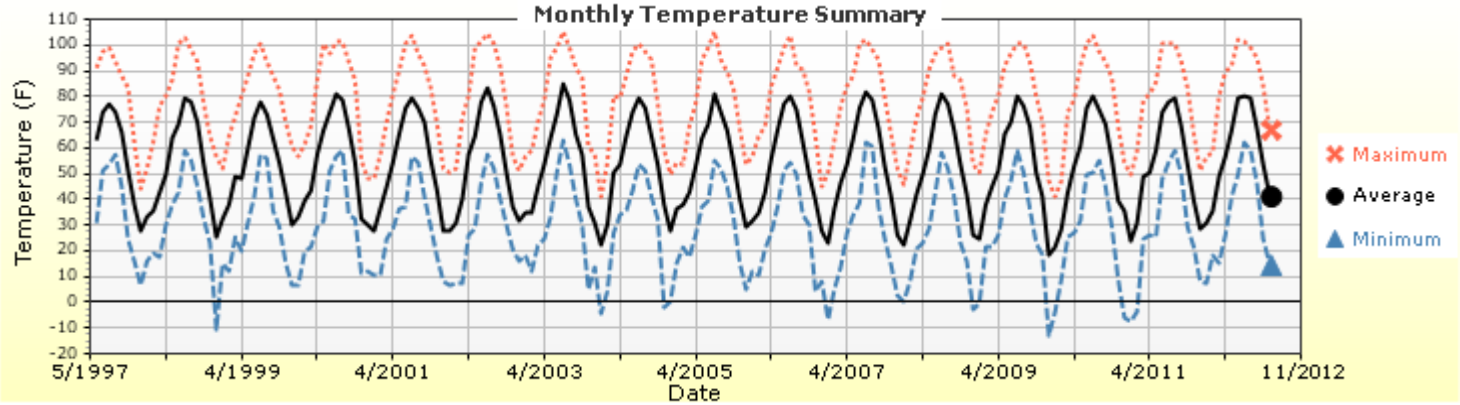


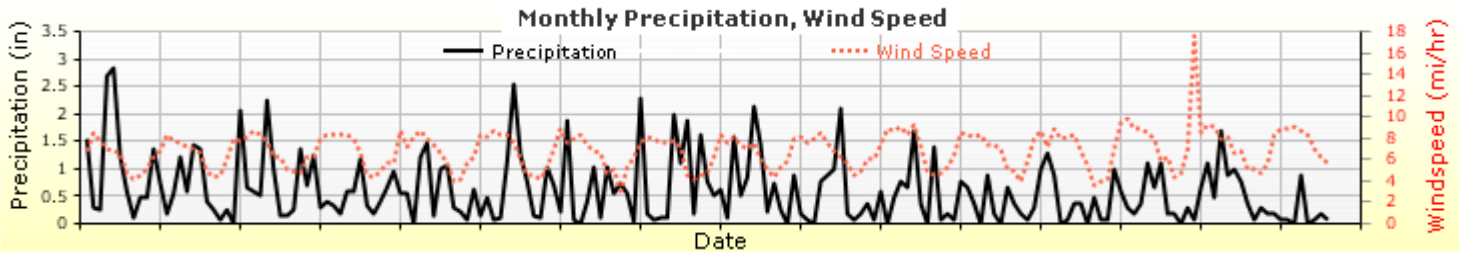
Annual Statistics:

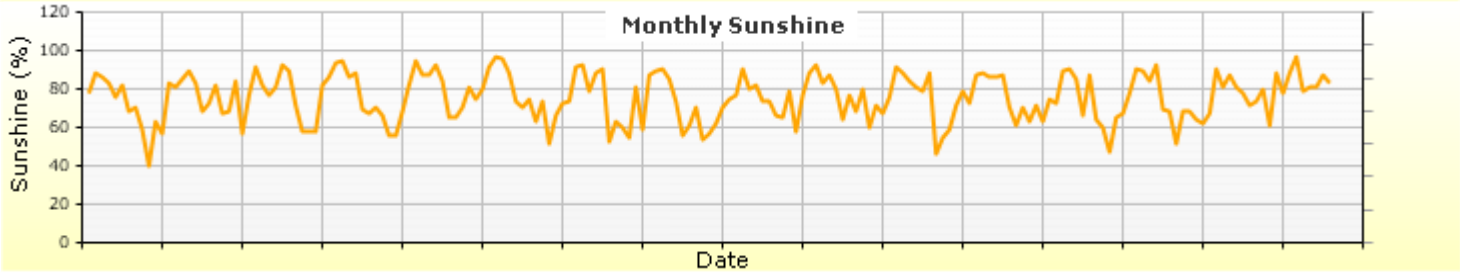
Mean annual air temperature (°F)	53.55
Mean annual precipitation (in)	7.76
Freezing index (°F - days)	398.73
Average annual number of freeze/thaw cycles:	111.77

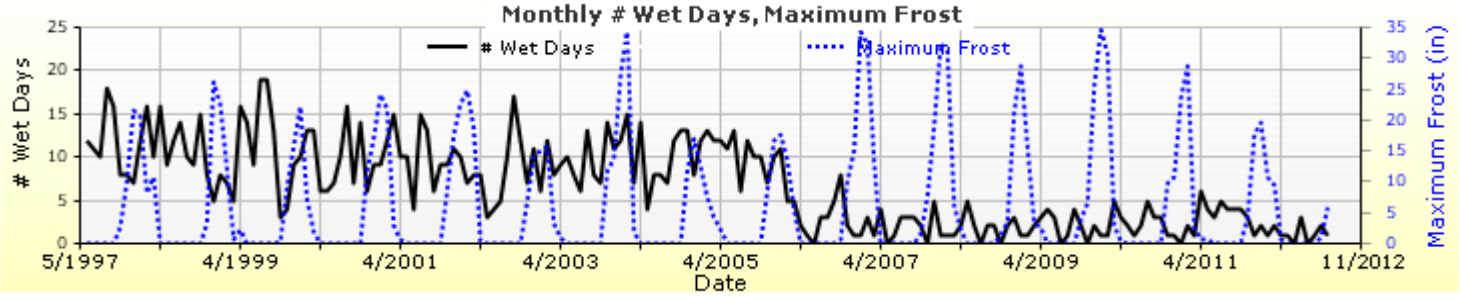
Water table depth (ft)	4.00

Monthly Climate Summary:

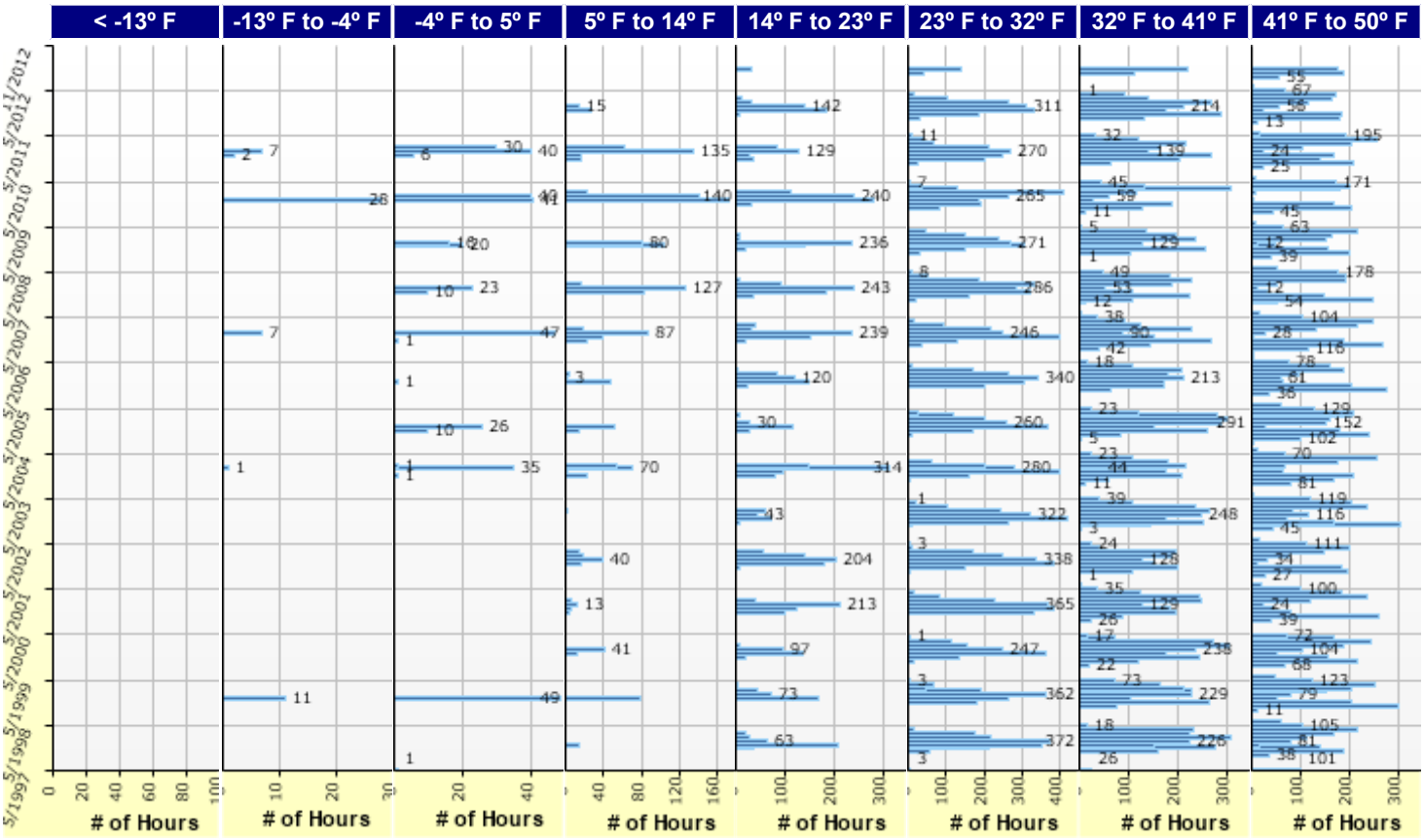


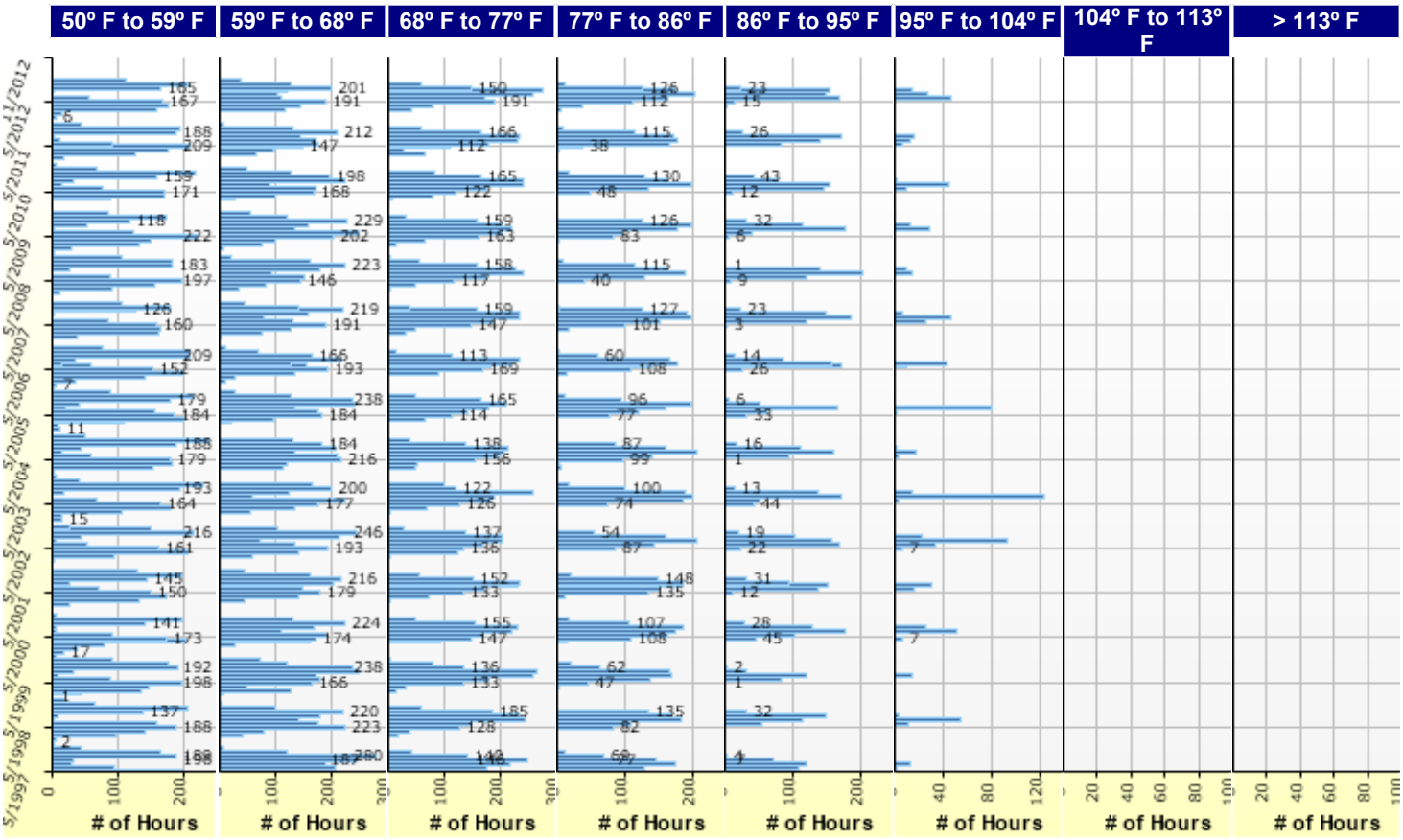






Hourly Air Temperature Distribution by Month:





Design Properties

HMA Design Properties

Use Multilayer Rutting Model	False
Using G* based model (not nationally calibrated)	False
Is NCHRP 1-37A HMA Rutting Model Coefficients	True
Endurance Limit	-
Use Reflective Cracking	True

Structure - ICM Properties	
AC surface shortwave absorptivity	0.85

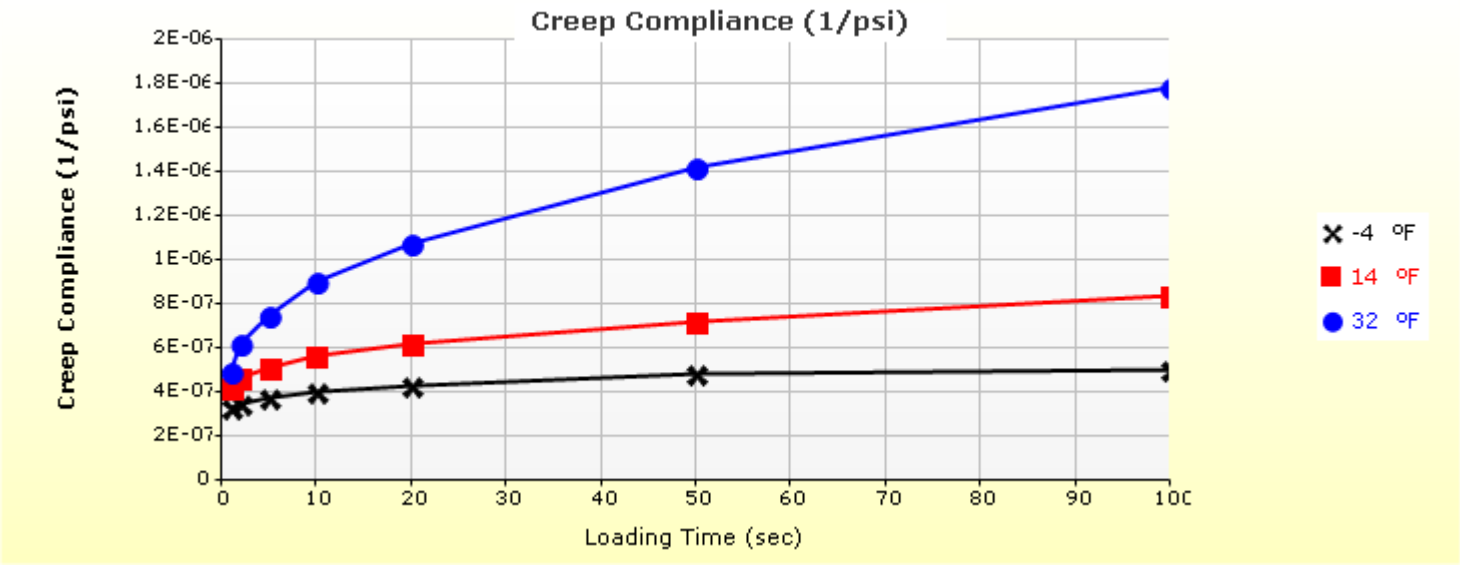
Layer Name	Layer Type	Interface Friction
Layer 1 Flexible : R2 Level 1 SX (75) PG 64-22	Flexible (1)	1.00
Layer 2 Non-stabilized Base : Crushed gravel	Non-stabilized Base (4)	1.00
Layer 3 Non-stabilized Base : CDOT Class 2 ABC	Non-stabilized Base (4)	1.00
Layer 4 Subgrade : A-4	Subgrade (5)	1.00
Layer 5 Subgrade : A-4	Subgrade (5)	-

Thermal Cracking (Input Level: 1)

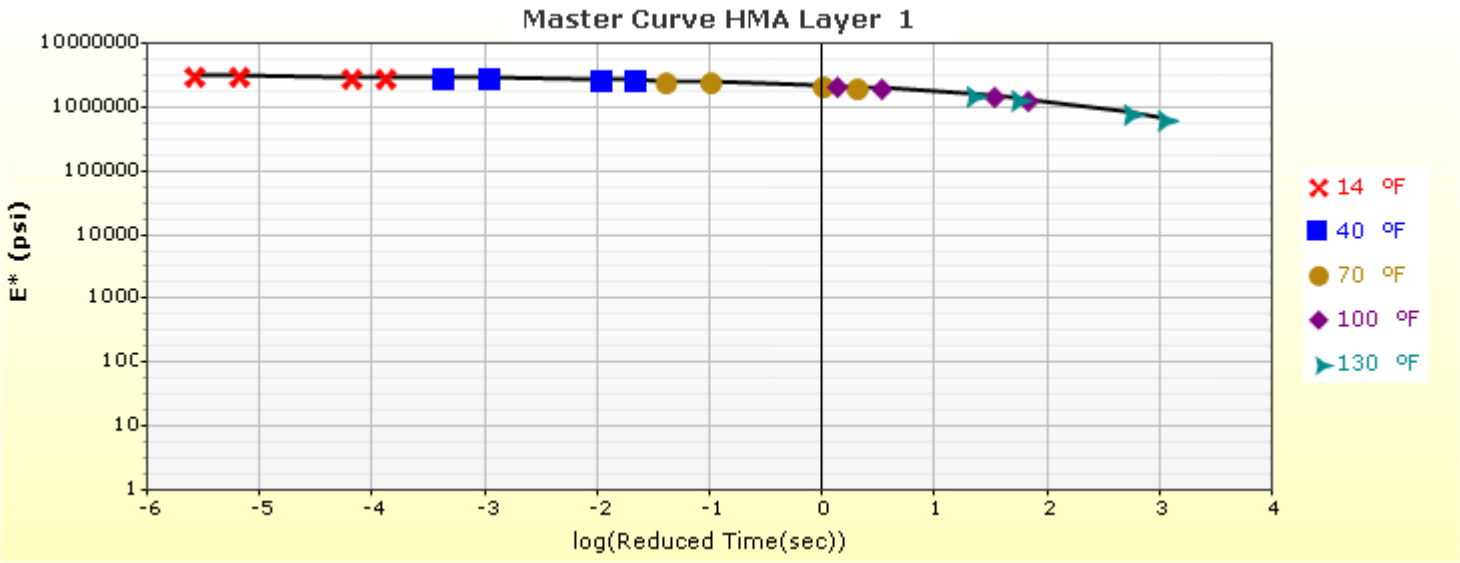
Indirect tensile strength at 14 °F (psi)	451.00

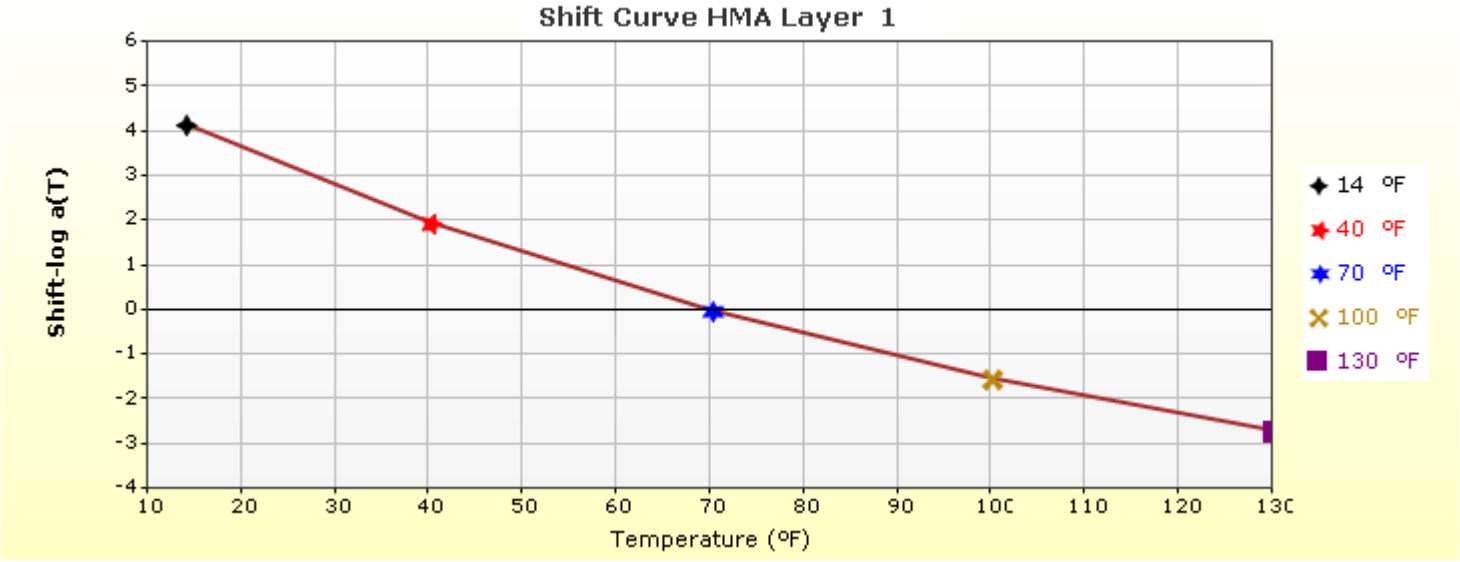
Thermal Contraction	
Is thermal contraction calculated?	True
Mix coefficient of thermal contraction (in/in/°F)	-
Aggregate coefficient of thermal contraction (in/in/°F)	5.0e-006
Voids in Mineral Aggregate (%)	18.7

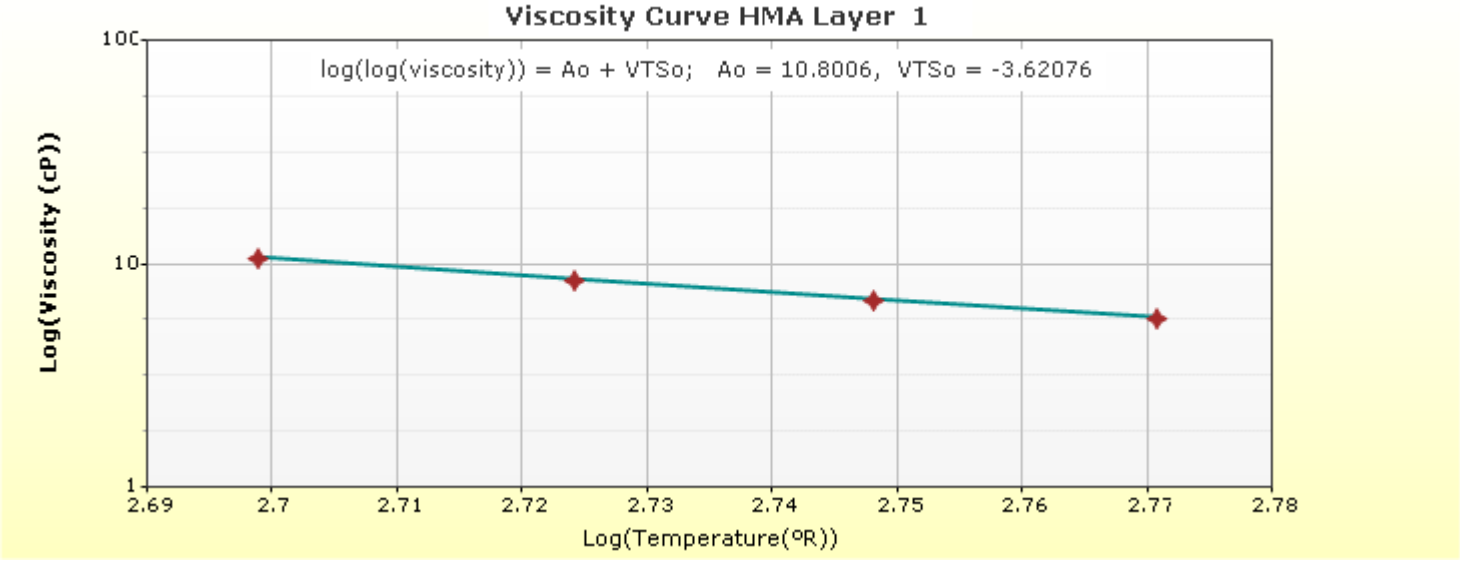
	Creep Compliance (1/psi)		
Loading time (sec)	-4 °F	14 °F	32 °F
1	3.34e-007	4.19e-007	4.99e-007
2	3.53e-007	4.64e-007	6.19e-007
5	3.79e-007	5.15e-007	7.49e-007
10	4.05e-007	5.70e-007	9.08e-007
20	4.31e-007	6.26e-007	1.08e-006
50	4.87e-007	7.27e-007	1.43e-006
100	5.05e-007	8.41e-007	1.79e-006



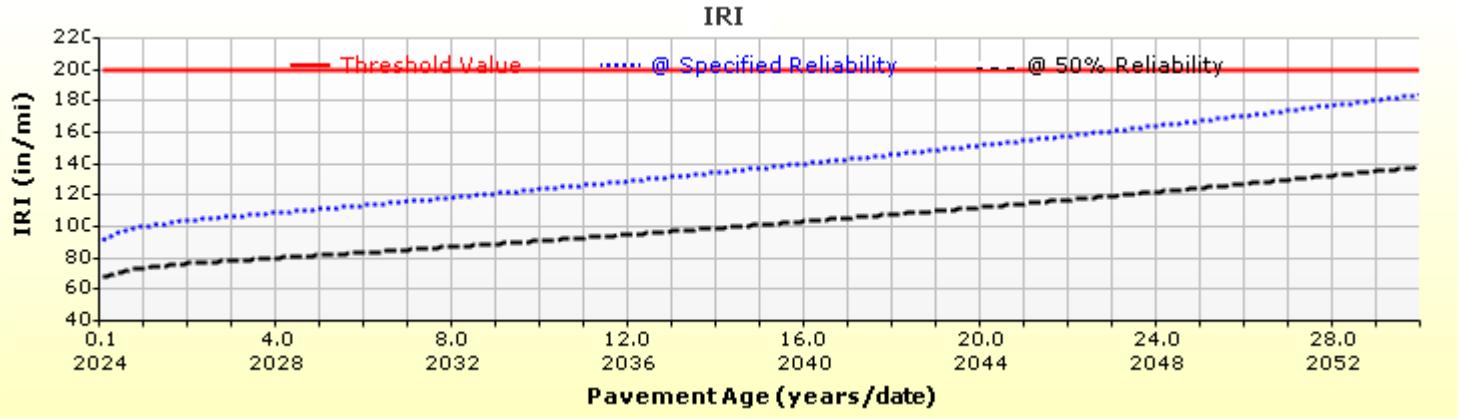
HMA Layer 1: Layer 1 Flexible : R2 Level 1 SX(75) PG 64-22

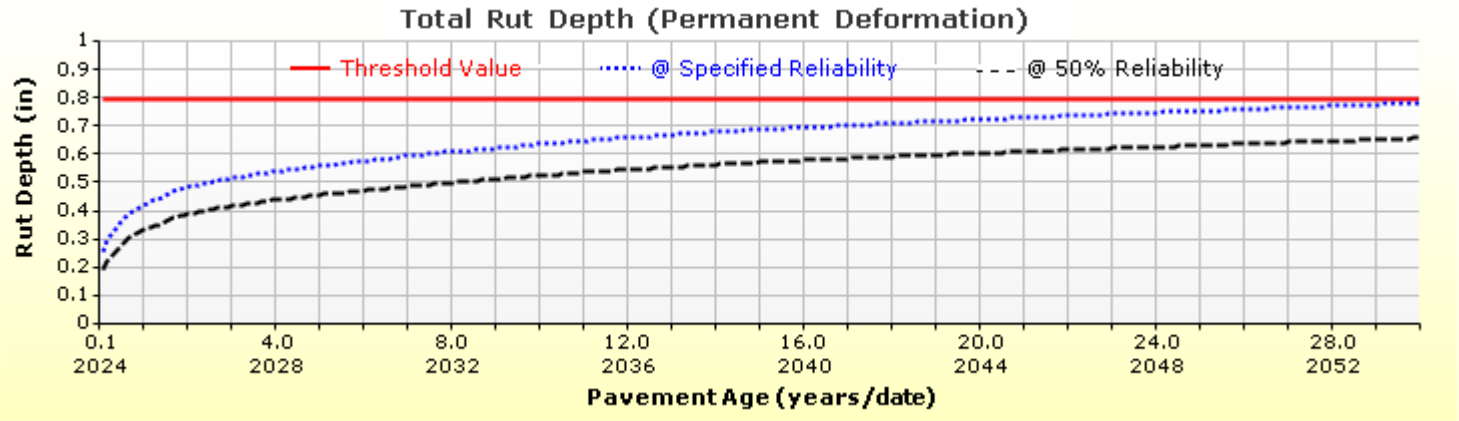


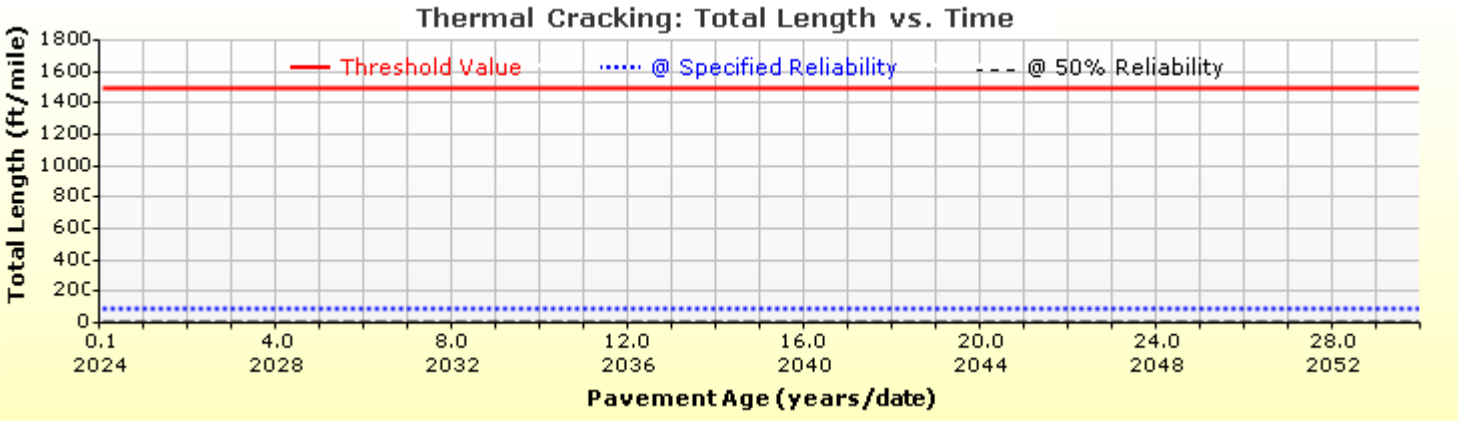


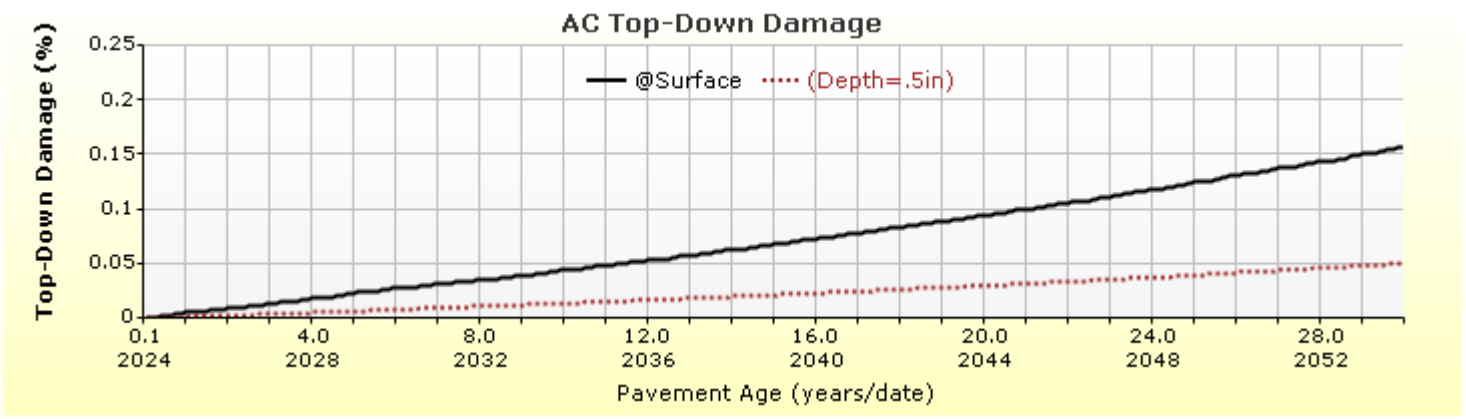


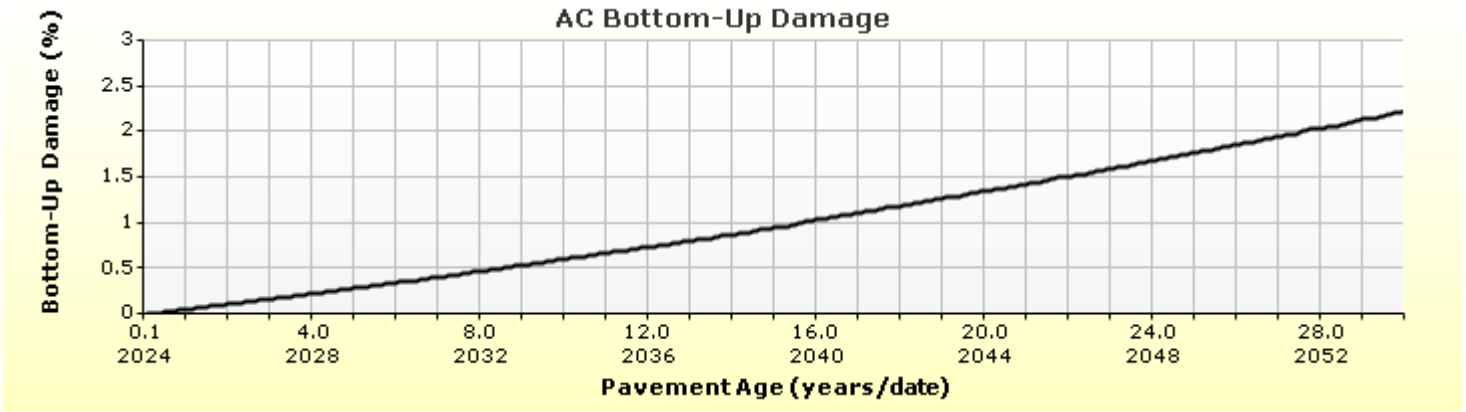
Analysis Output Charts

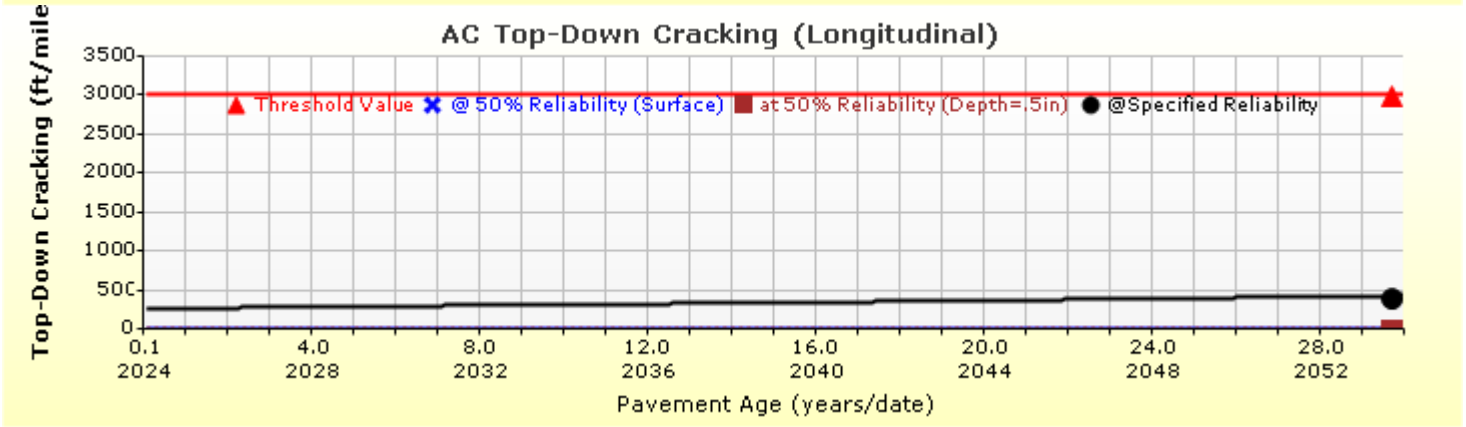


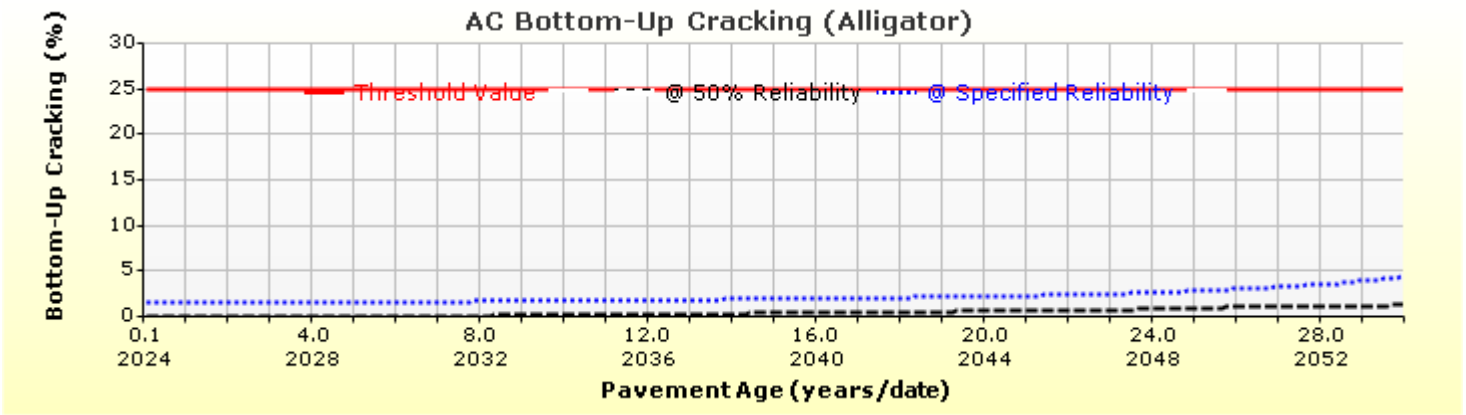


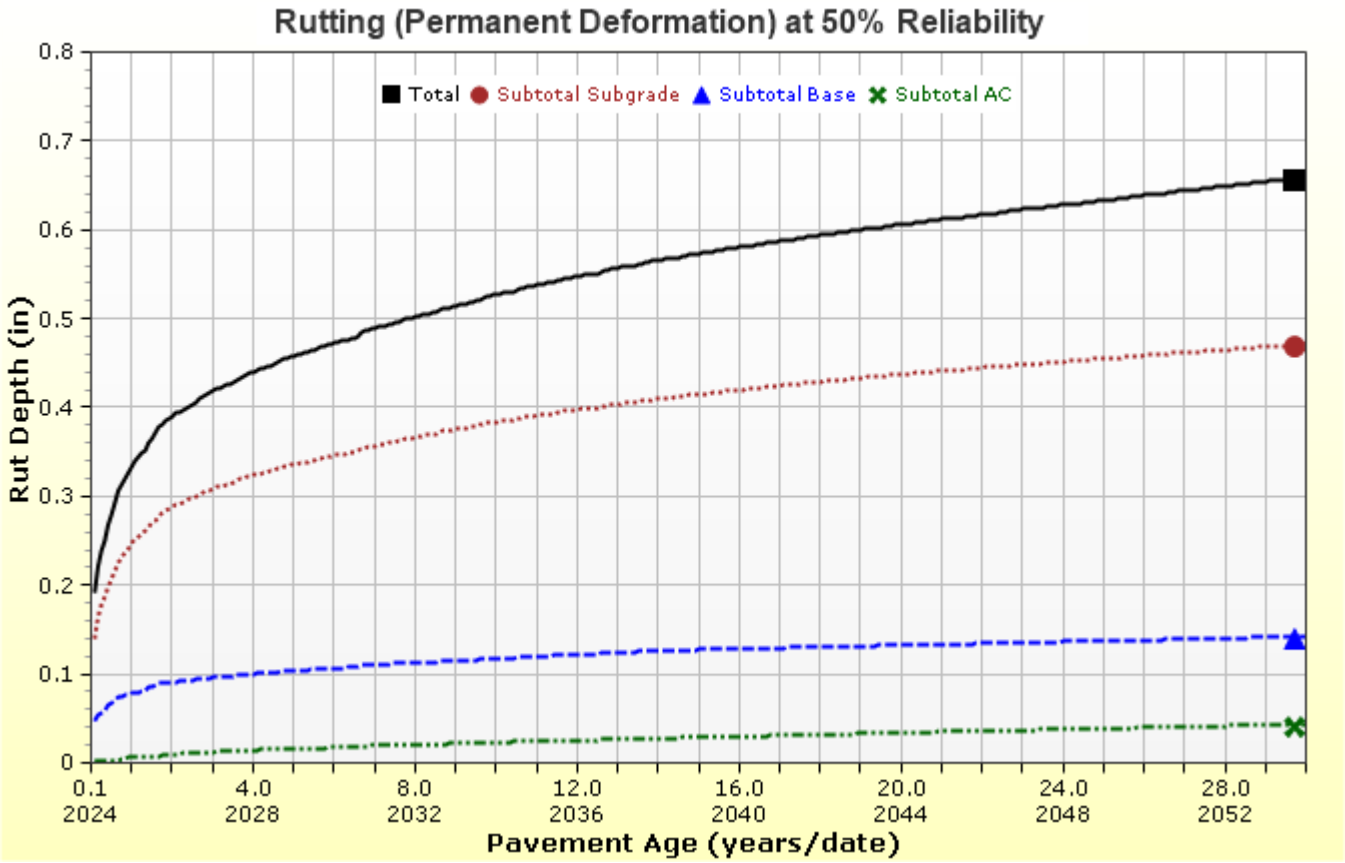


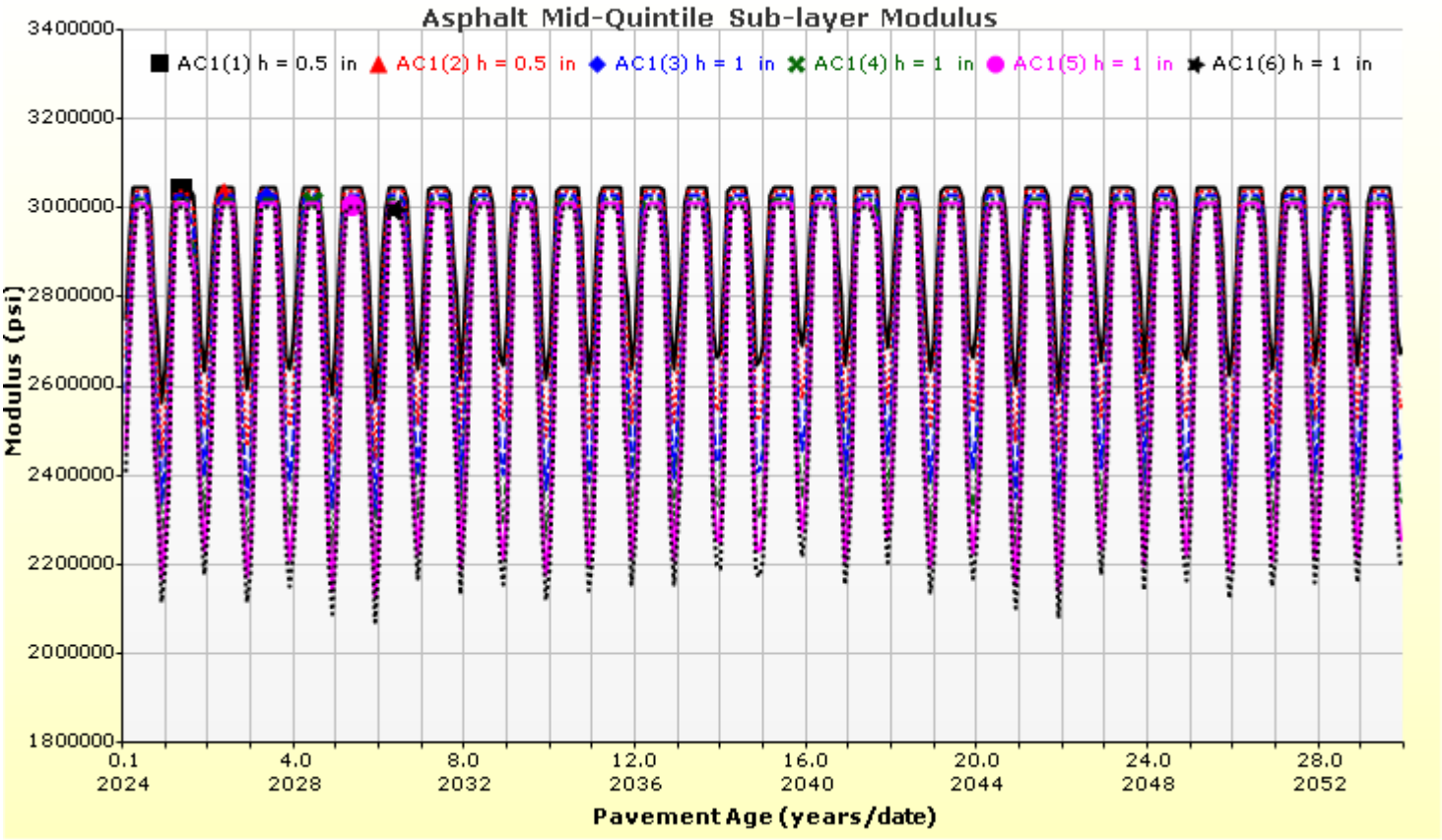

AC Top-Down Damage
Top-Down Damage (%)
0.25
0.2
0.15
0.1
0.05
0
@Surface
(Depth=.5in)
0.1
2024
4.0
2028
8.0
2032
12.0
2036
16.0
2040
20.0
2044
24.0
2048
28.0
2052
Pavement Age (years/date)

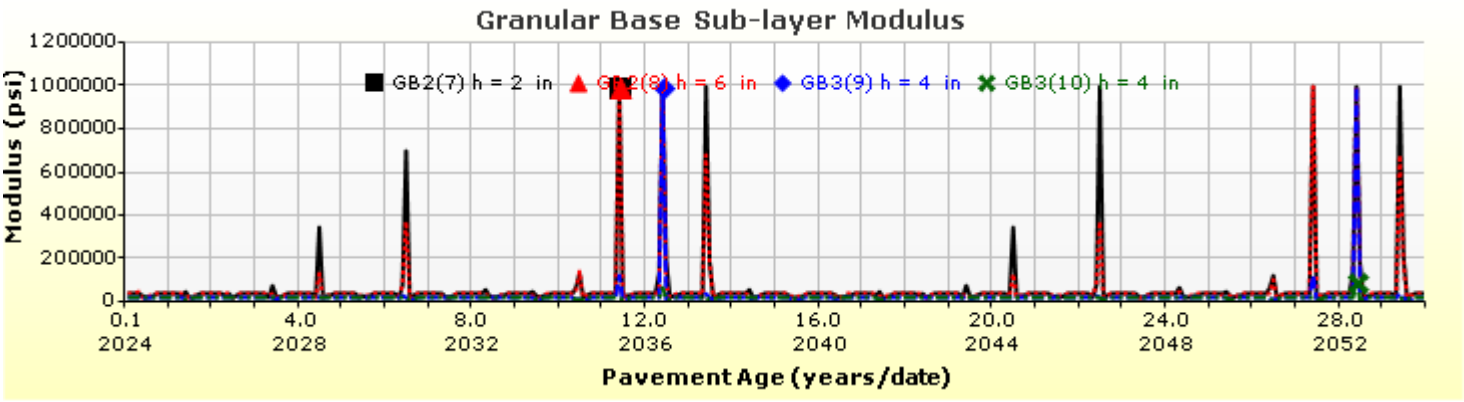

AC Bottom-Up Damage
Bottom-Up Damage (%)
3
2.5
2
1.5
1
0.5
0
0.1
2024
4.0
2028
8.0
2032
12.0
2036
16.0
2040
20.0
2044
24.0
2048
28.0
2052
Pavement Age (years/date)

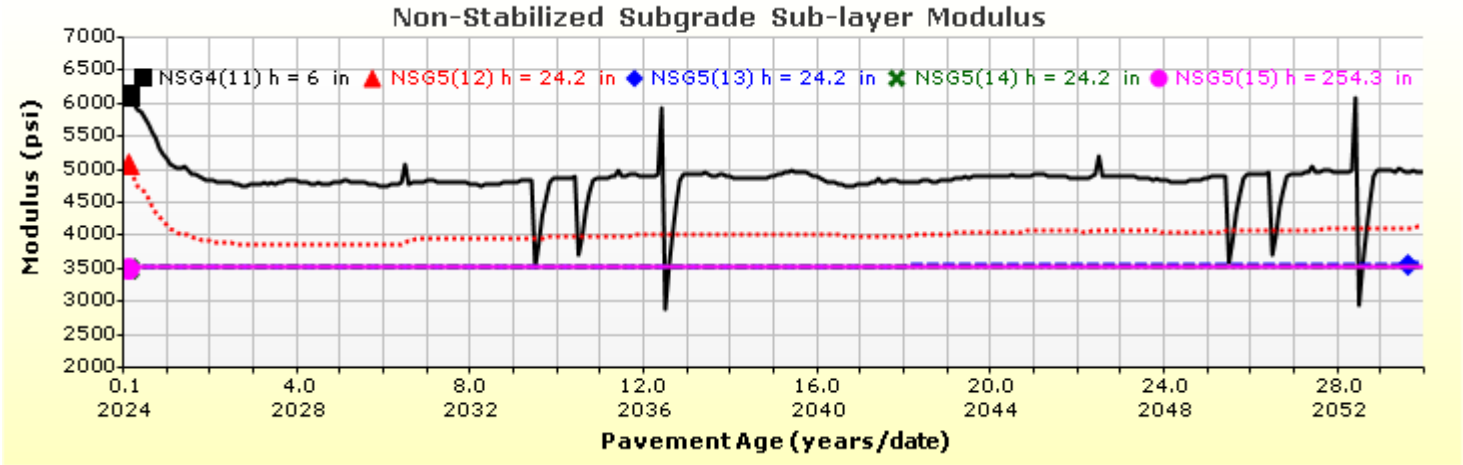

AC Top-Down Cracking (Longitudinal)
Top-Down Cracking (ft/mile
3500
3000
2500
2000
1500
1000
500
0
Threshold Value
@ 50% Reliability (Surface)
at 50% Reliability (Depth=.5in)
@Specified Reliability
0.1
2024
4.0
2028
8.0
2032
12.0
2036
16.0
2040
20.0
2044
24.0
2048
28.0
2052
Pavement Age (years/date)


AC Bottom-Up Cracking (Alligator)
Bottom-Up Cracking (%)
30
25
20
15
10
5
0
Threshold Value
@ 50% Reliability
@ Specified Reliability
0.1
2024
4.0
2028
8.0
2032
12.0
2036
16.0
2040
20.0
2044
24.0
2048
28.0
2052
Pavement Age (years/date)


Rutting (Permanent Deformation) at 50% Reliability
Total
Subtotal Subgrade
Subtotal Base
Subtotal AC
Rut Depth (in)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
2024
4.0
2028
8.0
2032
12.0
2036
16.0
2040
20.0
2044
24.0
2048
28.0
2052
Pavement Age (years/date)


Asphalt Mid-Quintile Sub-layer Modulus
AC1(1) h = 0.5 in
AC1(2) h = 0.5 in
AC1(3) h = 1 in
AC1(4) h = 1 in
AC1(5) h = 1 in
AC1(6) h = 1 in
Modulus (psi)
3400000
3200000
3000000
2800000
2600000
2400000
2200000
2000000
1800000
0.1
2024
4.0
2028
8.0
2032
12.0
2036
16.0
2040
20.0
2044
24.0
2048
28.0
2052
Pavement Age (years/date)


Granular Base Sub-layer Modulus
GB2(7) h = 2 in
GB2(8) h = 6 in
GB3(9) h = 4 in
GB3(10) h = 4 in
Modulus (psi)
1200000
1000000
800000
600000
400000
200000
0
0.1
2024
4.0
2028
8.0
2032
12.0
2036
16.0
2040
20.0
2044
24.0
2048
28.0
2052
Pavement Age (years/date)


Non-Stabilized Subgrade Sub-layer Modulus
NSG4(11) h = 6 in
NSG5(12) h = 24.2 in
NSG5(13) h = 24.2 in
NSG5(14) h = 24.2 in
NSG5(15) h = 254.3 in
Modulus (psi)
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
0.1
2024
4.0
2028
8.0
2032
12.0
2036
16.0
2040
20.0
2044
24.0
2048
28.0
2052
Pavement Age (years/date)

Layer Information

Layer 1 Flexible : R2 Level 1 SX(75) PG 64-22

Asphalt		
Thickness (in)	5.0	
Unit weight (pcf)	140.5	
Poisson's ratio	Is Calculated?	True
	Ratio	-
	Parameter A	-1.63
	Parameter B	3.84E-06

Asphalt Dynamic Modulus (Input Level: 1)

T (ºF)	0.5 Hz	1 Hz	10 Hz	25 Hz
14	2910500	2947100	3034800	3058600
40	2620500	2695700	2882400	2934800
70	2057300	2190500	2549800	2658300
100	1334300	1500400	2017600	2195500
130	697600	836500	1365200	1584000

Asphalt Binder

Temperature (ºF)	Binder Gstar (Pa)	Phase angle (deg)
168.8	451	85
147.2	1857	81.6
158	889	83.1

General Info

Name	Value
Reference temperature (ºF)	70
Effective binder content (%)	11.8
Air voids (%)	6.9
Thermal conductivity (BTU/hr-ft-ºF)	0.67
Heat capacity (BTU/lb-ºF)	0.23

Identifiers

Field	Value
Display name/identifier	R2 Level 1 SX(75) PG 64-22
Description of object	Mix ID # 19127A
Author	CDOT
Date Created	4/3/2013 12:00:00 AM
Approver	CDOT
Date approved	4/3/2013 12:00:00 AM
State	Colorado
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	SX
User defined field 2	
User defined field 3	
Revision Number	0

Layer 2 Non-stabilized Base : Crushed gravel

Unbound	
Layer thickness (in)	8.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
25000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Crushed gravel
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	42

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.7
Saturated hydraulic conductivity (ft/hr)	False	5.054e-02
Specific gravity of solids	False	2.7
Water Content (%)	False	7.4

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	7.2555
bf	1.3328
cf	0.8242
hr	117.4000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20.0
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8-in.	57.2
1/2-in.	63.1
3/4-in.	72.7
1-in.	78.8
1 1/2-in.	85.8
2-in.	91.6
2 1/2-in.	
3-in.	
3 1/2-in.	97.6

Layer 3 Non-stabilized Base : CDOT Class 2 ABC

Unbound	
Layer thickness (in)	8.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
12000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	CDOT Class 2 ABC
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.7
Saturated hydraulic conductivity (ft/hr)	False	5.054e-02
Specific gravity of solids	False	2.7
Water Content (%)	False	7.4

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	7.2555
bf	1.3328
cf	0.8242
hr	117.4000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20.0
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8-in.	57.2
1/2-in.	63.1
3/4-in.	72.7
1-in.	78.8
1 1/2-in.	85.8
2-in.	91.6
2 1/2-in.	
3-in.	
3 1/2-in.	97.6

Layer 4 Subgrade : A-4

Unbound	
Layer thickness (in)	6.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
7844.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	A-4
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	21.0
Plasticity Index	5.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	119
Saturated hydraulic conductivity (ft/hr)	False	7.589e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	11.8

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	68.8377
bf	0.9983
cf	0.4757
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	60.6
#100	
#80	73.9
#60	
#50	
#40	82.7
#30	
#20	
#16	
#10	89.9
#8	
#4	93.0
3/8-in.	95.6
1/2-in.	96.7
3/4-in.	98.0
1-in.	98.7
1 1/2-in.	99.4
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.8

Layer 5 Subgrade : A-4

Unbound	
Layer thickness (in)	Semi-infinite
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
7844.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	A-4
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	21.0
Plasticity Index	5.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	118.4
Saturated hydraulic conductivity (ft/hr)	False	8.325e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	11.8

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	68.8377
bf	0.9983
cf	0.4757
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	60.6
#100	
#80	73.9
#60	
#50	
#40	82.7
#30	
#20	
#16	
#10	89.9
#8	
#4	93.0
3/8-in.	95.6
1/2-in.	96.7
3/4-in.	98.0
1-in.	98.7
1 1/2-in.	99.4
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.8

Calibration Coefficients

AC Fatigue

$$N_f = 0.00432 * C * \beta_{f1} k_1 \left(\frac{1}{\varepsilon_1}\right)^{k_2\beta_{f2}} \left(\frac{1}{E}\right)^{k_3\beta_{f3}}$$

$$C = 10^M$$

$$M = 4.84\left(\frac{V_b}{V_a + V_b} - 0.69\right)$$

k1: 0.007566	
k2: 3.9492	
k3: 1.281	
Bf1: 1	
Bf2: 1	
Bf3: 1	

AC Rutting

$$\frac{\varepsilon_p}{\varepsilon_r} = k_z \beta_{r1} 10^{k_1 T^{k_2 \beta_{r2}} N^{k_3 \beta_{r3}}}$$

$$k_z = (C_1 + C_2 * depth) * 0.328196^{depth}$$

$$C_1 = -0.1039 * H_{ac}^2 + 2.4868 * H_{ac} - 17.342$$

$$C_2 = 0.0172 * H_{ac}^2 - 1.7331 * H_{ac} + 27.428$$

Where:

$H_{ac} = total\ AC\ thickness(in)$

$\varepsilon_p = plastic\ strain\left(^{in}/_{in}\right)$
$\varepsilon_r = resilient\ strain\left(^{in}/_{in}\right)$
$T = layer\ temperature(^{\circ}F)$
$N = number\ of\ load\ repetitions$

AC Rutting Standard Deviation	0.24 * Pow(RUT,0.8026) + 0.001	
AC Layer	K1:-3.35412 K2:1.5606 K3:0.4791	Br1:1 Br2:1 Br3:1

Thermal Fracture

$$C_f = 400 * N\left(\frac{\log C / h_{ac}}{\sigma}\right)$$

$$\Delta C = (k * \beta t)^{n+1} * A * \Delta K^n$$

$$A = 10^{(4.389 - 2.52 * \log(E * \sigma_m * n))}$$

$C_f = observed\ amount\ of\ thermal\ cracking(ft/500ft)$
$k = refression\ coefficient\ determined\ through\ field\ calibration$
$N() = standard\ normal\ distribution\ evaluated\ at()$
$\sigma = standard\ deviation\ of\ the\ \log\ of\ the\ depth\ of\ cracks\ in\ the\ pavments$
$C = crack\ depth(in)$
$h_{ac} = thickness\ of\ asphalt\ layer(in)$
$\Delta C = Change\ in\ the\ crack\ depth\ due\ to\ a\ cooling\ cycle$
$\Delta K = Change\ in\ the\ stress\ intensity\ factor\ due\ to\ a\ cooling\ cycle$
$A, n = Fracture\ parameters\ for\ the\ asphalt\ mixture$
$E = mixture\ stiffness$
$\sigma_M = Undamaged\ mixture\ tensile\ strength$
$\beta_t = Calibration\ parameter$

Level 1 K: 1.5	Level 1 Standard Deviation: 0.1468 * THERMAL + 65.027
Level 2 K: 0.5	Level 2 Standard Deviation: 0.2841 * THERMAL + 55.462
Level 3 K: 1.5	Level 3 Standard Deviation: 0.3972 * THERMAL + 20.422

CSM Fatigue

$$N_f = 10^{\left(\frac{k_1 \beta_{c1} \left(\frac{\sigma_s}{M_r}\right)}{k_2 \beta_{c2}}\right)}$$

$N_f = number\ of\ repetitions\ to\ fatigue\ cracking$
$\sigma_s = Tensile\ stress(psi)$
$M_r = modulus\ of\ rupture(psi)$

k1: 1	k2: 1	Bc1: 0.75	Bc2:1.1

Subgrade Rutting

$$\delta_a(N) = \beta_{s_1} k_1 \varepsilon_v h \left(\frac{\varepsilon_0}{\varepsilon_r}\right) \left| e^{-\left(\frac{\rho}{N}\right)^{\beta}} \right|$$

$\delta_a = permanent\ deformation\ for\ the\ layer$
$N = number\ of\ repetitions$
$\varepsilon_v = average\ veritcal\ strain(in/in)$
$\varepsilon_0, \beta, \rho = material\ properties$
$\varepsilon_r = resilient\ strain(in/in)$

Granular		Fine	
k1: 2.03	Bs1: 1	k1: 1.35	Bs1: 1
Standard Deviation (BASERUT) 0.1477 * Pow(BASERUT,0.6711) + 0.001		Standard Deviation (BASERUT) 0.1235 * Pow(SUBRUT,0.5012) + 0.001	

AC Cracking

AC Top Down Cracking

$$FC_{top} = \left(\frac{C_4}{1 + e^{(C_1 - C_2 * log_{10}(Damage))}}\right) * 10.56$$

c1: 7	c2: 3.5	c3: 0	c4: 1000

AC Cracking Top Standard Deviation

200 + 2300/(1+exp(1.072-2.1654*LOG10 (TOP+0.0001)))

AC Bottom Up Cracking

$$FC = \left(\frac{6000}{1 + e^{(C_1 * C_1' + C_2 * C_2' log_{10}(D * 100))}}\right) * \left(\frac{1}{60}\right)$$

$$C_2' = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$$

$$C_1' = -2 * C_2'$$

c1: 1	c2: 1	c3: 6000

AC Cracking Bottom Standard Deviation

1.13 + 13/(1+exp(7.57-15.5*LOG10 (BOTTOM+0.0001)))

CSM Cracking

$$FC_{ctb} = C_1 + \frac{C_2}{1 + e^{C_3 - C_4 (Damage)}}$$

C1: 0	C2: 75	C3: 5	C4: 3

CSM Standard Deviation

CTB*1

IRI Flexible Pavements

C1 - Rutting
C2 - Fatigue Crack
C3 - Transverse Crack
C4 - Site Factors

C1: 40	C2: 0.4	C3: 0.008	C4: 0.015

APPENDIX H

CROSBY AVENUE RIGID PMED OUTPUT SHEETS

Crosby Avenue PCCP Design

File Name: C:\Users\goldbaum\Documents\My PMED Designs\My ME Design\Projects\Crosby Avenue\Crosby Avenue PCCP Design.dgpx

Design Inputs

Design Life: 30 years
Design Type: JPCP

Existing construction: -
Pavement construction: May, 2024
Traffic opening: September, 2024

Climate Data Sources (Lat/Lon): 39.134, -108.538

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 1 Lawson	9.0
NonStabilized	Crushed gravel	8.0
Subgrade	A-4	6.0
Subgrade	A-4	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.25
Slab width (ft)	12.0

Traffic

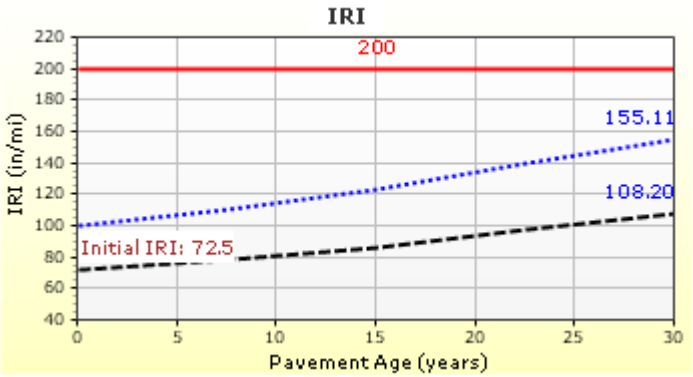
Age (year)	Heavy Trucks (cumulative)
2024 (initial)	670
2039 (15 years)	2,285,280
2054 (30 years)	5,360,970

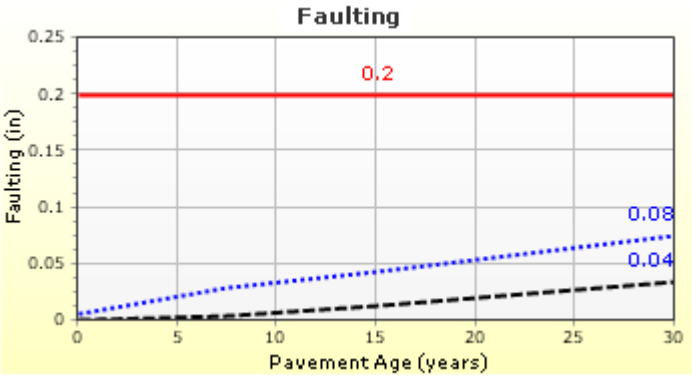
Design Outputs

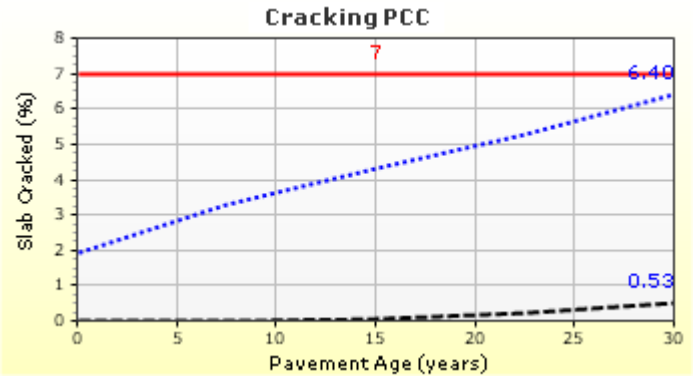
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	200.00	155.11	90.00	99.39	Pass
Mean joint faulting (in)	0.20	0.08	90.00	100.00	Pass
JPCP transverse cracking (percent slabs)	7.00	6.40	90.00	92.11	Pass

Distress Charts



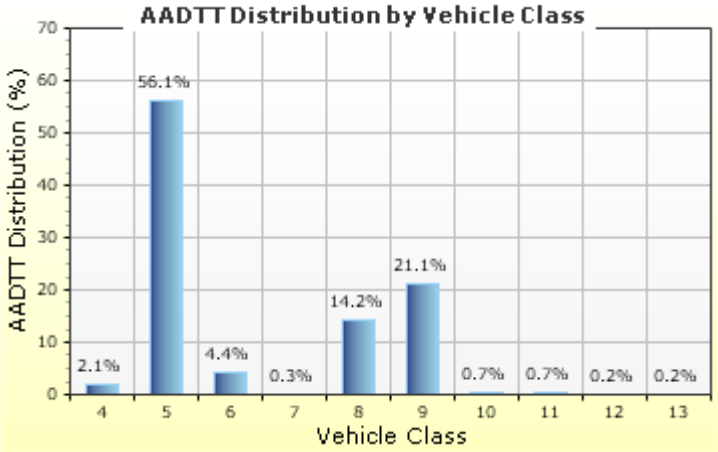


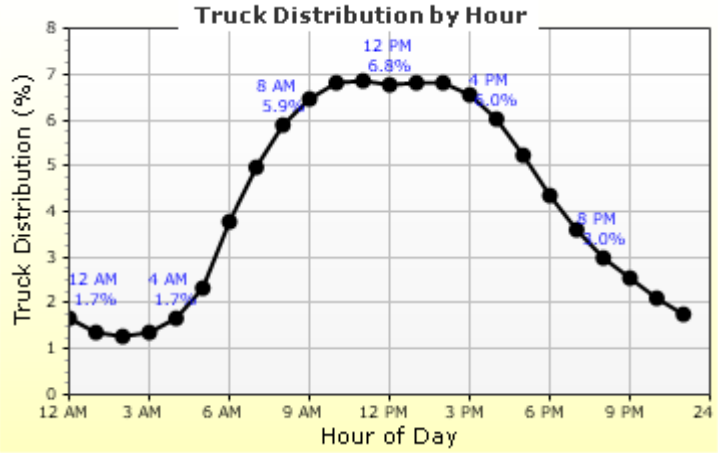


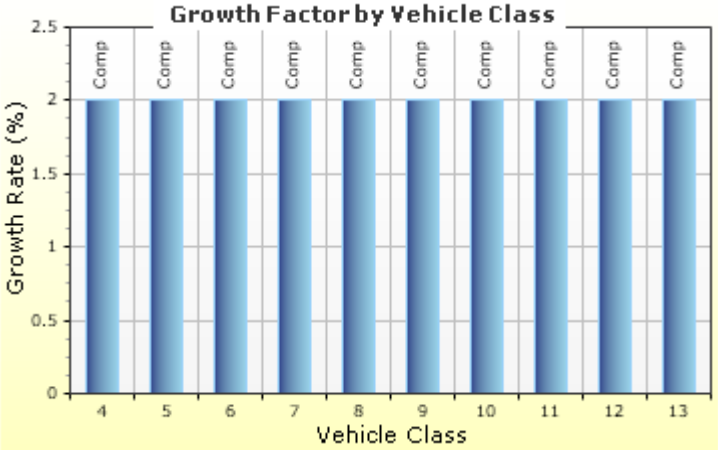
Traffic Inputs

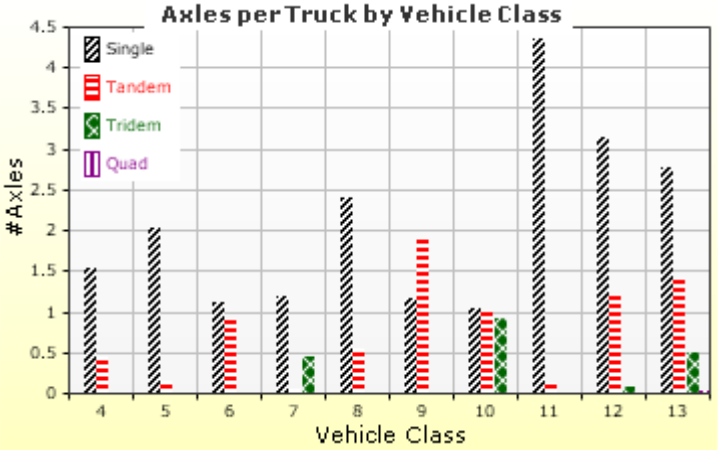
Graphical Representation of Traffic Inputs

Initial two-way AADTT:	670	Percent of trucks in design direction (%):	60.0
Number of lanes in design direction:	1	Percent of trucks in design lane (%):	90.0
		Operational speed (mph)	35.0

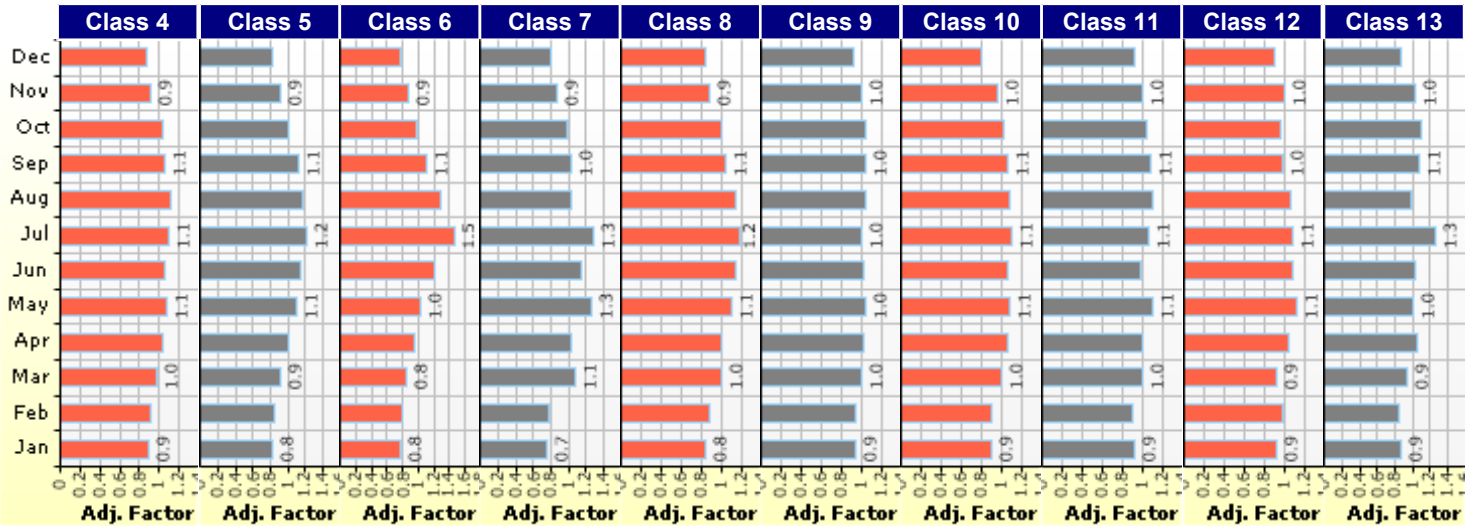








Traffic Volume Monthly Adjustment Factors



Tabular Representation of Traffic Inputs

Volume Monthly Adjustment Factors

Level 3: Default MAF

Month	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
January	0.9	0.8	0.8	0.7	0.8	0.9	0.9	0.9	0.9	0.9
February	0.9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	0.8
March	1.0	0.9	0.8	1.1	1.0	1.0	1.0	1.0	0.9	0.9
April	1.0	1.0	0.9	1.0	1.0	1.0	1.1	1.0	1.0	1.1
May	1.1	1.1	1.0	1.3	1.1	1.0	1.1	1.1	1.1	1.0
June	1.1	1.1	1.2	1.1	1.1	1.0	1.1	1.0	1.1	1.0
July	1.1	1.2	1.5	1.3	1.2	1.0	1.1	1.1	1.1	1.3
August	1.1	1.2	1.3	1.0	1.1	1.0	1.1	1.1	1.1	1.0
September	1.1	1.1	1.1	1.0	1.1	1.0	1.1	1.1	1.0	1.1
October	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.1
November	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0
December	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.9	0.9	0.9

Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	2.1%	2%	Compound
Class 5	56.1%	2%	Compound
Class 6	4.4%	2%	Compound
Class 7	0.3%	2%	Compound
Class 8	14.2%	2%	Compound
Class 9	21.1%	2%	Compound
Class 10	0.7%	2%	Compound
Class 11	0.7%	2%	Compound
Class 12	0.2%	2%	Compound
Class 13	0.2%	2%	Compound

Truck Distribution by Hour

Hour	Distribution (%)	Hour	Distribution (%)
12 AM	1.65%	12 PM	6.75%
1 AM	1.37%	1 PM	6.81%
2 AM	1.28%	2 PM	6.83%
3 AM	1.36%	3 PM	6.56%
4 AM	1.66%	4 PM	6.02%
5 AM	2.32%	5 PM	5.23%
6 AM	3.8%	6 PM	4.35%
7 AM	4.95%	7 PM	3.59%
8 AM	5.9%	8 PM	2.98%
9 AM	6.48%	9 PM	2.56%
10 AM	6.83%	10 PM	2.12%
11 AM	6.85%	11 PM	1.75%
		Total	100%

Axle Configuration

Traffic Wander	
Mean wheel location (in)	18.0
Traffic wander standard deviation (in)	10.0
Design lane width (ft)	12.0

Axle Configuration	
Average axle width (ft)	8.5
Dual tire spacing (in)	12.0
Tire pressure (psi)	120.0

Average Axle Spacing	
Tandem axle spacing (in)	51.6
Tridem axle spacing (in)	49.2
Quad axle spacing (in)	49.2

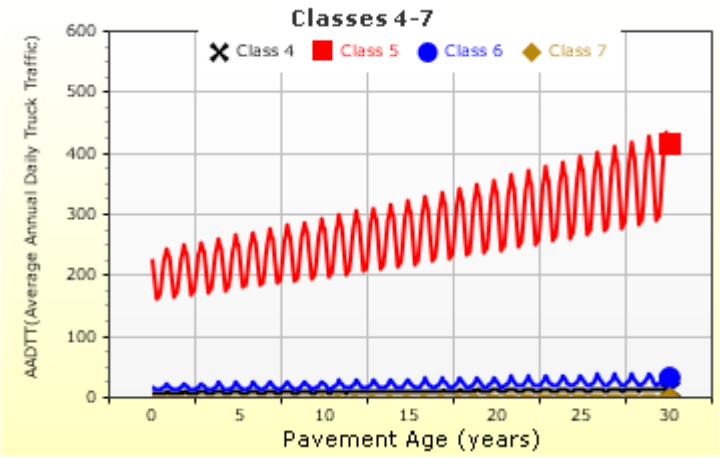
Wheelbase				
Value Type	Axle Type	Short	Medium	Long
Average spacing of axles (ft)		12.0	15.0	18.0
Percent of Trucks (%)		17.0	22.0	61.0

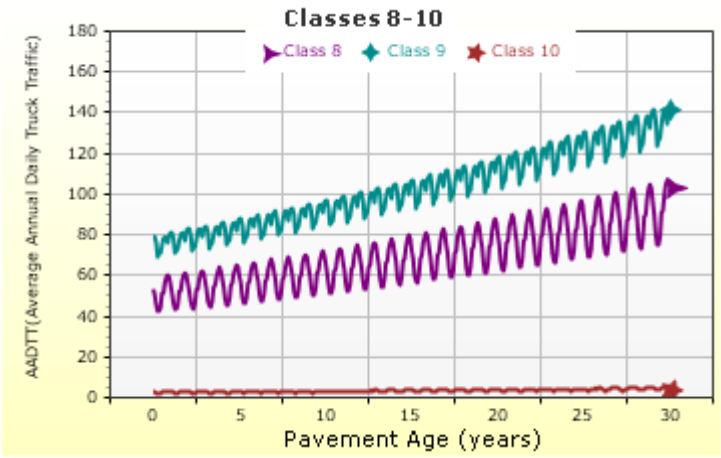
Number of Axles per Truck

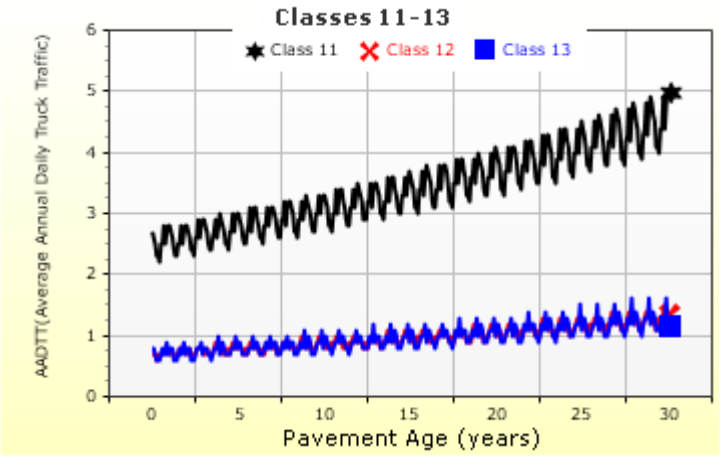
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.53	0.45	0	0
Class 5	2.02	0.16	0.02	0
Class 6	1.12	0.93	0	0
Class 7	1.19	0.07	0.45	0.02
Class 8	2.41	0.56	0.02	0
Class 9	1.16	1.88	0.01	0
Class 10	1.05	1.01	0.93	0.02
Class 11	4.35	0.13	0	0
Class 12	3.15	1.22	0.09	0
Class 13	2.77	1.4	0.51	0.04

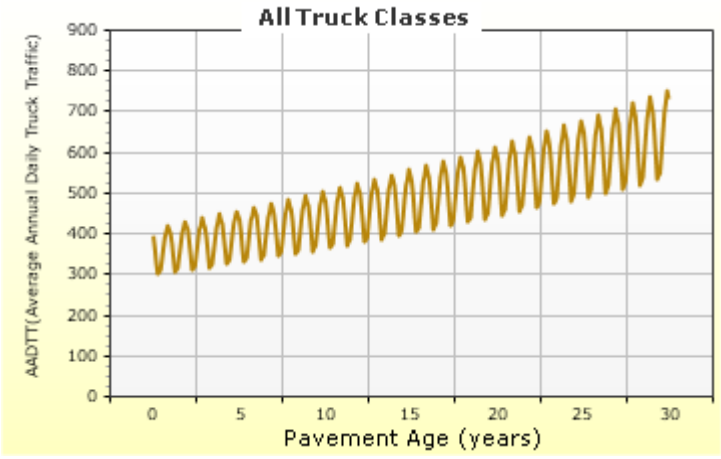
AADTT (Average Annual Daily Truck Traffic) Growth

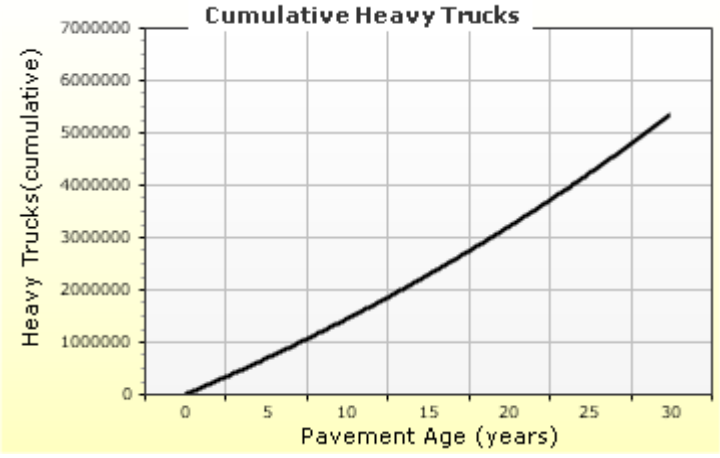
*** Traffic cap is not enforced**







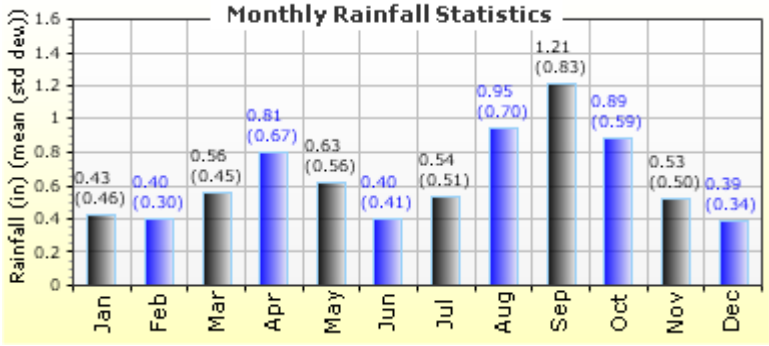




Climate Inputs

Climate Data Sources:

Climate Station Cities:	Location (lat lon elevation(ft))
GRAND JUNCTION, CO	39.13400 -108.53800 4839

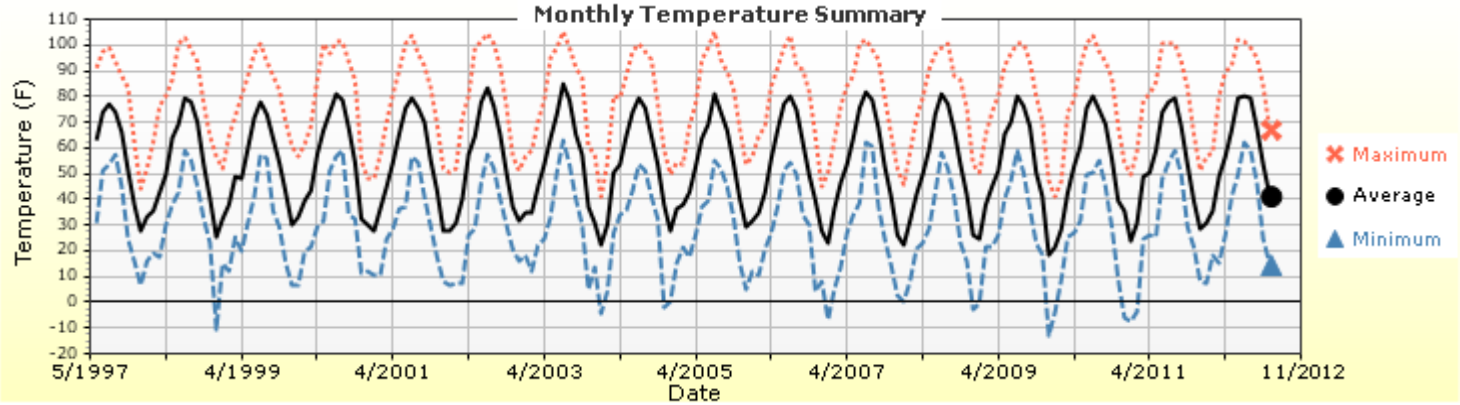


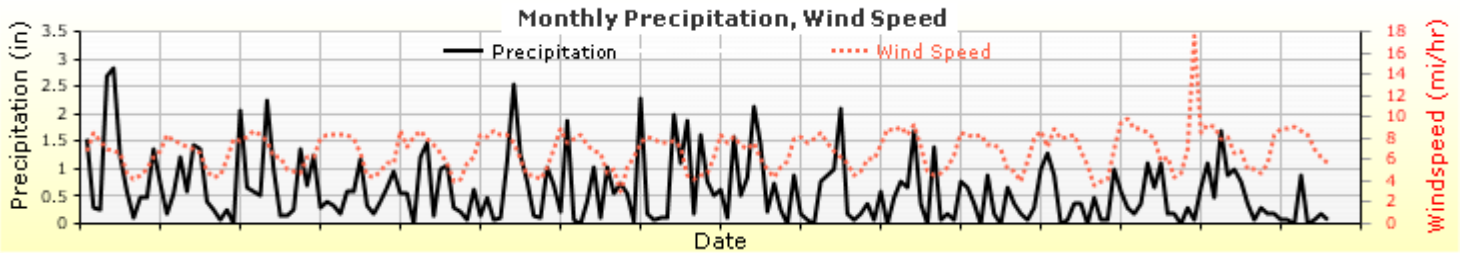
Annual Statistics:

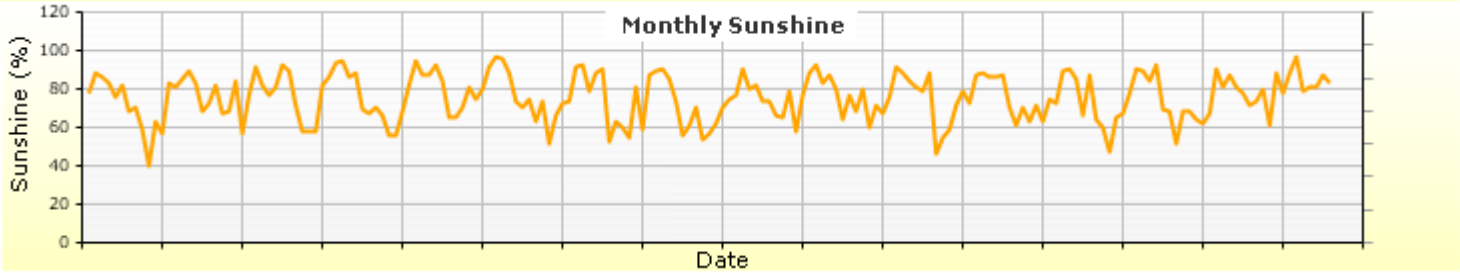
Mean annual air temperature (°F)	53.55
Mean annual precipitation (in)	7.76
Freezing index (°F - days)	398.73
Average annual number of freeze/thaw cycles:	111.77

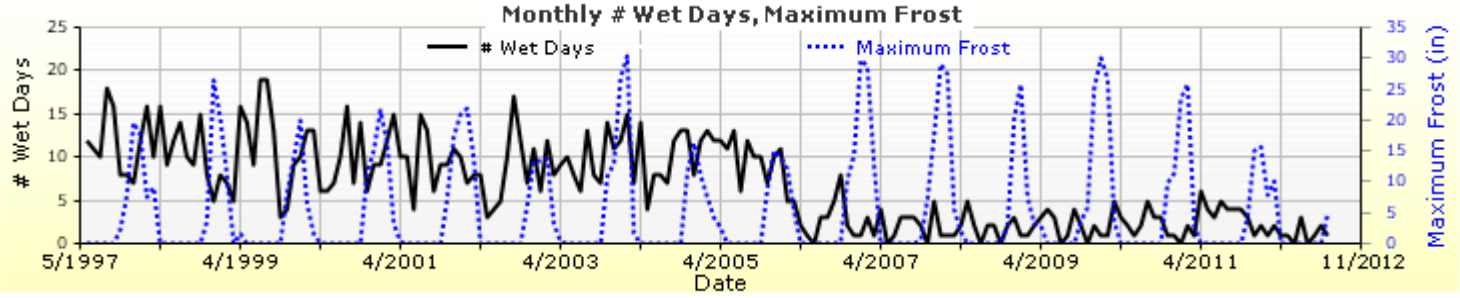
Water table depth (ft)	4.00

Monthly Climate Summary:

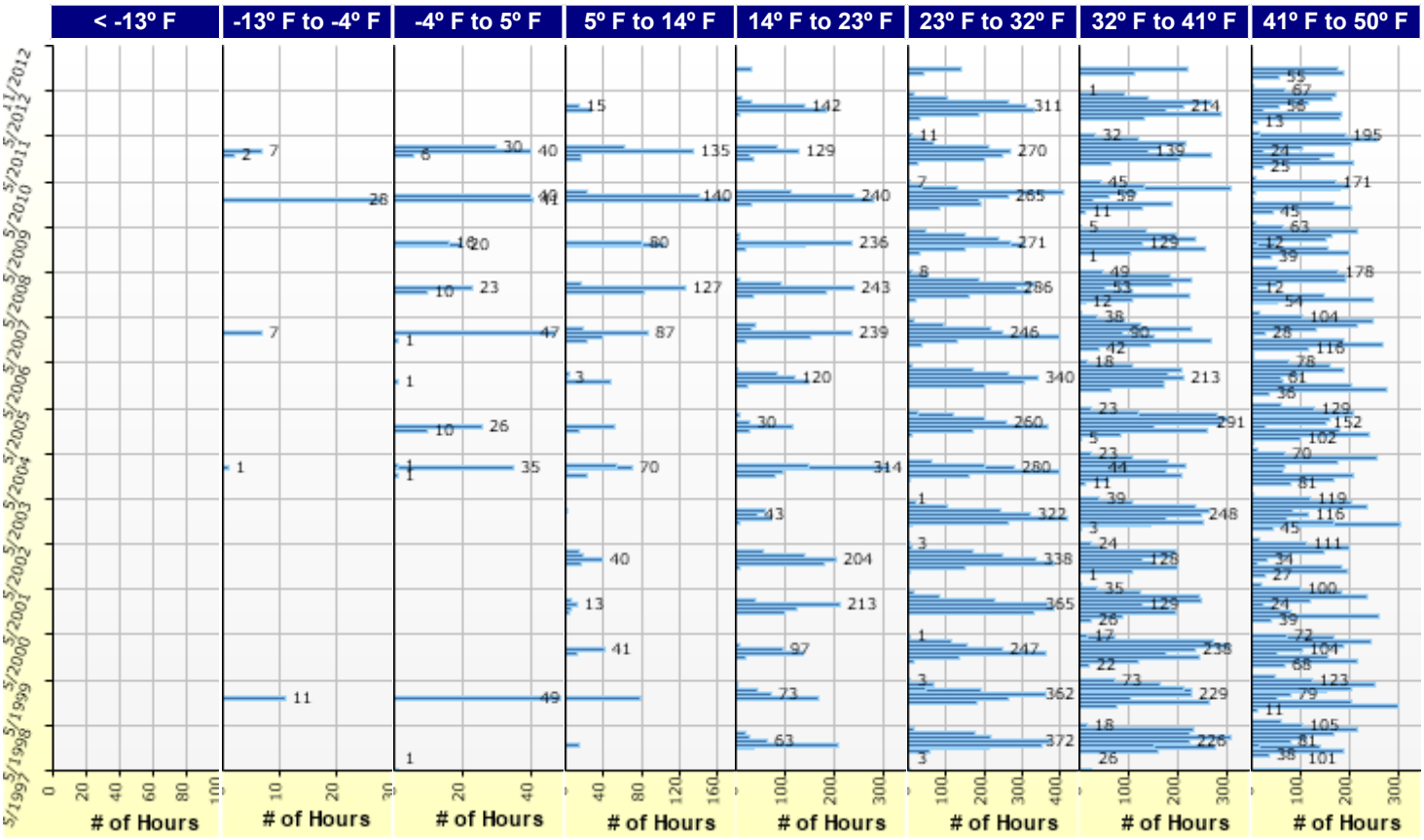


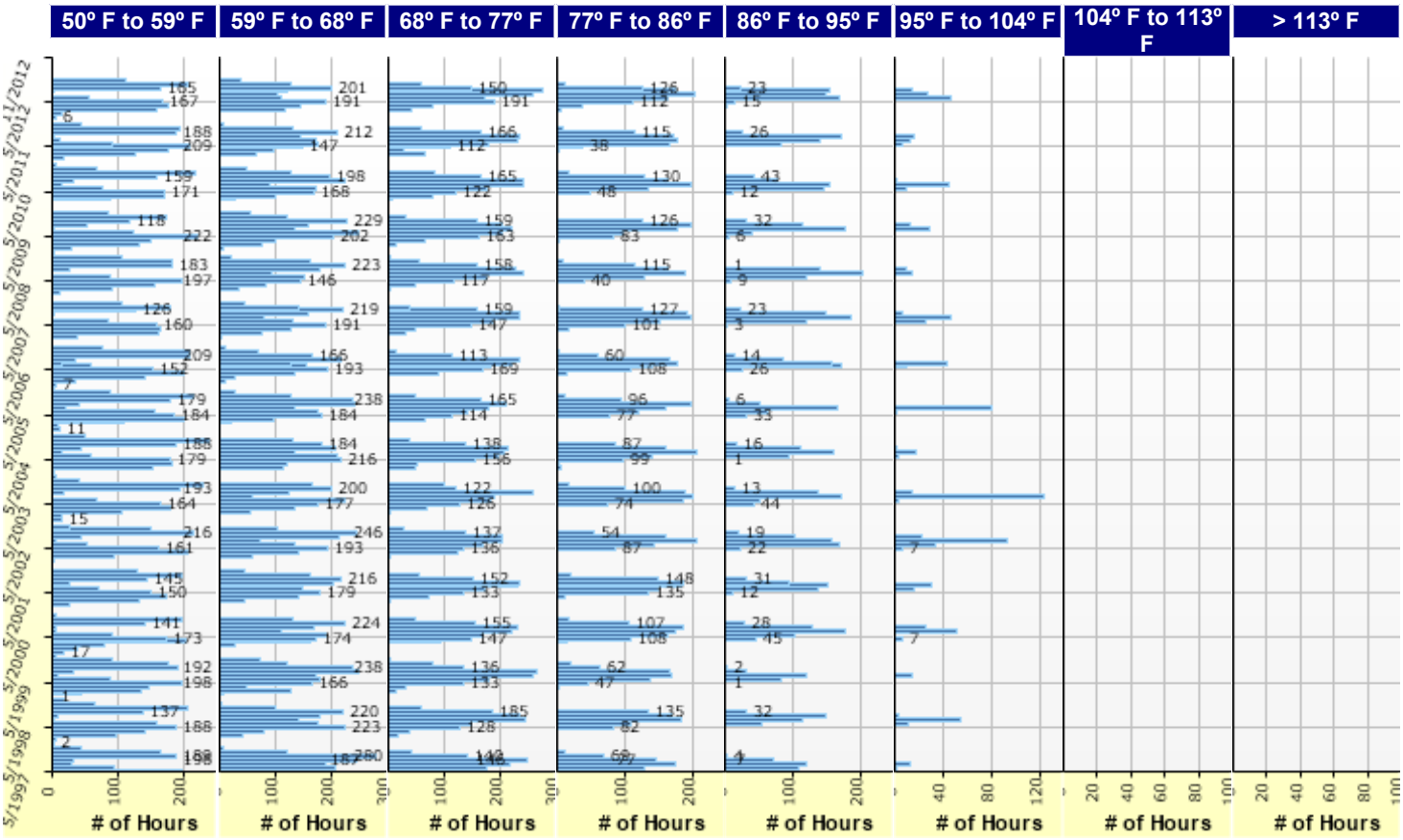






Hourly Air Temperature Distribution by Month:





Design Properties

JPCP Design Properties

Structure - ICM Properties	
PCC surface shortwave absorptivity	0.85

Doweled Joints	
Is joint doweled ?	True
Dowel diameter (in)	1.25
Dowel spacing (in)	12.00

Tied Shoulders	
Tied shoulders	True
Load transfer efficiency (%)	50.00

PCC joint spacing (ft)	
Is joint spacing random ?	False
Joint spacing (ft)	15.00

Widened Slab	
Is slab widened ?	False
Slab width (ft)	12.00

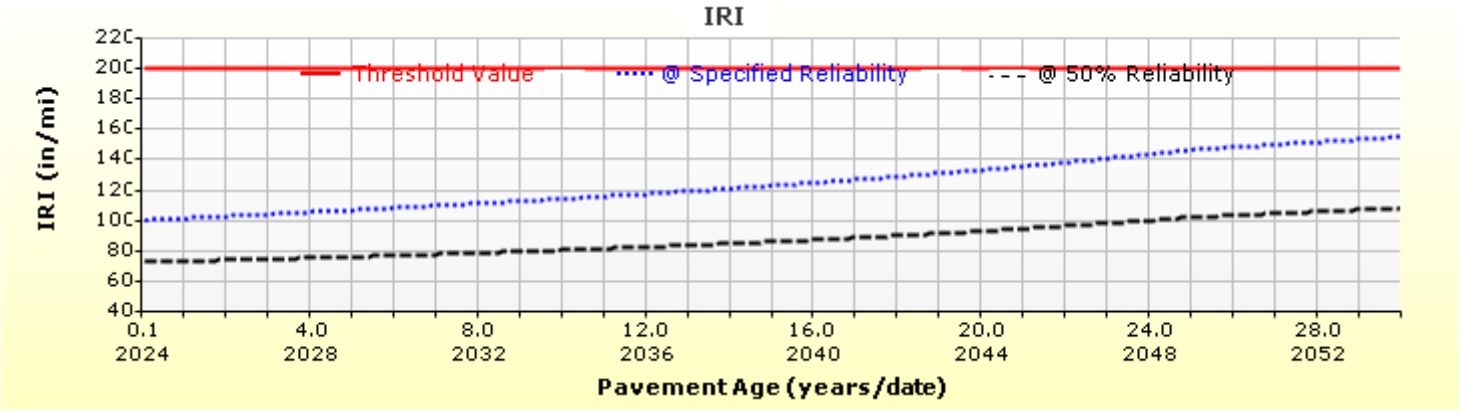
PCC-Base Contact Friction	
PCC-Base full friction contact	True
Months until friction loss	360.00

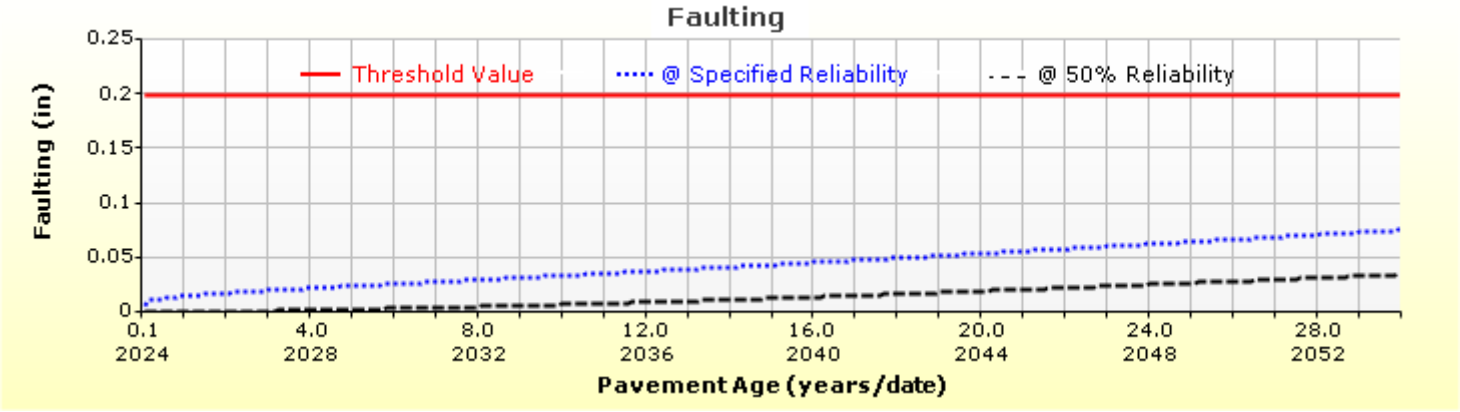
Sealant type	Other(Including No Sealant... Liquid... Silicone)

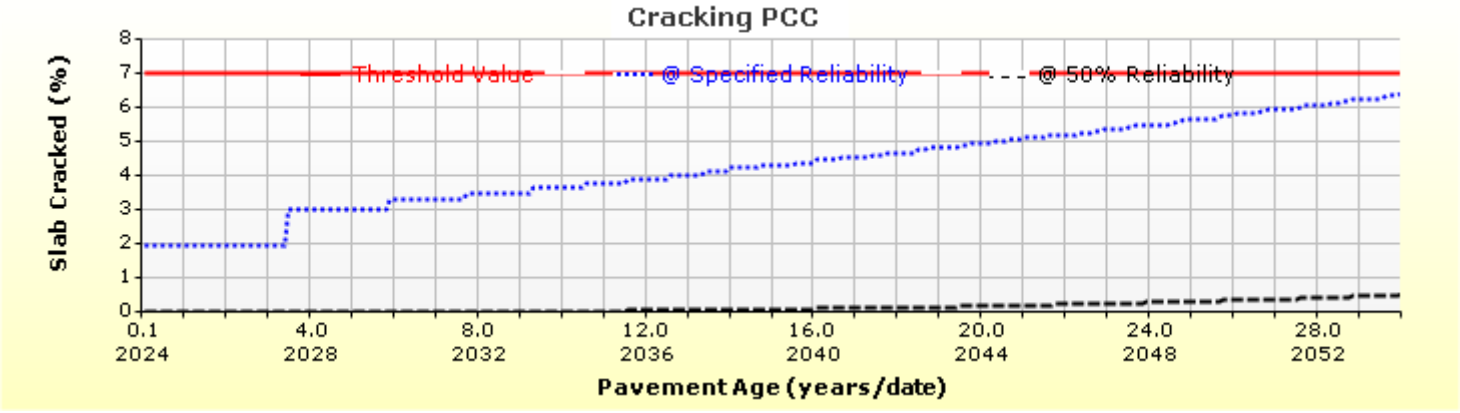
Erodibility index	4

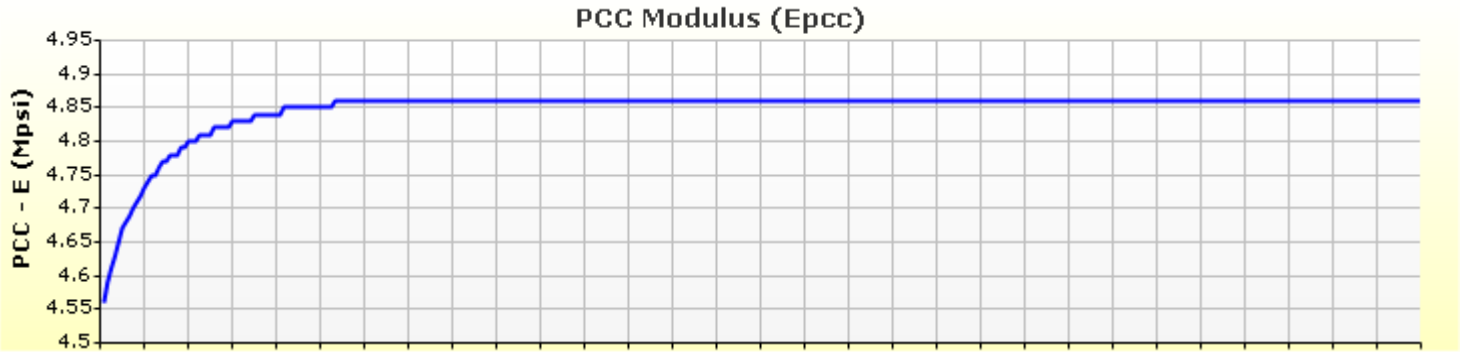
Permanent curl/warp effective temperature difference (ºF)	-10.00

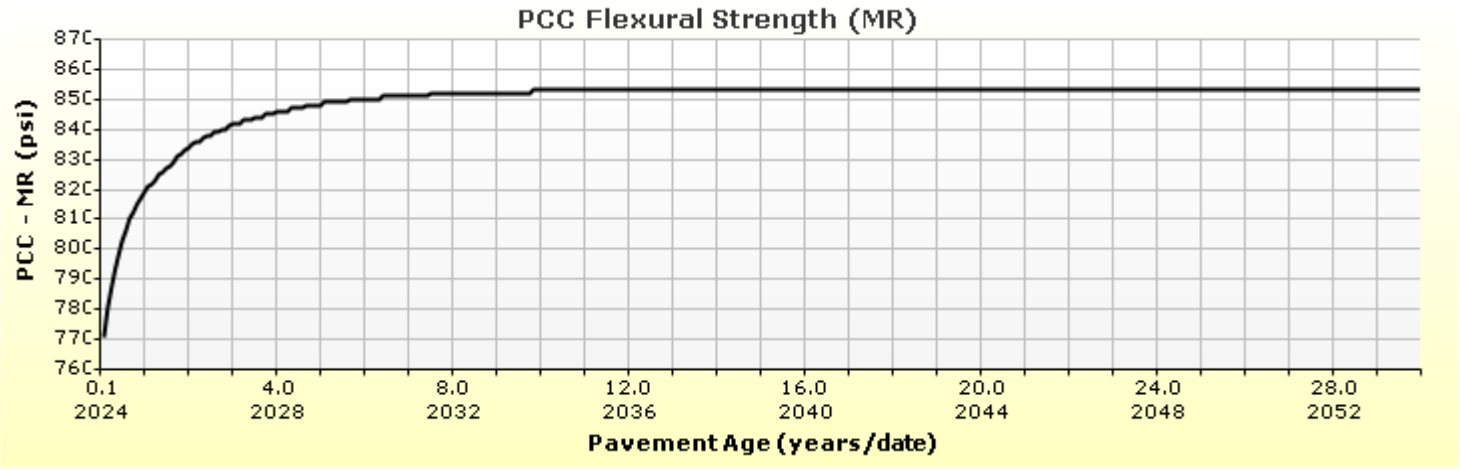
Analysis Output Charts

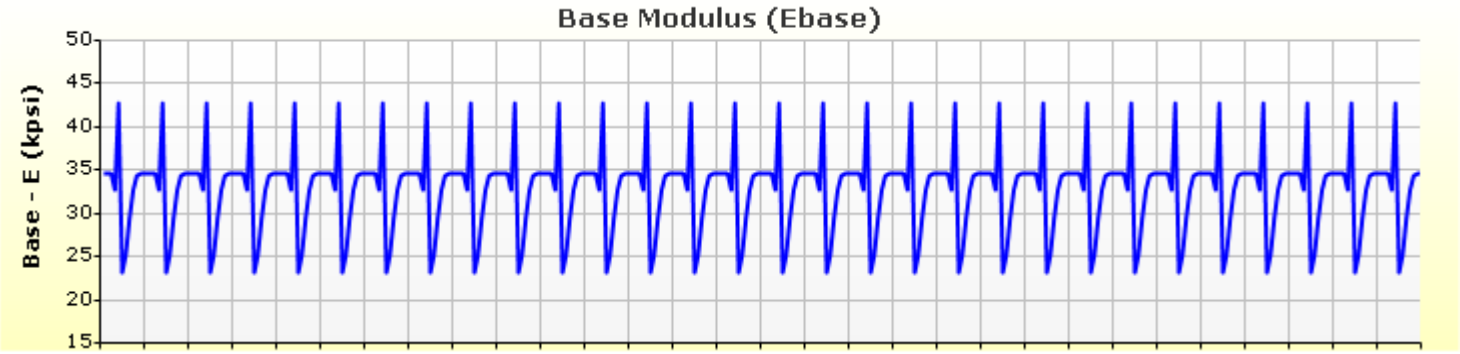


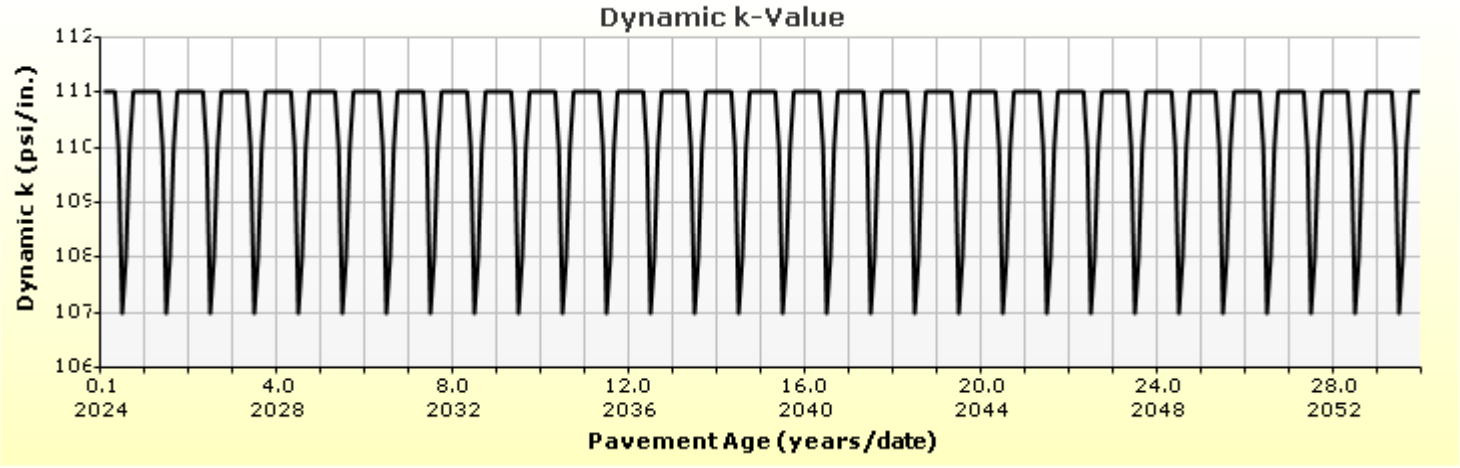


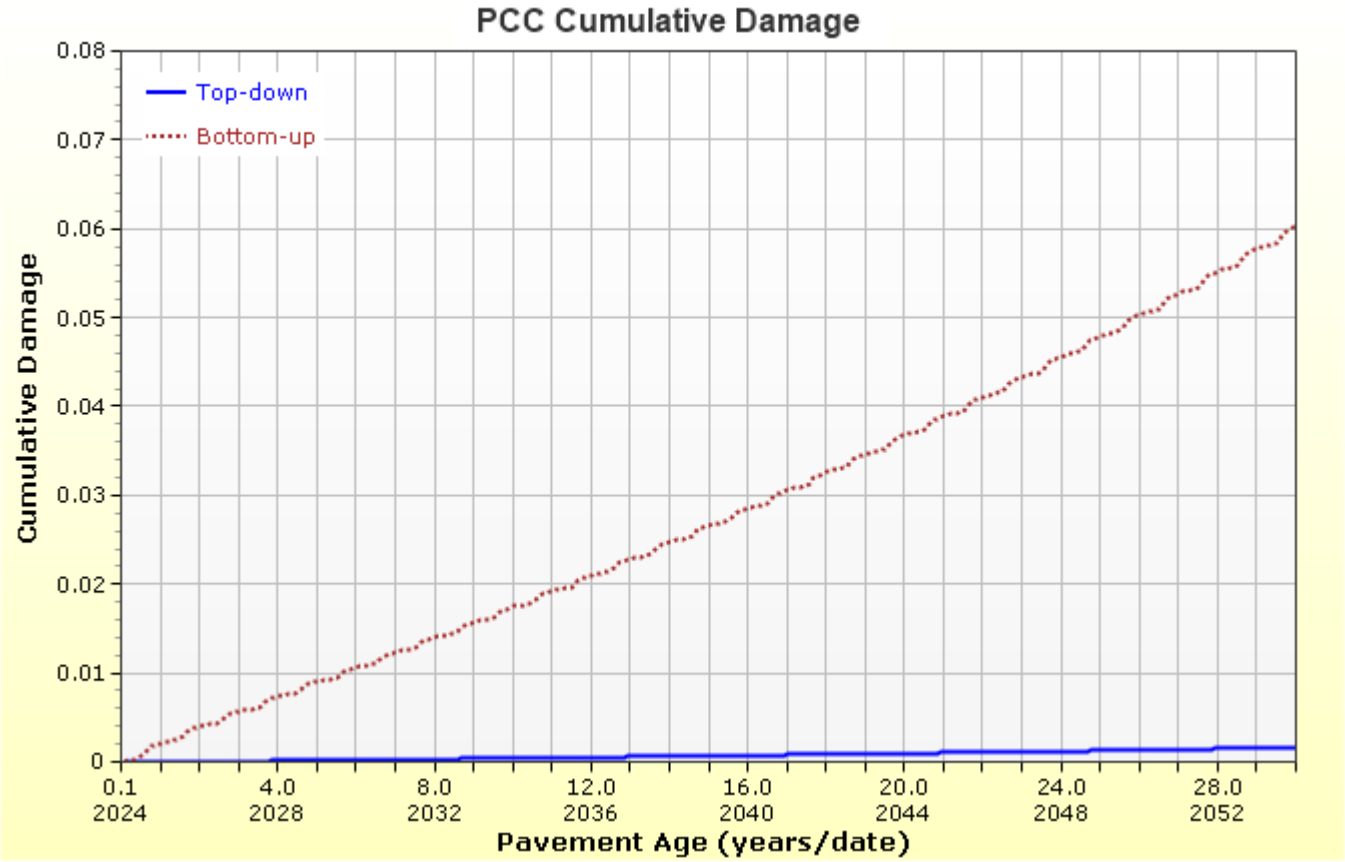


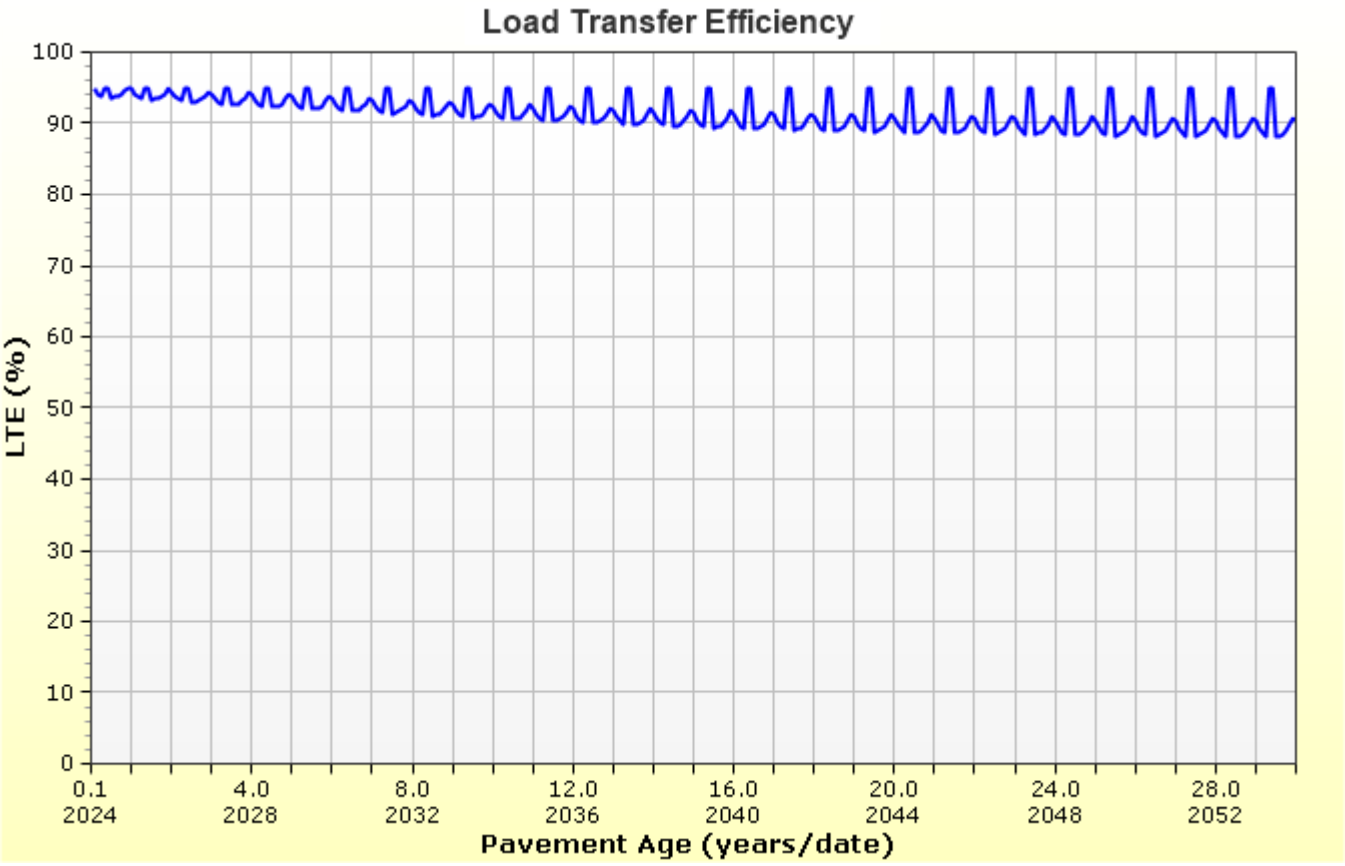

PCC Modulus (Epcc)
PCC - E (Mpsi)
4.95
4.9
4.85
4.8
4.75
4.7
4.65
4.6
4.55
4.5


PCC Flexural Strength (MR)
PCC - MR (psi)
870
860
850
840
830
820
810
800
790
780
770
760
0.1
2024
4.0
2028
8.0
2032
12.0
2036
16.0
2040
20.0
2044
24.0
2048
28.0
2052
Pavement Age (years/date)


Base Modulus (Ebase)
Base - E (kpsi)
50
45
40
35
30
25
20
15


Dynamic k-Value
Dynamic k (psi/in.)
112
111
110
109
108
107
106
0.1
2024
4.0
2028
8.0
2032
12.0
2036
16.0
2040
20.0
2044
24.0
2048
28.0
2052
Pavement Age (years/date)


PCC Cumulative Damage
Top-down
Bottom-up
Cumulative Damage
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.1
2024
4.0
2028
8.0
2032
12.0
2036
16.0
2040
20.0
2044
24.0
2048
28.0
2052
Pavement Age (years/date)


Load Transfer Efficiency
LTE (%)
100
90
80
70
60
50
40
30
20
10
0
0.1
2024
4.0
2028
8.0
2032
12.0
2036
16.0
2040
20.0
2044
24.0
2048
28.0
2052
Pavement Age (years/date)

Layer Information

Layer 1 PCC : R4 Level 1 Lawson

PCC	
Thickness (in)	9.0
Unit weight (pcf)	140.6
Poisson's ratio	0.2

Thermal	
PCC coefficient of thermal expansion (in/in/ºF x 10^-6)	4.86
PCC thermal conductivity (BTU/hr-ft-ºF)	1.25
PCC heat capacity (BTU/lb-ºF)	0.28

Mix		
Cement type		Type I (1)
Cementitious material content (lb/yd^3)		563
Water to cement ratio		0.36
Aggregate type		Dolomite (2)
PCC zero-stress temperature (ºF)	Calculated Internally?	True
	User Value	-
	Calculated Value	90.7
Ultimate shrinkage (microstrain)	Calculated Internally?	True
	User Value	-
	Calculated Value	516.0
Reversible shrinkage (%)		50
Time to develop 50% of ultimate shrinkage (days)		35
Curing method		Curing Compound

PCC strength and modulus (Input Level: 1)

Time	Modulus of rupture (psi)	Elastic modulus (psi)
7-day	560	3230000
14-day	620	3500000
28-day	710	4030000
90-day	730	4240000
20-year/28-day	1.2	1.2

Identifiers

Field	Value
Display name/identifier	R4 Level 1 Lawson
Description of object	Mix ID # 2009105
Author	CDOT
Date Created	4/3/2013 12:00:00 AM
Approver	CDOT
Date approved	4/3/2013 12:00:00 AM
State	Colorado
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	Region 4/1/6
User defined field 2	
User defined field 3	
Revision Number	0

Layer 2 Non-stabilized Base : Crushed gravel

Unbound	
Layer thickness (in)	8.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
22000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Crushed gravel
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	42

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.7
Saturated hydraulic conductivity (ft/hr)	False	5.054e-02
Specific gravity of solids	False	2.7
Water Content (%)	False	7.4

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	7.2555
bf	1.3328
cf	0.8242
hr	117.4000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20.0
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8-in.	57.2
1/2-in.	63.1
3/4-in.	72.7
1-in.	78.8
1 1/2-in.	85.8
2-in.	91.6
2 1/2-in.	
3-in.	
3 1/2-in.	97.6

Layer 3 Subgrade : A-4

Unbound	
Layer thickness (in)	6.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
7844.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	A-4
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	21.0
Plasticity Index	5.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	119
Saturated hydraulic conductivity (ft/hr)	False	7.589e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	11.8

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	68.8377
bf	0.9983
cf	0.4757
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	60.6
#100	
#80	73.9
#60	
#50	
#40	82.7
#30	
#20	
#16	
#10	89.9
#8	
#4	93.0
3/8-in.	95.6
1/2-in.	96.7
3/4-in.	98.0
1-in.	98.7
1 1/2-in.	99.4
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.8

Layer 4 Subgrade : A-4

Unbound	
Layer thickness (in)	Semi-infinite
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
7844.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	A-4
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	21.0
Plasticity Index	5.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	118.4
Saturated hydraulic conductivity (ft/hr)	False	8.325e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	11.8

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	68.8377
bf	0.9983
cf	0.4757
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	60.6
#100	
#80	73.9
#60	
#50	
#40	82.7
#30	
#20	
#16	
#10	89.9
#8	
#4	93.0
3/8-in.	95.6
1/2-in.	96.7
3/4-in.	98.0
1-in.	98.7
1 1/2-in.	99.4
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.8

Calibration Coefficients

PCC Faulting

$$C_{12} = C_1 + (C_2 * FR^{0.25})$$
$$C_{34} = C_3 + (C_4 * FR^{0.25})$$
$$FaultMax_0 = C_{12} * \delta_{curling} * \left[\log(1 + C_5 * 5.0^{EROD}) * \log\left(P_{200} * \frac{WetDays}{p_S}\right)\right]^{C_6}$$
$$FaultMax_i = FaultMax_0 + C_7 * \sum_{j=1}^{m} DE_j * \log(1 + C_5 * 5.0^{EROD})^{C_6}$$
$$\Delta Fault_i = C_{34} * (FaultMax_{i-1} - Fault_{i-1})^2 * DE_i$$
$$C_8 = DowelDeterioration$$

C1: 0.5104	C2: 0.00838	C3: 0.00147	C4: 0.008345
C5: 5999	C6: 0.8404	C7: 5.9293	C8: 400
PCC Reliability Faulting Standard Deviation			
0.0831*Pow(FAULT,0.3426) + 0.00521			

IRI-jpcp

C1 - Cracking
C2 - Spalling
C3 - Faulting
C4 - Site Factor

C1: 0.8203	C2: 0.4417
C3: 1.4929	C4: 25.24
Reliability Standard Deviation	
5.4	

PCC Cracking

$$\log(N) = C1 \cdot \left(\frac{MR}{\sigma}\right)^{C2}$$
$$CRK = \frac{100}{1 + C4\ FD^{C5}}$$

Fatigue Coefficients		**Cracking Coefficients**	
C1: 2	C2: 1.22	C4: 0.6	C5: -2.05
PCC Reliability Cracking Standard Deviation			
Pow(57.08*CRACK,0.33) + 1.5			

APPENDIX I

CROSBY AVENUE AASHTO 1993 FLEXIBLE PAVEMENT OUTPUT SHEETS

INITIAL VALUES

Initial Serviceability Index=	2.5
Final Serviceability Index=	2
Overall Standard Deviation, So=	0.44
Reliability, R (percent)=	90
Standard Normal Deviate (ZR)=	-1.282
Structural Coefficient of HMA=	0.44
Structural Coefficient of ABC=	0.12
Design Life ESALs=	2,070,000
R-Value=	**20**

INTERMEDIATE CALCULATIONS

Calculated Mr=	7844
Design Mr=	7844
Design Serviceability Loss (ΔPSI)=	2.5

FINAL CALCULATIONS

SN= **3.5460**

	Such That:	
$Log_{10}ESAL$	≤	**Thickness Equation**
6.3160	≤	6.3161

Full HMA:

Depth= **8.06** in

HMA over ABC:

Depth Class 6 and Class 2 ABC=	**16**	in	
Depth HMA=	**3.88**	in	Use 4.0 inches

Crosby Avenue
20-Year Design Life

THIS SHEET USES THE "NEW" CDOT R-VALUE TO RESILIENT MODULUS EQUATION

ESAL's = the number of Equivalent 18-kip axle loads for the appropriate design period
Mr = subgrade Resilient Modulus in pounds per square inch (psi)

R-Value = 20
If Mr is based on R-Value ===> Mr = 7,844 psi For Post-2015 CDOT Correlation

2,070,000 = Design Life ESALs

SN = 3.546 = Required SN when B equals (or slightly exceeds) A

$Log_{10}ESAL$ = A = 6.31597
=
Thickness Equation= B = 6.31611 with no drainage reduction

Design Mr = 7,844 psi

When A = B, ESAL's and SN agree, then calculate thickness
Take Calculated Thickness and round appropriately for design thickness

0.9653681	A	
4.55	B	
2588.91848	C	
0.82257028	D	
-0.04063331	E	
0.200000	F	
4.55	G	
6.15545048	H	
-0.56408	I	

Structural Coefficient of HMA = 0.44
Structural Coefficient of Class 6 ABC = 0.12
Structural Coefficient of Class 2 ABC = 0.11

Design Serviceability Loss (ΔPSI)= 2.5

Initial Serviceability Index= 4.5
Final Serviceability Index = 2.0

Calculated thickness, inches = 8.06
FULL DEPTH HMA

Overall Standard Deviation, So = 0.44
Reliability, R (percent) = 90
Standard Normal Deviate (ZR) = -1.282
(Use Table 1.4 from CDOT Pavement Design Manual)

Composite HMA over ABC
(using specified layer of ABC)
Inches of Class 6 ABC = 8.0
Inches of Class 2 ABC = 8.0
Calculated Inches of HMA = 3.88 Use 4.0 inches

Reliability, R (percent)	Standard Normal Deviate(Z_R)
50	0.000
60	-0.253
70	-0.524
75	-0.674
80	-0.841
85	-1.037
90	-1.282
91	-1.340
92	-1.405
93	-1.476
94	-1.555
95	-1.645
98	-2.054

INITIAL VALUES

Initial Serviceability Index=	2.5
Final Serviceability Index=	2
Overall Standard Deviation, So=	0.44
Reliability, R (percent)=	90
Standard Normal Deviate (ZR)=	-1.282
Structural Coefficient of HMA=	0.44
Structural Coefficient of ABC=	0.12
Design Life ESALs=	3,450,000
R-Value=	**20**

INTERMEDIATE CALCULATIONS

Calculated Mr=	7844
Design Mr=	7844
Design Serviceability Loss (ΔPSI)=	2.5

FINAL CALCULATIONS

SN= **3.8090**

	Such That:	
$Log_{10}ESAL$	≤	**Thickness Equation**
6.5378	≤	6.5386

Full HMA:

Depth= **8.66** in

HMA over ABC:

Depth Class 6 and Class 2 ABC=	**16**	in	
Depth HMA=	**4.48**	in	Use 4.5 inches

Crosby Avenue
30-Year Design Life

THIS SHEET USES THE "NEW" CDOT R-VALUE TO RESILIENT MODULUS EQUATION

ESAL's = the number of Equivalent 18-kip axle loads for the appropriate design period
Mr = subgrade Resilient Modulus in pounds per square inch (psi)

R-Value = 20
If Mr is based on R-Value ===> Mr = 7,844 psi For Post-2015 CDOT Correlation

3,450,000 = Design Life ESALs

SN = 3.809 = Required SN when B equals (or slightly exceeds) A

Log_{10}ESAL = A = 6.53782
=
Thickness Equation= B = 6.53861 with no drainage reduction

Design Mr = 7,844 psi

When A = B, ESAL's and SN agree, then calculate thickness
Take Calculated Thickness and round appropriately for design thickness

0.9653681	A	
4.81	B	
3466.2852	C	
0.71561165	D	
-0.04670656	E	
0.200000	F	Structural Coefficient of HMA = 0.44
4.81	G	Structural Coefficient of Class 6 ABC = 0.12
6.38403271	H	Structural Coefficient of Class 2 ABC = 0.11
-0.56408	I	

Design Serviceability Loss (ΔPSI)= 2.5

Initial Serviceability Index= 4.5
Final Serviceability Index = 2.0

Calculated thickness, inches = 8.66
FULL DEPTH HMA

Overall Standard Deviation, So = 0.44
Reliability, R (percent) = 90
Standard Normal Deviate (ZR) = -1.282
(Use Table 1.4 from CDOT Pavement Design Manual)

Composite HMA over ABC
(using specified layer of ABC)
Inches of Class 6 ABC = 8.0
Inches of Class 2 ABC = 8.0
Calculated Inches of HMA = 4.48 Use 4.5 inches

Reliability, R (percent)	Standard Normal Deviate(Z_R)
50	0.000
60	-0.253
70	-0.524
75	-0.674
80	-0.841
85	-1.037
90	-1.282
91	-1.340
92	-1.405
93	-1.476
94	-1.555
95	-1.645
98	-2.054

APPENDIX J

CROSBY AVENUE AASHTO 1998 RIGID PAVEMENT OUTPUT SHEETS

Rigid Pavement Design - Based on AASHTO Supplemental Guide

Reference: *LTPP DATA ANALYSIS - Phase I: Validation of Guidelines for k-Value Selection and Concrete Pavement Performance Prediction*

Results

Project # 599.81
Description: Crosby Avenue Improvement Project

Location: Grand Junction, CO

Slab Thickness Design

Pavement Type	JPCP	
18-kip ESALs Over Initial Performance Period (million)	4.46	million
Initial Serviceability	4.5	
Terminal Serviceability	2	
28-day Mean PCC Modulus of Rupture	650	psi
Elastic Modulus of Slab	3,400,000	psi
Elastic Modulus of Base	12,000	psi
Base Thickness	16.0	in.
Mean Effective k-Value	125	psi/in
Reliability Level	90	%
Overall Standard Deviation	0.34	
Calculated Design Thickness	**8.05**	in

Temperature Differential

Mean Annual Wind Speed	8.8	mph
Mean Annual Air Temperature	50.3	^{o}F
Mean Annual Precipitation	15.3	in
Maximum Positive Temperature Differential	**6.61**	^{o}F

Modulus of Subgrade Reaction

Period	Description	Subgrade k-Value, psi

Seasonally Adjusted Modulus of Subgrade Reaction	psi/in
Modulus of Subgrade Reaction Adjusted for Rigid Layer and Fill Section	psi/in

Traffic

Performance Period	years
Two-Way ADT	
Number of Lanes in Design Direction	
Percent of All Trucks in Design Lane	
Percent Trucks in Design Direction	

Vehicle Class	Percent of ADT	Annual Growth	Initial Truck Factor	Annual Growth in Truck Factor	Accumulated 18-kip ESALs (millions)

Total Calculated Cumulative ESALs	million

Faulting

Doweled

Dowel Diameter	1.25	in
Drainage Coefficient	1.00	
Average Fault for Design Years with Design Inputs	**0.04**	in
Criteria Check **PASS**		

Nondoweled

Drainage Coefficient	1	
Average Fault for Design Years with Design Inputs	**0.07**	in
Criteria Check **FAIL**		