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GEOTECHNICAL ENGINEERING STUDY AND PAVEMENT THICKNESS DESIGN 8TH STREET IMPROVEMENTS PROJECT US HIGHWAY 85 TO WELD COUNTY PARKWAY GREELEY, COLORADO

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SUMMARY

1. Twenty-one (21) exploratory borings were drilled within the project limits. The borings encountered variable pavement sections consisting of hot mix asphalt over aggregate base course. The thicknesses of the existing asphalt ranged from about 2½ to 5½ inches. The aggregate base course ranged from 5½ to 9¼ inches in thickness. Man-placed fill of various thickness was encountered beneath the pavement sections in the exploratory borings. The fill material continued to the explored depths of about 5 feet in six (6) of the exploratory borings and to depths of 4 to 5 feet in five (5) of the borings. The fill generally consisted of sandy lean clay to clayey sand to silty-clayey sand with various gravel contents. Borings 12 and 13 did not encounter fill below the pavement.

   Natural soils were encountered in fifteen (15) of the exploratory borings at depths ranging from just below the pavement section to 7 feet below the ground surface. The natural soils underlying the fill material were generally composed of silty sand to clayey sand with the vast majority of the soils being granular in nature. The natural soils were fine to medium grained and slightly moist to moist. Based on sampler penetration resistance values, the natural soils were medium dense in consistency. Bedrock was not encountered in borings.

   Groundwater was encountered in one of the borings at the time of drilling at a depth of about 17 feet. All of the borings were backfilled with cementitious flowable fill and patched with similar thicknesses of asphalt immediately after drilling and sampling due to safety concerns.

2. Rehabilitation and reconstruction alternatives for the project roadway was evaluated from an asphalt overlay approach as well as a total pavement reconstruction approach. The recommended overlay thicknesses are presented in the report. It is our opinion that the roadway may be rehabilitated with a mill/overlay combination, assuming a possible reduction in pavement life expectancy (discussed herein) is acceptable. Thin asphalt associated with the existing asphalt may make it difficult for proper milling. The remaining alignment should be completely reconstructed.

   Full depth reclamation technique of the existing pavement surface to provide a stable paving platform for new asphalt pavement may be considered.

PURPOSE AND SCOPE

This report presents the results of a geotechnical engineering study and pavement thickness design for the proposed 8th Street improvements between State Highway 85 and Weld County Parkway in Greeley, Colorado. The study was conducted for the purpose of obtaining subsurface data, developing subgrade preparation and paving recommendations for the identified roadway segments generally shown on Figs. 1 through 1B. The study was conducted in accordance with our Proposal No. P3-18-16 dated April 25, 2018 to Felsburg, Holt & Ullevig.

A field exploration program consisting of exploratory borings was conducted to obtain information on the subsurface conditions. Samples of the subgrade materials obtained during the field exploration were tested in the laboratory to determine their classification and engineering characteristics. The results of the field exploration and laboratory testing were analyzed to develop recommendations for possible pavement reconstruction and/or rehabilitation considerations. The results of the field exploration and laboratory testing are presented herein.

This report has been prepared to summarize the data obtained during this study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to construction of the proposed roadway improvements are included in the report.

PROPOSED CONSTRUCTION

East 8th Street between State Highway 85 and Weld County Parkway is currently an asphalt surfaced, two (2) lane road (one lane in each travel direction) with no dedicated turn lanes at any location. Improvements of East 8th Street will include increasing the street width to a modified two-lane arterial configuration with up to a 120-foot Right of Way corridor.

The City of Greeley is currently proposing full roadway reconstruction along East 8th Street from U.S. Highway 85 through the intersection of Balsam Avenue. We understand that the currently planned roadway configuration between U.S. Highway 85 and Balsam Avenue will be such that there will one (1) 12-foot wide travel lane in each direction along with a 13-foot wide center turn lane in-between the travel lanes. Concrete curb and gutter will be provided along the roadway in this area.

We understand that the currently planned roadway configuration between Balsam Avenue and Fern Avenue will be such that there will one (1) 12-foot wide travel lane in each direction along with a 13-foot wide center turn lane in-between the travel lanes with 1-foot wide paved shoulders and 5-foot gravel shoulders on each side of the roadway. The intersection of Fern Avenue and East 8th Street will be designed to correct offset conditions of the intersection with the Air Force National Guard entrance. Reconstruction or overlay techniques may be used on this portion of 8th Street if the ultimate roadway configuration is not constructed.

The remainder of East 8th Street from east of Fern Avenue to Weld County Parkway may be rehabilitated (asphalt mill and overlay) until full roadway reconstruction can be performed. We understand that the existing roadway configuration between Balsam Avenue and Weld County Parkway is such that there is (1) 12-foot wide travel lane in each direction along with 2-foot paved shoulders adjacent to the travel lanes and a 4-foot wide gravel shoulder outside of the paved shoulders. There will be no concrete curb and gutter along this portion of the roadway and all surface flows will be directed towards roadside ditches or water quality features near the roadway.

If the proposed construction varies significantly from that generally described above or depicted in this report, we should be notified to reevaluate the conclusions and recommendations provided herein.

SITE CONDITIONS

At the time of drilling, 8th Street within the project limits consisted of a two-lane asphalt paved roadway with one travel lane in each easterly and westerly direction. It appears that 8th Street is currently designed with a paved width of 24 to 26 feet leaving lane widths on the order of 11- to 12-foot depending on the striping. 8th Street serves as a major roadway for the Greeley community and provides access to the adjacent properties. Roadside storm water drainage ditches / swales are present along the length of the roadway where local street access is not provided.

The roadway surface roughly follows the topography in the area, which is rolling hills with gentle slopes. There appeared to be occasional corrugated metal culvert crossings along the roadway to allow storm waters to drain below the road surface.

GEOTECHNICAL CONSIDERATIONS

Based on the data from the field exploration and laboratory testing programs, the proposed alignment is underlain by varying and generally significant thicknesses of man-placed fills. The fills are of variable types and quality. The existing fills are considered to be non-engineered in absence of placement records and are expected to provide variable subgrade support for the pavement structure and to exhibit variable and unpredictable post-construction settlement behavior; however, given the assumed age of the roadway we believe that a majority of the settlement has occurred and little additional settlement of the fills can be expected.

Pavement rehabilitation usually consists of milling the existing pavement and placing an overlay. In such an approach, areas of moderate to high severity distress are completely removed and/or replaced prior to placement of the final overlay section. For this particular pavement, areas of thin asphalt pavement will make it difficult for successfully remove distressed pavement by milling operations without removing the entire asphalt section

Complete reconstruction of the pavement is also an option. In this option the entire pavement section, or just the asphalt pavement section is removed and pavement is reconstructed as needed. There is an alternative for complete reconstruction including complete removal of the existing pavement section. A suitable alternate would be the use of a full-depth reclamation (FDR) process. This consists of pulverizing the existing asphalt and base course pavement section and blending it with the underlying materials to create a stable platform upon which an asphalt pavement could be placed. This procedure may require removal of excess material as needed for grading purposes.

Existing Subgrade: Although not encountered in the exploratory borings, it is common to uncover soft and very moist subgrade soils below existing pavement sections. The contractor should be prepared to handle soft soils during construction. Regardless of the procedure selected, the pavement section should be placed on stable subgrade.

SUBSURFACE CONDITIONS

The initial field exploration for the study was conducted on July 19, 2018. Thirteen (13) exploratory borings (Borings 1 through 13) were drilled at that time for the geotechnical engineering study and pavement thickness design addressed in this report. The borings were drilled to depths ranging from approximately 5 to 10 feet. Subsequent to the initial investigation, we were requested to excavate an additional eight (8) exploratory borings (Borings 14 through 21) near areas of planned surface water infiltration features. The additional borings were excavated on November 8, 2018. Additional laboratory testing as well as field infiltration testing was performed on these borings. A vicinity map is presented on Fig. 1. The approximate locations of the exploratory borings are shown on Figs. 1A and 1B.

The borings were advanced through the pavement sections and into the overburden soils with 4-inch diameter continuous flight augers. The borings were logged by a representative of Kumar & Associates, Inc. The borings were generally drilled in the travel lanes of the pavement on alternating sides of the alignment, utilities permitting.

Samples of the soils were obtained with a 2-inch I.D. California liner sampler. The sampler was driven into the various strata with blows from a 140-pound hammer falling 30 inches. The test is similar to the standard penetration test described by ASTM Method D 1586. Penetration resistance values, when properly evaluated indicate the relative density or consistency of the soils. Large disturbed bulk samples were taken from the borings. Depths at which samples were taken and the penetration resistance values are shown on the Logs of Exploratory Borings, Fig. 2. The legend and explanatory notes associated with the graphic logs describing the soils encountered are presented on Fig. 3.

The borings encountered variable pavement sections consisting of hot mix asphalt over aggregate base course. The thicknesses of the existing asphalt ranged from about 2½ to 5½ inches. The aggregate base course ranged from 5½ to 9¼ inches in thickness. The thicknesses of the pavement sections encountered are also shown on the Logs of Exploratory Borings, Fig. 2.

Man-placed fill of various thickness was encountered beneath the pavement sections in the exploratory borings. The fill material continued to the explored depths of about 5 feet in six (6) of the exploratory borings and to depths of 4 to 5 feet in five (5) of the borings. The fill generally consisted of sandy lean clay to clayey sand to silty-clayey sand with various gravel contents. The fill was fine to medium-grained, slightly moist to very moist, and brown to black. The vertical and horizontal limits, as well as the degree of compaction of the fill were not evaluated in detail as part of this study. Borings 12 and 13 did not encounter fill below the pavement.

Natural soils were encountered in seven (7) of the exploratory borings at depths ranging from just below the pavement section to 5 feet below the ground surface. The natural soils underlying the fill material were generally composed of silty sand to clayey sand with the vast majority of the soils being granular in nature. The natural soils were fine to medium grained and slightly moist to moist. Based on sampler penetration resistance values, the natural soils were medium dense in consistency. Bedrock was not encountered in borings.

Groundwater was encountered in Boring 14 at a depth of about 17 feet below the ground surface. All of the borings were backfilled with cementitious flowable fill and patched with similar thicknesses of asphalt immediately after drilling and sampling due to safety concerns.

LABORATORY TESTING

Samples obtained from the exploratory borings were visually classified in the laboratory by the project engineer and samples were selected for laboratory testing. Laboratory testing included moisture content and dry unit weight, liquid and plastic limits, and concentration of water soluble sulfates. The laboratory testing was conducted in general accordance with applicable ASTM standards.

Swell-consolidation testing was conducted on several samples of the natural soils and man-placed fill materials to determine their swell-consolidation characteristics when wetted under a static surcharge load. The samples obtained from the proposed pavement areas for swell-consolidation testing were loaded with a 200-psf surcharge pressure.

The swell-consolidation test results indicated that the on-site overburden natural soils and fill materials possess low swell potential (0.1% to 0.7%).

Results of the laboratory testing program are shown adjacent to the boring logs on Fig. 2, plotted graphically on Figs. 4 through 11 and are summarized in the attached Summary of Laboratory Test Results in Table I.

PAVEMENT CONDITION

The pavement surface along much of the alignment was in fair condition with occasional low to moderate severity transverse cracking. Portions of the roadway appeared to have recent patching operations performed. Other areas showed moderate to high severity alligator cracking. The alligator cracking appeared to existing largely within the wheel ruts although was found to extend from the edge of the asphalt to as far as about 8 to 10 feet from the edge of the asphalt. Based on our knowledge of the roadway, the alligator cracking is likely the result of softened subgrade conditions in combination with heavily loaded trucks travelling the roadway.

EXCAVATION AND GRADING CONSIDERATIONS

Site Preparation: As previously discussed, existing fills were encountered within the explored depths. Ideally, existing fills should be completely removed from beneath reconstructed pavement sections. Removed fill should be backfilled with compacted fill meeting the material and compaction criteria presented in this section. Pavement structures and other structures that can tolerate some settlement, partial removal and replacement may be appropriate provided the City of Greeley understands and accepts the risk of potential settlements.

Where partial removal of existing fills occurs, the remaining fill should be scarified to a minimum depth of 8 inches, adjusted to moisture contents near optimum, and compacted to at least 95% of the standard Proctor (ASTM D698) maximum dry density. Additional over-excavation may be required if excessively loose or soft fills, deleterious material, or organic materials, are encountered at the base of the new fill zone. We did not encounter deleterious materials or organic materials during our field investigation and do not anticipate that such materials are present on the site; however, the possibility exists that such materials may be encountered in isolated areas between the exploratory borings. Subgrade preparation should include proofrolling with a heavily-loaded pneumatic-tired vehicle or a heavy, smooth-drum vibratory roller compactor. Areas that deform excessively during proofrolling should be removed and replaced to achieve a reasonably stable subgrade.

Temporary Excavations: Excavations that will not require temporary or permanent shoring can be constructed by over-excavating the side slopes to stable configurations where enough space is available. All excavations should be constructed in accordance with OSHA requirements, as well as state, local and other applicable requirements. The existing fills and native granular overburden soils classify as OSHA Type C soils.

Due to the variable nature of the fills underlying the alignment, it is possible that some seasonal perched groundwater conditions may be encountered in deeper excavations, particularly where lenses or layers of lean clay materials are present. Excavations below groundwater, if encountered, could require flatter side slopes than those specified by OSHA or may require temporary shoring and/or dewatering if an unsupported slope is not feasible.

Surface water runoff into the excavations can act to erode and potentially destabilize the excavation side slopes and result in excessively loose or soft ground conditions at the base of the excavation and should not be allowed. Diversion berms and other measures should be used to prevent surface water runoff into the excavations from occurring. If significant runoff into the excavations does occur, further excavation to remove and replace the soft subgrade materials or stabilize the slopes may be required.

Excavation Dewatering: Although not anticipated, excavations extending below groundwater should be properly dewatered during and possibly prior to the excavation process to help maintain the stability of excavation side slopes and provide stable subgrade conditions for fill placement. The construction dewatering systems should be capable of intercepting groundwater before it can reach the face of excavation side slopes or to maintain a groundwater level 2 to 3-feet below the bottom of the excavation. Dewatering should continue until construction and associated backfilling extends above the ground water table.

Permanent Cut and Fill Slopes: As previously discussed, we anticipate planned grades along the proposed roadway alignment to be relatively close to existing grades, with possible low permanent embankment fills and minor permanent cuts for drainage. Based on our experience with soils similar to those encountered on the site, we recommend permanent fill slopes and cuts in existing overburden soils be constructed no steeper than 3H:1V. No formal stability analyses were performed to evaluate the slope recommended above. Published literature and our experience with similar cuts and fills indicate the recommended slopes should have adequate factors of safety. If a detailed stability analysis is required, we should be notified. The risk of slope instability will be significantly increased if seepage is encountered in cuts, and a stability investigation should be conducted to determine if the seepage will adversely affect the cut. The slopes should be protected from erosion by suitable means.

To provide a uniform base for fill placement, the ground surface underlying all fills should be carefully prepared by removing all organic matter and deleterious materials (if present), scarifying to a depth of 12 inches, and re-compacting to 95% of the standard Proctor (ASTM D698) maximum dry density at moisture contents within 2 percentage points of optimum. Fills should be benched into cuts exceeding 4H:1V. Vertical bench heights should be between 2 and 4 feet.

Subgrade Stabilization: In the event that widening of the roadway extends into the roadside drainage ditch(es), stabilization of the subgrade ditch section will be required. Stabilization should consist of removal of the vegetation and near surface soils to a depth of about 12 to 18 inches, and placement of a multi-axial geogrid or Tencate RS380i geotextile fabric. An aggregate base course layer should be placed on the geogrid/geotextile within the zone of soil removal.

WATER SOLUBLE SULFATES

The concentrations of water-soluble sulfates measured in a sample obtained from the exploratory borings was 0.03%. These concentrations of water-soluble sulfates represent a Class 0 level of severity for exposure in accordance with the guidelines presented by the American Concrete Institute (ACI). The guidelines have severity levels for potential exposure of Class 0 through Class 3 as indicated by ACI 201.2R.

Based on the laboratory test results, special sulfate resistant cement generally would not be required for concrete exposed to the on-site soils.

INFILTRATION TESTING

Percolation tests were performed in Borings B-14 through B-21. The percolation holes were drilled to depths of approximately 20 feet using 4-inch diameter continuous flight augers.

The percolation tests were performed at depths within the borings ranging from about 5.5 feet to about 18 feet in general accordance with the procedures outlined in Michigan's Low Impact Design (LID) Manual. A series of five to seven measurement intervals were performed in each boring as part of conducting the percolation tests by allowing the water level to continue dropping. The test intervals in each boring varied from 1-minute intervals to 30-minute intervals depending on the rate of percolation. The percolation tests resulted in stabilized measured percolation rates ranging from about 0.1 to 15.2 minutes per inch.

Infiltration rates were evaluated using the percolation test results and by applying a reduction factor to those results to convert the percolation rate into an infiltration rate using an empirical method outlined in the LID Manual. The infiltration rate is the rate of downward vertical flow into the infiltration system subgrade, whereas the percolation test measures both lateral exfiltration through the sides of the test hole as well as vertical flow through the base of the hole. A percolation reduction factor was applied to the percolation rate to discount horizontal flow in calculating the infiltration rate. The reduction factor was calculated in accordance with the procedure in the LID Manual and is based on the initial water depth (start of test), average drop in water level, and diameter of the bore hole. Reduction factors ranging from about 5.3 to 10.0 were used, which when divided into the percolation rates resulted in the calculated infiltration rates summarized in the following table.

Summary of Percolation Test Results

Borehole	Approximate Bottom of Testing Depth (ft)	Average Percolation Rate (min/inch)	Average Percolation Rate (in/hr)	Reduction Factor	Average Infiltration Rate (in/hr)
B-14	5.71	15.5	4.2	10.0	0.4
B-15	11.34	0.1	594.2	6.8	89.3
B-16	6.42	12.0	6.5	7.3	0.9
B-17	11.95	0.6	120.6	5.3	23.5
B-18	18.08	4.1	15.1	7.2	20.0
B-19	17.70	10.0	10.3	6.9	0.8
B-20	10.18	0.6	110.6	6.7	16.7
B-21	13.78	0.1	450.0	6.0	75.0

The percolation test borings generally encountered 4.5 to 7 feet of sandy lean clay man-placed fill at the ground surface overlying silty sand to silty sand with gravel.

The clayey soils are considered to classify generally as Hydrologic Soil Group B based on the Natural Resources Conservation Service (NRCS) classification, while the granular soils are likely to classify as Hydrologic Group A.

Based on the results of the percolation tests and our experience, we recommend using an infiltration rate of 0.5 inches per hour for design where infiltration will occur in the clayey soils and an infiltration rate of 20 inches per hour where the infiltration will occur in the silty sand soils. Groundwater was encountered at a depth of about 17 feet in Boring 14 at the time of drilling. Those conditions should be considered in design.

PAVEMENT DESIGN

A pavement section is a layered system designed to distribute concentrated traffic loads to the subgrade. Performance of the pavement structure is directly related to the physical properties of the subgrade soils and traffic loadings. Soils are represented for pavement design purposes by means of a resilient modulus for flexible pavements and a modulus of subgrade reaction for rigid pavement. These values are empirically related to strength.

Subgrade Materials: Samples of the subgrade materials were taken from the roadway segments. Based on the results of the field and laboratory studies, the soils obtained varied across the sites and classify between A-1-a and occasionally A-7-6 soils with group indices between 0 and 16 in accordance with the American Association of State Highway and Transportation Officials (AASHTO) soil classification system.

Subgrade support testing consisting of Hveem (R-value) was performed on a bulk sample of the subgrade materials. The R-Value testing, presented on Fig. 16, indicates an R-value of 14 at an exudation pressure of 300 psi for the subgrade soils. In accordance with Colorado Department of Transportation (CDOT) correlation procedures, the R-Value was converted to an equivalent resilient modulus value (M_r) of 4,060 psi. We believe this value is a reasonable value to represent the on-site soils and have used an M_r value of 4,060 psi to represent the on-site subgrade soils in the pavement thickness calculations.

Thickness Design Assumptions and Criteria: FHU provided us with traffic data to estimate the traffic loadings for the roadways. Specifically, for an opening year of 2020 we used 11,000 vehicles per day (vpd) with 1,200 vehicles during the peak hour. Also, an estimated 16% trucks (11% single axle trucks and 5% multi-unit trucks) was used in the calculations. We estimated a growth rate such that in year 2040, the vpd will be 17,000. Using the above values, we estimated an 18-kip equivalent single axle load ($ESAL_{20}$) of 4,391,800.

Flexible Pavement Criteria: In accordance with the “Design Criteria and Construction Specifications: Streets Volume I”, the following values were used in the pavement thickness design:

- Asphalt Strength Coefficient = 0.44
- Aggregate base course coefficient = 0.11
- Reliability (Z_r) = 90%
- Terminal Serviceability (P_t) = 2.5

We have also assumed an overall standard deviation (S_0) of 0.44 for the required design parameter input in order to calculate the pavement thickness using AASHTO design equations.

Utilizing the above data and AASHTO 1993 methodology, we calculate a required pavement structural number of 5.13.

Rigid Pavement Criteria: In accordance with the "Design Criteria and Construction Specifications: Streets Volume I", the following values were used in the pavement thickness design:

- Reliability (Z_r) = 90%
- Terminal Serviceability (P_t) = 2.5

Additional criteria used in the rigid pavement design calculations are:

- Load Transfer Coefficient (J) = 2.6
- PCCP 28-day Mean Modulus of Rupture = 650 psi
- PCCP 28-day Mean Elastic Modulus of Slab = 3,400,000 psi
- Overall Standard Deviation (S_0) = 0.34

Per common practice for high volume roadways, the Portland cement concrete pavement (PCCP) thicknesses obtained through calculation had ¼-inch added the calculated number. That number was then rounded up to the next highest ½-inch increment. For example, the calculated thickness for the PCCP with no geogrid was 8.10 inches. Adding ¼-inch and the rounding up to the next half inch results in the 8½ inch section presented below. The reasoning behind this methodology is that it gives the owner an opportunity to surface grind the pavement during the life span of the pavement and still result in a pavement section that will meet the minimum design thickness.

If the assumptions indicated above appear to be different than actual traffic values for the site, we should be notified to reevaluate pavement thickness requirements.

Asphalt Overlay: An asphalt overlay is an alternative for roadway rehabilitation. As discussed above, areas of the existing roadway with moderate to high distresses will need to be removed and reconstructed prior to placement of an overlay. The areas of reconstruction should be saw cut from the existing pavement section with the saw cuts being at least 3 feet away from the nearest edge of distress. The asphalt overlay option was analyzed based on the AASHTO Component Analysis approach. The structural coefficient for the existing asphalt was taken from Table 2.08.2 from the "Design Criteria and Construction Specifications: Streets Volume I" as a value of 0.24. The same table indicates a structural coefficient value of 0.10 for existing aggregate base course.

The representative existing asphalt thickness(es) were incorporated with the calculated structural coefficient to determine the existing structural number of the roadway segments. The deficiency between the design structural number and the calculated existing structural number is the required structural number needed for an asphalt overlay.

The analysis below includes a 1-inch mill to be performed of the existing asphalt pavement in order for the new asphalt overlay to be placed.

With no milling of the asphalt surface and utilizing the above structural coefficient values, we calculate structural numbers (SN) of the existing pavement sections ranging from 1.25 to 1.97. Between US Highway 85 and Balsam Avenue the existing SN values ranged from 1.25 to 1.76 with an average SN of 1.45. Between Balsam Avenue and Weld County Parkway the existing SN values ranged from 1.32 to 1.97 with an average SN of 1.63.

Asphalt Overlay Analysis (Balsam Avenue to Weld County Parkway): Based on the overlay approach discussed above, the design flexible pavement section requires a structural number of 5.13 to provide a 20-year design life. Milling 1-inch from the existing asphalt surface leaves an approximate average SN value of 1.39 for the portion of roadway between Balsam Avenue and Weld County Parkway. This means that the required thickness of asphalt to reach the design structural value is 8½ inches. If 8½ inches of asphalt were placed on the pavement surface after a 1-inch mill, then the proposed pavement surface would be as much as 7½ inches higher than the existing pavement surface.

If the required thickness of asphalt overlay is not feasible, a reduced overlay thickness is an option. If an overlay thickness was selected such that the proposed roadway surface was 2-inches higher than the existing pavement surface to allow for roadside drainages to be maintained, the design life of the pavement will be reduced. Given the above analysis and using a 1-inch mill and 3-inch overlay replacement, we estimate that the useful life of the roadway pavement to range from about 4 to 8 years. This estimated life can vary significantly based upon the actual traffic loading conditions.

If an asphalt overlay is not acceptable to the City of Greeley, then a complete reconstruction of the asphalt pavement section should be performed.

Asphalt Overlay Recommendations: The following recommendations should be followed in areas where an asphalt overlay is constructed. At the completion of the milling operation and just prior to placement of the asphalt overlay, the pavement surface should be thoroughly cleaned and provided with a proper concentration of tack coat.

Based on the distresses observed at the time of the field study, it does not appear that significant repair of distressed areas will be required. Placement of an asphalt overlay fabric on the existing/milled surface will reduce the tendency for reflection of the underlying pavement cracking. The overlay fabric will reduce the ability for surface water migration into the underlying pavement layers and subgrade materials. We have been informed by several Public Works agencies that the “water barrier” characteristics of the overlay fabric can result in stripping and deterioration of the bottom of the asphalt overlay.

As mentioned above, portions of the roadway are exhibiting moderate to high severity distresses. These areas should be properly reconstructed prior to placement of an overlay. We did not perform a formal pavement distress study; however, based upon travelling the roadway, we estimate 30 to 40% of the pavement may need reconstructed

<u>Pavement Reconstruction</u>: Complete pavement section reconstruction of the roadway may consist of removal of the asphalt and base course portions of the roadway and replacement with imported hot-mixed asphalt and base course materials. New pavement materials may be placed on properly prepared subgrade.

Recommended reconstructed asphalt pavement sections should meet the following minimums:

Complete Reconstruction Sections (No Geotextile Reinforcement)

Full-Depth HMA (inches)	Composite Section		Composite FDR Section		PCCP (inches)
	HMA (inches)	Imported ABC (inches)	HMA (inches)	FDR (inches)	
12	8	15	8	13	8½

HMA – Hot Mixed Asphalt
ABC – Aggregate Base Course
FDR – Full Depth Reclamation Base
PCC – Portland Cement Concrete

Use of a geotextile below the pavement section is generally not required, unless soft areas are encountered. Discussion of soft soil treatment is presented later in this report. As indicated above, the on-site materials possess an R-value of 14. These materials will generally provide fair to good support of the pavement section(s). If a high strength geotextile, such as a Tensar TX-160 or Mirafi RS380i is incorporated at the base of the aggregate base course layer, the resulting "apparent" subgrade strength values used in the calculations could be increased to represent an R-value near 40. The increase This apparent increase in subgrade strength would reduce the pavement thicknesses as follows:

Complete Reconstruction Sections (With Geotextile Reinforcement)

Composite Section		Composite FDR Section	
HMA (inches)	Imported ABC (inches)	HMA (inches)	FDR (inches)
6½	10	6½	13

HMA – Hot Mixed Asphalt
ABC – Aggregate Base Course
FDR – Full Depth Reclamation Base
PCC – Portland Cement Concrete

The above pavement sections were calculated using the DARWin™ pavement thickness design software, which solves the AASHTO equations using an iterative algorithm. Outputs of the DARWin™ program are presented in Appendix A.

Portland Cement Concrete Pavement Considerations: The above PCC pavement thicknesses are presented as un-reinforced slabs. Based on projects with similar vehicular loading in certain areas, dowels should be provided at transverse and tie bars for longitudinal joints within the slabs located in the travel lanes of heavily loaded vehicles, loading docks and areas where truck turning movements are likely to be concentrated. Additionally, curbs and/or pans should be tied to the slabs. The dowels and tie bars will help minimize the risk for differential movements between slabs to assist in more uniformly transferring axle loads to the subgrade. If dowels are not planned to be used, we should be contacted to re-evaluate the required concrete thickness by adjusting the load transfer coefficient to reflect a non-doweled concrete section.

The current CDOT *"Standard Specifications for Road and Bridge Construction"* provides some guidance on dowel and tie bar placement, as well as in the Standard Plans: M&S Standards. Additionally, we have been informed that Weld County uses 1¼-inch dowel and tie bars between panels at an approximate rate of about four (4) bars per panel edge.

The proper sealing and maintenance of joints to minimize the infiltration of surface water is critical to the performance of PCC pavement, especially if dowels and tie bars are not installed.

Some of the soils encountered during this study would be considered fine grained. Per the "Design Criteria and Construction Specifications: Streets Volume I", all rigid pavements with fine grained subgrade should be provided with a minimum of 6 inches of aggregate base course between the pavement section and the subgrade.

<u>Curb, Gutter and Sidewalk</u>: All attached/detached curb, gutter and sidewalk sections should be placed on subgrade prepared in accordance with the pavement subgrade criteria presented herein.

<u>Subgrade Preparation</u>: Subgrade preparation may include re-use of the existing on-site soils/materials or stabilization techniques such as cement modification or the process known as full depth reclamation (FDR). We anticipate that the most economical method of subgrade preparation will be the FDR process. FDR utilizes specialty machinery that pulverizes and grinds the existing pavement such that the pavement particle sizes are smaller than about 2-inches in diameter. The machine then blends the pulverized pavement into the underlying subgrade to a depth of about 8 inches. The depth of treatment should be discussed with the specialty contractor and should be partially based upon the existing thickness of asphalt pavement.

Subgrade materials (both on-site only and/or FDR generated) should scarified to a depth of at least 8 inches and be compacted to at least 95% of the standard Proctor (AASHTO T 99) maximum dry density at moisture contents within -2 to +2 percentage points above the optimum moisture content.

Prior to placement of the asphalt, the pavement subgrade should be proof rolled with a heavily loaded pneumatic-tired vehicle such as a loaded water truck or paving truck prior to paving. Pavement design procedures assume a stable subgrade. Areas that deform excessively under wheel loads are not stable and should be removed and replaced to achieve a stable subgrade prior to paving.

Geotextile Stabilization: There may be areas of soft subgrade encountered when the existing pavement is removed. These areas may be overexcavated to a depth where stable material is encountered. The overexcavated material may be replaced with the removed material (adjusted for moisture content and compacted according to the criteria listed above). An alternative to significant overexcavation would be to span the soft areas with a woven geotextile such as Mirafi Rs380i. Aggregate base course would then be placed over the geotextile to provide a stable paving platform. We anticipate an aggregate base course thickness of 12 inches would be required.

<u>Pavement Material Type Recommendations</u>: The following are recommended material and placement requirements for pavement construction for this project site. We recommend that properties and mix designs for all materials proposed to be used for pavements be submitted for review to the geotechnical engineer prior to placement.

1. *Aggregate Base Course*: Aggregate base course (ABC) used beneath HMA pavements should meet the material specifications for Class 6 ABC stated in the current CDOT *"Standard Specifications for Road and Bridge Construction"*. The ABC should be placed and compacted as outlined in the "SITE GRADING" section of this report.

2. *Hot Mix Asphalt:* Hot mix asphalt (HMA) materials and mix designs should meet the applicable requirements indicated in the current CDOT *"Standard Specifications for Road and Bridge Construction"*. We recommend that the HMA used for this project is designed in accordance with the SuperPave gyratory mix design method. The mix should meet

Grading S specifications with a SuperPave gyratory design revolution (N_{DESIGN}) of 75. A mix meeting Grading SX specification can be used for the top lift wearing course, however, this is optional. In accordance with Weld County criteria, we recommend that the mix design(s) for the HMA use a performance grade (PG) asphalt binder of PG 64-22 for the lower lifts of asphalt and a polymer modified binder asphalt mix for the top lift of asphalt that uses a PG 64-28 binder. Placement and compaction of HMA should follow current CDOT, Weld County, and/or City of Greeley standards and specifications.

3. *Portland Cement Concrete*: Portland Cement Concrete (PCC) pavement should meet Class P or D specifications and requirements in the current CDOT *"Standard Specifications for Road and Bridge Construction"*. Rigid PCC pavements are more sensitive to distress due to movement resulting from settlement or heave of the underlying base layer and/or subgrade than flexible asphalt pavements. The PCC pavement should contain sawed or formed joints to ¼ of the depth of the slab at a maximum distance of 12 to 15 feet on center for transverse joints, and the horizontal jointing limited to no more than 14 feet.

Subgrade Preparation: Prior to placing the new pavement section, the entire subgrade area should be thoroughly scarified and well-mixed to a minimum depth of 12 inches, adjusted in moisture content and compacted as indicated in the "SITE GRADING" section of this report. Fill placed beneath the pavement should meet the material and compaction requirements for structural fill presented in the "SITE GRADING" section of this report.

Pavement design procedures assume a stable subgrade and the pavement subgrade should be proof-rolled, preferably within 48 hours prior to paving. The proof-roll should be performed using a heavily loaded pneumatic-tired vehicle such as a loaded water truck or large front-end loader. Areas that deform under wheel loads that are not stable should be removed and replaced to achieve a stable subgrade prior to paving. The contractor should be aware that the clay soils may become somewhat unstable and deform under wheel loads if placed near the upper end of the moisture content range.

Drainage: The collection and diversion of surface drainage away from paved areas is extremely important to the satisfactory performance of pavement. Drainage design should provide for the removal of water from paved areas and prevent the wetting of the subgrade soils.

PAVEMENT LIFE CYCLE COST ANALYSIS

A high level (limited scope) life cycle cost analysis was performed for the project pavement section alternatives for 8th Street to provide additional data for the client to determine the most cost-effective pavement section over the life of the facility. The analysis was performed using LCCAExpress Version 2.0 software. The analysis was performed for the flexible composite pavement section against the rigid pavement section over a 20-year design life. The analyses were performed on the initial template to be constructed for three roadway segments. The first segment is between US 85 and Balsam Avenue, the second segment is from Balsam Avenue to Fern Avenue, and the third segment is from Fern Avenue to Weld County Parkway. The segment from US 85 to Balsam Avenue (approximately 2,825 feet long) was assumed to consist of one 12-foot lane in each travel direction with a 13-foot center turn lane and curb and gutter on both sides of the roadway resulting in approximately 12,000 square yards of pavement surface.

The segment from Balsam Avenue to Fern Avenue (approximately 8,000 feet long) was assumed to consist of one (1) 12-foot lane in each direction with a 13-foot center turn lane and 1-foot wide paved shoulders on each side with an additional 5-foot gravel shoulder on each side of the road resulting in approximately 34,700 square yards of pavement.

The remaining segment (approximately 5,250 feet long) was assumed to consist of one (1) 12-foot lane in each direction with 2-foot paved shoulders on each side of the road with an additional 4-foot gravel shoulder outside of the paved shoulders resulting in approximately 16,400 square yards of pavement.

It should be noted that the analysis was performed over a 20-year period to account for the useful life of the flexible pavement section. This analysis did not account for the typically expected 30-year design life of the concrete pavement section. It should also be noted that the concrete pavement section thickness was established using 20-year traffic design numbers.

Based on discussion with the design team and the most likely pavement sections to be constructed, the cost analyses were performed for the following pavement section thicknesses:

Complete Reconstruction Sections

Full-Depth HMA (inches)	Composite Section		Composite Section with Geogrid Reinforcement		PCCP (inches)
	HMA (inches)	Imported ABC (inches)	HMA (inches)	Imported ABC (inches)	
12	8	15	6½	10	8½

HMA – Hot Mixed Asphalt
ABC – Aggregate Base Course
PCC – Portland Cement Concrete

The analysis was performed on a cost per mile scenario with the results summarized as follows:

LCCA Summary of Results

Pavement Section Type	Cost per mile of Roadway US 85 to Balsam Avenue ($/mile)	Cost per mile of Roadway Balsam Avenue to Fern Avenue ($/mile)	Cost per mile of Roadway Fern Avenue to Weld County Parkway ($/mile)
Full Depth Asphalt	$2,821,643	$2,707,477	$1,601,855
Composite Asphalt over Base Course	$2,426,672	$2,292,251	$1,483,305
Composite Asphalt over Base Course with Geogrid Reinforcement	$2,279,284	$2,133,015	$1,084,036
Portland Cement Concrete	$2,275,848	$2,104,161	$1,836,922

A summary of the above data, the unit costs for the various pavement layers, the rehabilitation strategies, yearly maintenance costs and a summary of the cost per mile for the alternatives are provided in Appendix B.

Based on the above data, it appears that the Portland cement concrete pavement section would result in the lowest cost pavement section to construct and maintain between US Highway 85 and Fern Avenue. Where the roadway template is reduced (Fern Avenue to Weld County Parkway), it appears that a geogrid reinforced composite section consisting of hot mixed asphalt overlying an aggregate base course in-turn overlying a geogrid would result in the most economical pavement section.

DESIGN AND CONSTRUCTION SUPPORT SERVICES

Kumar & Associates, Inc. should be retained to review the project plans and specifications for conformance with the recommendations provided in our report. We are also available to assist the design team in preparing specifications for geotechnical aspects of the project, and performing additional studies if necessary to accommodate possible changes in the proposed construction.

We recommend that Kumar & Associates, Inc. be retained to provide observation and testing services to document that the intent of this report and the requirements of the plans and specifications are being followed during construction, and to identify possible variations in subsurface conditions from those encountered in this study so that we can re-evaluate our recommendations, if needed.

LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical and pavement engineering practices in this area for exclusive use by the client for design purposes. The conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings at the locations indicated on Figs. 1 and 1A, and the proposed type of construction. This report may not reflect subsurface variations that occur between the exploratory borings, and the nature and extent of variations across the site may not become evident until site grading and excavations are performed. If during construction, existing pavement section type and thickness, fill, soil, bedrock or groundwater conditions appear to be different from those described herein, Kumar & Associates, Inc. should be advised at once so that a re-evaluation of the recommendations presented in this report can be made. Kumar & Associates, Inc. is not responsible for liability associated with interpretation of subsurface data by others.

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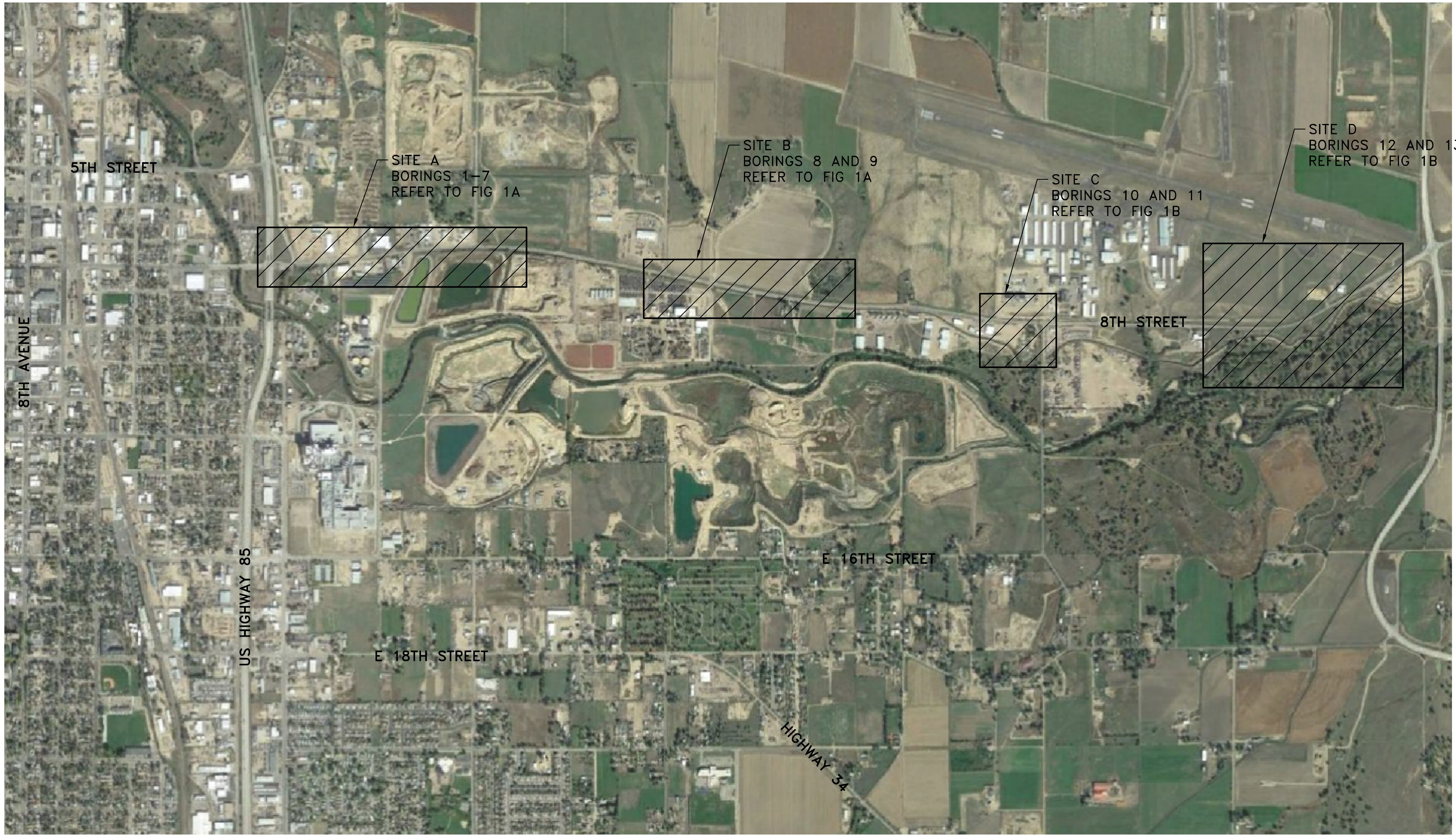
Rev. by: JAN
cc: Book, File



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18-3-158	Kumar & Associates	8th STREET IMPROVEMENTS	VICINITY MAP	Fig. 1

SITE A

SITE B

18-3-158	Kumar & Associates	8th STREET IMPROVEMENTS	LOCATION OF EXPLORATORY BORINGS	Fig. 1A

SITE C

SITE D

100 0 100 200

APPROXIMATE SCALE–FEET

150 0 150 300

APPROXIMATE SCALE–FEET

18–3–158	Kumar & Associates	8th STREET IMPROVEMENTS	LOCATION OF EXPLORATORY BORINGS	Fig. 1B

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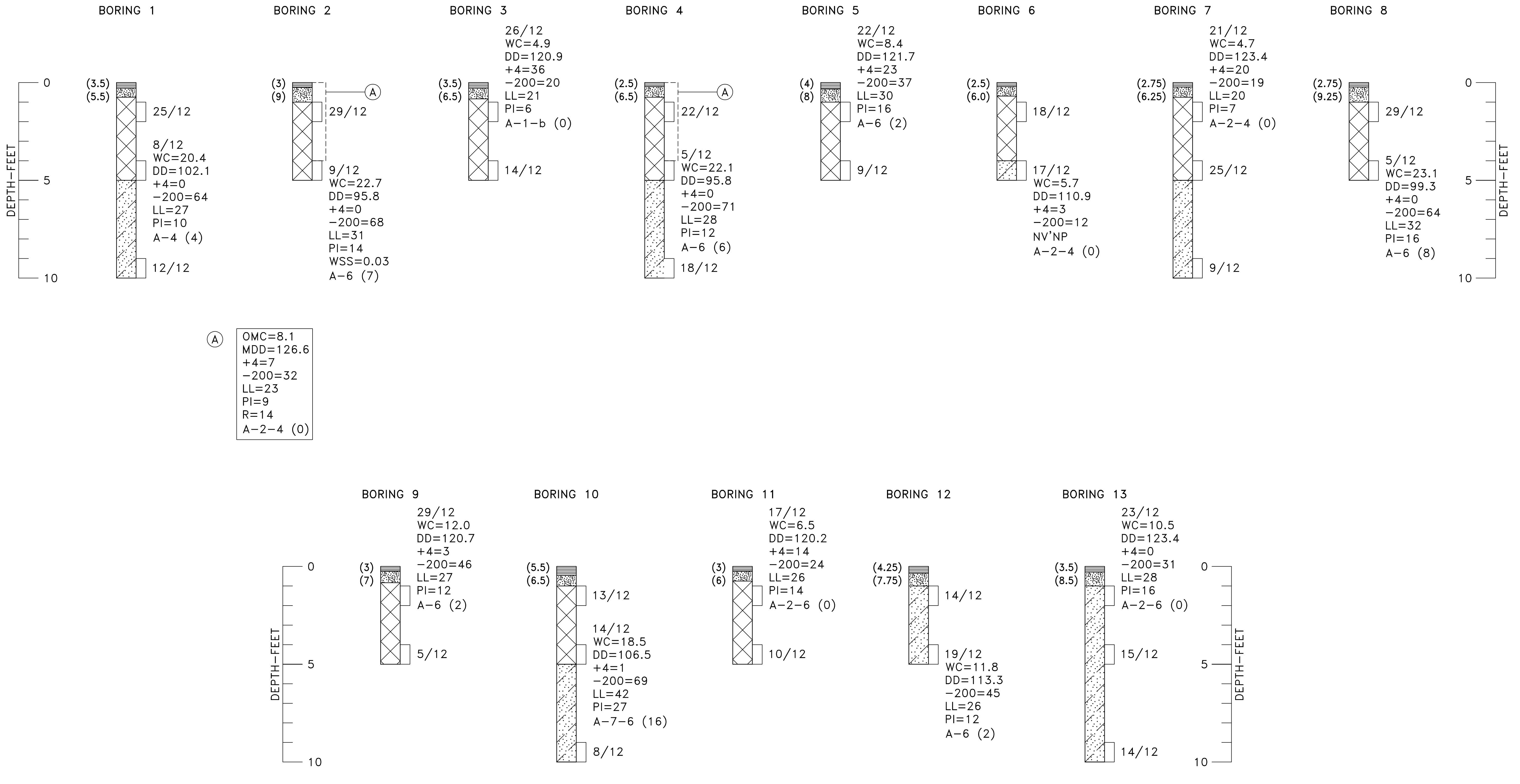
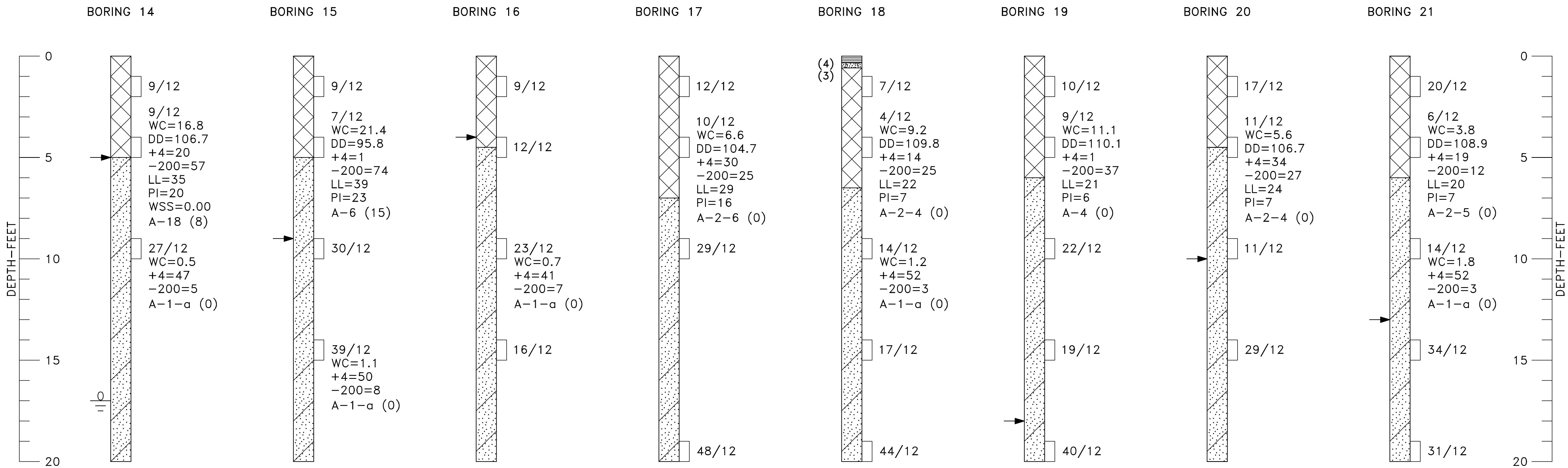


18-3-158	Kumar & Associates	8th STREET IMPROVEMENTS	LOGS OF EXPLORATORY BORINGS	Fig. 2



18–3–158	Kumar & Associates	8th STREET IMPROVEMENTS	LOGS OF EXPLORATORY BORINGS	Fig. 3

LEGEND

(3.5) ASPHALT, THICKNESS IN INCHES SHOWN IN PARENTHESES TO LEFT OF THE LOG.

(5.5) BASE COURSE, THICKNESS IN INCHES SHOWN IN PARENTHESES TO LEFT OF THE LOG.

FILL: SANDY LEAN CLAY (CL) TO CLAYEY SAND (SC) TO SILTY CLAYEY SAND WITH GRAVEL (SC-SM), VARIOUS SAND AND GRAVEL CONTENTS THROUGHOUT, SLIGHTLY MOIST TO VERY MOIST, BROWN TO BLACK.

SILTY SAND (SM), FINE TO COARSE GRAINED, OCCASIONAL GRAVEL, MEDIUM DENSE, SLIGHTLY MOIST, LIGHT BROWN TO BROWN.

CLAYEY SAND (SC), FINE TO COARSE GRAINED, OCCASIONAL GRAVEL, MEDIUM DENSE, SLIGHTLY MOIST TO MOIST, LIGHT BROWN TO BROWN.

POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM), FINE TO COARSE GRAINED, MEDIUM DENSE TO DENSE, SLIGHTLY MOIST TO MOIST, LIGHT BROWN, GRAVEL CONTENT APPEARED TO INCREASE WITH DEPTH.

DRIVE SAMPLE, 2-INCH I.D. CALIFORNIA LINER SAMPLE.

DISTURBED BULK SAMPLE.

25/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 25 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.

DEPTH TO WATER LEVEL ENCOUNTERED AT THE TIME OF DRILLING.

DEPTH AT WHICH BORING CAVED.

NOTES

1. THE EXPLORATORY BORINGS WERE DRILLED ON JULY 19 AND NOVEMBER 8, 2018 WITH A 4-INCH DIAMETER CONTINUOUS FLIGHT POWER AUGER.

2. THE LOCATIONS OF THE EXPLORATORY BORINGS WERE MEASURED APPROXIMATELY BY PACING FROM FEATURES SHOWN ON THE SITE PLAN PROVIDED.

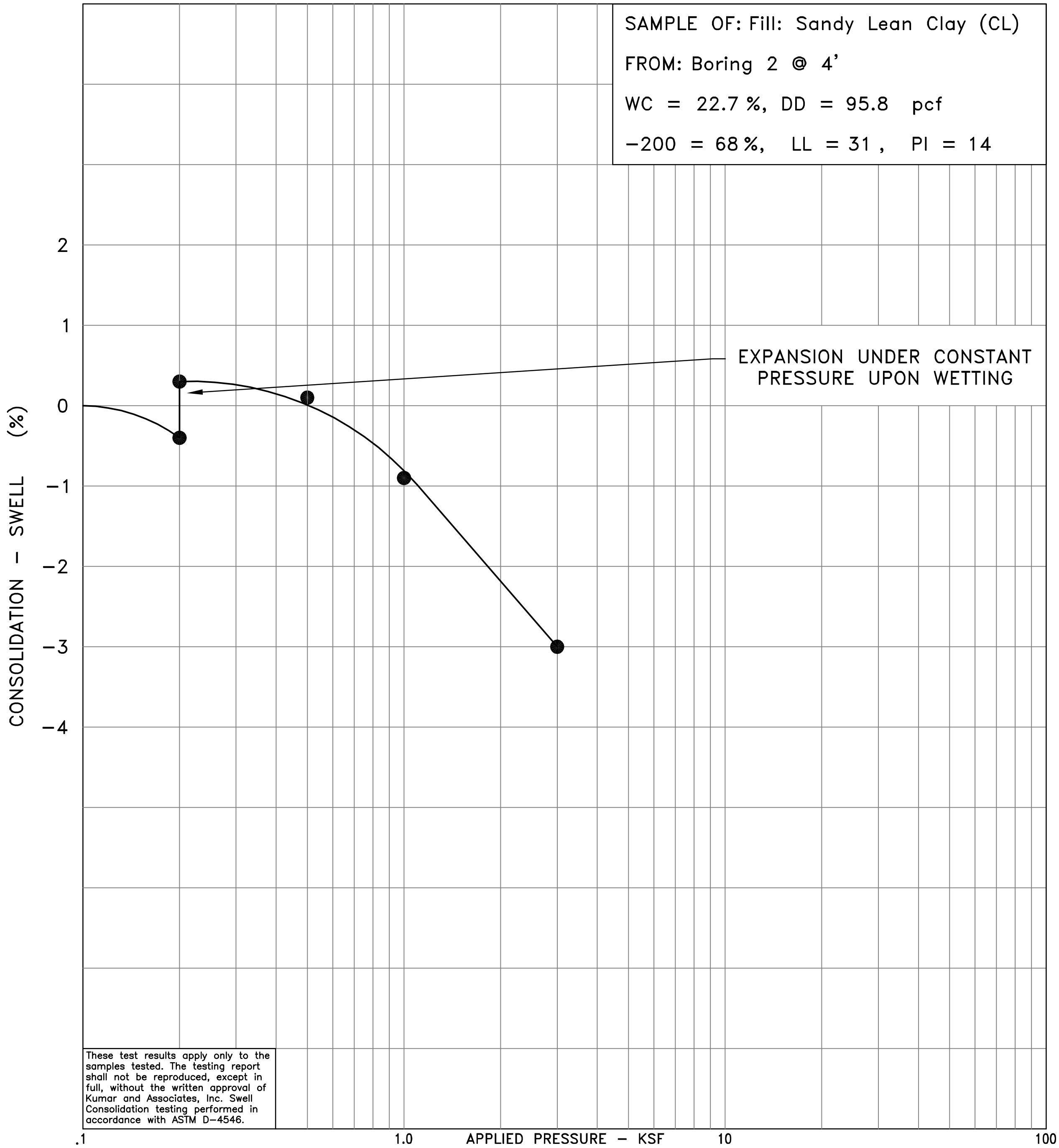
3. THE ELEVATIONS OF THE EXPLORATORY BORINGS WERE NOT MEASURED AND THE LOGS OF THE EXPLORATORY BORINGS ARE PLOTTED TO DEPTH.

4. THE EXPLORATORY BORING LOCATIONS SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.

5. THE LINES BETWEEN MATERIALS SHOWN ON THE EXPLORATORY BORING LOGS REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES AND THE TRANSITIONS MAY BE GRADUAL.

6. GROUNDWATER WAS NOT ENCOUNTERED IN THE BORINGS AT THE TIME OF DRILLING. THE BORINGS WERE BACKFILLED.

7. LABORATORY TEST RESULTS:
   WC = WATER CONTENT (%) (ASTM D 2216);
   DD = DRY DENSITY (pcf) (ASTM D 2216);
   +4 = PERCENTAGE RETAINED ON NO. 4 SIEVE (ASTM D 422);
   -200= PERCENTAGE PASSING NO. 200 SIEVE (ASTM D 1140);
   LL = LIQUID LIMIT (ASTM D 4318);
   PI = PLASTICITY INDEX (ASTM D 4318);
   NV = NO LIQUID LIMIT VALUE (ASTM D 4318);
   NP = NON-PLASTIC (ASTM D 4318);
   WSS = WATER SOLUBLE SULFATES (%) (CP-L 2103);
   R = HVEEM R-VALUE (AT 300 psi) (ASTM D 2844);
   A-4 (4) = AASHTO CLASSIFICATION (GROUP INDEX) (AASHTO M 145);
   OMC = OPTIMUM MOISTURE CONTENT (%) (ASTM D 1557) or (ASTM D 698);
   MDD = MAXIMUM DRY DENSITY (pcf) (ASTM D 1557) or (ASTM D 698).



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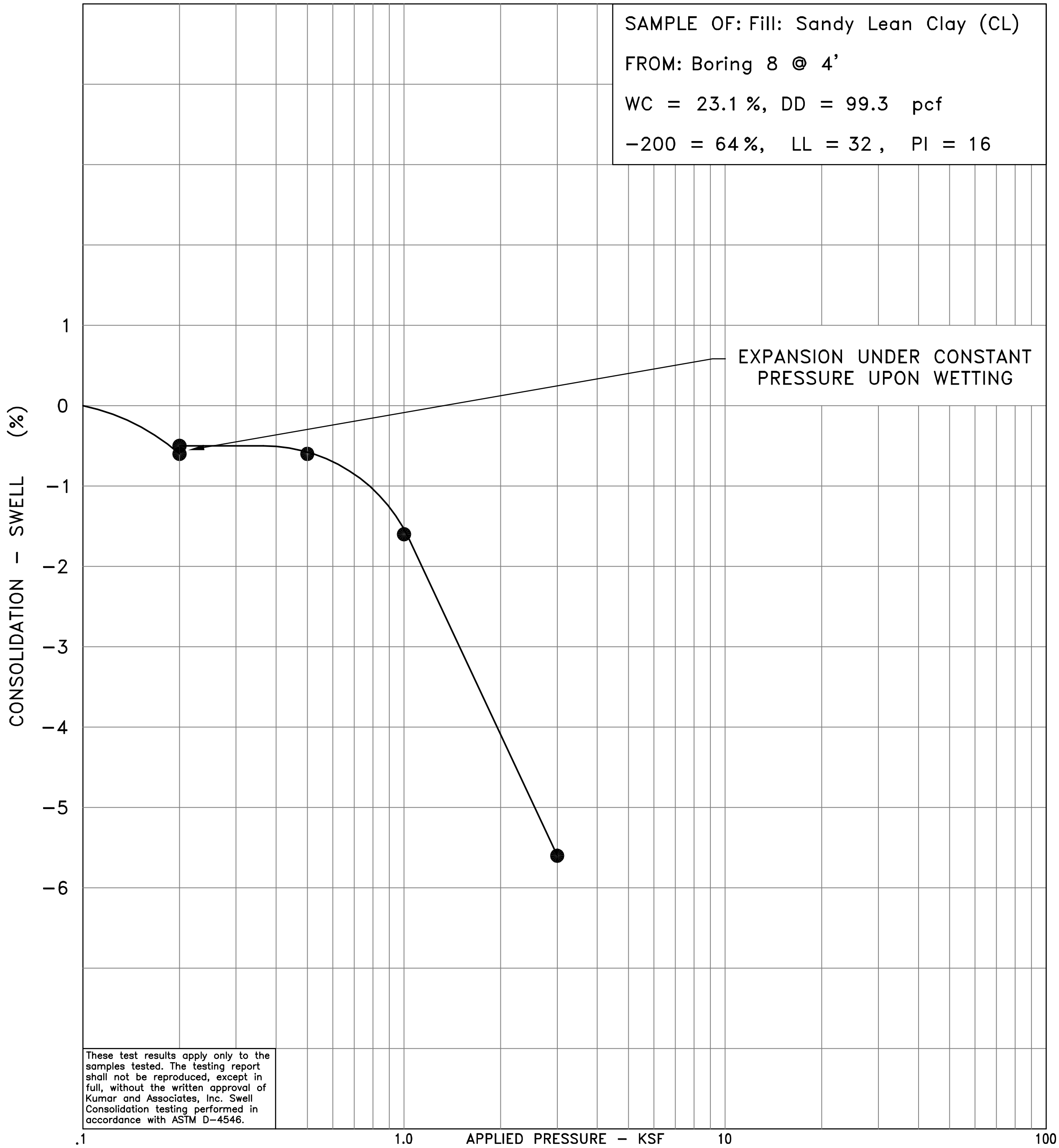
18-3-158	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 5



These test results apply only to the samples tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar and Associates, Inc. Swell Consolidation testing performed in accordance with ASTM D-4546.

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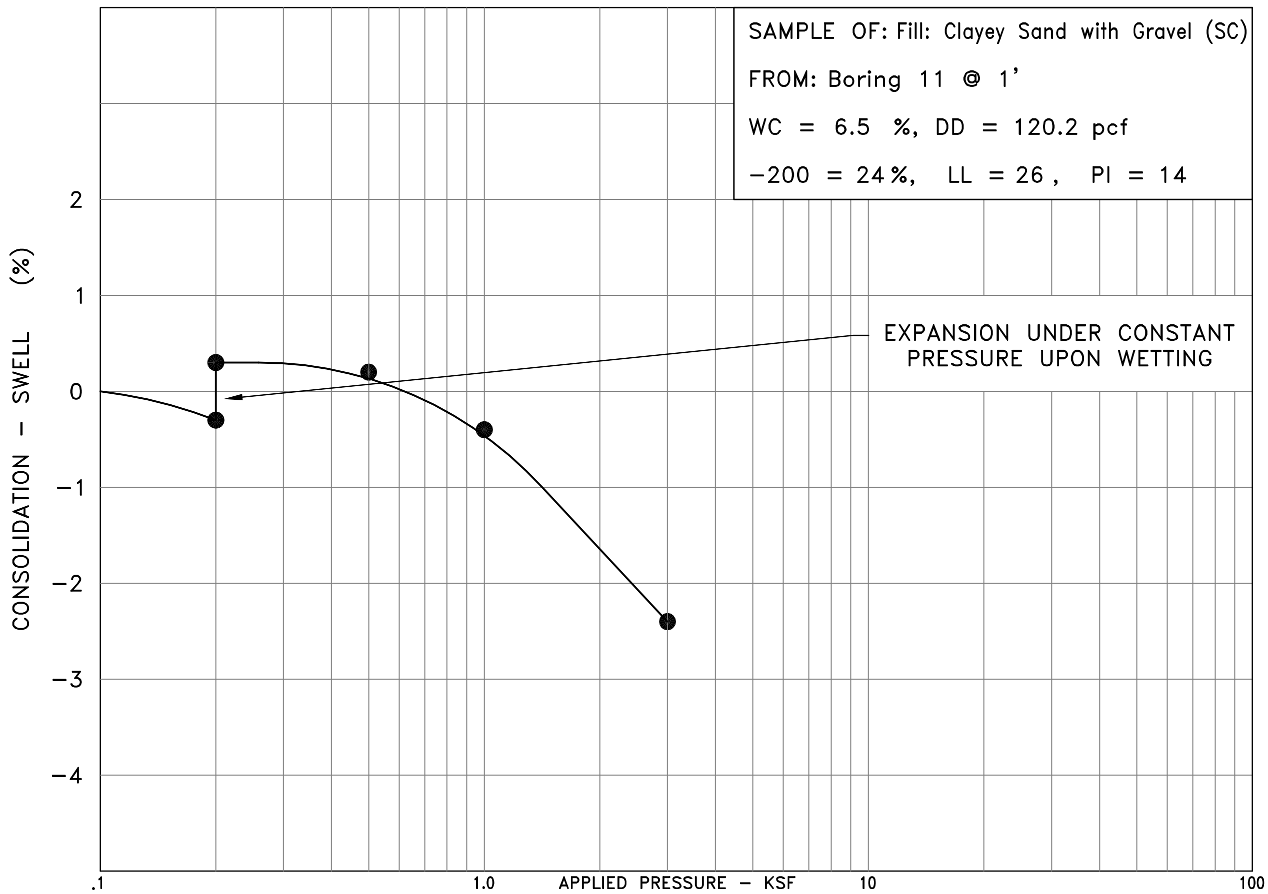
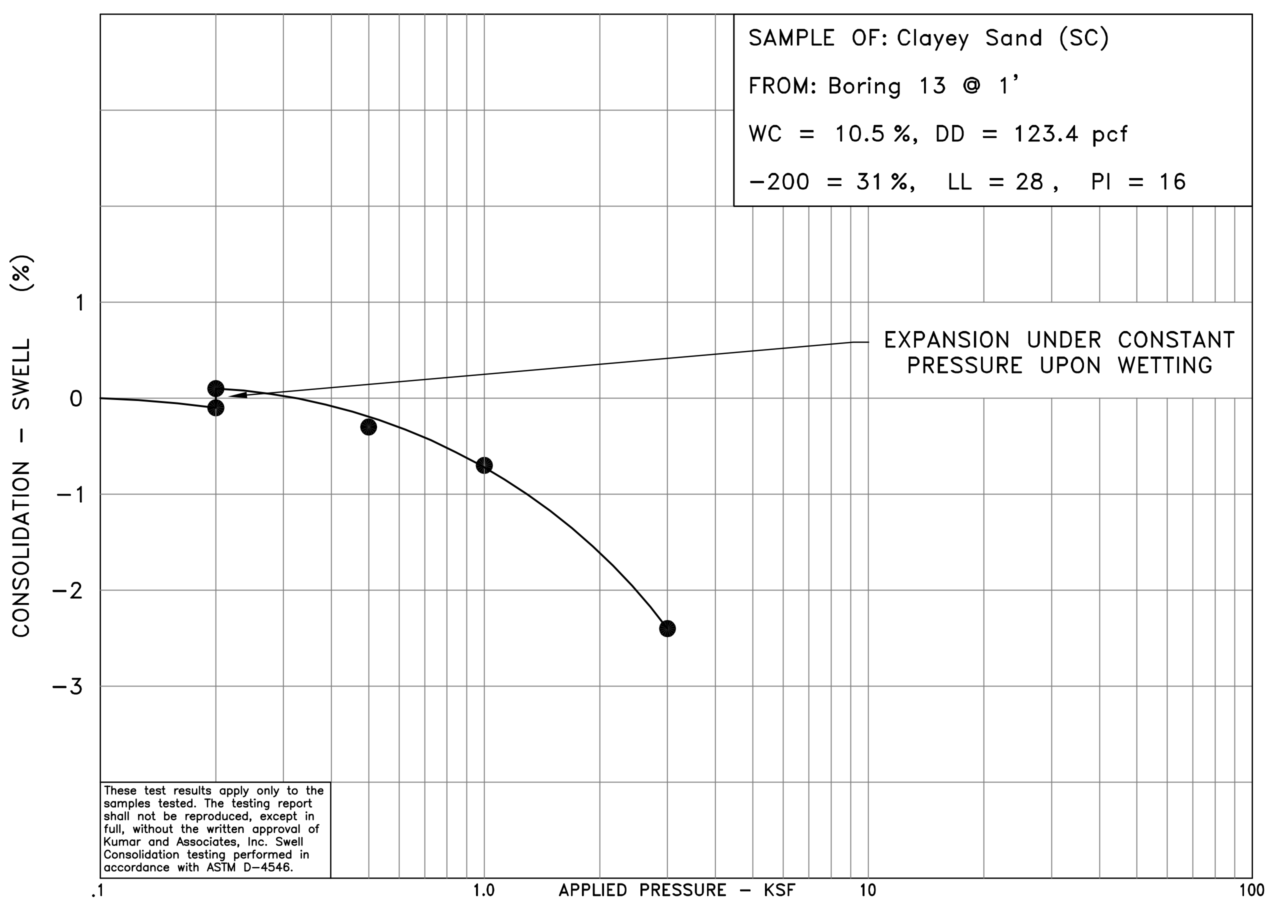
18−3−158	Kumar & Associates	SWELL−CONSOLIDATION TEST RESULTS	Fig. 6





These test results apply only to the samples tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar and Associates, Inc. Swell Consolidation testing performed in accordance with ASTM D-4546.

18−3−158	Kumar & Associates	SWELL−CONSOLIDATION TEST RESULTS	Fig. 7

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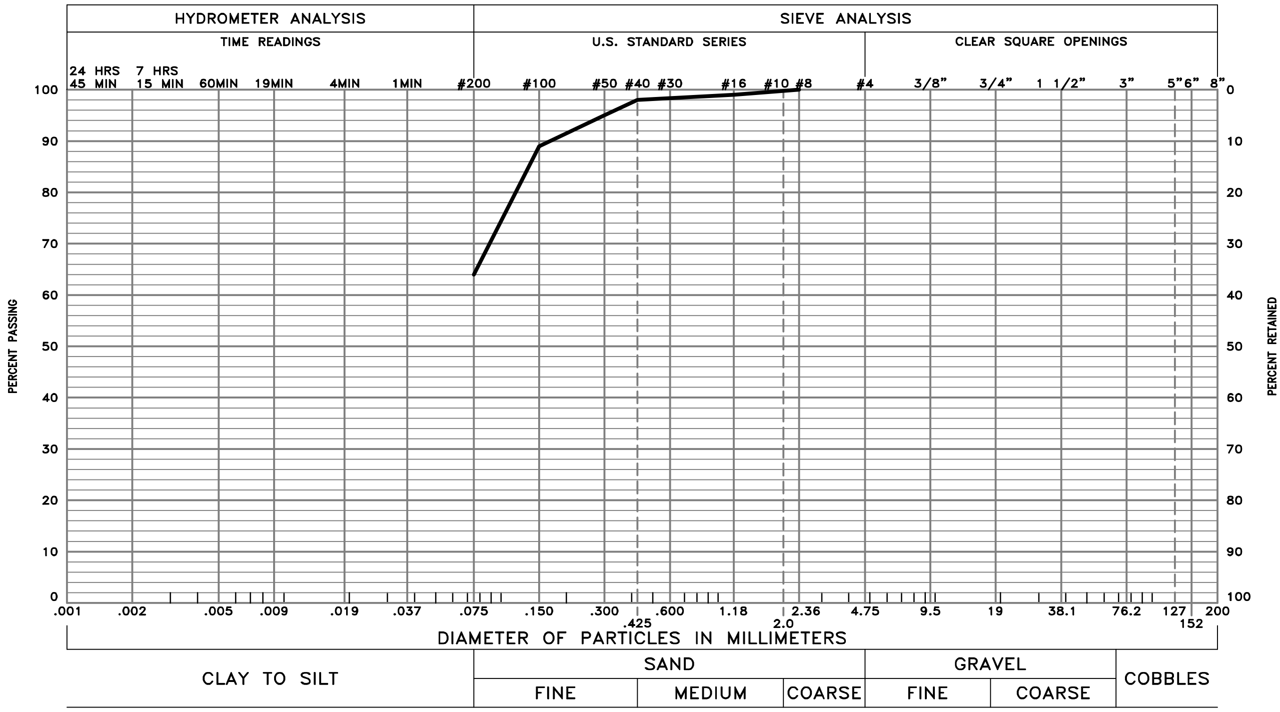
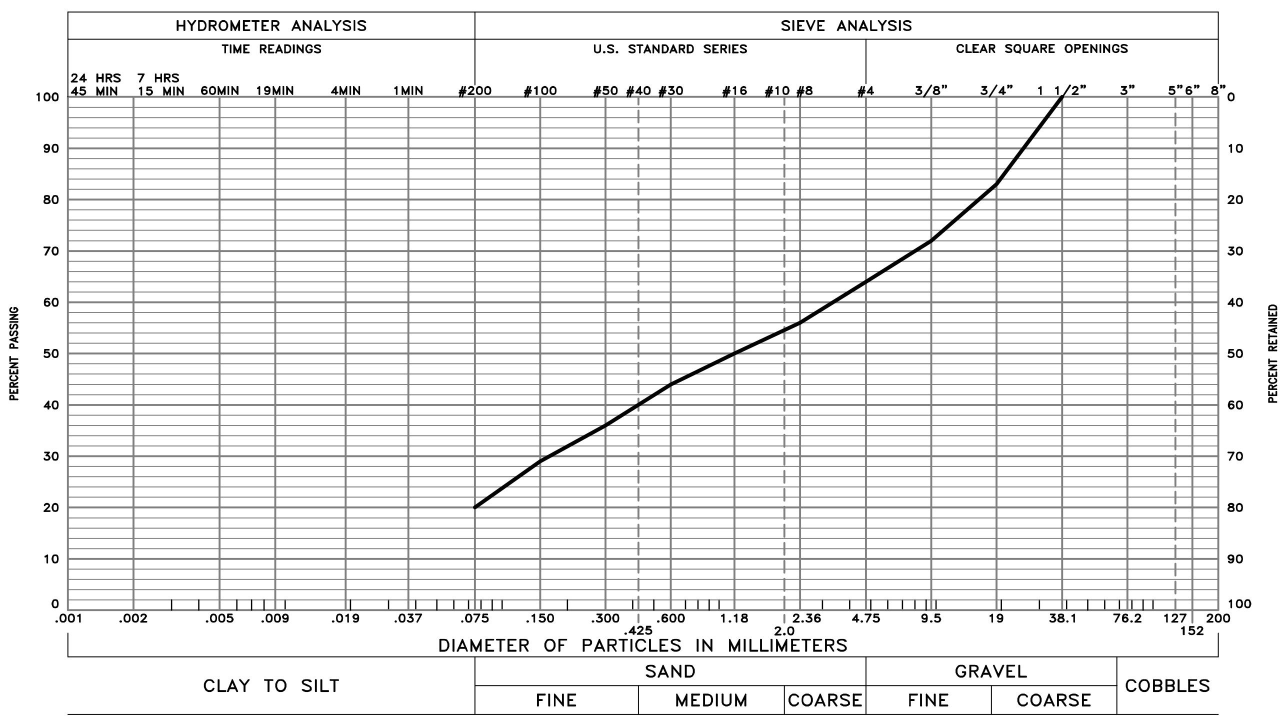


GRAVEL 0 % SAND 36 % SILT AND CLAY 64 %

LIQUID LIMIT 27 PLASTICITY INDEX 10

SAMPLE OF: Fill: Sandy Lean Clay (CL) FROM: Boring 1 @ 4'



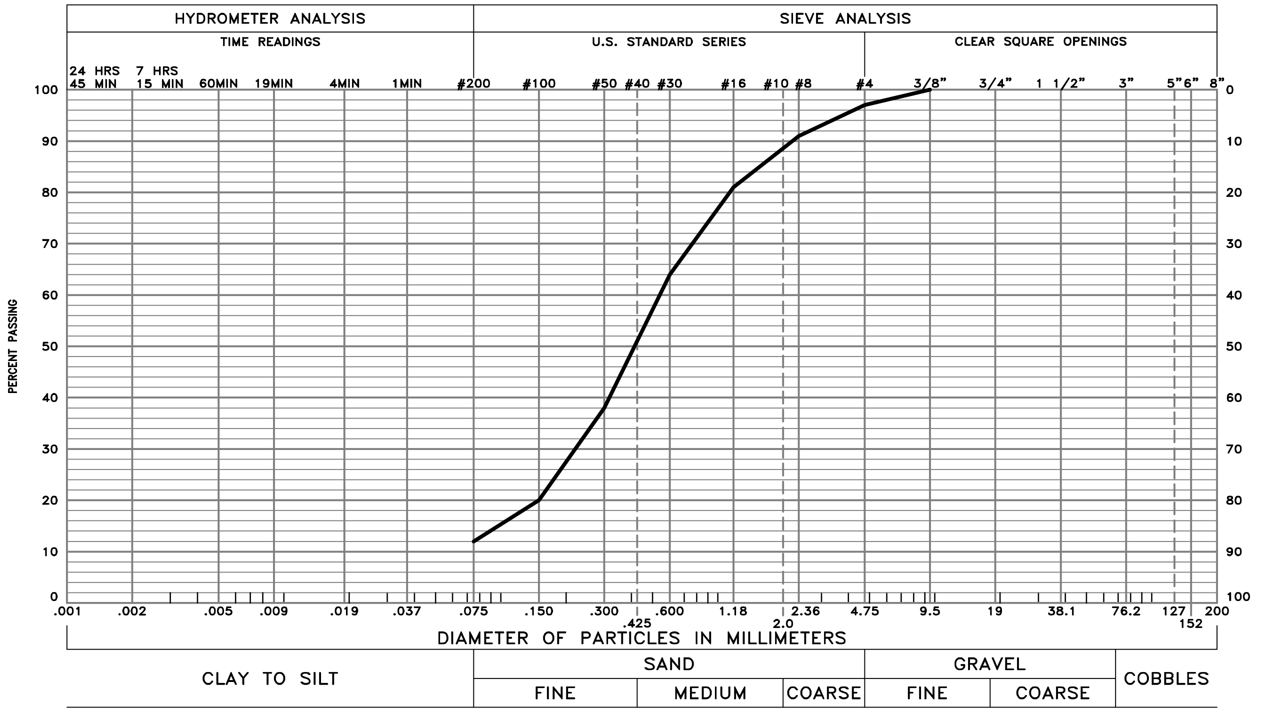
GRAVEL 36 % SAND 44 % SILT AND CLAY 20 %

LIQUID LIMIT 21 PLASTICITY INDEX 6

SAMPLE OF: Fill: Silty Clayey Sand with Gravel (SC-SM) FROM: Boring 3 @ 1'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D422, ASTM C136 and/or ASTM D1140.

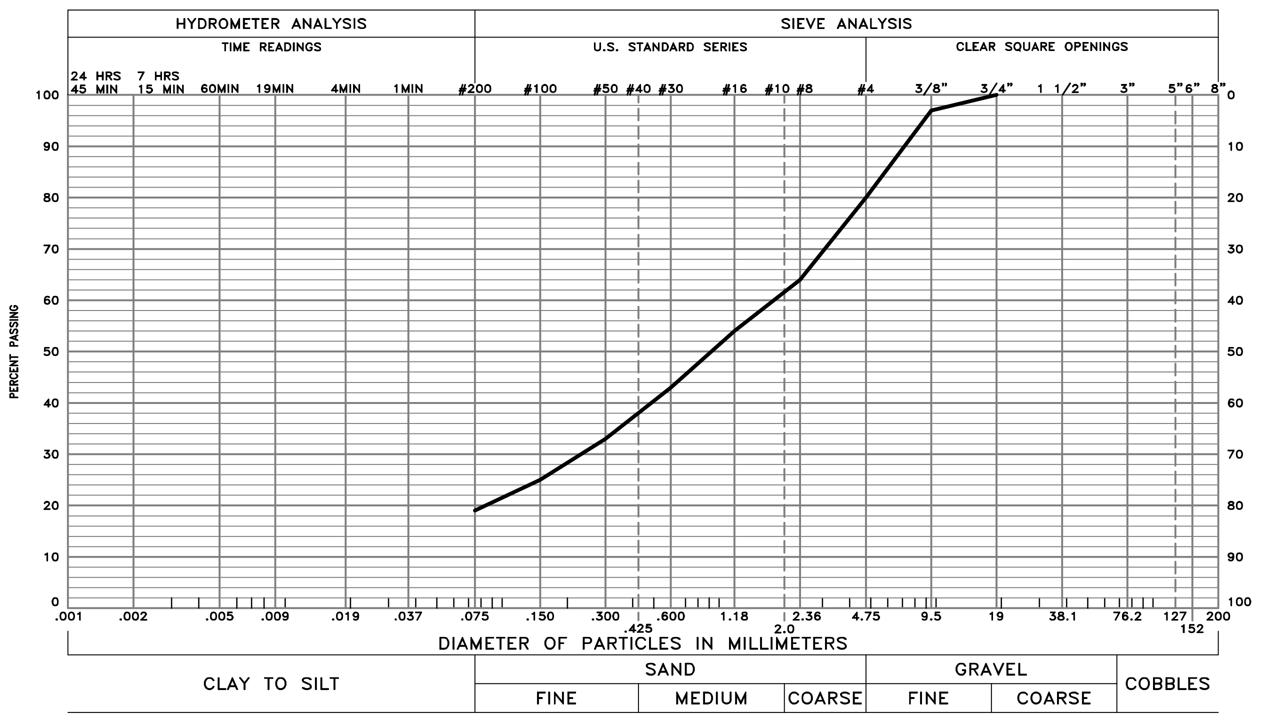
18-3-158	Kumar & Associates	GRADATION TEST RESULTS	Fig. 8



GRAVEL 3 % SAND 85 % SILT AND CLAY 12 %

LIQUID LIMIT NV PLASTICITY INDEX NP

SAMPLE OF: Silty Sand (SM) FROM: Boring 6 @ 4'



GRAVEL 20 % SAND 61 % SILT AND CLAY 19 %

LIQUID LIMIT 20 PLASTICITY INDEX 7

SAMPLE OF: Fill: Silty Clayey Sand with Gravel (SC-SM) FROM: Boring 7 @ 1'

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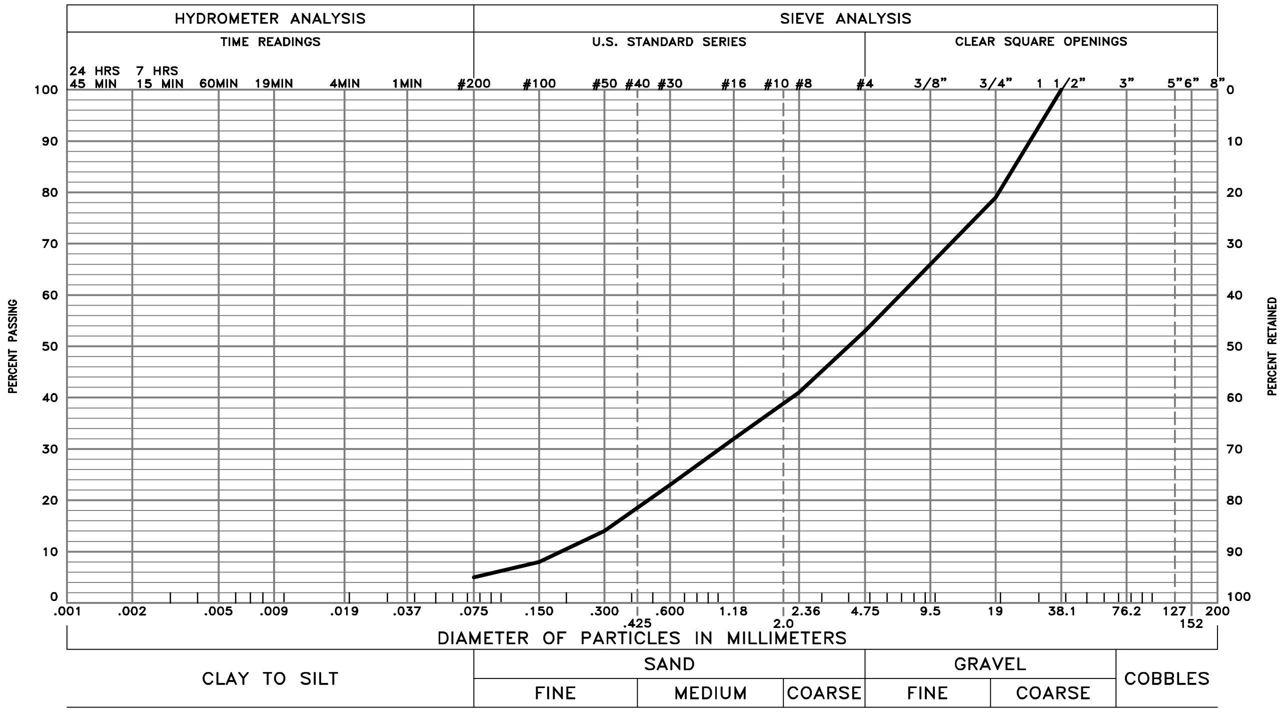
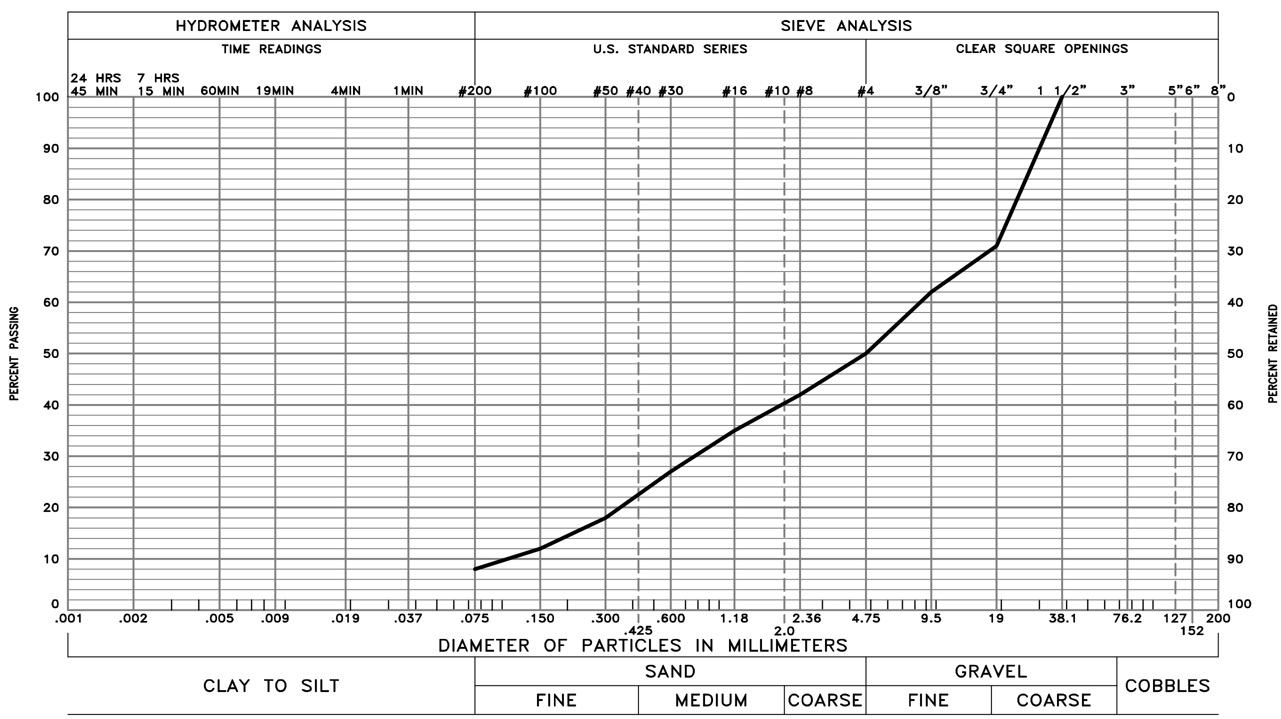
18-3-158	Kumar & Associates	GRADATION TEST RESULTS	Fig. 9



GRAVEL 47 % SAND 48 % SILT AND CLAY 5 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Poorly Graded Sand with Gravel (SW) FROM: Boring 14 @ 9'



GRAVEL 50 % SAND 42 % SILT AND CLAY 8 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Poorly Graded Gravel with Silt and Sand (GW-GM) FROM: Boring 15 @ 14'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D422, ASTM C136 and/or ASTM D1140.

18-3-158	Kumar & Associates	GRADATION TEST RESULTS	Fig. 10

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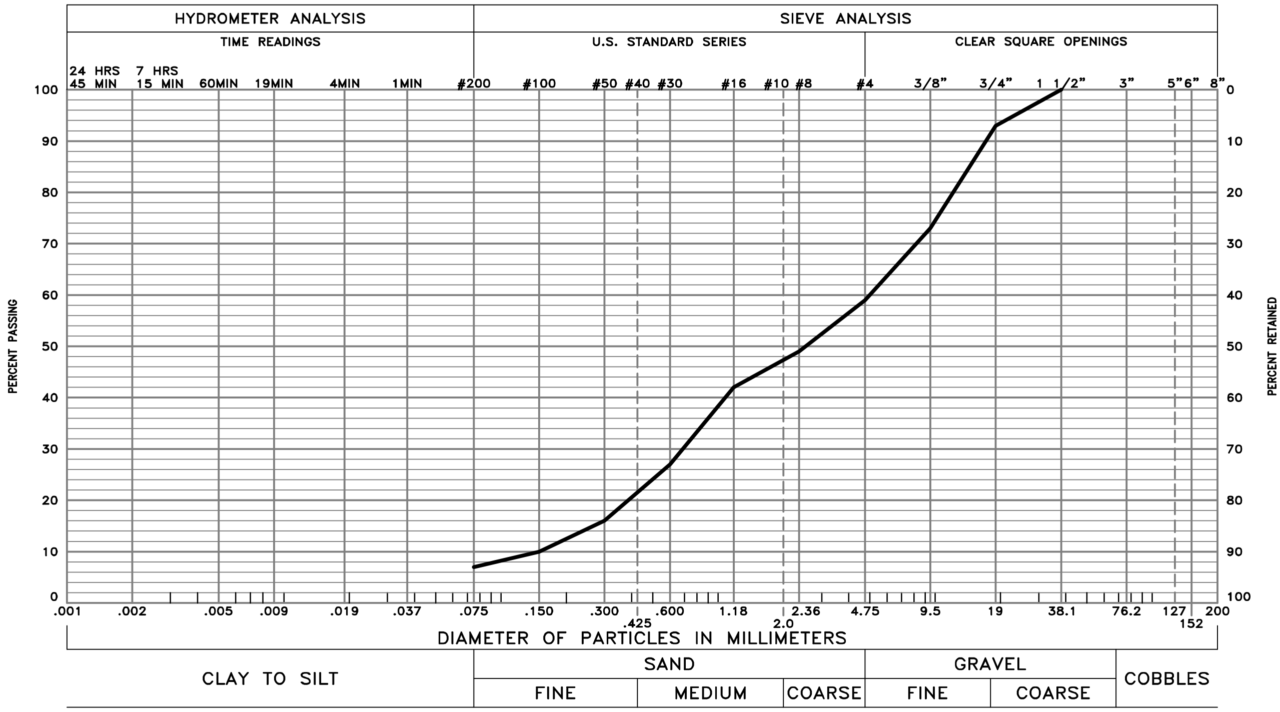
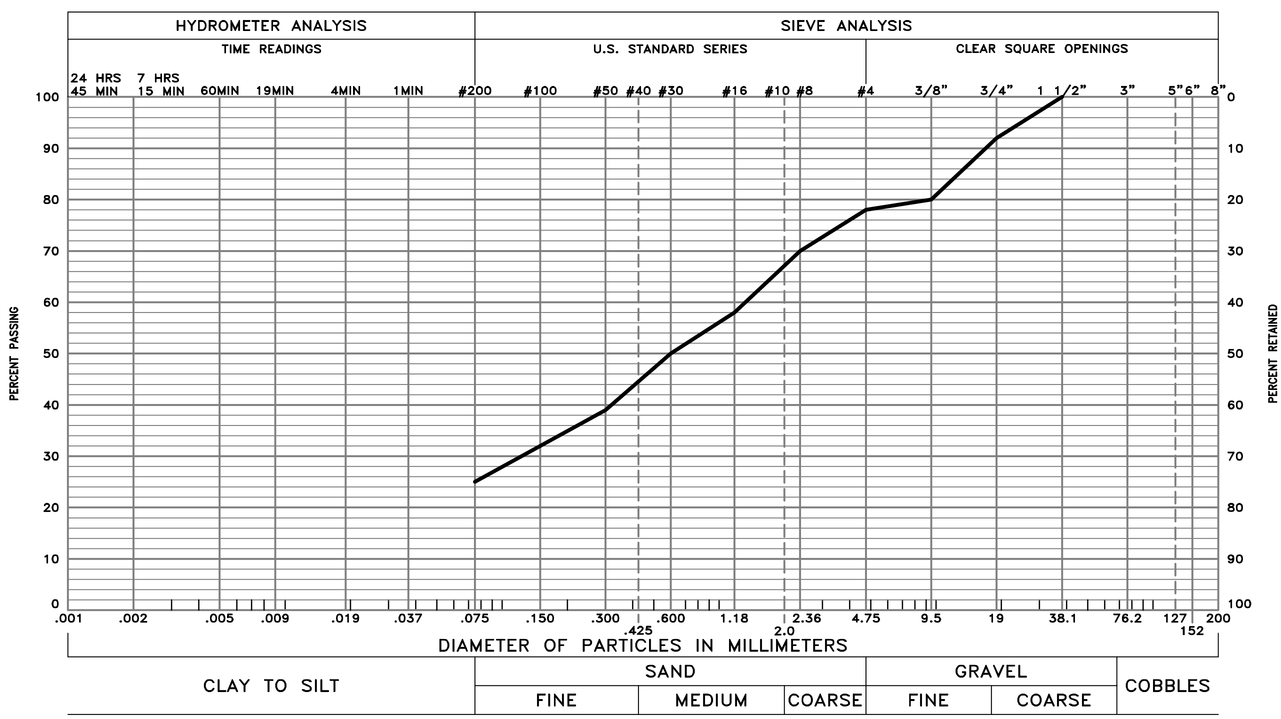


GRAVEL 41 % SAND 52 % SILT AND CLAY 7 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Poorly Graded Sand with Silt and Gravel (SP–SM) FROM: Boring 16 @ 9'

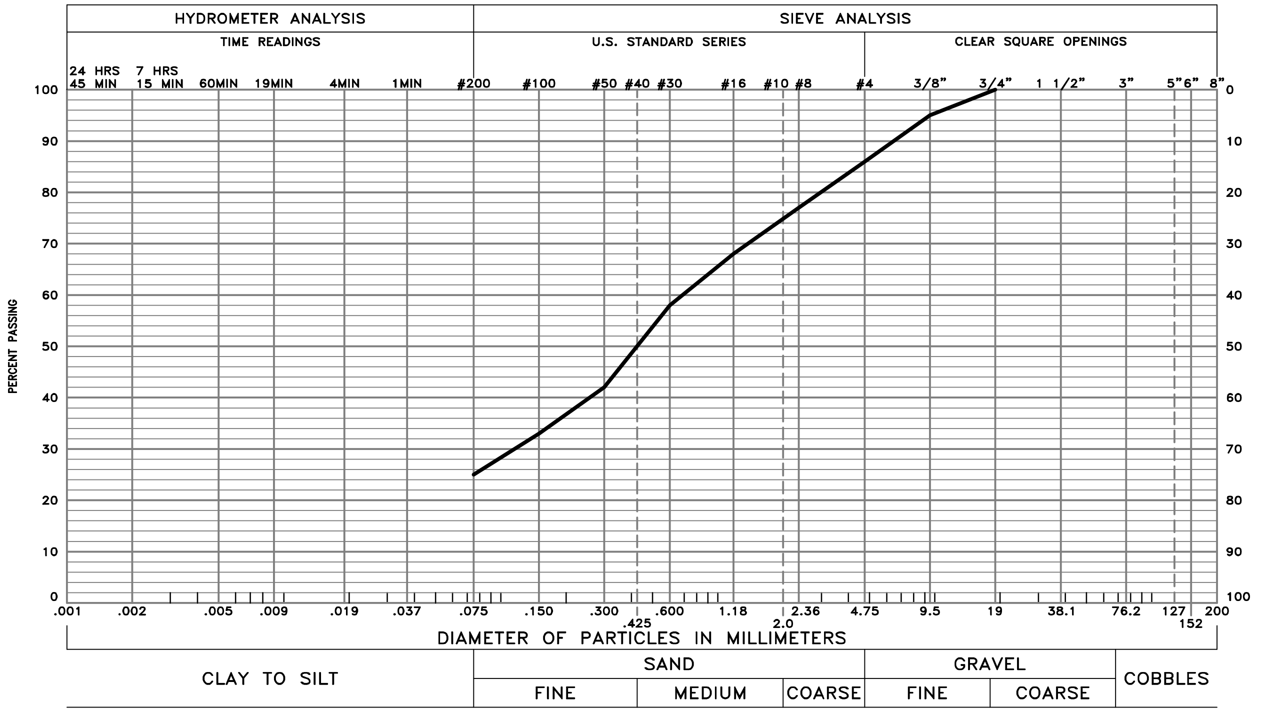


GRAVEL 30 % SAND 45 % SILT AND CLAY 25 %

LIQUID LIMIT 29 PLASTICITY INDEX 16

SAMPLE OF: Silty Sand with Gravel (SM) FROM: Boring 17 @ 4'

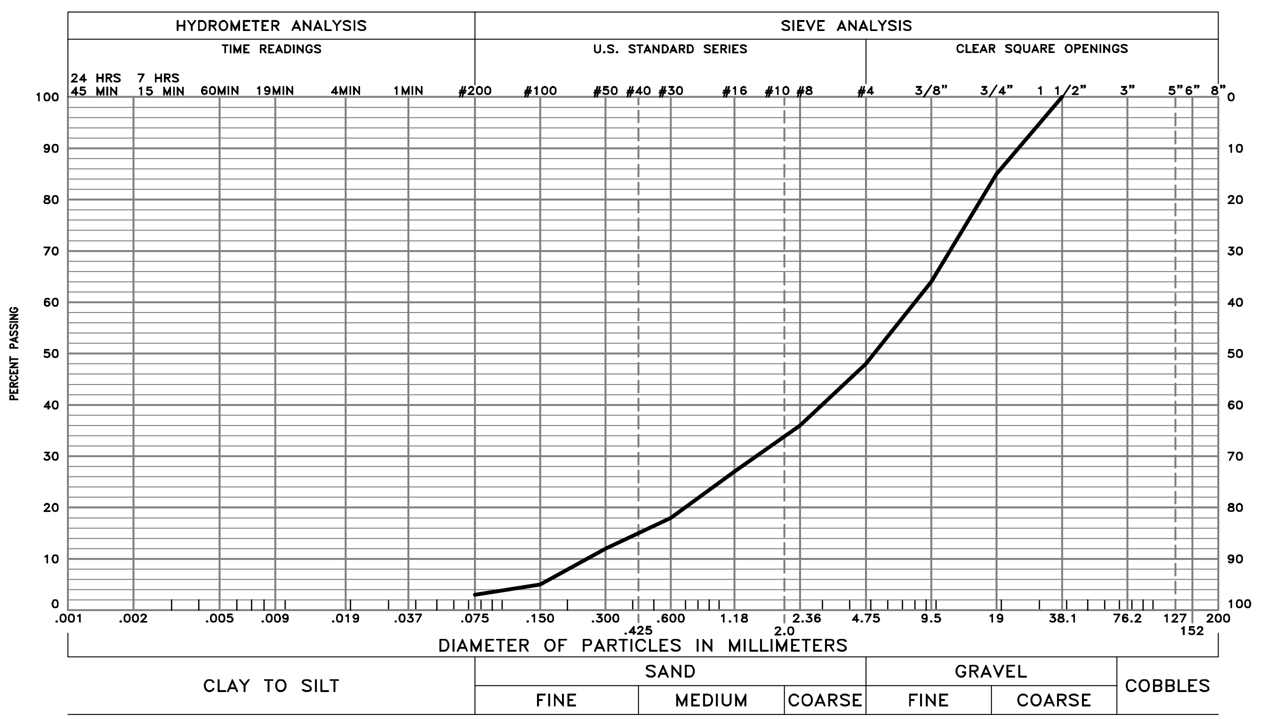
These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D422, ASTM C136 and/or ASTM D1140.



GRAVEL 14 % SAND 61 % SILT AND CLAY 25 %

LIQUID LIMIT 22 PLASTICITY INDEX 7

SAMPLE OF: Silty Sand (SM) FROM: Boring 18 @ 4'



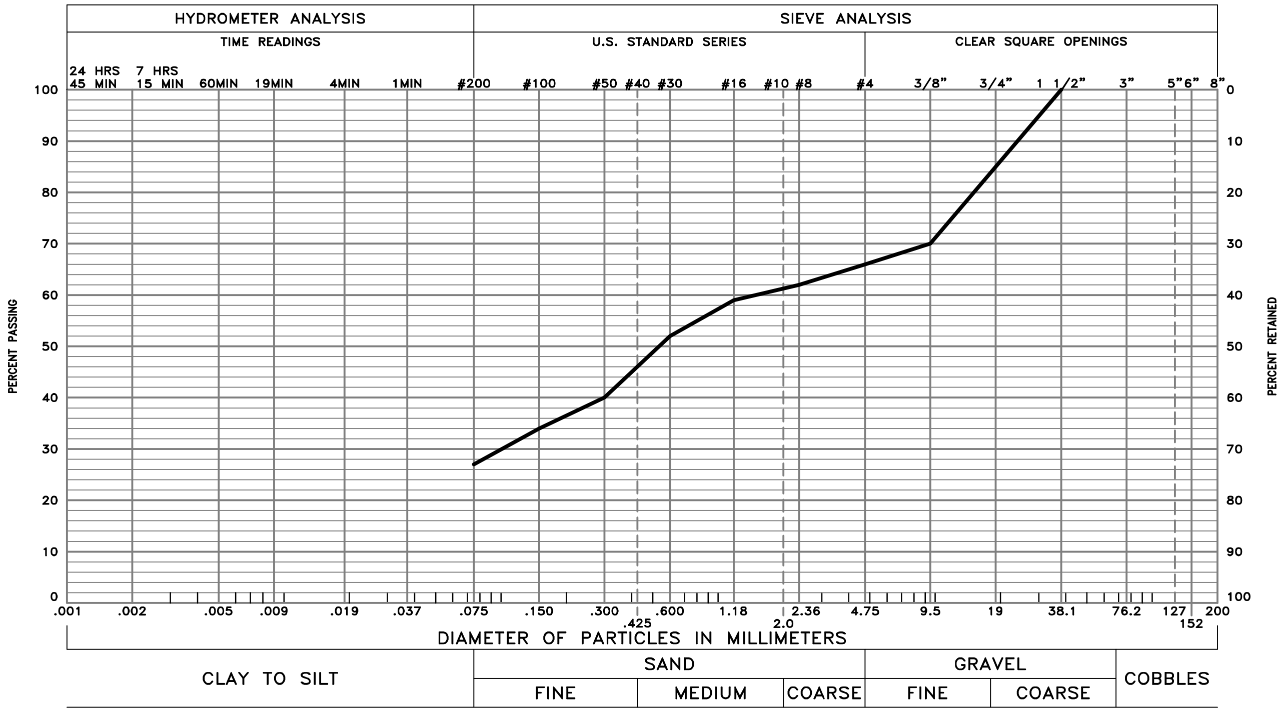
GRAVEL 52 % SAND 45 % SILT AND CLAY 3 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Well Graded Gravel with Sand (GW) FROM: Boring 18 @ 9'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D422, ASTM C136 and/or ASTM D1140.

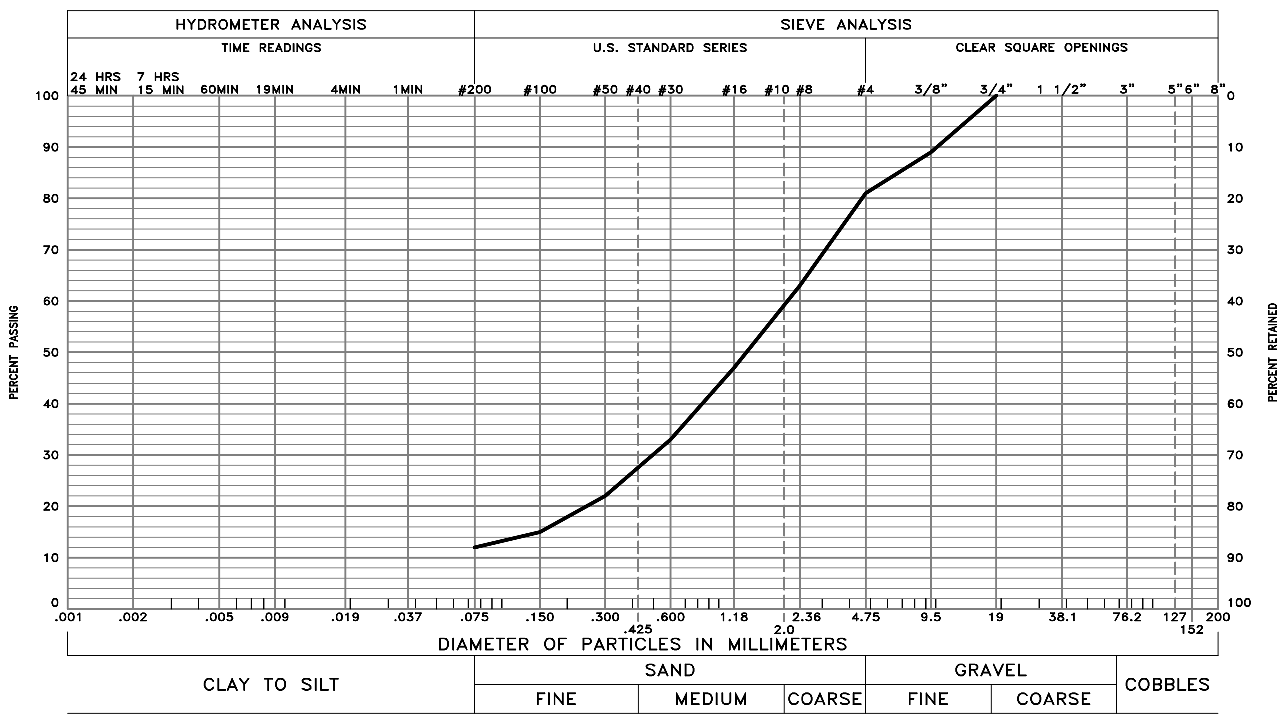
18-3-158	Kumar & Associates	GRADATION TEST RESULTS	Fig. 12



GRAVEL 34 % SAND 39 % SILT AND CLAY 27 %

LIQUID LIMIT 24 PLASTICITY INDEX 7

SAMPLE OF: Silty Sand with Gravel (SM) FROM: Boring 20 @ 4'



GRAVEL 19 % SAND 69 % SILT AND CLAY 12 %

LIQUID LIMIT 200 PLASTICITY INDEX 7

SAMPLE OF: Well Graded Sand with Silt and Gravel (SW-SM) FROM: Boring 21 @ 4'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D422, ASTM C136 and/or ASTM D1140.

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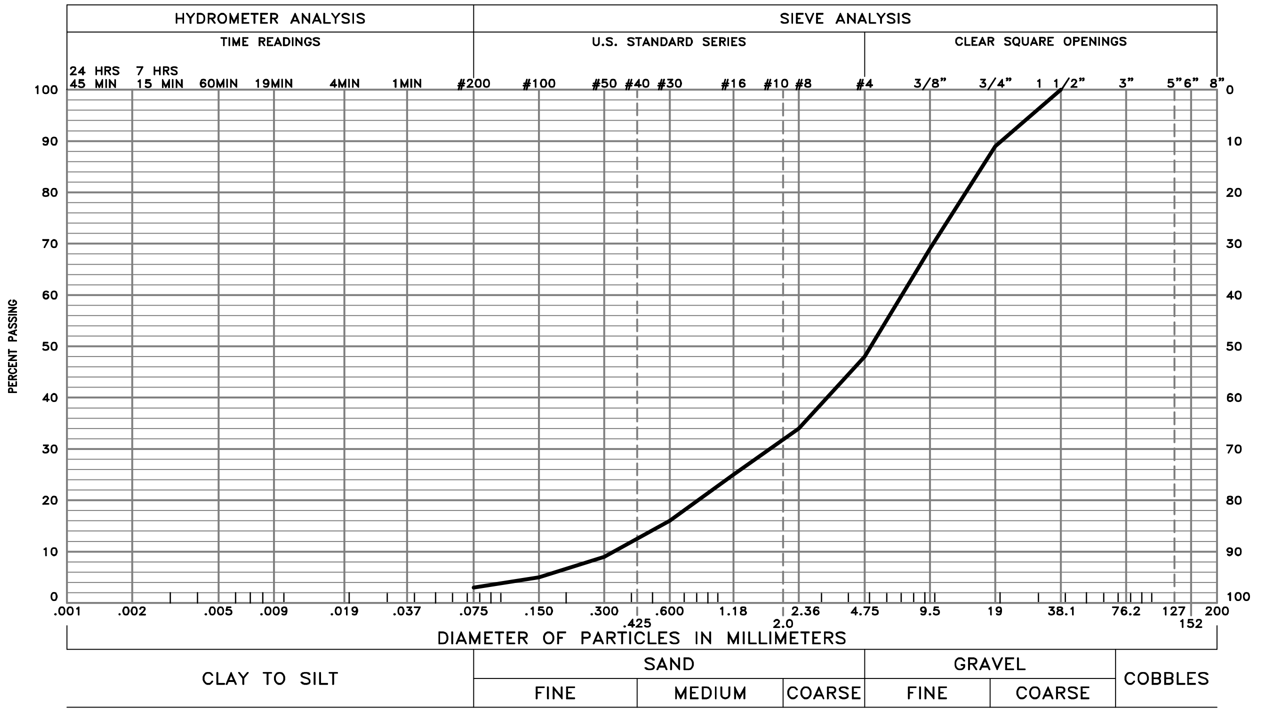
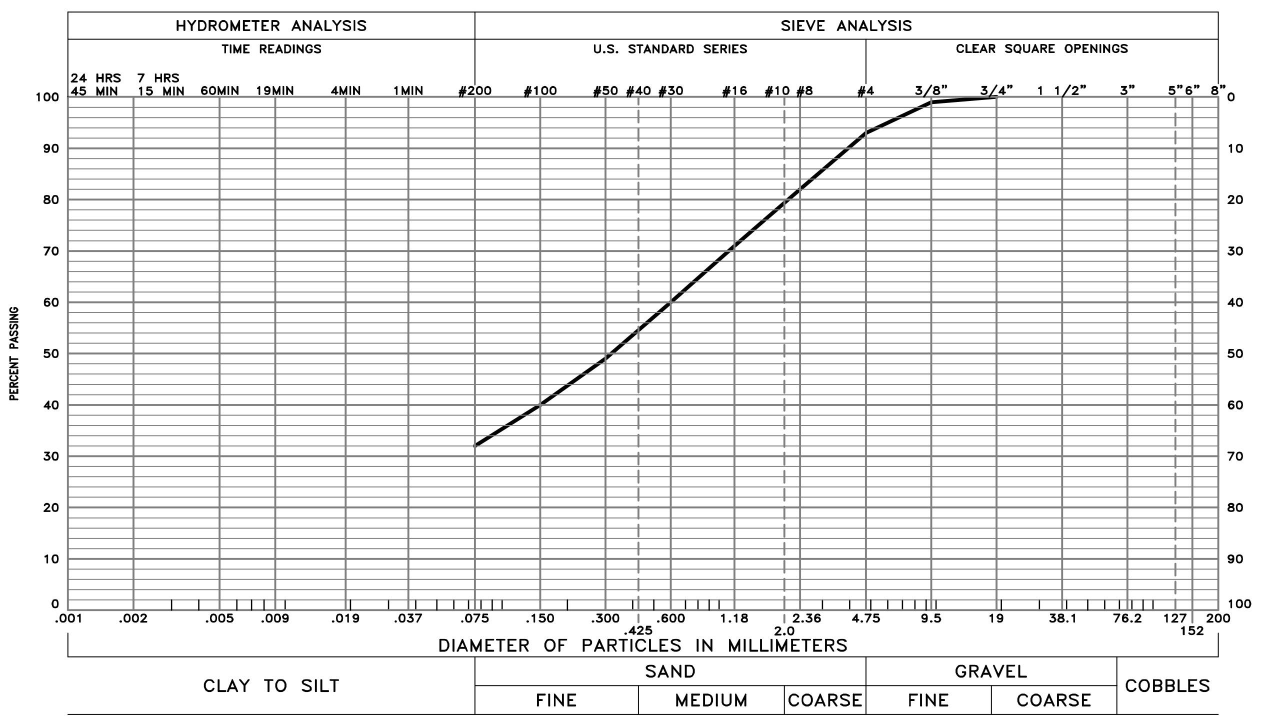
18-3-158	Kumar & Associates	GRADATION TEST RESULTS	Fig. 13



GRAVEL 52 % SAND 45 % SILT AND CLAY 3 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Well Graded Gravel with Sand (GW) FROM: Boring 21 @ 9'



GRAVEL 7 % SAND 61 % SILT AND CLAY 32 %

LIQUID LIMIT 23 PLASTICITY INDEX 9

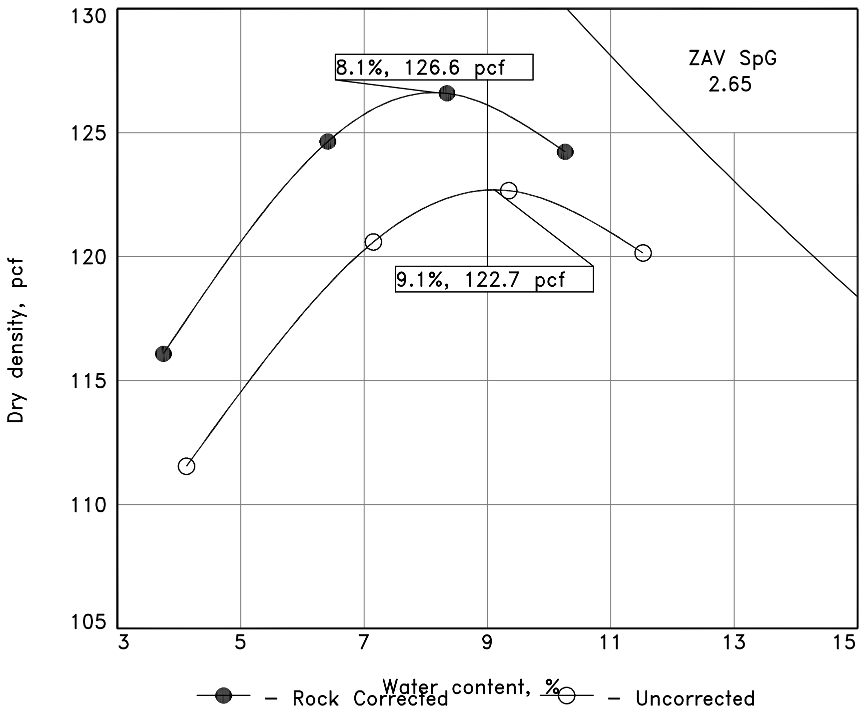
SAMPLE OF: Fill: Clayey Sand with Gravel (GC) FROM: Boring 2 & 4 @ 0-4'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D422, ASTM C136 and/or ASTM D1140.

18-3-158	Kumar & Associates	GRADATION TEST RESULTS	Fig. 14

COMPACTION TEST REPORT

Curve No. 2097



Preparation Method	
Rammer: Wt.	5.5 lb.
Drop	12 in.
Type	manual
Layers: No.	three
Blows per	25
Mold Size	0.03333 cu. ft.
Test Performed on Material Passing ___ Sieve	#4
%>#4	12
%<No.200	30
Atterberg (D 4318): LL	23
PI	9
NM (D 2216)	
Sp.G. (D 854)	2.65
USCS (D 2487)	SC
AASHTO (M 145)	A-2-4(0)
Date: Sampled	8/21/18
Received	7/1/18
Tested	8/21/18
Tested By	JLB

COMPACTION TESTING DATA
ASTM D 698-12 Method A Standard
ASTM D4718-15 Oversize Corr. Applied to Each Test Point

	1	2	3	4	5	6
WM + WS	3912.0	4109.0	4183.0	4181.0		
WM	2162.0	2162.0	2162.0	2162.0		
WW + T #1	635.0	647.0	665.6	688.9		
WD + T #1	618.7	618.3	627.4	639.7		
TARE #1	223.2	216.9	218.6	212.7		
WW + T #2						
WD + T #2						
TARE #2						
MOIST.	3.7	6.4	8.3	10.3		
DRY DENS.	116.1	124.6	126.6	124.2		

SIEVE TEST RESULTS
ASTM D 422 ASTM D 1140

Opening Size	% Passing	Specs.
3/4"	100	
3/8"	99	
#4	88	
#8	77	
#16	67	
#30	57	
#50	46	
#100	38	
#200	30	

ROCK CORRECTED TEST RESULTS	UNCORRECTED	Material Description
Maximum dry density = 126.6 pcf	122.7 pcf	Fill: Clayey Sand (SC)
Optimum moisture = 8.1 %	9.1 %	

Project No. 18-3-158 Client: Felsburg, Holt & Ullevig

Project: 8th Street Improvements

○ Location: B-2 and B-4 at 0-4 Feet Sample Number: 2097

Remarks:
These test results apply only to the samples which were tested. the testing report shall not be reproduced, except in full, without the written approval of Kumar and Associates, Inc. Moisture/density relationships performed in accordance with ASTM D698, D1557. Atterberg limits performed in accordance with ASTM D4318 sieve analysis performed in accordance with ASTM D422, D1140.

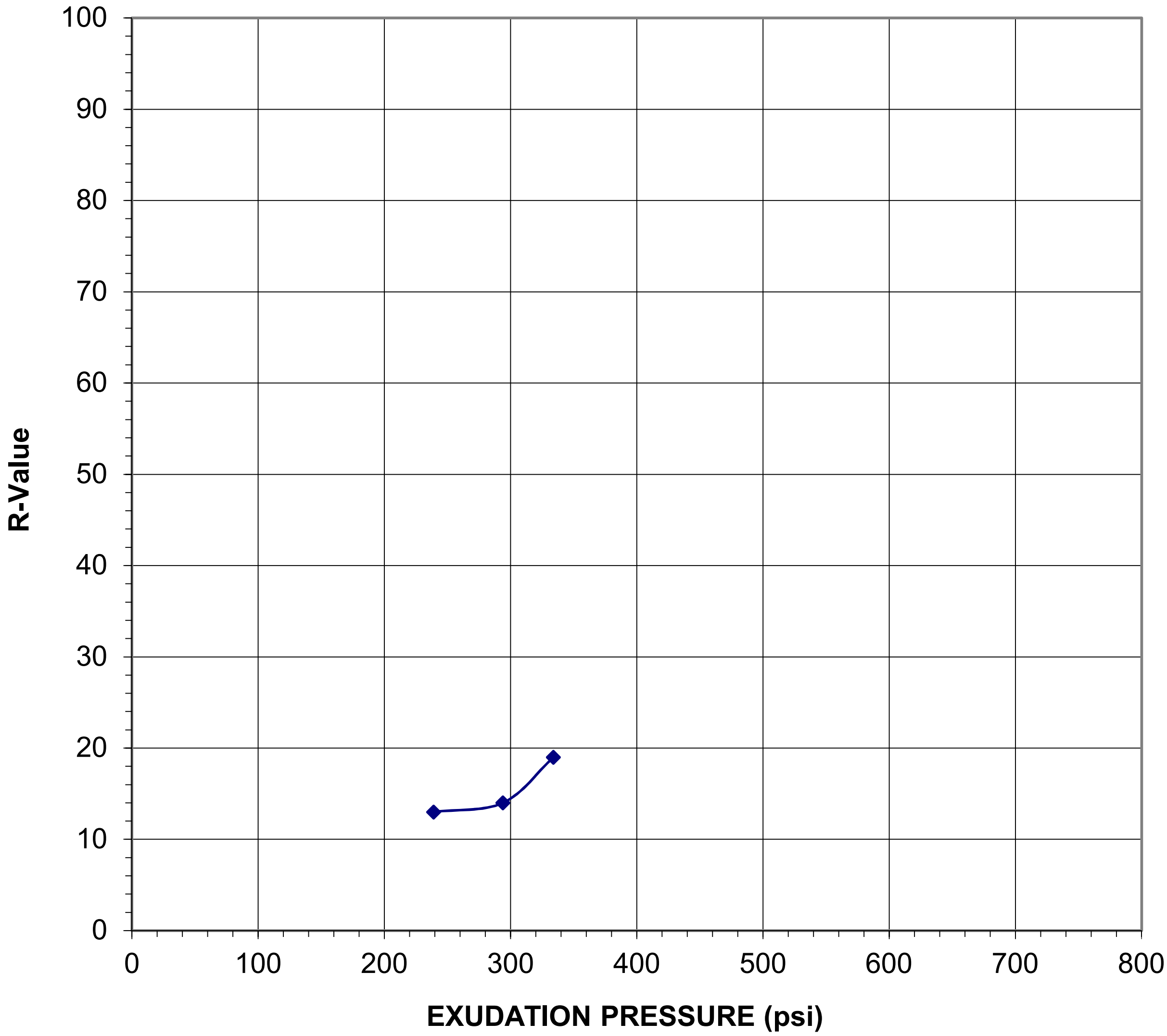
Checked by: JH

Title: Lab Deputy

18-3-158	Kumar & Associates	MOISTURE-DENSITY RELATIONSHIPS	Fig. 15

R-VALUE

TEST SPECIMEN	1	2	3	4	Rvalue @ 300 psi
MOISTURE CONTENT (%)	27.4	23.9	19.1		
DENSITY (pcf)	107.6	108.7	117.1		
EXPANSION PRESSURE (psi)	0.000	0.000	0.000		
EXUDATION PRESSURE (psi)	239	294	334		
R-VALUE	13	14	19		**14**



SOIL TYPE: **Fill: Clayey Sand with Gravel (SC)**

LOCATION: **Boring 2 and 4 @ 0-4'**

DATE SAMPLED: **7/19/2018** DATE RECEIVED: **7/19/2018** DATE TESTED: **8/3/2018**

GRAVEL: **12** SAND: **58** SILT AND CLAY: **30**

LIQUID LIMIT: **23** PLASTICITY INDEX: **9**

These test results apply to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. R-value performed in accordance with ASTM D2844. Atterberg limits performed in accordance with ASTM D4318. Sieve analyses performed in accordave with ASTM D422, D1140

Table I
Summary of Laboratory Test Results

Project No.: 18-3-158
Project Name: 8th Street Improvements - Greeley
Date Sampled: July 19, 2018
Date Received: July 19, 2018

Sample Location					Gradation			Atterberg Limits					
Boring	Depth (Feet)	Date Tested	Natural Moisture Content (%)	Natural Dry Density (pcf)	Gravel (%)	Sand (%)	Percent Passing No. 200 Sieve	Liquid Limit (%)	Plasticity (%)	Water Soluble Sulfates (%)	R-Value @ 300 psi Exudation Pressure	AASHTO Classification (Group Index)	Soil or Bedrock Type
1	4	7/23/18	20.4	102.1	0	36	64	27	10			A-4 (4)	Fill: Sandy Lean Clay (CL)
2	4	7/23/18	22.7	95.8	0	32	68	31	14	0.03		A-6 (7)	Fill: Sandy Lean Clay (CL)
3	1	7/23/18	4.9	120.9	36	44	20	21	6			A-1-b (0)	Fill: Silty Clayey Sand with Gravel (SC-SM)
4	4	7/23/18	22.1	95.8	0	29	71	28	12			A-6 (6)	Fill: Lean Clay with Sand (CL)
5	1	7/23/18	8.4	121.7	23	40	37	30	16			A-6 (2)	Fill: Clayey Sand with Gravel (SC)
6	4	7/23/18	5.7	110.9	3	85	12	NV	NP			A-2-4 (0)	Silty Sand (SM)
7	1	7/23/18	4.7	123.4	20	61	19	20	7			A-2-4 (0)	Fill: Silty Clayey Sand with Gravel (SC-SM)
8	4	7/23/18	23.1	99.3	0	36	64	32	16			A-6 (8)	Fill: Sandy Lean Clay (CL)
9	1	7/23/18	12.0	120.7	3	51	46	27	12			A-6 (2)	Fill: Clayey Sand (SC)
10	4	7/23/18	18.5	106.5	1	30	69	42	27			A-7-6 (16)	Fill: Sandy Lean Clay (CL)
11	1	7/23/18	6.5	120.2	14	62	24	26	14			A-2-6 (0)	Fill: Clayey Sand with Gravel (SC)
12	4	7/23/18	11.8	113.3			45	26	12			A-6 (2)	Clayey Sand (SC)
13	1	7/23/18	10.5	123.4	0	69	31	28	16			A-2-6 (0)	Clayey Sand (SC)
14	4	11/16/18	16.8	106.7	20	23	57	35	20	0		A-6 (8)	Sandy Lean Clay with Gravel (CL)
14	9	11/16/18	0.5		47	48	5					A-1-a (0)	Poorly Graded Sand with Gravel (SW)
15	4	11/16/18	21.4	95.8	1	25	74	39	23			A-6 (15)	Lean Clay with Sand (CL)
15	14	11/16/18	1.1		50	42	8					A-1-a (0)	Poorly Graded Gravel with Silt and Sand (GW-GM)
16	9	11/16/18	0.7		41	52	7					A-1-a (0)	Poorly Graded Sand with Silt and Gravel (SP-SM)
17	4	11/16/18	6.6	104.7	30	45	25	29	16			A-2-6 (0)	Silty Sand with Gravel (SM)
18	4	11/16/18	9.2	109.8	14	61	25	22	7			A-2-4 (0)	Silty Sand (SM)
18	9	11/16/18	1.2		52	45	3					A-1-a (0)	Well Graded Gravel with Sand (GW)
19	4	11/16/18	11.1	110.1	1	62	37	21	6			A-4 (0)	Poorly Graded Sand with Silt (SW-SM)
20	4	11/16/18	5.6	106.7	34	39	27	24	7			A-2-4 (0)	Silty Sand with Gravel (SM)
21	4	11/16/18	3.8	108.9	19	69	12	200	7			A-2-5 (0)	Well Graded Sand with Silt and Gravel (SW-SM)
21	9	11/16/18	1.8		52	45	3					A-1-a (0)	Well Graded Gravel with Sand (GW)
2 & 4	0-4	8/1/18	8.1*	126.6*	7	61	32	23	9		14	A-2-4 (0)	Fill: Clayey Sand with Gravel (SC)

* - Optimum moisture content and maximum driy density as determined by standard Proctor (ASTM D 698)

APPENDIX A

DARWin^{TM} SOFTWARE OUTPUTS

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Kumar & Associates, Inc.
2390 South Lipan Street
Denver, Colorado

Rigid Structural Design Module

8th Street Improvements
Greeley, Colorado
PCCP

Rigid Structural Design

Pavement Type	JPCP
18-kip ESALs Over Initial Performance Period	4,391,800
Initial Serviceability	4.5
Terminal Serviceability	2.5
28-day Mean PCC Modulus of Rupture	650 psi
28-day Mean Elastic Modulus of Slab	3,400,000 psi
Mean Effective k-value	60 psi/in
Reliability Level	90 %
Overall Standard Deviation	0.34
Load Transfer Coefficient, J	2.6
Overall Drainage Coefficient, Cd	1
Calculated Design Thickness	8.10 in

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Kumar & Associates, Inc.
2390 South Lipan Street
Denver, Colorado

Flexible Structural Design Module

8th Street Improvements
Greeley, Colorado
Composite Section with geotextile

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	4,391,800
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	9,497 psi
Stage Construction	1
Calculated Design Structural Number	3.87 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Hot Mixed Asphalt	0.44	1	6.5	-	2.86
2	Aggregate Base Course	0.11	1	10	-	1.10
Total	-	-	-	16.50	-	3.96

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Kumar & Associates, Inc.
2390 South Lipan Street
Denver, Colorado

Flexible Structural Design Module

8th Street Improvements
Greeley, Colorado
Composite Section

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	4,391,800
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	4,060 psi
Stage Construction	1
Calculated Design Structural Number	5.13 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Hot Mixed Asphalt	0.44	1	8	-	3.52
2	Aggregate Base Course	0.11	1	15	-	1.65
Total	-	-	-	23.00	-	5.17

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Kumar & Associates, Inc.
2390 South Lipan Street
Denver, Colorado

Flexible Structural Design Module

8th Street Improvements
Greeley, Colorado
Composite Section

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	4,391,800
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	4,060 psi
Stage Construction	1
Calculated Design Structural Number	5.13 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Hot Mixed Asphalt	0.44	1	8	-	3.52
2	Aggregate Base Course	0.11	1	15	-	1.65
Total	-	-	-	23.00	-	5.17

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Kumar & Associates, Inc.
2390 South Lipan Street
Denver, Colorado

Flexible Structural Design Module

8th Street Improvements
Greeley, Colorado
Full Depth Section

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	4,391,800
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	4,060 psi
Stage Construction	1
Calculated Design Structural Number	5.13 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Hot Mixed Asphalt	0.44	1	12	-	5.28
Total	-	-	-	12.00	-	5.28

APPENDIX B

SUMMARY OF PAVEMENT LIFE CYCLE COST ANALYSIS

LCCAExpress 2.0

Project Title

8th Street
18-3-158

Project Description

8th Street Greeley - US 85 to Balsam

Cost Summary

Full Depth Asphalt Option - Total Net Present Value ($/mile)
12 inches of Full Depth Asphalt
$2,821,643

Composite Asphalt and Base Course Option - Total Net Present Value ($/mile)
8 inches of Asphalt over 15 inches of ABC
$2,426,672

Composite Asphalt and Base Course with Geogrid Reinforcement Option - Total Net Present Value ($/mile)
6.5 inches of Asphalt over 10 inches of ABC with Geogrid at Base of ABC
$2,279,284

Concrete Option - Total Net Present Value ($/mile)
8.5 inches of Portland Cement Concrete Pavement
$2,275,848

LCCAExpress 2.0

Project Title

8th Street
18-3-158

Project Description

8th Street Greeley - Balsam to Fern

Cost Summary

Full Depth Asphalt Option - Total Net Present Value ($/mile)
12 inches of Full Depth Asphalt
$2,707,477

Composite Asphalt and Base Course Option - Total Net Present Value ($/mile)
8 inches of Asphalt over 15 inches of ABC
$2,292,251

Composite Asphalt and Base Course with Geogrid Reinforcement Option - Total Net Present Value ($/mile)
6.5 inches of Asphalt over 10 inches of ABC with Geogrid at Base of ABC
$2,133,015

Concrete Option - Total Net Present Value ($/mile)
8.5 inches of Portland Cement Concrete Pavement
$2,104,161

LCCAExpress 2.0

Project Title

8th Street
18-3-158

Project Description

8th Street Greeley - Fern Avenue to WCP

Cost Summary

Full Depth Asphalt Option - Total Net Present Value ($/mile)
12 inches of Full Depth Asphalt
$1,601,855

Composite Asphalt and Base Course Option - Total Net Present Value ($/mile)
8 inches of Asphalt over 15 inches of ABC
$1,483,305

Composite Asphalt and Base Course with Geogrid Reinforcement Option - Total Net Present Value ($/mile)
6.5 inches of Asphalt over 10 inches of ABC with Geogrid at Base of ABC
$1,084,036

Concrete Option - Total Net Present Value ($/mile)
8.5 inches of Portland Cement Concrete Pavement
$1,836,922

Asphalt Option Unit Prices

HMA Wearing Course:	110	$/ton
HMA Binder Course:	110	$/ton
HMA Base Course:	110	$/ton
Aggregate Base:	15.9	$/ton
Asphalt Milling:	5	$/sy
Asphalt Patching:	110	$/ton
Geogrid	7	$/sy
Traffic Control:	15	% of total construction cost

Concrete Option Unit Prices

Concrete:	70	$/sy
Aggregate Base:	15.9	$/ton
Concrete Grinding:	8	$/sy
Joint Sealing:	2	$/ft
Concrete Patching:	600	$/sy
Traffic Control:	15	% of total construction cost

Cost Detail - US 85 to Balsam

Full Depth Asphalt Option: Net Present Value, $/mile

Activity	Agency	User Delay
Initial Construction	$ 1,924,627	$ 338
1st Overlay	$ 457,218	$ 44
2nd Overlay	$ 308,880	$ 35
Recurring Maintenance	$ 130,389	Not Applicable
Subtotal	$ 2,821,114	$ 529

Asphalt Option: Total NPV, $/mile

$ 2,821,643

Composite Asphalt Option: Net Present Value, $/mile

Activity	Agency	User Delay
Initial Construction	$ 1,529,656	$ 338
1st Overlay	$ 457,218	$ 44
2nd Overlay	$ 308,880	$ 35
Recurring Maintenance	$ 130,389	Not Applicable
Subtotal	$ 2,426,143	$ 529

Asphalt Option: Total NPV, $/mile

$ 2,426,672

Composite Asphalt with Geogrid Option: Net Present Value, $/mile

Activity	Agency	User Delay
Initial Construction	$ 1,382,268	$ 338
1st Overlay	$ 457,218	$ 44
2nd Overlay	$ 308,880	$ 35
Recurring Maintenance	$ 130,389	Not Applicable
Subtotal	$ 2,278,755	$ 529

Asphalt Option: Total NPV, $/mile

$ 2,279,284

Concrete Option: Net Present Value, $/mile

Activity	Agency	User Delay
Initial Construction	$ 1,897,140	$ 338
1st Rehabilitation	$ 126,231	$ 48
2nd Rehabilitation	$ 151,361	$ 39
Recurring Maintenance	$ 100,669	Not Applicable
Subtotal	$ 2,275,401	$ 447

Concrete Option: Total NPV, $/mile

$ 2,275,848

Cost Detail - Balsam to Fern

Full Depth Asphalt Option: Net Present Value, $/mile

Activity	Agency	User Delay
Initial Construction	$ 2,023,326	$ 321
1st Overlay	$ 368,445	$ 42
2nd Overlay	$ 248,908	$ 34
Recurring Maintenance	$ 66,295	Not Applicable
Subtotal	$ 2,706,974	$ 503

Asphalt Option: Total NPV, $/mile

$ 2,707,477

Composite Asphalt Option: Net Present Value, $/mile

Activity	Agency	User Delay
Initial Construction	$ 1,608,100	$ 321
1st Overlay	$ 368,445	$ 42
2nd Overlay	$ 248,908	$ 34
Recurring Maintenance	$ 66,295	Not Applicable
Subtotal	$ 2,291,748	$ 503

Asphalt Option: Total NPV, $/mile

$ 2,292,251

Composite Asphalt with Geogrid Option: Net Present Value, $/mile

Activity	Agency	User Delay
Initial Construction	$ 1,448,864	$ 321
1st Overlay	$ 368,445	$ 42
2nd Overlay	$ 248,908	$ 34
Recurring Maintenance	$ 66,295	Not Applicable
Subtotal	$ 2,132,512	$ 503

Asphalt Option: Total NPV, $/mile

$ 2,133,015

Concrete Option: Net Present Value, $/mile

Activity	Agency	User Delay
Initial Construction	$ 1,951,532	$ 321
1st Rehabilitation	$ 51,744	$ 45
2nd Rehabilitation	$ 64,696	$ 37
Recurring Maintenance	$ 35,764	Not Applicable
Subtotal	$ 2,103,736	$ 425

Concrete Option: Total NPV, $/mile

$ 2,104,161

Cost Detail - Fern to WCP

Full Depth Asphalt Option: Net Present Value, $/mile

Activity	Agency	User Delay
Initial Construction	$ 1,381,784	$ 813
1st Overlay	$ 64,349	$ 107
2nd Overlay	$ 43,472	$ 85
Recurring Maintenance	$ 110,973	Not Applicable
Subtotal	$ 1,600,578	$ 1,277

Asphalt Option: Total NPV, $/mile

$ 1,601,855

Composite Asphalt Option: Net Present Value, $/mile

Activity	Agency	User Delay
Initial Construction	$ 1,098,215	$ 813
1st Overlay	$ 162,835	$ 107
2nd Overlay	$ 110,005	$ 85
Recurring Maintenance	$ 110,973	Not Applicable
Subtotal	$ 1,482,028	$ 1,277

Asphalt Option: Total NPV, $/mile

$ 1,483,305

Composite Asphalt with Geogrid Option: Net Present Value, $/mile

Activity	Agency	User Delay
Initial Construction	$ 863,965	$ 813
1st Overlay	$ 64,349	$ 107
2nd Overlay	$ 43,472	$ 85
Recurring Maintenance	$ 110,973	Not Applicable
Subtotal	$ 1,082,759	$ 1,277

Asphalt Option: Total NPV, $/mile

$ 1,084,036

Concrete Option: Net Present Value, $/mile

Activity	Agency	User Delay
Initial Construction	$ 1,411,254	$ 813
1st Rehabilitation	$ 229,511	$ 115
2nd Rehabilitation	$ 167,701	$ 19
Recurring Maintenance	$ 27,455	Not Applicable
Subtotal	$ 1,835,921	$ 1,001

Concrete Option: Total NPV, $/mile

$ 1,836,922

Full Depth Asphalt Work Activities - US 85 to Balsam

	Initial Construction	1st Overlay	2nd Overlay
Year:	0	10	20
HMA Wearing Course, in.:	12	2	2
HMA Wearing Course, pcf:	145	145	145
Aggregate Base, in.:	2	0	0
Aggregate Base, pcf:	135	135	135
Milling, sy:	0	12000	12000
Patching, ton:	0	1000	1000
Days to Complete:	30	5	5

Composite Asphalt Work Activities - US 85 to Balsam

	Initial Construction	1st Overlay	2nd Overlay
Year:	0	10	20
HMA Wearing Course, in.:	8	2	2
HMA Wearing Course, pcf:	145	145	145
Aggregate Base, in.:	15	0	0
Aggregate Base, pcf:	135	135	135
Milling, sy:	0	12000	12000
Patching, ton:	0	1000	1000
Days to Complete:	30	5	5

Composite with Geogrid Asphalt Work Activities - US 85 to Balsam

	Initial Construction	1st Overlay	2nd Overlay
Year:	0	10	20
HMA Wearing Course, in.:	6.5	2	2
HMA Wearing Course, pcf:	145	145	145
Aggregate Base, in.:	10	0	0
Aggregate Base, pcf:	135	135	135
Geogrid	12000	0	0
Milling, sy:	0	12000	12000
Patching, ton:	0	1000	1000
Days to Complete:	30	5	5

Concrete Work Activities - US 85 to Balsam

	Initial Construction	1st Rehab	2nd Rehab
Year:	0	7	15
Concrete, sy:	12000	0	0
Concrete Milling, sy:	0	0	6000
Joint Sealing, ft:	0	9000	10000
Concrete Patching, sy:	0	100	100
Aggregate Base, in.:	6	0	0
Aggregate Base, pcf:	135	135	135
Days to Complete:	30	5	5

Full Depth Asphalt Work Activities - Balsam to Fern

	Initial Construction	1st Overlay	2nd Overlay
Year:	0	10	20
HMA Wearing Course, in.:	12	2	2
HMA Wearing Course, pcf:	145	145	145
Aggregate Base, in.:	2	0	0
Aggregate Base, pcf:	135	135	135
Milling, sy:	0	34700	34700
Patching, ton:	0	1000	1000
Days to Complete:	30	5	5

Composite Asphalt Work Activities - Balsam to Fern

	Initial Construction	1st Overlay	2nd Overlay
Year:	0	10	20
HMA Wearing Course, in.:	8	2	2
HMA Wearing Course, pcf:	145	145	145
Aggregate Base, in.:	15	0	0
Aggregate Base, pcf:	135	135	135
Milling, sy:	0	34700	34700
Patching, ton:	0	1000	1000
Days to Complete:	30	5	5

Composite with Geogrid Asphalt Work Activities - Balsam to Fern

	Initial Construction	1st Overlay	2nd Overlay
Year:	0	10	20
HMA Wearing Course, in.:	6.5	2	2
HMA Wearing Course, pcf:	145	145	145
Aggregate Base, in.:	10	0	0
Aggregate Base, pcf:	135	135	135
Geogrid	34700	0	0
Milling, sy:	0	34700	34700
Patching, ton:	0	1000	1000
Days to Complete:	30	5	5

Concrete Work Activities - Balsam to Fern

	Initial Construction	1st Rehab	2nd Rehab
Year:	0	10	20
Concrete, sy:	34700	0	0
Concrete Milling, sy:	0	0	8000
Joint Sealing, ft:	0	15000	15000
Concrete Patching, sy:	0	100	100
Aggregate Base, in.:	6	0	0
Aggregate Base, pcf:	135	135	135
Days to Complete:	30	5	5

Full Depth Asphalt Work Activities - Balsam to WCP

	Initial Construction	1st Overlay	2nd Overlay
Year:	0	10	20
HMA Wearing Course, in.:	12	0	0
HMA Wearing Course, pcf:	145	145	145
Aggregate Base, in.:	2	0	0
Aggregate Base, pcf:	135	135	135
Milling, sy:	0	16400	16400
Days to Complete:	30	5	5

Composite Asphalt Work Activities - Fern to WCP

	Initial Construction	1st Overlay	2nd Overlay
Year:	0	10	20
HMA Wearing Course, in.:	8	0	0
HMA Wearing Course, pcf:	145	145	145
Aggregate Base, in.:	15	0	0
Aggregate Base, pcf:	135	135	135
Milling, sy:	0	41500	41500
Days to Complete:	30	5	5

Composite with Geogrid Asphalt Work Activities - Fern to WCP

	Initial Construction	1st Overlay	2nd Overlay
Year:	0	10	20
HMA Wearing Course, in.:	6.5	0	0
HMA Wearing Course, pcf:	145	145	145
Aggregate Base, in.:	10	0	0
Aggregate Base, pcf:	135	135	135
Milling, sy:	0	16400	16400
Days to Complete:	30	5	5

Concrete Work Activities - Fern to WCP

	Initial Construction	1st Rehab	2nd Rehab
Year:	0	10	20
Concrete, sy:	16400	0	0
Concrete Milling, sy:	0	0	3000
Joint Sealing, ft:	0	10000	10000
Concrete Patching, sy:	0	400	400
HMA Overlay, pcf:	145	145	145
Aggregate Base, in.:	6	0	0
Aggregate Base, pcf:	135	135	135
Days to Complete:	30	5	1

Recurring Maintenance All Asphalt Sections - US 85 to Balsam

Activity	Quantity	Unit Price	Years Between Treatments	# Treatments in Analysis
Yearly Maintenance	1	4000	1	20
Seal Coat	12000	1	7	2

Recurring Maintenance Concrete - US 85 to Balsam

Activity	Quantity	Unit Price	Years Between Treatments	# Treatments in Analysis
Yearly Maintenance	1	4000	1	20

Recurring Maintenance All Asphalt Sections - Balsam to Fern

Activity	Quantity	Unit Price	Years Between Treatments	# Treatments in Analysis
Yearly Maintenance	1	4000	1	20
Seal Coat	34700	1	7	2

Recurring Maintenance Concrete - Balsam to Fern

Activity	Quantity	Unit Price	Years Between Treatments	# Treatments in Analysis
Yearly Maintenance	1	4000	1	20

Recurring Maintenance All Asphalt Sections - Fern to WCP

Activity	Quantity	Unit Price	Years Between Treatments	# Treatments in Analysis
Yearly Maintenance	1	4000	1	20
Seal Coat	41500	1	7	2

Recurring Maintenance Concrete - Fern to WCP

Activity	Quantity	Unit Price	Years Between Treatments	# Treatments in Analysis
Yearly Maintenance	1	2000	1	20