PRELIMINARY GEOTECHNICAL ENGINEERING REPORT

SILVER RIDGE ESTATES - HILL PROPERTY
SOUTHWEST OF LARIMER COUNTY ROADS 38 AND 1
TIMNATH, LARIMER COUNTY, COLORADO

TERRACON PROJECT NO. 20025220

DECEMBER 16, 2002

Prepared for:

SUMMIT LAND MANAGEMENT SERVICES, INC.
1166 SILVER FIR DRIVE
LOVELAND, COLORADO 80538

ATTN: MR. ANDY KRILL

Prepared by:

Terracon
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December 16, 2002

Summit Land Management Services, Inc.
1166 Silver Fir Drive
Loveland, Colorado 80538

Re: **Preliminary Geotechnical Engineering Report**
Silver Ridge Estates – Hill Property
Southwest of Larimer County Roads 38 and 1
Timnath, Larimer County, Colorado
Terracon Project No. 20025220

Terracon has completed a preliminary geotechnical engineering exploration for the proposed residential development to be located south of Larimer County Road 38, (Harmony Road) and west of Larimer County Road 1, southeast of Timnath, Colorado. This study was performed in general accordance with our Proposal No. D2002409 dated November 27, 2002.

The results of our engineering study, including the boring location diagram, laboratory test results, test boring records, USDA-SCS map, and the preliminary geotechnical recommendations needed to aid in the design and construction of foundations and other earth connected phases of this project are attached.

The subsurface soils at the site generally consisted of sandy lean clay extending to the underlying granular soils. The granular soils included silty sand and well-graded sand with silt and gravel. The granular soils were encountered at approximate depths of 5 to 12-feet below existing site grades and extended to the bedrock below. Claystone/siltstone bedrock was encountered in Test Boring Nos. 1, 3 and 4 at approximate depths of 18 to 38-feet below existing site grades. Bedrock was not encountered in Test Boring No. 2 to the maximum depth explored, approximately 40-feet. Groundwater was encountered at approximate depths of 9 to 25-feet below existing site grades when checked on December 3, 2002.

The results of our field exploration and laboratory testing completed for this study indicate that the soils at anticipated foundation bearing stratum have low to moderate load bearing capability and the bedrock has moderate to high bearing characteristics.

Based on the geotechnical engineering analyses, subsurface exploration and laboratory test results, we recommend proposed structures be supported on spread footing foundation systems bearing a minimum of 3-feet above the maximum anticipated groundwater level. In view of the depth to groundwater encountered at the site, basement construction is feasible provided the lower level slabs bear a minimum of 4-feet above the maximum anticipated groundwater levels and complete dewatering systems are placed around all basement areas. Slab on grade may be utilized for the interior floor system provided the enclosed recommendations are followed. If slab movement cannot be tolerated, structural floor systems should be considered.

Other design and construction recommendations, based upon geotechnical conditions, are presented in the report.

We appreciate being of service to you in the geotechnical engineering phase of this project, and are prepared to assist you during the construction phases as well. If you have any questions concerning this report or any of our testing, inspection, design and consulting services please do not hesitate to contact us.

Sincerely,
TERRACON

Daniel R. Lambert, E.I.T.
Geotechnical Engineer

David A. Richer, P.E.
Geotechnical Engineer/Department Manager

COLORADO REGISTERED PROFESSIONAL ENGINEER
DAVID A. RICHER
27712

Copies to: (4) Addressee

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SILVER RIDGE ESTATES
HILL PROPERTY
SOUTHWEST OF LARIMER COUNTY ROADS 38 AND 1
TIMNATH, LARIMER COUNTY, COLORADO

TERRACON PROJECT NO. 20025220

DECEMBER 16, 2002

INTRODUCTION

This report contains the results of our preliminary geotechnical engineering exploration for the proposed residential development to be located south of Larimer County Road 38, (Harmony Road) and west of Larimer County Road 1, southeast of Timnath, Colorado. The site is located in the East ½ of Section 1, Township 6 North, Range 68 West of the 6th Principal Meridian, Larimer County, Colorado.

The purpose of these services is to provide information and preliminary geotechnical engineering recommendations relative to:

- geologic considerations
- subsurface soil and bedrock conditions
- groundwater conditions
- preliminary foundation design and construction
- basement construction
- floor slab design and construction
- preliminary pavement design
- earthwork
- drainage

The preliminary recommendations contained in this report are based upon the results of field and laboratory testing, engineering analyses, and experience with similar soil conditions, structures and our understanding of the proposed project.

PROJECT DESCRIPTION

It is anticipated the proposed site will be developed for residential purposes along with interior roadways to accommodate the project. At this time the development is in the preliminary stages. Therefore, Terracon has been requested to provide preliminary subsurface exploration recommendations.

SITE EXPLORATION

The scope of the services performed for this project included a site reconnaissance by an engineering geologist, a subsurface exploration program, laboratory testing and engineering analyses.

Field Exploration

A total of 4 test borings were drilled at the site on December 2, 2002. The borings were drilled to approximate depths of 20 to 40-feet below existing site grades at the locations shown on the Site Plan, Figure 2. The test borings were advanced with a truck-mounted drilling rig, utilizing 4-inch diameter solid stem augers.

The number of borings and the boring locations were determined by the client. Approximate surface elevations at each test boring were obtained by interpolation from contours indicated on the U.S.G.S. Timnath Quadrangle. The accuracy of boring locations and elevations should only be assumed to the level implied by the methods used.

Lithologic logs of each test boring were recorded by the engineering geologist during the drilling operations. At selected intervals, samples of the subsurface materials were taken by means of driving split-spoon and/or ring-barrel samplers.

Penetration resistance measurements were obtained by driving the split-spoon into the subsurface materials with a 140-pound hammer falling 30 inches. The penetration resistance value is a useful index in estimating the consistency, relative density or hardness of the materials encountered.

Groundwater conditions were evaluated in each boring during initial drilling operations and again on December 3, 2002.

Laboratory Testing

All samples retrieved during the field exploration were returned to the laboratory for observation by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System described in Appendix C. Samples of bedrock were classified in accordance with the general notes for Bedrock Classification. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials. Boring logs were prepared and are presented in Appendix A.

Laboratory tests were conducted on selected soil samples and are presented in Appendix B. The test results were used for the geotechnical engineering analyses, and the development of foundation and earthwork recommendations. All laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.

Selected soil and bedrock samples were tested for the following engineering properties:

- Water Content
- Dry Density
- Expansion
- Grain size

SITE CONDITIONS

The proposed development is located south of Larimer County Road 38, north of Larimer County Road 36 and west of Larimer County Road 1, southeast of Timnath, Colorado. The site is currently being used for agricultural purposes. The Timnath Reservoir Outlet borders the site to the southwest. The site is relatively flat and exhibits positive drainage in the southern direction.

SUBSURFACE CONDITIONS

Geology

The project area is located within the Colorado Piedmont section of the Great Plains physiographic province. The Colorado Piedmont, formed during Late Tertiary and Early quaternary time (approximately two-million (2,000,000) years ago), is a broad, erosional trench, which separates the Southern Rocky Mountains from the High Plains. Structurally, the site lies along the western flank of the Denver Basin. During the Late Mesozoic and Early Cenozoic

Periods (approximately seventy million (70,000,000) years ago), intense tectonic activity occurred, causing the uplifting of the Front Range and associated downwarping of the Denver Basin to the east. Relatively flat uplands and broad valleys characterize the present-day topography of the Colorado Piedmont in this region.

The Cretaceous Pierre Formation underlies the property. The Pierre Shale in this area consists of interbedded claystone/siltstone. The bedrock was encountered in Test Boring Nos. 1, 3 and 4 at approximately depths of 18 to 38-feet below the surface. Valley Fill deposits of Pleistocene and/or Recent Age overlies the bedrock in the project area. These deposits consist of sand with gravel and cobbles. The granular materials appear to be suitable for use in construction materials such as concrete and asphalt aggregate, aggregate base course, structural fill and pipe bedding. Screening, washing and/or crushing of these materials will be required to use the material in concrete, asphalt, base course and bedding materials. Dewatering of the site will be needed if any of the granular material is mined from the site.

The majority of the site is relatively flat and consists of irrigated farm and pastureland. Due to the relatively flat to gently sloping nature of the site, geologic hazards at the site due to movement caused by gravity, such as landslides, mudflows, etc., are anticipated to be low. Due to the sandy nature of the subsoils in the majority of the site some erosion can be anticipated. With proper site grading around proposed structures and re-vegetation of stripped areas, erosional problems at the site should be minimal. Seismic activity in the area is anticipated to be low. Therefore, from a structural viewpoint, the property should be relatively stable.

Groundwater was encountered at approximate depths of 9 to 25-feet below existing site grades when checked on December 3, 2002. Dewatering of portions of the site where groundwater is shallow may be required for construction of homes with basements, streets, and utilities. A hydrologist or engineer should carefully plan dewatering methods such as area underdrains to adequately lower water levels at the site and not disturb water levels and well yields on adjacent properties. The property lies within the drainage basin of the Cache La Poudre River and appears to lie north of the flood plain of the stream. A hydrologist of engineer should determine if the south edge of the site lies within the 100-year flood plain of the Cache La Poudre River. Construction should not be allowed with the 100-year flood plain of the river or it should be elevated above it.

The Timnath Reservoir Outlet Ditch is located on the site. The banks of this ditch are vegetated with grasses, weeds and brush. Erosion was noted along portions of the banks of this ditch. It is recommended construction be maintained a safe distance from the irrigation ditches or some form of slope protection be provided for the irrigation ditches to minimize future bank erosion.

Mapping completed by the Colorado Geological Survey ([1]Hart, 1972), indicates the site is in an area of "Low Swell Potential". Potentially expansive materials mapped in this area include bedrock, weathered bedrock and colluvium (surficial units).

Soil and Bedrock Conditions

The majority of the site is overlain by an approximate 6-inch layer of cultivated silty topsoil. The topsoil is penetrated by root growth and organic matter. The subsurface soils at the site generally consisted of sandy lean clay extending to the underlying granular soils. The granular soils included silty sand and well-graded sand with silt and gravel. The granular soils were encountered at approximate depths of 5 to 12-feet below existing site grades and extended to the bedrock below. Claystone/siltstone bedrock was encountered in Test Boring Nos. 1, 3 and 4 at approximate depths of 18 to 38-feet below existing site grades. Bedrock was not encountered in Test Boring No. 2 to the maximum depth explored, approximately 40-feet.

According to the Soil Survey of Larimer County, Colorado and as shown on the enclosed soil conservation map, Figure 4 in Appendix A, the soils at the site consist of:

- 7- Ascalon sandy loam, 0 to 3 percent slopes,
- 22 – Caruso clay loam, 0 to 1 percent slopes,
- 54 – Kim-Thedalund loam, 3 to 15 percent slopes,
- 77 – Otero sandy loam, 0 to 3 percent slopes,
- 78 - Otero sandy loam, 3 to 5 percent slopes,
- 79 - Otero sandy loam, 5 to 9 percent slopes,
- 81 – Paoli fine sandy loam, 0 to 1 percent slopes,
- 98 – Satanta Variant clay loam, 0 to 3 percent slopes, and

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[1] Hart, Stephen S., 1972, ***Potentially Swelling Soil and Rock in the Front Range Urban Corridor, Colorado***, Colorado Geological Survey, Environmental Geology No. 7.

- 105 – Table Mountain loam, 0 to 1 percent slopes.

Groundwater Conditions

Groundwater was encountered at approximate depths of 9 to 25-feet below existing site grades when checked on December 3, 2002. These observations represent groundwater conditions at the time of the field exploration, and may not be indicative of other times, or at other locations. Groundwater levels can be expected to fluctuate with varying seasonal and weather conditions.

Based upon review of U.S. Geological Survey maps ([2]Hillier, et al, 1983), regional groundwater in the western and southwestern portions of the site is expected to be encountered in unconsolidated alluvial deposits in this portion of the site, at depths ranging from 5 to 25-feet below the existing ground surface at the project site.

Zones of perched and/or trapped groundwater may also occur at times in the subsurface soils overlying bedrock, on top of the bedrock surface or within permeable fractures in the bedrock materials. The location and amount of perched water is dependent upon several factors, including hydrologic conditions, type of site development, irrigation demands on or adjacent to the site, fluctuations in water features, seasonal and weather conditions.

The possibility of groundwater fluctuations should be considered when developing design and construction plans for the project.

Field and Laboratory Test Results

Field test results indicate that the overburden soils vary from medium stiff to very stiff in consistency and loose to medium dense in relative density. The bedrock varies from moderately hard to hard.

The overburden soils are low to non-expansive and exhibit low to moderate load bearing characteristics. The bedrock exhibits high bearing characteristics and low to moderate swell potential.

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[2] Hillier, Donald E.; Schneider, Paul A., Jr.; and Hutchinson, E. Carter, 1983, ***Depth to Water Table (1979) in the Boulder-Fort Collins-Greeley Area, Front Range Urban Corridor, Colorado***, United States Geological Survey, Map I-855-I.

ENGINEERING RECOMMENDATIONS

Geotechnical Considerations

The site appears suitable for the proposed construction. The shallow depths to groundwater will require particular attention in the design and construction.

The following foundation systems were evaluated for use on the site:

- spread footings bearing on undisturbed soils; and
- spread footings bearing on engineered fill.

Design criteria for alternative foundation systems are subsequently outlined. Use of the alternative foundation systems outlined in this report should be determined for individual residential and/or proposed structures on the basis of supplemental geotechnical exploration of each lot prior to construction.

Slab-on-grade construction for basement or garage areas is considered acceptable for use when subgrade soils consist of the on-site sands, clays and gravels, provided a minimum 4-foot separation between the bottom of the slab and the maximum anticipated groundwater level be maintained and the design and construction recommendations are followed.

Foundation Systems - Preliminary Recommendations for Spread Footings

Due to the presence of low to moderate swelling soils on the site, spread footing foundations bearing upon undisturbed subsoils and/or engineered fill a minimum of 3-feet above the maximum anticipated groundwater level are recommended for support for the proposed structures. Based on preliminary test results, footings may be designed for a net allowable bearing pressure between 1,000 and 2,000 psf. In addition, the footings should be sized to maintain a minimum dead-load pressure of 0 to 500 psf.

Basement Construction

Groundwater was encountered at approximate depths of 9 to 25-feet below existing site grades when checked on December 3, 2002. Therefore, lower level construction may be feasible for portions of the site provided lower level slabs are placed a minimum of 4-feet above the maximum anticipated rise of groundwater, and/or an area underdrain/dewatering system is installed. It is recommended the lower level slab be placed a minimum of 4-feet above the groundwater level and an interior perimeter drain is installed and connected to the subsurface underdrain system.

To reduce the potential for groundwater to enter lower levels, installation of an area underdrain and/or permanent dewatering system is recommended. In conjunction with the area underdrain system, each residential lot should have an independent system, which connects to the area underdrain. This perimeter dewatering system should, at a minimum, include an underslab gravel drainage layer sloped to an interior perimeter drainage system.

The individual lot drainage systems should consist of a properly sized perforated pipe, embedded in free-draining gravel, placed in a trench at least 12-inches in width. The trench should be inset from the interior edge of the nearest foundation a minimum of 12-inches. In addition, the trench should be located such that an imaginary line extending downward at a 45-degree angle from the foundation does not intersect the nearest edge of the trench. Gravel should extend a minimum of 3-inches beneath the bottom of the pipe. The drainage system should be sloped at a minimum 1/8 inch per foot to a suitable outlet, such as a sump and pump system.

The underslab drainage layer should consist of a minimum 6-inch thickness of free-draining gravel meeting the specifications of ASTM C33, Size No. 57 or 67. Cross-connecting drainage pipes should be provided beneath the slab at 15-foot intervals, and should discharge to the perimeter drainage system. Each individual lot's perimeter drainage system should then be connected to the adequately sized street/roadway underdrain system.

Floor Slab Design and Construction

The variability of the existing soils at approximate slab subgrade elevation could result in differential movement of floor slab-on-grade should expansive soils become elevated in moisture content. Conventional slab-on-grade construction is feasible provided a minimum separation of 4-feet be maintained between the bottom of the slab and the maximum anticipated groundwater level. If slab movement cannot be tolerated, the use of a structural floor system should be considered.

Preliminary Pavement Design and Construction

The subsurface soils encountered on the site have low to moderate subgrade strength characteristics. It is our opinion the subgrade clays to be utilized primarily as the pavement subgrade section for the site exhibit a low swell potential, and low to moderate subgrade strength characteristics. The fine granular and/or coarse granular sand and gravel strata exhibit moderate subgrade characteristics. For preliminary planning purposes, we anticipate a composite pavement section consisting of 3 to 5-inches of asphaltic concrete over 6 to 8-inches of base course for automobile and/or drive/access areas or for local residential and/or minor collector roadways. A subgrade investigation and pavement design should be performed in general accordance with the Larimer County Urban Area Street Standards (LCUASS) pavement design criteria prior to placement of any pavement sections, to determine the required pavement section after final design configuration for the site has been completed.

Earthwork

- **General Considerations**

  The following presents recommendations for site preparation, excavation, subgrade preparation and placement of engineered fills on the project.

  All earthwork on the project should be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during the construction of the project.

- **Site Preparation**

  Strip and remove existing vegetation, debris and other deleterious materials from proposed building and pavement areas. All exposed surfaces should be free of mounds and depressions, which could prevent uniform compaction.

  Stripped materials consisting of vegetation and organic materials should be wasted from the site, or used to revegetate landscaped areas or exposed slopes after completion of grading operations. If it is necessary to dispose of organic materials on-site, they should be placed in non-structural areas and in fill sections not exceeding 5-feet in height.

The site should be initially graded to create a relatively level surface to receive fill, and to provide for a relatively uniform thickness of fill beneath proposed building structures.

If fill is placed in areas of the site where existing slopes are steeper than 3:1 (horizontal:vertical), the area should be benched to reduce the potential for slippage between existing slopes and fills. Benches should be wide enough to accommodate compaction and earth moving equipment, and to allow placement of horizontal lifts of fill. All exposed areas which will receive fill, once properly cleared and benched where necessary, should be scarified to a minimum depth of eight inches, conditioned to near optimum moisture content, and compacted.

Demolition of any existing buildings to accommodate the proposed development should include complete removal of all foundation systems within the proposed construction area. This should include removal of any loose backfill found adjacent to existing foundations. All materials derived from the demolition of existing structures and pavements should be removed from the site and not be allowed for use in any on-site fills.

Although evidence of fills or underground facilities such as septic tanks, cesspools, basements, and utilities was not observed during the site reconnaissance, such features could be encountered during construction. If unexpected fills or underground facilities are encountered, such features should be removed and the excavation thoroughly cleaned prior to backfill placement and/or construction.

It is anticipated that excavations for the proposed construction can be accomplished with conventional earthmoving equipment.

Groundwater seepage should be anticipated for excavations approaching the level of bedrock. Depending upon depth of excavation and seasonal conditions, groundwater may be encountered in excavations on the site. Pumping from sumps may be utilized to control water within the excavations.

Based upon the subsurface conditions determined from the geotechnical exploration, subgrade soils exposed during construction are anticipated to be relatively stable. However, the stability of the subgrade may be affected by precipitation, repetitive construction traffic or other factors. If unstable conditions develop, workability may be improved by scarifying and drying. Overexcavation of wet zones and replacement with granular materials may be necessary. Use of lime, fly ash, kiln dust, cement or geotextiles could also be considered as a stabilization technique. Laboratory evaluation is recommended to determine the effect of chemical stabilization on subgrade soils prior to construction. Lightweight excavation equipment may be required to reduce subgrade pumping.

The individual contractor(s) is responsible for designing and constructing stable, temporary excavations as required to maintain stability of both the excavation sides and bottom. All excavations should be sloped or shored in the interest of safety following local and federal regulations, including current OSHA excavation and trench safety standards.

- **Subgrade Preparation**

Areas of loose soils may be encountered at foundation bearing depth after excavation is completed for footings. When such conditions exist beneath planned footing areas, the subgrade soils should be compacted prior to placement of the foundation system.

Subgrade soils beneath interior and exterior slabs, and beneath pavements should be scarified, moisture conditioned and compacted to a minimum depth of 8 inches. The moisture content and compaction of subgrade soils should be maintained until slab or pavement construction.

- **Fill Materials and Placement**

Clean on-site soils or approved imported materials may be used as fill material.

Imported soils (if required) should conform to the following:

Gradation	Percent finer by weight (ASTM C136)
3"	100
No. 4 Sieve	50-100
No. 200 Sieve	60 (max)

- Liquid Limit ....35 (max)

- Plasticity Index..15 (max)

Engineered fill should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift. It is recommended all fill material be compacted to a minimum 95 percent of Standard Proctor Density ASTM D698.

On-site or imported clay soils should be compacted within a moisture content range of 2 percent below, to 2 percent above optimum. On-site granular soils should be compacted within a moisture range of 3 percent below to 3 percent above optimum unless modified by the project geotechnical engineer.

- **Shrinkage**

For balancing grading plans, estimated shrink or swell of soils and bedrock when used as compacted fill following recommendations in this report are as follows:

Material	Estimated Shrink(-) Swell (+) Based on ASTM D698
On-site soils:	
Clays	-15 to -20%
Sands	-10 to -15%
Bedrock	-5 to +10%

- **Slopes**

For permanent slopes in compacted fill areas, recommended maximum configurations for on-site materials are as follows:

Material	Maximum Slope Horizontal:Vertical
Cohesive soils (clays)	2:1
Cohesionless soils	2:1
Bedrock	1-1/2:1

If steeper slopes are required for site development, stability analyses should be completed to design the grading plan.

The face of all slopes should be compacted to the minimum specification for fill embankments. Alternately, fill slopes can be over-built and trimmed to compacted material. If any slope in cut or fill will exceed 25 feet in height, the grading design should include mid-height benches to intercept surface drainage and divert flow from the face of the embankment.

- **Excavation and Trench Construction**

Excavations into the on-site soils will encounter a variety of conditions. Excavations into the clays and bedrock can be expected to stand on relatively steep temporary slopes during construction. However, caving soils may also be encountered. The individual contractor(s) should be made responsible for designing and constructing stable, temporary excavations as required to maintain stability of both the excavation sides and bottom. All excavations should be sloped or shored in the interest of safety following local, and federal regulations, including current OSHA excavation and trench safety standards.

Underground Utility Systems

All piping should be adequately bedded for proper load distribution. It is suggested that clean, graded gravel compacted to 75 percent of Relative Density ASTM D4253 be used as bedding. Where utilities are excavated below groundwater, temporary dewatering will be required during excavation, pipe placement and backfilling operations for proper construction. Utility trenches should be excavated on safe and stable slopes in accordance with OSHA regulations as discussed above. Backfill should consist of the on-site soils or existing bedrock. If bedrock is used, all plus 6-inch material should be removed from it prior to its use. The pipe backfill should be compacted to a minimum of 95 percent of Standard Proctor Density ASTM D698.

- **Surface Drainage**

Positive drainage should be provided during construction and maintained throughout the life of the proposed project. Infiltration of water into utility or foundation excavations must be prevented during construction. Planters and other surface features, which could retain water in areas adjacent to the building or pavements, should be sealed or eliminated. In areas where sidewalks or paving do not immediately adjoin the structure, we recommend that protective slopes be provided with a minimum grade of approximately 10 percent for at least 10 feet from perimeter walls. Backfill against footings, exterior walls, and in utility and sprinkler line trenches should be well compacted and free of all construction debris to reduce the possibility of moisture infiltration.

Downspouts, roof drains or scuppers should discharge into splash blocks or extensions when the ground surface beneath such features is not protected by exterior slabs or paving. Sprinkler systems should not be installed within 5 feet of foundation walls. Landscaped irrigation adjacent to the foundation system should be minimized or eliminated.

PRELIMINARY GENERAL COMMENTS

It should be noted this was a preliminary investigation and the foundation systems recommended in this report are based on preliminary tests. Due to variations in soil conditions encountered at the site, it is recommended that additional test borings be made prior to final design. Samples obtained from the borings should be tested in the laboratory to provide a basis for evaluating subsurface conditions.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranty, express or implied, is made. This report has been prepared to aid in the evaluation of the property and to assist the architect and/or engineer in the preliminary design of this project.

This report is for the exclusive purpose of providing preliminary geotechnical engineering and/or testing information and recommendations. The scope of services for this project does not include, either specifically or by implication, any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential for such contamination, other studies should be undertaken.

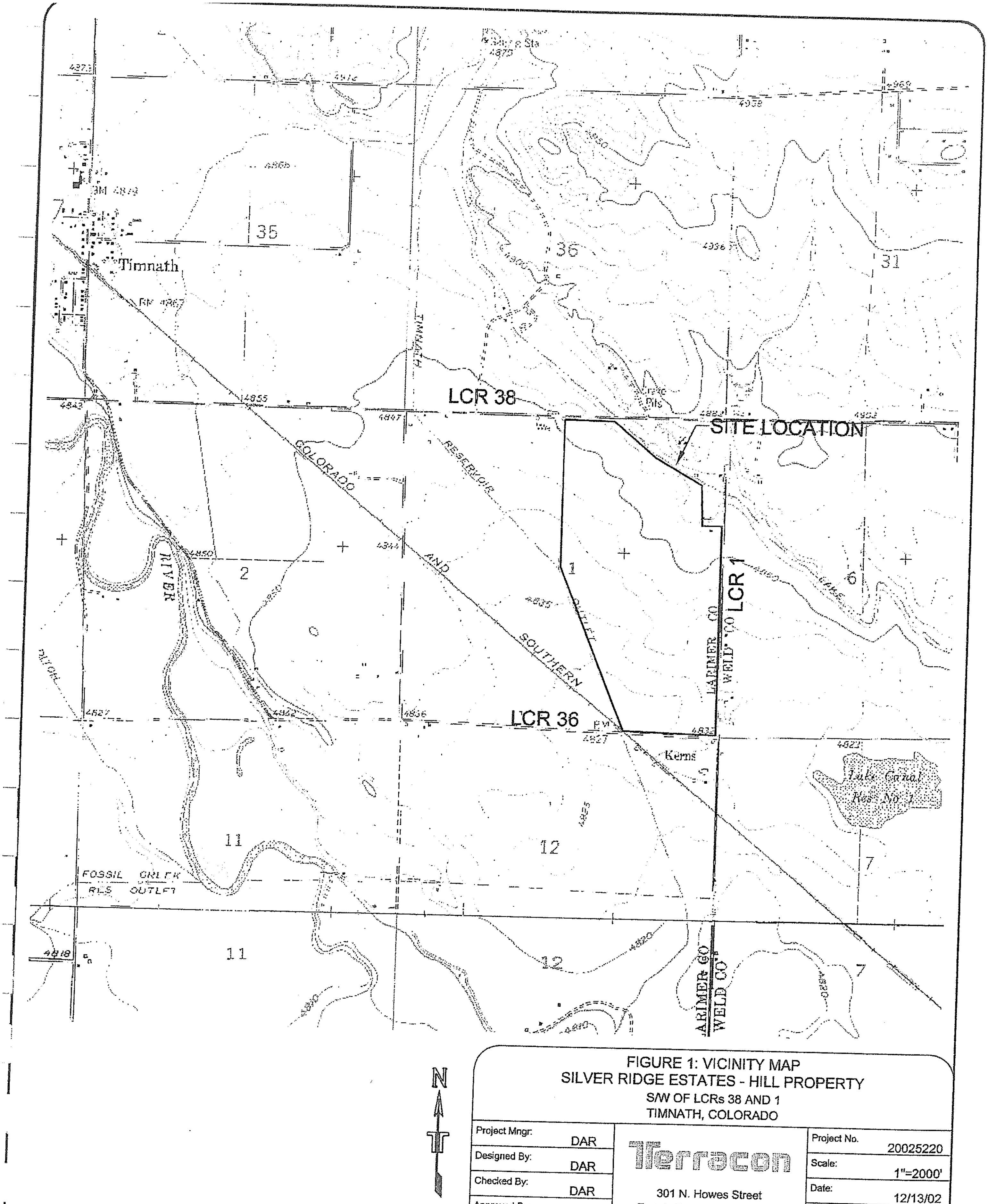

DIAGRAM IS FOR GENERAL LOCATION ONLY,
AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES.

FIGURE 1: VICINITY MAP
SILVER RIDGE ESTATES - HILL PROPERTY
S/W OF LCRs 38 AND 1
TIMNATH, COLORADO

Project Mngr: DAR
Designed By: DAR
Checked By: DAR
Approved By: DAR
File Name: 20025220-1

Terracon
301 N. Howes Street
Fort Collins, Colorado 80521

Project No. 20025220
Scale: 1"=2000'
Date: 12/13/02
Drawn By: SDC
Figure No. 1

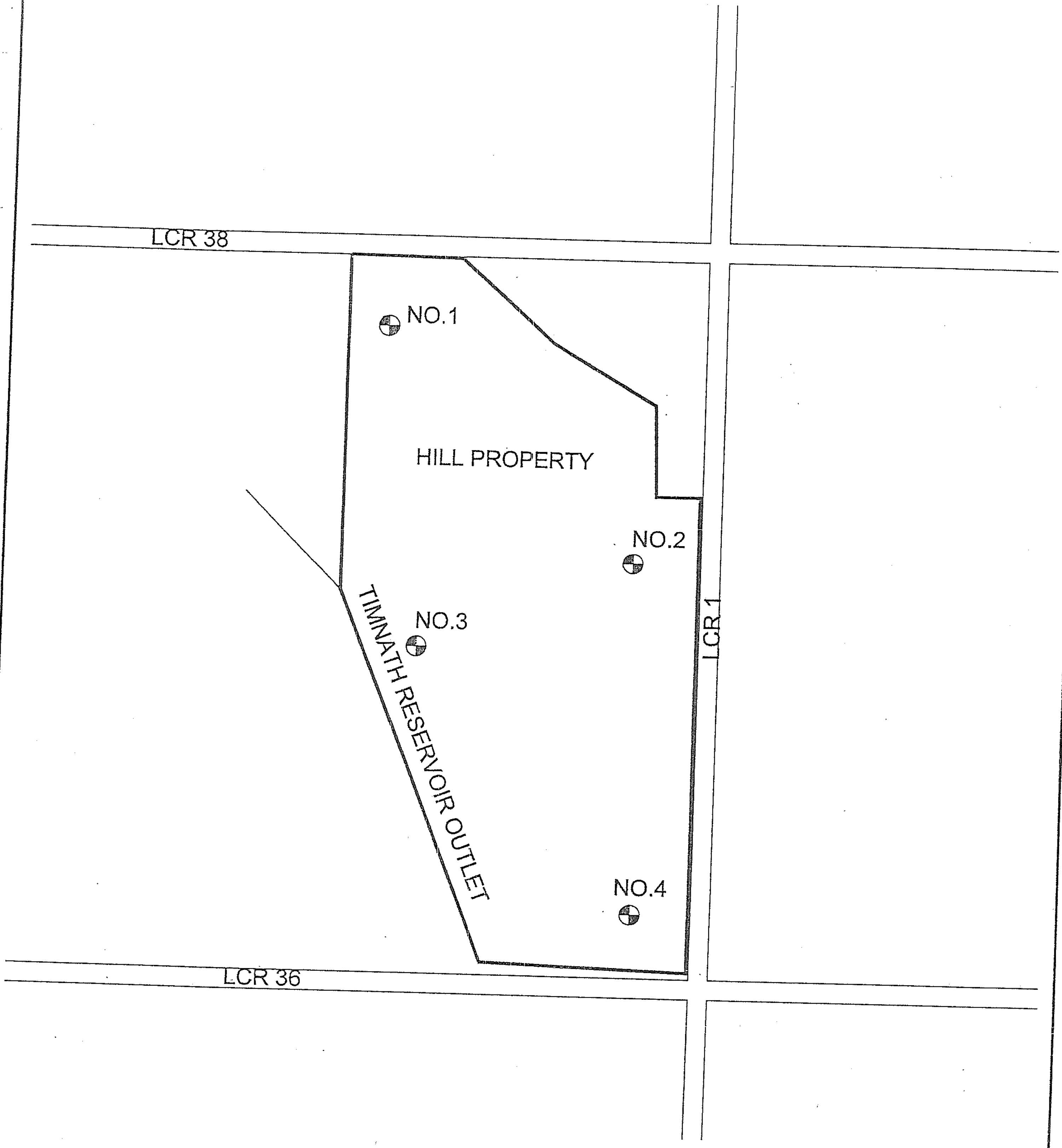

FIGURE 2: SITE PLAN
SILVER RIDGE ESTATES - HILL PROPERTY
S/W OF LCRs 38 AND 1
TIMNATH, COLORADO

Project Mngr: DAR
Designed By: DAR
Checked By: DAR
Approved By: DAR

Terracon
301 N. Howes Street
Fort Collins, Colorado 80521

Project No. 20025220
Scale: 1"=1000'
Date: 12/13/02
Drawn By: SDC

File Name: 20025220-2
Figure No. 2

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES.

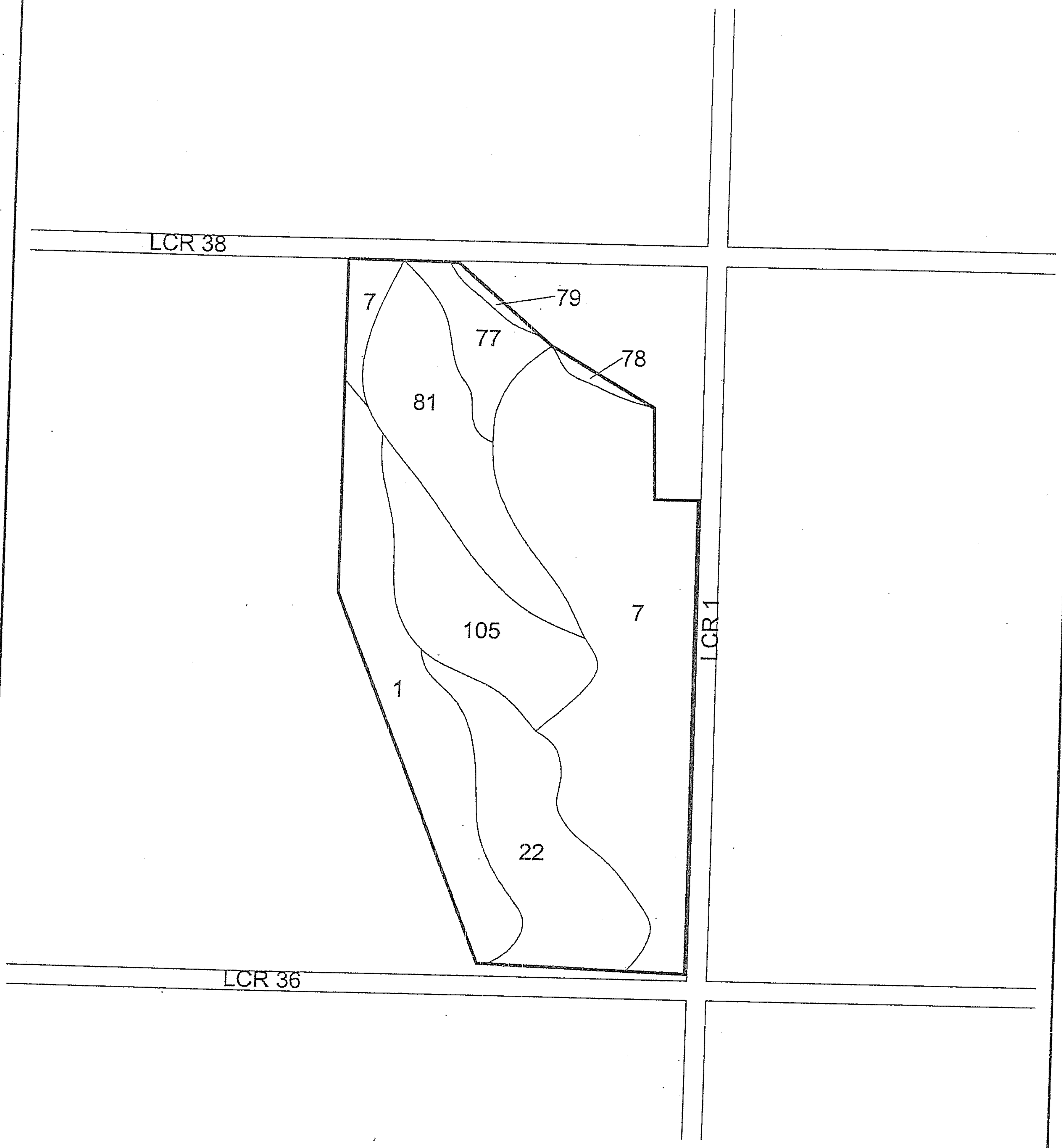

FIGURE 3: USDA SOILS MAP
SILVER RIDGE ESTATES - HILL PROPERTY

S/W OF LCRs 38 AND 1
TIMNATH, COLORADO

Project Mngr: DAR	Terracon	Project No.	20025220
Designed By: DAR		Scale:	1"=1000'
Checked By: DAR	301 N. Howes Street	Date:	12/13/02
Approved By: DAR	Fort Collins, Colorado 80521	Drawn By:	SDC
File Name:	20025220-3	Figure No.	3

DIAGRAM IS FOR GENERAL LOCATION ONLY,
AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES.

7—Ascalon sandy loam, 0 to 3 percent slopes. This nearly level soil is on uplands and high terraces. It has the profile described as representative of the series.

Included with this soil in mapping are a few areas of soils that have a surface layer of sandy clay loam. Also included are some small areas of soils in which sandstone is at a depth of 40 to 60 inches and small areas of Otero soils.

Runoff is slow. The hazard of wind erosion is moderate, and the hazard of water erosion is slight.

If irrigated, this soil is well suited to corn, beans, alfalfa, sugar beets, and barley. Under dryland management it is suited to wheat or barley. It is also well suited to pasture and native grasses. Capability units IIe–2, irrigated, and IIIe–8, dryland; Sandy Plains range site; windbreak suitability group 2.

22—Caruso clay loam, 0 to 1 percent slopes. This level soil is on low terraces and bottom lands.

Included with this soil in mapping are a few areas of soils that are more sloping. Also included are small areas of Loveland soils and a few minor areas of gravel bars.

Runoff is slow, and the hazard of erosion is slight.

If irrigated, this soil is suited to barley and sugar beets and, to a lesser extent, corn. It is also well suited to pasture and native grasses. Capability units IIIw–1, irrigated, and Vw–1, dryland; Wet Meadow range site; windbreak suitability group 5.

54—Kim loam, 3 to 5 percent slopes. This gently sloping soil is on uplands and fans. This soil has a profile similar to the one described as representative of the series, but the surface layer is about 10 inches thick.

Included with this soil in mapping are small areas of soils that are more sloping or less sloping and small areas of soils that have a surface layer of clay loam. A water table is within the root zone during the growing season in a few small areas. Also included are a few small areas of Fort Collins, Stoneham, and Thedalund soils.

Runoff is medium, and the hazard of erosion is moderate.

If irrigated, this soil is suited to barley, alfalfa, and wheat and, to a lesser extent, corn and beans. Under dryland management it is suited to pasture and native grasses. Capability units IIIe–2, irrigated, and IVe–3, dryland; Loamy Plains range site; windbreak suitability group 1.

77—Otero sandy loam, 0 to 3 percent slopes. This nearly level soil is on uplands and fans. This soil has a profile similar to the one described as representative of the series, but the surface layer is about 10 to 12 inches thick.

Included with this soil in mapping are some small areas of soils that have a surface layer of loam or fine sandy loam. Also included are some areas of soils that are redder and a few small areas of Ascalon, Nelson, and Kim soils.

Runoff is slow. The hazard of water erosion is slight, and the hazard of wind erosion is moderate.

If irrigated, this soil is suited to corn, barley, sugar beets, wheat, and beans. Under dryland management it is suited to pasture and native grasses and, to a lesser extent, wheat and barley. Capability units IIIe-5, irrigated, and IVe-5, dryland; Sandy Plains range site; windbreak suitability group 2.

78—Otero sandy loam, 3 to 5 percent slopes. This gently sloping soil is on uplands and fans. This soil has a profile similar to the one described as representative of the series, but the surface layer is about 8 inches thick.

Included with this soil in mapping are a few small areas of soils that are more sloping or less sloping. Also included are some small areas of soils in which sandstone is at a depth of 40 to 60 inches and a few small areas of Ascalon, Nelson, and Kim soils.

Runoff is medium, and the hazard of erosion is moderate.

If irrigated, this soil is suited to barley, wheat, alfalfa, and pasture and, to a lesser extent, corn and beans. Under dryland management it is well suited to pasture and native grasses. Capability units IIIe-4, irrigated, and VIe-2, dryland; Sandy Plains range site; windbreak suitability group 2.

79—Otero sandy loam, 5 to 9 percent slopes. This strongly sloping soil is on uplands and fans.

Included with this soil in mapping are small areas of soils that are more sloping or less sloping. Also included are a few small areas of Nelson, Kim, and Tassel soils.

Runoff is rapid, and the hazard of erosion is severe.

If irrigated, this soil is well suited to pasture and, to a lesser extent, wheat, barley, or alfalfa. Under dryland management it is suited to pasture or native grasses. Capability units IVe-2, irrigated, and VIe-2, dryland; Sandy Plains range site; windbreak suitability group 2.

81—Paoli fine sandy loam, 0 to 1 percent slopes. This level soil is on low terraces.

Included with this soil in mapping are a few small areas of soils that are more sloping. Also included are a few small areas of Caruso and Table Mountain soils and some gravel spots.

Runoff is slow. The hazard of water erosion is slight, and the hazard of wind erosion is moderate. This soil is flooded in places, especially near stream channels.

If irrigated, this soil is suited to corn, sugar beets, beans, barley, alfalfa, and wheat. Under dryland management it is suited to wheat and barley. It is also well suited to pasture and native grasses. Capability units IIs–2, irrigated, and IIIe–8, dryland; Overflow range site; windbreak suitability group 2.

98—Satanta Variant clay loam, 0 to 3 percent slopes. This nearly level soil is on terraces.

Included with this soil in mapping are a few small areas of soils that have a surface layer and subsurface layer of loam. Also included are a few small areas of Nunn clay loam, wet, and areas of Caruso and Loveland soils.

Runoff is slow. The hazard of erosion is slight to moderate, except in areas near stream channels where cutting occurs.

If irrigated, this soil is suited to corn, barley, alfalfa, wheat, and pasture. Under dryland management it is suited to pasture and native grasses and, to a lesser extent, wheat and barley. Capability units IIe–1, irrigated, and IVe–3, dryland; Overflow range site; windbreak suitability group 3.

105—Table Mountain loam, 0 to 1 percent slopes. This level soil is on low terraces and bottom lands.

Included with this soil in mapping are some small areas of soils that have a surface layer of sandy loam and some small areas of soils in which slopes are more than 1 percent. Also included are a few small areas of Caruso and Paoli soils and small areas of soils in which sand and gravel layers are at a depth of about 40 inches.

Runoff is slow, and the hazard of erosion is slight. This soil is flooded or receives overflow in places.

If irrigated, this soil is well suited to corn, sugar beets, beans, alfalfa, wheat, and barley. It is also well suited to wheat or barley under dryland management. Capability units I, irrigated, and IIIc–1, dryland; Overflow range site; windbreak suitability group 1.

LOG OF BORING NO. 1

Page 1 of 1

CLIENT Summit Land Management Services, Inc.	ARCHITECT/ENGINEER
SITE Hill Property - S/W/C of LCRs 38 and 1 Timnath, Colorado	PROJECT Silver Ridge Estates Preliminary Study

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT - N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, psf	% WATER SOLUBLE SULFATE
0.5	6" CULTIVATED TOPSOIL										
▨	**SANDY LEAN CLAY** Brown, rust, moist, calcareous, medium stiff to stiff										
5		5		1	SS	12	9	23.0			
░	**WELL GRADED SAND with SILT and GRAVEL** Brown, tan, rust, moist to wet, loose to medium dense										
░		10	SW	2	SS	12	16	1.6			
░	* Intermittent Cobbles Encountered ∇										
░		15		3	SS	3	50/0.2	16.4			0.0002
░	▼	20									
░		25									
░		30									
░		35									
38											
39	**CLAYSTONE/SILTSTONE** Gray, brown, moist, moderately hard to hard			4	AC			15.1			
	BOTTOM OF BORING										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL ∇ 14.0	WD ▼ 20.0	WCI
WL ∇	∇	
WL Water Level Checked on 12/3/2002		

Terracon

BORING STARTED			12-2-02
BORING COMPLETED			12-2-02
RIG	CME-55	FOREMAN	ASR
APPROVED	DAR	JOB #	20025220

LOG OF BORING NO. 2

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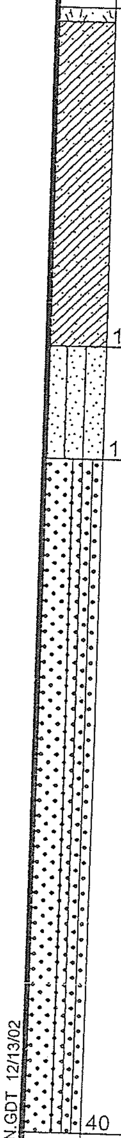
CLIENT
Summit Land Management Services, Inc.

ARCHITECT/ENGINEER

SITE Hill Property - S/W/C of LCRs 38 and 1
Timnath, Colorado

PROJECT
Silver Ridge Estates Preliminary Study



Depth	DESCRIPTION
0.5	6" CULTIVATED TOPSOIL
12	**SANDY LEAN CLAY** Brown, rust, moist, calcareous, medium stiff to stiff
16	**SILTY SAND** Brown, tan, rust, moist, loose to medium dense
40	**WELL GRADED SAND with SILT and GRAVEL** Brown, tan, rust, moist to wet, loose to medium dense * Intermittent Cobbles Encountered ▼ (25) ∇ (30)
	BOTTOM OF BORING

		SAMPLES				TESTS		
DEPTH, ft.	USCS SYMBOL	NUMBER	TYPE	RECOVERY, in.	SPT - N BLOWS / ft.	WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf
5		1	RB	12	17	11.7	100	
10		2	SS	12	8	15.7		
15		3	SS	12	9	3.8		
25		4	SS	12	50	1.9		
40								

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	∇ 30.0 WD	▼ 25.0	AB
WL	∇	▼	
WL	Water Level Checked on 12/3/2002		

Terracon

BORING STARTED			12-2-02
BORING COMPLETED			12-2-02
RIG	CME-55	FOREMAN	ASR
APPROVED	DAR	JOB #	20025220

LOG OF BORING NO. 3

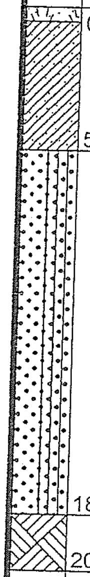
Page 1 of 1

CLIENT
Summit Land Management Services, Inc.

SITE Hill Property - S/W/C of LCRs 38 and 1
Timnath, Colorado

ARCHITECT/ENGINEER

PROJECT
Silver Ridge Estates Preliminary Study



GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	TYPE	RECOVERY, in.	SPT - N BLOWS / ft.	TESTS WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf	EXPANSION TEST (PSF)
0.5	6" CULTIVATED TOPSOIL										
5	**SANDY LEAN CLAY** Brown, rust, moist, calcareous, very stiff to medium stiff * Intermittent Silty Clayey Sand with Gravel Lenses Encountered	5		1	SS	12	10	11.3	103		
	WELL GRADED SAND with SILT and GRAVEL Brown, tan, rust, moist to wet, loose to medium dense ▽ ▼	10	SW	2	SS	12	9	14.4			
	* Intermittent Cobbles Encountered	15		3	SS	12	22	10.9			
18											
20	**CLAYSTONE/SILTSTONE** Gray, brown, moist, moderately hard to hard	20		4	AC			19.4			130
	BOTTOM OF BORING										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 7.0	WD ▼ 9.0	WCI
WL	▽	▽	
WL	Water Level Checked on 12/3/2002		

Terracon

BORING STARTED			12-2-02
BORING COMPLETED			12-2-02
RIG	CME-55	FOREMAN	ASR
APPROVED	DAR	JOB #	20025220

BOREHOLE 99 20025220.GPJ TERRACON.GDT 12/13/02

LOG OF BORING NO. 4

Page 1 of 1

CLIENT Summit Land Management Services, Inc.	ARCHITECT/ENGINEER
SITE Hill Property - S/W/C of LCRs 38 and 1 Timnath, Colorado	PROJECT Silver Ridge Estates Preliminary Study

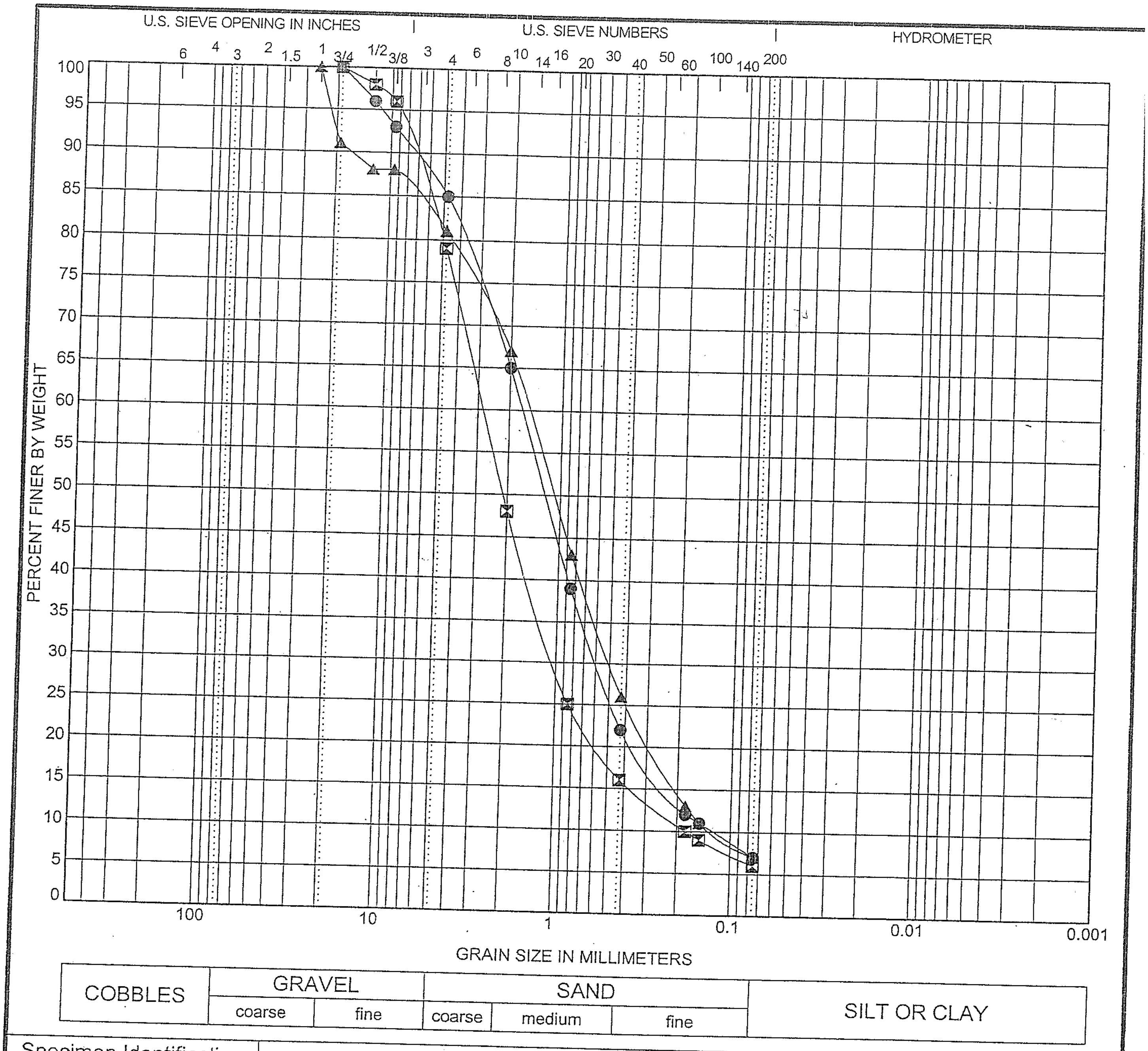
GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT - N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, psf	TESTS % WATER SOLUBLE SULFATE
▨	0.5 6" CULTIVATED TOPSOIL **SANDY LEAN CLAY** Brown, rust, moist, calcareous, medium stiff to stiff 5										
░	**WELL GRADED SAND with SILT and GRAVEL** Brown, tan, rust, moist to wet, loose to medium dense	5		1	SS	12	8	9.2	109		
░	* Intermittent Cobbles Encountered	10	SW	2	SS	12	19	0.9			
░		15		3	SS	3	50/0.2	2.1			0.0000
░	▼	20									
░	▽	25									
░	31	30									
▩	**CLAYSTONE/SILTSTONE** Gray, brown, moist, moderately hard to hard 34			4	AC			18.3			
	BOTTOM OF BORING										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 27.0	WD ▼ 21.0	AB
WL	▽	▼	
WL	Water Level Checked on 12/3/2002		

Terracon

BORING STARTED			12-2-02
BORING COMPLETED			12-2-02
RIG	CME-55	FOREMAN	ASR
APPROVED	DAR	JOB #	20025220



Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	1	9.0ft	WELL-GRADED SAND with SILT and GRAVEL(SW-SM)	NP	NP	NP	1.62	13.45
☒	3	9.0ft	WELL-GRADED SAND with SILT and GRAVEL(SW-SM)	NP	NP	NP	2.08	15.53
▲	4	9.0ft	WELL-GRADED SAND with SILT and GRAVEL(SW-SM)	NP	NP	NP	1.27	12.35

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	1	9.0ft	19	1.697	0.589	0.126	15.0	78.0	7.0	
☒	3	9.0ft	19	2.795	1.024	0.18	21.0	73.0	6.0	
▲	4	9.0ft	25	1.558	0.5	0.126	19.0	74.0	7.0	

Terracon

GRAIN SIZE DISTRIBUTION

Project: Silver Ridge Estates Preliminary Study
Site: Hill Property - S/W/C of LCRs 38 and 1 Timnath, Colorado
Job #: 20025220
Date: 12-13-02

TC_GRAIN_SIZE 20025220.GPJ TERRACON.GDT 12/13/02

DRILLING AND EXPLORATION

DRILLING & SAMPLING SYMBOLS:

R : Ring Barrell - 2.42" I.D., 3" O.D., unless otherwise noted
SS : Split Spoon - 1_" I.D., 2" O.D., unless otherwise noted
ST : Thin-Walled Tube - 2" O.D., unless otherwise noted
PA : Power Auger
HA : Hand Auger
DB : Diamond Bit = 4", N, B
AS : Auger Sample
HS : Hollow Stem Auger

PS : Piston Sample
WS : Wash Sample
FT : Fish Tail Bit
RB : Rock Bit
BS : Bulk Sample
PM : Pressure Meter
DC : Dutch Cone
WB : Wash Bore

Penetration Test: Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch O.D. split spoon, except where noted.

WATER LEVEL MEASUREMENT SYMBOLS:

WL : Water Level
WCI : Wet Cave in
DCI : Dry Cave in
AB : After Boring

WS : While Sampling
WD : While Drilling
BCR : Before Casing Removal
ACR : After Casting Removal

Water levels indicated on the boring logs are the levels measured in the borings at the time indicated. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels is not possible with only short term observations.

DESCRIPTIVE SOIL CLASSIFICATION:

Soil Classification is based on the Unified Soil Classification system and the ASTM Designations D-2487 and D-2488. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; they are described as: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are described as: clays, if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse grained soils are defined on the basis of their relative in-place density and fine grained soils on the basis of their consistency. Example: Lean clay with sand, trace gravel, stiff (CL); silty sand, trace gravel, medium dense (SM).

CONSISTENCY OF FINE-GRAINED SOILS:

Unconfined Compressive Strength, Qu; psf	Consistency
< 500	Very Soft
500 - 1,000	Soft
1,001 - 2,000	Medium
2,001 - 4,000	Stiff
4,001 - 8,000	Very Stiff
8,001 -16,000	Very Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS:

N-Blows/ft.	Relative Density
0-3	Very Loose
4-9	Loose
10-29	Medium Dense
30-49	Dense
50-80	Very Dense
80+	Extremely Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) (of Components Also Present in Sample)	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) (of Components Also Present in Sample)	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Size Range
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75mm)
Sand	#4 to #200 sieve (4.75mmto 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]					Soil Classification	
					Group Symbol	Group Name[B]
Coarse-Grained Soils more than 50% retained on No. 200 sieve	Gravels more than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]		GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]		GP	Poorly graded gravel[F]
		Gravels with Fines more than 12% fines[C]	Fines classify as ML or MH		GM	Silty gravel,G,H
			Fines classify as CL or CH		GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[E]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]		SW	Well-graded sand[1]
			$Cu < 6$ and/or $1 > Cc > 3$[E]		SP	Poorly graded sand[1]
		Sands with Fines more than 12% fines[D]	Fines classify as ML or MH		SM	Silty sand[G,H,I]
			Fines Classify as CL or CH		SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A line[J]		CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]		ML	Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OL	Organic clay[K,L,M,N]
			Liquid limit - not dried			Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line		CH	Fat clay[K,L,M]
			PI lots below "A" line		MH	Elastic Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OH	Organic clay[K,L,M,P]
			Liquid limit - not dried			Organic silt[K,L,M,Q]
Highly organic soils			Primarily organic matter, dark in color, and organic odor		PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains $\geq$ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains $\geq$ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.

[L] If soil contains $\geq$ 30% plus No. 200 predominantly sand, add "sandy" to group name.

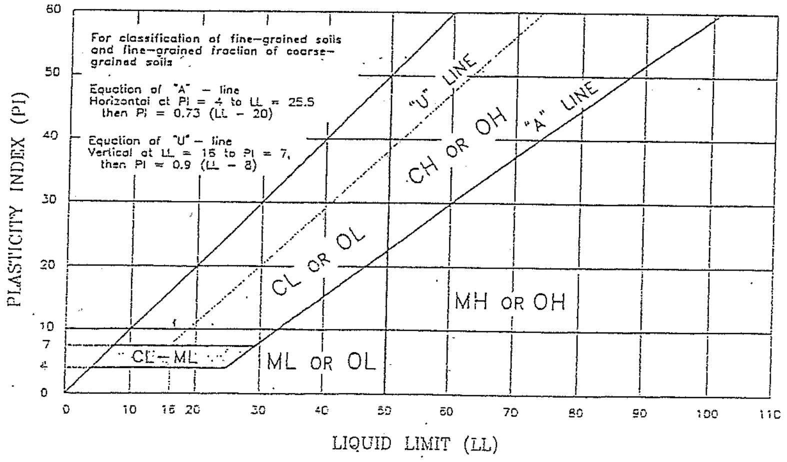
[M] If soil contains $\geq$ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] $PI \geq 4$ and plots on or above "A" line.

[O] $PI \leq 4$ or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



Terracon

LABORATORY TESTS
SIGNIFICANCE AND PURPOSE

TEST	SIGNIFICANCE	PURPOSE
California Bearing Ratio	Used to evaluate the potential strength of subgrade soil, subbase, and base course material, including recycled materials for use in road and airfield pavements.	Pavement Thickness Design
Consolidation	Used to develop an estimate of both the rate and amount of both differential and total settlement of a structure.	Foundation Design
Direct Shear	Used to determine the consolidated drained shear strength of soil or rock.	Bearing Capacity, Foundation Design & Slope Stability
Dry Density	Used to determine the in-place density of natural, inorganic, fine-grained soils.	Index Property Soil Behavior
Expansion	Used to measure the expansive potential of fine-grained soil and to provide a basis for swell potential classification.	Foundation & Slab Design
Gradation	Used for the quantitative determination of the distribution of particle sizes in soil.	Soil Classification
Liquid & Plastic Limit, Plasticity Index	Used as an integral part of engineering classification systems to characterize the fine-grained fraction of soils, and to specify the fine-grained fraction of construction materials.	Soil Classification
Permeability	Used to determine the capacity of soil or rock to conduct a liquid or gas.	Groundwater Flow Analysis
pH	Used to determine the degree of acidity or alkalinity of a soil.	Corrosion Potential
Resistivity	Used to indicate the relative ability of a soil medium to carry electrical currents.	Corrosion Potential
R-Value	Used to evaluate the potential strength of subgrade soil, subbase, and base course material, including recycled materials for use in road and airfield pavements.	Pavement Thickness Design
Soluble Sulphate	Used to determine the quantitative amount of soluble sulfates within a soil mass.	Corrosion Potential
Unconfined Compression	To obtain the approximate compressive strength of soils that possess sufficient cohesion to permit testing in the unconfined state.	Bearing Capacity Analysis for Foundations
Water Content	Used to determine the quantitative amount of water in a soil mass.	Index Property Soil Behavior

REPORT TERMINOLOGY
(Based on ASTM D653)

Allowable Soil Bearing Capacity	The recommended maximum contact stress developed at the interface of the foundation element and the supporting material.
Alluvium	Soil, the constituents of which have been transported in suspension by flowing water and subsequently deposited by sedimentation.
Aggregate Base Course	A layer of specified material placed on a subgrade or subbase usually beneath slabs or pavements.
Backfill	A specified material placed and compacted in a confined area.
Bedrock	A natural aggregate of mineral grains connected by strong and permanent cohesive forces. Usually requires drilling, wedging, blasting or other methods of extraordinary force for excavation.
Bench	A horizontal surface in a sloped deposit.
Caisson (Drilled pier or Shaft)	A concrete foundation element cast in a circular excavation which may have an enlarged base. Sometimes referred to as a cast-in-place pier or drilled shaft.
Coefficient of Friction	A constant proportionality factor relating normal stress and the corresponding shear stress at which sliding starts between the two surfaces.
Colluvium	Soil, the constituents of which have been deposited chiefly by gravity such as at the foot of a slope or cliff.
Compaction	The densification of a soil by means of mechanical manipulation.
Concrete Slab-on-Grade	A concrete surface layer cast directly upon a base, subbase or subgrade, and typically used as a floor system.
Differential Movement	Unequal settlement or heave between, or within foundation elements of a structure.
Earth Pressure	The pressure or force exerted by soil on any boundary such as a foundation wall.
ESAL	Equivalent Single Axle Load, a criteria used to convert traffic to a uniform standard, (18,000 pound axle loads).
Engineered Fill	Specified material placed and compacted to specified density and/or moisture conditions under observations of a representative of a geotechnical engineer.
Equivalent Fluid	A hypothetical fluid having a unit weight such that it will produce a pressure against a lateral support presumed to be equivalent to that produced by the actual soil. This simplified approach is valid only when deformation conditions are such that the pressure increases linearly with depth and the wall friction is neglected.
Existing Fill (or man-made fill)	Materials deposited through the action of man prior to exploration of the site.
Existing Grade	The ground surface at the time of field exploration.

REPORT TERMINOLOGY
(Based on ASTM D653)

Expansive Potential	The potential of a soil to expand (increase in volume) due to absorption of moisture.
Finished Grade	The final grade created as a part of the project.
Footing	A portion of the foundation of a structure that transmits loads directly to the soil.
Foundation	The lower part of a structure that transmits the loads to the soil or bedrock.
Frost Depth	The depth of which the ground becomes frozen during the winter season.
Grade Beam	A foundation element or wall, typically constructed of reinforced concrete, used to span between other foundation elements such as drilled piers.
Groundwater	Subsurface water found in the zone of saturation of soils, or within fractures in bedrock.
Heave	Upward movement.
Lithologic	The characteristics which describe the composition and texture of soil and rock by observation.
Native Grade	The naturally occuring ground surface.
Native Soil	Naturally occurring on-site soil, sometimes referred to as natural soil.
Optimum Moisture Content	The water content at which a soil can be compacted to a maximum dry unit weight by a given compactive effort.
Perched Water	Groundwater, usually of limited area maintained above a normal water elevation by the presence of an intervening relatively impervious continuing stratum.
Scarify	To mechanically loosen soil or break down existing soil structure.
Settlement	Downward movement.
Skin Friction (Side Shear)	The frictional resistance developed between soil and an element of structure such as a drilled pier or shaft.
Soil (earth)	Sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks, and which may or may not contain organic matter.
Strain	The change in length per unit of length in a given direction.
Stress	The force per unit area acting within a soil mass.
Strip	To remove from present location.
Subbase	A layer of specified material in a pavement system between the subgrade and base course.
Subgrade	The soil prepared and compacted to support a structure, slab or pavement system.

RECOMMENDED PREVENTATIVE MAINTENANCE POLICY FOR JOINTED CONCRETE PAVEMENTS

Distress Type	Distress Severity	Recommended Maintenance
Blow-up	Low	None
	Medium	Full-Depth Concrete Patch/ Slab Replacement
	High	
Corner Break	Low	Seal Cracks
	Medium	Full-Depth Concrete Patch
	High	
Divided Slab	Low	Seal Cracks
	Medium	Slab Replacement
	High	
Durability Cracking	Low	None
	Medium	Full-Depth Patch
	High	Slab Replacement
Faulting	Low	None
	Medium	Grind
	High	
Joint Seal	Low	None
	Medium	Reseal Joints
	High	
Lane/Shoulder Drop-off	Low	Regrade and Fill Shoulders to Match Lane Height
	Medium	
	High	
Linear Cracking Longitudinal, Transverse and Diagonal Cracks	Low	Clean & Seal all Cracks
	Medium	
	High	Full-Depth Patch
Large Patching and Utility Cuts	Low	None
	Medium	Seal Cracks or Replace Patch
	High	
Small Patching	Low	None
	Medium	Replace Patch
	High	
Polished Aggregate	No Severity Levels Defined	Groove Surface or Overlay
Popouts	No Severity Levels Defined	None
Pumping	No Severity Levels Defined	Underseal, Seal cracks/joints and Restore Load Transfer
Punchout	Low	Seal Cracks
	Medium	Full-Depth Concrete Patch
	High	
Railroad Crossing	Low	No Policy for this Project
	Medium	
	High	
Scaling Map Cracking Crazing	Low	None
	Medium	Slab Replacement, Full-depth Patch, or Overlay
	High	
Shrinkage Cracks	No Severity Levels Defined	None
Spalling (Corner)	Low	None
	Medium	Partial-Depth Concrete Patch
	High	
Spalling (Joint)	Low	None
	Medium	Partial-Depth Patch
	High	Reconstruct Joint

RECOMMENDED PREVENTATIVE MAINTENANCE POLICY FOR ASPHALT CONCRETE PAVEMENTS

Distress Type	Distress Severity	Recommended Maintenance
Alligator Cracking	Low	None
	Medium	Full-Depth Asphalt Concrete Patch
	High	
Bleeding	Low	None
	Medium	Surface Sanding
	High	Shallow AC Patch
Block Cracking	Low	None
	Medium	Clean & Seal All Cracks
	High	
Bumps & Sags	Low	None
	Medium	Shallow AC Patch
	High	Full-Depth Patch
Corrugation	Low	None
	Medium	Full-Depth Asphalt Concrete Patch
	High	
Depression	Low	None
	Medium	Shallow AC Patch
	High	Full-Depth Patch
Edge Cracking	Low	None
	Medium	Seal Cracks
	High	Full-Depth Patch
Joint Reflection	Low	Clean & Seal All Cracks
	Medium	
	High	Shallow AC Patch
Lane/Shoulder Drop-Off	Low	None
	Medium	Regrade Shoulder
	High	
Longitudinal & Transverse Cracking	Low	None
	Medium	Clean & Seal All Cracks
	High	
Patching & Utility Cut Patching	Low	None
	Medium	Full-Depth Asphalt Concrete Patch
	High	
Polished Aggregate	Low	None
	Medium	
	High	Fog Seal
Potholes	Low	Shallow AC Patch
	Medium	Full-Depth Asphalt Concrete Patch
	High	
Railroad Crossing	Low	No Policy for This Project
	Medium	
	High	
Rutting	Low	None
	Medium	Shallow AC Patch
	High	Full-Depth Patch
Shoving	Low	None
	Medium	Mill & Shallow AC Patch
	High	
Slippage Cracking	Low	None
	Medium	Shallow Asphalt Concrete Patch
	High	
Swell	Low	None
	Medium	Shallow AC Patch
	High	Full-Depth Patch
Weathering & Ravelling	Low	Fog Seal
	Medium	
	High	

Terracon