Rule 908.b(7) Geologic and Hydrologic Data

Piceance Energy LLC
Harrison Creek Water Management Facility – DAF Unit

OA Project No. 014-0465

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Geologic Hazards Investigation

Revised July 6, 2009

Mega Vega Compressor Station
Mesa County, Colorado

Operated by:

Delta Petroleum Corporation
370 17th St., Suite 4300
Denver, CO 80202

Prepared by:

B&A Buys & Associates, Inc.
Environmental Consultants

300 East Mineral Ave., Suite 10
Littleton, CO 80122
Ph 303 781-8211

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Geologic Hazard Report for the Proposed Delta Petroleum Mega Vega Compressor Station

Geomorphic Features

The proposed site is located on relatively flat terrain to the west of Harrison Creek. The existing land surface at the site slopes gently to the northeast and is covered by grasses and mature sagebrush. Elevations at the site range from 7,476 feet to 7,448 feet. A 150-foot tall ridge is located adjacent to the site. There are no earthquake scarps, landslide deposits, debris flows, erosion scarps, or avalanche paths in the proposed project area.

Subsurface Conditions

The subsurface beneath the site consists of relatively stiff, low- to high-swelling sandy, lean clays containing occasional to frequent gravel- to –cobble-sized shale and sandstone fragments and occasional lenses of silty to clayey sand and gravel. Bedrock consisting of hard, cemented sandstone and very hard shale of the Eocene/Paleocene Wasatch Formation is present at depths ranging from 22 to 33 feet beneath the site. Groundwater was not encountered beneath the site to a depth of 40 feet (Kumar and Associates 2008).

Soil Conditions

Surface deposits in the area consist of weathered shales and sandstones of the Wasatch Formation and Quaternary alluvium, eolian, and lake deposits. As stated in the geotechnical report (Kumar & Associates 2008), the site is underlain by expansive clay soils. These soils have low infiltration rates and will naturally act to pond water on the surface. The geotechnical report recommends the use of a zone of non- to –low-swelling fill material beneath the foundations to mitigate the potential affects of swelling on the integrity of the proposed structures. In addition, the geotechnical report states that proper grading of the site will be required to facilitate drainage of surface water, and the use of irrigation on landscaping should be minimized.

Based on the character of the soils beneath the site, and the low site seismicity, the potential for liquefaction of soils is considered to be low.

Seismicity

The site is located in an area of relatively low seismic activity. Based on fault and earthquake epicenter maps prepared by the Colorado Geological Survey and available on the CGS website (Colorado Geological Survey 2009), the closest known Quaternary-aged faults and earthquake epicenters are located about 30 miles to the east-northeast. Historic earthquake data for western Colorado indicate maximum magnitudes of about 4.9. In addition, the Colorado Geophysical Survey estimates that the maximum credible magnitude for active faults in western Colorado is about 5.0. Therefore, the seismic risk at the site is considered to be low.

Landslides and Debris Flows

There are no mapped landslide or debris flow deposits in the project area or immediate vicinity (Ellis and Freeman 1984). In addition, the site is located on gently-sloping land that is covered with grasses and sagebrush. Therefore, no ground stability problems are expected.

Mineral Resources

Mineral resources in the area include coal and sand and gravel deposits. Coal mines are located in the Collbran, Paonia, and Cedaredge areas to the west and south of the proposed compressor station location. Sands and gravel deposits are present along Plateau Creek. However, no coal or sand and gravel mining is located in the immediate area of the proposed compressor station. Therefore, construction of the station would have no impact on these resources.

Subsidence

There are no coal mines in the immediate vicinity of the proposed compressor station. Therefore, no ground subsidence is expected to occur.

References

Ellis, M.S., and V. L. Freeman, 1984, Geologic Map and Cross Sections of the Carbondale 30’ x 60’ Quadrangle, West-Central Colorado, U.S. Geological Survey Coal Investigations Map C-97-A.

Kumar and Associates, 2008, Geotechnical Engineering Study, Proposed Delta Petroleum Mega Vega Compressor Station South of County Road 330, Approximately 12.5 miles east of Collbran, Mesa County, Colorado

Colorado Geological Survey, 2009, Colorado Earthquake Information, available on the Internet at http://geosurvey.state.co.us/Default.aspx?tabid=303

Geologic and Hydrologic Assessment

COGCC Form 28

Piceance Energy LLC
Harrison Creek Water Treatment Facility (HWCTF) DAF Plant
(Former Delta 212 and Current Mega Vega Compressor Site)
SE ¼ NE ¼ Section 22, Township 9 South, Range 93 West, 6th P.M.

Olsson has reviewed the Geologic Hazards Investigation Report, prepared and revised by Buys & Associates, Inc. on July 6, 2009, and also available professional published geologic maps and reports for the area. There are no earthflow or soil creep, mudflow, slumps, or landslides shown in the immediate vicinity of the proposed DAF Plant Site.

The revised Buys and Associates report concluded that there were no mapped landslide or debris flow deposits in the project area or immediate vicinity, as cited in Exhibit 4 Geologic Map of Study Area Map C-97-A (Ellis and Freeman, 1984) The Buys and Associates report additionally concluded that the site is located on gently-sloping land that is covered with grasses and sagebrush; therefore, no ground stability problems were expected.

Olsson personnel visited the site on June 26, 2014. The site was observed to be located on relatively flat terrain located to the west of Harrison Creek. The land surface slopes to the northeast and is at an elevation of approximately 7,476 feet to 7,448 feet above sea level. The West Salt Creek landslide occurred on May 25, 2014, near the headwaters of West Salt Creek. Olsson personnel viewed the West Salt Creek landslide area on June 26, 2014 from county road areas that were open to public access at that time.

Olsson personnel reviewed the USGS Professional Paper 617, Quaternary Geology of the Grand and Battlement Mesas Area, Colorado and accompanying Geologic Map of Surficial Deposits in the Grand and Battlement Mesas Area, Delta, Mesa, and Garfield Counties, Colorado scale 1:96,000 (Yeend, 1969). The map shows terrace gravels (Qga) overlying Wasatch bedrock in proximity to the site, and alluvial and eolian and lake sand, silt, and clay deposits in Section 22. A generalized geology map of the site is presented as **G-1 Geology Map of the HCWTF DAF Unit**.

Olsson reviewed the Surficial-Geologic and Landslide Map of Veg Reservoir and Vicinity, Mesa County, Colorado at a scale of 1:24,000 (Soule, 1988). Almost all the bedrock outcrops exposed in the area of Vega Reservoir and vicinity consist of Tertiary sedimentary rocks of the Wasatch Formation and the overlying Green River Formation. This map was prepared as an evaluation of the state of landsliding and landsliding potential in an area where both surficial deposits and bedrock are, or have been in the recent geologic past, prone to mass slope movements. Exposures of in situ bedrock are uncommon due to widespread ancient and modern landslides of various scales. The map hazard assessment divides landslides into four types: 1) ancient, 2) old, 3) young, and 4) modern or active.

Ancient landslides (ols) are defined as areas where the landsliding process took place long enough ago that erosion and other surficial processes have considerably modified the form of the deposit. It is thought that these landslide deposits formed thousands or tens of thousands of years ago and that the area affected has been in static equilibrium since that time. Climate conditions may have been very different at that time and greater precipitation rates, soil moisture, and shallow groundwater conditions are thought to have resulted in much larger landslides due to loading on top of the weak claystone of the Wasatch Formation.

Old landslides (ls) are defined as areas where surficial deposits are composed of landslide material that retains most of its landslide form and where recent or modern movement is clearly not taking place. These may include composites of several individual landslides of different ages. Evidence is based on location of drainage(s), assessment of landslide landforms, and the steepness and composition of the slope.

Young landslides (yls) are features that have all of the attributes of modern landslides except that present movement is unlikely or uncertain. In most instances, these young landslides are in a state of metastable equilibrium and would likely move if ground moisture were to increase or slopes became oversteepened. In many places, young landslides are contained within old landslides or ancient landslides suggesting a continuous process occurs whereby one type may grade into another.

Modern landslides (Als) are features that exhibit simple to complex slope failures, usually no more than a few tens of feet thick and are undoubtedly active at the present time. Movement of these slope failures can range from a few feet per day (earth creep) to nil depending on local and seasonal moisture conditions and changes, oversteepening of slopes by erosion or other means, seasonal weather changes, and variation in bedrock types beneath them. In almost all cases, landslides in the area are composed of material derived from sandstone and shale of the Wasatch Formation.

According to the Open File 88-1, Plate 1 map, the proposed site is mapped as being underlain by sandstone, shale, and marlstone of the Wasatch Formation. An ancient landslide is shown in the NW ¼ NE ¼ of Section 22, and old landslides are shown in the SE ¼ of Section 22. Topography in these areas slopes to the south and away from the proposed DAF Plant Site.

There is a small area in the NW ¼ NW ¼ of Section 23 to the east that is mapped as a young landslide (yls); however, this is located along the Jeep trail and in close proximity to Harrison Creek and Bogue Gulch. There are no mapped old landslides or ancient landslides in the vicinity of the young landslide, and is not expected to affect the proposed DAF Plant Site. There is also a young landslide mapped in the NW ¼ NW ¼ of Section 22 that overlooks Buzzard Creek, and is not expected to affect the proposed DAF Plant Site.

Hydrology plays a critical role in the potential for landslide development. Hydrologic factors often trigger landslides, posed by the soil and geological conditions, and topographic slope of a slide prone area. The frequency and amount of precipitation within a given year, the amount of groundwater storage capacity and groundwater transmissivity within a slide prone area, pumping rates from area water wells, the density and types of vegetation in the area, and the proximity to springs and surface drainages all are potential factors or contributing factors in landslide occurrence. A hydrology map of the DAF Plant Site is included as **H-1 Hydrology Map of the HCWTF DAF Unit**.

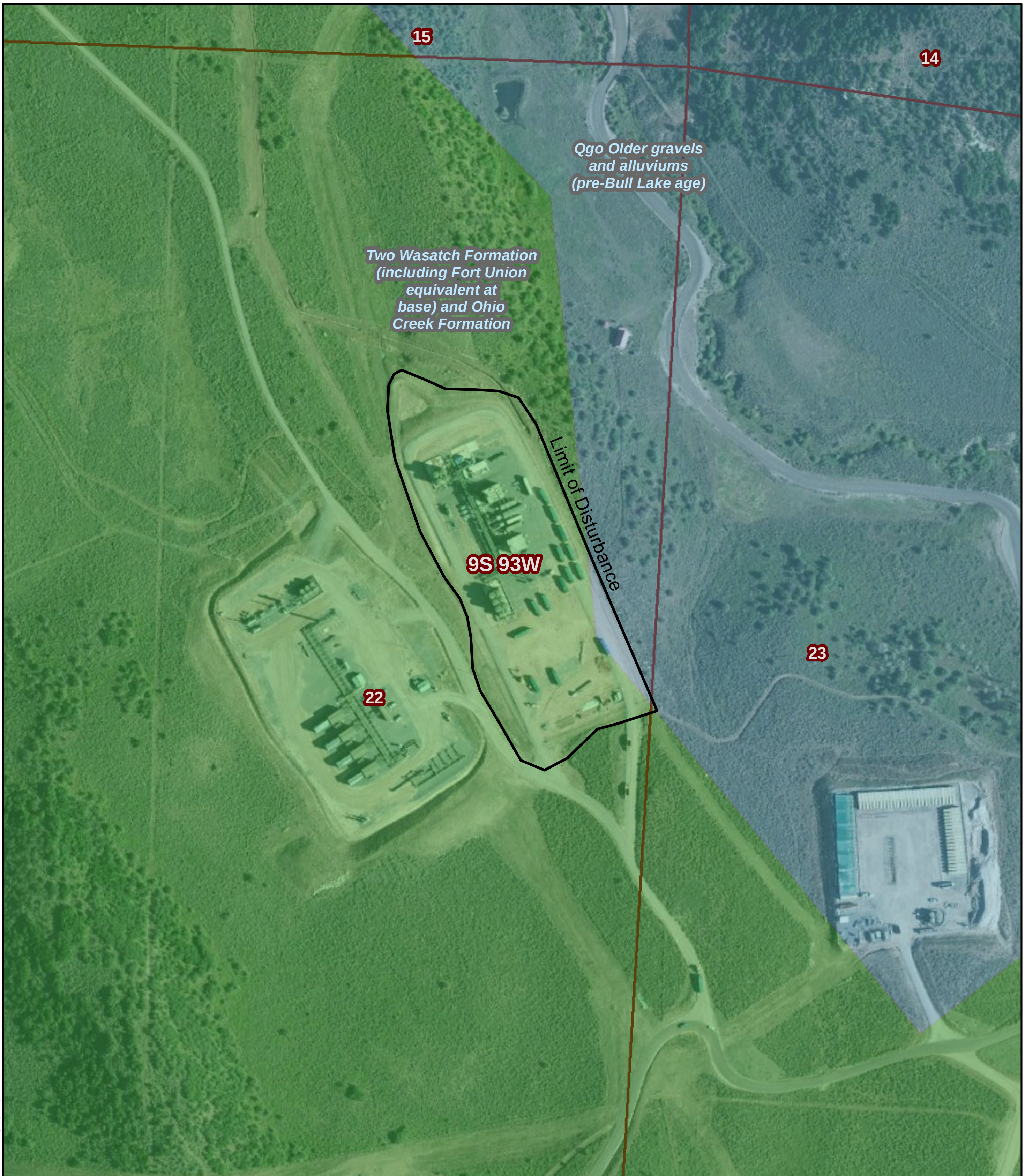
The nearest modern landslide areas mapped in proximity to the prosed DAF Plant Site are located to the east in Section 24, to the east of Harrison Creek, and in the north part of Section 26, and the NE ¼ NE ¼ of Section 28. These slides are not expected to affect the proposed site and are in areas that slope away from the proposed DAF Plant Site.

Colluvium and slope wash (c-sw) deposits are also shown in the NW ¼ of Section 22. These deposits are usually found on gentle slopes and consist of fine-grained alluvium and colluvium derived from nearby sandstone and shale supported hillslopes. These deposits can be coincident with places that are flood prone and can therefore pose a hazard of flooding. These deposits are located to the northwest of the site and the young landslide in the NW ¼ NW ¼ of Section 22, and slope to the north-northwest, away from the proposed DAF Plant Site.

The proposed DAF Plant site is located approximately 7 miles to the northeast of the West Salt Creek landslide location. The Open File 88-1 Plate 2 (Soule, 1988) shows the location of the West Salt Creek landslide, in Section 23. Landslide deposits and beaver ponds are shown in the area where the headwaters for West Salt Creek are located. The West Salt Creek headwaters are in a broad basin at an elevation of approximately 9,600 feet and surrounded by steep slopes. Ancient landslide deposits were mapped to the north along West Salt Creek in the west half of Section 14, and in the SW ¼ of Section 15, Township 10 South, Range 94 West.

The soil type in the vicinity of West Salt Creek landslide is mapped as the Clayburn, warm-Booneville-Needleton family complex (unit 121), formed on 25 to 65 percent slopes. The proposed DAF Plant site is primarily underlain by soils of the Hesperus-Empedrado, moist Pagoda complex. This unit is found on mountain slopes and benches with 5 to 35 percent slopes. A soil map for the DAF Plant site is presented as **S-1 Soils Map of the HCWTF DAF Unit**.

Therefore, the slope, elevation, drainage conditions, and soil types are very different between the West Salt Creek landslide area and the proposed DAF Plant Site. While there is evidence of landslides in Section 22, Township 9 South, Range 93 West, they are not in the immediate vicinity of the proposed Site. The proposed DAF Plant is located on a site that gently slopes to the northeast. Surrounding areas are covered with grasses and sagebrush. Vegetative cover should be maintained to stabilize slopes. Proper design and engineering controls may be necessary to drain water from cut slopes and away from the project area to minimize the chance of slope failure.



DISCLAIMER : This Geographic Information System (GIS) and its components are designed as a source of reference for answering inquiries, for planning and for modeling. GIS is not intended, nor does it replace legal description information in the chain of title and other information contained in official government records such as the County Clerk and Recorders office or the courts. In addition, the representations of locations in this GIS cannot be substituted for actual legal surveys.

0 125 250 Feet

N

Project Number: 014-0465

Drawn By: JWH

Revision Date: 2/19/2015

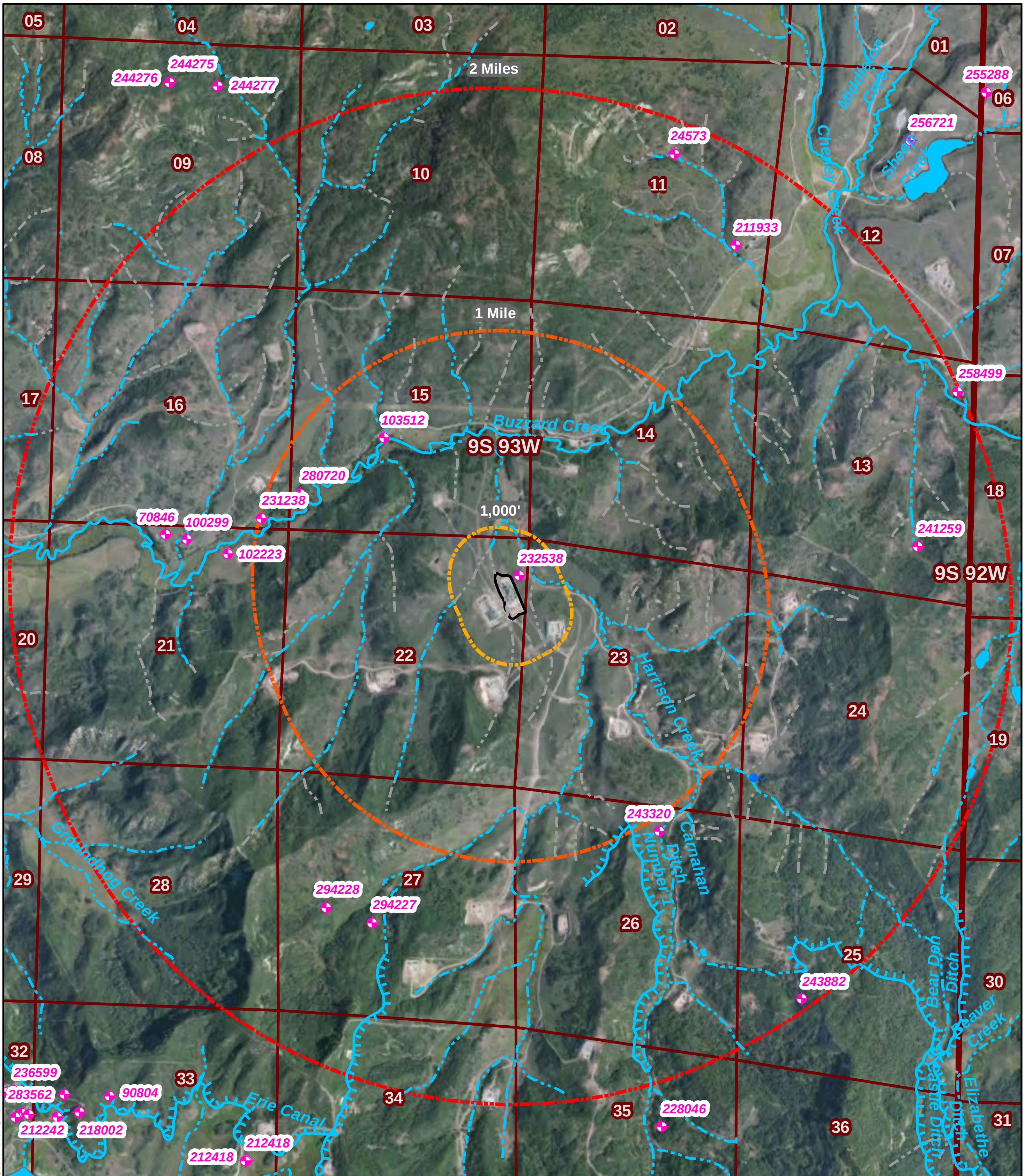
Geology Map
Harrison Creek Water Treatment Facility
DAF Unit
Piceance Energy, LLC
Mesa County, CO
Sec. 22, T9S, R93W, 6th PM

OLSSON® ASSOCIATES
760 Horizon Drive, Suite 102
Grand Junction, CO 81506
P: 970.263.7800
F: 970.263.7456

Figure

G-1

F:\Projects\014-0465\GIS\MXD\S-1 Geology Map HCWTF DAF Unit.mxd



Site footprint
Water Well
Spring
Waterbody
Perennial Stream
Intermittent Stream
Ephemeral Stream
Ditch / Canal

DISCLAIMER : This Geographic Information System (GIS) and its components are designed as a source of reference for answering inquiries, for planning and for modeling. GIS is not intended, nor does it replace legal description information in the chain of title and other information contained in official government records such as the County Clerk and Recorders office or the courts. In addition, the representations of locations in this GIS cannot be substituted for actual legal surveys.

0 0.25 0.5 Miles

N

Project Number: 014-0465

Drawn By: JWH

Revision Date: 2/19/2015

Hydrology Map
Harrison Creek Water Treatment Facility
DAF Unit
Piceance Energy, LLC
Mesa County, CO
Sec 22, T9S, R93W, 6th PM

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Figure

H-1

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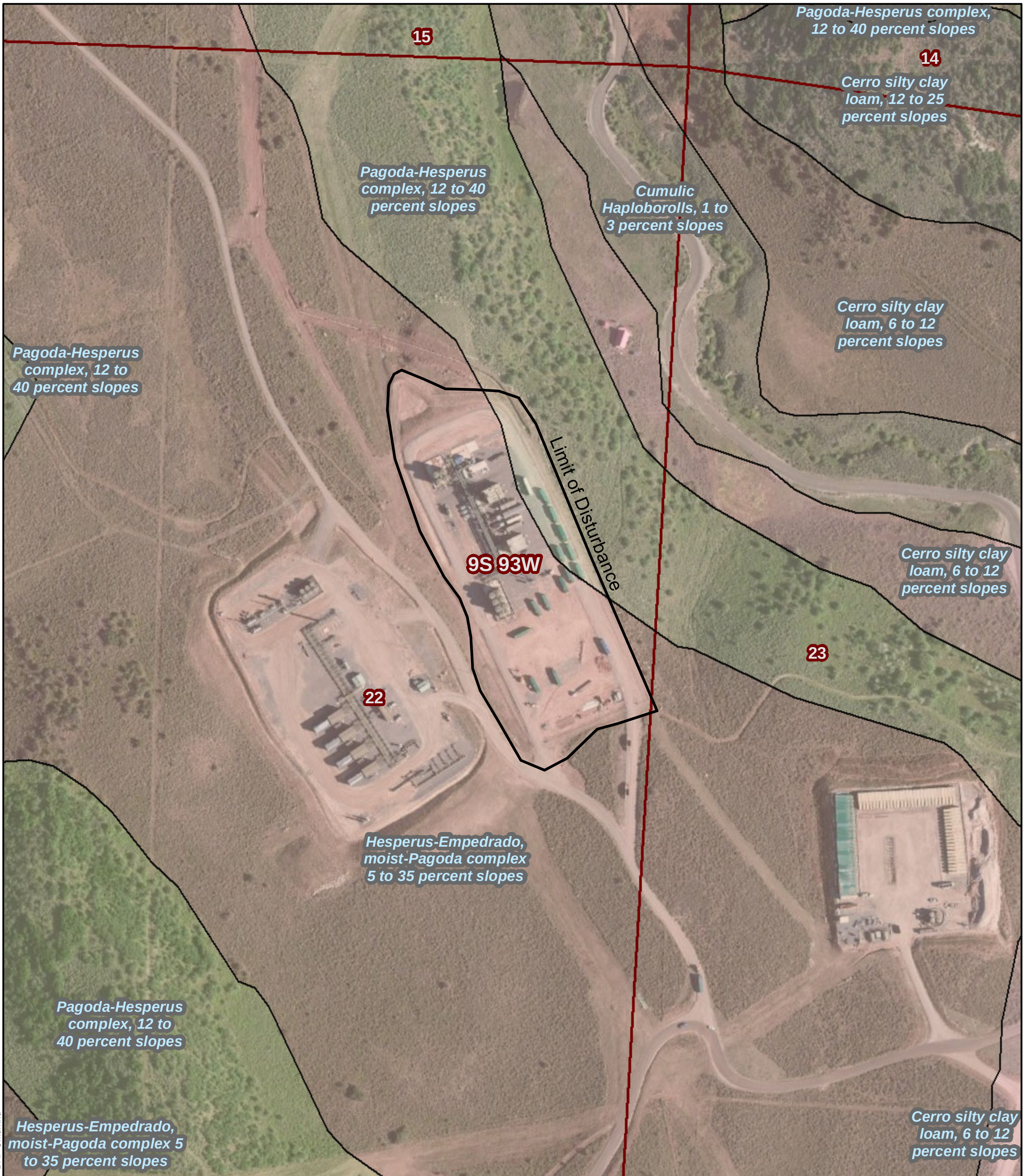

0 125 250
Feet

N

Project Number: 014-0465	**Soils Map** Harrison Creek Water Treatment Facility DAF Unit Piceance Energy, LLC Mesa County, CO Sec. 22, T9S, R93W, 6th PM	OLSSON ASSOCIATES®	760 Horizon Drive, Suite 102 Grand Junction, CO 81506 P: 970.263.7800 F: 970.263.7456	Figure **S-1**
Drawn By: JWH				
Revision Date: 2/19/2015				

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United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties

Piceance Energy LLC Harrison Creek Water Management Facility DAF Unit

April 30, 2010

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://soils.usda.gov/sqi/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://soils.usda.gov/contact/state_offices/).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Soil Data Mart Web site or the NRCS Web Soil Survey. The Soil Data Mart is the data storage site for the official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

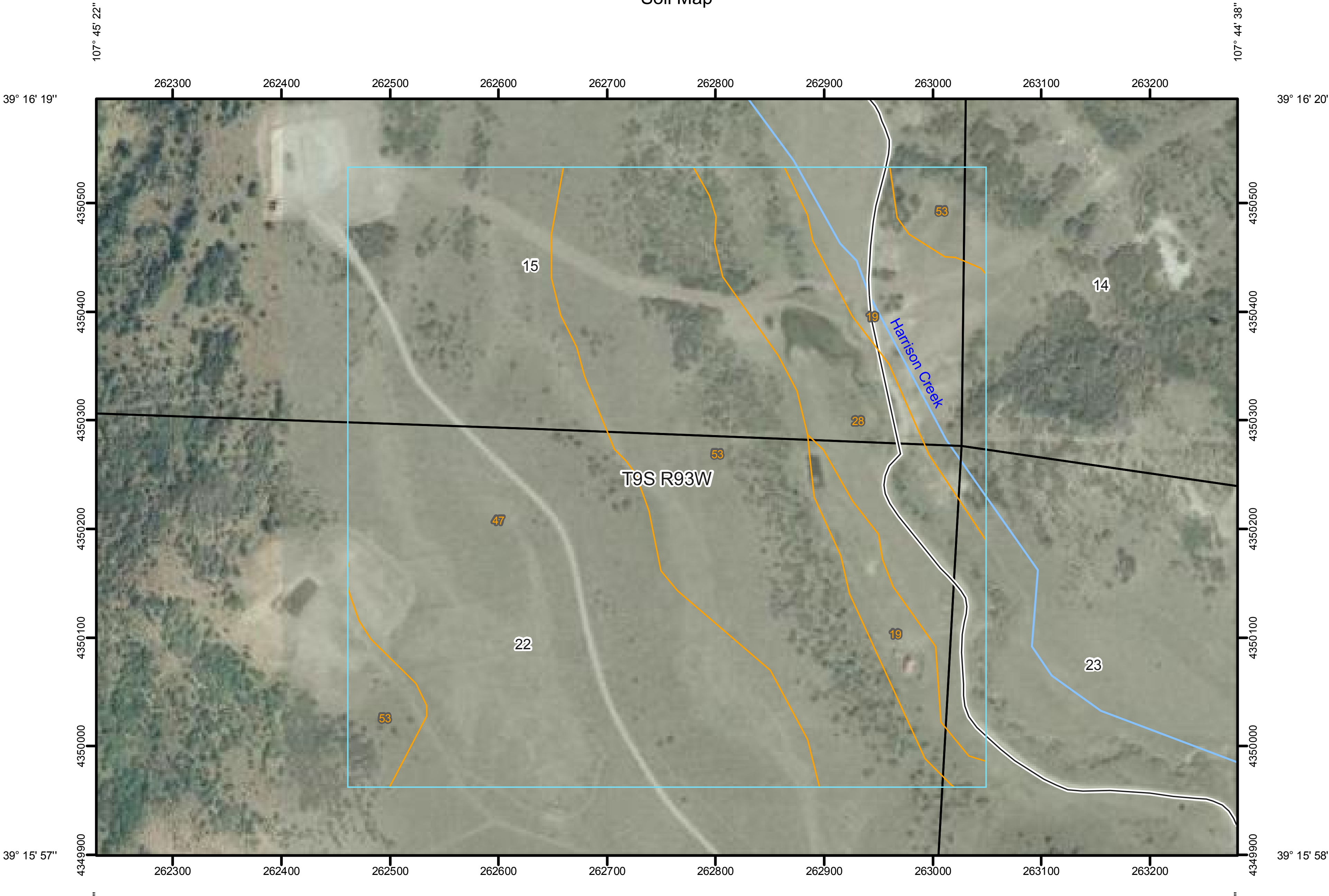
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

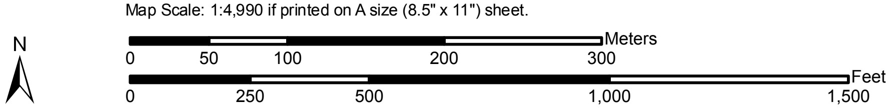
Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map



Map Scale: 1:4,990 if printed on A size (8.5" x 11") sheet.



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Gully

Short Steep Slope

Other

Political Features

Cities

PLSS Township and Range

PLSS Section

Water Features

Oceans

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

MAP INFORMATION

Map Scale: 1:4,990 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 5, Feb 1, 2008

Date(s) aerial images were photographed: 8/29/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties (CO682)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
19	Cerro silty clay loam, 6 to 12 percent slopes	9.9	11.9%
28	Cumulic Haploborolls, 1 to 3 percent slopes	10.9	13.1%
47	Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes	37.5	45.2%
53	Pagoda-Hesperus complex, 12 to 40 percent slopes	24.6	29.7%
Totals for Area of Interest		**82.9**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties

19—Cerro silty clay loam, 6 to 12 percent slopes

Map Unit Setting

Elevation: 6,600 to 7,000 feet
Frost-free period: 80 to 90 days

Map Unit Composition

Cerro and similar soils: 70 percent

Description of Cerro

Setting

Landform: Hills
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Marine shales of the wasatch formation colluvium and/or marine shales of the wasatch formation residuum

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: High (about 10.7 inches)

Interpretive groups

Land capability (nonirrigated): 4e
Ecological site: Deep Clay Loam (R048AY247CO)

Typical profile

0 to 7 inches: Silty clay loam
7 to 12 inches: Silty clay loam
12 to 35 inches: Silty clay
35 to 60 inches: Silty clay loam

28—Cumulic Haploborolls, 1 to 3 percent slopes

Map Unit Setting

Elevation: 5,800 to 7,400 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 40 to 46 degrees F

Frost-free period: 80 to 110 days

Map Unit Composition

Cumulic haploborolls and similar soils: 90 percent

Description of Cumulic Haploborolls

Setting

Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Wasatch shale formation alluvium and/or green river shale formation alluvium

Properties and qualities

Slope: 1 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: About 36 to 72 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: Low (about 4.6 inches)

Interpretive groups

Land capability (nonirrigated): 4e
Ecological site: Foothill Swale (R048AY285CO)

Typical profile

0 to 8 inches: Gravelly sandy clay loam
8 to 20 inches: Very channery sandy clay loam
20 to 28 inches: Clay loam
28 to 60 inches: Stratified very gravelly sand to extremely gravelly loamy sand

47—Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes

Map Unit Setting

Elevation: 6,200 to 8,500 feet
Mean annual precipitation: 18 to 20 inches
Mean annual air temperature: 42 to 44 degrees F
Frost-free period: 85 to 100 days

Map Unit Composition

Hesperus and similar soils: 35 percent
Empedrado, moist, and similar soils: 30 percent
Pagoda and similar soils: 20 percent

Description of Hesperus

Setting

Landform: Mountainsides
Landform position (three-dimensional): Mountainflank
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 5 to 35 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very high (about 21.2 inches)

Interpretive groups

Land capability (nonirrigated): 6e
Ecological site: Brushy Loam (R048AY238CO)

Typical profile

0 to 7 inches: Loam
7 to 60 inches: Clay loam, loam

Description of Empedrado, Moist

Setting

Landform: Benches
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium derived from sandstone and shale and/or residuum weathered from sandstone and shale

Properties and qualities

Slope: 5 to 35 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: High (about 9.7 inches)

Interpretive groups

Land capability (nonirrigated): 6e
Ecological site: Brushy Loam (R048AY238CO)

Typical profile

0 to 10 inches: Loam
10 to 21 inches: Clay loam

21 to 28 inches: Gravelly sandy clay loam
28 to 60 inches: Loam

Description of Pagoda

Setting

Landform: Benches, mountains
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear, concave
Across-slope shape: Linear
Parent material: Colluvium derived from shale

Properties and qualities

Slope: 5 to 35 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Very high (about 18.7 inches)

Interpretive groups

Land capability (nonirrigated): 6e
Ecological site: Brushy Loam (R048AY238CO)

Typical profile

0 to 6 inches: Clay loam
6 to 17 inches: Clay loam
17 to 27 inches: Clay loam, clay
27 to 60 inches: Clay loam, clay

53—Pagoda-Hesperus complex, 12 to 40 percent slopes

Map Unit Setting

Elevation: 7,400 to 8,000 feet
Mean annual precipitation: 18 to 22 inches
Frost-free period: 75 to 85 days

Map Unit Composition

Pagoda and similar soils: 50 percent
Hesperus and similar soils: 20 percent

Description of Pagoda

Setting

Landform: Mudflows

Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Alluvium derived from shale and/or colluvium derived from shale

Properties and qualities

Slope: 12 to 40 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Very high (about 18.7 inches)

Interpretive groups

Land capability (nonirrigated): 7e
Ecological site: Brushy Loam (R048AY238CO)

Typical profile

0 to 6 inches: Clay loam
6 to 17 inches: Clay loam
17 to 27 inches: Clay loam, clay
27 to 60 inches: Clay loam, clay

Description of Hesperus

Setting

Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear

Properties and qualities

Slope: 12 to 40 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very high (about 21.2 inches)

Interpretive groups

Land capability (nonirrigated): 7e
Ecological site: Brushy Loam (R048AY238CO)

Typical profile

0 to 7 inches: Loam
7 to 60 inches: Clay loam, loam

Soil Information for All Uses

Suitabilities and Limitations for Use

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

Building Site Development

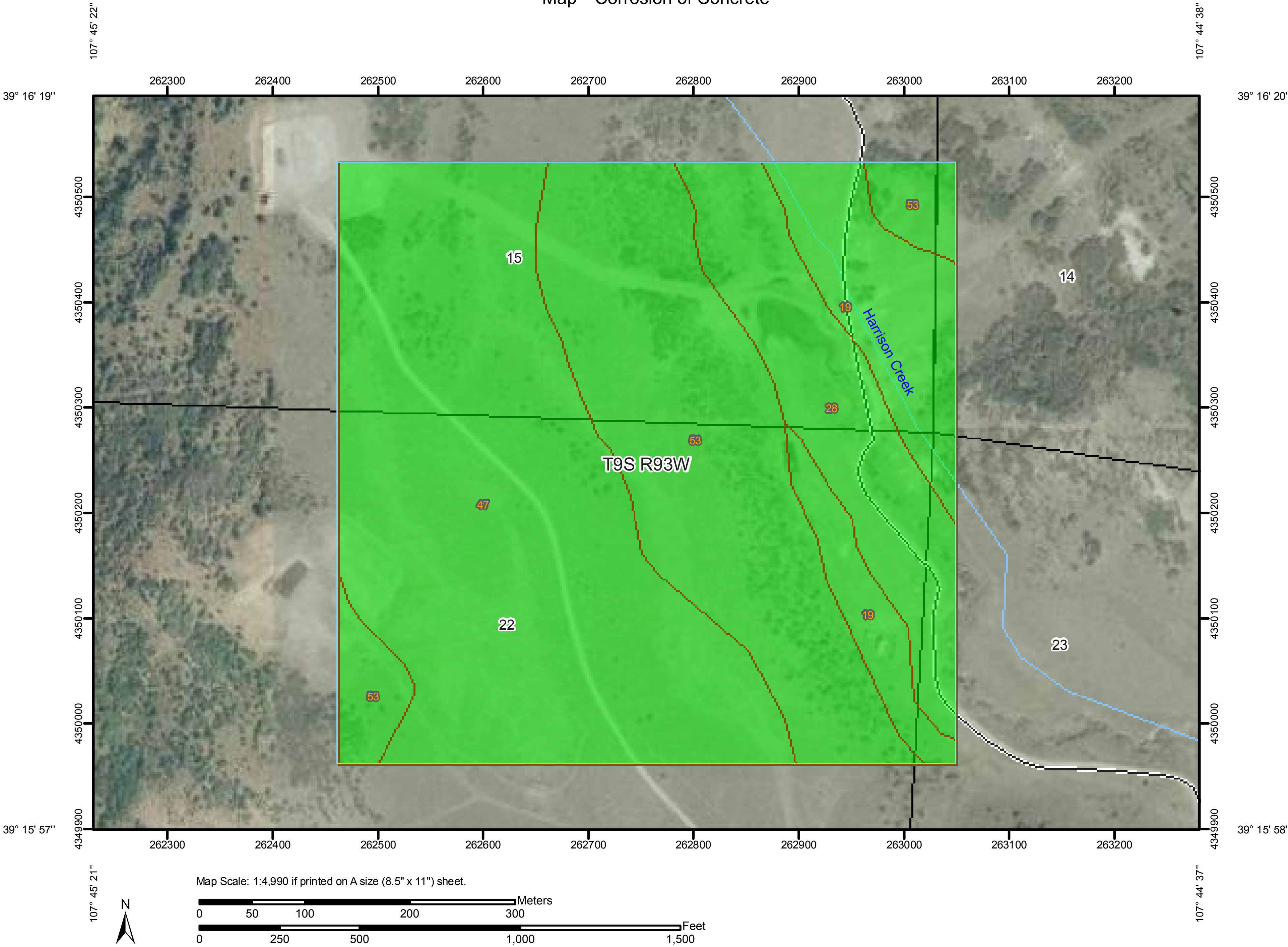
Building site development interpretations are designed to be used as tools for evaluating soil suitability and identifying soil limitations for various construction purposes. As part of the interpretation process, the rating applies to each soil in its described condition and does not consider present land use. Example interpretations can include corrosion of concrete and steel, shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping.

Corrosion of Concrete

"Risk of corrosion" pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens concrete. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the concrete in installations that are entirely within one kind of soil or within one soil layer.

The risk of corrosion is expressed as "low," "moderate," or "high."

Custom Soil Resource Report
Map—Corrosion of Concrete



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- High
- Moderate
- Low
- Not rated or not available

Political Features

- Cities
- PLSS Township and Range
- PLSS Section

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:4,990 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 5, Feb 1, 2008

Date(s) aerial images were photographed: 8/29/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Corrosion of Concrete

Corrosion of Concrete— Summary by Map Unit — Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
19	Cerro silty clay loam, 6 to 12 percent slopes	Low	9.9	11.9%
28	Cumulic Haploborolls, 1 to 3 percent slopes	Low	10.9	13.1%
47	Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes	Low	37.5	45.2%
53	Pagoda-Hesperus complex, 12 to 40 percent slopes	Low	24.6	29.7%
Totals for Area of Interest			**82.9**	**100.0%**

Rating Options—Corrosion of Concrete

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

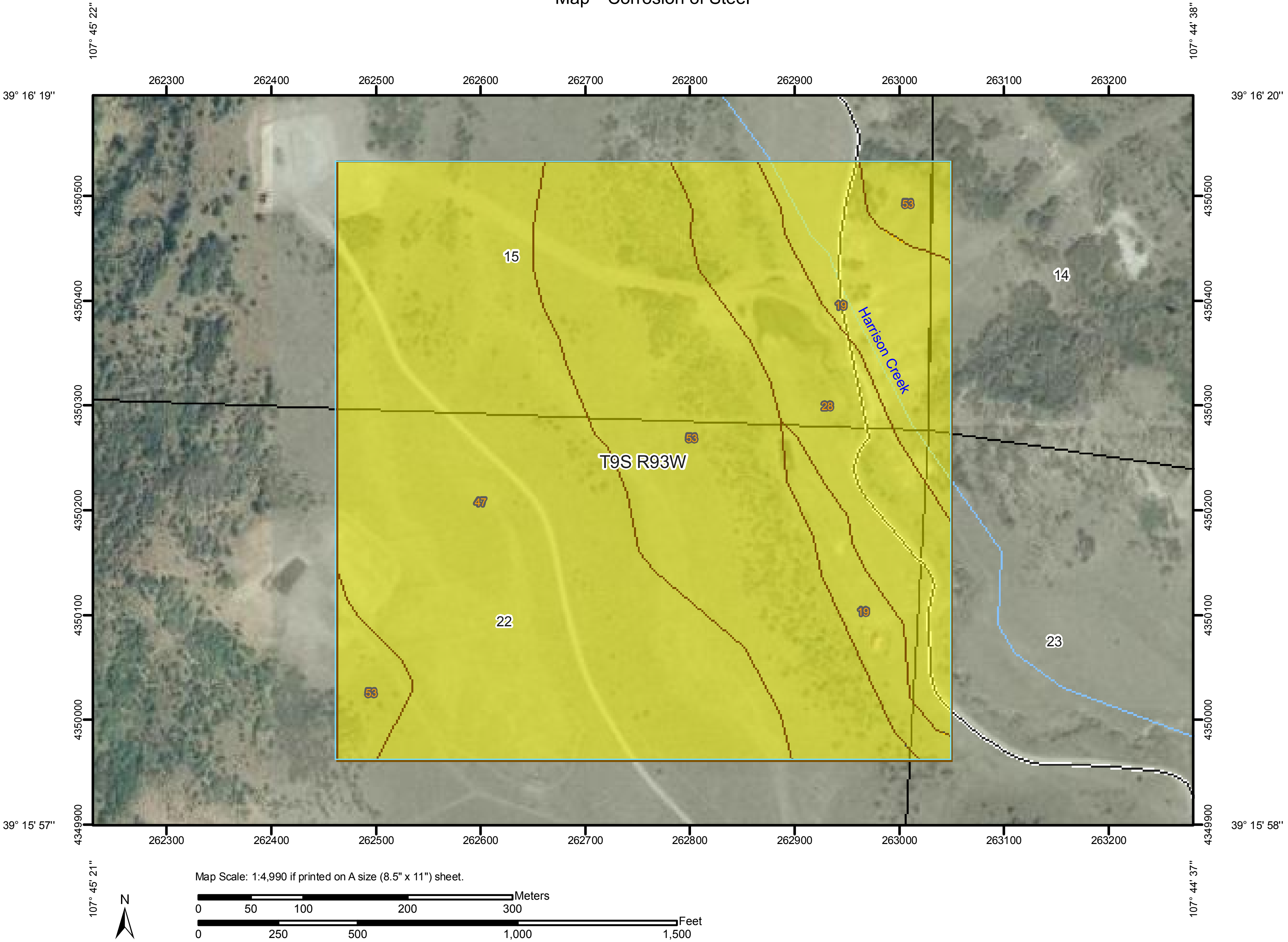
Tie-break Rule: Higher

Corrosion of Steel

"Risk of corrosion" pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel in installations that are entirely within one kind of soil or within one soil layer.

The risk of corrosion is expressed as "low," "moderate," or "high."

Map—Corrosion of Steel



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- High
- Moderate
- Low
- Not rated or not available

Political Features

- Cities
- PLSS Township and Range
- PLSS Section

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:4,990 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 5, Feb 1, 2008

Date(s) aerial images were photographed: 8/29/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Corrosion of Steel

Corrosion of Steel— Summary by Map Unit — Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
19	Cerro silty clay loam, 6 to 12 percent slopes	Moderate	9.9	11.9%
28	Cumulic Haploborolls, 1 to 3 percent slopes	Moderate	10.9	13.1%
47	Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes	Moderate	37.5	45.2%
53	Pagoda-Hesperus complex, 12 to 40 percent slopes	Moderate	24.6	29.7%
Totals for Area of Interest			**82.9**	**100.0%**

Rating Options—Corrosion of Steel

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

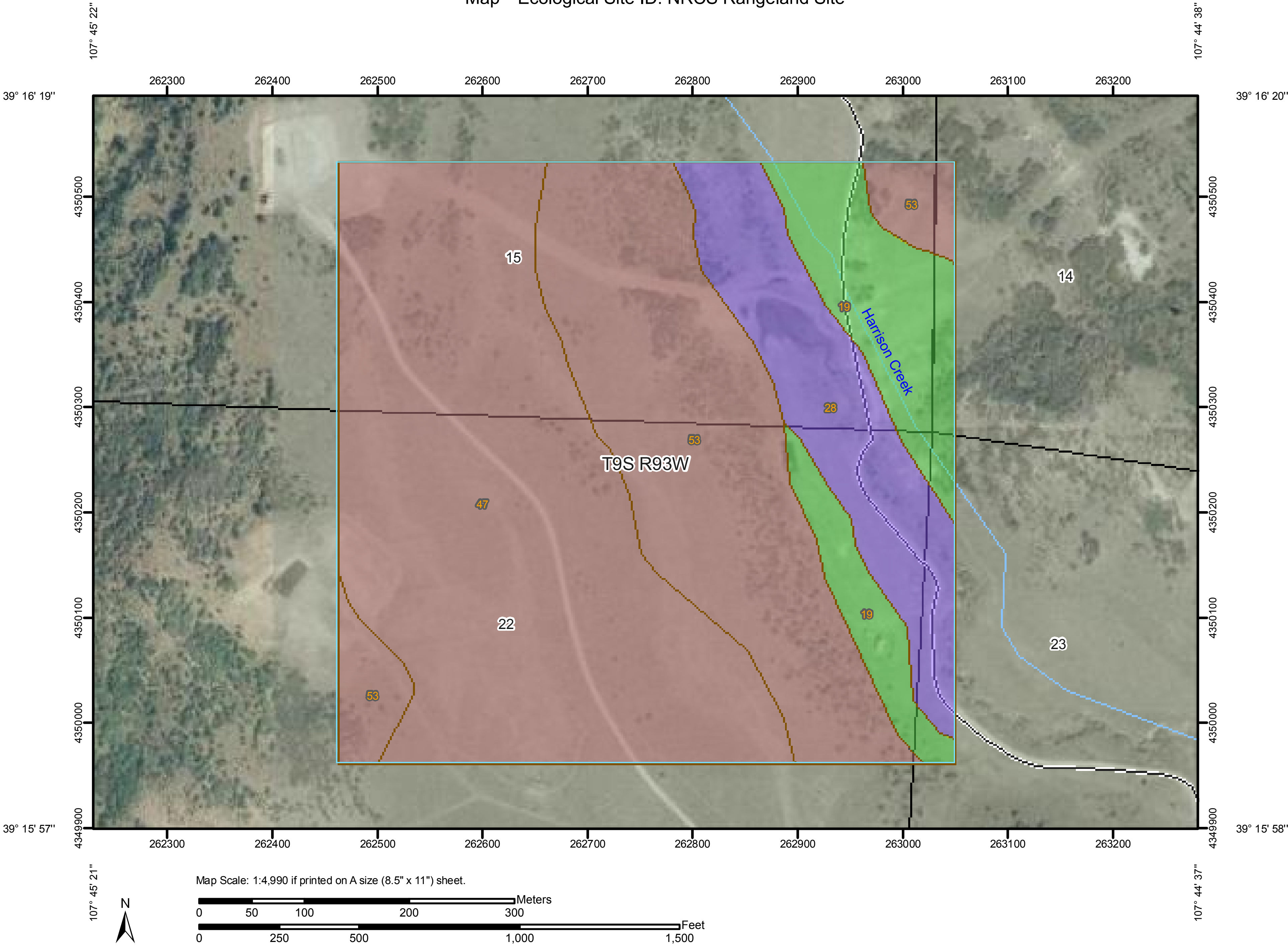
Land Classifications

Land Classifications are specified land use and management groupings that are assigned to soil areas because combinations of soil have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil. Example classifications include ecological site classification, farmland classification, irrigated and nonirrigated land capability classification, and hydric rating.

Ecological Site ID: NRCS Rangeland Site

An "ecological site ID" is the symbol assigned to a particular ecological site. An "ecological site" is the product of all the environmental factors responsible for its development. It has characteristic soils that have developed over time; a characteristic hydrology, particularly infiltration and runoff, that has developed over time; and a characteristic plant community (kind and amount of vegetation). The vegetation, soils, and hydrology are all interrelated. Each is influenced by the others and influences the development of the others. For example, the hydrology of the site is influenced by development of the soil and plant community. The plant community on an ecological site is typified by an association of species that differs from that of other ecological sites in the kind and/or proportion of species or in total production. Descriptions of ecological sites are provided in the Field Office Technical Guide, which is available in local offices of the Natural Resources Conservation Service.

Map—Ecological Site ID: NRCS Rangeland Site



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- R048AY238CO
- R048AY247CO
- R048AY285CO
- Not rated or not available

Political Features

- Cities
- PLSS Township and Range
- PLSS Section

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:4,990 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 5, Feb 1, 2008

Date(s) aerial images were photographed: 8/29/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Ecological Site ID: NRCS Rangeland Site

Ecological Site ID: NRCS Rangeland Site— Summary by Map Unit — Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
19	Cerro silty clay loam, 6 to 12 percent slopes	R048AY247CO	9.9	11.9%
28	Cumulic Haploborolls, 1 to 3 percent slopes	R048AY285CO	10.9	13.1%
47	Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes	R048AY238CO	37.5	45.2%
53	Pagoda-Hesperus complex, 12 to 40 percent slopes	R048AY238CO	24.6	29.7%
Totals for Area of Interest			**82.9**	**100.0%**

Rating Options—Ecological Site ID: NRCS Rangeland Site

Class: NRCS Rangeland Site

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Land Management

Land management interpretations are tools designed to guide the user in evaluating existing conditions in planning and predicting the soil response to various land management practices, for a variety of land uses, including cropland, forestland, hayland, pastureland, horticulture, and rangeland. Example interpretations include suitability for a variety of irrigation practices, log landings, haul roads and major skid trails, equipment operability, site preparation, suitability for hand and mechanical planting, potential erosion hazard associated with various practices, and ratings for fencing and waterline installation.

Mechanical Site Preparation (Surface)

The ratings in this interpretation indicate the suitability for use of surface-altering soil tillage equipment during site preparation in forested areas. The ratings are based on slope, depth to a restrictive layer, plasticity index, rock fragments on or below the surface, depth to a water table, and ponding. The part of the soil from the surface to a depth of about 1 foot is considered in the ratings.

The ratings are both verbal and numerical. Rating class terms indicate the degree to which the soils are suited to this aspect of forestland management. The soils are described as "well suited," "poorly suited," or "unsuited" to this management activity.

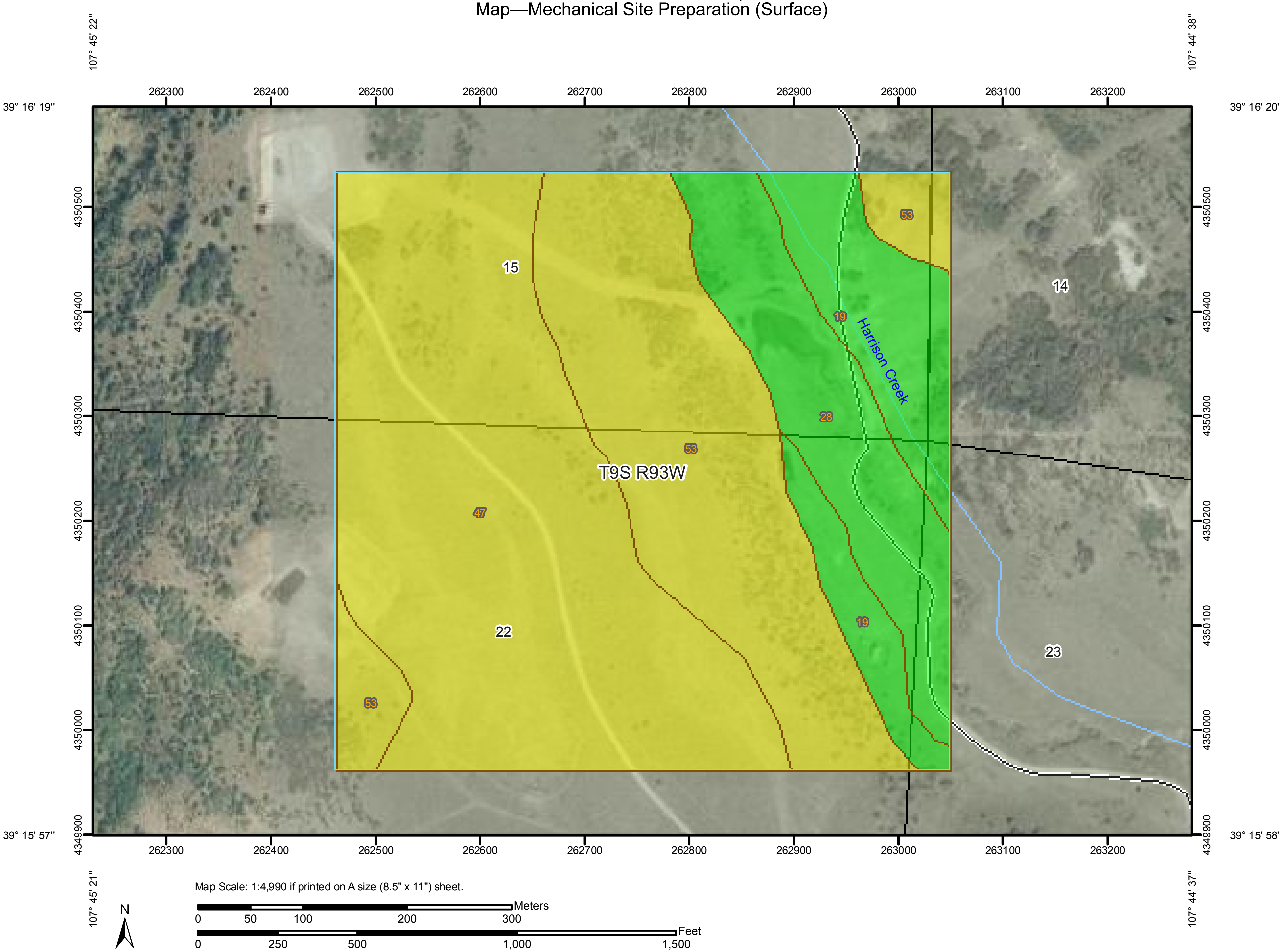
"Well suited" indicates that the soil has features that are favorable for the specified kind of site preparation and has no limitations. Good performance can be expected, and little or no maintenance is needed. "Poorly suited" indicates that the soil has one or more properties that are unfavorable for the specified kind of site preparation. Overcoming the unfavorable properties requires special design, extra maintenance, and costly alteration. "Unsuited" indicates that the expected performance of the soil is unacceptable for the specified kind of site preparation or that extreme measures are needed to overcome the undesirable soil properties.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified aspect of forestland management (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Map—Mechanical Site Preparation (Surface)



Map Scale: 1:4,990 if printed on A size (8.5" x 11") sheet.

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- Unsuited
- Poorly suited
- Well suited
- Not rated or not available

Political Features

- Cities
- PLSS Township and Range
- PLSS Section

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:4,990 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 5, Feb 1, 2008

Date(s) aerial images were photographed: 8/29/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables—Mechanical Site Preparation (Surface)

Mechanical Site Preparation (Surface)— Summary by Map Unit — Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
19	Cerro silty clay loam, 6 to 12 percent slopes	Well suited	Cerro (70%)		9.9	11.9%
28	Cumulic Haploborolls, 1 to 3 percent slopes	Well suited	Cumulic Haploborolls (90%)		10.9	13.1%
47	Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes	Poorly suited	Hesperus (35%)	Slope (0.50)	37.5	45.2%
			Empedrado, moist (30%)	Slope (0.50)		
			Pagoda (20%)	Slope (0.50)		
53	Pagoda-Hesperus complex, 12 to 40 percent slopes	Poorly suited	Pagoda (50%)	Slope (0.50)	24.6	29.7%
			Hesperus (20%)	Slope (0.50)		
Totals for Area of Interest					**82.9**	**100.0%**

Mechanical Site Preparation (Surface)— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Poorly suited	62.1	74.9%
Well suited	20.8	25.1%
Totals for Area of Interest	**82.9**	**100.0%**

Rating Options—Mechanical Site Preparation (Surface)

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Water Management

Water Management interpretations are tools for evaluating the potential of the soil in the application of various water management practices. Example interpretations include pond reservoir area, embankments, dikes, levees, and excavated ponds.

Excavated Ponds (Aquifer-Fed)

Excavated ponds (aquifer-fed) are pits or dugouts that extend to a ground-water aquifer or to a depth below a permanent water table. Excluded are ponds that are fed only by surface runoff and embankment ponds that impound water 3 feet or more above the original surface. Excavated ponds are affected by depth to a permanent water table, saturated hydraulic conductivity (Ksat) of the aquifer, and quality of the water as inferred from the salinity of the soil. Depth to bedrock and the content of large stones affect the ease of excavation.

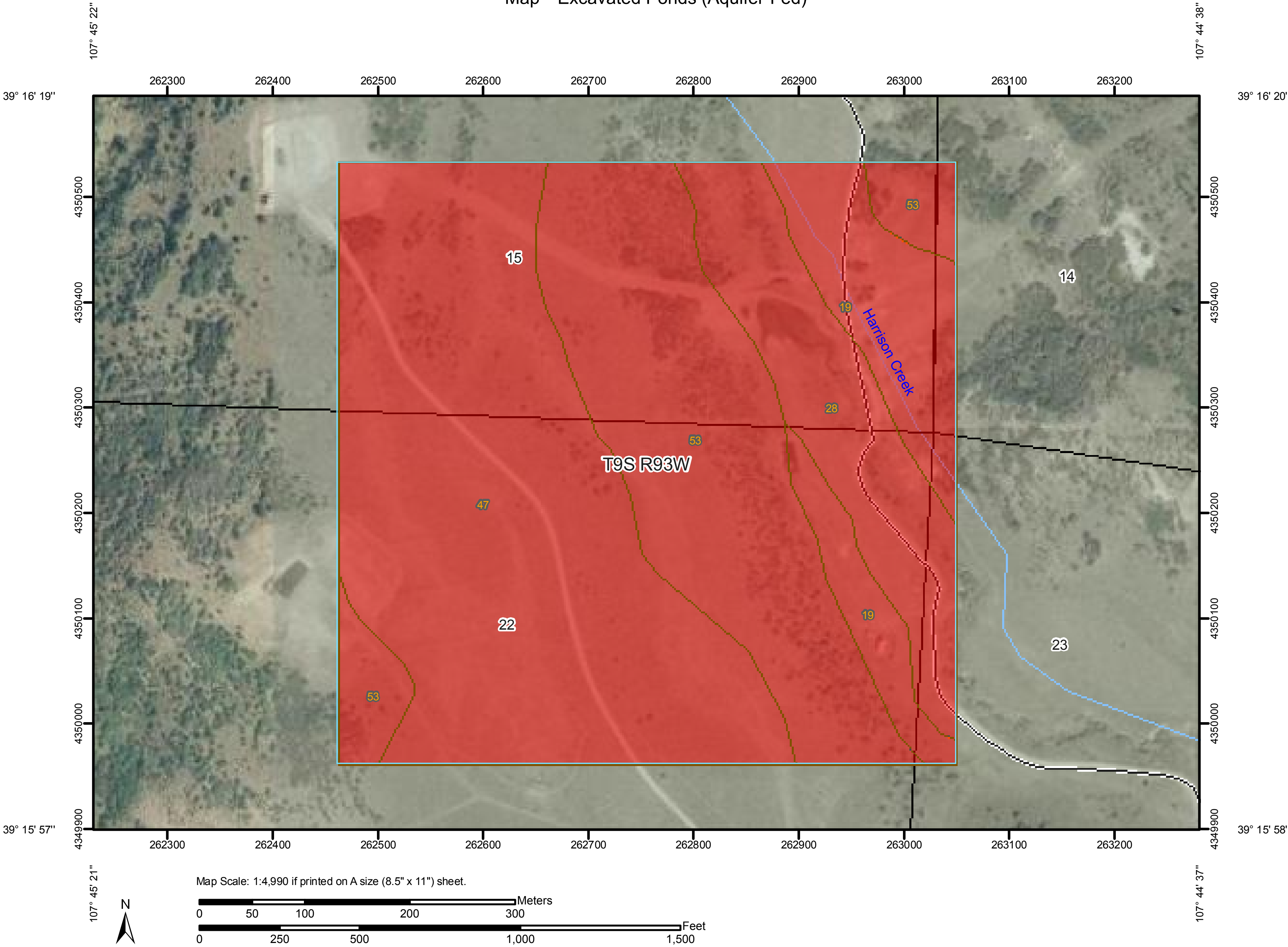
The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Custom Soil Resource Report
Map—Excavated Ponds (Aquifer-Fed)



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Political Features

- Cities
- PLSS Township and Range
- PLSS Section

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:4,990 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 5, Feb 1, 2008

Date(s) aerial images were photographed: 8/29/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables—Excavated Ponds (Aquifer-Fed)

Excavated Ponds (Aquifer-Fed)— Summary by Map Unit — Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
19	Cerro silty clay loam, 6 to 12 percent slopes	Very limited	Cerro (70%)	Depth to water (1.00)	9.9	11.9%
28	Cumulic Haploborolls, 1 to 3 percent slopes	Very limited	Cumulic Haploborolls (90%)	Cutbanks cave (1.00)	10.9	13.1%
				Depth to saturated zone (0.96)		
47	Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes	Very limited	Hesperus (35%)	Depth to water (1.00)	37.5	45.2%
			Empedrado, moist (30%)	Depth to water (1.00)		
			Pagoda (20%)	Depth to water (1.00)		
53	Pagoda-Hesperus complex, 12 to 40 percent slopes	Very limited	Pagoda (50%)	Depth to water (1.00)	24.6	29.7%
			Hesperus (20%)	Depth to water (1.00)		
Totals for Area of Interest					**82.9**	**100.0%**

Excavated Ponds (Aquifer-Fed)— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Very limited	82.9	100.0%
Totals for Area of Interest	**82.9**	**100.0%**

Rating Options—Excavated Ponds (Aquifer-Fed)

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Pond Reservoir Areas

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the saturated hydraulic conductivity (Ksat) of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

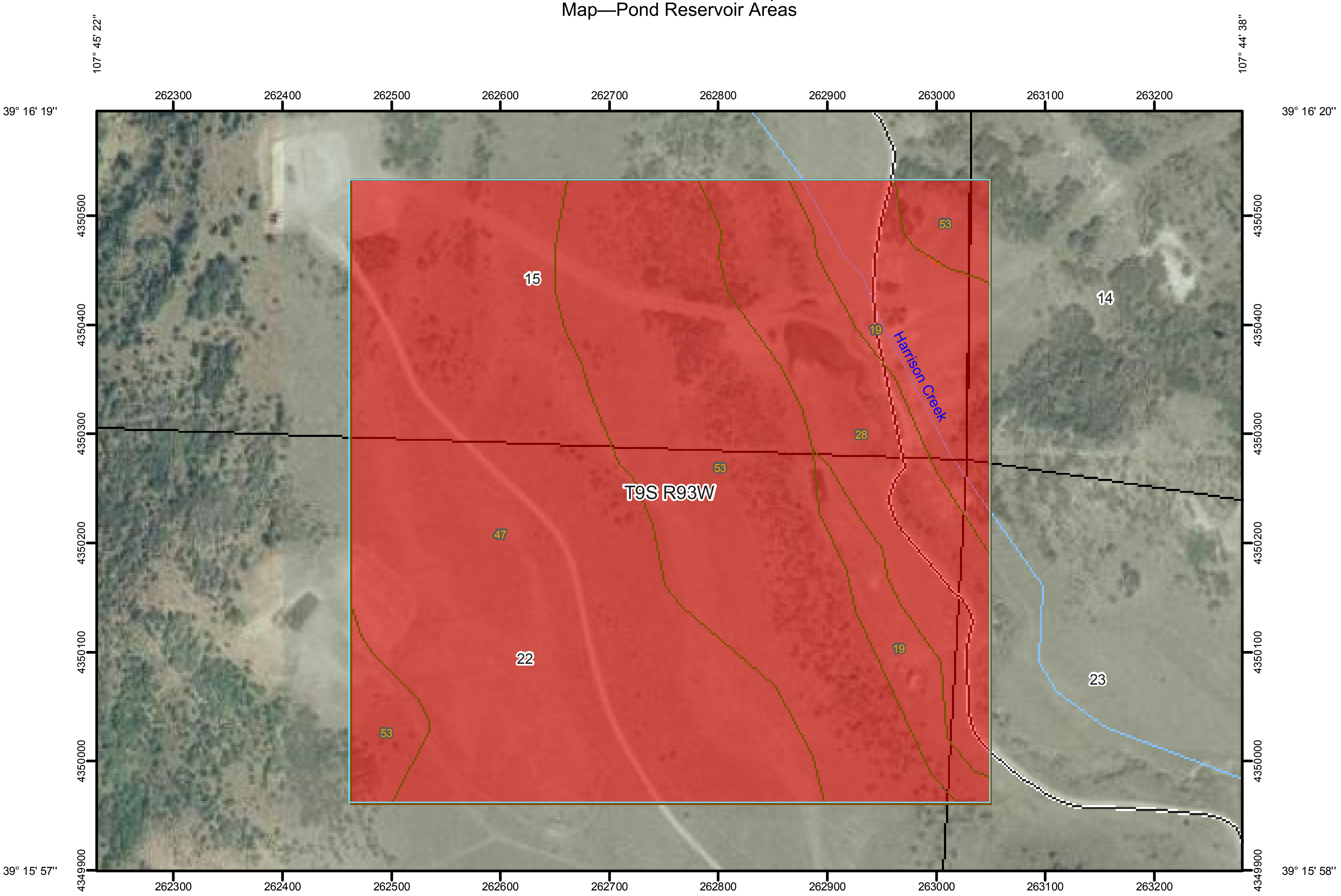
The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

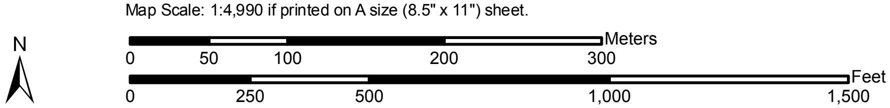
The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Custom Soil Resource Report
Map—Pond Reservoir Areas



Map Scale: 1:4,990 if printed on A size (8.5" x 11") sheet.



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Soil Ratings
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Political Features
- Cities
- PLSS Township and Range
- PLSS Section

Water Features
- Oceans
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:4,990 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 5, Feb 1, 2008

Date(s) aerial images were photographed: 8/29/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables—Pond Reservoir Areas

Pond Reservoir Areas— Summary by Map Unit — Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
19	Cerro silty clay loam, 6 to 12 percent slopes	Very limited	Cerro (70%)	Slope (1.00)	9.9	11.9%
				Seepage (0.02)		
28	Cumulic Haploborolls, 1 to 3 percent slopes	Very limited	Cumulic Haploborolls (90%)	Seepage (1.00)	10.9	13.1%
47	Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes	Very limited	Hesperus (35%)	Slope (1.00)	37.5	45.2%
				Seepage (0.04)		
			Empedrado, moist (30%)	Slope (1.00)		
				Seepage (0.72)		
			Pagoda (20%)	Slope (1.00)		
				Seepage (0.02)		
53	Pagoda-Hesperus complex, 12 to 40 percent slopes	Very limited	Pagoda (50%)	Slope (1.00)	24.6	29.7%
				Seepage (0.02)		
			Hesperus (20%)	Slope (1.00)		
				Seepage (0.04)		
Totals for Area of Interest					**82.9**	**100.0%**

Pond Reservoir Areas— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Very limited	82.9	100.0%
Totals for Area of Interest	**82.9**	**100.0%**

Rating Options—Pond Reservoir Areas

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

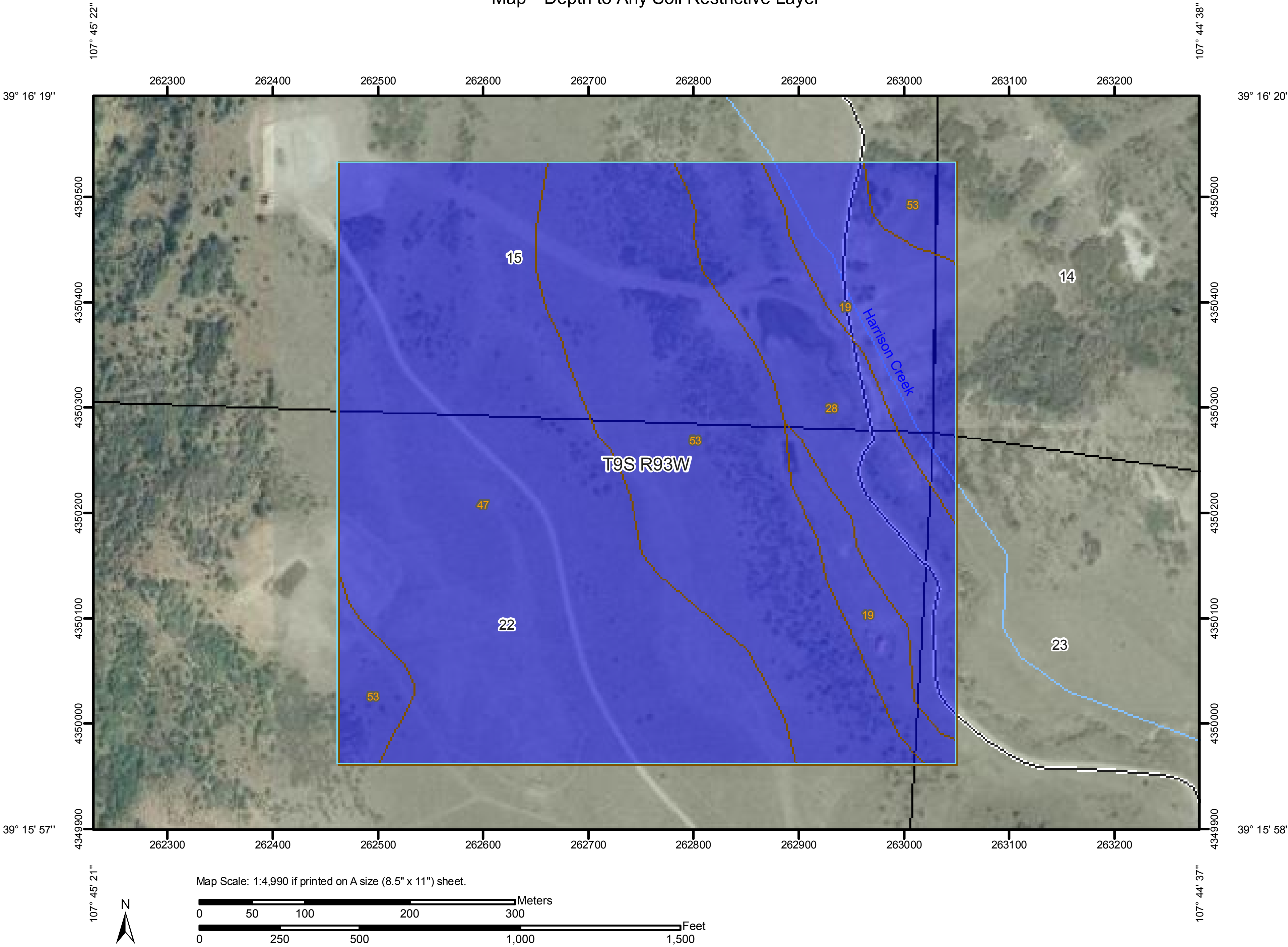
Depth to Any Soil Restrictive Layer

A "restrictive layer" is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers.

This theme presents the depth to any type of restrictive layer that is described for each map unit. If more than one type of restrictive layer is described for an individual soil type, the depth to the shallowest one is presented. If no restrictive layer is described in a map unit, it is represented by the "> 200" depth class.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Map—Depth to Any Soil Restrictive Layer



Map Scale: 1:4,990 if printed on A size (8.5" x 11") sheet.

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Soil Ratings

0 - 25

25 - 50

50 - 100

100 - 150

150 - 200

> 200

Political Features

Cities

PLSS Township and Range

PLSS Section

Water Features

Oceans

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

MAP INFORMATION

Map Scale: 1:4,990 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 5, Feb 1, 2008

Date(s) aerial images were photographed: 8/29/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Depth to Any Soil Restrictive Layer

Depth to Any Soil Restrictive Layer— Summary by Map Unit — Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties				
Map unit symbol	**Map unit name**	**Rating (centimeters)**	**Acres in AOI**	**Percent of AOI**
19	Cerro silty clay loam, 6 to 12 percent slopes	>200	9.9	11.9%
28	Cumulic Haploborolls, 1 to 3 percent slopes	>200	10.9	13.1%
47	Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes	>200	37.5	45.2%
53	Pagoda-Hesperus complex, 12 to 40 percent slopes	>200	24.6	29.7%
Totals for Area of Interest			**82.9**	**100.0%**

Rating Options—Depth to Any Soil Restrictive Layer

Units of Measure: centimeters

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

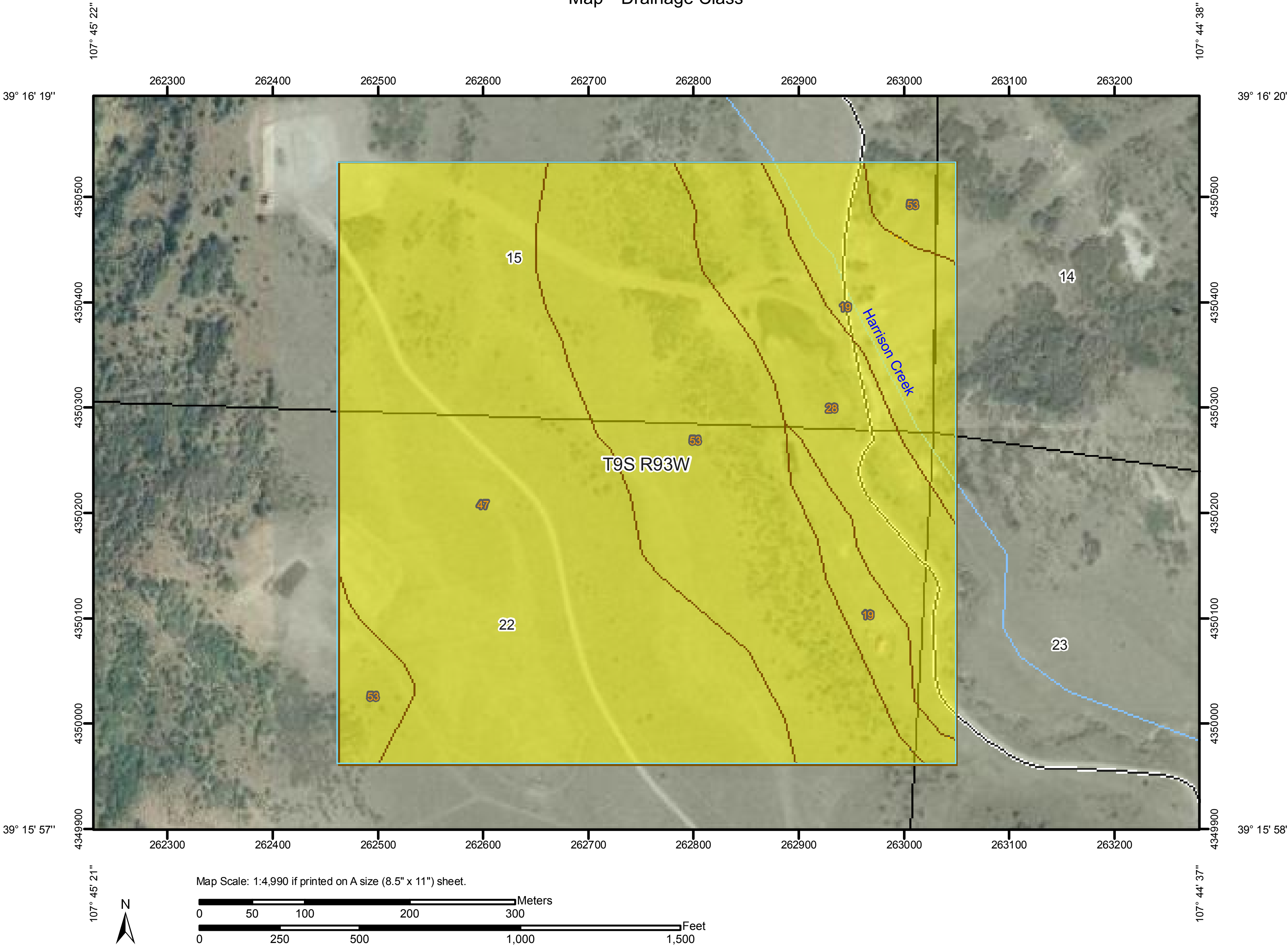
Tie-break Rule: Lower

Interpret Nulls as Zero: No

Drainage Class

"Drainage class (natural)" refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized-excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. These classes are defined in the "Soil Survey Manual."

Custom Soil Resource Report
Map—Drainage Class



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- Excessively drained
- Somewhat excessively drained
- Well drained
- Moderately well drained
- Somewhat poorly drained
- Poorly drained
- Very poorly drained
- Not rated or not available

Political Features

- Cities
- PLSS Township and Range
- PLSS Section

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:4,990 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 5, Feb 1, 2008

Date(s) aerial images were photographed: 8/29/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Drainage Class

Drainage Class— Summary by Map Unit — Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
19	Cerro silty clay loam, 6 to 12 percent slopes	Well drained	9.9	11.9%
28	Cumulic Haploborolls, 1 to 3 percent slopes	Well drained	10.9	13.1%
47	Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes	Well drained	37.5	45.2%
53	Pagoda-Hesperus complex, 12 to 40 percent slopes	Well drained	24.6	29.7%
Totals for Area of Interest			**82.9**	**100.0%**

Rating Options—Drainage Class

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Hydrologic Soil Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

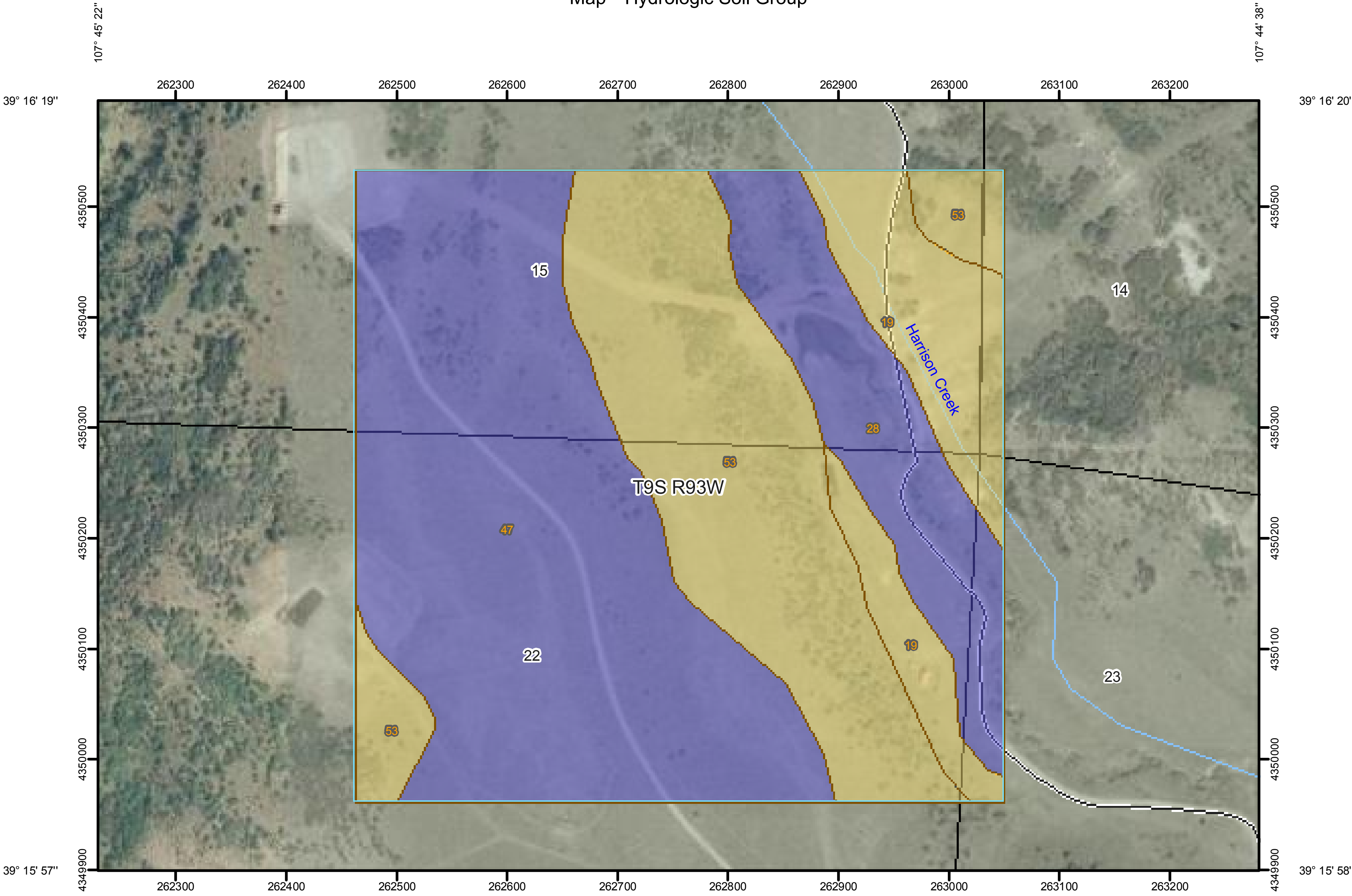
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Custom Soil Resource Report
Map—Hydrologic Soil Group



Map Scale: 1:4,990 if printed on A size (8.5" x 11") sheet.

N

Meters: 0, 50, 100, 200, 300

Feet: 0, 250, 500, 1,000, 1,500

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Soil Ratings
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Political Features
- Cities
- PLSS Township and Range
- PLSS Section

Water Features
- Oceans
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:4,990 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 5, Feb 1, 2008

Date(s) aerial images were photographed: 8/29/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
19	Cerro silty clay loam, 6 to 12 percent slopes	C	9.9	11.9%
28	Cumulic Haploborolls, 1 to 3 percent slopes	B	10.9	13.1%
47	Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes	B	37.5	45.2%
53	Pagoda-Hesperus complex, 12 to 40 percent slopes	C	24.6	29.7%
Totals for Area of Interest			**82.9**	**100.0%**

Rating Options—Hydrologic Soil Group

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

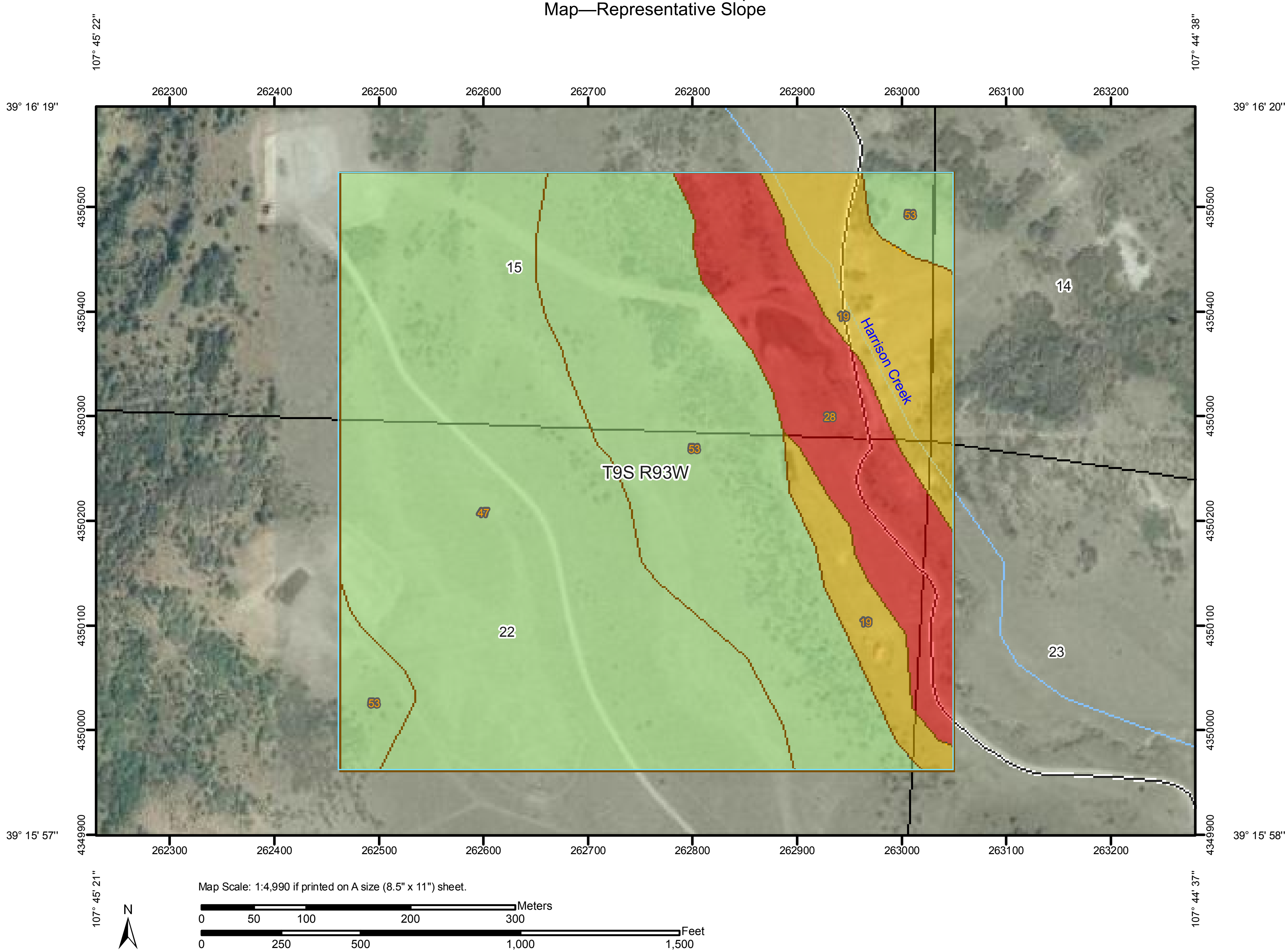
Tie-break Rule: Lower

Representative Slope

Slope gradient is the difference in elevation between two points, expressed as a percentage of the distance between those points.

The slope gradient is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Map—Representative Slope



Map Scale: 1:4,990 if printed on A size (8.5" x 11") sheet.

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Soil Ratings

0 - 5

5 - 15

15 - 30

30 - 45

45 - 60

Not rated or not available

Political Features

Cities

PLSS Township and Range

PLSS Section

Water Features

Oceans

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

MAP INFORMATION

Map Scale: 1:4,990 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 5, Feb 1, 2008

Date(s) aerial images were photographed: 8/29/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Representative Slope

Representative Slope— Summary by Map Unit — Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties				
Map unit symbol	**Map unit name**	**Rating (percent)**	**Acres in AOI**	**Percent of AOI**
19	Cerro silty clay loam, 6 to 12 percent slopes	9.0	9.9	11.9%
28	Cumulic Haploborolls, 1 to 3 percent slopes	2.0	10.9	13.1%
47	Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes	20.0	37.5	45.2%
53	Pagoda-Hesperus complex, 12 to 40 percent slopes	26.0	24.6	29.7%
Totals for Area of Interest			**82.9**	**100.0%**

Rating Options—Representative Slope

Units of Measure: percent

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

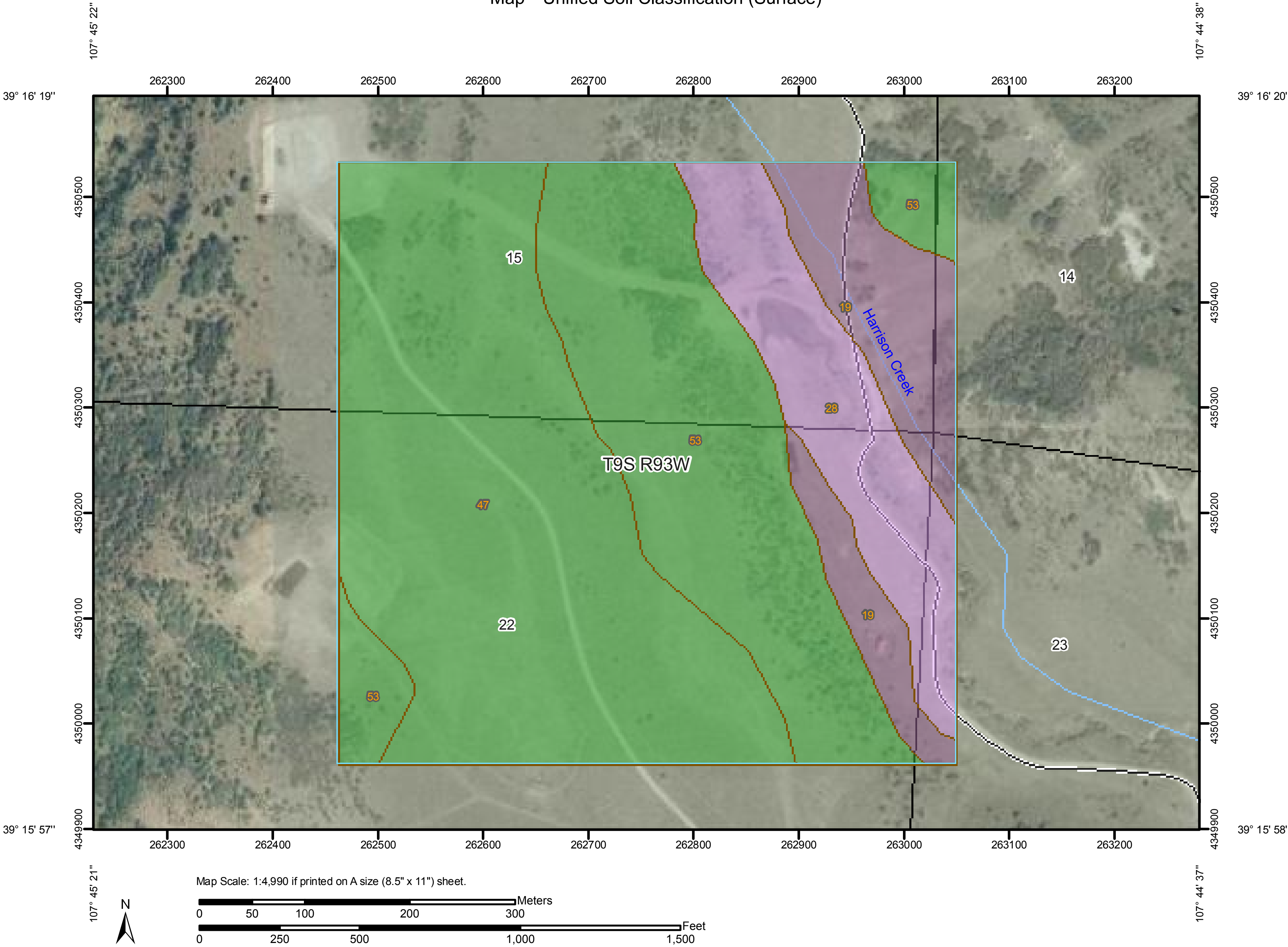
Unified Soil Classification (Surface)

The Unified soil classification system classifies mineral and organic mineral soils for engineering purposes on the basis of particle-size characteristics, liquid limit, and plasticity index. It identifies three major soil divisions: (i) coarse-grained soils having less than 50 percent, by weight, particles smaller than 0.074 mm in diameter; (ii) fine-grained soils having 50 percent or more, by weight, particles smaller than 0.074 mm in diameter; and (iii) highly organic soils that demonstrate certain organic characteristics. These divisions are further subdivided into a total of 15 basic soil groups. The major soil divisions and basic soil groups are determined on the basis of estimated or measured values for grain-size distribution and Atterberg limits. ASTM D 2487 shows the criteria chart used for classifying soil in the Unified system and the 15 basic soil groups of the system and the plasticity chart for the Unified system.

The various groupings of this classification correlate in a general way with the engineering behavior of soils. This correlation provides a useful first step in any field or laboratory investigation for engineering purposes. It can serve to make some general interpretations relating to probable performance of the soil for engineering uses.

For each soil horizon in the database one or more Unified soil classifications may be listed. One is marked as the representative or most commonly occurring. The representative classification is shown here for the surface layer of the soil.

Map—Unified Soil Classification (Surface)



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- CH
- CL
- CL-A (proposed)
- CL-K (proposed)
- CL-ML
- CL-O (proposed)
- CL-T (proposed)
- GC
- GC-GM
- GM
- GP
- GP-GC
- GP-GM
- GW
- GW-GC
- GW-GM
- MH
- MH-A (proposed)
- MH-K (proposed)
- MH-O (proposed)
- MH-T (proposed)
- ML
- ML-A (proposed)
- ML-K (proposed)
- ML-O (proposed)
- ML-T (proposed)
- OH
- OH-T (proposed)
- OL
- PT
- SC
- SC-SM
- SM
- SP
- SP-SC
- SP-SM
- SW
- SW-SC
- SW-SM
- Not rated or not available

Political Features

- Cities
- PLSS Township and Range
- PLSS Section

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:4,990 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 5, Feb 1, 2008

Date(s) aerial images were photographed: 8/29/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Unified Soil Classification (Surface)

Unified Soil Classification (Surface)— Summary by Map Unit — Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
19	Cerro silty clay loam, 6 to 12 percent slopes	ML	9.9	11.9%
28	Cumulic Haploborolls, 1 to 3 percent slopes	GC	10.9	13.1%
47	Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes	CL	37.5	45.2%
53	Pagoda-Hesperus complex, 12 to 40 percent slopes	CL	24.6	29.7%
Totals for Area of Interest			**82.9**	**100.0%**

Rating Options—Unified Soil Classification (Surface)

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Layer Options: Surface Layer

Water Features

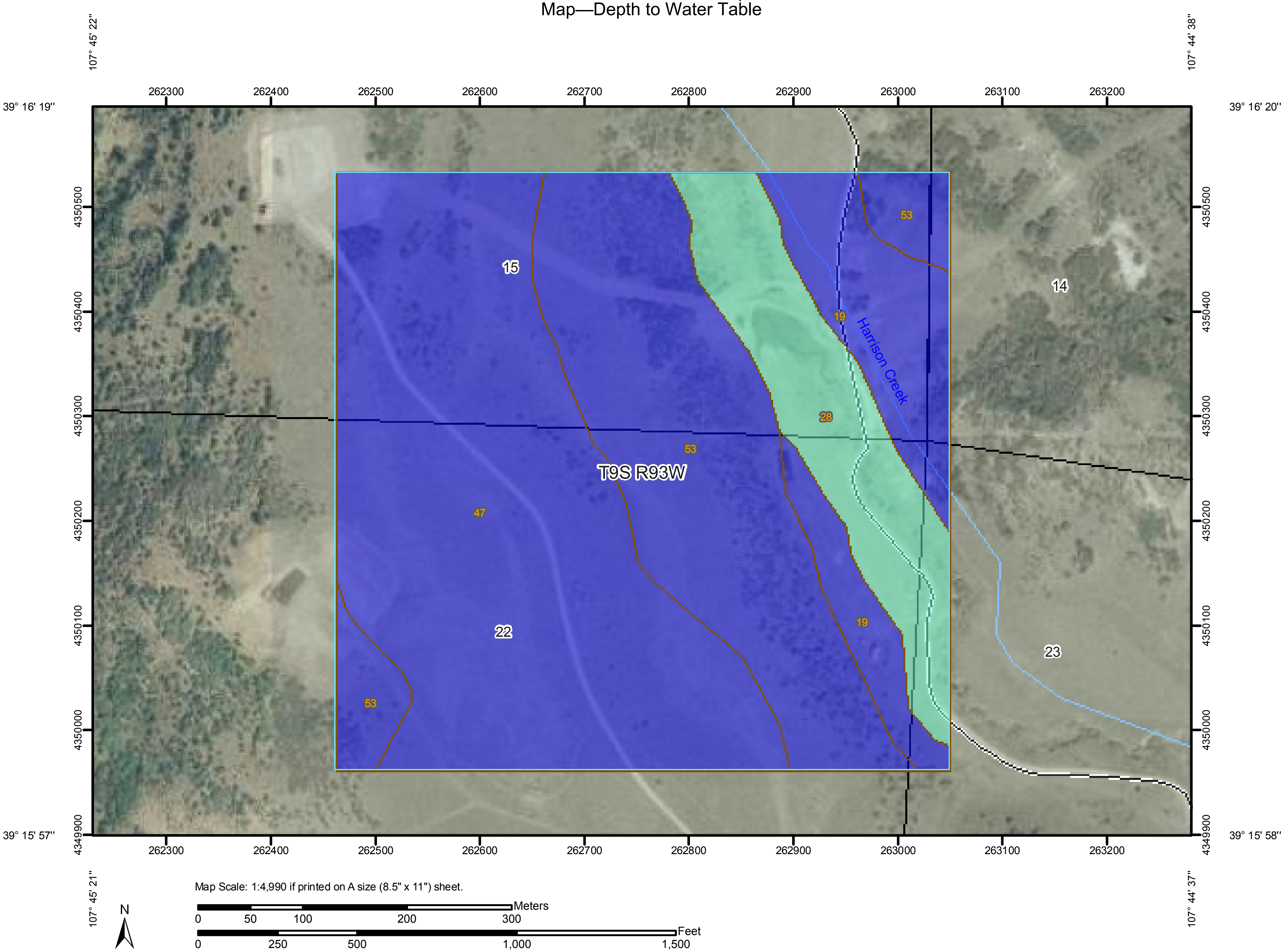
Water Features include ponding frequency, flooding frequency, and depth to water table.

Depth to Water Table

"Water table" refers to a saturated zone in the soil. It occurs during specified months. Estimates of the upper limit are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Map—Depth to Water Table



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Soil Ratings

0 - 25

25 - 50

50 - 100

100 - 150

150 - 200

> 200

Political Features

Cities

PLSS Township and Range

PLSS Section

Water Features

Oceans

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

MAP INFORMATION

Map Scale: 1:4,990 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 5, Feb 1, 2008

Date(s) aerial images were photographed: 8/29/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Depth to Water Table

Depth to Water Table— Summary by Map Unit — Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties				
Map unit symbol	**Map unit name**	**Rating (centimeters)**	**Acres in AOI**	**Percent of AOI**
19	Cerro silty clay loam, 6 to 12 percent slopes	>200	9.9	11.9%
28	Cumulic Haploborolls, 1 to 3 percent slopes	137	10.9	13.1%
47	Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes	>200	37.5	45.2%
53	Pagoda-Hesperus complex, 12 to 40 percent slopes	>200	24.6	29.7%
Totals for Area of Interest			**82.9**	**100.0%**

Rating Options—Depth to Water Table

Units of Measure: centimeters

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Interpret Nulls as Zero: No

Beginning Month: January

Ending Month: December

Flooding Frequency Class

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent.

"None" means that flooding is not probable. The chance of flooding is nearly 0 percent in any year. Flooding occurs less than once in 500 years.

"Very rare" means that flooding is very unlikely but possible under extremely unusual weather conditions. The chance of flooding is less than 1 percent in any year.

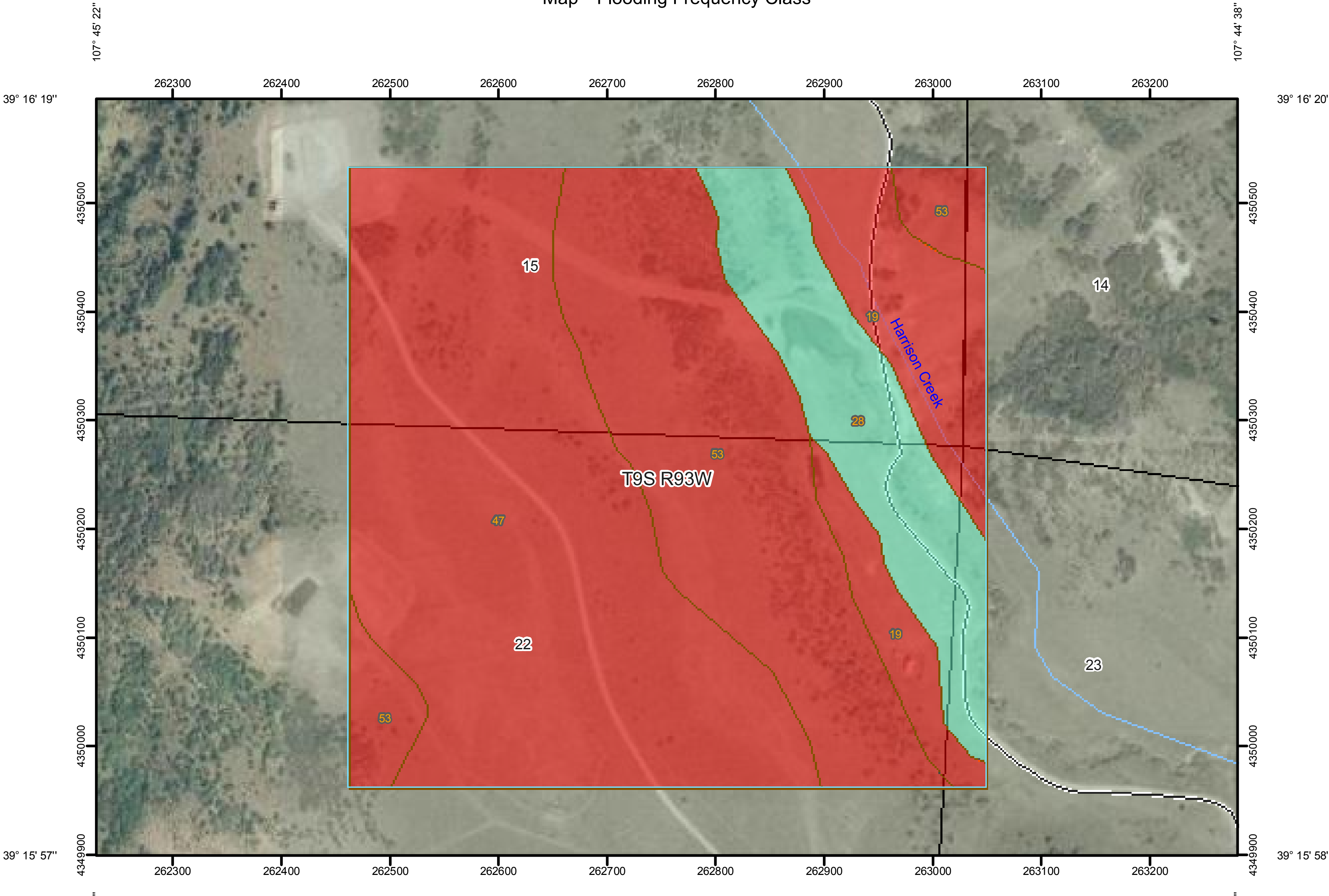
"Rare" means that flooding is unlikely but possible under unusual weather conditions. The chance of flooding is 1 to 5 percent in any year.

"Occasional" means that flooding occurs infrequently under normal weather conditions. The chance of flooding is 5 to 50 percent in any year.

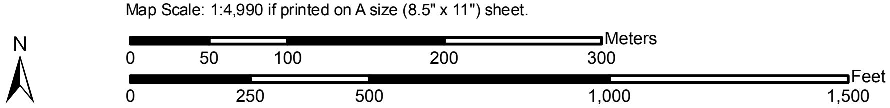
"Frequent" means that flooding is likely to occur often under normal weather conditions. The chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year.

"Very frequent" means that flooding is likely to occur very often under normal weather conditions. The chance of flooding is more than 50 percent in all months of any year.

Custom Soil Resource Report
Map—Flooding Frequency Class



Map Scale: 1:4,990 if printed on A size (8.5" x 11") sheet.



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- None
- Very Rare
- Rare
- Occasional
- Frequent
- Very Frequent

Political Features

- Cities
- PLSS Township and Range
- PLSS Section

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:4,990 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 5, Feb 1, 2008

Date(s) aerial images were photographed: 8/29/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Flooding Frequency Class

Flooding Frequency Class— Summary by Map Unit — Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
19	Cerro silty clay loam, 6 to 12 percent slopes	None	9.9	11.9%
28	Cumulic Haploborolls, 1 to 3 percent slopes	Occasional	10.9	13.1%
47	Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes	None	37.5	45.2%
53	Pagoda-Hesperus complex, 12 to 40 percent slopes	None	24.6	29.7%
Totals for Area of Interest			**82.9**	**100.0%**

Rating Options—Flooding Frequency Class

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: More Frequent

Beginning Month: January

Ending Month: December

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Building Site Development

This folder contains a collection of tabular reports that present soil interpretations related to building site development. The reports (tables) include all selected map units and components for each map unit, limiting features and interpretive ratings. Building site development interpretations are designed to be used as tools for evaluating soil suitability and identifying soil limitations for various construction purposes. As part of the interpretation process, the rating applies to each soil in its described condition and does not consider present land use. Example interpretations can include corrosion of concrete and steel, shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping.

Roads and Streets, Shallow Excavations, and Lawns and Landscaping

Soil properties influence the development of building sites, including the selection of the site, the design of the structure, construction, performance after construction, and maintenance. This table shows the degree and kind of soil limitations that affect local roads and streets, shallow excavations, and lawns and landscaping.

The ratings in the table are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect building site development. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material; a base of gravel, crushed rock, or soil material stabilized by lime or cement; and a surface of flexible material (asphalt), rigid material (concrete), or gravel with a binder. The ratings are based on the soil properties that affect the ease of excavation and grading and the traffic-supporting capacity. The properties that affect the ease of excavation and grading are depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, depth to a water table, ponding, flooding, the amount of large stones, and slope. The properties that affect the traffic-supporting capacity are soil strength (as inferred from the AASHTO group index number), subsidence, linear extensibility (shrink-swell potential), the potential for frost action, depth to a water table, and ponding.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for graves, utility lines, open ditches, or other purposes. The ratings are based on the soil properties that influence the ease of digging and the resistance to sloughing. Depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, the amount of large stones, and dense layers influence the ease of digging, filling, and compacting. Depth to the seasonal high water table, flooding, and ponding may restrict the period when excavations can be made. Slope influences the ease of using machinery. Soil texture, depth to the water table, and linear extensibility (shrink-swell potential) influence the resistance to sloughing.

Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. Irrigation is not considered in the ratings. The ratings are based on the soil properties that affect plant growth and trafficability after vegetation is established. The properties that affect plant growth are reaction; depth to a water table; ponding; depth to bedrock or a cemented pan; the available water capacity in the upper 40 inches; the content of salts, sodium, or calcium carbonate; and sulfidic materials. The properties that affect trafficability are flooding, depth to a water table, ponding, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer.

Information in this table is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil between the surface and a depth of 5 to 7 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this table. Local ordinances and regulations should be considered in planning, in site selection, and in design.

Report—Roads and Streets, Shallow Excavations, and Lawns and Landscaping

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

Roads and Streets, Shallow Excavations, and Lawns and Landscaping– Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties							
Map symbol and soil name	Pct. of map unit	Local roads and streets		Shallow excavations		Lawns and landscaping	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
19—Cerro silty clay loam, 6 to 12 percent slopes							
Cerro	70	Very limited		Somewhat limited		Somewhat limited	
		Low strength	1.00	Too clayey	0.28	Slope	0.04
		Shrink-swell	1.00	Cutbanks cave	0.10		
		Slope	0.04	Slope	0.04		
28—Cumulic Haploborolls, 1 to 3 percent slopes							
Cumulic haploborolls	90	Very limited		Very limited		Somewhat limited	
		Flooding	1.00	Cutbanks cave	1.00	Flooding	0.60
				Flooding	0.60	Large stones content	0.20
				Depth to saturated zone	0.35	Gravel content	0.09
						Droughty	0.02
47—Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes							
Hesperus	35	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Low strength	1.00	Cutbanks cave	0.10		
		Shrink-swell	0.50				
		Frost action	0.50				
Empedrado, moist	30	Very limited		Very limited		Very limited	
		Slope	1.00	Cutbanks cave	1.00	Slope	1.00
		Frost action	0.50	Slope	1.00		
Pagoda	20	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Low strength	1.00	Cutbanks cave	0.10		
		Shrink-swell	0.50	Too clayey	0.03		

Roads and Streets, Shallow Excavations, and Lawns and Landscaping– Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties							
Map symbol and soil name	Pct. of map unit	Local roads and streets		Shallow excavations		Lawns and landscaping	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
53—Pagoda-Hesperus complex, 12 to 40 percent slopes							
Pagoda	50	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Low strength	1.00	Cutbanks cave	0.10		
		Shrink-swell	0.50	Too clayey	0.03		
Hesperus	20	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Low strength	1.00	Cutbanks cave	0.10		
		Shrink-swell	0.50				
		Frost action	0.50				

Land Classifications

This folder contains a collection of tabular reports that present a variety of soil groupings. The reports (tables) include all selected map units and components for each map unit. Land classifications are specified land use and management groupings that are assigned to soil areas because combinations of soil have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil. Example classifications include ecological site classification, farmland classification, irrigated and nonirrigated land capability classification, and hydric rating.

Taxonomic Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (Soil Survey Staff, 1999 and 2003). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. This table shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Twelve soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol.* An example is Alfisols.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Udalfs (*Ud*, meaning humid, plus *alfs*, from Alfisols).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; type of saturation; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Hapludalfs (*Hapl*, meaning minimal horizonation, plus *udalfs*, the suborder of the Alfisols that has a udic moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic subgroup is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other taxonomic class. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that typifies the great group. An example is Typic Hapludalfs.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineralogy class, cation-exchange activity class, soil temperature regime, soil depth, and reaction class. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine-loamy, mixed, active, mesic Typic Hapludalfs.

SERIES. The series consists of soils within a family that have horizons similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile.

References:
Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.
Soil Survey Staff. 2006. Keys to soil taxonomy. 10th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. (The soils in a given survey area may have been classified according to earlier editions of this publication.)

Report—Taxonomic Classification of the Soils

[An asterisk by the soil name indicates a taxadjunct to the series]

Taxonomic Classification of the Soils– Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties	
Soil name	**Family or higher taxonomic classification**
Cerro	Fine, montmorillonitic Ustertic Argiborolls
Cumulic Haploborolls	Cumulic Haploborolls
Empedrado	Fine-loamy, mixed Typic Argiborolls
Hesperus	Fine-loamy, mixed Pachic Argiborolls
Pagoda	Fine, montmorillonitic Pachic Argiborolls

Soil Chemical Properties

This folder contains a collection of tabular reports that present soil chemical properties. The reports (tables) include all selected map units and components for each map unit. Soil chemical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil chemical properties include pH, cation exchange capacity, calcium carbonate, gypsum, and electrical conductivity.

Chemical Soil Properties

This table shows estimates of some chemical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Cation-exchange capacity is the total amount of extractable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. Soils having a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils having a high cation-exchange capacity. The ability to retain cations reduces the hazard of ground-water pollution.

Effective cation-exchange capacity refers to the sum of extractable cations plus aluminum expressed in terms of milliequivalents per 100 grams of soil. It is determined for soils that have pH of less than 5.5.

Soil reaction is a measure of acidity or alkalinity. It is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Calcium carbonate equivalent is the percent of carbonates, by weight, in the fraction of the soil less than 2 millimeters in size. The availability of plant nutrients is influenced by the amount of carbonates in the soil.

Gypsum is expressed as a percent, by weight, of hydrated calcium sulfates in the fraction of the soil less than 20 millimeters in size. Gypsum is partially soluble in water. Soils that have a high content of gypsum may collapse if the gypsum is removed by percolating water.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Sodium adsorption ratio (SAR) is a measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration. Soils that have SAR values of 13 or more may be characterized by an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity and aeration, and a general degradation of soil structure.

Chemical Soil Properties– Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties								
Map symbol and soil name	**Depth**	**Cation-exchange capacity**	**Effective cation-exchange capacity**	**Soil reaction**	**Calcium carbonate**	**Gypsum**	**Salinity**	**Sodium adsorption ratio**
	In	*meq/100g*	*meq/100g*	*pH*	*Pct*	*Pct*	*mmhos/cm*	
19—Cerro silty clay loam, 6 to 12 percent slopes								
Cerro	0-7	20-30	—	6.6-7.3	0	0	0	0
	7-12	15-35	—	7.4-7.8	0	0	0	0
	12-35	25-45	—	7.9-8.4	0-2	0	0.0-2.0	0
	35-60	15-30	—	7.9-8.4	5-15	0	0.0-2.0	0
28—Cumulic Haploborolls, 1 to 3 percent slopes								
Cumulic haploborolls	0-8	10-25	—	6.6-8.4	0-5	0	0.0-4.0	0
	8-20	10-20	—	7.4-8.4	5-10	0	0.0-4.0	0
	20-28	10-25	—	7.4-8.4	5-10	0	0.0-4.0	0
	28-60	4.0-10	—	7.4-8.4	5-10	0	0.0-4.0	0
47—Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes								
Hesperus	0-7	10-20	—	6.6-7.3	0	0	0	0
	7-60	15-25	—	6.6-7.8	0	0	0	0
Empedrado, moist	0-10	10-25	—	6.6-7.3	0	0	0	0
	10-21	10-25	—	6.6-7.3	0	0	0	0
	21-28	10-20	—	6.6-7.8	0	0	0	0
	28-60	5.0-15	—	7.9-8.4	5-10	0	0.0-2.0	0
Pagoda	0-6	15-25	—	6.6-7.8	0	0	0	0
	6-17	15-25	—	6.6-7.8	0	0	0	0
	17-27	15-30	—	6.6-7.8	0	0	0	0
	27-60	10-30	—	7.9-8.4	5-15	0	0.0-2.0	0

Chemical Soil Properties– Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties								
Map symbol and soil name	**Depth**	**Cation-exchange capacity**	**Effective cation-exchange capacity**	**Soil reaction**	**Calcium carbonate**	**Gypsum**	**Salinity**	**Sodium adsorption ratio**
	In	*meq/100g*	*meq/100g*	*pH*	*Pct*	*Pct*	*mmhos/cm*	
53—Pagoda-Hesperus complex, 12 to 40 percent slopes								
Pagoda	0-6	15-25	—	6.6-7.8	0	0	0	0
	6-17	15-25	—	6.6-7.8	0	0	0	0
	17-27	15-30	—	6.6-7.8	0	0	0	0
	27-60	10-30	—	7.9-8.4	5-15	0	0.0-2.0	0
Hesperus	0-7	10-20	—	6.6-7.3	0	0	0	0
	7-60	15-25	—	6.6-7.8	0	0	0	0

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Physical Soil Properties

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots.

Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Physical Soil Properties– Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties														
Map symbol and soil name	**Depth**	**Sand**	**Silt**	**Clay**	**Moist bulk density**	**Saturated hydraulic conductivity**	**Available water capacity**	**Linear extensibility**	**Organic matter**	**Erosion factors**			**Wind erodibility group**	**Wind erodibility index**
										Kw	**Kf**	**T**		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
19—Cerro silty clay loam, 6 to 12 percent slopes														
Cerro	0-7	-20-	-48-	30-33- 35	1.15-1.30	1.41-4.23	0.17-0.21	3.0-5.9	1.0-2.0	.28	.28	5	7	38
	7-12	- 8-	-55-	35-38- 40	1.15-1.30	0.42-4.23	0.17-0.21	3.0-5.9	0.5-1.0	.32	.32			
	12-35	- 6-	-47-	40-48- 50	1.15-1.30	0.42-1.41	0.14-0.17	6.0-8.9	0.5-1.0	.24	.24			
	35-60	-19-	-48-	27-34- 40	1.15-1.30	0.42-4.23	0.17-0.21	3.0-5.9	0.0-0.5	.37	.37			
28—Cumulic Haploborolls, 1 to 3 percent slopes														
Cumulic haploborolls	0-8	-57-	-18-	20-25- 30	1.25-1.40	1.41-14.11	0.10-0.13	0.0-2.9	2.0-3.0	.10	.17	3	5	56
	8-20	-57-	-18-	20-25- 30	1.25-1.40	1.41-14.11	0.07-0.09	0.0-2.9	1.0-2.0	.05	.17			
	20-28	-35-	-34-	27-31- 35	1.25-1.40	1.41-14.00	0.16-0.19	0.0-2.9	1.0-2.0	.20	.20			
	28-60	—	—	5-10- 15	1.45-1.60	42.34-141.14	0.03-0.04	0.0-2.9	1.0-2.0	.05	.15			

Physical Soil Properties– Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties														
Map symbol and soil name	**Depth**	**Sand**	**Silt**	**Clay**	**Moist bulk density**	**Saturated hydraulic conductivity**	**Available water capacity**	**Linear extensibility**	**Organic matter**	**Erosion factors**			**Wind erodibility group**	**Wind erodibility index**
										Kw	**Kf**	**T**		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
47—Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes														
Hesperus	0-7	-44-	-41-	10-15- 20	1.25-1.40	4.23-42.34	0.14-0.17	0.0-2.9	2.0-5.0	.20	.20	5	5	56
	7-60	-36-	-34-	20-31- 35	1.25-1.40	1.41-4.23	0.17-0.20	3.0-5.9	1.0-2.0	.20	.20			
Empedrado, moist	0-10	-40-	-38-	18-23- 27	1.25-1.40	4.23-14.11	0.16-0.18	0.0-2.9	2.0-4.0	.24	.24	5	6	48
	10-21	-35-	-34-	27-31- 35	1.25-1.40	4.00-14.00	0.17-0.21	3.0-5.9	0.5-1.0	.24	.24			
	21-28	-57-	-18-	20-25- 30	1.25-1.40	4.00-14.00	0.10-0.13	0.0-2.9	0.5-1.0	.10	.20			
	28-60	-40-	-38-	18-23- 27	1.25-1.40	4.23-14.11	0.14-0.18	0.0-2.9	0.0-0.5	.43	.43			
Pagoda	0-6	-35-	-34-	27-31- 35	1.25-1.40	1.41-4.23	0.17-0.21	3.0-5.9	2.0-3.0	.20	.20	5	6	48
	6-17	-35-	-34-	27-31- 35	1.25-1.40	1.41-4.23	0.17-0.21	3.0-5.9	1.0-3.0	.20	.20			
	17-27	-28-	-30-	35-43- 50	1.15-1.40	0.42-1.41	0.14-0.21	6.0-8.9	0.5-1.0	.32	.20			
	27-60	-29-	-31-	30-40- 50	1.15-1.40	0.42-4.23	0.14-0.21	3.0-5.9	0.0-0.5	.20	.20			
53—Pagoda-Hesperus complex, 12 to 40 percent slopes														
Pagoda	0-6	-35-	-34-	27-31- 35	1.25-1.40	1.41-4.23	0.17-0.21	3.0-5.9	2.0-3.0	.20	.20	5	6	48
	6-17	-35-	-34-	27-31- 35	1.25-1.40	1.41-4.23	0.17-0.21	3.0-5.9	1.0-3.0	.20	.20			
	17-27	-28-	-30-	35-43- 50	1.15-1.40	0.42-1.41	0.14-0.21	6.0-8.9	0.5-1.0	.32	.20			
	27-60	-29-	-31-	30-40- 50	1.15-1.40	0.42-4.23	0.14-0.21	3.0-5.9	0.0-0.5	.20	.20			
Hesperus	0-7	-44-	-41-	10-15- 20	1.25-1.40	4.23-42.34	0.14-0.17	0.0-2.9	2.0-5.0	.20	.20	5	5	56
	7-60	-36-	-34-	20-31- 35	1.25-1.40	1.41-4.23	0.17-0.20	3.0-5.9	1.0-2.0	.20	.20			

Soil Qualities and Features

This folder contains tabular reports that present various soil qualities and features. The reports (tables) include all selected map units and components for each map unit. Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

Soil Features

This table gives estimates of various soil features. The estimates are used in land use planning that involves engineering considerations.

A *restrictive layer* is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers. The table indicates the hardness and thickness of the restrictive layer, both of which significantly affect the ease of excavation. *Depth to top* is the vertical distance from the soil surface to the upper boundary of the restrictive layer.

Subsidence is the settlement of organic soils or of saturated mineral soils of very low density. Subsidence generally results from either desiccation and shrinkage, or oxidation of organic material, or both, following drainage. Subsidence takes place gradually, usually over a period of several years. The table shows the expected initial subsidence, which usually is a result of drainage, and total subsidence, which results from a combination of factors.

Potential for frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, saturated hydraulic conductivity (Ksat), content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured, clayey soils that have a high water table in winter are the most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage to pavements and other rigid structures.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel or concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel or concrete in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low*, *moderate*, or *high*, is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion also is expressed as *low*, *moderate*, or *high.* It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Soil Features– Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties									
Map symbol and soil name	Restrictive Layer				Subsidence		Potential for frost action	Risk of corrosion	
	Kind	Depth to top	Thickness	Hardness	Initial	Total		Uncoated steel	Concrete
		In	*In*		*In*	*In*			
19—Cerro silty clay loam, 6 to 12 percent slopes									
Cerro		—	—		0	—	Low	Moderate	Low
28—Cumulic Haploborolls, 1 to 3 percent slopes									
Cumulic haploborolls		—	—		0	—	Low	Moderate	Low
47—Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes									
Hesperus		—	—		0	—	Moderate	Moderate	Low
Empedrado, moist		—	—		0	—	Moderate	High	Low
Pagoda		—	—		0	—	Low	Moderate	Low
53—Pagoda-Hesperus complex, 12 to 40 percent slopes									
Pagoda		—	—		0	—	Low	Moderate	Low
Hesperus		—	—		0	—	Moderate	Moderate	Low

Water Management

This folder contains a collection of tabular reports that present soil interpretations related to water management. The reports (tables) include all selected map units and components for each map unit, limiting features and interpretive ratings. Water management interpretations are tools for evaluating the potential of the soil in the application of various water management practices. Example interpretations include pond reservoir area, embankments, dikes, levees, and excavated ponds.

Ponds and Embankments

This table gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas; embankments, dikes, and levees; and aquifer-fed excavated ponds. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect these uses. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the saturated hydraulic conductivity (Ksat) of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. Embankments that have zoned construction (core and shell) are not considered. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of 5 or 6 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability.

Aquifer-fed excavated ponds are pits or dugouts that extend to a ground-water aquifer or to a depth below a permanent water table. Excluded are ponds that are fed only by surface runoff and embankment ponds that impound water 3 feet or more above the original surface. Excavated ponds are affected by depth to a permanent water table, Ksat of the aquifer, and quality of the water as inferred from the salinity of the soil. Depth to bedrock and the content of large stones affect the ease of excavation.

Information in this table is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil between the surface and a depth of 5 to 7 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this table. Local ordinances and regulations should be considered in planning, in site selection, and in design.

Report—Ponds and Embankments

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

Ponds and Embankments– Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties							
Map symbol and soil name	Pct. of map unit	Pond reservoir areas		Embankments, dikes, and levees		Aquifer-fed excavated ponds	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
19—Cerro silty clay loam, 6 to 12 percent slopes							
Cerro	70	Very limited		Somewhat limited		Very limited	
		Slope	1.00	Piping	0.32	Depth to water	1.00
		Seepage	0.02				
28—Cumulic Haploborolls, 1 to 3 percent slopes							
Cumulic haploborolls	90	Very limited		Somewhat limited		Very limited	
		Seepage	1.00	Seepage	0.19	Cutbanks cave	1.00
						Depth to saturated zone	0.96

Ponds and Embankments– Douglas-Plateau Area, Colorado, Parts of Garfield and Mesa Counties							
Map symbol and soil name	Pct. of map unit	Pond reservoir areas		Embankments, dikes, and levees		Aquifer-fed excavated ponds	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
47—Hesperus-Empedrado, moist-Pagoda complex 5 to 35 percent slopes							
Hesperus	35	Very limited		Somewhat limited		Very limited	
		Slope	1.00	Piping	0.66	Depth to water	1.00
		Seepage	0.04				
Empedrado, moist	30	Very limited		Very limited		Very limited	
		Slope	1.00	Piping	1.00	Depth to water	1.00
		Seepage	0.72				
Pagoda	20	Very limited		Somewhat limited		Very limited	
		Slope	1.00	Piping	0.24	Depth to water	1.00
		Seepage	0.02				
53—Pagoda-Hesperus complex, 12 to 40 percent slopes							
Pagoda	50	Very limited		Somewhat limited		Very limited	
		Slope	1.00	Piping	0.24	Depth to water	1.00
		Seepage	0.02				
Hesperus	20	Very limited		Somewhat limited		Very limited	
		Slope	1.00	Piping	0.66	Depth to water	1.00
		Seepage	0.04				

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July 15, 2009

Mr. Boris Vilner
ForeRunner Corporation
3900 South Wadsworth Boulevard, #600
Lakewood, Colorado 80235

Subject: Geotechnical Engineering Study, Proposed Delta Petroleum Harrison Creek Produced Water Recycling Facility, South of County Road 330, Approximately 12.5 Miles East of Collbran, Colorado

Project No. 08-1-179A

Dear Mr. Vilner:

This letter presents the results of a geotechnical engineering study performed for Delta Petroleum's proposed Harrison Creek Produced Water Recycling Facility in Mesa County, Colorado. The project site is located about 12.5 miles east of Collbran and south of County Road 330. The site is shown on Fig. 1.

Kumar & Associates performed a geotechnical engineering study for the adjacent Mega Vega compressor station, the results of which were provided under our Project No. 08-1-179 in a report dated April 3, 2008. This current study was conducted to determine if subsurface conditions at the water recycling facility site are reasonably similar to the conditions at the compressor station site, including depth to bedrock, and to determine if the geotechnical engineering recommendations provided in our 2008 report are applicable to the water recycling facility site.

Planned Construction: We understand that the proposed water recycling facility will eventually consist of up to five pods of modular process equipment and support equipment and facilities, and will be constructed in two phases. The initial phase will consist of Pods 1 and 2, along with a battery of inlet storage tanks, a battery of outlet storage tanks, a solids management area, pipe racks, an access road that circles the perimeter of the facility, and other miscellaneous equipment and facilities. The overall dimensions of the facility within the access road will be approximately 210 feet by 750 feet.

Each processing pod will include a packaged process unit, a generator pad, a utility pad, glycol cooler pads (with containment), and building enclosures for operations, maintenance and electrical facilities. The pod equipment will have footprints ranging in size from about 8 feet by 18 feet to about 36 feet by 42 feet. The building enclosures will have footprint areas ranging from about 10 feet by 40 feet to about 12 feet by 40 feet. The inlet and outlet tank batteries will have footprint areas ranging from about 50 feet by 70 feet to 50 feet by 100 feet, and will consist of concrete containment pads each holding up to 10 tanks ranging in size up to 15 feet in diameter and 30 feet in height. Equipment point loads are expected to range up to 110 kips, and distributed pad loads are expected to be 1,000 psf or less.

We assume the building enclosures will be at-grade, single-level structures with no below-ground structures. We assume the building enclosures will be pre-engineered wood or metal structures with light to moderate column loads. We understand that the equipment will not include large pumps or compressors, and that dynamic loads due to machinery operation will not be significant.

Information about site grading was not available at the time of this report. We anticipate cuts and fills up to 10 feet may be required to establish site finished grades.

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

Site Conditions: The site is an approximately 5.5-acre, undeveloped parcel located near the confluence of Harrison and Buzzard Creeks, about 1 mile south of County Road 330 and 12.5 miles east of the town of Collbran. An existing, unpaved private road extends along the west side of the site; the Mega Vega compressor station is located on the west side of the unpaved road. The project site is located in a slightly sloping area on the west side of Bogue Gulch. Based on topographic information provided by ForeRunner and shown on Fig. 1, the project site generally slopes downward from south to north with surface elevations ranging from approximately 7445 feet near the southeast corner to approximately 7415 feet near the northeast corner. The site is covered primarily with grasses and scattered to thick sage brush, and scattered cobbles and boulders in places.

Subsurface Conditions: The subsurface conditions at the general location of the water recycling facility were explored by drilling three (3) exploratory borings to depths ranging from about 15 to 30 feet at the approximate locations shown on Fig. 1. The logs of the exploratory borings are presented on Fig. 2, and a legend and associated explanatory notes are presented on Fig. 3.

Laboratory testing was performed on selected soil and bedrock samples obtained from the borings to determine soil moisture content, dry density, gradation, and Atterberg limits. The results of the laboratory tests are shown to the right of the logs on Fig. 2 and summarized in Table I.

The borings generally encountered natural colluvial overburden soils consisting primarily of sandy lean clays and clayey sands extending to bedrock at depths of about 19 and 16 feet in Borings 1 and 3; bedrock was not encountered in Boring 2 to full depth explored of about 15 feet. The lean clay and clayey sand overburden soils encountered at the boring locations contained occasional to frequent gravel- to cobble-sized shale and sandstone fragments, and isolated lenses of poorly-graded sand with silt. Practical auger refusal was encountered at the location of Boring 2 at a depth of about 15 feet due to an apparent relatively high concentration of cobble-sized fragments that was first encountered at a depth of about 5 feet. Drilling attempts at six locations within about 30 feet of the planned location of Boring 2 encountered generally similar conditions, including auger refusal. Based on the presence of boulders scattered across the ground surface, boulder-sized rock fragments should be expected within the overburden soils.

The overburden soils were generally slightly moist to moist to wet below ground water, and ranged from various shades of brown to gray and gray-brown in places. Based on sampler penetration resistance, the clays ranged from soft to very stiff, and the sands ranged from medium dense to very dense. Based on the results of swell-co9nsolidation

The bedrock encountered in Borings 1 and 3 consisted primarily of shale with an isolated zone of clayey sandstone. The bedrock was generally slightly moist and ranged from medium hard at the bedrock contact surface to very hard within a few feet of the bedrock surface. The shale bedrock varied from red-brown to blue-gray, and the sandstone was blue-gray.

Unstabilized ground water was encountered in the borings during drilling at depths ranging from about 14 to 17 feet below existing ground surface. The borings were backfilled immediately after drilling was completed. Based on our observations and our experience in mountain terrain and with similar subsurface conditions, we anticipate that ground water is perched above the underlying shale bedrock, and that seasonal variations in level are likely.

Geotechnical Engineering Considerations: Based on the data from the subsurface exploration and laboratory testing programs, it is our opinion that the geotechnical engineering recommendations provided for the adjacent compressor facility should be applicable to the proposed water recycling facility. Although there are some minor differences between the sites, the subsurface conditions encountered at the recycling facility site are substantially similar to the subsurface conditions encountered at the adjacent compressor facility site. Bedrock was encountered at the site at somewhat shallower depths than at the compressor facility, and a higher concentration of cobble-sized fragments were encountered within the overburden soils in places. In addition, ground water was encountered at the boring locations during drilling; ground water was not encountered in the borings drilled for the compressor facility. Overall, these differences are not considered to be significant enough to require modification of our previous geotechnical engineering recommendations.

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 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 Fig. 1, observed site conditions, and the proposed type of construction, and on data from our Project No. 08-1-179. This report may not reflect subsurface variations that occur between the exploratory borings and the extent of variations across the site may not become evident until site grading and excavations are performed. If during construction, fill, soil, rock or water 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.

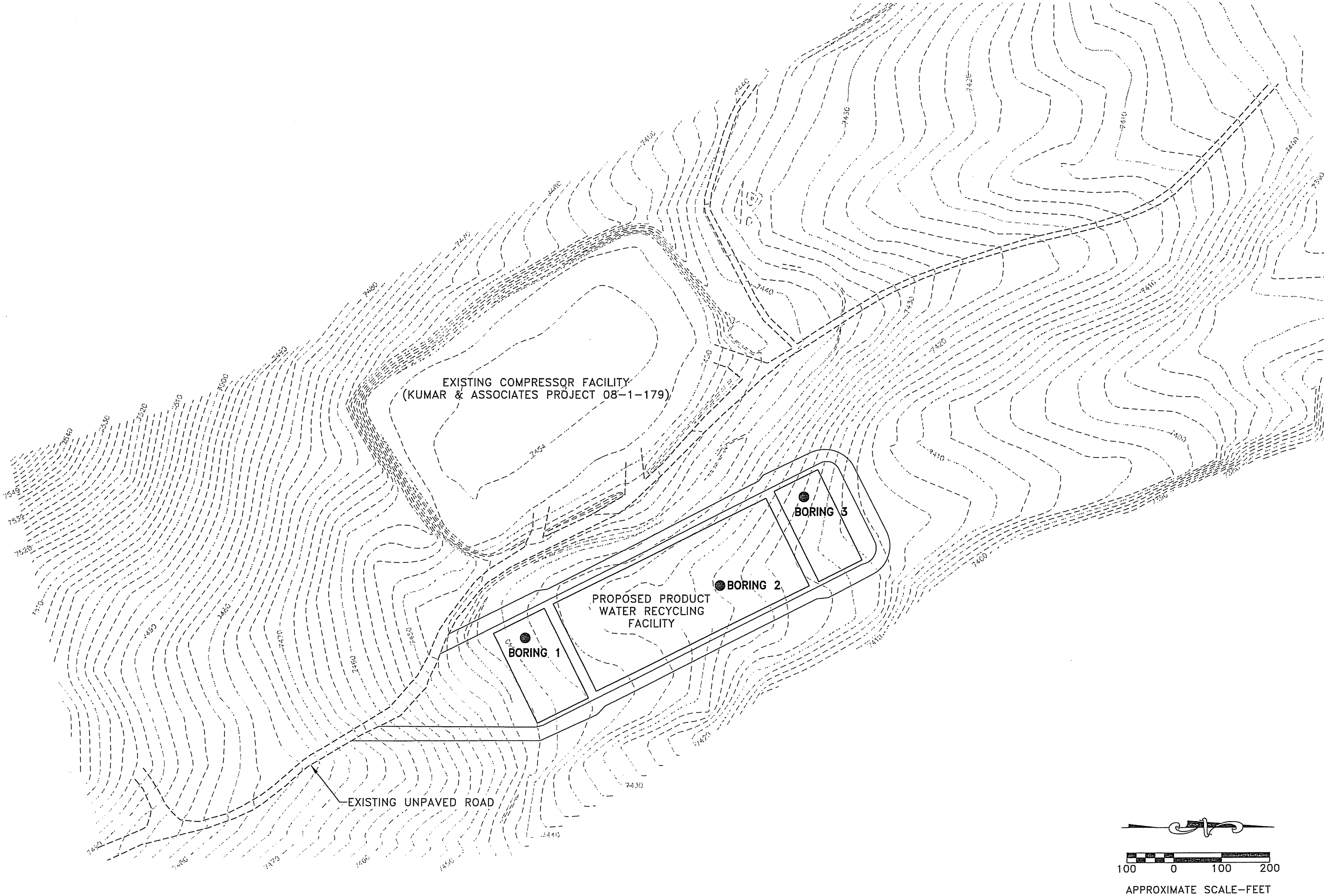
If you have any questions, or if we can be of further assistance, please contact us.

Sincerely,

KUMAR & ASSOCIATES, INC.

Wade Gilbert, P.E.

JWG/mj
Rev. by: AFC
Enclosures
cc: file, book



08-1-179A	Kumar & Associates	PROPOSED DELTA PETROLEUM HARRISON CREEK PRODUCT WATER RECYCLING FACILITY, APPROXIMATELY 12.5 MILES EAST OF COLLBRAN, MESA COUNTY, COLORADO	LOCATIONS OF EXPLORATORY BORINGS	Fig. 1

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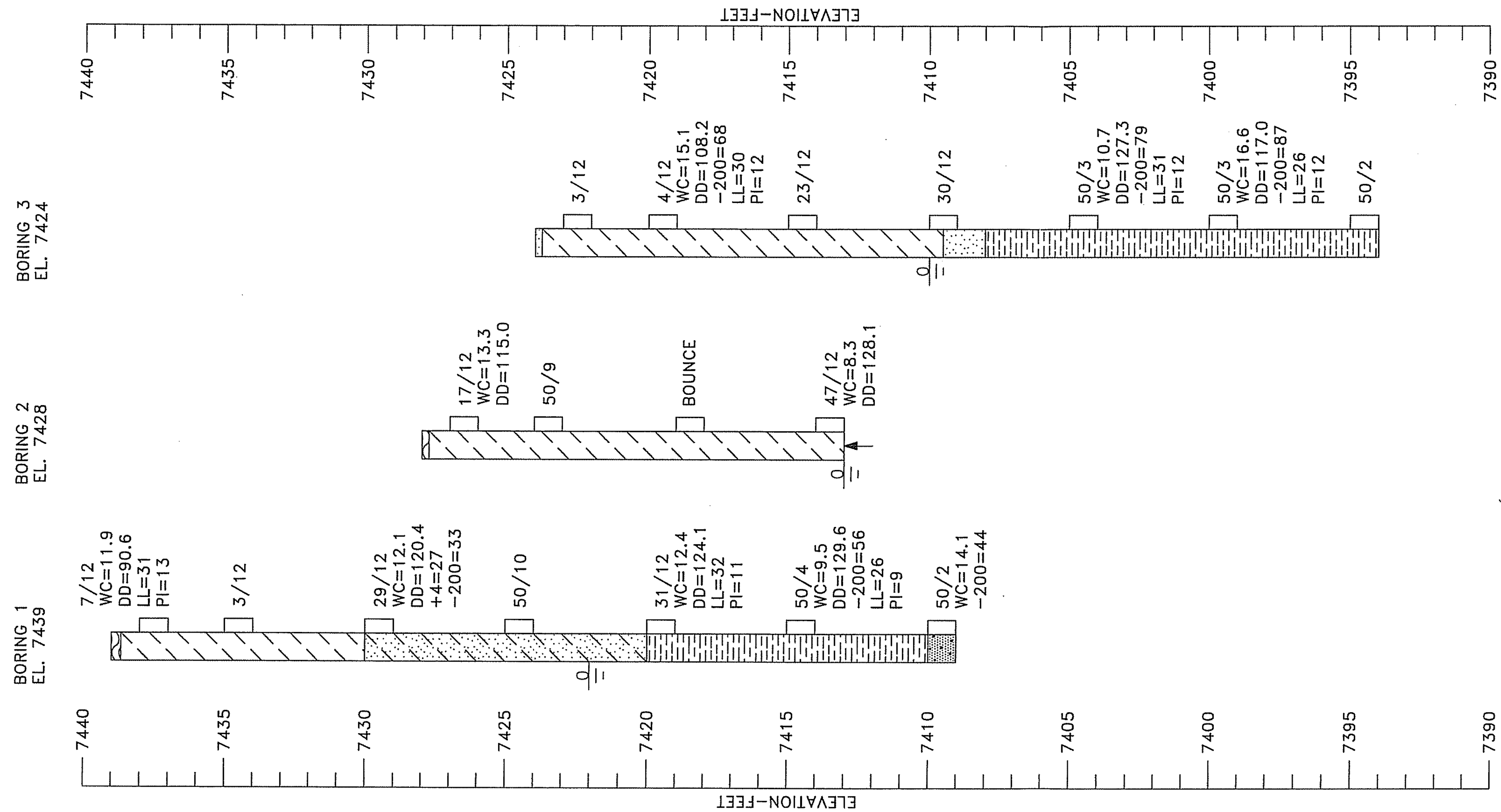

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08-1-179A	Kumar & Associates	PROPOSED DELTA PETROLEUM HARRISON CREEK PRODUCT WATER RECYCLING FACILITY, APPROXIMATELY 12.5 MILES EAST OF COLLBRAN, MESA COUNTY, COLORADO	LOGS OF EXPLORATORY BORINGS	Fig. 2

LEGEND

TOPSOIL.

SANDY LEAN CLAY (CL), FINE TO COARSE SAND, OCCASIONAL TO FREQUENT GRAVEL– AND COBBLE–SIZED SANDSTONE AND SHALE FRAGMENTS, OCCASIONAL LENSES OF CLAYEY SAND WITH GRAVEL, SOFT TO VERY STIFF, SLIGHTLY MOIST TO MOIST, DARK BROWN TO BROWN AND GRAY.

CLAYEY SAND WITH GRAVEL (SC), FINE TO COARSE SAND, OCCASIONAL TO FREQUENT COBBLE–SIZED SANDSTONE AND SHALE FRAGMENTS, MEDIUM DENSE TO VERY DENSE, SLIGHTLY MOIST, BROWN TO GRAY AND RED–BROWN.

POORLY–GRADED SAND WITH SILT AND GRAVEL, DENSE, WET, GRAY–BROWN.

SHALE BEDROCK, MEDIUM HARD TO VERY HARD, FINE GRAINED, CLAYEY, SLIGHTLY MOIST, RED–BROWN TO BLUE–GRAY.

SANDSTONE BEDROCK, CLAYEY, VERY HARD, FINE TO COARSE GRAINED, SLIGHTLY MOIST, BLUE–GRAY.

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

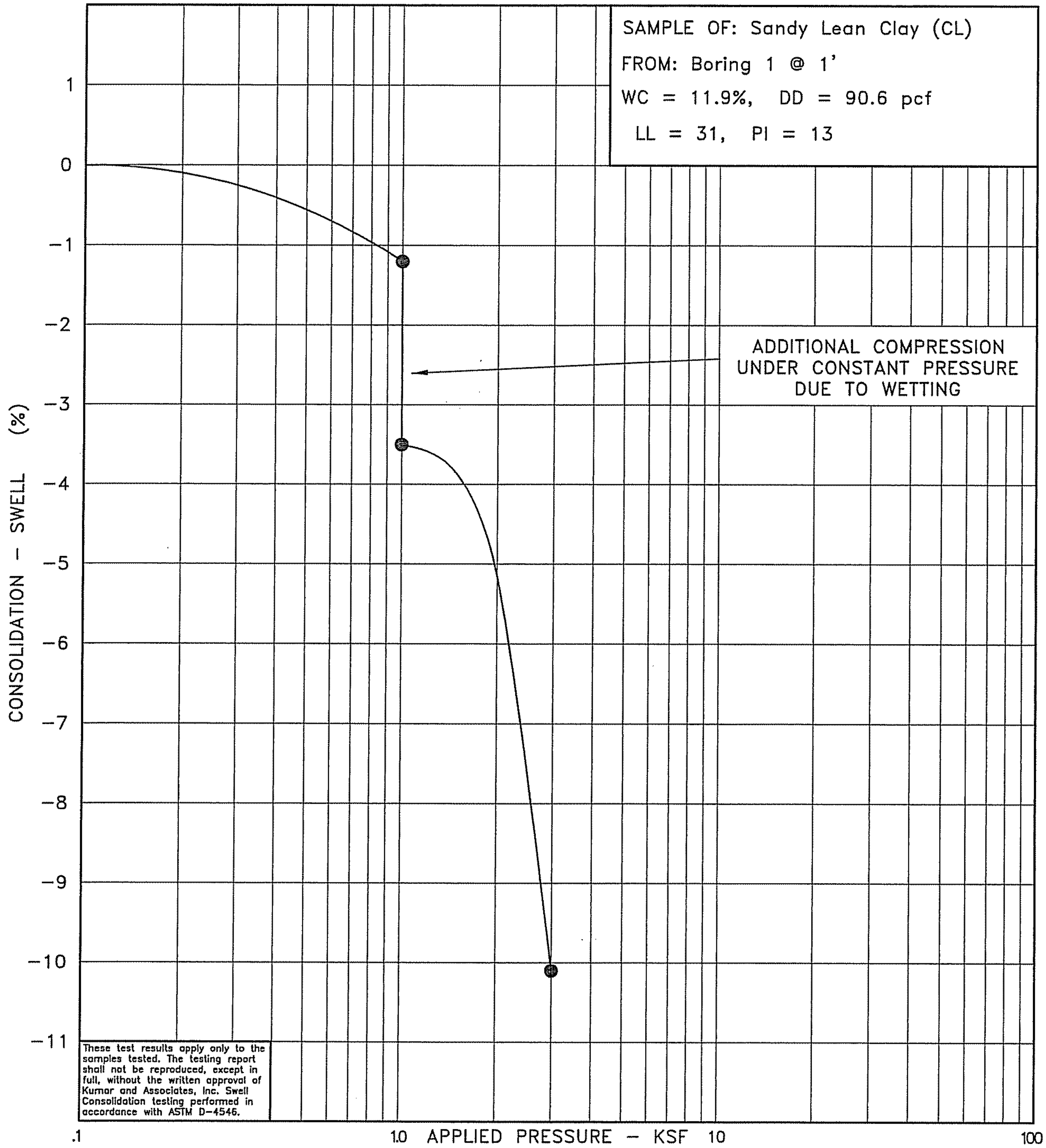
7/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 7 BLOWS OF A 140–POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.

0 DEPTH TO WATER LEVEL ENCOUNTERED AT THE TIME OF DRILLING.

→ PRACTICAL AUGER REFUSAL.

NOTES

1. THE EXPLORATORY BORINGS WERE DRILLED ON JULY 1, 2009 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 OBTAINED BY INTERPOLATION BETWEEN CONTOURS ON THE SITE PLAN PROVIDED.
4. THE EXPLORATORY BORING LOCATIONS AND ELEVATIONS 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. GROUND WATER LEVELS SHOWN ON THE LOGS WERE MEASURED AT THE TIME AND UNDER CONDITIONS INDICATED. FLUCTUATIONS IN THE WATER LEVEL MAY OCCUR WITH TIME.
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).



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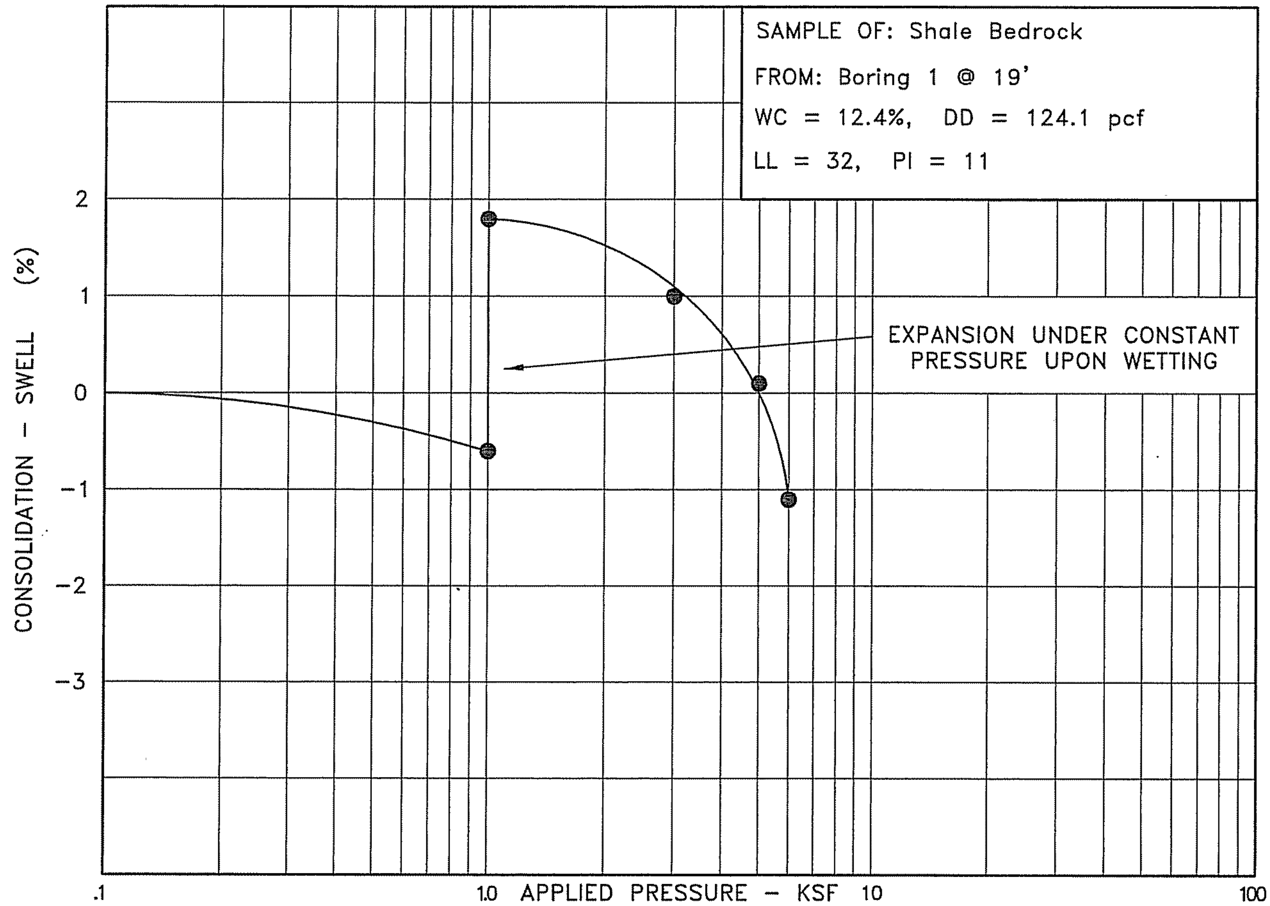
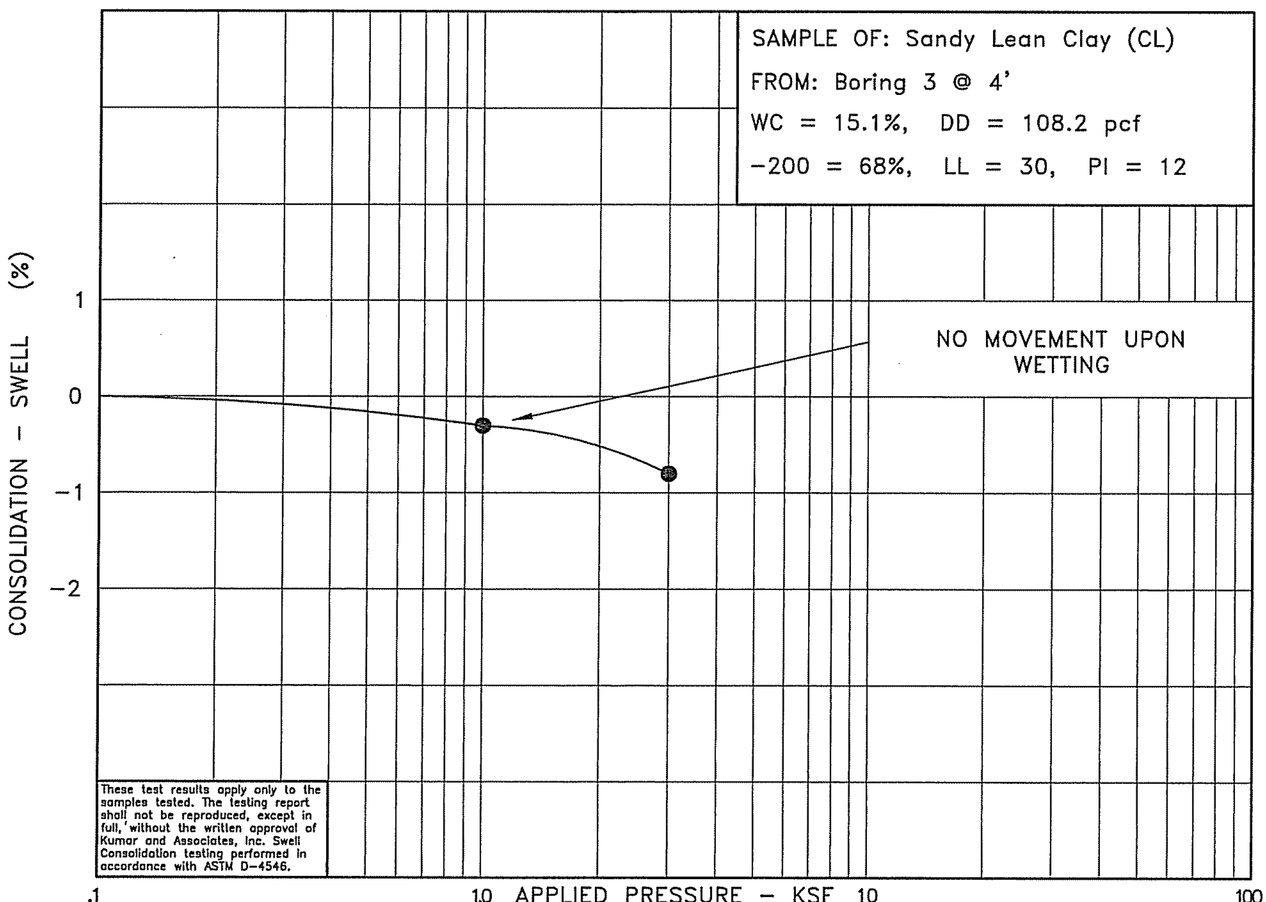
08-1-179A	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULT	Fig. 4





08-1-179A	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 5

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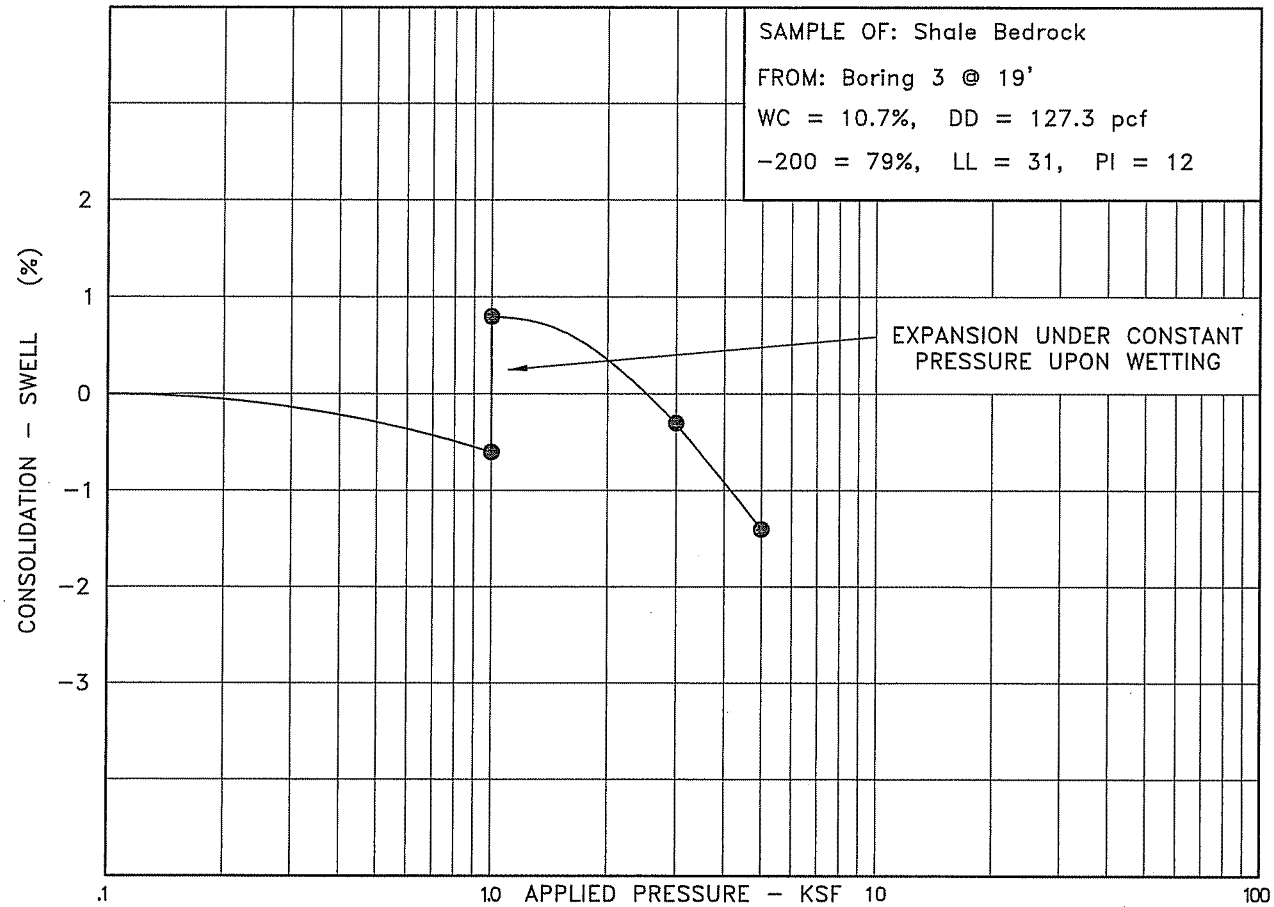

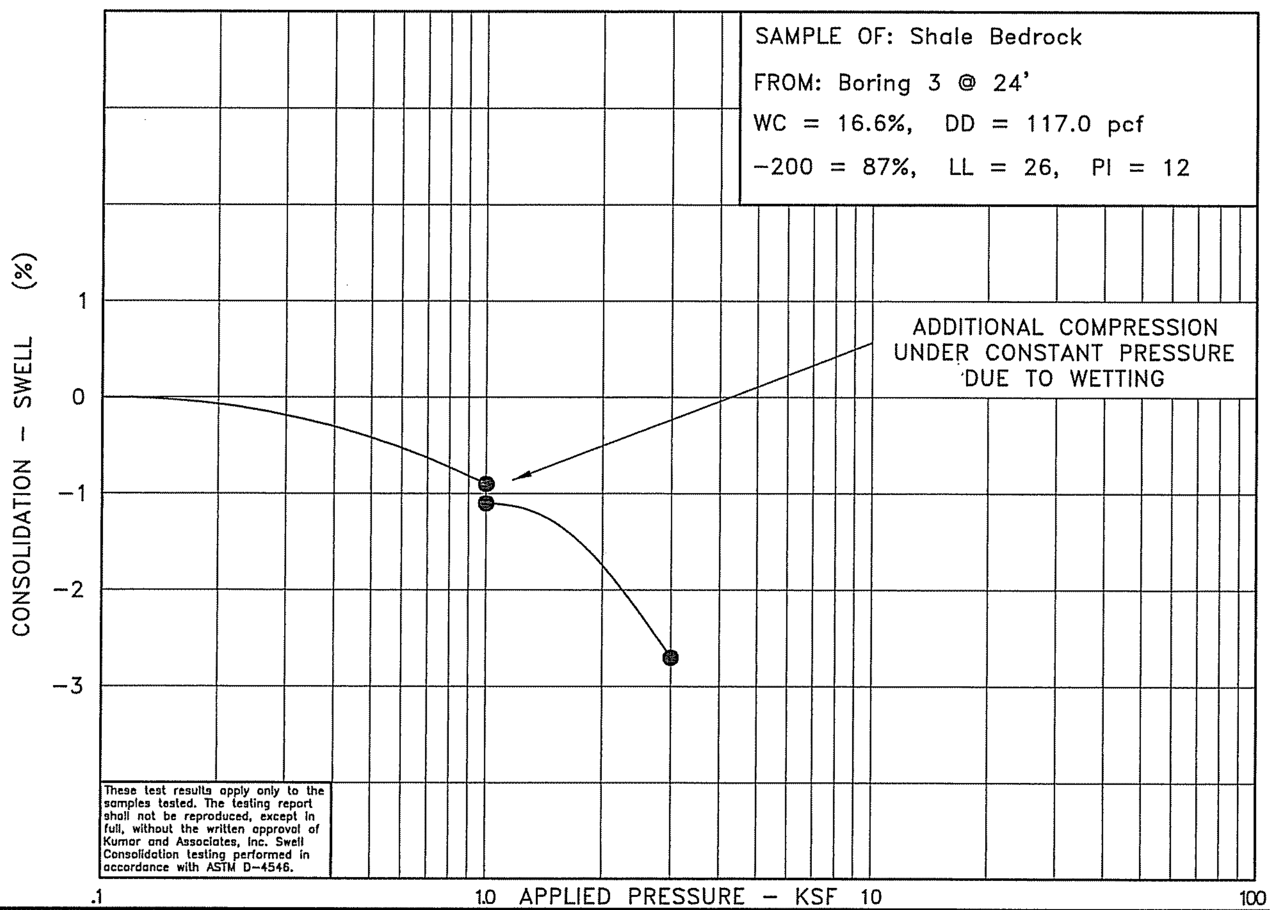

08−1−179A	Kumar & Associates	SWELL−CONSOLIDATION TEST RESULTS	Fig. 6

TABLE I
SUMMARY OF LABORATORY TEST RESULTS

PROJECT NO.: 08-1-179A
PROJECT NAME: Delta Petroleum, Collbran Product Water Recycling Facility
DATE SAMPLED: 7-1-09
DATE RECEIVED: 7-2-09

SAMPLE LOCATION		DATE TESTED	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		SOIL OR BEDROCK TYPE
BORING	DEPTH (feet)				GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)	
1	1	7-6-09	11.9	90.6				31	13	Sandy Lean Clay (CL)
1	9	7-2-09	12.1	120.4	27	40	33			Clayey Sand with Gravel (SC)
1	19	7-2-09	12.4	124.1				32	11	Shale Bedrock
1	24	7-2-09	9.5	129.6			56	26	9	Shale Bedrock
1	29	7-2-09	14.1				44			Sandstone Bedrock
2	1	7-2-09	13.3	115.0						Sandy Lean Clay (CL)
2	14	7-2-09	8.3	128.1						Sandy Lean Clay (CL)
3	4	7-2-09	15.1	108.2			68	30	12	Sandy Lean Clay (CL)
3	19	7-6-09	10.7	127.3			79	31	12	Shale Bedrock
3	24	7-2-09	16.6	117.0			87	26	12	Shale Bedrock

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Kumar & Associates, Inc.
Geotechnical and Materials Engineers
and Environmental Scientists

ACEC MEMBER

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GEOTECHNICAL ENGINEERING STUDY
PROPOSED DELTA PETROLEUM
MEGA VEGA COMPRESSOR STATION
SOUTH OF COUNTY ROAD 330
APPROXIMATELY 12.5 MILES EAST OF COLLBRAN
MESA COUNTY, COLORADO

Prepared By:
Wade Gilbert, P.E.

COLORADO REGISTERED PROFESSIONAL ENGINEER
JAMES WADE GILBERT
39256
4-3-08

Reviewed By:

Alan F. Claybourn, P.E.

Prepared For:

ForeRunner Corporation
3900 South Wadsworth Boulevard, #600
Lakewood, Colorado 80235

Attention: Mr. Paul Janke

Project No. 08-1-179

April 3, 2008

TABLE OF CONTENTS

SUMMARY

1. Subsurface conditions encountered in the borings generally consisted of relatively stiff, low- to high-swelling, sandy lean clays containing occasional to frequent gravel- to cobble-sized shale and sandstone fragments and occasional lenses of silty to clayey sand with gravel. Hard, cemented sandstone and very hard shale bedrock were encountered in two borings at depths of about 22 and 33 feet, respectively. Ground water was not encountered in the borings during drilling or when measured one day after drilling. Seasonal perched ground water due to up-gradient infiltration should be anticipated.

3. In general, the site facilities can be supported on shallow spread foundations or mats, provided the foundations or mats are underlain by at least 8 feet of compacted structural fill extending to natural soils. Shallow foundations should have a minimum dimension of 18 inches for continuous footings and 2 feet for isolated pad footings. Shallow spread foundations and mats should be designed for an allowable bearing pressure of 2,500 psf. To limit potential excessive differential settlements due to variable soil conditions, we recommend supporting the compressors or other settlement sensitive facilities on mats, which would distribute the equipment load over a broad area and result in relatively low foundation contact pressures. Allowable bearing pressures may be increased by ⅓ for transient load conditions.

3. Floor slabs should be supported on compacted structural fill extending to natural soils.

4. Expansive clay soils are present at the site. Proper surface drainage will be very important for acceptable performance of site structures and facilities. Site finished grades should be designed and constructed to promote drainage and reduce ponding of water, and site development plans should include control of up-gradient storm water runoff and site drainage in order to limit site and embankment erosion and ponding of water adjacent to structures.

5. The existing natural soils should be suitable for use as site grading fill and structural fill beneath foundations and floor slabs. The geotechnical engineer should evaluate the suitability of proposed fill materials prior to placement.

PURPOSE AND SCOPE OF WORK

This report presents the results of a geotechnical engineering study for Delta Petroleum's proposed Mega Vega compressor station in Mesa County, Colorado. The project site is located about 12.5 miles east of Collbran and south of County Road 330. The site is shown on Fig. 1. The study was conducted for the purpose of obtaining data and developing geotechnical recommendations for the design and construction of the proposed facility. The study was conducted in general accordance with the scope of work presented in our Proposal No. P-08-216 to ForeRunner Corporation dated February 28, 2008.

A field exploration program consisting of exploratory borings was conducted to obtain information on subsurface conditions. Samples of the soils obtained during the field exploration program were tested in the laboratory to determine their classification and engineering characteristics. The results of the field exploration and laboratory testing programs were analyzed to develop geotechnical recommendations for use in design and construction of the proposed compressor station facilities. 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 facility are included in the report.

PROPOSED CONSTRUCTION

The proposed compressor station layout and existing contours are shown on Fig. 1. The compressor station will have overall dimensions of about 375 feet in the east-west direction and about 600 feet in the north-south direction, and will initially include four compressors in separate buildings/enclosures, a generator building, a control building, an instrument air building, miscellaneous auxiliary process and support equipment and storage vessels, and a central pipe rack and other miscellaneous piping. The site will also include space for adding up to four additional individually housed compressors in the future. The compressor buildings will have dimensions of about 25 by 40 feet, and the other buildings will range from 12 to 20 feet in width and 24 to 40 feet in length. We assume the buildings will be prefabricated metal-framed structures with relatively light column loads, and that equipment weights will range from about 200 to 400 kips for the compressors and from about 200 to 400 kips for various storage and processing equipment.

The site will have three 24-foot wide access driveways ranging in length from about 68 to 170 feet. The site will be encircled by a storm water diversion ditch leading to a detention basin to the north of the north access driveway. We understand that the general site finished grade will be at an elevation of about 7459 feet, which will require cuts ranging from about 1 to 14 feet along the west side of the site and fills ranging up to 8 to 9 feet along the east side of the site.

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

SITE CONDITIONS

The site is an approximately 6-acre, undeveloped parcel located near the confluence of Harrison and Buzzard Creeks, about 1 mile south of County Road 330 and 12.5 miles east of the town of Collbran. An existing, unpaved private road extends along the east side of the site. The project site is located in a slightly sloping area on the west side of Bogue Gulch. Based on topographic information provided by ForeRunner and shown on Fig. 1, the project site generally slopes downward from south to north with surface elevations ranging from approximately 7476 feet near the southwest corner to approximately 7448 feet near the northeast corner. It should be noted that Fig. 1 is a composite of two drawings that do not have a defined common coordinate; accordingly, the locations of the contour lines shown on Fig. 1 should be considered approximate with respect to the proposed site layout.

The site was covered by several inches of snow at the time of drilling. Based on limited observations at the drilling locations and a review of available aerial photos, the site apparently is existing or former pasture land covered with grasses and scattered sage brush.

SUBSURFACE CONDITIONS

The subsurface conditions were explored by drilling eight relatively widely-spaced exploratory borings to depths ranging from about 20 to 40 feet below ground surface. The boring locations were established by Kumar & Associates and staked by Delta Petroleum; the approximate locations are shown on Fig. 1. The logs of the exploratory borings are presented on Fig. 2, along with a legend and associated explanatory notes on Fig. 3.

The borings generally encountered natural colluvial soils consisting primarily of expansive, sandy lean clays containing occasional to frequent gravel- to cobble-sized shale and sandstone fragments and occasional lenses of silty to clayey sand with gravel. The soils were slightly moist to moist and brown. Based on sampler penetration resistance, the clays were generally stiff to hard, although a relatively softer medium consistency sample was encountered in Boring 7 at a depth of about 4 feet. Boring 5 encountered hard, cemented, slightly moist, brown sandstone at a depth of about 22 feet, and Boring 7 encountered very hard, slightly moist, brown shale at a depth of about 33 feet.

Ground water was not encountered in the borings during drilling. Three of the borings were left open for at least 24 hours after drilling was completed in order to obtain ground water level measurements; however, those bore holes were dry to the full depths drilled of 25 to 40 feet when measured. The borings were backfilled immediately after either drilling or ground water measurement was completed. Based on our experience in mountain terrain and with similar subsurface conditions, we anticipate that seasonal perched ground water conditions may develop above the shale bedrock or lower permeability zones in the soil.

LABORATORY TESTING

Laboratory testing was performed on selected soil samples obtained from the borings to determine in situ soil moisture content and dry density, Atterberg limits, swell-consolidation characteristics, gradation, concentration of water soluble sulfates, chloride content, pH, electrical resistivity, and moisture-density relationships (standard Proctor). The results of the laboratory tests are shown to the right of the logs on Fig. 2 and summarized in Table I. The results of specific tests are graphically plotted on Figs. 4 through 8. The testing was conducted in general accordance with recognized test procedures, primarily those of the American Society for Testing of Materials (ASTM).

Swell-Consolidation: Swell-consolidation tests were conducted on five samples of the soils encountered in the borings in order to determine their compressibility and swell characteristics under loading and when submerged in water. Each sample was prepared and placed in a confining ring between porous discs, subjected to a surcharge pressure of 500 psf, and allowed to consolidate before being submerged. The sample height was monitored until deformation practically ceased under each load increment.

Results of the swell-consolidation tests are presented on Figs. 4 through 6 as plots of the curve of the final strain at each increment of pressure against the log of the pressure. Based on the results of the laboratory swell-consolidation testing, the samples exhibited moderate to high swell behavior upon wetting. Based on the fines content and Atterberg limits of other samples, we anticipate some of the site soils to exhibit low swell potential.

A swell-consolidation test was also conducted on a hand-drive sample of remolded natural lean clay soil obtained from a compaction mold prepared during a laboratory moisture-density relationship (standard Proctor) test. The hand-drive sample was obtained from a mold compacted at 100 percent of the standard Proctor (ASTM D695) maximum dry density at a moisture content slightly below optimum moisture content. The results of the moisture-density relationship test, Fig. 8, indicate low swell potential after remolding.

Index Properties: Samples were classified into categories of similar engineering properties in general accordance with the Unified Soil Classification System. This system is based on index properties, including liquid limit and plasticity index, and grain size distribution. Values for moisture content, dry density, liquid limit, plasticity index, and the percent of soil passing the U.S. No. 200 sieve are presented in Table I and adjacent to the corresponding sample on the boring logs.

SITE DEVELOPMENT CONSIDERATIONS

Based on conditions encountered in the borings, the site appears to be underlain to depths of 20 to 30 feet or more by natural, relatively stiff, sandy lean clays underlain by relatively hard sandstone and shale bedrock. Based on the results of the swell-consolidation testing, the clays are moisture sensitive and are expected to exhibit erratic moisture-dependent volume change characteristics ranging from low to high swell potential in the presence of increased moisture. Without proper site preparation, moisture-induced swelling of the natural subgrade soils could adversely affect site structures and other facilities supported on those soils.

Based on the moisture-volume change characteristics of the soils encountered in the borings, we believe shallow spread footing and/or mat foundations and floor slab-on-grade construction should be feasible across the site provided the risk of distress resulting from potential ground heave is accepted by the owner, and mitigation measures provided in this report are followed. As discussed in the following section, use of shallow spread footing and/or mat foundations and slab-on-grade construction will require sub-excavation beneath foundation and slab subgrades to remove the natural clay soils to sufficient depths and replacing those soils with properly moisture-conditioned compacted fill. Although there would still be some risk of foundation and slab movement due to the potential swelling of the natural clays beneath the moisture-conditioned fill, and due to slight expansion of the fill itself, the potential for foundation and slab movement would be mitigated by implementing the recommended over-excavation and fill placement, by constructing and maintaining good surface drainage, and by minimizing landscape irrigation. The potential for wetting of the soils from typical precipitation would be low, but the risk of wetting from poor surface drainage, heavily irrigated landscaping, pipe breaks or leaks, or other facility-related reasons would still be a concern.

While we believe there is a high probability that foundations and slabs supported on a zone of structural fill would perform well, there would be some remaining risk of foundation and/or slab movement. Deep foundation alternatives, such as straight-shaft drilled piers drilled into bedrock or engineered steel screw piles bearing in the bedrock, may be considered if that risk cannot be accepted by the owner. Steel screw piles bearing in the bedrock can be installed fairly quickly and may be more cost effective when compared to drilled piers. Load capacity criteria for screw pile foundation systems are typically provided by the specialty contractor who installs the piles, and would be based on site-specific load testing. We are available to develop alternative foundation recommendations, if requested.

Discussion of Foundation and Floor Slab Movement: The following discussion presents estimates of ground heave for different wetting depth scenarios to aid in the decision making process for foundation and floor support systems. The risk of ground heave beneath structures and equipment can be mitigated to a certain degree by providing a zone of non- to low-swelling, relatively impervious fill directly beneath foundations and floor slabs. Heave estimate calculations can be useful in evaluating the relative effectiveness of varying the thickness of this prepared fill zone. However, such calculations can not address the uncertainty in the potential depth and degree of wetting that may occur under beneath the structures or equipment or the variability of swell potential across a site.

We have performed calculations to demonstrate the potential for ground heave if the soils beneath structures and equipment should become thoroughly wetted to significant depth, including below the depth of the prepared fill zone. The following table presents estimates of potential heave based on the results of swell-consolidation tests using test and analysis methods generally accepted in Colorado. Both depth of wetting and depth of the prepared fill were considered as variables in the analysis.

Alternative	Ground Heave in Inches		
	10 feet of wetting	15 feet of wetting	20 feet of wetting
No moisture treatment	4.2	5.5	6.6
6 feet of moisture treatment	1.6	2.9	4.0
8 feet of moisture treatment	1.0	2.3	3.4
4 feet non-expansive over 2 feet of moisture treatment	1.3	2.6	3.7
4 feet of non-expansive over 4 feet of moisture treatment	0.7	2.0	3.1

The heave estimate calculations demonstrate that significant heave should be expected if wetting of the natural soils beneath structures and equipment occurs to significant depth below the bottom of the prepared fill zone. However, our experience indicates that the large majority of similar structures underlain by similar subsoils do not experience extreme moisture increases in the underlying soils to significant depth provided that good surface drainage is designed, constructed, and maintained. Wetting can also occur as a result of unforeseeable influences such as piping leaks or breaks, or in some cases even due to off-site influences depending on geologic conditions.

Based on the classification test results, we expect the swell potential of the site soils to be erratic, with much of the site soils exhibiting low swell potential. The classification test results also indicated that there are zones of soils that should exhibit very little to no swell potential. This means that the total heave magnitudes shown in the above table may be over-estimated for portions of the site, although there may also be chances for non-uniform heave due to variable site conditions.

Considering the above discussion, we believe shallow spread footing and/or mat foundations and floor slab-on-grade construction may be used for the project, provided that the potential for foundation and slab movement due to ground heave and associated possible distress is recognized by the owner. The intent of our recommendations is to provide for conditions where there is a good chance ground heave beneath structures and other facilities will not exceed amounts acceptable to the owner. In this evaluation, we are assuming the proposed equipment will be able to tolerate movements normally considered acceptable for typical building structures. These recommendations should result in heave movements that do not exceed 1 inch and are unlikely to significantly exceed 1 to 2 inches unless extreme wetting is allowed. Barring unforeseen events, we do not believe extreme wetting is likely to occur if the surface drainage and irrigation recommendations presented in this report are followed.

FOUNDATION RECOMMENDATIONS

We assume the working loads that will be exerted by the planned structures and other facilities will be light to moderate. We understand that the critical structures and equipment will include the compressor building and compressors, and possibly taller gas processing equipment. We assume these facilities can tolerate relatively little differential settlement, although we have not been provided with settlement tolerances.

In general, the planned structures and facilities, and miscellaneous equipment, can be supported on shallow spread footing or mat foundations, provided the spread footings or mats are underlain by compacted structural fill extending to natural soils. While it would be feasible to support the compressors on isolated or continuous footings, subsurface soils across the building location are expected to be variable and could lead to excessive differential settlements between individual foundation elements. To limit potential excessive local differential settlements due to variable soil conditions, we recommend supporting the compressors and other settlement-sensitive facilities on mats, which would distribute the equipment loads over a broader area and result in relatively low foundation contact pressures.

Spread Footings: The design and construction criteria presented below should be observed for a spread footing foundation system. The construction details should be considered when preparing project documents.

1. Spread footings should be underlain by at least 8 feet of non- to low-swelling compacted structural fill extending to undisturbed natural soils. Subexcavation of natural soils to a sufficient depth to allow placement of the minimum thickness of new structural fill may be required in places.

2. Footings established as recommended should be designed for an allowable soil bearing pressure of 2,500 psf. The footings should also be designed for a minimum dead load pressure of 800 psf. Allowable bearing pressures may be increased by 1/3 for transient load conditions.

3. Spread footings should have a minimum footing width of 18 inches for continuous footings and 24 inches for isolated pads.

4. Based on experience, we estimate total settlement for footings designed and constructed as discussed in this section will be approximately 1 inch or less. Differential settlements between adjacent foundation elements are estimated to be approximately ½ to ¾ of the total settlement.

5. Exterior footings and footings beneath unheated areas should be provided with adequate soil cover above their bearing elevation for frost protection. Placement of foundations at least 36 inches below the exterior grade is typically used in the site vicinity.

6. The lateral resistance of a spread footing placed on properly compacted structural fill material will be a combination of the sliding resistance of the footing on the foundation materials and passive earth pressure against the side of the footing. Resistance to sliding at the bottoms of the footings can be calculated based on an allowable coefficient of friction of 0.30. Passive pressure against the sides of the footings can be calculated using an equivalent fluid pressure of 175 pcf. The above values are working values.

7. Structural fill placed against the sides of the footings to resist lateral loads should conform to the general material and compaction criteria provided in the Excavation and Grading section of this report.

8. Structural fill beneath spread footing foundations should conform to the general material and compaction criteria provided in the Excavation and Grading section of this report with the exception that structural fill placed beneath footing foundations should be compacted to at least 98% of the maximum standard Proctor density (ASTM D698). Prior to placing structural fill, the subgrade soils should be scarified to a depth of 8 inches, adjusted to a moisture content near optimum, and re-compacted to at least 95% of the standard Proctor (ASTM D 698) maximum dry density to provide a firm, uniform base for subsequent fill placement. Structural fill should extend down and out from the edges of the footings at a 1:1 (horizontal: vertical) projection.

9. A representative of the project geotechnical engineer should observe all footing excavations and observe and test structural fills prior to concrete placement.

Mats: The design and construction criteria presented below should be observed for a mat foundation system. Construction details should be considered when preparing project documents.

1. Mat foundations should be underlain by at least 8 feet of non- to low-swelling compacted structural fill extending to undisturbed natural soils. Subexcavation of natural soils to a sufficient depth to allow placement of the minimum thickness of new structural fill may be required in places.

2. A mat foundation placed on a minimum of eight feet of properly compacted structural fill extending to natural soils may be designed for an allowable contact pressure of 2,500 psf. This contact pressure may be increased by 1/3 for transient loadings.

3. Settlements under static load were estimated for a relatively large, rigid mat with a uniformly distributed working load based on the combined weight of the heaviest planned compressor and mat. It should be noted that the estimated working contact pressure was significantly less than the allowable contact pressure. Settlement due to compression of the predominantly cohesive foundation soil was estimated based on elastic theory. Settlement is assumed to occur immediately after the application of loads.

   Based on the above, we estimate total settlements beneath a rigid mat will be on the order of 1 inch. Differential settlements across the mat are estimated to be ½ to ¾ of the total settlement. Non-uniformity of the subsurface conditions and deviation from the rigid mat assumption will contribute to total and differential settlements.

   Rigidity of the mat is dependent on the mat dimensions, load distribution, and the modulus of subgrade reaction of the supporting soils. We recommend the mat foundation be analyzed to determine if the rigidity assumption is valid. If the mat cannot be considered rigid, the soil pressure distribution should be computed using a method which models the soil-structure interaction, such as the beam on an elastic foundation procedure. A modulus of vertical subgrade reaction equal to 175 tcf may be used for predominantly granular soils and 125 tcf for predominantly fine-grained soils. The modulus value given is for a 1-foot square plate and must be corrected for mat shape and size.

When the soil pressure distribution has been determined, we should be contacted to reanalyze the settlement pattern of the foundation. The process of evaluating soil pressure distribution beneath the foundation may require several iterations for a foundation which classifies between rigid and flexible.

4. The lateral resistance of a mat foundation placed on properly compacted structural fill material will be a combination of the sliding resistance of the mat on the foundation materials and passive earth pressure against the side of the footing. Resistance to sliding at the bottoms of the footings can be calculated based on a coefficient of friction of 0.30. Passive pressure against the sides of the mat foundations can be calculated using an equivalent fluid density of 175 pcf. The above values are working values.

5. Structural fill placed against the sides of the footings to resist lateral loads should conform to the general material and compaction criteria provided in the Excavation and Grading section of this report.

6. For dynamic analysis, we recommend using a low-strain, dynamic shear modulus of 1,350 ksf and a Poisson's ratio of 0.3. These values are for sandy clays similar to those encountered at the site and are based on empirical relationships between soil type and density.

7. Structural fill beneath mat foundations should conform to the general material and compaction criteria provided in the Excavation and Grading section of this report with the exception that structural fill placed beneath mat foundations should be compacted to at least 98% of the maximum standard Proctor density (ASTM D698). Prior to placing sub-slab structural fill, the subgrade soils should be scarified to a depth of 8 inches, adjusted

to a moisture content near optimum, and re-compacted to at least 95% of the standard Proctor (ASTM D 698) maximum dry density to provide a firm, uniform base for subsequent fill placement. Structural fill should extend down and out from the edges of the mat at a 1:1 (horizontal: vertical) projection.

8. A representative of the geotechnical engineer should observe all mat excavations prior to concrete placement in order to evaluate the supporting capacity of foundation materials.

SEISMICITY

The site is located on an area of relatively low seismic activity. Based on fault and earthquake epicenter maps prepared by the Colorado Geological Survey, mapped Quarternary to Late Quarternary faults and earthquake epicenters closest to the site are located about 30 miles to the east-northeast. Historic earthquake data for western Colorado indicate recorded moment magnitudes of 4.9 or less, and the Colorado Geophysical Survey estimates a maximum moment magnitude of 5 for potentially active faults in western Colorado.

The soil profile to depths ranging from about 20 to 30 feet or more consists primarily of relatively stiff natural cohesive soils that classify as IBC Site Class D. Based on our experience, the sandstone and shale bedrock underlying the site would classify as IBC Site Class B or C. Based an anticipated depth to bedrock around 30 feet, we recommend a design soil profile for the site of IBC Site Class C.

Site soils were generally relatively stiff and dense to the full depths explored of 20 to 40 feet, and static ground water was not encountered above those depths. In general, sites with similar soil profiles and ground water conditions, and low site seismicity, are not susceptible to liquefaction.

FLOOR SLABS

To help mitigate movements caused by swelling of the potentially expansive natural clay soils, we recommend sub-excavating the natural soils to a depth of at least 8 feet below slab subgrade elevation and backfilling with properly compacted non- to low-swelling structural fills extending to natural soils. The thickness of the backfill zone, and required subexcavation, may be reduced for Isolated slabs that more tolerant of movement; however, we recommend a minimum of 6 feet of non- to low-swelling structural fill beneath those slabs. The following measures also should be taken to reduce the risk of movement-related damage to slabs-on-grade:

1. Structural fill beneath at-grade slabs, where required, should conform to the material and compaction criteria provided in the "Excavation and Grading" section of this report. Prior to placing sub-slab structural fill, the subgrade soils should be scarified to a depth of 8 inches, adjusted to a moisture content near optimum, and re-compacted to at least 95% of the standard Proctor (ASTM D 698) maximum dry density to provide a firm, uniform base for subsequent fill placement.

2. To reduce the effects of differential movements, floor slabs should be separated from all bearing walls and columns with expansion joints that allow unrestrained vertical movement.

3. Floor-slab control joints should be used to reduce damage due to shrinkage cracking. The joint spacing and slab reinforcement should be established by the designer based on experience and the intended slab use.

4. The geotechnical engineer should evaluate the suitability of proposed underslab fill material.

WATER SOLUBLE SULFATES

The concentrations of water soluble sulfates measured in two samples of the natural soils, including a sample of sandy lean clay and a sample of silty sand with gravel, were less than 0.02 percent. This concentration of water soluble sulfates represents a negligible degree of sulfate attack on concrete exposed to these materials. The degree of attack is based on a range of negligible, positive, severe and very severe as presented in the U.S. Bureau of Reclamation Concrete Manual. Based on the laboratory test results, we believe special sulfate resistant cement will generally not be required for concrete exposed to the natural soils or to fills consisting of the on-site natural soils.

BURIED METAL CORROSION

The potential for corrosion of buried metals or pipes placed beneath the ground surface at the site was evaluated based on the results of laboratory tests on two samples of the natural soils, including a sample of sandy lean clay and a sample of silty sand with gravel. The samples were tested to determine pH, chloride content and electrical resistivity.

The pH tests indicated the tested soils are mildly alkaline, which should have a negligible affect on corrosion, and have chloride contents of 0.02 and 0.03 percent for the clay and sand samples, respectively. The results of the electrical resistivity tests are presented on Fig. 7. The test results for the samples indicate minimum laboratory electrical resistivity values of about 1,580 ohm-cm for the lean clay sample and about 3,210 ohm-cm for the silty sand sample at moisture contents of about 19 percent. The test results indicate an estimated resistivity value of about 1,950 ohm-cm at an in situ moisture content of about 12 percent for the lean clay sample, and a resistivity value greater than 12,000 ohm-cm at an in situ moisture content of about 5 percent for the silty sand sample. Based on the resistivity test results, the natural lean clay soils would generally be classified as very corrosive at in situ moisture contents below about 6 percent and moderately corrosive at moisture contents above about 6 percent, and the natural silty sand soils would generally be classified as very corrosive at in situ moisture contents below about 12 percent and moderately corrosive at moisture contents above about 12 percent. The corrosion classification is based on a range of slightly, mildly, moderately, to very corrosive as presented by the U.S. Bureau of Reclamation.

Based on laboratory test results, samples of the natural clays encountered in the borings had moisture contents generally ranging from about 10 to 18 percent, and samples of the natural sands had moisture contents below about 7 percent. The natural soils are expected to exhibit poor to fair drainage characteristics.

Corrosion of buried metal is a complex process and requires an understanding of the combined affects of pH, ion content, electrical resistivity, soil moisture, and other conditions not evaluated as part of this study. We recommend a qualified corrosion engineer review the information presented herein to determine the need for and appropriate level of corrosion protection for buried metals at the site.

SURFACE DRAINAGE

Proper surface drainage is very important for acceptable performance of site structures and facilities during construction and after the construction has been completed. The site may be subject to storm water runoff from higher elevation areas to the south and west. The site soils are expected to be moderately susceptible to erosion from storm water flows. Although the site soils are expected to be moderately impervious, the natural clays are potentially expansive and could be affected by infiltration of surface water. Accordingly, site finished grades should be designed and constructed to promote drainage and reduce ponding of water. Site development plans should include control of up-gradient storm water runoff and site drainage in order to limit site and embankment erosion and ponding of water adjacent to structures.

Drainage recommendations provided by local, state and national entities should be followed based on the intended use of the facility. The following recommendations should be used as guidelines and changes should be made only after consultation with the geotechnical engineer:

1. Excessive wetting or drying of the foundation and slab subgrades should be avoided during construction.

2. The ground surface surrounding the exterior of buildings and other structures should be sloped to drain away from the foundations in all directions. We recommend a minimum slope of 6 inches in the first 10 feet, although a minimum slope of 12 inches would be preferable. Site drainage beyond the 10-foot zone should be designed to promote runoff and reduce infiltration.

3. To promote runoff, the upper 1 to 2 feet of the backfill adjacent to buildings and other structures should consist of relatively impervious on-site soil.

4. Ponding of water should not be allowed within 10 feet of structure foundations.

5. Runoff form roofed structures should be collected and discharged well beyond the limits of all foundation backfill.

6. Construct appropriate surface drainage measures to collect and remove runon and runoff, and to reduce ponding, infiltration, and flow over fill slopes. We recommend grading the site to promote and direct runoff, installing collection and diversion measures such as ditches and berms where appropriate, and constructing discharge points designed to reduce potential erosion.

EXCAVATION AND GRADING

Site Preparation: Site preparation should include stripping and/or grubbing existing vegetation and removal of topsoil, where present, from beneath structures and other site facilities and from beneath roadway and yard areas. Prior to placing compacted fills or roadway and yard area surfacing, the natural subgrade soils should be scarified to a minimum depth of 8 inches, adjusted to a moisture content near optimum, and compacted to at least 95% of the standard Proctor (ASTM D 698) maximum dry density. Fills should be benched into existing natural slopes exceeding 4H:1V (horizontal:vertical), with vertical bench heights between 2 and 4 feet.

Prior to placement of concrete, foundation and floor slab areas should be proof-rolled to identify any areas of soft or excessively loose subgrade soils. Soft or excessively loose soils that cannot be properly densified during proof-rolling should be over-excavated to suitable soils and replaced with compacted structural fill.

Temporary Excavation Slopes: All excavations should be constructed in accordance with OSHA requirements, as well as state, local and other applicable requirements. For temporary excavations that occur during site grading, the natural sand soils generally classify as OSHA

Type C soils and the natural lean clay soils generally classify as OSHA Type B soils. If unstable soil conditions or ground water are encountered, the geotechnical engineer should be notified so that additional recommendations can be provided, if necessary.

Permanent Cut and Fill Slopes: Based on our experience with soils similar to those encountered on the site, we recommend that unreinforced embankment fills and permanent cut slopes be constructed no steeper than 2H:1V based on stability requirements and 3H:1V for reducing erosion susceptibility. No formal stability analyses were performed to evaluate the slopes 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.

We do not anticipate seepage will be encountered in permanent excavation slopes. However, 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.

Slopes of 2H:1V (horizontal:vertical) constructed of or excavated in on-site natural soils are expected to be moderately to highly susceptible to surface erosion under moderate sheet flows and highly susceptible to erosion under concentrated flows. Susceptibility to erosion can be limited by constructing the slopes at flatter inclinations, as recommended above, or by establishing an appropriate vegetative cover, which may be difficult at the site.

Fill Materials and Compaction Criteria: We anticipate that the primary source of structural fill material will be on-site natural soils, and that materials will be imported as necessary where additional volume is required or for specific purposes such as road and yard area surfacing. Based on subsurface conditions encountered in the explorations, on-site borrow will consist primarily of natural sandy lean clay soils exhibiting moderate to high potential for expansion, with minor volumes of silty sands with gravel.

Structural fill placed beneath structures and soil-supported slabs should be non- to low-swelling. Non- to low-swelling structural fill, when placed at a moisture content within 0 to 3 percentage points above optimum and compacted to at least 95% of the standard Proctor (ASTM D 698) maximum dry density, should have a swell potential that does not exceed 1% when tested under a 200 psf surcharge. Based on the laboratory moisture-density relationship test and remolded swell test performed for this study, the on-site clays should meet these criteria if properly moisture conditioned.

Imported fill material, if required, should be non-expansive and free of vegetation, brush, sod and other deleterious substances and should not contain rocks or lumps larger than 6 inches in greatest dimension. Rocks or lumps should be dispersed throughout the fill and "nesting" of these materials should be avoided. Imported materials used as structural fill beneath structures should also consist of a low-permeability soils with more than 25% material passing the No. 200 sieve. The geotechnical engineer should evaluate the suitability of proposed fill materials prior to placement.

Unless recommended otherwise in this report, structural fill should be compacted to at least 95% of the standard Proctor (ASTM D 698) maximum dry density. Fine-grained structural fill materials (more than 50% passing the No. 200 sieve) should be compacted at a moisture content between 0 to 3 percentage points above optimum moisture content. Granular structural fill materials (less than 50% passing the No. 200 sieve) should be compacted at a moisture content within 2 percentage points of the optimum moisture content.

Based on the moisture-density relationship shown on Fig. 8, the on-site natural clays are expected to have an optimum moisture content of about 14 percent. Based on the laboratory test data, the in situ moisture contents of the near-surface natural clay soils are expected to be generally below the optimum moisture content for those materials. Achieving the required moisture content for compaction of the finer-grained on-site natural soils will require the addition of moderate to possibly significant amounts of water. The contractor should be aware that on-site fine-grained soils, as well as granular soils with moderate to significant amounts of material passing the No. 200 sieve, may become somewhat unstable and deform under wheel loads if placed near the upper end of the moisture range. This is generally not a concern in structural fills beneath buildings and other structures, but could be problematic at shallow depth in drive and yard areas.

A representative of the geotechnical engineer should observe and test structural and embankment fill placement.

ACCESS ROADS AND SITE TRAFFIC AREAS

We assume site access driveways and site yard areas subject to vehicle traffic will have aggregate surfacing. Based on our experience, an aggregate surface thickness of 6 to 12 inches should be considered in areas accessed by vehicles, with the greater thicknesses used in turn-around areas and on-site areas that may be used routinely by heavier vehicles. A thickness greater than 12 inches may be preferred for the access driveways. The owner may have other preferences for construction of the access driveways and other vehicle areas based on their experience. Since the aggregate subgrade soils are likely to be fills and/or natural soils consisting primarily of fine-grained clay soils, we recommend considering the use of a geotextile separation fabric between the subgrade soils and aggregate surfacing materials to reduce the potential for migration of fines into the surfacing materials.

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 to perform 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 engineering practices in this area for exclusive use by the client for planning and design purposes. The conclusions and recommendations submitted in this report are based upon data obtained from the exploratory borings drilled at the locations indicated on Fig. 1, and upon the proposed construction. This report may not reflect subsurface variations that occur between the explorations or across the remainder of the site, and the nature and extent of variations across the site may not become evident until site grading and excavations are performed. If during construction, fill, soil, rock or water 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.

The scope of services for this project does not include any environmental assessment of he site or identification of contaminated or hazardous materials or conditions. If Delta Petroleum is concerned about the potential for such contamination, other studies should be undertaken.

JWG/mj

cc: book, file

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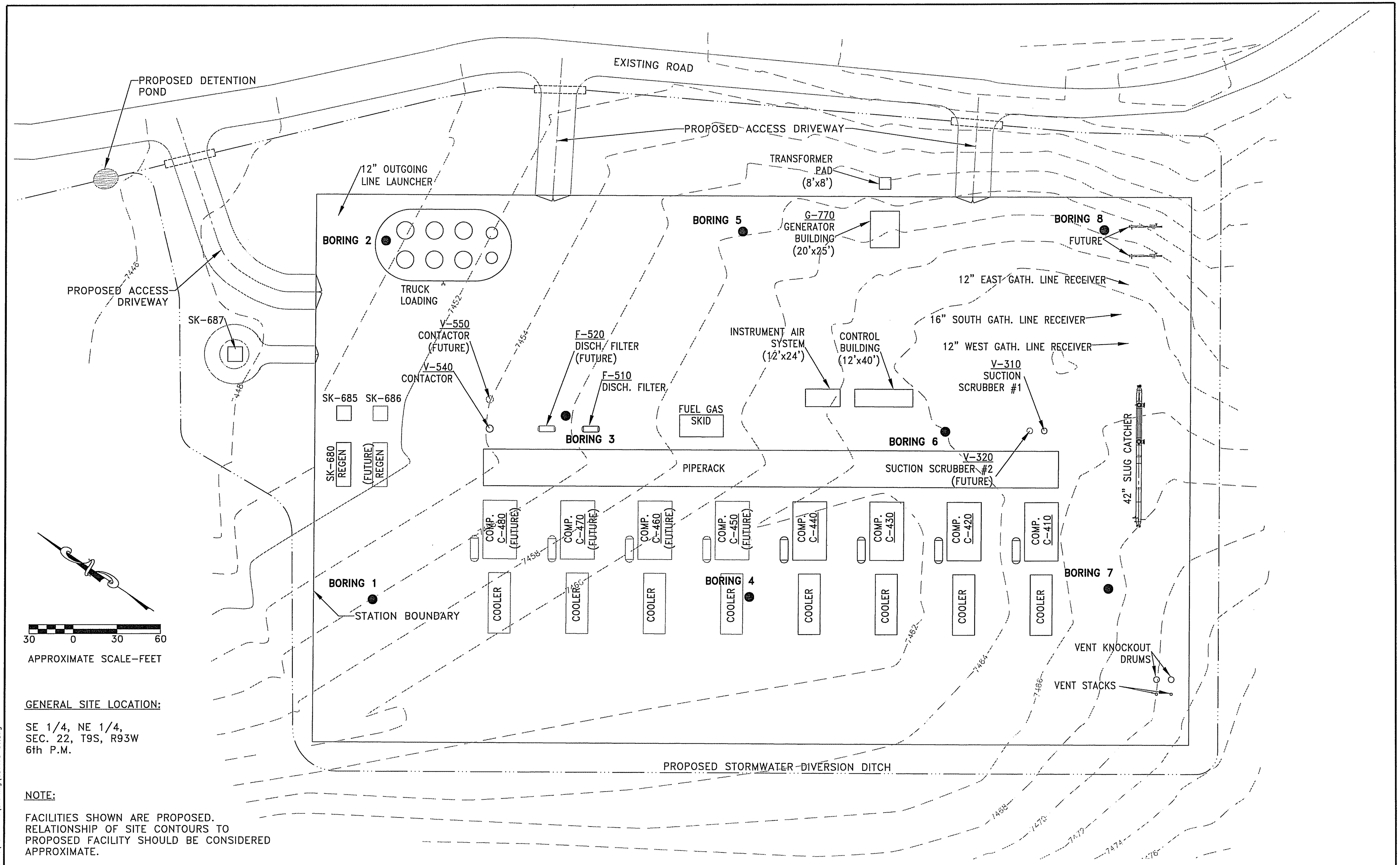

08-1-179	Kumar & Associates	PROPOSED DELTA PETROLEUM MEGA VEGA COMPRESSOR STATION, APPROXIMATELY 12.5 MILES EAST OF COLLBRAN, MESA COUNTY, COLORADO	LOCATIONS OF EXPLORATORY BORINGS	Fig. 1

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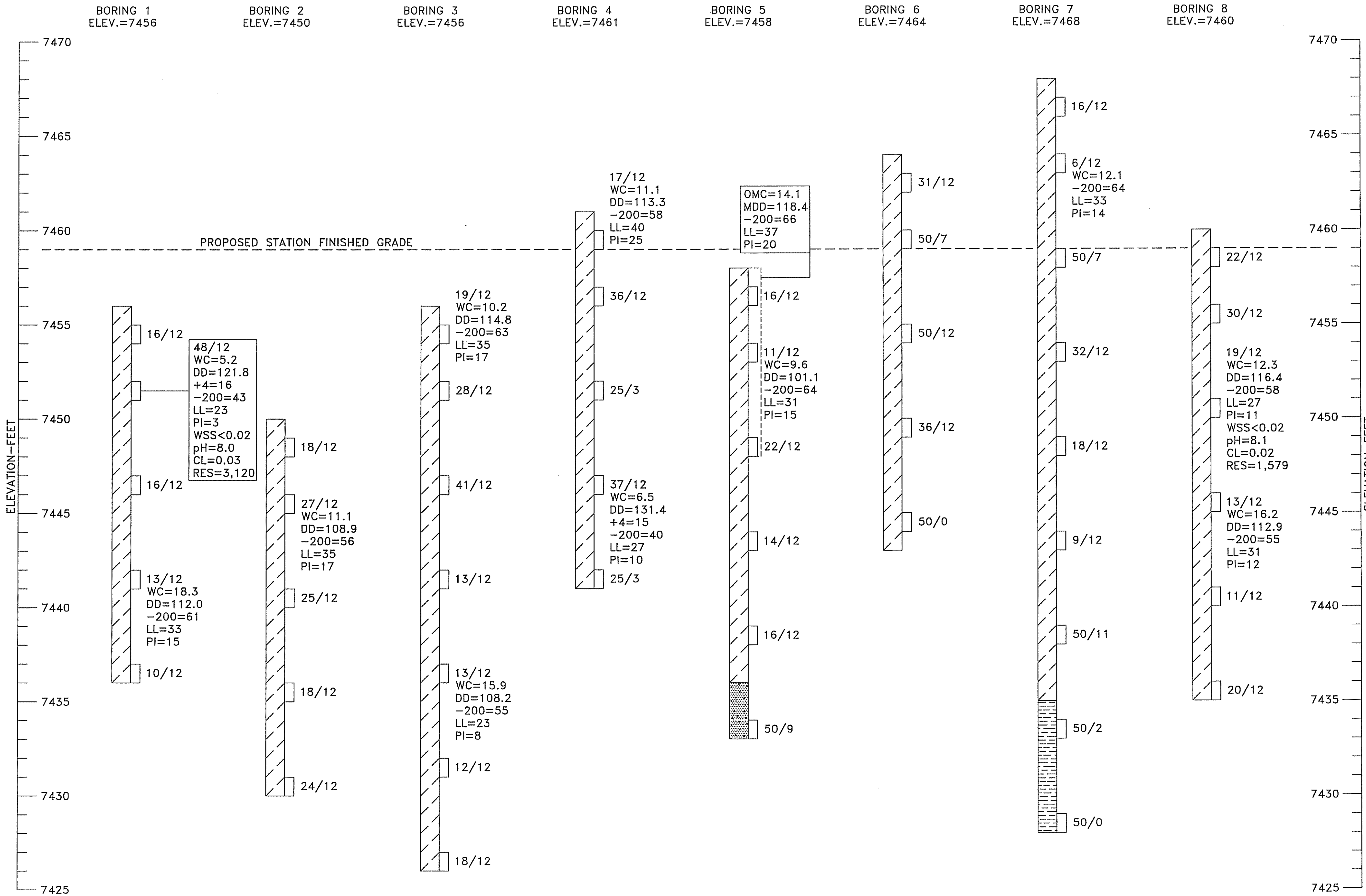

08–1–179	Kumar & Associates	PROPOSED DELTA PETROLEUM MEGA VEGA COMPRESSOR STATION, APPROXIMATELY 12.5 MILES EAST OF COLLBRAN, MESA COUNTY, COLORADO	LOGS OF EXPLORATORY BORINGS	Fig. 2

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LEGEND

SANDY LEAN CLAY (CL), FINE TO COARSE SAND, OCCASIONAL TO FREQUENT GRAVEL- AND COBBLE-SIZED SANDSTONE AND SHALE FRAGMENTS, OCCASIONAL LENSES OF SILTY TO CLAY SAND WITH GRAVEL, STIFF TO HARD, SLIGHTLY MOIST TO MOIST, BROWN.

SANDSTONE BEDROCK, HARD, FINE- TO MEDIUM-GRAINED, WELL-CEMENTED, SLIGHTLY MOIST, BROWN.

SHALE BEDROCK, VERY HARD, FINE-GRAINED, SLIGHTLY MOIST, BROWN.

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

16/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 16 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.

DISTURBED BULK SAMPLE.

NOTES

1. THE EXPLORATORY BORINGS WERE DRILLED ON MARCH 6 AND 7, 2008 WITH A 4-INCH DIAMETER CONTINUOUS FLIGHT POWER AUGER.

2. THE LOCATIONS OF THE EXPLORATORY BORINGS WERE MEASURED BY INSTRUMENT SURVEY BY DELTA PETROLEUM.

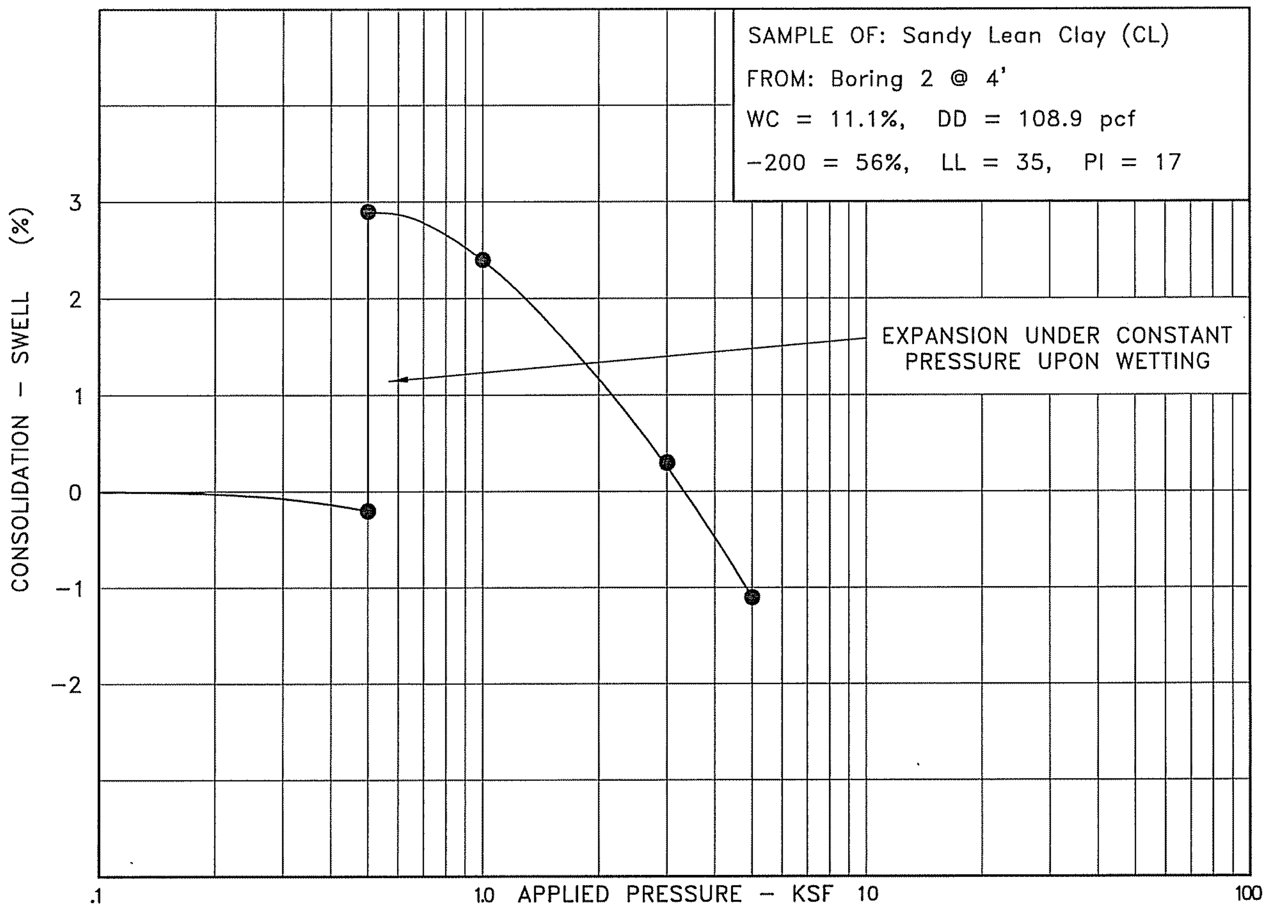
3. THE ELEVATIONS OF THE EXPLORATORY BORINGS WERE OBTAINED BY INTERPOLATION BETWEEN CONTOURS ON THE SITE PLAN PROVIDED.

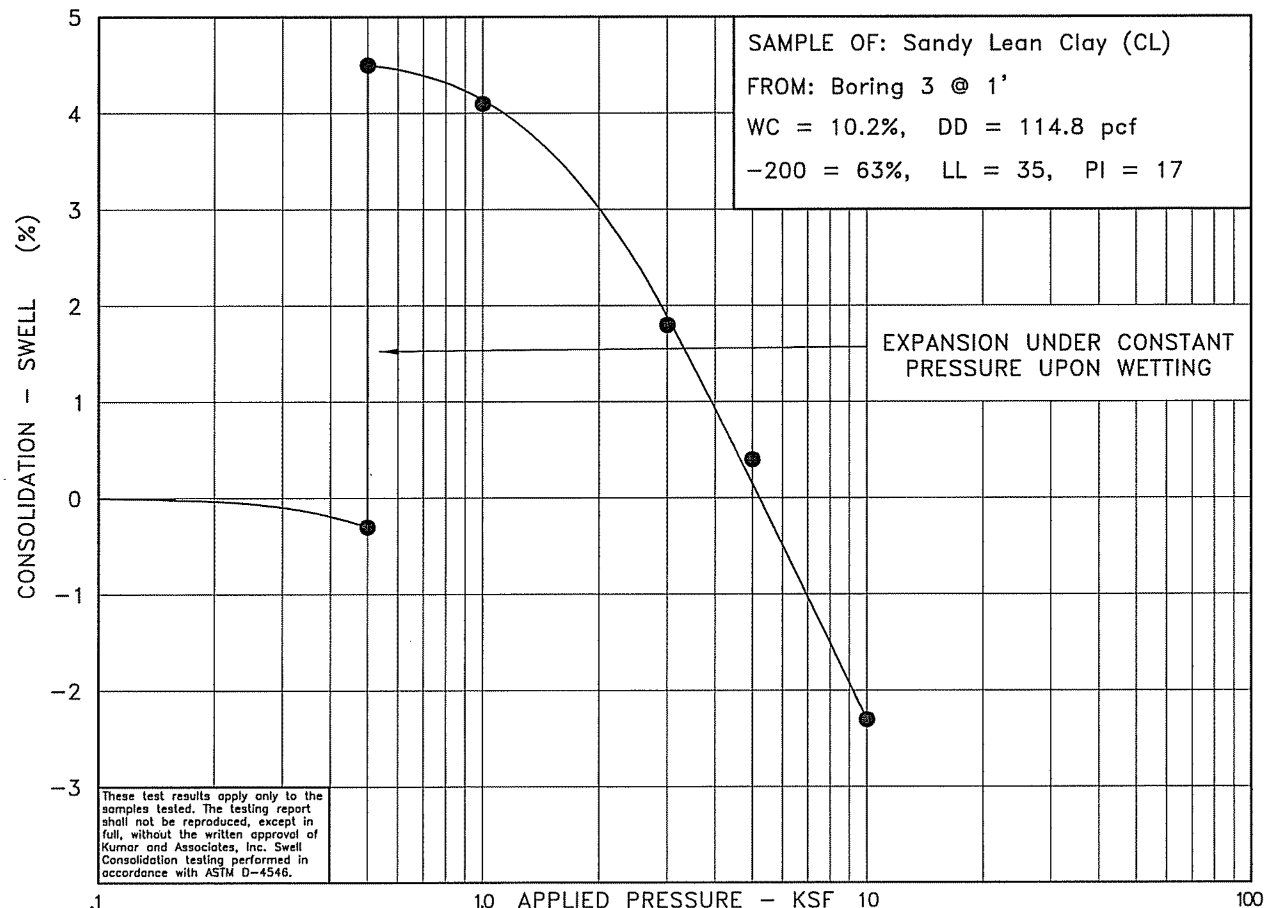
4. THE EXPLORATORY BORING LOCATIONS AND ELEVATIONS SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.

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. GROUND WATER WAS NOT ENCOUNTERED IN THE BORINGS AT THE TIME OF DRILLING.

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);
RES = MINIMUM LABORATORY RESISTIVITY (ohm-cm.) (ASTM G 57);
WSS = WATER SOLUBLE SULFATES (%) (AASHTO T 290);
pH = HYDROGEN ION CONCENTRATION (ASTM E 70);
OMC = OPTIMUM MOISTURE CONTENT (%) (ASTM D 1557) or (ASTM D 698);
MDD = MAXIMUM DRY DENSITY (pcf) (ASTM D 1557) or (ASTM D 698);
CL = CHLORIDE CONTENT (%) (AASHTO T 291).





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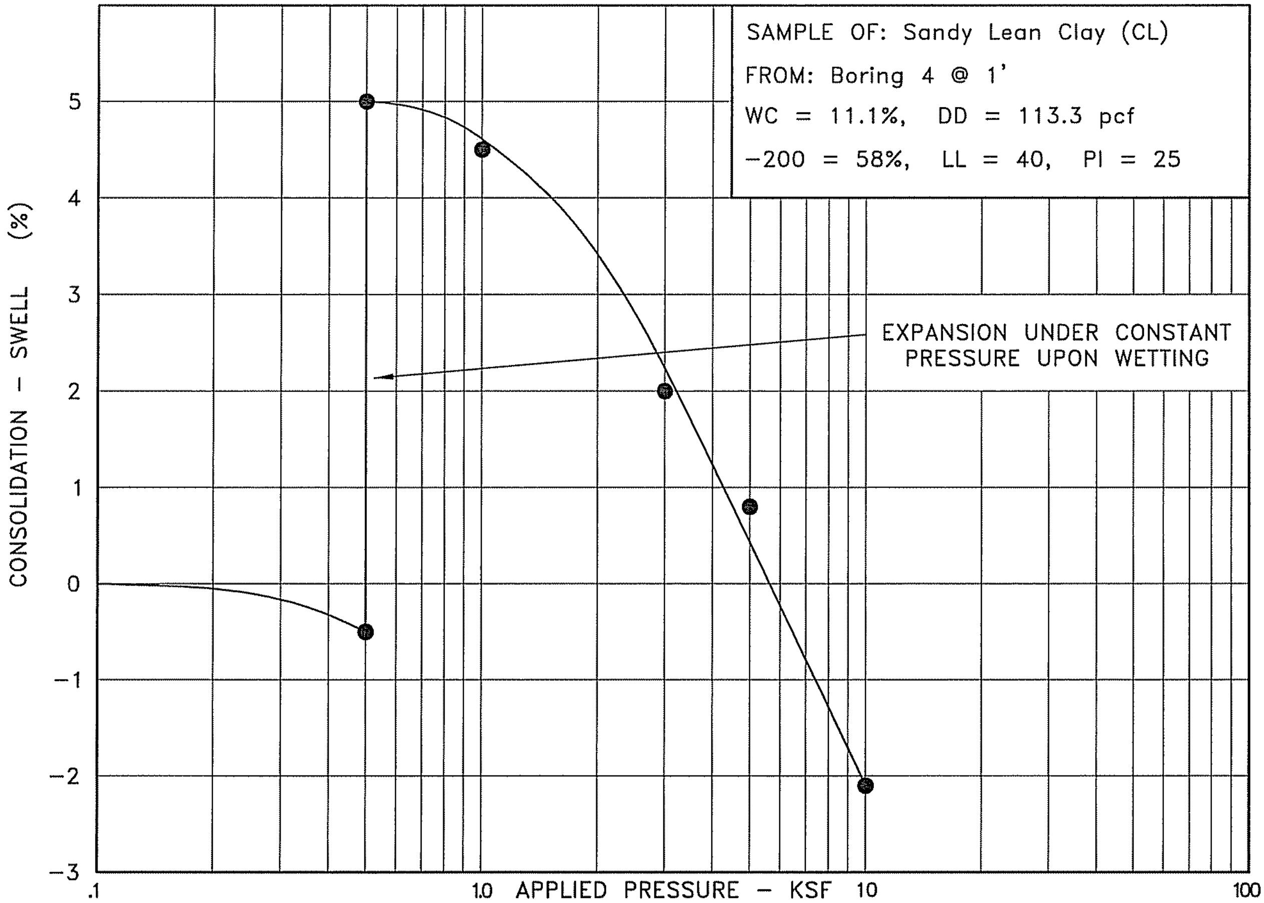
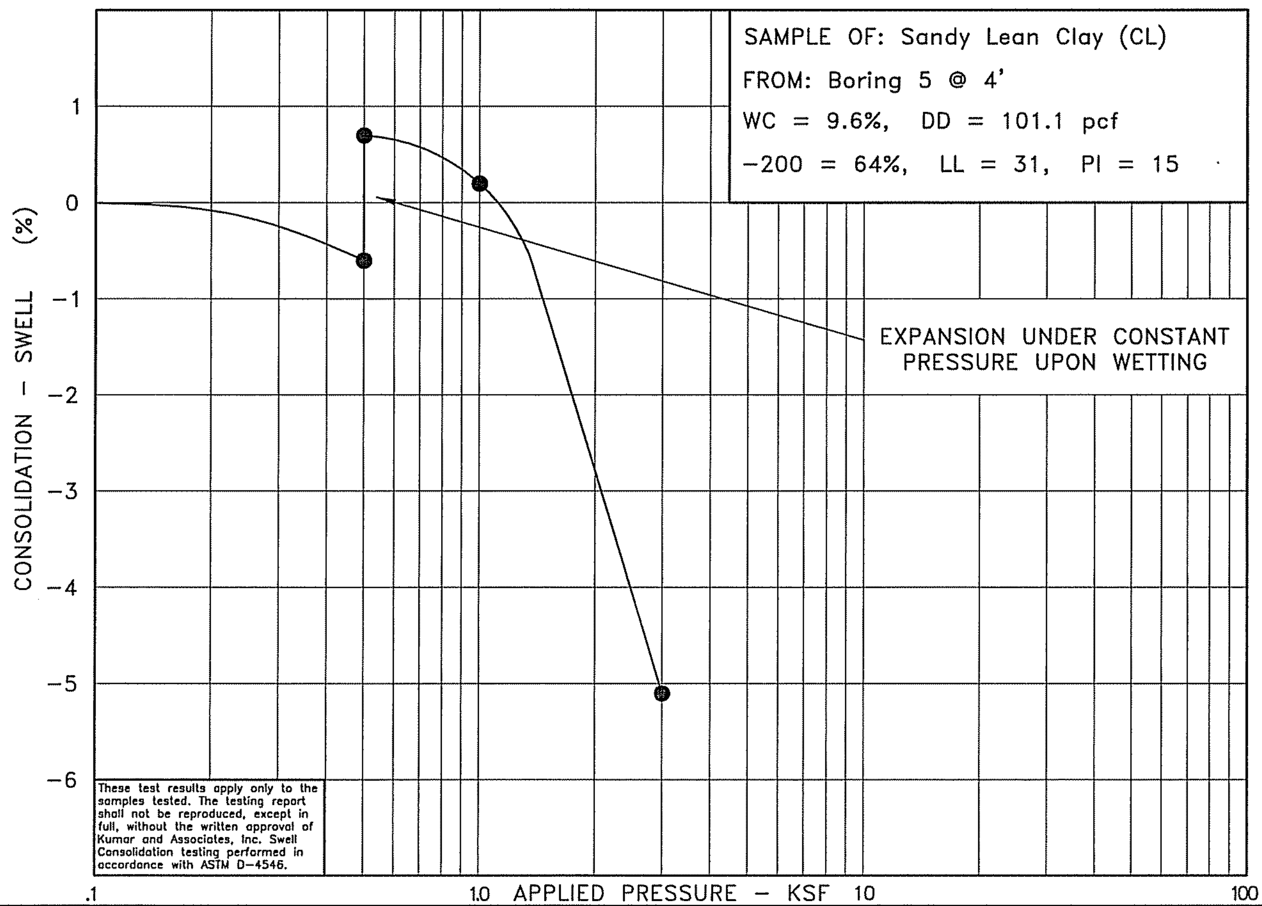
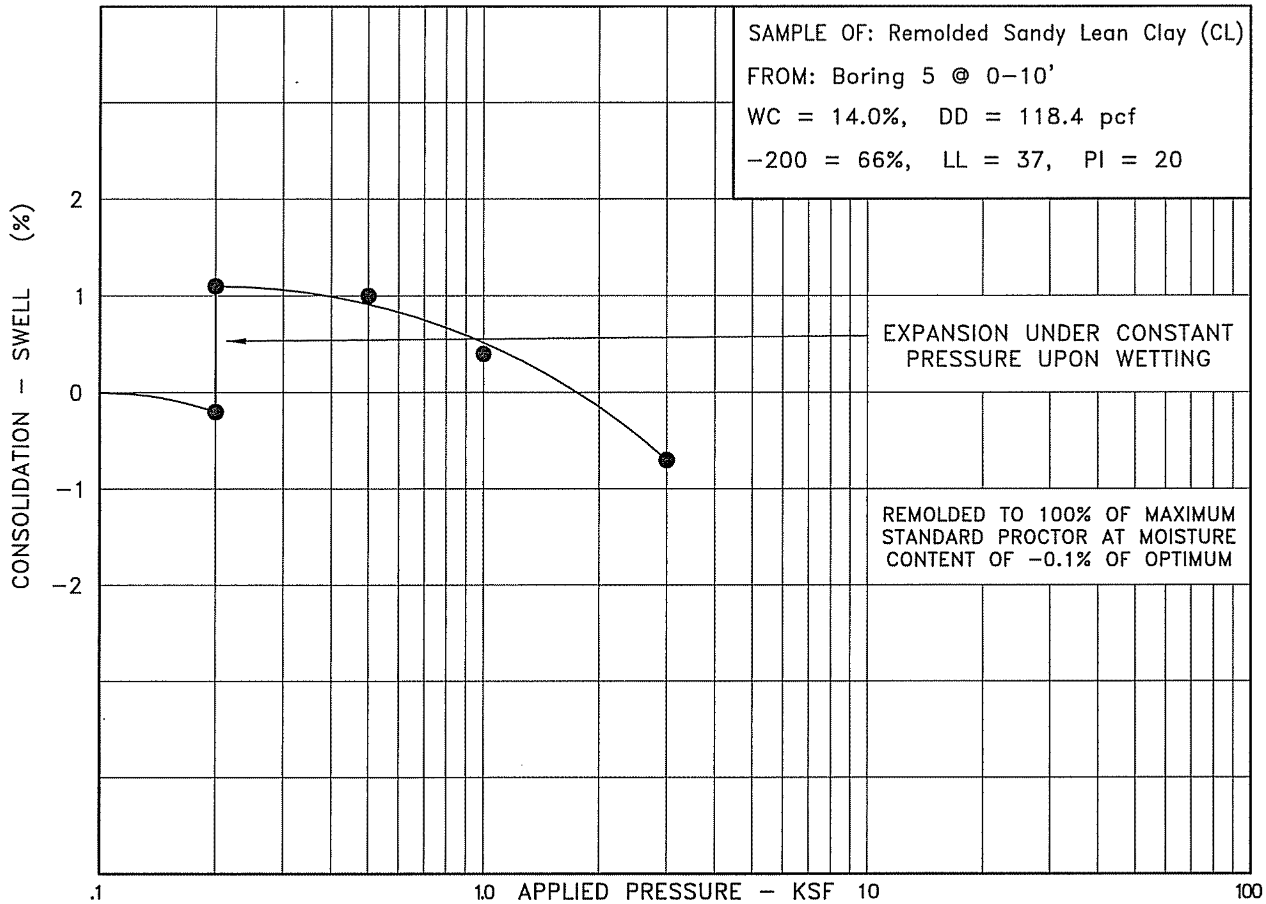
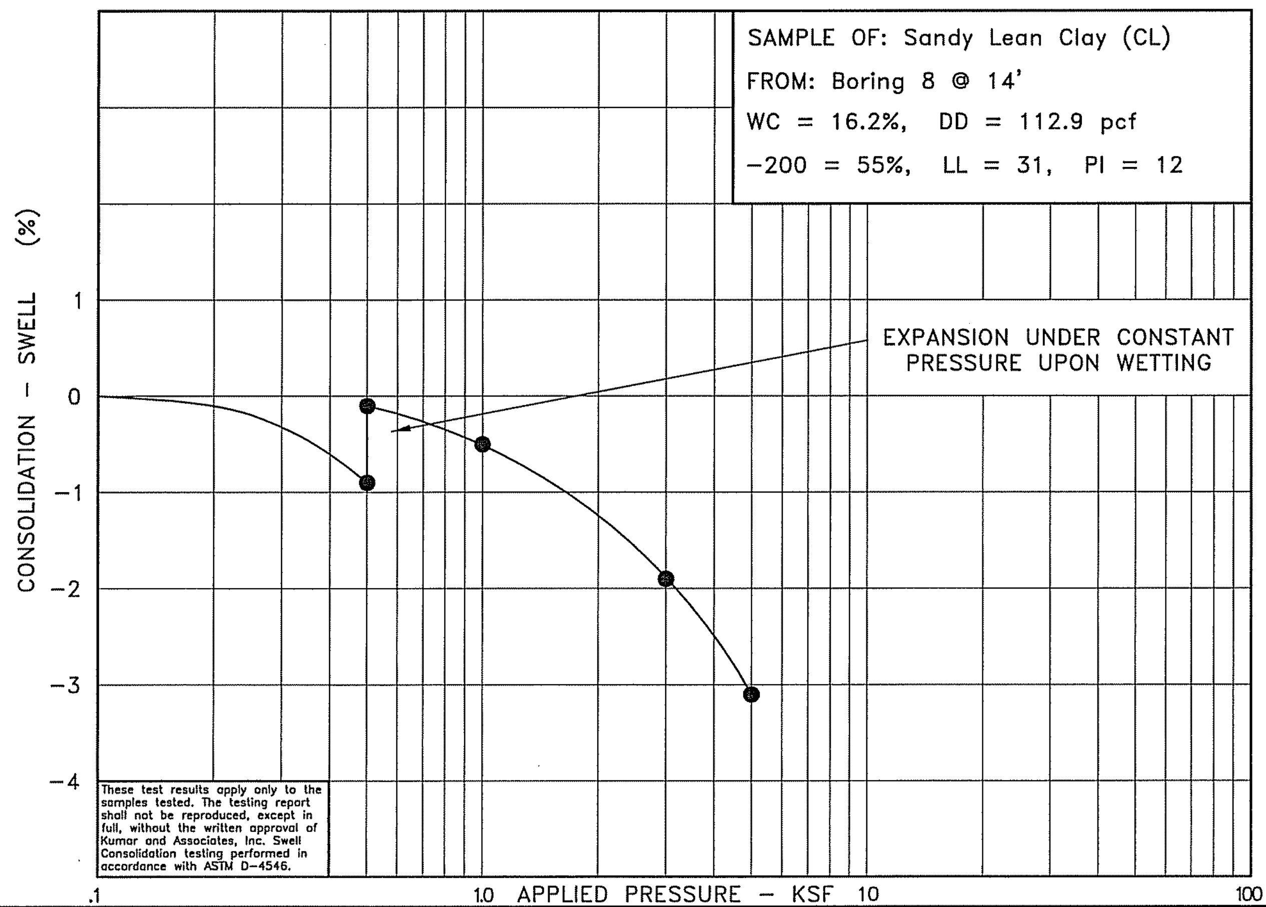
08-1-179	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 4





08-1-179	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 5





08–1–179	Kumar & Associates	SWELL–CONSOLIDATION TEST RESULTS	Fig. 6

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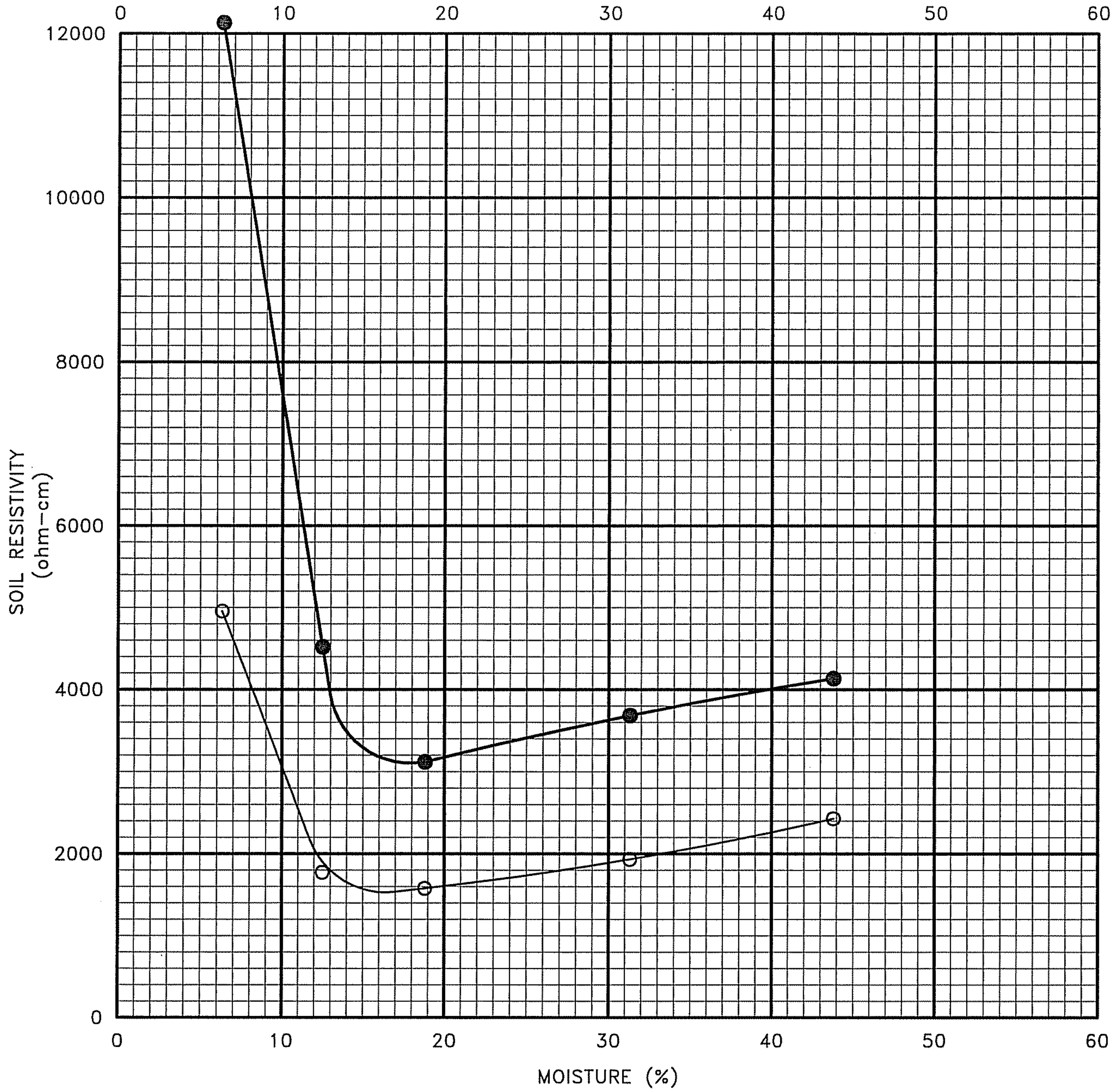

CURVE SYMBOL	SAMPLE IDENTIFICATION	SOIL OR BEDROCK TYPE	MINIMUM RESISTIVITY (ohm-cm)	RESISTIVITY AT IN SITU MOISTURE CONTENT (ohm-cm)
●	BORING 1 @ 4 FT.	Silty Sand with Gravel (SM)	3,120	>12,000
○	BORING 8 @ 9 FT.	Sandy Lean Clay (CL)	1,580	1,950

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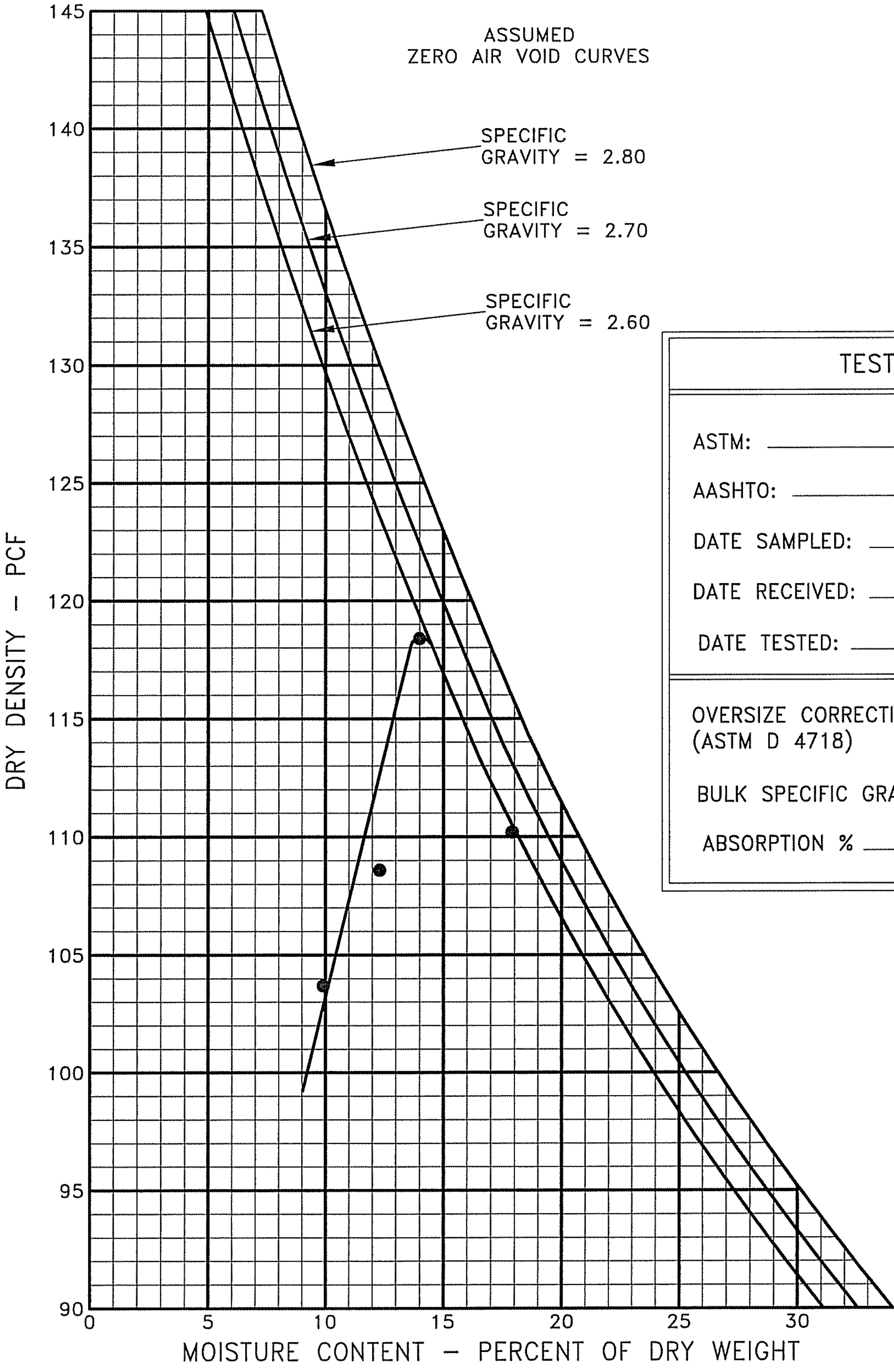
08-1-179	Kumar & Associates	LABORATORY RESISTIVITY RESULTS	Fig. 7



TEST METHOD

ASTM: D 698-00A

AASHTO:

DATE SAMPLED: 03-20-08

DATE RECEIVED: 03-20-08

DATE TESTED: 03-21-08

OVERSIZE CORRECTION (ASTM D 4718) N/A

BULK SPECIFIC GRAVITY

ABSORPTION %

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.

MAXIMUM DRY DENSITY: 118.4 pcf OPTIMUM MOISTURE CONTENT: 14.1 %

SOIL TYPE: Sandy Lean Clay (CL)	GRAVEL: %	LIQUID LIMIT: 37	
SAMPLE NO.:	SAND: %	PLASTICITY INDEX: 20	
	SILT AND CLAY(-200): 66 %		
LOCATION: Delta Petroleum Mega Vega Compressor Station		BORING NO.: 5	DEPTH: 0'-10'
08-1-179	Kumar & Associates	MOISTURE-DENSITY RELATIONSHIPS	Fig. 8

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TABLE I
SUMMARY OF LABORATORY TEST RESULTS

PROJECT NO.: 08-1-179
PROJECT NAME: Delta Petroleum Mega Vega Compressor Station
DATE SAMPLED: 3-6-08 and 3-7-08
DATE RECEIVED: 3-10-08

SAMPLE LOCATION		DATE TESTED	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		OMC/ MDD	WATER SOLUBLE SULFATES (%)	pH	CHLORIDE CONTENT (%)	MINIMUM ELECTRICAL RESISTIVITY (ohm-cm)	SOIL OR BEDROCK TYPE
BORING	DEPTH (feet)				GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)						
1	4	3-12-08	5.2	121.8	16	41	43	23	3		<0.02	8.0	0.03	3,120	Silty Sand with Gravel (SM)
1	14	3-12-08	18.3	112.0			61	33	15						Sandy Lean Clay (CL)
2	4	3-12-08	11.1	108.9			56	35	17						Sandy Lean Clay (CL)
3	1	3-12-08	10.2	114.8			63	35	17						Sandy Lean Clay (CL)
3	19	3-12-08	15.9	108.2			55	23	8						Sandy Lean Clay (CL)
4	1	3-12-08	11.1	113.3			58	40	25						Sandy Lean Clay (CL)
4	14	3-12-08	6.5	131.4	15	45	40	27	10						Clayey Sand with Gravel (SC)
5	0-10	3-21-08					66	37	20	14.1/118.4					Sandy Lean Clay (CL)
5	4	3-12-08	9.6	101.1			64	31	15						Sandy Lean Clay (CL)
7	4	3-12-08	12.1				64	33	14						Sandy Lean Clay (CL)
8	9	3-12-08	12.3	116.4			58	27	11		<0.02	8.1	0.02	1,579	Sandy Lean Clay (CL)
8	14	3-12-08	16.2	112.9			55	31	12						Sandy Lean Clay (CL)

THIS PAGE LEFT BLANK FOR TWO-SIDED DUPLICATION.