CHAPTER XI

SOIL RESOURCES

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1.0 INTRODUCTION AND OBJECTIVES

A detailed Order 1-2 soil survey was conducted during June 1988 on the entire permit area for Idemitsu Alaska, Inc.'s (IAI) proposed Wishbone Hill surface coal mining project northeast of Palmer, Alaska.

The basic objective of the field investigation was to map and sample the soils of the Wishbone Hill proposed permit area in sufficient detail to characterize their physical and chemical properties and depths to which they may be salvaged as a source of topsoil for mine reclamation purposes. This task included an estimation of the volume of topsoil within the "A" and "B" horizons which could be salvaged and re-used to facilitate reestablishment of vegetation on the mine site. For this study, both the "A" and "B" horizons were evaluated in an attempt to increase the depth of salvageable topsoil material and ultimately enhance reclamation efforts. Thus, the site-specific characteristics of the soil that may influence soil salvage stockpiling and redistribution were inventoried. This inventory entailed the following:

- Determination and delineation of soil series and soil mapping units
- Sampling and description of representative horizons of each soil series or series variant for chemical and physical characteristics
- Interpretation of the analytical results and site specific characteristics to determine depth, volume, and suitability of soils for topsoil material

This report presents all field and laboratory methods used in the study as well as:

- Soil maps delineating all soil mapping units
- Mapping unit descriptions
- Soil series descriptions

- Chemical and physical data

- Recommended topsoil salvage depths for each soil series and soil mapping unit

- Soil suitability ratings, by soil horizon, for each mapped soil series

The following section presents a detailed Scope-of-Work (SOW) which was implemented for the Wishbone Hill soil resource assessment soil survey.

The methods described in Section 2.0 are all standard methods for detailed Order 1-2 soil surveys. All procedures and methods are in accordance with current state-of-the-art soil survey methods for Alaskan coal mining projects. They comply with and exceed the specific requirements set forth in the Alaska Surface Coal Mining Control and Reclamation Act and the Division of Mining's Surface Coal Mining Program requirements. Furthermore, all technical specifications are in accordance with the standards for the USDA-SCS National Cooperative Soil Survey.

2.0 SCOPE OF WORK

2.1 Review of Existing Information

All existing soils and related discipline information for the general study area was compiled, reviewed, and evaluated as preparation for initiation of soils field work. This review included all previous soils and surficial geology information for the Wishbone Hill area as well as the Soil Conservation Service (SCS) soil survey for the Matanuska Valley Area (1968), and the recently completed but unpublished soil surveys for the Yentna and Susitna Valley Areas.

All previous soils information (soil mapping units, soil series descriptions, sampled pedon descriptions, laboratory data to the extent available, and interpretive data) was reviewed for familiarity purposes as well as technical adequacy.

Meetings were held with Dr. Chien-Lu Ping (University of Alaska Agricultural and Forestry Experiment Station) and Mr. Mark Clark (SCS, Palmer) in order to discuss soil issues pertinent to the study area. Mr. Clark is the SCS soil scientist most familiar with the study area, and is in the process of revising and extending SCS information of the Matanuska Valley. Dr. Ping is considered the foremost authority on Alaska soils and has reviewed previous soil and reclamation baseline reports for proposed Alaska coal development projects.

2.2 <u>Meeting with Alaska Division of Mining</u>

An initial scoping meeting was held in Palmer, Alaska on June 17, 1988 with Mr. Sam Dunaway (Division of Mining) to discuss the general components of the soil inventory program. A second scoping meeting was held on June 22, 1988 with Ms. Carol Pahlke (Division of Mining) to again discuss the general soils inventory program plans and objectives. Items discussed included: data review and evaluation, Order 1 soil mapping, soil sampling, profile descriptions, soil laboratory analysis and report preparation.

A second meeting with Dr. Chien-Lu Ping was held on June 22, 1988 in order to discuss the specific list of soil analyses to be performed on sampled soils from the study area.

2.3 <u>Soil Mapping - Order 1 and Order 2</u>

Mr. Jim Nyenhuis (JN) mapped and sampled soils at the Order 1 level of intensity for most of the 1353 acres of the proposed Wishbone Hill Coal Project permit area. All project disturbance areas, with adjacent reasonable buffer zones, were mapped at the Order 1 level. All remaining areas were mapped at the slightly less detailed Order 2 level. The purpose of the survey was to insure that salvage of all suitable topsoil in areas to be disturbed by mining will occur. Therefore, those site-specific characteristics of the soil that may influence soil salvage, stockpiling, and redistribution were emphasized.

All map unit and soil profile descriptions were described in accordance with current SCS methods - National Soils Handbook (July 1983), updated Soil Survey Manual chapter revisions (1982-1984), and Soil Taxonomy (1975, and as amended through 1988). Order 1 mapping units consist primarily of soil consociations (one soil type) with some soil complexes (two or more soil types) where it is impossible to cartographically accomplish soil series separation at the base map scale.

Taxonomic units are phases of soil series, series taxajuncts or series variants. Phases of soil series were based on inherent soil characteristics as well as factors important to soil suitability, salvage, and reclamation potential. Map unit component percentages, and the percentages of major soil series inclusions, were generated during the mapping phase. The slope percentage categories used for the map units emphasized soil suitability and machinery salvageability limitations. All boundaries of mapping units were plotted in the field on the base maps utilized for soil mapping.

All map units were delineated as specified below:

1) If soils were dissimilar (i.e., highly contrasting in physical and/or chemical properties and/or depth of suitable soil), consociations of a minimum size of 1 to 1.5 acres were delineated. Spot symbols were used, as appropriate, for contrasting soil types which comprise less than one acre. Dissimilar soils on Order 2 areas were delineated based on a minimum size of five acres. Spot symbols were also used, if appropriate, for contrasting soil types which comprise less than five acres.
2) If soils were similar (i.e., low contrasting in physical and/or chemical properties and/or depths of suitable soil), consociations of a minimum size of two to five acres were delineated.

3) Map unit descriptions included the site specific percentages of the soil series components found in each mapping unit, as well as the percentages of major soil inclusions, and reflected the site specific conditions (ranges, variability, associated competing soils) of the study area.
4) All map units were correlated with existing SCS map units and soil series, where possible. Where soils were significantly different than established soil series, these soils were classified and described using variant, taxadjunct, and phase terminology.
5) Definitions and limits for the terms: phase, consociation, complex, similar, and dissimilar were used as described in the National Soils Handbook (July 1983).

Furthermore, each map was fully described and the following items addressed:

- map unit symbols
- map unit name

- major map unit components and their percentages
- major inclusions and their percentages
- slopes
- physiography type
- erosion hazard from wind
- erosion hazard from water
- surface runoff

As an additional product, JN provided MMC-IA with a complete and legible field notebook that describes the soil characteristics (in an appropriate method of field notation) for each hole that was dug during the basic soil mapping phase.

JN believes this additional product was necessary for several reasons. It provided survey-area-wide data beyond the standard point specific sampling data. This information is valuable for establishing a site specific range of characteristics for all soil series mapped on the study area as well as for more specific topsoil volume calculations based on percent inclusions as well as major map unit components. It also provides a written record of all field work that can be utilized in any subsequent field reviews initiated by MMC-IA or the State of Alaska regulatory personnel. All dug holes were appropriately numbered in the field book and plotted on the base map.

Map units were delineated on a 1" = 500' base map. The legend on the map included all map unit symbols and appropriate component soil series names, soil sample location numbers, as well as recommended soil salvage depths.

2.4 Soil Sampling and Profile Description

All soil taxonomic units (including organic soils) appearing in the soil survey legend were described and characterized. The number of samples per taxonomic unit adequately characterized each map unit.

Component soils in consociations and complexes were sampled a minimum of one time each. All major inclusions in consociations and complexes were also sampled a minimum of one time each. Rock outcrop, disturbed areas, reclaimed areas, and "water" (Moose Creek riverwash) were described but not sampled. Additional composite samples were taken to provide information on spatial variability.

Sample sites were located where they represented the map unit. Transition zones between map units, road edges, fence rows, or previously disturbed areas were avoided. Sample sites were placed so that they represent the entire permit area.

A profile pit at each sampling site was excavated by hand. The profile pit was excavated by spade to approximately 25 inches. This was generally sufficient depth to expose the solum (A and B horizons) and some of the substratum (C horizon). Below this depth, samples were taken by means of a 3-inch diameter hand auger.

As sampled by hand auger, each profile was described and sampled to a minimum depth of 60 inches or to indurated bedrock or clay shales, whichever was shallower.

The major soil horizons (O, A, E, B, and C) were separately described and characterized. All horizons were sampled and analyzed. A two-quart sample was retained for each specific sampled horizon. Subhorizons greater than about 6 inches occurring within any major horizon were also separately sampled and analyzed. Subhorizons less than 3 inches thick were combined in the sample with the adjacent horizon which they most closely resemble. Where a major soil horizon was more than 18 inches thick in the lower part of the profile or more than 12 inches thick in the upper part, these horizons were subdivided and sampled separately.

In addition, the following information was described on standard SCS "232" field soil profile description forms for each soil at the respective sampling location:

- vegetation
- erosion condition
- parent material
- slope
- relief
- elevation
- physiography
- aspect
- permeability
- drainage
- depth to groundwater (if encountered)
- moisture
- salt and/or alkali

The following were also described for each horizon of the sampled pedon:

- depth
- color (Munsell color - dry, moist, and crushed if necessary)

- texture (fine earth, and coarse fragment modifier)
- structure (grade, size, type)
- consistency (dry, moist, wet)
- roots (number and size)
- clay films (number, thickness, occurrence)
- coarse fragments (gravels, cobbles, stones, boulders)
- mottles (number, size, distinctiveness, color)
- boundaries (distinctness, color)

A legal description was recorded for each sampling site and included as part of the profile description in the technical narrative. The sampling location was plotted on the soil survey map and staked and flagged in the field.

2.5 Laboratory Analysis

All soil samples were sent to the Colorado State University Soil Testing Laboratory (CSU) for standard soil analyses as outlined below, and presented in Table XI-1. These parameters included:

- pH (1:1 water and saturated paste)
- EC
- Saturation Percent
- Texture (including very fine sand)

- Organic Matter Percent (reported as organic carbon)

- Coarse Fragment Percent (field determination)

- SAR (if pH > 8.4)

- Calcium Carbonate Percent (if pH > 7.0)

Fertility assessments including nitrogen (nitrate, ammonium, total), Cation Exchange Capacity (CEC) by ammonium acetate, and phosphorous (P) by Mehlich 3 were analyzed for selected representative samples.

In addition, E, Bhs, and Bs horizons of Spodosols were also analyzed for iron and aluminum (sodium pyrophosphate and citrate-dithionate). All sampled Oe organic horizons were analyzed for organic matter (weight loss on ignition), pH, and total N.

The specific list of soil analyses to be performed was discussed with Mr. Sam Dunaway and Ms. Carol Pahlke of the Division, and subsequently reviewed by Dr. Chien-Lu Ping.

2.6 Evaluation of Soils for Reclamation Potential

The soils and parent materials on the Wishbone Hill study area were rated for suitability based on criteria derived from discussions with the Alaska Division of Mining, the Soil Conservation Service, and Dr. Ping as well as reference to standard western coal mining topsoil suitability criteria. Suitability criteria specific to the Wishbone Hill project are given in Table XI-2. Because project area soils are very low in salts (electrical conductivity - EC), sodium content (the dominant component of Sodium Adsorption Ratio - SAR), calcium carbonates, and other parameters that can be unsuitable in other western states, only those parameters which are specific to suitability of Wishbone Hill soils are listed in Table XI-2.

An unsuitability criterion for pH of less than 4.2 was established based on discussion with Dr. Ping

(MMCI Memo WH-003, June 23, 1988). He recommended pH 4.2 based on his experience with soils in the Palmer, Alaska area. He considers a soil with pH 5.0 to be a good soil in this area.

Slopes of greater than 50 percent are considered to be too steep for salvage based on the inability of equipment to operate safely on the slope. This limiting slope percent was determined based on discussion with reclamation personnel at various mines in the western states.

Recommended topsoil salvage depths were generated for each soil series mapped on the project area. A salvage depth for each mapping unit was obtained from the individual soil series salvage depths weight-averaged for the percent of each map unit that they comprise. Topsoil salvage depths were generated for each soil series based on average depths to the suspect parameter or average soil profile depths (if the entire profile was suitable) across the study area. All stated threshold levels were used as a guide for topsoil evaluation. In some cases, individual factors changed the significance of a particular parameter. Any modification of the evaluation process was accompanied by appropriate rationale and support data. The projected salvage depths were developed in consultation with McKinley Mining Consultants personnel. The topsoil evaluations relied on the field descriptions of each soil series and mapping unit as well as extensive laboratory data generated by the study. Each map unit was given a salvage depth recommendation that represents suitable rated material. Unsuitable rated material was not recommended for salvage.

These suitability evaluations, based on averages across the study area, were used for topsoil volume (Acre-Feet/Acre) determinations which are presented in Section D of the Mine and Operation Plans of the permit application. These calculations present volume of topsoil in acre feet for each soil map unit present in projected disturbance areas. Composition of the mining area, in acres and percent of total, of each map unit was also developed. A brief statement of soil limitations for each map unit was prepared.

3.0 RESULTS AND DISCUSSION

3.1 <u>General Nature of the Study Area</u>

3.1.1 Climate

The climate of the Wishbone Hill study area reflects the combined influences of latitude, nearness to the ocean, and the presence of nearby mountains. The following material is taken verbatim from Ping (1987). The area has a mixed continental and maritime climate. Moist, warm air from the Pacific Ocean to the south brings in snow in the winter and rain in spring and summer. In nearby Palmer, the MAAT is 1.3C, with extremes of 33 and -40C. The average maximum daily temperature reaches 19C in the summer when the day length is long. The average minimum daily temperature is usually below -5C in the winter. The MAP is 380 mm. Precipitation increases through the summer months to a maximum in September. Average annual snowfall is 137 cm. Snowfall generally starts in October and peaks in both December and March. In addition to intermittent strong winds, mid-winter temperature fluctuations in the freeze-thaw range are common, thus snow cover can either be blown away by wind or melted away by winter rains. The average number of frost-free days is 108 at the 0C limit, and 135 at the -2C limit based on air temperature (Ping 1987). The MAP of the Wishbone Hill area, in comparison to Palmer, should be slightly higher.

The soil temperature regime of the study area is "cryic" and the soil moisture regimes include "udic" and "aquic". A discussion of wetland (hydric) soils which have an aquic soil moisture regime is in Section 3.3.4. Permafrost does not exist in the study area, but seasonably frozen ground can occur in kettle holes and basins within glaciofluvial outwash areas as well as slight depressional areas on upland glacial till areas (Moore 1988).

3.1.2 Geology

The Wishbone Hill area lies in a zone of moderately deformed clastic rocks of Tertiary age, ranging from claystone to conglomerate. Prominent formations include the Chickaloon, Wishbone, and Tsadaka. Wishbone Hill is a conglomerate-capped synclinal ridge that extends from the former Premier mine on Moose Creek northeastward about six miles to Eska Creek. Bedrock is largely concealed by Quaternary glacial and alluvial deposits, which cover all but the steeper slopes (Barnes 1956). As such, soils are developing in the glacial and Holocene deposits and not in weathered bedrock.

3.1.3 Geomorphology

The Wishbone Hill area is a prominent topographic upland within the lower Matanuska Valley. It is separated from the Talkeetna Mountains to the north by a broad valley drained by tributaries of Moose and Eska Greeks. Sharply incised valleys of Moose and Eska Creeks comprise the west and east sides of Wishbone Hill. On the south, it is flanked by a broad undulating sand and gravel glacial outwash surface about 700 to 800 feet in altitude. The main Wishbone Hill upland is underlain by very gravelly, sandy loam glacial till. A surface mantle of wind deposited loess overlies both the glacial outwash and till surfaces. This silt loam material, about 18 inches thick, is derived primarily from fluvial deposits within the upper Matanuska River Valley. The surface mantle also contains a small admixture of volcanic ash. Although the silt loam loess has a high inherent wind and water erosion hazard, no significant erosion was noted on the Wishbone Hill upland or at any of the soil sample sites.

The convex upland position of Wishbone Hill and the very thick, very coarse glacial deposits both contribute to well drained conditions on the study area. Buffalo Creek is the main drainageway on the upland and is narrow and generally without bordering lowland areas.

3.2 Soil Survey Maps

Ten soil types (series, series variants, taxadjuncts, and soil subgroups) were mapped in eleven soil map units. Four miscellaneous map units (Rock Outcrop, Disturbed Land, Reclaimed Land, and Water) were also mapped on the study area. The distribution of each map unit on the study area is provided on a 1" = 500' scale topographic base map included as Plate XI-1 accompanying this report. A complete legend, which identifies all mapping unit symbols is provided on the map as well.

Typical soil profile pedons (soil sample locations) are also denoted on the maps, as well as all 157 soil profile description locations. A List of Soil Profile Descriptions is provided as Table XI-3.

3.3 Soil Characterization and Classification

3.3.1 Soil Horizon Nomenclature

In 1982 the Soil Conservation Service adopted a new system of soil horizon nomenclature (Guthrie and Witty 1982). All soil series being mapped within ongoing soil surveys would be revised before publication. Published surveys (such as the 1968 Matanuska Valley Area Soil Survey which includes the study area) would not be revised. All soil series that were mapped on the current 1988 Wishbone Hill soil survey had been mapped elsewhere in Alaska since the 1968 Matanuska survey and therefore had been revised by SCS. This provided up-to-date series descriptions that did not need horizon nomenclature revision before comparison to the site-specific Wishbone Hill soils could be made. Soil horizon nomenclature was not a problem on the Wishbone Hill survey and easy comparisons could be made between soil series mapped on the Wishbone Hill study area and those same or similar series mapped and described in other parts of the Matanuska-Susitna Valleys areas.

3.3.2 Soil Series Correlation

All Wishbone Hill study area soils were correlated with existing SCS soil series criteria. Current soil series descriptions, "Form 5" (SOI-5) Soil Interpretation Records, and all available soil laboratory data were obtained from Joe Moore, Assistant State Soil Scientist for Alaska.

SCS is in the process of revising the taxonomic classification of Spodosols and when revisions are finalized in the next few years, the classification of Wishbone Hill soils could change. However, as Dr. Ping has said (Ping 1988), this survey only needs to be responsive to the soil taxonomy currently used, and not worry about probable revisions.

In addition, several specific issues came up concerning Wishbone Hill soil classification. Does the dominantly silty loess mantle on Wishbone Hill contain volcanic ash, and if it does, how much? How deep do the spodic horizons go in these soils - lower than 10 inches? These are questions that affect soil taxonomy and SCS will attempt to answer these for themselves when they re-map the Wishbone Hill area (they originally mapped it as part of the 1968 Matanuska Valley Area Soil Survey) in the near future. Reference should be made to the lengthy discussion in each soil's range of characteristics discussion (Appendix 11-A) concerning these and other soil classification issues.

3.3.3 Prime Farmland Status

No soils on the Wishbone Hill study area meet criteria for prime farmland soils (Moore 1988).

3.3.4 Wetland Soils Status

The presence of wetland soils is one of three diagnostic environmental characteristics used to determine the presence of wetlands. Wetland soils are soils classified as "hydric" or that are associated with anaerobic soil conditions.

The Soil Conservation Service (SCS 1987) defines hydric conditions as when the soil in its undrained condition is saturated, flooded, or ponded long enough during the growing (frost-free) season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation. Features frequently associated with hydric conditions include:

1) Aquic moisture regime, as defined in Soil Taxonomy (Soil Survey Staff 1987),

2) A deficiency of oxygen at or near the surface during much of the growing season, or

3) Flooding or ponding of long duration during the growing season.

SCS distinguishes between soils that consistently display hydric conditions and those that may exhibit hydric conditions. The Army Corps of Engineers (COE) defines wetland soils as those soils that are either on the SCS list of hydric soils (SCS 1987) or display hydric conditions upon field examination.

Wetland soils are classified into either organic or mineral groups. Organic soils are called histosols and develop under conditions of nearly continuous saturation and/or inundation. For this study area, all organic soils are considered to be wetland soils.

Organic wetland soils are commonly known as peats and mucks. Organic matter requirements vary with taxonomic category. Generally speaking, histosols must have between 20 and 30 percent organic matter in the surface 8 to 24 inches (depending on clay content).

All wetland soils other than histosols are mineral soils. Mineral soils range from clayey to sandy and vary in color from gray to red. Mineral wetland soils are those periodically saturated for a sufficient duration to significantly impact soil chemical and physical properties. They are usually gray, mottled immediately below the surface horizon, or have thick, dark-colored surface layers overlying gray or mottled subsurface horizons (Environmental Laboratory 1987).

Three soils characterized in the field during the detailed Order 1/2 Wishbone Hill Soil Survey meet criteria for wetland soil status:

- Terric Cryosaprists (Map Unit D)

- Lucile (a component of Map Unit F and I)

- Torpedo Lake Variant (a component of Map Unit B)

Terric Cryosaprists was not classified to the soil series level because SCS has not set up series names for this soil subgroup. Terric Cryosaprists are hydric soils because they meet the criteria for Histosols, organic soils indicative of wet conditions. Lucile (Sideric Cryaquod) and Torpedo Lake Variant (Humic Cryaquept) are hydric soils because they have "aquic" moisture regimes which indicate the presence of a reducing regime that is virtually free of dissolved oxygen due to saturation by water.

Although all three soils are hydric soils, only Terric Cryosaprists appear in this situation to be indicators of potential wetlands. Only one small area of Terric Cryosaprist soil exists on the Wishbone Hill project area. This area, immediately adjacent to Buffalo Creek, supports some hydrophytic vegetation in a narrow zone; however, detailed analysis of the vegetation component (see Chapter VIII) indicated that the area is not a true wetland.

Both Lucile and torpedo Lake Variant (TLV) meet hydric soil status for atypical reasons, and do not support vegetation unique to wetland areas. Lucile soils have a surface mantle of about 18 inches of wind deposited loess (with a small admixture of volcanic ash) over very gravelly glacial outwash. The upper two feet of the soil profile freezes during the winter and then thaws from the surface downward during May or as soon as weather permits. As the thaw progresses downward, the saturated zone above cannot drain and becomes a seasonally reduced zone due to a perched saturated condition. The Lucile soils are found in kettle positions within the large eskers found in the S 1/2 of Section 27, and in most of Sections 34 and 35, T19N, R2E. Soil mottling is found close to the surface and meets criteria for hydric status. As soon as the thaw is complete, the soil water freely drains through the coarse sand and gravel substrate, and the soil becomes well drained for the remainder of the frost-free season. The soil is not saturated long enough to provide conditions favorable for unique wetland plants. The kettles do not support wetlands even though Sideric Cryaquods are hydric soils.

SCS soil scientist Mark Clark, (Project Leader - Matanuska Area Soil Survey, Palmer, Alaska) and Jim Nyenhuis spent one day in the field in June, 1988, reviewing principal soils on the project area. The typical location for Lucile (WH-62) was visited and an additional auger hole was dug about 10 feet away from the previously described and sampled soil at WH-62. Mr. Clark verified the taxonomic classification, and also believes the kettle holes do not have unique wetland plants and should not be considered true wetlands (Clark 1988). He also concurred on the genesis of soil mottling due to a seasonally perched saturated zone.

The Torpedo Lake Variant soil has a similar thickness of loess at the surface but the substratum is a dense gravelly sandy loam till rather than glacial outwash. This soil also has mottling near the surface that meets criteria for hydric soils. The dense, compact till is acting as the impermeable zone and a saturated zone is perching above the till for a period of time during snowmelt. Again, unique wetland plants are not found in these areas and they should not be considered wetlands. The TLV soil is found in scattered areas on the upland till surface upslope from the glacial outwash areas, and is mapped in complex with the Talkeetna soil which is well drained.

The Niklason taxadjunct soil, mapped on terraces of Moose Creek, is well drained with no mottling and is not a hydric soil. Also, Typic Cryumbrepts which are mapped in swales and small drainageway positions on the upland till surface are also well drained and have no soil mottling or other indicators of hydric soils.

3.4 Mapping Unit Descriptions and Soil Interpretations

Mapping units are depicted by map symbol, name, and slope percentages in Table XI-4, Guide to Soil Map Units. Detailed descriptions of each mapping unit are provided in Table XI-5, Soil Map Unit Descriptions. These descriptions are presented in alphabetical order by map unit symbol and include:

- Map unit symbol and name with associated slope range
- Major map unit components and their percentages
- Map unit inclusions and their percentages
- Slope and physiography (terrain) description
- Parent material type
- Erosion hazard from wind and water (descriptive term)

Additional information is provided for each major soil component of the mapping units in Table XI-6, Soil Interpretations. Information provided in this table includes:

- Texture of particle-size control section
- Depth of profile
- Effective rooting depth (inches)
- Internal drainage
- Permeability

- Available water holding capacity
- Rate of surface runoff
- Typical reaction class (surface/subsoil)
- Wind erodibility group number (surface layer)
- Wind and water erosion potential (I and K factor for surface/subsoil)
- Hydrologic group status

3.5 Soil Series Descriptions

The soil series found on the study area and their taxonomic classifications are provided in Table XI-7, Soil Series Information. This table also lists the map unit number, sample numbers, and related SCS information concerning soil series descriptions. The SCS descriptions are for the series only, not the series variants or taxadjuncts. The soil series mapped on the Wishbone Hill study area are established series (E) as well as variants, taxadjuncts, and soil subgroups.

Copies of the SCS Official Soil Series Descriptions, accompanying "Form 5" (SOI-5) Soil Interpretation Records, and profile descriptions of all 157 auger hole observations, are on file at McKinley Mining Consultants in Palmer, Alaska.

Soil series descriptions are provided in Appendix A and identify the morphology of representative soil profiles on the study area. Series descriptions were obtained from sampled soil pits and have been correlated with their analytical results as well as with SCS series information to the extent applicable.

All 15 soil profiles which were sampled, either by horizon or by composite, were fully described by soil horizon in the field and this data is presented in Appendix A. No samples were composited during sampling of the major soils. Only three sampled profiles had portions composited

(Homestead, Nancy Variant, and Chulitna Variant) for the reasons explained below. Based on conversations with SCS soil scientists, Mark Clark and Joe Moore, information contained in official SCS soil descriptions (for Homestead, Kashwitna, Nancy and Chulitna soils), and site-specific information obtained during the Wishbone Hill soils field work, it became apparent that all of these soils are similar Typic Cryorthods differing primarily in the thickness of the loess cap. Homestead has a loess mantle less than 10 inches thick. Kashwitna's mantle is between 10 and 20 inches thick, Nancy Variant between 20 and 30 inches, and Chulitna Variant between 30 and 40 inches to the very gravelly glaciofluvial deposits which constitute the 2C horizons of these soils. Each has the same major horizons and they differ primarily in distance from the Matanuska River, the source of the loess mantle. The closer an area is to the river, the thicker the loess mantle. Nancy Variant and Chulitna Variant are mapped in the area where the mine access road is proposed, an area closer to the river than the mine area. Homestead is an exception due to truncation of a portion of the solum. Kashwitna is by far the most extensive soil of this group, and was sampled three times. Because there were no major differences among these soils' loess mantles as detected in the field or in discussions with SCS personnel, it was decided in the field to composite the loess mantle into one sample for both Nancy Variant and Chulitna Variant. The entire loess mantle is suitable for salvage, and could be treated as one sample for laboratory analysis. The method of composite sampling involved the collection of an appropriate amount of soil material based on the relative thickness of the horizons within the composited depth ("weight averaging"). In scoping meetings with Dr. Ping, he recommended composite sampling where appropriate. In addition, this composite sampling resulted in some economy of laboratory expense which was justified due to the similar nature (all of it suitable topsoil) of the loess mantle. Homestead's loess mantle (less than 10 inches thick) was composited for the same suitability reason in addition to the fact that there are four horizons within the top 10 inches.

It was the intent of the soils field work, at the beginning of the survey, to describe and sample soil material down to a minimum of 60 inches. Several factors emerged during the survey that resulted in a modification of this intent. All 15 sampled profiles were fully described (including the 2C glacial till or outwash horizon) throughout the depth of observation, regardless of whether the 2C horizon was sampled. The descriptions of the 2C horizons are contained in Appendix A. Not all 2C horizons were sampled to 60 inches. All major soils had at least one profile (Talkeetna had three) sampled to 60 inches, or to the lowest depth possible before coarse fragments (cobbles) prevented further digging. Conversations with SCS soil scientists Joe Moore and Mark Clark, Dr. Chien-Lu Ping (University of Alaska Agricultural and Forestry Experiment Station), as well as information obtained in the field during the initial portion of the soils field work, indicated that the glacial materials (very gravelly dense till and very gravelly to cobbly outwash) were unsuitable for use as topsoil. Mr. Moore, Assistant State Soil Scientist for SCS-Alaska, commented on the sterile, very dense nature of glacial till in southcentral Alaska that results in loss of agricultural production once the fertile loess mantle is removed. Dr. Ping recommended an unsuitability level for coarse fragment content of greater than 10 to 15 percent for cobbles, and greater than 30 percent for gravels. The soil profiles described in the early part of the survey, as well as the sampled 2C horizons, clearly had coarse fragment contents that exceeded limiting values. Discussions with drillers on site who were routinely drilling through glacial materials supported the very coarse nature of the glacial materials. Observations of road cuts on site also supported this conclusion. In addition, soil auger holes were extremely difficult to dig through the glacial materials, and often required a larger diameter auger bucket and/or a companion hole dug immediately adjacent to a first hole so that coarse fragments could be moved sideways enough to permit continued digging. A backhoe was not used because trails would have been required through the dense vegetation, resulting in more disturbance than necessary to confirm the widely held view that glacial materials should not be used as a source of topsoil. As a result, a change in sampling protocol occurred during the survey which emphasized the sampling and laboratory characterization of the fertile loess mantle rather than the very gravelly, sterile glacial materials. All 2C horizons continued to be described but limited sampling occurred.

In regard to sampling thick and thin horizons, the O (organic) horizon was sampled as one horizon regardless of thickness. Actual thickness ranged from 1 inch (WH-89) to 5 inches (Wh-137), but most averaged 2 or 3 inches. The E horizon, where present, was also sampled as one horizon with sample thickness ranging from 2 to 5 inches. The B horizon was sampled by major subhorizon (Bhs, Bs, Bsg, Bwlg, Bw2g, etc.) regardless of thickness, with sample thickness ranging from 4 to 16 inches (most are closer to the low end of the range). The BC or 2BC transition horizon was sampled as one sample, with thickness ranging from 5 to 10 inches. The 2C horizon (glacial parent material) was sampled as one sample regardless of thickness, except for Lucile (WH-62) which is a special case (see Lucile Range of Characteristics discussion) where 4 subhorizons of the 2C horizon were sampled separately. The decision to sample the 2C horizon as one sample was based on the recommendation of Dr. Ping as stated in MMCI Memo WH-003 (June 23, 1988).

3.6 Soil Laboratory Results

The results of laboratory analysis of all soil samples collected during the 1988 soil survey are provided in Appendix B. The results were thoroughly checked by Mr. Steve Workman, Director of the Colorado State University Soil Testing Laboratory, before release, and have meet all CSU internal quality assurance-quality control criteria. Jim Nyenhuis reviewed the results in detail and then had the opportunity to show the data to Dr. Chien-Lu Ping who reviewed it and concluded that it appeared reasonable (Ping 1988). As a result, it was decided that laboratory analysis of a 5% split by an alternate laboratory was not necessary because the data appeared reasonable and the Division of Mining did not request it after the Soils Scope of Work document was reviewed by them (it was offered as an option if requested).

Laboratory results indicate that Wishbone Hill soils are very low in salts (electrical conductivity-EC) and sodium, generally low in calcium and magnesium, and have low pH's characteristic of Alaskan soils. Most soils have spodic horizons which are accumulation zones of illuviated organic matter, aluminum, and iron. All soils have an acidic surface organic layer. The loess mantle which covers the entire site has dominant silt loam texture whereas the underlying glacial till or outwash is a gravelly to very gravelly sandy loam or loamy sand. Results are typical for Matanuska-Susitna Valley soils (Clark 1988), with the possible exception that solum thickness (the thickness of the soil from the surface to the base of the B horizon) on the Wishbone Hill study area is slightly greater. Soil productivity is discussed in Section 3.8.

3.7 Topsoil Suitability

An evaluation of each soil series, variant, taxadjunct, or soil subgroup's suitability for topsoiling has been performed. Each soil type was evaluated by individual sampled horizons for significant physical and chemical parameters presented previously in Table XI-2. The range of characteristics for each soil type (presented in Appendix A) was also evaluated. Recommended topsoil salvage depths, a summary of soil suitability limitations, and topsoil quantities (Acre-Feet/Acre) for each map unit is presented in Table XI-8.

The silt loam (loess) material which blankets the entire study area is suitable for use as topsoil during reclamation. This loess mantle has been deposited by wind during the last 10,000 years. It is the dominant topsoil source on the study area. The underlying glacial outwash and till are unsuitable for use as topsoil because the coarse fragment content is too high, especially in the outwash material where there are few "fines" once the true outwash is encountered.

All till and outwash substrata (2C horizons) have greater than 35 percent gravels and/or more than 15 percent cobbles and are, therefore, unsuitable for salvage. The amount of gravel and cobbles in the 2C horizons of each sampled profile is listed in Appendix A. There is one special case which concerns "local alluvial" materials which are found between the loess mantle and underlying glaciofluvial materials in enclosed basins and kettle holes within esker systems in the south 1/2 of Section 27, and in Sections 34 and 35, T19N, R2E (see range of characteristics discussion for Lucile). These alluvial materials apparently washed down into the kettle holes and basins before loess deposition. Coarse fragment content is less than limiting, and this material is suitable for salvage. Map units F and I which contain Lucile, the soil with suitable alluvial materials below the loess cap, have been mapped very accurately because they occupy such a distinct kettle hole and basin topographic position. Although mapped as complexes, Lucile is dominantly found on lower positions within these depressions. The miscellaneous inclusions rated suitable to 51 inches are also found on lower positions within kettle holes and basins and can be separately salvaged with the Lucile.

In addition, the glacial till upland areas (Map Units A, B, and C), have been compacted by former permafrost and are too dense for use as topsoil. Assistant State Soil Scientist Joe Moore has commented on the undesirable characteristics of glacial till in the Matanuska-Susitna valley area (Moore 1988).

Fortunately, the glacial outwash and till is blanketed by the silt loam loess and there is a sufficient amount of this material that topsoil salvage is recommended. In general, about 18 inches of the silt loam material covers the entire study area. This depth increases along the proposed mine access road as one approaches the loess source area, the Matanuska River Valley. In the kettle holes and basins within the glacial outwash areas, the loess is underlain by a variable thickness of local alluvial material before the very coarse textured true glacial outwash is encountered. As stated above, this alluvial material is also suitable and is recommended for salvage.

The only cases in which unsuitable material was included with suitable material were the O and E horizon of profile WH-4, and the E horizon of profile WH-8, both of which have a pH of 4.1. This material is just outside the suitability limit for pH, and should mix to a suitable level during salvage operations.

Topsoil salvage depths for each soil type were generated by averaging the thickness of the silt loam mantle over the underlying outwash or till. The hemic (Oe) and sapric (Oa) organic horizons were included with the silt loam as salvageable topsoil. The surface forest litter (Oi) horizon (usually about one inch thick) was not included in the topsoil salvage depth.

The depth and suitability of Wishbone Hill soils compares favorably to other Alaskan soils. The Wishbone Hill silt loam loess mantle is definitely suitable for salvage although the underlying glacial materials are not. In other areas of Alaska, the glacial materials can be closer to the surface with less overlying suitable material, or there can be more volcanic ash in the soil profile. Ash is less desirable than loess for use as salvageable topsoil.

Based on the soil suitability evaluation, sufficient soil material does exist on the Wishbone Hill proposed permit area to achieve successful reclamation.

3.8 Soil Productivity

Fertility assessments were conducted on study area soils in order to provide a baseline for comparison to reclaimed minesoils. The approved list of soil analyses was discussed in Section 2.5. Eleven surface layer hemic (Oe) horizons were analyzed for pH, total nitrogen, and organic matter (weight loss on ignition) as well as two buried organic sapric horizons (Oab). All other samples (all mineral), except for approximately one half of the underlying glacial substratum 2C horizons, were tested for nitrogen (nitrate, ammonium, and total), phosphorus (Mehlich 3), potassium and CEC (ammonium acetate) in addition to standard soil parameters. Three composite soil profile samples were also tested for these fertility related parameters. This data has provided a sizable amount of fertility information compared to typical mining baseline soil surveys which generally postpone fertility assessments until the salvaged soil material has been reapplied.

It should be noted, however, that revegetation must utilize native plant species regardless of generally low native soil fertility. In addition, fertility recommendations for native species have not been firmly established. The best time for fertility testing is after salvaged soil material has been reapplied but prior to reseeding. Any fertility changes due to topsoil salvaging and possible stockpiling would be reflected in subsequent testing.

Nitrogen levels in the Wishbone Hill soils are low as indicated by low levels of extractable nitrate and ammonium nitrogen. Total nitrogen is relatively high and could act as a source of additional fertility but apparently has slow release as shown by the low nitrate and ammonium nitrogen levels. This is probably due to low soil temperatures and biological degradation that is limited to the short frost free season. An adequate amount of nitrogen for an Alaskan plowlayer is about 50 to 75 ppm (Ping 1988).

Phosphorous levels vary from low to high based on an adequate level of approximately 15 ppm (Ping 1988). Minesoil phosphorous levels should be adequate due to soil mixing during salvage operations. Potassium levels are relatively high with most over 40 ppm. They range from about 10 to 350 ppm. An adequate level is approximately 40 ppm (Ping 1988). Micronutrient levels (Manganese, Iron, Boron, Copper, Zinc, and Molybdenum) were not tested, with the exception of iron which was high, but should be suitable based on the low pH's of native soils.

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6.0 GLOSSARY OF SELECTED TERMS

ALLUVIUM - 1) locally derived - unconsolidated mineral material deposited on sideslopes and valley floors by local unconcentrated downslope runoff, accompanied somewhat by gravitational forces. 2) stratified-mineral material that has been subjected to appreciable transport in suspension with concentrated water flow and deposited in highly variable layers.

CLAY - As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

COARSE FRAGMENTS - mineral particles or rocks having diameter greater than 2 millimeters, such as gravels, cobbles, channels, and stones.

COARSE-LOAMY - As a soil particle size class, the soil has less than 18 percent clay by weight in the fine-earth fraction, and 15 percent or more of the soil particles are fine sand or coarser. Textures are not sandy (see sandy).

COARSE-SILTY - As a soil particle size class, the soil, by weight, has <15 percent of the particles are fine sand or coarser, including fragments up to 7.5 cm in diameter; <18 percent clay in the fine-earth fraction.

COLLUVIUM - Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the bases of slopes.

CRYIC - a soil temperature regime with mean annual soil temperature higher than 0C (32F) but lower than 8C (47F). Special conditions apply to both mineral and organic soils.

DEEP - the soil is 40 to 60 inches deep over bedrock.

DRAINAGE CLASS - Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized.

Excessively drained - Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained - Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained - Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained - Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically they are wet long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained - Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained - Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained - Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients.

FAMILY - A level of classification in the soil taxonomic system; a group of soils having similar physical and chemical properties that affects their response to management and manipulation for use.

FINE-EARTH FRACTION - that portion of the soil particles which has diameter of less than 2 millimeters.

FINE-LOAMY - by weight, a textural class in which the fine earth fraction has 18 to 34 percent clay and greater than 15 percent fine or coarser sand.

GLACIAL OUTWASH - Gravel, sand, and silt, commonly stratified, deposited by glacial melt water.

GLACIAL TILL - Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

GLACIOFUVIAL DEPOSITS - Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur as kames, eskers, deltas, and outwash plains.

HORIZON (SOIL) - contrasting layers of soil material approximately parallel to the land surface and differing from adjacent layers in physical, chemical, and biological properties or characteristics produced by soil forming processes. The major horizons of mineral soil are as follows:

O HORIZON - an organic layer of fresh and decaying plant residue at the surface of a mineral soil.

A HORIZON - commonly the uppermost mineral layer in the soil profile often referred to as the surface soil. It is the horizon where humus is accumulative or formed and also called the zone of eluviation.

E HORIZON - a mineral horizon, mainly a residual concentration of sand and silt high in Content of resistant minerals as a result of the loss of silicate clay, iron, aluminum, or a combination of these.

B HORIZON - the master horizon commonly found immediately beneath the A horizon and often called the subsoil or zone of illuviation.

C HORIZON - a mineral layer, excluding bedrock or unconsolidated lithologic materials, that is only slightly affected by pedogenic processes and lacks properties diagnostic of A and B horizons. It is often called the substratum.

LOAMY-SKELETAL - As a soil particle size class, the soil has rock fragments hat make up 35 percent or more by volume; enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is loamy as defined for the loamy particle-size class.

LOESS - fine grained material, dominantly of silt-sized particles, deposited by wind.

MEDIAL - term used to replace texture particle size class for soils with high organic matter content and a spodic horizon in a cryic temperature regime; medial has less than 60 percent by weight volcanic ash cinders and pumice; <35 percent by volume is 2 mm in diameter or larger; the fine earth fraction is not thixotropic and the exchange complex is dominated by amorphous materials.

MODERATELY DEEP - the soil is 20 to 40 inches deep over bedrock.

MOTTLING, SOIL - irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage.

MUNSELL NOTATION - A designation of color by degrees of the three variables - hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

PARALITHIC CONTACT - boundary between soil and hard (greater than three on Moh's scale), continuous, coherent underlying materials. Roots generally do not extend below a paralithic contact. Much disagreement exists concerning the nature and placement of the paralithic contact.

PARENT MATERIAL - the unconsolidated organic and mineral material in which soil forms.

PEDON - a conceptual unit area of soil which represents the nature and variabilities of its horizons and other properties. The smallest volume that can be called a "soil".

PHASE - a subdivision of a soil series based on such factors as slope, surface texture, stoniness, salinity, internal drainage, etc.

PROFILE - the sequence of horizons present in a soil.

RESIDUUM - unconsolidated material which accumulates by weathering of parent material in place.

SAND - As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

SANDY - As a soil particle size class, the soil has texture of fine earth is sand or loamy sand but not loamy very fine sand or very fine sand; rock fragments make up less than 35 percent by volume.

SANDY-SKELETAL - same as above but rock fragments make up more than 35 percent by volume.

SERIES - a level of classification in the soil taxonomic system; somewhat similar to the species category in the Linnean taxonomic system.

SHALLOW - the soil is 10 to 20 inches deep over bedrock.

SILT - As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

SKELETAL - the soil contains 35 percent or more coarse fragments, by volume. Fine earth modifiers of sandy, loamy, or clayey precede the term skeletal in soil particle size classification.

SOIL SEPARATES - Mineral particles less than 2mm in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: Very coarse sand 2.0 to 1.0; Coarse sand 1.0 to 0.5; Medium sand 0.5 to 0.25; Fine sand 0.25 to 0.10; Very fine sand 0.10 to 0.05; Silt 0.05 to 0.002; Clay Less than 0.002.

TEXTURE, SOIL - The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are sand, loamy sand, sandy loam, loam, silt, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine".

VERY DEEP - the soil is greater than 60 inches deep over bedrock.

VERY SHALLOW - the soil is less than 10 inches deep over bedrock.

TABLES

TABLE XI-1

PARAMETERS AND ANALYTICAL PROCEDURES UTILIZED FOR TOPSOIL ANALYSIS

Parameter-Units	Procedure-Reference
Sample Preparation	Samples were air dried at ≦35°C. Clods were broken up prior to grinding and sieving of sample. Large coarse fragments were removed. Sample material was sieved. Remaining rock coarse fragments left on the 10-mesh (2 mm) sieve were removed. Remaining soil clods left on the 10-mesh screen were ground until the sample just passed the screen. Excessive grinding of sample material was avoided during the entire sample preparation procedure.
Subsampling of sieved (<2 mm) soil materials for analysis	USDA Handbook 60, 1954 - Diagnosis and Improvement of Saline and Alkali Soils, pp. 83-84. U.S. Salinity Laboratory Staff.
Coarse fragment content, percent by volume (field estimate)	SCS - Soil Survey Investigations Report No. 1 Procedures for Collecting Soil Samples and Methods of Analysis for Soil Survey (SSIR No. 1), Method 1A2a, page 14.
pH (1:1 water, and saturated paste)	USDA Handbook 60, Method (21A), page 102, and Method (2), page 84.
Conductivity in mmhos/cm @25°C	USDA Handbook 60, Method (3a), page 84, and Method (4b) pages 89-90.
Preparation of saturation extract and saturation percent determination	USDA Handbook 60, Methods 2 and 3a, pages 84 and 88, and 27a and b, page 107.
Particle-Size Analysis in Percent clay, silt, sand, and very fine sand (vfs = 0.05-0.1mm)	Hydrometer Method. ASA Mono. No. 9, part 1, Method 43-5, pages 562-566. Two-hour and 8-hour settling times were used for clay. Sieve analysis used for vfs (140-270) mesh. ASA Mono. No. 9, Part 1, pages 554-556. Black, 1965 and 1982.
Texture (based on 8 hour readings)	USDA Handbook 18, pages 205-223.
Soluble Ca, Mg, and Na, meq/100g	Extraction of Ca, Mg, and Na, by USDA Handbook 60, Method (3a), page 84. Analysis by atomic adsorption spectrophotometry.

TABLE XI-1 (CONTINUED)

Parameter-Units	Procedure-Reference
Organic Carbon Percent	A.S.A. Monograph No. 9, 1982, Part 2, Method 29-2.5.2, page 570.
Organic Matter (% Wt. Loss on Ignition)	Adapted from Davies, B.E. 1974. Soil Science Society of America Proceedings. 38:150.
Nitrate-Nitrogen, mg/kg	Extraction by ASA Monograph No. 9, Part II, method 84.5.3.3., p. 1216. Analysis by automated cadmium reduction, EPA 600/4-79-020, method 353.2.
Ammonium-Nitrogen mg/kg	Extraction by ASA Monograph No. 9, Part II, method 84.5.3.3., p. 1216. Analysis by automated cadmium reduction, EPA 600/4-79020, method 353.2.
Phosphorus, ppm	Extraction by ASA Monograph No. 9, Part II, method 73-4.4, p. 1044-1047. Analysis by Standard Methods, method 425 F., p. 481-482.
Potassium, ppm	Ammonium Acetate Extraction, ASA Mono. No. 9, Part II, method 71-3, p. 1025-1027. Analysis by atomic absorption.
Cation Exchange Capacity (CEC)	SCS-SSRI No. 1, Method 5A8, Page 37; Extractable bases from NH_4OAc extract, methods 6N2, 6O2, 6P2, 6Q2.
Iron (Pyrophosphate),%	SCS-SSRI No. 1, Method 6C8, page 50.
Aluminum (Pyrophosphate), %	SCS-SSRI No. 1, Method 6G10, page 60.
Iron (Dithionite-Citrate), %	SCS-SSRI No. 1, Method 6C2, page 49.
Aluminum (Dithonite-Citrate), %	SCS-SSRI No. 1, Method 6G7, page 58.

TABLE XI-2

CRITERIA TO ESTABLISH SUITABILITY OF TOPSOIL

Parameter	Unsuitable Level
pH	<4.2
Coarse Fragments	
gravel (2mm-3")	≥30%
cobbles (3-10")	≥15%
Slope	>50%

TABLE XI-3

LIST OF SOIL PROFILE DESCRIPTIONS

Soil Profile Description Number	Soil Series Name
1	Kashwitna, terrace
2	Kashwitna
3	Disturbed Land
4*	Talkeetna
5	Kashwitna
6	Nancy Variant
7	Kashwitna
8*	Kashwitna
9	Kichatna
10	Kashwitna
11	Unnamed
12	Nancy Variant
13	Kashwitna
14	Typic Cryaquent
15	Homestead
16	Kashwitna
17	Kashwitna
18	Kashwitna
19	Homestead
20	Kashwitna
21	Kashwitna
22	Kashwitna
23	Kashwitna
24	Kashwitna
25	Kashwitna
26*	Nancy Variant
27*	Chulitna Variant
28	Kashwitna
29	Knick
30	Kashwitna
31	Homestead

TABLE XI-3 (CONTINUED)

Soil Profile Description Number	Soil Series Name
32	Kashwitna
33	Kashwitna
34	Kashwitna
35	Homestead
36	Kashwitna
37	Homestead
38*	Kashwitna
39*	Homestead
40	Kashwitna
41	Kashwitna
42	Kashwitna
43	Kashwitna
44	Kashwitna
45	Kashwitna
46	Kashwitna
47	Kashwitna
48	Typic Cryocrept
49	Homestead
50	Homestead
51	Kashwitna
52	Nancy Variant
53	Kashwitna, terrace
54	Kashwitna, terrace
55	Kashwitna, terrace
56	Rock outcrop
57	Lucile
58	Unnamed
59	Kashwitna
60*	Talkeetna
61	Disturbed Land
62*	Lucile
63	Kashwitna

TABLE XI-3 (CONTINUED)

Soil Profile Description Number	Soil Series Name
64	Kashwitna
65	Lucile
66*	Kashwitna
67	Kashwitna
68	Kashwitna
69	Kashwitna
70	Kashwitna
71	Kashwitna
72	Kashwitna
73	Kashwitna
74	Kashwitna
75	Kashwitna
76	Kashwitna
77*	Torpedo Lake Variant
78	Torpedo Lake Variant
79	Talkeetna
80	Talkeetna
81	Talkeetna
82	Talkeetna
83*	Talkeetna
84	Talkeetna
85	Talkeetna
86	Torpedo Lake Variant
87	Talkeetna
88	Talkeetna
89*	Niklason Taxadjunct
90	Talkeetna
91	Talkeetna
91	Talkeetna
91	Talkeetna
92	Talkeetna
93	Talkeetna

TABLE XI-3 (CONTINUED)

Soil Profile Description Number	Soil Series Name
94	Talkeetna
95	Talkeetna
96	Talkeetna
97	Lithic Cryorthod
98	Talkeetna
99	Torpedo Lake Variant
100*	Torpedo Lake Variant
101	Kashwitna, terrace
102	Niklason Taxadjunct
103	Talkeetna
104	Talkeetna
105	Talkeetna
106	Talkeetna
107	Terric Cryosaprist
108*	Terric Cryosaprist
109	Talkeetna
110	Kashwitna, terrace
111	Talkeetna
112	Talkeetna
113	Typic Cryumbrepts
114	Talkeetna
115	Terric Cryosaprist
116	Talkeetna
117	Talkeetna
118	Talkeetna
119	Talkeetna
120	Talkeetna
121	Talkeetna
122	Talkeetna
123	Torpedo Lake Variant
124	Torpedo Lake Variant
125	Talkeetna
126	Torpedo Lake Variant

TABLE XI-3 (CONTINUED)

Soil Profile Description Number	Soil Series Name
127	Talkeetna
128	Talkeetna
129	Talkeetna
130	Talkeetna
131	Talkeetna
132	Talkeetna
133	Talkeetna
134	Talkeetna
135	Talkeetna
136	Talkeetna
137*	Typic Cryumbrepts
138	Talkeetna
139	Talkeetna
140	Talkeetna
141	Talkeetna
142	Talkeetna
143	Talkeetna
144	Talkeetna
145	Talkeetna
146	Typic Cryumbrepts
147	Talkeetna
148	Kashwitna
149	Nancy Variant
150	Nancy Variant
151	Nancy Variant
152	Lucile
153	Nancy Variant
154	Nancy Variant
155	Nancy Variant
156	Unnamed
157	Chulitna Variant

*Sampled for laboratory characterization.

TABLE XI-4

GUIDE TO SOIL MAP UNITS

Map Unit	Name
A	Talkeetna silt loam, 2 to 30% slopes
B	Talkeetna - Torpedo Lake Variant Complex, 1 to 20% slopes
C	Typic Cryumbrepts, 1 to 15% slopes
D	Terric Cryosaprists, 0 to 4% slopes
E1	Kashwitna silt loam, 2 to 50% slopes
E2	Nancy Variant silt loam, 2 to 50% slopes
F	Chulitna Variant - Lucile Complex, 1 to 35% slopes
G	Homestead - Kashwitna Complex, 1 to 15% slopes
H	Niklason Taxadjunct gravelly sand, 1 to 6% slopes
I	Lucile - Chulitna Variant Complex, 1 to 12% slopes
J	Kashwitna silt loam, terrace, 1 to 30% slopes
RO	Rock Outcrop
DL	Disturbed Land
RL	Reclaimed Land
W	Water

TABLE XI-5

SOIL MAP UNIT DESCRIPTIONS

Map Unit Number	Map Unit Name	Percent of Map Unit	Inclusions Within Map Unit	Slopes and Terrain[1]	Parent Material Type[2]	Erosion Hazard of Bare Surface[3] Water	Erosion Hazard of Bare Surface[3] Wind
A	Talkeetna silt loam, 2 to 30% slopes	85	Torpedo Lake Variant 10% Typic Cryumbrepts 5%	Very gently sloping to moderately steep soils on the Wishbone Hill upland	Silt loam loess over gravelly to very gravelly sandy loam glacial till	High	High
B	Talkeetna– Torpedo Lake Variant Complex, 1 to 20% slopes	55 35	Typic Cryumbrepts 10%	Nearly level to moderately steep soils on the Wishbone Hill upland	Silt loam loess over gravelly to very gravelly sandy loam glacial till	High Moderate	High High
C	Typic Cryumbrepts, 1 to 15% slopes	75	Torpedo Lake Variant 15% Talkeetna 10%	Nearly level to moderately sloping soils in swales, upland meadows, and drainage-ways on the Wishbone Hill upland	Silt loam loess over gravelly to very gravelly sandy loam glacial till	Moderate	High
D	Terric Cryosaprists, 0 to 4% slopes	95	Torpedo Lake Variant 5%	Nearly level to very gently sloping organic soils primarily on lowlands along Buffalo Creek on the Wishbone Hill upland	Surface organic materials over stratified gravelly sand and organic silt loam	Low	Low
E1	Kashwitna silt loam, 2 to 50% slopes	80	Homestead 10% Nancy Variant 5% Lucile 5%	Nearly level ridge crests to steep ridge sideslopes within the esker dominated glacial outwash area	Silt loam loess over gravelly to very cobbly glaciofluvial outwash deposits	High	High

TABLE XI-5 (CONTINUED)

Map Unit Number	Map Unit Name	Percent of Map Unit	Inclusions Within Map Unit	Slopes and Terrain[1]	Parent Material Type[2]	Erosion Hazard of Bare Surface[3]	
						Water	Wind
E2	Nancy Variant silt loam, 2 to 50% slopes	80	Kashwitna 10% Chulitna Variant 5% Lucile 5%	Nearly level ridge crests to steep ridge sideslopes within the esker dominated glacial outwash area	Same as above except silt loam loess mantle is 20 to 30 inches thick (rather than 10 to 20 inches)	High	High
F	Chulitna Variant–Lucile Complex, 1 to 35% slopes	50 30	Nancy Variant 10% Kashwitna 10%	Nearly level "kettle hole" bottoms to steep kettle hole sideslopes within the glacial outwash area	Silt loam loess over local alluvial material over gravelly to very gravelly loamy sand to sand and gravel glacial outwash. Lucile soils are mottled to gleyed within one foot of the soil surface.	High High	High High
G	Homestead-Kashwitna, 1 to 15% slopes	55 40	Nancy Variant 5%	Nearly level to moderately rolling soils in a somewhat large basin within the glacial outwash area	Generally thin (<10 inches) silt loam loess over gravelly to very cobbly glaciofluvial outwash deposits	High	High
H	Niklason Taxadjunct gravelly sand, 1 to 6% slopes	85	Kashwitna, terrace 10% Water 5%	Nearly level to gently sloping soils on low terraces adjacent to Moose Creek	Stratified gravelly sand, loamy sand, and sand and gravel (streamlain alluvium). Can contain buried organic-silt loam lenses	Moderate	High

TABLE XI-5 (CONTINUED)

Map Unit Number	Map Unit Name	Percent of Map Unit	Inclusions Within Map Unit	Slopes and Terrain[1]	Parent Material Type[2]	Erosion Hazard of Bare Surface[3]	
						Water	Wind
I	Lucile— Chulitna Variant Complex, 1 to 12% slopes	50 30	Miscellaneous inclusions 10% Nancy Variant 5% Kashwitna 5%	Nearly level to gently sloping somewhat large basins within the glacial outwash area—Lucile soils are on the lower areas	Silt loam loess over local alluvial material over gravelly to very gravelly loamy sand to sand and gravel glacial outwash. Lucile soils are mottled to gleyed within one foot of soil surface	High High	High High
J	Kashwitna silt loam, terrace, 1 to 30% slopes	90	Nancy Variant 5% Miscellaneous inclusions 5%	Nearly level terrace tops to moderately steep terrace sideslopes on terraces adjacent to Moose Creek	Silt loam loess over stratified coarse-textured streamlain alluvium	High	High
RO	Rock Outcrop	90	Shallow Cryorthents 10%	Steep sideslopes and cliffs adjacent to Moose Creek	Rock Outcrop with scattered small areas of shallow soils over rock	—	—
DL	Disturbed Land	90	Rock outcrop 10%	Nearly level to steep areas disturbed by previous mining activities. Some areas have been naturally revegetated (alder shrubs) but the original soils have been scraped or otherwise disturbed and cannot be salvaged	Mixed overburden for mining activities is at the surface, scattered rock outcrop is also present	—	—

TABLE XI-5 (CONTINUED)

Map Unit Number	Map Unit Name	Percent of Map Unit	Inclusions Within Map Unit	Slopes and Terrain[1]	Parent Material Type[2]	Erosion Hazard of Bare Surface[3]	
						Water	Wind
RL	Reclaimed Land	100	—	Revegetated lands within old mining areas	Mixed overburden (with no soil cover) has been re-vegetated with native species	—	—
W	Water	90	Moose Creek gravel bars 10%	Moose Creek	Contains gravel bars and river-wash within Moose Creek channel	—	—

[1] Terminology from USDA-SCS. June 1981.
[2] Ibid.
[3] Erosion hazard class taken from SCS Official Soil Series Descriptions for water erosion hazard, and National Soils Handbook (SCS 1983) criteria for wind erosion hazard.

TABLE XI-6

SOIL INTERPRETATIONS

Soil Series	Map Unit*	Texture of Control Section[1]	Depth[2]	Major Rooting Depth (inches)[3]	Internal Drainage[4]	Permeability[5]	Available Water Holding Capacity[6]	Rate of Surface Runoff[7]	Typical Reaction Class[8]	Erosion Factors: Wind Erod. Group[9]	Erosion Factors: I Factor T/AC/YR[10]	Erosion Factors: Erosion Potential K Factor[11]	Hydrol. Group[12]
Talkeetna	A, B	Medial over loamy-skeletal	Deep	15	Well	Moderate over mod. rapid (2C)	Moderate	Moderate to Rapid	Ext. Acid to Str. Acid	1	160	.41 over over .10 (2C horizon)	B
Torpedo Lake Variant	B	Coarse-silty over loamy-skeletal	Deep	18	Somewhat poorly to poorly	Moderate over rapid (2C)	Moderate	Slow to Rapid	Very Str. to Str. Acid	1	160	.37 over .10 (2C horizon)	D
Typic Cryumbrepts	C	Coarse-silty over loamy-skeletal	Deep	12	Somewhat poorly	Moderate over rapid (2C)	Moderate	Slow to Rapid	Mod. Acid	1	160	.37 over .10 (2C horizon)	B-C
Terric Cryosaprists	D	Loamy	Deep	20	Very poorly	Moderate	High	Slow	Very Str. Acid	8	--	.05	D
Kashwitna	E1, I, G	Medial over sandy or sandy-skeletal	Deep	12	Well	Moderate over rapid (2C)	Moderate	Slow to Rapid	Ext. Acid to Str. Acid	1	160	.41 over .05 (2C horizon)	B
Nancy Variant	E2	Coarse-silty over sandy-skeletal	Deep	12	Well	Moderate over rapid (2C)	Moderate	Slow to Rapid	Mod. Acid	1	160	.41 over .05 (2C horizon)	B
Chulitna Variant	F	Coarse-silty over sandy or sandy-skeletal	Deep	15	Well	Moderate over rapid (2C)	Moderate	Slow to Rapid	Str. Acid	1	160	.41 over .05 (2C horizon)	B

TABLE XI-6(CONTINUED)

Soil Series	Map Unit*	Texture of Control Section[1]	Depth[2]	Major Rooting Depth (inches)[3]	Internal Drainage[4]	Permeability[5]	Available Water Holding Capacity[6]	Rate of Surface Runoff[7]	Typical Reaction Class[8]	Erosion Factors: Wind Erod. Group[9]	Erosion Factors: I Factor T/AC/YR[10]	Erosion Factors: Erosion Potential K Factor[11]	Hydrol. Group[12]
Lucile	F	Medial over sandy or sandy-skeletal	Deep	12	Poor-part of spring Well-rest of year	Moderate	Moderate	Slow to Rapid	Very Str. to Mod. Acid	1	160	.41 over .05 (2C horizon)	D
Homestead	G	Loamy-skeletal	Deep	8	Well	Moderate over rapid (2C)	Low	Slow to Very Rapid	Str. Acid	1	160	.41 over .10 (2C horizon)	A
Niklason Taxadjunct	H	Sandy	Deep	18	Excessively Drained	Rapid	Low	Slow	Sl. Acid to Str. Acid	1	160	.24 over .10 (lower horizons)	B

*Map Units for Rock Outcrop (J), Disturbed Land (DL), Reclaimed Land (RL), and Water (W) do not have soil interpretation information. These map units could be evaluated for certain attributes on a site-specific case by case basis. Also, soil engineering classifications ("Unified" system and "Aashto," the American Association of State Highway and Transportation Officials) for all map unit soil components are on file.

TABLE XI-6(CONTINUED)

SOIL INTERPRETATIONS

FOOTNOTES

1 Texture of Control Section: as defined in Soil Taxonomy (pp. 383-386). The textural control section is generally the upper 20 inches or the whole of a argillic horizon; or from 10-40" or bedrock whichever is shallower; or the whole soil if bedrock is 14" deep or less.

2 Depth: refers to the soil profile depth before encountering bedrock or a paralithic contact.

Depth Class	Inches
Very Shallow	<10
Shallow	10-20
Moderately Deep	20-40
Deep	40-60
Very Deep	60+

3 Major Rooting Depth: depth to which the majority of plant roots were observed to occur.

4 Internal Drainage: refers to aeration or saturation characteristics within the soil profile. Well drained soils allow water to move through the profil readily but not rapidly, and soil aeration is typically not a problem. Somewhat excessively drained soils allow water to move rapidly through the profile and are typically droughtly, sandy, and poorly developed. Somewhat poorly drained soils have a wet state relatively high in the profile for a significan length of time to impede most uses, unless artifically drained. Poorly drained soils commonly are wet at or near the surface during a considerable par of the year.

5 Permeability: Permeability is a characteristic of soil which relates to the movement of water through the profile. Permeability criteria are based on th rate at which water moves through the most slowly permeable layer to a depth of 60 inches in a saturated soil profile.

Permeability Class	Rate (inches/hour)	Typical Soil Texture
Very Slow	less than 0.06	C, SiCL, and SiC
Slow	0.06-0.2	CL+
Moderately Slow	0.2-0.6	CL, SiL
Moderate	0.6-2.0	L, Vfsl, and SCL
Moderately Rapid	2.0-6.0	SL, LS
Rapid	6.0-20.0	GLS, S, and G
Very Rapid	More than 20	G

TABLE XI-6(CONTINUED)

SOIL INTERPRETATIONS

FOOTNOTES

6 Available Water Holding Capacity: the relative amount of water that a soil, from 0-60 inches or to a paralithic or lithic contact, can hold available for use by plants. Affected by such characteristics as soil texture, depth, structure, salts, and organic matter. AWHC modifiers are site-specific for the sampled soil profiles. Class criteria is taken from USDA-SCS, May 1981, Wyoming Soil Interpretation Procedure Guide, pg. 31 and Soil Survey Manual, pg. 4-33. Classes are: Very Low 0-3 inches; Low = 3-6 inches; Moderate = 6-9 inches; High = >9 inches.

7 Rate of Runoff: This indicates the relative rate that water is removed by flow over the surface of the soil. Classes are defined in the Soil Survey Manual. pg. 4-34 and 4-35.

8 Typical Reaction Class: narrative range of pH of surface (A horizon)/subsoil (B horizon, or if B is lacking, the first C horizon).

Extremely Acid: below 4.5; Very Strongly Acid: 4.5-5.0; Strongly Acid: 5.1-5.5; Moderately Acid: 5.6-6.0
Slightly Acid: 6.1-6.5; Neutral: 6.6-7.3; Mildly Alkaline: 7.4-7.8; Moderately Alkaline: 7.9-8.4;
Strongly Alkaline: 8.5-9.0; Very Strongly Alkaline: greater than 9.0

Soils that are mildly alkaline usually are calcareous. Soils of moderate alkalinity or stronger are assumed to be calcareous. Strongly alkaline soils have increased sodium concentrations.

9 Wind Erodibility Group: This is an arbitrary grouping of soils based on texture and aggregation. Values range from 1 to 8, with lower numbers indicating increased susceptibility to wind erosion. The Wind Erodibility Group classification is for the surface layer only, but could be applied to any layer within a soil profile. Classes are defined in the National Soils Handbook (430-VI-NSH, July 1983, pg. 603-37), and USDA-SCS, May 1981, Wyoming Soil Interpretation Procedure Guide, pg. 35.

	WEG	Soil Texture of Surface Layer
Very High Erodibility	1	Very fine sand, fine sand, sand, or coarse sand
	2	Loamy very fine sand, loamy fine sand, loamy coarse sand
High Erodibility	3	Very fine sandy loam, fine sandy loam, sandy loam, or coarse sandy loam
	4	Clay, silty clay, noncalcareous clay loam, or silty clay loam with more than 35 percent clay content
	4L	Calcareous loam and silt loam, or calcareous clay loam, and silty clay loam
Medium Erodibility	5	Noncalcareous loam and silt loam with less than 20 percent clay content, sandy clay loam, or sandy clay
	6	Noncalcareous loam and silt loam with more than 20 percent clay content, or noncalcareous clay loam with less than 35 percent clay content
Low Erodibility	7	Silt, noncalcareous silty clay loam with less than 35 percent clay content
	8	Soils not suitable for cultivation due to coarse fragments or wetness, wind erosion not a problem

TABLE XI-6(CONTINUED)

SOIL INTERPRETATIONS

FOOTNOTES

[10] I Factor: This value indicates the relative amount of soil that can be expected to erode, through wind influence, in Tons-Per-Acre-Per-Year (T/AC/YR). It is related to the Wind erodibility Group number and the percent of dry soil aggregates >0.84 mm in diameter. Values are taken from USDA-SCS, May 1981 Wyoming Soil Procedures Guide, pg. 35.

[11] K Factor: This value indicates the relative susceptibility of a surface soil to water erosion. Values may range from .00 to .70. Higher K values indicate higher erosion susceptibility. Soils with K factor over about 0.40 are generally considered to be highly susceptible to water erosion. It should be noted that the K factor is primarily derived from physical characteristics of the soil, and does not reflect other soil erosion factors such as management practices, precipitation, or length and steepness of slope.

Low Erodibility = .20 or less; Moderate Erodibility = .21 - .40; High Erodibility = >.40

[12] Hydrologic Group Classification of Soils: Hydrologic soil groups are used in watershed planning to estimate runoff from rainfall. Soil properties are considered that influence the minimum rate of infiltration obtained for a bare soil after prolonged wetting. These properties are: depth of seasonally high water table, intake rate and permeability after prolonged wetting, and depth to a very slowly permeable layer. The influence of ground cover is treated independently - not in hydrologic soil groupings.

The soils have been classified into four groups, A through D. The individual classifications are taken from the most current official soil series "Form 5" sheets, as summarized in "Erosion Factors and Hydrologic Group for Soils of Montana", October 3, 1981, and a similarly named and dated publication for Wyoming. Statements in parentheses following the definitions may be helpful to soil scientists wishing to place soils into hydrologic groups using the soil classification system.

A. (Low runoff potential). Soils have high (rapid) infiltration rates even when thoroughly wetted and consist chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission. (Includes Psamments except those in Lithic, Aquic, and Aquodic subgroups; soils in Grossarenic subgroups of Undults and Udalfs, and soils in Arenic subgroups of Udults and Udalfs except those in clayey or fine families).

B. (Moderately low runoff potential). Soils have moderate infiltration rates when thoroughly wetted and consist chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission. (Soils other than those in groups A, C, or D).

TABLE XI-6 (CONTINUED)

SOIL INTERPRETATIONS

FOOTNOTES

C. (Moderately high runoff potential). Soils have slow infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water, soils with moderately fine to fine texture, soils with slow infiltration due to salts or alkali, or soils with moderate water tables. These soils may be somewhat poorly drained. This category also includes well and moderately well drained soils with slowly and very slowly permeable layers (fragipans, hardpans, hard bedrock, and the like) at moderate depth (20-40 inches). (Includes soils in Albic or Aquic subgroups; soils in Aeric subgroups of Aquents, Aquepts, Aquolls, Aqualfs, and Aquults in loamy families; soils other than those in group D that are in fine or clayey families except those with kaolinitic, oxidic, or halloysitic mineralogy; Humods and Orthods; soils with fragipans or petrocalcic horizons; soils in shallow families that have permeable substrata; soils in Lithic subgroups that have rock that is pervious or cracked enough to allow water to penetrate.)

D. (High runoff potential). Soils have very slow infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, soils with very slow infiltration due to salts or alkali, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission (Includes all vertisols; all Histosols; all Aquods; soils in Aquents, Aquepts, Aquolls, Aqualfs, and Aquults except for aeric subgroups in loamy families; soils with natric horizons; soils in Lithic subgroups that have impermeable substrata; and soils in shallow families that have impermeable substrata.)

TABLE XI-7

SOIL SERIES INFORMATION

(Soil Series -in alphabetic order, Map Unit, Sample Numbers, Taxonomic Classification, and SCS Soil Series Information for Soils on Idemitsu Kosan's Wishbone Hill Project Study Area)

Soil Series Name	Map Unit	Sample Numbers[1]	Soil Classification: Family	Soil Classification: Subgroup	SCS Soil Series Information[2]
Chulitna Variant	F, I	WH-27	Coarse-silty over sandy or sandy-skeletal, mixed	Typic Cryorthod	E, 3/87, AK 0105
Homestead	G	WH-39	Loamy-skeletal, mixed	Typic Cryorthod	E, 9/86, AK 0030
Kashwitna	E1, I, J, G	WH-8, WH-38 WH-66	Medial over sandy or sandy-skeletal, mixed	Typic Cryorthod	E, 9/86, AK 0034
Lucile	F, I	WH-62	Medial over sandy or sandy-skeletal, mixed	Sideric Cryaquod	E, 9/86, AK 00
Nancy Variant	E2	WH-26	Coarse-silty over sandy or sandy-skeletal, mixed	Typic Cryorthod	E, 9/86, AK 0042
Niklason Taxadjunct	H	WH-89	Sandy, mixed	Typic Cryofluvent	E, 9/86, Ak 0044
Talkeetna	A, B	WH-4, WH-83 WH-60	Medial over loamy-skeletal, mixed	Humic Cryorthod	E, 5/84, AK 0054
Torpedo Lake Variant	B	WH-77, WH-100	Coarse-silty over loamy-skeletal, mixed, acid	Humic Cryaquept	E, 4/84, AK 0055
Terric Cryosaprists[3]	D	WH-108	Loamy, mixed, euic	Terric Cryosaprist	—
Typic Cryumbrepts[3]	C	WH-137	Coarse-silty over loamy-skeletal, mixed	Typic Cryumbrept	—

[1]All sample numbers are preceded with "WH" (for Wishbone Hill), e.g. WH-4. See Table 3 for the entire list of 157 soil profile descriptions.

[2]Listed information includes: status of the soil series (E-Established), date of most recent SCS Official Soil Series Description, and the SCS Soil Interpretation Record ("SOI-5") computer reference number. The SOI-5 contains engineering and interpretative information in addition to basic quantitative information about the soil series. For soils mapped and classified site-specifically as series variants or taxadjuncts, the SCS information is for the Official Soil Series, not the variant. A variant is a soil that is sufficiently different from any established soil series that it would warrant establishment as a new soil series. A new SOI-5 would be developed for this new soil. However, known acreages are not large enough to justify establishment of a new series at this time. As a result, this soil is called a variant of the soil it most closely resembles, with the variations clearly described in the soils range of characteristics discussion (Table 8). A taxadjunct is a soil similar to its attached soil series, but different enough to necessitate a new SOI-5.

[3]SCS has not set up individual soil series names for these soil subgroups in the Matanuska-Susitna valleys area for various reasons- either the known acreage is small and does not warrant a new series, or the soil has not been observed in the areas previously mapped. For this IK Wishbone Hill soil survey, the soil subgroup classification (e.g. Typic Crymbrept) has been substituted for the series name. This approach is preferred to using an "Unnamed" designation for the soil.

TABLE XI-8

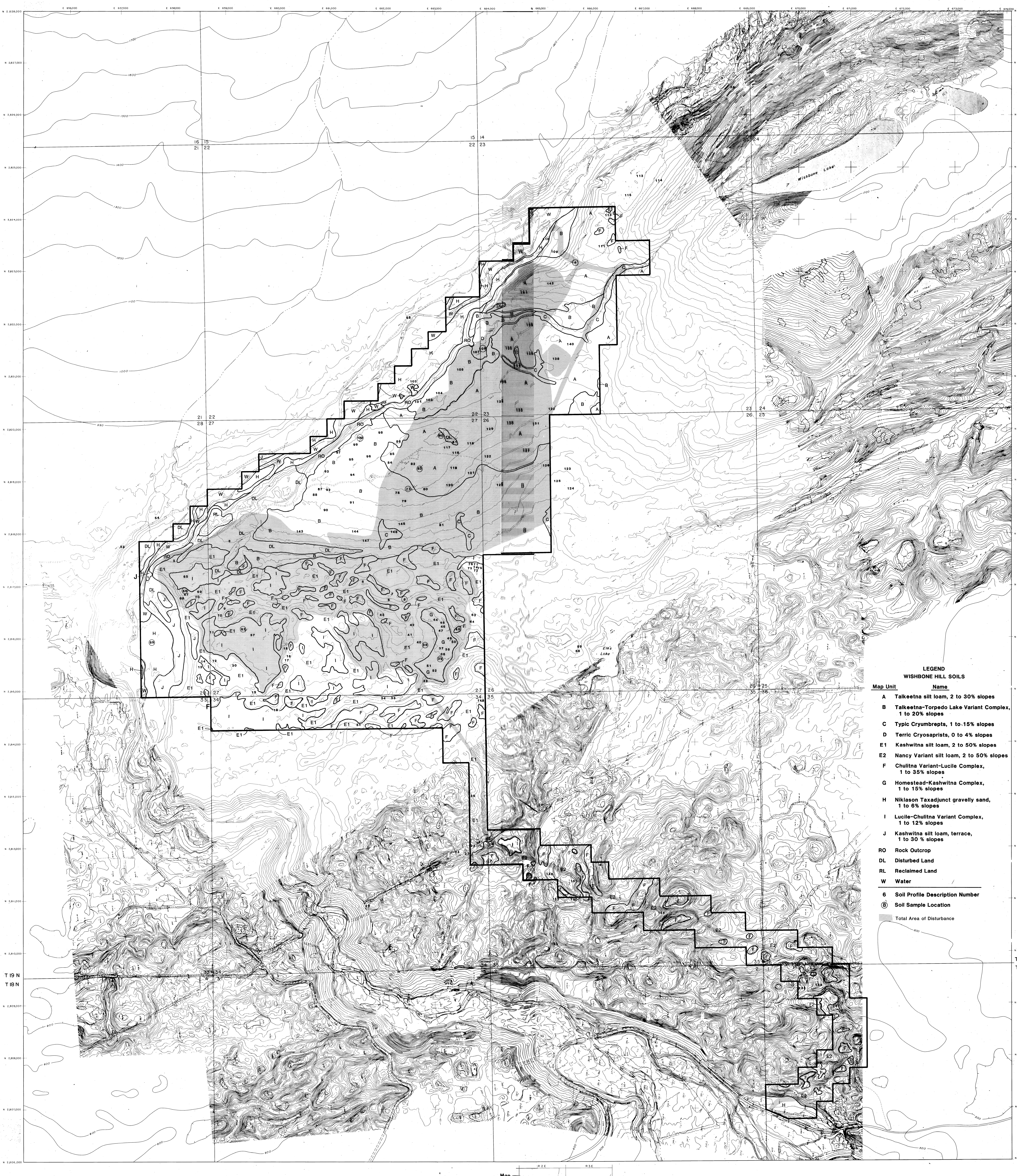
TOPSOIL SALVAGE DEPTHS, SOIL LIMITATIONS, AND SOIL QUANTITIES

Map Unit Symbol	Major soil Components and Inclusions (I)	Percent of Map Unit	Topsoil Salvage Depth (Inches)	Major Soil Limitations	Volume of Topsoil (A ft./Ac)
A	Talkeetna Torpedo Lake Variant (I) Typic Cryumbrepts (I)	85 10 5	18.5 18.2 17.3	Unsuitable glacial till substratum (too many coarse fragments, till is too dense)	Map Unit A = 18.4" (1.53 A ft./Ac)
B	Talkeetna Torpedo Lake Variant Typic Cryumbrepts (I)	55 35 10	18.5 18.2 17.3	Unsuitable glacial till substratum (too many coarse fragments, till is too dense)	Map Unit B = 18.3" (1.52 A ft./Ac)
C	Typic Cryumbrepts Torpedo Lake Variant (I) Talkeetna (I)	75 15 10	17.3 18.2 18.5	Unsuitable glacial till substratum (too many coarse fragments, till is too dense)	Map Unit C = 17.6" (1.46 A ft./Ac)
D	Terric Cryosaprists Torpedo Lake Variant (I)	95 5	0.0 0.0	Too wet to salvage, cannot separately salvage TLV	Map Unit D = 0.0" (0.0 A ft./Ac)
E1	Kashwitna Homestead (I) Nancy Variant (I) Lucile (I)	80 10 5 5	16.3 9.4 26.1 53.4	Unsuitable glacial outwash substratum (too many gravels and cobbles - too loose and cannot salvage)	Map Unit E1 = 18.0" (1.5 A ft./Ac)
E2	Nancy Variant Kashwitna (I) Chulitna Variant (I) Lucile (I)	80 10 5 5	26.1 16.3 37.5 53.4	Unsuitable glacial outwash substratum (too many gravels and cobbles - too loose and cannot salvage)	Map Unit E2 = 27.1" (2.25 A Ft./A)
F	Chulitna Variant Lucile Nancy Variant (I) Kashwitna (I)	50 30 10 10	37.5 53.4 26.1 16.3	Unsuitable glacial outwash substratum (becomes unsuitable when very gravelly-cobbly glacial outwash is encountered)	Map Unit F = 39.0" (3.25 A ft./A)

TABLE XI-8 (CONTINUED)

Map Unit Symbol	Major soil Components and Inclusions (I)	Percent of Map Unit	Topsoil Salvage Depth (Inches)	Major Soil Limitations	Volume of Topsoil (A ft./Ac)
G	Homestead Kashwitna Nancy Variant (I)	55 40 5	9.5 16.3 26.1	Unsuitable glacial outwash substratum (becomes unsuitable when very gravelly-cobbly glacial outwash is encountered)	Map Unit G = 13.1" (1.09 A ft./A)
H	Niklason Taxadjunct Kashwitna, terrace (I) Water (I)	85 10 5	9.5 19.0 0.0	Becomes unsuitable when very sandy-gravelly streamlain alluvium is encountered	Map Unit H = 10.0" (0.83 A ft./A)
I	Lucile Chulitna Variant Miscellaneous inclusions (I) Nancy Variant (I) Kashwitna (I)	50 30 10 5 5	53.4 37.5 51.0 26.1 16.3	Unsuitable glacial outwash substratum becomes unsuitable when very gravelly-cobbly glacial outwash is encountered	Map Unit I = 45.2" (3.8 A ft./A)
J	Kashwitna, Terrace Nancy Variant (I) Miscellaneous inclusions (I)	90 5 5	19.0 26.1 19.0	Becomes unsuitable when very sandy-gravelly streamlain alluvium is encountered	Map Unit J = 19.4" (1.61 A ft./A)
RO	Rock Outcrop Cryorthents, shallow	90 10	0.0 0.0	Slope too steep, cannot separately salvage shallow Cryorthents	—
DL	Disturbed Land Rock outcrop (I)	90 10	0.0 0.0	Soil has been disturbed, is not suitable for reclamation, scattered rock outcrop	—
RL	Reclaimed Land	100	0.0	Already reclaimed	—
W	Water Moose Creek gravel bars (I)	90 10	0.0 0.0	No soil to salvage	—

PLATES

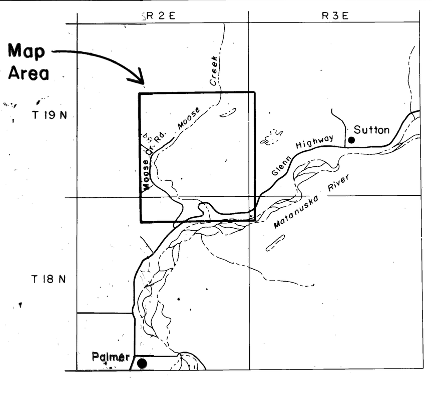


The core map area was photogrammetricaly mapped from photography of 5/8/84, 5/8/83, 6/22/85 by Air Photo Tech, Inc. of Anchorage, Alaska.

The core map area meets National Map Accuracy Standards at 1"=200' and smaller scales. Topographic and Planimetric features outside of the core area were taken from a photo enlarged 1"=1mile USGS Anchorage C-6 quad map of 1987.

Horizontal datum is Alaska State Plane, zone 4.

Vertical datum is based on USC & GS monumentation.



North

500 250 0 500 1000 1500

SCALE IN FEET
1"=500'
CONTOUR INTERVAL
5 FEET

SUBJECT REVISIONS			
REV.	DATE:	BY:	DESCRIPTION
1	2009	JEH	MINOR REVISIONS

DESIGN BY:
DRAWN BY:
CHECK BY:
DWG FILE:
DATE DRAWN:

WISHBONE HILL MINE

USIBELLI COAL MINE INC. UCM

PERMIT NUMBER 01-89-796

WISHBONE HILL COAL PROJECT
SOILS MAP

WISHBONE HILL MINE

USIBELLI COAL MINE, INC.
P.O. BOX 1000, HEALY, ALASKA 99743
(907) 683-2226

PLATE No. XI-1
SHEET No. 1 OF 1
REV. 1

APPENDICIES

APPENDIX A

SOIL PROFILE DESCRIPTIONS FOR ALL SAMPLED PEDONS

APPENDIX 11-A

SOIL PROFILE DESCRIPTIONS

Map Unit, Soil Series, Sample No., & Soil Classification	Horizon and Depth, Inches[1]	Texture[2]	Color Dry[3]	Color Moist[3]	Structure[4]	Consistency[5] Dry	Consistency[5] Moist	Consistency[5] Wet	Roots[6]	Coarse Fragments, Percent[7]	Reaction[8]	Boundary[9]	Additional Features and Comments
Map Unit A													
Talkeetna, WH-4	Medial over loamy-skeletal, mixed		Humic Cryorthod		12% slope, north aspect								
Oi	4-3	forest litter (leaves and twigs)											
Oe	3-0	moderately decomposed organic matter	10YR 2/2						Many CO, M, F, VF			CS	
E	0-4	SiL	10YR 5/3, 4/3	10YR 3/3	W F GR	SO	VFR	SS/SP	Many F, VF, Com M, Few Co 0-13"		EO	AI	
Bhs	4-13	Loam	7.5YR 4/4, 4/6	7.5YR 3/4	W M&F SBK	SO	FR	SS/SP			EO	CW	
BC	13-22	GR SL	7.5YR 4/4	7.5YR 3/4	W F SBK	SH	FR	SS/NP		15 GR 5 CB	EO	CW	
2C	22-60	GRV SL	10YR 5/4	10YR 4/4	SG	LO	LO	NS/NP		30 GR 15 CB	EO	—	

Map Unit, Soil Series, Sample No., & Soil Classification	Horizon and Depth Inches[1]	Texture[2]	Color Dry[3]	Color Moist[3]	Structure[4]	Consistency[5] Dry	Consistency[5] Moist	Consistency[5] Wet	Roots[6]	Coarse Fragments Percent[7]	Reaction[8]	Boundary[9]	Additional Features and Comments
Map Unit B													
Talkeetna, WH-83	Medial over loamy-skeletal		Humic Cryorthod		2% slope, southeast aspect								
Oi	3-2	forest litter (leaves and a few twigs)											
Oe	2-0	organic mat		10YR 2/2					Many CO, M, F, VF			AS	
E	0-3	SiL		10YR 5/1, 4/2	W M GR		FR	SS/SP	Many CO, M F, VF		EO	AI	
Bhs	3-8	SiL		5YR 3/2	W M SBK		FR	SS/SP	Com CO, M F, VF 3-16.5"		EO	CW	
Bs	8-16.5	SiL		10YR 4/4	Massive/ W M&F SBK		FR	SS/SP			EO	GW	
2C	16.5-30+	GRV SL		10YR 4/4, 4/6	Massive		FR	NS/NP		35 GR 15 CB	EO	—	

Map Unit, Soil Series, Sample No., & Soil Classification	Horizon and Depth Inches[1]	Texture[2]	Color Dry[3]	Color Moist[3]	Structure[4]	Consistency[5] Dry	Consistency[5] Moist	Consistency[5] Wet	Roots[6]	Coarse Fragments Percent[7]	Reaction[8]	Boundary[9]	Additional Features and Comments
Map Unit B													
Talkeetna, WH-60	Medial over loamy-skeletal			Humic Cryorthod	4% slope, northeast aspect								
Oe	2-0	organic mat		10YR 2/2								AS	
E	0-2	SiL		10YR 5/1	W F GR		VFR	SS/SP	Many F, VF Com M, Few CO 0-10"		EO	AI	
Bhs	2-6	SiL		7.5YR 3/2	W M&F SBK		FR	SS/SP			EO	CW	
Bs	6-13.5	SiL		7.5YR 4/4	W F SBK		FR	SS/SP	Few M, F, VF 10-13.5"		EO	CW	
2C	13.5-40+	VGR SL (sampled for lab)		10YR 5/4	Massive		FR	SS/NP		35 GR 15 CB	EO	—	

Range of Characteristics: Talkeetna soils are deep, well drained soils formed in a mantle of ash-influenced loess overlying glacial till. Depth to the gravelly 2C horizon ranges from 15 to 24 inches. The solum may be bisequal. The lower part of the spodic materials may extend into the gravelly till. the upper 4 inches of the combined spodic horizons have more than 6 percent organic carbon. The upper part of the control section formed in loess dominated by amorphous material and is designated "medial". The 2C horizon has 30 to 55 percent gravel and 10 to 20 percent cobble. Consistence ranges from friable to firm. Bedrock occurs below 40 inches. Talkeetna soils on Wishbone Hill are typical for the Talkeetna series.

Map Unit, Soil Series, Sample No., & Soil Classification	Horizon and Depth Inches[1]	Texture[2]	Color Dry[3]	Color Moist[3]	Structure[4]	Consistency[5] Dry	Consistency[5] Moist	Consistency[5] Wet	Roots[6]	Coarse Fragments Percent[7]	Reaction[8]	Boundary[9]	Additional Features and Comments
Map Unit B													
Torpedo Lake Variant, WH-77 Coarse-silty over loamy-skeletal, mixed, acid Humic Cryaquept 3% slope, southwest aspect													
Oi	4-3	forest litter (leaves and twigs)											
Oe	3-0	organic mat		10YR 2/2							EO	AS	
Bw1g	0-2	SiL		10YR 3/2 matrix. 7.5YR 4/6, 5YR 3/4, mottles, common med. distinct streaks and spots	Massive/ W F GR		FR	NS/SP	Many CO, M F, VF		EO	CS	Gleyed
Bw2g	2-7	SiL		10YR 3/2 matrix	Massive/ W F GR		FR	NS/SP	Many CO, M, F, VF		EO	CW	Gleyed
	(2-5)			Some 10YR 4/1 streaks, also 10YR 2/1 black spots									
	(5-7)			5YR 3/4 few streaks									
	(7-7.5)	CO SL lense		7.5YR 4/6	Massive		FR	SS/NP			EO	AW	
2BC	7.5-14.5	SiL		10YR 4/4 Few 7.5YR 4/6 mottled streaks	Massive/ W M SBK		FR	SS/SP	Many F, VF		EO	GW	
2C	14.5-38	GRV SL		10YR 4/4	Massive		FR	SS/NP		25 GR 15 CB	EO	—	

Map Unit, Soil Series, Sample No., & Soil Classification	Horizon and Depth Inches[1]	Texture[2]	Color Dry[3]	Color Moist[3]	Structure[4]	Consistency[5] Dry	Consistency[5] Moist	Consistency[5] Wet	Roots[6]	Coarse Fragments Percent[7]	Reaction[8]	Boundary[9]	Additional Features and Comments
Map Unit B													
Torpedo Lake Variant, WH-100	Coarse-silty over loamy-skeletal, mixed, acid Humic Cryaquept 2% slopes, west aspect												
Oi	4-3.5	forest litter (leaves and twigs)											
Oe	3.5-0	organic mat		10YR 2/2								AS	
Bw1g	0-6	SiL		10YR 2/1 w few high & low chroma mottles	W M PL/ W F GR		FR	SS/P	Many CO, M F, VF 0-8"		EO	CW	Gleyed
Bw2g	6-22	SiL		7.5YR 3/2 w high & low chroma mottles (few to com fine distinct)	Massive/ W M SBK		FR	SS/SP	Com CO, M, F, VF 8-22"		EO	GW	Gleyed
2C	22+	GRV SL		10YR 4/4	Massive		LO	NS/NP		30 GR 15 CB	EO	—	

<u>Range of Characteristics</u>: Torpedo Lake Variant (TLV) soils consist of deep, somewhat poorly to poorly drained soils formed in a thin mat of organic materials underlain by silty deposits over gravelly sandy loam glacial till. The organic materials are about 4 inches thick. The organic carbon content of the surface mineral layer is high (average of seven percent) but is not part of a histic epipedon and thereby differs from Torpedo Lake which does have a histic epipedon. TLV does have an umbric epipedon and classifies as a Humic Cryaquept. Matrix chromes of 1 or less occur within 24 inches of the mineral surface. TLV is a "hydric" soil. Thickness of the loess mantle ranges from about 14 to 22 inches and dominantly is silt loam texture. The upper part of the control section (10 to about 22 inches) is coarse-silty while the lower part which extends into the glacial-till is loamy-skeletal with greater than 35 percent coarse fragments. TLV soils are in small drainageways, seep areas, and nearly level depressions on the Wishbone Hill till surface. Other similar soils include Slikok which has a histic epipedon and a control section that is coarse-loamy.

Map Unit, Soil Series, Sample No., & Soil Classification	Horizon and Depth Inches[1]	Texture[2]	Color Dry[3]	Color Moist[3]	Structure[4]	Consistency[5] Dry	Consistency[5] Moist	Consistency[5] Wet	Roots[6]	Coarse Fragments Percent[7]	Reaction[8]	Boundary[9]	Additional Features and Comments
Map Unit C													
<u>Typic Cryumbrepts</u>, WH-137	Coarse-silty over loamy-skeletal			Typic Cryumbrept		2% slopes, west aspect							
Oi	7-5	herbaceous litter									EO	AS	
Oe&Oa	5-0	moderately and highly decomposed organic matter									EO	CW	
A	0-3	SiL	10YR 3/3	10YR 3/2	W F GR	SO	VFR	SS/SP	Many CO, F, VF		EO	CW	
Bw	3-12	SiL	10YR 4/3	10YR 3/4	W F SBK	SH	FR	SS/SP	Many CO, M F, VF		EO	GW	
2C	12+	GRV SL		10YR 4/2	Massive					30 GR 15 CB	EO	—	

<u>Range of Characteristics</u>: There were no named soil series that had a classification of Typic Cryumbrepts (TC) that were components of a map unit on the previous Matanuska Valley soil survey, or the recently completed Susitna Valley or Yenta Area surveys. This soil does exist on the Wishbone Hill area, and was set up at the family level because no named series exist for it. TC soils are deep, somewhat poorly drained soils found in upland swales and old, largely abandoned drainageways on the glacial till surface. These soils have an umbric epipedon but no obvious soil mottling or gleyed conditions. The natural fertility of the organic mat and loess mantle of this soil is high, and the soil supports dominantly herbaceous and shrub vegetation. Depth to the gravelly sandy loam glacial till is greater than 10 inches. Similar soils include Torpedo Lake and Slikok both of which have a histic epipedon and an aquic soil moisture regime, and the previously described Torpedo Lake Variant.

Map Unit, Soil Series, Sample No., & Soil Classification	Horizon and Depth Inches[1]	Texture[2]	Color Dry[3]	Color Moist[3]	Structure[4]	Consistency[5] Dry	Consistency[5] Moist	Consistency[5] Wet	Roots[6]	Coarse Fragments Percent[7]	Reaction[8]	Boundary[9]	Additional Features and Comments
Map Unit D													
Terric Cryosaprists, WH-108		Loamy, mixed, euic		Terric Cryosaprist		0% slope							
Oi	0-1												
Oe	1-7	organic mat							Many CO, F, F, VF			AS	
Cg	7-20	SiL	10YR 4/3	10YR 3/2	Massive		VFR	SS/SP	Few to Com F, VF		EO	CW	Gleyed
Oab	20-41	Highly decomposed organic material	10YR 3/3	10YR 3/2	—		—	NS/NP	Many old roots		EO	AW	
Cgb	41-45	GRV Sand		10YR 4/1	Massive/ SG		LO	NS/NP		50 GR	EO	—	Gleyed

Range of Characteristics: Terric Cryosaprists have a mineral layer greater than 12 inches in thickness that has its upper boundary within the control section below the surface tier. For WH-108, the surface tier is 0-12 inches, and the subsurface tier is 12 to 51 inches. The upper boundary of the Cg mineral layer is within the surface tier, not below it, and does not qualify for Terric. The lower Cgb mineral layer was not sampled below 45 inches due to hole instability due to water (not coarse fragments or a bedrock contact) and it is not known whether this layer is greater than 12 inches thick. Its upper boundary is in the control section below the surface tier. The alternative subgroup modifier of "fluvaquentic" requires a mineral layer between two organic layers (the Cg layer is such a layer) but must be less than 12 inches thick (the Cg is 13 inches thick), and therefore does not meet fluvaquentic criteria. This soil was classified as terric, not typic, because of the presence of two mineral layers, both of substantial thickness, which is the concept of the terric subgroup (thick subsurface mineral layer or layers). An additional issue concerns this soil. Is the soil temperature regime cryic (Cryosaprists) or frigid (Borosaprists)? There is no soil temperature and freezing characteristics to directly answer this question. Lacking this data, SCS uses an elevation of about 1000 feet to separate these soils (Clark 1988). The two delineations of this soil are both higher than 1,000 feet and therefore this soil is classified as a Cryosaprist. This soil is a "hydric" soil.

Map Unit, Soil Series, Sample No., & Soil Classification	Horizon and Depth Inches[1]	Texture[2]	Color Dry[3]	Color Moist[3]	Structure[4]	Consistency[5] Dry	Consistency[5] Moist	Consistency[5] Wet	Roots[6]	Coarse Fragments Percent[7]	Reaction[8]	Boundary[9]	Additional Features and Comments
Map Unit E1													
Kashwitna, WH-8	Medial over sandy or sandy-skeletal, mixed				Typic Cryorthod				28% slope, north aspect				
Oi	4-3	forest litter (leaves and twigs)											
Oe	3-0	mod. decomposed organic matter		10YR 2/2								AS	
E	0-2.5	SiL	10YR 5/1	10YR 3/2	W F GR	SO	VFR	SS/SP	Many CO, M F, VF 0-10"		EO	AS	
Bs	2.5-15	SiL		7.5YR 3/4	W F SBK	SO	FR	SS/SP			EO	AS	
2BC	15-24	GR Loam		10YR 4/4, 5/3	Massive	SH	FR	SS/NP		15 GR	EO	CW	
2C	24-60	GRV LS		10YR 3/4, 5/6	Massive/ SG	LO	LO	NS/NP		40 GR 25 CB	EO	—	

Map Unit, Soil Series, Sample No., & Soil Classification	Horizon and Depth, Inches[1]	Texture[2]	Color Dry[3]	Color Moist[3]	Structure[4]	Consistency[5] Dry	Consistency[5] Moist	Consistency[5] Wet	Roots[6]	Coarse Fragments, Percent[7]	Reaction[8]	Boundary[9]	Additional Features and Comments
Map Unit E1													
Kashwitna, WH-38 Medial over sandy or sandy-skeletal, mixed Typic Cryorthod 4% slope, east aspect													
Oe	2.5-0	mod. decomposed organic matter		10YR 2/2								CS	
E	0-5	SiL		10YR 4/2	W F GR		VFR	SS/SP	Many CO, M, F, VF 0-13"		EO	AI	
Bs	5-19	SiL		7.5YR 3/4	W F SBK		FR	SS/SP			EO	CW	
2BC	19-24	Loam		10YR 3/4	W F SBK		FR	SS/P			EO	AW	
2C	24-40+	GRV LS-SL (not sampled for lab)		10YR 3/4, 5/6	Massive/ SG	LO	LO	NS/NP		40 GR 20 CB	EO	—	

Map Unit, Soil Series, Sample No., & Soil Classification	Horizon and Depth[1] Inches	Texture[2]	Color Dry[3]	Color Moist[3]	Structure[4]	Consistency[5] Dry	Consistency[5] Moist	Consistency[5] Wet	Roots[6]	Coarse Fragments Percent[7]	Reaction[8]	Boundary[9]	Additional Features and Comments
Map Unit E1													
Kashwitna, WH-66	Medial over sandy or sandy-skeletal, mixed			Typic Cryorthod		30% slopes, north aspect							
Oi	4-2	forest litter (leaves & twigs)											
Oe	2-0	organic mat		10YR 2/2					Many CO, M F, VF			AS	
E	0-3.5	SiL		10YR 4/2	W F GR		FR	NS/SP	Many CO, M F, VF		EO	AS	
Bs	3.5-14	SiL		7.5YR 4/6	W M&F SBK		FR	NS/SP	Com CO, M & F, VF Few CO, M, F, VF 8-14"		EO	CW	
2C	14+	GRV LS (not sampled for lab)		10YR 3/4	Massive/SG		Lo	NS/NP		45 GR 30 CB	EO	—	

Range of Characteristics: Kashwitna soils are very deep, well drained formed in a thin mantle of silty loess overlying very gravelly glaciofluvial deposits. Thickness of the loess mantle is between 10 and 20 inches. The pedons often have bisequal sola. The sola is usually formed entirely in the eolian loess mantle, but in some pedons it extends into the underlying material. The exchange complex of the sola is dominated by amorphous material. This amorphous material is found in spodic Bs horizons and small pockets of ash that occur in the loess mantle. In personal communication with J. Nyenhuis concerning the Wishbone Hill survey area, Mark Clark (SCS-Palmer) has questioned whether sufficient amorphous material exists below 10 inches to warrant the upper portion of the particle size control section being called medial rather than coarse-silty. It is thought that not enough volcanic ash is present in the loess mantle, and that the spodic B horizons do not extend below 10 inches (Clark 1988), although SCS has not remapped the wishbone Hill area since 1968, and SCS's current thinking on medial vs. coarse-silty is more recent than that. It was decided to keep the medial designation (and therefore not to use Variant status for Kashwitna) because the spodic horizons of Kashwitna on Wishbone Hill were deeper than 10 inches when the bisequal spodic Bs horizons were combined. As Mark Clark readily agrees, this soil classification issue does not change the soil reclamation suitability of Kashwitna and thereby is largely academic, but it is important to properly classify the soil in its own right. Kashwitna is similar to Homestead, Nancy Variant, and Chulitna Variant. Homestead has a loess mantle less than 10 inches thick, Nancy Variant 20 to 30 inches, and Chulitna Variant between 30 and 40 inches thick. Kashwitna, terrace, soils (map unit J) are very similar to Kashwitna and differ only in the substratum (2C horizon). Kashwitna's substratum consists of coarse textured glaciosfluvial materials deposited during the last glaciation. Kashwitna, terrace, soils are on fluvial terraces adjacent to Moose Creek, primarily on the west side. The streamlain deposits are younger than the glaciofluvial deposits and are found only on Moose Creek terraces. It was decided to make Kashwitna, terrace, soils a separate map unit because of the difference in substratum origin and geographic location within the study area. Kashwitna, terrace, soils have similar sola (O, E, and Bs horizons), and soil classification as Kashwitna, and as such, no Kashwitna, terrace, soils were sampled for laboratory characterization. Kashwitna, terrace, soils are outside of projected disturbance areas and it was more important to sample Kashwitna where it might be disturbed.

Map Unit, Soil Series, Sample No., & Soil Classification	Horizon and Depth Inches[1]	Texture[2]	Color Dry[3]	Color Moist[3]	Structure[4]	Consistency[5] Dry	Consistency[5] Moist	Consistency[5] Wet	Roots[6]	Coarse Fragments Percent[7]	Reaction[8]	Boundary[9]	Additional Features and Comments
Map Unit E2													
Nancy Variant, WH-26	Coarse-silty over sandy or sandy-skeletal, mixed					Typic Cryorthod			6% slopes, south aspect				
Oi	4-3	forest litter (leaves and twigs)											
Oe	3-0	organic mat							Many CO, M, F, VF				
E	0-2	SiL		10YR 4/2	W F GR	SO	VFR	SS/SP	Many CO, M, F, VF 0-6"		EO	AS	
Bs	2-6	SiL		7.5YR 3/4	W F SBK	SO	FR	SS/SP			EO	CW	
BC	6-28	SiL		7.5YR 3/4, 10YR 3/4	W F SBK	SO-SH	FR	SS/SP	Com M, F, VF 6-12"		EO	CW	
2C	28+	GRV LS (not sampled for lab)		10YR 3/4,	Massive/ 5/6	LO SG	LO	NS/NP		35 GR	EO 10 CB	—	
Composite Sample	0-28	SiL		7.5YR 4/4, 10YR 4/4	—	SO	FR	SS/SP			EO	CW	

Range of Characteristics: The Nancy Variant soils are deep, well drained soils formed in a mantle of loess overlying sand or very gravelly sand and gravel. These soils are on outwash terraces and eskers. Nancy Variant soils are similar to Kashwitna soils except the thickness of the loess mantle is less than 20 inches for Kashwitna and between 20 and 30 inches for Nancy Variant. Chulitna soils have a loess mantle greater than 30 inches. Variant status is used because the loess mantle has less volcanic ash (and therefore is coarse-silty rather than medial in the upper part of the particle size control section) than for Nancy soils mapped in the Susitna Valley and Yenta Area soil surveys. An additional reason is that the spodic Bs horizon has its lower boundary above 10 inches in Nancy Variant, and therefore is not in the upper part of the control section (and thereby cannot contribute "amorphous materials" - present in the spodic Bs horizon - to the upper portion of the control section which is "medial" in Nancy but "coarse-silty" in Nancy Variant). Many pedons have a bi-sequal solum as well as churned upper horizons due to threethrow and/or frost action.

Map Unit, Soil Series, Sample No., & Soil Classification	Horizon and Depth Inches[1]	Texture[2]	Color Dry[3]	Color Moist[3]	Structure[4]	Consistency[5] Dry	Consistency[5] Moist	Consistency[5] Wet	Roots[6]	Coarse Fragments Percent[7]	Reaction[8]	Boundary[9]	Additional Features and Comments
Map Unit F													
Chulitna Variant, WH-27		Coarse-silty over sandy or sandy-skeletal, mixed				Typic Cryorthod			6% slopes, west aspect				
Oi	4-3	forest Litter											
Oe	3-0	organic mat							Many CO, M, F, VF			AS	
E	0-3	SiL		10YR 4/2	W F GRR	SO	VFR	SS/SP	Many CO, M, F, VF 0-10"		EO	AI	
Bs	3-10	SiL		7.5YR 3/4	W F SBK	SO	FR	SS/SP			EO	CW	
BC	10-38	SiL		7.5YR 3/4 10YR 3/4	W F SBK	SO-SH	FR	SS/SP	Com M, F, VF 10-15"		EO	CW	
2C1	38-56	GR SL (not sampled for lab)		10YR 4/2	Massive/	SH SG	FR	SS/NP		30 GR	EO	CW	
2C2	56-72+	VGR SL (not sampled for lab)		10YR 4/2	Massive/	Lo SG	LO	NS/NP		40 GR	EO 20 CB	—	
Composite Sample	0-38	SiL	7.5YR 5/4	7.5YR 3/3	—	SO-SH	FR	SS/SP			EO	CW	

Range of Characteristics: The Chulitna Variant soils are deep, well drained soils formed in a mantle of loess overlying gravelly or very gravelly sandy loam over sand to very gravelly sand and gravel glaciofluvial deposits. On the study area, Chulitna Variant soils are found in enclosed basins within the glacial outwash esker systems. Variant status is used for the same reasons as Nancy Variant (see Nancy Variant range of characteristics). Chulitna Variant soils have a loess mantle 30 to 40 inches in thickness compared to 20 to 30 for Nancy and less than 20 for Kashwitna and less than 10 for Homestead.

Map Unit, Soil Series, Sample No., & Soil Classification	Horizon and Depth Inches[1]	Texture[2]	Color Dry[3]	Color Moist[3]	Structure[4]	Consistency[5] Dry	Moist	Wet	Roots[6]	Coarse Fragments Percent[7]	Reaction[8]	Boundary[9]	Additional Features and Comments
Map Unit F													
Lucile,	WH-62	Medial over sandy or sandy-skeletal		Sideric Cryaquod		2% slope, south aspect							
Oi	3-2	forest litter (leaves and twigs)											
Oe	2-0	organic mat		10YR 2/2							EO	AS	
Eg	0-2	SiL		10YR 4/1, 3/2 crushed, Com 7.5YR 3/4 med. distinct mottles	W M GR		FR	NS/SP	Many CO, M F, VF 0-6"		EO	AI	
Bsg	2-15	SiL		7.5YR 3/4, 4/4. Com 10YR 3/1 large distinct mottles	W M SBK		FR	SS/SP	Com M, F, & Few CO 6-12" Few CO, M, F, VF below 12"		EO	CW	
2BC	15-25	GR LS		10YR 3/4	SG		LO	NS/NP		15 GR	EO	GW	
2C1	25-37	GR Sand		10YR 4/4, 7.5YR 4/4	SG		LO	NS/NP		20 GR	EO	GW	
2C2	37-48	GR Sand		10YR 4/4 7.5 YR 4/4 Few 7.5 YR med. distinct mottles	SG		Lo	NS/NP		25 GR	EO	CW	
3C	48-62	SiL		10YR 4/2	Massive		VFI	S/P		5 GR	EO	CW	Water table at 48"
4C	62-72	GR LS		10YR 4/2	SG		LO	NS/NP		15 GR	EO	CW	

Range of Characteristics: Lucile soils are deep, alternately seasonally poorly drained and seasonally well drained soils that formed in mantle of silty loess over alluvial materials over glaciofluvial deposits. These soils are found in kettle holes and enclosed basins within the esker systems found in the S 1/2 of Section 27, and in most of Sections 34 and 35, T19N, R2E. Lucile soils have a surface mantle of about 18 inches of wind deposited loess (with a small admixture of volcanic ash) over very gravelly glacial outwash. The upper two feet of the soil profile freezes during the winter and then thaws from the surface downward during May or as soon as weather permits. As the thaw progresses downward, the saturated zone above cannot drain and becomes a seasonally reduced zone due to a perched saturated condition. Soil mottling is found close to the surface and meets criteria for hydric status. As soon as the thaw is complete, the soil water freely drains through the coarse sand and gravel substrate, and the soil becomes well drained for the remainder of the frost-free season. This perched saturated zone would exist during April and May of normal years and could be gone by mid-May to late July in some years (Moore 1988). SCS soil scientist Mark Clark visited Lucile sampling site WH-62 with Jim Nyenhuis in late June 1988, and they dug an additional auger hole nearby to WH-62, as well as reviewed the description and site for WH-62. Mark Clark verified the taxonomic classification and concurred on the genesis of soil mottling due to a seasonally perched saturated zone. Lucile soils are considered "hydric" soils (SCS 1987), although it should be noted that SCS has set up a Lucile, well drained, phase for Lucile that has morphological characteristics of soil mottling but an observed water table below 60 inches (Moore 1988). The water table in late June 1988 for WH-57 was observed at 60 inches, and at 48 inches for WH-62. Apparently, the site specific Lucile would not qualify for a well drained phase based on observations to date. Similar soils include Longmare which is also a Sideric Cryaquod. It has 24 to 40 inches of nonashy loess over sandy or sandy-skeletal glaciofluvial deposits but has a cemented "ortstein" layer between 32 and 54 inches.

Map Unit, Soil Series, Sample No., & Soil Classification	Horizon and Depth Inches[1]	Texture[2]	Color Dry[3]	Color Moist[3]	Structure[4]	Consistency[5] Dry	Consistency[5] Moist	Consistency[5] Wet	Roots[6]	Coarse Fragments Percent[7]	Reaction[8]	Boundary[9]	Additional Features and Comments
Map Unit G													
Homestead, WH-39	Loamy-skeletal, mixed		Typic Cryorthod		2% slope, west aspect								
Oe	1-0	organic mat		10YR 2/2								AS	
E	0-3	SiL		10YR 4/2	W M GR		FR	NS/SP	Many CO, M, F, VF 0-4"		EO	AI	
Bs	3-8	SiL-L		7.5YR 3/4	W M SBK		FR	SS/P	Com CO, M, F, VF 4-8"		EO	CW	
2C	8-20+	GR-VGR SL-LS		10YR 5/6	SG		LO	NS/NP	Few F, VF	25 GR 10 CB	EO	—	
Composite Sample	0-8	SiL		10YR 4/2	—		FR	SS/SP			EO	CW	

Range of Characteristics: Homestead soils consist of deep well drained soils that are very shallow (less than 10 inches) to sand and gravel. They formed in a thin layer of loess over glacial fluvial sediments. The silty loess mantle ranges from 6 to 10 inches thick, with the solum developed in the loess mantle. The 10 to 40 inch control section occurs in the glacial sediments and is loamy-skeletal with the fine earth fraction most commonly silt loam. Coarse fragment content ranges from 35 to 60 percent and consists of gravels and cobbles. Below the control section, sandy-skeletal textures are dominant. The Homestead soil series is one of the soils that was mapped and described in the earliest soil surveys of the Matanuska-Suistna Valleys area (Physical Land Survey 1941, and SCS 1968). As such, Homestead was mapped on both outwash and moraine deposits. Later surveys (Suistna Valley and Yenta Areas) distinguished between soils on these two different deposits. SCS intends to drop the Homestead series and establish Kichnatna (sandy-skeletal) on outwash and Deception (loamy-skeletal) on moraine deposits (Clark 1988). Because SCS has not yet made this change, the Wishbone Hill soil survey will retain the Homestead series.

Map Unit, Soil Series, Sample No., & Soil Classification	Horizon and Depth Inches[1]	Texture[2]	Color Dry[3]	Color Moist[3]	Structure[4]	Consistency[5] Dry	Moist	Wet	Roots[6]	Coarse Fragments Percent[7]	Reaction[8]	Boundary[9]	Additional Features and Comments
Map Unit H													
Niklason Taxadjunct, WH-89 Sandy, mixed Typic Cryofluvent 1% slope, east aspect													
Oi	2-1	forrest litter (leaves and twigs)											
Oe	1-0	organic mat		10YR 2/2							EO	AW	
C1	0-6	GR Sand		10YR 3/2	SG		LO	NS/NP	Com M, F, VF	15 GR	EO	CW	
Oab	6-8.5	highly decomp. organic material		10YR 2/2	—		—	—	Many M, F, VF		EO	CW	
C2	8.5-22	GR LS		10YR 3/3	SG		LO	NS/NP	Com M, F, VF 8.5 - 18"	25 GR	EO	CW	
C3	22-31	GRV LS		10YR 4/3	SG		LO	NS/NP	Few F, VF below 18"	60 GR	EO	CW	
C4	31-38	SL		10YR 3/3	Massive		FR	NS/SP		—	EO	GW	
			Com. 7.5YR 4/6 med distinct mottles										
C5	38-47+ (stopped by large cobble)	GR LS		10YR 3/3	SG, Massive spots of silty material		LO	NS/NP		15 GR	EO	—	

Range of Characteristics: Niklason Taxadjunct soils are similar to Niklason except they have slightly different soil textures. This is the reason for Taxadjunct status. The particle size control section (from 10 to 40 inches in the soil profile) is sandy (with an average of 29 percent coarse fragments) for Niklason Taxadjunct and coarse loamy over sandy or sandy-skeletal for Niklason. Niklason Taxadjunct has gravelly sand or loamy sand in the upper part of the soil profile compared to silt loam, or fine or very fine sandy loam for Niklason. Coarse fragment content in the lower part of the profile is slightly higher for Niklason. Both have pockets and lenses of buried organic matter at varying depths. Both have stratified layers of varying textures throughout the profiles. Other similar soils include Jarvis, Klutima, Chena, and Susitna. Jarvis has significant amounts of mica. Klutima has free carbonates in the underlying material. Chena has less than 10 inches of silty or fine sandy material over gravelly material. Susitna is 27 to 40 inches to sand and gravel.

FOOTNOTES

1 Soil Profile Description abbreviations are listed and described in USDA-SCS, April 1974. West Technical Service Center. "Definitions and abbreviations for soil descriptions." The new designations for soil horizons and layers (Soil Survey Manual, Agriculture Handbook No. 18, revised Chapter 4, "Examination and Description of Soils in the Field, May 1981, pp. 39-51) are used in this report.

2 Texture and texture modifier abbreviations:

S	Sand	SCL	Sandy Clay Loam	CB	Cobbly	GR	Gravely
LS	Loamy Sand	CL	Clay Loam	CBV	Very Cobbly	GRV	Very Gravely
SL	Sandy Loam	SICL	Silty Clay Loam	CBX	Extremely Cobbly	GRX	Extremely Gravely
L	Loam	SIC	Silty Clay	CN	Channery	SH	Shaley
SIL	Silt Loam	C	Clay	CNV	Very Channery	SR	Stratified
SI	Silt			CNX	Extremely Channery		

3 Color, Dry and Moist: Munsell Soil Color Chart, 1975 Edition.

4 Structure:

Grade		Size		Type	
W	Weak	VF	Very Fine	PL	Platy
M	Moderate	F	Fine	GR	Granular
S	Strong	M	Medium	SBK	Subangular Blocky
		CO	Coarse	ABK	Angular Blocky
		VCO	Very Coarse	PR	Prismatic
				W Massive	Weak Massive
				Massive	
				S Massive	Strong Massive
				SG	Single Grained
				Cloddy	

5 Consistency:

Dry		Moist		Wet	
LO	Loose	LO	Loose	NS	Non Sticky
SO	Soft	VFR	Very Friable	SS	Slightly Sticky
SH	Slightly Hard	FR	Friable	S	Sticky
H	Hard	FI	Firm	VS	Very Sticky
VH	Very Hard	VFI	Very Firm	NP	Non Plastic
EH	Extremely Hard	EFI	Extremely Firm	SP	Slightly Plastic
				P	Plastic
				VP	Very Plastic

6 Roots:

Number	Type	
Very Few	VF	Very Fine
Few	F	Fine
Com (Common)	M	Medium
Many	CO	Coarse

Roots are described in terms of a specified size (type) and quantity (number). The size classes are:

Very Fine: Less than 1 mm in diameter
Fine: 1 to 2 mm in diameter
Medium: 2 to 5 mm in diameter
Coarse: 5 mm or larger in diameter
Roots larger than 10 mm in diameter may be described separately.

Quantity classes or roots are defined in terms of numbers of each size per unit area—1 square centimeter for very fine and fine roots, and 1 square decimeter for medium and coarse roots. All roots smaller than 10 mm in diameter are described in terms of the following quantity classes:

Few: Less than 1 per unit area of the specified size
Common: 1 to 5 per unit area of the specified size
Many: More than 5 per unit area of the specified size

Roots are described as to number first, and type second.

7 Coarse Fragments: All coarse fragment percentages (% by weight) are taken from Soil Laboratory Data. Numbers are rounded to the nearest whole number. Lithologic modifier types (gravely, channery, etc.) are taken from the "232" field soil profile description form for each sampled profile.

8 Reaction:

Effervescence

EO	Non-Effervescent
SE	Slightly Effervescent
EM	Moderately Effervescent
ES	Strongly Effervescent
EV	Violently Effervescent

Reaction		pH
Str. Acid	Strongly Acid	5.1 - 5.5
Mod. Acid	Moderately Acid	5.6 - 6.0
Sl. Acid	Slightly Acid	6.1 - 6.5
Neutral	Neutral	6.6 - 7.3
Mild. Alk.	Mildly Alkaline	7.4 - 7.8
Mod. Alk.	Moderately Alkaline	7.9 - 8.4
Strong Alk.	Strongly Alkaline	8.5 - 9.0
Very Strong Alk.	Very Strongly Alkaline	>9.0

9 Horizon Boundaries:

Distinctness
A Abrupt (<2 cm thick)
C Clear (2 to 5 cm thick)
G Gradual (5 to 15 cm thick)
D Diffuse (>15 cm thick)

Topography
S Smooth (the boundary is a plane with few or no irregularities)
W Wavy (the boundary has undulations in which depressions are wider than they are deep)
I Irregular (the boundary has pockets that are deeper than they are wide)
B Broken (at least one of the horizons or layers separated by the boundary is discontinuous and the boundary is interrupted).

APPENDIX B

SOIL LABORATORY DATA

CSU Soil Testing Lab
Room 6, Voc. Ed. Bldg.
Fort Collins, CO 80523
303-491-5061
Date: 8/22/88

Soil Analysis Report

Lab #	Sample ID #	Depth In.	-2M KCl ext.- NO3-N (mg/kg)	-2M KCl ext.- NH4-N (mg/kg)	CEC meq/100	NH4oAc Extractable Ca (meq/100g)	Mg (meq/100g)	Na (meq/100g)	K (meq/100g)	Mehlich P ppm	* Fe %	* Al %	** Fe %	** Al %
R 51	WH-4	3-0												
52		0-4	2	24	38.4	1.00	0.50	0.06	0.20	1	0.61	0.31	0.83	0.28
53		4-13	3	6	60.0	0.35	0.27	0.08	0.12	4	1.50	1.66	2.58	1.61
54		13-22	<1	3	20.6	0.37	0.21	0.08	0.10	7	0.22	0.62	1.12	0.61
55		22-60												
56	WH-8	3-0												
57		0-2.5	16	4	39.1	5.26	1.17	0.09	0.19	6	0.49	0.24	0.62	0.20
58		2.5-15	1	8	37.3	3.81	0.89	0.09	0.04	1	1.19	1.09	2.33	1.30
59		15-24	<1	5	26.3	1.65	0.47	0.10	0.03	1	0.59	0.64	1.80	0.91
60		24-60												
61	WH-26	0-28	<1	11	24.5	5.12	1.55	0.09	0.28	11				
62	WH-27	0-38	2	8	28.1	4.06	0.78	0.08	0.42	31				
63	WH-38	2.5-0												
64		0-5	1	11	31.6	4.18	1.06	0.08	0.39	2	0.90	0.36	1.04	0.31
65		5-19	2	6	35.6	2.16	0.39	0.07	0.30	1	1.53	1.08	2.21	1.24
66		19-24	1	5	21.0	1.69	0.36	0.06	0.45	6	0.50	0.64	1.16	0.71
67	WH-39	0-8	1	7	30.6	4.01	0.85	0.11	0.24	4				

* - Sodium Pyrophosphate
** - Citrate Dithionite

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Soil Analysis Report

Lab #	Sample ID #	Depth In.	-2M KCl ext.- NO3-N ---mg/kg---	NH4-N	CEC meq/100	-----NH4oAc Extractable---- Ca ----------meq/100g---------	Mg	Na	K	Mehlich P ppm	* Fe ----------%----------	* Al	** Fe	** Al
68	WH-62	2-0												
69		0-2	1	14	25.2	2.51	0.76	0.11	0.39	5	0.87	0.31	1.05	0.26
70		2-15	1	7	28.0	3.01	0.60	0.10	0.20	2	1.49	1.01	1.99	1.11
71		15-25	<1	2	11.7	0.57	0.11	0.05	0.18	14	0.13	0.31	0.63	0.45
72		25-37	<1	1	8.9	0.60	0.16	0.06	0.19	15	0.06	0.22	0.41	0.33
73		37-48												
74		48-62												
75		62-72												
76	WH-66	2-0												
77		0-3.5	1	6	25.6	3.05	1.16	0.13	0.35	32	0.52	0.23	0.62	0.17
78		3.5-14	1	8	41.2	3.15	0.64	0.11	0.09	1	1.31	1.12	2.94	1.74
79	WH-77	3-0												
80		0-7	1	10	29.5	1.68	0.38	0.10	0.15	11	0.76	0.53	1.26	0.57
81		7-14.5	1	4	26.7	0.97	0.16	0.11	0.07	6	0.89	0.96	1.54	1.07
82		14.5-38	<1	5	17.1	2.07	0.49	0.08	0.03	15	0.18	0.30	0.90	0.52
83	WH-83	2-0												
84		0-3	1	9	27.4	3.20	1.09	0.14	0.26	7	0.78	0.27	1.16	0.29
85		3-8	1	13	55.8	4.60	1.19	0.15	0.11	3	2.39	1.75	2.76	1.70
86		8-16.5	1	8	42.7	1.55	0.49	0.14	0.20	5	1.66	1.60	2.51	1.74
87		16.5-30	1	8	21.7	0.70	0.24	0.09	0.10	5	0.40	0.55	1.21	0.88

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Soil Analysis Report

Lab #	Sample ID #	Depth In.	-2M KCl ext.- NO3-N mg/kg	NH4-N mg/kg	CEC meq/100	NH4oAc Extractable Ca meq/100g	Mg meq/100g	Na meq/100g	K meq/100g	Mehlich P ppm	* Fe %	* Al %	** Fe %	** Al %
88	WH-89	1-0												
89		0-6												
90		6-8.5												
91		8 1/2-22												
92		22-31												
93		31-38												
94		38-47												
95	WH-100	3.5-0												
96		0-6	<1	13	37.0	8.57	1.94	0.19	0.14	3	0.56	0.35	0.60	0.34
97		6-22	1	8	30.9	4.39	0.87	0.16	0.09	1	0.68	0.66	0.95	0.56
98	WH-108	1-7												
99		7-21	<1	21	39.1	11.79	2.00	0.27	0.12	4				
100		21-42	<1	16	55.1	14.44	3.03	0.26	0.09	7				
101	WH-137	5-0	34	26	124.4	76.48	11.73	0.47	0.79	17				
102		0-3	16	29	61.9	35.37	5.30	0.34	0.24	13				
103		3-12	2	6	35.9	12.34	2.16	0.54	0.14	14				
104	WH-60	13.5-40	<1	8	14.9	0.86	0.25	1.29	0.09	23	0.05	0.25	0.79	0.41
105	WH-8	2-9	3	9	51.5	4.76	1.13	0.22	0.09	1	1.68	0.95	2.49	1.00

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Room 6, Voc. Ed. Bldg.
Fort Collins, CO 80523
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Date: 8/22/88

Soil Analysis Report

Lab #	Sample ID #	Depth In.	1:1 (H2O) pH	% Wt. Loss ignition	Total N %	---paste--- pH	E.C. mmhos/cm	Sat. %	VFS	TS	--2 hr.-- Silt	Clay	--8 hr.-- Silt	Clay	Org. C %	8 hr. Texture
									%	%	%	%	%	%		
R 51	WH-4	3-0	4.1	57.30	1.285											
52		0-4	4.1		0.325	4.1	0.18	96.8	4	15	69	16	73	12	8.5	SiL
53		4-13	4.3		0.320	4.7	0.11	66.3	9	50	40	10	40	10	7.1	L
54		13-22	4.7		0.077	5.0	0.11	28.9	10	69	20	11	23	8	1.3	SL
55		22-60	5.0			5.2	0.09	22.6	10	65	23	12	27	8	0.7	SL
56	WH-8	3-0	4.5	81.37	1.692											
57		0-2.5	4.1		0.452	4.2	0.32	98.0	3	19	66	15	70	11	8.6	SiL
58		2.5-15	4.9		0.242	5.2	0.12	57.9	10	33	55	12	59	8	4.9	SiL
59		15-24	5.0		0.117	5.3	0.09	40.8	15	50	38	12	40	10	1.3	L
60		24-60	5.3		0.045	5.6	0.12	28.8	15	82	12	6	14	4	0.6	LS
61	WH-26	0-28	5.6		0.147	5.8	0.14	52.3	5	18	64	18	70	12	2.1	SiL
62	WH-27	0-38	5.3		0.186	5.6	0.15	57.4	10	17	68	15	73	10	2.6	SiL
63	WH-38	2.5-0	5.0	47.41	1.190											
64		0-5	4.9		0.266	5.2	0.14	82.8	5	12	74	14	78	10	4.5	SiL
65		5-19	5.0		0.202	5.3	0.09	60.9	9	16	70	14	74	10	4.1	SiL
66		19-24	5.2		0.115	5.4	0.08	35.7	10	42	46	12	48	10	1.3	L
67	WH-39	0-8	5.1		0.221	5.3	0.09	64.7	9	14	70	17	74	13	3.6	SiL

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Soil Analysis Report

Lab #	Sample ID #	Depth In.	1:1 (H2O) pH	% Wt. Loss ignition	Total N %	paste pH	paste E.C. mmhos/cm	Sat. %	VFS %	TS %	2 hr. Silt %	2 hr. Clay %	8 hr. Silt %	8 hr. Clay %	Org. C %	8 hr. Texture
68	WH-62	2-0	5.1	48.56	0.955											
69		0-2	4.7		0.210	4.8	0.15	80.7	5	9	74	17	79	12	4.8	SiL
70		2-15	5.2		0.219	5.3	0.09	61.8	13	27	56	17	61	12	4.5	SiL
71		15-25	5.1		0.046	5.5	0.06	29.0	2	87	4	9	5	8	0.6	LS
72		25-37	5.4		0.032	5.7	0.05	29.3	4	90	7	3	7	3	0.5	S
73		37-48	5.5			5.8	0.06	34.4	11	91	7	2	7	2	0.4	S
74		48-62	5.8			6.0	0.13	26.1	9	26	56	18	61	13	0.4	SiL
75		62-72	5.8			6.2	0.09	23.1	9	85	11	4	11	4	0.1	LS
76	WH-66	2-0	4.7	62.71	0.956											
77		0-3.5	4.3		0.220	4.9	0.20	92.5	10	22	62	16	68	10	6.2	SiL
78		3.5-14	5.2		0.193	5.6	0.09	81.3	7	39	51	10	53	8	5.4	SiL
79	WH-77	3-0	4.8	52.15	0.960											
80		0-7	4.9		0.339	5.2	0.12	88.4	9	16	67	17	72	12	5.1	SiL
81		7-14.5	4.8		0.179	5.4	0.07	50.6	10	23	59	18	64	13	2.8	SiL
82		14.5-38	5.3		0.050	5.8	0.11	28.9	10	57	25	18	29	14	0.7	SL
83	WH-83	2-0	5.3	55.72	1.420											
84		0-3	4.8		0.281	5.1	0.16	99.1	8	12	71	17	77	11	5.6	SiL
85		3-8	5.1		0.436	5.5	0.11	99.6	14	32	57	11	60	8	8.9	SiL
86		8-16.5	4.9		0.284	5.4	0.08	89.1	16	30	57	13	61	9	5.3	SiL
87		16.5-30	5.0		0.108	5.2	0.08	36.1	6	53	28	19	34	13	1.6	SL

CSU Soil Testing Lab
Room 6, Voc. Ed. Bldg.
Fort Collins, CO 80523
303-491-5061
Date: 8/22/88

Soil Analysis Report

Lab #	Sample ID #	Depth In.	1:1 (H2O) pH	% Wt. Loss ignition	Total N %	---paste--- pH	E.C. mmhos/cm	Sat. %	VFS	TS	--2 hr.-- Silt	Clay	--8 hr.-- Silt	Clay	Org. C %	8 hr. Texture
									----	----	----	%	----	----		
88	WH-89	1-0	6.6	65.30	1.128											
89		0-6	6.5		0.029	6.9	0.19	30.6	8	90	3	7	4	6	0.8	S
90		6-8.5	5.9	28.69	0.694	6.0	0.71	158.2								
91		8 1/2-22	5.7		0.045	6.0	0.11	34.3	13	79	13	9	15	7	0.8	LS
92		22-31	5.6		0.020	6.1	0.08	26.7	7	88	4	8	5	7	0.3	LS
93		31-38	5.6		0.081	5.9	0.11	42.2	20	58	27	15	30	12	2.4	SL
94		38-47	5.5		0.032	6.0	0.09	28.2	10	83	5	12	8	9	0.6	LS
95	WH-100	3.5-0	4.9	58.05	1.098											
96		0-6	5.0		0.588	5.3	0.23	118.8	5	14	71	15	75	11	8.9	SiL
97		6-22	5.2		0.342	5.4	0.15	80.5	12	18	63	19	68	14	6.0	SiL
98	WH-108	1-7	5.2	46.62	0.996	5.7	0.21	273.5								
99		7-21	4.9		0.325	5.1	0.11	78.1	10	30	52	18	58	12	4.3	SiL
100		21-42	4.7	35.90	0.780	4.9	0.29	129.4								
101	WH-137	5-0	5.9	55.64	1.540											
102		0-3	5.7		0.800	6.0	0.15	127.7	10	26	62	13	65	10	11.8	SiL
103		3-12	5.9		0.292	6.2	0.08	68.7	7	21	61	18	66	13	4.3	SiL
104	WH-60	13.5-40	5.2		0.034	5.6	0.07	32.4	10	63	22	15	25	12	0.7	SL
105	WH-8	2-9	4.9		0.299	5.3	0.13	78.1	7	21	63	16	67	12	6.3	SiL