



**PEBBLE PROJECT
ENVIRONMENTAL BASELINE DOCUMENT
2004 through 2008**

**CHAPTER 5.
SOILS
Bristol Bay Drainages**

PREPARED BY:
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ACRONYMS AND ABBREVIATIONS

cm	centimeter(s)
ESS	Exploratory Soil Survey of Alaska
g/cm ³	grams per cubic centimeter
mm	millimeter(s)
NRCS	Natural Resources Conservation Service
USDA	United States Department of Agriculture

5. SOILS

5.1. Soils—Bristol Bay Region

5.1.1. Introduction

The overall Pebble Project study area is divided into the Bristol Bay region, which comprises 84 percent of the project study area, and the Cook Inlet region. A literature review and previous studies for the Bristol Bay region are discussed in this document. Review of existing data for the Cook Inlet region drainage is discussed in Chapter 29.

The *Exploratory Soil Survey of Alaska* (ESS) was completed by the U.S. Department of Agriculture (USDA) Soil Conservation Service (now the USDA Natural Resources Conservation Service [NRCS]) about 40 years ago (Rieger et al., 1979). The ESS covers the entire Pebble Project area and is the only direct coverage available. Soil investigations had also been completed for the village of Nondalton (Hinton and Neubauer, 1965) (Appendix 5B) and for Chisik Island (Clark and Ping, 1995). Both of these areas are near or within the Pebble Project study area.

5.1.2. Study Objectives

The goal of the soil studies for the Bristol Bay region of the Pebble Project was to gain an understanding of the general types of soils that occur in the region. The objective of the soils program was to review historical soils data from the region to determine the typical and common soil types occurring in the study area.

5.1.3. Study Areas

The soil study areas within the Bristol Bay region total approximately 773,000 acres in size. The study areas are north of Iliamna Lake and include part of the north shore of the lake. They extend from a large outwash plain in the west to steep mountains in the east. The study areas encompass parts of the North and South Forks of the Koktuli River, the Upper and Lower Talarik Creeks, and Nondalton River drainages. Figure 5-1 shows the extent of both the mine study area and transportation corridor within the region.

The study areas were glaciated during the Pleistocene and are in relatively close proximity to several active volcanoes in the Alaska Range. The fine textured soil layers that cover some of the landscapes is thought to be an admixture of glacial loess and volcanic ash. The nearest source of ash, Augustine Volcano, is an active stratovolcano on Augustine Island about 70 miles southeast of the study areas.

5.1.4. Previous Studies

The entire Pebble Project study area is included in the ESS. The ESS is a product of the National Cooperative Soil Survey, an interagency program responsible for classifying and mapping the soils of the

entire United States. The ESS is useful as a general soils map but is not intended to be used for site-specific interpretations. The mapping scale used was necessarily very small (1:1,000,000, i.e., 1 inch is the equivalent of 15.8 miles). The small scale precludes the definition of soil details at the square-mile scale or smaller, but the mapping provides an introduction to the types of soils and their variability across the project study area. Figure 5-1 and Table 5-1 show the five ESS map unit delineations that occur within the Bristol Bay region study areas.

Soil map units can comprise areas of soils, soils and intermingled miscellaneous areas (non-soil, e.g., rock outcrop or ice), or miscellaneous areas alone. Small scale mapping commonly defines map units as associations that combine multiple associated soil types together. These associations may consist entirely of soil types or may be a grouping of soil types and associated miscellaneous areas. Miscellaneous areas may also stand alone as a map unit if the mapped area is almost entirely non-soil. Four of the five map units identified for the study area are soil associations; the remaining map unit is a miscellaneous area (Table 5-1).

The soil types within each of the soil association map units are classified to the subgroup level, which is an intermediate level of detail in *Soil Taxonomy*, the United States soil taxonomic system (USDA NRCS, 1999).

The field work for the ESS was completed between 1967 and 1973. At that time, *Soil Taxonomy* included 10 soil orders, which is the highest categorical level. Two additional soil orders, Andisols and Gelisols, were added later. This addition to *Soil Taxonomy* affects the classification of some soil types described in the ESS that occur in the Pebble Project study areas.

Andisols are defined by the presence of andic soil properties within the upper 24 inches of soil. Andic soil properties result from volcanic ash or the products of weathered volcanic ash. The criteria for andic soil properties are presented in Appendix 5A. It is likely that the Andisols of this region may classify as more than one of 18 subgroups defined in *Keys to Soil Taxonomy*, 10th edition (Soil Survey Staff, 2006). However, accurate classification to and within the Andisol order requires laboratory analyses.

Gelisols are soils that have permafrost within 40 inches of the soil surface and/or have gelic materials within 80 inches of the soil surface. The ESS mapped and described pergelic cryofibrists in the study areas as relatively undecomposed organic materials that remained frozen throughout the year. These soils would currently classify as Gelisols in the typic fibristel subgroup.

A detailed soils investigation is available for an area surrounding the village of Nondalton, located several miles north of the transportation corridor (Hinton and Neubauer, 1965). This report is available in electronic format only (Appendix 5B). Throughout Alaska, relatively small areas such as Nondalton were mapped in detail to provide baseline reference data for the broader ESS of Alaska.

A detailed soils investigation is also available for Chisik Island, an area about 30 miles northeast of the Bristol Bay region study areas (Clark and Ping, 1995).

5.1.5. Scope of Work

The scope of work for the Bristol Bay soil studies included the following:

- A literature review, including scientific journals, soil survey reports, and online sources, for data related to the study area and region.
- A review and summary of the ESS map unit descriptions in the project area.

Three Parameters Plus, Inc. conducted this work.

5.1.6. Methods

A review of library reference and/or search systems was conducted using key words, including volcanic ash, tephra, Andisols, Alaska, and other terms. The literature search generated lists of documents with data pertinent to the study area and references were added to an in-house library.

5.2. Soil Map Units in the Mine Study Area

The ESS recognized four soil map units in the mine study area (approximately 265,000 acres). The map units are delineated on Figure 5-1 and are described below in decreasing order by the percentage of the mine study area that they comprise (Figure 5-2):

- **IA9: Typic cryandepts, very gravelly, hilly to steep association** (approximately 155,000 acres, 58 percent). In the mine study area, this map unit includes the upper reaches of the north and south forks of the Koktuli River, as well as the upper reaches of Upper Talarik Creek. These soils formed in volcanic material, are well drained, are strongly acidic, and have a thin surface mat of partly decomposed plant litter mixed with volcanic ash. The vegetation is either alder and grasses or low shrubs and associated plants.
- **IA7: Typic cryandepts, very gravelly, nearly level to rolling and pergelic cryofibrists, nearly level association** (approximately 105,000 acres, 40 percent). This map unit includes the headwaters of Upper Talarik Creek, the lower part of the South Fork Koktuli River, and portions of the north shore of Iliamna Lake. These soils are composed of well-drained acidic soils developed in shallow volcanic ash over very gravelly glacial material. They occur on ground moraines, terminal moraines, outwash plains, and old beach ridges. The vegetation is dominantly low tundra species, but white spruce and paper birch also occur in the Iliamna Lake area.
- **RM1: Rough mountainous land** (approximately 3,500 acres, 1 percent). This map unit includes sparsely vegetated, steep rocky slopes on Groundhog Mountain. The sparsely vegetated soils are thin, overlying bedrock or stones/boulders.
- **HY4: Pergelic cryofibrists, nearly level association** (approximately 1,300 acres, less than 1 percent). This map unit includes a small portion of the north shore of Lake Iliamna, southwest of Newhalen. These soils are very poorly drained, perennially frozen peat soils located on broad, nearly level muskegs. In summer, water is perched above the permafrost table, and the thawed material is wet, soft, and spongy. Plants that grow on these soils are sedges, mosses, and low shrubs. The peat consists of dark brown, coarse sedge and moss fibers that are perennially frozen below a depth of 10 to 30 inches.

5.3. Soil Map Units in the Transportation Corridor

The ESS recognized five soil map units in the transportation corridor study area within the Bristol Bay region (approximately 507,000 acres). The map units are delineated on Figure 5-1 and are described below in decreasing order by the percentage of the transportation corridor study area that they comprise (Figure 5-3):

- **RM1: Rough mountainous land** (approximately 248,000 acres, 49 percent). This unit consists of steep rocky slopes, primarily east of Lake Clark, sloping towards the divide with Groundhog Mountain. This unit dominates the eastern portion of the transportation corridor study area. The sparsely vegetated soils are thin, overlying bedrock or stones/boulders.
- **IA7: Typic cryandepts, very gravelly, nearly level to rolling and pergelic cryofibrists, nearly level association** (approximately 155,000 acres, 31 percent). This unit encompasses all of the Newhalen River drainage and portions of the north shore of Lake Iliamna, primarily to the east of Iliamna and Newhalen. These soils are composed of well-drained acidic soils developed in shallow volcanic ash over very gravelly glacial material. They occur on ground moraines, terminal moraines, outwash plains, and old beach ridges. The vegetation is dominantly low tundra species, but white spruce and paper birch also occur in the Iliamna Lake area.
- **SO11: Humic cryorthods, very gravelly, hilly to steep and pergelic cryofibrists, nearly level association** (approximately 72,000 acres, 14 percent). This association includes land west of Lake Clark as well as at the northeast end of Iliamna Lake. Humic cryorthods are well-drained soils on footslopes and moraines under forests dominated by white spruce and paper birch on steeper slopes and by black spruce on more gentle slopes. These soils developed in volcanic ash over gravelly glacial till. In areas that are nearly level, such as muskegs in valleys and depressions in moraines, pergelic cryofibrist soils develop. These soils are very poorly drained, perennially frozen peat. In summer, water is perched above the permafrost table, and the thawed material is wet, soft, and spongy. Plants that grow on these soils are sedges, mosses, and low shrubs. The peat consists of dark brown, coarse sedge and moss fibers that are perennially frozen below a depth of 10 to 30 inches.
- **IA9: Typic cryandepts, very gravelly, hilly to steep association** (approximately 18,000 acres, 4 percent). This soil association includes land in the Newhalen River drainage. These soils form in volcanic material, are well drained, are strongly acidic, and have a thin surface mat of partly decomposed plant litter mixed with volcanic ash. The vegetation is either alder and grasses or low shrubs and associated plants.
- **HY4: Pregelic cryofibrists, nearly level association** (approximately 14,000 acres, 3 percent). This association was mapped in a block along the north shore of Iliamna Lake, southwest of Newhalen. These soils are very poorly drained, perennially frozen peat soils located on broad, nearly level muskegs. In summer, water is perched above the permafrost table, and the thawed material is wet, soft, and spongy. Plants that grow on these soils are sedges, mosses, and low shrubs. The peat consists of dark brown, coarse sedge and moss fibers that are perennially frozen below a depth of 10 to 30 inches.

5.4. Results and Discussion

The 1979 ESS survey summarized three major soil types that occur in one or more of the five soil map units delineated over the Bristol Bay region study areas. These summaries are based on descriptions of representative pedons. The source pedons for the summaries were not necessarily located within the Pebble Project study area. The three soil types are described as follows:

- **Pergelic cryofibrists** are fibrous organic soils that have mean annual soil temperatures below freezing. The permafrost table is commonly less than 30 inches (75 centimeters [cm]) deep in these soils. The soils are composed dominantly of laminated sedge peat, but in many places the upper part of the soil consists of sphagnum moss peat. The thickness of the peat ranges from 16 inches (40 cm) to more than 10 feet (3 meters). The soils occupy shallow depressions in lowlands throughout interior, arctic, and western Alaska. The vegetation is dominantly sedge tussocks or, in the interior, black spruce forests.
- **Typic cryandepts** are soils in which less than half of the soil between depths of 10 and 40 inches (25 and 100 cm) exhibit thixotropic properties. They generally are dark reddish brown or dark brown. Some are made up mostly of ash grains of sand or cinder size. Others consist of fine thixotropic ashy material that is fairly thin over other material.
- **Humic cryorthods** have large accumulations of organic matter in at least the upper part of the spodic horizon. They are similar in appearance and thickness to the typic cryohumods, but have higher iron content. These soils dominate well drained forested uplands in Southeastern Alaska, areas along the north shore of the Gulf of Alaska, and areas with high precipitation rates west of the Alaska and Aleutian Ranges.

Soil Taxonomy is periodically updated and expanded; therefore, terminology used in 1979 may not still be in use in the current classification system. The soil descriptions and laboratory data presented in the ESS survey were used to determine how the 1979 soil classifications for the study areas would translate to the 2006 classification system (Soil Survey Staff, 2006). Table 5-2 matches the 1979 ESS taxonomic classification with a current equivalent.

5.5. Summary

A thorough literature review revealed three existing soil studies that covered or were near the Pebble Project mine study area and transportation corridor study area in the Bristol Bay Region. These studies, the ESS and the soil investigations of the Nondalton Area and Chisik Island represent the only previously published soils information for the study areas.

The three existing publications indicate that many of the soils in the study areas are influenced to some degree by volcanic ash within the parent materials. The ESS classifies the dominant soils of the area as typic cryandepts and describes their ash-influenced, or andic, properties. The Nondalton and Chisik Island soil investigations describe similar soils, although the soil classifications reflect the version of *Soil Taxonomy* current at the time of each publication.

5.6. References

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5.7. Glossary

- Andic soil properties—soil material of volcanic origin. These properties include organic carbon content, bulk density, phosphate retention, and iron and aluminum extractable with ammonium oxalate; containing a significant content of volcanic glass in the fine-earth fraction (less than 2 mm).
- Andisols—one of the 12 orders of soil taxonomy (the broadest level of soil classification). These include soils that are strongly influenced by volcanic ash. Andic soils have distinct properties including low organic carbon content, low bulk density, phosphate retention, ammonium oxalate extractable iron and aluminum, and significant content of volcanic glass in the fine-earth fraction (less than 2 mm).
- Ash [volcanic]—fine material (under 2.0 mm diameter; under 0.063 mm diameter for fine ash) blown from a volcanic vent, usually referring to the unconsolidated material but sometimes also used to refer to its consolidated counterpart, tuff.
- Gelic materials—mineral or organic soil materials that have evidence of cryoturbation (frost churning) and/or ice segregation in the active layer (seasonal thaw layer) and/or the upper part of the permafrost.

Gelisols—one of the 12 orders of soil taxonomy (the broadest level of soil classification). The unique property of gelisols is the presence of permafrost and soil features and properties associated with freezing and thawing. These features include irregular or broken horizons and incorporation of organic materials in the lower horizons, especially along the top of the permafrost table. Freezing and thawing produce granular, platy, and vesicular structures in surface and subsurface horizons.

Horizons—a specific layer or stratum of soil or subsoil in a vertical cross section of land. Horizons are designated and subdivided on the basis of color, texture, structure, and the observation of soil-forming properties. Primary horizon designations are O, A, E, B, and C horizons:

- O horizon: layers dominated by organic material.
- A horizon: mineral soil layer at soil surface or below O horizon having an accumulation of organic matter.
- E horizon: mineral soil layer characterized by loss of clay, iron, and/or aluminum in some combination, leaving a combination of sand and silt particles.
- B horizon: mineral soil layer characterized by any of the following: pedogenic structure; accumulation of iron, aluminum, or humus; reddish colors due to pedogenic processes.
- C horizon: subsurface layers showing little effect by pedogenic processes.

Humic cryothods—(obsolete) subgroup level of soil taxonomy, and belonging to the Spodosols soil order. Humic cryothods are cold, well drained soils that have relatively high organic carbon content and may or may not have andic soil properties.

Inceptisols—one of the twelve orders of soil taxonomy (the broadest level of soil classification). These include soils that are moderately well developed and are transitioning toward other soil orders.

Loess—a widespread, homogeneous, commonly nonstratified, porous, friable, slightly coherent, fine-grained blanket deposit), consisting predominantly of silt with secondary grain sizes ranging from clay to fine sand.

Pedogenic—related to the formation and development of soil.

Pedon—a three-dimensional body of soil with lateral dimensions large enough to permit the study of horizon shapes and relations. Its area ranges from 1 to 10 square meters.

Pergelic cryofibrists—(obsolete) subgroup level of soil taxonomy, and belonging to the Histosols soil order. Pergelic cryofibrists are wet soils composed of minimally decomposed organic matter and that have a mean annual soil temperature of less than 0 degrees Celsius.

Pyroclastic—fragmented rock material formed by a volcanic explosion or ejection from a volcanic vent.

Spodic horizon—a B horizon consisting of an accumulation of black or reddish amorphous materials that have a high cation-exchange capacity.

Spodosols—one of the 12 orders of soil taxonomy (the broadest level of soil classification). These include highly leached soils in which a combination of environmental conditions (high precipitation, high soil acidity) lead to the removal of organic matter and aluminum from upper soil layers and deposition of these materials in lower soil layers.

Stratovolcano—a volcano that is constructed of alternating layers of lava and pyroclastic deposits, along with abundant dikes and sills. Viscous, acidic lava may flow from fissures radiating from a central vent, from which pyroclastics are ejected.

Tephra—materials of all types and sizes that are erupted from a crater or volcanic vent and deposited from the air.

Till—dominantly unsorted and unstratified drift, generally unconsolidated, deposited directly by and underneath a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, and boulders ranging widely in size and shape.

Thixotropic—subject to loss of structural support upon movement due to positive pore pressures.

Typic cryandepts—(obsolete) subgroup level of soil taxonomy, and belonging to the Inceptisols soil order. Typic cryandepts are cold, moderately well developed soils strongly influenced by volcanic ash.

Typic fibristels—subgroup level of soil taxonomy, belonging to the Gelisols soil order. Typic fibristels are very cold, wet soils comprised of slightly decomposed organic matter and have permafrost.

Sources for glossary: American Geological Institute, 2008; Soil Survey Staff, 1993; and USDA-NRCS, 1999.

TABLES

TABLE 5-1
Map Units for the Bristol Bay Study Areas as Defined in the 1979 Soil Survey

Map Unit Code	Map Unit Name	Total Acreage in Project Vicinity (% of total)
IA7	Typic cryandepts, very gravelly, nearly level to rolling - Pergelic cryofibrists, nearly level association	260,000 (34%)
RM1	Rough mountainous land	252,000 (33%)
SO11	Humic cryorthods, very gravelly, hilly to steep - Pergelic cryofibrists, nearly level association	72,000 (9%)
IA9	Typic cryandepts, very gravelly, hilly to steep association	173,000 (22%)
HY4	Pergelic cryofibrists, nearly level association	16,000 (2%)

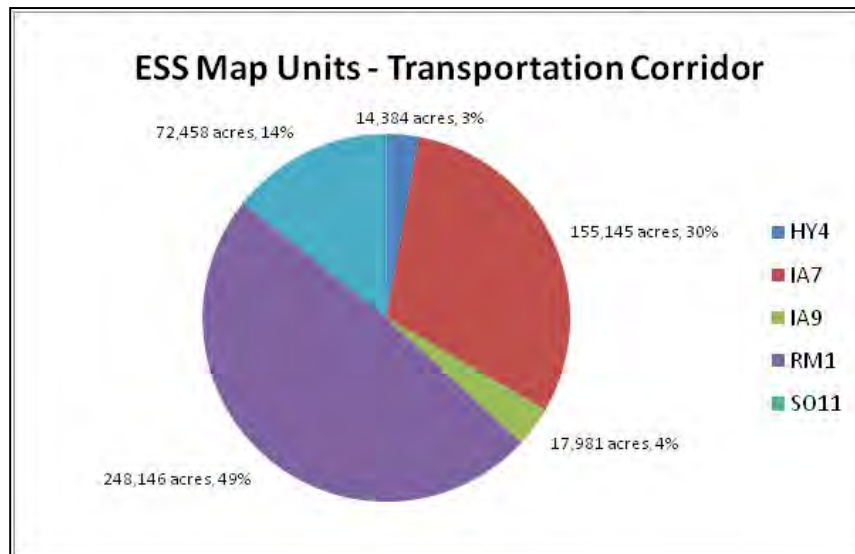
Source: Rieger et al., 1979.

TABLE 5-2
Corresponding 1979 and 2006 Classifications for Pedons as Described in the ESS

ESS Map Units	1979 Classification (ESS pedons)	2006 Classification (ESS pedons)
HY4, SO11, IA7	Pergelic cryofibrists	Typic fibristels
SO11	Humic cryorthods	Typic humicryods
IA7, IA9	Typic cryandepts	Typic haplocryands, Typic vitricryands

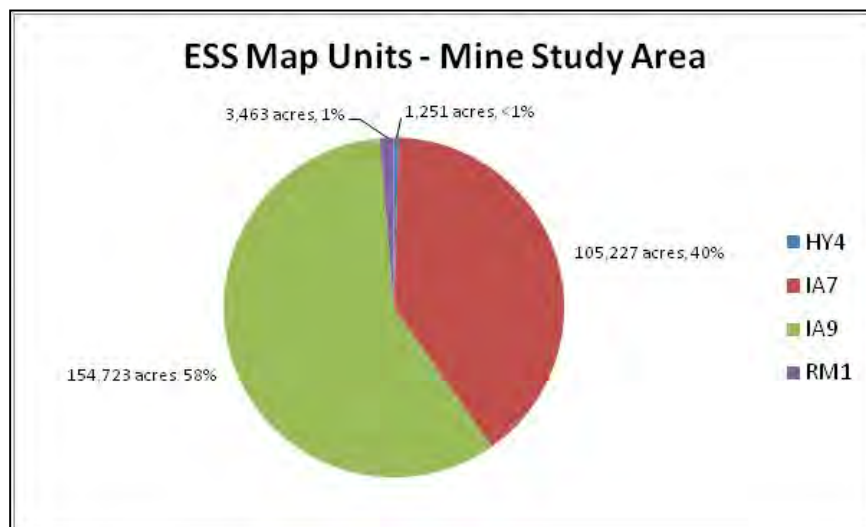
FIGURES

FIGURE 5-2



ESS Map Units, Mine Study Area

FIGURE 5-3



ESS Map Units, Transportation Corridor Survey

Map Unit Code	Map Unit Name
IA7	Typic cryandepts, very gravelly, nearly level to rolling - Pergelic cryofibrists, nearly level association
RM1	Rough mountainous land
SO11	Humic cryorthods, very gravelly, hilly to steep - Pergelic cryofibrists, nearly level association
IA9	Typic cryandepts, very gravelly, hilly to steep association
HY4	Pergelic cryofibrists, nearly level association

Source: Rieger et al., 1979.

APPENDICES

APPENDIX 5A

Required Characteristics for Andic Soil Properties

Soil materials with andic soil properties must have a fine earth fraction that meets the following requirements:

- Less than 25 percent organic carbon (by weight) and one or both of the following:
- All of the following:
 - Bulk density, measured at 33 kPa water retention, of 0.90 grams per cubic centimeter (g/cm^3) or less; and
 - Phosphate retention of 85 percent or more; and
 - Al + $\frac{1}{2}$ Fe content (by ammonium oxalate) equal to 2.0 percent or more; or
- All of the following:
 - Thirty percent or more of the fine-earth fraction is 0.02 to 2.0 millimeters (mm) in size; and
 - Phosphate retention of 25 percent or more; and
 - Al + $\frac{1}{2}$ Fe content (by ammonium oxalate) equal to 0.4 percent or more; and
 - Volcanic glass content of 5 percent or more; and
 - $[(\text{Al} + \frac{1}{2} \text{Fe content, percent}) \times (15.625)] + [\text{volcanic glass content, percent}] = 36.25$ or more.

APPENDIX 5B

Soils of the Nondalton Area, Alaska

SOILS OF THE NONDALTON AREA, ALASKA

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P R E F A C E

This soil survey is intended to serve several groups of readers. It will help those interested in farming and gardening to select suitable locations and to plan the kind of management that will protect their soils and provide good yields. It will assist community planners and engineers in selecting sites for buildings, roads, and other structures. It is also intended to provide detailed information about this part of Alaska to soil scientists and others interested in soils.

In making this survey soil scientists examined and described soils in every part of the Area and, on aerial photographs, prepared a map showing the distribution of the soils. Boundaries of soils are outlined and a distinctive symbol identifies each different kind of soil.

Persons interested in farming or gardening on a particular tract of land should first locate that tract on the soil map, and then identify the soils in it. They will find descriptions of these soils in the section headed "Soils", and a discussion of the suitability of the soils for crops and good management practices in the section, "Use and Management of the Soils".

Engineers and others concerned with construction will find general information on the physical characteristics of the soils in the section, "Engineering Applications". Classification of the soils is discussed briefly in a section intended primarily for soil scientists.

Field work for this survey was completed in 1965, and all statements in the report refer to conditions at that time. The soil survey is part of the technical assistance furnished by the Soil conservation Service to the Alaska Soil Conservation District. Additional help in planning can be obtained from the staff of the Soil Conservation Service in Palmer.

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SOILS OF THE NONDALTON AREA, ALASKA

This soil survey area includes about 13 square miles bordering Sixmile Lake and the southwest end of Lake Clark, in the vicinity of the village of Nondalton. Elevations range from about 250 feet at the lake level to more than 1100 feet on the slopes of Hoknede Mountain. Rhyolites and basalts are the principal rocks of the mountain (3). Lake Clark and Sixmile Lake occupy basins carved by glaciers. Gravelly till plains border the lakes, and glacial drift extends up the slopes of the adjacent high hills. Spots of gravelly glacial drift, rounded boulders, and the hummocky topography on Hoknede Mountain indicate that it also was covered by ice in the past. Several creeks rising in the hills flow across the till plain and empty into Sixmile Lake. Bordering the creeks are narrow bands of gravelly alluvium, which widen along the lower course of the streams into fairly extensive deltas. Nondalton is located just south of a delta containing more than 300 acres which extend into Sixmile Lake.

A thin silty mantle of mixed volcanic ash and loess covers the area. It ranges in thickness from a few inches to more than 20 inches. At the soil surface or mixed with the surface plant litter, there is a thin layer of recent sandy volcanic ash.

A variety of vegetation patterns occur in the Area; they are partly the result of past burning. No part is heavily forested. Generally the well drained south-facing slopes and the narrow alluvial plains support a scant growth of trees including white spruce, paper birch, and cottonwood. The understory is dominated by willows, alder, and, in places, bluejoint grass. North-facing slopes and the lower slopes bordering Sixmile Lake support a sparse forest of spindly black spruce with a rank ground cover

of low-growing shrubs and forbs, which include dwarf birch, willows, sedges, mosses, and lichens. There are many small muskegs at lower elevations with the same plants but in which sedges and mosses are dominant.

At elevations ranging from about 700 to 800 feet the forest grades to grasses and shrubs. Bluejoint grass is the dominant species. Thickets of alder and willows grow in drainageways and on benches. At elevations above 1000 to 1100 feet, the vegetation is characteristic of alpine tundra. It consists of low-growing shrubs and other plants seldom more than six inches in height.

INDUSTRY AND COMMERCE

Nondalton has a population of about 200. The principal means of support are fishing, hunting, trapping, and seasonal work in the Bristol bay fishing industry. There is a school, post office, trading post, and church. Charter air service provides connections with other areas. Local travel is by out-board motor boats on the lakes, and in winter by dog team or motorized over-snow vehicles. Supplies come in by air from Anchorage or by boat or dog team from Iliamna.

CLIMATE*

The climate is cool continental but, because of the maritime influence of Bristol bay to the south, it does not have the extreme temperatures of areas farther inland. Winters are long, cold, and relatively dry, and summers are short, warm, and fairly wet. Climatic data for Nondalton are insufficient to be representative, but data from Iliamna, 15 miles to the south, is available. Iliamna is near to open water, and the areas are

* This section is based on information from the U. S. Weather Bureau, Anchorage, Alaska.

separated by low hills, but it is likely that the conditions are similar. Table 1 gives mean monthly precipitation, temperature, and inches of snow-fall for Iliamna.

HOW SOILS ARE NAMED, MAPPED, AND CLASSIFIED

Soils are made up of a series of nearly horizontal layers, or horizons. A soil profile is the sequence of these horizons from the surface down to the underlying material which has not been altered by weathering or by plant roots. Soils that have profiles almost alike make up a soil series. All soils of one series have major horizons that are similar in important characteristics. These include (1) color; (2) texture, or relative proportions of gravel, sand, silt, and clay; (3) structure, or arrangement of soil particles into aggregates or clusters; (4) consistence, or degree of compaction and plasticity; (5) aeration and drainage conditions; (6) reaction, or degree of acidity or basicity; (7) thickness; and (8) arrangement in the profile. Each soil series is named for a town or other geographic feature near where it was first observed.

Soil series are further subdivided on the basis of external features that are important in the use and management of the soil. These subdivisions are called phases.

Areas that have little plant cover, or are extremely stony and rocky are called miscellaneous land types rather than soils.

Mapping units on the soil map of the Nondalton Area are slope phases of soil series, associations of soil series, and miscellaneous land types. Because it is not possible, even on a detailed map, to show very small areas of a soil, most mapping units contain patches of soil of some other kind that are too small to delineate separately.

Table 1. Mean monthly temperatures, precipitation, and inches of snowfall, Iliamna, Alaska
(19 year record through 1960)

	J	F	M	A	M	J	J	A	S	O	N	D	Ann
Temperatures, °F													
Mean Max.	21.0	24.8	27.5	38.7	49.5	59.2	62.1	60.6	53.4	41.3	29.3	20.4	40.7
Mean Min.	7.5	10.0	10.9	23.3	34.1	41.8	46.9	47.4	40.6	29.7	18.0	6.7	26.4
Mean	14.3	17.4	19.2	31.0	41.8	50.6	54.6	54.0	47.0	35.5	23.7	13.6	33.6
Precipitation, inches of moisture													
	1.46	1.23	1.17	.98	1.19	1.33	2.78	5.13	3.90	2.97	1.55	1.64	25.33
Snowfall, inches													
	11.2	11.5	11.1	5.6	.5	Tr	.0	.0	Tr	2.2	7.3	14.2	63.6

SOILS

Eight soil series^{1/} and one land type are recognized in the Nondalton Area. The location and distribution of the soils are shown on the soil map attached to this report. Their acreage and proportionate extent are given in Table 2.

Table 2. Acreage and proportionate extent of soils of Nondalton Area, Alaska

Map Symbol	Soil or Land Type	Approx. Area (acres)	Proportionate Extent (%)
66B)	Anchorage very fine sandy loam, 3 to 12% slopes	41	.5
66C)			
141A	Anchor Point silt loam, 0 to 3% slopes	156	1.8
141B	Anchor Point silt loam, 3 to 7% slopes	381	4.4
56-230A	Doroshin-Jacobsen Association	752	8.7
226A	Hk fine sandy loam, 0 to 3% slopes	91	1.0
226B	Hk fine sandy loam, 3 to 7% slopes	290	3.4
171A	Kuskokwim silt loam, 0 to 3% slopes	103	1.2
171B	Kuskokwim silt loam, 3 to 7% slopes	18	.2
230C	Nb gravelly silt loam, 7 to 12% slopes	82	.9
230E	Nb gravelly silt loam, 20 to 30% slopes	9	.1
227A	Nondalton silt loam, 0 to 3% slopes	121	1.4
227B	Nondalton silt loam, 3 to 7% slopes	783	9.1
227C	Nondalton silt loam, 7 to 12% slopes	1,871	21.6
227D	Nondalton silt loam, 12 to 20% slopes	1,024	11.7
227E	Nondalton silt loam, 20 to 30% slopes	352	4.1
227F	Nondalton silt loam, 30 to 45% slopes	310	3.6
227-			
230B	Nondalton-Jacobsen Association, 3 to 7% slopes	131	1.5
227-	Nondalton-Jacobsen Association,		
230C	7 to 12% slopes	206	2.4
229A	Pyramid silt loam, 0 to 3% slopes	20	.2
229E	Pyramid silt loam, 20 to 30% slopes	59	.7
229F	Pyramid silt loam, 30 to 45% slopes	892	10.3
9	Rough mountainous land	965	11.1
Total		8,663	100.0%

^{1/} The soil series described in this report are tentatively named and are subject to review and possible correlation with other series. Two of the series were observed in relatively small areas, and cannot yet be adequately defined. These series are identified only by a two-letter symbol in this report.

Anchorage Series

The Anchorage series consists of excessively drained soils developed on established sand dunes. They occur in a small area along the northern end of Sixmile Lake. A typical profile has a very thin bleached surface layer over dark reddish brown and brown horizons, which grade to olive brown substrata at depths of about 10 inches. They are very strongly to extremely acid throughout. Slopes are short and choppy, with gradients ranging from 3 to 12 percent.

The vegetation is a sparse forest of black spruce with a thick ground cover of Labrador tea, dwarf birch, blueberry, and associated low-growing shrubs. A few large white spruce and paper birch trees with an understory of willows grow near the lake shore.

Representative profile of Anchorage fine sandy loam, 1/2 mile south of Lake Clark and 150 feet west of channel connecting it with Sixmile Lake.

O1	4-0"	Dark reddish brown (5YR 3/2) partially decomposed organic materials with silty mixture; abrupt smooth boundary.
A2	0-1"	Gray (10YR 5/1) silt loam; weak fine granular structure; very friable; many roots; common charcoal and sand-size grains of volcanic ash in upper part; clear smooth boundary.
B21	1-4"	Dark reddish brown (5YR 2/3, 2/2) very fine sandy loam; weak thin platy structure; very friable; roots common; few charcoal fragments in upper part and a few white grains of volcanic ash; gradual boundary.
B22	4-6½"	Mixed dark reddish brown (5YR 3/3), reddish brown (5YR 4/3), and brown (7.5YR 4/4) sandy loam; weak thin platy structure; very friable; roots common; gradual boundary.
B23	6½ -9"	Brown (7.5YR 4/4) sandy loam with spots of reddish brown (5YR 4/4); massive; very friable; few roots; gradual boundary.
B3	9-16"	Yellowish brown (10YR 5/1) fine sand with common medium distinct mottles of dark reddish brown (5YR 3/2) and common medium faint mottles of strong brown (7.5YR 5/6); massive; friable; few roots; gradual boundary.

C1 16-40" Light olive brown (2.5Y 5/4) fine sand with common medium distinct mottles of strong brown (7.5YR 5/6); massive; loose; few roots in upper part.

The texture is commonly medium to coarse sand near the lake shores.

Silty strata may occur in the profile. With distance shores

the Anchorage soils become shallow and the sand becomes finer. They have a gradual boundary with the Nondalton soils. There are inclusions of steeper slopes, wet spots between dunes, and small areas of Nondalton soils.

Two slope phases of Anchorage fine sandy loam were mapped:

Anchorage fine sandy loam, 3 to 7% slopes

Anchorage fine sandy loam, 7 to 12% slopes

Both are assigned to capability subclass IVE.

Anchor Point Series

The Anchor Point series consists of moderately well to somewhat poorly drained soils developed in stratified silty and sandy alluvial sediments that are moderately deep over gravel. A typical profile has a thin mat of decomposing plant litter over mottled grayish brown and brown silt loam. A gravelly substratum occurs at depths of about 20 inches.

Anchor Point soils occur in narrow bands bordering the creeks in their course across the till plain. Narrow overflow channels dissect some areas, and flooding may occur during spring thaw or after prolonged heavy rains. Slopes range from nearly level to gently sloping with slope gradients commonly between 1/2 and 4 percent.

The Anchor Point soils support a forest containing some of the largest trees in the Area. The principal trees are white spruce, paper birch, and cottonwood. There is an understory of varying density consisting of

willows, alder, and other shrubs. Small openings covered with bluejoint grass are common.

Representative profile of Anchor Point silt loam, 1/4 mile northeast of Nondalton airstrip and about 20 yards west of small creek.

- | | | |
|------|--------|---|
| 01 | 3-0" | Dark reddish brown (5YR 3/2) partially decomposed organic matter; many white mycelia; abrupt smooth boundary. |
| A1 | 0-4" | Patches and streaks of very dark grayish brown (10YR 3/2), brown (10YR 4/3 and 7.5YR 4/4), and dark brown (10YR 3/3) silt loam; weak fine granular structure; very friable; roots common; thin layer of volcanic ash in upper part; very strongly acid; clear smooth boundary. |
| C1 | 4-18" | Patches and streaks of dark brown (7.5YR 3/2), dark brown (10YR 3/3), dark grayish brown (10YR 4/2) silt loam with common medium distinct mottles of light olive brown (10YR 5/4) and olive gray (5Y 5/2); weak thin platy structure; very friable; roots common; very strongly acid; gradual boundary. |
| IIC2 | 18-32" | Mixed brown (10YR 4/3) and olive brown (2.5Y 4/4) gravelly sand stratified with lenses of silty materials; single-grain except the silty material, which has weak thin platy structure; loose; very strongly acid. |

The surface organic mat ranges from 2 to 6 inches in thickness. Depth to the gravelly substratum ranges from 12 to 28 inches, but is commonly about 20 inches. The surface may be sandy in frequently flooded areas.

There are many inclusions of wet spots and shallow gravelly spots less than one acre in size. Most areas are dominantly moderately well drained with spots of somewhat poorly drained soils. In places the Anchor Point soils have a gradual boundary with the Kuskokwim and Hk soils.

Two slope phases of Anchor Point silt loam were mapped;

Anchor Point silt loam, 0 to 3% slopes

Anchor Point silt loam, 3 to 7% slopes

Both are assigned to capability subclass IVw.

Doroshin Series

The Doroshin series consists of very poorly drained sedge and moss peat moderately deep over mineral substrata. The surface is covered with live sphagnum moss, sedges, and other low-growing forbs and shrubs. Below this is soft fibrous sedge peat with layers of moss peat. A compact sandy loam or loam substratum occurs at depths of about 24 inches. The water table is always above the mineral substratum and commonly near the surface of the peaty material.

The Doroshin soils occur in areas varying in size from less than 1/2 acre to more than 50 acres. They mostly occupy low positions in the landscape. Slopes are mostly nearly level, but in places in the hills Doroshin peat occurs on gentle slopes.

Typical vegetation on the Doroshin soils is a dense growth of sedges, dwarf birch, sphagnum moss, and associated low-growing shrubs. A few spindly black spruce grow in places, and alder patches also occur.

The Doroshin soils are not mapped as individual units but in association with other soils. This is because of its common occurrence in such small units that it was not feasible to delineate them separately. The Doroshin-Jacobsen Association is described on page 10. and the Nondalton-Jacobsen Association is described on page 18.

Representative profile of Doroshin peat, 0.7 mile NNE of north end of airstrip.

- | | | |
|----|---------|--|
| 01 | 0-24" | Dark reddish brown (5YR 3/2, wet) to dark reddish gray (5YR 4/2, squeezed dry), mostly soft fibrous sedge and moss peat; abrupt smooth boundary. |
| C1 | 24-42"+ | Very dark grayish brown (2.5Y 3/2) gravelly sandy loam; massive; firm; nonsticky, nonplastic. |

The depth to the mineral substratum ranges from 18 to 26 inches.

The texture of the substratum ranges from silt loam to sandy loam. Gravel and, in places, cobblestones may comprise about 15 percent of the soil mass. Buried woody materials may occur in the peat. Some profile consist almost entirely of sedge peat. Thin lenses of sandy volcanic ash may occur in the upper layers of the peat.

Doroshin-Jacobsen Association

This Association is made up of different kinds of soils which could not be shown as individual units on the map because of their close association in small areas. The Doroshin soils are described in detail on page 9., and the Jacobsen soils on page 12.

The Association is most extensive in the northeastern portion of the till plain, north of the old village site of Nondalton. This area is characterized by old lake beds and channels of former fairly large streams. The typical pattern consists of slight depressions from less than an acre to more than 40 or 50 acres in size separated by low ridges or, in places, low knolls. The Doroshin soils occupy lower portions of the depressions, and the Jacobsen soils the outer borders and low ridges between the depressions. In a few places the highest parts of the knolls or ridges may be occupied by Hk soils.

Typically the Association consists of about 35 to 45 percent Doroshin soils and about 30 to 45 percent Jacobsen soils; the remainder is made up of deep peaty spots, Hk soils, and intergrades between the several components of the Association.

The Doroshin-Jacobsen Association is assigned to capability subclass VIIw.

Hk Series

The Hk series consists of moderately well drained soils developed in shallow stratified silty and sandy alluvium over a gravelly substratum. A typical profile consists of a fairly thick mossy mat, a thin bleached surface layer over reddish horizons and, at depths of about 12 inches, very gravelly sand. These soils are extremely acid in the upper layers, and very strongly acid in the substrata.

The Hk soils occur on nearly level to gentle slopes bordering streams, on deltas, and on slightly raised positions bordering muskegs. Slope gradients are generally from 3 to 7 percent, but there are nearly level areas, mostly footslopes, with gradients of less than one percent. Generally these level areas are slower to dry. The water table is higher during rainy periods as a result of runoff and seepage from higher areas.

The Hk soils support a sparse forest of spindly black spruce with a dense ground cover of dwarf birch, willows, low-growing shrubs, and mosses and lichens.

Representative profile of Hk fine sandy loam, about 1/2 mile northeast of Nondalton.

011	5-2"	Dark brown (7.5YR 3/2) mat of undecomposed moss; many roots; abrupt smooth boundary.
012	2-0"	Yellowish red (5YR 4/6) moss peat, with woody particles in lower part; many roots; abrupt smooth boundary.
A2	0-1"	Dark grayish brown (10YR 4/2) silt loam; massive; very friable; roots common; many fine dark concretions; abrupt wavy boundary.
B21	1-3"	Very dusky red (2.5YR 2/2) very fine sandy loam; moderate very fine granular structure; friable; few roots; clear wavy boundary.
B22	3-6"	Dark reddish brown (5YR 3/3) fine sand; single grain; loose; few roots; clear wavy boundary.

- B3 6-12" Dark brown (7.5YR 3/2) stratified fine sand and very fine sandy loam; single grain to very thin platy; loose to very friable; no roots; clear wavy boundary.
- IIC1 12-24" Very dark grayish brown (10YR 3/2) very gravely coarse sand; single grain; loose.

The O horizon ranges from 4 to 8 inches in thickness. The solum may be silty throughout or stratified with silty and sandy materials. Depth to the gravelly substratum ranges from 10 to 18 inches. In shallow profiles the reddish brown horizon extends into the gravelly material.

Small inclusions of Kuskokwim and Anchor Point soils make up less than 15 percent of most mapping areas.

Two slope phases were mapped and assigned to capability subclasses as follows:

- Hk fine sandy loam, 0 to 3% slopes - Subclass IIIs
Hk fine sandy loam, 3 to 7% slopes - Subclass IIIE

Jacobsen Series

The Jacobsen series consists of poorly drained gravelly and cobbly soils with thick peaty surface mats. On the till plains these soils occur on the periphery of muskegs or occupy depressions that were formerly shallow lakes or, in places, stream courses. On the hillsides, Jacobsen soils occupy benches and slopes affected by seepage. Generally these soils occur in small areas ranging from less than one acre to 40 or 50 acres in size.

A typical profile has 10 to 12 inches of moss and decaying organic materials over gravelly and cobbly medium textured materials that are brown near the surface and at greater depths are strongly mottled and streaked with gray, olive, and brown. The water table is at depths of 10 to 24 inches. Slopes dominantly have gradients of less than 3 percent, but they range up to 7 percent.

The vegetation is mostly a thin forest of black spruce with scattered patches of willows and alder, and ground cover of dwarf birch, mosses, and other low-growing plants.

Representative profile of Jacobsen cobbly loam, 3/4 mile west of Nondalton school.

011	11-4"	Brown (7.5YR 5/4) undecomposed organic matter; abrupt smooth boundary.
012	4-0"	Dark reddish gray (5YR 4/2) partially decomposed organic matter; common charcoal fragments; discontinuous layer about one inch thick of dark grayish brown (10YR 4/2) volcanic ash at base of horizon; clear smooth boundary.
A1	0-4"	Very dark grayish brown (10YR 3/2) silt loam; weak fine granular structure; friable; many roots, few rounded pebbles and boulders; clear smooth boundary.
AC	4-6½"	Brown (10YR 4/3) cobbly sandy loam with few large faint mottles of dark brown (7.5YR 3/2); weak fine granular structure; friable; roots common; cobblestones and pebbles stained with dark brown; gradual boundary.
C1	6½-20"	Streaks and patches of greenish gray (5GY 5/1), yellowish brown (10YR 5/4), light olive brown (2.5Y 5/4) and brown (7.5YR 4/4) very cobbly loam with sandy lenses; massive; firm; few roots in upper part; cobblestones have dark stains; vesicles common.

Thickness of the 0 horizon ranges from 6 to 16 inches. The A horizon may not be present. Cobblestones and pebbles are generally rounded and vary considerably in relative proportion. Generally the areas on the hillsides contain more cobblestones than areas on the till plain.

Because of the small size of most areas the Jacobsen soils are not shown as separate units on the soil map, but are mapped in association with other soils. These units, the Doroshin-Jacobsen Association and the Nondalton-Jacobsen Association, are described under their respective headings.

Kuskokwim Series

The Kuskokwim series consists of poorly drained silty soils with thick peaty surface mats and shallow permafrost tables. These soils are not extensive in the Nondalton Area; they occur on the deltas bordering Sixmile Lake. A typical profile has a peaty mat about 12 inches in thickness over mottled brown and gray silt loam that grades to olive gray and is perennially frozen at depths of about 5 inches. Slopes are dominantly nearly level with gradients of less than 2 percent, but they range to as much as 7 percent.

These soils support a scant forest of spindly black spruce, with a thick ground cover of low-growing shrubs, sedges, and mosses.

Representative profile of Kuskokwim silt loam, about 1 mile NW of Nondalton School.

011	13-4"	Brown (7.5YR 4/4) mat of undecomposed sphagnum and hypnum moss; abrupt smooth boundary.
012	4-0"	Dark reddish brown partially decomposed sedge peat with many woody particles; abrupt smooth boundary.
C1	0-5"	Silt loam in streaks and patches of olive gray (5Y 5/2) and very dark grayish brown (10YR 3/2); common large distinct mottles of dark reddish brown (10YR 3/3); few roots; few charcoal fragments; extremely acid; gradual boundary.
C2f	5-10"	Olive gray (5Y 5/2) silt loam; extremely acid; less than 15 percent of soil mass by volume is fine gravel; frozen.

The O horizon ranges from 8 to 16 inches in thickness. In places a thin dark A1 horizon may be present. A few pea-size pebbles occur and in places make up almost 15 percent of the soil mass. A few gravelly spots are included, and there are inclusions of small areas of Doroshin, Hk, and Anchor Point soils. Inclusions make up less than 15 percent of most mapped units.

Two slope phases of Kuskokwim silt loam were mapped:

Kuskokwim silt loam, 0 to 3% slopes

Kuskokwim silt loam, 3 to 7% slopes

Both were assigned to capability subclass VIIw.

Nb Series

The Nb series consists of somewhat poorly drained soils formed in compact gravelly silty glacial drift mantled with a thin covering of silty loess. They occupy north and northeast slopes near Lake Clark. A typical profile has a fairly thick peaty surface mat over mottled and streaked gray, olive, and brown gravelly silt loam. With greater depth colors grade to gray with decreasing mottling, and the amount of gravel increases. Seepage affects most areas. Because of their northerly exposure, these soils receive little direct insolation and are cold and damp even in late summer. Ice pitting occurs in places; these pits are very thinly vegetated.

The vegetation consists of a few scattered black spruce and a thick low growth of tundra shrubs and forbs. Among the common shrubs are Labrador tea, dwarf birch, blueberry, and low-growing willows. There is typically a surface covering of lichens.

Representative profile of Nb gravelly silt loam about 100 yards west of Lake Clark near the north survey boundary.

01	6-0"	Very dark brown (10YR 2/2) mat of decomposing mosses and lichens; abrupt smooth boundary.
A1	0-1"	Dark brown (7.5YR 3/2) gravelly silt loam, weak very fine granular structure; friable; roots common; extremely acid; abrupt smooth boundary.
C1	1-5"	Gravelly coarse silt loam in streaks and patches of grayish brown (2.5Y 5/2), strong brown (10YR 5/6), olive brown (2.5Y 4/4), and pale olive (5Y 6/3); weak thin platy structure; friable; roots common; many fine vesicles; few pebbles; extremely acid; gradual boundary.

- | | | |
|----|--------|---|
| C2 | 5-10" | Light olive brown (2.5Y 5/4) gravelly silt loam with streaks of yellowish brown (10YR 5/4); massive; friable; many fine vesicles; no roots; extremely acid. |
| C3 | 10-30" | Gray (5Y 5/1) gravelly silt loam; massive; firm; extremely acid. |

The organic mat ranges in thickness from 6 to 12 inches. Gravel in the upper part of the soil ranges from few to about 15 percent, and is related to the thickness of the silty loess mantle over gravelly glacial drift. A thin dark surface horizon may or may not be present. Typically the substratum is gray, compact gravelly silt loam, but mottles and streaks of olive and brown may occur; the gravel content ranges from 15 to 35 percent by volume.

Two slope phases were mapped and assigned to capability subclasses as follows:

- Nb gravelly silt loam, 7 to 12% slopes - subclass IVw.
- NB gravelly silt loam, 20 to 30% slopes - subclass VIw.

Nondalton Series

The Nondalton series consists of well drained soils formed in a shallow silty mixture of volcanic ash and loess over a very gravelly substratum. A typical profile has 12 to 15 inches of silty material over the coarse underlying material. It has an organic surface mat about 4 inches in thickness and a thin gray surface layer over reddish colored horizons that grade to brown with depth. The soils are very strongly acid. These are the dominant soils of the till plain and the lower, forested slopes of the adjacent hills. They occur on nearly level to steep slopes, but they are mostly on gentle to strong slopes with gradients ranging from 3 to 20 percent. The Nondalton soils are extensive and make up more than 50 percent of the Area.

The vegetation varies with the slope, aspect, and elevation. In general the south-facing slopes with gradients of more than 20 percent support the best trees of the Area. The white spruce forest on these slopes is somewhat denser than is typical for the Area. Dominant trees are 40 to 50 feet in height. At elevations above 700 feet the forest grades into the grass-covered areas of the Pyramid soils. On gentler footslopes and north-facing slopes there is a sparse forest of black spruce containing only a few white spruce and paper birch. The ground cover here consists of low growing vegetation dominated by willows, dwarf birch, and a thick surface mat of lichens and mosses.

Representative profile of Nondalton silt loam, about one mile NW of Nondalton.

01	6-0"	Dark reddish brown (5YR 2/2) mat of decomposing organic materials; many roots; extremely acid; abrupt smooth boundary.
A2	0-2"	Mixed dark gray (10YR 4/1) and dark grayish brown (10YR 4/2) coarse silt loam; weak fine granular structure; very friable; many roots; extremely acid; abrupt wavy boundary.
B21	2-6"	Very dusky red (2.5YR 2/2) silt loam; moderate fine granular structure; slightly brittle, but very friable when crushed; roots common; very strongly acid; abrupt wavy boundary.
B22	6-10"	Dark reddish brown (5YR 3/3) silt loam; weak very fine granular structure; very friable; roots common; very strongly acid; clear wavy boundary.
B3	10-13"	Dark brown (7.5YR 4/4) silt loam; weak very fine granular structure; very friable; few roots; strongly acid; clear wavy boundary.
IIC1	13-18"+	Dark brown (10YR 4/3) gravelly sandy loam; common medium faint mottles of dark yellowish brown; structureless; very friable; few to no roots; medium acid.

Depth to the gravelly substratum ranges from 10 to 18 inches. Included in the mapping unit are a few areas of sandy substrata. They are mostly

adjacent to areas of Anchorage soils. In very shallow profiles the reddish brown horizon is developed partly in the gravelly substratum. Some areas on slopes of less than 7 percent include as much as 20 percent of poorly drained soils influenced by seepage from adjoining wet areas. Ice pitting occurs on the low hills in the eastern part of the survey area; some of these areas are underlain by firm gravelly glacial till. Areas with gradients exceeding 20 percent are mostly on Hoknede Mountain. There the substratum commonly contains angular cobblestones. In places on the low hills southwest of Lake Clark there are inclusions of shallow soils over basalt bedrock and a few rock outcrops. These areas are mostly on the crests of low hills bordering north slopes.

The Nondalton soils are also mapped in association with the Jacobsen soils. The Nondalton-Jacobsen Association is described below.

Six slope phases were mapped and assigned to capability subclasses as follows:

- Nondalton silt loam, 0 to 3% slopes - subclass IIIs
- Nondalton silt loam, 3 to 7% slopes - subclass IIIe
- Nondalton silt loam, 7 to 12% slopes - subclass IIIe
- Nondalton silt loam, 12 to 20% slopes - subclass IVe
- Nondalton silt loam, 20 to 30% slopes - subclass VIe
- Nondalton silt loam, 30 to 45% slopes - subclass VIIe

Nondalton-Jacobsen Association

This Association consists of two distinctly different soil series that occur in such close association in small areas that it was not feasible to delineate them separately on the soil map. The Nondalton soils are described in detail on page 16, and the Jacobsen soils on page 12.

The Nondalton-Jacobsen Association is not extensive. It occurs mostly north of Nondalton on gently to moderately sloping footslopes. These foot-slopes are characterized by many drainageways, seepage spots, and in places,

knolls of glacial till separated by shallow depressions. The Jacobsen soils occupy low irregular areas influenced by seepage. The Nondalton soils occupy the knolls and higher areas between drainageways and depressions. Some of the Jacobsen soils in the seepage areas exceed fifty acres, but in general both the Jacobsen and Nondalton soils are in tracts of less than one to a few acres in size. In the mapping unit of 3 to 7 percent slopes the Nondalton soils make up about 25 percent of the Association and the Jacobsen soils about 60 percent, and other soils, mostly intergrades, make up 15 percent. In the mapping unit of 7 to 12 percent slopes the Nondalton soils make up about 45 percent, the Jacobsen soils about 35 percent, and other soils that are too mucky, too silty, or too peaty to be Jacobsen soils about 20 percent.

In general these soils support the vegetation described as typical for the two series, but in the higher areas the Jacobsen soils commonly have a moderately thick growth of alders and willows.

Two slope phases of the Nondalton-Jacobsen Association were mapped:

Nondalton-Jacobsen Association, 3 to 7% slopes
Nondalton-Jacobsen Association, 7 to 12% slopes

Both are assigned to capability subclass VIIw.

Pyramid Series

The Pyramid series consists of dark colored, well drained silty soils which are shallow to bedrock. They occupy grass covered slopes above tree line, generally at elevations between 800 and 1100 feet. Above 1100 feet they grade to Rough mountainous land. A typical profile has a thin mat of plant litter over reddish silt loam horizons which, at depths of about 12 inches, grade to brown gravelly silt loam that becomes more gravelly with depth and overlies shattered basalt bedrock at depths of less than 20 inches.

The soils are strongly acid. A few rock outcrops and loose boulders occur in places. The Pyramid soils are dominantly on steep slopes with gradients exceeding 20 percent, but nearly level areas occur on benches. These soils occur only on Hoknede Mountain and make up about ten percent of the Area.

The vegetation is dominated by bluejoint grass, but bluegrass and fescue are also present. There are many alder and willow thickets in drainageways and on benches. The transition between these grasslands and the forest on the lower slopes is gradual. Young vigorous white spruce and paper birch at the forest edge indicate that the tree line may be advancing upward.

Representative profile of pyramid silt loam, about 2½ miles north of Nondalton on Hoknede Mountain.

01	3-0"	Dark brown (7.5YR 3/2) partially decomposed mat of plant materials; abrupt smooth boundary.
A1	0-4"	Very dusky red (2.5Y 2/2) silt loam; weak very fine granular structure; very friable; roots common; clear wavy boundary.
B21	4-6"	Dark reddish brown (5YR 2/2) silt loam; weak very fine granular structure; very friable, but smeary when rubbed; roots common; clear wavy boundary.
B22	6-10"	Dark reddish brown (5YR 3/3) silt loam; weak very fine granular structure; very friable; smeary when rubbed; roots common; clear wavy boundary.
B3	10-14"	Dark brown (7.5YR 3/2) gravelly silt loam; weak very fine granular structure; few roots; gradual boundary.
C1	14-19"	Dark brown (7.5YR 4/2) cobbly loam; massive; friable; few roots in the upper part; dark stains on stones; coarse material increases with depth.
R	19"+	Shattered basalt bedrock.

Depth to shattered bedrock ranges from 8 to 20 inches. A few soils as much as 30 inches deep to bedrock are included. Cobbly materials may occur throughout the profile. Other inclusions are small areas of Nb soils and wet spots. Because most areas are made up of steep slopes with narrow

benches and ravines, there are commonly inclusions of small areas with slope gradients ranging from 45 to 60 percent. On lower slopes these soils grade into the forested Nondalton soils. The upper boundary is commonly the base of an escarpment that separates the Pyramid soils from the very rocky and stony Rough mountainous land above. However, the upper boundary may be gradual with areas of Pyramid soils interspersed with rocky and stony spots.

Three slope phases were mapped:

- Pyramid silt loam, 0 to 3% slopes
- Pyramid silt loam, 20 to 30% slopes
- Pyramid silt loam, 30 to 45% slopes

All are assigned to capability subclass VIIe.

Rough Mountainous Land

Rough mountainous land consists of very shallow coarse textured soils that in many places are barren of vegetation except for lichens. As much as 75 percent of the surface may be gravel and stones. Frost features, including stone rings, frost boils, and stone stripes, occur in many areas. Slopes vary, but most of the area is steep with slope gradients exceeding 30 percent. Peaty spots, small areas of gravelly glacial drift, and areas with shallow gravelly silt loam soils occur. Many areas support a thick growth of alpine tundra. Common plants include Labrador tea, dwarf birch, crowberry, blueberry, Dryas, willows, and sedges.

Rough mountainous land is assigned to capability subclass VIIIE.

USE AND MANGEMENT OF THE SOILS

Many of the crops commonly grown in Alaska, including grasses and

hardy vegetables, can be produced in the Nondalton Area. Adapted vegetables include potatoes, carrots, turnips, cabbage, and lettuce. Strawberries and other berries do well. At present the only agricultural practice is vegetable gardens for home use. The Nondalton soils on gentle to moderate slopes are the best suited in the Area for cropping. Other soils would require artificial drainage, are subject to damage by flooding, or are not suited for cropping because of wetness, steepness, shallowness, or location at high elevations.

It is likely that water erosion will occur on sloping clean tilled areas unless practices such as contour cultivation, diversion ditches, and grassed waterways are maintained. The soils of the Area are acid. For most crops lime and fertilizer are required for good yields.

Capability Classification

The capability grouping is a system of classification designed to show the relative suitability of soils for crops, grazing, forestry, and wildlife. It is a practical grouping based on the needs and limitations of the soils, the risks of damage to them, and their response to management. In this report soils have been grouped on two levels, the capability class and the subclass.

The capability class is identified by a Roman numeral. All the soils in one class have limitations and management problems of about the same degree, but of different kinds. There are eight of these general classes in the system. In classes I, II, III, and IV are soils that are suitable for annual or periodic cultivation of annual or short lived crops. Class I soils are those that have the widest range of use and the least risk of damage. Classes II and III have increasingly narrow ranges of use.

In classes V, VI, and VII are soils that normally should not be cultivated for annual or short lived crops but that can be used for pasture, for woodland, or for plants that support or shelter wildlife. Soils in class VIII have no agricultural value, but may be useful for watershed protection or for wildlife.

The subclass designation is based on the dominant kind of limitation. The letter symbol "e" means that the main limiting factor is risk of erosion if the plant cover is not maintained. The symbol "w" means that excess water retards plant growth or interferes with cultivation. The symbol "s" means that the soils are shallow, droughty, or low in nutrients. The symbol "c" means that choice of crops is limited by climatic factors.

Primarily because of low summer temperatures and the resulting limited range of use of the soils, classes I and II are not recognized in the Nondalton Area.

In the section below, each subclass is described briefly, the soils in each are listed, and some suggestions on use, management, and conservation are made. Specific recommendations are not given for kinds and amounts of fertilizer, crop varieties, or seeding rates, because these recommendations change as new information is obtained and new crop varieties are developed. Soil samples from individual fields may be mailed to the Cooperative Extension Service, University of Alaska, College, Alaska, for laboratory tests and specific fertilizer recommendations.

Subclass IIIs - Shallow, well to moderately well drained soils on nearly level land.

Hk fine sandy loam, 0 to 3% slopes
Nondalton silt loam, 0 to 3% slopes

There is no serious erosion problem on these soils. Because of a seasonal high water table the Hk soils are cold in the spring. Some low-lying areas receiving seepage from adjacent wet areas need ditches to intercept the seep water. These medium textured soils with gravelly substrata dry out following thaw and in unusually dry years may be droughty. Any crop adapted to the Area can be grown if good management practices, including liming and fertilizing, are practiced.

Subclass IIIe - Shallow, medium textured, well to moderately well drained soils with gentle to moderate slopes.

Hk fine sandy loam, 3 to 7% slopes
Nondalton silt loam, 3 to 7% slopes
Nondalton silt loam, 7 to 12% slopes

The management and use of Hk soils on 3 to 7 percent slopes are similar to that on 0 to 3 percent slopes (Subclass IIIs) except that these soils have a water erosion hazard. The Nondalton soils are among the best soils of the Area for farming. Being naturally well drained, they warm up and dry sooner in spring than the moderately well drained soils. All of the soils may be droughty in dry years. There is a moderate erosion hazard on the 3 to 7 percent slopes and a severe hazard on the 7 to 12 percent slopes. On these slopes erosion control practices should include farming on the contour and grass crops in a regular rotation. If lime and fertilizer are applied as recommended by soil tests and other good management practices are used, these soils will produce good yields of climatically adapted crops.

Subclass IVe - Shallow, well drained, strongly sloping soils.

Nondalton silt loam, 12 to 20% slopes

These soils have very severe erosion hazard and should remain in permanent vegetation most of the time. Row crops can be grown as part of a regular rotation, but practices such as cultivation on the contour and closely spaced grass strips are required to prevent erosion.

Subclass IVs - Excessively drained sandy soils on dunes.

Anchorage very fine sand, 3 to 7% slopes
Anchorage very fine sand, 7 to 12% slopes

These soils could be used for forage crops, but short choppy slopes limit the use of equipment. There is a tendency towards droughtiness even in years with normal rainfall. They occur in areas with strong winds which cause a moderate blowing hazard.

Subclass IVw - Moderately well drained medium textured soils bordering streams.

Anchor Point silt loam.

These soils are flooded during spring thaw and periods of prolonged rain. Most areas also have seasonally high water tables. Generally they occur in fairly small elongated areas bordering streams, overflow channels, and abandoned channels. They are generally suited for vegetable gardens, despite the flooding hazard. In places channel straightening and widening would prevent overflow and would lower the water table. Low-lying frequently flooded areas should be left in permanent vegetation.

Subclass VIe - Shallow, well drained, moderately steep soils.

Nondalton silt loam, 20 to 30% slopes

Erosion would be severe if the native vegetation was removed and these soils were used for cultivated crops. If cleared, they should be used for permanent grass.

Subclass VIw - Moderately sloping to moderately steep, somewhat poorly drained soils on north slopes.

Nb gravelly silt loam, 12 to 20% slopes

Nb gravelly silt loam, 20 to 30% slopes

Because of their north exposure, these soils receive less heat than soils on other exposures. In addition they have fairly compact substrata which slows internal drainage. They are too cold for any crop, except grass. They are best left in native tundra.

Subclass VIIe - Shallow well drained silty soils on steep slopes or high elevations.

Nondalton silt loam, 30 to 45% slopes

Pyramid silt loam, 0 to 3% slopes

Pyramid silt loam, 20 to 30% slopes

Pyramid silt loam, 30 to 45% slopes

The Nondalton soils are too steep for cultivation, and should be left in forest. The Pyramid soils are all at high elevations, and generally remain snow-covered longer in the spring. The nearly level Pyramid soils are on high narrow ridges that will probably erode if the native vegetation is disturbed. These soils are not suited for cultivated crops because of the low early summer soil temperatures and steep slopes. The rank growth of bluejoint grass and other plants is well suited for summer range for cattle and sheep. They should remain as natural grasslands.

Subclass VIIw - Poorly drained soils with permanently high water tables.

Doroshin-Jacobsen Association

Kuskokwim silt loam, 0 to 3% slopes

Kuskokwim silt loam, 3 to 7% slopes

Nondalton-Jacobsen Association, 3 to 7% slopes

Nondalton-Jacobsen Association, 7 to 12% slopes

All of these soils have characteristics associated with wetness and low soil temperatures. Drainage is generally not feasible because of the

low position in the landscape, seep springs, or a high permafrost table. The native plant cover offers limited forage of low quality for cattle and sheep. It would be well suited for reindeer, however.

Subclass VIIIe - Cold, steep, rocky and stony areas at high elevations.

Rough mountainous land

The land type supports a growth of lichens and other plants characteristic of alpine tundra. It is suited only for reindeer or caribou range.

ENGINEERING APPLICATIONS

The information in this section, together with the soil map and the descriptions of soils given above, can be used in a general way to determine soil conditions of significance in engineering. It is important to recognize that this will not eliminate the need for detailed investigations at the site of any proposed construction.

Many engineers classify soil materials in accordance with the system approved by the American Association of State Highway Officials (1). In this system, soil materials are classified in seven principal groups. The groups range from A-1, consisting of gravelly soils of high bearing capacity, to A-7, consisting of clay soils having low strength when wet.

Other engineers prefer to use the Unified Soil Classification System (5). In this system, soil materials are identified as coarse grained (8 classes), fine grained (6 classes), or highly organic.

Both classification systems are explained in the PCA Soil Primer (2).
Estimated Physical Properties of the Soils

Table 3 gives estimates of some of the physical and chemical properties significant in engineering and the probable classification of each soil in the Area according to the AASHO and the Unified systems.

Table 3. Soils of the Nondalton Area, Alaska and their Estimated Physical and Chemical Properties.

Classification								
Soil Name	Depth from surface (Typical profile) (inches)	USDA 1/ Texture	Unified	AASHO	Permeability (in./hr.)	Available water capacity (in./in. of soil)	Reaction pH	
Anchorage very fine sandy loam	0-4	vfsl	ML	A-4	0.8-2.5	.18-.23	4.5-5.5	
	4-9	sl	SM	A-4	2.5-5	.10-.14	4.5-5.5	
	9-40+	fs	SP	A-3	5-10	.04	4.5-5.5	
Anchor Point silt loam	0-18	sil	ML	A-4	0.8-2.5	.18-.23	5.0-5.5	
	18-30+	gs	GW or GM	A-1	5	.02	5.0-5.5	
Doroshin peat	0-24	pt	--	--	--	.25	4.5-5.0	
	24-42	qsl	SM	A-2	.2	.07-.12	4.5-5.0	
Hk fine sandy loam	0-12	fsl, fs	SM	A-2 or A-4	2.5-4	.06-.10	4.0-5.0	
	12-24	vgcos	GP or GW	A-1	5	.02	5.5-6.0	
Jacobsen cobbly loam	0-4	sil	ML	A-4	0.8-2.5	.18-.23	4.0-4.5	
	4-20+	cbsl & cbl	ML or SM	A-4 or A-2	.08	.09-.13	4.5-5.5	
Kuskokwim silt loam	0-5	sil	ML	A-4	0.8-2.5	.18-.23	4.5-5.5	
	5+		Permafrost					
Nb gravelly silt loam	0-30	gsil	ML	A-4	0.8-2.5	.18-.23	4.0-4.5	
Nondalton silt loam	0-13	sil	ML	A-4	0.8-2.5	.18-.23	4.0-5.0	
	13-18+	gsil	GM	A-1	3-10	.06-.08	5.5-6.0	
Pyramid silt loam	0-10	sil	ML	A-4	--	.18-.23	4.0-5.0	
	10-19	gsil & cbl	ML or GM	A-4 or A-1	--	.12-.16	4.5-5.5	
1/ Explanation of Symbols:								
	cbl	cobbly loam	fs	fine sand	gsil	gravelly silt loam	pt	peat
	cbsil	cobbly silt loam	fsl	fine sandy loam	gsil	gravelly sandy loam	sil	silt loam
	cbsl	cobbly sandy loam	gcsl	gravelly coarse sand	gs	gravelly sand	vfsil	very fine sandy loam
							vgcos	very gravelly coarse sand

Specific characteristics of soils that may affect engineering practices and estimates of the suitability of soils for various uses are given in Table 4.

In the Nondalton Area most soils below the steep mountain slopes are formed in shallow silty deposits of mixed volcanic ash and loess over gravelly glacial drift. On the mountain slopes basalt bedrock commonly occurs at depths of less than 20 inches, but talus slopes and areas underlain by gravelly glacial drift also occur. Above 1100 feet the soils are typically very gravelly and stony with many exposures of basalt bedrock. At lower elevations only a few areas bordering Sixmile Lake have permafrost. These soils are silty and have thick peaty surface mats.

Frost heaving is a major problem in areas with silty soils, with permafrost, and with peaty soils. Seepage is common along many footslopes. On the till plain shallow depressions, either former lakes or old stream courses, generally have high water tables as a result of seepage or because of low positions in the landscape. Overflow commonly occurs along the streams, especially the lower courses.

All soils of the area have low shrink-swell potential.

The Nondalton and Hk soils have gravelly substrata and are generally suitable as sources of gravel. Near the channel connecting Sixmile Lake and Lake Clark, the sandy Anchorage soils are a good source of sand.

Classification of the Soils

The soil is a natural, three-dimensional body occurring on the surface of the earth. It contains living matter, and supports or is capable of supporting plants. Its characteristics at any one place result from the combined influence of climate, living matter, parent material, relief, and

Table 4. Interpretation of Engineering Properties of soils in the Nondalton Area, Alaska

Soil Series or Symbol	Suitability of source of -			
	Topsoil	Sand and Gravel	Roadfill	
Anchorage	Poor, sandy texture	Good for sand; sandy substrata	Fair, no gravel	
Anchor Point	Good above 18"; gravelly substratum	Good, below 18"gravelly medium and coarse sand (maximum size of gravel about 4"). High water table in places	Good	
Doroshin	Not suited	Not suited above 24"; poor below. High water table	Not suited	
Hk	Fair above 12"; gravelly Below	Good below 12"; gravelly coarse sand (maximum size of gravel 4")	Good	
Jacobsen	Not suited	Poor. High water table	Fair to poor	
Kuskokwim	High permafrost table	Not suited	Not suited; permafrost	
Nb	Fair	Not suited	Poor; silty	
Nondalton	Good above 13"; gravelly below	Good below 13"; gravelly sandy loam	Good	
Pyramid	Good in surface 10"; gravelly below	Poor; silt admixture	Very poor to unsuited	

Table 4. Interpretation of Engineering Properties of Soils in the Nondalton Area, Alaska (Cont'd)

Soil Features Affecting Engineering Practices -				
Soil Series or Symbol	Potential Frost Action	Highway Location	Agricultural Drainage	Remarks
Anchorage	Very slight	Irregular surface	Not needed	Occurs on sand dunes
Anchor Point	Medium	Subject to flooding; seasonally high water table	Flooding; seasonally high water table	Alluvial plains bordering streams
Doroshin	High	Peat; high water table	Low position in land- scape; outlets diffi- cult to find	Peat moderately deep over compact sub- stratum
Hk	Medium	Seasonally high water table; same areas are affected by seepage	Some areas affected by seepage; inter- ceptor ditches needed	Stratified sandy and gravelly soils
Jacobsen	High	High water table; mucky	High water table; most areas affected by seepage; some areas in depressions; outlets difficult to find	Poorly drained gravelly soils
Kuskokwim	High	High permafrost table	High permafrost table	Silty soils; perma- frost near surface
Nb	High	Silty materials; and affected by seepage	Areas influenced by seepage	Deep poorly drained silty soils
Nondalton	Medium	Gravelly substrata; some steep slopes	Not needed	Shallow silt over gravelly substrata
Pyramid	Medium to high	Bedrock below 20"; steep mountain slopes	Not needed	Silty soils shallow to basalt bedrock on mountain slopes

time, plus the effects of the cultural environment and man's use of the soil.

Covering most of the Nondalton area is a silty surface mantle, averaging 12 inches in thickness, of mixed volcanic ash and loess. The substrata on the till plain consist of stratified gravelly and sandy glacial and alluvial deposits. On Hoknede Mountain, to elevations of about 1100 feet, the silty mantle overlies shallow weathered basalt bedrock. At still higher elevations the weathered bedrock is commonly near the surface.

In this Area elevation has a distinct influence on the type of vegetative cover. Below elevations of about 800 feet, well drained soils on south slopes generally support a thin forest of white spruce and paper birch. Soils on north slopes and in poorly drained areas are covered by a sparse forest of spindly black spruce. There is commonly a thick ground cover of willows, dwarf birch, and associated low-growing tundra shrubs and forbs. Between elevations of 800 to 1100 feet bluejoint grass is the dominant cover, but low-growing shrubs and thickets of alder and willows are common in drainageways and on narrow benches. Above 1100 feet alpine tundra is the dominant vegetation. The principal plants are lichens, mosses, sedges, and low-growing shrubs.

Under the cool humid climate of the Area, rates of evaporation and transpiration are low. A large proportion of the annual precipitation percolates through the soil and is effective in leaching. As a result all the soils are very strongly to extremely acid.

Relief, topography, and elevation are significant factors in soil development. Horizon differentiation is commonly less advanced on steep

north-facing slopes and at high elevations. Well drained soils at lower and moderate elevations have gray leached A2 horizons and reddish spodic horizons; poorly drained soils in depressions and in seep areas exhibit characteristics of wetness including mottles, gley colors, and histic epipedons. The soils under grass at moderately high elevations have developed thick dark umbric epipedons. Permafrost is generally absent except in a few areas with silty substrata and a thick peaty surface mat.

The classification of the soils of the Area according to the system adopted for use in the United States in 1964 is given in Table 5. Definitions and descriptions in each category are given by the Soil Survey Staff (4).

Table 5. Soil Series of the Nondalton Area Arranged According to the Comprehensive Classification Scheme of the United States Department of Agriculture (4).

Order	Suborder	Great Group and Subgroup	Family	Series
Histosols	Hemists			Doroshin
	Andepts	Dystic Lithic Cryandepts	Thixotropic	Pyramid
	Aquepts	Histic Cryaquepts	Coarse loamy, mixed, acid	Nb
			Loamy-skeletal, mixed, acid	Jacobsen
		Histic Pergelic Cryaquepts	Loamy, mixed, acid	Kuskokwim
	Typic Cryaquepts	Coarse-loamy over sandy-skeletal, mixed, acid		Anchor Point
Spodosols	Cryorthods	Entic Cryorthods	Sandy, mixed	Anchorage
		Humic Cryorthods	Loamy-skeletal, mixed	Nondalton
			Sandy-skeletal, mixed	Hk

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NONDALTON SOIL SURVEY AREA, ALASKA
LEGEND

Field Sheet	Symbol	Mapping Unit
66B)		Anchorage very fine sandy loam, 3 to 12% slopes
66C)		Anchor Point silt loam, 0 to 3% slopes
141A		Anchor Point silt loam, 3 to 7% slopes
141B		Doroshin-Jacobsen Association
56-230A		HK fine sandy loam, 0 to 3% slopes
226A		HK fine sandy loam, 3 to 7% slopes
226B		Kuskokwim silt loam, 0 to 3% slopes
171A		Kuskokwim silt loam, 3 to 7% slopes
171B		HK silt loam, 7 to 12% slopes
230C		NS silt loam, 20 to 30% slopes
230E		Nondalton silt loam, 0 to 3% slopes
230A		Nondalton silt loam, 3 to 7% slopes
230B		Nondalton silt loam, 7 to 12% slopes
237C		Nondalton silt loam, 12 to 20% slopes
237D		Nondalton silt loam, 20 to 45% slopes
237E		Nondalton silt loam, 30 to 45% slopes
227F		Nondalton-Jacobsen Association, 3 to 7% slopes
227-230B		Nondalton-Jacobsen Association, 7 to 12% slopes
227-230C		Pyramid silt loam, 0 to 3% slopes
229A		Pyramid silt loam, 20 to 30% slopes
229E		Pyramid silt loam, 30 to 45% slopes
229F		Rough mountainous land
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