TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

2.4 Soil Resources

In accordance with:

- Section 38-14.1-14, North Dakota Century Code (NDCC);
- Section 38-14.1-24, NDCC;
- Section 69-05.2-08, North Dakota Administrative Code (NDAC);
- Section 69-05.2-09, NDAC;
- Section 69-05.2-15, NDAC; and
- Section 69-05.2-26, NDAC.

2.4.1 Introduction

This section describes the soil resources within the Study Area. The Study Area includes areas within the Permit Boundary and surrounding tracts (Figure 2.4-1), all of which were surveyed at the same level of intensity. Samples were collected concurrent with the field survey to represent the variations in soil conditions, describe dominant series components, and support determination of salvage depths. Northern Analytical Laboratories, Inc. of Billings, Montana analyzed the samples. This baseline study report presents the findings of the soil survey within the Study Area, including the area within the Permit Boundary. Series and map unit descriptions reflect the soils as they occur in the Study Area as a whole and are not limited to those characteristics only found in the Permit Boundary.

2.4.2 Study Objectives

The primary objective of this study was to collect data that document and quantify the soil resource conditions to the extent necessary to support permitting and reclamation planning. Related survey objectives are to generate data sufficient to serve additional purposes including:

- Identification of the location and characteristics of prime farmland soils;
- Preliminary investigation of potential Alluvial Valley Floors (AVFs);
- Refinement of the mine and reclamation plan design to account for any unique soil related factors;

- Evaluation of alternatives including locations of mine facilities and closure options; and
- Preparation of an environmental review document (e.g., Environmental Assessment or Environmental Impact Statement) for the SHLM, if necessary.

Data provided in this Baseline Study Report, combined with existing data and information, may be used by project scientists and engineers to accomplish the foregoing. In order to ensure data are suitable for these uses, all data were collected in compliance with applicable standards including the regulations administered by the North Dakota Public Service Commission (PSC) and the United States Department of Agriculture (USDA) National Cooperative Soil Survey (NCSS) standards.

2.4.3 Soil Resources Study Area

The Study Area for the soil survey included a number of tracts in the vicinity of the South Heart Lignite Mine, as described in Section 2.4.1 of this report. This soil survey includes a literature review of other soil studies previously conducted in the Study Area. Background information related to previous surveys and the soil forming factors are presented in this section.

2.4.3.1 Prior Soil Surveys

Prior surveys conducted in the Study Area include:

- Soil Survey of Stark County, North Dakota (Larson et al. 1968); and,
- A soil survey update compiled into the Soil Survey Geographic (SSURGO) database for Stark County, North Dakota (NRCS 2007a).

The existing 1968 survey identified the range of soil conditions to be expected within the Study Area. The survey generally described the soils within the Study Area as being comprised of three associations. The Morton-Regent-Grail association is on uplands dissected by swales and drainage ways with slopes ranging from 0 to 9 percent. The Promise-Moreau association consists of nearly level soils in upland swales and on valley terraces with slopes ranging from 2 to 9 percent. The Farland-Havre-Parshall association consists of soils on nearly level stream terraces and bottom lands with slopes ranging from 0 to 3 percent (Larson et al. 1968). The published report presented maps, soil series and map unit descriptions using a level of detail commensurate with an Order II survey.

Natural Resources Conservation Service (NRCS) soil survey staff initiated field work associated with the soil survey update in 2000 and continued this effort through 2003. Lines and attributes of the original soil survey were adjusted based on photo interpretation and field observations. Documentation was collected for many map units to adjust composition and assess needs for additional map units (NRCS 2007a). These adjustments resulted in a number of changes to the mapped soil distribution within the Study Area.

2.4.3.2 Soil Forming Factors

2.4.3.2.1 Geology and Parent Materials

The soils within the Study Area were developed from the following four primary geologic units (Trapp and Croft 1975).

Sentinal Butte Formation (Ts) – This member comprises the vast majority of the upland portions of the Permit Boundary. The formation consists of silty fine-medium grained sandstone, carbonaceous and bentonitic shale, and coal.

The Golden Valley Formation (Tg) – This unit consists of the upper member of the landscape. It is predominantly a tan micaceous cross-bedded sandstone with olive-drab shale and siltstone and a few thin coal beds.

Alluvium of modern channels and flood plains (Qu) – This unit consists of silty and clayey sediments on terraces of the Heart River, the South Branch Heart River, and an un-named drainage to the south. This unit is composed of very dark brown clayey sediments overlying pale brown loam or silt loam sediments. Gravelly and sandy sediments occur on high terraces.

Clinkers – Areas of porcelanite and clinkers (locally referred to as “scoria”) exist within the Sentinal Butte member. Clinker is usually red or pink, very resistant metamorphosed sandstone, siltstone, or shale of the Ft. Union Group. Soils are formed from rock baked by natural burning of the underlying coal. These areas are often mined (as a substitute for gravel) for local roads.

Materials and alluvial deposits originating from the four primary geologic units described above, are the parent materials found within the Permit Boundary. Residual bedrock materials often occur at shallow and moderate depths on upper slopes, ridge crests, and hill tops. Where bedrock occurs at

shallow to moderate depth, coarse-loamy and fine-silty textured materials commonly occur. Swales and low-lying areas are dominated by deep alluvial deposits. These deep deposits are more frequently composed of fine-loamy and fine textured deposits.

2.4.3.2.2 Topography

Elevation in the Study Area ranges from 2,480 feet to about 2,660 feet above mean sea level. The highest elevation occurs on the western fringe of the Permit Boundary. The flood plain and nearly level terraces along the South Branch Heart River have the lowest elevations. Upland areas are dominated by generally stable one to 10 percent slopes. The most level areas are associated with river terraces and other low-lying areas. The steepest slopes generally occur on river cutbanks that have slopes up to 30 or 40 percent grade. The steepest slopes in most upland areas are less than 15 percent grade.

2.4.3.2.3 Vegetation and Land Use

The Study Area lies in the rolling, soft shale plains Major Land Resource Area (MLRA) 54. The native plant communities of the area are typified by mid to short grassland vegetation with scattered shrubs and very few trees. Upland areas are dominated by grasses including: *Agropyron smithii* (Bluestem), *Bouteloua gracilus* (Blue grama), *Stipa viridula* (Green needlegrass), and *Stipa comata* (Needle-and-thread). *Andropogon scoparius* (Prairie beardgrass) is found on steep side slopes where the soils are calcareous. *Distichlis stricta* (Desert saltgrass) and cactus species are often present where native vegetation is present over thin sodic soils. Deciduous trees and shrubs occur along terraces and flood plains. A detailed description of the vegetation communities found within the Permit Boundary is provided in Section 2.7.2 (Vegetation Baseline Study Report).

Agricultural practices including cultivation and grazing have significantly affected the vegetation in the Study Area. The majority of the area is currently cultivated and many of the tracts with perennial vegetation have been historically cultivated. River bottoms, steep slopes, and areas with shallow bedrock or salt affected soils comprise the majority of non-cultivated areas. A detailed description of the land uses within the Permit Boundary is provided in Section 2.7.1 (Land Use Baseline Study Report).

2.4.3.2.4 Climate

Average annual precipitation for Stark County is approximately 16 inches with notable fluctuations from year to year and is discussed in more detail in Section 2.2. Summer rainfall often occurs in the form of intense short duration thunderstorms. Winter precipitation is in the form of snow. The mean annual temperature near the Study Area is approximately 42.4°F and is discussed in more detail in Section 2.2. The temperature regime in the Study Area is frigid and the moisture regime is ustic.

2.4.3.2.5 Time

Most of the soil profiles have developed over the last 30,000 years. Younger soil profiles occur on the river and stream floodplains and terraces and in swales, depressions, and steep upland slopes where erosion and deposition processes are active.

2.4.4 Study Approach and Methodology

The study was initiated with review of existing data to develop a clear understanding of soil types present in the Study Area and issues related to their management and utility. Data review was followed by implementation of survey protocol including soil observation, classification, and sample collection. The soil field survey was completed using methods adapted from NCSS Standards as presented in the Soil Survey Manual (USDA 1993) and other references cited herein. Guidelines provided in the National Soil Survey Handbook (NRCS 2007b), and Field Book for Describing and Sampling Soils (Schoeneberger et al. 2002) were consulted during the field and reporting effort to ensure consistency with other surveys. Greater detail regarding the methods implemented, including deviations from the original scope of work, are provided.

2.4.4.1 Data Review

The following information was reviewed prior to initiating the soil survey to assist resource specialists in identifying soil types, describing their characteristics, and assessing their capabilities and limitations:

- The existing soil surveys for Stark County;
- Official series descriptions for the series expected to be present in the Study Area (USDA 2007c); and,
- Color and false-color infrared aerial photographs of the Study Area taken in 2006.

Information collected from this review was used in planning for the field effort. Reference maps showing previous survey results were prepared and official series descriptions summarized for use in the field.

2.4.4.2 Field Survey

Soil types were determined through observation of pedons (soil profiles) at locations distributed throughout the Study Area. Map unit boundaries were interpolated through review of pedon descriptions and consideration of geology units, aerial photographs, landform characteristics, and other supporting information collected during the literature review and field effort. Observations made in conjunction with profile observation and soil mapping were recorded in detailed field notes and used to compile the technical report.

In completion of the field survey, soil scientists performed the following tasks:

- Developed preliminary maps of soil variability based on existing data;
- Observed pedons at locations distributed throughout the Study Area; and
- Prepared detailed maps and descriptions of the soils in the Study Area.

The field survey was conducted to achieve the stated objectives, which are comparable to those of an Order I soil survey. Soil sampling and laboratory analysis was completed for the entire Study Area, including areas within the Permit Boundary. The results of this survey are adequate to describe the distribution and extent of soil types, depths, watershed stability, erosion potential, general soil quality and productivity, and other characteristics as necessary to assess impacts of surface disturbances and develop a soil salvage and reclamation plan.

Map units were delineated on field maps with a scale of 1:4,800. While the original intent was to delineate units equal to or greater than 2.0 acres in size, smaller units were delineated where they were a) easily discernable on aerial photographs, and b) adjacent to or within units of strongly contrasting capability (e.g., limitations existing in one of the units).

2.4.4.3 Pedon Descriptions

Soil pedon observation points were distributed to collectively represent the variability of soil types within the Study Area, including areas within the Permit Boundary. Traverse and transect survey methods (USDA 1993) were employed to distribute observation points in a manner that ensured that the

map unit descriptions would be accurate and landform-soil relationships were identified and validated. A total of nearly 2,000 observation points were recorded during the survey, including 922 within the Permit Boundary. Many additional profiles were cursorily investigated and recorded.

Pedons were described using methods and abbreviations as noted in the Field Book for Sampling and Describing Soils (Shoeneberger et al. 2002) with modification as described in this section. Complete pedon descriptions were recorded at all sample locations. Complete descriptions generally included notes for horizons to a minimum depth of 60 inches or bedrock contact, whichever occurred first. However, at some sites excavation was less than 60 inches due to very high gravel content or the presence of hard, massive (not necessarily rock) substrata.

The complete pedon descriptions contain the following information:

Site Data: Site ID; date and time; excavation type (boring, backhoe pit, other); location (UTM coordinates); photo (Y/N); observers' name; slope; aspect; parent material; vegetation (general description only); drainage; landform and topographic position; and, other information.

Horizon Data: Horizon designation (e.g., A1); depth intervals; matrix and mottle color; texture; estimated clay percent; clay film description; structure (size, grade, class); abundance and size of roots; presence of carbonates or visible salt crystals; and estimates of coarse fragment size and quantity.

Partial (abbreviated) pedon descriptions were prepared to document a subset of notable characteristics at the vast majority of observation points. Partial descriptions were only completed to the extent necessary to determine series or distinguish characteristics differing from nearby observed pedons (e.g., change in horizon thicknesses along a slope). Where coarse fragments or hard soil prevented excavation or coring to 60 inches, partial pedon descriptions describe the profile to the maximum depth observed. Partial pedon descriptions recorded classifications and other information adequate to provide a context for evaluation of nearby profiles and make salvage recommendations.

The recorded observation points in the Study Area occur at a rate of 1 point per 4 acres, which is at the upper density limit outlined in the scope of work for this survey. These additional observations were made to further verify the depth of materials available for salvage and confirm the differences between the previous NRCS survey and the findings of this study, especially those related to depth to salts and bedrock contact.

2.4.4.4 Sample Collection

Samples were collected from a total of 129 sites, including 77 within the Permit Boundary, to quantitatively describe the variability of soil chemical and physical properties within the Study Area and within the soil profiles. At each of these sites, soil samples were collected from all topsoil and subsoil horizons above bedrock contact except for occasional circumstances where it was possible to readily determine that materials were unsuitable based on field observations. Horizons less than 3 inches thick were sampled in conjunction with the most comparable adjacent horizon unless the "thin" horizon was the only A-horizon present. Samples from horizons greater than 24 inches thick were collected as composites from sections of the horizon with no sub-sample representing greater than 24 inches of thickness except where this horizon was the lowest in the profile and extended below the depth of excavation.

A minimum of one pint of material composed of fine fraction components (less than 2 mm) was collected for each sample and the coarse fragment content was noted in field notes when excluded from samples. Soil samples were placed into clean polyethylene bags and transported to the laboratory or suitable storage facility as soon as practicable following collection.

2.4.4.5 Laboratory Analyses

Soil samples were collected in accordance with the protocol described in Section 2.4.4.4 and transported under chain-of-custody to Northern Analytical Labs, Inc. in Billings, Montana. Analyses focused on those parameters critical to satisfying the requirements specified in the NDAC section 69-05.2-08-10, study objectives stated in Section 2.4.2, and sampling-specific objectives stated in Section 2.4.4.4 of this document. The parameters and methods of analyses, including methods for sample preparation and individual elemental concentrations, are provided in Table 2.4-1. The primary parameters to be analyzed for each typical profile were determined in accordance with the following protocol:

- All samples from pedons selected to be representative were analyzed for sand, silt, clay, very fine sand, organic matter, electrical conductivity (EC), sodium adsorption ratio (SAR), and acidity (pH).

- A subset of horizons (usually deep subsoil horizons) were analyzed for only EC and SAR to identify the depth at which salvage suitability limits are exceeded and correlate this with field observations.

The sites selected for sample analyses were determined at the discretion and best professional judgment of the project scientists. Sites were generally selected to verify hypotheses regarding soil chemical and physical properties typical of the soil type observed. The pedons analyzed are generally

considered typical of the soil type (e.g., series or variant) and are often a dominant component of the map unit in which they are located.

The number of sites to be analyzed was initially based on the anticipated variability of soil series and their extent in the Study Area. However, the distribution of series encountered differed significantly from the existing soil survey, necessitating corresponding adjustment to the number of samples for each series. In addition, field observations of fine-silty textures and natric horizons were invalidated by laboratory testing. This further affected the classification of soils and distribution of samples between series, favoring more samples for series with fine and fine-loamy texture and sodic, but non-natric, chemical properties.

Following receipt of the laboratory results, pedons were evaluated for suitability and limiting factors according to the NDAC section 69-05.2-08-10. These evaluations were used to make soil salvage recommendations and further interpret the soil properties for use in reclamation planning. In addition, the data were used to estimate the erodibility factor (Kf) for the surface horizon and recommended lifts (for series sampled) in accordance with the National Soil Survey Handbook (NRCS 2007b). Where laboratory data were not available for select series, the updated NRCS soil survey (NRCS 2007a) was referenced as the source of the erodibility factors.

2.4.4.6 Classification

Soil profiles were classified to the USDA series level based on information recorded on pedon description forms and other unrecorded field observations. Following receipt of laboratory results, sampled profiles were reviewed and reclassified as necessary using the most accurate data available. Where field observations or assumptions were invalidated by laboratory data, initial classifications at nearby sites were also re-evaluated and some profiles were reclassified, where appropriate, to ensure all records reflect the most current and accurate information. Following review of the laboratory results and range of characteristics, typical profiles were identified for all dominant series in the Study Area.

Soil Taxonomy (USDA 1999) and Keys to Soil Taxonomy (USDA 2006) were the primary references used during soil classification efforts. In most cases, the families and subgroup classifications of soils encountered were direct matches to series previously identified and described in the Soil Survey of Stark County (Larson et al. 1958) and updates (NRCS 2007a). However, many profiles did not

closely match previously mapped series. Where this occurred, the profiles were classified as series taxadjuncts or variants.

2.4.4.7 Soil Mapping

Field maps were prepared with backgrounds consisting of combinations of topography, previous surveys, and color. Field observations, including delineations, were directly recorded on these maps as they were observed. Following tabulation of observation site coordinates, classifications, and related information, soil units were delineated at a scale of 1:4,800 (1 inch = 400 feet) using these various resource bases overlaid with observation point data. This final mapping ensured that delineations reflect the most accurate information available. The mapping process was iterative, where units and delineations were continually adjusted throughout the process to ensure each final map unit and each delineation is composed of soils with similar characteristics.

Map units primarily consist of consociations dominated by a single series defined by a slope class (phase characteristics). The only complexes delineated are areas composed of variable textured soils of a common subgroup, which frequently occurred on river and stream terraces. The mechanisms of fluvial deposition in these areas resulted in a complex arrangement of textures, especially in the control section.

Delineations were initially separated by unique slope classes, but several classes for select series were later combined where soil characteristics and map unit composition were not sufficiently different to warrant separate delineation and description. Descriptions attending each map unit designation identify the dominant taxa in each unit and their typical characteristics.

Miscellaneous area soils map units include surface disturbances, farmsteads and water bodies. The surface disturbance areas include mines and roads, road rights-of-way (ROW) and borrow ditches. The farmsteads include yards, corrals, feedlots and related areas. Water bodies include river channels and reservoirs. These miscellaneous areas were mapped as part of this survey. The surface disturbance areas, rights-of-way, and farmsteads were digitized directly from the 2006 aerial photography at a scale of approximately 1:2,400. The water body dataset is consistent with the open water and unconsolidated bed units identified in the Wetland Baseline Study Report (Section 2.10). These units were overlaid on the final soil maps to identify those areas where salvage is further limited by natural or anthropogenic factors. In addition, they are described separately in this report as unique map units.

2.4.4.8 Determination of Suitable Salvage Materials

The results of laboratory analyses were reviewed in conjunction with field observations to determine the thickness of suitable plant growth media at each recorded observation point. The definitions and characteristics of Lift 1 and Lift 2 materials as defined by NDAC section 69-05.2-08-10 follow:

Lift 1 (topsoil) – Suitable plant growth material that is considered the best topdressing for the area to be reclaimed. This material is the noncalcareous surface horizon material that is dark colored due to organic staining, has an EC less than 2.0 millimhos per centimeter (mmhos/cm), an SAR less than 4, and an organic matter percentage of 1 or more.

Lift 2 (subsoil) – Remaining suitable plant growth material (usually below Lift 1) that has an EC less than 4.0 mmhos/cm and an SAR less than 10.

Field observations related to soil color, structure, reactivity, and salt (especially gypsum) content were used to make salvage lift recommendations. These properties were correlated to the chemical and physical properties of typical profiles determined through laboratory analyses to ensure that recommendations at each point reflect all available data. Salvage recommendations for each delineation were analyzed from observation points contained within it. Results of the analysis were subsequently compared to other delineations in the map unit to arrive at the final salvage lift recommendations for each delineation.

All water bodies and disturbed areas were determined to have no materials suitable for salvage. Road rights of way and farmsteads are assumed to have no materials suitable for Lift 1, with the total depth of Lift 2 salvage equal to the total salvage depth (Lift 1 and 2 combined) of other portions of adjacent soil map units.

2.4.4.9 Prime Farmlands

In accordance with NDAC section 69-05.2-01-01, the absence of prime farmlands was confirmed through review of the most current NRCS cooperative soil survey (NRCS 2007a).

2.4.4.10 Hydric Soils

Hydric soils were investigated in a manner similar to other soils in the Study Area. A detailed investigation of hydric soils (where they occur in the presence of wetland hydrology and vegetation) was conducted under the Wetland Baseline Study.

2.4.5 Results

The results of the soil survey for the Study Area and Permit Boundary are presented in this section. This section begins with presentation of results of laboratory analyses followed by discussion of soil series and map units. Prime farmlands and hydric soils are noted at the end of this section.

2.4.5.1 Laboratory Results

The results of all laboratory analyses conducted under the soil survey are presented in Table 2.4-2 and laboratory reports are presented in Appendix 2.4-1. This dataset includes the results for sites outside the Permit Boundary collected to document the typical characteristics and variability of a soil type in the area. The sample results are presented in alphabetical order according to their soil series classification and, within each series group, in numeric order according to the Site ID. The horizon designation is also provided for each sample to provide a context in which to assess the results. Blank cells in Table 2.4-2 indicate that the parameter was not analyzed. Results were reported as "INSF" where the saturated paste extract volume for determination of EC was inadequate for analysis and additional materials were not available for alternative analyses.

2.4.5.2 Soil Series and Map Unit Components

A total of 41 soil series and four miscellaneous areas, including disturbed areas, rights of way, farmsteads, and water bodies were determined to have notable occurrence within the Permit Boundary. The 41 series and their respective textural classes and taxonomic classifications are presented in Table 2.4-3. This table also identifies whether they are a dominant component of any map unit within the Permit Boundary. The characteristics of the miscellaneous groups are not further described in this survey but are shown on maps and described in the map unit discussion presented later in this section.

A detailed description of the series found in the Study Area is presented in the following subsections. A typical pedon for each of the dominant series (as noted in Table 2.4-3) is presented in Appendix 2.4-2.

Amor (AR)

Taxonomic Description: Fine-loamy, mixed, superactive, frigid Typic Haplustolls

Taxadjuncts: Coarse-loamy; sand or gravel at depth; pachic

The Amor series consists of well drained, moderately permeable soils that are moderately deep (20 to 40 inches) to soft sandstone bedrock. They formed in material weathered from stratified soft sandstone, siltstone and mudstone. Taxadjuncts were frequently encountered.

The Amor series commonly occurs on 2 to 12 percent slopes. Landscape positions include upland hill slopes, lowland swales, and drainage bottoms away from river floodplains and terraces. The series that are commonly found in association with Amor include the Morton, Reeder, Stady, and Cabba series.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 9 and 17 inches, respectively, for a total of 26 inches of salvageable material. Rock and salt content were both frequently limiting. Where encountered, rock was present at an average depth of 30 inches, while salt occurred at a shallower depth of 23 inches. Sand and gravel content were also considered limiting in taxadjuncts containing significant amounts of these course materials.

Arnegard (AD)

Taxonomic Description: Fine-loamy, mixed, superactive, frigid Pachic Haplustolls

Taxadjuncts: Low organic matter content; profiles with more than 30 percent clay

The Arnegard series consists of very deep (bedrock over 40 inches below ground surface), well or moderately well drained soils that formed in calcareous loamy alluvium on upland swales, terraces, fans and foot slopes. Permeability is moderate. Coarse fragment content is always less than 10 percent. Cambic horizons are prominent features of the profile. Bedrock is infrequently encountered within 60 inches of the ground surface. The Arnegard series commonly occurs on 0 to 8 percent slopes and is commonly found in association with the Straw, Grail, and Lawther series.

Taxadjuncts include some soils with low or variable organic matter content and slightly finer textures than allowed by the official series description. These differences do not significantly affect the interpretation of this series.

In the Study Area, the Lift 1 and Lift 2 thicknesses average 21 and 25 inches, respectively, for a total of 46 inches of salvageable materials. Limiting factors were not encountered in most profiles. However, salt content (visible) was determined to be limiting at an average depth of 37 inches in 30 percent of the profiles observed. Sand content was especially high below 33 inches in one profile best classified as a taxadjunct to this series.

Banks (BS)

Taxonomic Description: Coarse-loamy, mixed, superactive, calcareous, frigid Typic Ustifluvents

Taxadjuncts: None noted

The Banks series are very deep, well and moderately well drained soils formed in alluvium. These soils occur very infrequently on river terraces in association with other sandy, fine, and fine-loamy Ustifluvents including Trembles, Lohler, and Havrelon. This series is found in complex with these Fluvents and was not mapped separately. Slopes are commonly near level, although cutbanks and terrace breaks frequently occur.

The average Lift 1 thickness for the Banks series is 5 inches. The suitability of subsoil for salvage is dependent on the characteristics of the delineations in which it occurs. The official series description for this series does not identify any limiting characteristics. However, this series is often found in association with the saline and sodic substrata of select Fluvent and Havrelon map units. In these units, the salvage of the subsoil material is not recommended. Where this series is found in association with more suitable soils, salvage to a depth of 60 inches is possible.

Cabba (CB)

Taxonomic Description: Loamy, mixed, superactive, calcareous, frigid, shallow Typic Ustorthents

Taxadjuncts: Textures vary from coarse-loamy to fine-loamy; ochric, weak development, and moderately deep

The Cabba series consists of shallow, well drained soils that formed in residuum or colluvium derived from semiconsolidated (paralithic), loamy sedimentary beds. These soils are common within the area and occur on residual upland hill slopes, crests, and ridge tops with slopes ranging from 2 to 18 percent. The series that are commonly found in association with the Cabba series include the Wayden, Chama, and Vebar series.

In the Study Area, the Lift 1 and Lift 2 thicknesses average 6 and 7 inches, respectively, for a total of 13 inches of salvageable materials. Bedrock occurs within 20 inches in all profiles. The depth to bedrock averages 13 inches. Salt is also frequently encountered, with visible crystals present at an average depth of 10 inches in slightly less than 10 percent of the profiles observed. Salts were also frequently observed in the fractures of the soft bedrock.

Chama (CH)

Taxonomic Description: Fine-silty, mixed, superactive, frigid Typic Calciustolls

Taxadjuncts: Infrequent non-calcareous surface soil

The Chama series consists of well drained soils formed in materials weathered from soft siltstone, mudstone and shale on uplands. These soils are moderately deep (within 40 inches) to soft siltstone, mudstone or shale. These soils are moderately or moderately to slowly permeable. The profiles are commonly calcareous to the surface.

The Chama series was infrequently encountered and was not separately mapped. The series usually occurs as an inclusion in units dominated by the Sen and Morton series with slopes ranging from 2 to 7 percent.

In the Study Area, the Lift 1 and Lift 2 thicknesses average 7 and 19 inches, respectively, for a total of 26 inches of salvageable materials. Bedrock is the limiting factor in all profiles and occurs at an average depth of 26 inches below ground surface.

Cherry (CY)

Taxonomic Description: Fine-silty, mixed, superactive, frigid Typic Haplustepts

Taxadjuncts: None noted

The Cherry series consists of very deep, well drained, moderately slowly or slowly permeable soils that formed in alluvium of upland slopes and swales. These soils are moderately or moderately to slowly permeable. The Cherry series was very infrequently encountered and was not separately mapped. It was found as a very minor inclusion of units mapped as the Shambo and Cabba series on slopes ranging from 3 to 6 percent.

In the Study Area, the Lift 1 and Lift 2 thicknesses average 6 and 54 inches, respectively, for a total of 60 inches of salvageable materials. No limiting chemical or physical factors were encountered in the profiles observed.

Daglum (DM)

Taxonomic Description: Fine, smectitic, frigid Vertic Natrustolls

Taxadjuncts: Fine-loamy; SAR from 10 to 13 in Btn; high SAR below Bt.

The Daglum series consists of deep and very deep, moderately well and well drained soils formed in clayey alluvium or residuum on foot slopes and swales on terraces and uplands. These soils have slow or very slow permeability. Visible salts occur in some profiles at depths below 16 inches from the ground surface.

This series was difficult to identify in the field due to argillic horizons having variable SAR. Many profiles originally mapped as Daglum were subsequently reclassified as the Savage series where the SAR of the argillic horizon was determined to be less than a value of 13 (unitless). Where lab data was not available, it is possible that some sodic, but non-natric profiles were misclassified as Daglum due to their similar physical characteristics.

The Daglum series commonly occurs on 2 to 6 percent slopes. The series commonly found in association with Daglum include the Savage (non-natric), Lawther (vertic, non-natric), and Moreau (mod-deep, non-natric) series. The similar Rhoades series which has visible salts within 16 inches of the ground surface is also associated with Daglum in some areas where these soils are found in complexes often dominated by the more limiting Rhoades.

In the Study Area, the Lift 1 and Lift 2 thicknesses of profiles observed averaged 6 and 8 inches, respectively, for a total of 14 inches of salvageable materials. The high EC and SAR of these salt and sodium affected soils were limiting factors in all profiles.

Dimmick (DK)

Taxonomic Description: Fine, smectitic, frigid Vertic Epiaquolls

Taxadjuncts: None noted

The Dimmick series consists of very deep, very poorly drained, very slowly permeable soils that formed in clayey sediments. These soils are in depressions on uplands and in lake basins with minimal slopes. The series occurs very infrequently in the area and is found in association with the Lallie series and similar wetland soils.

The chemical and physical properties of the Dimmick series are generally not limiting for use in reclamation. However, the saturated nature of the materials may limit the depth of salvage in units containing this series.

Dogtooth (DH)

Taxonomic Description: Fine, smectitic, frigid Leptic Natrustolls

Taxadjuncts: Some profiles identified as having an Ap horizon (tilled surface)

The Dogtooth series consists of moderately deep, well drained, very slowly permeable soils formed in residuum weathered from saline-alkali, calcareous, soft shale, siltstone or mudstone.

Where tillage has altered the structure and color of the surface soil materials, these profiles were occasionally noted to have an Ap horizon. However, this mixed zone is more appropriately characterized as the E horizon mixed with the top of the Btn horizon. Profiles were identified as the Dogtooth series where visible gypsum could be observed within 16 inches of the soil surface.

This series was occasionally difficult to identify in the field due to the effects of tillage, which alters the columnar structure, and argillic horizons having variable SAR. Many profiles originally mapped as Dogtooth were subsequently reclassified as the Regent series where the SAR of the argillic horizon was determined to be less than a value of 13 (unitless).

The Dogtooth series commonly occurs on 4 to 6 percent slopes. The series commonly found in association with Dogtooth include Regent (non-natric), Savage (deep, non-natric), and Moreau (mod-deep, non-natric) series. The similar Janesburg series has visible salts below 16 inches from the ground surface and is also associated with Dogtooth in some areas.

In the Study Area, the Lift 1 and Lift 2 thicknesses of profiles observed averaged 5 and 4 inches, respectively, for a total of 9 inches of salvageable materials. The high EC and SAR of these salt and sodium affected soils are limiting factors in all profiles. Many delineations of this series were not assigned suitable salvage thicknesses due to the poor quality of the soil materials.

Farland (FD)

Taxonomic Description: Fine-silty, mixed, superactive, frigid Typic Argiustolls

Taxadjuncts: Some profiles with cambic (non-calcareous) horizons above Bk.

The Farland series consists of very deep, well drained soils that formed in stratified alluvium on terraces, valley foot slopes and fans on uplands. Permeability is moderate or moderately slow.

The Farland series was infrequently encountered in the Study Area and was not separately delineated. Instead, it was included as an inclusion of Shambo, Sen, and Amor delineations. Lift 1 and Lift 2 salvage thicknesses averaged 10 and 12 inches, respectively. Salt content of deep profiles was identified as a limiting factor in most profiles.

Flasher (FR)

Taxonomic Description: Mixed, frigid, shallow Typic Ustipsamments

Taxadjuncts: None.

The Flasher series consists of shallow, somewhat excessively drained soils formed in soft sandstone on side slopes, shoulder slopes and summits of hills and ridges on uplands and side slopes of valleys. Slopes commonly range from 4 to 18 percent. Permeability is moderately rapid or rapid. The series is commonly found in association with the Vebar (moderately deep, mollic) and Parshall (deep, pachic) series and similar finer textured soils.

Physical characteristics including sandy texture and shallow depth to bedrock made identification and delineation of the series very easy relative to other map units. Similarly, the analytical results from samples collected from other well drained, sandy soils (i.e., Vebar and Parshall) concluded that the depth to bedrock and differences between topsoil and subsoil horizons were the primary factors affecting salvage. As a result, a representative profile of this series was not sampled due to the ease of distinguishing between topsoil and subsoil horizons, ease of identifying bedrock contact as the

lower limit of salvage, shallow depth of suitable soil, and limited extent of the series within the Permit Boundary.

In the Study Area, the Lift 1 and Lift 2 thicknesses each averaged 6 inches, respectively, for a total of 12 inches of salvageable materials. Bedrock contact was the limiting factor in all profiles.

Grail (GL)

Taxonomic Description: Fine, smectitic, frigid Pachic Vertic Argiustolls

Taxadjuncts: Profiles that are saline and/or sodic at depth.

The Grail series consists of deep and very deep, well or moderately well drained, moderately slow or slowly permeable soils that formed in alluvium. These soils are on terraces, fans, swales and foot slopes on uplands with slopes commonly ranging from 1 to 5 percent. The dark surface materials (mollic colors) are at least 16 inches thick in all profiles. Commonly associated soils include the Lawther (very high clay content) and Savage (non-pachic) series.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 10 and 29 inches, respectively, for a total of 39 inches of salvageable materials. High salt and sodium content deep in the profiles were identified as limiting factors in two-thirds of the profiles observed where the average depth to unsuitable materials was 33 inches. Most other profiles did not exhibit unsuitable characteristics. Bedrock was encountered in only three profiles. In the three profiles where it occurred, the average depth to bedrock was 44 inches.

Harriet (HT)

Taxonomic Description: Fine, smectitic, frigid Typic Natraquolls

Taxadjuncts: None specifically identified, but several similar salt affected soils likely occur.

The Harriet series consists of very deep, poorly drained, slowly and very slowly permeable soils that formed in calcareous alluvium. These soils are on low lying flats, terraces, drainage ways and bottom lands. These soils were combined in a wet saline map unit that included similar wet and salt affected soils including Hoven and taxadjuncts. Other smaller delineations of these wet-saline series occur as minor inclusions of drainage bottom and swale map units. The detail of their occurrence is provided

in Section 2.10-1 (Wetland Baseline Study Report). No suitable materials are found in these profiles or the map units in which they are a dominant component.

Havrelon (HL)

Taxonomic Description: Fine-loamy, mixed, superactive, calcareous, frigid Typic Ustifluvents

Variants: Profiles with high EC and SAR in the substratum may be more common than non-saline/sodic profiles.

The Havrelon series consists of very deep, well and moderately well drained, moderately permeable soils that formed in loamy alluvium. These soils are on floodplains and terraces of the Heart River and South Branch Heart River and tributaries with slopes ranging from 0 to 10 percent. Near level areas are typical, but cutbanks and terrace breaks are also frequently included in these delineations.

The characteristics of the Havrelon series vary with the location in the landscape. While nearly pure delineations of Havrelon are common, this series is also mapped as a component of the Fluvents map unit adjacent to the South Branch Heart River where soils of variable texture are found in complex arrangement. While most of the profiles have clay loam, silty clay loam, or loam topsoils, clay and silty clay topsoils do occur.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 7 and 20 inches, respectively, for a total of 27 inches of salvageable materials. The suitability of the Havrelon series is not typically limited by chemical or physical properties. However, this series and other fluvents were observed to have light colored (and often hard and massive) substrata with very high EC and SAR. In consideration of this, many delineations of Havrelon and these other similar soils were determined not to have suitable Lift 2 materials. These unsuitable materials are most commonly encountered along the South Tributary where it drains the Little Badlands to the south of the Study Area.

Hoven (HN)

Taxonomic Description: Fine, smectitic, frigid Vertic Natraquolls

Taxadjuncts: None specifically identified, but several similar salt affected soils likely occur.

The Hoven series consists of very deep, poorly drained, slowly and very slowly permeable soils that formed in calcareous alluvium. These soils are on low lying flats, terraces, drainage ways and bottom

lands. These soils were combined in a wet saline map unit that included similar wet and salt affected soils including Harriet and taxadjuncts. Other smaller delineations of these wet-saline series occur as minor inclusions of drainage bottom and swale map units. The detail of their occurrence is provided in Section 2.10-1 (Wetland Baseline Study Report). No suitable materials are found in these profiles or the map units in which they are a dominant component.

Janesburg (JG)

Taxonomic Description: Fine, smectitic, frigid Typic Natrustolls

Taxadjuncts: High sodium content but non-argillic (Moreau-like) or non-natric (high SAR below Bt)

The Janesburg series consists of moderately deep, well drained soils formed in residuum weathered from alkaline, soft shale, siltstone and mudstone. These soils have slow or very slow permeability. Profiles of the Janesburg series do not have visible salts within 16 inches of the soil surface.

This series was occasionally difficult to identify in the field due to the variable SAR of the argillic horizons and the effects of tillage, which alters the columnar structure. Many profiles originally mapped as Janesburg were subsequently reclassified as the Moreau series where the SAR of the argillic horizon was determined to be well below 13. In other areas where lab data were not available to confirm the SAR value, areas exhibiting the typical physical characteristics were mapped as Janesburg. These soils are expected to be sodic at depth, but are possibly non-natric in some areas. Due to the reclassification of sampled profiles, a typical pedon of the Janesburg series was not sampled and analyzed. The pedon presented in Appendix 2.4-2 is a taxadjunct of the Janesburg series that could also be classified as a taxadjunct of the similar Moreau series.

The Janesburg series commonly occurs on 1 to 6 percent slopes. The series commonly found in association with Janesburg include the Morton (fine-silty, non-natric) and Moreau (non-natric, argillic) series. The similar Dogtooth series has visible salts within 16 inches of the ground surface and is commonly found in association with the Janesburg series.

In the Study Area, the Lift 1 and Lift 2 thicknesses of profiles observed averaged 5 and 10 inches for a total of 15 inches of salvageable materials. The high EC and SAR of these salt and sodium affected soils are limiting factors in all profiles.

Korchea (KA)

Taxonomic Description: Fine-loamy, mixed, superactive, calcareous, frigid Mollic Ustifluvents

Taxadjuncts: Profiles with saline and/or sodic substratum; coarse-loamy textures

The Korchea series consists of very deep, well drained, moderately permeable soils that formed in stratified alluvium. These soils are common on river flood plains and low stream terraces with nearly level slopes, although cutbanks and terrace breaks frequently occur. This series was not mapped separately and occurs as an inclusion of the Havrelon map unit and in conjunction with other Ustifluvents.

The mollic A-horizon materials averaged 6 inches and were immediately underlain by light colored alluvial parent materials in most profiles. Similar to the Haverlon series, in many profiles the substratum is violently effervescent and is expected to be unsuitable due to high EC or SAR.

Korell (KL)

Taxonomic Description: Fine-loamy, mixed, superactive, frigid Fluventic Haplustolls

Taxadjuncts: Profiles with saline and/or sodic substratum; fine textures

The Korell series consists of very deep, well drained, soils that formed in alluvium. These soils are common on river flood plains and low stream terraces adjacent to other weakly developed Haplustolls and Ustifluvents of variable texture. This series is found in complex with these similar soils and was not mapped separately. Slopes are commonly near level, although cutbanks and terrace breaks frequently occur.

This series is very similar to the Havrelon series, which occurs frequently in similar landscape positions. The primary difference between these series is the mollic epipedon of the Korell series. The Korell series may have slightly higher clay content than allowed by the official series description, but is a more appropriate classification for these soils than Havrelon.

The mollic A-horizon materials averaged eleven inches and were immediately underlain by light colored alluvial parent materials in most profiles. In some of the profiles observed the substratum is very light colored and violently effervescent and is expected to be unsuitable due to high EC or SAR. The color and reaction of the substratum are expected to be good indicators of suitability. In some delineations, no subsoil (Lift 2) salvage is recommended.

Lallie (LE)

Taxonomic Description: Fine, smectitic, calcareous, frigid Vertic Fluvaquents

Taxadjuncts: None noted

The Lallie series consists of very deep, poorly drained and very poorly drained, slowly permeable soils formed in abandoned stream channels and other depressions along drainage bottoms. The series occurs very infrequently, but was mapped as a discrete unit. This unit also includes the Dimmick series and similar wetland soils.

The chemical and physical properties of the Lallie series are generally not limiting for use in reclamation. However, the saturated nature of the materials may limit the depth of salvage in units containing this series. The Lift 1 materials averaged 7 inches thick in the profiles observed.

Lawther (LR)

Taxonomic Description: Fine, smectitic, frigid Typic Haplusterts

Taxadjuncts: Without slicken-slides; fine-loamy textures deep in profile

The Lawther series consists of very deep, well drained, slowly permeable soils that formed in calcareous clayey sediments. These soils are very common and are found in upland swales and similar positions with slopes ranging from nearly level to 6 percent. The series is commonly found in association with the Grail (less clay) and Savage (non-pachic) series.

Dark topsoil horizons (mollic colors) range exceeded 16 inches in thickness and often included some B-horizons to a depth of 20 inches or more. Prominent prismatic structure, surface cracks, and deep cracks (into B-horizon) filled with A-horizon materials are common. The official series description states that slicken-slides are common, but were infrequently observed. In consideration of this, most profiles may be more appropriately classified as taxadjuncts to this series, which was considered a more appropriate designation than the similar Grail series (less than 45 percent clay). Clay content in the profiles observed exceeds 45 percent and commonly ranges as high as 60 percent.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 8 and 36 inches, respectively, for a total of 44 inches of salvageable materials. Approximately half of the profiles observed did not exhibit limiting characteristics. The remainder of the profiles had high salt or sodium content at depths averaging 30 inches below ground surface. These materials were generally correlated to field observations of gypsum crystals or violent reaction. Rock was encountered at an average depth of 46 inches in less than 5 percent of the profiles observed.

Lohler (LO)

Taxonomic Description: Fine, smectitic, calcareous, frigid Vertic Ustifluvents

Taxadjuncts: Profiles with saline and/or sodic substratum

The Lohler series consists of very deep, well drained, moderately permeable soils that formed in stratified clayey alluvium. These soils are common on river flood plains and low stream terraces adjacent to the Havrelon series and other Ustifluvents of variable texture. Slopes are commonly near level, although cutbanks and terrace breaks frequently occur.

The Ochric A-horizon materials averaged 9 inches in thickness and were immediately underlain by light colored alluvial parent materials in most profiles. Similar to the Haverlon series, in many profiles the substratum is violently effervescent and is expected to be unsuitable due to high EC or SAR. Lift 2 salvage is not recommended.

Manning (MG)

Taxonomic Description: Coarse-loamy over sandy or sandy-skeletal, mixed, superactive, frigid Typic Haplustolls

Taxadjuncts: Pachic profiles with gravel at depth

Variants: Profiles with coarse textures and shallow depths to gravel

In the Study Area, the Manning series consists of very deep, somewhat excessively drained soils on high remnant river terraces. These soils formed in loamy fluvial sediments overlying sand and gravel. They are typically 24 to 40 inches deep to sandy gravel or fine to medium gravel. Permeability is moderately rapid in the upper part and very rapid in the substratum. The topographic is variable over short distances as eroded slopes of the high terraces transition into adjacent upland areas and lower terraces. Slopes commonly range from 1 to 8 percent. Other coarse textured soils are commonly found in association with the Manning series.

Coarse textured soils with gravel substrata occur infrequently and are variable in nature. The depth to gravel averages 24 inches, but is frequently more shallow (6 to 20 inches) and occasionally deep (over 40 inches). Where mollic epipedons and coarse-loamy textures overlaid gravel deposits, they were collectively combined as the Manning series regardless of the depth to bedrock or thickness of the mollic epipedon. As a result, some profiles are more appropriately considered taxadjuncts or variants of this series.

In the Study Area, the recommended Lift 1 and Lift 2 thicknesses averaged 14 and 12 inches, respectively, for a total of 26 inches of salvageable materials. The Lift 1 is composed of dark colored A and Bw horizons. The high gravel content of the substratum was determined to be limiting in most profiles due to the associated low water holding capacity.

Moreau (MU)

Taxonomic Description: Fine, smectitic, frigid Vertic Haplustolls

Taxadjuncts: Some profiles have an ochric epipedon

The Moreau series consists of moderately deep, well or moderately well drained, slowly permeable soils that formed from soft calcareous alkaline shales on residual uplands with slopes ranging from 1 to 6 percent. The Moreau series is commonly associated with the Morton (fine-silty, argillic), Savage (fine, deep, argillic), Regent (argillic), and Wayden (shallow to shale) series. Profiles originally classified as Argiustolls or Natrustolls but determined (via lab analyses) not to have argillic or natric horizons were reclassified to the Moreau series. Moderately deep fine textured soils with ochric epipedons were classified as a taxadjunct to the Moreau series.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 7 and 19 inches, respectively, for a total of 26 inches of salvageable materials. Bedrock contact limits salvage to an average depth of 29 inches in approximately 70 percent of the profiles. Salvage of the remainder of the profiles is limited to an average depth of 18 inches by concentrations of salt in the horizons immediately above the bedrock.

Morton (MN)

Taxonomic Description: Fine-silty, mixed, superactive, frigid Typic Argiustolls

Taxadjuncts: No frequently occurring taxadjuncts were noted

The Morton series consists of moderately deep, well drained, moderately permeable soils that formed in material weathered from soft calcareous silty shales, siltstones, and fine grained sandstones. The series commonly occurs on high, near-level ridge tops and adjacent residual upland positions with slopes ranging from one to 11 percent. The series is associated with the Sen (non-argillic), Regent (fine, argillic), and Savage (fine, deep, argillic) series.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 7 and 24 inches, respectively, for a total of 31 inches of salvageable materials. Bedrock contact limits salvage in all profiles.

Parshall (PL)

Taxonomic Description: Coarse-loamy, mixed, superactive, frigid Pachic Haplustolls

Taxadjuncts: Similar profiles developed in aeolian deposits; fine textures over coarse-loamy

The Parshall series generally consists of very deep, well or moderately well drained, moderately rapidly permeable soils formed in alluvium. However, in the Study Area profiles with this classification commonly occur on leeward, often east-facing, slopes and swales where coarse textured aeolian materials have accumulated. Slopes commonly range from 4 to 20 percent. The series is commonly found in association with the Vebar (mod-deep, non-pachic) series.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 25 and 30 inches, respectively, for a total of 55 inches of salvageable materials. Limiting factors are not often encountered within 60 inches of the ground surface. However, a few profiles exhibited high salt content in deep horizons (average depth of 37 inches) and bedrock was encountered in one profile at a depth of 56 inches.

Reeder (RR)

Taxonomic Description: Fine-loamy, mixed, superactive, frigid Typic Argiustolls

Taxadjuncts: Profiles with bedrock below 40 inches; ochric epipedons

The Reeder series consists of moderately deep, well drained, moderately permeable soils that formed in material weathered from soft, calcareous sandstone, siltstone or mudstone. This series is found on residual upland hill slopes in association with the Amor (non-argillic) and Regent (fine) series. Slopes commonly range from 2 to 6 percent. The textures are often very nearly fine-silty and some misclassification may have occurred where textures were on the borderline between classes. Taxadjuncts include occasional intermingled profiles with bedrock below 40 inches or with lighter colored A-horizons that do not meet mollic color requirements.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 7 and 21 inches, respectively, for a total of 28 inches of salvageable materials. Bedrock is commonly found at depths ranging from 20 to

40 inches below ground surface. Bedrock limits salvage to an average depth of 34 inches in approximately one-third of all profiles. The remaining profiles have horizons with visible salt at an average depth of 24 inches.

Regent (RT)

Taxonomic Description: Fine, smectitic, frigid Vertic Argiustolls

Taxadjuncts: Pachic mollic epipedons; ochric epipedons; profiles with very high EC or SAR at depth

The Regent series consists of moderately deep, well drained, slowly permeable soils formed in residuum weathered from alkaline soft shale, siltstone or mudstone. The series occurs on residual upland hill slopes and ridges in association with the Moreau (non-argillic) series, Wayden (shallow) series, and deeper fine textured soils. Slopes generally range from 2 to 11 percent.

Many profiles were classified as taxadjuncts to this series. Soils originally classified as Janesburg or Dogtooth, but subsequently determined (via lab analyses) to not be natric were reclassified as the Regent series. These profiles often have visible salts or other physical properties that suggest high salt or sodium content at depth. Other profiles exhibit either thick mollic (pachic) or light colored (ochric) epipedons. These profiles were included with this series if an argillic horizon was noted and bedrock was encountered from 20 to 40 inches below ground surface.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 6 and 19 inches, respectively, for a total of 25 inches of salvageable materials. Rock limits salvage to an average depth of 28 inches in approximately two-thirds of the profiles. Salt or sodium content limit salvage to an average depth of 20 inches in the remainder of the profiles. These limiting factors are often found in the same delineation.

Rhoades (RS)

Taxonomic Description: Fine, smectitic, frigid Leptic Vertic Natrustolls

Taxadjuncts: High SAR below Bt (non-natric, but sodic)

The Rhoades series consists of deep and very deep, well or moderately well drained, very slowly permeable soils formed in stratified loamy and clayey materials derived from soft shale, siltstone or mudstone. Visible salts are present within 16 inches of the ground surface in all profiles. These soils

are in swales on upland slopes and plains with slopes ranging from 0 to 7 percent. Associated soils include the Savage (non-natric), Lawther (non-natric verisol), Daglum (moderately deep), Regent (moderately deep, non-natric), and Wayden (shallow, non-natric) series.

Where tillage has altered the structure and color of the surface soil materials, these profiles were occasionally noted to have an Ap horizon. However, this mixed zone is more appropriately characterized as the E horizon mixed with the top of the Btn horizon. Profiles were identified as the Rhoades series where visible gypsum could be observed within 16 inches of the soil surface.

This series was occasionally difficult to identify in the field due to the effects of tillage, which alters the columnar structure, and argillic horizons having variable SAR. Many profiles originally mapped as Rhoades were subsequently reclassified as the Savage series where the SAR of the argillic horizon was determined to be less than a value of 13 (unitless). However, in the absence of lab data, some sodic, but non-natric profiles may have been misclassified and are included as taxadjuncts of this series.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 5 and 4 inches, respectively, for a total of 9 inches of salvageable materials. Salt and sodium content (EC and SAR) at depth limit salvage to less than 16 inches in all profiles. The presence of more suitable materials elsewhere in Rhoades mapping units increase the volume of material available for salvage there.

Savage (SE)

Taxonomic Description: Fine, smectitic, frigid Vertic Argiustolls

Taxadjuncts: Ochric epipedons; non-argillic

The Savage series consists of very deep, well drained soils that formed in silty and clayey alluvium. This series is found on upland hill slopes and swales with slopes commonly ranging from 0 to 7 percent. The most common taxadjuncts include similar soils without A-horizons that do not meet mollic color requirements or profiles without enough clay increase to meet the requirements for designation as an argillic horizon. These soils are very similar and are intermingled throughout the Savage delineations. Closely associated soils include the Lawther (pachic; high clay content), Grail (pachic), Daglum (natric), Regent (moderately deep), and Moreau (moderately deep, non-argillic) series.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 7 and 29 inches, respectively, for a total of 37 inches of salvageable materials. Salt and sodium content at depth limit salvage to 28 inches in approximately 65 percent of the profiles observed. Some profiles and a few delineations with very limited salvage due to EC or SAR are comparable to sodic, but non-natric, Daglum and Rhoades taxadjuncts. The majority of the remaining profiles do not exhibit limiting characteristics within 60 inches of the ground surface. Bedrock was encountered in very few profiles at an average depth of 48 inches.

Schaller (SR)

Taxonomic Description: Sandy, mixed, frigid Fluventic Haplustolls

Taxadjuncts: None noted

The Schaller series consists of very deep, excessively drained, rapid or very rapidly permeable soils formed in sandy alluvial deposits. These soils are common on river flood plains and low stream terraces adjacent to other weakly developed Haplustolls and Ustifluvents of variable texture. Schaller is similar to the Telfer series except that Schaller's control section is composed of coarser materials, including gravel. This series is found in complex with these similar soils and was not mapped separately. Slopes are commonly near level, although cutbanks and terrace breaks frequently occur.

The mollic A-horizon materials averaged 8 inches and were immediately underlain by coarse textured alluvial parent materials in most profiles. Subsoil is likely suitable for salvage, but may have less suitable materials at depth in some profiles. The recommended average subsoil salvage depth is 36 inches.

Sen (SN)

Taxonomic Description: Fine-silty, mixed, superactive, frigid Typic Haplustolls

Taxadjuncts: Profiles with slightly coarser materials at depth; some silty, but fine-loamy profiles

The Sen series consists of well drained, moderately permeable soils that formed in calcareous siltstone or shale. They are moderately deep to soft bedrock and occur on residual uplands with slopes ranging from 1 to 6 percent. Associated soils include the Farland series (argillic) and similar fine-loamy and fine textured soils. Many of the control textures, including that of the typical pedon,

are on the borderline between fine loamy and fine-silty. As a result, some misclassification to Amor may have occurred. This is not expected to significantly affect interpretations or use of this survey.

Many profiles had silty textures that were on the borderline between fine-loamy and fine silty. Many of these profiles may have been misclassified as Sen due to errors in the field estimation of texture. However, these profiles were not all reclassified where delineation of similar soils dominated by silt loam or silty clay loam soils is present.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 12 and 16 inches, respectively, for a total of 28 inches of salvageable materials. Bedrock contact limits salvage opportunities in all profiles at depths of 20 to 40 inches below ground surface.

Shambo (SO)

Taxonomic Description: Fine-loamy, mixed, superactive, frigid Typic Haplustolls

Variants: Profiles with saline/sodic substrata

Taxadjuncts: Profiles with thick (pachic) mollic epipedons

The Shambo series consists of deep and very deep, well drained, moderately permeable soils that formed in calcareous alluvium mainly from soft sandstone, mudstone and shale. These soils are on terraces and fans along the river valleys and are also found on upland slopes and in upland swales. Slopes commonly range from 0 to 8 percent. This series often occurs on terraces of the South Branch Heart River and tributaries. Associated soils include the Cherry (inceptisol not separately delineated) series, Arnegard (pachic) series, and Ustifluvents and Entic Haplustolls with variable textures.

The subsoil horizons of this series are slightly more yellow than otherwise allowed by the official series description. These materials often differ chemically as well. The salinity and sodicity of highly reactive substratum on river terraces limits salvage in these areas. These unsuitable materials occur immediately below the darker A and upper B horizons, which, in contrast, have limited reactivity.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 11 and 23 inches, respectively, for a total of 34 inches of salvageable materials. The suitability of the normal Shambo series is not typically limited by chemical or physical properties and approximately one-third of the profiles observed (in

upland positions) had salvageable materials to a depth of 60 inches. Approximately 10 percent of these upland profiles had bedrock contact at an average depth of 47 inches.

The majority of this series occurs on river terraces were high EC and SAR limit salvage of the substratum. In consideration of this, many delineations of Shambo and these other similar soils were determined not to have suitable Lift 2 materials below an average depth of 20 inches. These unsuitable materials are most commonly encountered along the South Tributary where it drains the Little Badlands to the south of the Study Area.

Stady (SY)

Taxonomic Description: Fine-loamy over sandy or sandy-skeletal, mixed, superactive, frigid Typic Haplustolls

Taxadjuncts: Profiles with bedrock contact within 60 inches

The Stady series consists of very deep, well drained soils moderately deep to sand and gravel. Permeability is moderate in the upper horizons and very rapid in the 2Bk and 2C horizons. These soils formed in loamy alluvium over sand and gravel on river terrace remnants.

The Stady series occurs infrequently in the Study Area and is commonly mapped as an inclusion of units dominated by the Manning series. In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 9 and 19 inches, respectively, for a total of 28 inches of salvageable materials. Salvage is frequently limited by the presence of visible salts or coarse fragment content at average depths of 14 and 21 inches, respectively. Profiles with bedrock contact were commonly associated with delineations of the Cabba series.

Straw (SW)

Taxonomic Description: Fine-loamy mixed, superactive, frigid Cumulic Haplustolls

Taxadjuncts: None noted

The Straw series consists of very deep, moderately well and well drained soils that formed in alluvium. These soils are on floodplains, stream terraces and drainage ways with slopes ranging from 0 to 3 percent. This series occurs very infrequently and was mapped in conjunction with the Arnegard series.

Tally (TY)

Taxonomic Description: Coarse-loamy, mixed, superactive, frigid Typic Haplustolls

Taxadjuncts: None noted

The Tally series consists of very deep, well drained soils that formed in material derived from alluvial or eolian deposits. The series commonly occurs on remnant high river terraces, swales, and leeward, (often east-facing) locations with slopes ranging from 1 to 10 percent. Associated series include the Parshall (deep, pachic) and Vebar (moderately-deep) series and other similar fine-loamy series.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 10 and 40 inches, respectively, for a total of 50 inches of salvageable materials. Most profiles do not have limiting characteristics. However, some profiles have high coarse fragment content or salt content at depth.

Telfer (TR)

Taxonomic Description: Sandy, mixed, frigid Fluventic Haplustolls

Taxadjuncts: None noted

The Telfer series consists of very deep, excessively drained, rapid or very rapidly permeable soils formed in sandy alluvial deposits. These soils are common on river flood plains and low stream terraces adjacent to other weakly developed Haplustolls and Ustifluvents of variable texture. Telfer is similar to the Schaller series except that Telfer's control section is composed of fine sands. This series is found in complex with these similar soils and was not mapped separately. Slopes are commonly near level, although cutbanks and terrace breaks frequently occur.

The mollic A-horizon materials averaged 8 inches and were immediately underlain by coarse textured alluvial parent materials in most profiles. Subsoil is likely suitable for salvage, but may have less suitable materials at depth in some profiles. Materials are likely suitable for salvage to depths of 60 inches in most profiles.

Trembles (TS)

Taxonomic Description: Coarse-loamy, mixed, superactive frigid Typic Ustifluvents

Taxadjuncts: None noted

The Trembles series are very deep, well and moderately well drained soils formed in alluvium. These soils are commonly found on river terraces in association with other sandy, fine, and fine-loamy Ustifluvents including Banks, Lohler, and Havrelon. This series is found in complex with these similar soils and was not mapped separately. Slopes are commonly near level, although cutbanks and terrace breaks frequently occur.

The average Lift 1 thickness for the Trembles series is 7 inches. The suitability of subsoil for salvage is dependent on the characteristics of the delineations in which it occurs. The official series description for this series does not identify any limiting characteristics. However, this series is often found in association with the saline and sodic substrata of select Fluvent and Havrelon map units. In these units, the salvage of the subsoil material is not recommended. Where this series is found in association with more suitable soils, salvage to a depth of 60 inches is possible.

Vebar (VR)

Taxonomic Description: Coarse-loamy, mixed, superactive, frigid Typic Haplustolls

Taxadjuncts: Ochric epipedons

The Vebar series consists of well drained, moderately deep, moderately rapidly permeable soils that formed in residuum weathered from soft calcareous sandstone. This series is commonly found on ridges and adjacent areas with slopes commonly ranging from 3 to 10 percent. Associated soils include similar fine-loamy and entic soils with moderate depths to bedrock. Similar soils with ochric epipedons occurred infrequently and were included as taxadjuncts.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 7 and 20 inches, respectively, for a total of 27 inches of salvageable materials. Bedrock contact limited salvage to an average depth of 27 inches in the vast majority of the profiles observed. Visible salts found at an average depth of 28 inches limited salvage opportunities at depth in some slightly deeper profiles.

Velva (VA)

Taxonomic Description: Coarse-loamy, mixed, superactive, frigid Fluventic Haplustolls

Taxadjuncts: Profiles with saline and/or sodic substratum; fine textures

The Velva series consists of very deep, well drained, moderately or moderately rapidly permeable soils that formed in alluvium. These soils are common on river flood plains and low stream terraces adjacent to other weakly developed Haplustolls and Ustifluvents of variable texture. This series is found in complex with these similar soils and was not mapped separately. Slopes are commonly near level, although cutbanks and terrace breaks frequently occur.

The mollic A-horizon materials averaged 9 inches and were immediately underlain by light colored alluvial parent materials in most profiles. In some of the profiles observed the substratum is very light colored and violently effervescent and is expected to be unsuitable due to high EC or SAR. The color and reaction of the substratum are expected to be good indicators of suitability. In some delineations, no subsoil (Lift 2) salvage is recommended. In other areas, salvage is not recommended beyond a depth of 30 inches due to the potential presence of saline or sodic materials.

Wabek (WK)

Taxonomic Description: Sandy-skeletal, mixed, frigid Entic Haplustolls

Taxadjuncts: None noted

The Wabek series consists of very deep, excessively drained, rapid or very rapidly permeable soils formed in sand and gravel deposits. These soils infrequently occur on high river terrace remnants adjacent to other weakly developed Haplustolls and Ustifluvents of variable texture. Wabek is similar to the Schaller series except that Wabek's control section contains more than 35 percent coarse fragments. This series is found infrequently as inclusions of the Manning and Cabba map units series and was not mapped separately.

The mollic, and often calcareous, A-horizon materials averaged 7 inches and were immediately underlain by skeletal materials in most profiles. Subsoil was generally considered unsuitable for salvage due to the coarse texture and associated low water holding capacity. Although calcareous, the A-horizon can likely be considered Lift 1 materials to be mixed with adjacent non-calcareous materials during salvage.

Wayden (WN)

Taxonomic Description: Clayey, smectitic, calcareous, frigid, shallow Typic Ustorthents

Taxadjuncts: Moderately deep with shallow depths to salt; profiles with mollic epipedons

The Wayden series consists of well drained, slowly permeable soils that formed in soft alkaline shales. The series occurs on residual hill slopes, ridge tops, and crests with slopes ranging from 1 to 16 percent. These soils are typically shallow (10 to 20 inches) to soft shale, but slightly deeper taxadjuncts were included where salts limited salvage depths to well under 20 inches. Similar soils with mollic epipedons are also included with this series.

In the Study Area, the Lift 1 and Lift 2 thicknesses averaged 6 and 7 inches, respectively, for a total of 13 inches of salvageable materials. Bedrock contact limited salvage to an average depth of 14 inches in over 80 percent of the profiles observed. Visible salts at an average depth of 10 inches limit suitability for salvage in the remaining profiles. Some delineations have salts and bedrock at such shallow depths that no material is suitable for salvage.

2.4.5.3 Delineations and Map Units

A total of 47 soil map units and 4 miscellaneous units were developed as part of the survey effort. The soil units occur across 402 separate delineations within the Permit Boundary (not including separate units identified as miscellaneous areas). The soil map produced by this survey is shown on Figure 2.4-2A, Figure 2.4-2B and Figure 2.4-2C where each delineation is assigned the appropriate map unit symbol. The miscellaneous groups are color shaded to denote the distribution of areas where current and historic uses and water bodies would affect suitability for salvage.

Descriptions of the various map units are provided in Table 2.4-4. This table provides the map unit symbol (MUSYM), map unit name, range and average for slope and Lift 1 and Lift 2 thicknesses, dominant components, factors limiting salvage, landform, inclusions, capability classification, and ecological site for each unit. The range for slopes and lift recommendations were determined through geographic information system analysis of all delineations in the Study Area (including areas outside the Permit Boundary). The range was determined to be all values within one standard deviation of the mean.

The extent of each map unit's occurrence within the Permit Boundary is presented in Table 2.4-5. This data has been further summarized by landowner as presented in the Land Use section, Appendix 2.7.1-1. The acreage for the wetland water regime and hydromorphic classifications are provided in the Wetlands Section 2.10-1. Acreage calculations for vegetation mapping units by landowner are presented in the Vegetation Section 2.7.2. A summary of salvageable volume is presented in Section 4.1.

2.4.5.4 Observation Points and Salvage Recommendations

The findings at each observation point, including sample locations, are presented in Table 2.4-6. The table presents the site identification (Site ID), site coordinates (i.e., easting and northing), series classification (including notation of variants and taxadjuncts), notation of whether lab data is available, recommended salvage lifts at each location, and the factor limiting salvage in each profile (where noted). The sites are presented in numeric order according to their site identification.

2.4.5.5 Prime Farmlands

A review of the soil survey update for Stark County (NRCS, 2007a) reveals that no prime farmlands are present within the Permit Boundary.

2.4.5.6 Hydric Soils

Hydric soils within the Permit Boundary include the Dimmick, Lallie, Harriet, and Hoven series and similar soils of minor extent. The Dimmick and Lallie series were mapped as a complex, while the Harriet and Hoven series were mapped together with similar salt affected and generally wet soils as a more diverse Wet-Saline map unit. These hydric soil units usually occur along river and stream channels and in association with reservoirs and upland seeps and springs. No hydric soils were found in upland positions away from these easily recognizable water sources. The occurrences of these series are further noted in the map unit descriptions in Table 2.4-4.

A detailed report of wetlands, which include areas with wetland vegetation, wetland hydrology, and hydric soils, is presented in Wetlands Baseline Study Report (Section 2.10-1) of this permit application. Differences between wetland delineations and hydric soil units in part reflect the relative difference in the intensity (precision) of the survey methods. All wetlands were delineated regardless of size, whereas small delineations of hydric soils are present as inclusions in larger units partially or

mostly comprised of non-hydric soils. Other significant differences reflect the consideration of vegetative and hydrologic characteristics when delineating wetlands, which exclude areas not meeting all wetland criteria. The Wetland Baseline Study Report (Section 2.10-1) is the more precise reference regarding the distribution and extent of hydric soils where these additional criteria are also met.

TABLES

FIGURES

APPENDIX 2.4-1

LABORATORY REPORTS FOR ALL SAMPLE SITES

APPENDIX 2.4-2

TYPICAL SOIL SERIES PEDON DESCRIPTIONS