GEOLOGY of the JAMESTOWN, BLOOM, and SPIRITWOOD LAKE QUADRANGLES, STUTSMAN COUNTY, NORTH DAKOTA

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ABSTRACT

The surface geology of the Jamestown, Bloom, and Spiritwood Lake quadrangles is dominated by sediments and landforms of the last two (Late Wisconsinan) glacial advances. Much of the map area consists of a gently rolling till plain, with transverse marginal ridges and eskers indicating ice retreat to the northwest. Parts of three meltwater channels dissect this plain and expose much older glacial deposits and gray shales of the Cretaceous Pierre Formation. The Kensal end moraine, deposited by ice that advanced from the northeast, defines the eastern margin of the map area.

The accompanying 1:24,000 scale (1" = 2,000') geologic maps display four elements of the surface geology: sediment type, morphology, age, and origin. The maps emphasize sediment types that directly underlie the soil horizon, and so complement existing soil maps.

Five lithostratigraphic units (tills) were characterized based on grain size (% sand, silt, and clay) and coarse sand lithology (% crystalline, carbonate, and shale rock fragments). The percentage of shale in the coarse sand fraction, in concert with stratigraphic position, geomorphic expression, and the physical characteristics of joints, compaction, and staining, have proven most useful in till identification and correlation. A strong correlation exists between lithostratigraphic units so defined and morphostratigraphic units apparent on aerial photographs.

The principal mineral resources of the Jamestown - Spiritwood Lake area are sand and gravel, and groundwater. Sand and gravel deposits are abundant though restricted to meltwater channels; they have a relatively high though widely variable shale content. Buried meltwater channels, including the Stutsman diversion channel and the channel that contains the North Aquifer, contain significant groundwater reserves.

Landslides, shoreline erosion, flooding, and abandoned sand and gravel pits are the principal geologic hazards in the three-quadrangle area. Landslides alone caused significant damage in 1993. Most occurred as relatively small rotational slumps where slopes have been modified by undercutting or improperly placed fill.

INTRODUCTION

This report and maps are the first in a new NDGS mapping program whose principal objective is to produce 1:24,000 scale multi-purpose geologic maps and reports of the State's major urban, recreational, and other critical areas. Like the NDGS Atlas Series maps (1:250,000), this "new generation" of maps display four elements of the surface geology: sediment type, morphology, age, and origin. The maps emphasize sediment types that directly underlie the soil horizon, and so complement existing soil maps.

Sediment type and morphology are descriptive elements, whereas age and origin are interpretative. Sediments of similar lithology are represented by map units of the same basic color. All sand and gravel units, for example, are a shade of yellow, regardless of their interpreted age or origin. The morphology of the map area - for example, terraces, sinuous or arcuate ridges, or steep valley walls - is shown by contour lines on the topographic base map. An inset map shows major geomorphic features of the area and lists common landforms found in each.

The age and origin of the sediments (interpretative elements) are shown by the use of map unit symbols. For example, a sand and gravel unit may have been deposited in contact with glacial ice (Qe, Qk) or in modern river channels (Qa, Qa_1, Qa_2, Qa_3). The correlation diagram shows the relationships between sediment type, age, and origin.

The Jamestown, Bloom, and Spiritwood Lake quadrangles lie in the glaciated plains of eastern North Dakota (Figure 1). The surface geology of these quadrangles is dominated by landforms and sediments of the last two Late Wisconsinan glacial advances. Parts of three major meltwater channels - the James River, Pipestem Creek, and Sevenmile Coulee - dissect the area and expose much older glacial deposits and the Cretaceous Pierre Formation bedrock. At least four tills were observed in the three-quadrangle area, and one or more tills are known to be present at depth in the Stutsman diversion channel.

Methods

This map is the result of fieldwork during the summer of 1993. Mapping was done directly on the topographic base maps with the aid of black and white aerial photographs taken in 1957 (1:20,000) and 1990 (1:41,000). Where exposures were poor, a soil probe and hand auger was used for sampling. Several hundred shallow (5 to 20 feet deep) borings were made in such areas. A Mobil Drill 8-inch hollow-stem auger were used for nearly continuous shelby tube sampling of six deeper test holes (Appendix I). Sample color descriptions generally follow that of the Geological Society of America's Rock-Color Chart (Goddard, et al., 1979), except where

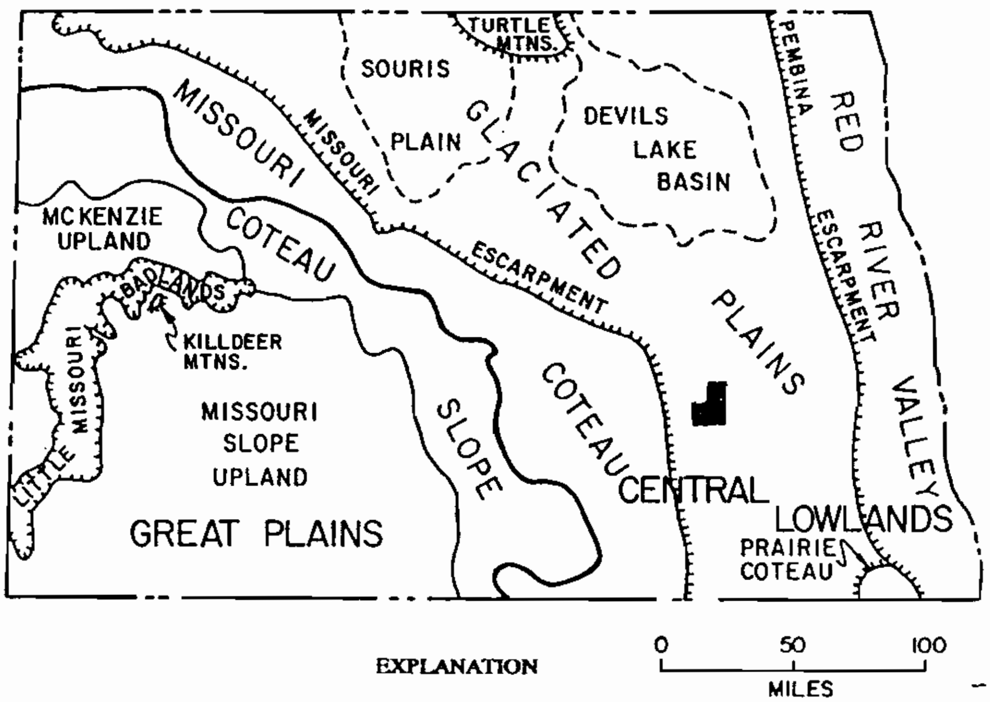

Figure 1. Physiographic regions of North Dakota, showing the location of the Jamestown, Bloom, and Spiritwood Lake quadrangles (shaded). The glaciated plains are a gently rolling or locally hilly glaciated landscape. From Bluemle (1991).

less bulky or less precise descriptions are needed. Grain size classification follows that of the modified Wentworth scale. Figure 2 explains Township, range, and section designations.

Till characterization was based on grain size (% sand, silt, and clay) and coarse sand lithology (% crystalline, carbonate, and shale rock fragments). In all, 127 mostly near-surface samples were analyzed for the parameters above using a cluster analysis program developed by Harris (1987) (Appendix II). Here, the percentage of shale in the coarse sand fraction, in concert with stratigraphic position, geomorphic expression, and the physical characteristics of joints, compaction, and staining, have proven most useful in till identification and correlation.

Test boring and well driller's logs used as control points for the bedrock topographic map (Plate VI) are available at the NDGS. Some can also be found in Huxel and Petri (1963) and Wald and Christensen (1986). Most well driller's reports were not used due to uncertainties in location and inadequate lithologic descriptions.

Previous Geologic Investigations

Winters (1963) provided the first modern, intermediate-scale geologic map (1:125,000) of the Jamestown, Bloom, and Spiritwood Lake quadrangles in his larger study of Stutsman County. That report, and others like it in the NDGS county bulletin series, formed the basis of the state geologic map (1:500,000) by Clayton et al. (1980). Winters (1960) also reported in more detail on the geology and geomorphology of the Jamestown, Bloom, Spiritwood Lake, Fried, Ypsilanti, and Homer quadrangles.

Earlier geologic investigations include those of Caine and Kocher (1904), who mapped soils of the Jamestown area; Willard (1909), who provided geologic, topographic, and water resource maps of parts of Stutsman, LaMoure, Barnes, and Ransom Counties (1:125,000); Simpson (1929), who reported on groundwater resources of North Dakota, including the Jamestown area; the U.S. Bureau of Reclamation, which in 1957 reported on the geology of the Jamestown Dam site; Huxel and Petri (1963a, 1963b), who reported on groundwater resources of Stutsman County; Schulte (1972), who reported on the groundwater of the Spiritwood Lake area; Wald and Christensen (1986) and Christensen and Miller (1988) who studied groundwater of the Jamestown area as well as areas farther south; Olson and Greer (1994) who reported on the Jamestown landfill; and the USDA Soil Conservation Service, which recently mapped the soils of Stutsman County.

Holland (1957) prepared a general interest guidebook and roadlog for the area surrounding Jamestown. Clayton and Freers (1967) provided a similar though more technical roadlog to the geology of the Missouri Coteau southwest of Jamestown, and made

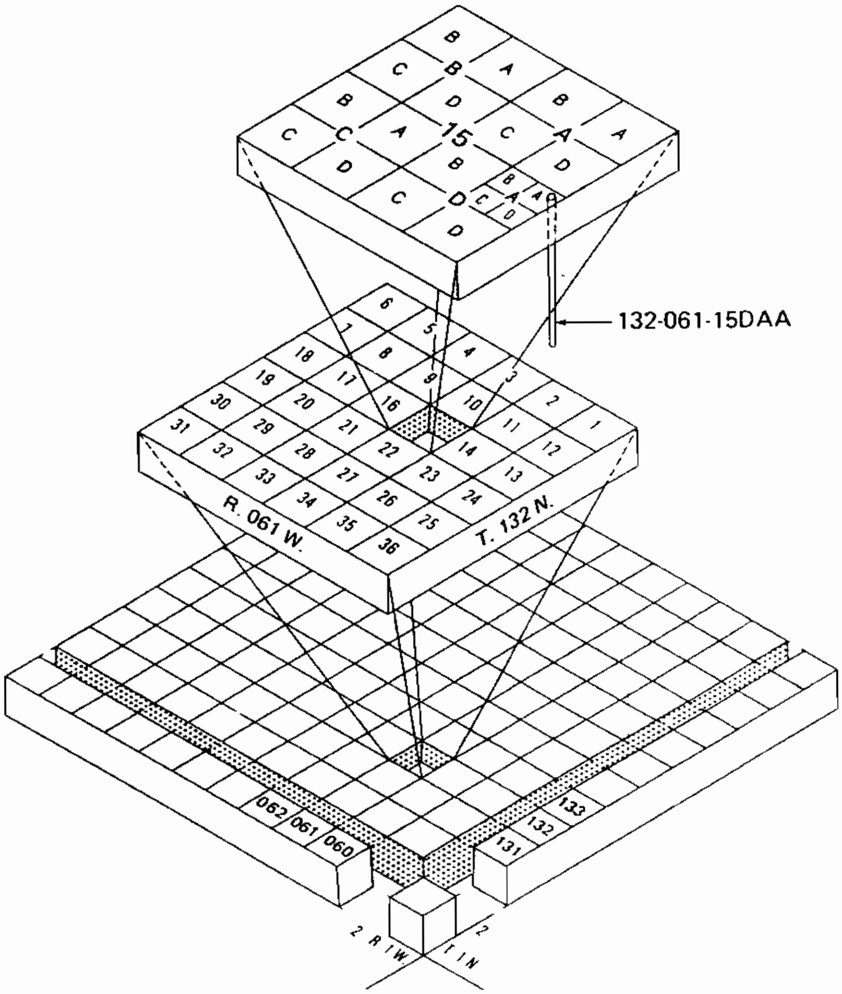

Figure 2. System of numbering wells, test holes, and outcrop locations.

reference to the glaciated plains south and west of Jamestown. Bluemle (1988) provided a general interest guidebook and roadlog to the geology of south-central North Dakota, including the Jamestown area.

STRATIGRAPHY

A total of one bedrock unit, five glacial-sediment units, four river-sediment units, one lake-sediment unit, two mass-wasting units, and one artificial-sediment unit have been mapped. Descriptions of these units follow. For a discussion of older, buried bedrock formations see Bluemle (1991), Winters (1963), or one of the many NDGS Bulletins or Reports of Investigation that deal with these units in the Williston Basin.

PIERRE FORMATION

The Pierre Formation consists of up to 2,300 feet of gray shale deposited in an offshore marine environment (Gill and Cobban, 1965). In the Pembina Hills, four members are recognized (from youngest to oldest):

Odanah Member	gray, hard, siliceous, noncalcareous shale;
DeGrey Member	dark gray, flaky, noncalcareous shale with ironstone concretions;
Gregory Member	dark gray to yellowish, soft, slightly calcareous to marly shale and claystone;
Pembina Member	grayish brown, soft, noncalcareous shale with yellowish streaks of jarosite and gypsum-encrusted phosphate nodules. Highly organic in middle part, with montmorillonitic clay beds at base.

Beds equivalent to the Gammon Ferruginous Member - gray mudstone with calcareous and ferruginous concretions - may be present in the Pembina Hills. Gill and Cobban (1965) also recognized the Pembina, Gregory, and DeGrey Members in the Valley City - Fort Ransom area. Exposures in the Jamestown area seem best to fit the description of the DeGrey Member. The Pierre Formation is probably about 500 feet thick in the Jamestown area (Winters, 1963), although there is considerable relief on the bedrock surface (see Figure 17).

For want of sufficient exposures, detailed stratigraphic studies of the Pierre Formation were not undertaken in the Jamestown area. What follows is a brief description based principally on field observations in the James River Valley. For a detailed account of the Pierre Formation, readers are encouraged to review Gill and Cobban (1965) and Schultz et al. (1980).

In the greater Jamestown area, the Pierre Formation is exposed along the shores of Jamestown Reservoir and Pipestem Lake, and for a short distance south of these two reservoirs. Smaller, mostly disrupted exposures can be found in the Spiritwood Lake area. Most Pierre Formation exposures are restricted to wave-cut banks several feet in height; smaller exposures crop out sporadically through a colluvial cover (Figure 3a). There is often a subtle break in slope at the contact of the Pierre Formation with overlying glacial sediments. The best exposures are generally found along the east side of the reservoirs, probably due to prevailing northwest winds and hence greater erosion. Two of the best Pierre Formation exposures are in 140-64-13bac (Figure 3b), and 141-63-31abb.

Where mapped, the Pierre Formation consists of medium-light gray (N6, dry) to light olive gray (5 Y 6/1, dry), fissile, flaky, noncalcareous shale. Locally it is blocky in outcrop, although it invariably weathers to thin flakes. Where a colluvial cover is thin or absent, the Pierre Formation weathers to sparsely vegetated slopes of small shale flakes. The shale is highly jointed, with iron-manganese stains common on joint surfaces, but no consistent joint pattern was observed. Joints are occasionally healed with coarsely crystalline calcite or iron-manganese oxides. Bedding is generally poorly developed and obscured by the fissile character of the shale.

Concretions are common and occur along selected horizons. They are oblate in shape and commonly about 1 foot in diameter. The most conspicuous feature of these concretions is their weathered rind of moderate yellowish brown (10 YR 5/4, dry) to brownish black (5 YR 2/1, dry) iron-manganese oxides (probably limonite and siderite). The interiors of the concretions are normally massive, light olive gray (5 Y 6/1, dry) micrite, or, rarely, a similarly colored calcareous mudstone. They are harder than the enclosing shale, but like the shale are also jointed, and so tend to form broken piles when weathered. Fragments of *Baculites* sp. were found in several of the concretions, but were too poorly preserved to be further identified. Poorly preserved trace fossils and fossil fragments are also apparent.

A single, thin (about 1/2 inch thick) bentonite bed was observed in 140-64-13bdc (elevation about 1440 feet)(see Figure 3d), and a bentonite bed approximately 2 inches thick was observed near the base of a new roadcut in 140-64-24cca (elevation about 1410 feet)(Figure 4). Both beds are grayish yellow (5 YR 8/4) when wet, locally mottled light olive gray (5 Y 6/1) to olive gray (5 Y 4/1), and have a waxy luster. Iron-manganese stains are common within the bentonite.

A recently exhumed, wave-washed exposure of Pierre Formation shale (140-64-13bdc) revealed prominent box-like joints healed by iron-manganese oxides (Figures 5a, 5b). The staining is most prominent on horizontal joints where it grades from a one -

Figure 3a. Wave-eroded exposures of Pierre Formation shale. Note break in slope (just below houses on horizon) at the contact of undisturbed glacial sediment with the Pierre Formation. Most of the Pierre Formation is concealed beneath a colluvial cover. Looking south along east shore of Jamestown Reservoir from 140-64-1caa.

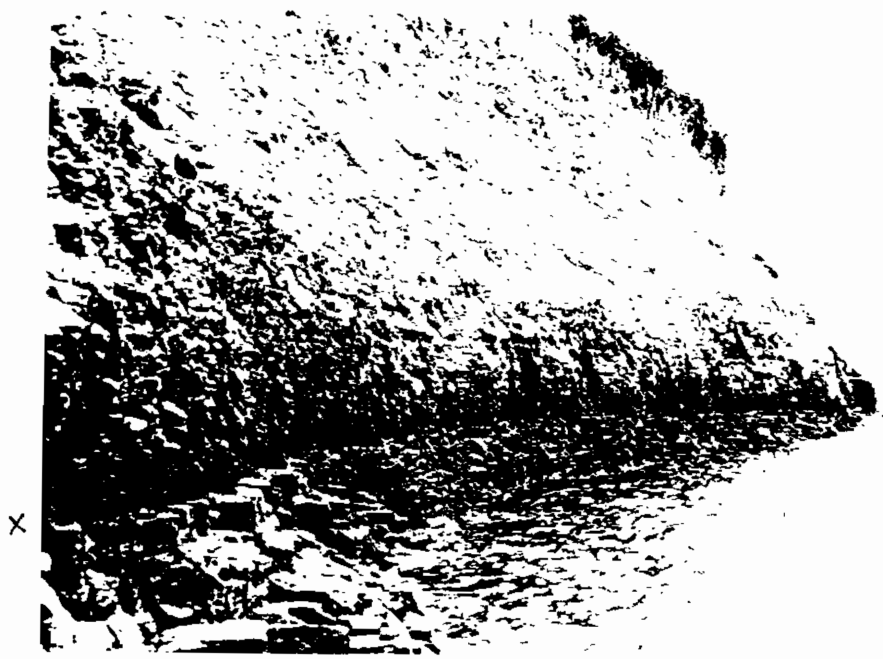

Figure 3b. Wave-eroded Pierre Formation exposure in 140-64-13bac. A one-half inch thick bentonite bed occurs at "x". Exposure is about 20 feet high.

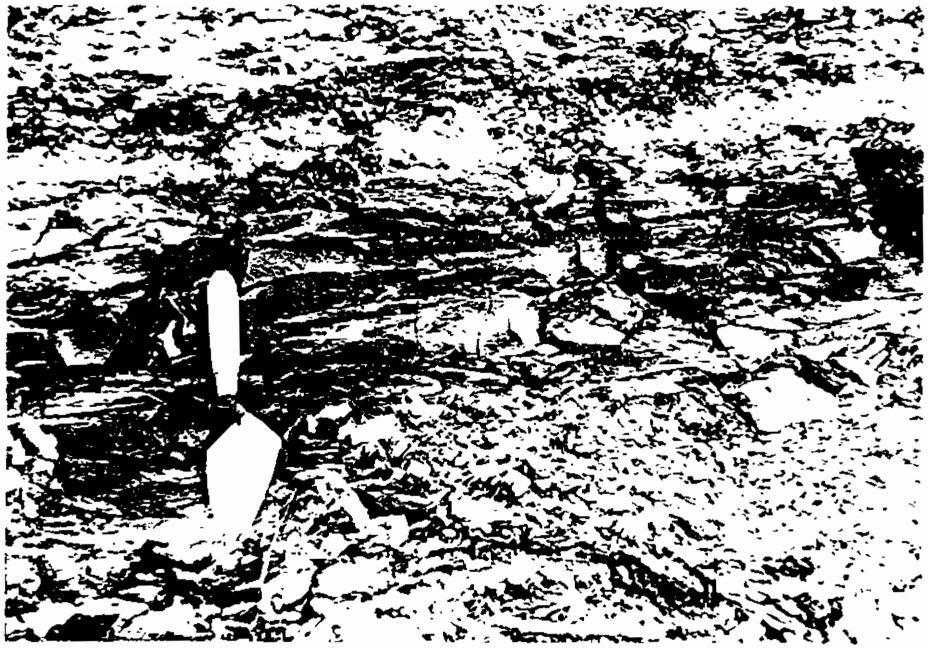

Figure 4. A two-inch-thick bentonite bed exposed in a new roadcut in 140-64-24cca.

Figure 5a. Box-like network of joints healed by iron-manganese oxides. Recently exhumed wave-washed exposure is located in 140-64-13bdc. Lens cap in left foreground is about 3" in diameter.

millimeter thick crust to rows of "dots" of equal thickness.

At three locations (140-64-3cdc; 140-64-13ccb; and 140-64-24bdb), apparently at the contact of Quaternary sediments with the Pierre Formation, a calcite-cemented zone is present. These zones are thin (ranging from a few inches to about one foot in thickness) and are traceable along strike for only a few tens of feet. They consist of recemented shale fragments, locally with sand and gravel, and likely formed at zones of groundwater discharge (Figure 6). At 140-64-24bdb, again at the top of the Pierre Formation, small (to 4 inches long), irregularly shaped, white, limy, sandy nodules were found. The sand and fine pebbles appear to float in a fine-grained calcite matrix.

Essentially horizontal bedding of the Pierre Formation is locally gently to severely deformed, probably due to action by glacial ice. In 140-64-13bdc, wave-erosion has revealed exposures of contorted bedrock cut by thrust and reverse faults (Figure 7). In 140-64-24cca, bedrock exposed midway up a new roadcut strikes N40W and dips 30N, while lower in the section essentially horizontal bedding has been displaced about one foot to the south along an east-trending normal fault; the apparently intervening thrust fault was concealed. In the Spiritwood Lake area (142-63-36dad), Pierre Formation exposures appear to have been thrust in place, but exposures are insufficient to determine exact relationships. Elsewhere, outcrops of the Pierre Formation often show evidence of frost heaving.

COLEHARBOR GROUP

All glacial deposits in North Dakota are included in the Coleharbor Group. For a discussion of Coleharbor Group nomenclature, see Bluemle (1971) and Clayton (1972).

Undisturbed Glacial Sediment

Undisturbed glacial sediment - till that has not been significantly modified by glacial thrusting or subsequent erosion - is the most widespread map unit in the Jamestown, Bloom, and Spiritwood Lake quadrangles. It consists of unsorted, unbedded, pebbly sand, silt, and clay with abundant cobbles and boulders deposited by glacial ice. Generally the upper 15 to 20 feet is oxidized to a moderate yellow brown (10 YR 5/4, moist), although it is often mottled light gray (N7, moist). Unoxidized tills are generally olive gray (5 Y 4/1, moist) to olive black (5 Y 2/1, moist).

Four distinct lithostratigraphic units, or tills, are recognized in exposures in the Jamestown, Bloom, and Spiritwood Lake quadrangles. The composition and physical properties of these

Figure 5b. Close-up of joints in Figure 5a. Note two parallel, inch-wide bands of iron-manganese oxides that grade outward to discrete clumps. This crust of iron-manganese oxides is about one millimeter thick on horizontal joints.

Figure 6. Calcite-cemented zone at the contact of undisturbed glacial sediment with the Pierre Formation (140-64-3cdc). This zone is about one foot thick and is traceable along strike for only a few tens of feet. It likely formed at a zone of groundwater discharge.

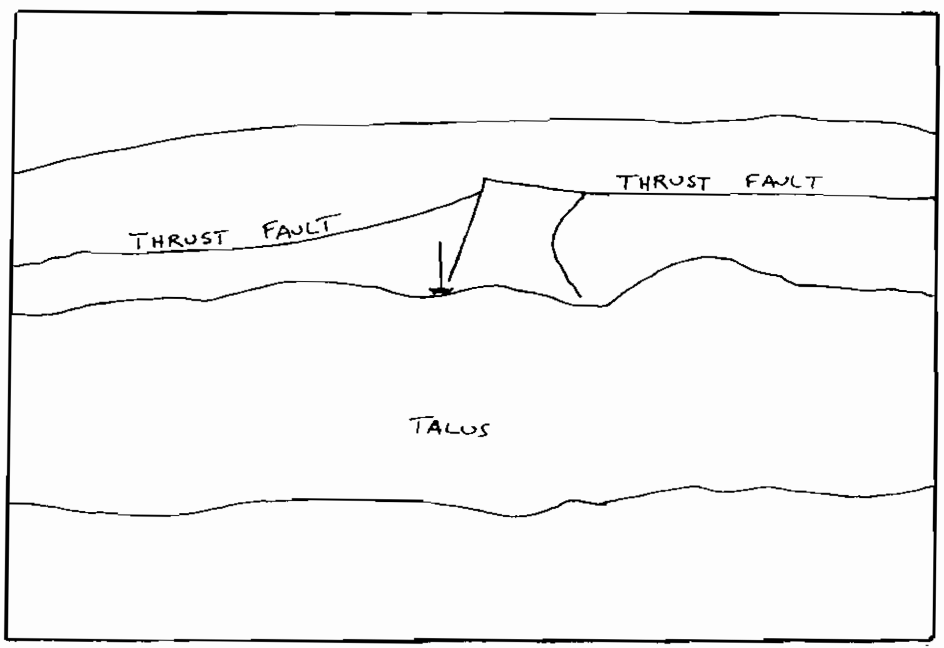

Figure 7. Exposure of deformed Pierre Formation shale in 140-64-13bdc. Pick handle near center of photo is 30" long.

tills vary considerably, from a relatively soft, shale-poor till to a very compact, jointed, shale-rich till stained by iron-manganese oxides. Using the Unified Soil Classification System, most of this map unit would be classified CL; using USDA terminology, most would be classified as a loam, silty loam, or clay loam. Characteristics of these four lithostratigraphic units are discussed on page 24.

At the surface, this unit contains small, discontinuous sand and sand and gravel deposits that, because of their size, poor exposure, and poor expression, could not be mapped at this scale. Such deposits are most common near the James River, Pipestem Creek, and Sevenmile Coulee valleys (within the area defined as the outer channel). These deposits formed during the initial stages of formation of those meltwater valleys, before the main channel was fully developed (see page 35). In addition, very fine to fine sand forms the core of the transverse lineation in 140- 64-3dda, and in 140-63-5aab, 25 feet of mostly fine to medium sand was found to underlie 5 feet of slough sediments. In the Bloom quadrangle, in 140-63-34abb, 12 feet of undisturbed, laminated silt of probable lacustrine origin was found, and in 140-63-36aaa, test borings revealed about 23 feet of mostly fine sand. None of these deposits could be traced laterally and so they have not been mapped. They do, however, indicate that this map unit is complex and that other isolated deposits of silt, sand, and sand and gravel doubtless are present.

The surface of this unit forms a gently undulating plain in the greater Jamestown area, and conspicuously hillier topography in the Spiritwood and Spiritwood Lake areas. These topographic differences arise from deposition by different ice advances (see pages 35 and 36)(Clayton, et al., 1980).

River-eroded Glacial Sediment

River-eroded glacial sediment has been mapped along the Pipestem, James, and Sevenmile Coulee River valleys. It consists principally of undisturbed glacial sediment (till) that has been eroded by meltwater rivers. This unit forms steep valley walls (see Figure 3b). The contact of this unit with adjacent units at higher elevation is gradational and necessarily somewhat arbitrary. In most cases it has been drawn to coincide with a sharp break in slope, above which comparatively minor erosion has taken place.

A veneer of river, colluvial, and slopewash sediment is commonly present. Small, discontinuous patches of sand and gravel can be found on promontories, and where extensive, these have been mapped as Qal_3. Glacial erratics are concentrated at the surface of this map unit, particularly along promontories; intervening swales contain fine-grained colluvial and slopewash debris (Figure 8).

Lake-eroded Glacial Sediment

Lake-eroded glacial sediment has been mapped in the Bloom and Spiritwood Lake quadrangles. It consists of undisturbed glacial sediment (till) that has been eroded by wave action along the shores of small lakes. This unit forms planar surfaces that slope gently lakeward. The contact of this unit with adjacent units at higher elevation is sharp and corresponds to the maximum high water level. It is usually marked by a ring of glacial erratics that form natural rip-rap along the shoreline.

A veneer of lake and slough sediment is commonly present (Figure 9). Locally, beach berms, beach cusps, and spits are well developed.

Palimpsest Glacial Sediment

Two portions of Sevenmile Coulee in the Spiritwood Lake quadrangle, and an area southwest of Rush Island Lake in the Bloom quadrangle, contain glacial sediment (till) of the Kensal ice advance deposited over and only partly obscuring river channel sediments (sand and gravel). The original extent and shape of the buried channels are still apparent, hence the term "palimpsest," meaning to partly conceal. The till in the northern blocked stretch of Sevenmile Coulee is probably about 60 feet thick; that in the southern stretch about 25 feet thick, and that southwest of Rush Island Lake probably about 25 feet thick.

Ice-thrust Glacial Sediment

Rush Island Lake and the adjacent hill to the southwest form what is often called a hill-hole pair. This hill consists of glacial sediment that was thrust, as a single block or series of blocks, into place by glacial ice. It probably consists mostly of till, but may contain river channel sediment as well. Rush Island Lake occupies the depression from which the sediments came.

Ice-contact Stream-channel Sediment

Ice-contact stream-channel sediment consists of sand and gravel deposited in contact with glacial ice. These sediments are usually more poorly sorted than glacial outwash or river channel sediment and may contain blocks of till. All exposures observed contained significant amounts of shale, usually in excess of 25% by volume. The contact with adjacent sediments is typically sharp and was based on topography. This unit was deposited by meltwater streams flowing within, on, or under glacial ice (eskers) or at or near the ice margin (kames)(Figures 10a, 10b). These sediments are up to 30 feet thick.

Figure 8. Glacial erratics concentrated at the surface of river-eroded glacial sediment. Looking northeast to 140-64-1ccc.

Figure 9. Veneer of shoreline sediment over shale of the Pierre Formation (140-64-1ccb). Similar deposits occur over lake-eroded glacial sediments.

Figure 10a. Looking southwest at esker in 141-63-21dd. Steep, rocky surface precludes cultivation.

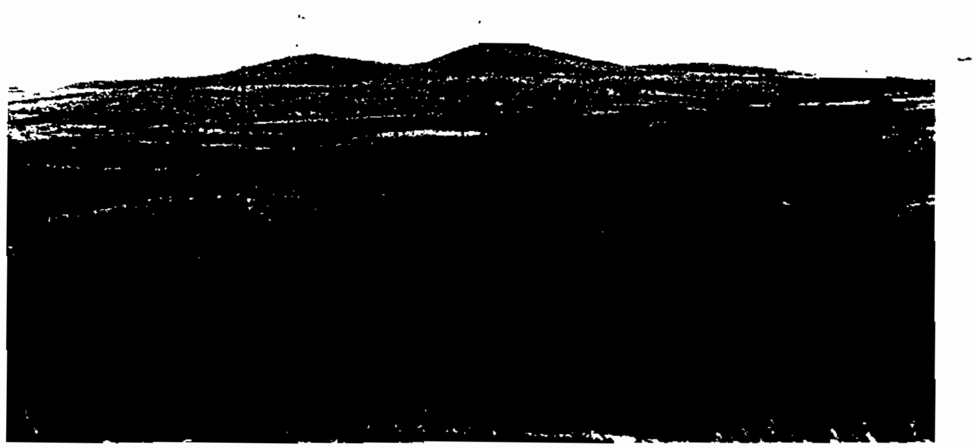

Figure 10b. Looking southeast at two prominent kames in 141-63-1.

River Channel Sediment

Two groups of Pleistocene river channel sediment have been mapped in the Pipestem Creek, James River, and Sevenmile Coulee valleys: High-level terraces, consisting of a thin veneer of sand and gravel deposited over till (Qa_3); and lower-level terraces near the channel bottom (Qa_2)(Figures 11a, 11b, 11c, 11d). Both map units form level to gently sloping surfaces and consist of generally poorly bedded (locally tabular crossbedded) sand and gravel; small to medium boulders are common. Both units are interpreted as depositional features deposited by glacial-lake outbursts (except Qa_3 deposits that trend southwest from the Nine Lake area, see page 34), and despite their high shale content, both have been exploited for their sand and gravel. Inspection of aerial photographs indicates that other, minor, terrace levels may be present, but were not mapped separately.

High-level terraces over till (Qa_3) have been mapped in the Jamestown and Bloom quadrangles. The sand and gravel of this unit is generally less than 10 feet thick. Terraces within the main meltwater channel (Qa_2) are present in each of the three quadrangles, and are typically found on the inside bends of meanders. Sand and gravel of this unit is as much as 45 feet thick above the base level of the modern channels.

Pitted Outwash

Pitted outwash, mapped in the southeast quarter of the Bloom quadrangle, consists of sand and gravel deposited by meltwater streams. The sand and gravel is identical to the terrace alluvium described above, except that near the pits small blocks of till may be present and bedding is likely to be deformed by slumping. The characteristic pitted surface results from deposition around or over blocks of stagnant ice that later melted. The thickness of this unit is uncertain, but likely less than about 30 feet.

OAHE FORMATION

The Oahe Formation consists of all sediments above the Coleharbor Group. These non-glacial sediments can generally be distinguished from those of the underlying Coleharbor Group by their better sorting and presence of dispersed organic material. For a discussion of Oahe Formation nomenclature, see Clayton et al. (1980).

Modern River Channel and Floodplain Sediment

Modern river channel and floodplain sediment has been mapped in the Pipestem, James, and Sevenmile Coulee River valleys, and in

Figure 11a. Looking east at terraces in 140-64-26b. Upper terrace is mapped as Qa_3 while the lower, main terrace is mapped as Qa_2.

Figure 11b. Looking south across Pipestem Creek meltwater channel and gravel pits in Qa_2 (140-64-23c). Cultivated field in foreground is modern alluvium mapped as Qa_1.

Figure 11c. Looking south at exposure of Qa_3 terrace alluvium near Ft. Seward (140-64-26dbc). Sand and gravel deposits of this and other high-level terraces are generally less than 10 feet thick.

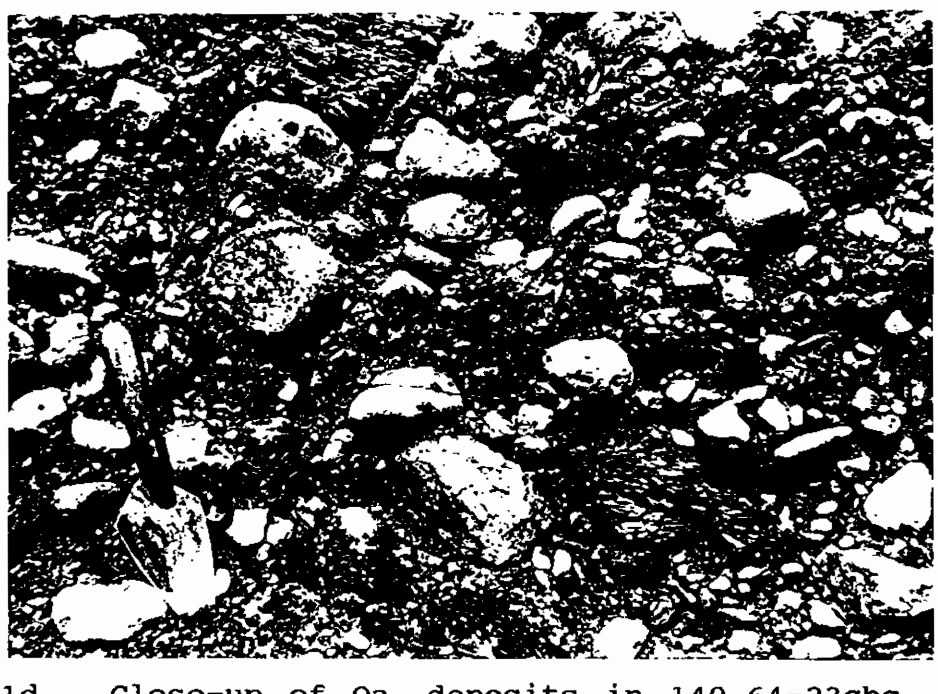

Figure 11d. Close-up of Qa_2 deposits in 140-64-23cbc. Highly fractured and weathered shale cobbles comprise roughly 15% of this deposit. Trowel is 11 inches long.

tributaries to these valleys. It consists of dark colored silt, clay, sand, and disseminated organic debris. It is typically very silty and obscurely bedded, though locally planar to crossbedded. Near valley walls, it is commonly overlain by an apron of colluvial and slopewash sediment. It is distinguished from older terrace alluvium by its disseminated organic debris and general lack of gravel.

The thickness of this unit is highly variable, ranging from less than 10 feet to perhaps over 100 feet thick. Studies of glacial-lake outburst channels by Kehew and Lord (1986) and Lord and Kehew (1987) show that Holocene alluvial and lacustrine deposits cover most spillway bottoms. If this is true for the Pipestem Creek, James River, and Sevenmile Coulee meltwater channels, Holocene deposits are locally in excess of 100 feet thick. Accompanying cross-sections show selected thicknesses of this unit.

Slopewash

Slopewash consists of poorly sorted sand, silt, clay, and lesser gravel derived from adjacent upslope areas, principally river-eroded till. It is deposited by alluvial and slopewash processes at the base of valley walls. It typically forms an apron at the base of steep slopes and is present in such locations throughout the three-quadrangle area. Only the larger such deposits have been mapped, and these occur near and south of Interstate 94 in the James River Valley, and in 141-63-25 in the Sevenmile Coulee diversion channel.

The contact with upslope sediments is normally sharp, and gradational with overbank sediments of valley floor. This unit is generally less than 10 feet thick.

Pond and Slough Sediment

Pond and slough sediment consists of dark brownish black (5 YR 2/1, moist) silt, clay, and organic debris deposited in modern ponds and sloughs (potholes). It is planar to obscurely bedded and typically greenish gray (5 GY 6/1, wet) and sandy at the base. It is generally less than 6 feet thick. The contact with surrounding sediments, normally undisturbed glacial sediment (till), is generally gradational. Sediments at the base of this unit likely record initial sedimentation immediately following deglaciation, and some may record events prior to complete deglaciation.

These sediments have been mapped based largely on interpretation of 1:20,000 scale aerial photographs taken in 1957. Due to differences in sediment type, vegetation, and moisture content, potholes contrast sharply with adjacent sediments when seen from the air. The contrast is still apparent, though not as great, when the potholes have been drained and farmed. Pond and slough sediment is likely present, but was not mapped, under water bodies shown on the topographic base map.

Areas mapped as pond and slough sediment can be expected to flood except perhaps during the driest of years. Flooding is not restricted to these areas though, as demonstrated by the widespread flooding of farmed land during the summer of 1993.

MASS-WASTING SEDIMENT

Landslides

Two large landslides have been mapped: along Pipestem Creek (140-64-23), and southeast of Spiritwood Lake in the west-central portion of 141-62-9. Both formed in river-eroded glacial sediment (till) on the outside bend of a meltwater channel meander. Each landslide has a characteristic hummocky topography slightly subdued by erosion. The landslide along Pipestem Creek has been extensively reshaped by excavation and placement of fill.

Smaller, recent landslides are shown with a symbol. Most of these occurred during the summer of 1993, an uncommonly wet year. All are located on the steep walls of the major river channels. A majority of these occurred where existing slopes had been modified by undercutting or improper placement of fill (Figures 12a through 12e).

These steep valley walls are also subject to the process of soil creep. Soil creep, as its name implies, occurs when soil creeps slowly downhill under the influence of gravity. It is apparent as shallow, concentric scars on valley walls, where the soil horizon has pulled away and crept sightly downhill (Figure 13). Soil creep is especially common where bedrock is close to the surface.

Colluvium

Colluvium consists of poorly sorted sand, silt, clay, and gravel derived by mass-wasting of river-eroded till and Pierre Formation immediately upslope. It is shaly and strongly resembles the till from which it is principally derived, though is less well compacted and contains scattered organic debris. It is found on steeply sloping valley walls where it is generally less than 5 feet thick.

Colluvium has been mapped only where it obscures the Pierre Formation (see Figure 3b). It is often present as a thin veneer over river-eroded glacial sediment, but due to map scale has not

Figure 12a. Rotational slump that occurred in July, 1993 (140-64-26abd). The toe of this slope was cut to make room for a swimming pool and backyard. The slump caved in the backside of the house.

Figure 12b. Looking down on the slump in Figure 12a. The slump reaches up to an abandoned dirt road, which itself resulted in an oversteepened slope and poor drainage.

Figure 12c. Slump at the northeast corner of the Jamestown College track (140-64-25dab). Slump occurred in fill; a buried soil horizon marks the base of the slump.

Figure 12d. Rotational slump in upper right corner of photo (looking east to 140-64-24adb). Slump occurred in fill that was placed to extent backyard. The roadcut below exposes pre-Wisconsinan till over a deformed section of Pierre Formation shale.

Figure 12e. A series of rotational slumps behind the fire station (looking northwest, 140-64-35dad). The toe of this slope was cut, perhaps to extend the buildable portion of the lot.

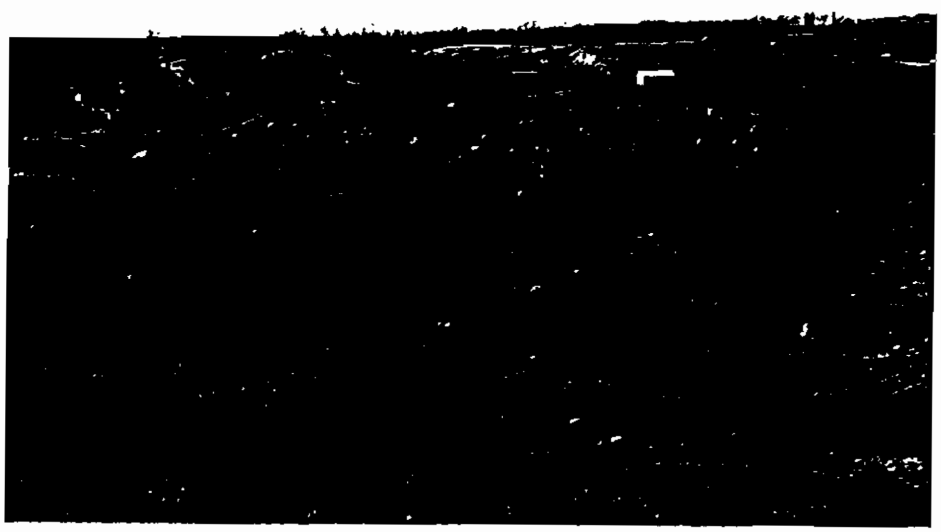

Figure 13. Shallow scars indicative of soil creep (looking west to 140-64-1bdd). Soil creep is especially common where Pierre Formation bedrock is close to the surface.

been mapped there. Below the high-water level of the Jamestown and Pipestem Reservoirs, it has been reworked and sorted by lacustrine processes, locally forming beach berms and spits. Due to problems of scale, these features have not been mapped.

ARTIFICIAL DEPOSITS

Fill

Fill - sediments placed in conjunction with major construction activities - has been mapped in several places in the Jamestown and Bloom quadrangles. Fill generally consists of well-compacted, pebbly sand, silt, and clay similar in character to the till from which most of it is derived. This fill has been used to build dams, road bases, and other man-made structures.

Generally, smaller amounts of fill are present wherever construction activities have taken place. Many such areas are shown on the topographic base map, such as section-line roads, railroads, and built-up areas of Jamestown and surrounding smaller communities. Fill should be anticipated in all of these areas.

TILL STRATIGRAPHY

Till characterization based on grain size (% sand, silt, clay) and coarse sand lithology (% crystalline, carbonate, and shale rock fragments) has been used by many geologists in North Dakota to help define lithostratigraphic units (tills) (for example, Hobbs, 1975; Camara, 1977; Harris, 1987). Such an approach has been used here and has resulted in the definition and delineation of four lithostratigraphic units in the Jamestown, Bloom, and Spiritwood Lake quadrangles. The correspondence between lithostratigraphic units so defined and morphostratigraphic units apparent on aerial photographs is exceptional (Figure 14). In addition, test-boring logs from wells in the James River Valley indicate the presence of at least two additional tills buried deep within the Stutsman Diversion Channel.

The surface geology of the three-quadrangle area is well constrained by several hundred shallow soil borings and hand auger holes; 127 of these mostly near surface samples were analyzed for the parameters above (see Table I and Appendix II). Here, the percentage of shale in the coarse sand fraction, in concert with stratigraphic position, geomorphic expression, and the physical characteristics of joints, compaction, and staining, have proven most useful in till identification and correlation.

The four lithostratigraphic units identified are described below.

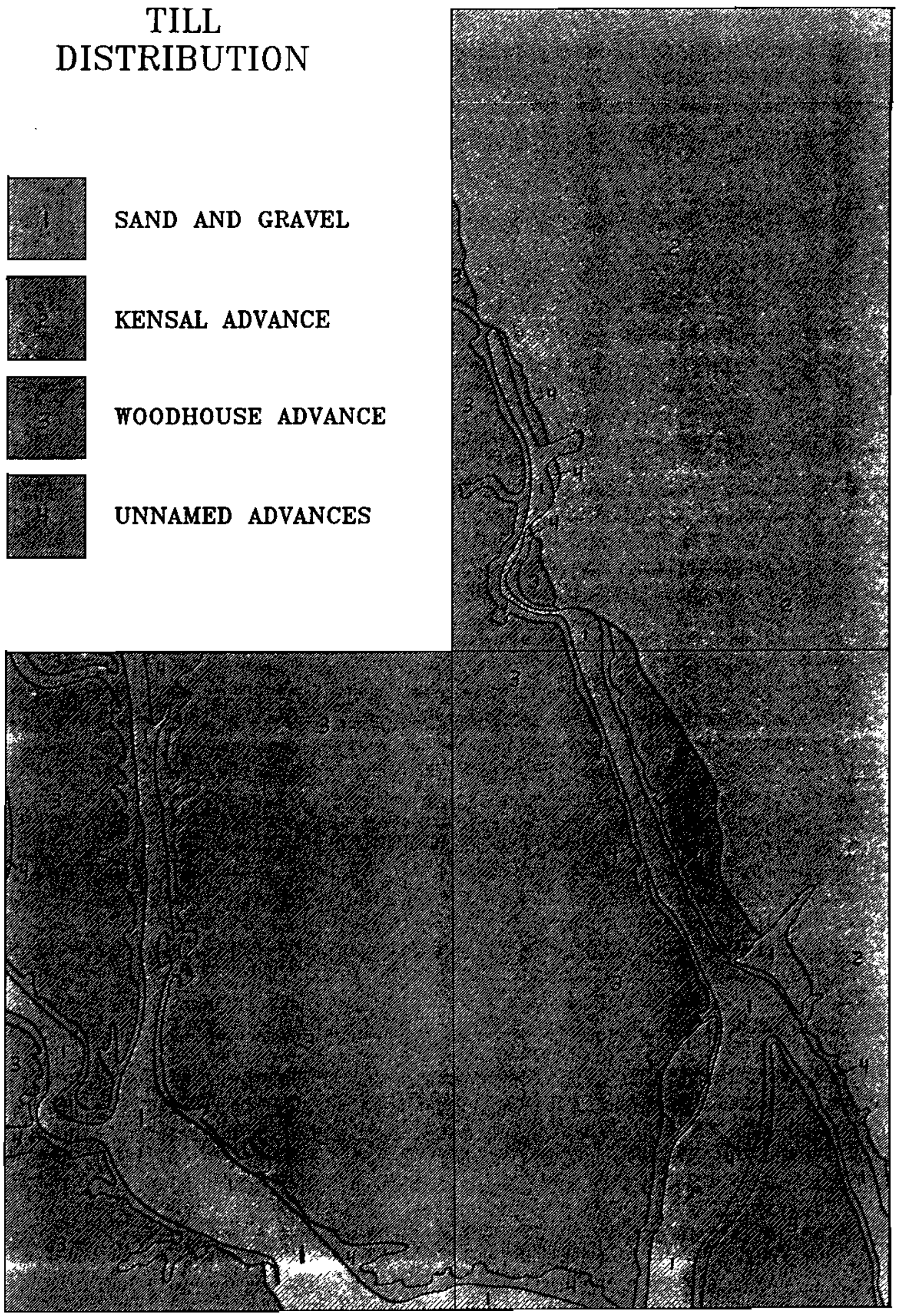

Figure 14. Generalized map showing the distribution of lithostratigraphic units (tills).

Ice Advance	Formation	Age	# samples	Sand[1]	Silt[1]	Clay[1]	Xtal[1]	CO_3[1]	Shale[1]
Kensal	Dahlen[2]	12,800 BP[3]	39	40/5	42/7	18/6	44/19	19/11	37/21
Woodhouse	unnamed	13,000 BP[3]	23	38/6	39/6	24/3	83/10	14/7	3/3
Woodhouse?	unnamed	13,000 BP?	17	36/4	43/6	21/4	58/7	20/5	22/8
"Y"	unnamed	pre. Wisc?	22	36/5	40/4	25/5	33/7	21/9	48/5
"Z"	unnamed	pre. Wisc?	13	30/11	45/10	25/8	15/9	8/5	78/13

[1] arithmetic mean/standard deviation

[2,3] Clayton, Lee, Moran, S.R., and Bluemle, J.P., 1980, Explanatory text to accompany the geologic map of North Dakota: NDGS Report of Investigation 69, p. 57.

Table I. Textural and coarse sand lithologic analyses.

Kensal Advance

The Kensal advance deposited till that forms the Kensal moraine, a generally rolling to hilly area characterized by numerous small potholes or sloughs. That the Kensal is a true end moraine is clearly shown by the truncation of transverse marginal ridges (in the Bloom and Spiritwood Lake quadrangles) and partial obstruction of meltwater channels (in the Spiritwood Lake quadrangle). Clayton and Moran (1982) cite additional evidence gleaned from nearby areas.

Geomorphic evidence of minor glacial thrusting is present within the Kensal end moraine (140-63-36dad, and 140-62-9), but the moraine is largely characterized by hummocky collapsed topography. Till samples taken where there is no geomorphic evidence of thrusting show a wide range in lithologic components (Table I), suggesting incorporation of blocks of pre-Kensal till. This till characterization has shown the lithologically chaotic nature of these end moraine sediments compared to those of the older Woodhouse advance.

The Kensal ice margin position marks the western limit of the Dahlen Formation (Clayton et al., 1980). Because the Dahlen Formation here apparently consists of blocks of pre-Kensal till, and is not homogenized, as would be expected, of tills deposited farther behind the ice margin, the parameters listed in Table I are not characteristic of the Dahlen Formation elsewhere in North Dakota.

Woodhouse Advance

The gently undulating till plain characteristic of the Woodhouse advance is marked by conspicuous transverse marginal ridges commonly known as washboard moraines, and compared to the Kensal end moraine, comparatively fewer but larger potholes. The lineations typically show up on aerial photographs with crests lighter in color than their flanks due to loss of the organic-rich upper soil horizon. Only prominent lineations have been shown on the map. The lineations probably resulted from a minor pause in the retreat of the ice front, or may have formed in crevasses parallel to the ice front.

Till of the Woodhouse Advance is characterized by a uniformly low shale content (Table I). This till is generally a moderate yellow brown (10 YR 5/4, moist) or pale yellowish brown (10 YR 6/2, moist), comparatively soft, calcareous, pebbly, clayey silt loam. It contains a trace of lignite fragments, often contains small (millimeter scale) pockets of iron hydroxide (limonite?), and is often mottled light gray (N7, moist).

Where it directly overlies Pierre Formation bedrock, the lower portion of this unit is noticeably enriched in shale, and in places probably better classified as a shale breccia; the few samples obtained from such locations were not included in determining mean nor standard deviation of grain size and lithologic parameters.

The surface till within the outer channel of the Pipestem Creek, James River, and Sevenmile Coulee meltwater channels often contains about 15% to 20% more shale than is common elsewhere for till of the Woodhouse advance, but is similar in other characteristics. These samples have been grouped separately (Table I). Both the "shale breccia" and this shale-enriched till may simply represent a basal, shale-enriched phase of the Woodhouse advance.

Till of the Woodhouse Advance contrasts sharply with older, more shale-rich, more compact and jointed tills exposed in and near the James River, Pipestem Creek, and Sevenmile Coulee meltwater channels. The till is distinguished from the Kensal till by its surface expression, and from older tills by its low shale content and generally soft, unjointed character.

Unnamed Advances

Two tills have been recognized in generally small, isolated exposures in the steep walls of the Pipestem Creek, James River, and Sevenmile Coulee valleys. The stratigraphic relationship between these units is uncertain. The principal distinguishing characteristics of these two units is shale content (Table I), and that in unit "Y" traces of lignite were found, but on the whole they are otherwise similar and difficult to distinguish in the field. Both units range in color from light olive gray (5 Y 6/1, moist), to yellowish gray (5 Y 7/2, moist), to light olive brown (5 Y 5/6, moist) or dusky yellow (5 Y 6/4, moist). Both are very compact, prominently jointed, calcareous, pebbly, clayey silt loam. The joints and pebble molds are stained by iron-manganese oxides.

The till identified as "Y" (Table I) is best exposed in 139-63-6bdd, where a dirt road leads straight down the valley wall from the State Hospital. This unit is intermittently exposed for approximately 50 vertical feet in a gully along this road.

The till identified as "Z" (Table I) is best exposed in numerous small slumps in and around Jamestown (e.g., 140-64-25dab, 140-64-25 bdb, and 140-64-24bcb); an old driveway cut on private land in 140-64-2ada; in a new roadcut in 140-64-24cdb; and in a railroad cut in 140-64-27cdd (Figures 15a, 15b; see also Figure 12d). In the creekbed, at the base of the railroad cut, mentioned above, the unit is olive gray (5 Y 4/1, moist) and contains a small, deformed block of finely laminated silt (Figure 15c).

Figure 15a. Tills "Y" and "Z" overlying Pierre Formation shale (140-64-2ada). Both of these units are very hard, fractured tills stained by iron-manganese oxides; they are distinguished primarily due to differences in shale content.

Figure 15b. Looking north at a 50-foot-high exposure of till in 140-64-27ccd. This entire exposure may belong to a single lithostratigraphic unit (till). The upper 10 feet of this exposure is oxidized and generally less well consolidated than that below, but the entire exposure has a relatively uniform, high shale content.

Figure 15c. Close-up of till exposed at base of photo in Figure 15b. Here, the till is very compact and jointed, and contains inclusions of laminated silt. Lens cap is about 3 inches in diameter.

GEOLOGIC INTERPRETATIONS

The sketches in Figure 16 and explanations below are based principally on information revealed in the sediments and landforms of the Jamestown, Bloom, and Spiritwood Lake quadrangles. Like other terrestrial Quaternary sequences, the record preserved and accessible in this area is incomplete. Still, the sketches outline a general geologic history of the three-quadrangle area. For a more detailed summary of the geologic history of North Dakota, see Clayton et al. (1980) and Bluemle (1991).

Phase I

The channel incised into the lower part of the Jamestown and Bloom quadrangles (Figure 17) is part of the Stutsman diversion channel, which formed when the ancestral Cannonball and Knife Rivers were diverted to the southeast by advancing ice (Kelly and Block, 1967) (Figure 18). The age of this diversion is unknown, but is certainly pre-Wisconsinan; two tills thought to be pre-Wisconsinan in age lie stratigraphically above this buried channel.

The Stutsman diversion channel is apparently a tributary to the much larger Spiritwood channel. The origin of the Spiritwood channel is uncertain. Kelly and Block (1967) summarize three interpretations: 1) The buried channel is part of a south-trending drainage system that formed when ice diverted drainage to the south; 2) It was eroded as a meltwater channel unrelated to pre-glacial drainage; and 3) It was part of the north-flowing ancestral Cheyenne River drainage system. It seems likely, however, that by the time ice advanced into North Dakota and the Stutsman diversion channel was formed, the Spiritwood channel drained south, away from the ice sheet.

The Spiritwood and Stutsman diversion channels mark the eastern and southern margins of a local Pierre Formation highland that still exists today.

Phases II + III

Little is known about phases II and III. Test boring logs and well-driller reports reveal at least two deeply buried tills, indicating that the Stutsman diversion channel was likely overridden by two ice advances. Sand and silt that separates these two tills indicates that the channel continued to serve as a drainage way, and may have been blocked to form a pro-glacial lake.

Phase IV

Sometime after ice retreated from the area, the Stutsman

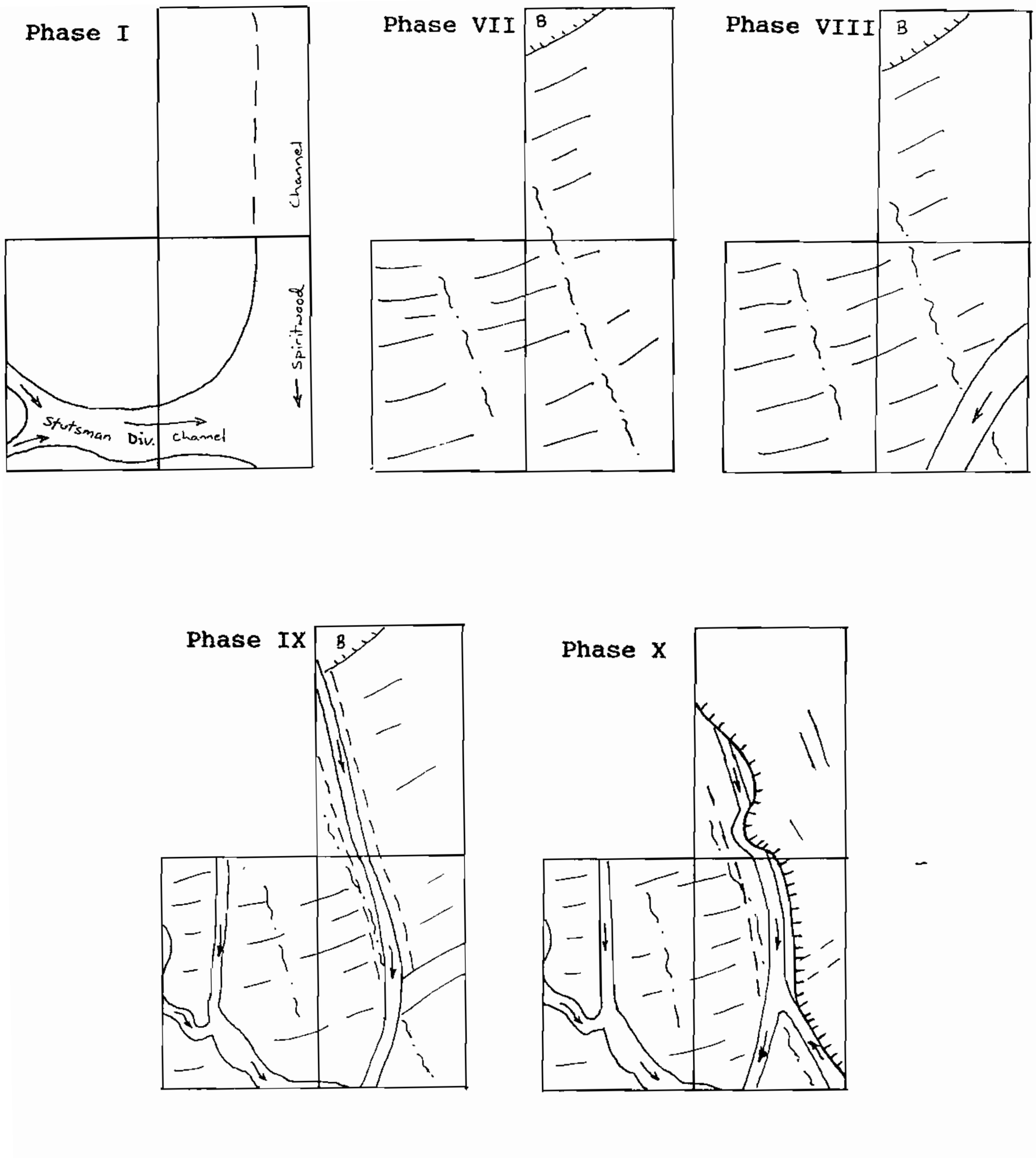

Figure 16. Sketches of major geomorphic features over time in the Jamestown, Bloom, and Spiritwood Lake quadrangles.

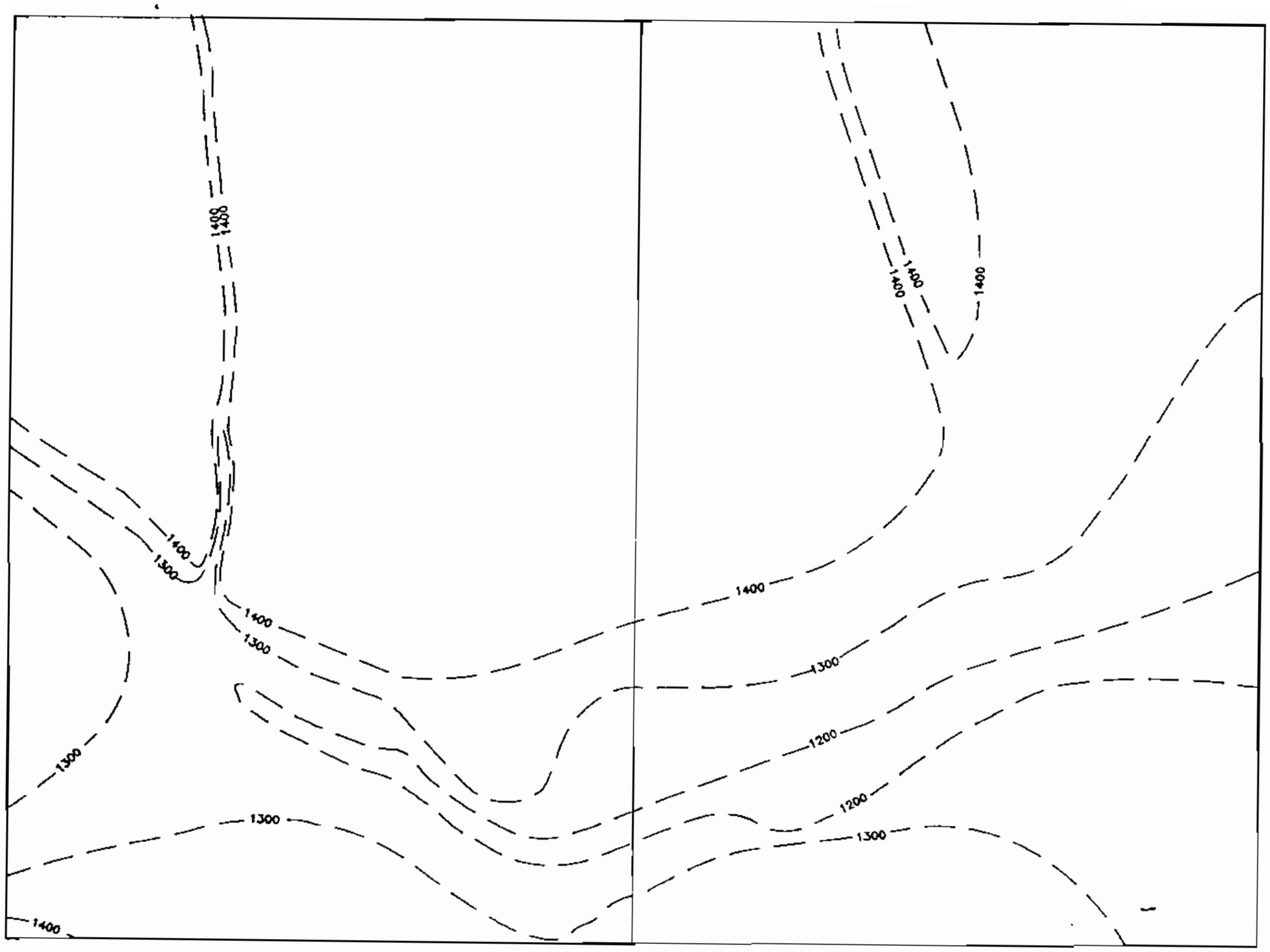

Figure 17. Topographic map of the bedrock surface in the Jamestown and Bloom quadrangles (see Plate VI for control points). The Stutsman Diversion Channel trends east through the lower portion of the Jamestown and Bloom quadrangles. Note the narrow channels, now occupied by the underfit James River and Sevenmile Coulee, cut into the bedrock surface.

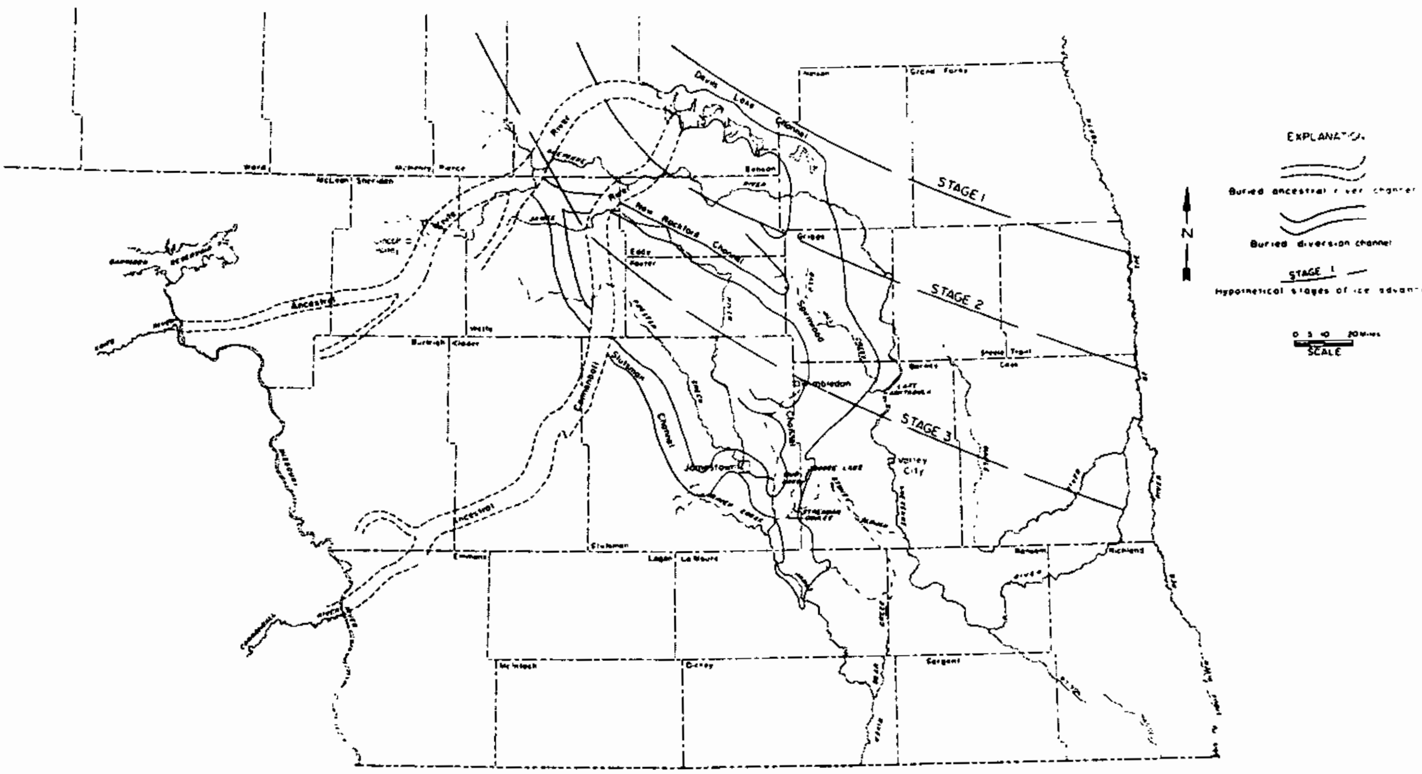

Figure 18. Pre-glacial drainage systems and resulting diversion trenches that formed as ice advanced from the north. From Kelly and Block (1967).

diversion channel again served as a major meltwater channel. At least 100 feet of channel sediments were eroded. Sand and gravel refilled the channel and it is these coarse sediments that form the Midway Aquifer (Christensen and Miller, 1988). The Midway Aquifer is apparently confined to the Stutsman diversion channel, although it merges to the east with the North Aquifer (also part of the Spiritwood Aquifer System).

Phase V + VI

Little is known about phases V and VI. It appears that the area was overridden by at least two ice advances. Although stratigraphic relationships are not clear, the first of the two probably advanced over a bedrock plain and deposited a till with a very high shale content (Table I, "z"), followed by a later advance (Table I, "y"). Both units are very compact, prominently jointed, and stained by iron-manganese oxides; they appear to be pre-Wisconsinan in age.

Phase VII

The area was overridden by ice of the Woodhouse advance approximately 13,000 BP (Clayton et al., 1980). The surface geology of the Jamestown quadrangle, and the western half of the Bloom quadrangle, is dominated by landforms and sediments of this advance. Till of this advance has a uniformly low shale content and forms a gently undulating till plain cut by the Pipestem Creek, James River, and Sevenmile Coulee meltwater channels. Transverse marginal ridges (washboard moraines) trend northeast, indicating that the ice retreated towards the northwest. Two poorly expressed eskers trend southeast, perpendicular to the washboard moraines. The Buchannan moraine of Winters (1963), present in the northwest portion of the Spiritwood Lake quadrangle, marks a minor pause in this retreat.

Phase VIII

A broad, shallow meltwater channel formed that flowed south-southeast through the Bloom quadrangle. Sand and gravel in this channel is thin (about 5 to 15 feet thick). This channel is subsequently truncated by Sevenmile Coulee, and partially overridden by ice of the Kensal advance.

Phase IX

The modern Pipestem Creek, James River, and Sevenmile Coulee meltwater channels formed during phase IX. That portion of the James River channel north of Jamestown, and the Sevenmile Coulee channel, probably formed catastrophically as a result of sudden, rapid drainage of one or more upstream pro-glacial lakes (see Kehew and Lord, 1986). Such outbursts typically form relatively straight, steep-walled channels, often with a well-defined outer channel. It was this outer channel that contained flow before the main channel was eroded. The Pipestem Creek channel may have formed similarly, but its significantly higher sinuosity channel suggests that it formed simply as a meltwater drainage channel along the retreating Woodhouse ice margin; it may have been modified by subsequent catastrophic drainage. If so, a precursor to the James River Valley south of Jamestown would have held Pipestem Creek.

A catastrophic origin for Sevenmile Coulee is supported by the channel geometry (relatively straight, steep-walled, and containing an underfit intermittent stream) and by the presence of a well-defined outer channel. Sevenmile Coulee truncates the broad, shallow channel formed in Phase VIII. North of this broad, shallow channel, Sevenmile Coulee truncates washboard moraines. To the south, the pre-existing channel was able to contain the entire flow of the coulee and so no outer channel formed.

The James River Valley lacks a well-defined outer channel. It does, however, contain features interpreted to have formed within the outer channel environment. The flat-topped promontories adjacent to either side of the channel have thin, discontinuous deposits of sand and gravel. Areas adjacent to the channel generally lack closed depressions, or prairie potholes, that are common farther away from the channel; such areas may have been scoured and filled with fluvial deposits. Also, till exposed at the surface within the outer channel appears to be a shale-enriched basal phase of the Woodhouse advance, indicating that till characteristic of the Woodhouse advance, one with a uniformly low shale content, has been mostly removed by erosion.

As have Kehew and Lord (1986), Qa_2 deposits are interpreted as depositional features - sand and gravel bars deposited in alcoves and at the inside bends of meanders - and not erosional remanents of a once continuous outwash deposit.

Phase X

This phase marks the maximum extent of Kensal ice. That the Kensal is a true end moraine is clearly shown by the truncation of transverse marginal ridges (in the Bloom and Spiritwood Lake quadrangles) and partial obstruction of meltwater channels (in the Spiritwood Lake quadrangle). Clayton and Moran (1982) cite additional evidence gleaned from nearby areas.

The Kensal advance was comprised of two adjacent lobes that merged in the Spiritwood Lake quadrangle. Spiritwood Lake, and the unnamed channel leading to its northeast edge, mark the boundary of the two lobes. The northern lobe of Kensal ice partly overrode the Buchannan end moraine (the prominent hill in 142-63-23 is believed to be part of the Buchannan moraine). The topography associated with the northern lobe is hillier than that of the southern lobe and may be the result of stagnation of this portion of the ice sheet. The southern lobe is also hilly, but contains transverse marginal ridges.

Kensal ice blocked Sevenmile Coulee at two locations: in 141-62-19, 141-63-13, and 141-63-24; and in 141-63-1, 141-63-2, and 142-63-35. In the first instance, meltwater scoured the till plain immediately west of the blocked channel, and eventually abandoned that route in favor of a narrow, steep walled channel cut through 141-63-24 and 141-63-25. That the blocked portion of Sevenmile Coulee just southwest of Spiritwood Lake was not similarly bypassed suggests that at that time the source of meltwater was from the northeast, from the junction of the two lobes of Kensal ice.

Rush Island Lake lies in a depression formed when the hill immediately to the southwest was thrust into place; the two create a classic hill-hole pair as described by Bluemle and Clayton (1984). That the thrust feature is associated with a partially overridden channel (formed during Phase VIII) and an esker, suggests that elevated pore water pressures may have facilitated thrusting. Nearby Nine Lake is believed to have formed in the depression left by a melting block of ice.

The channel in the southeast corner of the Bloom quadrangle is believed to have formed as a north-flowing outwash channel at the Kensal margin. Late in its development, the channel was partially blocked by ice, which later melted leaving the present "pitted" surface.

MINERAL RESOURCES

A mineral resource assessment was not undertaken as a part of this mapping project. The maps, however, show the distribution of sand and gravel resources, and the bedrock topographic map shows the general location of buried meltwater channels, which contain important aquifers.

SAND and GRAVEL

The greater Jamestown area has significant reserves of sand and gravel. These deposits, mapped as Qa_2 and Qa_3 (Plates I, II, III), are restricted to the Pipestem Creek, James River, and Sevenmile Coulee meltwater channels, and to terraces adjacent to those valleys. The lower-level terraces, mapped as Qa_2, commonly rise 20 or more feet above the modern valley floor. The thickness of these deposits below the valley floor is uncertain. They are believed to have been deposited as bars in alcoves along the valley walls and on the inside bends of meanders, and so do not represent erosional remanents of a once more continuous valley train deposit. If true, some of these deposits are likely as deep as the channels themselves.

Sand and gravel deposits of the higher-level terraces, mapped as Qa3, are relatively thin, ranging from less than one foot up to 10 to 15 feet thick; they are commonly 5 to 10 feet thick (see Figure 11c). Several of the deposits mapped as eskers or kames have provided local borrow material, but these deposits are too poorly sorted and generally too small to be of commercial value.

Aggregate quality was not tested as part of this mapping project, but all sand and gravel deposits in the Jamestown - Spiritwood Lake area contain significant, though highly variable, amounts of shale. The gravel fraction of most exposures contained about 15% shale, although the lateral and vertical variation between exposures was great - some exposures contained as little as 5% shale, some more than 50%. The shale tends to be highly weathered and brittle, a fact that quarry operators take advantage of in reducing shale content by mechanical screening and by exposing it to further weathering.

GROUNDWATER RESOURCES

Figure 17 is a map of the bedrock topography, which shows the general location of meltwater channels cut into the Pierre Formation. These channels contain sand and gravel deposits that form the Jamestown, Midway, and North Aquifers. Characteristics of these aquifers, and those farther south in the James River Valley, are most recently discussed by Wald and Christensen (1986) and Christensen and Miller (1988). Additionally, the North Dakota State Water Commission recently began an investigation of groundwater resources of the greater Jamestown area.

GEOLOGIC HAZARDS

Geologic hazards in the Jamestown - Spiritwood lake area are generally confined to landslides, shoreline erosion, flooding, and abandoned sand and gravel pits; it is not known whether radon is a problem. A 1993 EPA report indicates that areas overlying shale of the Pierre Formation, and glacial deposits derived from this shale, are highly suceptible to indoor radon problems. The shale content of tills in this area ranges from uniformly low (Woodhouse advance) to very high (older unnamed advances) and the distribution of these units may be useful in evaluating potential radon problems (see Figure 14).

Landslides alone in the greater Jamestown area caused significant damage in the summer of 1993. Most were relatively small rotational slumps that occurred where slopes were undercut or steepened with improperly placed fill (see Figures 12a through 12e). Because much new construction in the Jamestown-Spiritwood Lake area is taking place on and near the steep valley walls, the potential for additional landslide damage is increasing. Property damage can also result from soil creep, a process wherein the soil horizon creeps slowly downhill under the influence of gravity. Soil creep is apparent as shallow, concentric scars on valley walls (see Figure 13) and is especially common where bedrock is close to the surface.

The principal concern with shoreline erosion, aside from reservoir siltation and loss of shoreline property, is that it undercuts adjacent slopes, creating conditions favorable for landslides (Figures 19a, 19b). Several landslides along the shores of the Jamestown Reservoir can be directly linked to shoreline erosion.

With the closing of the Jamestown Dam in 1957 and the Pipestem Reservoir in 1971, flooding in the James River Valley has been greatly reduced. However, flooding can and does still occur in low-lying areas adjacent to the river. Closed depressions in upland areas are also subject to flooding, and while such areas are generally mapped as pond and slough sediment, significantly larger areas can be flooded.

Abandoned sand and gravel pits represent a potential hazard not so much from their often steep walls, but from the fact that they are often used as dumps for bulky or other waste (Figure 20). Sand and gravel pits are often associated with important groundwater supplies, and any waste placed in these pits may adversely affect groundwater quality.

Figure 19a. Erosion along the west shore of the Jamestown Reservoir (140-64-13ccb).

Figure 19b. Rotational slump along west shore of Jamestown Reservoir (140-64-13bbc).

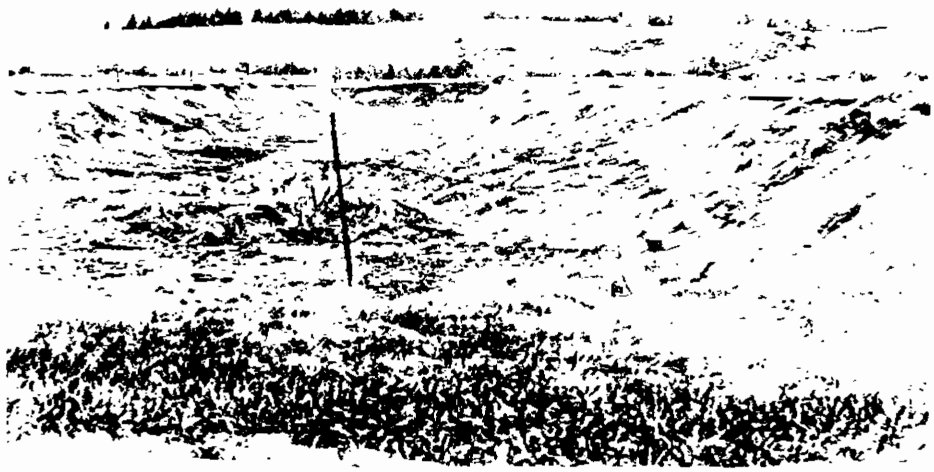

Figure 20. Abandoned sand and gravel pit, with bulky waste (looking north at 140-64-22ddd).

SUMMARY

Principal findings of this investigation include:

1. Landslides are common along the steep valley walls of the Pipestem Creek, James River, and Sevenmile Coulee meltwater channels. Most occur as relatively small rotational slumps where slopes have been undercut or oversteepened by improperly placed fill.

2. In the Bloom quadrangle, a well-defined outer channel is present along Sevenmile Coulee. This, in combination with the channel geometry (relatively straight and steep-walled), suggests that the channel formed catastrophically from the rapid drainage of one or more upstream glacial lakes. Thin, discontinuous sand and gravel deposits are common within the outer channel area. The outer channel is missing in the southern portion of the quadrangle because flow was confined by a pre-existing outwash channel.

3. The James River and Pipestem Creek valleys likely also formed catastrophically. While well-defined outer channels are lacking, upland areas adjacent to both valleys contain features believed to have formed in an outer channel environment, including discontinuous sand and gravel deposits, and surfaces that appear "washed".

4. Four lithostratigraphic units (tills) have been identified in exposures in the Jamestown, Bloom, and Spiritwood Lake quadrangles. The composition and physical properties of these tills vary considerably, from a soft, shale-poor till to a very compact, jointed, shale-rich till stained by iron-manganese oxides. At least two additional tills are buried deeply within the Stutsman diversion channel.

5. The distribution of these lithostratigraphic units (tills) corresponds closely with easily identified geomorphic features.

6. The Kensal end moraine represents a true ice margin position, as shown by truncated transverse marginal ridges (washboard moraines), partially obstructed meltwater channels, and the different topographic and lithologic character of the drift sheets.

7. Till characterization has shown the lithologically chaotic nature of true end moraine sediments compared to those deposited farther behind the ice margin. Till samples taken where there is no geomorphic evidence of thrusting show a wide range in lithologic components, suggesting incorporation of blocks of pre-Kensal till.

8. This mapping refines the Kensal ice margin position as suggested by Winters (1963). The distribution of lithostratigraphic units shows that Kensal ice advanced west of Sevenmile Coulee only at two places in the Spiritwood Lake quadrangle. The "kame terraces" identified by Winters in Sevenmile Coulee are believed to be have formed as bars along the inside bends of meanders and in alcoves along the valleys walls. The "kames" mapped west of Sevenmile Coulee (141-63-23 and 141-63-26) are believed to be part of a braided esker that parallels and is truncated by Sevenmile Coulee in the Bloom quadrangle.

9. Differences in topographic expression indicate that the Kensal advance was comprised of two adjacent sublobes. In the mapped area, the northern lobe lacks linear trends and is instead characterized by hilly, collapsed topography deposited in part over the Buchannan end moraine. The southern lobe is marked by several prominent transverse marginal ridges and undulating collapsed topography. Spiritwood Lake and associated channels formed at the junction of these two sublobes.

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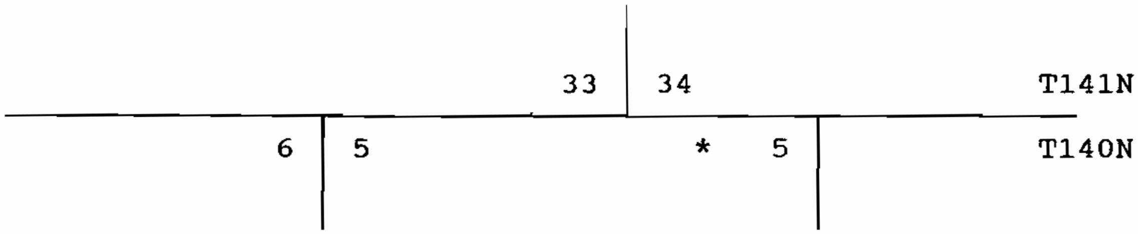
APPENDIX I

Test Hole Logs

Test Boring: 140-63-5aab Elev.: +/-1495
Date Drilled: 7-22-92 Filled upon Completion: w/cuttings
Rig: Mobil Drill Sample Type: 8" HS auger, 3" OD shelby
Logged by: R.F. Biek
Location: in drainage ditch about 25 feet south of road centerline



Depth (Ft)	Rec. (Ft)	Sample No.	Log	Description
0.0 – 2.5	1.2		SILT	Topsoil. Dusky yel brn (10 YR 2/2) loam. @ 1' color change to pale yel brn (10 YR 6/2)
2.5 – 5.0	1.0	1	clayey	Mottled lt olive gray (5 Y 6/1) and mod yel brn (19 YR 5/4) clayey loam w/calcareous concretions
5.0 – 7.5	0.8	2	SAND (dirty)	Mottled as above, f-m silty SAND, tr c sand to f gravel
7.5 – 10.0	0.5	3		Mottled as above, clayey, silty SAND, Fe stains
10.0 – 12.5	1.2	4, 5	---H_2O	Dark yel brn (10 YR 4/2) m-c silty SAND, Fe stains, @ 11.5' color change to mottled olive black (5 Y 2/1) and med dark gray (N4)
12.5 – 15.0	1.5	6	SAND	Dark gray (N3) f-m shaley SAND
15.0 – 17.5	0			
17.5 – 20.0	0.5			

Test Boring: 140-63-5aab Elev.:
Date Drilled: Filled upon Completion:
Rig: Sample Type:
Logged by:
Location:

Depth (Ft)	Rec. (Ft)	Sample No.	Log	Description
20.0	auger			
22.5	2.5	7	SAND	Dark gray (N3) f-m shaley SAND
25.0	0			
27.5	0			
30.0				
				TD 31' refusal
32.5				
35.0				
37.5				
40.0				

Test Boring: 141-64-36ccd Elev.: +/-1515

Date Drilled: 7-22-92 Filled upon Completion: w/cuttings

Rig: Mobil Drill Sample Type: 8" HS auger, 3" OD shelby

Logged by: R.F. Biek

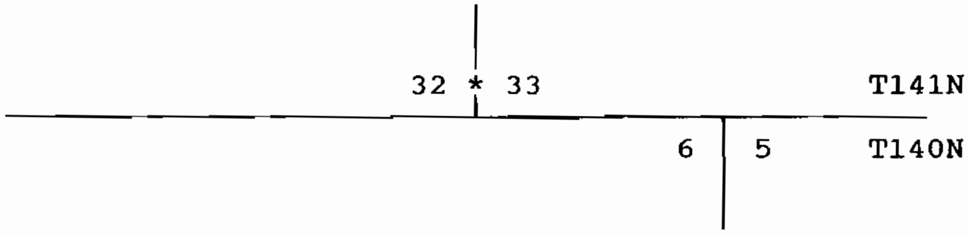
Location: 45′ north of road centerline on half-section line

35 | 36 * R64W | R63W T141N

3 | 2 2 | T140N

Depth (Ft)	Rec. (Ft)	Sample No.	Log	Description
0.0 – 2.5	1.5		SILT	Plow zone. Mottled drk and dusky yel brn (10 YR 4/2 and 10 YR 2/2) vf sandy SILT @ 1.5′ color change to mod yel brn (10 YR 5/4)
2.5 – 5.0	1.2	1	SAND	Mod yel brn (10 YR 5/4) silty f SAND, caliche at base
5.0 – 7.5	1.5	2	TILL	Mottled mod yel brn (10 YR 5/4) and med lt gray (N6) silty pebbly loam, soft, tr lignite, Fe stains
7.5 – 10.0	0.5	3		Gray, silty CLAY, abundant shale, soft, crumbly Fe stains
10.0 – 12.5	1.0	4	shaley TILL	
12.5 – 15.0	1.2	5		
15.0 – 17.5	2.0	6 7		Pierre Fm. Highly weathered, crumbly, dry, Fe stained, gray SHALE
17.5 – 20.0	1.5		Pierre Fm	Unweathered, unstained below 18′
20.0				TD 22.5′

Test Boring: 141-62-32ddd Elev.: +/-1498
Date Drilled: 7-21-92 Filled upon Completion: w/cuttings
Rig: Mobil Drill Sample Type: 8" HS auger, 3" OD shelby
Logged by: R.F. Biek
Location: 40 feet north of road centerline

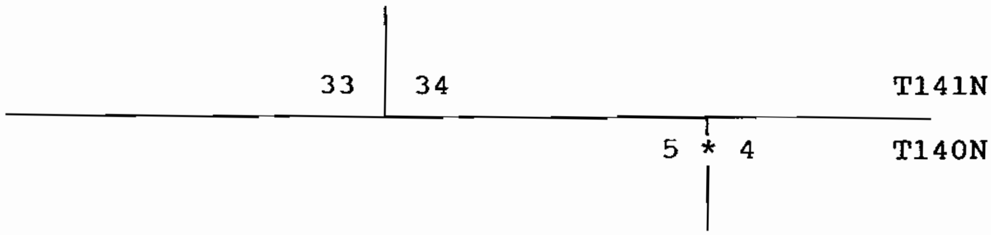


Depth (Ft)	Rec. (Ft)	Sample No.	Log	Description
0.0	1.0		SILT	Disturbed soil
2.5	1.0			
			-------	--
				Dusky yel brn (10 YR 2/2) SILT
5.0	1.0			
			-------	--
		1		Mod yel brn (10 YR 5/4) to pale yel brn (10 YR 6/2) pebbly loam, Fe stains
7.5	1.0	2		Mottled med lt gray (N6) and mod yel brn (10 YR 5/4) sandy loam, Fe stains, calcite-filled joints, very silty
10.0	1.0			@ 10′ color change to mottled dark and mod yel brn (10 YR 4/2 and 10 YR 5/4)
			TILL	
12.5	1.0	3		
15.0	1.0	4		Fe-MN stains on joint surfaces, tr lignite, locally mottled med gray (N5)
17.5	1.2	5		
20.0				

Test Boring: 141-62-32ddd Elev.:
Date Drilled: Filled upon Completion:
Rig: Sample Type:
Logged by:
Location:

Depth (Ft)	Rec. (Ft)	Sample No.	Log	Description
20.0				
	1.0	6	TILL	tr lignite
22.5				
			--------	--
	1.0	7		drk to mod yel brn (10 YR 4/2 to 10 YR 5/4) m-c SAND, tr c sand to f gravel
25.0			SAND	
	0.2			
27.5				
			---?---	--------?--------------?-------------?--------
	0			
30.0				
	0			
				No recovery because auger plugged. Cuttings reveal drk grn gray (5 GY 4/1) silty clay loam, pebbly
32.5				
	0		TILL	
35.0				
	0			
37.5				
			---H_2O	
	auger	8		
40.0				TD 43'

Test Boring: 140-62-4bbb Elev.: +/-1500
Date Drilled: 7-20-92 Filled upon Completion: w/cuttings
Rig: Mobil Drill Sample Type: 8" HS auger, 3"OD shelby
Logged by: R.F. Biek
Location: 60 feet south of road centerline



Depth (Ft)	Rec. (Ft)	Sample No.	Log	Description
0.0	2.0		SILT	Dusky yel brn (10 YR 2/2) SILT, @ 2' yel gray (5 Y 7/2) caliche zone, grades down to drk yel brn (10 YR 4/2) SILT
2.5	1.0		SAND	lt gray (N7) f SAND
5.0	1.0		SILT + SAND	Drk yel brn SILT, @ 6' grades down to lt olive gray (5 Y 5/2) clayey SILT, Fe stains
7.5	2.0	1		Mottled mod yel brn (10 YR 5/4) and lt gray (N7) clayey SILT
10.0	1.8	2		Lt gray (N7) f SAND grades to drk yel brn (10 YR 4/2) f-m SAND, tr c sand to f gravel, some lt gray (N7) clayey SAND laminae
12.5	2.5	3	TILL	Drk yel brn (10 YR 4/2) pebbly loam, Fe stains, hard, blocky
15.0	2.5	4		@ 16' small (1mm) gypsum xtals
17.5	2.5			@ 18' tr lignite
20.0				

Test Boring: 140-62-4bbb   Elev.:

Date Drilled: Filled upon Completion:

Rig: Sample Type:

Logged by:

Location:

Depth (Ft)	Rec. (Ft)	Sample No.	Log	Description
20.0	2.5	5	TILL	@ 20' color change to dusky yel brn (10 YR 2/2) to olive gray (5 Y 4/1). Less gravel and softer than above. Local sand pockets.
22.5	1.5	6		@ 22.5' oxidized zone (3" thick) of f SAND
25.0	1.5	7		
27.5	1.5		TILL	Dusky yel brn (10 YR 2/2) to olive gray (5 Y 4/1) pebbly loam, local sand pockets
30.0	2.0			perched water table at 32.5'
32.5	0			Med lt gray (N6) vf SAND
35.0	0		SAND	
37.5	0			
40.0				

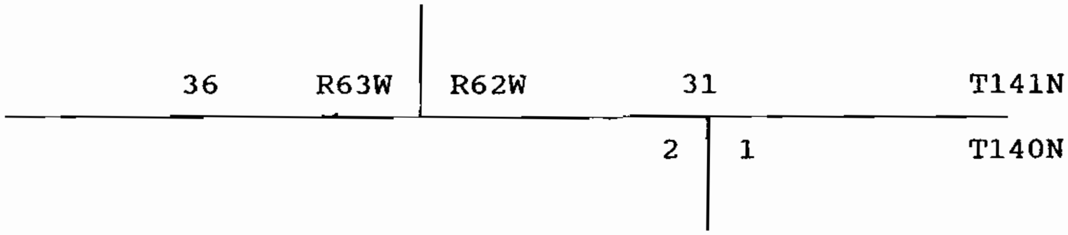
Test Boring: 140-62-4bbb Elev.:
Date Drilled: Filled upon Completion:
Rig: Sample Type:
Logged by:
Location:

Depth (Ft)	Rec. (Ft)	Sample No.	Log	Description
40.0	0.5		SAND	Olive gray (5 Y 4/1) f-m SAND, wet
42.5	1.0	9		
		10		Olive gray (5 Y 4/1) pebbly loam with same color vf SAND laminae and pockets, dry, blocky, hard
45.0	1.0			@ 47′ more c sand
47.5	0.5	11	TILL	w/f-m SAND laminae and pockets (wet) in dry till
50.0	2.5	12		moist, med soft
52.5	0.5			Olive gray (5 Y 4/1) f-m SAND, grades to m-c sand, wet
55.0	0		SAND	
57.5	0			
60.0				

Test Boring: 140-62-4bbb Elev.: ____________
Date Drilled: ____________ Filled upon Completion: ____________
Rig: ____________ Sample Type: ____________
Logged by: ____________
Location:

Depth (Ft)	Rec. (Ft)	Sample No.	Log	Description
60.0	-----			
62.5	0		SAND?	
				Dark gray (N3)to olive black (5 Y 2/1) c shaley SAND, wet
65.0	-----		---?---	---------?-----------?-----------?-----------
	1.0			Olive gray (5 Y 4/1) pebbly loam, soft, moist
67.5	-----			
	0.5		TILL?	
70.0	-----			
72.5				
	0			
75.0				
77.5	-----	------	-------	-----------------------------------
				TD 77.5'
80.0				

Test Boring: 141-62-31cdc Elev.: +/-1475
Date Drilled: 7-21/22-92 Filled upon Completion: w/cuttings
Rig: Mobil Drill Sample Type: 8" HS auger, 3" OD shelby
Logged by: R.F. Biek
Location: in fallow field 60' north of road centerline



Depth (Ft)	Rec. (Ft)	Sample No.	Log	Description
0.0	1.2		SILT	Plowzone. Drk yel brn (10 YR 4/2) silty loam
2.5	0.8	1		Mottled med lt gray (N6) and mod yel brn (10 YR 5/4) clayey SILT
			SAND	Mod yel brn (10 YR 5/4) f-m SAND, Fe stains
5.0	1.0	2		Mod yel brn (10 YR 5/4) pebbly loam, Fe stains, tr lignite
7.5	1.2	3	TILL	
10.0	0			@ 11' color change to olive black (5 Y 2/1)
12.5	0	4		
15.0	0			
17.5	2.0	5		abundant shale, very hard, dry
20.0				

Test Boring: 141-62-31cdc Elev.: ____

Date Drilled: ____ Filled upon Completion: ____

Rig: ____ Sample Type: ____

Logged by: ____

Location:

Depth (Ft)	Rec. (Ft)	Sample No.	Log	Description
20.0	2.5	6		@ 21′ softer sandy clay zone 4" thick
22.5	2.0			very hard, could not extract from shelby
25.0	1.3	7		@ 26′ thin (< 1/2" thick) dry f-m SAND over 3" thick SILT
27.5	1.0		TILL	blew hydraulic hose trying to pull out of hole very hard
30.0	auger			
35.0	1.2	8		
37.5	auger			
40.0				---- TD 43′ refusal

APPENDIX II

Till Data

KENSAL TILL

qqq	geologist	ID #	N-File #	Township	Range	Section	Elev	Depth	Sand	Silt	Clay	Xtal	Carb	Shale	NSlt	NXtl	0=Subsurface 1=Surface
"ADD"	"RFB"	"R057 94"	10008	140	62	4	1490	9	40	48	12	17	16	67	80	52	0
"BBB"	"RFB"	"R057 94"	10009	140	62	4	1500	14	39	49	12	38	18	44	80	68	0
"BBB"	"RFB"	"R057 94"	10010	140	62	4	1500	17	41	43	16	39	22	39	72	64	0
"BBB"	"RFB"	"R057 94"	10011	140	62	4	1500	22	40	42	18	33	14	53	70	70	0
"BBA"	"RFB"	"R057 94"	10014	140	62	8	1505	7	43	38	19	47	21	32	67	69	0
"BAA"	"RFB"	"R057 94"	10015	140	62	9	1510	7	22	39	39	46	13	41	50	78	0
"DDA"	"RFB"	"R057 94"	10016	140	62	9	1480	9	38	39	23	41	13	46	63	76	0
"AAD"	"RFB"	"R057 94"	10020	140	62	21	1480	8	32	49	19	44	29	27	84	60	0
"BBB"	"RFB"	"R057 94"	10021	140	62	27	1485	9	37	45	18	48	25	27	71	66	0
"DDD"	"RFB"	"R057 94"	10073	141	62	4	1500	8	40	39	21	33	10	57	66	77	0
"ABA"	"RFB"	"R057 94"	10075	141	62	6	1500	8	44	40	16	63	21	16	71	75	0
"BBA"	"RFB"	"R057 94"	10077	141	62	10	1500	7	48	41	11	48	22	30	79	69	0
"DDD"	"RFB"	"R057 94"	10078	141	62	18	1480	7	46	40	14	49	23	28	74	68	0
"DCD"	"RFB"	"R057 94"	10079	141	62	18	1470	7	45	36	19	47	25	28	65	65	0
"AAB"	"RFB"	"R057 94"	10080	141	62	27	1500	8	46	45	9	32	55	13	83	37	0
"BBB"	"RFB"	"R057 94"	10081	141	62	28	1505	7	36	46	18	70	24	6	72	74	0
"AAB"	"RFB"	"R057 94"	10082	141	62	29	1490	7	34	42	24	88	6	6	63	94	0
"DDD"	"RFB"	"R057 94"	10088	141	62	32	1498	9	42	46	12	40	10	40	81	67	0
"ABA"	"RFB"	"R057 94"	10093	141	62	34	1520	10	40	39	21	46	9	45	65	84	0
"BBA"	"RFB"	"R057 94"	10094	141	62	34	1530	8	44	45	11	33	12	55	79	73	0
"CCC"	"RFB"	"R057 94"	10095	141	62	35	1500	9	38	39	23	30	17	53	63	64	0
"BCB"	"RFB"	"R057 94"	10096	141	62	35	1520	7	40	44	16	24	18	58	73	57	0
"BBA"	"RFB"	"R057 94"	10097	141	63	1	1510	8	40	44	16	64	21	15	73	75	0
"BCC"	"RFB"	"R057 94"	10108	141	64	36	1510	14	51	29	20	1	0	99	59	1	0
"AAA"	"RFB"	"R057 94"	10111	142	62	17	1545	8	42	46	12	27	11	62	79	71	0
"BCC"	"RFB"	"R057 94"	10112	142	62	18	1530	8	42	40	18	52	19	29	68	73	0
"CCB"	"RFB"	"R057 94"	10113	142	62	19	1520	8	37	53	10	30	15	55	85	67	0
"DCC"	"RFB"	"R057 94"	10114	142	62	21	1520	6	41	36	23	89	11	0	61	89	0
"BCC"	"RFB"	"R057 94"	10116	142	62	22	1495	8	47	35	18	67	22	11	65	75	0
"BCC"	"RFB"	"R057 94"	10117	142	62	23	1520	8	31	43	26	39	55	6	63	41	0
"CCC"	"RFB"	"R057 94"	10118	142	62	23	1495	8	40	49	11	21	13	66	80	62	0
"ABB"	"RFB"	"R057 94"	10119	142	62	29	1525	8	46	36	18	65	26	9	67	71	0
"ABB"	"RFB"	"R057 94"	10120	142	62	30	1530	8	40	42	18	33	15	52	70	69	0
"CDC"	"RFB"	"R058 94"	10121	142	62	31	1500	8	38	46	16	49	22	29	74	69	0
"ABB"	"RFB"	"R057 94"	10122	142	62	31	1530	6	48	36	16	65	19	16	69	77	0
"DDD"	"RFB"	"R057 94"	10123	142	63	14	1540	8	41	42	17	45	12	43	72	79	0
"ADD"	"RFB"	"R057 94"	10124	142	63	23	1540	6	34	43	23	15	11	74	66	58	0
"CCD"	"RFB"	"R057 94"	10125	142	63	24	1530	7	40	42	18	35	20	45	70	64	0
"CDD"	"RFB"	"R057 94"	10126	142	63	36	1515	6	44	42	14	70	17	13	75	80	0

Woodhouse Till

"CCC"	"RFB"	"R057 94"	10000	139	62	5	1485	10	43	32	25	86	13	1	57	87	0
"CBC"	"RFB"	"R057 94"	10007	139	64	2	1500	7	33	40	27	69	23	8	60	75	0
"CCC"	"RFB"	"R057 94"	10024	140	63	1	1485	9	45	33	22	94	6	0	60	94	0
"DDD"	"RFB"	"R057 94"	10025	140	63	5	1520	9	29	51	20	66	24	10	72	73	0
"DDD"	"RFB"	"R057 94"	10026	140	63	9	1510	9	31	46	23	69	25	6	68	73	0
"ADA"	"RFB"	"R057 94"	10027	140	63	9	1520	6	30	43	27	73	21	6	61	78	0
"BBC"	"RFB"	"R057 94"	10028	140	63	11	1490	14	26	52	22	78	17	5	71	82	0
"ADA"	"RFB"	"R057 94"	10029	140	63	11	1500	7	36	37	27	87	13	0	58	87	0

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Woodhouse? TILL

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"CDC","RFB","R057 94",10019,140,62,19,1455,13,40,40,20,61,20,19,67,75,0
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"ABA","RFB","R057 94",10039,140,63,36,1485,7,31,44,25,65,22,13,64,75,0
"ADA","RFB","R057 94",10040,140,64,2,1485,0,36,44,20,50,17,33,69,75,1
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"CDC","RFB","R057 94",10043,140,64,10,1500,6,35,44,21,52,27,21,68,66,0
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"DAA","RFB","R057 94",10057,140,64,23,1500,7,36,42,22,52,16,32,66,76,0
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"Y" TILL

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"Z" TILL

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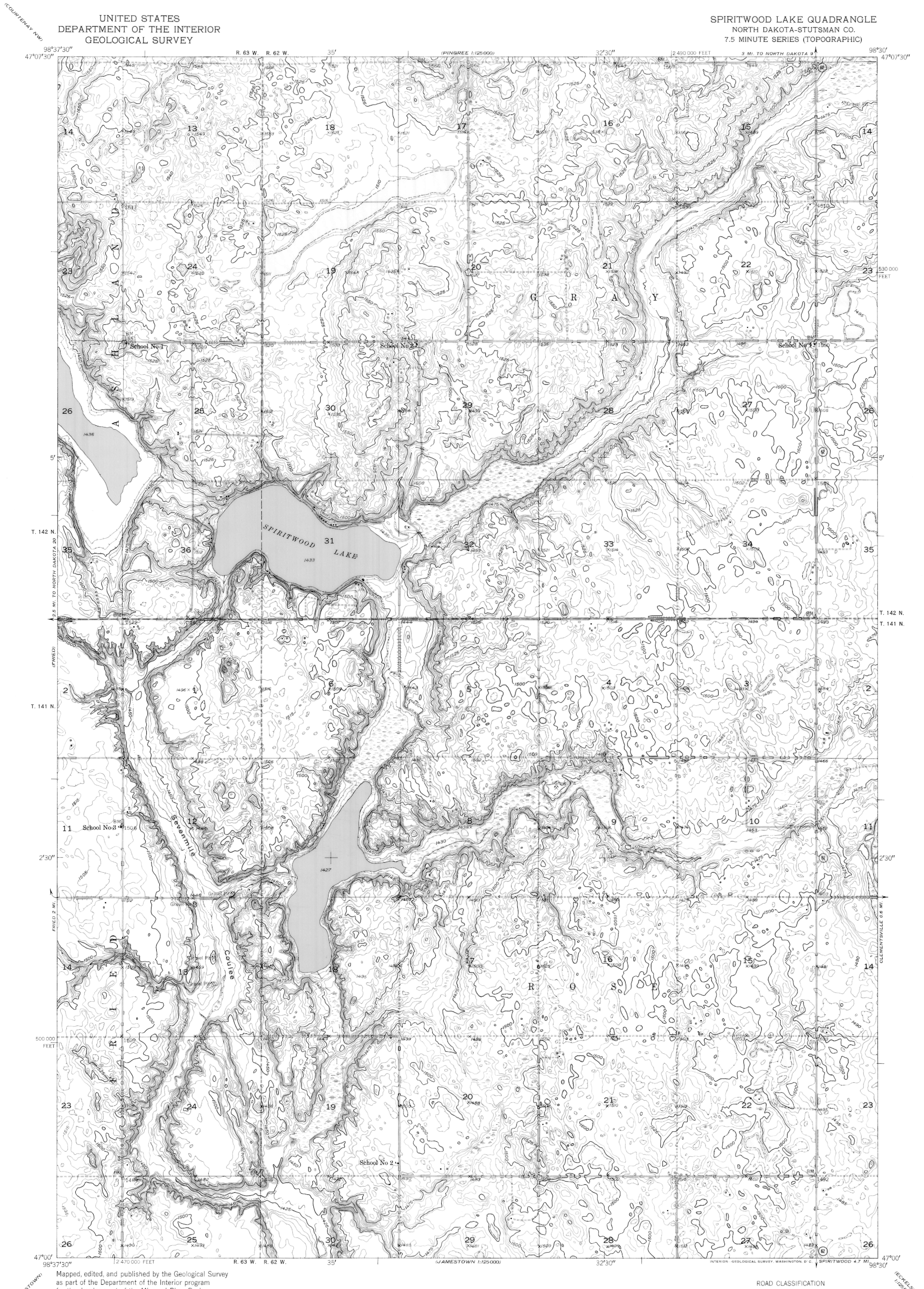
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SPIRITWOOD LAKE QUADRANGLE
NORTH DAKOTA-STUTSMAN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

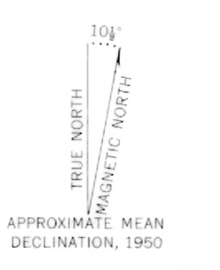


Mapped, edited, and published by the Geological Survey as part of the Department of the Interior program for the development of the Missouri River Basin

Control by USGS and USC&GS

Topography by multiplex methods from aerial photographs taken 1948, and by plane-table surveys 1948 and 1950
Field check 1950

Polyconic projection. 1927 North American datum
10,000-foot grid based on North Dakota coordinate system, south zone



APPROXIMATE MEAN DECLINATION, 1950

CONTOUR INTERVAL 5 FEET
DATUM IS MEAN SEA LEVEL

SCALE 1:24000

ROAD CLASSIFICATION
Heavy-duty — 4 LANE | 6 LANE — Light duty
Medium-duty — 4 LANE | 6 LANE — Unimproved dirt
U. S. Route — State Route

SPIRITWOOD LAKE, N. DAK.
N4700—W9830/7.5

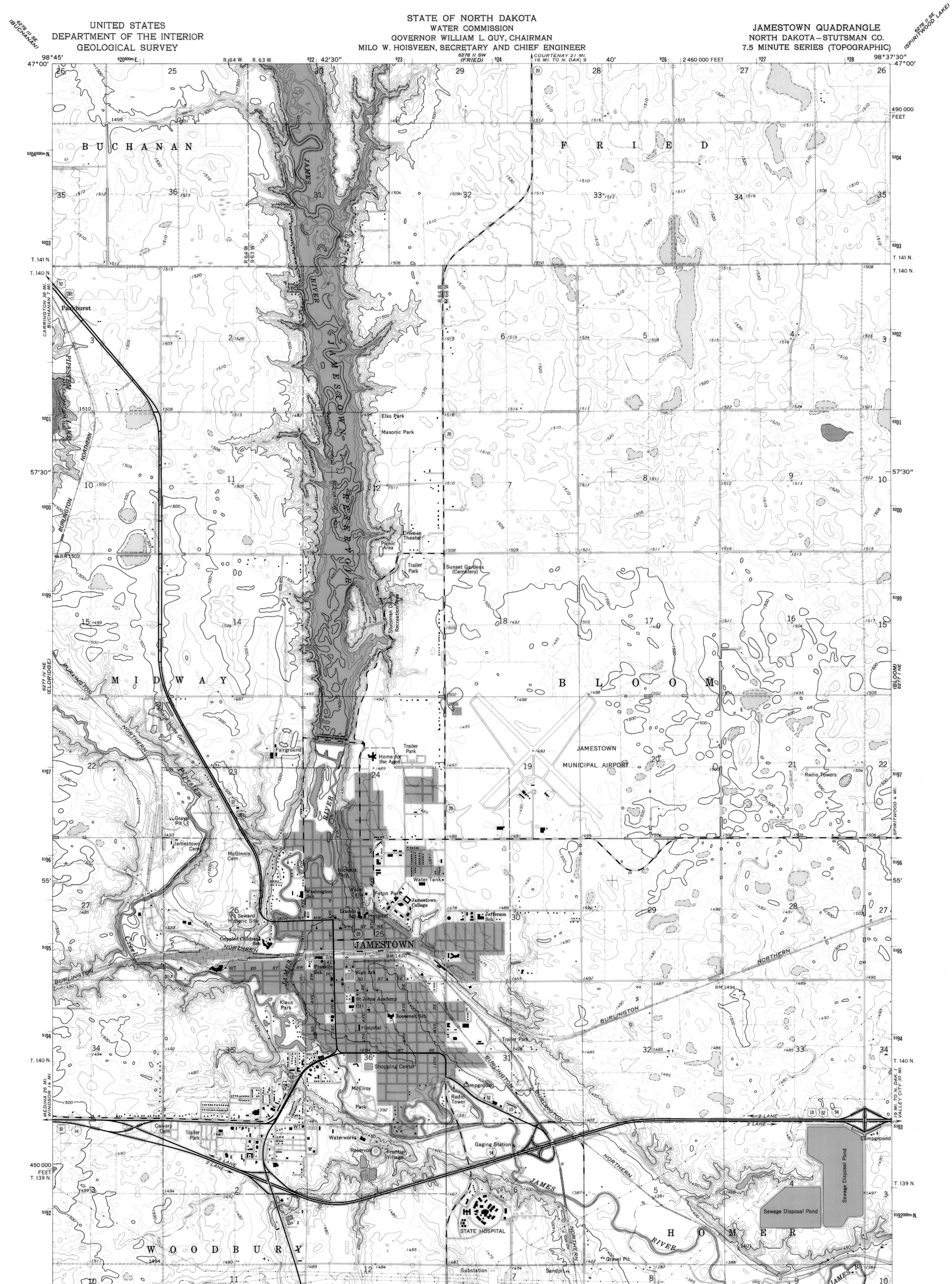
EDITION OF 1951

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, FEDERAL CENTER, DENVER, COLORADO OR WASHINGTON 25, D. C.
AND BY THE STATE WATER CONSERVATION COMMISSION, BISMARCK, NORTH DAKOTA
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF NORTH DAKOTA
WATER COMMISSION
GOVERNOR WILLIAM L. GUY, CHAIRMAN
MILO W. HOISVEEN, SECRETARY AND CHIEF ENGINEER

JAMESTOWN QUADRANGLE
NORTH DAKOTA–STUTSMAN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



Mapped, edited, and published by the Geological Survey as part of the Department of the Interior program for the development of the Missouri River Basin

Control by the USGS and USC&GS

Topography by photogrammetric methods from aerial photographs taken 1948 and planetable surveys 1950. Revised 1966

Polyconic projection. 1927 North American datum
10,000-foot grid based on North Dakota coordinate system, south zone
1000-meter Universal Transverse Mercator grid ticks, zone 14, shown in blue

Red tint indicates areas in which only landmark buildings are shown
Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked

UTM GRID AND 1975 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
AND BY THE STATE WATER COMMISSION, BISMARCK, NORTH DAKOTA 58501
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

ROAD CLASSIFICATION

Heavy-duty — Light-duty
Medium-duty — Unimproved dirt
Interstate Route — U. S. Route — State Route

NORTH DAKOTA
QUADRANGLE LOCATION

JAMESTOWN, N. DAK.
N4652.5—W9837.5/7.5

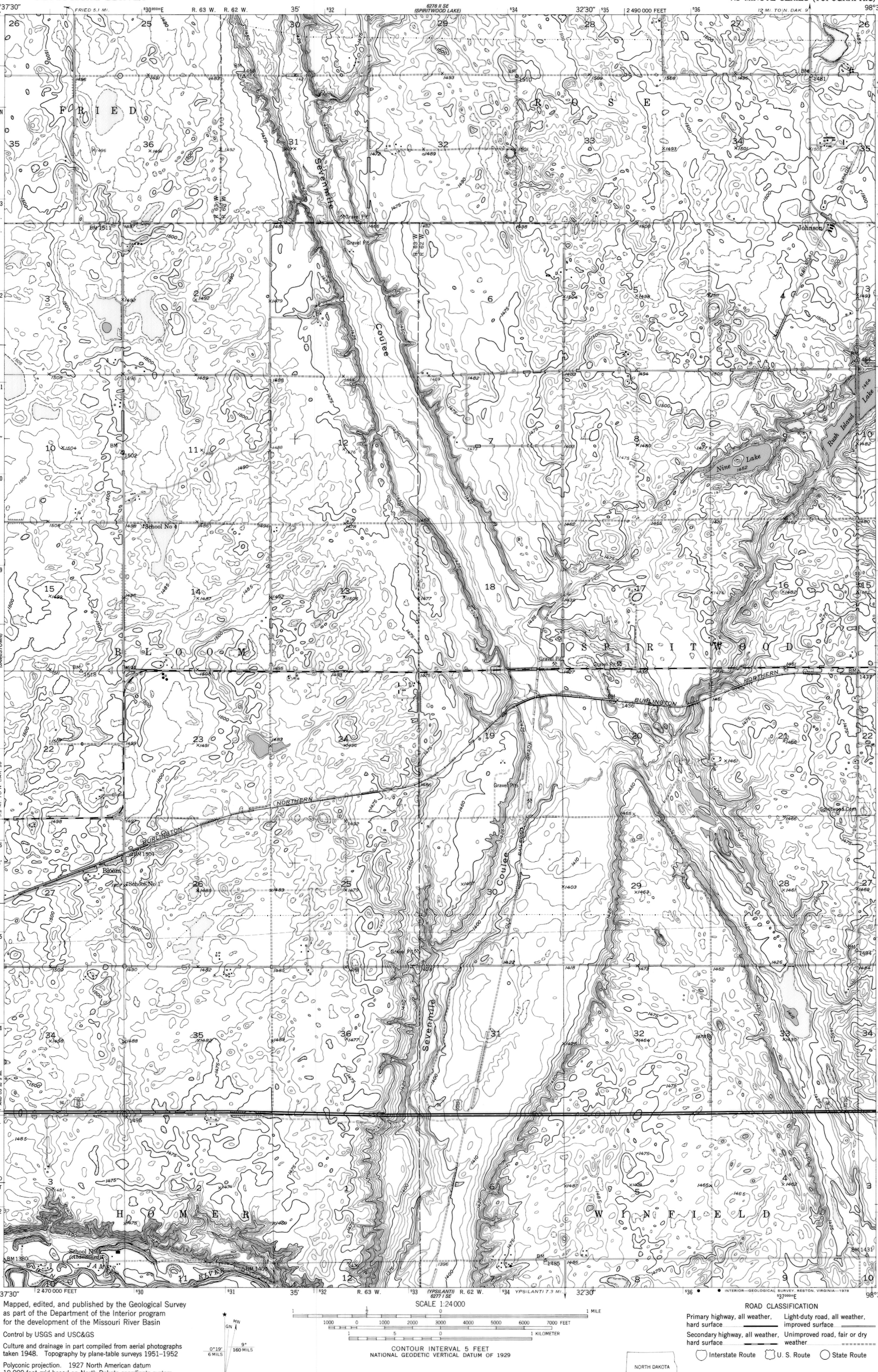
Revisions shown in purple compiled from aerial photographs taken 1975. This information not field checked

Purple tint indicates extension of urban areas

1966
PHOTOREVISED 1975
AMS 6277 I NW—SERIES V871

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

BLOOM QUADRANGLE
NORTH DAKOTA-STUTSMAN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



Mapped, edited, and published by the Geological Survey as part of the Department of the Interior program for the development of the Missouri River Basin

Control by USGS and USC&GS

Culture and drainage in part compiled from aerial photographs taken 1948. Topography by plane-table surveys 1951–1952

Polyconic projection. 1927 North American datum
10,000-foot grid based on North Dakota coordinate system, south zone
1000-meter Universal Transverse Mercator grid ticks, zone 14, shown in blue

Revisions shown in purple compiled from aerial photographs taken 1975. This information not field checked

UTM GRID AND 1975 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
AND BY THE STATE WATER COMMISSION, BISMARCK, NORTH DAKOTA 58501
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

NORTH DAKOTA
QUADRANGLE LOCATION

ROAD CLASSIFICATION

Primary highway, all weather, hard surface
Light-duty road, all weather, improved surface
Secondary highway, all weather, hard surface
Unimproved road, fair or dry weather
Interstate Route
U. S. Route
State Route

BLOOM, N. DAK.
N4652.5—W9830/7.5

1952
PHOTOREVISED 1975
AMS 6277 I NE—SERIES V871