# Sand and Gravel Resources Show Record Production in North Dakota

Fred J. Anderson

**Introduction**

Sand and gravel resources are being produced in record volumes across North Dakota, thanks arguably to increased demands throughout western North Dakota in supplying the needs of transportation and oil and gas-related development projects across the Williston Basin. The North Dakota Geological Survey (NDGS) first reported on the production of the state's mineral resources in the Mineral Statistics portion of the Second Biennial Report of the State Geological Survey of North Dakota, published in 1902 by North Dakota's second State Geologist, Frank A. Wilder. In this report an accounting of the production of $5,000 of stone and an undetermined amount of gravel was noted. Wilder commented later in the report on North Dakota's vast gravel resources and stated: "It is impossible to estimate the value of the great gravel deposits of North Dakota, from which thousands of cars are taken annually for railroad ballast." Over a century later, the NDGS continues to report on the mineral production of the state annually in the State Geologist's report to the U.S. Geological Survey's National Minerals Information Center. Over the past three years, from 2009 to 2011, the reported volume of sand and gravel produced in North Dakota has increased by a factor of 3.7, from just over 1.6 million cubic yards (MCY) to just over 5.9 MCY, which is an historical high for the production of this resource over the period of reported production from 1977 to 2011 (NDSSCC, 1977-2011).

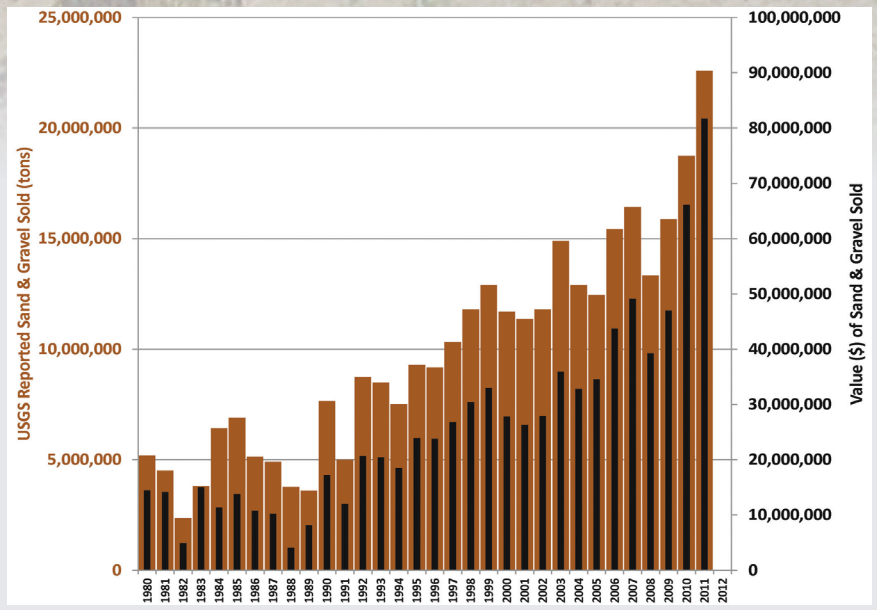


**Figure 1.** Annual reported production of sand and gravel (brown columns) and value ($) of sand and gravel sold in North Dakota (black columns) from 1980 to 2011. Production and sales of construction sand and gravel in the state have been continually on the rise since the early 1990s.

A similar increase can also be seen in the amount of sand and gravel produced in North Dakota as reported to the U.S. Geological Survey's National Mineral Information Center, which bases its production accounting and reporting on the amount of resource reported "as measured by mine shipments, sales, or marketable production (including consumption by producers)" (USGS, 2011). The USGS reported in 2011 that an estimated 22.6 million tons of construction sand and gravel was mined in North Dakota (USGS, 2012), up nearly 6.7 million tons from 15.9 in 2009, with a value of just over $80,000,000 (fig. 1).

**Mined Quantities and County Production**

According to data compiled by the North Dakota State Soil Conservation Committee (NDSSCC), over the last 35 years in North Dakota, the production of sand and gravel has ranged from an annual low of just over 1.3 MCY reported in 2002 to the historic annual high of 5.9 MCY reported in 2011. The average annual production of sand and gravel in North Dakota, based on annual reported production from the past 35 years, is approximately 2.9 MCY (fig. 2). Unfortunately, these numbers are suspect because they are submitted on a voluntary basis and most likely reflect an under-reported condition.

The majority of sand and gravel production in North Dakota has been from the western part of the state with reported recent increases in production from locations dominantly in northwestern North Dakota (fig. 3).

**Increasing Interest from Industry**

As well as the marked reported production increases, there has been a surge in recent public and industry interest and inquiries to the NDGS, in the form of letters, emails, phone calls, and office visits. Inquiries related to sand and gravel resources in the state have been on a relatively steady rise since mid-2009. Of the 676 individual public inquiries serviced over this time period, 211 (31%) were related to sand & gravel resources in North Dakota. In the 2009-2011 biennium the author serviced 87 separate sand and gravel related inquires. In the current biennium (2011-2013) we continue on an increasing trend to service likely double the inquiries from the previous biennium (fig. 4).

Since the earliest days of the North Dakota Geological Survey, sand and gravel has been one of the important mineral resources that we have evaluated. As part of both our county and urban surface geologic mapping programs we have identified where

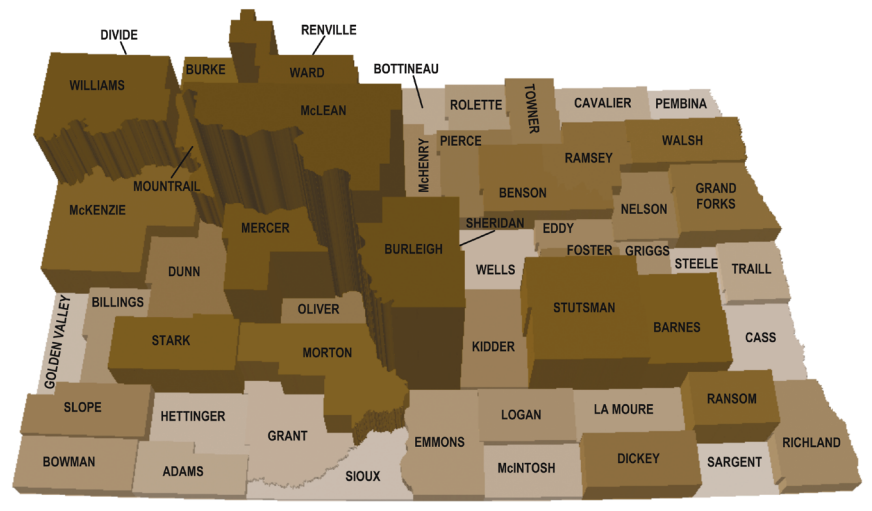


**Figure 2.** Reported sand and gravel volumes produced in North Dakota by county from 1977 to 2011. Counties in western North Dakota have produced the greatest volumes while McLean County has the highest reported production (NDSSCC, 1977-2011).

sand and gravel deposits are located. In doing so, we have noted the various landforms that are most likely to contain economically viable sand and gravel deposits.

**Sand & Gravel Deposits associated with Glacial Landforms**

The most common types of glacial landforms in North Dakota that contain sand and gravel resources include kames (fig. 5), eskers, linear ridges or drumlins, beach deposits associated with glacial lakes, and sand and gravel deposits associated with glacial meltwater channels and outwash plains.

Kames are glacial landforms commonly comprised of mixed sand and gravel deposits formed during the stagnation of glacial ice and localized melting within the glacier. One of the larger kames in the state is Black Butte, located in southeastern Ward County, just northeast of Sawyer and originally identified and interpreted by Lemke (1960). Eskers are long sinuous ridges of mixed sand and gravel deposits commonly formed in subglacial (i.e.

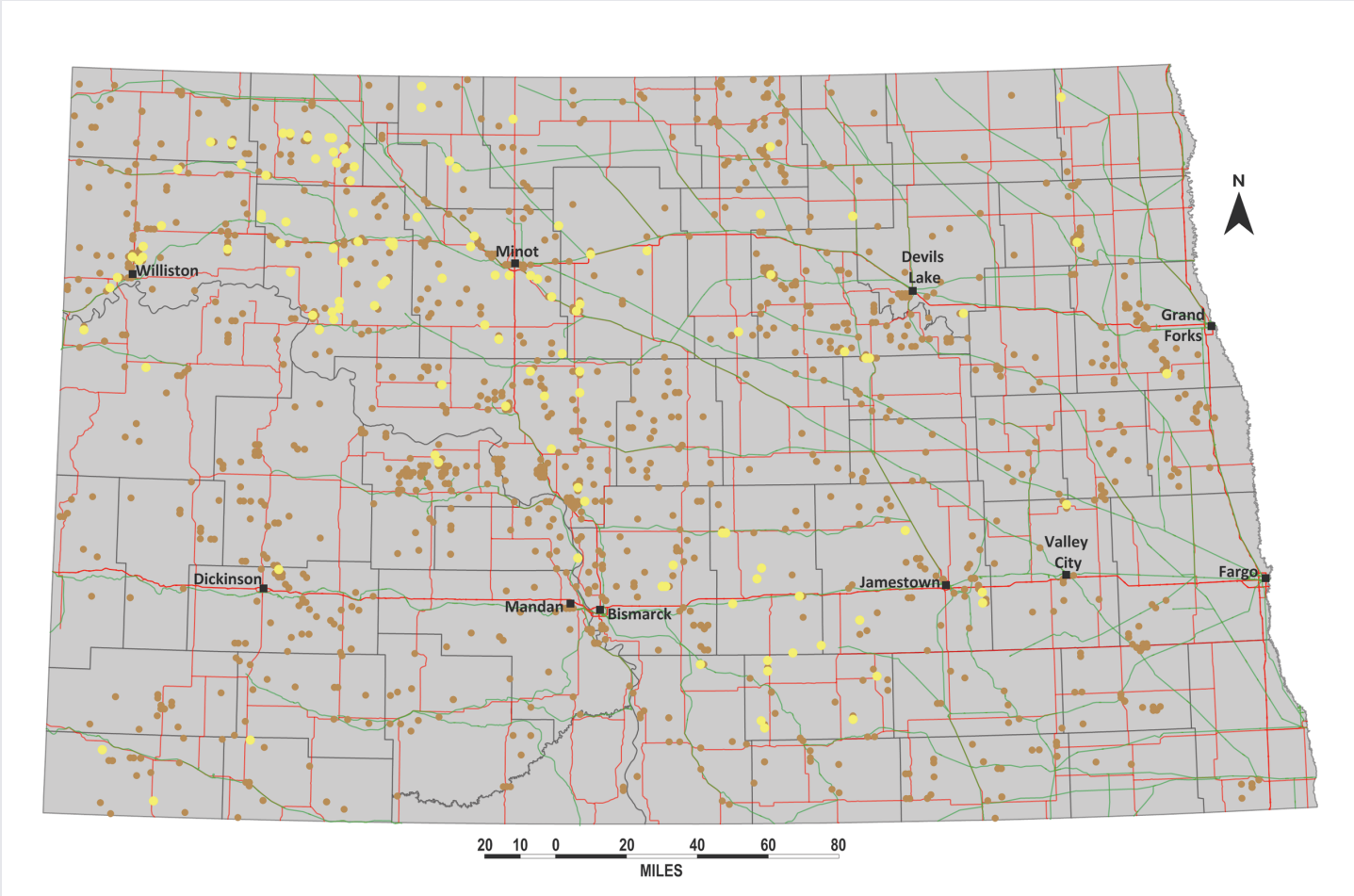


**Figure 3.** Locations where sand and gravel (brown dots) has been produced in North Dakota from 1977 to 2011. Reported production has come dominantly from northwestern North Dakota in Williams, Burke, Mountrail, Ward, and McLean counties. Locations where sand and gravel (yellow dots) was produced from 2009 to 2011, displaying the recent increasing trend in production, are found dominantly in northwestern and southeast-central North Dakota. Transportation routes are shown as roads (in red) and rail lines (in green). County boundaries are delineated in gray.

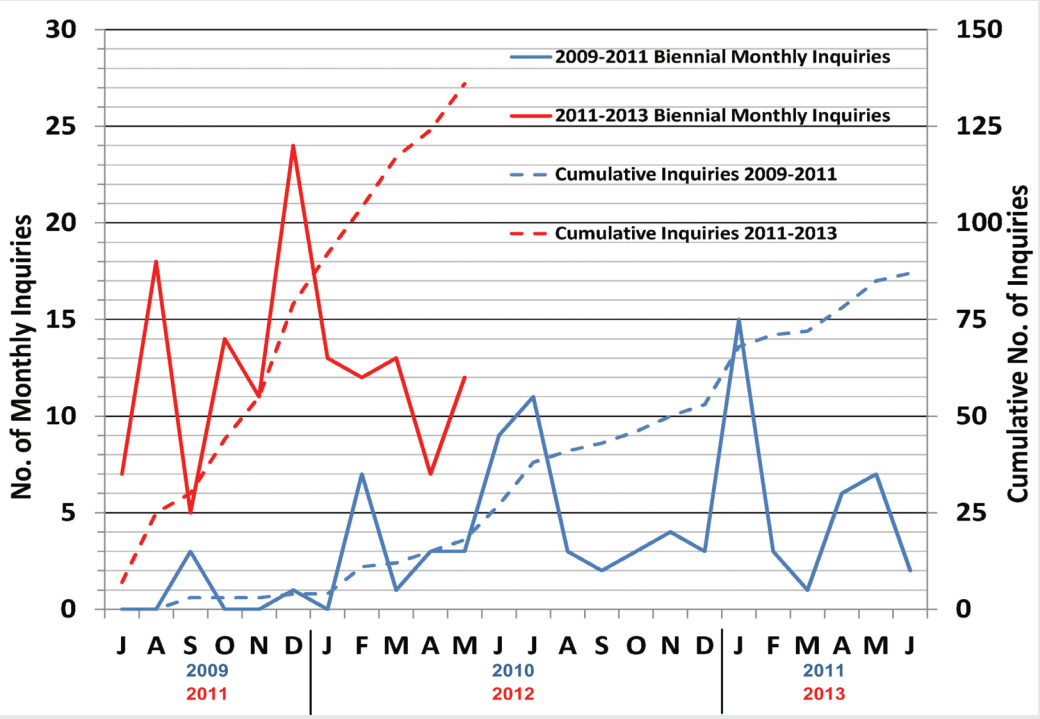


**Figure 4.** Trends in sand and gravel-related inquiries in North Dakota received by the NDGS and serviced by the author during the 2009-2011 biennium (highlighted in blue) and the current biennium (highlighted in red). The increasing trend is likely to continue with increasing oil and gas development in the Williston Basin and continued interest in the state's sand and gravel resources.

beneath the ice) drainage tunnels, where glacial meltwaters carry and deposit sand and gravel underneath, out and away from the melting glacier. The Dahlen Esker, in northeastern North Dakota in northwestern Grand Forks County, is one of the more notable and picturesque esker landforms in the state (Kume, 1967). Linear ridges or drumlins can also be found in North Dakota, and may consist of either clay-rich glacial sediments commonly referred to as "till" or mixed sand and gravel deposits with appreciable fines and cobbles. Some of the most impressive linear ridges in the state are found in southern McHenry County (Manz, 2006) and have been characterized and interpreted by several notable past Survey geologists such as Bluemle and Clayton (2006). The beaches of the former Glacial Lake Agassiz in eastern North Dakota in the Red River Valley also contain sand and gravel deposits and tend to follow long, linear trends parallel to the former lake's shorelines, like the subtle beach landforms found in western Grand Forks County (Hansen and Kume, 1970). Glacial meltwater channels, such as the Verendrye diversion channel southeast of Velva, and outwash plains like the Kidder County sand plain in central Kidder County also contain appreciable amounts of sand and gravel. Sand and gravel deposits can also be found along the valley walls of existing rivers and streams in terrace deposits in North Dakota. Terrace gravels (and sands) along the Souris River Valley in Minot or Sheyenne River Valley near Valley City offer examples of glaciofluvial (i.e. flowing glacial meltwater) deposits currently being developed (Anderson, 2011).

**Sand and Gravel in Non-Glacial Settings**

Sand and gravel is also found in non-glacial settings in parts of western and southwestern North Dakota. Gravel is very rare in Cretaceous and Tertiary rocks, but isolated Eocene-age deposits are present in western North Dakota in the Chalky Buttes Member of the Chadron Formation (fig. 6). Quaternary sands and gravels, deposited as alluvium associated with streams and rivers such as the Cannonball and Heart Rivers (fig. 7), are also common throughout southwestern North Dakota.

**Quality Concerns**

The intended end-use is one of the most important considerations when evaluating a particular sand and gravel deposit for development. For example, some sand and gravel deposits, based on their inherent mineralogical character, may be well suited for some applications while being wholly unsuitable for others. A detailed characterization can aid in determining the suitability and potentially identify uses and markets that may have been overlooked. The potential for degradative mineral-solution reactivity in some types of deposits (e.g. silicates, carbonates, and shales), is one of the most common considerations in initial quality assessments and is best evaluated by specific materials testing (fig. 8). Alkali-silica reactivity, carbonate dissolution, and expansive clays in shales are some of the most common issues and can lead to the rejection of materials for certain applications such as aggregate for concrete. Engineering standards and specifications, such as those published by the American Society for Testing and Materials (ASTM), the American Petroleum Institute (API), and the International Organization for Standardization (ISO), are best consulted when attempting to determine the most efficient and reliable testing and characterization methodologies for a particular sand and gravel deposit given the end use. In addition, contractor specifications published by the county or state can also be useful in determining the suitability of a sand and gravel deposit for a particular use.

**Extraction and Production**

According to reported data, the majority (89%) of producing sand and gravel pits in North Dakota are commonly excavated to depths of 25 feet or less with an average depth of 15 feet (fig. 10). Only a few pits have been excavated to depths of 100 feet or more.

The majority of sand and gravel resources in the state are commonly readily accessible at the land surface with the depth of the local water table serving as the limiting factor on deposit extraction and development. Excavations into local water tables characteristically create concerns with respect to the handling of accumulated pit waters, both from the mining and production side, and potential for ground-water contamination, from the environmental side. Consequently, the depth to the water table commonly limits the depth of excavation possible for a particular deposit. In addition, storm-water management issues may also need to be considered in the development of a particular sand

**Figure 5.** Aerial oblique view to the south across Black Butte, a glacial kame deposit interpreted as a Moulin kame, just northeast of the Souris River Valley at Sawyer, North Dakota. This unique glacial landform consists of a mixture of sand, gravel, and cobbles, deposited within a melting, flowing-water depression (Moulin) within glacial ice (Photo by Anderson, NDGS).

and gravel deposit and may also require a permit from the ND Department of Health (NDDH).

**Figure 6.** Outcrop of sandy and pebbly conglomerate in the Chalky Buttes Member of the Chadron Formation in southwestern North Dakota (Photo by Murphy, NDGS).

**Reclamation**

Current state regulations require that sand and gravel mining operators restore and reclaim the land areas disturbed during extraction and production of sand and gravel to a condition of productive use and in such manner as is agreed upon between the landowner and the operator. According to the North Dakota Century Code (38-16-01), "Reclamation" is defined as ". . . the reconditioning of the area of land affected by a surface mining operation to make the area suitable for productive use, including, but not limited to, forestry, agriculture, grazing, wildlife, recreation, residential, and industrial sites." Commonly in the past, but less so now, old sand and gravel pits became a collection area for old, unused, or unwanted items i.e. garbage (fig. 10). Being good stewards of the land and its resources by adhering to development and reclamation best practices decreases the risk of a pit being unintentionally misused and further decreases the likelihood of the area being a safety concern for future generations.

**Regulation and Permitting Process in ND**

Currently there are several agencies, at the state level, that deal with sand and gravel resources development within the State of North Dakota. The Survey *does* regulate and permit the development of subsurface minerals in North Dakota, in accordance with the ND Century Code (Chapter 38-11.2), but this *does not* include the extraction and\or production of sand and gravel

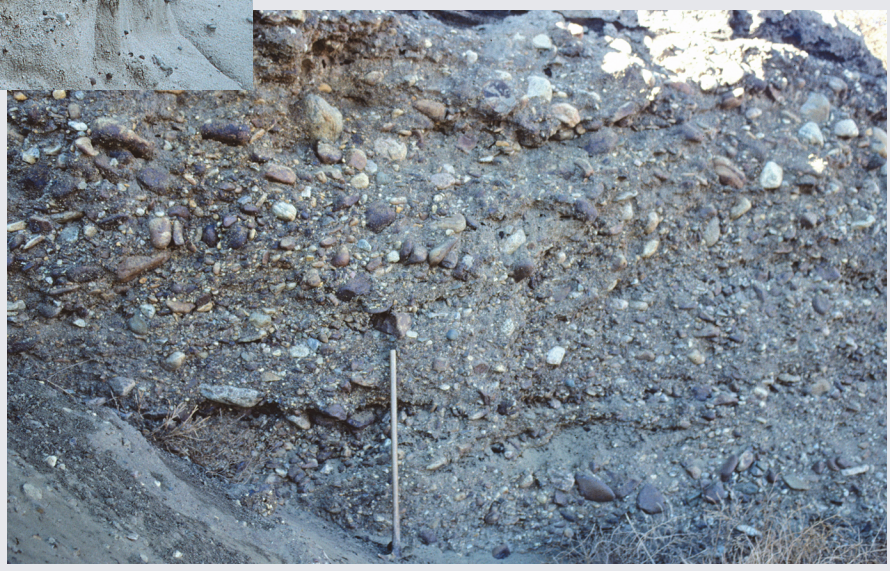

**Figure 7.** Alluvial gravels of the Heart River just west of Mandan currently being developed as a sand and gravel resource (Photo by Murphy, NDGS).

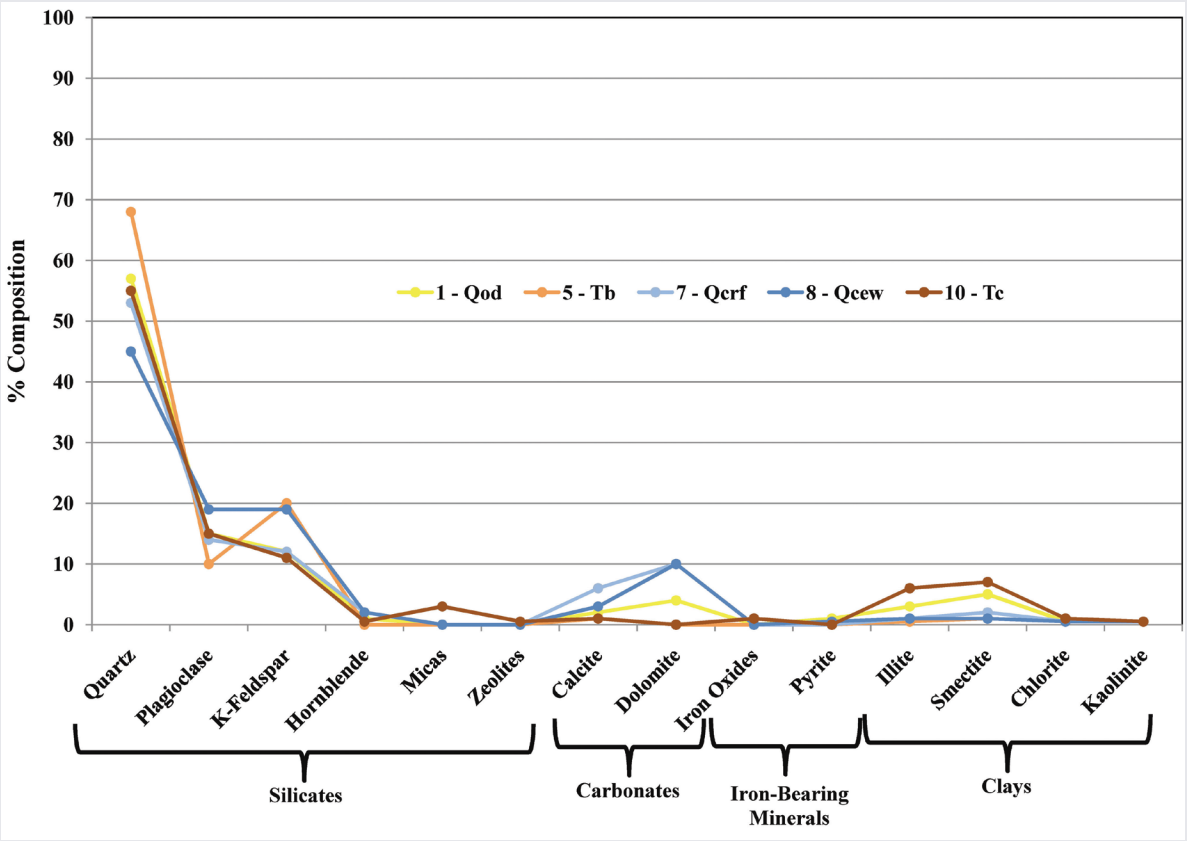


**Figure 8.** Mineralogical composition of selected sands in North Dakota as determined from X-Ray Diffraction Analysis (XRD) completed as a part of recent Survey investigations into the use of North Dakota sand resources as natural sand proppant (Anderson, 2011). Qod: Quaternary-age dune sand of the Oahe Formation from the Denbigh Dunes area in McHenry County, Tb: Tertiary-age (Paleocene) fluvial sand from the Bullion Creek Formation in northwestern Grant County, Qcrf: Quaternary-age glaciofluvial sand from southwestern McHenry County, Qcew: Glaciolacustrine (Glacial Lake Agassiz) beach sands from southwestern Grand Forks County, Tc: Tertiary-age (Paleocene) fluvial sand from the Cannonball Formation in southern Burleigh County.

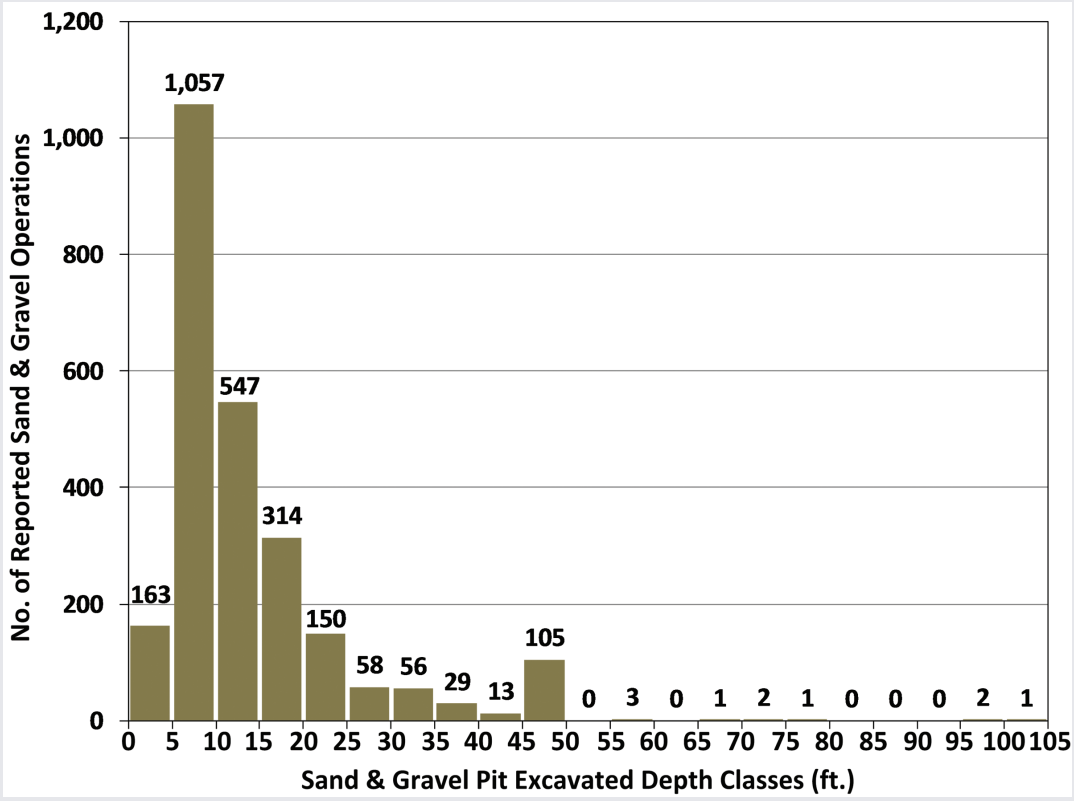


**Figure 9.** Distribution of sand and gravel pit excavation depths in North Dakota. Data compiled from the NDSSCC.

**Figure 10.** An example of an abandoned sand and gravel operation in southeastern North Dakota where waste has accumulated in the excavated area of the former pit (Manz and Biek, 2004) (Photo by Manz, NDGS).

resources in North Dakota. As stated in North Dakota Century Code, Chapter 38-11.2-01: " 'Subsurface mineral' means any naturally occurring element or compound recovered under the provisions of chapter 38-12, but for the purpose of this chapter *excludes coal, oil and gas, sand and gravel, and rocks crushed for sand and gravel* [emphasis added]." Currently, the requirements for the production of sand and gravel, as well as other aggregate resources (e.g. "scoria" or clinker), are managed by the ND State Soil Conservation Committee. The reclamation and reporting requirements are published in their annual Surface Mining Report (NDSSCC, 1977-2011).

Additionally, several counties in the state also have permitting requirements (e.g. conditional use permits) related to the extraction and production of sand and gravel and related aggregate resources (fig. 11). At the time of writing, 16 counties located primarily in west-central North Dakota have a permitting requirement. Of the remaining 37 counties surveyed, five require some form of permitting, depending on the volume of sand and gravel excavated, while the other 32 counties reportedly do not. Additional county requirements can be found by contacting the corresponding county offices directly. Although many counties in North Dakota currently do not have permitting requirements, it is always good practice to contact the individual counties where a new project is planned in order to learn of any changes or updates to their existing requirements (NDACo, 2012).

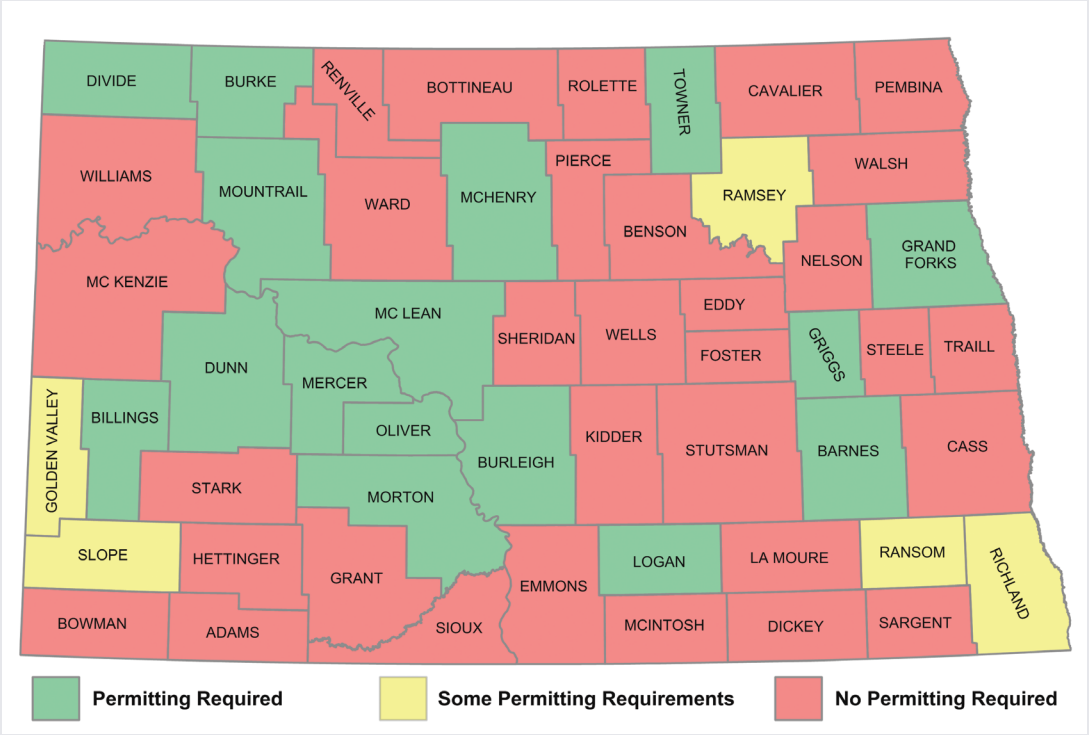


**Figure 11**. Sand and gravel permitting requirements by county in North Dakota.

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