Data Report for the Geologic and Scenic Quality Evaluation of Selected Sand and Gravel Sites on the Wind River Indian Reservation, Wyoming

Open-File Report 2011–1302

U.S. Department of the Interior
U.S. Geological Survey

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By William H. Langer, Bradley S. Van Gosen, Belinda Arbogast, and David A. Lindsey

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Executive Summary

This data report contains the results for 12 sites investigated in April 2005 on the Wind River Indian Reservation, Wyoming, including:

- The U.S. Geological Survey (USGS) geologic studies and engineering tests.
- A conclusion and suggestions for the best use of sand and gravel materials.
- Calculations of available sand and gravel materials.
- A scenic quality landscape inventory and evaluation.
- A digital dataset of sand and gravel deposits on the Wind River Indian Reservation, Wyoming.

Appendix 1 contains the detailed information mentioned above for each site. Appendix 2 contains the photographic documentation that represents the scenic quality of each site. Appendix 3 contains the engineering test results from Inberg-Miller Engineers, Riverton, Wyoming.

The text of this report is presented in a Portable Document Format (pdf). Adobe Acrobat Reader or similar software is required to view it. The digital dataset is presented as a shapefile. Suitable GIS or CAD software is required to view it.

Geologic Quality

For this assessment, the estimates of the quantity and quality of aggregate resources are based largely on a generalized knowledge of the geologic character of the deposits and on limited engineering tests. Our estimates were based on an assumed continuity of materials made by comparing the geologic characteristics of the unknown parts of the deposit against other similar, better understood, parts of the deposit such as observations made in gravel pits or exposed edges of the terraces. It is recommended that a detailed examination of any deposit be made before developing a large-scale commercial operation on that deposit.

Sources of sand and gravel were evaluated regarding their potential for use as aggregate in Portland cement concrete, asphalt, and base course. All deposits evaluated generally meet the requirements for these three uses. Gravel from all the deposits will have to be crushed and screened if used for asphaltic concrete, and oversized gravel will have to be crushed and screened for use in Portland cement concrete. The final product may require washing for certain high-specification uses.

All deposits evaluated contain coatings of caliche (calcium carbonate–$CaCO_3$), which may cement the particles. Some deposits contain large boulders. These factors may complicate the extraction and processing of sand and gravel.

There is a special consideration regarding the use of Wind River terrace gravels for aggregate in Portland cement concrete. Certain varieties of quartz minerals present in rocks throughout the region are susceptible to the alkali-silica reaction (ASR) when used in Portland cement concrete. All the deposits evaluated contain potentially reactive quartz minerals.

Evaluation Factors	Generally suitable for use as Portland cement concrete, asphalt, and base	Thickness of caliche may complicate excavation and processing	Presence of large boulders may complicate excavation and processing	Increased concern for alkali-silica reaction potential
Site Name	**All evaluated sites**	**Airport Kane Draw Winkleman Dome Willow Creek**	**Red Rocks Kane Draw Kinear Winkleman Dome**	**Winkleman Dome**

Scenic Quality

For this assessment, the scenic quality inventory focuses on features that occur naturally in the landscape and ranking proposed sites. The rankings can be used as a guide to analyze potential visual impacts of sand and gravel development at each site.

Information collected for this scenic quality classification indicates that two of the Wind River Indian Reservation sites are classified with a scenic quality rating of A (highest), four sites are rated B (moderate), and six sites are rated C (lowest). Scenic quality ratings are listed below for each site.

Scenic Qualty Rating	**A**	**B**	**C**
Site Name	**Red Rocks Willow Creek**	**Burma Hill Crowheart Butte #1 Kane Draw Le Clair**	**Airport E Boysen Causeway Johnstown Kinnear Sheer Winkleman Dome**

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Introduction

During April 2005, the U.S. Geological Survey (USGS) conducted field work on the Wind River Indian Reservation, Wyoming, to inventory and evaluate sand and gravel deposits underlying river terraces on tribal lands along the Wind River. The geologic approach conducted by the USGS places the results of previous and current engineering tests in a context more useful to the tribes, which will allow them to take advantage of a wealth of existing technical data. A scenic quality inventory was conducted simultaneously in order for the tribes to evaluate some of the visual impacts of developing aggregate resources. This document consists of two major products: (1) a report of the field study undertaken by the USGS for this project, and (2) a dataset of sand and gravel deposits on the Wind River Indian Reservation, Wyoming.

This report is structured primarily for the reader who starts with no knowledge of geology or landscape assessment. It also provides an accessible source of information for the geologist or land planner.

The specific objectives are several. One objective is to provide a geologic description for each site including the deposit location, geologic observations on sand and gravel deposits such as gravel rock type, particle roundness, general condition of the particles, overburden, deposit thickness, deleterious minerals, and river-terrace level.

A second objective is to provide engineering tests including gradation, Los Angeles (LA) abrasion, soundness, specific gravity, and absorption on 14 samples from 12 sites on tribal lands or on allotment land. The samples were delivered to a certified engineering laboratory for testing and the results are included in Appendix 3.

A third objective is to document and rate the scenic quality of the sites investigated in the project area. This includes a scenic quality field inventory, score, and classification. The purpose of the scenic quality inventory is to establish a consistent database describing the inherent scenic values of the natural landscape.

Acknowledgments

The USGS would like to thank Floyd Phillips, Bureau of Indian Affairs; Ed Womack, Bureau of Land Management; and John Enos, Shoshone Oil and Gas Commission, for their cooperation and help in undertaking this project.

Background Statement

The U.S. Bureau of Land Management (BLM) solicited the USGS to conduct an evaluation of some of the gravel resources on the Wind River Indian Reservation, Wyo. The Wind River Indian Reservation is located in central Wyoming and includes portions of Fremont and Hot Springs counties. The reservation occupies about 3,500 square miles just east of the Continental Divide and is home of two Tribes, the Eastern Band of the Shoshones and the Northern Band of the Arapaho.

Currently, a number of active, inactive, and abandoned mines could be re-opened to provide sand and gravel. This would make better use of existing resources where disturbance has already occurred. After discussions with the BLM, it was agreed that the USGS would conduct a traditional geologic investigation of 12 sand and gravel deposits, and have engineering testing conducted on samples from those sites. The sites include: Airport, Burma Hill, Crowheart Butte #1, East Boysen Causeway, Johnstown, Kane Draw, Kinnear, Le Clair, Sheer, Red Rocks, Willow Creek, and Winkleman Dome (fig. 1).

Landscape has many definitions. For the purpose of this report, it is the visual setting that deals with perception. It consists of the space surrounding the observer and what can be seen of a site from a point within or from a travel route (pedestrian or vehicular). Visual resource management is a program to identify and protect visual values of landscapes.

Mineral development, if not carefully planned, has the potential to modify the character of the landscape and create visual impacts. The development of proposed sand and gravel operations in the Wind River Reservation could affect visual resources and visual quality within the project area. It was therefore also agreed that the USGS would conduct scenic quality landscape evaluations as part of the field work. One premise is that visual (scenic) attractiveness is related to the essential character of a landscape. Landscape character, according to the Bureau of Land Management, (1986) includes three key factors: (1) landform/water; (2) vegetation; and (3) structure (human-made features of the landscape); each of which is described in terms of form, line, color, and texture. Resource managers, including the U.S. Forest Service and BLM, recognize a scenic quality evaluation of the visual landscape is not a stand-alone item, but is one part of a larger integrated program with other biological, physical, and social/cultural resources. An evaluation of the visual contrast which would occur between the existing landscape and the proposed project, and, if necessary, measures to reduce this contrast (and thus minimize adverse visual impacts) could be undertaken.

After a meeting with the BLM, the Bureau of Indian Affairs, and a representative from the Shoshone and Arapaho Tribes, it was agreed that the USGS would inventory and evaluate the sand and gravel deposits underlying river terraces on tribal lands along the Wind River and would provide: (1) a data report and (2) a dataset of sand and gravel deposits on the Wind River Indian Reservation, Wyoming.

During April, 2005, fieldwork was undertaken to evaluate the sand and gravel resources on the Wind River Reservation. The field party consisted of geologists, Bill Langer (Contact Person, USGS, MS 973, BOX 25046, Denver, Colorado, 80225, Tel: 303-236-1249, email: blanger@usgs.gov), Brad Van Gosen, Dave Lindsey, and landscape architect Belinda Arbogast. Access to study area was along unimproved roads by four-wheel-drive vehicle or by walking.

This report was originally transmitted to the Bureau of Land Management as an Administrative report in January, 2006. Tables 1 and 2 have been updated since that original transmittal.

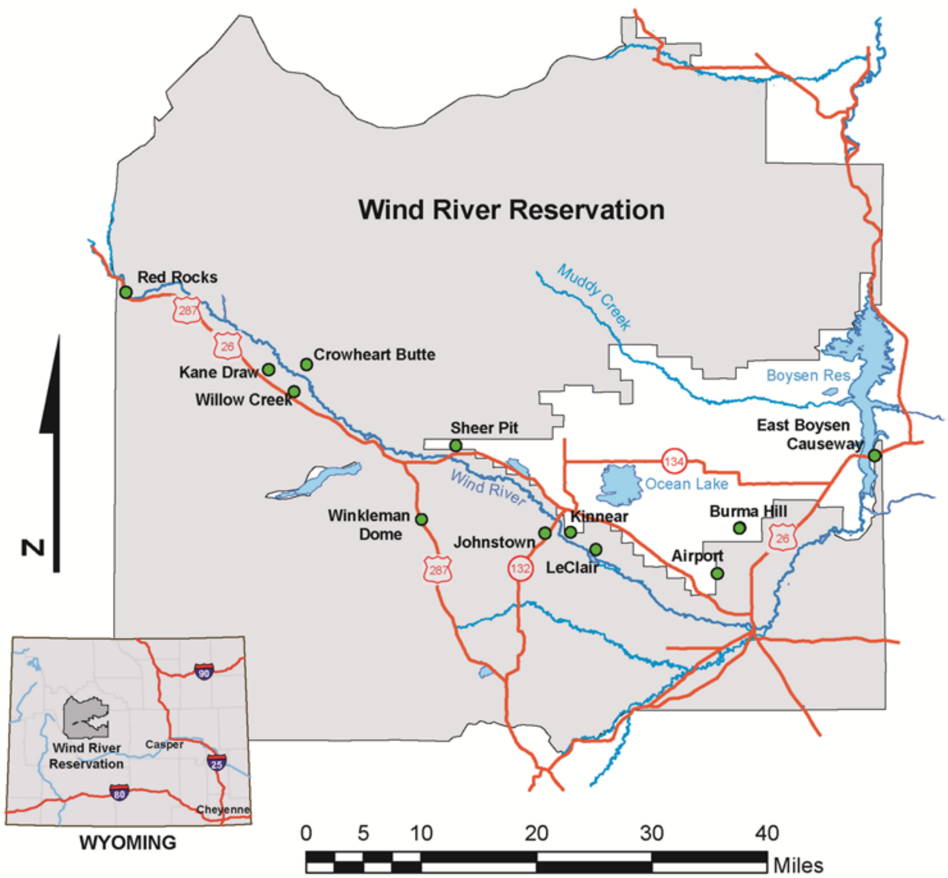


Figure 1. Map of the Wind River Reservation (grey shaded area) and site locations.

General Geology and Resources of the Wind River Indian Reservation

The Wind River Indian Reservation lies in a complex structural setting that includes a large inter-mountain depositional basin—the Wind River Basin—bordered by large Rocky Mountain uplifts: the Wind River Range, the Absaroka Range, and the Owl Creek Mountains (fig. 2). During the Laramide Orogeny of North America, large faults along the mountain-basin boundaries offset rocks that formed earlier in the Precambrian, Paleozoic, and Mesozoic geologic eras, moving the rock units upward at least 39,000 feet (ft) (12 kilometers (km)) to form the Wind River Range and Owl Creek Mountains and adjacent Wind River Basin (Keefer, 1965a, 1965b; Keefer and Van Lieu, 1966; Willis and Groshong, 1993). Rocks now exposed in the mountains and their flanks include representatives of each of the major time periods: Precambrian, Paleozoic, Mesozoic, and Cenozoic eras. Only rocks of the Silurian time period are missing (Keefer and Van Lieu, 1966; McGreevy and others, 1969). The Precambrian-age rocks are primarily igneous intrusions and metamorphic rocks, while the overlying Paleozoic and Mesozoic rocks are layers of sedimentary rocks, including dolomite, limestone, sandstone, conglomerate, siltstone, and shale.

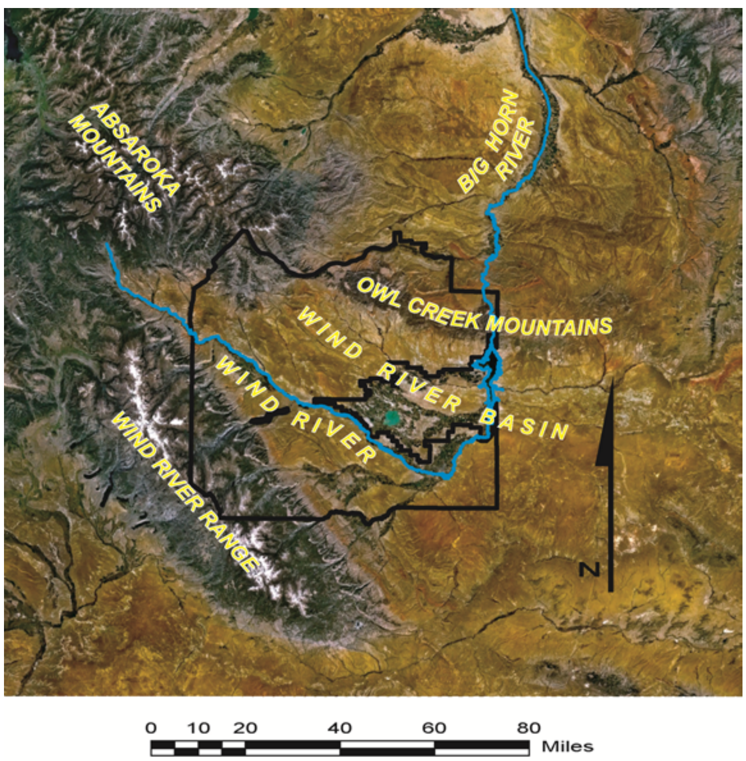


Figure 2. The Wind River Reservation (outlined in black) features include the Wind River Basin, three mountain ranges in a general north-south direction, and the Wind River. The Wind River becomes the Big Horn River just a few miles north of the reservation.

The majority of the exposed rocks in the center of the Wind River Basin are those of the Wind River Formation (lower Eocene in age), which consists primarily of sandstone, conglomerate, siltstone, and shale (McGreevy and others, 1969, plate 2). The Wind River Formation is covered locally by Cenozoic age deposits of glaciers, ancient river terraces, landslides, slope wash and alluvium. Tertiary-age volcanic rocks are the dominant rock type of the Absaroka Range in the northwestern region of the Reservation.

Considerable energy resources are hosted by the Wind River Basin in the Reservation. Dome-like folds in the sedimentary layers trap numerous reservoirs of petroleum and natural gas, which continue to supply productive wells for several oil fields within the Reservation (Keefer and others, 1993). Coal beds underlie about half of the Reservation (Peterson, 1993) and potential coalbed methane resources also exist (Johnson and Flores, 1993; Johnson and others, 1993).

The varied geology of the Wind River Reservation also contains a number of nonmetallic mineral resources with potential for development. Sand and gravel resources occur in glacial deposits, slope wash, river terraces, and recent alluvium. Sand and gravel resources are especially plentiful within the large river terrace deposits in the basin, which are discussed below. Rock strata that contain bentonite, gypsum, phosphate rock, clay, dolomite, limestone, granite, pumicite, sandstone, and shale exist within the Reservation (Gersic, 1993). Development of these industrial minerals would depend on effective marketing, likely to local industries and users.

For an overview of the geologic rock units and a geologic map of the Reservation the reader is referred to McGreevy and others (1969). The geologic history of this area is described by Keefer (1965b).

Geology of the Sand and Gravel Resources in River Terraces

The Wind River Basin, including the Wind River Indian Reservation, contains considerable sand and gravel resources suitable for multiple uses as aggregate. These sand and gravel resources lie mainly in terraces of the ancient Wind River and its tributaries. The terraces were deposited as the rivers migrated across and cut downward into the basin over approximately the last 1,700,000 years (Chadwick and others, 1997). Cobbles, gravel, sand, and silt were moved by the rivers during high water flow events and deposited as terrace deposits adjacent to each river in their floodplain. As a result, the terraces contain mixtures of sand, cobbles, and gravel composed of various rock types that came from the surrounding upstream region. The terraces, typically capped by cobble, gravel, and sand deposits, now lie well above the present Wind River in the form of broad, gently dipping slopes bounded by bench or step-like ledges, or isolated remnants, such as buttes or flattish ridges, which were left behind by the erosion of the surrounding land (fig. 3).

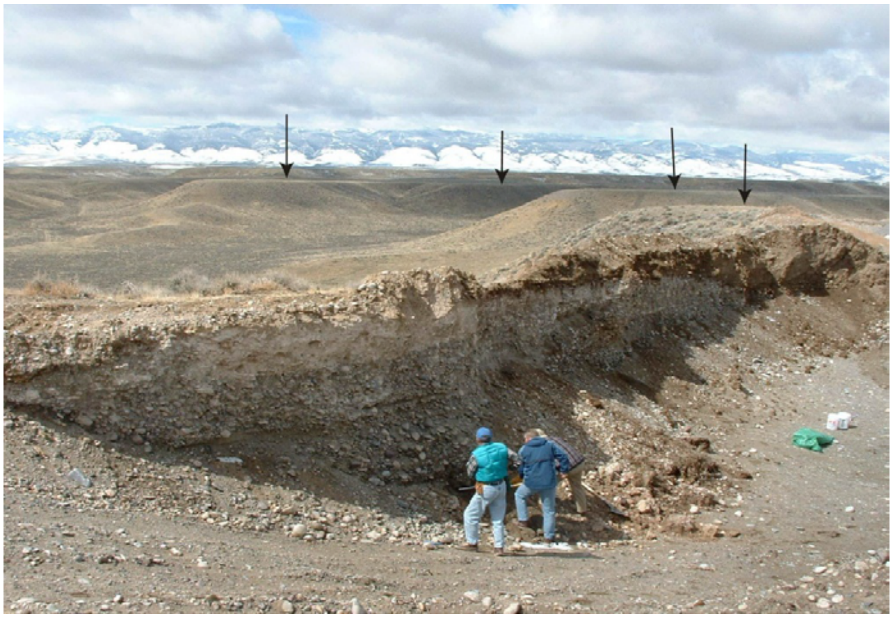


Figure 3. The prominent flat terrace tops (black arrows point to the treads) and gently sloping terrain with mountain backdrop compose a typical Wind River Indian Reservation landscape. At Winkleman Dome, USGS staff examines the exposed terrace scarp for geologic information concerning the sand and gravel. Photograph courtesy of Floyd Phillips.

The cobble-gravel-sand-silt deposits that cap the terraces in the Wind River Basin can be over 20 ft thick, but typically range from about 12 to15 ft thick. The rock types found in the cobbles and gravel include sedimentary rocks derived from erosion of the basin, as well as sedimentary, igneous, and metamorphic rocks supplied by erosion of the mountain ranges that surround the basin (such as the Wind River and Absaroka Ranges and the Owl Creek Mountains). As a result, a wide variety of rock types (lithologies) are found in the terrace deposits, such as: (1) sedimentary rocks (sandstone, limestone, dolostone, and chert); (2) igneous rocks (volcanic rocks, granitic rocks, and dark magnesium-iron-rich (mafic) plutonic rocks); and (3) metamorphic rocks (granitic gneiss, mafic gneiss, quartzite, and quartz-rich veins).

At least a dozen terrace levels are preserved in the Wind River Basin, indicating a dozen or more major elevation levels for the Wind River and its tributaries as they eroded down into the basin (Morris and others, 1959; Chadwick and others, 1997). The terraces are arranged vertically in a step-wise manner with a stratigraphy that is counter intuitive to the arrangement of most sedimentary deposits (typically the oldest deposits lie at the bottom of the pile, youngest at the top). Rather, the down cutting rivers left the oldest individual terraces to rest at the highest elevations in the basin, while the lower terraces are progressively younger and younger as they step down towards the banks of the current Wind River that lies in the low points of the basin.

In addition to the Wind River and its tributaries, glaciers provided an important source of the rock material supplied to the basin and the river terraces. Glaciers of considerable size extended down from the Wind River Range into the western flanks of the basin during the Pleistocene glacial periods that affected North America. The remaining glacial deposits are well displayed near Bull Lake and northwestward for about 24 miles to the Dinwoody Lakes area (Richmond, 1964, 1965; Murphy and Richmond, 1965; Richmond and Murphy, 1965, 1989; McGreevy and others, 1969; Dahms and others, 2003, and references cited in Dahms and others, 2003). The glacial deposits of this area are classic remains of the glacial events in the Rocky Mountain region referred to as the Bull Lake (23,000–16,000 years before present) and Pinedale (>130,000–95,000 years before present) glacial advances (Chadwick and others, 1997).

These glacial events likely had much influence on the development of the river terraces in Wind River Basin over the last 130,000 years or more, such as: (1) the glaciers contributed significant rock debris and sediment loads to the basin, which were redistributed by the rivers and re-deposited as terraces; (2) the glaciers likely influenced the course and base level for the rivers in the area; and (3) retreat and melting of the glaciers during the late Pleistocene supplied significant water and additional sediment to the rivers in the basin.

Recent Alteration of the River Terraces

After the river terraces were deposited and left exposed, three primary processes affected their surfaces—soil development, weathering, and caliche formation.

Soil development within the upper intervals of the terraces ranges from negligible to several feet in thickness. The soil formation on each terrace was controlled by several factors that can vary from site to site, including local climate, elevation, exposure, drainage, and the primary rock types within the deposit (see Shroba, 1989). The soil horizon in the uppermost parts of the terrace, primarily a silt-clay-sand mixture, is usually considered a waste material that is removed and stored for later use in an aggregate mining operation (such as in site reclamation).

Following deposition, terrace deposits are subjected to natural weathering processes including physical weathering such as wetting, drying, freezing, thawing, and chemical weathering by acids dissolved in water percolating through the soil. Weathering processes can weaken some gravel particles, particularly granite, gneiss, and some volcanic gravels. Weathering processes can produce some deleterious materials including clays, which are altered feldspar minerals from granite and gneiss, or mica flakes, which remain after granite and gneiss is weathered. The degree of weathering of granite and volcanic clasts was observed and recorded in the field as part of this study.

Caliche is a calcium carbonate material ($CaCO_3$) similar in character and appearance to whitish cement, which commonly forms coatings and weak cement within the uppermost several feet of the sand-gravel-cobble terrace deposits in the Wind River Basin. During relatively dry climate cycles, precipitation can leach calcium from the soil and rocks in the ground (see Machette, 1985). Carbonate ions are then carried in the waters through pores and openings within the sand-gravel deposit. The calcium is re-deposited as a calcium carbonate (caliche, $CaCO_3$) that coats or cements the sand grains, cobbles, and gravel. Caliche development observed in the sand-gravel deposits of the Wind River Indian Reservation extended to a depth of eight feet below the land surface, but typically extends to a depth of 1–2 ft. The carbonate stage (see Glossary) was observed and recorded in the field as part of this study.

Geologic Investigations and Engineering Tests

Sand and Gravel

Natural aggregate consists of sand, gravel, and crushed stone. Sand and gravel is a naturally occurring deposit that is commonly excavated with conventional earth-moving equipment and used as is or is further processed by crushing, screening, and washing. Crushed stone is a manufactured material created by drilling, blasting, and mining hard rock, which is crushed into gravel and sand-sized pieces. This report addresses only sand and gravel.

Sand and gravel is one of the most widely used mineral resources. The production of sand and gravel in Wyoming (table 1), as well as the number of operations providing that material, has generally increased every year until the recent downturn in the housing and construction market. It is expected that this upward trend eventually will resume. Meanwhile, it is becoming more difficult to find new sources of suitable quality aggregate in Wyoming (Harris, 2005). The value of sand and gravel depends in part on the product sold (table 2) and its proximity to market.

Table 1. Sand and gravel sold or used by producers, and number of active sand and gravel operations in Wyoming. Data from Bolen (1995–2009); Willett and Bolen (2011).

Year	Production of sand and gravel (thousand metric tons)	Value (thousand dollars)	Unit value Per ton	Number of active operations
1995	3,860	17,500	$4.55	57
1996	3,420	14,700	$4.38	49
1997	3,090	12,300	$3.99	46
1998	4,770	18,100	$3.80	52
1999	4,410	17,200	$3.91	70
2000	6,340	23,800	$3.75	78
2001	7,200	35,100	$4.87	81
2002	7,710	32,100	$4.16	86
2003	8,290	36,400	$4.39	100
2004	8,690	38,900	$4.48	87
2005	11,700	52,400	$4.49	87
2006	17,200	74,600	$4.35	129
2007	19,100	95,800	$5.02	150
2008	17,500	103,000	$5.88	134
2009	17,200	92,200	$5.36	146
2010	15,000	69,300	$4.26	No data

Table 2. Construction sand and gravel sold or used in Wyoming in 2002, by major use category. Data from U.S. Geological Survey (2007).

Use (2007)	Quantity (thousand metric tons)	Value (thousand dollars)	Unit value Per ton
Concrete aggregate	814	7,940	$9.76
Bituminous aggregate	705	7,460	$10.59
Road base and coverings	3,820	19,600	$5,13
Other, unspecified, and estimated	13,719	61,166	$4.46
Total or average	19,058	96,166	$5.05

If aggregate is to be produced from new sources certain conditions must be met:

Aggregate must be available—it must exist in sufficient quantity to make mining worthwhile.

Aggregate must be of good quality—it must meet physical and chemical quality requirements for the intended use.

Aggregate must be accessible—it must physically be able to be mined, and must be accessible to transportation systems and to markets.

Aggregate operation must be environmentally acceptable—the site must be permittable and the operation must withstand public scrutiny with minimal impact to the environment or the lifestyle of nearby residents.

Aggregate Availability

Estimating the volume of a sand and gravel or bedrock deposit is a complex process. Geologists determine the thickness and character of the material overlying the sand and gravel (overburden), the thickness of the sand and gravel, and identify layers of unsuitable material within the deposit (interburden), as well as the yield of usable material from the deposit (fig. 4). The areal extent and thickness of the deposit (used with other factors to determine the quantity of mineable material) commonly results from the origin and subsequent erosional history of the deposit. When only limited data exist, better understood "typical" deposits from other areas can be used to predict overall geometry and the lateral and third dimensional variability of texture of the local deposit (Bliss, 1993).

Figure 4. Geologist taking sample from pit face using a technique referred to as vertical trenching.

For this assessment, the quantity estimates of aggregate resources should be considered inferred reserves, which are quantitative estimates based largely on a generalized knowledge of the geologic character of the deposits (Blondel and Lasky, 1956). Our estimates were based on an assumed continuity of materials; the assumption was made by comparing the geologic characteristics of the unknown parts of the deposit against other similar, better understood, parts of the deposit, such as observations made in gravel pits or exposed edges of the terraces.

Aggregate Quality

Aggregate for most construction applications can be produced from sand and gravel deposits containing a wide range of particle sizes, especially if there is a large amount of particles larger than 1½ inches (in). In addition, the larger the gravel to sand ratio, the better the deposit (Langer and Knepper, 1998). Silt and clay occurring either as layers or interstitial material are undesirable but commonly can be removed by processing. Gravel deposits in the Wind River terraces studied in this project commonly have a large percentage of large particles and commonly do not contain significant amounts of fine materials.

Sand and gravel aggregate should be durable and strong, which means it should support the intended load and resist mechanical breakdown resulting from the action of mixers, mechanical equipment, and traffic. The aggregate should also be sound, which means it should be able to resist weathering such as repeated freezing and thawing or wetting and drying. There is a general relationship between these properties and rock type. Gravel deposits in the Wind River terraces studied in this project commonly contain rock types that yield suitable quality gravel, unless weathered.

Chemical properties of aggregate are important in the manufacture of concrete or bituminous mixes. Ideally, aggregate is inert filler and should not change chemically within the concrete or bituminous mixes. However, some aggregates contain minerals that chemically react with, or otherwise affect, the concrete. This chemical process is referred to as the alkali-silica reaction. Alkali from cement in concrete pore-water solution can react with aggregate that contains certain silica minerals, forming a gel around the aggregate. The gel imbibes water, resulting in the expansion of the aggregate and subsequent destruction of the concrete (Dolar-Mantuani, 1983; Mather and Mather, 1991). Rocks that contain potentially reactive silica in the Wind River terraces include quartzite and volcanic rocks. These rocks are present in most gravel deposits in the Wind River terraces studied in this project.

Sand and gravel should not be excessively weathered. Weathering of gravel clasts lessens the strength of aggregate and increases the overall cost of mining and processing the aggregate. The rate and type of weathering depends on the local climatic conditions, the geometry of the deposit, the relationship to the water table, and the properties of the sand and gravel clasts. Weathering can range from slight discoloration of the clasts, through the introduction of fractures and alteration of minerals, to complete decomposition and disintegration of the clasts. In the Wind River Basin, weathered granite, gneiss and volcanic rocks tend to be unsound, but also commonly are removed from aggregate during processing.

In arid and semiarid climates, sand and gravel may be coated or cemented with caliche, a calcium carbonate, and may be difficult to extract and process. In the Wind River Basin, caliche thickness ranges from 0–8 ft, and commonly is 2–3 ft thick.

The quality of the aggregate may be further defined by its conformance to standard specifications or special specifications set by the user. Because aggregate commonly is used in highway construction, its specifications are usually set by State Departments of Transportation. Most states conform to the grading and testing standards of the American Association of State Highway Transportation Officials (AASHTO) or the American Society for Testing and Materials (ASTM). The specifications for natural aggregate used to make Portland-cement concrete or bituminous mixes are generally more rigorous than for other construction-related uses. Consequently, if sand and gravel can meet the specifications for these uses, it will satisfy almost any other use.

Figure 5. Geologist dividing a large bulk sample using a technique referred to as “cone and quartering.”

As part of this study, samples were collected in the field (fig. 5) and were taken to Inberg-Miller Engineers, Riverton, Wyo., where they were subjected to three engineering tests (in addition to determining particle size distribution): the Los Angeles Abrasion test, the Sodium Sulfate Soundness test, and tests to determining specific gravity and absorption. The tests generally yielded satisfactory results and are reported in Appendixes 1 and 2.

Aggregate Accessibility

Aggregate mining requires sufficient land area to locate a processing plant, stockpiles, equipment storage, maintenance areas, and other service areas. The land must also be accessible to standard earth-moving equipment.

Construction aggregates are the lowest price of the mined products, and transportation can be a major part of the cost to the consumer. In Wyoming, the cost of shipping aggregate is about $1.10 per ton per mile (Harris, 2005). Therefore sources of aggregate should be located near the point of use. Many of the river terraces along the Wind River where it traverses the Wind River Reservation are underlain with significant quantities of aggregate resources. Because of their proximity to US Route 26, US Route 287, or other major thoroughfares, some of these resources may be valuable sources for construction aggregate.

Environmental Acceptability

Sand and gravel resources cannot be obtained without causing some environmental impacts, but most of the environmental impacts are relatively benign and are typical of nearly any construction project. The most obvious environmental impacts of sand and gravel mining are the loss of habitat, noise, dust, erosion, sedimentation, and changes to the landscape. Some of the impacts are short-lived, and most are easy to predict and easy to observe. Most impacts can be controlled, mitigated, or kept at tolerable levels and can be restricted to the immediate vicinity of the aggregate operation by employing responsible operational practices that use available technology. Serious environmental health hazards are rare (Langer and others, 2004).

However, some areas have great scenic value or special cultural significance. The project landscape architect prepared a visual assessment of the study area (see below). Similarly, some areas serve as habitat for rare or endangered species. Mining aggregate might be acceptable in some of these areas, but should be conducted only after careful consideration, and then only with extreme prudence. Failure to do so can lead to serious, long-lasting, and irreversible environmental consequences.

Scenic Quality Inventory

Visual resources of the landscape have long been recognized as having value for enjoyment by people and future generations. Since some landscapes are able to tolerate more change or absorb more impacts (and thus able to withstand mining development) it is important to identify and rate landscape resources before they are developed.

Evaluation of scenic quality is done in relationship to the natural landscape and is a measure of the visual appeal of a parcel of land (Bureau of Land Management, 1986). Scenery is also ranked relative to similar features in the same physiographic region. The project area lies within the Wyoming Basin Physiographic Province (Fenneman, 1946; Liams and others, 1993); thus, scenery in the Wyoming Basin is compared to scenery in the Wyoming Basin, not the Middle or Southern Rocky Mountains.

Landform in the Wind River Reservation

The mountains and foothills rise steeply from the floor of the Wind River and Wyoming Basins. Elevation differences range from approximately 4,740 ft at Boysen Reservoir to 9,000 ft in the Dubois area. The intermontane basin is relatively flat and the mean elevation of the state of Wyoming is 6,700 ft above sea level. The Wind River Indian Reservation lies within the Wind River/Bighorn River drainage. The average annual precipitation recorded at Boysen Dam, Lander, Riverton, and Shoshoni is 9.3 in and temperatures range from more than 100°F (38°C) to less than -40°F (-20°C) (Liams and others, 1993). Precipitation from the Pacific Ocean is blocked by the mountain ranges. Summers are hot and dry, winds are common, and hard, freezing temperatures have occurred in every month of the year (Liams and others, 1993).

The most typical site encountered has gentle slopes and distant views. The landforms give the area an overall appearance of being in wide open country with elevation changes apparent in the terraces. Any typical view in the area combines foreground and middle ground with mountains as background images. The lines in the landscape are strongly horizontal in nature and are formed by the shape of the terraces. The texture of the landform is mostly fine/medium with the exception of a few scattered rock outcrops. The second type of landscape has more variety in landform; including a dominant feature such as a butte, irrigated land, or river valley. The most unusual landscape encountered in this assessment has varied topography or running water with a variety of color and vegetation.

Vegetation in the Wind River Reservation

The Wind River Reservation is dominated by arid grasslands and shrub lands and interrupted by high hills (terraces) and low mountains. The area is substantially natural appearing in character for most people. Parts of the region are used for livestock grazing and agriculture (including grains and hay). Farms are operated near the Wind River and along the irrigation canals. Ranches are located up in the foothills of both the Wind River and Owl Creek ranges (Perkins, 2005).

"Fire, wind, grazing, and variations in precipitation and temperature are the major disturbances in the ecoregion. * * * Seasonal browsing and grazing by native herbivores including elk (*Cervus elaphus*), mule deer *(Odocoileus hemionus*), and pronghorn *(Antilocapra Americana a.*) is another influential disturbance. * * * Conversion of sagebrush habitat types to grasslands for domestic grazing has taken place in areas where the climate will support grass production" (World Wildlife Fund, 2001, p. 2). Many two-track roads traverse the area. Soil is exposed and usually is a buff to light-brown color.

Characterizing and tracking vegetation communities would be helpful in more reliably assessing the impact of mineral operations on a landscape or site. It would provide benefits in conservation, identifying rare or endangered species. The existing vegetation, while sparse in many areas, is typical of shrub steppe with sagebrush (*Artemesia* spp.), often associated with various wheat grasses (*Agropyron* spp.) or fescue (*Festuca* spp). Usually grasses are identified by their seed-reproducing structures. The forbs are commonly identified by the pattern and shape of their leaves and the color and structure of their flowers. This characterization is not possible to accomplish in one site visit due to the varying seasons of blooms. For most of the year, the landscape has a strong grey color with a coarse to medium texture in the foreground and medium to fine in the middle and background.

Study Method

Each site is rated using a table adapted from the BLM Scenic Quality Field Inventory Form 8400-1 for scenic quality assessment of federal lands use (Bureau of Land Management, 1984). Ideally, scenic quality is rated under the most critical conditions (highest user period or season of use, proper atmospheric conditions, etc.)

(Bureau of Land Management, 1986). The field trip was conducted in April, just after and before two snow storms. The time of year and weather conditions may have limited the extent of views and vegetation (in relation to seasonal changes in forbs and grasses) but do not prevent an analysis of the dominant and important landscape elements. A portion of table 4 illustrates the framework used for the scenic quality data reporting. Although the BLM visual resource management approach is intended for BLM lands, Tribal land may benefit from an application of the BLM methodology. Ranking proposed sites could be used as a guide to analyze potential visual impacts of mineral development based on scenic value in the area. The scenic quality inventory provides a baseline assessment which will allow the Tribes a means to analyze the trade-off between economic, environmental, and scenic considerations.

A scenic quality inventory of each sand and gravel site investigated includes key factors such as: (1) landform/water, (2) vegetation, and (3) cultural modifications (human-made features of the landscape) using vocabulary associated with form, line, color, and texture. One assumption of the BLM Visual Resource Management (VRM) system is that complex landscapes with an abundance and variety in form, line, color, and texture are typically the most interesting and visually appealing. Researchers have found consistent levels of agreement among individuals asked to evaluate visual quality of landscapes using the basic elements of form, line, color, and texture (Bureau of Land Management, 1984). The concept behind this methodology is that the stronger the influence of these elements, the more evidence there will be *harmony* and *contrast* (see Glossary), and hence a more diverse and interesting landscape of beauty and ecological quality.

Due to the budget and time constraints of this assessment, one person (a landscape architect) was selected to conduct a visual analysis of the existing landscape, summarized in Appendix 1. The resulting data aid in describing the landscape character: that is, the overall impression created by its unique combination of visual features. Three components are used for this landscape analysis: (1) landscape type, (2) landscape character elements, and (3) landscape analysis factors. Types of landscapes include: *panoramic, enclosed, feature, focal,* and *canopied*. Landscape character elements include: *form, line, color,* and *texture*. Landscape analysis factors include *contrast, sequence, axis, convergence, co-dominance, enframement*, and *scale* (see Glossary). Lands are given an A (high), B (medium), or C (low) rating based on the apparent scenic quality which is determined using seven key factors: landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications.

Scenic Quality Rating Results

A critical first step in understanding and defining the scenic quality of a landscape is cataloging and describing types. A summary of information collected for the Wind River Indian Reservation scenic quality classification is indicated in table 3. The methodology used to arrive at these scenic quality ratings is explained more fully in table 4 (page 23).

Table 3. Scenic quality rating summary for 13 field sites in the Wind River Indian Reservation. (Based upon methodology developed by the Bureau of Land Management, 1986. Winkleman Dome 1 and Winkleman Dome 2 are listed under Winkleman Dome in Appendix 1).

FIELD SITES BY NAME	Landform	Vegetation	Water	Color	Adjacent Scenery	Scarcity	Cultural Modifications	Total Score	Scenic Quality Rating	Landscape Type
AIRPORT	2	2	0	1	1	1	0	7	C	Pan*
BURMA HILL	2	3	0	2	3	3	0	13	B	Feature
CROWHEART BUTTE # 1	3	1	0	2	3	3	0	12	B	Feature
E BOYSEN CAUSEWAY	1	2	0	1	3	1	-2	6	C	Pan
JOHNSTOWN	1	3	0	2	3	1	-2	8	C	Pan
KANE DRAW	2	4	0	3	3	3	0	15	B	Pan
KINNEAR	1	2	0	1	1	1	-2	4	C	Pan
LE CLAIR	1	2	0	2	5	2	1	13	B	Pan
RED ROCKS	5	5	5	5	0	5	-2	23	A	Enclosed
SHEER	1	2	0	1	1	1	-2	4	C	Pan
WILLOW CREEK	3	5	0	3	4	4	2	21	A	Focal
WINKLEMAN DOME 1	1	1	0	1	4	2	-2	7	C	Pan
WINKLEMAN DOME 2	3	2	0	3	4	3	-2	11	C	Pan

*Pan=panoramic

According to the BLM (1984 and 1986), a scenic quality inventory is one part of determining visual resource inventory classes (objectives). Future work to be considered includes:

• A sensitivity analysis (ranked high, medium, or low)—the measure of public concern for scenic quality that changes over time. The Tribes may want to consider types of users, amount of use, public interest, adjacent land use, and special areas (including areas of religious, archeological, environmental, or cultural significance).

• A map delineating distance zones (foreground, background, and seldom seen) showing relative visibility from travel routes and/or observation points.

Framework for Data Reporting (Table 4)

Table 4 is the framework followed for data reporting in this assessment. The table includes the information necessary to understand the data from geologic field notes on sand and gravel deposits, engineering tests, and scenic quality for the all of the sites investigated on the Wind River Indian Reservation, Wyo. In writing about geology and landscape, several terms may not be fully understood by all readers. Before passing on to the substance of this report, then, definitions are provided as they are introduced in the table. Appendix 1 contains the raw data for each site and follows the framework of table 4. A glossary section summarizing technical terms has been included for the benefit of non-specialists.

The first component of the framework is a cover sheet with the site name, location, USGS topographic sheet, date of sample collection, and location map. The upper right hand corner identifies the site name and sheet number for the data report. Pagination at the bottom of the page continues sequentially in order to locate sites easily from the table of contents.

The second component is boxes identifying the sample number, geologic observations, engineering tests, production constant, and conclusions. A geologic column and photograph are included that illustrate the stratigraphy at the evaluation sites.

The third component is the scenic quality field inventory, landscape narrative, scenic quality, score, and scenic quality classification. Photographs are included that aid in the explanation or rationale for rating the visual quality of the scenic resources.

Table 4. Framework in Appendix 1 for data reporting sand and gravel studies on the Wind River Indian Reservation.

SITE NAME: Sheet 1 of 6

Site Name: Name assigned by BIA

Location: Section, township and range
USGS Topographic Sheet: Name from topographic sheet
Date: Date of field work

Aerial photograph overlain with contour lines, roads, water bodies, and sample site location (yellow-colored dot).

SCALE BAR

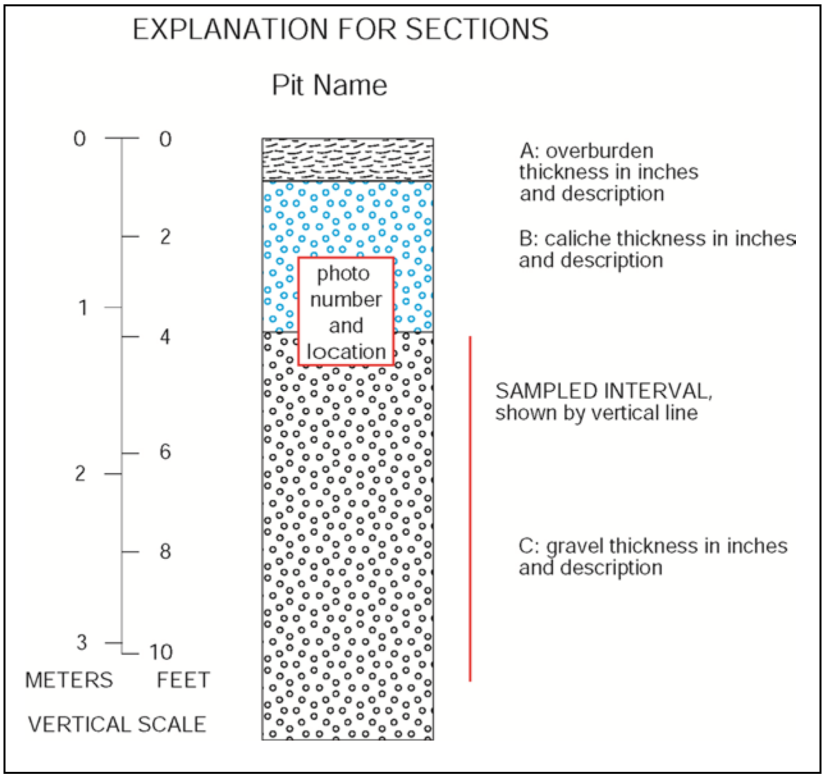
Site Name: Name assigned by BIA

Location: Half or quarter section, quarter section, section, township, range, Wind River Meridian
USGS Topographic Sheet: Name from topographic sheet

GEOLOGIC DESCRIPTION	
Sample number	Numbers assigned at each site, starting with #1.
Location	Latitude and longitude in degrees, minutes, and seconds
Terrace level Qt	As assigned by Morris and others (1959), or converted from WR units assigned by Chadwick and others (1997)
Gravel thickness (feet)	Measured at pit face (see Glossary).
Overburden thickness (feet)	Overburden is soil or other material other than gravel that overlies the gravel. Measured at pit face (See Glossary).)
Water table	Location of water table, if observed
Caliche thickness (feet)	Caliche (see glossary) is calcium carbonate ($CaCO_3$) commonly occurring in the subsurface as a white crust on stones. Measured at pit face.
Maximum carbonate stage	Maximum carbonate stage refers to the degree of coating or cementation of particles by $CaCO_3$ (caliche) in gravel (Birkeland, 1999). Stage I, thin discontinuous coatings on particles; stage II, continuous coatings; stage III, coalesced coatings; stage IV, pore space plugged by $CaCO_3$. Stages II and III are common in Wind River gravel. Carbonate stage varies within an outcrop, from none to the maximum specified. Caliche coatings may or may not be detrimental to the quality of the aggregate.
Maximum clast weathering	Maximum clast weathering refers the degree of alteration and disintegration of clasts in gravel. Not all clasts show maximum weathering; only granite-gneiss and volcanic rocks were evaluated. (See Glossary for an explanation of how stage of weathering is determined.) Stage 1, minor pitting or oxidation; stage 2, moderate pitting, slight fracturing, and oxidation; stage 3, highly pitted, iron stains, strong fracturing ; and stage 4, strongly weathered and fractured, disintegrates easily. Rocks weathered to stage 3 may be unsuitable for aggregate and rocks weathered to stage 4 are unsuitable for aggregate. Unsuitable rocks commonly are broken down and removed during processing.
Lithologies (expressed as a percent of the total sample)	Lithology refers to the type of rock. Approximately 100 rock particles were randomly selected from each gravel sample and were identified in the field.
Granite-gneiss	Granite-gneiss rocks are light-colored, coarsely crystalline rocks. They commonly make good aggregate although some minerals in the rocks may weather, weakening the rocks and increasing the amount of fine material in the deposit.
Mafic plutonic-metamorphic	Mafic-plutonic–metamorphic rocks are dark-colored, coarsely crystalline rocks. They commonly make good aggregate although some large crystals in the rocks may weaken the aggregate.
Quartzite	Quartzite is a dark or light colored quartz dominant rock that is hard, dense, and durable. It commonly is an excellent rock for aggregate although it may be difficult to crush.
Vein quartz	Vein quartz is hard and strong, but may be brittle. Vein quartz may also be reactive when used in Portland cement concrete.
Sandstone	Sandstone has a wide variety of properties and may make good aggregate when well cemented and strong, or make poor aggregate when poorly cemented and weak.
Limestone	Limestone (includes other carbonate rocks including marble and dolomite) has a wide variety of properties and may make good or poor aggregate.
Chert	Chert is hard and strong, but may be brittle. Chert commonly is reactive when used in Portland cement concrete.
Volcanics	Volcanic rocks are light- or dark-colored, finely crystalline rocks. They commonly make good aggregate, but may be reactive when used in Portland cement concrete.
Total	The total of all lithologies of rocks commonly equals 100 percent, but may be more or less than 100 percent due to rounding.

ENGINEERING TESTS	
Sample number	Numbers assigned at each site, starting with #1. Samples from other agencies are identified.
Particle Size Analysis– See Glossary for an expanded description of particle size analysis	
Maximum clast size (inches)	Longest dimension of largest clast observed at the site. Large clasts, especially boulders, may complicate excavation and processing of gravel. Boulders commonly are not processed, and are set aside for use as rip rap or decorative landscaping rock.
Size distribution (percent)	The grain size distribution of particles was calculated as the percentage of the sample for each grain size class.
Cobbles	Cobbles are retained on the 3-in sieve
Coarse Gravel	Coarse gravel passes through the 3-in sieve and is retained on the ¾"sieve.
Fine Gravel	Fine gravel passes through the ¾-in sieve and is retained on the #4 (4.75 millimeter (mm)) sieve.
Sand	Fine gravel passes through the #4 (4.75 mm or 0.187 in) sieve and is retained on the #200 (75 micrometer (µm)) sieve.
Fines	Fines pass through the #200 (75 µm or 0.003 in) sieve.
Total	The total of all grain size classes commonly equals 100 percent, but may be more or less than 100 percent due to rounding
LA Value	The Los Angeles (LA) Abrasion test is a measure of the ability of aggregate to resist breakdown due to abrasion, impact, and grinding. It is a benchmark test commonly applied to potential aggregate resources. LA values should be less than 30 percent. See Glossary for an expanded description of the Los Angeles Abrasion test
Soundness	The soundness test is a measure of the ability of aggregate to resist breakdown due to cycles of wetting and drying or freezing and thawing. The test commonly is applied to different size ranges. Loss should be less than 10 percent when sodium sulfate is used, which was used for these tests (ASTM C-33). See Glossary for an expanded description of the soundness test.
Specific gravity	Specific gravity is the ratio of the mass of a given volume of aggregate to the mass of an equal volume of water. Very low specific gravity frequently indicates aggregate that is porous, weak, or absorptive. High specific gravity generally indicates high-quality aggregate. Specific gravity should be 2.55 or greater. See Glossary for an expanded description of testing to determine specific gravity.
Percent absorption	Absorption should not exceed 3 percent. In addition, rocks with water absorption of 2 percent or less will usually produce good aggregate, whereas otherwise suitable rocks with a water absorption that exceeds 4 percent may not (Smith and Collis, 2001). See Glossary for an expanded description of testing to determine absorption.

PRODUCTION CONSTANT	
Estimated thickness	Estimated thickness of deposit in vicinity of sample site
Constant - Maximum recoverable product.	Throughout the United States about 5 percent of the total production of an aggregate operation consists of unmarketable waste (not including overburden) (Hudson and others, 1997). This is the minimum waste factor applied to aggregate in this study. This value can be adjusted based on experience gained during the processing of material.
Constant - Minimum recoverable product	Gravel clasts larger than 3-in may be difficult to handle and crush. This material may be set aside and sold as rip rap, decorative stone, or other products. Furthermore, throughout the United States, about 23.8 percent of the total production of an aggregate operation consists of minus 3/8-in product (not including overburden) that is very difficult to market (Hudson and others, 1997). This constant calculates production from particles less than 3-in and includes a waste factor of 23.8 percent, assuming none of the minus 3/8-in material will be marketed. These values can be adjusted based on experience gained during the processing and marketing of material.
CONCLUSIONS	
Describes aggregate suitability for use in Portland cement concrete, asphalt, and as road base. Lists deleterious materials.	



SCENIC QUALITY FIELD INVENTORY AND EVALUATION CHART*			
LANDSCAPE TYPE			
Panoramic, feature, enclosed, or focal (see Glossary for definitions).			
LANDSCAPE ANALYSIS FACTORS			
Contrast, sequence, axis, convergence, co-dominance, enframement, and scale if applicable (see Glossary for definitions).			
LANDSCAPE CHARACTER			
The arrangement of a particular landscape as formed by the variety and intensity of the landscape features and the four basic elements of form, line, color, and texture.			
Visual Features	LANDFORM/WATER	VEGETATION	STRUCTURE
FORM The mass or shape of an object or of a combination of objects which appear unified.	The dominant physical topographical element (earth and water) upon which all other elements in the landscape rest.	Plant size and form is the most notable visual characteristic of plant material (Booth, 1983).	Man-made features are typically geometric and simple. Spaces may be delineated by buildings, storage tanks, electrical transmission facilities, and so on.
LINE The path (real or imagined) that the eye follows in a landscape.	Edge, band, and silhouette are line types. Examples for landform include ridges and skylines.	Same as landform types only refers to changes in vegetation or individual trees. An example is the boundary between areas dominated by trees and those in which there are no trees.	Same as landform types. Traditionally, the effect of man-made elements tends to be straight and hard. Examples include roads, poles, and fences.
COLOR The property of reflecting light of a particular intensity and wavelength; light colors typically recede and dark colors typically advance.	Color clearly distinguishes a form from its environment and is the major visual property of surfaces.	Plant color is significant because it is easily seen and can be noticed at relatively great distances in the landscape (Booth, 1983).	Same as landform. All surfaces have some inherent color.
TEXTURE The aggregation of small forms or color mixtures into a continuous surface pattern; determined by light and shadow.	The surface characteristic that makes patterns relatively coarse or fine, rough or smooth. Texture varies with distance and seasons.	Same as landform.	Same as landform.
LANDSCAPE NARRATIVE			
Briefly describes the general character of the landscape as it relates to the immediate surroundings and to similar landscape features within the physiographic province.			

*Based on the Visual Resource Management Manual 8400 BLM Standards, Scenic Quality Inventory and Evaluation Chart. (Bureau of Land Management, 1984; Bureau of Land Management, 1986)

SCENIC QUALITY FIELD INVENTORY AND EVALUATION CHART cont.			
SCENIC QUALITY RATING Derived by evaluating the seven key factors and rating criteria below.			
Key Factors	Rating Criteria and Score. Values for each rating criteria are maximum and minimum scores only. It is also possible to assign scores within these ranges.		
LANDFORM Topography becomes more interesting as it gets steeper or more massive, or more sculptured. They may be monumental or exceedingly artistic and subtle.	High vertical relief as expressed in prominent cliffs, spires, or massive rock outcrops; or severe surface variations or highly eroded formations; or detail features dominant and exceptionally striking. 5	Steep canyons, mesas, buttes, cinder cones; or interesting erosional patterns or variety in size and shape of landforms; or detail features which are interesting though not dominant or exceptional. 3	Low rolling hills, foothills, or flat valley bottoms; or few or no interesting landscape features. 1
VEGETATION Gives consideration to the variety of patterns, forms, and textures created by plant life.	A variety of vegetative types as expressed in interesting forms, textures, and patterns. 5	Some variety of vegetation, but only one or two major types. 3	Little or no variety or contrast in vegetation. 1
WATER The ingredient which adds movement or serenity to a scene.	Clear and clean appearing, still, or cascading white water, any of which are a dominant factor in the landscape. 5	Flowing, or still, but not dominant in the landscape. 3	Absent, or present, but not noticeable. 0
COLOR Consider the overall color(s) of the basic components of the landscape as they appear during seasons or periods of high use. Key factors are variety, contrast, and harmony.	Rich color combinations, variety, or vivid color; or pleasing contrasts in the soil, rock, vegetation, water, or snow fields. 5	Some intensity or variety in colors and contrast of the soil, rock, and vegetation, but not a dominant scenic element. 3	Subtle color variations, contrast, or interest; generally mute tones. 1
ADJACENT SCENERY Degree to which scenery outside the scenery unit being rated enhances the overall impression of the scenery within the area.	Adjacent scenery greatly enhances visual quality. 5	Adjacent scenery moderately enhances overall visual quality. 3	Adjacent scenery has little or no influence on overall visual quality. 0
SCARCITY Added importance to scenic features that appear to be relatively unique or rare within the physiographic region.	One of a kind; or unusually memorable, or very rare within region. 5	Distinctive, though somewhat similar to others within the region. 3	Interesting within its setting, but fairly common within the region. 1
CULTURAL MODIFICATIONS The change in landscape by humans which may add or detract from the scenery.	Modifications add favorably to visual variety while promoting visual harmony. 2	Modifications add little or no visual variety to the area, and introduce no discordant elements. 0	Modifications add variety but are very discordant and promote strong disharmony. -4
TOTAL SCORE	The sum of the individual scores determines the overall scenic quality classification.		
SCENIC QUALITY CLASSIFICATION	A being the highest rating, B a moderate rating, and C the lowest rating. A = 19 or more B = 12–18 C= 11 or less		

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Glossary

aesthetics Generally, the study, science, or philosophy dealing with beauty. In scenery management, it describes landscapes that give visual and sensory pleasure.

axis A straight line, real or imaginary, passing through the center of a landscape such that each half is symmetrical.

background The landscape area located from 5 miles to infinity from the viewer. (The Bureau of Land Management, 1984, considers the background distance zone as the visible area usually from a minimum of 3–5 miles to a maximum of about 15 miles).

caliche thickness and maximum carbonate stage
Caliche coatings may be detrimental to the strength of concrete if the bond of the cement paste to the coating is greater than the bond of the coating to the aggregate. However, caliche may not affect the aggregate/matrix bond if it is strongly cemented to the gravel, or if it is broken from the surface of the aggregate during crushing and processing. The presence of caliche may increase the amount of fines in the final product due to attrition during processing.

Maximum carbonate stage refers to the degree of coating or cementation of particles by $CaCO_3$ (caliche) in gravel (Birkeland, 1999). Calcium carbonate ($CaCO_3$) at stages III and IV may cement gravel into large blocks or layers, thus complicating the excavation and processing of aggregate.

canopied A landscape type where features create a ceiling or canopy effect.

co-dominance Two major landscape form features that are nearly identical.

color The property of reflecting light of a particular wavelength that enables the eye to differentiate objects even though they have identical form, line, and texture. A hue (red, green, blue, yellow, and so on), as contrasted with a value (black, white, or gray).

contrast Diversity or distinction of adjacent parts in a landscape. Contrast has the effect of creating striking differences in form, line, color, or texture of a landscape.

convergence A landscape factor that tends to focus attention on one point or small area.

cultural modification Any human-caused change in the land form, water form, vegetation, or the addition of a structure which creates a visual contrast in the basic elements of the naturalistic character of a landscape.

digitate edge The complex indented edge between two interlocking and contrasting areas.

disturbance A discrete event, either natural or human-induced, that causes a change in the existing condition of an ecological system.

edge The line where an object or area begins or ends. Edge serves to define borders, limits, or boundaries.

enclosed A landscape type with elements that form walls and floor.

enframement A landscape factor created when features in the landscape direct the viewer's attention inwards like the frame of a picture.

feature A landscape type dominated by a feature or a group of feature objects in the distance to which the eye is drawn.

focal A landscape type where the eye is led to a focal point in the landscape.

form Structure, mass, or shape of a landscape or of an object.

foreground The landscape area generally located from the viewer to ½ mile away (U.S. Forest Service, 1995). The Bureau of Land Management considers the foreground-middle ground distance zone as the area visible from a travel route, use area, or other observation point to a distance of 3 to 5 miles (Bureau of Land Management, 1984).

gravel thickness The thickness of gravel varies throughout an area because of variations in the surface of the bedrock at the base of the gravel, variations in the thickness of overburden, and variations in the land surface. The thickness of the gravel is a judgment value based on observations at the pit face and natural exposures along terrace edges, stream banks, and so forth. The greater the overburden-to-gravel ratio, the more expensive it will be to mine the gravel.

harmony Combination of parts of a landscape into a pleasing or orderly whole.

in Abbreviation for inch.

landform One of the attributes or features that make up the Earth's surface, such as plain, mountain, or valley.

landscape character The overall impression created by a landscape's unique combination of visual features.

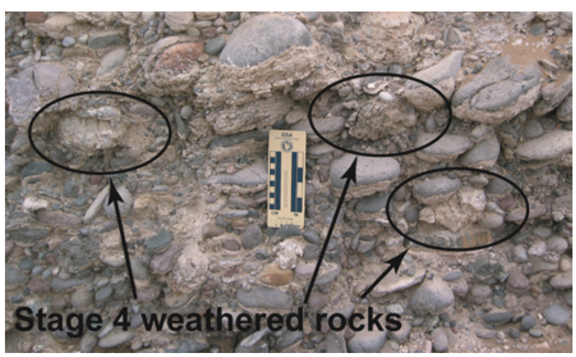
line An intersection of two planes; a point that has been extended; a silhouette of form. The path may be real or imagined in a landscape.

Los Angeles abrasion test The Los Angeles abrasion test is a measure of degradation of aggregate resulting from abrasion, impact, and grinding. The testing method is described in ASTM C535 and C131.

A sample of standard gradations of aggregate is placed in a rotating steel drum containing a specified number of steel spheres. As the drum rotates, a shelf picks up the aggregate and spheres and drops them to the other side of the drum. After a prescribed number of revolutions, the contents are sieved to measure degradation as percent loss (American Society of Testing and Materials, 2003). Consequently, the higher the test value, the higher the percent loss, and the lower the strength of the rock.

Rocks with LA values in the 20s commonly have the necessary strength properties for aggregate. Many specifications accept aggregate with an L.A. value of less than 30.

maximum weathering Maximum particle weathering refers to degree of alteration and disintegration of particles in gravel (Birkeland, 1999). Stage 1, minor pitting or oxidation (rings sharply when struck by hammer); stage 2, moderate pitting, slight fracturing, and oxidation (solid sound when struck by hammer); stage 3, highly pitted, iron stains, strong fracturing (emits dull sound, broken with difficulty when struck by hammer); and stage 4, strongly weathered and fractured, disintegrates easily (emits punky sound when struck by hammer).



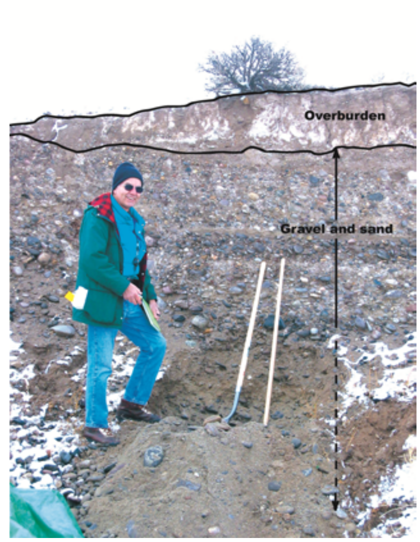
Rocks weathered to stage 4 commonly are not suitable for use as aggregate. However, weathered rock may be broken into smaller, unweathered particles during crushing and processing, thus increasing the amount of smaller particles in the final product, but not affecting the overall quality of the final product.

mesa A small, flat elevation with steep slopes on all sides.

mi Abbreviation for mile.

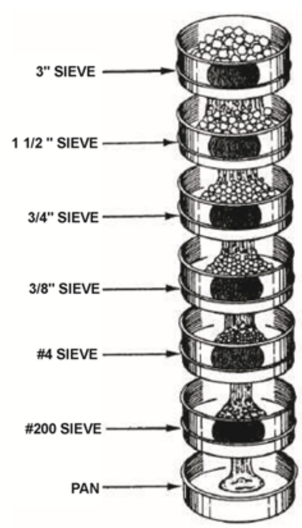
middle ground The zone between the foreground and the background in a landscape. The area is generally located from ½ mile to 5 miles away.

overburden thickness Overburden is soil or other material other than gravel that overlies the gravel. Overburden must be stripped from the top of the gravel and removed from the site or stockpiled for future use in reclamation.   The thickness of the gravel is a judgment value based on observations at the pit face and natural exposures along terrace edges, stream banks, and so forth.



Panorama A type of landscape in which breadth is the dominant characteristic and there are no apparent limits to the view.

particle size analysis Terrace gravels are composed of particles of various size and composition. Sand and gravel can be analyzed by size by sifting a dried and weighed sample through a set of testing sieves. The testing method is described in ASTM C136.



A series of sieves are stacked upon on another, with the sieve with the largest openings on the top and the smallest opening on the bottom. A weighed and dried sample is placed on the top sieve. The stack of sieves is shaken by hand or mechanically.

The material that remains on each sieve is weighed, and is expressed as a percentage of the total sample.

production constant–maximum recoverable product A common industry rule of thumb is that there are 2,420 tons of sand and gravel per acre per foot of gravel thickness. However, not all of that material is recoverable. Some is turned into waste during aggregate extraction and processing. Throughout the United States, about 5 percent of the total production of an aggregate operation consists of unmarketable waste (not including overburden) (Hudson and others, 1997). This is a minimum waste factor applied to aggregate in this study. This value can be adjusted based on experience gained during the processing of material.

The production constant was calculated using the following equation:

Maximum recoverable material = (2,420 tons per acre per foot) × (thickness of deposit in feet) - (waste factor)
where:

thickness of deposit is unique to each site
waste factor is 5 percent of the total tonnage

production constant–minimum recoverable product Gravel particles larger than 3 inches may be difficult to handle and crush. This material may be set aside and sold as rip rap, decorative stone, or other products. Furthermore, throughout the United States, about 23.8 percent of the total production of an aggregate operation consists of -3/8 in product (not including overburden) that is very difficult to market (Hudson and others, 1997). This constant calculates production from particles 3 in or less with a waste factor of 23.8 percent, assuming none of the -3/8 in material will be marketed. These values can be adjusted based on experience gained during the processing and marketing of material. The constant was calculated using the following equation:

Minimum recoverable material = (2,420 tons per acre per foot) × (thickness of deposit in feet) - (percentage of sample $\geq$3 inches) x (waste factor)
where:

thickness of deposit is unique to each site
percentage of sample greater than or equal to 3 inches is unique to each site
waste factor is 23.8 percent of the total tonnage

scale The proportionate size relationship between an object and the surroundings in which it is placed.

sequence A repetitious dominance of form, line, color, or texture.

soundness test This test provides an estimate of the ability of aggregates to resist alternate cycles of freezing and thawing or wetting and drying. The testing method is described in ASTM C88. Because the precision of this test method is poor it may not be suitable for rejection of aggregates without confirmation from other tests. Testing was performed by Inberg-Miller Engineers, Riverton, Wyo.

A set of weighed, sieved samples of specific particle sizes are alternately immersed in saturated solution of sodium or magnesium sulfate (sodium sulfate was used in these tests) and dried to precipitate salt in the permeable pore spaces. The internal forces derived from the hydration of salt simulate the expansion of water due to freezing. After a specified number of immersion and drying cycles, the material is put on the original sieve, and the material passing is measured as a percentage of the original sample.

specific gravity and absorption This test is used to determine to provide an average value of the specific gravity (relative density) of the solid portion of a number of aggregate particles, not including the volume of voids in between the particles. The testing method is described in ASTM C127. Testing was performed by Inberg-Miller Engineers, Riverton, Wyo.

A sample of aggregate is immersed in water to fill the pores, the water is dried from the surface of the particles, and the sample weighed. The saturated sample then is weighed while submerged in water. Finally the sample is oven dried and weighed.

Specific gravity is calculated using the following equation:

Specific gravity = weight of dry sample–(weight of dry sample–weight of saturated sample in water)

Absorption is calculated using the following equation:

Absorption = (weight of saturated sample–weight of dry sample) / weight of dry sample.

texture A property of surface deriving from the material of which it is composed, chiefly apprehended by the manner in which it reflects light.

topography The general configuration of varying heights that give shape to Earth’s surface.

visual resources The visible physical features on a landscape (for example, land, water, vegetation, animals, structures, and other features).

Appendix A–Data Sheets Describing Geologic, Engineering, and Visual Assessment Observations

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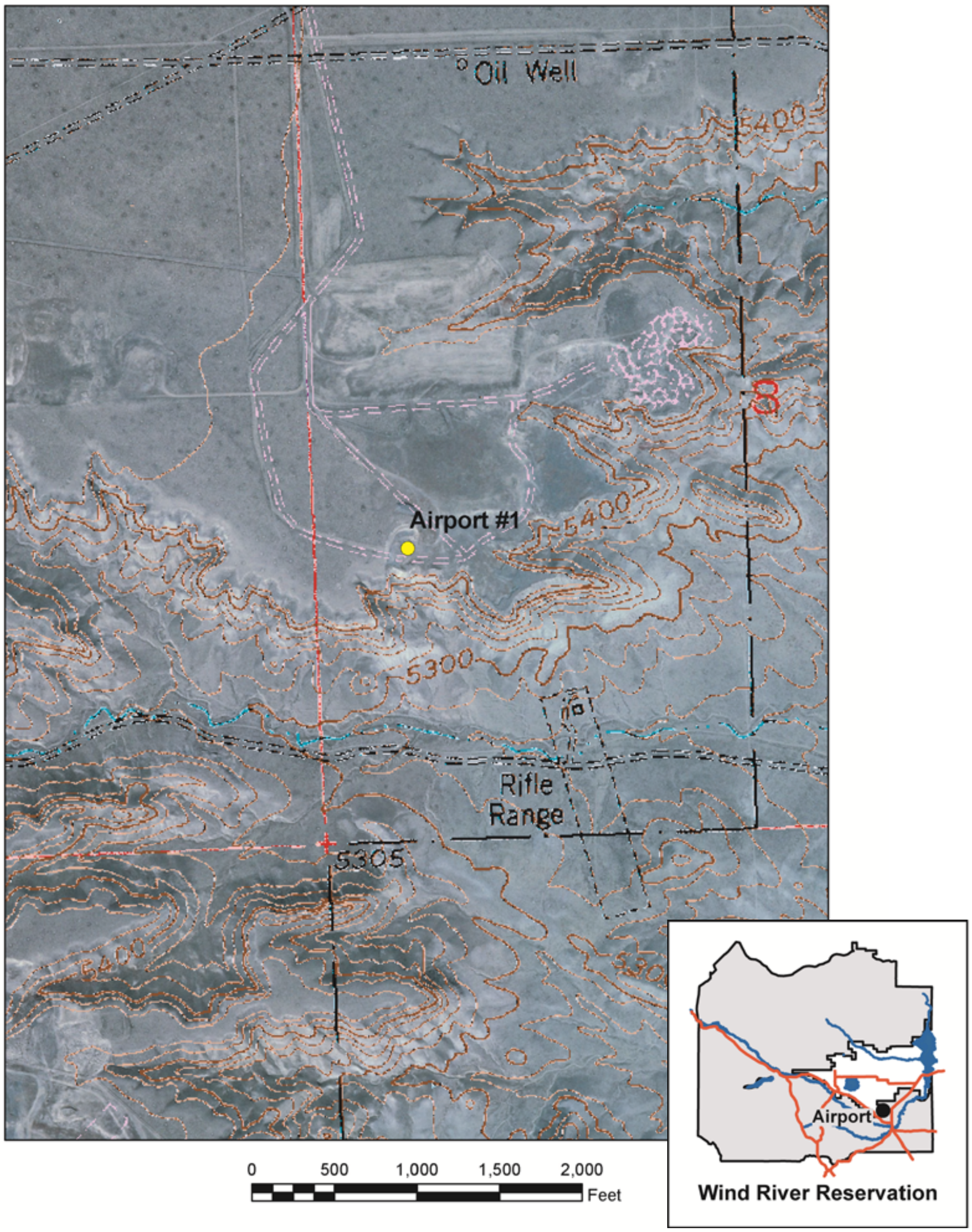
Site Name: Airport

Location: NW ¼, SW ¼, S8, T1N, R4E, Wind River Meridian
USGS Topographic Sheet: Riverton West
Date: 20 April 2005



GEOLOGIC DESCRIPTION	
Sample number	#1
Location	43° 04' 29.5" 108° 26' 15.0"
Terrace level Qt	10
Gravel thickness (feet)	20
Overburden thickness (feet)	2
Water table	None observed
Caliche thickness (feet)	6-7
Maximum carbonate stage:	III
Maximum clast weathering	4
Lithologies (pct)	
Granite-gneiss	28
Mafic plutonic-metamorphic	4
Quartzite	43
Vein quartz	-
Sandstone	Trace
Limestone	Trace
Chert	Trace
Volcanics	25
Total	100

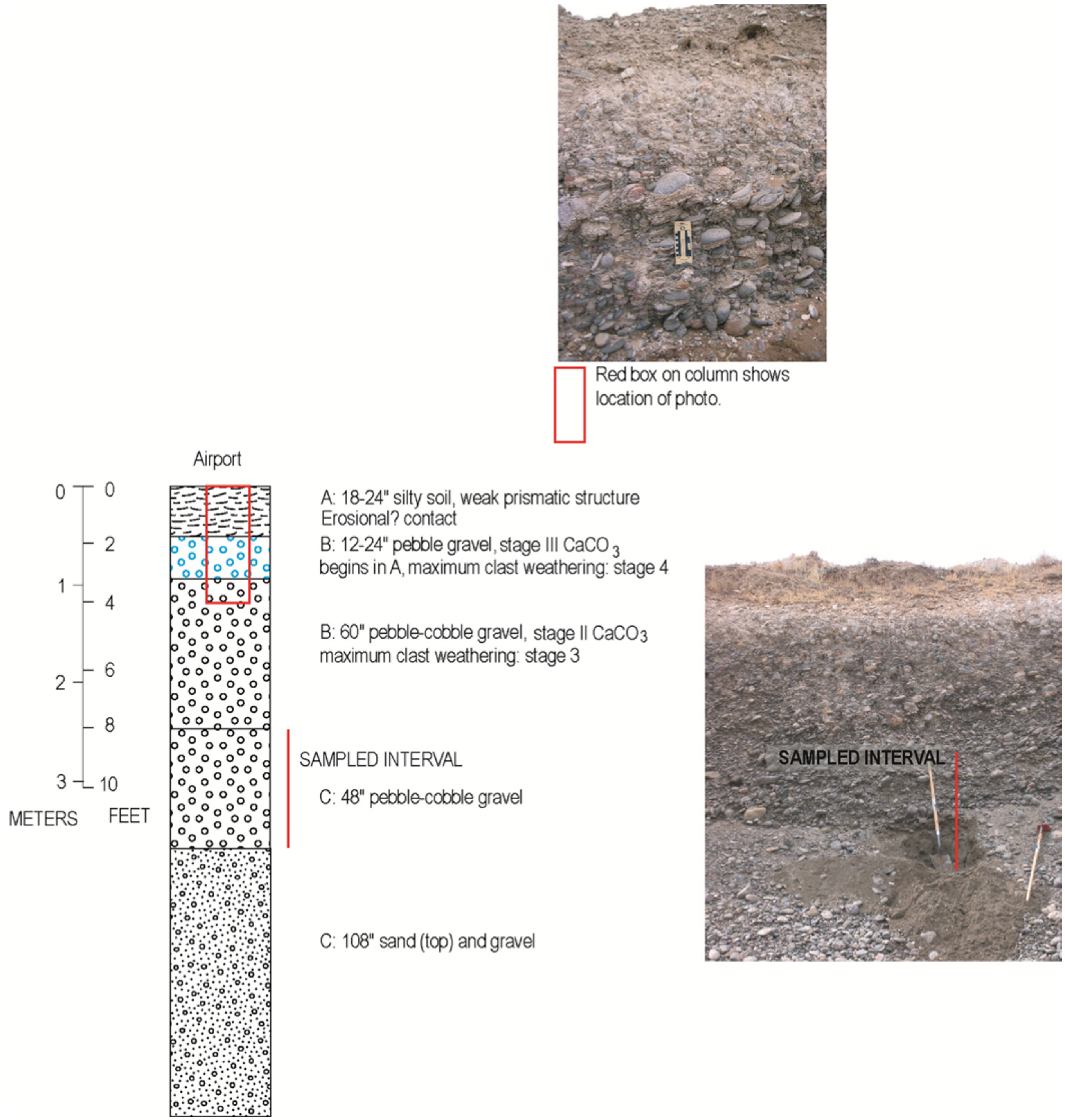
ENGINEERING TESTS	
Sample number	#1
Maximum clast size (inches)	Cobble
Size distribution (percent)	
Cobbles	27
Coarse Gravel	34
Fine Gravel	18
Sand	21.3
Fines	0.7
Total	101*
LA Value	22.6
Soundness	
≤1.5” - >0.75”	0.1
≤0.75” - >0.375”	0.2
≤0.375 - > #4 sieve	0.1
Specific gravity	2.575
Percent absorption	1.2

* Numbers do not add to 100 due to rounding

PRODUCTION CONSTANT	
Estimated gravel thickness (feet)	20
Constant - Maximum recoverable product (tons per acre)	45,980
Constant - Minimum recoverable product (tons per acre)	26,923

CONCLUSIONS

Portland cement concrete – May be suitable. Will require crushing and screening and may require washing. Determine susceptibility to alkali-silica reaction. May require use of low-alkali cement or additives.
Asphalt concrete – Suitable. Will require crushing and screening.
Base – Suitable. Will require crushing and screening.
Deleterious Material – Large amount of calcium carbonate (caliche) coating. Crushing will reduce extent of coating.


Red box on column shows
location of photo.
Airport
0
1
2
3
METERS
0
2
4
6
8
10
FEET
A: 18-24" silty soil, weak prismatic structure
Erosional? contact
B: 12-24" pebble gravel, stage III $CaCO_3$
begins in A, maximum clast weathering: stage 4
B: 60" pebble-cobble gravel, stage II $CaCO_3$
maximum clast weathering: stage 3
SAMPLED INTERVAL
C: 48" pebble-cobble gravel
C: 108" sand (top) and gravel
SAMPLED INTERVAL

SCENIC QUALITY FIELD INVENTORY AND EVALUATION CHART			
LANDSCAPE TYPE			
Panoramic—Top of terrace, sky and foreground elements occupies much of the space.			
LANDSCAPE ANALYSIS FACTORS			
Small scale with small local relief.			
LANDSCAPE CHARACTER			
	LANDFORM/WATER	VEGETATION	STRUCTURE
FORM	Gentle scarps.	Spotty, patchy.	Domed spoils, rectangular blocks of concrete.
LINE	Straight horizontal terrace tops.	Simple.	Undulating.
COLOR	Shades of pink-grey, light brown.	Yellow, buff, small amounts of green; fairly monotone.	Tan, grey.
TEXTURE	Rough, hard, medium grain.	Fine, medium, random clumps.	Coarse and stippled.

LANDSCAPE NARRATIVE

The Airport site (el 5,420 ft) is accessed via U.S. Hwy 26 approximately 4.5 mi north of Riverton. North of the Riverton Municipal Airport, there is an additional 3 mi of unimproved road to get to the site.

The landscape is strongly horizontal. The landforms give the area an overall appearance of being in wide open country with elevation changes apparent in the terraces. Level sites are traditionally more flexible for development. However, any introduced vertical element has the potential to become a dominant feature. This site has numerous spoil piles and a placement within the terrace scarp that blocks views from below the terrace. There are few anticipated vehicles along the unimproved road.

There is little visual variety in the vegetation. Grasses occupy most of the land area.

SCENIC QUALITY RATING				
				SCORE
LANDFORM	5	3	1	2
VEGETATION	5	3	1	2
WATER	5	3	0	0
COLOR	5	3	1	1
ADJACENT SCENERY	5	3	0	1
SCARCITY	5	3	1	1
CULTURAL MODIFICATIONS	2	0	-4	0
TOTAL SCORE				= 7
SCENIC QUALITY CLASSIFICATION	C			

Upper, Large tracts of grassland and stream terraces are visible in this southeast-oriented view from the Airport site. *Lower,* Photo from within site showing concrete drainage slabs from canal work are saved for recycling. Sand and gravel spoils surround the pit area.

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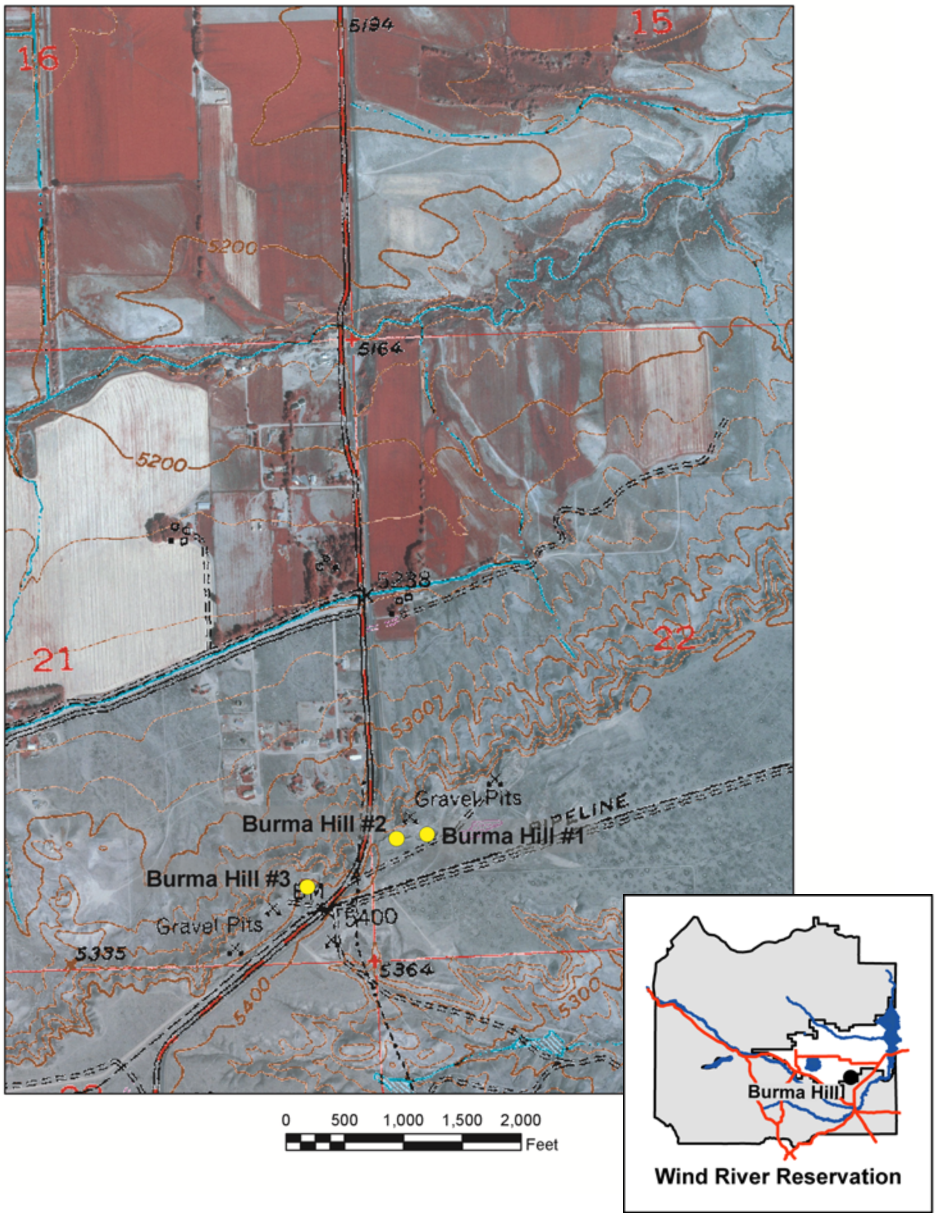
Site Name: Burma Hill

Location: SW ¼, SW ¼, S22, T2N, R4E, Wind River Meridian
USGS Topographic Sheet: Lost Wells Butte
Date: 20 April 2005



GEOLOGIC OBSERVATIONS				
Sample number	#1	#2	#3	General site characteristics
Location	43° 07' 52.5" 108° 23' 54.5"	43° 07' 52.2" 108° 23' 58.0"	43° 07' 48.4" 108° 24' 08.4"	
Terrace level Qt	10	10	10	10
Gravel thickness (feet)	9	5	8	8
Overburden thickness (feet)	2	6	2	2
Water table	None observed	None observed	None observed	None observed
Caliche thickness (feet)	2	3	1	2
Maximum carbonate stage:	III	III	III	III
Maximum clast weathering	4	3	3	4
Lithologies (pct)				
Granite-gneiss	33	31	26	30
Mafic plutonic-metamorphic	13	10	7	10
Quartzite	23	23	17	21
Vein quartz	-	2	6	3
Sandstone	4	5	6	5
Limestone	-	-	Trace	Trace
Chert	5	3	1	3
Volcanics	22	25	37	28
Total	100	99*	100	100

* Numbers do not add to 100 due to rounding

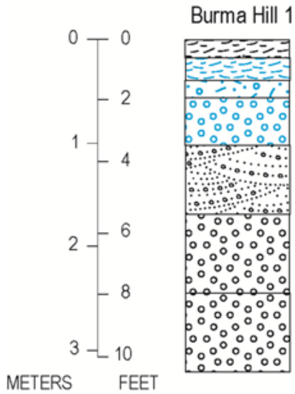
ENGINEERING TESTS				
Sample number	#1	#2	#3	General site characteristics
Grain Size Analysis				
Maximum clast size (inches)	6	6	6	6
Size distribution (percent)				
Cobbles	5	3	11	6
Coarse Gravel	38	34	44	39
Fine Gravel	20	20	12	17
Sand	34.4	39.4	30.8	34.9
Fines	2.6	3.6	2.2	2.8
Total	100	100	100	99.7*
LA Value	27.4	25.6	26.4	26.5
Soundness				
≤1.5" - >0.75"	1.6	0.4	1.4	1.1
≤0.75" - >0.375"	0.7	0.4	0.2	0.4
≤0.375 - > #4 sieve	0.2	0.4	0.3	0.3
Specific gravity	2.533	2.527	2.572	2.544
Percent absorption	1.6	1.8	1.3	1.6

* Numbers do not add to 100 due to rounding

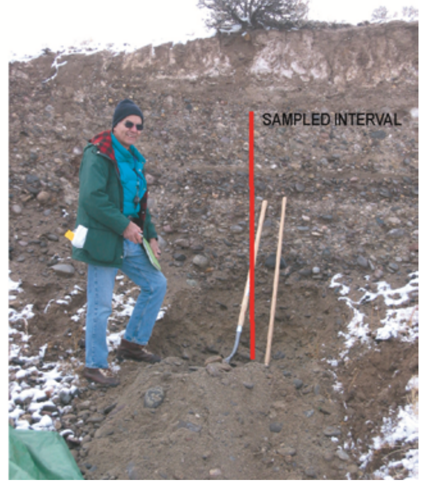
PRODUCTION CONSTANT	
Estimated gravel thickness (feet)	8
Constant - Maximum recoverable product (tons per acre)	18,392
Constant - Minimum recoverable product (tons per acre)	13,867

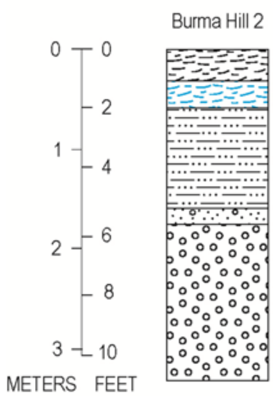
CONCLUSIONS

Portland cement concrete – May be suitable. Will require crushing and screening and may require washing. Determine susceptibility to alkali-silica reaction. May require use of low-alkali cement or additives.
Asphalt concrete – Suitable. Will require crushing and screening.
Base – Suitable. Will require crushing and screening.
Specific gravity – May be marginally acceptable.

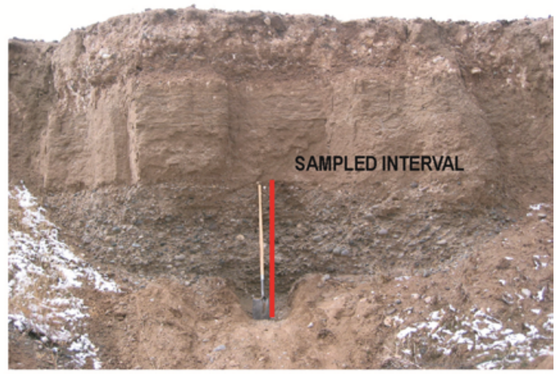


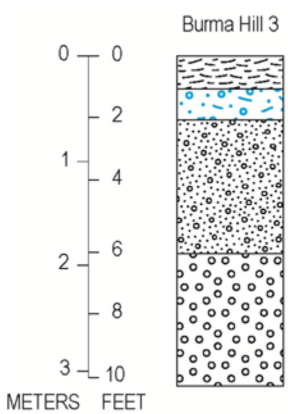
A: 8" clay soil, prismatic structure
B: 9" clay silt soil, stage III $CaCO_3$
B: 6" silt, sand, and fine gravel, stage III $CaCO_3$
B: 18" pebble gravel, stage III $CaCO_3$
C: 27" pebble gravel with sand lenses up to 6" thick
SAMPLED INTERVAL
C: 30"+ cobble gravel, maximum clast weathering: stage 4
C: 30"+ covered, probably gravel
Sandstone



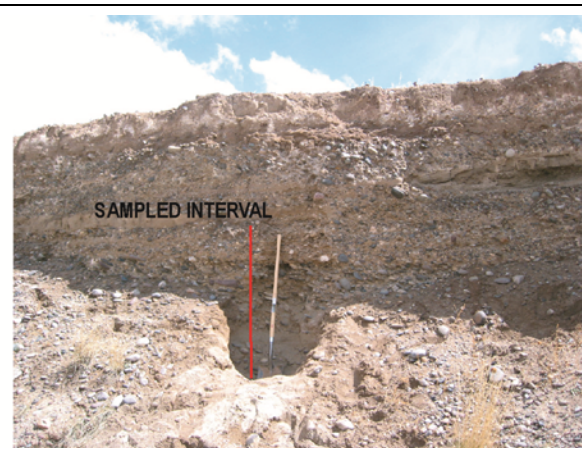


A: 12" clay soil, prismatic structure
B: 11" clay soil, stage III $CaCO_3$
C: 40" silt and sand overbank deposits, laminated structure
C: 6" silt and granule gravel overbank deposits, grades into unit below
SAMPLED INTERVAL
C: 56" pebble gravel, stage II $CaCO_3$ upper 36", maximum clast weathering: stage 3
Sandstone





A: 12" clay soil
B: 12" silt, sand, and fine gravel, stage III $CaCO_3$
C: 50" pebble gravel with sand lenses, stage II $CaCO_3$ in lower 12", maximum clast weathering: stage 3
SAMPLED INTERVAL
C: 50" cobble gravel with sand lenses
Sandstone



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SCENIC QUALITY FIELD INVENTORY AND EVALUATION CHART			
LANDSCAPE TYPE			
Feature—Dominated by a distant butte and riparian areas.			
LANDSCAPE ANALYSIS FACTORS			
Repetitious dominance of line from landform, vegetation, and road. Lines tend to converge.			
LANDSCAPE CHARACTER			
	LANDFORM/WATER	VEGETATION	STRUCTURE
FORM	Gentle slope in foreground; steep vertical at far edge of middle ground.	Patchy, cushion.	Rectangular, cylindrical, simple.
LINE	Broken horizontal skyline, dominant ridgeline.		Linear road, vertical (telephone poles, barbed wire fence).
COLOR	Tan, dark grey, red color in butte.	Grey, celadon green, buff, cream.	Brown, rust, grey, cream.
TEXTURE	Medium and fine grain.	Uneven and coarse shrubs; fine grasses.	Ordered, asymmetrical.

LANDSCAPE NARRATIVE

The Burma Hill site is bisected by Burma Road (Hwy 320) and is within 9 mi of Riverton. The elevation ranges from approximately 5,400 ft at the terrace tread to 5,200 ft in Paradise Valley and Sand Gulch to the north. Riverton Valley is to the south. Slope is gentle with views in the area containing foreground, middle ground, and background (Owl Creek Mountains to the north). Sand Gulch (riparian area in the middle ground) and Lost Wells Butte (highest el 5,675ft) are visible from the east side despite poor atmospheric conditions. Snow capped peaks are visible in the distance on the west side. A low cloud ceiling and snowfall gives an overall softness to the landscape and mutes color. Irrigated crop areas and human settlement are evident. The texture of the land is mostly fine.

Big sagebrush and mixed-grass occupy the undisturbed land areas. For most of the year the landscape has a strong grey color. The texture of the vegetation appears coarse in the foreground and fine in the middle ground.

The eastern Burma Hill site is viewed from Burma Road for about 17 seconds heading south; the view is hidden traveling north. The western Burma Hill site is screened in both directions from Burma Road. It is surrounded by existing spoil piles and the view of the site is hidden from the valley floor. Cultural modifications both complement (pastoral landscape) and detract (oil or gas development, telephone poles). Some trash was evident on the eastern side. For this assessment, the modifications are rated as canceling each other out.

SCENIC QUALITY RATING

	SCORE			
LANDFORM	5	3	1	2
VEGETATION	5	3	1	3
WATER	5	3	0	0
COLOR	5	3	1	2
ADJACENT SCENERY	5	3	0	3
SCARCITY	5	3	1	3
CULTURAL MODIFICATIONS	2	0	-4	0
TOTAL SCORE	= 13			
SCENIC QUALITY CLASSIFICATION	B			

Upper, View north from eastern site at Burma Hill. Paradise Valley, riparian, and irrigated land cover are visible in the middle ground. *Lower,* View from western site at Burma Hill. Spoil piles and sand and gravel are visible on site.

Left, A winter storm has left snow on the ground at the eastern Burma Hill site. Sagebrush (in this case, big sagebrush, *Artemisia tridentate.*) dominates sagebrush steppe communities along with an abundance of perennial grasses. Sagebrush is an important plant food for many species of wildlife. Its reestablishment of mined lands has generally been difficult (Schuman and others, 1998). *Below,* Plains pricklypear cactus, *Opuntia polyacantha,* can be troublesome on overgrazed pastures and rangelands. The western Burma Hill site also exhibited prairie sagewort, rubber rabbitbrush, and alsike clover (an introduced species to the United States).

Left, The Wind River Indian Reservation field work was conducted in April, 2005, when emergent plant growth was underway. Identifying prairie plants, both grasses and forbs, can be frustrating unless flowers or seed heads are observed. In the early spring, last year's seed heads are tattered, if present at all. Is this grass basin wildrye (*Leymus cinereus*) or western wheatgrass (*Pascopyrum smithii*)?

Some plant species will be easy to distinguish; others will be confusing and difficult. *Lower left,* This speciman could be an *Oenothera* while the plant, *lower right*, is unknown. Since plants have varying flowering times, three field visits during the spring/summer would provide the best chance of seeing as many plants as possible.

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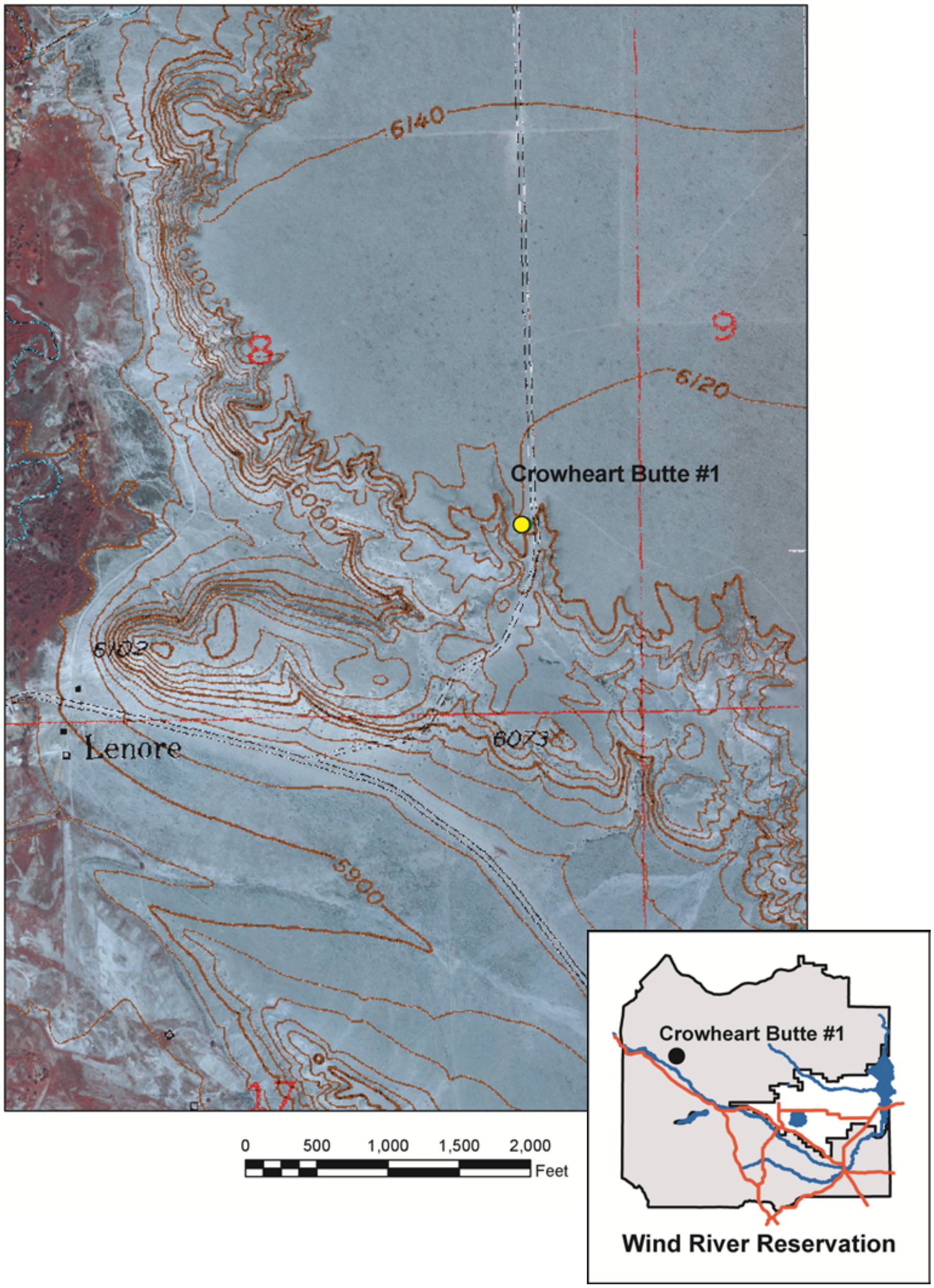
Site Name: Crowheart Butte #1

Location: SE ¼, SE ¼, S8, T4N, R3W, Wind River Meridian
USGS Topographic Sheet: Crowheart
Date: 22 April 2005



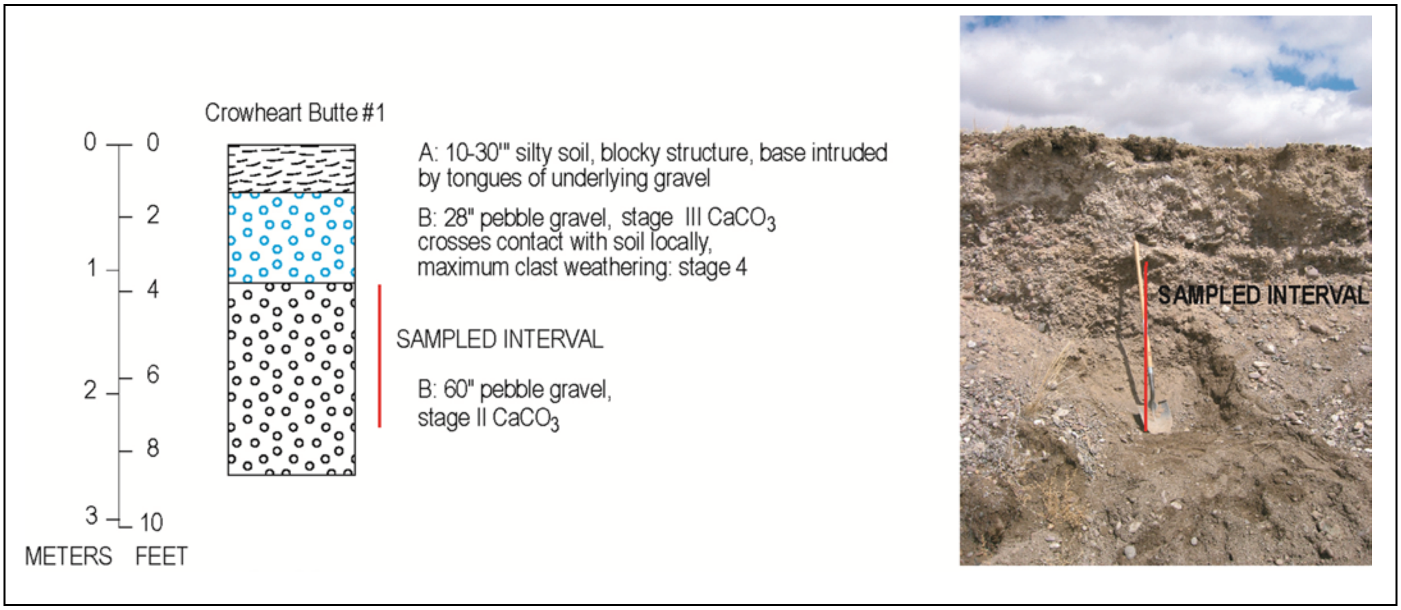
GEOLOGIC DESCRIPTION	
Sample number	#1
Location	43° 20' 02.2" 109° 07' 57.7"
Terrace level Qt	8 (?)
Gravel thickness (feet)	7-8
Overburden thickness (feet)	1-2
Water table	None observed
Caliche thickness (feet)	2-3
Maximum carbonate stage	III
Maximum clast weathering	4
Lithologies (pct)	
Granite-gneiss	21
Mafic plutonic-metamorphic	5
Quartzite	25
Vein quartz	-
Sandstone	12
Limestone	-
Chert	1
Volcanics	36
Total	100

ENGINEERING TESTS	
Sample number	#1
Maximum clast size (inches)	>3
Size distribution (percent)	
Cobbles	4
Coarse Gravel	36
Fine Gravel	26
Sand	31.8
Fines	2.2
Total	100
LA Value	29.3
Soundness (pct)	
≤1.5” - >0.75”	1.0
≤0.75” - >0.375”	1.4
≤0.375 - > #4 sieve	1.3
Specific gravity	2.502
Percent absorption	2.0

PRODUCTION CONSTANT	
Estimated gravel thickness (feet)	7.5
Constant - Maximum recoverable product (tons per acre)	17,243
Constant - Minimum recoverable product (tons per acre)	13,277

CONCLUSIONS

Portland cement concrete – May be suitable. Will require crushing and screening and may require washing. Determine susceptibility to alkali-silica reaction. May require use of low-alkali cement or additives.
Asphalt concrete – Suitable. Will require crushing and screening.
Base – Suitable. Will require crushing and screening.
Specific gravity – May be unacceptable.


Crowheart Butte #1
0
0
2
1
4
6
2
8
3
10
METERS
FEET
A: 10-30'" silty soil, blocky structure, base intruded by tongues of underlying gravel
B: 28" pebble gravel, stage III $CaCO_3$ crosses contact with soil locally, maximum clast weathering: stage 4
SAMPLED INTERVAL
B: 60" pebble gravel, stage II $CaCO_3$
SAMPLED INTERVAL

SCENIC QUALITY FIELD INVENTORY AND EVALUATION CHART

LANDSCAPE TYPE

Feature—Dominated by a prominent landform, Crowheart Butte.

LANDSCAPE ANALYSIS FACTORS

Scale is vast with middle ground merging with background.

LANDSCAPE CHARACTER

	LANDFORM/WATER	VEGETATION	STRUCTURE
FORM	Flattened, pyramidal, high, jagged.	Rounded, spreading, few, nondirectional.	
LINE	Horizontal, broken, hard.	Weak, broken.	Curving, straight.
COLOR	Tan, pale orange.	Grey/green, pale yellow.	Tan.
TEXTURE	Clumped, angular, coarse, and medium.	Medium, rough, discontinuous.	Smooth.

LANDSCAPE NARRATIVE

The Crowheart Butte #1 site (el 6,120 ft) is located about 3 air miles from U.S. Hwy 26/287. However, the site is accessed approximately 7 mi, via Lenore Bridge Road, on a dirt road from the highway. The site is approximately 54 mi northwest of Lander.

There is a vista of surrounding mountains forming a backdrop; the Wind River valley is visible in the middle ground. Low cloud cover may have reduced back ground visibility. Flat, rolling terrain characterizes the foreground. Surrounding terraces are discernable. The site would be exposed from all sides in terms of possible development. It is distant enough from the main road and housing along Crow Creek that there would be little impact to observers. Crowheat Butte itself (el 6,764 ft) is about 2.5 mi southeast. Crowheart Butte has a historic significance, but the Crowheart Butte #1 site is considered to be outside its viewshed.

The vegetation is sparse and consists mainly of sagebrush and grasses. The vegetation density and size increase in the draws. The landform exhibits some contrast due to exposed sandstone and gravel.

SCENIC QUALITY RATING

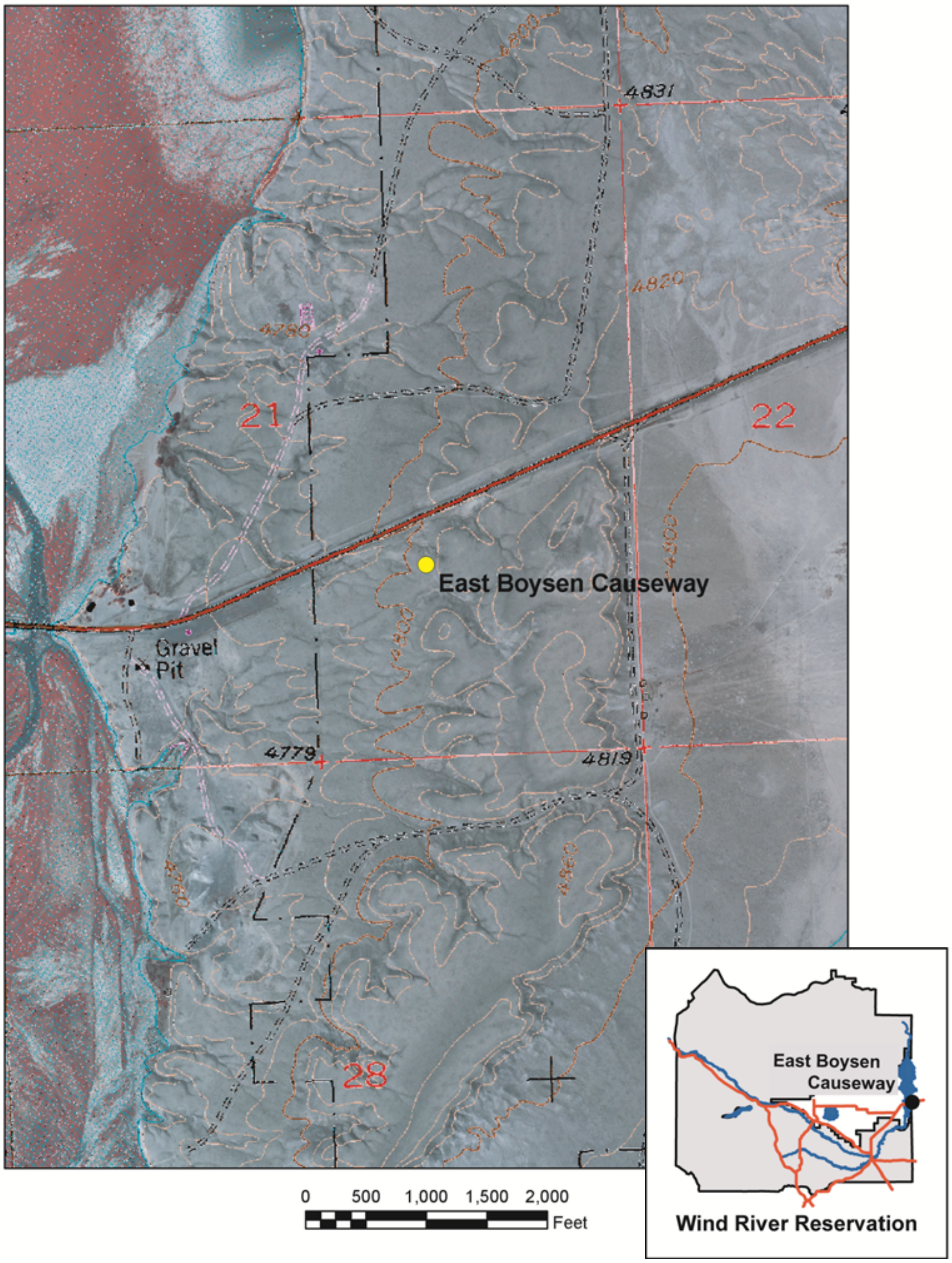
				SCORE
LANDFORM	5	3	1	3
VEGETATION	5	3	1	1
WATER	5	3	0	0
COLOR	5	3	1	2
ADJACENT SCENERY	5	3	0	3
SCARCITY	5	3	1	3
CULTURAL MODIFICATIONS	2	0	-4	0
TOTAL SCORE				= 12
SCENIC QUALITY CLASSIFICATION	**B**			

Upper, View north from terrace tread, from Crowheart Butte #1 site. *Lower,* The Wind River Formation is exposed in this view west. The Wind River Mountains are in the background.

Upper, Crowheart Butte, a monolithic table-top mesa, is near the Wind River and is a dominant feature of this landscape. *Lower,* Vehicular traffic crosses the Wind River via a simple truss bridge and continues on Lenore Bridge Road to the Crowheart Butte #1 site. Note the condition of the bridge abutment on the right side of the river.

Site Name: East Boysen Causeway

Location: NE¼, SE¼, S21, T3N, R6E, Wind River Meridian
USGS Topographic Sheet: Hidden Valley
Date: 18 April 2005: 23 April 2005



GEOLOGIC OBSERVATIONS					
Investigator	USGS	HMK Engineering*[1]			General site characteristics
Sample number	#1	Causeway # 2, 3	Causeway # 5, 6	Causeway Average 11 test pits	
Location	43º 13' 15.4" 108º 09' 56.6"	-	-	-	-
Terrace level Qt	2	-	-	-	2
Gravel thickness (feet)	6.5	-	-	-	6.5
Overburden thickness (feet)	1	-	-	-	1
Water table	None observed	-	-	-	-
Caliche thickness (feet)	2	-	-	-	2
Maximum carbonate stage	II	-	-	-	II
Maximum clast weathering	-	-	-	-	-
Lithologies (pct)					
Granite-gneiss	36	-	-	-	36
Mafic plutonic-metamorphic	7	-	-	-	7
Quartzite	15	-	-	-	15
Vein quartz	Trace	-	-	-	Trace
Sandstone	5	-	-	-	5
Limestone	Trace	-	-	-	Trace
Chert	-	-	-	-	-
Volcanics	36	-	-	-	36
Total	99*[2]	-	-	-	99*[2]

*[1] Eastern Shoshone Oil & Gas Commission, 2005

*[2] Total does not equal 100 due to rounding.

ENGINEERING TESTS					
Investigator	USGS	HMK Engineering*[1]			General site characteristics
Sample number	#1	Causeway # 1, 3	Causeway # 6	Causeway Average 11 test pits	
Grain Size Analysis					
Maximum clast size (inches)	>3	-	-	-	>3
Size distribution (percent)					
Cobbles	-	11.5	18.0	11	11
Coarse Gravel	-	36.5	28.0	29	30
Fine Gravel	-	7.0	16.0	16	15
Sand	-	37.0	33	37.2	37.2
Fines	-	8.0	4.9	6.8	6.9
Total	-	100	99.9*	100	100.1*[2]
LA Value	-	27	26		27
Soundness					
≤1.5" - >0.75"	-	3.3	1.4	-	2.35
≤0.75" - >0.375"	-	1.9	2.0	-	1.95
≤0.375 - > #4 sieve	-	-	-	-	-
Specific gravity	-	2.596	2.617	-	2.607
Percent absorption	-	1.24	1.12	-	1.18

*[1] Eastern Shoshone Oil & Gas Commission, 2005

*[2] Total does not equal 100 due to rounding.

PRODUCTION CONSTANT	
Estimated gravel thickness (feet)	6.5
Constant - Maximum recoverable product	14,944
Constant - Minimum recoverable product	10,668

CONCLUSIONS
Portland cement concrete – May be suitable. Will require crushing and screening and may require washing. Determine susceptibility to alkali-silica reaction. May require use of low-alkali cement or additives. **Asphalt concrete** – Suitable. Will require crushing and screening. **Base** – Suitable. Will require crushing and screening.

There are no natural or man-made exposures at this site. No geologic columns were prepared.

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SCENIC QUALITY FIELD INVENTORY AND EVALUATION CHART

LANDSCAPE TYPE

Panoramic

LANDSCAPE ANALYSIS FACTORS

The landscape has little contrast.

LANDSCAPE CHARACTER

	LANDFORM/WATER	VEGETATION	STRUCTURE
FORM	Flat, convex.	Grasses and sparse sage.	Square sheds, highway, barbed wire fence, and dirt road.
LINE	Smooth.	Points.	Parallel to terrace.
COLOR	Pale green, blue, grey, pale pink.	Grey-green, tan.	Dark grey, light brown.
TEXTURE	Medium.	Matte.	Rough, even, fine.

LANDSCAPE NARRATIVE

The East Boysen Causeway site (el 4,830 ft) is easily accessible from U.S. Hwy 26. It is approximately 20 miles east of Riverton and 4 miles west of Shoshoni. There are distant views of Boysen Reservoir, the town of Shoshoni, and the Owl Creek Mountains that normally would not be considered under Adjacent Scenery. However, due to the low overall rating, a score of 3 was given due to the dominant landform, besides the foreground terraces, Water Tank Hill (in the middle ground). The Chicago and North Western Railroad is approximately 1 mi to the southeast.

The E. Boysen Causeway site includes an example of reclamation by the Wyoming Department of Transportation. A former sand and gravel pit was apparently reclaimed so that a terrace edge was utilized for camouflage, acted as a buffer, and blended with small terrace toes to conform to surrounding topography.

Antelope were observed in the foreground. The texture is mainly fine both for landform and vegetation. The landscape is monotone and tiered.

Cultural modifications include wood sheds, poles, and storage piles of sand and gravel (poorly positioned). Some vegetation is grazed out. The site is in view from the highway heading south for 0.5 mi.

SCENIC QUALITY RATING

	SCORE			
LANDFORM	5	3	1	1
VEGETATION	5	3	1	2
WATER	5	3	0	0
COLOR	5	3	1	1
ADJACENT SCENERY	5	3	0	3
SCARCITY	5	3	1	1
CULTURAL MODIFICATIONS	2	0	-4	-2
TOTAL SCORE				= 6
SCENIC QUALITY CLASSIFICATION	**C**			

This view is from U.S. Hwy 26, looking south, towards the terraces and the E. Boysen Causeway site. The terrace slopes are plainly visible and block viewing of background objects. The site is not visible from the road despite being located on the terrace top. The vegetation and landform lack visual variety and therefore typically are considered less visually appealing.

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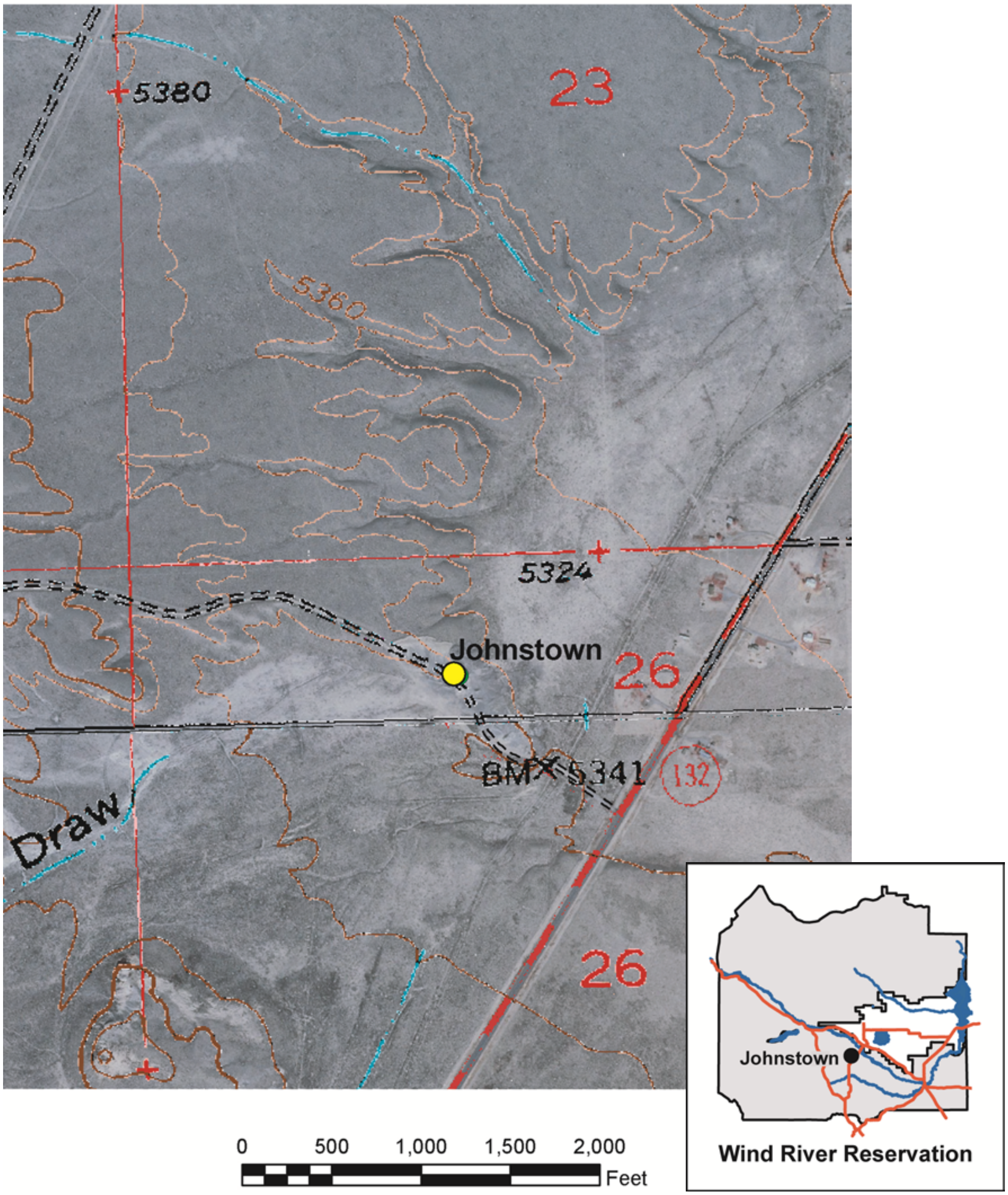
Site Name: Johnstown

Location: NE ¼, NW ¼, S26, T2N, R1E, Wind River Meridian
USGS Topographic Sheet: Pavillion
Date: 23 April 2005



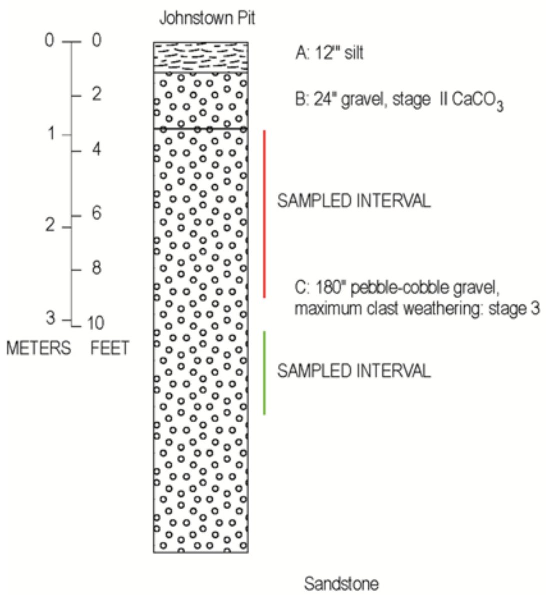
GEOLOGIC DESCRIPTION	
Sample number	#1
Location	43° 07' 32.2" 108° 43' 42.2"
Terrace level Qt	5
Gravel thickness (feet)	17
Overburden thickness (feet)	1
Water table	None observed
Caliche thickness (feet)	2
Maximum carbonate stage:	II
Maximum clast weathering	3
Lithologies (pct)	
Granite-gneiss	42
Mafic plutonic-metamorphic	4
Quartzite	16
Vein quartz	-
Sandstone	13
Limestone	Trace
Chert	Trace
Volcanics	25
Total	100

ENGINEERING TESTS	
Sample number	#1
Maximum clast size (inches)	>3
Size distribution (percent)	
Cobbles	35
Coarse Gravel	28
Fine Gravel	15
Sand	20.8
Fines	1.2
Total	100
LA Value	22.9
Soundness (pct)	
≤1.5” - >0.75”	0.2
≤0.75” - >0.375”	0.2
≤0.375 - > #4 sieve	0.1
Specific gravity	2.592
Percent absorption	1.3

PRODUCTION CONSTANT	
Estimated gravel thickness (feet)	17
Constant - Maximum recoverable product (tons per acre)	39,083
Constant - Minimum recoverable product (tons per acre)	20,377

CONCLUSIONS

Portland cement concrete – May be suitable. Will require crushing and screening and may require washing. Determine susceptibility to alkali-silica reaction. May require use of low-alkali cement or additives.
Asphalt concrete – Suitable. Will require crushing and screening.
Base – Suitable. Will require crushing and screening.
Difficult mining – Large amount of cobbles may require removal with a grizzly screen.



The poor exposures at this site necessitated sampling at two nearby locations.

SCENIC QUALITY FIELD INVENTORY AND EVALUATION CHART			
LANDSCAPE TYPE			
Panoramic			
LANDSCAPE ANALYSIS FACTORS			
The landscape offers refuge in the built form.			
LANDSCAPE CHARACTER			
	LANDFORM/WATER	VEGETATION	STRUCTURE
FORM	Co-dominance, flat, definite, large, few.	Low, simple, rounded.	Rectangular, low, regular.
LINE	Indistinct, horizontal.	Curvilinear edge, contrasting, horizontal (riparian)	Straight, vertical, regular.
COLOR	Yellow, light brown.	Light tan, grey-green.	Glaring, tan, green, white.
TEXTURE	Smooth	Stippled, smooth	Matte

LANDSCAPE NARRATIVE

The Johnstown site (el 5,360 ft) is on a dirt road, just 0.5 mile from the Ethete Cutoff, Hwy 132. U.S. Hwy 26 is about 3 mi north and Riverton is approximately 22 mi away. The Johnstown Valley and Wind River are east and discernable only by the flat expanse and string of cottonwoods. Edmo Buttes give the only visual landform relief; blending with the valley and appearing to stretch along in the back ground. A draw north of the site is hidden from view.

Vegetation is characterized by medium (sage) and fine (grazed) texture. It appears monotonous over a majority of the space.

Nine homes are located 0.5 mi, adjacent to Hwy 32, from the site. The medium-duty road has a lot of local traffic. The site is visible (mainly due to the sand piles) along Hwy 132 for 1.7 mi after reaching the lower terrace heading north. The site is visible heading south for 0.5 mi. The sand piles are noticeable on the flat landscape.

SCENIC QUALITY RATING				
				SCORE
LANDFORM	5	3	1	1
VEGETATION	5	3	1	3
WATER	5	3	0	0
COLOR	5	3	1	2
ADJACENT SCENERY	5	3	0	3
SCARCITY	5	3	1	1
CULTURAL MODIFICATIONS	2	0	-4	-2
TOTAL SCORE				= 8
SCENIC QUALITY CLASSIFICATION	**C**			

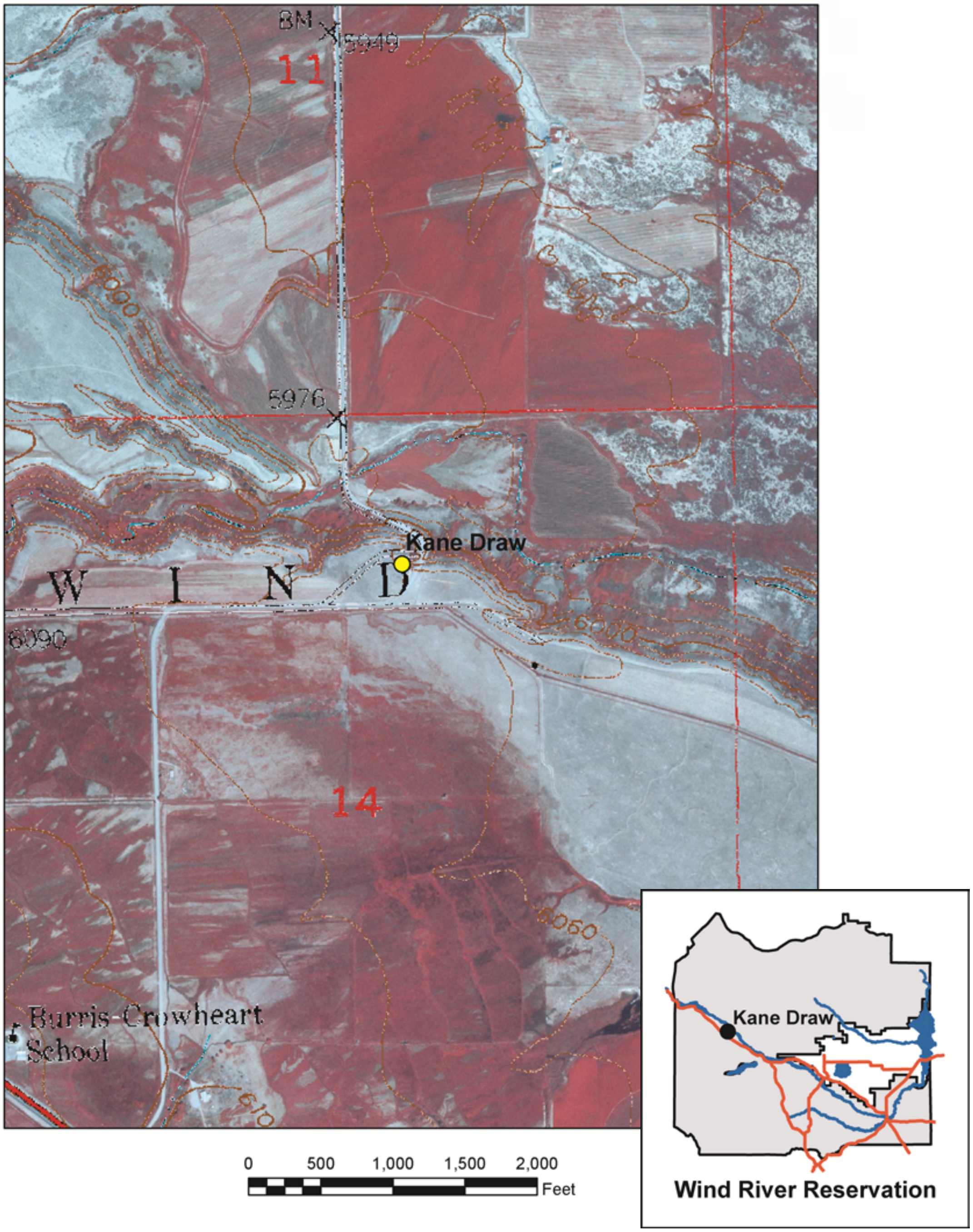
Upper, View east from the Johnstown site across Johnstown Valley and Edmo Buttes. Residences are in close proximity to the site. *Left,* Southern view of the sand and gravel pit on the Johnstown site. The sand piles are visible from Hwy 132, not the gravel pit itself, due to the contrast in color, profile, and orientation. Lower photograph courtesy Floyd Phillips.

Upper, Prostrate or Bigbract verbena (*Verbena bracteata)* seed heads. It is common in disturbed land, along drainages, mesas, and rocky slopes. *Right, Eriogonoideae (Polygonaceae spp).*

Left, Possibly prairie larkspur, *Delphinium virescens,* (far left) and fringed sagewort (right side). *Lower,* Evening primrose, *Oenothera spp.*

Site Name: Kane Draw

Location: NW ¼, NE ¼, S14, T4N, R4W, Wind River Meridian
USGS Topographic Sheet: Crowheart
Date: 21 April 2005



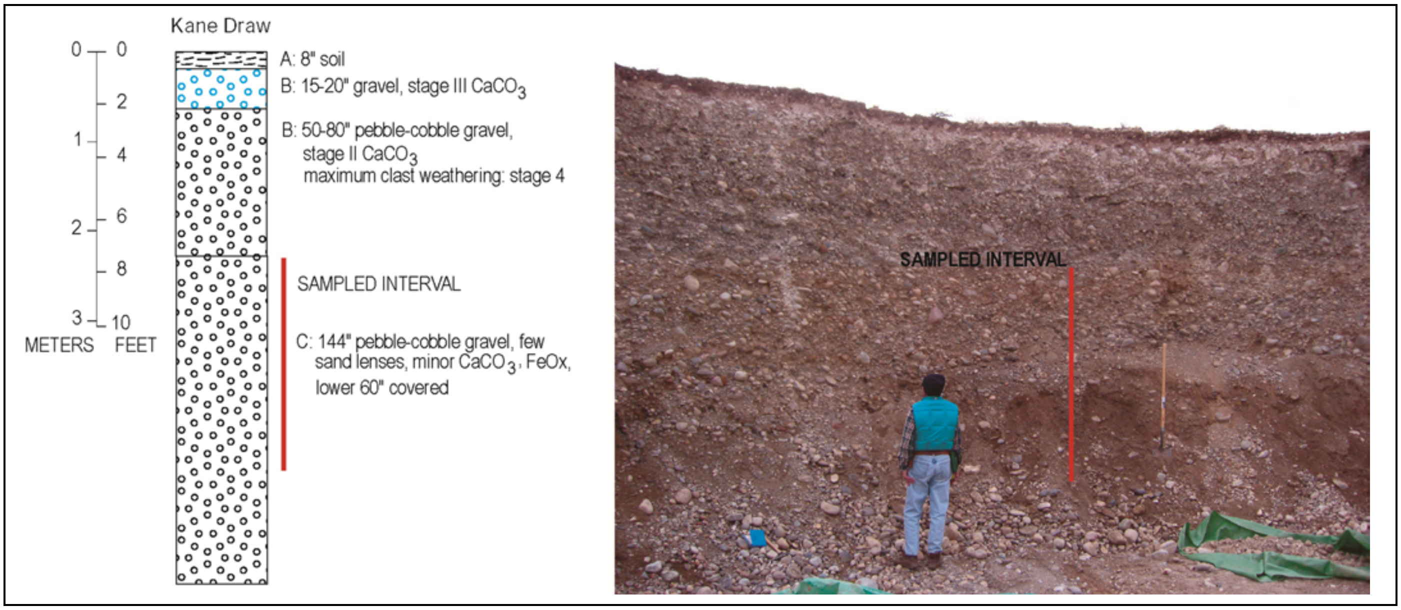
GEOLOGIC DESCRIPTION	
Sample number	#1
Location:	43° 19' 38.7" 109° 11' 50.3"
Terrace level Qt	5
Gravel thickness (feet)	20
Overburden thickness (feet)	1
Water table	Water at base of gravel
Caliche thickness (feet)	6-8
Maximum carbonate stage:	III
Maximum clast weathering	4
Lithologies (pct)	
Granite-gneiss	21
Mafic plutonic-metamorphic	4
Quartzite	16
Vein quartz	2
Sandstone	21
Limestone	-
Chert	-
Volcanics	36
Total	100

ENGINEERING TESTS	
Sample number	#1
Maximum clast size (inches)	10
Size distribution (percent)	
Cobbles	34
Coarse Gravel	60
Fine Gravel	21
Sand	17.3
Fines	1.7
Total	100
LA Value	26.2
Soundness (pct)	
≤1.5" - >0.75"	0.6
≤0.75" - >0.375"	0.4
≤0.375 - > #4 sieve	0.4
Specific gravity	2.576
Percent absorption	1.6

PRODUCTION CONSTANT	
Estimated gravel thickness (feet)	20
Constant - Maximum recoverable product (tons per acre)	45,980
Constant - Minimum recoverable product (tons per acre)	24,341

CONCLUSIONS

Portland cement concrete – May be suitable. Will require crushing and screening and may require washing. Determine susceptibility to alkali-silica reaction. May require use of low-alkali cement or additives.
Asphalt concrete – Suitable. Will require crushing and screening.
Base – Suitable. Will require crushing and screening.
Deleterious Material – Large amount of calcium carbonate (caliche) coating. Crushing will reduce extent of coating.
Difficult mining – Large amount of cobbles may require removal with a grizzly screen.


Kane Draw
0 0
2
1 4
2 6
8
3 10
METERS FEET
A: 8" soil
B: 15-20" gravel, stage III $CaCO_3$
B: 50-80" pebble-cobble gravel, stage II $CaCO_3$ maximum clast weathering: stage 4
SAMPLED INTERVAL
C: 144" pebble-cobble gravel, few sand lenses, minor $CaCO_3$, FeOx, lower 60" covered
SAMPLED INTERVAL

SCENIC QUALITY FIELD INVENTORY AND EVALUATION CHART			
LANDSCAPE TYPE			
Panoramic—The middle ground objects do not substantially block viewing of back ground objects.			
LANDSCAPE ANALYSIS FACTORS			
The terraces form a western backdrop to the Wind River Valley creating a comfortable human scale. Views in other directions appear vast and exposed.			
LANDSCAPE CHARACTER			
	LANDFORM/WATER	VEGETATION	STRUCTURE
FORM	Middle ground takes on importance, fairly flat. Convergence, diverse, triangular.	Fastigiate, rounded, spreading.	Rectangular, wide, simple.
LINE	Complex, broken.	Strong horizontal in distance (riparian). Horizontal line along terraces.	Angular, linear (road).
COLOR	Brown, grey, tan, pink.	Grey, gold.	Tan, white, muted.
TEXTURE	Medium foreground, fine middle and back ground.	Fine and medium foreground, fine middle and back ground. Subtle.	Smooth.

LANDSCAPE NARRATIVE

The Kane Draw site (el 6,040 ft) is approximately 1 mile north of U.S. Hwy 26/287 on Urbigket Road. It is located above a natural drainage, Kane Draw, which is visible in the foreground. Urbigket Road continues nearly due north for 2 mi providing linear views of the site. The Wind River flood plain is in the middle ground. The widely spaced terraces create a slow rhythm. Distant views include terraces and mountains (Owl Creek and Wind River). Low cloud cover may have interfered with the impact of adjacent scenery. Crowheart Butte is barely visible to the east (elevation 6,764 ft).

The texture of vegetation varies from fine to medium. Sagebrush and rubber rabbitbrush cover the north facing slope of the terrace site, along with isolated groups of willows and immature cottonwoods in drainage areas

Cultural modifications include irrigated land cover, pasture, and a water pipeline. The pastures add a sense of calm but overgrazing adjacent to the site detracts giving a scenic rating of zero for Cultural Modifications. The improved road surface to the north is noticeable from the site and the line is reinforced by telephone poles and barbed wire fencing. The site is visible for nearly 87 seconds in the valley as one heads south towards the site. The route appears to be well used by local residents. The view south from the pit is of ranch land but the site itself is not discernable.

SCENIC QUALITY RATING				
				SCORE
LANDFORM	5	3	1	2
VEGETATION	5	3	1	4
WATER	5	3	0	0
COLOR	5	3	1	3
ADJACENT SCENERY	5	3	0	3
SCARCITY	5	3	1	3
CULTURAL MODIFICATIONS	2	0	-4	0
TOTAL SCORE	= 15			
SCENIC QUALITY CLASSIFICATION	B			

Upper, View northwest from terrace tread with exposed terrace face in foreground. Urbigket Road, riparian, and irrigated land cover occupy the middle ground. Owl Creek Mountains are to the right. *Lower left,* View east of north-facing terrace riser viewed from the road. Crowheart Butte is in the distance. *Lower right,* Overgrazed land cover on terrace tread, view northeast.

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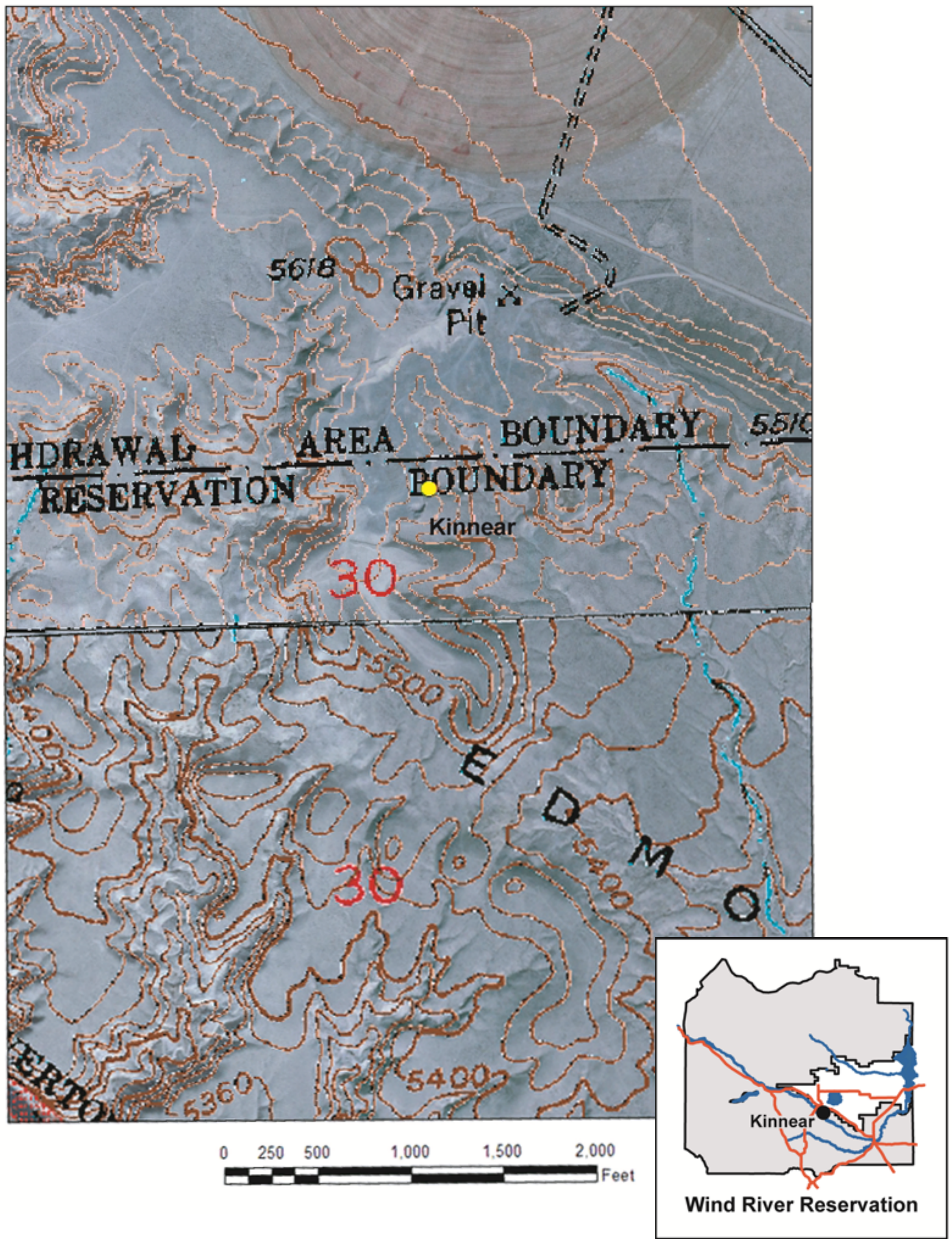
Site Name: Kinnear

Location: NW ¼, NE ¼, S30, T2N, R2E, Wind River Meridian
USGS Topographic Sheet: Pavillion
Date: 23 April 2005



GEOLOGIC DESCRIPTION	
Sample number	#1
Location	43° 07' 36.8" 108° 41' 05.7"
Terrace level Qt	8
Gravel thickness (feet)	15
Overburden thickness (feet)	1
Water table	None observed
Caliche thickness (feet)	3
Maximum carbonate stage	II
Maximum clast weathering	4
Lithologies (pct)	
Granite-gneiss	29
Mafic plutonic-metamorphic	5
Quartzite	24
Vein quartz	-
Sandstone	12
Limestone	-
Chert	Trace
Volcanics	30
Total	100

ENGINEERING TESTS	
Sample number	#1
Maximum clast size (inches)	10
Size distribution (percent)	
Cobbles	15
Coarse Gravel	40
Fine Gravel	20
Sand	23.6
Fines	1.4
Total	100
LA Value	21.8
Soundness (pct)	
≤1.5” - >0.75”	0.2
≤0.75” - >0.375”	0.2
≤0.375 - > #4 sieve	0.1
Specific gravity	2.591
Percent absorption	1.4

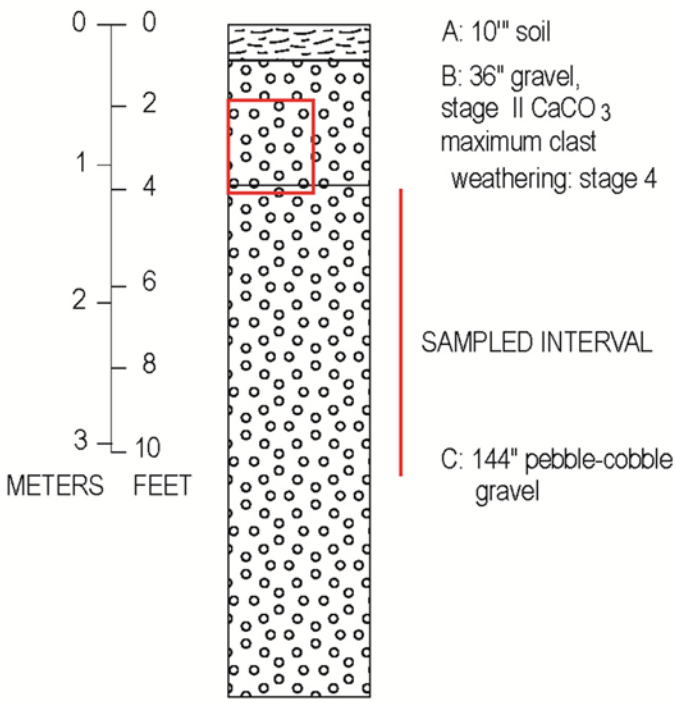
PRODUCTION CONSTANT	
Estimated gravel thickness (feet)	15
Constant - Maximum recoverable product (tons per acre)	34,485
Constant - Minimum recoverable product (tons per acre)	23,512

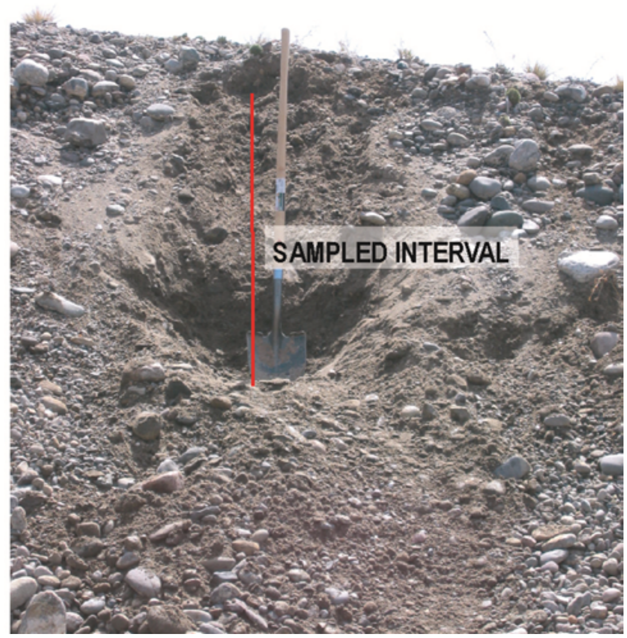
CONCLUSIONS

Portland cement concrete – May be suitable. Will require crushing and screening and may require washing. Determine susceptibility to alkali-silica reaction. May require use of low-alkali cement or additives.
Asphalt concrete – Suitable. Will require crushing and screening.
Base – Suitable. Will require crushing and screening.

White caliche deposits on underside of dark-colored rocks. Red box in column shows location of photograph.

Kinnear Pit





SCENIC QUALITY FIELD INVENTORY AND EVALUATION CHART			
LANDSCAPE TYPE			
Panoramic			
LANDSCAPE ANALYSIS FACTORS			
The landscape has little contrast.			
LANDSCAPE CHARACTER			
	LANDFORM/WATER	VEGETATION	STRUCTURE
FORM	Flat, long rectangular.	Cushion, low, sparse.	
LINE	Gently curving, strong edge terrace.	Indistinct.	Short, interrupted (dirt road).
COLOR	Tan, light brown.	Tan, pale yellow, green.	Grey, tan.
TEXTURE	Smooth.	Random stipple, medium.	Rough.

LANDSCAPE NARRATIVE

The Kinnear site (el 5,540 ft) is located approximately 0.6 mi south of River Road. River Road connects with the Ethete Cutoff, Hwy 132. The site is nearly 2 mi east of Johnstown and approximately 22 mi from Riverton.

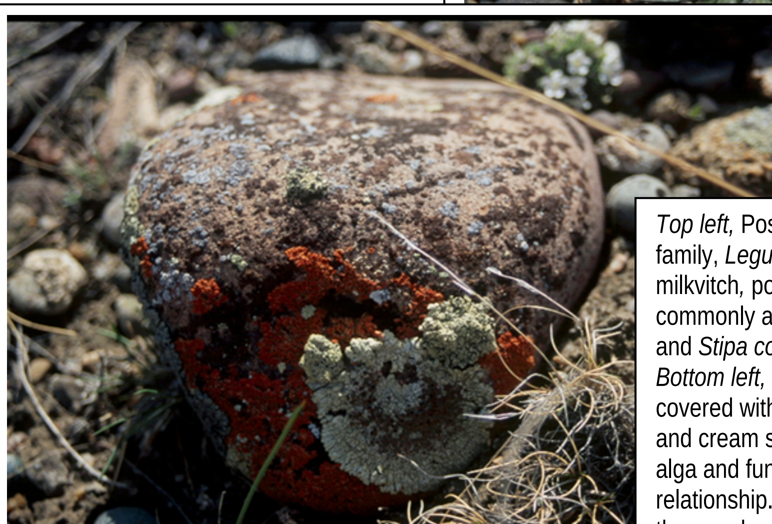
The landform and vegetation are monotonous. Prairie plants are in spring bloom but they are too small and sparse to create a color impact. Insects, butterflies and bees, are active. Cottonwoods and irrigated land is just visible in the eastern middle ground. This would be more pronounced in the summer when the leaves are out.

There are at least three sand and gravel pits, in the foreground, visible from the terrace top so a scenic rating of -2 was given to Cultural Modifications. The site is not visible from below because the outside terrace rims were not altered.

SCENIC QUALITY RATING				
				SCORE
LANDFORM	5	3	1	1
VEGETATION	5	3	1	2
WATER	5	3	0	0
COLOR	5	3	1	1
ADJACENT SCENERY	5	3	0	1
SCARCITY	5	3	1	1
CULTURAL MODIFICATIONS	2	0	-4	-2
TOTAL SCORE				= 4
SCENIC QUALITY CLASSIFICATION	**C**			

Upper, View east of an adjacent sand and gravel pit from the Kinnear site, River Road, riparian land cover in the middle ground, and Big Ridge in the back ground. *Lower left,* Typical grass. *Lower right,* Sulfur flower, possibly *Eriogonum flavum.*

Clockwise from upper left, Hood's phlox, *Phlox hoodii*. A low cushion- or mat-forming forb. The second plant is possibly a Bladderpod, *Lesquerella ssp*. The third photo is possibly of *Hymenopappus filifolius.* The last image is of a Western wallflower, *Erysimum asperum,* a western North American species confined to plains and sagebrush steppes.



Top left, Possibly a member of the pea family, *Leguminosae spp. Top right,* A milkvitch, possibly *Astragalus oreganos,* commonly associated with *Artemisia tridenta* and *Stipa comata. Bottom right,* unknown. *Bottom left,* Rock faces in the area are covered with lichen (orange, brown, grey, and cream shades). Lichens are colonies of alga and fungus living in a symbiotic relationship. A colony may be hundreds or thousands of years old and grows slowly outward to form circular patches.

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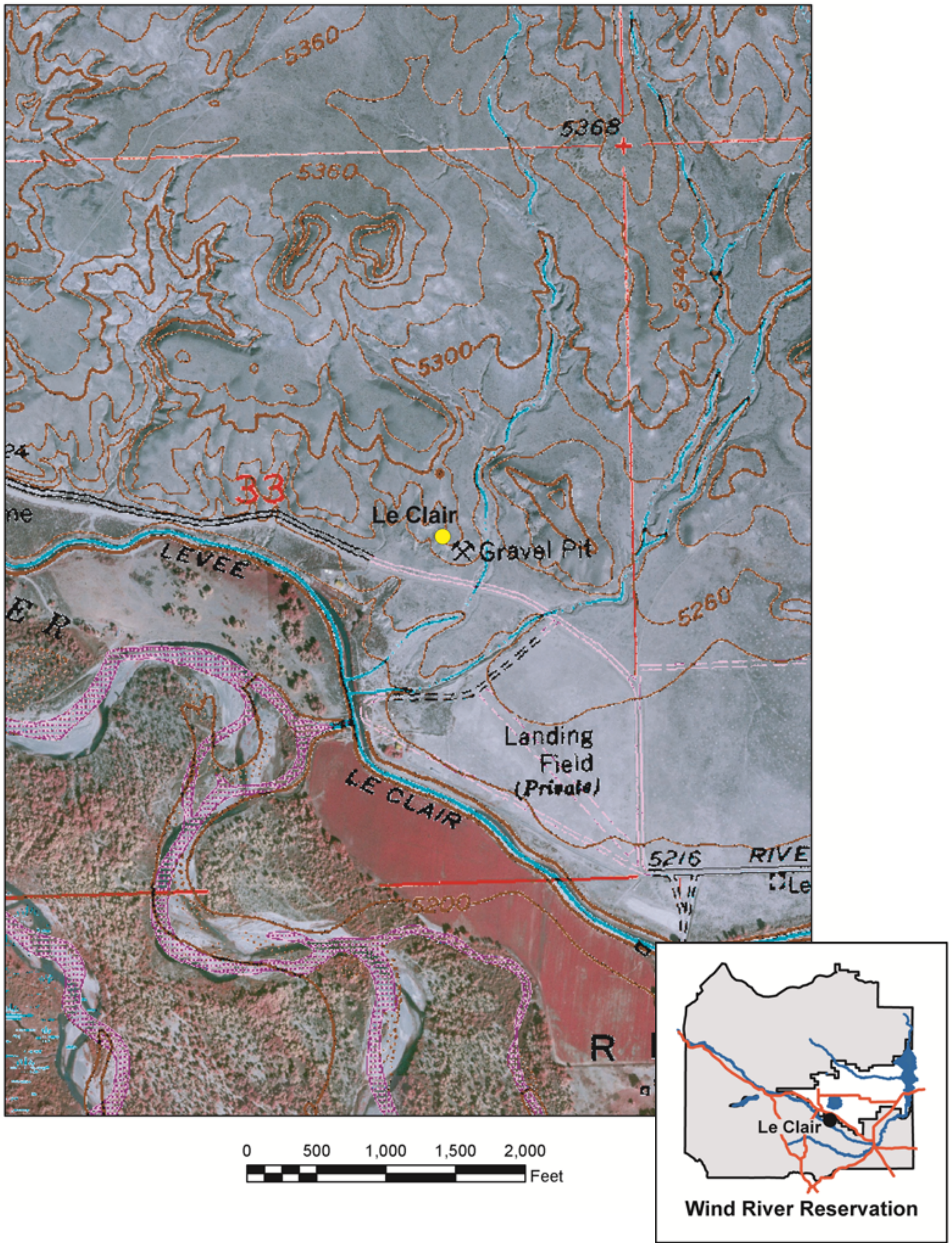
Site Name: Le Clair
Location: NE ¼, SE ¼, S33, T2N, R2E, Wind River Meridian
USGS Topographic Sheet: Mule Butte
Date: 23 April 2005



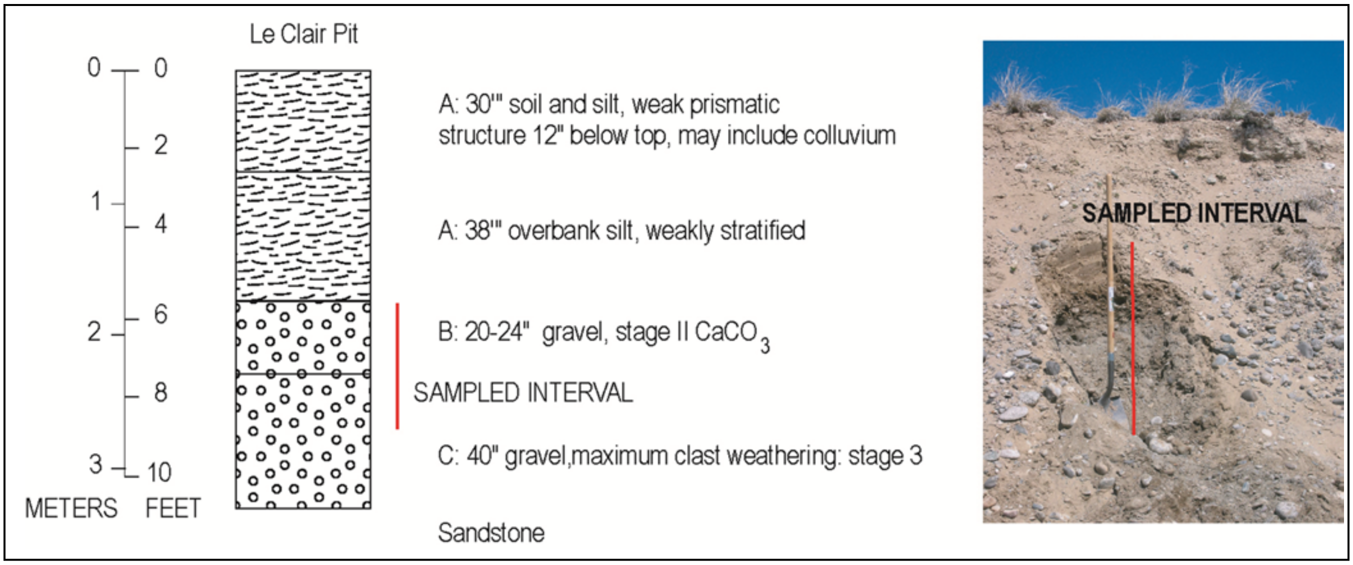
GEOLOGIC DESCRIPTION	
Sample number	#1
Location:	43° 06' 19.9" 108° 38' 32.9"
Terrace level Qt	2
Gravel thickness (feet)	5
Overburden thickness (feet)	6
Water table	None observed
Caliche thickness (feet)	2
Maximum carbonate stage	II
Maximum clast weathering	3
Lithologies (pct)	
Granite-gneiss	18
Mafic plutonic-metamorphic	3
Quartzite	26
Vein quartz	-
Sandstone	15
Limestone	Trace
Chert	Trace
Volcanics	38
Total	100

ENGINEERING TESTS	
Sample number	#1
Maximum clast size (inches)	>3
Size distribution (percent)	
Cobbles	13
Coarse Gravel	38
Fine Gravel	20
Sand	26.6
Fines	2.4
Total	100
LA Value:	22.7
Soundness (pct)	
≤1.5” - >0.75”	0.3
≤0.75” - >0.375”	0.4
≤0.375 - > #4 sieve	0.3
Specific gravity	2.553
Percent absorption	1.5

PRODUCTION CONSTANT	
Estimated gravel thickness (feet)	5
Constant - Maximum recoverable product (tons per acre)	11,495
Constant - Minimum recoverable product (tons per acre)	8,022

CONCLUSIONS

Portland cement concrete – May be suitable. Will require crushing and screening and may require washing. Determine susceptibility to alkali-silica reaction. May require use of low-alkali cement or additives.
Asphalt concrete – Suitable. Will require crushing and screening.
Base – Suitable. Will require crushing and screening.
Difficult mining – This property has small, isolated deposits of gravel, which might complicate mining efforts


Le Clair Pit
0
1
2
3
0
2
4
6
8
10
METERS
FEET
A: 30'" soil and silt, weak prismatic structure 12" below top, may include colluvium
A: 38'" overbank silt, weakly stratified
B: 20-24" gravel, stage II $CaCO_3$
SAMPLED INTERVAL
C: 40" gravel,maximum clast weathering: stage 3
Sandstone
SAMPLED INTERVAL

SCENIC QUALITY FIELD INVENTORY AND EVALUATION CHART			
LANDSCAPE TYPE			
Panoramic			
LANDSCAPE ANALYSIS FACTORS			
Line sequence from systematic repetition of vegetative patterns (cottonwoods).			
LANDSCAPE CHARACTER			
	LANDFORM/WATER	VEGETATION	STRUCTURE
FORM	Gentle slope, trapezoid (sandstone), boulders (Wind River Formation).	Sparse small grasses, cushions. Long tapering cylinder (cottonwoods).	Rectangular.
LINE	Curving.	Undulating band cutting area in two (grazed and sagebrush land cover). Diagonal.	Vertical, horizontal, sequence from fencing and road.
COLOR	Eggshell, sand, pale orange.	Sage green (cool dull colors retreat).	Red, yellow, white, shiny (warm bright colors advance.)
TEXTURE	Fine ground plane, smooth.	Clumps, uneven, rough in foreground, fine in middle ground.	Smooth.

LANDSCAPE NARRATIVE

The Le Clair site (el 5,280 ft) is approximately 18 mi from Riverton via River Road. The Wind River and Le Clair Canal are only 0.3 mi away. The foreground and middle ground objects do not substantially block viewing. A private landing field shows on the land cover map less than 0.5 mi southeast of the site.

The vegetation includes prickleypear cactus, rubber rabbitbrush or sand sage, and larger specimens of sagebrush in the draws. Cow pies and snake skins are in evidence. The variety of Adjacent Scenery, (including cottonwoods, irrigated fields, sandstone formations, and a historic gravel tip), give a scenic rating of 5.

The site is in view from the dirt road for 3 sec and is in plain view of the homes opposite. Local traffic was noted.

SCENIC QUALITY RATING				
	SCORE			
LANDFORM	5	3	1	1
VEGETATION	5	3	1	2
WATER	5	3	0	0
COLOR	5	3	1	2
ADJACENT SCENERY	5	3	0	5
SCARCITY	5	3	1	2
CULTURAL MODIFICATIONS	2	0	-4	1
TOTAL SCORE	= 13			
SCENIC QUALITY CLASSIFICATION	**B**			

Left, View north of gravel tip and rocky outcrops east of the Le Clair site. *Upper,* Possibly a paccoon or stoneseed, *Lithospermum spp. Below,* Field work being conducted on exposed sand and gravel terrace on site, view east.

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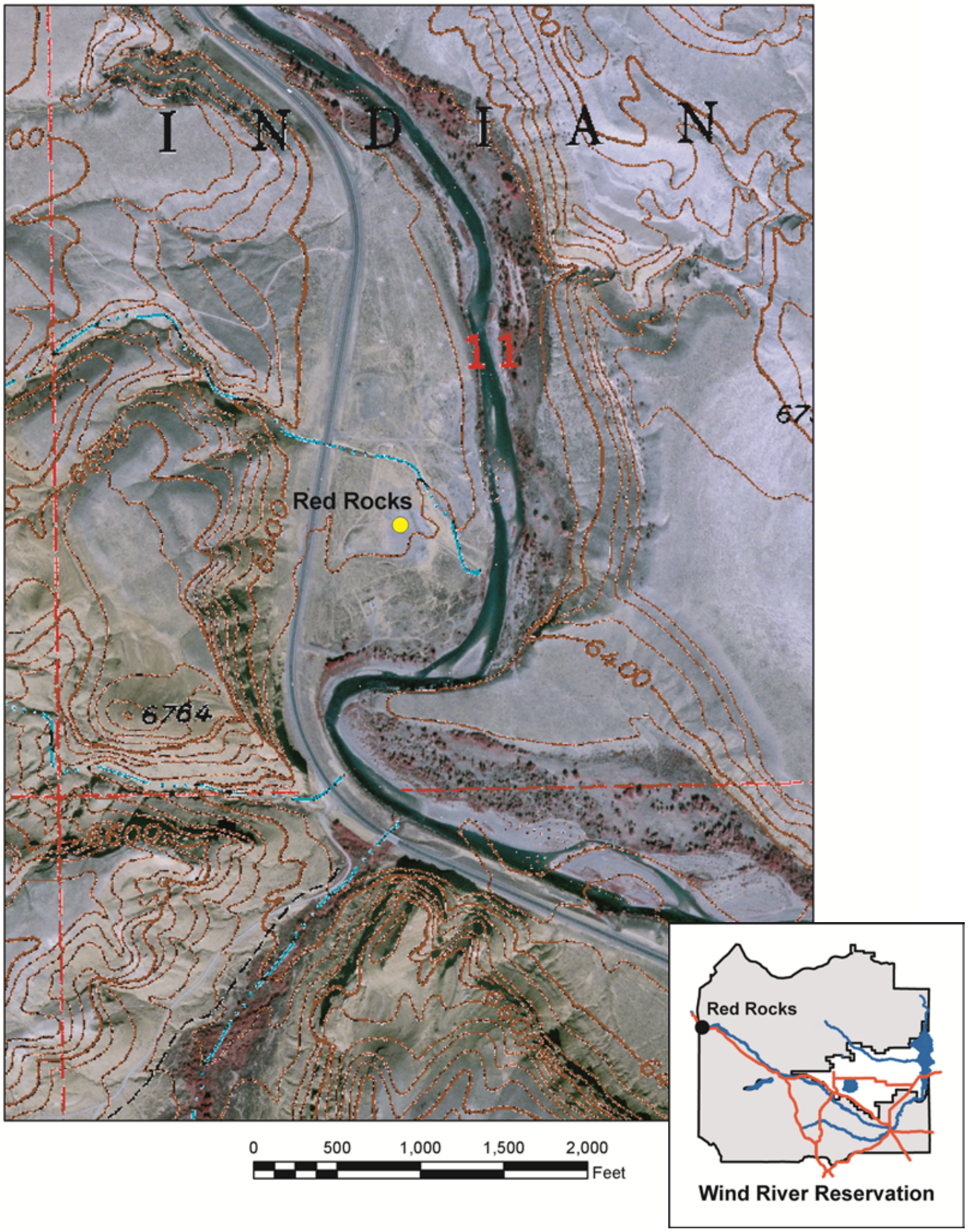
Site Name: Red Rocks

Location: NE¼, SW¼, S11, T5N, R6W, Wind River Meridian
USGS Topographic Sheet: Blue Holes
Date: 24 April 2005



GEOLOGIC OBSERVATIONS					
Investigator	USGS	HMK Engineering*			General site characteristics
Sample number:	#1	Red Rocks # 2, 3	Red Rocks # 5, 6	Red Rocks Average 7 samples	
Location	43º 25' 20.7" 109º 26' 28.5"	-	-	-	-
Terrace level Qt	2	-	-	-	2
Gravel thickness (feet)	20	>7	>6	-	20
Overburden thickness (feet)	1	1.3 – 1.4	2.9 – 7.1	-	1
Water table	Near river level	-	-	-	
Caliche thickness (feet)	2	-	-	-	2
Maximum carbonate stage:	II	-	-	-	II
Maximum clast weathering:	3	-	-	-	3
Lithologies (pct)					
Granite-gneiss	23	-	-	-	23
Mafic plutonic-metamorphic	3	-	-	-	3
Quartzite	6	-	-	-	6
Vein quartz	-	-	-	-	-
Sandstone	25	-	-	-	25
Limestone	13	-	-	-	13
Chert	-	-	-	-	-
Volcanics	30	-	-	-	30
Total	100	-	-	-	100

* Eastern Shoshone Oil & Gas Commission, 2005

ENGINEERING TESTS					
Investigator	USGS	HMK Engineering*			General site characteristics
Sample number	#1	Red Rocks # 2, 3	Red Rocks # 5, 6	Red Rocks Average 7 samples	
Grain Size Analysis:					
Maximum clast size (inches)	62	-	-	-	62
Size distribution (percent)					
Cobbles	-	-	-	30	30
Coarse Gravel	-	-	-	25	25
Fine Gravel	-	-	-	14	14
Sand	-	-	-	27	27
Fines	-	-	-	4	4
Total	-	-	-	100	100
LA Value	-	27.2	26.8	-	27
Soundness					
≤1.5” - >0.75”	-	1.5	1.2	-	1.35
≤0.75” - >0.375”	-	3.9	2.6	-	3.25
≤0.375 - > #4 sieve	-	-	-	-	-
Specific gravity	-	2.605	2.591	-	2.598
Percent absorption	-	1.24	1.12	-	1.18

* Eastern Shoshone Oil & Gas Commission, 2005

PRODUCTION CONSTANT	
Estimated gravel thickness (feet)	20
Constant - Maximum recoverable product	45,980
Constant - Minimum recoverable product	25,817

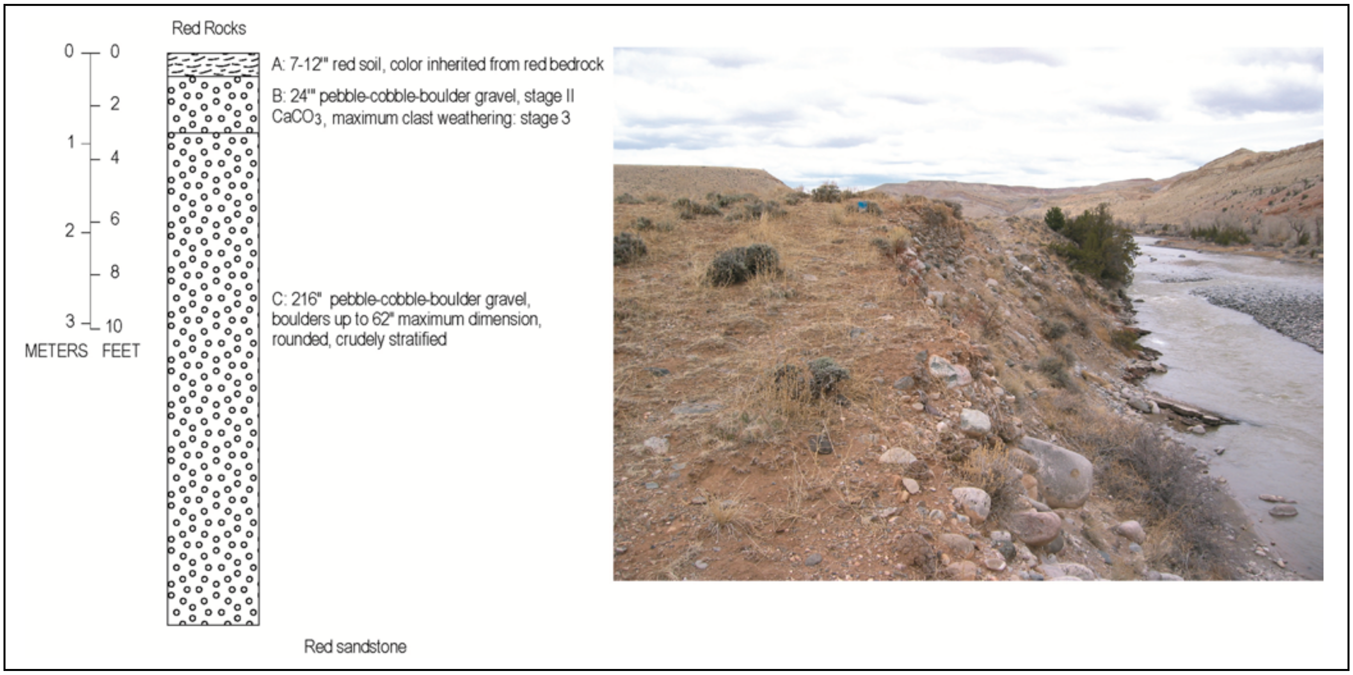
CONCLUSIONS

Portland cement concrete – May be suitable. Will require crushing and screening and may require washing. Determine susceptibility to alkali-silica reaction. May require use of low-alkali cement or additives.

Asphalt concrete – Suitable. Will require crushing and screening.

Base – Suitable. Will require crushing and screening.

Difficult Mining – The large boulders will be difficult to handle with conventional equipment and may complicate mining. However, it might be possible to set aside the boulders and sell them as landscaping rock or rip-rap. Smaller cobbles may have to be removed with a grizzly screen.


Red Rocks
0 0
2
1 4
2 6
8
3 10
METERS FEET
A: 7-12" red soil, color inherited from red bedrock
B: 24'" pebble-cobble-boulder gravel, stage II $CaCO_3$, maximum clast weathering: stage 3
C: 216" pebble-cobble-boulder gravel, boulders up to 62" maximum dimension, rounded, crudely stratified
Red sandstone

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SCENIC QUALITY FIELD INVENTORY AND EVALUATION CHART			
LANDSCAPE TYPE			
Enclosed—Landscape elements form "wall" and "floor."			
LANDSCAPE ANALYSIS FACTORS			
Contrast due to red rocks and yellow earth; soil and large boulders; evergreens and grasses. Enframement created by slopes on either side. Intimate scale makes objects within area appear larger.			
LANDSCAPE CHARACTER			
	LANDFORM/WATER	VEGETATION	STRUCTURE
FORM	Gently sloping surfaces above relatively narrow flood plain; interesting drainage areas closely spaced. Slopes take on visual importance.	Few rounded sage and some grasses. Picturesque junipers concentrated along water. Rubber rabbit brush in hollows.	Rectangular (mobile home).
LINE	Strong horizontal banding of rocks; linear and directional movement of water.	Interrupted line parallel to river.	None.
COLOR	Bold red-orange in the exposed sandstone, gray river rock, yellow.	Dark green, tan, grey.	White, light blue.
TEXTURE	Coarse stone along river, fine middle ground.	Medium, sparse density in trees and shrubs; fine, medium density in forbs and grasses.	Fine, reflective.
LANDSCAPE NARRATIVE			
The Red Rocks site is located in a narrow valley floor (approximately 0.3 miles wide) and is adjacent to the Wind River and U.S. Highway 26/ 287. Lander is approximately 60 mi southeast. Two Wildlife Habitat Management Areas and the Shoshone National Forest are within 5 mi. Elevation differences within the foreground range from approximately 6,380 to 6,600 ft. Views from the area are obstructed by the surrounding topography. The sky appears reduced to a smaller area overhead. The landforms give the area an appearance of a small space. Due to the sense of enclosure, the landscape within the river valley is vulnerable to modification. The lines in the area are strongly horizontal in nature. They are formed by the shape of the terraces, striations in the sedimentary rock, and the strong contrast in color. Erosional processes are evident with naturally occurring areas of bare rock and soil. An abandoned pit is discernable. Rounded river rock is evident. The existing vegetation cover is dominated by grasses, while sparse in some areas, and includes: cottonwood-willow riparian habitat (streamside), conifer, and sagebrush. Western riparian ecosystems are considered essential habitat for many vertebrate species. The dominant color for much of the year is tan; green during the summer. The texture of the vegetation appears fine in the immediate foreground and medium in the middle distance. The site is in view by highway users approximately 10 seconds heading north. Heading south, the site is visible for 32 seconds. Approximately 10 more seconds would be hidden by summer foliage of deciduous trees.			

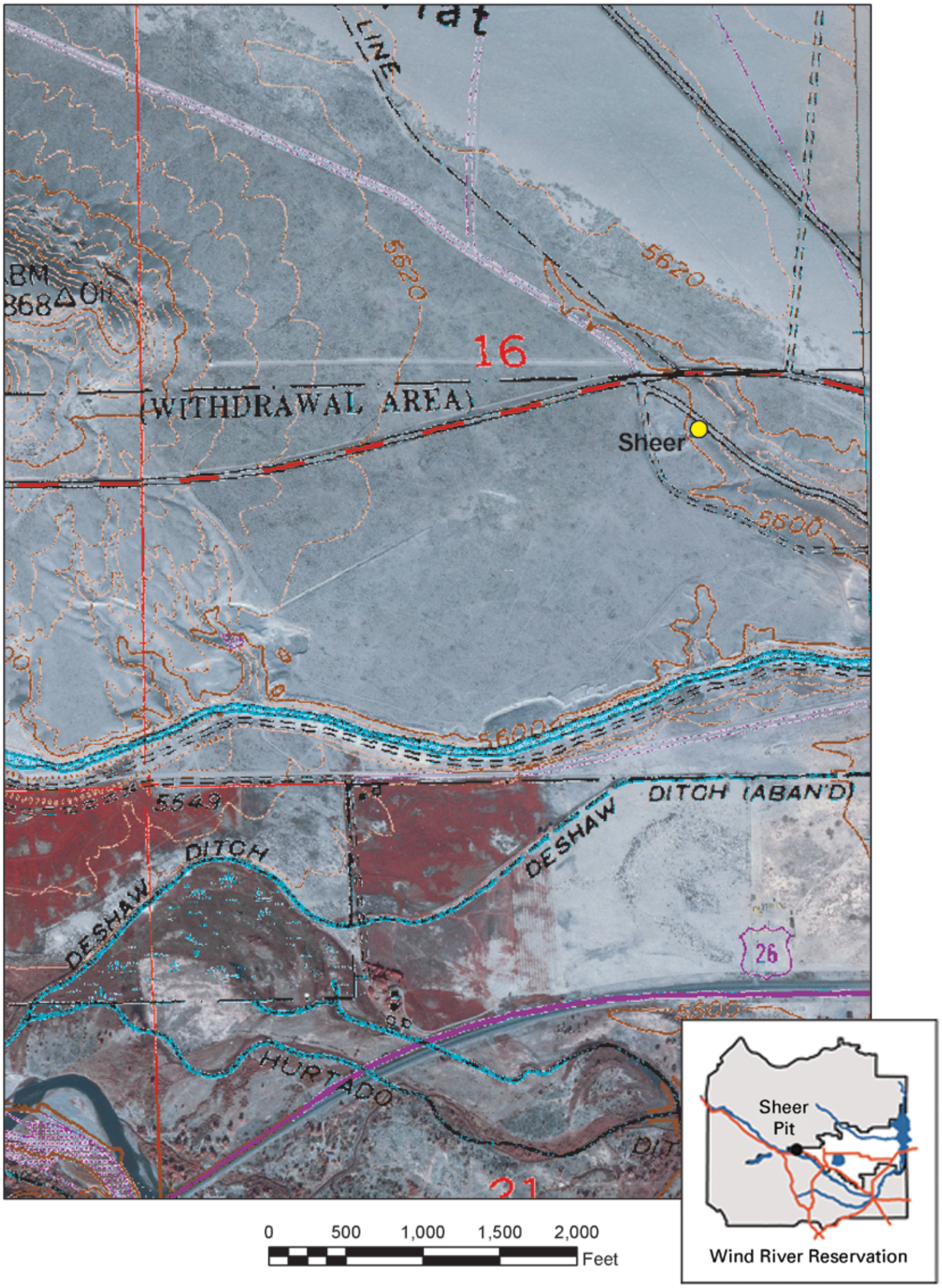
SCENIC QUALITY RATING				
	SCORE			
LANDFORM	5	3	1	5
VEGETATION	5	3	1	5
WATER	5	3	0	5
COLOR	5	3	1	5
ADJACENT SCENERY	5	3	0	0
SCARCITY	5	3	0	5
CULTURAL MODIFICATIONS	2	0	-4	-2
TOTAL SCORE	= 23			
SCENIC QUALITY CLASSIFICATION	A			

The two photographs above were taken from approximately the same location but at different times of the year. They illustrate how much greener the habitat is in August than April. The deciduous vegetation along U.S. Hwy 26/287 camouflages the site from vehicular observers more in the summer than the rest of the year. (Both photographs courtesy of Floyd Phillips.)

Upper left, View of the Wind River looking northeast from the Red Rocks site. Conifers (including pines and junipers) are scattered across the area in small groups. *Upper right,* Last season's dried seed heads are of broom snakeweed (*Gutierrezia sarothrae*). It is a native perennial found in plant communities of wheatgrass, sagebrush, and short grasses. *Below,* Exposed red sandstone bluffs, cottonwood species, and surrounding terraces are visible to the southeast. Gravel bar is visible in the Wind River.

Site Name: Sheer Pit

Location: NW ¼, SE ¼, S16, T3N, R1W, Wind River Meridian
USGS Topographic Sheet: Argo Butte
Date: 22 April 2005



GEOLOGIC DESCRIPTION	
Sample number	#1
Location	43° 14' 03.5" 108° 52' 44.6"
Terrace level Qt	5
Gravel thickness (feet)	10
Overburden thickness (feet)	1
Water table	None observed
Caliche thickness (feet)	1
Maximum carbonate stage	III
Maximum clast weathering	4
Lithologies (pct)	
Granite-gneiss	32
Mafic plutonic-metamorphic	6
Quartzite	26
Vein quartz	-
Sandstone	13
Limestone	1
Chert	Trace
Volcanics	22
Total	100

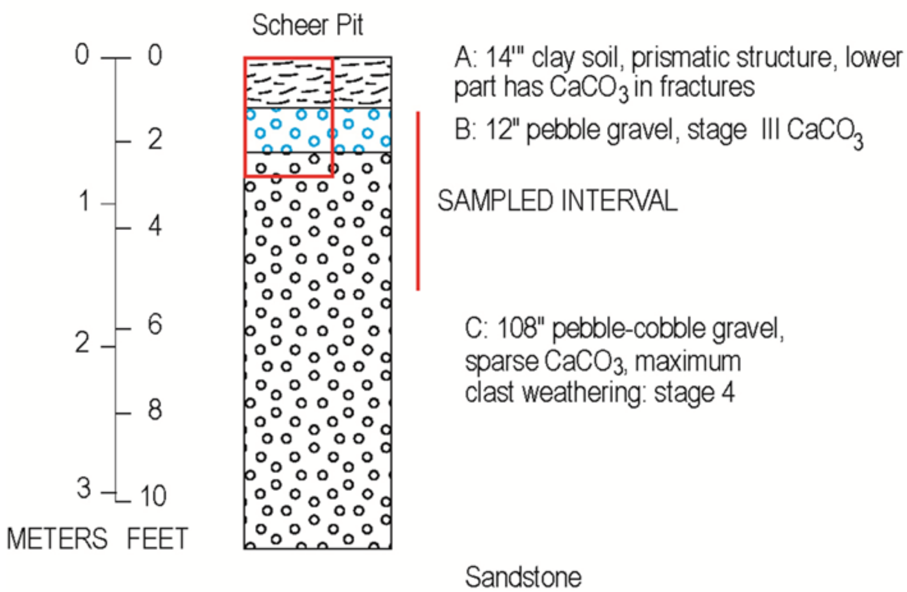
ENGINEERING TESTS	
Sample number	#1
Maximum clast size (inches)	8
Size distribution (percent)	
Cobbles	12
Coarse Gravel	49
Fine Gravel	18
Sand	18.9
Fines	2.1
Total	100
LA Value	26.4
Soundness (pct)	
≤1.5" - >0.75"	0.4
≤0.75" - >0.375"	0.3
≤0.375 - > #4 sieve	0.4
Specific gravity	2.572
Percent absorption	1.3

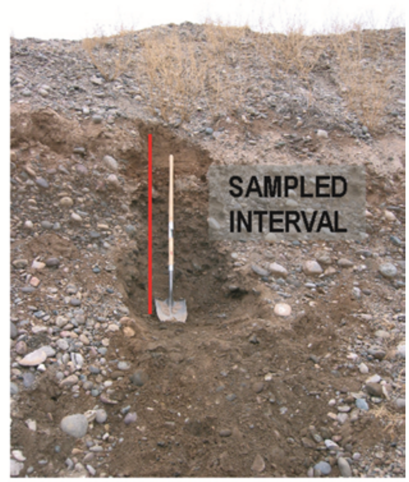
PRODUCTION CONSTANT	
Estimated gravel thickness (feet)	10
Constant - Maximum recoverable product (tons per acre)	22,990
Constant - Minimum recoverable product (tons per acre)	16,228

CONCLUSIONS

Portland cement concrete – May be suitable. Will require crushing and screening and may require washing. Determine susceptibility to alkali-silica reaction. May require use of low-alkali cement or additives.
Asphalt concrete – Suitable. Will require crushing and screening.
Base – Suitable. Will require crushing and screening.
Difficult mining – Large cobbles may require removal with a grizzly screen.

Red box in column shows location of photograph





SCENIC QUALITY FIELD INVENTORY AND EVALUATION CHART			
LANDSCAPE TYPE			
Panoramic			
LANDSCAPE ANALYSIS FACTORS			
Scale of the landscape is expansive.			
LANDSCAPE CHARACTER			
	LANDFORM/WATER	VEGETATION	STRUCTURE
FORM	Simple, strong, flattened.	Rounded.	Vertical, narrow.
LINE	Horizontal.	None directional.	Angular, vertical (poles), fence.
COLOR	Grey, tan.	Grey, green, light yellow.	Khaki.
TEXTURE	Medium in foreground, fine in back ground.	Discontinuous.	Striated.
LANDSCAPE NARRATIVE			

The Sheer site (el 5,600 ft) is located approximately 1.5 mi north of Argo Butte (el 5,970 ft) and the Wind River. It is adjacent to Mexican Flat. A secondary highway connects the site with U.S. Hwy 26. The Sheer site is approximately 56 mi east of Dubois, 54 mi west of Riverton, and 58 mi north of Lander. Low cloud cover covered distant views. A sandstone formation and mountains could be discerned to the west. Foreground and sky occupy much of the landscape.

Vegetation is sparse, consisting of small sage and grasses, some tumbleweed. The soil appears sandy.

The site appears isolated except for cultural modifications. The Wyoming Canal and Deshaw Ditch are less than 2,000 ft to the south. There is the intermittent smell of sulfur. Fencing, power lines, pipeline (orange), and oil jacks are visible in the middleground. The Steamboat Butte Oil Field is less than 1 mile northwest of the site. The site is well hidden from vehicular traffic except for 3 seconds.

SCENIC QUALITY RATING				
	SCORE			
LANDFORM	5	3	1	1
VEGETATION	5	3	1	2
WATER	5	3	0	0
COLOR	5	3	1	1
ADJACENT SCENERY	5	3	0	1
SCARCITY	5	3	1	1
CULTURAL MODIFICATIONS	2	0	-4	-2
TOTAL SCORE	= 4			
SCENIC QUALITY CLASSIFICATION	**C**			

Upper, Photograph of Sheer pit site in February, 2002. Photograph courtesy of Floyd Phillips. The pit forms a convex landform. The scene is not markedly different in 2005. *Left,* Typical vegetation is sparse and uneven.

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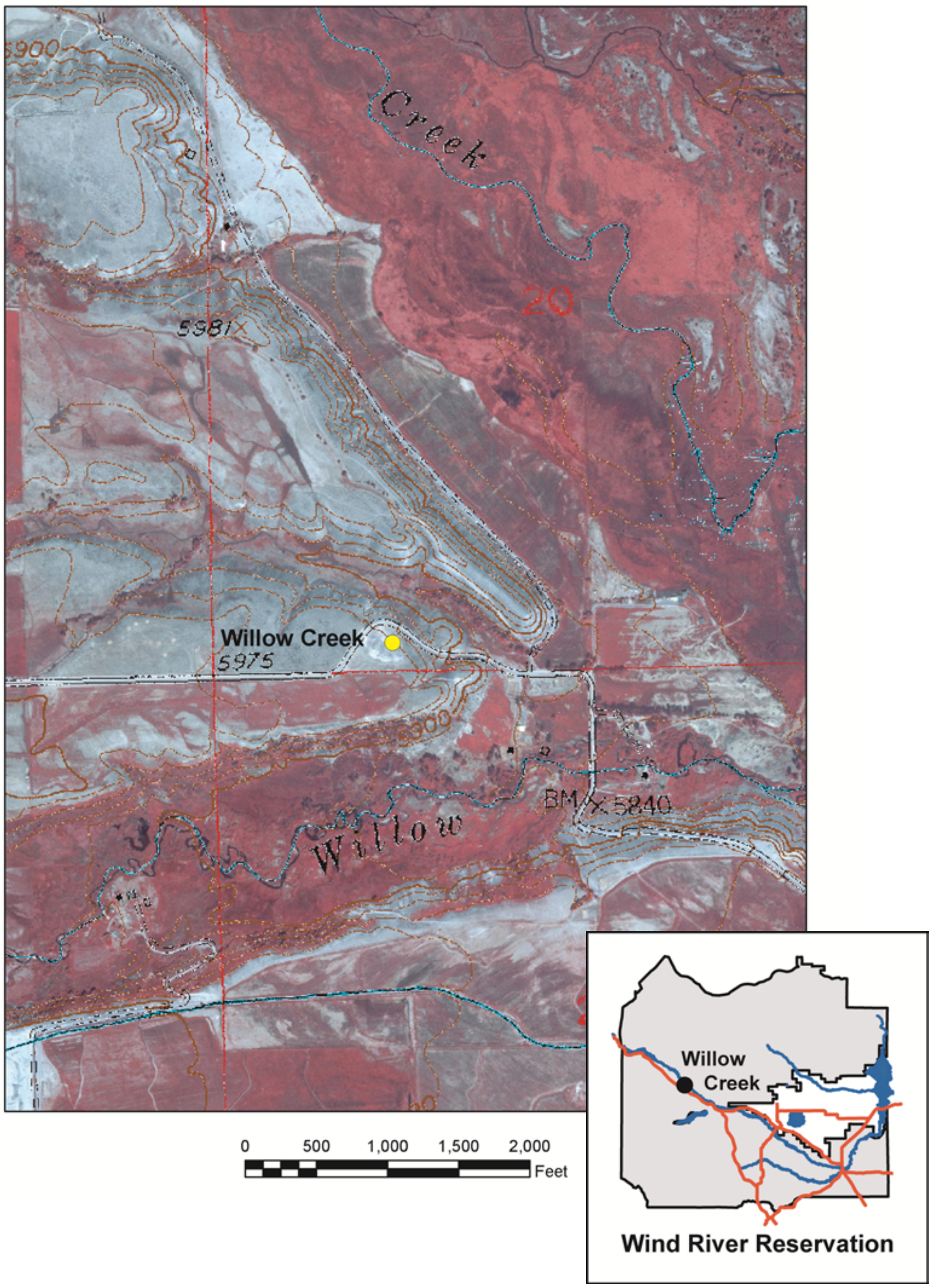
Site Name: Willow Creek

Location: SW ¼, SW ¼, S20, T4N, R3W, Wind River Meridian
USGS Topographic Sheet: Crowheart
Date: 21 April 2005



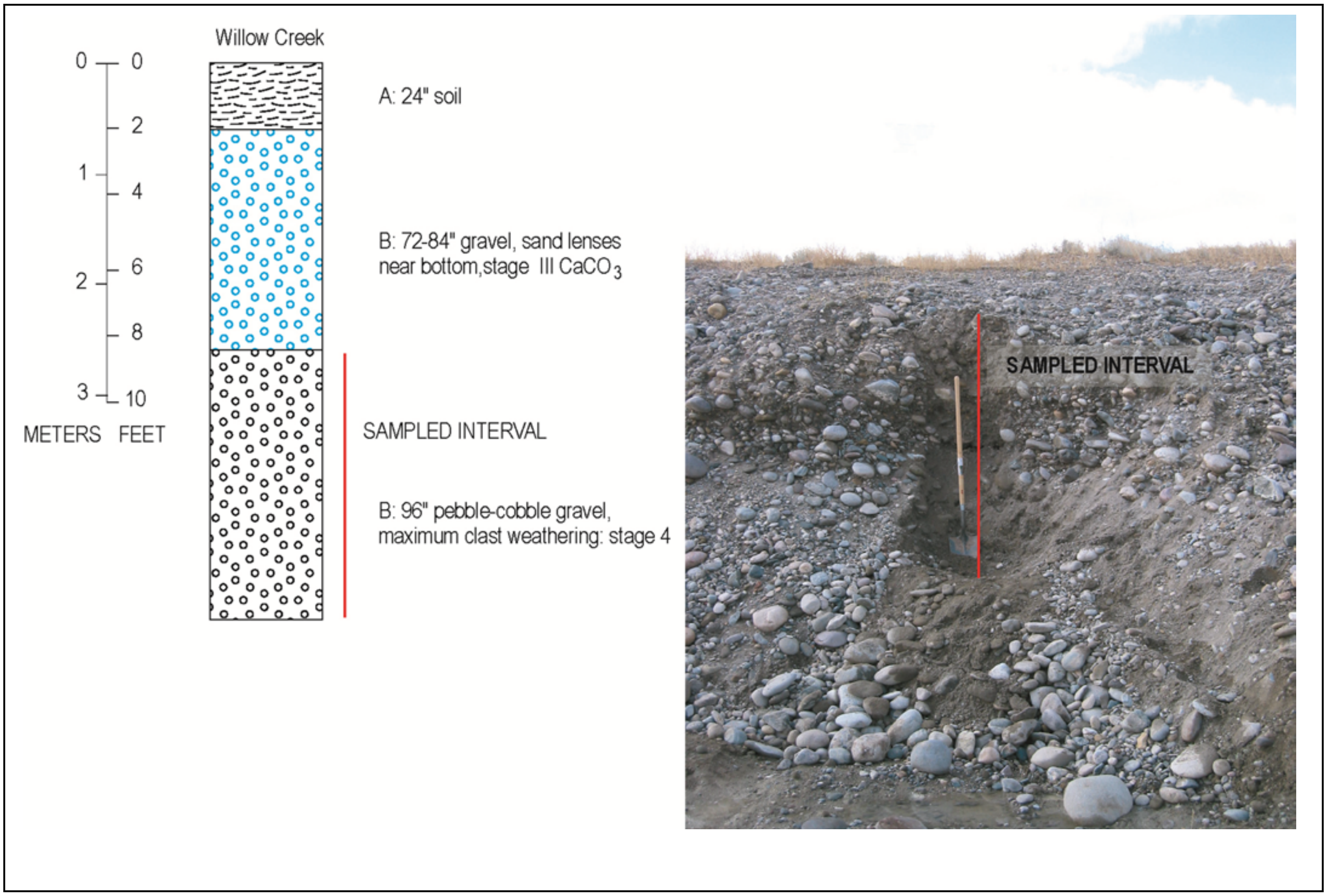
GEOLOGIC DESCRIPTION	
Sample number	#1
Location	43° 18' 06.7" 109° 08' 42.7"
Terrace level Qt	5
Gravel thickness (feet)	15
Overburden thickness (feet)	2
Water table	None observed
Caliche thickness (feet)	6-7
Maximum carbonate stage	III
Maximum clast weathering	4
Lithologies (pct)	
Granite-gneiss	18
Mafic plutonic-metamorphic	9
Quartzite	26
Vein quartz	-
Sandstone	33
Limestone	1
Chert	-
Volcanics	13
Total	100

ENGINEERING TESTS	
Sample number	#1
Maximum clast size (inches)	14
Size distribution (percent)	
Cobbles	39
Coarse Gravel	39
Fine Gravel	12
Sand	9
Fines	1
Total	100
LA Value	26.8
Soundness (pct)	
≤1.5” - >0.75”	1.4
≤0.75” - >0.375”	1.1
≤0.375 - > #4 sieve	0.4
Specific gravity	2.559
Percent absorption	2.1

PRODUCTION CONSTANT	
Estimated gravel thickness (feet)	15
Constant - Maximum recoverable product (tons per acre)	34,485
Constant - Minimum recoverable product (tons per acre)	16,873

CONCLUSIONS

Portland cement concrete – May be suitable. Will require crushing and screening and may require washing. Determine susceptibility to alkali-silica reaction. May require use of low-alkali cement or additives.
Asphalt concrete – Suitable. Will require crushing and screening.
Base – Suitable. Will require crushing and screening.
Deleterious Material – Large amount of calcium carbonate (caliche) coating. Crushing will reduce extent of coating.
Difficult mining – Large boulders and large amount of cobbles may complicate mining. Oversized material may have to be removed with a grizzly screen.


Willow Creek
0
0
2
1
4
6
2
8
3
10
METERS FEET
A: 24" soil
B: 72-84" gravel, sand lenses near bottom,stage III $CaCO_3$
SAMPLED INTERVAL
B: 96" pebble-cobble gravel, maximum clast weathering: stage 4
SAMPLED INTERVAL

SCENIC QUALITY FIELD INVENTORY AND EVALUATION CHART			
LANDSCAPE TYPE			
Focal—The eye is led to a drainage area that connects with the Wind River.			
LANDSCAPE ANALYSIS FACTORS			
Contrast in vegetation and landform; repetition of form and line sequence; human scale.			
LANDSCAPE CHARACTER			
	LANDFORM/WATER	VEGETATION	STRUCTURE
FORM	Diverse, pyramidal, solid.	Rounded, fastigiate, columnar.	Rectangular, narrow, vertical.
LINE	Bold, curving, convex, horizontal. .	Organic.	Continuous, curvilinear road.
COLOR	Tan, brown, verdi green.	Golden yellow, sage green, cream.	Brown, white, grey.
TEXTURE	Rough, scattered.	Random, dotted, medium foreground; fine middle ground.	Rough, smooth.

LANDSCAPE NARRATIVE

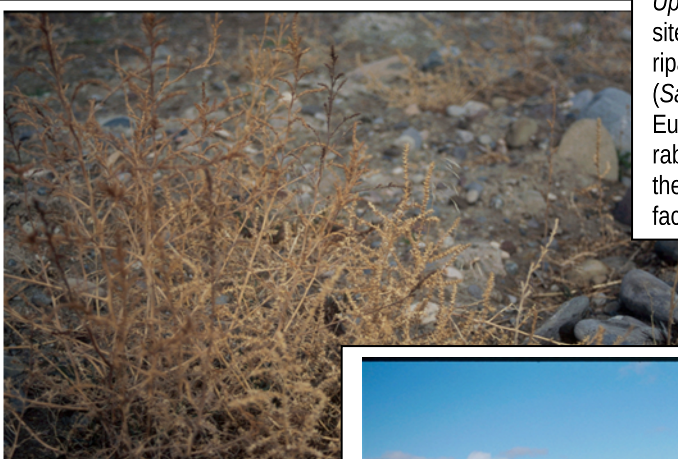
Willow Creek (el 5,975 ft) is approximately 2.3 mi from U.S. Hwy 26/287. It is accessed via a light duty road to the southeast or via the Old Yellowstone Highway to the west. Lander is approximately 44 mi south of Willow Creek. The site is on a south facing terrace and is not visible from the highway.

Views of the Wind River, creeks, draws, and Crowheart Butte tend to converge. The scenic rating of 4 was given to Adjacent Scenery because of the high scenic value of the surrounding valley, terraces, and butte that can be seen from the site. There are views around the entire site. Snow capped mountains are also in view to the west.

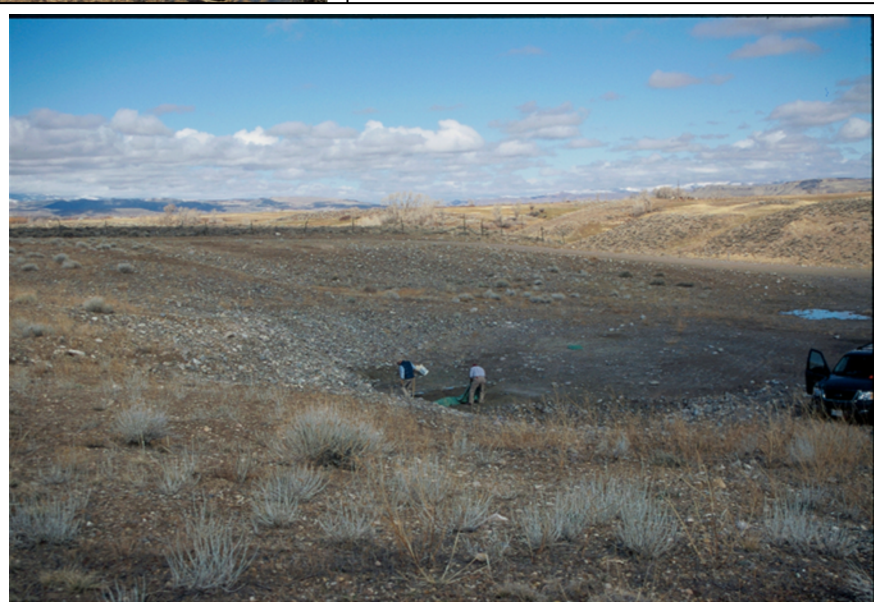
There is great contrast and visual variety in landform and vegetation. Sagebrush and mixed-grass occupy most of the area. Riparian habitat and drainage areas include willows and cottonwoods. Clovers (*Fabaceae*) are an important cultivated forage legume and have naturalized, along with tumbleweed, at the site. Five sandhill cranes, seven deer, and one ringneck pheasant were observed.

Power lines are above the pit face.

SCENIC QUALITY RATING				
	SCORE			
LANDFORM	5	3	1	3
VEGETATION	5	3	1	5
WATER	5	3	0	0
COLOR	5	3	1	3
ADJACENT SCENERY	5	3	0	4
SCARCITY	5	3	1	4
CULTURAL MODIFICATIONS	2	0	-4	2
TOTAL SCORE	= 21			
SCENIC QUALITY CLASSIFICATION	**A**			



Upper, Panoramic view northeast from the Willow Creek site. Crowheart Butte and the drainage areas, supporting riparian habitat, are the visual focus. *Left,* Tumbleweed (*Salsola kali*) is an introduced noxious weed from Eurasia. *Lower,* Western view from above pit. Rubber rabbitbrush or sand sagebrush has established around the pit perimeter. Sample collection at the exposed pit face is underway by USGS staff.



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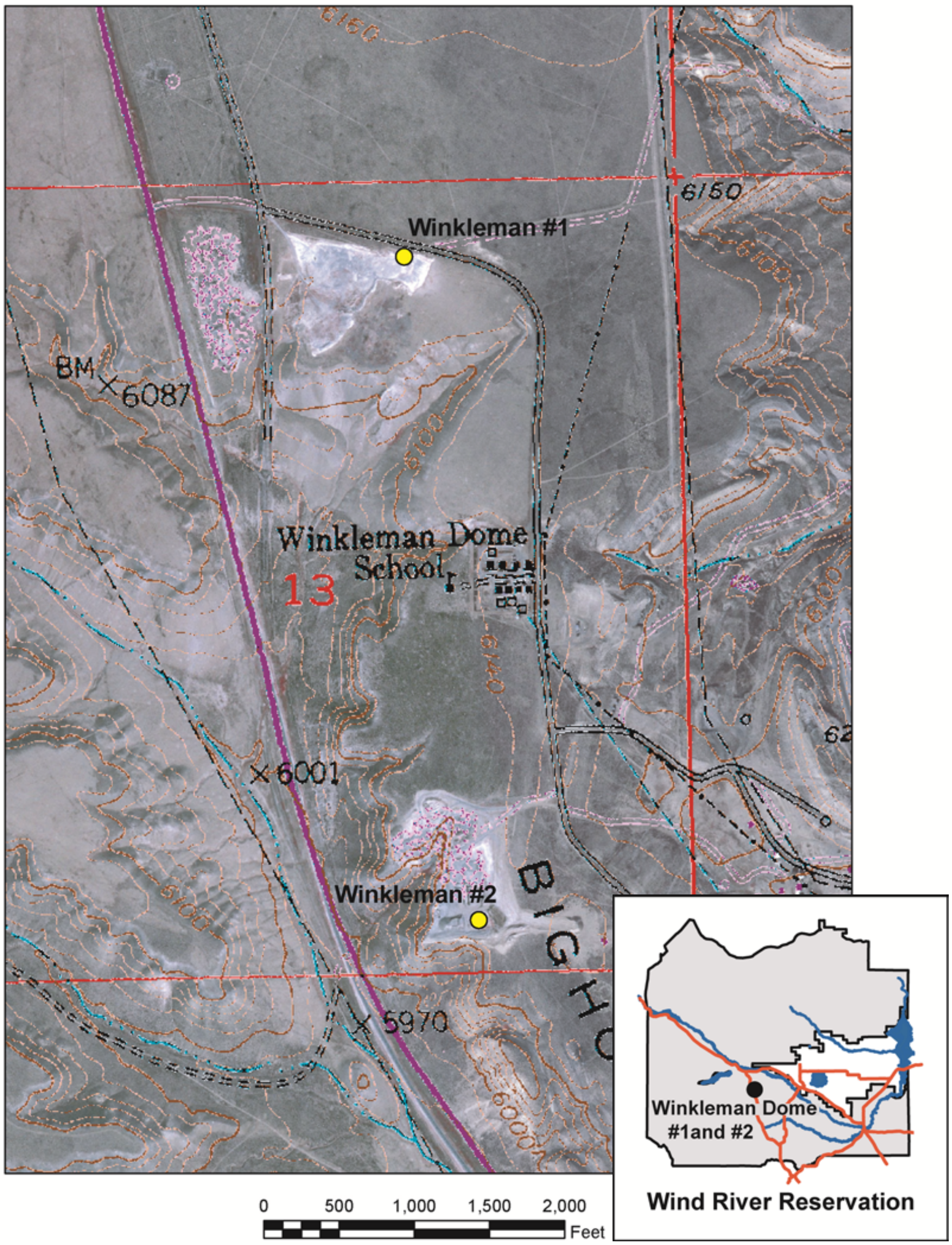
Winkleman Dome #1 and #2

Section 13, T2N, R2W, Wind River Meridian
USGS Topographic Sheet: Argo Butte
Date: 21 April 2005



GEOLOGIC OBSERVATIONS					
Investigator	USGS			WRMT*	General site characteristics
Sample number	Winkleman Dome #1 Sample #1	Winkleman Dome #2 Sample #1	Winkleman Dome #2 Stockpile Sample	Average 6 samples	
Location	43° 09' 16.2" 108° 56' 19.1"	43° 08' 32.6" 108° 56' 13.9"	-	-	-
Terrace level Qt	11	11	-	-	11
Gravel thickness (feet)	9	9	-	-	9
Overburden thickness (feet)	1	1	-	-	1
Caliche thickness (feet)	7	5	-	-	6
Maximum carbonate stage	III	III	-	-	III
Maximum clast weathering	4	4	-	-	4
Lithologies (pct)					
Granite-gneiss	18	18	-	-	18
Mafic plutonic-metamorphic	8	5	-	-	6.5
Quartzite	20	8	-	-	14
Vein quartz	1	2	-	-	1.5
Sandstone	2	4	-	-	3
Limestone	-	-	-	-	-
Chert	Trace	1	-	-	0.5
Volcanics	51	62	-	-	56.5
Total	100	100	-	-	100

* Wind River Materials Testing, 2004

ENGINEERING TESTS					
Investigator	USGS			WRMT*[1]	General Site Characteristics Excluding Stockpile
Sample number	Winkleman Dome #1 Sample #1	Winkleman Dome #2 Sample #1	Winkleman Dome #2 Stockpile Sample	Average 6 samples	
Grain Size Analysis					
Maximum clast size (inches)	10	Cobble	-	-	10
Size distribution (percent)					
Cobbles	27	6	0	25.9	22.8
Coarse Gravel	39	43	15	31.6	34.0
Fine Gravel	16	19	41	14.4	15.2
Sand	17	30.4	35.4	25.5	25.0
Fines	1.0	1.6	8.6	2.7	2.4
Total	100	100	100	100.1*[2]	99.4*[2]
LA Value	23.6	24.8	28.2	-	24.2
Soundness					
≤1.5” - >0.75”	0.4	0.2		-	0.3
≤0.75” - >0.375”	0.4	0.6	0.9	-	0.5
≤0.375 - > #4 sieve	0.5	0.5	0.7	-	0.5
Specific gravity	2.553	2.525	2.540	-	2.539
Percent absorption	1.7	1.9	1.7	-	1.8

*[1] Wind River Materials Testing, 2004

*[2] Numbers do not add to 100 due to rounding

PRODUCTION CONSTANT	
Estimated gravel thickness (feet)	9
Constant - Maximum recoverable product	20,691
Constant - Minimum recoverable product	12,812

CONCLUSIONS

Portland cement concrete – May be suitable. Will require crushing and screening and may require washing. Large amount of volcanics indicate likelihood for alkali-silica reaction. Determine susceptibility to alkali-silica reaction. May require use of low-alkali cement or additives.

Asphalt concrete – Suitable. Will require crushing and screening.

Base – Suitable. Will require crushing and screening.

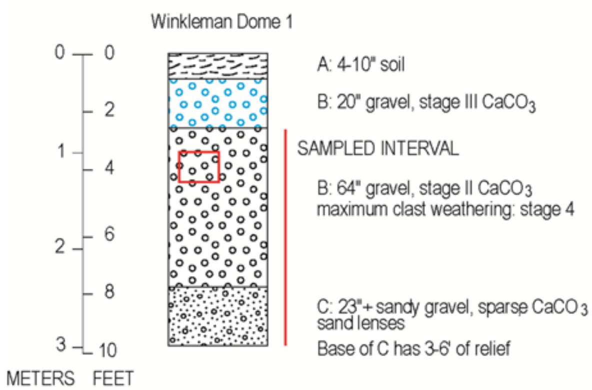
Specific gravity – May be marginally acceptable.

Deleterious Material – Large amount of calcium carbonate (caliche) coating. Crushing will reduce extent of coating.

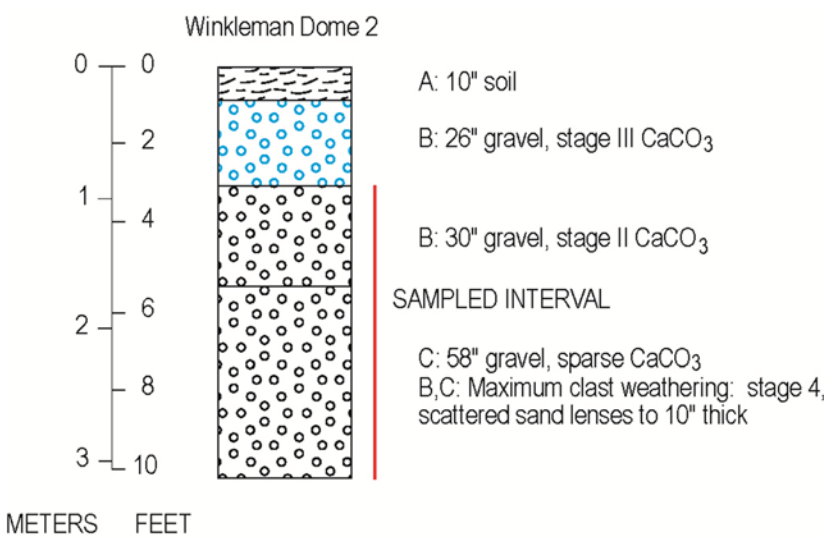
Difficult mining – Large boulders and large amount of cobbles may complicate mining. Oversized material may have to be removed with a grizzly screen.

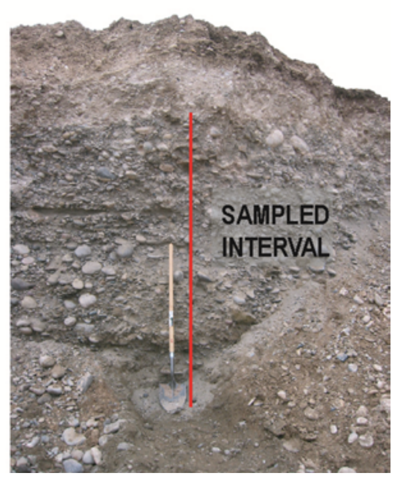
Winkleman Dome #1

Red box in column shows location of photo.



Winkleman Dome #2





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Winkleman Dome #1

SCENIC QUALITY FIELD INVENTORY AND EVALUATION CHART			
LANDSCAPE TYPE			
Panoramic			
LANDSCAPE ANALYSIS FACTORS			
Scale—Mountains fill the background, the foreground and middle ground appear unified.			
LANDSCAPE CHARACTER			
	LANDFORM/WATER	VEGETATION	STRUCTURE
FORM	Relatively flat foreground, concave middle ground.	Simple, low (limited to grasses and tiny cushion forbs.	Rectangular (single residence).
LINE	Bold, angular, diagonal.	Soft, continuous.	Vertical (telephone poles).
COLOR	White (seasonal), shades of grey.	Tan and light green, monotone.	White.
TEXTURE	Medium in foreground.	Uniform and smooth throughout.	Discontinuous.

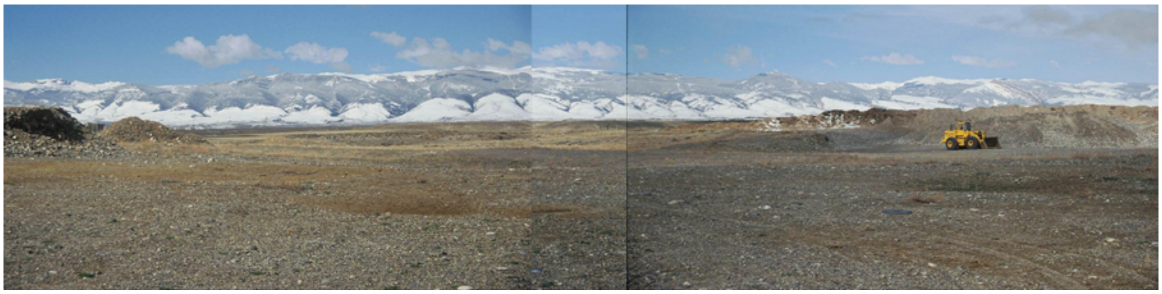
LANDSCAPE NARRATIVE

The Winkleman Dome #1 site (el 6,160 ft) is located south of Bighorn Flat, approximately 0.4 mi from U.S. Hwy 287. Lander is approximately 26 mi south. Access and linear views are along a dirt road, frequented mainly by trucks. Oil and gas development, Winkleman Dome oil field, is less than 1 mile away to the south. Spoils are visible around the entire active sand and gravel pit. There is little visual variety in the landscape.

The scenic rating of 4 was given to Adjacent Scenery because of the high scenic value of the surrounding Wind River Mountains that can be seen from the site. There are uninterrupted views around the entire site.

Most of the foreground and middle ground views are of uniformly colored and textured mixed grass; there is little contrast or variety.

SCENIC QUALITY RATING				
				SCORE
LANDFORM	5	3	1	1
VEGETATION	5	3	1	1
WATER	5	3	0	0
COLOR	5	3	1	1
ADJACENT SCENERY	5	3	0	4
SCARCITY	5	3	1	2
CULTURAL MODIFICATIONS	2	0	-4	-2
TOTAL SCORE				= 8
SCENIC QUALITY CLASSIFICATION	C			



Upper, the Winkleman Dome #1 site has little sense of boundary except for the Wind River Mountains to the west. The photograph was taken with a 50 mm lens in order to represent the cone of vision and depth of field an observer would experience on site. The photographs were joined together in Adobe Photoshop. *Lower,* Typical mixed grass vegetation and terrace slopes in the area.

Winkleman Dome #2

SCENIC QUALITY FIELD INVENTORY AND EVALUATION CHART			
LANDSCAPE TYPE			
Panoramic			
LANDSCAPE ANALYSIS FACTORS			
High contrast between landform and vegetative patterns. Line sequence of telephone poles.			
LANDSCAPE CHARACTER			
	LANDFORM/WATER	VEGETATION	STRUCTURE
FORM	Flat top terraces; ovals (exposed sedimentary rocks along terrace face).	Spreading, rounded.	Vertical, rectangular.
LINE	Flowing and interrupted horizontal.	Undulating.	Simple, regular.
COLOR	Light orange, tan, white (seasonal).	Grey, green.	Black, brown, beige, white.
TEXTURE	Small patches, striated.	Medium, stippled, fairly even.	Rough.

LANDSCAPE NARRATIVE

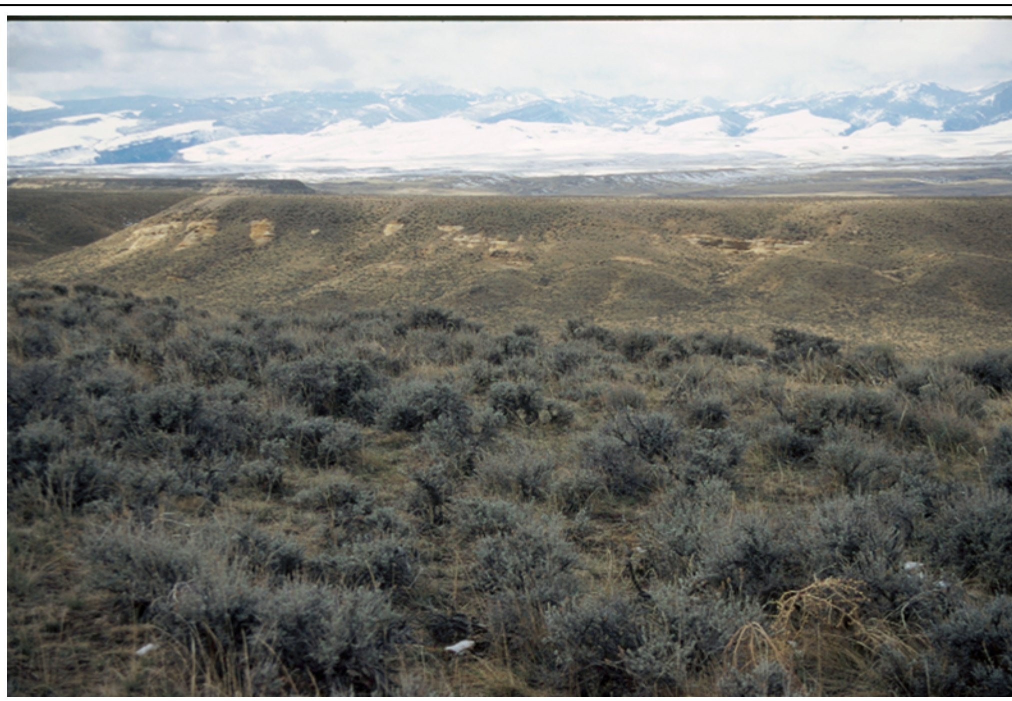
The Winkleman Dome 2 site (el 6,120 ft) is located along Bighorn Ridge, approximately 3 mi away from U.S. Hwy 28, and 32 mi from Lander to the south. The Shoshone Tribal processing plant is located at this site. Access and linear views are along a dirt road to the east, frequented mainly by trucks. Winkleman Dome oil field is less than 0.3 mi to the east. Oil derricks and the smell of sulfur are noticeable and considered detrimental cultural modifications. Telephone poles are visible along the southwest skyline. An aqueduct (water source) is within 0.2 mi to the east.

Winkleman Dome 2 is visible for 360° but there are few anticipated observers from the unimproved road. There is a definite foreground, middle ground (two terraces with some exposed sandstone providing contrast) and back ground (mountains). The Owl Creek Mountains are to the northeast and the Wind River Mountains are to the southwest. Low cloud cover may have minimized the drama of the background views.

The vegetation is dominated by Wyoming big sagebrush. The texture of the vegetation appears coarse in the foreground and medium in the middle ground. There is contrast in color between the rock and vegetation in the middle ground.

SCENIC QUALITY RATING				
				SCORE
LANDFORM	5	3	1	3
VEGETATION	5	3	1	2
WATER	5	3	0	0
COLOR	5	3	1	3
ADJACENT SCENERY	5	3	0	4
SCARCITY	5	3	1	3
CULTURAL MODIFICATIONS	2	0	-4	-4
TOTAL SCORE	= 11			
SCENIC QUALITY CLASSIFICATION	C			

Upper, The Winkleman Dome 2 site includes a Shoshone Tribal processing plant. Stock piles and equipment are evident in this northeast view. *Lower,* The view southwest is of the typical Wyoming big sagebrush land cover. Photograph was taken from above the pit on the terrace tread. The Wind River Mountains are in the background.



View east. The Winkleman Dome 2 site is adjacent to the Winkleman Dome oil field. Roads, storage tanks, and an oil derrick are noticeable cultural modifications, even during an early spring snowstorm.

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Appendix B–Photographic Documentation Representing Scenic Quality of Each Site

Plate Number 1
Location: AIRPORT HILL
View Direction: Southeast
Date and Time of Day: April 20, 2005 AM
General Description: The snow has melted and the sky is overcast with grey clouds, windy. The surface dries quickly. The panoramic, relatively flat, grassy terrain is dotted with small spoil heaps.

Plate Number 2
Location: BURMA HILL
View Direction: Northwest
Date and Time of Day: April 20, 2005, AM
General Description: Despite snow on the ground, contours are still visible. The falling snow gives a textured look and low cloud cover limits distant views. The feature landscape is dominated by Paradise Valley, Sand Gulch, and Lost Wells Butte in the middle ground. The area shows transitional-mixed land use; agricultural, industrial (oil), and residential. The foreground vegetation appears to be big sagebrush and mixed grasses.

Plate Number 3
Location: CROWHEART BUTTE # 1
View Direction: Southeast
Date and Time of Day: April 22, 2005, NOON
General Description: Clearing sky illuminates a feature landscape dominated by Crowheart Butte, a historical landmark, on the left. The gently rolling hills give way to a vista of surrounding mountains. Terraces scarps and sandstone outcrops are noticeable. The vegetation is sparse sagebrush and grasses.

Plate Number 4
Location: E BOYSEN CAUSEWAY
View Direction: North
Date and Time of Day: April 24, 2005 AM
General Description: A panoramic landscape type with little vertical relief except for adjacent terraces and foothills. Water Tank Hill (on right) adds to the scarcity of landform variety. The flat area is characterized by short grasses and sparse short brush. Example of sand and gravel pit reclamation by the Wyoming Department of Transportation.

Plate Number 5
Location: JOHNSTOWN
View Direction: East
Date and Time of Day: April 23, 2005 AM
General Description Clear skies and a trace of clouds allow the panoramic landscape to be appreciated. The relatively flat terrain of Johnstown Valley and adjacent terraces appear to blend together. The only vertical relief is the distant buttes. Even the small sand and gravel heaps are visible from the main highway. Homes are less than ½ mile away.

Plate Number 6
Location: KANE DRAW
View Direction: North
Date and Time of Day: April 21, 2005 PM
General Description The terraces are separated by the Wind River Valley. The panoramic landscape type allows distant views of the Owl Creek Mountains. Shrubs dominate the north facing terrace slopes; cottonwoods and willows occur in drainage areas. Urbigket Road crosses the landscape.

Plate Number 7
Location: KINNEAR
View Direction: West
Date and Time of Day: April 23, 2005 PM
General Description: The gently sloping panoramic landscape has little variety in topography. Three sand and gravel pits are visible from the terrace tread. Spotted clumps of vegetation are unevenly distributed.

Plate Number 8
Location: LE CLAIR
View Direction: Southwest
Date and Time of Day: 23, 2005 PM
General Description: The foreground and middle ground do not substantially block views in this panoramic type landscape. A large patch mosaic is formed by mounds of sagebrush, prickleypear cactus, cottonwoods, and grazing lands. Exposed sandstone and the Wind River provide contrast in the landform.

Plate Number 9
Location: RED ROCKS
View Direction: East
Date and Time of Day: April 24, 2005 PM
General Description: The narrow Wind River Valley floor and exposed bluffs form an enclosed landscape. Picturesque pines and junipers are scattered across the area in small groups. Strands of cottonwood-willow mark the major drainage. Large grey river rocks provide a color contrast to the exposed red-orange terrace slopes.

Plate Number 10
Location: SHEER
View Direction: West
Date and Time of Day: April 22, 2005 PM
General Description The isolated panoramic landscape has industrial development nearby. Typical vegetation is sparse and uneven.

Plate Number 11
Location: WILLOWCREEK
View Direction: Northeast
Date and Time of Day: April 22, 2005
General Description The eye is led along a horizontal curve to distant Crowheat Butte and the Wind River Valley in this focal landscape. Farming, ranching, and wildlife habitat make up the pastoral setting.

Plate Number 12
Location: WINKLEMAN DOME 1
View Direction: North
Date and Time of Day: April 21, 2005 AM
General Description This photograph is of a common wraparound horizon landscape in the Wind River Reservation. Flat terrain with mountain backdrop (not visible in this view). Spoils are visible around the site and most of the vegetation is uniformly colored and textured grasses.

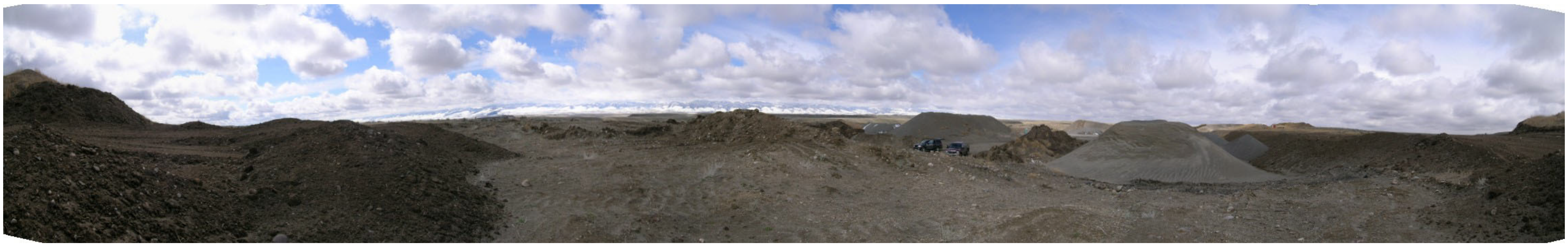

Plate Number 13
Location: WINKLEMAN DOME 2
View Direction: West
Date and Time of Day: April 21, 2005 NOON
General Description Atmospheric conditions mute the impact of the Wind River Mountains forming a dramatic backdrop. The Shoshoni Tribe is actively processing sand and gravel on site and there is oil development to the east (out of observer's view from this vantage point). Stock piles and overburden are in the foreground. The surrounding area is dominated by sagebrush and grasses.

Appendix C–Engineering Test Results From Inberg-Miller Engineers

AGGREGATE LABORATORY TEST RESULTS SUMMARY SHEET

INBERG-MILLER ENGINEERS
QUALITY SOLUTIONS THROUGH TEAMWORK

☒ 124 E. Main Street, Riverton, WY 82501, (307) 856-8136 (ph), (307) 856-3851 (fax)

☐ 1120 E. "C" Street, Casper, WY 82601, (307) 577-0806 (ph), (307) 472-4402 (fax)

☐ 350 Parsley Boulevard, Cheyenne, WY 82007, (307) 635-6827 (ph), (307) 635-2713 (fax)

☐ 428 Alan Road, Powell, WY 82435, (307) 754-7170 (ph), (307) 754-7088 (fax)

☐ 520 Wilkes, Suite 13, Green River, WY 82935, (307) 875-4394 (ph), (307) 875-4395 (fax)

Project: Testing **Project No.:** 11919 RM

Client: USGS **Date:** 5-20-05

Sample Type: Bulk, Native Gravel **Sample Source:** Airport Hill #1

Sampled By: Client **Sampled Date:** ______

T-84,T-85/ C127,C128 Bulk Specific Gravity: 2.575

Percent Absorption: 1.2%

T-96/C131 Percent Loss by L.A. Abrasion Machine grading: A

% Loss, 100 revolutions ______ % Loss, 500 revolutions 22.6

T-99/D698 Standard Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-180/D1557 Modified Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-19/C29 Unit Weight & Percent Voids: Unit Wt: ______ pcf % Voids: ______

T-21/C40 Organic Impurities in Fine Aggregate: Rating: ______

T-89,T-90 D4318 Atterberg Limits: LL: ______ PL: ______ PI: ______

D2419/T-176 Sand Equivalent: ______

D1883/T-193 CBR Value: ______

Additional Tests:

T-30/C136 Sample Gradation

Sieve Size	Percent Finer	Specification Low	Specification High
3"			
2½"	99		
2"	88		
1½"	78		
1"	64		
¾"	54		
½"	42		
3/8"	37		
#4	30		
#8	26		
#10			
#16	25		
#30	22		
#40			
#50	8		
#100	2		
#200	0.9		

Note: Light to moderate caliche deposits on aggregate

C88 Soundness by Sodium Sulfate:

Sieve Size:	Weighted % Loss:
-1.5 "- + 0.75"	0.1
-0.75" - +0.375	0.2
-0.375 - #4	0.1

Signature

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☐ 520 Wilkes, Suite 13, Green River, WY 82935, (307) 875-4394 (ph), (307) 875-4395 (fax)

Project: Testing **Project No.:** 11919 RM

Client: USGS **Date:** 5-12-05

Sample Type: Bulk, Native Gravel **Sample Source:** Burma Hill # 1

Sampled By: Client **Sampled Date:** ______

T-84,T-85/ C127,C128 Bulk Specific Gravity: 2.533

Percent Absorption: 1.6%

T-96/C131 Percent Loss by L.A. Abrasion Machine grading: A

% Loss, 100 revolutions ______ % Loss, 500 revolutions 27.4

T-99/D698 Standard Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-180/D1557 Modified Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-19/C29 Unit Weight & Percent Voids: Unit Wt: ______ pcf % Voids: ______

T-21/C40 Organic Impurities in Fine Aggregate: Rating: ______

T-89,T-90 D4318 Atterberg Limits: LL: ______ PL: ______ PI: ______

D2419/T-176 Sand Equivalent: ______

D1883/T-193 CBR Value: ______

Additional Tests:

T-30/C136 Sample Gradation

Sieve Size	Percent Finer	Specification Low	Specification High
3"			
2½"	99		
2"	90		
1½"	82		
1"	68		
¾"	60		
½"	50		
3/8"	46		
#4	39		
#8	34		
#10			
#16	27		
#30	16		
#40			
#50	6		
#100	4		
#200	2.7		

Note: Minor caliche deposits on aggregate

C88 Soundness by Sodium Sulfate:

Sieve Size:	Weighted % Loss:
-1.5 "- + 0.75"	1.6
-0.75" - +0.375	0.7
-0.375 - #4	0.2

Signature

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❑ 520 Wilkes, Suite 13, Green River, WY 82935, (307) 875-4394 (ph), (307) 875-4395 (fax)

Project: Testing **Project No.:** 11919 RM

Client: USGS **Date:** 5-12-05

Sample Type: Bulk, Native Gravel **Sample Source:** Burma Hill # 2

Sampled By: Client **Sampled Date:** ______

T-84,T-85/ C127,C128 Bulk Specific Gravity: 2.527

Percent Absorption: 1.8 %

T-96/C131 Percent Loss by L.A. Abrasion Machine grading: A

% Loss, 100 revolutions ______ % Loss, 500 revolutions 25.6

T-99/D698 Standard Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-180/D1557 Modified Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-19/C29 Unit Weight & Percent Voids: Unit Wt: ______ pcf % Voids: ______

T-21/C40 Organic Impurities in Fine Aggregate: Rating: ______

T-89,T-90 D4318 Atterberg Limits: LL: ______ PL: ______ PI: ______

D2419/T-176 Sand Equivalent: ______

D1883/T-193 CBR Value: ______

Additional Tests:

T-30/C136 Sample Gradation

Sieve Size	Percent Finer	Specification Low	Specification High
3"			
2½"	97		
2"	93		
1½"	86		
1"	73		
¾"	65		
½"	56		
3/8"	51		
#4	44		
#8	39		
#10			
#16	30		
#30	18		
#40			
#50	10		
#100	5		
#200	3.7		

Note: Minor caliche deposits on aggregate

C88 Soundness by Sodium Sulfate:

Sieve Size:	Weighted % Loss:
-1.5 "- + 0.75"	0.4
-0.75" - +0.375	0.4
-0.375 - #4	0.4

Signature

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(307) 754-7170 (ph)
(307) 754-7088 (fax)

❑ 520 Wilkes, Suite 13
Green River, WY 82935
(307) 875-4394 (ph)
(307) 875-4395 (fax)

Project: Testing **Project No.:** 11919 RM

Client: USGS **Date:** 5-12-05

Sample Type: Bulk, Native Gravel **Sample Source:** Burma Hill # 3

Sampled By: Client **Sampled Date:** ______

T-84,T-85/ C127,C128 Bulk Specific Gravity: 2.572

Percent Absorption: 1.3%

T-96/C131 Percent Loss by L.A. Abrasion Machine grading: A

% Loss, 100 revolutions ______ % Loss, 500 revolutions 26.4

T-99/D698 Standard Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-180/D1557 Modified Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-19/C29 Unit Weight & Percent Voids: Unit Wt: ______ pcf % Voids: ______

T-21/C40 Organic Impurities in Fine Aggregate: Rating: ______

T-89,T-90 D4318 Atterberg Limits: LL: ______ PL: ______ PI: ______

D2419/T-176 Sand Equivalent: ______

D1883/T-193 CBR Value: ______

Additional Tests:

T-30/C136 Sample Gradation

Sieve Size	Percent Finer	Specification Low	Specification High
3"			
2½"	94		
2"	80		
1½"	69		
1"	57		
¾"	51		
½"	45		
3/8"	42		
#4	37		
#8	31		
#10			
#16	27		
#30	16		
#40			
#50	8		
#100	4		
#200	2.5		

Note: Minor caliche deposits on aggregate

C88 Soundness by Sodium Sulfate:

Sieve Size:	Weighted % Loss:
-1.5 "- + 0.75"	1.4
-0.75" - +0.375	0.2
-0.375 - #4	0.3

Signature

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❑ 520 Wilkes, Suite 13, Green River, WY 82935, (307) 875-4394 (ph), (307) 875-4395 (fax)

Project: Testing **Project No.:** 11919 RM
Client: USGS **Date:** 6-23-05
Sample Type: Bulk, Native Gravel **Sample Source:** Crowheart Butte Pit #1
Sampled By: Client **Sampled Date:** ______

T-84,T-85/C127,C128 Bulk Specific Gravity: 2.502
Percent Absorption: 2.0%

T-96/C131 Percent Loss by L.A. Abrasion Machine grading: A
% Loss, 100 revolutions ______ % Loss, 500 revolutions 29.3

T-99/D698 Standard Proctor: Method: ______
Max Density: ______ pcf Opt. Moisture ______ %

T-180/D1557 Modified Proctor: Method: ______
Max Density: ______ pcf Opt. Moisture ______ %

T-19/C29 Unit Weight & Percent Voids: Unit Wt: ______ pcf % Voids: ______

T-21/C40 Organic Impurities in Fine Aggregate: Rating: ______

T-89,T-90 D4318 Atterberg Limits: LL: ______ PL: ______ PI: ______

D2419/T-176 Sand Equivalent: ______

D1883/T-193 CBR Value: ______

Additional Tests:

T-30/C136 Sample Gradation

Sieve Size	Percent Finer	Specification Low	Specification High
3"	100		
2½"	92		
2"	87		
1½"	82		
1"	70		
¾"	63		
½"	53		
3/8"	48		
#4	36		
#8	28		
#10			
#16	21		
#30	15		
#40			
#50	9		
#100	4		
#200	2.3		

Note: Minor to light caliche deposits on aggregate

C88 Soundness by Sodium Sulfate:

Sieve Size:	Weighted % Loss:
-1.5 "- + 0.75"	1.0
-0.75" - +0.375	1.4
-0.375 - #4	1.3

Signature

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❑ 520 Wilkes, Suite 13, Green River, WY 82935, (307) 875-4394 (ph), (307) 875-4395 (fax)

Project: Testing **Project No.:** 11919 RM

Client: USGS **Date:** 6-23-05

Sample Type: Bulk, Native Gravel **Sample Source:** Johnstown Pit #1

Sampled By: Client **Sampled Date:** ______

T-84,T-85/ C127,C128 Bulk Specific Gravity: 2.592

Percent Absorption: 1.3%

T-96/C131 Percent Loss by L.A. Abrasion Machine grading: A

% Loss, 100 revolutions ______ % Loss, 500 revolutions 22.9

T-99/D698 Standard Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-180/D1557 Modified Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-19/C29 Unit Weight & Percent Voids: Unit Wt: ______ pcf % Voids: ______

T-21/C40 Organic Impurities in Fine Aggregate: Rating: ______

T-89,T-90 D4318 Atterberg Limits: LL: ______ PL: ______ PI: ______

D2419/T-176 Sand Equivalent: ______

D1883/T-193 CBR Value: ______

Additional Tests:

T-30/C136 Sample Gradation

Sieve Size	Percent Finer	Specification Low	Specification High
3"	100		
2½"	93		
2"	87		
1½"	78		
1"	64		
¾"	57		
½"	47		
3/8"	42		
#4	34		
#8	29		
#10			
#16	26		
#30	20		
#40			
#50	9		
#100	4		
#200	1.8		

Note: Minor to light caliche deposits on aggregate

C88
Soundness by Sodium Sulfate:

Sieve Size:	Weighted % Loss:
-1.5 "- + 0.75"	0.2
-0.75" - +0.375	0.2
-0.375 - #4	0.1

Signature

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☐ 520 Wilkes, Suite 13, Green River, WY 82935, (307) 875-4394 (ph), (307) 875-4395 (fax)

Project: Testing **Project No.:** 11919 RM

Client: USGS **Date:** 5-20-05

Sample Type: Bulk, Native Gravel **Sample Source:** Kane Draw Site #1

Sampled By: Client **Sampled Date:** ________

T-84,T-85/ C127,C128 Bulk Specific Gravity: 2.576

Percent Absorption: 1.6%

T-96/C131 Percent Loss by L.A. Abrasion Machine grading: A

% Loss, 100 revolutions ________ % Loss, 500 revolutions 26.2

T-99/D698 Standard Proctor: Method: ________

Max Density: ________ pcf Opt. Moisture ________ %

T-180/D1557 Modified Proctor: Method: ________

Max Density: ________ pcf Opt. Moisture ________ %

T-19/C29 Unit Weight & Percent Voids: Unit Wt: ________ pcf % Voids: ________

T-21/C40 Organic Impurities in Fine Aggregate: Rating: ________

T-89,T-90 D4318 Atterberg Limits: LL: ________ PL: ________ PI: ________

D2419/T-176 Sand Equivalent: ________

D1883/T-193 CBR Value: ________

Additional Tests:

T-30/C136 Sample Gradation

Sieve Size	Percent Finer	Specification Low	Specification High
3"			
2½"	91		
2"	80		
1½"	66		
1"	49		
¾"	40		
½"	31		
3/8"	26		
#4	19		
#8	16		
#10			
#16	13		
#30	8		
#40			
#50	4		
#100	2		
#200	1.7		

Note: Moderate to heavy caliche deposits on aggregate

C88 Soundness by Sodium Sulfate:

Sieve Size:	Weighted % Loss:
-1.5 "- + 0.75"	0.6
-0.75" - +0.375	0.4
-0.375 - #4	0.4

Signature

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❑ 520 Wilkes, Suite 13, Green River, WY 82935, (307) 875-4394 (ph), (307) 875-4395 (fax)

Project: Testing **Project No.:** 11919 RM

Client: USGS **Date:** 6-23-05

Sample Type: Bulk, Native Gravel **Sample Source:** Kineer Pit #1

Sampled By: Client **Sampled Date:** ______

T-84,T-85/ C127,C128 Bulk Specific Gravity: 2.591

Percent Absorption: 1.4%

T-96/C131 Percent Loss by L.A. Abrasion Machine grading: A

% Loss, 100 revolutions ______ % Loss, 500 revolutions 21.8

T-99/D698 Standard Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-180/D1557 Modified Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-19/C29 Unit Weight & Percent Voids: Unit Wt: ______ pcf % Voids: ______

T-21/C40 Organic Impurities in Fine Aggregate: Rating: ______

T-89,T-90 D4318 Atterberg Limits: LL: ______ PL: ______ PI: ______

D2419/T-176 Sand Equivalent: ______

D1883/T-193 CBR Value: ______

Additional Tests:

T-30/C136 Sample Gradation

Sieve Size	Percent Finer	Specification Low	Specification High
3"	100		
2½"	94		
2"	85		
1½"	74		
1"	63		
¾"	53		
½"	43		
3/8"	38		
#4	30		
#8	26		
#10			
#16	23		
#30	17		
#40			
#50	8		
#100	4		
#200	1.7		

Note: Minor to light caliche deposits on aggregate

C88 Soundness by Sodium Sulfate:

Sieve Size:	Weighted % Loss:
-1.5 "- + 0.75"	0.2
-0.75" - +0.375	0.2
-0.375 - #4	0.1

Signature

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❑ 520 Wilkes, Suite 13, Green River, WY 82935, (307) 875-4394 (ph), (307) 875-4395 (fax)

Project: Testing **Project No.:** 11919 RM

Client: USGS **Date:** 6-23-05

Sample Type: Bulk, Native Gravel **Sample Source:** LeClair Pit #1 (ALC)

Sampled By: Client **Sampled Date:** ______

T-84,T-85/ C127,C128 Bulk Specific Gravity: 2.553

Percent Absorption: 1.5%

T-96/C131 Percent Loss by L.A. Abrasion Machine grading: A

% Loss, 100 revolutions ______ % Loss, 500 revolutions 22.7

T-99/D698 Standard Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-180/D1557 Modified Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-19/C29 Unit Weight & Percent Voids: Unit Wt: ______ pcf % Voids: ______

T-21/C40 Organic Impurities in Fine Aggregate: Rating: ______

T-89,T-90 D4318 Atterberg Limits: LL: ______ PL: ______ PI: ______

D2419/T-176 Sand Equivalent: ______

D1883/T-193 CBR Value: ______

Additional Tests:

T-30/C136 Sample Gradation

Sieve Size	Percent Finer	Specification Low	Specification High
3"	100		
2½"	97		
2"	93		
1½"	81		
1"	65		
¾"	56		
½"	44		
3/8"	40		
#4	33		
#8	30		
#10			
#16	28		
#30	23		
#40			
#50	11		
#100	5		
#200	2.8		

Note: Minor to light caliche deposits on aggregate

C88 Soundness by Sodium Sulfate:

Sieve Size:	Weighted % Loss:
-1.5 "- + 0.75"	0.3
-0.75" - +0.375	0.4
-0.375 - #4	0.3

Signature

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Project: Testing　　**Project No.:** 11919 RM

Client: USGS　　**Date:** 6-23-05

Sample Type: Bulk, Native Gravel　　**Sample Source:** Sheer Pit #1

Sampled By: Client　　**Sampled Date:** ______

T-84,T-85/ C127,C128 Bulk Specific Gravity: 2.572

Percent Absorption: 1.3%

T-96/C131 Percent Loss by L.A. Abrasion Machine grading: A

% Loss, 100 revolutions ______ % Loss, 500 revolutions 26.4

T-99/D698 Standard Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-180/D1557 Modified Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-19/C29 Unit Weight & Percent Voids: Unit Wt: ______ pcf % Voids: ______

T-21/C40 Organic Impurities in Fine Aggregate: Rating: ______

T-89,T-90 D4318 Atterberg Limits: LL: ______ PL: ______ PI: ______

D2419/T-176 Sand Equivalent: ______

D1883/T-193 CBR Value: ______

Additional Tests:

T-30/C136 Sample Gradation

Sieve Size	Percent Finer	Specification Low	Specification High
3"	100		
2½"	89		
2"	85		
1½"	68		
1"	53		
¾"	44		
½"	35		
3/8"	31		
#4	24		
#8	20		
#10			
#16	18		
#30	14		
#40			
#50	7		
#100	4		
#200	2.4		

Note: Minor to light caliche deposits on aggregate

C88 Soundness by Sodium Sulfate:

Sieve Size:	Weighted % Loss:
-1.5 "- + 0.75"	0.4
-0.75" - +0.375	0.3
-0.375 - #4	0.4

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Signature

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Project: Testing **Project No.:** 11919 RM

Client: USGS **Date:** 6-23-05

Sample Type: Bulk, Native Gravel **Sample Source:** ~~Dry~~ Willow Creek Pit #1

Sampled By: Client **Sampled Date:** ______

T-84,T-85/ C127,C128 Bulk Specific Gravity: 2.559

Percent Absorption: 2.1%

T-96/C131 Percent Loss by L.A. Abrasion Machine grading: A

% Loss, 100 revolutions ______ % Loss, 500 revolutions 26.8

T-99/D698 Standard Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-180/D1557 Modified Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-19/C29 Unit Weight & Percent Voids: Unit Wt: ______ pcf % Voids: ______

T-21/C40 Organic Impurities in Fine Aggregate: Rating: ______

T-89,T-90 D4318 Atterberg Limits: LL: ______ PL: ______ PI: ______

D2419/T-176 Sand Equivalent: ______

D1883/T-193 CBR Value: ______

Additional Tests:

T-30/C136 Sample Gradation			
Sieve Size	Percent Finer	Specification	
		Low	High
3"	100		
2½"	90		
2"	83		
1½"	62		
1"	47		
¾"	36		
½"	27		
3/8"	23		
#4	16		
#8	13		
#10			
#16	11		
#30	8		
#40			
#50	4		
#100	2		
#200	1.6		

Note: Minor to light caliche deposits on aggregate

C88 Soundness by Sodium Sulfate:	
Sieve Size:	Weighted % Loss:
-1.5 "- + 0.75"	1.4
-0.75" - +0.375	1.1
-0.375 - #4	0.4

Signature

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Project: Testing
Project No.: 11919 RM
Client: USGS
Date: 5-20-05
Sample Type: Bulk, Native Gravel
Sample Source: Winkleman Dome, Pit 1, #1
Sampled By: Client
Sampled Date: ______

T-84,T-85/C127,C128 Bulk Specific Gravity: 2.553

Percent Absorption: 1.7%

T-96/C131 Percent Loss by L.A. Abrasion Machine grading: A

% Loss, 100 revolutions ______ % Loss, 500 revolutions 23.6

T-99/D698 Standard Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-180/D1557 Modified Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-19/C29 Unit Weight & Percent Voids: Unit Wt: ______ pcf % Voids: ______

T-21/C40 Organic Impurities in Fine Aggregate: Rating: ______

T-89,T-90 D4318 Atterberg Limits: LL: ______ PL: ______ PI: ______

D2419/T-176 Sand Equivalent: ______

D1883/T-193 CBR Value: ______

Additional Tests:

T-30/C136 Sample Gradation

Sieve Size	Percent Finer	Specification Low	Specification High
3"			
2½"	90		
2"	82		
1½"	70		
1"	55		
¾"	47		
½"	37		
3/8"	32		
#4	25		
#8	22		
#10			
#16	20		
#30	14		
#40			
#50	7		
#100	3		
#200	1.4		

Note: Moderate to heavy caliche deposits on aggregate

C88 Soundness by Sodium Sulfate:

Sieve Size:	Weighted % Loss:
-1.5 "- + 0.75"	0.4
-0.75" - +0.375	0.4
-0.375 - #4	0.5

Signature

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Project: Testing
Project No.: 11919 RM
Client: USGS
Date: 5-20-05
Sample Type: Bulk, Native Gravel
Sample Source: Winkleman Dome, Pit 2, #1
Sampled By: Client
Sampled Date: ______

T-84,T-85/ C127,C128 Bulk Specific Gravity: 2.525

Percent Absorption: 1.9%

T-96/C131 Percent Loss by L.A. Abrasion Machine grading: A

% Loss, 100 revolutions ______ % Loss, 500 revolutions 24.8

T-99/D698 Standard Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-180/D1557 Modified Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-19/C29 Unit Weight & Percent Voids: Unit Wt: ______ pcf % Voids: ______

T-21/C40 Organic Impurities in Fine Aggregate: Rating: ______

T-89,T-90 D4318 Atterberg Limits: LL: ______ PL: ______ PI: ______

D2419/T-176 Sand Equivalent: ______

D1883/T-193 CBR Value: ______

Additional Tests:

T-30/C136 Sample Gradation

Sieve Size	Percent Finer	Specification Low	Specification High
3"			
2½"	92		
2"	81		
1½"	74		
1"	62		
¾"	54		
½"	45		
3/8"	41		
#4	34		
#8	32		
#10			
#16	28		
#30	18		
#40			
#50	7		
#100	3		
#200	1.7		

Note: Moderate to heavy caliche deposits on aggregate

C88 Soundness by Sodium Sulfate:

Sieve Size:	Weighted % Loss:
-1.5 "- + 0.75"	0.2
-0.75" - +0.375	0.6
-0.375 - #4	0.5

Signature

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☐ 520 Wilkes, Suite 13, Green River, WY 82935, (307) 875-4394 (ph), (307) 875-4395 (fax)

Project: Testing
Project No.: 11919 RM
Client: USGS
Date: 5-20-05
Sample Type: Bulk, Crushed Aggregate
Sample Source: Winkleman Dome, Pit 2, Stockpile
Sampled By: Client
Sampled Date: ______

T-84,T-85/ C127,C128 Bulk Specific Gravity: 2.540

Percent Absorption: 1.7%

T-96/C131 Percent Loss by L.A. Abrasion Machine grading: A

% Loss, 100 revolutions ______ % Loss, 500 revolutions 28.9

T-99/D698 Standard Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-180/D1557 Modified Proctor: Method: ______

Max Density: ______ pcf Opt. Moisture ______ %

T-19/C29 Unit Weight & Percent Voids: Unit Wt: ______ pcf % Voids: ______

T-21/C40 Organic Impurities in Fine Aggregate: Rating: ______

T-89,T-90 D4318 Atterberg Limits: LL: ______ PL: ______ PI: ______

D2419/T-176 Sand Equivalent: ______

D1883/T-193 CBR Value: ______

Additional Tests:

T-30/C136 Sample Gradation

Sieve Size	Percent Finer	Specification Low	Specification High
3"			
2½"			
2"			
1½"			
1"	98		
¾"	85		
½"	67		
3/8"	59		
#4	44		
#8	39		
#10			
#16	34		
#30	25		
#40			
#50	17		
#100	12		
#200	8.6		

Note: No caliche deposits on aggregate

C88 Soundness by Sodium Sulfate:

Sieve Size:	Weighted % Loss:
-1.5 "- + 0.75"	
-0.75" - +0.375	0.9
-0.375 - #4	0.7

Signature

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Appendix D–Digital GIS Dataset of Sand and Gravel Deposits on the Wind River Indian Reservation, Wyoming

INTRODUCTION

The set of six digital data files in this report form an ESRI™ polygon Shapefile, which can be used in Geographic Information System (GIS) software to plot maps of sand and gravel deposits within the Wind River Indian Reservation, Wyoming.

The gravel deposits outlined by this shapefile (609 polygons) were adapted and digitized from two geologic maps of the Wind River Indian Reservation:

Plate 1, scale 1:63,360, of Morris, D.A., Hackett, O.M., Vanlier, K.E., and Moulder, E.A., 1959, Ground-water resources of Riverton Irrigation Project Area, Wyoming: U.S. Geological Survey Water-Supply Paper 1375, 205 p., 6 plates.

Plate 2, scale 1:125,000, of McGreevy, L.J., Hodson, W.G., and Rucker, S.J., IV, 1969, Ground-water resources of the Wind River Indian Reservation, Wyoming: U.S. Geological Survey Water-Supply Paper 1576-I, 145 p., 3 plates.

Most of the shapefile polygons (549 of 609) are sand and gravel deposits of terraces of the ancient Wind River and its tributaries. The terraces were deposited as the rivers migrated across and cut downward into the Wind River Basin over the last 1,700,000 years (Chadwick, O.A., Hall, R.D., and Phillips, F.M., 1997, Chronology of Pleistocene glacial advances in the central Rocky Mountains: Geological Society of America Bulletin, v. 109, no. 11, p. 1443-1452). The geology and characteristics of these terrace deposits are described in this report. Deposits of sand and gravel (alluvium) within the active channels and floodplains of the modern rivers and streams were not included in the shapefile.

Some of the sand and gravel deposits (60 of 609 polygons) in the shapefile were interpreted by this study to be alluvial fan deposits. Alluvial fans are gently sloping, apron-shaped masses (fans) of rock debris and sediment (alluvium) that form along the base of mountain slopes. Alluvial fans typically form where a mountain stream exits a narrow mountain valley and deposits its water-laden material onto a broad valley or plain. Alluvial fan deposits are preserved along the eastern base of the Wind River Range and the southern base of the Owl Creek Mountains.

SHAPEFILE CREATION

The geologic maps of Morris and others (1959, plate 1) and McGreevy and others (1969, plate 2) were digitally scanned and georeferenced. The resulting digital geologic maps were superimposed upon digital USGS 7½-minute (scale 1:24,000) topographic quadrangles. Using the GIS software program ArcMap (ESRI™), the mapped sand and gravel deposits of Morris and others (1959) and McGreevy and others (1969) were hand digitized on-screen approximately one square mile at a time at a screen-view scale of 1:12,000. The geologic mapping of Morris and others (1959) and McGreevy and others (1969) was adjusted to match the topography (as viewed at a scale of 1:12,0000). The digital mapping shown in the shapefile must be considered approximately located because no field inspections were made.

Where the geologic maps overlap, the geologic mapping of Morris and others (1959) was preferentially used because their mapping is at a larger, more detailed scale and includes information on river terrace level. Ten polygons were added by the authors, which are sand and gravel deposits that are not shown on the maps of Morris and others (1959) or McGreevy and others (1969).

A Universal Transverse Mercator map projection with map parameters of NAD 1927, UTM Zone 12N, and in meters, was used. The datum information is supplied by the data file *gravels.prj*

DATA FIELDS IN THE SHAPEFILE

Four data fields were attributed in each of the 609 polygons in the *gravels* shapefile, as follows:

Data field	***Entries***	***Description***
'**FID**'	'0' to'608'	Unique number used to identify each polygon.
'**Landform**'	'fan'	Interpreted as an alluvial fan deposit (n=60).
	'terrace'	Interpreted as an ancient river terrace (n=549).
'**Map_source**'	'Morris and others (1959)'	Polygon adapted from the geologic map of Morris and others (1959) (n=305).
	McGreevy and others (1969)'	Polygon adapted from the geologic map of McGreevy and others (1969) (n=294).
	'not mapped'	Polygon added by this study; previously unmapped (n=10).
'**Map_unit**'	'Qf'	Alluvial fan deposit (n=67); as interpreted by this study based on the slope of their surface and their close proximity to a mountain front. Mapped as 'Qt' by McGreevy and others (1969).
	'Qt'	"Terrace and pediment deposits", as mapped by McGreevy and others (1969) (n=237).
	'Qtu'	River terrace of uncertain terrace level, mapped by Morris and others (1959) (n=8).
	'Qt1'	River terrace level 1 of Morris and others (1959) n=3).
	'Qt2'	River terrace level 2 of Morris and others (1959) (n=57).
	'Qt3'	River terrace level 3 of Morris and others (1959) (n=54).
	'Qt4'	River terrace level 4 of Morris and others (1959) n=11).
	'Qt5'	River terrace level 5 of Morris and others (1959) (n=68).
	'Qt6'	River terrace level 6 of Morris and others (1959) (n=33).
	'Qt7'	River terrace level 7 of Morris and others (1959) (n=9).
	'Qt8'	River terrace level 8 of Morris and others (1959) (n=30).
	'Qt9'	River terrace level 9 of Morris and others (1959) (n=10).
	'Qt10'	River terrace level 10 of Morris and others (1959) (n=14).
	'Qt11'	River terrace level 11 of Morris and others (1959) (n=3).
	'Qt12'	River terrace level 12 of Morris and others (1959) (n=1).
	'Qt13'	River terrace level 13 of Morris and others (1959) (n=4).