Road-Related Erosion Issues on Bureau of Land Management-Administered Lands in Northwestern New Mexico

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for

U.S. Bureau of Land Management
Albuquerque Field Office
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NOTATION

The following is a list of the acronyms, initialisms, and abbreviations (including units of measure) used in this document.

ACRONYMS, INITIALISMS, AND ABBREVIATIONS

BLM	U.S. Bureau of Land Management
ft	foot (feet)
ft^2	square foot (feet)
mi^2	square mile(s)
MFRC	Minnesota Forest Resources Council
mph	mile(s) per hour
NRCS	Natural Resources Conservation Service
USFS	U.S. Forest Service

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1 INTRODUCTION

Oil and gas exploration and production activities in the San Juan Basin of northwestern New Mexico have resulted in the development of a dense network of access roads constructed with natural soil surfaces. This development falls within the Largo Cañon, Animas River, and Rio Puerco watersheds (Figure 1.1), which are characterized by some of the highest natural erosion rates in the United States because of the presence of highly erodible soils. Erosion problems associated with the natural surface access roads have become the focus of concern for both the Bureau of Land Management (BLM) and private landowners.

The BLM is actively working to define and address these road-related erosion problems. Among other activities, the BLM's efforts include a road maintenance program that has been established in the Farmington Field Office and a project undertaken with the U.S. Geological Survey to quantify soil erosion rates within the Largo Cañon watershed. In addition, the BLM funded Argonne National Laboratory to conduct a programmatic and engineering review of the erosion problems, the objectives being to (1) identify, characterize, and prioritize the issues; (2) assess the adequacy of existing road design standards and construction practices; (3) identify potential solutions; and (4) recommend follow-on actions. This report summarizes the observations, conclusions, and recommendations of Argonne's review.

To accomplish the programmatic and engineering review of road-related erosion problems, Argonne's efforts included reviews of relevant documentation, including the *Oil and Gas Surface Operating Standards for Oil and Gas Development* (BLM 1989; also known as the "Gold Book"); interviews with BLM staff and private landowners; and a visit to the study area on May 8 through 9, 2003. This study focused on erosion problems related primarily to roads constructed and used by the petroleum industry. Erosion problems caused or exacerbated by other activities, such as livestock grazing or installation of utilities (e.g., buried communication cables), were observed during the field visit; however, these issues are beyond the scope of this study. The observations made during the field visit are discussed throughout this text and supplemented with photographs. The locations in which the photos were taken are noted in Figure 1.2.

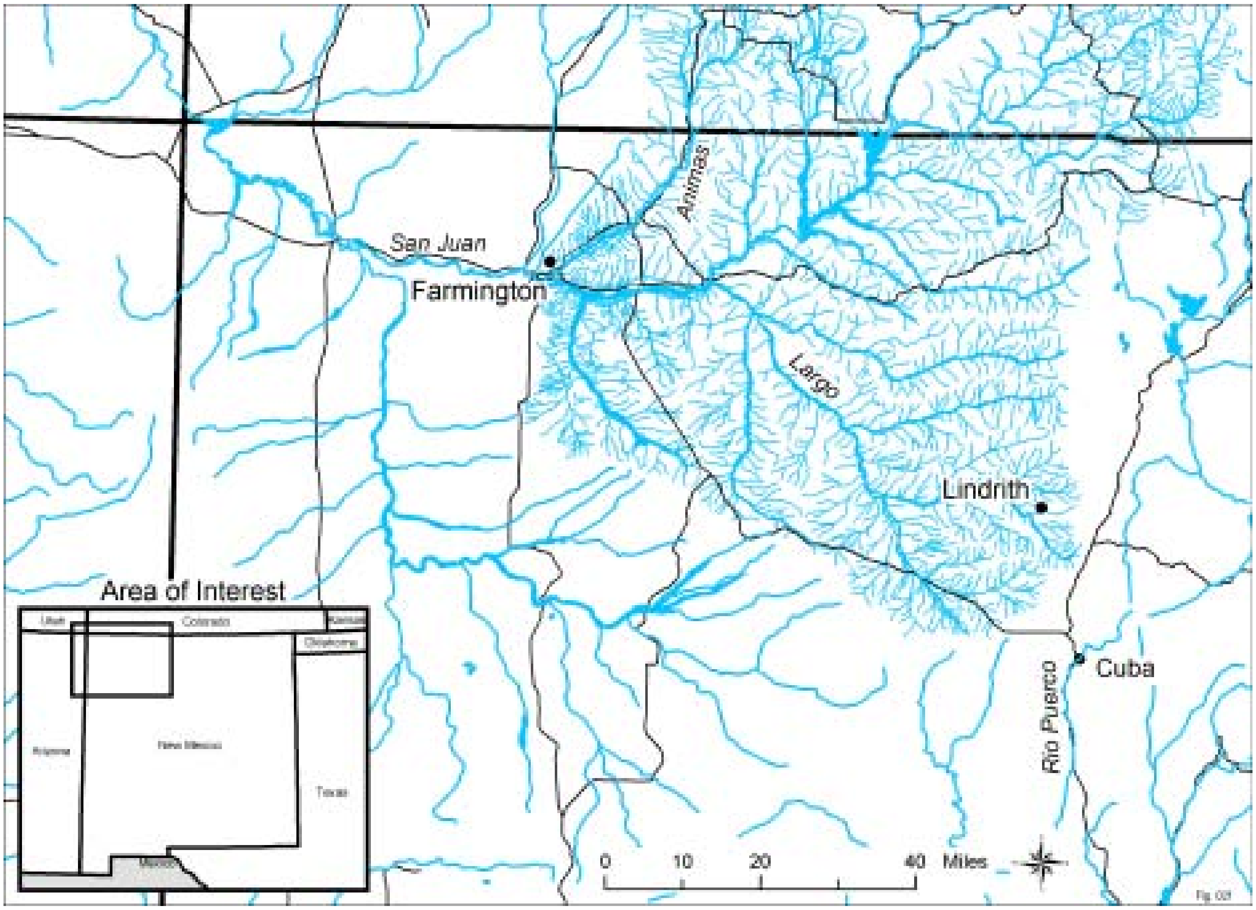

Figure 1.1 Location Map of Watersheds in the Study Area

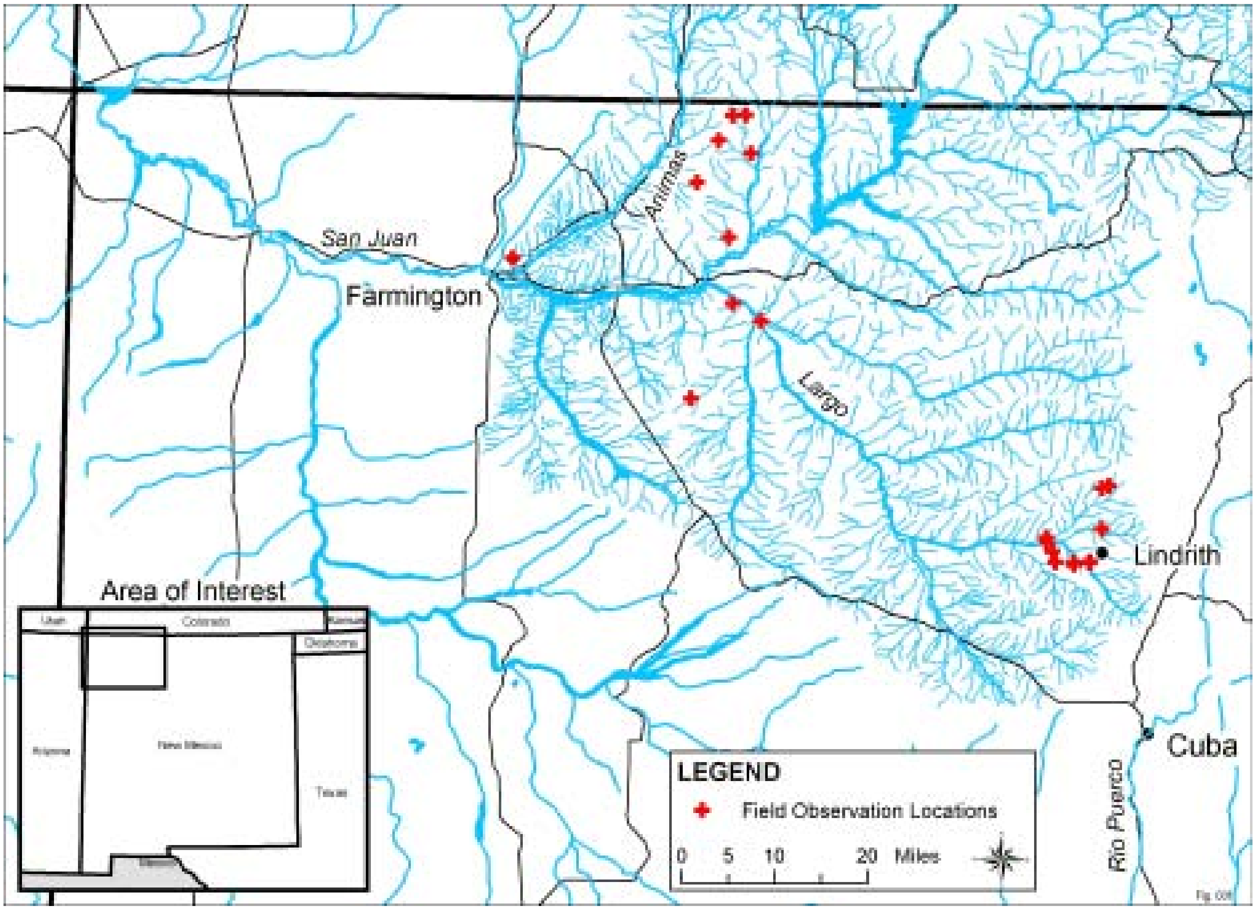

Figure 1.2 Locations of Field Visit Observation Points

2 BACKGROUND INFORMATION

The study area, which encompasses approximately 400 mi^2 of land, includes portions of the Largo Cañon, Animas River, and Rio Puerco watersheds. These watersheds encompass several counties in northwestern New Mexico and southwestern Colorado; the lands located within New Mexico are the focus of this review. The Largo Cañon and Animas River watersheds drain into the San Juan River, and the Rio Puerco drains into the Rio Grande. The soils within these watersheds are very fine grained and highly erodible, particularly if the vegetation is disturbed. High erosion rates within the watersheds can dramatically alter local landscapes and ultimately threaten downstream water quality and natural habitats.

The BLM administers both surface and mineral rights on a portion of the lands located within the study area and has authority over all oil and gas exploration and production activities associated with those lands, including the construction and maintenance of access roads. On lands with split ownership, where private parties own the surface rights and the mineral rights are federally owned, the BLM still has authority over road construction related to oil and gas development. Under this authority, the BLM is responsible for approving the construction of all roads, including location and design, and overseeing on-going road maintenance. The BLM has developed general road design criteria establishing engineering standards for all oil and gas service roads, ranging from low-volume, temporary access roads to high-volume, collector roads. These design criteria, discussed in Section 3, are contained in the Gold Book (BLM 1989).

Excessive soil erosion is frequently associated with the natural surface roads used by the petroleum industry to access well sites, drilling pads, and other production facilities. For the purpose of this study, a natural surface road is any road built on natural soils without any supplementary paving or aggregate materials (see Figure 2.1). Throughout the study area, these roads are characterized by extensive drainage-related problems, including severe rutting and impaired culverts and relief ditches During wet periods, heavy vehicles cause extensive damage from rutting as they traverse saturated roads. Some grading practices aggravate the drainage problems. For example, grading the road surface to elevations below the elevations of the road shoulders or grading across and blocking relief ditches causes runoff to channel or be trapped within the road prism. A further description of the erosion problems is provided in Section 4.

The study area was divided into two areas on the basis of several factors, including BLM Field Office boundaries, soil types, oil and gas production activities, and landownership patterns. These areas are referred to as the Lindrith area and the Farmington area. The Lindrith area includes lands administered by the Albuquerque Field Office, located primarily within the Rio Puerco watershed and westernmost edges of the Largo Cañon watershed. The Farmington area includes a portion of the lands administered by the Farmington Field Office and encompasses lands in both the Largo Cañon and Animas River watersheds. Although the road-related erosion issues are similar in the two areas, differences in the factors listed above have resulted in different effects and may require different solutions.

The San Juan Basin is the location of extensive oil and gas exploration and production. San Juan and Rio Arriba Counties are the top two gas producing counties in New Mexico and are

Figure 2.1 Natural Surface Road

in the top four oil producing counties in the state (New Mexico Oil and Gas Association 2003). In general, however, the level of development and exploration activity is greater in the Farmington area where major natural gas plays are being developed. Another key distinction between the Farmington and Lindrith areas is the distribution of federal versus private surface ownership. Private parties own roughly 80% of the surface rights in the Lindrith area, whereas in the Farmington area, approximately 80% of the surface ownership is federal.

Physical differences in landform also exist among the two areas studied. In comparison to soils in the Farmington area, Lindrith area soils are generally more fine grained and erodible. Furthermore, resources that can be used to improve road construction are less readily available in the vicinity. In the Farmington area, borrow material, consisting primarily of a well-graded (poorly sorted) mixture of different sized pieces of friable sandstone that range from coarse sand to large gravel, has been used as aggregate to improve the natural surface roads. Similar material is not readily available in the Lindrith area. As a result, the cost to construct and maintain roads using some form of aggregate is potentially higher in the Lindrith area than in the Farmington area. However, because the soils in the Lindrith area are more erodible, the impact of not using road surfacing materials is greater than in the Farmington area. In other words, the area with the greater potential for road-related erosion problems is also the area in which the cost to mitigate those erosion problems may be higher.

In 2000, the Farmington Field Office began addressing the road-related erosion issues; in 2001, a road maintenance program was implemented. Under this program, the Field Office planning area has been divided into 13 road maintenance units with industry representatives assigned to each unit to oversee road construction and maintenance activities. This program has provided a structure within which the BLM has increased its influence and control over road construction and maintenance activities. The BLM works closely with petroleum industry operators during the construction of new roads to ensure that appropriate engineering standards are incorporated into the design. Road maintenance activities also are undertaken in conjunction with BLM oversight. Operators are required to pay 95% of the cost of road maintenance activities; these costs are divided proportionately among the companies. The public, through BLM, contributes the remaining 5%. In addition to cost sharing, the BLM provides other resources, including aggregate materials, culverts, cattleguards, signage, and other services (e.g., engineering consultations, cultural resource survey data).

The road maintenance program, coupled with some other initiatives, appears to be successfully producing an overall improvement in road conditions in the Farmington area. One related effort entails the closure and reclamation of unnecessary, redundant roads (i.e., roads that only access locations accessible by other roads or provide a shortcut). Another initiative allows the application of magnesium chloride to road surfaces to help establish a hard, less erodible surface. Similar programs have not been initiated in the Lindrith area.

3 BLM ROAD DESIGN CRITERIA

The Gold Book (BLM 1989) was developed to aid oil and gas operators in obtaining permit approval and conducting oil and gas operations on federal lands, from exploration to development and production, to abandonment. In the area of roads and access ways, the Gold Book provides the operators with BLM and U.S. Forest Service (USFS) policies and standards relative to planning, locating, designing, constructing, maintaining, and operating roads and access ways on public and National Forest System lands.

Special concerns, such as steep slopes, erosion hazards, and visual resources, require consideration when roads and access ways are being planned or constructed. In addition, areas that have high environmental sensitivity might require special road locations, designs, and construction.

As specified in the Gold Book, road locations and design criteria are developed to implement the goals of transportation planning. The planning process discussed in the Gold Book considers other resource values, public access needs, and future use of the road, and tries to avoid "leapfrogging" (i.e., using straight-line roads to connect well sites) from one well site to another. New road construction or reconstruction by the operator is specified to comply with BLM/USFS standards, consistent with the needs of the users.

The Gold Book characterizes roads in New Mexico as belonging to one of four classes: short-term, local, collector, or arterial. Short-term roads are characterized by a low volume of traffic, with a single lane built for a specific purpose or use. They are located, designed, and constructed for temporary use; upon completion of use, they are to be made impassable to vehicle travel and returned to near natural conditions. Short-term roads have a width of 12 ft and have little or no grading or blade use. Such roads are usually built for dry weather but may be surfaced, drained, and maintained for all weather conditions. Local roads are also roads that have a low volume of traffic and are located on the basis of the specific resource activity need rather than on travel efficiency (e.g., connecting a well site to collector, local, arterial, or other higher class roads). After a particular use terminates, these roads may be reclaimed. They are 12 to 14 ft wide with intervisible turnouts on single-lane roads. They are used for dry weather conditions but may be surfaced, drained, and maintained for all weather conditions. Collector roads are single- or double-lane roads that are 12 to 24 ft wide with intervisible turnouts. They are graded, drained, and surfaced, and are designed to carry highway loads and provide access to large areas for various uses. Arterial roads are double lane, graded, drained, and surfaced. They are used as major access routes and have high average daily traffic rates. They are located and designed to maximize mobility and travel efficiency rather than a specific resource management service.

Design specifications differ according to road type. Table 3.1 lists some of the Gold Book design specifications for short-term, local, and collector roads. Arterial roads were not included in this table because they were not relevant to the study. These specifications include road geometrics (e.g., width, design speed, gradient, curve radii, turnouts, drainage, and surface) and related issues. Table 3.2 lists additional Gold Book design criteria (culvert size, spacing,

Table 3.1 Gold Book Standards for Road Geometrics and Related Issues by Road Type

Geometric	Road Type		
	Short-Term	**Local**	**Collector**
Width	12 ft	12 ft	12–24 ft
Design speed	15 mph	15 mph	15–25 mph
Gradient	<8%; >8% for short pitch of <300 ft; >8% in mountainous terrain with prior approval of the BLM	8%; >8% for short pitch of <300 ft	<8%; >8% for short pitch of <300 ft
Curve radius	100-ft minimum	100-ft minimum	100-ft minimum
Turnouts	Naturally occurring locations	1,000-ft intervals or intervisible	750-ft intervals for single lane; >100-ft length with 25-ft transitional tapers at each end.
Drainage	Insloping drainage dips; natural rolling topography; ditches and culverts may be required, but not the norm	Insloping drainage dips; natural rolling topography; relief ditches or culverts. Roadbed culverts to drain inside road ditches when drainage dips not feasible	Culverts – 18-in. minimum, sized in accordance with accepted engineering practices and environmental concerns; 10-year or less storm design; culvert cross drains instead of drainage dips for grades >10%.
Surface	Dirt, gravel if needed (not required)	Gravel, if all weather use	Required for all weather use. Aggregate size, type, amount, and method of application specified by the local office of the BLM.

Source: BLM (1989).

slope, and construction; ditch size and construction; relief ditch spacing; and rolling dip spacing and design) applicable to roads in New Mexico.

Table 3.2 Additional Gold Book Road Standards

Issue	Gold Book Standards
Culverts	
Location	Streams and gullies, inside drain ditches if no drainage dips present.
Size	18-in. minimum
Spacing	Grade / Spacing 1–2% <1,000 ft 2–4% <800 ft 4–6% <600 ft 6–8% <400 ft 8–10% <250 ft
Slope	>3% grade; no reverse camber
Construction	CMP (corrugated metal pipe - steel or aluminum) or concrete
Design criteria	10-yr or more frequent storm capacity, 1-ft head at pipe inlet allowed. Outlet must extend 1-ft beyond toe of any slope. Ditch culverts skewed 15 to 30 degrees across road.
Other	– >35 ft^2 or bridge installation requires approval at Regional or State offices – Subdrainage may be required to remove standing water; e.g., perforated pipe drains – Wetlands may require flat (zero grade) culverts to allow movement of water
Ditches	
Location	Inside of road with inslope
Size	Depth of 1-ft minimum below finished road surface. Backslope no flatter than 2:1.
Material	Natural
Construction	Conform to slope, grade, and shape of required cross sections. No projections of roots, rocks, stumps, etc.; grade > 0.5% to provide positive drainage and to avoid siltation.
Relief ditches	
Spacing	<500 ft; slopes >5% require closer spacing or relief ditch furrows (wing ditches).
Rolling dips (drainage dips)	
Location	Per BLM
Spacing	<1,000 ft
Design	Grade 0.002 to natural ground

Source: BLM (1989).

4 CHARACTERIZATION OF THE EROSION PROBLEMS

Site visits were made to the Lindrith area on May 8, 2003, and to the Farmington area on May 9, 2003. The objectives of these visits were to:

- Determine the characteristics of the local transportation demands for the road system and the nature of the problems that arise as a result of those demands;
- Observe and document the types and causes of road-related erosion problems;
- Determine the degree to which existing design standards are being used in the construction and maintenance of the roads; and
- Interview BLM personnel and private landowners familiar with the local road-related erosion issues.

The site visits entailed driving through the study area and making observations. Specific stops were made at the locations shown in Figure 1.2 to collect measurements of various features (e.g., road width, grade, depth of roadbed below surrounding land surface) and take photographs. Observations made during the site visits can be organized into the following categories:

- Transportation demands for the road system;
- Road system planning;
- Road design;
- Road maintenance; and
- Quality assurance, implementation, and enforcement.

Problems arising from each of these categories are experienced in both the Lindrith and Farmington areas to varying degrees. Because road-related erosion problems stem from a complex set of causes, it is difficult to isolate those that arise solely as a result of deficient design standards or as a result of particularly problematic physical conditions. The approach used here considers the range of factors contributing to the problems and provides recommendations to address them.

In the instances where problems may be due almost completely to problematic physical factors or lack of adequate design standards, recommendations are advanced to correct the situation. However, as a result of the field visit, it became clear that such single-source problems are rare, and that a great deal of improvement can be expected by addressing the full range of problem categories.

4.1 TRANSPORTATION DEMANDS

The primary demands on the road system are due to oil and gas development and production activities. Private landowners also use the roads to access their properties; however, this use places far fewer demands on the road system. To support the oil and gas industry, the roads must be adequate to handle vehicles associated with the installation of wells (i.e., drill rigs and support equipment), construction of ancillary facilities surrounding the production sites, installation of pipeline, maintenance of wells and pipelines (including removal of produced water), and other field services. The roads must be passable during all weather conditions, primarily to support oil and gas field maintenance activities, the most demanding of which is arguably the removal of produced water (see Figure 4.1). Field observations indicated that some portion of the roads have not been designed or constructed to adequately meet the current transportation demands.

4.2 ROAD SYSTEM PLANNING

Many of the road-related erosion problems have developed as a result of poor transportation planning. The need for transportation planning is driven by the demand for access to the oil and gas fields. The primary mechanism for implementing road system planning and for developing and approving road designs is the permit process. Approval for road construction is conducted on a case-by-case basis. An overarching scheme of classifying roads on the basis of transportation demand exists, but has generally not been followed in the design and construction of oil and gas field roads in the study area.

Little effort has been made to control the number of roads throughout the study area. Historically, new roads have been constructed, often with the primary objective of taking the shortest distance between two points, without consideration of how existing roads can be used to access the new location. This has resulted in the existence of many redundant roads; that is, roads that only access locations accessible by other roads or that only provide a shortcut. The Farmington Field Office has begun evaluating and closing redundant roads in the past few years.

Figure 4.2, which shows a map of the southwest corner of the Cutter Canyon Quadrangle, illustrates how approximately 10% of the roads in this area, marked by a bold black line, can be eliminated without cutting off access to any facilities or significantly increasing drive times for field personnel. Although this example does not take into consideration all the possible concerns with road closures, it does illustrate that, with some planning, it would be possible to reduce the number of roads in a given area. Reducing the number of both future and existing roads would translate into (1) reduced construction costs, (2) reduced maintenance costs, (3) less potential for road-related erosion problems, and (4) less fragmentation of wildlife habitat.

In addition, little effort has been made to evaluate the use of specific roads to determine that the road design is adequate either for the number of vehicles or vehicle weight. In many instances, road use has evolved over time, resulting in increased traffic volumes; the road itself, however, has not been improved or re-engineered. What was once a temporary road to access a drill pad might now serve as a collector road for multiple production facilities.

The road system planning situation has begun to change over the course of the last few years in the Farmington Field Office with marked improvements and is discussed in the recommendations section. The legacy of not applying standards and developing road designs on a case-by-case basis, however, is clearly one that has resulted in the many roads being inadequately designed and constructed for the existing uses. There appears to be no integrating

Figure 4.1 Water Truck

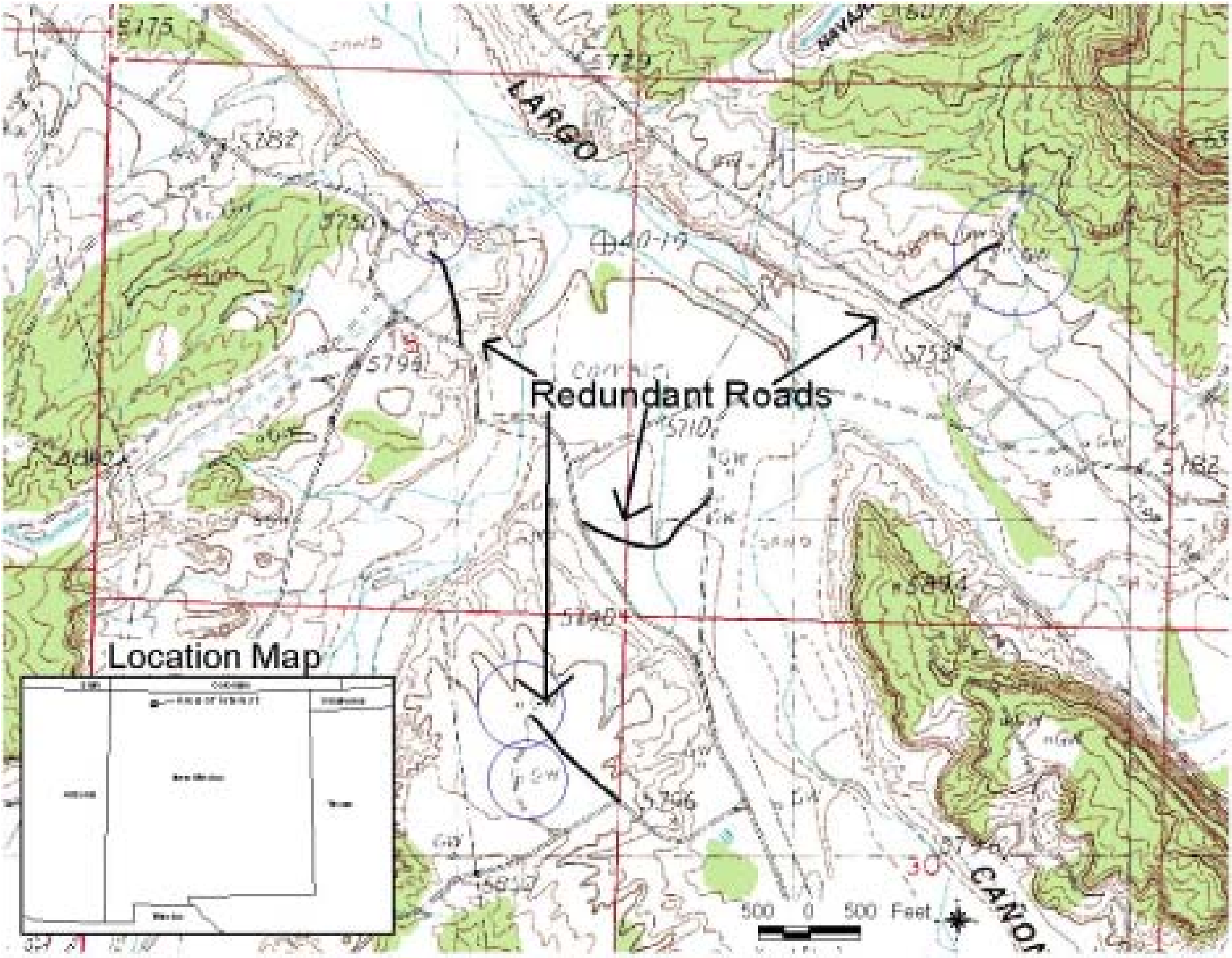

Figure 4.2 Redundant Roads on Cutter Canyon Quadrangle

planning process in the Lindrith area, and one has only recently been initiated in the Farmington area.

4.3 ROUTE PLANNING

Several issues arise as a result of how route planning is conducted for the oil and gas field road system. They include:

- Straight-line routes,
- The use of grades that are too steep for the materials from which the roads are constructed,
- The assimilation of *ad hoc* shortcuts into the road system, and
- Property boundaries that force the route away from the optimum location.

Straight-line routes are used as the shortest paths to potential well sites. The industry's justification for taking the straight-line route is that improved route selection and road design will be implemented if producible quantities of oil or gas are discovered; otherwise, the "temporary" route will be abandoned. Straight-line routes are often cut-through areas that, for numerous reasons, will not support an adequate long-term road. Typically, however, when oil or gas is discovered, the original "temporary" road continues to be used. This makes road maintenance and improvement efforts burdensome because good route selection was not used to anticipate and avoid perennial trouble spots.

Problem areas also develop on road segments where the grade is too steep for the materials with which the road is constructed. An exacerbating factor is that good quality road construction materials are scarce in both the Lindrith and Farmington areas. This problem is particularly acute in the Lindrith area. Consequently, the maximum maintainable grade is constrained by the engineering properties of the locally available materials. When road segments exceed this maximum grade, road erosion is inevitable.

Ad hoc routes are roads that are created in the absence of any design or approval process, frequently as shortcuts. Often, they are straight-line routes that fail to consider relevant constraints, such as grade, soil type, and natural drainage patterns. Over time, the *ad hoc* routes become a part of the permanent road system and are subjected to continued use. By allowing *ad hoc* routes to remain in use and to become part of the road system, the BLM tacitly sanctions the practice of skipping the transportation planning and road design processes and effectively assimilates some of the poorest of all road segments into the road maintenance inventory.

Route planning is frequently dominated by the presence of property boundaries that force the roadway from its optimum location. As a result, routes often run in straight lines regardless of relevant constraints, such as grade, soil type, and natural drainage patterns. Additional efforts should be made to accommodate both property boundaries and improper placement of routes so that future erosion problems can be minimized.

4.4 ROAD DESIGN

As discussed in Section 3, the BLM has existing road design criteria that establish engineering standards for the various types of roads that may be constructed to support oil and gas activities. While these criteria may be supplemented to better address the study area's erosive soils (see Section 5), it is apparent that a significant portion of the road-related erosion problems in this area are the result of a failure to implement the criteria, not a failure of the criteria themselves.

Road design standards exist in the form of the Gold Book (BLM 1989). However, in most instances where problems were observed, it was evident that the Gold Book standards were not used. Examples include:

- Poor route selection (see Section 4.3),
- Grades that are too steep,
- Improper culvert spacing and design (see Figure 4.3),
- Lack of proper use of aggregate on road surfaces,
- Inadequate compaction (see Figure 4.4), and
- Pipelines installed too close to where roads will be graded.

Some of the roads in the study area were constructed before 1989 when the design criteria were published in the Gold Book. Other roads, constructed after 1989, apparently were built without regard to the criteria. Using the existing design criteria to address the problems listed above could minimize road-related erosion.

4.5 ROAD MAINTENANCE AND MONITORING

A significant portion of the road-related erosion problems in the study area are the result of a failure to monitor for problems, implement corrective actions, require routine maintenance of the roads, and ensure that the maintenance activities are appropriate and effective. Many of the erosion problems observed in the field probably could have been mitigated early on to prevent the resulting damage. Also, field observations indicate that where road maintenance has been conducted, it has often been done incorrectly, suggesting a failure by companies to adequately train employees or hire qualified contractors capable of maintaining the roads properly.

Local contractors provide most of the maintenance support for the road system. The contractors are typically unaware of the broader perspective required to maintain a well-functioning road system over the long-term. Maintenance usually is performed to address relatively immediate problems. For instance, grading (flat blading) is performed to smooth the road surface. However, flat blading often results in eliminating the road crown and lowering the entire road surface below the grade of the surrounding land surface (see Figure 4.5). In essence, the entire road becomes a channel for runoff because it is the lowest point on the landscape. Flat blading also often results in the plugging of relief ditches by blading across the mouth of the ditch (see Figure 4.6). Because the graders move relatively quickly along the road, it is

Top left and right – poor drainage design and maintenance.

Bottom left and right – “Shotgun culvert” – Discharge excessive for receiving soil.

Figure 4.3 Failed Culvert and Drainage Design

Figure 4.4 Inadequate Compaction

Figure 4.5 Flat-blading

Figure 4.6 Plugged Drainage

considered inefficient to take the time to avoid plugging the relief ditch or to go back and clear the plugged ditch. Similarly, where performed incorrectly, blading has effectively blocked or otherwise altered adjacent drainage structures, causing them to not function properly.

During wet periods, roads are easily rutted by the heavy vehicles that travel the roads (see Figure 4.7). In addition, low spots tend to act as mud holes and vehicles often become stuck there. These temporary, localized problems typically are addressed by any expedient measure available, usually to the detriment of long-term road quality objectives. Some of the most damaging expediencies include literally dragging the vehicles through the soft spots and blading the low segments of road to remove the soft surface. This only serves to lower the road surface further and cause a greater accumulation of water in the next precipitation event.

Monitoring for road-related erosion problems should be conducted to identify those roads that need to be closed or moved on the basis of their location. Some of the roads within the study area are either so poorly constructed or are located in such unsuitable locations that mitigating and preventing the associated erosion problems may be too expensive or otherwise illogical.

4.6 QUALITY ASSURANCE, IMPLEMENTATION, AND ENFORCEMENT

When road construction details are specified as part of a design and a contract is let to implement the design, there must be some significant measure of quality assurance on the part of the BLM to verify that the design standards have been met. However, during the field visit, it was noted that the BLM cannot make quality assurance a priority because resources are not available to perform the necessary tasks. Therefore, even when good designs are specified, there is no way to follow up to ensure that the design has been implemented properly.

In addition, some of the erosion problems in the study area can be attributed to lack of implementation and enforcement of certain best management practices, including:

- A requirement to replace topsoil on well pads and the shoulders of roads and spread native seed mixtures, and
- A ban on road use when muddy conditions exist.

Figure 4.7 Wet Season Ruts

5 RECOMMENDED SUPPLEMENT TO EXISTING DESIGN STANDARDS AND PROCEDURES

The existing standards defined in the Gold Book could be supplemented in order to improve road conditions in the study area. These supplements can be categorized as general or maintenance related.

5.1 General Supplements to the Gold Book Standards

5.1.1 Apply More Rigorous Culvert Spacing Recommendations

The culvert spacing recommendations in the Gold Book are more lenient compared with guidelines recommended in other publications. For example, recommended culvert spacing as a function of slope is much less for Minnesota (MFRC 2003) and Nebraska (University of Nebraska 2003) forest roads (Table 5.1). In addition, for highly erosive road material, as is the case in New Mexico, Guenther et al. (1997) and the National Resources Conservation Service (NRCS 2003) recommend shorter culvert spacings than are recommended in the Gold Book (Table 5.2). The BLM should consider adopting more rigorous culvert spacing recommendations for the study area.

5.1.2 Limit Slope According to Surface Material

The Gold Book standards should be supplemented to limit the allowable slope of a road in the study area according to the type of material present for natural surface roads or the type of aggregate available for road surfacing. This modification would require developing an algorithm for determining the maximum slope that could be used without causing excessive erosion for a given natural material or aggregate. For example, because aggregate available in the Lindrith area is much finer and more subject to erosion than aggregate available in the Farmington area, maximum slopes for short-term and local roads should be smaller in the Lindrith area than those in the area of Farmington.

5.1.3 Limit Travel on Wet Roads

Under wet conditions, vehicular traffic can produce significant rutting in the road surface, particularly if the vehicles traversing the road are heavy. Unsurfaced roads may be usable only when hard and dry or frozen solid. If roads must be used during wet seasons, they should be appropriately surfaced to reduce damage. If damage is discovered, repair should be made as soon as possible to prevent further damage.

Table 5.1 Comparison of Culvert Spacing Recommendations for Local Roads

Gold Book[a]		Minnesota Upland Forest Roads[b]		Nebraska Forest Roads[c]	
Slope (%)	Recommended Culvert Spacing (ft)	Slope (%)	Recommended Culvert Spacing (ft)	Slope (%)	Recommended Culvert Spacing (ft)
1–2	<1,000	0–2	500	2–5	300–500
2–4	<800	3–4	300	6–10	200–300
4–6	<600	5–7	180	11–15	100–200
6–8	<400	8–10	150	16–20	100
8–10	<250	11–15	130		
		>16	110		

[a] BLM 1989.
[b] MFRC (2003).
[c] University of Nebraska (2003).

Table 5.2 Maximum Recommended Culvert Spacing for Different Soil Types

	Maximum Recommended Culvert Spacing (ft)					
	Road Slope 2–4%		Road Slope 5–8%		Road Slope 9–12%	
Soil Type	Guenther et al. 1997	NRCS 2003	Guenther et al. 1997	NRCS 2003	Guenther et al. 1997	NRCS 2003
Highly erosive granitic or sandy	500	240	350	180	200	140
Intermediate erosive clay or load	700	310	500	260	350	200
Low erosive shale or gravel	900	400	700	325	500	250

Sources: Guenther et al. (1997); NRCS (2003).

5.1.4 Minimize Standing Water on a Road Surface by Using Outsloping or Crowning

Under wet conditions, standing water on a road surface can quickly lead to rutting and deterioration of the road surface. Standing water can be reduced by altering the shape of the road surface. Under low to moderate slopes and low-volume traffic with stable soils, the surface can be outsloped, allowing surface runoff to spread outward and down from the road surface. For flat terrains or steep-sided hills with high volumes of traffic, the road can be crowned, thereby promoting safe drainage of surface water from the road surface.

5.1.5 Stabilize Fill Slopes with Plantings/Revegetation

A common problem on many roadways is erosion of the roadway adjacent to the fill slope. Stabilizing the cut slope by using indigenous plantings reduces the possibility of mass wasting during storm events.

5.1.6 Follow Topographic Contours in Laying Out Roads

Local roads in the study area have been often constructed using a point-to-point design. While this approach minimizes construction costs, unnecessarily steep slopes must often be traversed. By following topographic contours, roads would be subjected to less erosion and would require less maintenance.

5.2 MAINTENANCE ISSUES

Maintenance of short-term and local roads is a key problem for roadways in the Farmington and Lindrith areas. Little attention is given to this topic in the Gold Book; however, best management practice manuals frequently discuss this topic (e.g., University of Nebraska 2003). Some particularly useful concepts are listed below.

- Inspect the road system regularly, including inactive and temporary roads;
- Perform regular maintenance to reduce ruts and holes;
- Maintain crowns and outslopes;
- Inspect and maintain associated ditches, culverts, and relief ditches;
- Avoid creating berms that channel water;
- Avoid cutting the toe of the cut slope to prevent mass wasting;
- Only grade if needed for maintenance;
- Repair problems as soon as possible;
- Schedule additional inspections following heavy or prolonged rainfall to look for drainage and siltation problems; and
- Ensure that maintenance operators have proper training.

6 RECOMMENDED ACTIONS

In areas where the local geology and soils are more conducive to road construction and transportation demands are lower, it is possible to create roads with minimal attention paid to design issues, maintenance practices, and road system management. However, under the demanding circumstances present in the study area, until these issues are fully addressed, the most intransigent environmental mechanisms of erosion cannot be isolated and tackled. The following actions should be undertaken to help reduce the road-related erosion problems occurring within the study area.

Supplement the existing road design criteria with recommendations provided in this report. The design criteria in the Gold Book (BLM 1989) should be supplemented with the recommended changes discussed in Section 5 of this report. These supplemented criteria should be distributed to operators in the study area as quickly as possible.

Implement and enforce the supplemented road design criteria for all new road construction within the study area. Recently constructed roads in the Farmington area have been built using design standards. This practice is resulting in good quality roads (see Figure 6.1). This practice should be continued in the Farmington area and introduced in the Lindrith area. In addition to implementing and enforcing the supplemented road design criteria, the BLM should examine the need for each new proposed road in the context of transportation planning (see below). The BLM should treat selected new projects as trials and establish a plan for evaluating the long-term performance of the new roads.

Continue and expand the Farmington Field Office's road maintenance program. The road maintenance program has successfully produced improvements to both road construction and maintenance activities. It has provided the necessary structure within which the BLM can enforce its standards with maximum cooperation and contribution from the operators. This program should be continued in the Farmington area and either be expanded to include the Lindrith area or replicated in the Albuquerque Field Office. Because of limited resources, perennial trouble spots should be identified, prioritized, and addressed on the basis of priority.

Conduct a resource assessment for the Lindrith area to determine the availability of suitable aggregate materials. To support the petroleum industry's efforts to reduce road-related erosion problems in the Lindrith area, the BLM should determine whether suitable construction materials are locally available. If so, the BLM should consider ways to make these materials available to the operators as has been done in the Farmington area. With very few exceptions, sandstone is not satisfactory as road material. Better sandstone grades are adequate for sub-base but will not hold up to traffic and weather; they are seldom cost-effective to produce, transport, and apply for the purpose of reducing erosion. A proportionately small amount (20%) of crushed hardrock applied over a sandstone base can be effective in protecting the sandstone, holding up to the traffic, and thereby helping to reduce erosion at a lower cost than all-hardrock surfacing. This procedure can be an effective alternative where good quality sandstone is available locally and hardrock has to be imported.

Figure 6.1 Good Road Design

This photo shows an example of the use of good design standards to construct a road. The road surface is crowned and slopes correctly, the alignment follows the natural topography, and the drainage ditches are adequate for the flow they are required to handle.

Identify redundant and problematic roads and implement a road closure program. The BLM should continue and expand upon the efforts of the Farmington Field Office to identify redundant and problematic roads and implement a road closure program. With respect to redundant roads, a study based in part upon the approach discussed in Section 4.2 using aerial photographs should be conducted. To supplement the aerial photograph analysis, a cost/benefit analysis should be conducted to assess the impact of road closures on road maintenance costs, other operator costs (e.g., drive time), sediment load in the watersheds, wildlife habitat fragmentation, and other key values.

Evaluate existing roads to ensure that they are adequate to support existing use. The BLM should evaluate all existing roads to ensure that they are adequate to support existing use. If they are not, the BLM should require that upgrades be implemented.

Develop and implement transportation planning. The Farmington Field Office's road maintenance program has entailed some amount of transportation planning; however, this activity should be formalized with specific goals and methodologies. At a minimum, transportation planning should be conducted to prevent the construction of redundant and problematic roads and to periodically review road use and traffic volumes throughout the study area.

Provide incentives for minimizing damage during wet seasons. The cost burden of repairing roads damaged during unsuitable travel conditions is high. The BLM should attempt to find ways to shift the cost of the repair to the owners of the relatively few vehicles causing the damage. Many of these vehicles are traveling the roads to collect produced water. In conjunction with shifting the repair costs to these users, the BLM should explore other methods for managing the produced water. For instance, the use of centralized collection points could minimize the number of trouble spots to be crossed, and temporarily expanding the capacity for storing produced water could minimize the number of trips needed during the wet season.

Provide training and incentives to contractors to use proper maintenance practices. Periodically, the BLM should provide training sessions for the contractors who maintain the roads. In addition, the BLM should explore ways to build incentives into the contracts to encourage good maintenance practices or establish penalties.

Consider modifying the permit process for road construction to new sites. The BLM should consider establishing a protocol whereby those companies that do not bring access roads up to design standards upon discovery of oil or gas, or do not properly abandon roads in the event of dry holes, are forced to develop and build properly designed initial roads for subsequent exploration road permit requests.

Undertake a wet season road survey. The BLM should undertake a survey to determine the most problematic road segments during the wet season and to determine whether paving or otherwise reinforcing the trouble spots is feasible.

Consider changing the practice of routing pipelines parallel and adjacent to the roads. The BLM should provide access from the roads to only the critical areas where regular pipeline maintenance is required.

7 REFERENCES

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