AADE-11-NTCE-42

Field Site Testing of Low Impact Oil Field Access Roads: Reducing the Environmental Footprint in Desert Ecosystems

Blake Scott, Scott Environmental Services; David Burnett, Texas A&M University

Abstract

Lease roads and well pads are a highly visible and often less than welcome aspect of O&G drilling and producing operations. In South Texas this is occurring as the Cretaceous Eagle Ford shale is being developed from near the Mexican border outward to the east/northeast across several counties stretching more than 150 miles. This "Brush Country", as it is often referred to, is a semi-arid landscape where measures to lessen the impact of developing the shale are fostering a host of new technologies.

To address environmental concerns about the development of the resource, Texas A&M University is adapting "Disappearing Roads" technology to the particular needs of the Eagle Ford. A collaborative project within the Environmentally Friendly Drilling Program has been testing new types of "disappearing roads" in a desert-like environment to measure their effectiveness and ability to lower the surface footprint of surface operations. One road was constructed with materials made with recycled drilling waste. This paper will describe the technology behind the recycled drilling waste road and document its performance in semi-arid rangeland landscapes.

Introduction

While the energy industry is developing better practices to manage its environmental impact, the industry's drilling activity faces restrictions, and in some cases, complete prohibitions of operations in sensitive areas. Environmental constraints, including laws, regulations, and implementation procedures, can limit natural gas development and production on both federal and private lands. More than 30 environmental policy and regulatory impediments to domestic natural gas production have been identified and documented.[1] Surface footprint is one of the more vexing problems that energy developers must face.

Public concerns about the footprint of human activity (ORV tracks and oil and gas operation lease roads) in ecologically sensitive desert locations have resulted in regulatory impediments to E&P activities. At the same time, significant amounts of oil and gas resources remain to be discovered and developed in arid regions of the U.S. This is particularly true of natural gas resources in the Rocky Mountains and the semi-arid Southwest U.S. where there is rapid development of gas shale resources.

Lease roads are a significant component of the impact of drilling and producing operations. If technologies can be developed to reduce the ecological impact of these roads, it may become possible to lessen regulatory impediments to development as well as impacts to sensitive arid landscapes. Constructing roads with materials that can be recycled from drilling waste as native road construction material could serve both environmental and economic objectives. Actions that eliminate or reduce the impacts can help the nation meet its natural gas demands.

Potential Impacts

There are two potential impacts that could result from this research. First, if the research shows that low impact roads can provide the same degree of safety, usage performance, and environmental performance as conventional roads, use of these roads could lead to overall reduced environmental impact, which in turn could lead to increased resource development. Studies have demonstrated that removing environmental concerns (and thus restrictions) to E&P operations can boost recoverable gas resources (perhaps by trillions of cubic feet). A second impact could result if the low impact roads are also less expensive to construct and maintain. Reduced operating costs could also lead to increased production. Any technology or practice that reduces the cost of operations will increase reserves and increase production. A $1/BOE ($170/MMcf) decrease in operating cost for a producing field can add 1% to its reserves[2]. For a true cost comparison, the life-cycle cost of building new lease roads conventionally and disposing of the drilling waste must be taken into account versus the life-cycle cost of building lease roads with recycled drilling waste.

Technology of Recycling Drilling Wastes – Converting Drilling Wastes into Road Bed Material

In 2005, the Railroad Commission of Texas (RRC) issued the Guidelines for Processing Minor Permits Associated with Statewide Rule 8, or *Guidelines Developed by Environmental Surface Waste Management in Coordination with Field Operations*. That document outlines the environmental specifications for drilling waste materials intended for use in road construction, including limits on total petroleum hydrocarbons (TPH), total organic halides (TOX), and electrical conductivity (EC), as well as analytical standards for the Toxicity Characteristic Leaching Procedure (TCLP) test for organics, metals and pH. These requirements would govern the development and testing of the proposed low impact roads. However, the RRC document did not address the physical requirements for constructing a road from oil and gas waste such as unconfined compressive strength and permeability.

Since then new waste treatment and disposal practices have been developed to convert drilling muds and associated cuttings to beneficial and environmentally friendly road base material to help minimize E&P operator liability. This includes guidance for chemical leaching and physical properties of the recycled material. Also, through Texas A&M University, a test facility has been used to evaluate these materials under field conditions and in an environmentally safe manner.

Description of Project – Installation in the West Texas Desert

The Texas A&M University Desert Test Center http://www.pecosrtc.org/ near Pecos, Texas on the edge of the Chihuahua desert, was chosen to evaluate a road built from recycled drilling waste. The drilling waste was fresh water mud and cuttings (FWMC) from south Texas. The Texas Transportation Institute Pavement and Materials (TTI) (Subgroup, Division?) manages this site, and their personnel assisted with the project. (http://tti.tamu.edu/research_areas/topic.htm?p_tid=5).

FIGURE 1 AND 1A shows an aerial view of the site and the site where road placement occurred.

Construction of Spine Road using Recycled Material

The recycled roadway was built by Scott Environmental Services, Inc. (SESI), using its proprietary process for the reuse of drilling waste. The project started with material taken from a FWMC reserve pit and mixed with a plasticity reducing agent (PRA), using a large excavator bucket. The amount of PRA used had been previously determined by laboratory test to be (i) sufficient to make the mixture, unlike the starting material, easily transportable by truck without loss from sloshing; and (ii) not sufficient to cause the mixture to harden into a monolithic structure.

The material was trucked to the site and used as road base for construction of the model lease road. A cross section of the road design is shown in FIGURE 2. The design was planned for a multi-season “spine road” that would serve as access to the field and serve as a high-use local or rural road. A test section of *in situ* soil approximately 170 feet long x 14 feet wide (FIGURE 3 AND 3A) was readied as the test site. Work began by watering, scarifying, and compacting the *in situ* soil using a water truck, grader, compactor, and roller to form the road subgrade. Then a single lift of plasticity-reduced material (PRM) and some water was placed on top of the prepared subgrade in sufficient quantity to have 10 inches of thickness after compaction, and the lift of material was smoothed, shaped, and compacted using the water truck, loader, grader, compactor and roller. Next, a pre-determined amount of Portland cement was spread over the prepared PRM by the cement truck, and then the cement and the PRM were mixed with the reclaimer and grader to a depth of 12 inches, and then compacted.

Water was then sprayed from the water truck over the mixture in an amount to achieve optimum moisture content, as determined by previous laboratory testing, and the wet mixture was again mixed using the reclaimer. After that, all of the emplaced materials were compacted, then bladed and shaped to get a uniform mixture again, with additional water added as needed.

Construction, as described above, was successfully accomplished in one day, although strength gain in the material continued for several days. FIGURE 4 shows the strength gain of the material in place. A photograph of the completed road is shown in FIGURE 5. The PRM was sampled at several instances during the placement, and a composite sample was formed from these samples and sent for evaluation to a geotechnical testing laboratory, where it was mixed with the percentage of cement used and with an amount of water determined to yield a maximum density mold, then aged for seven days while being maintained moist. After completion of aging, the compressive strength and dielectric properties were obtained by standard tests.

Description of Project – Monitoring Performance

Durability of Road

The hybrid lease road was used for traffic going to and coming from the field office at the Pecos facility. During the latter part of 2009 and the beginning of 2010, traffic levels ranged from 5 to 25 vehicle passages per day. During the summer of 2010, the site operator removed an overpass being used for inbound traffic and for a short time diverted trucks and automobiles across the road. In the fall of 2010, most traffic ceased across the road as a new entrance road was constructed.

Use of the recycled road bed during part of 2009 and 2010 did not appear to affect it.

Strength of Road

Road strength was measured by a number of standard tests used in civil engineering. The drilling waste used for road base material is similar in nature to other types of granular stabilized materials used for highway construction so the materials were measured in the laboratory using (1) Sieve Analysis, (2) Atterberg Limits, (3) Optimum Moisture Curve, and (4) Unconfined Compressive Strength. These are tests commonly used in Texas to characterize roadway base materials and for the latter two tests, completed roads; these tests provide an indication of the expected performance characteristics of the recycled materials. FIGURE 4 (UCS) shows strength values of the material. Tested before and after one year in the desert, the road base performed well.

Environmental Impact on Soils

One of the standard requirements of a road base of recycled oil field waste is that there are no hazardous materials leaching from the stabilized rock bed. To affirm that the material was stable, a set of samples of the adjacent soil was taken at the outset of the year-long test, then again after approximately 13 months. TABLE 1 contains the early and late time data. Very little difference in the total concentration of metals was observed – slight differences were judged to be within experimental error. TABLE 2 shows the comparison of untreated material total concentrations of constituents and the leachate of the finally treated material constituents. Finally, FIGURE 6 shows the dielectric values for the material after a ten-day soak. The dielectric values of the treated material are consistent with concrete which indicate that the material has very low hydraulic conductivity. In other words, the material allows very little water movement which reduces leaching of constituents of concern.

Figures and Tables

Figure 1 is an aerial view of Pecos Desert Test Center, located approximately 80 miles SW of the Midland Odessa TX airport.

Figure 1a shows the location of the planned test roads. Yuccas and agaves, growing with grasses and often Creosote Bushes, give this desert its characteristic appearance.

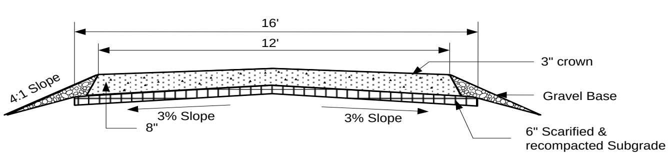

Figure 2 is a cross section schematic of the road bed, designed with a crown.

Figure 3 represents a site view ready for road construction. The area was cleared with a brush hog, but not graded. The entrance ramp to the test facility is shown in the background.

Figure 3a shows the road material being placed on the prepared base. The entire construction of the road required less than 8 hours.

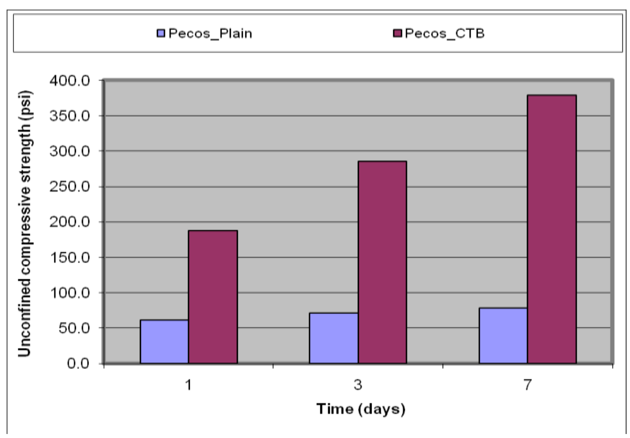

Figure 4 shows a comparison of the strength of materials as a function of time.

Figure 5 shows the completed SESI road. The segment of the road was laid out in such manner as to join the two other types of road and offer an alternate route to the offices to the staff at the test center.

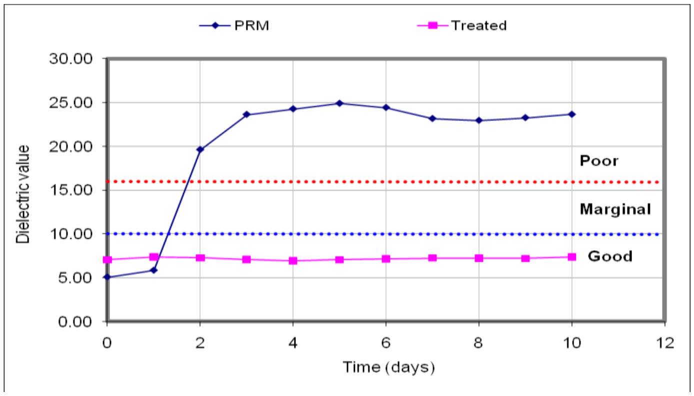

Figure 6 depicts three types of materials and provides a comparions of treated with PRM

	Metal Concentration, ppb							
	Date Samples Taken: July 15, 2009							
ID	Ba	Ag	Se	As	Pb	Hg	Cr	Cd
#1	316.1	96.88	34.44	4.283	2.343	0.344	47.12	29.29
#2	61.63	129.6	31.39	6.085	8.968	0.285	58.2	31.01
#3	106.1	40	31.61	1.014	7.974	0.47	62.93	31.84
#4	125.9	61.19	24.22	5.098	11.29	0.178	65.57	28.45
#5	107	11.67	32.18	4.434	5.764	0.325	66.87	40.94
#6	45.1	31.44	32.98	6.538	8.672	0.042	69.63	32.08
Avg	126.9	61.8	31.14	4.58	7.50	0.21	61.72	32.27
	Date Samples Taken: October 7, 2010							
ID	Ba	Ag	Se	As	Pb	Hg	Cr	Cd
#1	310.1	88.88	30.23	4.673	2.711	NDA	NDA	NDA
#2	60	133	23.99	5.085	8.678	NDA	NDA	NDA
#3	106.5	44.4	41.22	2.104	8.33	NDA	NDA	NDA
#4	120.9	53.99	55.68	6.67	9.98	NDA	NDA	NDA
#5	103.3	13.11	31.11	4.33	5.77	NDA	NDA	NDA
#6	50.7	55.6	31.88	5.80	8.090	0.01	NDA	NDA
Avg	125.2	64.83	35.69	4.78	7.10	0.01		

Table 1compares results of 6 sample sites showing trace analysis after an extended time period. There has been no leaching of materials from the road base material.

TABLE 2: COMPARISON OF UNTREATED MATERIAL AND FINALLY TREATED MATERIAL		
TESTED CHARACTERISTIC	ANALYTICAL VALUE FOR:	
	Untreated Material	Finally Treated Material
pH value, standard units	Not measured	11.9
Note: All of the following measurements are in milligrams per kilogram on a dry basis for the untreated material and in milligrams per liter of leachate for finally material.		
Arsenic	81.7	2.04×10^{-4}
Barium	8449	3.5×10^{-2}
Cadmium	1.16	5.88×10^{-5}
Chromium	269	2.49×10^{-2}
Lead	460	5.88×10^{-5}
Mercury	3.03	2.0×10^{-4}
Selenium	Not detected	2.3×10^{-4}
Silver	0.595	5.88×10^{-5}
Total C_{6-36} Petroleum Hydrocarbons	4880	7.70
Chloride*	2120	166
*Water soluble only for Untreated Material		

Conclusions

It is clear from **Tables 1 and 2** that the pollution potential from heavy metals and petroleum hydrocarbons has been reduced by orders of magnitude by the final treatment. It is also clear from **Figures 4 and 6** that the geotechnical properties of the final material are excellent for construction base for use on lease roads, drilling pads, tank battery locations, and compressor stations. The road base material made from recycled well material using this proprietary process performed well, exceeding expectations in every category. Finally, long term exposure of the road base material to the elements showed no discernable trace of any leachate material coming from the product.

Acknowledgements

This project could not have been performed without the support of its sponsors. Thanks are given to the Research Partnership to Secure Energy for America (RPSEA). Sponsor Scott Environmental Services, Inc., Longview, Texas, supplied and installed the recycled road made from drilling waste. Special thanks are given to Halliburton for its sponsorship of the Disappearing Road competition.

References

1. Young, W.T. Development of the Paradox Reservoir in the Four Corners Area, SPE paper 1011-G 1958 SPE
2. Theodori, G.L. 2008. “Public Perception of Perception of the Natural Gas Industry: Insights from Two Barnett Shale Counties,” SPE 115917. Proceeding of the 2008 Society of Petroleum Engineers Annual Technical Conference and Exhibition. Richardson, TX:
3. Jalkotzy, M.G., P.I. Ross, and M.D. Nasserden. 1997. The effects of linear developments on wildlife: a review of selected scientific literature. Prep. For Canadian Association of Petroleum Producers. Arc Wildlife Services Ltd., Calgary. 115pp.
4. [1]Elcock, Deborah: ‘Environmental Policy and Regulatory Constraints to Natural Gas Production,’ ANL/EAD/04-1, Argonne National Laboratory, December 2004.
5. https://sites.google.com/a/pe.tamu.edu/low-impact-access/Home/
6. Haut, R.C., Burnett, D.B., Williams, T.E., Environmentally Friendly Production of Unconventional Natural Gas Resources, 2007
7. Burnett, D. B., Yu, Ok-Youn, Schubert, J. J. SPE, Texas A&M University Well Design for Environmentally Friendly Drilling Systems: Using a Graduate Student Drilling Class Team Challenge to Identify Options for Reducing Impacts SPE/IADC 119297 presented at the SPE/IADC Drilling Conference and Exhibition held in Amsterdam, The Netherlands, 17–19 March 2009[1] Interactions Between Ungulates and Winter Gas Well Drilling Operations. Environmental Planning and Management, Mobil Oil Canada Ltd. 1979.
8. Haut, R.C., Burnett, D. B., Rogers, J. L., Williams, T. E. “Determining Environmental Tradeoffs Associated with Low Impact Drilling Systems,” SPE Paper 114592 presented at the Annual Technical Conference and Exhibit, Denver, 2008.
9. https://sites.google.com/a/pe.tamu.edu/low-impact-access/Home/low-impact-access-roads-demonstration
10. Rosentreter, R., Bowker, M., Belnap ,J., Lange, O. L., Biological Soil Crusts. Structure, Function, and Management, **USGS Canyonlands Research Station,** Moab, UT 84532
11. Series: Ecological Studies, ,Springer Series,Vol. 150 1st ed. 2001.,
12. Iverson, R.M., B.S. Hinckley, and R.M. Webb. 1981. Physical effects of vehicular disturbances on arid landscapes. Science. 212:915-917
13. Cornwell, J.R., Road Mixing Sand Produced From Steam drive Operations 25930 SPE/EPA Exploration and Production Environmental Conference, 7-10 March 1993, San Antonio, Texas
14. Page, P., W., Greaves, C., Lawson, R., Hayes, Sean, B., M.M., “The Options for Recycling Drill Cuttings,” paper SPE80583 presented at the SPE Exploration and Production Conference, 2003
15. http://www.trcr.bc.ca/index.htm
16. http://www.compositemats.comhttps://sites.google.com/a/pe.tamu.edu/disappearing-roads-competition/