DEMONSTRATION OF NORTH DAKOTA LIGNITE FLY ASH IN HAULROAD CONSTRUCTION

Submitted to:

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North Dakota Industrial Commission
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Funds Requested from NDIC: $59,426

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ABSTRACT

The Falkirk Mining Company (FALKIRK), a subsidiary of The North American Coal Corporation, was established, as a mining entity for Coal Creek Station (CCS) Lignite. FALKIRK proposes to perform a demonstration of the use of CCS fly ash in haulroad subgrade and subcut construction in conjunction with Great River Energy (GRE) and ENROCK, Inc. The project will take place at a site located within the Falkirk Mine near Underwood, North Dakota. The primary goal of this effort is to demonstrate the engineering performance of Lignite fly ash used to enhance the engineering performance of natural spoils and/or subsoil in the construction of an improved haulroad subgrade and subcut.

A section of haulroad subgrade and subcut will be constructed using a blend of CCS fly ash and spoils/subsoil while the remaining haulroad subgrade and subcut will be constructed using only spoils/subsoil (See Figure 1in Appendix E). Conventional construction techniques will be used for the placement of all of the haulroad subgrade and subcut. The haulroad will be surfaced with gravel following subgrade construction. This project provides an excellent opportunity to monitor the performance of the fly ash modified haulroad subgrade and subcut and to compare its performance to that of a conventional haulroad subgrade and subcut constructed at the same site with natural spoils and/or subsoil. ENROCK, Inc. of West Fargo, North Dakota, has agreed to assist in the design of the CCS fly ash blend(s) to be utilized in the construction of the proposed demonstration. In order to accomplish this demonstration, FALKIRK is requesting support from the Industrial Commission of North Dakota and GRE. The total project cost is estimated at $118,852.

With funding from the Industrial Commission of North Dakota and GRE, FALKIRK, proposes: 1) to have GRE provide the fly ash to the site at no cost; 2) to retain the services of ENROCK to provide technical assistance during the design and placement of the fly ash haulroad subgrade and subcut; 3) to conduct appropriate performance monitoring, through ENROCK and Midwest Testing (MT); 4) to have ENROCK assist GRE and ISG Resources of Kennesaw, Georgia (ISG) in developing a promotional activity to inform

local counties about fly ash utilization in road subgrade and subcut construction; and 5) prepare a final report on the overall project. A technical project team consisting of FALKIRK, GRE, ENROCK, ISG and MT will collaborate during the design, construction and monitoring activities.

It is anticipated that the fly ash blend haulroad subgrade and subcut will exhibit performance superior to the unblended haulroad subgrade and subcut. Promotion of this activity is expected to provide appropriate information to government and industry representatives that will facilitate incorporation of Lignite fly ash in future road subgrade and subcut construction projects both within the North Dakota Lignite Mines and in public works. This latter promotion will enable states, counties and cities to develop long lasting and superior road subgrades and subcuts at a reasonable cost. Utilization of Lignite fly ash has positive economic and environmental implications for the North Dakota Lignite and utility industries.

DEMONSTRATION OF NORTH DAKOTA LIGNITE FLY ASH IN HAULROAD CONSTRUCTION

1.0 PROJECT SUMMARY

FALKIRK proposes to demonstrate the use of CCS fly ash in a haulroad subgrade and subcut construction project at The Falkirk Mine near Underwood, North Dakota. The primary goal of this effort is to demonstrate the engineering performance of CCS fly ash in the construction of haulroad subgrade and subcut. CCS fly ash will be used in conjunction with spoils and/or subsoil in the haulroad subgrade and subcut construction at the site. A section of haulroad subgrade and subcut will be constructed using CCS fly ash blended with spoils and/or subsoil while the remaining haulroad subgrade and subcut will be constructed using conventional spoils and/or subsoil. Construction techniques will be the same for the entire haulroad subgrade and subcut placed. The haulroad will be surfaced with gravel following subgrade construction. This construction provides an excellent opportunity to monitor the performance of the fly ash haulroad subgrade and subcut and compare it to the performance of a conventional haulroad subgrade and subcut constructed at the same site with natural soils.

ENROCK of West Fargo, North Dakota, and MT of Bismarck, North Dakota, have been retained to assist in the development of CCS fly ash and soil blends for use in the construction and monitoring for the proposed demonstration. With funding from the Industrial Commission of North Dakota and GRE, FALKIRK proposes to: 1) have GRE and ISG provide the fly ash to the site; 2) to provide technical assistance through ENROCK and MT during the design and placement of the fly ash; 3) to conduct appropriate performance monitoring, through ENROCK and MT, for the haulroad in 1999 and 2000; 4) develop a promotional activity in conjunction with GRE and ISG to inform local cities, counties and state agencies about fly ash utilization in road subgrade and subcut construction; and 5) issue a final report on the construction and suitability of the roadway.

2.0 BACKGROUND

Coal combustion fly ash is an underutilized resource in the United States (ACAA, 1997) and in North Dakota (Bryggman and Nallick, 1993) despite the fact that fly ash has been shown to have characteristics suitable for utilization in numerous applications, including use as a soil amendment. North Dakota Lignite fly ash was included in an evaluation of the utilization potential of Lignite ash resources performed by the Energy & Environmental Research Center (Pflughoeft-Hassett, et al, 1996) with funding from the Industrial Commission of North Dakota, Cooperative Power Association, and the Department of Energy. Results of that project indicated potential for Lignite fly ash to be useful in road subgrade and subcut construction applications.

The fly ash produced at the CCS is a "Class C" fly ash as specified by ASTM C618. It is known to have excellent pozzolanic and hydraulic properties, and, in fact, large amounts of this fly ash are sold in the concrete market as a cement replacement. Since the soil at the mine site is expected to have a high clay content, it is expected that fly ash can be used to stabilize the haulroad subgrade and subcut.

Several companies have been successful in demonstrating the use of Class C fly ash in several projects in the United States. The fly ash was used to stabilize surface soils for a variety of purposes, including construction of the Denver International Airport (DIA). A project in McLean County in 1991 involved the use of CCS fly ash for a road surface on a county road. Overall the project was a mild success. Complications in the construction techniques caused a very rough surface, therefore, this project will focus only on the road subgrade and subcut. The Coteau mine has successfully utilized fly ash for haul road construction. The type of fly ash available to Coteau has limited their use due to its longer set time. Fly ash reportedly performed as well as traditional soil enhancement materials such as lime and cement in all projects. FALKIRK and EN-ROCK, have identified this opportunity to demonstrate the use of CCS fly ash in a haulroad subgrade and subcut construction project as a way to enhance the use of fly ash in mining, county and state road construction.

Subgrade and subcut enhancement was one of the utilization applications identified in the work performed by the EERC and funded jointly by the Industrial Commission of North Dakota and Cooperative Power, for use of fly ash in a high volume application. A full-scale demonstration will provide the technical

information and experience that can be transferred to engineers and contractors to facilitate marketing of Lignite fly ash for subgrade and subcut stabilization. Road building is a key market for high volume use of fly ash materials, so the proposed demonstration is anticipated to have broad implications for marketing CCS fly ash and other Lignite fly ash. The use of fly ash for the construction of road subgrade and subcut can result in significant cost savings, allowing for more construction to be done with the available tax dollars.

This project will be performed as a joint venture between FALKIRK, ENROCK, GRE and MT. ENROCK will be primarily responsible for working with MT in conducting the laboratory and field testing programs to develop and utilize soil stabilization mixtures for the construction activity. These mixtures will contain 5-15% fly ash exhibiting sufficient strength and durability so that the haulroad will have an expected service life of 20 years or more. The funding for a portion of the project is to be provided by the NDIC.

3.0 PROJECT DESCRIPTION

3.1 Introduction

Coal combustion fly ash is one of the high volume coal combustion byproducts that is currently underutilized in the United States and in North Dakota. As indicated in a Department of Energy Report to Congress (U.S. DOE, 1996), coal combustion byproducts are frequently not considered for use by government and commercial entities because of the lack of technical and engineering data on specific utilization applications. Demonstration projects have been identified as a primary means of providing the required information and also to provide an opportunity for hands on experience by contractors and government agency representatives. The projects completed by McLean County and the Coteau mine were successful, but not well documented for use by others. A full-fledged demonstration of Lignite fly ash use in haulroad subgrade and subcut construction is proposed to accomplish these things in North Dakota and facilitate additional market development for this valuable North Dakota resource.

3.2 Goals and Objectives

The primary goal of this Project is to demonstrate the technical performance of CCS fly ash in the construction of haulroad subgrade and subcut utilizing construction techniques typical for road building. Supporting objectives can be summarized as follows:

- Provide experience in using fly ash for soil enhancement with the demonstration;
- Provide technical data for educating contractors and engineers on the benefits of utilizing fly ash in road subgrade and subcut construction;
- Provide counties and local entities with a low cost method for enhanced road construction;

3.3 Methodology

The following sections detail the proposed work plan to achieve the stated goals and objectives of this effort. It is important to note that the proposed work and schedule will be coordinated between FALKIRK, ENROCK and MT. This team is responsible for designing the site and overseeing the site construction. The team has developed the following tasks for completion of the testing, design, construction, promotion and development of the project.

Task 1: Laboratory Testing and Design Activities

Work for Task 1 will commence immediately upon approval of funding. Two subtasks will be performed:

Subtask 1: Laboratory Mix Designs

Representative soil samples from The Falkirk Mine will be supplied to MT along with samples of GRE fly ash. Requested test data on a variety of CCS fly ash and soils will be supplied by MT and reported to FALKIRK and ENROCK. This data is expected to encompass all normal soil tests including tri-axial strength, compaction tests, and density testing. The results of these tests will lead to the determination of 2 or 3 optimum mixes to be field-tested. If additional tests are required, FALKIRK will contract to have these tests performed and reported to the project team.

The fly ash used for this research project will be generated at GRE's Coal Creek Power Plant located in Underwood, North Dakota. The fly ash is produced from a pulverized coal boiler, burning North Dakota lignite produced by The Falkirk Mining Company. The typical results of selected chemical and physical analyses performed on CCS fly ash are listed in Table 1, Appendix D.

Soil samples will be collected for testing from various locations near the haulroad site to determine the amount of fly ash needed to stabilize the soils. It is expected that the soil samples near the road site will contain significant amounts of clay with some amount of sand and gravel. For this reason, fly ash addition is the preferred method of stabilizing these soils. These samples will be subjected to sieve and hydrometer analyses and classified according to ASTM D2487.

The fly ash-stabilized soil mixtures tested in the laboratory for the haulroad construction task will be prepared following ASTM D3551. The optimum moisture content and maximum compacted density of each mixture will be determined using ASTM D1557. Specimens for unconfined compressive strength tests will be prepared by compacting the mixtures into 4-inch-diameter by 4.5-inch-long cylindrical molds at their optimum moisture contents and tested using a modified Proctor compactive effort.

The specimens will be cured for either 7 or 14 days at 100°F. Initially a 7-day curing period will be used, but may be changed to a 14-day period after the first set of samples is tested. The curing time for fly ash mixes is typically increased to allow the specimens more time to gain strength. After curing, the cylinders will be treated with a vacuum saturation procedure to simulate weathering stresses and then tested for residual unconfined compressive strength following ASTM C593. The general design criteria for acceptance of a specific stabilized soil mixture is that it display a minimum unconfined compressive strength of approximately150 psi after vacuum saturation treatment.

To determine the optimum strength of these samples, the fly ash content will gradually be raised. By repeated testing, the required percentage will be determined to achieve a compressive strength approximating 150 psi, the anticipated fly ash content should be between 5% and 15%. Based upon the results of the stabilization tests described above, appropriate fly ash addition levels will be selected for the haulroad construction site.

The various ASTM methods used to characterize the soil samples to evaluate the stabilized soil mixtures are listed in Table 2, Appendix D.

Subtask 2: Haulroad Subgrade and subcut Design

FALKIRK will work with ENROCK and MT to determine the appropriate methods to construct the field demonstration based upon the laboratory mixes. FALKIRK staff will perform the actual haulroad subgrade and subcut design and develop the construction costs of this project.

Task 2: Construction Activities

Work for Task 2 will commence immediately upon completion of the mix designs to be demonstrated in the field. Three subtasks will be performed:

Subtask 1: Pre- and Post-Construction Technical Support

Representatives of the FALKIRK project team will communicate with ENROCK on a regular basis to provide available technical information on the specific site for the haulroad subgrade and subcut construction. The specific construction methods and equipment needs will be determined by the team at this stage of the project. The construction schedule will be determined by the needs of the FALKIRK representatives based upon their need for a haulroad to be constructed to the mining area.

Subtask 2: Provide CCS Fly Ash to the Site

FALKIRK will work with GRE and ISG to provide the appropriate amount of CCS fly ash to the site on a schedule to be determined by GRE, ISG and FALKIRK.

Subtask 3: Construction Technical Support

ENROCK and MT will provide technical support at the time of the haulroad subgrade and subcut construction. Mr. Andrew Stewart of ENROCK will be present on the construction site at the time of fly ash haulroad subgrade and subcut construction to offer technical advice and input to the FALKIRK construction crew. He will be available to ensure appropriate sampling is performed using approved procedures. Mr. Stewart and FALKIRK team members will document the fly ash haulroad subgrade and subcut construction with photographs and/or videotape. This documentation may be used by ISG in the Task 5 promotional

activity. MT will also be present during the entire construction procedure to perform the necessary field sampling.

Construction of the road is expected to be performed in the following steps:

1. A tractor scraper will be used to place the soil on the roadbed. The soil will then be windrowed with a blade and stockpiled on the haulroad.
2. Fly ash will be transported from the CCS to the construction site in trucks and spread evenly down the center of the excavated roadbed.
3. The stockpiled soil will then be spread evenly over the fly ash, the amount of water required will be determined through testing of the soils and matching their water content to that of the laboratory optimum. The fly ash and soil will be mixed using a set of disks pulled by a tractor.
4. When the fly ash and water are thoroughly mixed with the soil, it will be respread and compacted with a sheepsfoot roller.
5. After compaction, a grader will be used to shape the crown to meet the specified slope.
6. After the road has been allowed to cure the gravel surface will be placed and the haulroad opened to traffic.

The haulroad test sections will be constructed in 300-500 foot intervals. Figure 1, Appendix E, illustrates the typical cross-section utilized in constructing the haulroad.

Task 3: Performance Monitoring

Determination of the performance of the fly ash haulroad subgrade and subcut will be accomplished through field sampling and laboratory testing of the collected samples. MT of Bismarck, North Dakota will perform this testing. Sampling will be performed during construction, in the Fall 1999 and Spring 2000 in an effort to evaluate the performance relative to both time and freeze-thaw cycles. Samples will be collected by coring at locations in the fly ash haulroad subgrade and subcut and at locations in the standard haulroad subgrade and subcut. These samples will then be subjected to standard tests for appropriate performance parameters. These are expected to include: hydraulic conductivity, strength, and density. Additional tests may be performed based on requests from ENROCK or FALKIRK. The test procedures used will be standard

tests and the procedures will be documented. A comprehensive report of the test data will be prepared and included in reports to the Industrial Commission of North Dakota and GRE. This data will also be instrumental in developing the promotional activity in Task 5.

Task 4: Cost Analysis

Construction data and cost information supplied by FALKIRK will be used to estimate the cost savings resulting from using fly ash to stabilize the haulroad soils. Savings will be estimated by comparing the actual construction costs to calculated costs for not stabilizing the soil and the subsequent rebuilding costs. The calculations will be based on the actual purchase costs of fly ash so that the true cost incurred by an outside entity can be determined.

Task 5: Promotion and Reporting

The Task 5 activities will be performed in two subtasks:

Subtask 1: Development of a Promotional Activity

EN-ROCK will develop a promotional activity in conjunction with ISG, to be utilized by GRE and ISG, to familiarize governmental and industrial representatives with the demonstration project. It is anticipated that this activity will be held at the construction site. The promotional activity will focus on the technical aspects of the demonstration to provide basic information that is required by engineers and others in specifying materials for construction projects. Technical data developed in the project will be presented. Photographic and/or videotape documentation developed in Task 2 will be incorporated into the activity. Additionally, EN-ROCK and ISG anticipate inviting representatives from FALKIRK to share their hands on experiences with participants in an informal program. Information from the promotional activity will also be collected and made available to interested parties not in attendance.

Subtask 2: Reporting

ENROCK will prepare and submit two project progress reports and a final report for the proposed project. The progress reports will be prepared in months 6 and 12 of the project and will report activities and results for the six-month period prior to submittal of the progress report. A comprehensive final report will

be prepared and submitted to project sponsors on completion of the project in month 18. FALKIRK project team members will contribute to all reports as appropriate to their role in the project.

4.0 STANDARDS OF SUCCESS

The standards of success for this effort include: 1) successful construction of haulroad subgrade and subcut with CCS fly ash; 2) development of performance monitoring data on the haulroad subgrade and subcut with fly ash and comparative data for standard haulroad subgrade and subcut; 3) cost analysis for the fly ash soil/spoils mixture versus standard soil and spoils placement; 4) development and accomplishment of appropriate promotional activities for North Dakota state, county and city officials; and 5) issue a final report on the construction and suitability of the roadway. These standards will be discussed in a comprehensive final report of all activities performed in this effort.

5.0 QUALIFICATIONS

Mr. Dave Kaufman will act as Project Manager and Principal Investigator for this effort. Mr. Kaufman is a mining engineer at The Falkirk Mine, responsible for all aspects of road construction, including agency coordination for special projects such as the Riverdale Haul Road Grade Separation – Lignite Ash Demonstration Project. Mr. Kaufman has been employed in the mining industry for 26 years.

The ENROCK portion of the project will be managed and coordinated by Mr. Andrew Stewart. Mr. Stewart will also be responsible for aspects of the project dealing with disposal costs, CCB characteristics and solid waste regulations. Mr. Stewart has degrees in Chemistry and Civil Engineering and is a registered professional engineer in North Dakota and Minnesota. He is currently in charge of technical services for ENROCK. He has over 20 years of experience in the engineering and construction fields, with 17 years at Cooperative Power, with responsibility for engineering services and by-products at Coal Creek Station. He is the immediate past chairman of the board of the American Coal Ash Association and was recently named as an honorary member of the European Association for Use of the By-Products of Coal-Fired Power Stations. Mr. Stewart is very involved in all aspects of by-product utilization and testing.

Mr. Mark Flaagan of ENROCK has experience in materials marketing and transportation. Mr. Flaagan is the President of EN-ROCK, Incorporated and has developed marketing plans and performed economic evaluations for both fly ash and other North Dakota Lignite byproducts. He has developed basic technical knowledge of fly ash utilization and has played an active role in promotional activities for a variety of products. Mr. Flaagan has worked with the agricultural, manufacturing and construction industries in North Dakota and surrounding states and has extensive contacts in these industries.

Resumes for all of the key participants in this project are included in Appendix A.

6.0 VALUE TO NORTH DAKOTA

The primary benefits to North Dakota are expected to be realized from accomplishment of this demonstration project:

- Savings to the Lignite mining industry through the construction of haulroads that do not require reconstruction due to premature failure.
- Savings to local governmental entities through the construction of road subgrades and subcuts that are more durable and long lasting.
- Increased utilization of Lignite fly ash will reduce disposal of Lignite byproducts, which has a direct economic benefit to Lignite-fired utilities and the Lignite industry.
- Environmental benefits are also expected to be realized from reduced disposal because of the resulting potential for improved land use. Further environmental benefits are derived from the beneficial use of a North Dakota by-product in lieu of a manufactured material such as cement or lime.

While the outcome of the proposed demonstration effort is not definitive, FALKIRK, ENROCK and GRE are committed to maximizing economic and environmental benefits for North Dakota. As such, they have chosen to partner with the Industrial Commission of North Dakota in this effort because of a demonstrated commitment to by-product research and development.

7.0 MANAGEMENT

The proposed project will be managed and coordinated by Mr. Dave Kaufman who will serve as the contact point for the Industrial Commission of North Dakota, ENROCK and GRE.

8.0 TIMETABLE

Table 3, Appendix D, lists the timetable for the proposed project. The target date for initiation of the effort is July 1, 1999. The overall period of performance is eighteen (18) months, so the completion date is projected to be December 31, 2000. Progress reports are scheduled for submission in project months 6 (December 31, 1999) and 12 (June 30, 2000). Submission of the final report is scheduled for December 31, 2000.

9.0 BUDGET

A budget detailing the costs associated with this proposed effort is included in Appendix B. The total project cost is estimated to be $118,852. GRE and ISG have agreed to provide a total contribution of 1,454 tons of fly ash for this effort, totaling a value of $27,626 of in-kind contribution. FALKIRK, will provide $31,800 in-kind contribution for personnel and materials handling. FALKIRK is requesting an additional $59,426 from the Industrial Commission of North Dakota through the Lignite Research Council.

MT and ENROCK (see Appendix B) have included budget estimates for their respective tasks. Falkirk has included cost breakdowns for all of the construction and testing in Appendix B. An affidavit stating that The Falkirk Mining Company does not have an outstanding tax liability owed to the state of North Dakota or any of its political subdivisions is also included in Appendix C.

10.0 REFERENCES

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