NORTH DAKOTA STATE UNIVERSITY

APPLICATION TRANSMITTAL

SPONSOR ORGANIZATION: ND Industrial Commission/Lignite Research Fund

Address

PROJECT TITLE: Comparative Evaluation of Productivity of Prime and Nonprime Soils

Principal Investigator/ Project Director: Dr. Gary Halvorson

Department: Land Reclamation Research Center

PROJECT BUDGET: $43,397

AUTHORIZED UNIVERSITY REPRESENTATIVE: R. Craig Schnell, Ph.D.

Title: Dean, Graduate Studies & Research

Address: NDSU, P.O. Box 5790

Fargo, North Dakota 58105-5790

Phone: (701) 237-7033

Signature: R Craig Schnell

Date

[Transmittal Letter]

Dear Mr. Porter :

Enclosed is the application of ND SU - LRRC for a grant from the North Dakota Lignite Research Fund. By this application, ND SU hereby commits itself to complete the project as described in the application should the Industrial Commission of North Dakota make the grant requested by the application.

The applicant certifies that it has read and understands the statutes and administrative rules governing grants from the Lignite Research Fund and agrees to all conditions and terms set forth therein. The applicant also certifies that all information contained in the application is true to the best of the applicant's knowledge, and acknowledges the right of the North Dakota Industrial Commission to modify or terminate any subsequent agreements with applicant if the Commission becomes aware of any material misrepresentation contained in this application.

R Craig Schnell

Name (print)
R. CRAIG SCHNELL, Ph.D.
Dean, Graduate Studies and Research

Title

1992

Signature

NDSU

Research Administration

Log # 93102

Date Rec'd 9-28-92

PROPOSAL TRANSMITTAL FORM

See proposal approval policies and instructions on back of form.

1. Is this a ___ new application; XX renewal (current fund #: 4936); XX Grant; ___ Contract?

2. Is this a research project? X yes ___ no. If yes, would you consider the research best described as X basic (directed toward an increase of knowledge; the primary aim of the investigator is a fuller knowledge or understanding of the subject rather than a specific application thereof)? or ___ **applied** (the application of current knowledge to special uses)?

3. If not research, is the project for ___ service; ___ instruction/curriculum development; ___ fellowship; ___ construction; or ___ other _____?

4. Is a project summary X attached; ___ to follow? See back of form, instruction #2.

5. Check any that will be involved: ___ human subjects; ___ vertebrate animals; ___ recombinant DNA; ___ hazardous chemicals/wastes; ___ radioisotopes.

Application due date: 10/1/92 Proposed dates of project: from 1/1/93 to 12/31/93

Funding agency: ND Industrial Commission Program or Division: Lignite Research Fund

Project Title: Comparative Evaluation of Productivity of Prime and Nonprime Soils

Amount requested from funding agency: $ ~~43,286~~ 43,397 : (direct $ ~~39,351~~ 35,571) (indirect $ ~~3,395~~ 7,826)

NDSU Matching funds: If you are requesting **new dollars** from NDSU (not cost sharing or in-kind contributions, but rather are asking for a cash match), indicate amount you are requesting from your department or college: $_____; and/or amount you are requesting from NDSU Administration (VP for Finance or VP for Academic Affairs): $_____

Principal Investigator/Project Director (P.I./P.D) Name: Gary A. Halvorson

Department Land Reclamation Research Center Phone (701) 667-3021

Additional Investigator: Steve Schroeder Dept. LRRC

Additional Investigator: Manjula Nathan Dept. LRRC

Approval Signatures:	Name (type or print)	Signature	Date
PI/PD	Gary A. Halvorson	Gary A. Halvorson	9/25/92
Dept. Head	Gary A. Halvorson	Gary A. Halvorson	9/25/92
College Dean	Donald E. Anderson for H. R. Lund	D E Anderson	Sept. 26, 1992

Submit to Research Administration (201 Old Main) for final approvals:

Restricted Fund Accounting	Carole Pedersom	9-28-92
VP for Finance and/or VP for Academic Affairs (if required)		
Dean, Graduate Studies and Research		SEP 28 1992

Copies of this form are available in Research Administration, 201 Old Main. rev. 03/91

LIGNITE ENERGY COUNCIL

2455

JOHN W. DWYER, *President*

M E M O R A N D U M

October 7, 1992

TO: TASK FORCE FOUR
JOE FRIEDLANDER, THE COTEAU PROPERTIES COMPANY
JIM KRAMER, BNI COAL, LTD.
GREG SMESTAD, KNIFE RIVER COAL MINING COMPANY
JOE CLARKE, THE FALKIRK MINING COMPANY
DAVE NILSON, BASIN COOPERATIVE SERVICES

FROM: JOHN W. DWYER, PRESIDENT, LIGNITE ENERGY COUNCIL

SUBJECT: COMPARATIVE EVALUATION OF PRODUCTIVITY OF PRIME AND NONPRIME SOILS

Pursuant to our telephone conversation today, enclosed please find the proposal for the "Comparative Evaluation of Productivity of Prime and Nonprime Soils" as requested by the Land Reclamation Research Center.

As you can see from the proposal, they do not meet the private matching funds requirement. It would take approximately $22,000 of private investment which could then be matched with $22,000 of Lignite Research Council funds to meet the $44,000 that they request.

This is a three year study so it would take a similar amount next year.

Please advise what you wish to do. One solution would be to amend the application to provide for additional industry support, so it can be considered on October 13th.

JWD/rw:24S5 & 23D

Enclosure

Copy: Clifford Porter

P.O. BOX 2277, SUITE 200
1016 E. OWENS AVENUE
BISMARCK, ND 58502
TEL. (701) 258-7117
FAX (701) 258-2755

PUBLIC SERVICE COMMISSION

State of North Dakota

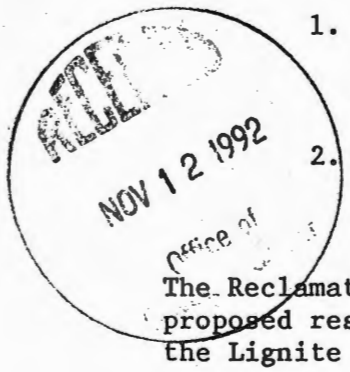
Memorandum

To: Commissioner Bruce Hagen

From: Nirander Safaya, RRAC Chairman

Date: November 12, 1992

Re: RRAC Recommendation to LRC on Reclamation Research Projects:



1. Improving the Public Service Commission Guidelines for Evaluating Success of Reclaimed Grasslands, submitted by Dr. Donald Kirby of NDSU-Animal and Range Science Department.

2. Comparative Evaluation of Productivity of Prime and Nonprime Soils, submitted by Dr. Gary Halvorson of NDSU-Land Reclamation Center.

The Reclamation Research Advisory Committee (RRAC) supports the above listed proposed research projects, and recommends that these projects be funded by the Lignite Research Council (LRC).

Project No. 1 is a revised proposal that was previously submitted to LRC in June, 1992. The RRAC comments and recommendation on the original proposal were submitted to you on August 31, 1992. Since the main objective and the methodology in the revised proposal are the same as before, and the few changes that have been made in the title, text and budget are reasonable, RRAC's previous recommendation remains unchanged.

Project No. 2 is an ongoing study for which 2nd-year funding is being requested. Preliminary data collection and establishment of field sites has been completed. This study is quite important as it is expected to answer the question whether handling of prime and nonprime topsoil is necessary. Therefore, continued funding of this project is recommended.

NMS205

cc: Commissioners Reinbold and Sandstrom
Janet Elkin, Executive Secretary
Ed Englerth, Reclamation Division Director
Carol Siegert, Governor's Office
Greg Smestad, RRAC member
Darell Herman, RRAC member
Clifford R. Porter, Lignite Energy Council
Karlene Fine, Industrial Commission

COMPARATIVE EVALUATION OF PRODUCTIVITY OF PRIME AND NONPRIME SOILS

A PROPOSAL SUBMITTED TO THE
LIGNITE RESEARCH COUNCIL
OF THE
NORTH DAKOTA INDUSTRIAL COMMISSION

FOR YEAR TWO (2) FUNDING

PRINCIPAL INVESTIGATOR
GARY A. HALVORSON
INTERIM SUPERINTENDENT/SOIL SCIENTIST

INDUSTRIAL COMMISSION FUNDING REQUESTED
$21,698

LAND RECLAMATION RESEARCH CENTER
NORTH DAKOTA STATE UNIVERSITY
MANDAN, NORTH DAKOTA

October 20, 1992

LAND RECLAMATION RESEARCH CENTER

TITLE OF PROJECT

Comparative Evaluation of Productivity of Prime and Nonprime Soils

PRINCIPAL INVESTIGATOR

Gary A. Halvorson
Interim Superintendent/Soil Scientist
Land Reclamation Research Center
North Dakota State University
P. O. Box 459
Mandan, ND 58554-0459
(701) 667-3021

CO-INVESTIGATORS

S. A. Schroeder
M. V. Nathan
F. S. Carter

FUNDING PROFILE

Program Year	Cost
FY'92	$108,241
FY'93	88,000
FY'94	88,000
TOTAL ESTIMATED PROJECT COST	$284,241

INDUSTRIAL COMMISSION FUNDING REQUESTED

$21,698

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ABSTRACT

Prior to mining, coal companies in North Dakota are required to separate prime land topsoil from nonprime land topsoil. Following mining, the prime topsoil must be replaced in a prime location and the nonprime topsoil in a nonprime location. This separate handling of these materials is expensive and may be unnecessary. Many of the soils in the mining area of western North Dakota differ in depth of topsoil because of their position in the landscape. The parent material for such soils as Bowbells, Williams and Zahl is the same and the quality of the topsoil between them is very similar.

The objectives of this research is to (1) compare the productivity of prime and nonprime topsoil materials placed side by side in different topographic positions, (2) determine whether the separate handling of prime and nonprime topsoil is necessary.

It is anticipated that this research will show that there is no difference in productivity between the different topsoil materials. If this is true then separation of prime and nonprime topsoils should not be necessary. It is expected to take three growing seasons to determine if differences are occurring. This request is for the second year of funding of this project.

The total project cost over three years is $286,019. Funding from the Industrial Commission for the second year of this study is $21,698. This will be matched with $21,699 from the Lignite Energy Council and $44,603 from the Land Reclamation Research Center.

The participants in this study include the Coteau Properties Co., the Falkirk Mining Co. and the Land Reclamation Research Center of the North Dakota Agricultural Experiment Station.

SUMMARY

Current surface coal mineland reclamation regulations require separate handling of prime and nonprime soils. The proportion of soils which qualify as prime due to their location in a landscape unit of west-central North Dakota is low, and hence the separate handling is costly. Previous research has not compared the topsoil material from prime and nonprime soils in the field. Past research has also suggested that a better measure of the productivity of a particular soil at a given topographic location is to measure soil properties which affect potential yield. The objective of this study is to systematically monitor both yield and the soil properties comparatively between prime and nonprime soils placed side by side in a given topographic position. This will be accomplished in three tasks. Task I will compile and analyze data from previous and ongoing prime/nonprime soil productivity research. Task II will establish experimental plots of prime and nonprime topsoil at a given topographic and different topsoil depths and monitor yield and soil and environmental factors that affect yield. Task III will summarize information from Task I and Task and analyze the data to compare actual as well as potential yields between prime and nonprime soils. This research is expected to help answer the prime and nonprime productivity issues and generate a more objective tool to evaluate reclamation success.

Task I is continuing. Other studies have been looking at prime and nonprime soils and the effect their topographic location has on yields. In task II the plots are essentially established and we have begun collecting soil and yield data. Task III is just beginning in this second year of the study.

PROJECT DESCRIPTION

A. Introduction

Current federal and state regulations require separate handling of prime and nonprime topsoils. According to the present interpretation of prime farmland criteria, soils designated prime in the ustic moisture zone of North Dakota qualify because of landscape position. Most of these soils occur on nearly level or concave portions of the landscape and receive run off from adjacent soils in a higher position which do not meet prime farmland criteria. Prime soils are therefore, the product of microclimate and local surface and root zone hydrology rather than macro-climate or parent material.

In western North Dakota, availability of water is the most dominant factor controlling crop yields. Under conditions of limited rainfall, which is the general rule, the yield potential of prime land may not be significantly different from the yield potential of nonprime land. If the differences in the productive capabilities of prime and nonprime soils are the result of moisture differences due to topographic location rather than to differences in the properties of soil materials, then the currently required separate removal and placement of topsoil materials is unwarranted. In addition, higher overall productivity of reclaimed land may be attained by replacing available soil materials uniformly on an area reshaped to the most effective topographic configuration.

B. Objectives

1. Compare the productivity of prime and nonprime topsoil materials in different topographic positions.

2. Determine whether the separate handling of prime or nonprime topsoil is necessary.

C. Methodology

The objectives of this research will be accomplished using three separate tasks:

Task I. Sites on reclaimed land have been established and monitored for yield for the past five years. Yields from these sites will be measured again in the coming years to evaluate effect of topographic positions in a reclaimed landscape. These sites include three soils on a topographic sequence at the BNI mine at Center, North Dakota and a site at the Falkirk mine near Underwood, North Dakota. In addition, an undisturbed micro-catchment at the Falkirk mine will also be monitored for wheat yields. Information from this undisturbed site should provide data that can be used to compare with reclaimed sites.

Task II. Plots will be established at two different locations on reclaimed land. Topsoil material from prime and nonprime soils will be transplanted to the site and respread on separate plots in the different topographic positions. Wheat will be grown on these test plots and yield measurements will be taken. In addition, the soils will be monitored for SAR, EC, saturation percentage, soil moisture throughout the growing season, texture, bulk density, hydraulic conductivity and water holding capacity. Precipitation will be monitored at the sites. Plant parameters which will be monitored include rooting depth, grain yield, degree of weed and insect infestations, and plant disease problems.

Task III. The data obtained from Tasks I and II will be compiled to determine if prime and nonprime topsoils need to be handled separately.

D. Anticipated Results

Based on the previous work done in the field and the greenhouse, it is anticipated that the nonprime topsoil material from the Zahl and Williams soils will have a productivity equal to that of the Bowbells soil. If the data do show no differences between topsoils, recommendations will be made to eliminate the separate handling of prime and nonprime topsoil.

E. Facilities, Resources and Techniques to be Used

Plots have been established on reclaimed land at the Coteau Properties Company Freedom Mine and at the Falkirk Mine. Personnel and equipment from these mines were used in the establishment of these plots.

The plots will be maintained by personnel from the LRRC. Equipment sufficient to do this job is owned by the LRRC. The LRRC is located on the grounds of the Northern Great Plains Research Laboratory, just south of Mandan, North Dakota. Laboratories at this location are sufficient to handle analyses of the physical and chemical characteristics of the soil and spoil in this study.

F. Environmental and Economic Impacts

This project is occurring in conjunction with the ongoing reclamation program of the Coteau Properties Company and the Falkirk Mining Company. During the course of the project therefore, the environmental impacts should not be very different from the normal mining and reclamation process.

Economically, the two companies involved do incur some costs related to the cost of the project. These costs are mainly equipment time for the construction of the plots. Compared to the overall cost of the mining operation, these costs were rather minor. In the long term the economic benefit to the coal companies could be substantial. If the requirement to separate prime and nonprime topsoil can be eliminated the coal companies should see a substantial savings in soil

handling costs. It is also our belief that a better job of reclamation can be done if the depth of topsoil is uniform throughout the landscape rather than deeper in the prime positions and shallower in the nonprime positions.

Need for the Project

This project is needed because the present regulations requiring separate handling of prime and nonprime topsoils may not be necessary. This project is designed to determine whether separate handling is necessary. If it can be shown that separate handling of prime and nonprime topsoils is not necessay substantial savings to the coal companies in reclamation costs should occur. In addition, a better job of reclamation would occur if the topsoil depth was uniform across a landscape.

STANDARDS FOR SUCCESS

The project will be considered successful if the data from the field experiment shows clearly whether or not there is any difference in productivity between prime or nonprime topsoil. This will allow us to proceed in seeking changes in the regulations.

BACKGROUND

Research was performed in a controlled greenhouse experiment comparing wheat yields from prime (Bowbells) and nonprime (Williams) soils from the same soil association (Carter and Doll, 1983). Two successive crops were grown under optimum conditions using the same soil materials. In the first crop, yields from the prime soil were significantly higher than from the nonprime soil. The higher organic matter content of the prime soil may have resulted in better aeration for crop growth. The structure of the soil samples was severely disrupted during the process of drying and screening. However, in the second crop, yield differences between the prime and nonprime soil were not apparent. Visual observations of the soil materials during reporting for the second crop indicated that the physical structure of the soils was appreciably better than when the first crop was planted. These results indicate that yields on reclaimed prime soils may initially be higher than yields on reclaimed nonprime soils. However, after soil structures have been reestablished, yields between the soils would not be expected to differ. Carter and Doll (1983) recommended the use of field experiments to adequately evaluate productivity differences among both disturbed and undisturbed prime and nonprime soils.

From the results of a three-year experiment comparing crop yields from reclaimed and undisturbed prime and nonprime soils located at two different mines, Schroeder and Doll (1984) concluded that, due to rainfall differences and insect and small animal damage on sites isolated from other cropped areas, precise evaluation of soil factors contributing to yield differences was not possible. Even though these plots were designed for statistical comparisons, and statistically significant differences were obtained, no consistent trends were obtained. Over the three-year period, the relation of yields on reclaimed soils to those on undisturbed soils were inconsistent;

in some cases they were significantly higher, in others significantly lower, and sometimes not different.

The capacity of a soil to produce a potential yield depends on soil parameters which can be measured quantitatively. Research at the Land Reclamation Research Center has shed new light on the measurement and importance of using soil parameters for the determination of reclamation success. Carter, et al. (1987) reported that "*in situ*" soil properties such as bulk density, macropore space, and hydraulic conductivity are the soil parameters most severely disrupted during mining and reclamation. In continued studies, Carter (1991) found that average values of soil chemical properties, texture, and calculated percents of pore sizes were not significantly different between prime and nonprime soils located in a 10 ha site. Bulk densities at all measured depths were generally higher (not significant) from the prime soils during all four years of the study. Surface infiltration rates, measured in 1990, were significantly higher from the nonprime soil which indicated the existence of greater or larger continuous macropores than in the prime soil. These results indicated the need for more investigation into the properties of reclaimed and undisturbed prime and nonprime soils and the effects of these properties on soil productivity.

QUALIFICATIONS

The Land Reclamation Research Center (LRRC) is a branch station of the NDSU Agricultural Experiment Station and has been conducting research exclusively on reclamation for more than a decade. The staff consists of six scientists and six support staff and has laboratory facilities located at the Northern Great Plains Research Laboratory. Research in the past has dealt with all aspects of returning soil to productivity following mining.

Gary Halvorson has a Ph.D in soil chemistry and fertility and has 13 years of experience in the reclamation of land in North Dakota following mining. Research projects he has been involved with include depth of topsoil replacement on cropland as well as rangeland, a study of how topography affects crop yields, the fertility requirements of reclaimed land and the productivity of reclaimed prime and nonprime land.

VALUE TO NORTH DAKOTA

If it can be shown that prime and nonprime topsoils do not need to be separated, substantial savings to the coal companies in soil handling and planning should occur. In addition, a better job of reclamation will occur. This will benefit the ultimate landowner in terms of the productivity of the land. Because of the lower costs for lignite production and the higher productivity of the land, the whole state of North Dakota will benefit.

MANAGEMENT

The project will be managed by the LRRC on land reclaimed by the Falkirk Mining Company and the Coteau Properties company. The plot sites will be seeded, fertilized, and harvested using good management techniques for agriculture. Soil physical and chemical parameters will be measured using techniques commonly used at the LRRC and recognized as standard procedures in *Agronomy Monograph #9*.

Timetable

Task	J	F	M	A	M	J	J	A	S	O	N	D
Planting					*							
Maintenance of plots				*	*	*	*					
Harvest								*				
Weather Data				*	*	*	*	*	*			
Soil Samples								*	*			
Laboratory Analysis										*	*	*
Evaluation of Data	*	*	*	*						*	*	*
Reports					*			*				*

BUDGET		
YEAR 1		
	Industrial Commission	**LRRC**
Salaries		
Scientists	24,000	20,000
Technicians	4,000	15,200
Fringe Benefits (.27)	7,560	9,504
Operating		
Supplies	3,000	1,000
Travel	2,000	-0-
Total Direct Costs	40,560	45,704
Indirect Costs (22%)	8,923	10,054
TOTAL	$49,483	$55,758
In kind contribution of ND Lignite Industry for equipment use and time for the construction of field plots is estimated to be $3,000.		

BUDGET			
YEAR 2			
	Industrial Commission	**Lignite Energy Council**	**LRRC**
Salaries			
Scientists	10,586	13,414	10,000
Technicians	2,828	0	14,952
Fringe Benefits (.27)	3,621	3,622	6,737
Operating			
Supplies	250	750	3,000
Travel	500	0	1,871
Total Direct Costs	17,785	17,786	36,560
Indirect Costs (22%)	3,913	3,913	8,043
TOTAL	$21,698	21,699	$44,603

BUDGET			
YEAR 3			
	Industrial Commission	**Lignite Energy Council**	**LRRC**
Salaries			
Scientists	10,586	13,414	10,000
Technicians	2,828	0	14,952
Fringe Benefits (.27)	3,621	3,622	6,737
Operating			
Supplies	250	750	3,000
Travel	500	0	1,871
Total Direct Costs	17,785	17,786	36,560
Indirect Costs (22%)	3,913	3,913	8,043
TOTAL	$21,698	21,699	$44,603

Appendix A.

LITERATURE REFERENCES

Carter, F. S. 1991. Physical properties of prime and nonprime reclaimed soils. p. 73-86. In 1991 Mine-land Reclamation Research Review Proceedings. Land Reclamation Research Center, North Dakota State University, March 19, 1991, Bismarck, ND.

Carter, F. S., K. N. Potter and E. C. Doll. 1987. Effects of physical factors on moisture relationships in undisturbed and reclaimed soils. p. 43-53. In 1987 Mine-Land Reclamation Research Review Proceedings. Land Reclamation Research Center, North Dakota State University, February 24, 1987, Bismarck, ND.

Doll, E. C., S. D. Merrill and G. A. Halvorson. 1984. Soil replacement for reclamation of stripmined land in North Dakota. North Dakota Agric. Exp. Sta. Bull. 514.

Erickson, W. R. 1985. McKinley Mine: Vegetation bond release criteria based on Soil Conservation Service Technical Guide Range Site Descriptions. p. 114-116. In Bridging the Gap between Science, Regulation and the Surface Mining Operation. Second Annual Meeting of the American Society for Surface Mining and Reclamation Proceedings. Denver, CO. 8-10 October.

Halvorson, G. A., S. W. Melsted, S. A. Schroeder, C. M. Smith, and M. W. Pole. 1986. Topsoil and subsoil thickness requirements for reclamation of nonsodic mined-land. Soil Sci. Soc. Am. J. 50:419-422.

Pole, M. W., A. Bauer, L. Zimmerman, and S. W. Melsted. 1979. Effects of topsoil thickness placed on spoilbanks on wheat and corn yields in North Dakota. p. 139-155. In Proceedings 4th Annual Meeting of Canadian Land Reclamation Association. Regina, Saskatchewan, Canada.

Schroeder, S. A. and E. C. Doll. 1984. Productivity of prime, nonprime and reclaimed soils in western north Dakota. North Dakota Agric. Exp. Sta. Farm Res. 41:3-6, 31.

Wollenhaupt, N. C. 1985. Soil-water characteristics of constructed minesoils and associated undisturbed soils in southwestern North Dakota. Ph.D Thesis, Library, North Dakota State University.

Wollenhaupt, N. C. and J. L. Richardson. 1982. The role of topography in revegetation of disturbed lands. p. C-2-1 to C-2-11. In F. F. Munshower et al. (ed). Mining and reclamation of coal mined lands in the northern Great Plains. Symp. Proc., Billings, MT. 8-9 March. Montana State University, Bozeman, MT.

Appendix B.

GARY A. HALVORSON
NORTH DAKOTA STATE UNIVERSITY
LAND RECLAMATION RESEARCH CENTER
P. O. BOX 459, MANDAN, ND 58554-0459

CURRENT EMPLOYMENT

Currently employed as Interim Superintendent/Soil Scientist by North Dakota State University at the Land Reclamation Research Center, Mandan, ND.

PREVIOUS EMPLOYMENT AND EXPERIENCE

Development Leave: Six months of developmental leave working with Dr. Jerry Jurinak at Utah State University; January 1, 1987 to June 30, 1987.

Fertility status of potato fields: Two months evaluating the fertility status of irrigated potato fields in eastern Oregon.

Research fellowship to the Soviet Union: Research fellowship to the Timiryazov Agricultural Academy in Moscow, USSR; February 1978 through November 1978.

Ph.D-cadmium and zinc chemistry: Ph. D in soil chemistry completed in 1979 at Oregon State University. Thesis title was "*Extraction and plant availability of cadmium and zinc in a Willamette sandy loam soil.*"

MS - Land application of municipal waste: MS degree in soil chemistry completed in 1975 at Oregon State University. Thesis title was "*Movement of elemental constituents in Sagehill loamy sand treated with municipal waste.*"

Graduate study - Geology: Completed one semester of graduate study in geology at the University of Colorado in the fall of 1971.

BA - Chemistry: Bachelor of Arts degree was obtained in chemistry from St. Olaf College in 1971; minor area of study was Russian.

RESEARCH PROJECTS

Reclamation of mined lands: Research has included reclamation of prime and nonprime agricultural land; fertility requirements of reclaimed cropland and pasture for N, P, and Zn; depth

requirements for topsoil and subsoil on reclaimed land on salt-affected and nonsaline, nonsodic spoil; and the spatial variability of regraded spoil chemical and physical properties.

Brine disposal pits: A grant from the North Dakota Water Resources Research Institute was used to study salt contamination of groundwater and agricultural land from buried brine disposal pits.

Reclamation of a saltwater blowout site: The saltwater blowout of an oil well drilling site caused extensive damage to soils and vegetation.

Topsoil depth requirements: A grant was obtained from the Falkirk Mining Company to study topsoil and subsoil replacement depth requirements on spoil material which is neither saline nor sodic. This research resulted in a change in the regulations on subsoil depth requirements.

Disposal of municipal wastes: Research at Oregon State University entered on the disposal of municipal refuse and sewage sludge on agricultural land and its effect on plant growth and contamination of the groundwater.

Appendix C.

PERTINENT LRRC PUBLICATIONS

Carter, F. S., and Doll, E. C. 1983. Wheat yields on prime and nonprime soils and soil mixtures in a greenhouse study. Technical Report-LRRC #3.

Carter, F. S., P. P. Sharma, and G. A. Halvorson. 1990. Soil water characteristics of coal-soil mixtures. Agron. Abstr., American Society of Agronomy, Madison, WI, p. 312.

Doll, E. C., Halvorson, G. A., and S. A. Schroeder. 1983. Reestablishing productivity on reclaimed soils. In: Can Mined Land be Made Better than Before Mining? Symposium Proceedings, November 17, 1983. Bismarck, ND. 99 p.

Doll, E. C., N. C. Wollenhaupt, G. A. Halvorson, and S A. Schroeder. 1984. Planning and evaluating cropland reclamation after stripmining in North Dakota. Minerals and the Environment. 6:121-126.

Doll, E. C., S. D. Merrill, and G. A. Halvorson. July 1984. Soil replacement for reclamation of stripmined lands in North Dakota. Agr. Expt. Station Bull. #514.

Doll, E. C. and Wollenhaupt, N. C. 1985. Use of soil parameters in the evaluation of reclamation success in North Dakota. Proc. 2nd Ann. Meet., Am. Soc. for Sur. Min. and Rec., Denver, CO, Oct 8-10, 1985.

Doll, E. C. 1986. Prime Land Reclamation in North Dakota - A Status Report - LRRC Technical Report #7, August, 1986.

Doll, E. C. 1986. Regulation, root zone properties and plant growth on reclaimed soils. In Proceedings, National Mined Land Reclamation Conference, St. Louis, MO, Oct. 28-29, 1986. Coal Extraction and Utilization Center, Southern Illinois University, Carbondale.

Doll, E. C. 1988. Relation of public policy to reclamation goals and responsibilities. In L. R. Hossner (ed.). Reclamation of Surface-Mined Lands. CRC Press, Inc., Boca Raton, Florida. (In press).

Gilley, J. E., Schroeder, S. A. and D. D. Schlenker. 1984. In situ saturated hydraulic conductivity and water-holding capacity of undisturbed and surface-mined sites. ND Ag. Exp. Sta. Research Report #102. May, 1984.

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October 21, 1992

Ms. Karlene Fine
ND Industrial Commission
State Capitol Building
Bismarck, ND 58502

Dear Karlene:

Enclosed are 35 copies of our proposal entitled "Comparative Evaluation of Productivity of Prime and Nonprime Soils." This is a request for the second year of funding for this project. We are requesting funding of $21,698 from the Lignite Research Fund. If you have any questions please feel free to contact me.

Sincerely,

Gary A. Halvorson

Gary A. Halvorson
Interim Superintendent/Soil Scientist

GAH/ks