Evaluating Reclamation Success at Three AML Sites in North Dakota in 1998 and 2003[1]

Presented by
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ABSTRACT

Lignite coal mining has been an important part of North Dakota's economy for over a century. The Abandoned Mine Lands (AML) Division of the North Dakota Public Service Commission has been charged with the reclamation of hazardous abandoned coal mine sites in North Dakota since 1981. Nearly 100 primary reclamation projects have been completed at surface and underground AML sites in North Dakota. The principal objective of reclamation at these sites has been hazard abatement. For surface mined sites, reclamation has usually included backsloping or backfilling dangerous highwalls, replacement of any available topsoil materials and seeding. Other reclamation design considerations have included disposal of hazardous materials, restoration of degraded land and water resources and improvements in land utility.

Reclamation of AML sites in North Dakota is usually considered complete when the hazards associated with an abandoned mine site have been reduced or eliminated and the area is stable. Quantitative assessments of the success of reclamation, other than with regard to hazard elimination, have not generally been attempted.

In 1998 and 2003, evaluations of the success of reclamation were made at three representative reclaimed surface mined sites: Hazen-West, Noonan and Fritz. Evaluation criteria focused on restoration of degraded land and water resources and restoration of degraded land utility. Sampling was conducted to evaluate soil materials, wetland and stockpond water quality and vegetative species composition, cover and forage production. Ocular surveys of plant and animal species were also conducted at each site. Comparisons were made between results of the 1998 and 2003 surveys.

Additional Key Words: Surface Mine Reclamation, Revegetation, Reclaimed Soils, Recreational Land Use, Fish and Wildlife Habit

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Introduction

Nearly 100 primary abandoned mine land reclamation projects, at a cost of over $26 million, have been completed North Dakota since 1981. In addition several secondary (maintenance) and emergency projects have been conducted. Reclamation is usually considered complete when the hazards associated with an AML site are reduced or eliminated.

In the summers of 1998 and 2003 comprehensive evaluations of the success of reclamation were made at three AML sites in North Dakota: Hazen-West, Noonan, and Fritz. In addition to hazard abatement these evaluations considered such factors as slope reduction, soil development, erosion control, revegetation success, wildlife use, wetland and stockpond quality, and improvements in land use capability. Comparisons of land utility for these sites have been made with adjacent unreclaimed mine spoils and with relatively lower producing agricultural lands in the area. The remainder of this paper is divided into the following sections:

A. Lignite Mining in North Dakota and Establishment of AML Program

B. Site Characterizations

C. Sampling materials and methods

D. Discussion and conclusions

E. References and Acknowledgements

F. Figures and Tables

A. Lignite Mining In North Dakota and Establishment of AML Program

North Dakota has the largest reserve of lignite coal in the United States, estimated at 600 billion tons (Burr 1954). The strippable reserves are estimated at 25.1 billion tons (Murphy 2001). These coal reserves are mainly in the western part of the state in the Tongue River and Sentinel Butte formations. The lignite bearing area in North Dakota covers about 32,000 square miles (Murphy 2001).

Lignite is a dark brown low-grade coal that is softer than bituminous or sub-bituminous coal. It is characterized by its relatively high moisture content, fairly low heating value (approximately 6000-7000 BTU), moderate ash and generally low sulfur content. Lignite has been mined commercially in North Dakota since 1873. Underground, room and pillar mining was the predominant method of coal extraction in North Dakota until the 1930s. Large equipment and construction of coal-fired electrical generating plants created a shift from small underground mines to large strip mines since the 1940s. Today North Dakota lignite is all strip mined and used almost exclusively for electrical generation and coal gasification.

Approximately 30 million tons of lignite is mined annually in North Dakota, making it the ninth leading coal producer in the nation. In 2003, the North Dakota lignite industry directly employed 3763 people and had expenditures of $514 million. Indirect employment was estimated at 16,223 jobs and total business activity

resulting from lignite mining is over $1.54 billion. The lignite industry generates over $72 million in state tax revenue (Lignite Energy Council 2003).

Although the importance of lignite mining in North Dakota is unquestionable, the effects of mining prior to environmental regulation has resulted in significant hazards to the public and the environment of the state. Past underground mining has resulted in dangerous collapse features, or sinkholes, and surface mining has left dangerous steep pits, waste piles and structures. Title IV of the Surface Mining Control and Reclamation Act of 1977(SMCRA) established an Abandoned mine land (AML) fund to be used to reclaim abandoned coal mines. Money for this fund comes from a ten cents per ton federal tax levied by the Office of Surface Mining Reclamation and Enforcement (OSMRE) on active lignite coal mining in North Dakota.

North Dakota Century Code Chapter 38-14.2, passed in 1979, established a state AML program to be administered by the North Dakota Public Service Commission. This program is funded by grants from OSMRE drawn from the AML Fund. The state's AML Reclamation Plan was approved by OSMRE in 1981. This plan contained an inventory of 616 known mines, abandoned prior to SMCRA, in the state. Of these, 87 were deemed potentially hazardous to the public health, safety, and welfare (Ogaard 1992). Several more abandoned mines have been added to the inventory since then.

B. Site Selection and Characterizations

The three sites chosen for this study, Hazen-West, Noonan, and Fritz, are relatively large representative reclaimed surface-mined AML sites in North Dakota. Each was characterized by dangerous steep highwalls and water filled pits. Each site represents a different geographical area within the coal mining region of North Dakota. Hazen-West is in the east-central portion, Noonan in the northwest and Fritz in the southwest (Figure 1).

Hazen-West

The Hazen-West site is located in the N1/2 of Section 17, T144N, R87W, Mercer County, approximately four miles west of the city of Hazen and 75 miles northwest of Bismarck. This is the site of the historic Knife River Coal Mining Company's North Beulah strip mine. This mine operated from 1952 to 1974 and produced coal for electrical generation, domestic and industrial use. The mine covered approximately 960 acres and about 70 acres were reclaimed under North Dakota's AML program.

The Hazen-West project was conducted during the summer of 1991, under Contract No. 195, by Lindemann Construction Company. The contract cost for this project was $531,569.73.

The objective of this project was to backfill a dangerous pit highwall located near a major U.S. highway. The highwall of this pit was approximately 60-70 feet deep and was very steep with slopes of approximately 1.3h: 1v or 75%. This pit was located within 100' of U.S. Highway 200 and erosion along the highwall was intruding into the south road ditch. This site was a part of the North Beulah Wildlife Management Area, owned by the North Dakota Game and Fish Department. The reclamation plan was developed in consultation with the land owner to enhance the wildlife value of the site while eliminating the hazardous pit. Two ponds and two wetlands were constructed for waterfowl habitat. The seed mix planted on the reclaimed site (Table 1) was a mixture of tall grasses and forbs to provide cover for nesting waterfowl and other wildlife.

No topsoil was available at this site but approximately 10,000 cubic yards of good quality spoil material was identified and salvaged. Spoil at this site was mostly glacial till material and was fairly high quality plant growth material. Dirt work consisted of moving 1,022,050 cubic yards of material from nearby dragline-cast spoil piles to backfill the pit to maximum slopes of 5h: 1v, or 25%. After backfilling and grading and construction of the water management structures, the salvaged good quality spoil was respread on the site. Coal fines were also used to supplement this substitute topsoil material. Subsequently the area was fertilized with approximately 200 lbs. per acre 35-18-0 fertilizer, seeded, and mulched with 2 tons per acre straw mulch.

Noonan

Five major AML reclamation projects have been conducted at the historic Baukol-Noonan Mine. However, for the purposes of this study only two of the project sites were used. These two are contiguous and were treated as one area. The Noonan site is located in Sections 3, 10, 11, and 12, T162N, R95W, Divide County, approximately one mile southwest of the city of Noonan and 240 miles northwest of Bismarck. The Baukol-Noonan Mine operated from 1930 to 1963 and produced coal that was shipped by rail for industrial and commercial use and sold locally for domestic use. The mine covered over 1400 acres and about 500 acres were reclaimed under North Dakota's AML program.

These projects were conducted in 1994 and 95, under Contracts No. 254904 and 283905, by American Contracting, Inc. and Hexom Earth Construction, Inc., respectively. These project sites comprised about 160 acres and the combined contract costs were $1,206,663. Seeding was conducted under a separate contract in 1995.

The objective of this project was to backfill more than two miles of dangerous pit highwall located along a trail used extensively by sportsmen. The highwall of this pit was approximately 60-70 feet deep and was very steep with slopes of approximately 1.3h: 1v or 75%. This pit was located immediately west of the trail and also near a county highway. This site was a part of the Harris M. Baukol Wildlife Management Area, owned by the North Dakota Game and Fish Department. The reclamation plan was developed in consultation with the owner to enhance the wildlife value of the site while eliminating the hazardous pit. Several large wetlands, diversions and a concrete weir structure were constructed for surface water management and to facilitate wildlife use. A portion of the water-filled pit was preserved and is used as a fishing pond. The seed mix planted on the reclaimed site (see table 1) was a mixture of tall grasses and forbs to provide cover for nesting waterfowl and other wildlife.

No topsoil was available at this site but approximately 15,000 cubic yards of good quality spoil material was identified and salvaged. Spoil at this site was generally poor quality sodic clay material. Dirt work consisted of moving about 2.5 million cubic yards of material from nearby dragline-cast spoil piles to backfill the pit to maximum slopes of 5h:1v, or 25%. After backfilling and grading and construction of the water management structures, the salvaged good quality spoil was respread on the site. Coal fines were also used to supplement this topsoil substitute material but most of the surface material was spoil. Subsequently the area was fertilized with approximately 200 lbs. per acre 35-18-0 fertilizer, seeded, and mulched with one or two tons per acre straw mulch, depending on the slope.

Fritz

The Fritz site is located in the N1/2 of Section 5, T136N, R100W, Slope County, approximately seventeen miles southwest of the city of Belfield and 140 miles southwest of Bismarck (figure 1). The Church and Hurick pits were located at this site. These were open pit mines operated from the late 1950s until about 1967 for the purpose of extracting uraniferous lignite coal. After extraction, the coal was either burned in the pit or hauled to nearby kilns and burned to concentrate the uranium it its ash (Karsmizki 1990). The uraniferous ash was sold to the Atomic Energy Commission and hauled out of state to be processed. Before reclamation this site was characterized by large water filled pits and acid forming spoil materials. The mined land was a wasteland and virtually unusable. It was nearly barren except for a few prickly pear cactus and water quality was poor due to acidity. In addition, surface materials were contaminated with heavy metals such as uranium, cadmium and molybdenum. Approximately 155 acres were reclaimed at this site.

This project was conducted in 1992, under Contract No. 208, by American Contracting Inc. The contract cost for this project was $457,147.10. The objective of this project was to reclaim contaminated spoils and acidic water filled pits. Because of the hazards presented by radioactive dust, workers were required to wear radiation film badges, dust respirators and were required to leave clothing on-site after working hours. No smoking or eating was allowed on the work site. The reclamation plan was developed in consultation with the owner, Rocky Fritz, with the goal of establishing a native grassland prairie capable of supporting grazing cattle.

One stockpond, 5 wetland sumps, and two terraces were constructed for surface water management and to support the post-reclamation land use. The seed mix planted on the reclaimed site (see table 1) was composed of both cool and warm season native grassland species. Topsoil and other non-contaminated materials were identified and salvaged. Dirt work consisted of moving about 905,334 cubic yards of material to backfill pits and grade to a gently rolling topography. Approximately 500,000 cubic yards of contaminated material were covered with a minimum of three feet of non-contaminated spoil. Identification of contaminated and non-contaminated materials was vital. Assistance in this effort was provided by the State Department of Health, the Geological Survey and other agencies.

After backfilling and grading and construction of the water management structures, the salvaged topsoil and good quality spoil was respread on the site. Subsequently the area was fertilized with approximately 200 lbs. per acre 35-18-0 fertilizer, seeded with a cover crop of oats, and mulched with two tons per acre straw mulch.

C. Sampling materials and methods

Sampling for evaluation of reclamation success was conducted at the three sites, Hazen-West, Noonan, and Fritz on June 30 - July 10, 1998, and again on June 24-30, 2003. Components of the evaluation process included an ocular survey of plant and animal species, soil and surface water samples from each site, and vegetation sampling for species composition, cover and production.

Wildlife surveys were conducted at each site in the early morning hours and species observed were recorded. In addition, plant and animal species were observed and recorded opportunistically during the remainder of the site evaluations.

A composite soil sample was collected from several areas at each site, mixed together and taken to Minnesota Valley Testing, Inc., Bismarck, for analysis. A single water sample was taken from one of the wetlands or stockponds at each site. These were also taken to the Minnesota Valley Testing for water quality analysis. Testing parameters for the soil samples included pH, Nitrogen, Phosphorous, Potassium, Sodium Adsorbtion Ratio, Heavy Metals (Fritz only) and Salts. Water quality testing parameters included pH, Total Suspended

Solids (TSS), Total Dissolved Solids (TSS), Nitrates, Iron, Heavy Metals (Fritz only) and several other parameters. Soil and Water test analyses are included in Table 2.

Procedures for sampling and measurement of vegetation parameters were intended to conform generally to those required for reclaimed sites at active mines in North Dakota (North Dakota Public Service Commission 2001). The point quadrat method was utilized for quantitative analysis of vegetative cover at each site. This method is recommended because it is the most commonly used technique for Northern Great Plains vegetation (North Dakota Public Service Commission 2001). A vertical ten-point frame was utilized. In this method, ten sharpened pins are lowered through a frame until each comes in contact with a portion of a live plant, bare ground, rock or vegetative litter. Frames were placed across randomly located transects on each reclaimed site. Vegetation sampling was also conducted, for purposes of comparison, on unreclaimed spoils at the Hazen-West and Noonan sites but not at the Fritz site because it was entirely reclaimed.

Species composition and above ground cover was recorded using the first-hit method, in which each pin is lowered until it hits a live plant, vegetative litter, rock or bare ground. Results of point frame analysis are summarized in Tables 3A, 3B and 3C.

Vegetative productivity was sampled by randomly placing a one-quarter square quadrat and clipping at ground level all vegetation within it. The square quadrat was placed at every other location that was sampled with the point frame (i.e. the first, third, fifth, etc.). Clipped samples were placed in paper bags and air dried to a constant weight. Based on dry weights of the replicated samples, forage production was estimated in pounds per acre for each site. This data is summarized in Table 4.

Sample adequacy for productivity was tested statistically using North Dakota Public Service Commission (2001) standards. Sampling did not meet the sample adequacy test at the 90% (one tailed t, α=.010) confidence interval at any of the sites. However, sample adequacy was sufficient at the Hazen-West and Noonan reclaimed sites using the 80% (one tailed t, α=0.20) and at the Fritz site using the 65% (one tailed t, α=0.35) confidence interval.

D. Discussion and Conclusions

Success of reclamation at Abandoned Mine Land Sites can be evaluated in several ways. From the most basic, hazard abatement; all three sites have certainly been successfully reclaimed. The Hazen-West and Noonan sites had dangerous steeply sloped highwalls at or near public-use areas. These were eliminated. The Fritz site was a virtual wasteland characterized by toxic spoils and acidic water filled pits. The toxic spoils and ash were a wind-borne health hazard to people and animals. This site was graded to a rolling topography, toxic surface materials were covered, and wetland sumps and a stock pond were constructed. All three sites have been stabilized with permanent vegetation including grass and forb species.

Table 2 provides a comparison of soil and water quality at each site in 1998 and 2003. The soils at each site, while less than high quality, are adequate to sustain the species seeded. North Dakota Administrative Code (NDAC), Article 69-05.2-08-10 provides minimum requirements for topsoil and subsoil resources for permitted mines. Soil quality at Hazen-West, Noonan and Fritz sites meet or exceed the requirements for subsoil material. Water quality at the wetlands sampled at the Hazen-West and Noonan Sites conforms to established standards (NDCC 33-16-02.1-09) for lakes and Class III Streams with regard to nitrate and sulfate concentrations. Water

quality at the stock pond at the Fritz site is within established parameters for stock watering impoundments in North Dakota (NDSU Extension Service 1988).

Numerous wildlife species were observed at each site in 1998 and 2003. At the Hazen West and Noonan Sites, many species of waterfowl and shorebirds were noted including Mallard (*Anas platyrhynchos)*, Blue Winged Teal (*Anas discors)*, Coot (*Fulica Americana)*, Terns & Gulls (*Sterna & Larus spp*.), Killdeer (*Charadrius vociferus),* and Avocet (*Recurvirostra Americana)* (Noonan only). A Whitetail Deer (*Odocoileus virginianus)* was observed at the Hazen West site in 1998 and a small covey of Hungarian Partridge (*Perdix perdix)* a Ring-neck Pheasant (*Phasianus colchicus)* and a Northern Harrier (*Circus cyaneus)* were seen at the Noonan Site in 2003. Yellow-Headed Blackbird (*Xanthocephalus xanthocephalus*), Red-Winged Blackbird (*Agelaius phoeniceus*), and Western Meadowlark (*Sturnella neglecta*) were observed at all sites. Several species of songbirds, mice and other small mammals were also observed. Although not observed directly on-site, Pronghorn Antelope (*Antilocapra Americana)* and Prairie Dogs (*Cynomys ludovicianus)* were observed near the Fritz Site.

The Fritz site, reclaimed in 1992, was the one acidic uraniferous site documented in North Dakota. A limited amount of topsoil was recovered through the process of segregating materials deemed acidic and radioactive. The seed mix chosen was based on an analysis of range sites described for this portion of the county. This mix included species that compose the climax vegetation described for soils endemic to the area.

A comparison of the seed mixture with the extant vegetation at Fritz yields some interesting results. First, the dominant species of the site, six years and eleven years after planting, are for the most part the species originally planted. The only species not encountered or observed that was part of the mix is Sideoats grama (*Bouteloua curtipendula*). Limited available topsoil and sandy spoil at this site may have not been conducive to establishment of this species.

The diversity of vegetation, over and above the dominant species, suggests the area is indeed returning to a condition similar to the climax vegetation found prior to mining. The productivity of live vegetation and the litter component, while the lowest of the three sites evaluated, still provides adequate erosion control. Estimated forage production for this site was 960 lbs/acre in 1998 and 817 lbs/acre in 2003. North Dakota Public Service Commission (2001) provided expected production values of native grasslands by range site. Expected forage yields in a normal year for relatively low producing, very shallow to shallow, range sites in this area were 700-1400 pounds per acre. The number of forbs encountered was remarkable. Even cactus (*Opuntia polycantha*) clipped in 1998; reflect the xeric conditions of the area. Mature cacti were present prior to reclamation.

While total first hit cover dropped slightly, from 90% to 87%, at the Fritz site between 1998 and 2003, it should be adequate to protect the area from erosion. North Dakota Public Service Commission (2001) established a fixed cover standard for reclaimed mine lands based on previous studies that indicated 83% first hit cover is required to adequately protect grassland areas from erosion.

The number of species encountered at the Fritz site increased from 19 to 23 between 1998 and 2003. Western Wheatgrass (A. smithii) decreased in relative frequency from about 40% to 23% but the frequency of Prairie Sandreed (C. longifolia) increased from about 8% to 24%. A few species such as Alfalfa (M. sativa), Buffalograss (B. dactyloides), and Needle and Thread (S. comata) which were significant components in 1998 were not encountered during sampling in 2003. These changes seem generally normal in this establishing

native community considering its sandy-textured soils and the near drought conditions in 2002 and 2003. For more information on species composition at the Fritz site, refer to Table 3C.

The Hazen-West site, reclaimed in 1991, had no topsoil. The glacial till spoil at this site was relatively high quality and was enhanced through the use of coal fines as an amendment. The seed mix used was requested by the landowner, North Dakota Game and Fish Department, to provide dense nesting cover for waterfowl and habitat for other wildlife species. The dominant species, seven and twelve years after initial planting, again reflect species originally planted. The road ditch adjacent to this site was seeded by the North Dakota Department of Transportation with the introduced species, Smooth Bromegrass (Bromis inermis). This is a very aggressive and ecologically tolerant species that has continued to invade the site. Its relative frequency increased from 12% to 32% between 1998 and 2003.

The diversity of this site is considerably less than Fritz, where native seed of climax vegetation was used. However, the number of species encountered increased from six in 1998 to eleven in 2003. Erosion control is excellent due not only to a vigorous plant community but also a good litter component (see Table 3A.). Vegetative cover and forage production at this site were excellent. Total first hit cover increased from 95% in 1998 to 99% in 2003 and estimated production from 1563 lbs/acre to 2304 lbs/acre. The increase in forage production may be due in part to the increase in the frequency of Smooth Bromegrass, a high-producing grass. Expected median pasture/hayland yields for relatively low producing, shallow to thin upland, soils in this area range from ½ to 1 ton per acre (NDPSC 2001). Estimated forage yields from adjacent orphaned spoils at the Hazen-West site were 1121 lbs/acre in 1998 and 688 lbs/acre in 2002 (Table 4).

The Noonan A(3) and Noonan A(4) sites were reclaimed in 1994 and 1995, respectively. The two sites are contiguous and represent a two-phased effort to eliminate a long stretch of dangerous highwall proximal to agricultural activity. While the seed mixes planted are a little different, wheatgrass species were used on both due to their tolerance to saline conditions. Agropyron (wheatgrass) species continue to dominate this site comprising about 67% of the relative cover in 1998 and 33% in 2003. Kentucky Bluegrass (P. pratensis) an invading species has increased significantly in relative frequency from less than 1% in 1998 to over 18% in 2003. Smooth Bromegrass (B. inermis) was the dominant species found on spoil as well as an invader on reclaimed areas. Total vegetative cover at the Noonan site remained excellent at 97% in 1998 and 2003. Estimated forage yield dropped slightly from 1010 to 917 lbs/acre. This value is still near the range of ½-1 ton/acre and is significantly higher than sampled forage yields on adjacent orphaned spoils of 703 lbs/acre in 1998 and 588 lbs/acre in 2003 (Table 4).

The results of this study have proven conclusively that in addition to eliminating hazards at these reclaimed minesites; reclamation has restored much of the pre-mine utility of these lands. The Hazen-West and Noonan sites provide excellent cover for wildlife species and provide fishing and hunting opportunities for citizens of the area. These sites could probably also be used agriculturally for hay production or cattle grazing. The Fritz site has been dramatically improved from a toxic wasteland to a productive and diverse native grassland ecosystem and has already been used for cattle grazing.

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F. Figures and Tables

Figure 1: General Site Locations

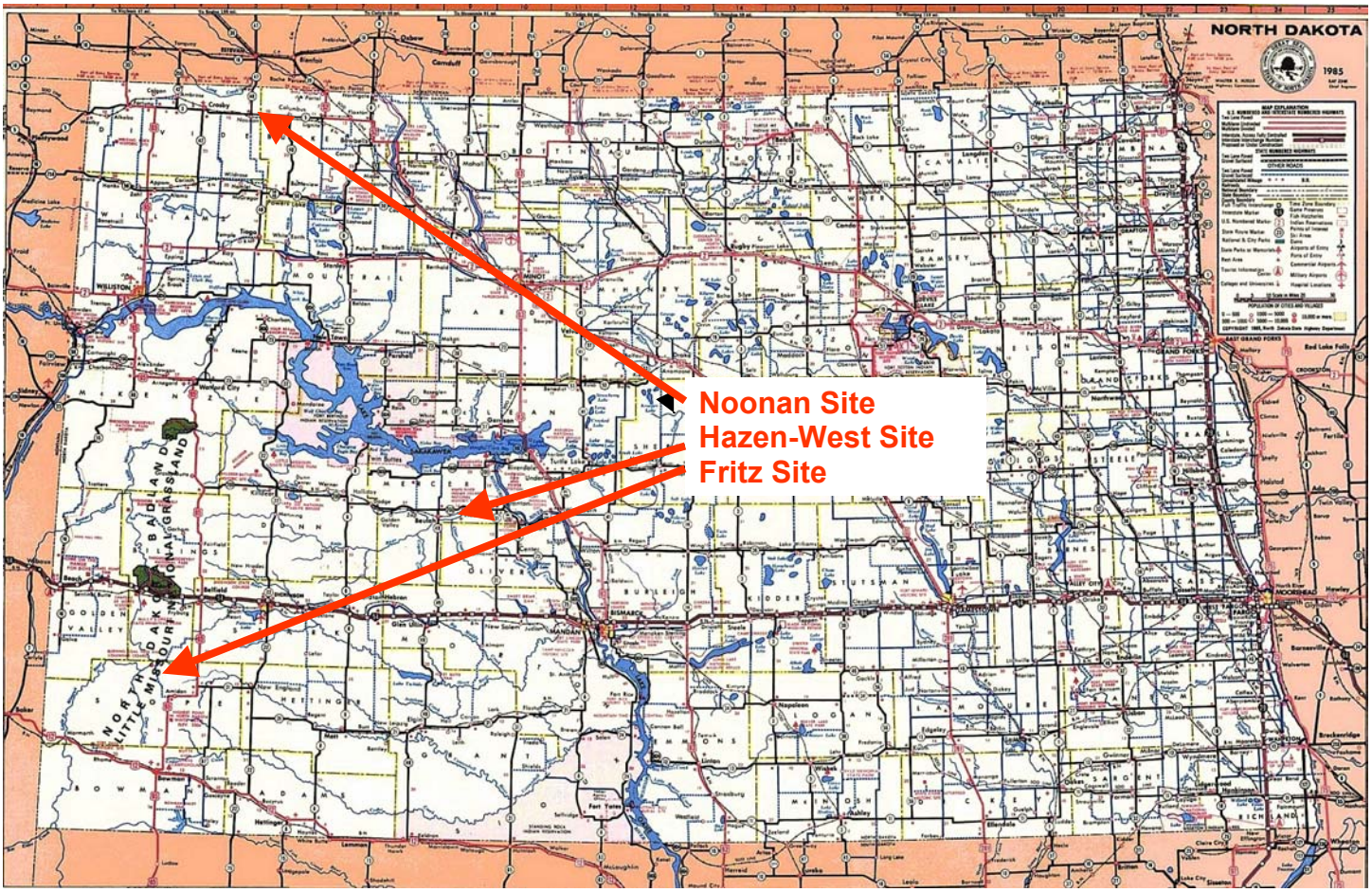

Table 1 Seed Mixtures Used at Reclaimed Sites

Site (year reclaimed)	Common Name (Species - 'Variety')	Lbs. PLS per acre
Hazen-West (1991)	Yellow Sweetclover (Melilotus officianalis)	2
	Alfalfa (Medicago sativa - 'Trevois')	2.5
	Intermediate Wheatgrass (Agropyron cristatum - 'Oahe')	6
	Tall Wheatgrass (Agropyron elongatum - 'Alkar')	7
	Total	17.5
Noonan (1994-5)	Western Wheatgrass (Agropyron smithii – 'Rodan')	10
	Slender Wheatgrass (Agropyron trachycaulum - Primar')	3.5
	Thickspike Wheatgrass (Agropyron dasystachum - Critana')	2
	Yellow Sweetclover (Melilotus officianalis)	1
	Total	16.5
Fritz (1992)	Buffalograss (Buchloe dactyloides – native harvest)	0.25
	Blue Grama (Bouteloua gracilis – native harvest)	1.5
	Sideoats Grama (Bouteloua cirtipenula –'Pierre')	3
	Western Wheatgrass (Agropyron smithii – 'Rodan')	3.5
	Prairie Sandreed (Calamovilfa longifolia – 'Goshen')	2
	Needle and Thread (Stipa comata – native harvest)	4
	Total	14.25

Table 2. Soil and Water Sample Analysis

Year	1998	2003	1998	2003	1998	2003
Parameter	Hazen W./Soil	Hazen W./Soil	Noonan/Soil	Noonan/Soil	Fritz/Soil	Fritz/Soil
Organic Matter (%)	2.7	4	1.8	1.7	3.1	0.85
Nitrogen (lbs/a)	1		3		1	
Phosphorous (ppm) Olsen	3	5	4	11	13	18
Potassium (ppm)	180	136	200	238	160	154
Salts (mmhos/cm)	1	0.4	0.7		0.4	
Texture	med/fine	med/fine	med/fine		med/fine	
Calcium (meq/l)	3.8	1.9	1.5	2.6	2.6	0.5
Magnesium (meq/l)	2.4	1.3	0.6	1.6	1.6	0.5
Sodium (meq/l)	11.9	7.3	9.7	4.2	6.6	3.3
Sodium Adsorbtion Ratio	6.76	5.77	9.47	2.9	4.55	4.67
pH	7.3	8	7.8	6.7	5.2	6.4
Uranium (ug/g) Fritz only					10.1	9.51
Cadmium (ug/g) Fritz only					<1.45	0.601
Molybdenum (ug/g) Fritz only					42	19.5

	Hazen W. Wetland	Hazen W. Wetland	Noonan Wetland	Noonan Wetland	Fritz Pond	Fritz Pond
pH	9.8	7.2	8.9	8.6	7.4	7.3
Total Alkalinity (mg/l CaCO3)	136	395	145	296	31	100
Phenolphthalein Alk. (mg/l CaCO3)	42	<1	17	30	<1	<1
Bicarbonate (mg/l CaCO3)	51	395	111	236	31	100
Carbonate (mg/l CaCO3)	85	<1	34	60	<1	<1
Hydroxide (mg/l CaCO3)	0	0	0	0	0	0
Specific Conductance (umhos/cm)	385	962	1010	780	128	328
Fluoride (mg/l)	0.38	0.19	0.3	0.44	0.3	0.72
Sulfate (mg/l)	80.6	161	349	332	125	69.5
Chloride (mg/l)	1.2	3.1	8.6	12.5	8.9	5.8
Nitrate-Nitrite as N (mg/l)	<1	<0.1	<1	<0.1	<1	<0.1
Ammonia-Nitrogen as N (mg/l)	<0.1		<0.1		0.42	
Total Suspended Solids (mg/l)	10		4		58	
Calcium-Total (mg/l)	15.5	64.8	48.6	15.5	10.1	10.8
Magnesium-Total (mg/l)	9.7	25.4	35.2	15.7	8.1	7.6
Sodium-Total (mg/l)	63.2	118	120	219	25.9	32.1
Potassium-Total (mg/l)	5.9	8	11.2	7.4	3.9	14.5
Iron-Total (mg/l)	0.32	0.45	0.32	0.11	39	6
Manganese-Total (mg/l)	<0.05	0.12	<0.05	<0.05	0.25	0.5
Total Dissolved Solids (mg/l)	258	617	660	780	200	200
Total Hardness as CaCO3 (mg/l)	78.6	266	266	103	58.6	58.3
Hardness (grains/gallon)	4.6	15.6	15.6	6.04	3.43	3.41
Cation Summation	4.48	10.7	10.8	11.8	3.83	3.16
Anion Summation	4.43	11.3	10.4	13.2	3.47	3.61
Sodium Adsorbtion Ratio	3.1	3.15	3.2	9.37	1.47	1.83
Uranium (mg/l) Fritz only					0.018	0.0232
Cadmium (mg/l) Fritz only					<0.01	<0.0002
Molybdenum (mg/l) Fritz only					<0.1	0.1

Table 3A. First Hit Cover at the Hazen West Site 1998 and 2003

A. Reclaimed Area
Data Based on 30 frames, 300 points, sampled July 1, 1998 and June 24-25, 2003

Species		% Cover 1998		% Cover 2003	
Common Name	**Scientific Name**	**Absolute**	**Relative**	**Absolute**	**Relative**
Intermediate Wheatgrass	Agropyron intermedium	30.63%	47.12%	19.67%	34.50%
Crested Wheatgrass	Agropyron cristatum			0.33%	0.58%
	Bare Ground	5.00%	0.00%	1.00%	
Blue Grama	*Bouteloua gracilis*			0.33%	0.58%
Smooth Bromegrass	*Bromus inermis*	8.13%	12.50%	18.00%	31.58%
Flodman's Thistle	*Cirsium flodmani*			1.00%	1.75%
Bastard Toadflax	*Comandra palida*			0.67%	1.17%
Creeping Jenny	*Convolvulus arvensis*	2.50%	3.85%	2.00%	3.51%
Foxtail Barley	*Hordeum jubatum*	1.25%	1.92%		
	Litter	30.00%		42.00%	
Alfalfa	*Medicago sativa*	22.50%	34.62%	13.00%	22.81%
Kentucky Bluegrass	*Poa pratensis*			1.33%	2.34%
Wild Buckwheat	*Polygonum convolvulvus*			0.33%	0.58%
Green Needlegrass	*Stipa viridula*			0.33%	0.58%
		100%	**100%**	**100%**	**100%**

B. Spoil Area
Data Based on 6 Frames, 60 points, sampled July 1, 1998 and June 25, 2003

Species		% Cover 1998		% Cover 2003	
Common Name	**Scientific Name**	**Absolute**	**Relative**	**Absolute**	**Relative**
Western Wheatgrass	*Agropyron smithii*			16.67%	30.30%
	Bare Ground	5.00%		11.67%	
Smooth Bromegrass	*Bromus inermis*	61.67%	97.37%	16.67%	30.30%
Creeping Jenny	*Convolvulus arvensis*				
American Licorice	*Glycyrrhiza lepidota*			5.00%	9.09%
	Litter	31.67%		30.00%	
Alfalfa	*Medicago sativa*				
Kentucky Bluegrass	*Poa pratensis*			11.67%	21.21%
	Rock			3.33%	0.00%
Missouri Goldenrod	*Solidago missouriensis*			3.33%	6.06%
Needle and Thread	*Stipa comata*			1.67%	3.03%
Unknown Forb		1.67%	2.63%		
	Total	**100%**	**100%**	**100%**	**100%**

Table 3B. First Hit Cover at the Noonan Site 1998 and 2003

A. Reclaimed Area
Data Based on 32 frames, 320 points, sampled July 7-8, 1998 and June 25-26, 2003

Species		% Cover 1998		% Cover 2003	
Common Name	**Scientific Name**	**Absolute**	**Relative**	**Absolute**	**Relative**
Crested Wheatgrass	*Agropyron cristatum*			0.94%	1.82%
Thickspike Wheatgrass	*Agropyron dasystachyum*	10.63%	16.83%		
Western Wheatgrass	*Agropyron smithii*	1.25%	1.98%	14.38%	27.88%
Slender Wheatgrass	*Agropyron trachycaulum*	29.38%	46.93%	1.88%	3.64%
Common Ragweed	*Ambrosia artemesifolia*			1.25%	2.42%
Absinth Wormwood	*Artemesia absinthium*			0.31%	0.61%
Wormwood Sage	*Artemesia caudata*	2.81%	4.48%		
	Bare Ground	3.13%		3.13%	
Smooth Bromegrass	*Bromus inermis*	10.94%	17.33%	8.44%	16.36%
Rubber Rabbitbrush	*Chrysothamnus naseosus*			0.63%	1.21%
Flodman's Thistle	*Cirsium flodmani*			0.31%	0.61%
Tansy Mustard	*Descurainia pinnata*	0.31%	0.50%		
Foxtail Barley	*Hordeum jubatum*	0.63%	0.99%		
Kochia	*Kochia scoparia*	2.50%	3.96%		
	Litter	33.44%		45.31%	
Alfalfa	*Medicago sativa*			3.44%	6.67%
Sweetclover	*Melilotus officinalis*	2.81%	4.46%	3.13%	6.06%
Reed canarygrass	*Phalaris arundinacea*			0.31%	0.61%
Kentucky Bluegrass	*Poa pratensis*	0.31%	0.50%	9.38%	18.18%
Knotweed	*Polygonum aviculare*	1.56%	2.48%	1.56%	3.03%
	Rock	0.31%			
Prairie Rose	*Rosa arkansana*				
Rigid Goldenrod	*Solidago rigida*			1.56%	3.03%
Buckbrush	*Symphoricarpos occidentalis*			0.31%	0.61%
Western Salsify	*Tragopogon dubius*			3.75%	7.27%
	Total	**100%**	**100%**	**100%**	**100%**

B. Spoil Area
Data Based on 15 Frames, 150 points, sampled July 8, 1998 and June 26, 2003

Species		% Cover 1998		% Cover 2003	
Common Name	**Scientific Name**	**Absolute**	**Relative**	**Absolute**	**Relative**
Silverscale Saltbush	*Atriplex Argentea*	1.33%	2.50%		
	Bare Ground	18.67%		31.33%	
Smooth Bromegrass	*Bromus inermis*	30.67%	57.50%	19.33%	52.73%
Flodman's Thistle	*Cirsium flodmani*			0.67%	1.82%
Horsetail	*Equsitum arvense*			0.67%	1.82%
Leafy Spurge	*Euphorbia esula*	4.67%	8.75%	0.67%	1.82%
Kochia	*Kochia scoparia*	2.67%	5.00%		
Prickly Lettuce	*Lactuca serriola*	0.67%	1.25%		
	Litter	26.67%	0.00%	31.33%	
Skeletonweed	*Lygodesmia juncea*	0.67%	1.25%		
Kentucky Bluegrass	*Poa pratensis*	1.33%	2.50%	4.67%	12.73%
Cottonwood	*Populus detoides*	1.33%	2.50%		
	Rock	1.33%		0.67%	
Scarlet Globemallow	*Sphaeralcea coccinea*			2.67%	7.27%
Prairie Dropseed	*Sporobolous heterolepis*	1.33%	2.50%		
Needle and Thread	*Stipa comata*			1.33%	3.64%
Green Needlegrass	*Stipa viridula*	3.33%	6.25%		
Buckbrush	*Symphoricarpos occidentalis*	5.33%	10.00%	6.00%	16.36%
Western Salsify	*Tragopogon dubius*			0.67%	1.82%
	Total	**100%**	**100%**	**100%**	**100%**

Table 3C. First Hit Cover at the Fritz Site 1998 and 2003

Data Based on 30 frames, 300 points, sampled July 10, 1998 and June 30, 2003

Species		% Cover 1998		% Cover 2003	
Common Name	**Scientific Name**	**Absolute**	**Relative**	**Absolute**	**Relative**
Western Yarrow	*Achillea lanulosa*	1.33%	1.77%	3.00%	5.17%
Western Wheatgrass	*Agropyron smithii*	30.33%	40.27%	13.33%	22.99%
Big Bluestem	*Andropogon gerardii*			2.67%	4.60%
Fringed Sagebrush	*Artemesia frigida*	0.67%	0.88%	1.00%	1.72%
Cudweed Sagewort	*Artemesia ludoviciana*	0.33%	0.44%	3.33%	5.75%
	Bare ground	10.00%		12.67%	
Blue Grama	*Bouteloua gracilis*	2.67%	3.54%	1.00%	1.72%
Smooth Bromegrass	*Bromus inermis*	0.67%	0.88%	3.67%	6.32%
Downy Brome	*Bromus tectorum*			0.67%	1.15%
Buffalograss	*Buchloe dactyloides*	4.00%	5.31%		
Sedges	*Carex sp.*	1.33%	1.77%	1.33%	2.30%
Prairie Sandreed	*Calamovilfa longifolia*	6.33%	8.41%	13.67%	23.56%
American Licorice	*Glycyrrhiza lepidota*			1.00%	1.72%
Foxtail Barley	*Hordeum jubatum*	0.67%	0.88%		
Kochia	*Kochia scoparia*			1.33%	2.30%
Praire Junegrass	*Koeleria pyrimida*	1.00%	1.33%	0.33%	0.57%
	Litter	14.33%		29.33%	
Alfalfa	*Medicago sativa*	8.33%	11.06%		
Sweetclover	*Melilotus officinalis*				
	Mertensea lanceolota			1.33%	2.30%
Switchgrass	*Panicum virgatum*	6.00%	7.96%	0.33%	0.57%
White Prairieclover	*Petalostemon candidum*			0.33%	0.57%
Woolly Indianwheat	*Plantago purshii*				
Silverleaf Scurfpea	*Psoralea argophylla*			0.67%	1.15%
Indian Breadroot	*Psoralea esula*			1.33%	2.30%
	Rock	0.33%			
Prairie Rose	*Rosa arkansana*			0.67%	1.15%
Prairie Cordgrass	*Spartina pectinata*	2.00%	2.65%		
Sand Dropseed	*Sporobolus cryptandrus*	2.33%	3.10%		
Needle and Thread	*Stipa comata*	6.33%	8.41%		
Green Needlegrass	*Stipa viridula*	1.00%	1.33%		
Dandelion	*Taraxicum officinale*			1.33%	2.30%
Unknown Forb 1				2.00%	3.45%
Unknown Forb 2				0.33%	0.57%
Unknown Forb 3				3.33%	5.75%
	Total	**100%**	**100%**	**100%**	**100%**

Table 4. Forage Production at Reclaimed Sites and Unreclaimed Spoils

Site	Date Sampled	No. of Samples	Mean Weight of Above Ground Forage gm/0.25m^2	Conversion. Factor	lbs/ac	Range (lbs/ac)
Hazen West	July 1, 1998	15	43.8	35.7	1563	832-2541
Hazen West	June 25-26, 2003	14	70.2	35.7	2504	846-3961
Hazen West Spoil	July 1, 1998		31.4	35.7	1121	985-1199
Hazen West Spoil	June 26, 2003	3	18.2	35.7	651	421-956
Noonan	July 7-8, 1998		28.3	35.7	1010	268-1920
Noonan	June 26-27, 2003	16	25.7	35.7	917	325-1463
Noonan Spoil	July 7-8, 1998		19.7	35.7	703	385-1181
Noonan Spoil	June 27, 2003	8	16.5	35.7	588	100-1353
Fritz	July 10, 1998		26.9	35.7	960	136-2223
Fritz	June 30, 2003	15	22.9	35.7	817	143-3176