2011 TOLNA COULEE PROJECT

A Report Submitted to the North Dakota State Water Commission

By

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Introduction

During their June 21, 2011 meeting, the North Dakota State Water Commission approved a motion directing the State Engineer to re-examine the data generated during the North Dakota Geological Survey's 1997 study of the Tolna Coulee. That study determined the elevation of the surface of the Tolna Coulee, within the area of study, at the time of statehood (Murphy and others, 1997). As a result of this meeting, the State Engineer contacted the ND Geological Survey and requested a follow-up study.

1997 Study of the Tolna Coulee and Jerusalem Outlets

In March 1997, the ND Geological Survey collected sediment samples in the Jerusalem Outlet and the Tolna Coulee for pollen analysis and radiocarbon dating. A backhoe was used to excavate to the base of the Holocene sediments (sediments deposited over the last 10,000 years) and cores were obtained from the near-surface sediments using a truck-mounted Giddings Probe. Holocene sediments were found to be 17-20 feet thick at the Tolna Coulee study site.

Historians and agricultural scientists have determined that settlers to North Dakota, at or around the time of statehood, inadvertently carried with them seeds of Russian thistle (*Salsoa*). Because Russian thistle and other opportunistic weeds quickly spread across the state, the deepest appearance of its pollen in undisturbed sediment marks the approximate time of statehood (the year 1889) for North Dakota.

In the 1997 study, 16 sediment samples were submitted for pollen analysis from the Jerusalem Outlet and 15 from the Tolna Coulee. Pollen, as with all fossils of living things, is not preserved equally across a given landscape. Pollen is best preserved in sedimentary environments lacking oxygen or those that are acidic. Pollen studies are most reliable when there is sufficient pollen preserved in the rock or sediments to enable statistically reliable pollen counts to be made or to construct pollen profiles that depict the abundance of various pollen assemblages with depth. As it turned out, pollen preservation was generally poor at the Jerusalem Outlet study site, but relatively good at the Tolna Coulee site. As a result, statistically reliable pollen counts and pollen profiles were possible for most samples obtained from the Tolna Coulee, but only possible for a few from the Jerusalem Outlet. Based upon the information generated, the ND Geological Survey determined that Russian thistle and other opportunistic weed pollen extended to a depth of one foot below the surface (to an elevation of 1,458 feet) at the Tolna Coulee study site and to a depth of six inches at the Jerusalem Outlet study site (Figure 1).

2002 Black Slough Project

In 2002, the ND Geological Survey examined the Black Slough Outlet for the North Dakota State Water Commission with the intent of once again identifying the surface at the time of statehood. One dozen trenches were excavated across the study site and 50 sediment samples were submitted for pollen analysis (Murphy and Fleming, 2002). All of the samples contained abundant fungal spores, but had poor recovery of pollen. In fact, 22% of the samples were totally barren of pollen and no Russian thistle pollen or other opportunistic weed pollen was identified. As a result, no conclusions could be drawn regarding the relationship between the present surface and that of

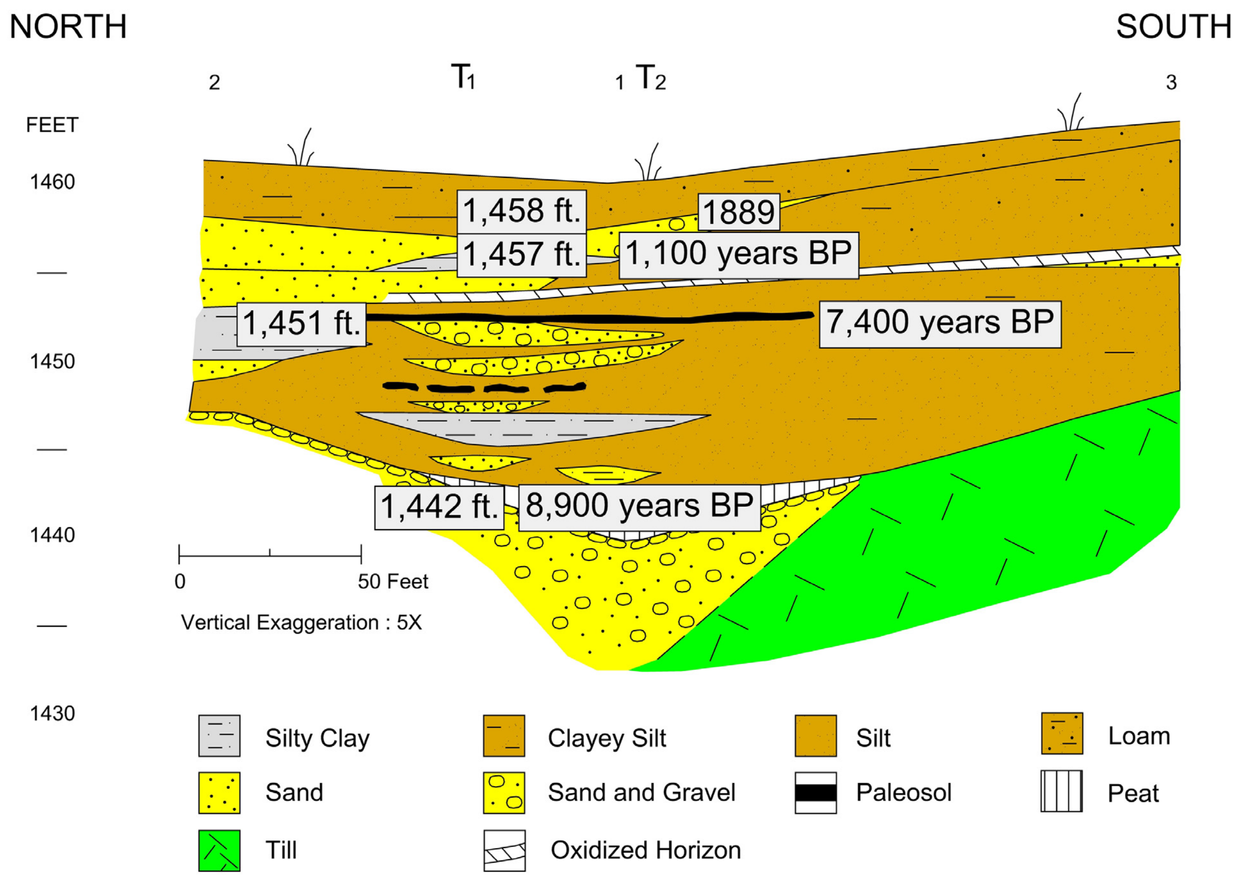

Figure 1. Geologic cross-section of the Tolna Coulee (modified from the 1997 study). The age of the sediment at an elevation of 1,458 was based on pollen analysis, all other dates were determined by radiocarbon dating.

the 1889 surface at this site.

2011 Project

On July 13, 2011, the Geological Survey attempted to obtain samples from the Tolna Coulee using the same truck-mounted Giddings Probe that had been used in 1997. However, the ground was too soft and would not support the weight of the truck in the study area. For that reason, the four-foot-long, two-inch-diameter core barrel was removed from the truck and either pushed manually or pounded through the soft sediment (Figure 2). Using this method, core retrieval ranged from 12 to 25 inches for the dozen core sites within the study area. The manual push/pound method resulted in a lesser recovery of sediment core than what is typically seen in truck-mounted coring. Most of the sediment core was obtained below an elevation of 1,458 feet. In fact, the surface elevation for the vast majority of the core sites ranged between 1,457 and 1,458 feet (Table 1, Figures 3 and 4).

Figure 2. Fred Anderson pushing a core barrel (with an interior plastic sleeve) through organic-rich sediment in the Tolna Coulee.

Table 1. The Elevations and Amount of Core Recovered for the 2011 Tolna Coulee Sediment Cores.

Core Site	Surface Elevation	Elevation at the Base of Core	Core Thickness (ft.)
1	1457.8	1455.55	2.25
1a	1457.8	1457.05	0.75
2	1458.89	1456.89	2
3	1458.61	1456.36	2.25
4	1457.96	1456.21	1.75
5	1457.86	1456.36	1.5
6	1457.6	1455.85	1.75
7	1457.67	1456.67	1
8	1458.09	1457.09	1
9	1456.64	1454.39	2.25
10	1457.08	1455.58	1.5
11	1456.98	1455.48	1.5

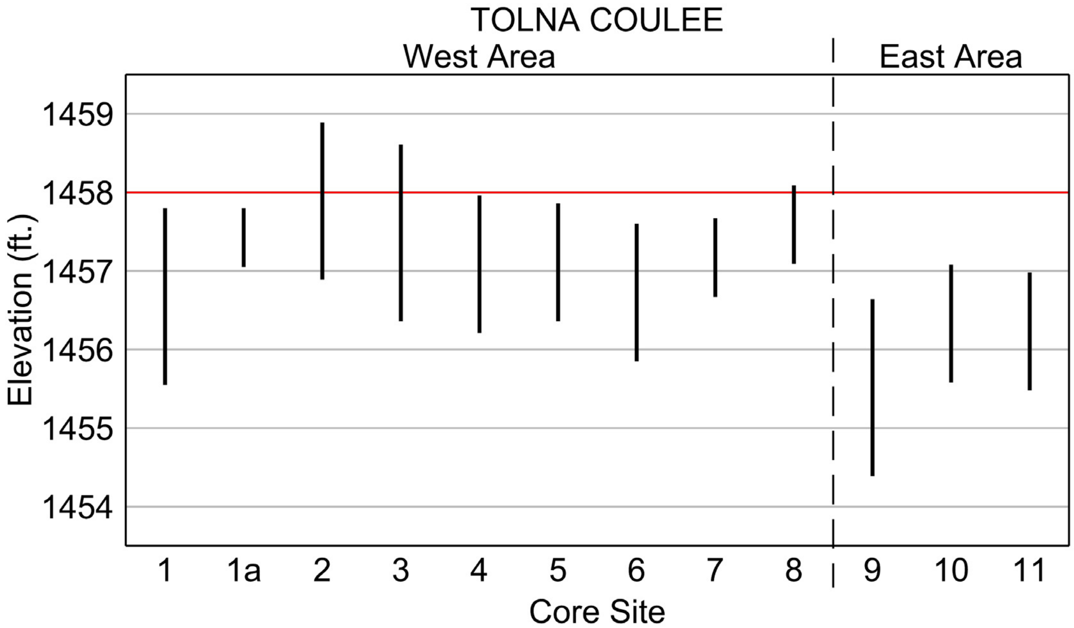

Figure 3. Vertical profile of the sediment cores retrieved in the Tolna Coulee.

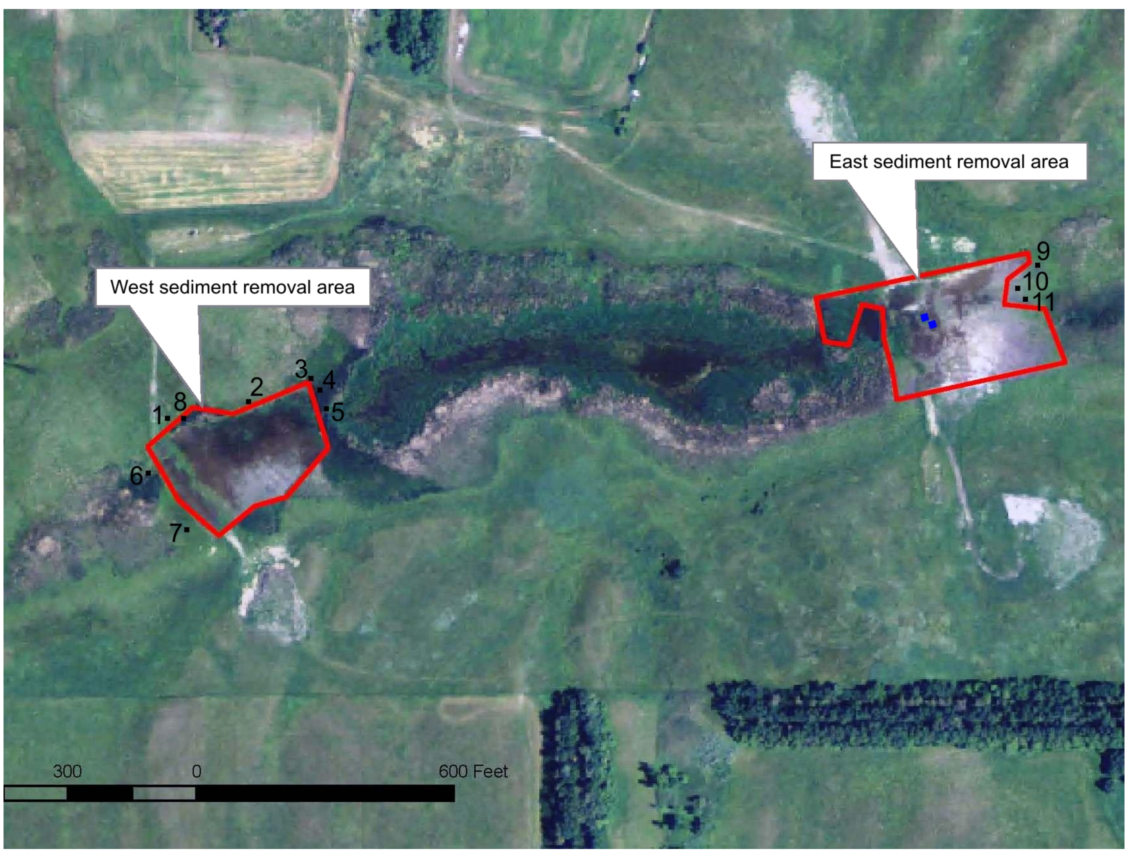

Figure 4. The 2011 Tolna Coulee study area, black squares represent core locations. The areas outlined in red are where sediment was removed to an elevation of 1,458 feet. The blue squares mark the approximate location of the study trenches excavated in 1997.

Figure 5. The 69 samples from the 2011 Tolna Coulee project prior to shipment to the pollen processing laboratory. The samples are three-inch increments of the sediment cores.

In the fall of 2009 and spring of 2010, the City of Devils Lake removed sediment to an elevation of 1,458 feet in two areas in the Tolna Coulee. This work was based upon the results of the 1997 ND Geological Survey study. Access within the Tolna Coulee study area on July 13, 2011 was limited, even on foot, due to either standing water or soft surface conditions. As a result a randomly generated sampling grid had to be abandoned and sampling sites were located just outside the perimeters of both the east and west sediment removal areas. No sampling was done within the sediment removal areas, or in any other areas where surface disturbance was evident, due to the potential for pollen cross-contamination. One dozen sites were sampled, nine adjacent to the west sediment removal area and three adjacent to the east site (Figure 4).

The 1997 study took place during the winter when modern pollen was virtually nonexistent. Since modern pollen was likely prevalent during the 2011 study, special precautions were taken to minimize contamination of the sediment samples. New, plastic tubes or sleeves were used inside the core barrel for each core. In addition, those tubes were thoroughly rinsed on the morning of July 13 and sealed in plastic bags. These interior sleeves were not removed from the plastic bags until they were needed and both ends were sealed with duct tape as soon as they were retrieved from the core barrel. Samples were frozen in the plastic sleeves, cut into three-inch segments, dried, placed in ziplok bags, and sent to Global Geolabs in Medicine Hat, Alberta, Canada for processing. A total of 69 sediment samples were submitted for analysis, 4.5 times the number of samples submitted during the 1997 Tolna Coulee project (Figure 5, Appendix A).

The procedures used for the palynological analysis in Murphy and others (1997) were followed as closely as possible in this study. Global Geolabs was instructed to follow the sample processing protocol as used in the previous study. Appendix B contains a transcription of the Palynology Processing Record that was sent with the palynology slides from the laboratory. Global Geolabs reported that the recovery from all of the samples was "Good." It is important to note that this assessment is based on the amount of organic material recovered, not on the quality of the palynological assemblages recovered. A sample can be reported to have good recovery because it contains abundant plant debris, but can be devoid of pollen.

The palynology slides were examined with an Olympus BH-2 microscope. The palynological analyses followed the approaches in Murphy and others (1997), which were based on Jacobson and Engstrom (1989).

Of the 69 samples that were processed, only two samples from two separate localities contained sufficient pollen to allow statistically reliable counts. Those samples were collected at the top of the section in both of the localities. Thus, none of the localities contained a suite of samples suitable for constructing a pollen profile as was done in the study by Murphy and others (1997). All of the palynology slides were completely scanned (a time intensive process) and presence/absence information for pollen was recorded. Preservation in all of the samples was poor and all of the samples are characterized by the presence of algal cysts, fungal spores, fungal hyphae, and fusinite. No pollen of *Salsola* sp. was observed in any of the samples.

Palynology Results

The detailed results for each of the localities are described below. Localities are discussed in three groups according to their geographic proximity and the similarity of the palynological results for each locality. The three groupings are Localities 1 and 8, Localities 2-7, and Localities 9-11 (Figures 3 and 4).

Localities 1 and 8

Tables C-1 and C-8 in Appendix C contain the occurrence data for the samples recovered from these two localities. The two uppermost samples from these localities are the only samples in this report that contained sufficient pollen to enable a count to be made. Table 2 shows the results of these counts.

Both samples are overwhelmingly dominated by pollen of *Typha* spp. All of the other pollen types in these assemblages are present in relatively low percentages, including pollen of *Pinus* spp., Cyperaceae, Gramineae, Chenopodiaceae, and Compositae. The assemblages also contain small percentages of fern and moss (*Sphagnum*) spores. No pollen of *Salsola* was seen in these samples. The samples contain abundant algal cysts, fungal spores, fungal hyphae, and fusinite.

These results strongly suggest that the uppermost part of the section was deposited in a wetlands setting dominated by *Typha* spp. (cattails). No interpretations can be made regarding the introduction of exotic species into the area that could be attributable to European settlers. The presence of abundant fusinite is sometimes interpreted to indicate a history of fire and this was also noted in samples examined in the previous study.

Table 2. Occurrence Data for Tolna Coulee Samples 1a-a and 8a (X = trace).

	1a-a	8a
Pinus sp.	7%	1%
Cyperaceae	2%	2%
Typha spp.	79%	92%
Gramineae	2%	1%
Chenopodiaceae	4%	4%
Salsola sp.	0	0
Compositae	4%	1%
Sphagnum sp.	1%	0%
Fern spores	1%	X

Localities 2-7

Tables C-2 through C-7 in Appendix C contain the occurrence data for the samples recovered from these six localities. None of the localities in this group contained sufficient pollen to enable a statistically reliable count to be made. For the most part, the assemblages from these samples were extremely sparse with only trace amounts of the pollen listed in the tables in Appendix C. The samples are characterized by abundant algal cysts, fungal spores, fungal hyphae, and fusinite.

No interpretations can be made from these samples because of the sparse nature of the assemblages.

Localities 9-11

Tables C-9 through C-11 in Appendix C contain the occurrence data for the samples recovered from these three localities. None of the localities in this group contained sufficient pollen to enable a statistically reliable count to be made. These samples were either barren or essentially barren with only trace amounts of the pollen listed in the tables in Appendix C. The samples are characterized by algal cysts, fungal spores, fungal hyphae, and fusinite.

No interpretations can be made from these samples because of the barren nature of the assemblages.

Conclusions

The 1997 Tolna Coulee study was able to use palynological data to determine the elevation of the land surface at or around the time of North Dakota statehood. However, due to the poor recovery of pollen in this study and the absence of *Salsola*, no conclusions can be drawn regarding the elevation of the 1889 land surface.

The two most logical explanations for the differences in pollen recovery between the 1997 and the 2011 Tolna Coulee study are procedural differences or local environmental conditions. Procedural differences can be ruled out because special care was taken to ensure that the same procedures were followed in both studies. Therefore, it is more likely that natural variations in the preservation of pollen at the different localities are the primary factor. Poor pollen preservation at the 2011 study sites could be due to local conditions at the time of deposition (e.g., winnowing) or to post-depositional degradation (e.g., oxidation).

References

Jacobson, H.A. and Engstrom, D.R., 1989, Resolving the chronology of recent lake sediments: an example from Devils Lake, North Dakota, Journal of Paleolimnology, v. 2 pp. 81-97.

Murphy, E.C., Fritz, A.M.K., and Fleming, R.F., 1997, The Jerusalem and Tolna Outlets in the Devils Lake Basin, North Dakota: North Dakota Geological Survey Report of Investigation no. 100, 36 p.

Murphy, E.C., and Fleming, R.F., 2002, The Black Slough Outlet Devils Lake, North Dakota: A report submitted to the North Dakota State Water Commission, 17 p.

APPENDIX A

Soil Sample Descriptions - Tolna Coulee Outlet

No.	Depth (in.)	Munsell Color	Soil Description
1a	0 -- 3	Dark Gray (10YR4/1)	CLAY, with silt, organics (roots) common.
1b	3 -- 6	Light Brownish Gray (10YR6/2)	SILT, with clay, organics (roots) common.
1c	6 -- 9	Light Brownish Gray (10YR6/2)	SILT, with clay, organics (roots) few.
1d	9 -- 12	Light Brownish Gray (10YR6/2)	SILT, with clay.
1e	12 -- 15	Light Gray (10YR7/2)	SAND, fine, with silt.
1f	15 -- 18	Light Gray (10YR7/2)	SAND, fine to medium, with silt.
1g	18 -- 21	Light Gray to White (10YR8/1)	SAND, very fine, with silt.
1h	21 -- 24	Light Gray (10YR7/2)	SAND, fine to coarse, with silt.
1aa	0 -- 3	Dark Gray (10YR4/1)	SILT, with clay, organics (roots) common.
1ab	3 -- 6	Light Gray (10YR6/1)	SILT, with clay, organics (roots) few.
1ac	6 -- 9	Light Gray (10YR6/1)	SILT, with clay.
2a	0 -- 3	Dark Gray (10YR4/1)	CLAY, with silt, organics (roots) common.
2b	3 -- 6	Gray (10YR5/1)	SILT, with clay, organics (roots) few.
2c	6 -- 9	Gray (10YR5/1)	SILT, with clay and trace coarse sand, organics (roots) few.
2d	9 -- 12	Light Gray (10YR7/2)	SAND, fine, with silt and clay.
2e	12 -- 15	Light Gray (10YR7/1)	SAND, fine to medium, silty.
2f	15 -- 18	Light Gray to White (10YR8/1)	SAND, fine to medium, with silt.
2g	18 -- 21	Light Gray to White (10YR7/2)	SAND, fine to coarsed, occasional fine gravel, with silt.
3a	0 -- 3	Dark Gray (10YR4/1)	CLAY, with silt, organics (roots) common.
3b	3 -- 6	Gray (10YR5/1)	CLAY, organics (roots) common.
3c	6 -- 9	Gray (10YR5/1)	CLAY, organics (roots) few.
3d	9 -- 12	Light Gray (10YR6/1)	CLAY, with silt.
3e	12 -- 15	Light Gray (10YR6/1)	SAND, fine, with silt.
3f	15 -- 18	Light Gray (10YR6/1)	SAND, fine, silty.
3g	18 -- 21	Light Gray (10YR7/2)	SAND, fine to coarse, subrounded to angular, silty.
3h	21 -- 24	Light Gray (10YR7/2)	SAND, fine to coarse, subrounded to angular.
4a	0 -- 3	Very Dark Brown (10YR2/2)	PEAT with clay, fibrous organics.
4b	3 -- 6	Dark Gray Brown (10YR3/2)	CLAY, with organics (roots) common.
4c	6 -- 9	Dark Gray (10YR4/1)	CLAY, with organics (roots) common.
4d	9 -- 12	Gray (10YR6/1)	SILT, with clay, trace organics (roots).
4e	12 -- 15	Light Gray (10YR7/1)	SILT, with clay.
4f	15 -- 18	Light Gray (10YR7/1)	SILT, with clay.
5a	0 -- 3	Very Dark Gray Brown (10YR3/2)	CLAY, Organic-rich (roots and cattail stalks common).
5b	3 -- 6	Dark Gray Brown (10YR4/1)	CLAY, organics (roots) common.
5c	6 -- 9	Dark Gray (10YR4/1)	CLAY, organics (roots) few.
5d	9 -- 12	Gray (10YR5/1)	CLAY, with silt.
5e	12 -- 15	Light Gray (10YR6/1)	SILT, with clay.
5f	15 -- 18	Light Gray (10YR6/1)	SILT, with clay.
6a	0 -- 3	Very Dark Gray (10YR3/1)	CLAY, organics (roots) common.
6b	3 -- 6	Dark Gray (10YR4/1)	CLAY, with silt, organics (roots) few.
6c	6 -- 9	Dark Gray (10YR4/1)	CLAY, with silt
6d	9 -- 12	Dark Gray (10YR4/1)	CLAY, with silt
6e	12 -- 15	Dark Gray (10YR4/1)	CLAY, with silt
6f	15 -- 18	Gray to Light Gray (10YR6/1)	CLAY, with silt
6g	18 -- 21	Gray to Light Gray (10YR6/1)	CLAY, with silt

No.	Depth (in.)	Munsell Color	Soil Description
7a	0 -- 3	Dark Gray Brown (10YR3/2)	CLAY, organic (roots) common.
7b	3 -- 6	Dark Gray (10YR5/1)	SILT, with clay, organics (roots and cattail stalks common).
7c	6 -- 9	Light Gray (10YR6/1)	SILT, with clay, trace organics (roots).
7d	9 -- 12	Light Gray (10YR7/1)	SILT, with clay, trace coarse sand.
7e	12 -- 15	Light Gray (10YR6/1)	SILT, with sand, very fine to fine.
8a	0 -- 3	Very Dark Gray Brown (10YR3/2)	Organics (PEAT) fibrous, with minor clay.
8b	3 -- 6	Dark Gray (10YR4/1)	SILT, with clay, trace organics (roots and cattail stalks).
8c	6 -- 9	Gray (10YR5/1)	CLAY, with silt, trace coarse sand.
8d	9 -- 12	Gray (10YR5/1)	SILT, with sand, very fine
9a	0 -- 3	Dark Gray (10YR4/1)	CLAY, with silt, trace organics (roots).
9b	3 -- 6	No Sample	
9c	6 -- 9	Dark Gray (10YR4/1)	CLAY, with silt, trace organics (roots).
9d	9 -- 12	No Sample	
9e	12 -- 15	Dark Gray (10YR4/1)	CLAY, with silt.
9f	15 -- 18	Dark Gray (10YR4/1)	CLAY, with silt, trace medium sand.
10a	12 -- 15	Gray (10YR5/1)	CLAY, with silt
10b	9 -- 12	Gray (10YR5/1)	CLAY, with silt
10c	6 -- 9	Gray (10YR5/1)	CLAY, with silt
10d	3 -- 6	Dark Gray (10YR4/1)	CLAY, with silt, organics (roots) common.
10e	0 -- 3	Very Dark Gray (10YR3/1)	CLAY, with organics (roots).
11a	0 -- 3	Dark Gray Brown (10YR4/2)	CLAY, with organics (roots) common.
11b	3 -- 6	Dark Gray (10YR4/1)	CLAY, with few (roots) organics.
11c	6 -- 9	Dark Gray (10YR4/1)	CLAY, with few (roots) organics.
11d	9 -- 12	Gray (10YR5/1)	CLAY, trace organics (roots).
11e	12 -- 15	Gray (10YR5/1)	CLAY, trace organics (roots).
11f	15 -- 18	Gray (10YR6/1)	CLAY, with silt.

Appendix B

Palynology Processing Record

Laboratory Record Number: 2779

Well Name: 1a-a etc.

Date of Sample In: August 10, 2011

Date of Sample Out: August 16, 2011

Company: North Dakota State Water Commission

Sample Type: O/C

Sample Count: 69

Sample Number	Depth	Recovery
1	1a-a	Good
2	1a-b	Good
3	1a-c	Good
4	1a	Good
5	1b	Good
6	1c	Good
7	1d	Good
8	1e	Good
9	1f	Good
10	1g	Good
11	1h	Good
12	2a	Good
13	2b	Good
14	2c	Good
15	2d	Good
16	2e	Good
17	2f	Good

Sample Number	Depth	Recovery
18	2g	Good
19	3a	Good
20	3b	Good
21	3c	Good
22	3d	Good
23	3e	Good
24	3f	Good
25	3g	Good
26	3h	Good
27	4a	Good
28	4b	Good
29	4c	Good
30	4d	Good
31	4e	Good
32	4f	Good
33	5a	Good
34	5b	Good
35	5c	Good
36	5d	Good
37	5e	Good
38	5f	Good
39	6a	Good
40	6b	Good
41	6c	Good
42	6d	Good
43	6e	Good
44	6f	Good

Sample Number	Depth	Recovery
45	6g	Good
46	7a	Good
47	7b	Good
48	7c	Good
49	7d	Good
50	7e	Good
51	8a	Good
52	8b	Good
53	8c	Good
54	8d	Good
55	9a	Good
56	9c	Good
57	9e	Good
58	9f	Good
59	10a	Good
60	10b	Good
61	10c	Good
62	10d	Good
63	10e	Good
64	11a	Good
65	11b	Good
66	11c	Good
67	11d	Good
68	11e	Good
69	11f	Good

Appendix C

Palynological Analyses

The following tables contain the results of the palynological analyses from this study. In all of the tables except Table C-10, the sample labeled "a" is from the highest stratigraphic position at the locality and each subsequent sample is from stratigraphically lower positions. In Table C-10 this order is reversed and sample 10e is from the highest stratigraphic position at the locality.

Table C-1
Occurrence Data for Tolna Coulee Sample Series 1
(X = observed in traces in scans, no counts made).

	1a-a	1a-b	1a-c	1a	1b	1c	1d	1e	1f	1g	1h
Pinus sp.	X	X	X	X	X	X	X	X	X	X	
Cyperaceae	X	X									
Typha spp.	X	X	X	X							
Gramineae	X	X									
Chenopodiaceae	X	X		X							
Salsola sp.											
Compositae	X	X	X	X							
Betula sp.											
Salix sp.	X			X							
Ulmus sp.			X								
Sphagnum sp.	X		X	X							
Fern spores	X	X							X		

Table C-2 Occurrence Data for Tolna Coulee Sample Series 2 (X = observed in traces in scans, no counts made)							
	2a	2b	2c	2d	2e	2f	2g
Pinus sp.	X	X	X	X	X	X	
Cyperaceae							
Typha spp.			X				
Gramineae	X				X		
Chenopodiaceae	X	X					
Salsola sp.							
Compositae	X	X		X	X		X
Betula sp.							
Salix sp.							
Ulmus sp.							
Sphagnum sp.					X		X
Fern spores	X		X	X	X		X

Table C-3 Occurrence Data for Tolna Coulee Sample Series 3 (X = observed in traces in scans, no counts made)								
	3a	3b	3c	3d	3e	3f	3g	3h
Pinus sp.	X	X	X		X	X	X	
Cyperaceae								
Typha spp.	X				X			
Gramineae		X						
Chenopodiaceae	X				X	X		
Salsola sp.								
Compositae	X		X		X			
Betula sp.								
Salix sp.	X							
Ulmus sp.								
Sphagnum sp.			X		X	X		
Fern spores		X	X			X		

Table C-4 Occurrence Data for Tolna Coulee Sample Series 4 (X = observed in traces in scans, no counts made)						
	4a	4b	4c	4d	4e	4f
Pinus sp.	X	X	X	X		X
Cyperaceae						
Typha spp.	X					
Gramineae	X					
Chenopodiaceae	X					
Salsola sp.						
Compositae	X					
Betula sp.						
Salix sp.						
Ulmus sp.						
Sphagnum sp.	X					
Other	X	X		X		

Table C-5 Occurrence Data for Tolna Coulee Sample Series 5 (X = observed in traces in scans, no counts made)						
	5a	5b	5c	5d	5e	5f
Pinus sp.	X	X	X	X	X	X
Cyperaceae						
Typha spp.	X					
Gramineae						
Chenopodiaceae	X	X		X		
Salsola sp.						
Compositae						
Betula sp.						
Salix sp.						
Ulmus sp.	X					
Sphagnum sp.						
Other	X	X				X

Table C-6 Occurrence Data for Tolna Coulee Sample Series 6 (X = observed in traces in scans, no counts made)							
	6a	6b	6c	6d	6e	6f	6g
Pinus sp.	X	X			X	X	X
Cyperaceae							
Typha spp.		X					
Gramineae							
Chenopodiaceae	X	X					
Salsola sp.							
Compositae		X				X	X
Betula sp.							
Salix sp.							
Ulmus sp.							
Sphagnum sp.	X	X		X			
Other	X				X		X

Table C-7 Occurrence Data for Tolna Coulee Sample Series 7 (X = observed in traces in scans, no counts made)					
	7a	7b	7c	7d	7e
Pinus sp.	X			X	
Cyperaceae					
Typha spp.	X				
Gramineae					
Chenopodiaceae					
Salsola sp.					
Compositae	X				
Betula sp.					X
Salix sp.					
Ulmus sp.	X				
Sphagnum sp.					
Other				X	

Table C-8 Occurrence Data for Tolna Coulee Sample Series 8 (X = observed in traces in scans, no counts made)				
	8a	8b	8c	8d
Pinus sp.	X	X	X	X
Cyperaceae	X			
Typha spp.	X			
Gramineae	X			
Chenopodiaceae	X	X		
Salsola sp.				
Compositae	X	X	X	X
Betula sp.				
Salix sp.				
Ulmus sp.				
Sphagnum sp.				X
Other			X	X

Table C-9 Occurrence Data for Tolna Coulee Sample Series 9 (X = observed in traces in scans, no counts made)				
	9a	9c	9e	9f
Pinus sp.	X			
Cyperaceae				
Typha spp.				
Gramineae				
Chenopodiaceae				
Salsola sp.				
Compositae				
Betula sp.				
Salix sp.				
Ulmus sp.				
Sphagnum sp.		X		
Other			X	

Table C-10 Occurrence Data for Tolna Coulee Sample Series 10 (X = observed in traces in scans, no counts made)					
	10a	10b	10c	10d	10e
Pinus sp.	X	X			
Cyperaceae					
Typha spp.					
Gramineae					
Chenopodiaceae			X		
Salsola sp.					
Compositae	X	X	X	X	X
Betula sp.					
Salix sp.					
Ulmus sp.					
Sphagnum sp.				X	
Other					

Table C-11 Occurrence Data for Tolna Coulee Sample Series 11 (X = observed in traces in scans, no counts made)						
	11a	11b	11c	11d	11e	11f
Pinus sp.		X	X			
Cyperaceae						
Typha spp.						
Gramineae						
Chenopodiaceae						
Salsola sp.						
Compositae	X		X	X	X	
Betula sp.						
Salix sp.						
Ulmus sp.						
Sphagnum sp.	X		X	X	X	X
Other						