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 (Salsola). 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.

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

<table>
<thead>
<tr>
<th></th>
<th>1a-a</th>
<th>8a</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Pinus</em> sp.</td>
<td>7%</td>
<td>1%</td>
</tr>
<tr>
<td>Cyperaceae</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td><em>Typha</em> spp.</td>
<td>79%</td>
<td>92%</td>
</tr>
<tr>
<td>Gramineae</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>Chenopodiaceae</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td><em>Salsola</em> sp.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Compositae</td>
<td>4%</td>
<td>1%</td>
</tr>
<tr>
<td><em>Sphagnum</em> sp.</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>Fern spores</td>
<td>1%</td>
<td>X</td>
</tr>
</tbody>
</table>

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


### APPENDIX A

#### Soil Sample Descriptions - Tolna Coulee Outlet

<table>
<thead>
<tr>
<th>No.</th>
<th>Depth (in.)</th>
<th>Munsell Color</th>
<th>Soil Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>0 -- 3</td>
<td>Dark Gray (10YR4/1)</td>
<td>CLAY, with silt, organics (roots) common.</td>
</tr>
<tr>
<td>1b</td>
<td>3 -- 6</td>
<td>Light Brownish Gray (10YR6/2)</td>
<td>SILT, with clay, organics (roots) common.</td>
</tr>
<tr>
<td>1c</td>
<td>6 -- 9</td>
<td>Light Brownish Gray (10YR6/2)</td>
<td>SILT, with clay, organics (roots) few.</td>
</tr>
<tr>
<td>1d</td>
<td>9 -- 12</td>
<td>Light Brownish Gray (10YR6/2)</td>
<td>SILT, with clay.</td>
</tr>
<tr>
<td>1e</td>
<td>12 -- 15</td>
<td>Light Gray (10YR7/2)</td>
<td>SAND, fine, with silt.</td>
</tr>
<tr>
<td>1f</td>
<td>15 -- 18</td>
<td>Light Gray (10YR7/2)</td>
<td>SAND, fine to medium, with silt.</td>
</tr>
<tr>
<td>1g</td>
<td>18 -- 21</td>
<td>Light Gray to White (10YR8/1)</td>
<td>SAND, very fine, with silt.</td>
</tr>
<tr>
<td>1h</td>
<td>21 -- 24</td>
<td>Light Gray (10YR7/2)</td>
<td>SAND, fine to coarse, with silt.</td>
</tr>
<tr>
<td>1aa</td>
<td>0 -- 3</td>
<td>Dark Gray (10YR4/1)</td>
<td>SILT, with clay, organics (roots) common.</td>
</tr>
<tr>
<td>1ab</td>
<td>3 -- 6</td>
<td>Light Gray (10YR6/1)</td>
<td>SILT, with clay, organics (roots) few.</td>
</tr>
<tr>
<td>1ac</td>
<td>6 -- 9</td>
<td>Light Gray (10YR6/1)</td>
<td>SILT, with clay.</td>
</tr>
<tr>
<td>2a</td>
<td>0 -- 3</td>
<td>Dark Gray (10YR4/1)</td>
<td>CLAY, with silt, organics (roots) common.</td>
</tr>
<tr>
<td>2b</td>
<td>3 -- 6</td>
<td>Gray (10YR5/1)</td>
<td>SILT, with clay, organics (roots) few.</td>
</tr>
<tr>
<td>2c</td>
<td>6 -- 9</td>
<td>Gray (10YR5/1)</td>
<td>SILT, with clay and trace coarse sand, organics (roots) few.</td>
</tr>
<tr>
<td>2d</td>
<td>9 -- 12</td>
<td>Light Gray (10YR7/2)</td>
<td>SAND, fine, with silt and clay.</td>
</tr>
<tr>
<td>2e</td>
<td>12 -- 15</td>
<td>Light Gray (10YR7/1)</td>
<td>SAND, fine to medium, silt.</td>
</tr>
<tr>
<td>2f</td>
<td>15 -- 18</td>
<td>Light Gray to White (10YR8/1)</td>
<td>SAND, fine to medium, with silt.</td>
</tr>
<tr>
<td>2g</td>
<td>18 -- 21</td>
<td>Light Gray to White (10YR7/2)</td>
<td>SAND, fine to coarse, occasional fine gravel, with silt.</td>
</tr>
<tr>
<td>3a</td>
<td>0 -- 3</td>
<td>Dark Gray (10YR4/1)</td>
<td>CLAY, with silt, organics (roots) common.</td>
</tr>
<tr>
<td>3b</td>
<td>3 -- 6</td>
<td>Gray (10YR5/1)</td>
<td>CLAY, organics (roots) common.</td>
</tr>
<tr>
<td>3c</td>
<td>6 -- 9</td>
<td>Gray (10YR5/1)</td>
<td>CLAY, organics (roots) few.</td>
</tr>
<tr>
<td>3d</td>
<td>9 -- 12</td>
<td>Light Gray (10YR6/1)</td>
<td>CLAY, with silt.</td>
</tr>
<tr>
<td>3e</td>
<td>12 -- 15</td>
<td>Light Gray (10YR6/1)</td>
<td>SAND, fine, with silt.</td>
</tr>
<tr>
<td>3f</td>
<td>15 -- 18</td>
<td>Light Gray (10YR6/1)</td>
<td>SAND, fine, silty.</td>
</tr>
<tr>
<td>3g</td>
<td>18 -- 21</td>
<td>Light Gray (10YR7/2)</td>
<td>SAND, fine to coarse, subrounded to angular, silty.</td>
</tr>
<tr>
<td>3h</td>
<td>21 -- 24</td>
<td>Light Gray (10YR7/2)</td>
<td>SAND, fine to coarse, subrounded to angular.</td>
</tr>
<tr>
<td>4a</td>
<td>0 -- 3</td>
<td>Very Dark Brown (10YR2/2)</td>
<td>PEAT with clay, fibrous organics.</td>
</tr>
<tr>
<td>4b</td>
<td>3 -- 6</td>
<td>Dark Gray Brown (10YR3/2)</td>
<td>CLAY, with organics (roots) common.</td>
</tr>
<tr>
<td>4c</td>
<td>6 -- 9</td>
<td>Dark Gray (10YR4/1)</td>
<td>CLAY, with organics (roots) common.</td>
</tr>
<tr>
<td>4d</td>
<td>9 -- 12</td>
<td>Gray (10YR6/1)</td>
<td>SILT, with clay, trace organics (roots).</td>
</tr>
<tr>
<td>4e</td>
<td>12 -- 15</td>
<td>Light Gray (10YR7/1)</td>
<td>SILT, with clay.</td>
</tr>
<tr>
<td>4f</td>
<td>15 -- 18</td>
<td>Light Gray (10YR7/1)</td>
<td>SILT, with clay.</td>
</tr>
<tr>
<td>5a</td>
<td>0 -- 3</td>
<td>Very Dark Gray Brown (10YR3/2)</td>
<td>CLAY, Organic-rich (roots and cattail stalks common).</td>
</tr>
<tr>
<td>5b</td>
<td>3 -- 6</td>
<td>Dark Gray Brown (10YR4/1)</td>
<td>CLAY, organics (roots) common.</td>
</tr>
<tr>
<td>5c</td>
<td>6 -- 9</td>
<td>Dark Gray (10YR4/1)</td>
<td>CLAY, organics (roots) few.</td>
</tr>
<tr>
<td>5d</td>
<td>9 -- 12</td>
<td>Gray (10YR5/1)</td>
<td>CLAY, with silt.</td>
</tr>
<tr>
<td>5e</td>
<td>12 -- 15</td>
<td>Light Gray (10YR6/1)</td>
<td>SILT, with clay.</td>
</tr>
<tr>
<td>5f</td>
<td>15 -- 18</td>
<td>Light Gray (10YR6/1)</td>
<td>SILT, with clay.</td>
</tr>
<tr>
<td>6a</td>
<td>0 -- 3</td>
<td>Very Dark Gray (10YR3/1)</td>
<td>CLAY, organics (roots) common.</td>
</tr>
<tr>
<td>6b</td>
<td>3 -- 6</td>
<td>Dark Gray (10YR4/1)</td>
<td>CLAY, with silt, organics (roots) few.</td>
</tr>
<tr>
<td>6c</td>
<td>6 -- 9</td>
<td>Dark Gray (10YR4/1)</td>
<td>CLAY, with silt.</td>
</tr>
<tr>
<td>6d</td>
<td>9 -- 12</td>
<td>Dark Gray (10YR4/1)</td>
<td>CLAY, with silt.</td>
</tr>
<tr>
<td>6e</td>
<td>12 -- 15</td>
<td>Dark Gray (10YR4/1)</td>
<td>CLAY, with silt.</td>
</tr>
<tr>
<td>6f</td>
<td>15 -- 18</td>
<td>Gray to Light Gray (10YR6/1)</td>
<td>CLAY, with silt.</td>
</tr>
<tr>
<td>6g</td>
<td>18 -- 21</td>
<td>Gray to Light Gray (10YR6/1)</td>
<td>CLAY, with silt.</td>
</tr>
<tr>
<td>No.</td>
<td>Depth (in.)</td>
<td>Munsell Color</td>
<td>Soil Description</td>
</tr>
<tr>
<td>-----</td>
<td>-------------</td>
<td>------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7a</td>
<td>0 -- 3</td>
<td>Dark Gray Brown (10YR3/2)</td>
<td>CLAY, organic (roots) common.</td>
</tr>
<tr>
<td>7b</td>
<td>3 -- 6</td>
<td>Dark Gray (10YR5/1)</td>
<td>SILT, with clay, organics (roots and cattail stalks common).</td>
</tr>
<tr>
<td>7c</td>
<td>6 -- 9</td>
<td>Light Gray (10YR6/1)</td>
<td>SILT, with clay, trace organics (roots).</td>
</tr>
<tr>
<td>7d</td>
<td>9 -- 12</td>
<td>Light Gray (10YR7/1)</td>
<td>SILT, with clay, trace coarse sand.</td>
</tr>
<tr>
<td>7e</td>
<td>12 -- 15</td>
<td>Light Gray (10YR6/1)</td>
<td>SILT, with sand, very fine to fine.</td>
</tr>
<tr>
<td>8a</td>
<td>0 -- 3</td>
<td>Very Dark Gray Brown (10YR3/2)</td>
<td>Organics (PEAT) fibrous, with minor clay.</td>
</tr>
<tr>
<td>8b</td>
<td>3 -- 6</td>
<td>Dark Gray (10YR4/1)</td>
<td>SILT, with clay, trace organics (roots and cattail stalks).</td>
</tr>
<tr>
<td>8c</td>
<td>6 -- 9</td>
<td>Gray (10YR5/1)</td>
<td>CLAY, with silt, trace coarse sand.</td>
</tr>
<tr>
<td>8d</td>
<td>9 -- 12</td>
<td>Gray (10YR5/1)</td>
<td>SILT, with sand, very fine</td>
</tr>
<tr>
<td>9a</td>
<td>0 -- 3</td>
<td>Dark Gray (10YR4/1)</td>
<td>CLAY, with silt, trace organics (roots).</td>
</tr>
<tr>
<td>9b</td>
<td>3 -- 6</td>
<td>No Sample</td>
<td></td>
</tr>
<tr>
<td>9c</td>
<td>6 -- 9</td>
<td>Dark Gray (10YR4/1)</td>
<td>CLAY, with silt, trace organics (roots).</td>
</tr>
<tr>
<td>9d</td>
<td>9 -- 12</td>
<td>No Sample</td>
<td></td>
</tr>
<tr>
<td>9e</td>
<td>12 -- 15</td>
<td>Dark Gray (10YR4/1)</td>
<td>CLAY, with silt.</td>
</tr>
<tr>
<td>9f</td>
<td>15 -- 18</td>
<td>Dark Gray (10YR4/1)</td>
<td>CLAY, with silt, trace medium sand.</td>
</tr>
<tr>
<td>10a</td>
<td>12 -- 15</td>
<td>Gray (10YR5/1)</td>
<td>CLAY, with silt</td>
</tr>
<tr>
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<td>9 -- 12</td>
<td>Gray (10YR5/1)</td>
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</tr>
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<td>Gray (10YR6/1)</td>
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## Appendix B

### Palynology Processing Record

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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). |
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<tr>
<td>1h</td>
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*Pinus* sp.  
Cyperaceae  
*Typha* spp.  
Gramineae  
Chenopodiaceae  
*Salsola* sp.  
Compositae  
*Betula* sp.  
*Salix* sp.  
*Ulmus* sp.  
*Sphagnum* sp.  
Fern spores
### Table C-2
Occurrence Data for Tolna Coulee Sample Series 2
(X = observed in traces in scans, no counts made)

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Occurrence Data for Tolna Coulee Sample Series 3
(X = observed in traces in scans, no counts made)

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Occurrence Data for Tolna Coulee Sample Series 4
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Occurrence Data for Tolna Coulee Sample Series 5
(X = observed in traces in scans, no counts made)

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<tr>
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<tr>
<td><strong>Salix sp.</strong></td>
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### Table C-6
Occurrence Data for Tolna Coulee Sample Series 6
(X = observed in traces in scans, no counts made)

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### Table C-7
Occurrence Data for Tolna Coulee Sample Series 7
(X = observed in traces in scans, no counts made)

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<td><em>Chenopodiaceae</em></td>
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### Table C-8
Occurrence Data for Tolna Coulee Sample Series 8
*(X = observed in traces in scans, no counts made)*

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### Table C-9
Occurrence Data for Tolna Coulee Sample Series 9
*(X = observed in traces in scans, no counts made)*

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### Table C-10
Occurrence Data for Tolna Coulee Sample Series 10
(X = observed in traces in scans, no counts made)

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### Table C-11
Occurrence Data for Tolna Coulee Sample Series 11
(X = observed in traces in scans, no counts made)

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