INTRODUCTION

The purpose of this memorandum is to provide information to the Rice Creek Watershed District (RCWD) Board to assist in establishing the “As Constructed and Subsequently Improved Condition” and “Repair Profile” for Anoka County Ditch 31 (ACD 31).

DEFINITIONS

This memorandum defines the condition and therefore by inference the capacity (i.e. the original design flow rate in cubic feet per second) of the legal drainage system using three definitions:

As-Designed / Established Condition: The alignment, grade and cross-sectional geometry of the legal drainage system as designed in 1898 and repaired in 1914 including all subsequent designs for legal repairs and alterations. The 1898 plan and profiles for ACD 31 established the length, flow direction and grade elevations for the Main Trunk and each of the branches. The As-Designed / Established Condition may or may not reflect the As-Constructed and Subsequently Improved Condition and is generally shown on construction plans and engineering drawings.

As-Constructed and Subsequently Improved Condition: The alignment, grade and cross-sectional geometry of the legal drainage system as constructed in 1898, including all subsequent legal repairs and alterations. A repair or alteration is considered legal if formally authorized is some legal proceedings. The definition of As-Constructed and Subsequently Improved Condition is intended to establish the condition to which the system can legally be repaired consistent with the definition in MS 103E.701, which states:

The term, "repair" means to restore all or a part of a drainage system, as nearly as practicable to the same condition as originally constructed, and subsequently improved, including resloping of ditches and leveling of waste banks if necessary to prevent further deterioration, realignment to original construction if necessary, to restore the effectiveness of the drainage system, and routine operations that may be required to remove obstructions and maintain the efficiency of the drainage system. "Repair" also includes:

(1) incidental straightening of a tile system resulting from the tile-laying technology used to replace tiles; and

(2) replacement of tiles with the next larger size that is readily available, if the original size is not readily available.
Recent survey data show that the alignment, profile and geometry (i.e., cross sectional area) of the existing legal drainage system is altered from the As-Designed / Established Condition. Alterations to the legal drainage system alignment, profiles and geometry from the As-Designed / Established Condition likely resulted from the use of less accurate survey methods and construction techniques than currently exist and because of the need to “fit” the drainage system to the existing topography. Alterations to the legal drainage system that were not performed per the requirements of MS 103E (i.e., ditch law) or its predecessors are not considered part of the As-Constructed and Subsequently Improved Condition.

**Repair Profile Condition:** The condition to which the RCWD Board of Manager repairs the legal drainage system. If the capacity of the Repair Profile Condition exceeds the As-Constructed and Subsequently Improved Condition, the work is considered an improvement under MS 103E.

**LOCATION AND GENERAL DESCRIPTION OF THE LEGAL DRAINAGE SYSTEM**

**Location**

The legal drainage system for ACD 31 is located in Sections 1, 2, 10, 11, 12 and 14 of T32N, R23W and in Sections 25, 26, 35 and 36 of T33N, R22W, Columbus Township, Anoka County (see Figure 1). The drainage area that contributes runoff to ACD 31 is approximately 1,360 acres and includes a number of different land uses such as wetlands, agricultural fields, woods and rural residential housing. The legal drainage system consists of the Main Trunk and Branches 1, 2, and 3 (see Figure 2) which drain the general area that extends just north of CSAH 18 (Broadway Avenue), just to the west of Furman Street and to the north and west of CSAH 23 (Kettle River Boulevard). There is additional evidence of Branches 4, 5, 6 and 7, with undetermined legal status (discussed below). The legal drainage system drains into Howard Lake and eventually terminates at Rice Creek.

The benefitted area, parcels and assessment values for ACD 31 were filed on April 30, 1898. ACD 31 legally benefited 1,223 acres and 58 parcels and had an original total assessment value of $2,113 (see Figure 3).

The vertical datum used for the 1898 ACD 31 profiles was an assumed local datum with no known bench mark. The As-Designed / Established stationing for the Main Trunk and the branches began at the upstream end of each branch and increased in a downstream direction to the termination point.

**History of the Legal drainage system**

The following is a chronology of documented proceedings, construction, and alterations of the legal drainage system based upon records archived by the RCWD:

- Petition for public ditch ACD 31 occurred on March 12, 1898 with Anoka County.
- Order establishing ACD 31 occurred on March 12, 1898.
- Construction of ACD 31 occurred shortly after the order of establishment in 1898.
- Assessment of ACD 31 occurred on October 10, 1898.
- Assessment of ACD 31 repairs occurred on May 27, 1905.
• Petition for ditch repair on ACD 31 occurred on December 31, 1913.
• Engineer’s Report occurred on April 16, 1914.
• Order of repair to ACD 31 occurred on May 19, 1914.
• Assessment of ACD 31 repairs occurred on December 7, 1915.

Other alterations to the ditch system performed outside of the scope of MS 103E (or its predecessors) have also been documented as follows:
• Replacement of culvert at CSAH 18 (Broadway Avenue) on the Main Trunk and Branch 1 by Anoka County in 1961.

Source of Survey Data Used in this Assessment
Two separate sources of survey data were used to assess the relationship between: 1) the historic and current alignments and stationing; and 2) to determine the vertical datum adjustment needed to establish the evaluate the As-Constructed and Subsequently Improved Condition from the construction plans. These data sources include:
• Survey provided by RCWD and completed by Emmons and Olivier Resources Inc. in 2004;
• Survey completed by Houston Engineering, Inc. as the District Engineer during the fall and early winter of 2008.

All survey data were collected by Houston Engineering, Inc. using Minnesota State Plane Coordinate system and North American Vertical Datum 1988. Initial use of the data showed that the survey information provided by the RCWD required an average vertical adjustment of 0.44-feet to establish consistency with the survey completed by Houston Engineering, Inc. Final survey data were placed in the RCWD survey geodatabase maintained by the District Engineer.

Historical Alignment of ACD 31
The As-Constructed and Subsequently Improved Main Trunk and Branch alignments correlate closely with the As-Designed / Established 1898 alignments. This portion of the memorandum describes the current condition as observed “on-the-ground” as determined by a review of the available records, survey data, aerial imagery and other available evidence (see Figure 4). The stations used to describe the alignment are those from the historic design documents.

Main Trunk
The alignment for the 1898 condition begins approximately 1,350 feet north of CSAH 18 at station 0+00. From station 0+00 the Main Trunk alignment extends to the north approximately 17,300 feet until it terminates at Anoka County Ditch 12 in Section 24 of Linwood Township and also extends to the south approximately 10,000 feet to Howard Lake eventually terminating at Rice Creek. The portion of the Main Trunk alignment that proceeds south of station 0+00 is for the most part located within RCWD and will be the focus of this historical alignment summary.
Rice Creek
Watershed District
1898/1914 Alignments
Anoka County Ditch 31

Source: MN DNR Data Deli
Note: Stationing represented in feet.

Figure 4 1898/1914 Alignments- Anoka County Ditch 31
The Main Trunk alignment proceeds south for 400 feet of station 0+00 where it intersects Branch 1. After Branch 1 the alignment continues south where it crosses under CSAH 18 (Broadway Avenue) through a 48” Corrugated Metal Pipe (CMP) culvert located approximately 1,475 feet west of the intersection of CSAH 18 and CSAH 23. The alignment proceeds south of CSAH 18 where it parallels CSAH 23 and flows under four different field accesses with culverts ranging in size from a 32” CMP to a 36” CMP prior to crossing under 170th Street through an 18” Reinforced Concrete Pipe (RCP) culvert located approximately 416 feet west of the intersection of 170th Street and CSAH 23. The alignment continues to the south crossing under a field access road through a 24” CMP culvert and intersecting Branch 2 approximately 650 feet south of 170th Street. After 170th Street the alignment continues to the south where it crosses 167th Street through a 36” High Density Polyethylene Pipe (HDPE) culvert located approximately 512 feet west of the intersection of 167th Street and CSAH 23. The alignment proceeds south of 167th Street where it crosses under CSAH 23 through a 36” CMP culvert and into Howard Lake terminating at the intersection of Rice Creek.

**Branch 1**

Branch 1 begins at the intersection of the Main Trunk. The alignment proceeds west 300 feet from the Main Trunk and then turns southwest for 200 feet until it intersects Branch 3. Branch 1 continues in a southwest direction until crossing CSAH 18 through a 43”x27” CMP arch culvert located approximately 2,830 feet west of the intersection of CSAH 18 and CSAH 23. After CSAH 18 the alignment continues in a southwest direction crossing under a field access road through a 36” CMP culvert and then turning to the southeast until it crosses Branch 2 located approximately 3,165 feet south of CSAH 18. Branch 1 follows Branch 2 to the northwest for 56 feet then turns to the southwest for an approximate distance of 1,000 feet before turning to the south and terminating at a private ditch alignment that was abandon in 1898.

**Branch 2**

The Branch 2 alignment begins at Furman Avenue approximately 3,150 feet south of the intersection of CSAH 18 and Furman Avenue. The Branch 2 alignment proceeds east of Furman Avenue 1420 feet and then turns to the northeast and intersects a private ditch alignment that was abandon in 1898, located approximately 250 feet west of Notre Dame Avenue. Branch 2 crosses under Notre Dame Avenue through a 24” CMP culvert and proceeds in a northeast direction until it crosses under a driveway through a 30” CMP culvert located approximately 290 feet east of Notre Dame Avenue. Branch 2 continues to the northeast for 678 feet where it intersects a private ditch alignment and then turns to the east for approximately 665 feet. At this point Branch 2 turns to the south for approximately 790 feet and then turns to the southeast where it intersects Branch 1 approximately 3,165 feet south of CSAH 18. Branch 2 proceeds in the same direction until terminating at the intersection of the Main Trunk.

**Branch 3**

Branch 3 begins northwest of its intersection of Branch 1. Branch 3 proceeds south for approximately 200 feet, then turns southeast for approximately 580 feet until it terminates at intersection with Branch 1.
Branch 4
Branch 4 originates from the portion of the Main Trunk that is north of Station 0+00 and is entirely outside of the RCWD.

Branch 5
Branch 5 originates at a point approximately 800 feet southwest from the Station 0+00 of Branch 2 and proceeds northeast for approximately 550 feet. At this point, it turns north along the west side of Furman Street for 302 feet where it terminates at the start of Branch 2. It is unknown whether this branch was established as a part of the legal drainage system (see below).

Branch 6
Branch 6 begins approximately 1650 feet southwest of Station 0+00 of Branch 2 and extends to the northeast to Furman Street, where it intersects with the beginning of Branch 2. It is unknown whether this branch was established as a part of the legal drainage system (see below).

Branch 7
Branch 7 begins approximately 450 feet north of Station 2+00 on Branch 2 and extends south to Branch 2 where it terminates. It is unknown whether this branch was established as a part of the legal drainage system (see below).

System Modifications Affecting Function
A portion of the system does not appear to function as originally designed. A considerable rise in the bottom of the open channel portion of Branch 2 from Stations 27+28 to 63+28 (current stations 53+00 to 17+00) prevents flows in the upper portion of Branch 2 from reaching the lower portion of Branch 2. Instead, water flows south into a private drainage ditch which eventually outlets into Howard Lake.

Items Requiring Legal Consideration
Based upon the historical review, there appear to be several issues for resolution by legal counsel:

- The alignment of ACD 31 crosses over two separate watersheds. The 1898 plans include over three miles of open channel, labeled as “The North Main Ditch” which flow to the north into Anoka County Ditch 12 and eventually Sunrise Creek. A portion of Branch 1 and all of Branch 3 also contribute to this watershed per the construction plans. The 1914 repair profiles show the As-Designed / Established watershed divide to exist at 1914 Plan Station 10+00 (Current Station 113+80) on the Main Trunk and 1914 Plan Station 10+00 (Current Station 74+00) on Branch 1. These design divide locations are located approximately 400’ and 500’, respectively, north of the current RCWD Boundary (which bisects Broadway Ave./CSAH 18).

The current physical divide between these watersheds, however, occurs well north of the divide locations indicated in the 1914 repair profile. At a minimum, drainage from Station 122+00 on the Main Trunk flows south as part of the watershed to Rice Creek (this segment also receives the north-flowing portion of Branch 1). Even farther north, the ditch grade is essentially flat to Station 124+00, where the extent of the available survey data terminates. Thus, the physical watershed
divide is appreciably north of the design watershed divide, which in turn is north of the legal RCWD Boundary. This raises two legal issues:

a) What portions of ACD 31 does the RCWD legally administer?

b) Which portion of the benefitting parties listed on the April 30, 1898 document are benefitting parties to the RCWD portion of ACD 31?

- Exhibit 1 of the 1914 Anoka County Ditch 31 Repairs exhibits a plan view of “Proposed Branches No. 5, 6, and 7.” These branches are located on the upstream (west) end of Branch 2. An Engineer’s Report for the 1914 repairs dated April 16th states:

  I did, at the request of the land owners interested, survey and locate four additional branches to be known as branches 4, 5, 6 and 7. The cost of constructing said branches is not included in the estimate, as these branches will be constructed by the landowners benefitted if established by your board. Maps showing the location of said branches is hereto attached marked exhibit “I”.

Since these branches were to be constructed by the benefitting landowners, they are not included in the 1914 repair profiles, excavation summary, or repair order. Although these branches currently physically exist as open channels, we have found no documentation that legally establishes these branches. Nor are these branches legally referenced in subsequent inspection and survey reports (see Available Information/Historical Records below.) Legal counsel should be consulted to determine the legal status of these branches.

**DETERMINATION OF THE AS-CONSTRUCTED AND SUBSEQUENTLY IMPROVED CONDITION**

**Alignment**

ACD 31 alignment analysis was completed for the Main Trunk and each branch by correlating the surveyed open channel alignments with the 1898 design alignments. To do this, available surveyed alignments were imported into Computer Aided Design software (CAD) and overlaid with scanned plan view sheets from the 1898 design alignments that were rectified to state plane coordinates. The surveyed alignments visually correlated very closely to the plan alignments and were deemed sufficiently accurate for the purposes of this analysis. Stationing was then assigned to the surveyed (i.e., As-Constructed and Subsequently Improved) alignments from downstream to upstream (see Figure 5). Station equations for each of the branches were then developed to correlate the 1898 plan stationing to the As-Constructed and Subsequently Improved stationing based on identifiable common points. For Branch 1 and the Main Trunk, the common points were intersections with roadways. For Branch 2 this common point was the intersection of the branch with the Main Trunk and roadways. Table 1 lists the station equations for the Main Trunk and each of the branches. Figure 5 shows the As-Constructed and Subsequently Improved alignment. (The current alignment and stationing for ACD 31 has been added to the district-wide drainage system GIS database.)
Rice Creek Watershed District
Revised Stationing
Anoka County Ditch 31

Branch 3
Maximum Stationing: 12396.19

Branch 1
Maximum Stationing: 7504.70

Branch 2
Maximum Stationing: 8028.39

Maximum Stationing:
785.99

Howard Mud

Anoka County Ditch 31

Public Open Channel
Private Open Channel
Lakes
RCWD Boundary
Columbus RMP Boundary
Section Lines

Source: MN DNR Data Deli
Note: Stationing represented in feet.

Figure 5 Revised Stationing Anoka County Ditch 31

Map created by:
Houston Engineering, Inc.
6901 E. Fish Lake Rd., Suite 140
Maple Grove, MN 55369
Bus: (763) 493-4522
Fax: (763) 493-5572
### Table 1
Conversion Equations from 1898 Stationing to 2009 Stationing

<table>
<thead>
<tr>
<th>Branch</th>
<th>Station Equation</th>
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</thead>
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<td>Main Trunk</td>
<td>= 12,380 – [1898 Stationing]</td>
</tr>
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<td>Branch 1</td>
<td>= 7,500 – [1898 Stationing]</td>
</tr>
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<td>= 8,028 – [1898 Stationing]</td>
</tr>
<tr>
<td>Branch 3</td>
<td>= 785 – [1898 Stationing]</td>
</tr>
</tbody>
</table>

### Profile

**Methods**

Ideally, the historical data necessary to determine the As-Constructed and Subsequently Improved Condition would include the construction as-built plans with a verifiable datum or benchmark, legal descriptions and surveyed maps of the original ditch alignment, and documentation of all subsequent changes to the ditch alignment and profile. Soil borings of the ditch bottom would be conducted by hand in areas where the open channel was constructed in glacial till and test pits would be dug with a backhoe to confirm the results. The boring data, along with surveyed elevations of culvert ends, would be checked against the as-built plan sheets to verify that the ditch was constructed per plan. If the field data does not match within an acceptable level of error, then the profile would be adjusted using statistical regression to match the field data yet still maintain a relatively continuous, downstream slope for the entire length of the system.

Unfortunately, rarely are as-built plans available which can be tied to the original construction benchmark. As is the case with ACD 31, the original design plans are typically based on an assumed datum with a no longer existing benchmark (if one is provided at all). Since the majority of each portion of open channel was typically constructed through wetlands, the placement of soil borings in glacial till areas can be very difficult if not impossible. The differentiation between sediment and parent soil in the soil borings thus may become infeasible. Existing culverts are typically not set per the plan profile, but instead are placed at the bottom of the existing channel, which may be significantly higher or lower than the as constructed profile. Because of the unreliability of the plan and survey data, determination of the As-Constructed and Subsequently Improved Condition is not an exact science and is base in part upon engineering judgment.

To determine an as-constructed profile for legal drainage systems like ACD 31, we must first assume the project was constructed as designed (reflected by the engineer’s plans) and approximate the constructed profile using a datum conversion based on the same locations surveyed today and shown on the plans; i.e., we match elevations. By matching many locations we can determine an “average” datum adjustment.

Once the datum adjustment is initially estimated and a preliminary profile established, segments of this profile (e.g., a Branch or between culverts) may be raised, lowered, or tilted to better match existing culvert inverts and locations where two portions of the system join (e.g., a branch and the main trunk). The resulting “as-constructed” profile is a close approximation of what was originally constructed, based upon the original design.
The datum adjustment for ACD 31 from the As-Designed / Established 1914 repair profiles to North American Vertical Datum (NAVD) 1988 is based upon the following approaches:

- Comparison of existing culvert inverts to the elevation of the channel at the same location, shown on the 1914 plans;
- Comparison of existing culvert inverts to those shown on the 1914 plans; and
- Cut sheet analysis.

The first piece of information for determining the datum adjustment is a comparison between existing surveyed culvert invert elevations and corresponding open channel profile elevations from the 1914 plans. Current invert elevations from the ends of each culvert were averaged and compared to the channel profile elevation using the calculated station equations. Since none of the culverts can be presumed to have existed in 1914, this comparison assumes that subsequent culvert installations were placed at the As-Designed / Established elevation. However, as stated above, the actual construction elevation typically is at the bottom of channel which existed at the time of installation, which may be higher or lower than the designed elevation shown on the plans. With a large number of points for comparison, random errors tend to cancel and more significant outliers can be eliminated. Elevations from 14 culverts were evaluated to estimate the datum conversion. This information generally has the greatest amount of reliability and is preferentially considered over other information, in the absence of originally installed, unmodified culverts.

The second piece of information for estimating the datum adjustment is a comparison between the existing culvert invert elevations with culverts shown on the 1914 repair profiles. There were four culvert locations identified on these profiles that correspond to existing culvert locations. This approach assumes that replacement culverts installed since the 1914 survey were placed at the elevations of their predecessors. However, each of these culverts was higher than the 1914 profile repair grades, and it is likely that these culverts were lowered as part of the repairs. Also, with only four data points, it may be difficult to obtain a strong statistical correlation. This approach would be used as a primary determiner of the datum adjustment, only if the four data points related very closely.

The third piece of information for determining the datum adjustment is a comparison between the 1914 open channel profile elevations shown on the plans raised by the depth of cut listed in the 1914 cut sheets and the surveyed natural ground elevation. This comparison assumes that the ground elevation adjacent to the open channel has not been altered since the original construction and that the currently surveyed elevation is at the same location as the plan elevation. To provide the greatest likelihood that the points of comparison have been unaltered, the 15 surveyed ground elevations were selected in predominantly wetland and wooded areas. However, adjacent points in even these areas are not necessarily reliable for comparison. Wetland elevations can change due to subsidence and erosion, and natural ground elevations in wooded areas may be difficult to determine, particularly where the open channel was constructed in natural swale locations. Because of the potential for error in this approach, this cut sheet comparison was used as a secondary source of information to estimate the datum adjustment.
Datum Analysis and Adjustment Results

The elevations of the existing culvert locations were tabulated and compared to their corresponding 1914 repair profile elevations. The full tabulation is shown in Table 2. Initially, the elevation differences for all 14 values were averaged. These differences were used to calculate a root mean square error (i.e., average error) of 2.17 feet, indicating that a strong correlation did not exist among the full set of culvert locations. However, when the culverts from the Main Trunk were isolated, a much stronger correlation was observed. This resulted in a datum adjustment of 803.02 and a root mean square error of 0.68 feet.

Table 2
Culvert-to-Profile Elevation Assessment

<table>
<thead>
<tr>
<th>Branch</th>
<th>1914 Station</th>
<th>Current Station</th>
<th>1914 Elevation</th>
<th>Survey Elevation</th>
<th>Difference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branch 1</td>
<td>30+67</td>
<td>48+50</td>
<td>93.64</td>
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<td>805.63</td>
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<td>Branch 2</td>
<td>66+94</td>
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<td>Main Trunk</td>
<td>49+60</td>
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Average Datum Adjustment – All Branches 803.92 Root Mean Square Error 2.17
Average Datum Adjustment – Main Trunk 803.02 Root Mean Square Error 0.68

Culvert invert elevations from the 1914 repair profiles were then compared to corresponding existing culvert elevations. Table 3 tabulates these culverts and their corresponding elevation differences. These data appear to be of limited value as there is a minimum of 2.7’ variance between any three of the values (see the “difference” column – typically these values would be within < 1-foot).
Results from the cut sheet analysis are compiled in Table 4. The average datum adjustment calculated through this assessment is 803.90, with a root mean squared error of 0.42 feet. This datum adjustment is 0.88' higher than the value determined by the culvert analysis, which could be the result of inconsistencies of how and where the natural ground elevation was determined between the 1914 and 2008 surveys.

### Table 3
**Culvert-to-Culvert Elevation Comparison**

<table>
<thead>
<tr>
<th>Branch</th>
<th>1914 Station</th>
<th>Current Station</th>
<th>1914 Elevation</th>
<th>Survey Elevation</th>
<th>Difference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Trunk</td>
<td>13+50</td>
<td>110+99</td>
<td>94.00</td>
<td>895.59</td>
<td>801.59</td>
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<td>804.43</td>
<td>43&quot;x27&quot; CMPA CSAH 18</td>
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<td>24&quot;CMP, Notre Dame St.</td>
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### Table 4
**Cut Sheet Analysis**

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<th>1914 Station</th>
<th>Current Station</th>
<th>1914 Elevation</th>
<th>1914 Cut Depth</th>
<th>1914 Natural Ground Elevation</th>
<th>Current Natural Ground Elevation</th>
<th>Difference b/w 1914 and Current</th>
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<tr>
<td>Branch 1</td>
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<td>6+17</td>
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Table 4 (cont.)
Cut Sheet Analysis

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<tr>
<th>Branch</th>
<th>1914 Station</th>
<th>Current Station</th>
<th>1914 Elevation</th>
<th>1914 Cut Depth</th>
<th>1914 Natural Ground Elevation</th>
<th>Current Natural Ground Elevation</th>
<th>Difference b/w 1914 and Current</th>
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<td><strong>Root Mean Square Error</strong></td>
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Although the cut sheet analysis produced a lower root mean square error, we believe there is greater uncertainty associated with this methodology, making it a less reliable method than the culvert-to-profile elevation comparison. Thus, a datum adjustment of 803.02 is believed to be the “best” estimate for converting the 1914 local datum to the 1988 NAVD. The As-Constructed and Subsequently Improved profile, using the 803.02 datum adjustment and the engineer’s plans, is shown with the existing channel bottom profile in Figure 6 and Figure 7.

**Cross-section Geometry**

The As-Designed / Established Condition cross sections were identified in Exhibit 2 of the 1914 Engineer’s report (cut sheets). Open channel bottom widths were specified at 2 feet for the Main Trunk and all branches. Cut depths ranged from one to seven feet, with all channel side slopes set at a 1:1 slope. Presumably the system was constructed to these dimensions.

Existing open channel cross-sections are for the most part wider, shallower, and flatter, with channel bottom widths of up to ten feet. This would be expected with the deterioration of the channels over a one hundred year period. Figure 6 shows an example cross-section at station 57+28 on the Main Trunk. The total channel-full capacity of the As-Designed / Established cross-section in the Main Trunk ranges from 9 to 21 cubic feet per second (cfs).

**Functional Drainage Issues / Areas Requiring Repair**

The intent of our site survey and this report is to document the existing geometry of the legal drainage system and determine the As-Constructed and Subsequently Improved Condition. This memorandum is not intended to be an inspection report. However, through our survey we did identify several locations that do not hydraulically function as originally designed.
NOTE: AS-DESIGNED PROFILES ARE BASED ON THE 1914 REPAIR PROFILES WITH A DATUM ADJUSTMENT OF 803.02'
NOTE: AS-DESIGNED PROFILES ARE BASED ON THE 1914 RIVER PROFILES WITH A SAWLOG ADJUSTMENT OF 803.02'
As noted previously, the profiles of the far upstream and downstream ends of Branch 2 correlate very well to the As-Designed / Established profile. However, from Stations 17+00 to 53+00, there is a hump in the existing open channel profile that prevents flows in the upper portion of Branch 2 from reaching the lower portion of Branch 2. Instead, this runoff currently flows south into a private drainage ditch which eventually outlets into Howard Lake. Given the difference in elevation between the As-Designed and Subsequently Improved Profile and the existing channel bottom, it may be prudent to perform a series of hand-auger borings in the channel bottom at this location to determine the depth of sediment in the channel. Since this area is mostly upland, it is likely that such a determination may be feasible. This sediment depth can then be used to establish if a relationship exists between the As-Designed / Established profile and the As- Constructed and Subsequently Improved profile.

The north end of Branch 1 also has a significant discrepancy between the As-Constructed and Subsequently Improved and existing profiles. The existing profile is three to four feet higher north of Station 45+00. It is possible that sediment has filled in the open channels in this area, or that the channel was not originally constructed to the As-Constructed and Subsequently Improved profile. Since much of this portion of Branch 1 flows through a wetland complex, sediment depths may be difficult to determine. However, if borings are performed elsewhere on this system, it would be relatively inexpensive to perform a small number of hand-auger borings to verify if the sedimentation depth can be measured.

**Recommendations / Conclusions**

Based on the analysis it is recommended that a datum adjustment of 803.02 be used with the 1914 open channel repair profiles to establish the As-Constructed and Subsequently Improved profile as shown in Figures 6 and 7. The As-Constructed and Subsequently Improved profile, along the with alignment shown in Figure 5 and the cross-section geometry (described on page 16) established the capacity and the As- Constructed and Subsequently Improved condition. In this case, the As-Constructed and Subsequently Improved conditions is the same as the As Designed / Established condition, because of the lack of as-built plans or other evidence.

We recommend some additional analysis to confirm the initial determination. Specifically, we recommend a minimum of five hand-auger borings between Stations 17+00 and 53+00 on Branch 2, and five borings between Stations 45+00 and 75+00 on Branch 1. These boring will help confirm the initial determination and may resolve inconsistencies between the As-Constructed and Subsequently Improved profile and the existing channel bottom profile exist in Branches 1 and 2.

To ensure that the system has a properly functioning outlet, Branch 2 should either be re-excavated to the As-Constructed and Subsequently Improved profile and cross-section geometry or the upper part of Branch 2 abandoned if no benefits can be documented.
AVAILABLE INFORMATION / HISTORICAL RECORDS
The following are documents for ACD 31 listed in chronological order:

_Historic Files_
- Petition for Public Ditch. March 12, 1898.
- Benefitted Parties. April 30, 1898.
- Summary of Excavation and Estimated Cost. April 30, 1898.
- Assessment Made on Land. October 10, 1898.
- Public Drainage Ditch Inventory Form. 1898.
- Benefitted Parties. December 1, 1904.
- Assessment of Repairs. May 27, 1905.

_Historic Plan and Profiles Files_
- Historic Alignment (West) for ACD 31. April 1898.
- Historic Alignment (East) for ACD 31. April 1898.
- Historic Profile for ACD 31. 1898.

_Alterations 1914_
- Petition for Ditch Repair. December 31, 1913.
- Remonstrance Against Ditch Repair. February 17, 1914.
- Summary of Excavation and Estimated Cost. April 21, 1914.
- Notice for Hearing on Petition for Repair to Ditch. May 19, 1914.
- Order of Repair to Ditch. May 19, 1914.

_1914 Plan and Profile Sheets_
- Repair Profiles for ACD 31. 1914.
MEMO

Final - Initial Legal Counsel Review Completed

- Repair Alignment for Branch 4. April 21, 1914.
- Repair Alignment for Branch 5, 6 and 7. April 21, 1914.

Inspection and Survey Reports

I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the state of Minnesota.

Mark Deutschman, PhD., P.E.
MN Reg. No 41259

Chris Otterness, P.E.
MN Reg. No 41961
Introduction

Previous work completed by Houston Engineering Inc. (HEI) for the Rice Creek Watershed District (RCWD) included the preparation of a Repair Report dated February 17, 2010 and associated Historical Review Memorandum dated January 22, 2010 for the Anoka County Ditch (ACD) 31 public drainage system (Figure 1). The Historical Review established the As Constructed and Subsequently Improved Condition (ACSIC) of ACD 31 using two primary lines of evidence: 1) existing structure elevations (culverts, stormsewer, etc.) where no profile documentation or test pit information existed; and 2) review of historic documentation of the public ditch.

The Board of Managers accepted the Historical Review Memorandum and the Repair Report and discussed the preferred repair alternative, but took no formal action on the As-Constructed and Subsequently Improved Condition. Additional discussion has occurred at the staff level about the best approach to repair the system since the completion of these documents. To provide more detailed analysis of the ACSIC of ACD 31, test pits were completed to determine the original ditch bottom. The RCWD has completed test pits on numerous public drainage systems in recent years, including several systems with a documented ACSIC approximated using other methodologies, because of the accuracy and reliability provided by test pitting in determining the historic open channel bottom. The purpose of this Memorandum is to describe the results from test pits, reevaluate the ACSIC based on the test pit data and available culvert data, LiDAR, and aerial photography and provide a recommendation to the Board of Managers.

Methods

Test pits were excavated along the Main Trunk and Branches 1, 2, and 5 of ACD 31 on June 25, 2014 by Roger Rydeen of Scandia Trucking and reviewed and surveyed by Garrett Monson of HEI and Tom Schmidt of the RCWD. The locations of the test pits were selected based on ease of access, minimal depth or absence of standing water, and likelihood of being a representative location. Test pits were completed at four locations, as shown in Figure 2 (numbered #1 - #4). Test pits were created by excavating a trench perpendicular to the existing open channel and adjacent spoil piles one bucket (approx. three feet) wide and deep enough to expose undisturbed mineral (non-organic) soils. Excavated root/vegetation mass and soils were separated into two piles and replaced once test pit
analysis was completed. Test pits are preferred over soil borings to estimate the “as-built” excavation depth because the interface between sediment and native material can be seen.

Excavation of each test pit generally reveals a channel cross-section with a U-shaped interface between the native\(^1\) mineral (sand) layer and the organic soils above. Within the channel, the soils above the mineral layer generally were a mixture of peat, topsoil, and sand -- the accumulated sediment since the original excavation of the channel. In the adjacent spoil bank, the mineral layer was generally topped by a peat layer (native soils), and followed by a mixture of sand and peat from the historic excavation. The historic channel elevation is determined by surveying the elevation of the interface between the mineral and organic layers at the bottom of the historic channel.

**Summary of Observations**

The following is a summary of the observations at each test pit.

*Test Pit #1 (Branch 5, west of Furman St NE)*

Test Pit #1 was located approximately 25 feet upstream (southwest) of Furman St NE on Branch 5. (Note – the profile of the ACSIC for Branch 5 was not previously determined in the January 22, 2010 Historical Review Memorandum). The test pit was located alongside the road where the public drainage system also serves as a road ditch. Excavation was completed across the open channel to reveal the soils profile within the cross-section. The historic open channel bottom was then surveyed at an elevation of 900.732 (see Photos 1 and 2). There is no historic profile design data for Branch 5, and thus the ACSIC profile was not previously determined. However, the ACSIC of the upstream end of Branch 2 (approximately 25 feet downstream of Test Pit #1) was previously determined at an elevation of 900.00.

*Test Pit #2 (Branch 2, west of Notre Dame St NE)*

Test Pit #2 was located approximately 60 feet upstream (southwest) of Notre Dame St NE on Branch 2. Water was present in the channel at this location and excavation was completed in the open channel incrementally until a hard bottom composed of native sands was encountered.\(^3\) The hard bottom of the test pit was surveyed at an elevation of 899.31 (see Photos 3 and 4). The test pit indicates an ACSIC 0.51 feet higher than the previously determined profile near this location.

*Test Pit #3 (Branch 1, south of Broadway Ave NE)*

Test Pit #3 was located downstream (southwest) of Broadway Ave NE (CR 18) along Branch 1 of ACD 31. Excavation was completed across the open channel to reveal the soils profile within the cross-section. No hard bottom composed of native sands encountered. Rather an approximate interface between deposited sediment and fibrous peat was observed at an approximate elevation of 899.31.

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1. “Native” refers to soil present prior to the original excavation of the public drainage system.
2. All elevations identified herein are based on North American Vertical Datum (NAVD) 1988.
3. The historic open channel bottom is generally identifiable as a distinct change in the soil horizon that may or may not occur at a “hard” bottom. In some cases, the open channel may have originally been constructed in deep peat or along an existing shallow watercourse. In these cases, the historic channel bottom the interface is visible as a U-shaped interface in the soil column.
897.65 (see Photos 5 and 6). Based on the surrounding area and lack of a hard bottom, it is evident that the original ditch was excavated in deep peat. Assuming that the interface between the deposited sediment and the fibrous peat is indicative of the open channel bottom as it was constructed, the test pit indicates an ACSIC approximately 0.63 feet higher than the previously determined profile.

*Test Pit #4 (Main Trunk, north of 167th Lane NE)*

Test Pit #4 was located 50 feet upstream (north) of 167th Lane NE on the Main Trunk of ACD 31. Water was present in the channel at this location and excavation was completed in the open channel incrementally until a hard bottom composed of native sands was encountered. The hard bottom of the test pit was surveyed at an elevation of 899.31 (see Photos 7 and 8). The test pit indicates an ACSIC approximately 0.61 feet lower than the previously determined profile.

**Conclusions**

Since Test Pit #1 was located in a portion of the public drainage system with no as-designed profile documentation, it cannot be used to corroborate the datum conversion previously determined in the Historical Review Memorandum. Likewise, Test Pit #3 cannot be utilized to modify the previous datum conversion due to the uncertainty of test pit analysis in deep peat soils. Therefore, only Test Pits #2 and #4 are pertinent in corroborating or modifying the previous datum conversion. These test pits respectively indicated higher and lower ACSIC channel elevations, (approximately 0.5 feet), than were previously determined. As the average error indicated by the two test pits is less than 0.1 feet, the data do not suggest that the previous datum conversion was in error, and therefore, no modifications are recommended to the previously determined ACSIC profile for the Main Trunk and Branches 1 through 3, as shown in Figures 3 through 5.

Because of the lack of historical profile data, the wet conditions, and the difficulty of access for test pitting, the ACSIC profile for Branches 5, 6 and 7 could not solely be determined through the use of test pit exploration, but instead was estimated based on Test Pit #1, available culvert data, and the grade of the natural ground surface (using LiDAR). The alignment and profile of the ACSIC for Branches 5 through 7 is shown in Figure 6.

Please note that portions of the ACD 31 public drainage system exist outside of the District boundary (and within the Sunrise River Watershed Management Organization) and thus are not under the legal authority of the RCWD to administer⁴. Funds cannot be legally expended on portions of the drainage system beyond their boundary. The RCWD has four options in managing the portions of the public drainage system outside of the District boundary:

1. Maintain only those portions of the public drainage system inside the RCWD boundary: The District could maintain only those portions of the public drainage system within their boundary. This is the least costly and time consuming option for the District. However, it does not enable restoration of drainage function to lands upstream of these locations. For example, a small segment of Branch 2 just west of Notre Dame

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⁴ This occurred unintentionally as a result of the transfer of the public drainage system from Anoka County as the drainage authority to the District at the time of District inception.
Street is outside of the District. Avoiding maintenance or repair in this area will prevent the restoration of function to all of the portions of the public drainage system upstream of this area (including all of Branches 5, 6, and 7).

2. **Abandon these portions of the public drainage system:** There are multiple properties along the portions of the public drainage system outside of the District, which rely on the system for an outlet. Partially abandoning those portions of the public drainage system outside of the District boundary will make future maintenance and/or repairs difficult as there will be no drainage authority to complete these actions. Landowners will essentially lose their drainage right. Because these parcels are outside of the District boundary, the RCWD will also be unable to charge these properties through a Water Management District even though these properties benefit from the outlet.

3. **Enter into a joint powers agreement with Anoka County:** The portions of the ACD 31 public drainage system outside of the District boundary could be managed through a joint powers agreement with Anoka County. This agreement would not only enable repair and maintenance of the system to occur, but would also enable the parcels outside of the District boundary contributing runoff to the system to be charged for a portion of the repair cost. However, there seems to be little incentive for the County to enter into a joint powers agreement with the District because of the administrative burden and cost, and the process for maintenance, repairs, and assessments will be much more cumbersome if such an agreement is in place than if the District had authority over the entire system.

4. **Petition the Board of Water and Soil Resources (BWSR) to incorporate the lands drained by ACD 31 including those beyond the boundary into the District.** This is the only viable option which enables all the lands which originally paid for and benefit from the public drainage system to receive benefit. The contributing drainage to the ACD 31 public drainage system could then be subject to the use of revenue resulting from ad valorem taxes and water management district charges to repair and maintain the public drainage system. The boundary adjustment will also provide the RCWD full authority over the entire public drainage system. For these reasons, it is the recommended option.

**Recommendations**

Based on the data provided by the test pit excavations, we recommend that the alignment and profile of the As-Constructed and Subsequently Improved Condition for ACD 31 (as shown in Figures 1 and 3 through 6) be formally adopted by the Board through a legal drainage proceedings per MS 103E.10. We further recommend that the Board of Managers petition BWSR to adjust the District boundary to incorporate the entire contributing drainage area from ACD 31.
**Photo 1:** Test Pit #1. View of test pit during excavation.

**Photo 2:** Test Pit #1 25 feet upstream of Branch 2.
Photo 3: Test Pit #2 60 feet upstream of Notre Dame St NE.

Photo 4: Test Pit #2. Survey of hard bottom.
**Photo 5:** Test Pit #3 50 feet downstream of Broadway Ave NE (CR 18)

**Photo 6:** Test Pit #3. Excavated peat.
Photo 7: Test Pit #4 50 feet upstream of 167th Lane NE.

Photo 8: Test Pit #4. Native sands encountered during excavation at hard bottom.
Figure 2 ACD 31 Test Pit Locations

Sources: TUG, EOR, RCWD, MN DOT

Legend:
- Test Pit Locations
- Public Open Channel
- Private (Serving Public Function)
- Watercourses
- County Roads
- Residential Streets
- ACD 31 Hydrologic Boundary
- RCWD Legal Boundary

Maple Grove

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