DRAINAGE & LATERAL EFFECTS DETERMINATIONS

CHRISTI FISHER, P.E.  ND STATE ENGINEER
TYPICAL ND DRAINAGE PROJECTS:

Pattern Tiling

Spot Tiling

Surface Ditches
HOW DOES NRCS ANSWER?

NATIONAL GUIDANCE: NATIONAL ENGINEERING HANDBOOK CH 19, HYDROLOGY TOOLS FOR WETLAND DETERMINATION (2004)

DEPENDING ON WETLAND TYPE AND HYDROLOGIC REGIME:

- STREAM/LAKE GAGE OR MONITORING WELL DATA BASED STATISTICAL DETERMINATION OF THE ELEVATION, FREQUENCY, AND DURATION OF INUNDATION
- SCOPE AND EFFECT EQUATIONS: ELLIPSE, HOGHOUDT, VAN SCHILFGAARDE, KIRKHAM
- DAILY WATER BALANCE MODELING- PRECIP, RUNOFF, GW INFLOW, EVAP, ET, SOIL PARAMETERS, DRAINAGE SYSTEM PARAMETERS (SPAW, DRAINMOD)
HOW DID/DOES NORTH DAKOTA NRCS ANSWER?

• 2004-2015:

✓ RIPARIAN WETLANDS- USE STREAM/LAKE GAGE DATA (??)

✓ OTHERS- USE VAN SCHILFGAARDE SCOPE AND EFFECT EQUATION
VAN SCHILFGAARDE EQUATION:

\[ S = \left[ \frac{9Ktd_e}{f'[\ln m_0 (2d_e + m) - \ln m (2d_e + m_0)]} \right] \]

**Parameters:**
- \( S \) = drain spacing, feet
- \( K \) = hydraulic conductivity in feet per day
- \( d_e \) = equivalent depth, feet, from drainage feature to impermeable layer
- \( m \) = height of water table above the center of the drain, feet
- \( m_0 \) = initial height of water table above the center of the drain, feet
- \( t \) = time in days for water table to drop from \( m_0 \) to \( m \)
- \( f \) = drainable porosity for the given water table change
- \( \alpha \) = depth from free water surface in drainage feature to impermeable layer, feet
- \( f' \) = drainable porosity adjusted for surface roughness, \( f + \frac{(s/12)}{(m_0 - m)} \)

**Equations:**
- For \( a/S' < 0.3 \):
  \[ d_e = \frac{a}{1 + \frac{a}{S'} \left( \frac{8}{\pi} \ln \frac{a}{r_e} - 3.4 \right)} \]
- For \( a/S' > 0.3 \):
  \[ d_e = \frac{S' \pi}{8 \left[ \ln \frac{S'}{r_e} - 1.15 \right]} \]

**Note:**
- Use zero if unsure
- \( S' \) = estimated drain spacing, feet

**References:**
- Modification by Tom Keep, NRCS
ITERATIVE CALCULATION PROCESS:

1) Use with the known depth, “a”, in place of “de” to determine Estimated spacing, S’

2) Use Estimated spacing, S’ in Appropriate Equation to determine Equivalent Depth “de”, which replaces “a” in the van Schilfgaarde Equation for final computations

3) Use “de” to determine the Spacing, S, in the van Schilfgaarde Equation

4) Compare the Estimated S’ to S, if they are within 10% of each other, the Difference Can Be Assumed to be Negligible. If the Difference is More Than 10%, use the Calculated S Value as S’, Repeat Calculations until the S’ and S Values are Within 10%
IN 2006, ND HY ENGINEER MADE STATEWIDE RUNS OF ND DRAIN BASED ON SOILS DATA AT THE TIME AND CREATED COUNTY WIDE SPREADSHEETS DISTRIBUTED PUBLICLY VIA EFOTG:

DID NOT COMPUTE FOR OPEN DITCHES, OR FOR DEPTHS GREATER THAN 6 FT. SOILS DATA CHANGES AFTER THAT 2006 DATE WERE NOT CONSIDERED.

* LARGEST LATERAL EFFECT OF ANY SOIL WITHIN THE MAP UNIT MAKING UP AT LEAST 10% OF THE UNIT BY AREA GOVERNS

* WINTER OF 2014, WE RECOMPUTED OLD SOILS DATA FOR OPEN DITCHES AND DOWN TO 9 FT IN DEPTH
SOME INPUTS STRAIGHT FORWARD:

t = time allowed for water table to drop from $m_o$ to $m$ (at the time a map was utilized based on the ND county)

d_e = 10 ft assumed depth from drain to impermeable layer

$m_o =$ assumed as depth of proposed ditch or tile (to centerline)

$m = m_o$ minus drawdown of 0.5 to 1.0 ft dependent on soil type

$s = 0.1$ inch assumption for water trapped due to surface roughness

$r_e =$ based on drainage structure:

<table>
<thead>
<tr>
<th>Tile Diameter</th>
<th>Effective Radius, re, inches</th>
<th>Effective Radius, re, feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 inches</td>
<td>0.20</td>
<td>0.0167</td>
</tr>
<tr>
<td>5 inches</td>
<td>0.41</td>
<td>0.034</td>
</tr>
<tr>
<td>6 inches</td>
<td>0.58</td>
<td>0.048</td>
</tr>
<tr>
<td>8 inches</td>
<td>0.96</td>
<td>0.080 (extrapolated)</td>
</tr>
<tr>
<td>10 inches</td>
<td>1.33</td>
<td>0.111 (extrapolated)</td>
</tr>
<tr>
<td>12 inches and larger</td>
<td>1.70</td>
<td>0.142 (extrapolated &amp; limit set)</td>
</tr>
<tr>
<td>Ditch, any size</td>
<td>12</td>
<td>1.0 (chosen by experience)</td>
</tr>
<tr>
<td>Drain tube</td>
<td>1.177n*</td>
<td>1.177n*</td>
</tr>
</tbody>
</table>

*surrounded by a gravel envelope with a square cross-section of length 2n on each side
SATURATED HYDRAULIC CONDUCTIVITY:

- Soil Survey
  - Listed multiple places
  - Use from map unit description

<table>
<thead>
<tr>
<th>Depth</th>
<th>Texture</th>
<th>Organic matter content</th>
<th>Saturated hydraulic conductivity (permeability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ap — 0 to 10</td>
<td>fine sandy loam</td>
<td>0.00</td>
<td>34.11 (2.00)</td>
</tr>
<tr>
<td>Bkg — 10 to 17</td>
<td>fine sandy loam</td>
<td>1.00</td>
<td>28.23 (4.00)</td>
</tr>
<tr>
<td>Cg — 17 to 28</td>
<td>fine sand</td>
<td>0.25</td>
<td>91.74 (13.00)</td>
</tr>
<tr>
<td>2Cdo — 28 to 80</td>
<td>loam</td>
<td>0.25</td>
<td>2.33 (0.33)</td>
</tr>
</tbody>
</table>

What value to use?

<table>
<thead>
<tr>
<th>Stratoclin, dense till</th>
<th>0-30</th>
<th>-99 - -22</th>
<th>5-10</th>
<th>10-19</th>
<th>1.20 - 1.50</th>
<th>10.00-705.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-17</td>
<td>-76 - -16</td>
<td>10-14</td>
<td>19</td>
<td>1.50 - 1.65</td>
<td>10.00-500.00</td>
<td></td>
</tr>
<tr>
<td>17-28</td>
<td>-94 - -1</td>
<td>2</td>
<td>19</td>
<td>1.35 - 1.70</td>
<td>10.00-205.00</td>
<td></td>
</tr>
<tr>
<td>28-60</td>
<td>-46 - -39</td>
<td>12</td>
<td>15-18</td>
<td>1.75-2.30</td>
<td>0.10-50.00</td>
<td></td>
</tr>
</tbody>
</table>
SATURATED HYDRAULIC CONDUCTIVITY:

Pedotransfer Functions

- Mainly statistical relationships based on thousands of data points to relate easy-to-measure variables to hard-to-measure variables
- Use %sand, %clay
- Modify w/ & org matter and %gravel
- Will also help with drainable porosity

![Pedotransfer Functions Diagram]
SATURATED HYDRAULIC CONDUCTIVITY:

Rosetta Pedotransfer function

- USDA-ARS Salinity Lab
- Hierarchical Neural Network Model
- Based on 2,085 data points
- Methodology that NRCS uses
Basics of Drainable Porosity ($f$)

- The volume of water drained per volume of soil, FOR A GIVEN MATRIC POTENTIAL
  - From Saturation to Field Capacity (gravity drainage ~ 24 hrs)
- $f = \text{depth drained water (hw)} / \text{total depth (ht)}$
- Example:
  - If $f = 0.10$ (10%) and we drain 2 feet (24 inches), what is depth water?
  - $= f \times ht = 0.10 \times 24'' = 2.4$ inches
2012 PRARIE POTHOLE STATES TILE SET-BACK COMMITTEE CONVENED:
(ND, SD, MN, IA AND NRCS NATIONAL TECHNICAL STAFF)

*GOAL WAS TO DEVELOP TECHNICALLY DEFENSIBLE, CONSISTENT APPROACH ACROSS THE 4 STATES

*COMMITTEE RECOMMENDATIONS:

EACH STATE SOIL SCIENTIST SHOULD DEVELOP A LIST OF SOILS CORRESPONDING TO WETLAND HYDRAULIC FUNCTION

VAN SCHILFGAARDE SHOULD BE UTILIZED ON: RECHARGE, UPLAND, MINERAL FLATS TYPE WETLANDS

RESULTS OF VAN SCHILFGAARDE SHOULD BE ROUNDED UP TO NEAREST 10 FT AND SET AT MINIMUM 50 FT, MAXIMUM 400 FT BASED ON MODEL LIMITATIONS

DRAWDOWN OF 1.0 FT SHOULD BE UTILIZED REGARDLESS OF SOIL TYPE

A DRAWDOWN TIME OF 14 DAYS SHOULD BE UTILIZED, AS OUTLINED IN THE NATIONAL FOOD SECURITY ACT MANUAL
2015/16 ND LATERAL EFFECTS WORK:

• DEVELOPED AN AUTOMATED METHODOLOGY TO TRANSFER WEBSOIL SURVEY INFORMATION, THROUGH ROSETTA AND ND DRAIN...EFFICIENTLY

• UTILIZED THE MOST RECENT METHODOLOGY RECOMMENDED BY NATIONAL EXPERTS FOR SOILS BASED INPUT PARAMETERS

• IMPLEMENTED THE 2012 TILE SETBACK COMMITTEE RECOMMENDATIONS:

THIS WILL ALLOW US TO REGENERATE RESULTS WITH THE ANNUAL REFRESH OF WEB SOIL SURVEY.
Drainage, Lateral Effects, and Drainage Water Management

Drainage is the practice of removing surface and sub-surface water from an area. Often drainage is used to improve crop production. Lateral effect refers to the extent at which the drainage influences the hydrology.

Common drainage policies and laws in North Dakota as well as information regarding lateral effects are found below.

The following document(s) may require Adobe Reader:
- North Dakota Lateral Effect Policy (RD EPH Part 556 Chapter 19 Supplement) (PDF: 65 KB)
- Memorandum - Tile Drain Systems - State of ND Office of the State Engineer (PDF: 35 KB)
- State of North Dakota Drainage Rules (PDF: 45 KB)

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Richland County
Minimal Effects Determination

Date Calculated: March 21, 2016

<table>
<thead>
<tr>
<th>Map Unit</th>
<th>Average Depth Below Ground (feet)</th>
<th>Tile Diameter (inches) / Open Ditch</th>
</tr>
</thead>
<tbody>
<tr>
<td>G12A</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

**SETBACK DISTANCE:**

For this map unit utilize a minimal effect setback distance of 90 feet from the certified wetland boundary.

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Lateral Effect Computations

<table>
<thead>
<tr>
<th>Map Unit Symbol</th>
<th>Component Name</th>
<th>Percent of Map Unit</th>
<th>Average Depth Below Ground (feet)</th>
<th>Tile Diameter (inches) / Open Ditch</th>
<th>Hydraulic Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>G12A</td>
<td>Pernell1125487</td>
<td>27</td>
<td>3</td>
<td>4</td>
<td>recharge</td>
</tr>
<tr>
<td>G12A</td>
<td>Valler1125492</td>
<td>31</td>
<td>8</td>
<td>4</td>
<td>discharge</td>
</tr>
<tr>
<td>G12A</td>
<td>Valler1125491</td>
<td>14</td>
<td>8</td>
<td>4</td>
<td>discharge</td>
</tr>
<tr>
<td>G12A</td>
<td>Tanks1125490</td>
<td>7</td>
<td>3</td>
<td>4</td>
<td>recharge</td>
</tr>
<tr>
<td>G12A</td>
<td>Wyard1125486</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>upland soils</td>
</tr>
<tr>
<td>G12A</td>
<td>Southam1125480</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>flow-through</td>
</tr>
<tr>
<td>G12A</td>
<td>Manfred1125488</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>discharge</td>
</tr>
<tr>
<td>G12A</td>
<td>Hamerly1125464</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>upland soils</td>
</tr>
<tr>
<td>G12A</td>
<td>Easby1125485</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>discharge</td>
</tr>
</tbody>
</table>
Site specific evaluation is required, given that lateral effects equations may not be applicable for the controlling hydrologic function. Contact one of the individuals shown on the ND NRCS Engineering Drainage Website.

In most cases, minimal effects determinations for these types of soils will require an approximate sketch of the proposed tile and/or open ditch layout on an aerial photo for evaluation. Exact location information is not critical, however orientation and approximate depth below ground surface of the drainage features is.

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<th>Hydraulic Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1350A</td>
<td>Hamar11324399</td>
<td>80</td>
<td>3</td>
<td>4</td>
<td>high water table sands</td>
</tr>
<tr>
<td>1360A</td>
<td>Ulen11324402</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>upland soils</td>
</tr>
<tr>
<td>1360A</td>
<td>Rosewood11324401</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>high water table sands</td>
</tr>
<tr>
<td>1360A</td>
<td>Hamar11324400</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>high water table sands</td>
</tr>
<tr>
<td>1360A</td>
<td>Venlo11324403</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>high water table sands</td>
</tr>
<tr>
<td>1360A</td>
<td>Garborg11324398</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>upland soils</td>
</tr>
</tbody>
</table>
WETLAND TYPES (PRESENT IN ND) WHERE VAN SCHILFGAARDE NOT APPROPRIATE:

✓ RIVERINE

✓ DISCHARGE DEPRESSIONAL WETLANDS

✓ HIGH WATER TABLE SANDS

✓ FLOW THROUGH WETLANDS

LATERAL EFFECTS ESTIMATES BEING HANDLED OUT OF THE STATE OFFICE BY SOILS/ENGINEERING STAFF USING AVAILABLE SOILS DATA, WELL LOGS, GROUNDWATER STUDIES, TOPOGRAPHIC DATA, RIVER GAUGE INFORMATION, ETC.
FLOW THROUGH WETLANDS

SOME RELAVENT QUESTIONS:

• WHICH WAY IS GROUNDWATER FLOWING?
• IS THERE AN IMPERVIOUS LAYER?
• WHAT IS THE FLOW CAPACITY OF THE DRAIN VERSUS THE AVERAGE INFLOW VOLUME?

Figure 4. Example of interception and diversion of groundwater away from a wetland area (figure adapted from a Purdue University illustration)
EXAMPLE SITE #1 - FLOW THROUGH WETLAND

96.92 = GS/GW
98.96 = GS, 95.96 = TILE
99.40 = GS, 97.91 = GW

NO IMPERMEABLE LAYERS
LARGE SURFACE WATERSHED
PROFILE:

DETERMINATIONS BASED ON FIELD VISIT:

• COMBINATION OF GROUNDWATER AND SURFACE WATER INFLOW FEEDS THIS WETLAND
• BASED ON ELEV OF HYDRIC INDICATORS ON SITE, GROUNDWATER FLOWS WITH SURFACE WATER AND NO IMPERVIOUS LAYER IS PRESENT
• TILE MAY INTERCEPT UP TO 50% OF GROUNDWATER FLOWS FROM THE SOUTHWEST
• TILE NOT LIKELY TO INTERCEPT OVER 30% OF CONTRIBUTING SURFACE WATER FLOWS HOWEVER
• CURRENTLY PERFORATED MAINLINE IS WITHIN 3 X Le DISTANCE OF WETLAND, SO CONVERT TO SOLID FOR UP TO 64 FT PERPENDICULAR TO WETLAND BOUNDARY
DISCHARGE DEPRESSIONAL WETLANDS

SOME RELATED QUESTIONS:

- WHICH WAY IS GROUNDWATER FLOWING?
- IS THERE AN IMPERVIOUS LAYER?
- WHAT IS THE FLOW CAPACITY OF THE DRAIN VERSUS THE AVERAGE GROUNDWATER INFLOW VOLUME?

Recharge $G_o > G_i$
Discharge $G_i > G_o$
Flow Through $G_i = G_o$
EXAMPLE SITE #2 - WETLAND IN HIGH WATER TABLE SANDS
LARGE PERCENTAGE OF SURFACE DA TO BE DRAINED:

* GROUNDWATER INFLOW ESTIMATED AT 27 CFS

* TILE DRAIN CAPACITY ESTIMATED AT 1 CFS
WILL THE DRAINAGE SYSTEM HAVE ANY IMPACT ON WETLANDS?

WILL THE DRAINAGE SYSTEM HAVE ANY IMPACT ON GROUNDWATER IN THE CROP FIELDS?
GOALS FOR THESE “NON-VS” WETLAND TYPE SITUATIONS:

• <14 DAY RESPONSE TIME TO REQUESTS

• MAKE THE BEST TECHNICAL RECOMMENDATION WE CAN WITH AVAILABLE DATA

• CONTINUE TO LEARN & COLLECT INFORMATION, AND SHARE WITH THOSE WORKING ON DRAINAGE IN ND