A Case Study

...From Planning Through Design

Nick Vande Hey, P.E.
McMAHON ASSOCIATES, INC.
Land acquisition: 87.9 acres
Site gently slopes from northwest to southeast
Current land uses:
- Agriculture / Pasture 87.2 %
- Woodland 7.0 %
- Farm Homestead 4.5 %
- Rural Residential 1.3 %
Total: 100.0 %
Mixed land use: Commercial, Residential, and Park
Public sanitary sewer and water along County Highway
Park dedication required within portion of woods
Driveway access restrictions along County Highway
Site topography and slopes
- Elevation difference: 24 ft
- Average slope: 0.8%
- Maximum slope: 17%

No remediation sites within 500 ft of site
No endangered species habitat
FEMA 100-year floodplain map
DNR Wisconsin Wetland Inventory map
Field Verification of Initial Screening:

- Topographic survey (1 foot contours)
- Wetland delineation
- Actual FEMA 100-year floodplain limits
- No karst features

Legend:
- Delineated Wetland
- Actual 100-yr Floodplain
- Existing Woods
Redevelopment areas
Private wells within 100 feet of site perimeter
No public wells

Field Verification of Initial Screening:
On-site soil textures
No bedrock encountered

Field Verification of Initial Screening:
- On-site soil textures
- No bedrock encountered
Hydrologic Soil Groups (HSG)

On-site surface soil textures determine actual HSG

Actual HSG limits different than NRCS Soil Survey

Field Verification of Initial Screening:

- Hydrologic Soil Groups (HSG)
  - On-site surface soil textures determine actual HSG
  - Actual HSG limits different than NRCS Soil Survey

Actual Soils for SLAMM/TR-55:

- SILT (HSG B)
- CLAY (HSG C)
- CLAY (HSG D)
Field Verification of Initial Screening:
- Depth to Seasonally High Groundwater.
Identifying Optimal Infiltration Areas:

- Infiltration Exclusions and Exemptions: Soils

<table>
<thead>
<tr>
<th>USDA Soil Texture</th>
<th>NR 151.12(5)(c)(6a) Infiltration Rate</th>
<th>NR 151.12(5)(c)(5) Percent Fines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravelly Coarse Sand</td>
<td>&lt;20%</td>
<td>-</td>
</tr>
<tr>
<td>Gravelly Sandy Loam</td>
<td>&gt;20%</td>
<td>-</td>
</tr>
<tr>
<td>Loam</td>
<td>&gt;20%</td>
<td>-</td>
</tr>
<tr>
<td>Sandy Clay Loam</td>
<td>&lt;0.6 in/hr</td>
<td>&gt;20%</td>
</tr>
<tr>
<td>Silty Clay Loam</td>
<td>&lt;0.6 in/hr</td>
<td>&gt;20%</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>&lt;0.6 in/hr</td>
<td>&gt;20%</td>
</tr>
</tbody>
</table>

*Information from WDNR Code 1002. No field measurements or laboratory tests conducted.
Identifying Optimal Infiltration Areas

- **Infiltration Exclusions and Exemptions: Groundwater**
  - Residential areas with less than 3 feet from bottom of infiltration system to high groundwater. Infiltration of roof runoff is not prohibited.
  - Commercial areas with less than 5 feet from bottom of infiltration system to high groundwater.
Identifying Optimal Infiltration Areas:

- Infiltration Exclusions and Exemptions: Groundwater
Identifying Optimal Infiltration Areas:

- Design Infiltration Rates
Identifying Optimal Infiltration Areas:

- Initial Ranking of Potential Infiltration Areas
Local Ordinances

- **Total Suspended Solids:**
  - Same as NR 151.12(5)(a)

- **Peak Discharge:**
  - New and redevelopment sites
  - Reduce post-development peak flows to pre-development peak flows for 2, 10, and 100-year, 24-hour storms.
  - Maximum pre-development curve number based on “meadow”
    - Hydrologic Soil Group A B C D
    - Runoff Curve Number 30 58 71 78

- **Infiltration:**
  - Same as NR 151.12(5)(c)

- **Protective Areas:**
  - Same as NR 151.12(5)(d)

- **Fueling and Vehicle Maintenance Areas:**
  - Same as NR 151.12(5)(e)
Southwest Corner of Site

WETLAND BOUNDARY OFFSITE IS APPROXIMATE. BOUNDARY WAS GENERATED FROM EXISTING CONTOURS AND AERIAL PHOTOGRAPHY FOR PURPOSES OF DETERMINING PROTECTIVE AREA LIMITS.

Protective Areas:
- Southwest Corner of Site

PROTECTIVE AREA LIMITS:

STREAMS ON USGS TOPOGRAPHIC MAPS = 50 FEET
DELINEATED WETLAND (LESS SUSCEPTIBLE)
10% OF AVERAGE WETLAND WIDTH, BUT NO LESS THAN 10 FT OR GREATER THAN 30 FT
DELINEATED WETLAND (HIGHLY SUSCEPTIBLE) = 50 FEET
Protective Areas:

PROTECTIVE AREA LIMITS:

- Streams on USGS Topographic Maps = 50 feet
- Delineated Wetland (Highly Susceptible) = 50 feet
- Delineated Wetland (Less Susceptible) = 10-30 feet

Legend:

- Re-development
- Protective Area Limits

NORTH
100-Year Floodplain
Preliminary Development Plan:
Preliminary Development Plan:

Infiltration:
Initial ranking of site areas suitable for infiltration:
1. High
2. Low

Infiltrate runoff from roofs only

Filling required:
- Poor sanitary sewer depth
- Conditions not ideal for infiltration
- Improve drainage
- Disposal area for wet pond construction

Wet Ponds:
- Silty clay soil
- Low point of site
- Maintain wetland hydrology
Final Development Plan

- Modifications to Preliminary Development Plan:
  - Conserve larger wooded area
  - Preserve permeable soils
  - Reduce imperviousness, particularly within permeable soils
  - Disconnect residential roof drains (Compared to DNR standard land use files)
  - Benefits of modifications include: Reduced runoff volume, peak flows, TSS load, and required infiltration volume

Curve Number Comparison: Post vs. Pre-Development

<table>
<thead>
<tr>
<th>TR-55 LAND USES</th>
<th>SOIL TYPE B CN</th>
<th>DIFF</th>
<th>SOIL TYPE C CN</th>
<th>DIFF</th>
<th>SOIL TYPE D CN</th>
<th>DIFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Meadow</td>
<td>58</td>
<td></td>
<td>71</td>
<td></td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>• Park Open Space</td>
<td>61</td>
<td>5%</td>
<td>74</td>
<td>4%</td>
<td>80</td>
<td>2%</td>
</tr>
<tr>
<td>• Residential (1/4 ac)</td>
<td>75</td>
<td>29%</td>
<td>83</td>
<td>17%</td>
<td>87</td>
<td>12%</td>
</tr>
<tr>
<td>• Commercial</td>
<td>92</td>
<td>59%</td>
<td>94</td>
<td>32%</td>
<td>95</td>
<td>22%</td>
</tr>
</tbody>
</table>
Limits of Land Disturbance:

- Land Acquisition = 87.90 AC.
- Land Disturbance = 75.50 AC.

- Include disturbed areas outside property lines
- Exclude natural wetlands inside property lines
Infiltration

- **Residential Development**
  - Post-development infiltration volumes shall be at least 90% of pre-development infiltration volumes
  - Max. 1 % of project site required for effective infiltration area

- **Non-Residential Development**
  - Post-development infiltration volumes shall be at least 60% of pre-development infiltration volumes
  - Max. 2 % of project site required for effective infiltration area

- **Redevelopment areas are exempt from infiltration**
Of the 75.5 acres of land disturbance:

- New development area = 70.30 AC.
- Redevelopment area = 5.20 AC.

Maximum required effective infiltration area:

- Residential (73.35 AC.) = 31,951 SQ. FT.
- Non-residential (2.15 AC.) = 1,723 SQ. FT.
- Total (75.50 AC.) = 33,674 SQ. FT. (CAP MAY BE VOLUNTARILY EXCEEDED)
**Infiltration**

- SLAMM “Undeveloped” source area for pre-developed
- Pre-development SLAMM results are as follows:

<table>
<thead>
<tr>
<th>NEW DEVELOPMENT AREAS ONLY</th>
<th>AREA (acres)</th>
<th>SLAMM SOIL TYPE</th>
<th>AVERAGE ANNUAL RAINFALL VOLUME (cu.ft.)</th>
<th>RUNOFF VOLUME (cu.ft.)</th>
<th>INFILTRATION VOLUME (cu.ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Non-Residential</td>
<td>0.20</td>
<td>Silt</td>
<td>16,429</td>
<td>543</td>
<td>15,886</td>
</tr>
<tr>
<td>• Residential</td>
<td>14.95</td>
<td>Silt</td>
<td>1,228,096</td>
<td>40,610</td>
<td>1,187,486</td>
</tr>
<tr>
<td>• Residential</td>
<td>55.15</td>
<td>Clay</td>
<td>4,530,402</td>
<td>213,542</td>
<td>4,316,860</td>
</tr>
<tr>
<td>Total</td>
<td>70.30</td>
<td></td>
<td>5,774,927</td>
<td>254,695</td>
<td>5,520,232</td>
</tr>
</tbody>
</table>
Infiltration

- Determine minimum required post-development infiltration volume

<table>
<thead>
<tr>
<th>NEW DEVELOPMENT AREAS ONLY</th>
<th>AREA (acres)</th>
<th>SLAMM SOIL TYPE</th>
<th>PRE-DEVELOP INFILTRATION VOLUME (cu.ft.)</th>
<th>NR 151 INFILTRATION REQUIRED</th>
<th>MINIMUM REQUIRED POST-DEVELOP INFILTRATION VOLUME (cu.ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Non-Residential</td>
<td>0.20</td>
<td>Silt</td>
<td>15,886</td>
<td>60%</td>
<td>9,532</td>
</tr>
<tr>
<td>• Residential</td>
<td>14.95</td>
<td>Silt</td>
<td>1,187,486</td>
<td>90%</td>
<td>1,068,737</td>
</tr>
<tr>
<td>• Residential</td>
<td>55.15</td>
<td>Clay</td>
<td>4,316,860</td>
<td>90%</td>
<td>3,885,174</td>
</tr>
<tr>
<td>Total</td>
<td>70.30</td>
<td></td>
<td>5,520,232</td>
<td></td>
<td>4,963,443</td>
</tr>
</tbody>
</table>
## Infiltration

- Post-development SLAMM results are as follows:

<table>
<thead>
<tr>
<th>NEW DEVELOPMENT AREAS ONLY</th>
<th>AREA (acres)</th>
<th>SLAMM SOIL TYPE</th>
<th>AVERAGE ANNUAL RAINFALL VOLUME (cu.ft.)</th>
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<th>INFILTRATION VOLUME (cu.ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Non-Residential</td>
<td>0.20</td>
<td>Silt</td>
<td>16,429</td>
<td>10,448</td>
<td>5,941</td>
</tr>
<tr>
<td>• Residential</td>
<td>14.95</td>
<td>Silt</td>
<td>1,228,096</td>
<td>167,205</td>
<td>1,060,891</td>
</tr>
<tr>
<td>• Residential</td>
<td>55.15</td>
<td>Clay</td>
<td>4,530,402</td>
<td>827,468</td>
<td>3,702,934</td>
</tr>
<tr>
<td>Total</td>
<td>70.30</td>
<td></td>
<td>5,774,927</td>
<td>1,005,161</td>
<td>4,769,766</td>
</tr>
</tbody>
</table>
Infiltration

- Determine required post-development runoff volume to be infiltrated:

<table>
<thead>
<tr>
<th>NEW DEVELOPMENT AREAS ONLY</th>
<th>AREA (acres)</th>
<th>SLAMM SOIL TYPE</th>
<th>MINIMUM REQUIRED (cu.ft.)</th>
<th>POST-DEVELOPMENT INFILTRATION VOLUME</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Non-Residential</td>
<td>0.20</td>
<td>Silt</td>
<td>9,532</td>
<td>5,941</td>
</tr>
<tr>
<td>• Residential</td>
<td>14.95</td>
<td>Silt</td>
<td>1,068,737</td>
<td>1,060,891</td>
</tr>
<tr>
<td>• Residential</td>
<td>55.15</td>
<td>Clay</td>
<td>3,885,174</td>
<td>3,702,934</td>
</tr>
<tr>
<td>Total</td>
<td>70.30</td>
<td></td>
<td>4,963,443</td>
<td>4,769,766</td>
</tr>
</tbody>
</table>

- Residential

- Required for BMP’s

- Total
Infiltration

- Preliminary evaluation of infiltration requirement
  - Runoff volume from silt soils is 177,693 cu.ft.
  - Infiltrate 15,984 cu.ft. or more runoff volume from clay soils to satisfy the 193,677 cu.ft. infiltration requirement
  - Clay soil designation only represents the uppermost soil texture

<table>
<thead>
<tr>
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<th>RUNOFF VOLUME (cu.ft.)</th>
<th>INFLTRATION VOLUME REQUIRED (cu.ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Non-Residential</td>
<td>0.20</td>
<td>Silt</td>
<td>10,488</td>
<td>3,591</td>
</tr>
<tr>
<td>• Residential</td>
<td>14.95</td>
<td>Silt</td>
<td>167,205</td>
<td>7,846</td>
</tr>
<tr>
<td>• Residential</td>
<td>55.15</td>
<td>Clay</td>
<td>827,468</td>
<td>182,240</td>
</tr>
<tr>
<td>Total</td>
<td>70.30</td>
<td></td>
<td>1,005,161</td>
<td>193,677</td>
</tr>
</tbody>
</table>
Infiltration Considerations:

- Infiltration Grass Swales (Code 1005):
  - Highest permeable soil is not at ground surface
  - Developer dislikes rural streets with culverts
  - Rural streets may have sidewalk challenges

- Infiltration Basin (Code 1003):
  - Residential pretreatment: 60% TSS removal
  - Highest permeable soil is not at ground surface
  - Groundwater mounding considerations

- Bioretention (Code 1004):
  - Engineered soil (3 ft) replaces low permeable soils
  - Bioretention device fits within a residential lot
  - Provides equivalent protection if < 20% fines
Infiltration Considerations

1. Potential Gas Station Site
2. Re-Development (Soil Compaction)
3. Proposed Sidewalk to TOT Lot/Park (Grass Swale Conflict)
4. Infiltration Basin Does Not Seem Practical
5. Proposed Bio-Retention Devices (Typ.)
PROPOSED BIO-RETENTION DEVICES:

- BIO-RETENTION DEVICES = 17
- AVERAGE DRAINAGE AREA/DEVICE = 1.1 AC.
- AVERAGE EFFECTIVE INFILTRATION AREA = 9FT. x 18 FT.
- TOTAL EFFECTIVE INFILTRATION AREA PROVIDED = 2,754 SQ. FT.
- MAXIMUM EFFECTIVE INFILTRATION AREA REQUIRED = 33,674 SQ FT.
- MIN. INFILTRATION VOLUME REQUIRED = 193,677 CU. FT.
- BIO-RETENTION INFILTRATION VOLUME PROVIDED = 206,991 CU. FT.

Infiltration:
- Proposed Bioretention Devices
Infiltration:
- Proposed Residential Bioretention Devices
Peak Discharge

- Local Ordinance more restrictive than NR 151:
  - New and redeveloped sites
  - Reduce post-development peak flows to pre-development peak flows for the 2, 10, and 100-year, 24-hour storms
  - Maximum pre-development curve number based on “meadow”
    - Hydrologic Soil Group A B C D
    - Runoff Curve Number 30 58 71 78
Predevelopment Peak Flows

Peak Discharge:
- Predevelopment Peak Flows

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>DRAINAGE AREA (AC.)</th>
<th>CN</th>
<th>PRE-DEVELOPMENT PEAK FLOWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTFALL A</td>
<td>10.10</td>
<td>67</td>
<td>2.13 7.38 16.38</td>
</tr>
<tr>
<td>OUTFALL B</td>
<td>3.20</td>
<td>76</td>
<td>9.20 29.92 63.53</td>
</tr>
<tr>
<td>OUTFALL C</td>
<td>18.50</td>
<td>70</td>
<td>4.60 13.92 28.17</td>
</tr>
<tr>
<td>OUTFALL D</td>
<td>11.70</td>
<td>66</td>
<td>2.29  8.69  19.20</td>
</tr>
<tr>
<td>TOTAL</td>
<td>75.50</td>
<td>72</td>
<td></td>
</tr>
</tbody>
</table>
Post-development peak flows without any detention

Peak Discharge:

- Post-development peak flows without any detention

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>DRAINAGE AREA (AC)</th>
<th>CN</th>
<th>2-YEAR (CFS)</th>
<th>10-YEAR (CFS)</th>
<th>100-YEAR (CFS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTFALL A</td>
<td>1.80</td>
<td>B4</td>
<td>2.03</td>
<td>3.03</td>
<td>6.38</td>
</tr>
<tr>
<td>OUTFALL B</td>
<td>48.35</td>
<td>B4</td>
<td>42.42</td>
<td>82.45</td>
<td>134.26</td>
</tr>
<tr>
<td>OUTFALL C</td>
<td>22.45</td>
<td>B1</td>
<td>11.71</td>
<td>24.35</td>
<td>41.18</td>
</tr>
<tr>
<td>OUTFALL D</td>
<td>2.90</td>
<td>B5</td>
<td>2.21</td>
<td>4.53</td>
<td>7.87</td>
</tr>
<tr>
<td>TOTAL</td>
<td>75.50</td>
<td>B3</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
Peak Discharge:

- Post-development peak flows with wet ponds and bioretention
Comparison of pre-development and post-development peak flows

Peak Discharge:

- Comparison of pre-development and post-development peak flows

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>PRE-DEVELOPMENT PEAK FLOWS</th>
<th>POST-DEVELOPMENT PEAK FLOWS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2-YEAR (CFS)</td>
<td>10-YEAR (CFS)</td>
</tr>
<tr>
<td>OUTFALL A</td>
<td>2.13</td>
<td>7.38</td>
</tr>
<tr>
<td>OUTFALL B</td>
<td>9.20</td>
<td>29.92</td>
</tr>
<tr>
<td>OUTFALL C</td>
<td>4.60</td>
<td>13.92</td>
</tr>
<tr>
<td>OUTFALL D</td>
<td>2.29</td>
<td>8.69</td>
</tr>
<tr>
<td>TOTAL</td>
<td>18.29</td>
<td>50.89</td>
</tr>
</tbody>
</table>
Total Suspended Solids (TSS)

- **New Development**: Reduce TSS load by 80% minimum as compared to no runoff management / BMP controls.

- **Redevelopment**: Reduce TSS load by 40% minimum as compared to no runoff management / BMP controls.
Total Suspended Solids (TSS):
- **Total Suspended Solids Removal Required**
Total Suspended Solids (TSS):

- Total Suspended Solids Removal Provided

<table>
<thead>
<tr>
<th>AREA (AC.)</th>
<th>TSS NO BMP'S (LBS.)</th>
<th>TSS REMOVAL PROVIDED WITH BMP'S (LBS.)</th>
<th>TSS REMOVAL PROVIDED WITH BMP'S</th>
</tr>
</thead>
<tbody>
<tr>
<td>POST B1</td>
<td>17.50</td>
<td>2,987</td>
<td>2,561</td>
</tr>
<tr>
<td>POST B2</td>
<td>26.65</td>
<td>3,627</td>
<td>3,627</td>
</tr>
<tr>
<td>POST C</td>
<td>19.50</td>
<td>3,506</td>
<td>2,981</td>
</tr>
<tr>
<td>UNCAPTURED A-D</td>
<td>11.85</td>
<td>1,531</td>
<td>0</td>
</tr>
</tbody>
</table>

**TOTALS:**

<table>
<thead>
<tr>
<th>AREA (AC.)</th>
<th>TSS NO BMP'S (LBS.)</th>
<th>TSS REMOVAL PROVIDED WITH BMP'S (LBS.)</th>
<th>TSS REMOVAL PROVIDED WITH BMP'S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>75.50</td>
<td>12,186</td>
<td>9,169</td>
</tr>
</tbody>
</table>

*TSS REMOVAL REQUIRED = 9,028 LBS. OR 74.1%*