DEVELOPING NONPOINT SOURCE WATER QUALITY LEVELS OF SERVICE FOR HILLSBOROUGH COUNTY, FLORIDA

Robert G. McConnell
Parsons Engineering Science, Inc.
2901 West Busch Boulevard, Tampa, Florida

Elie G. Araj
Hillsborough County Department of Public Works
601 East Kennedy Boulevard, Tampa, Florida

David T. Jones
CAiCE Software Corporation
410 Ware Boulevard, Tampa, Florida

ABSTRACT

A pollutant loading and removal model was developed by Hillsborough County Public Works/Stormwater Management Environmental Team to facilitate water quality assessments in Hillsborough County. The model was prepared in response to the county's desire to establish water quality levels-of-service. Water quality levels-of-service may in turn be used to guide development and management actions.

The pollutant loading and removal model has three main components: calculation of gross pollutant loads, estimation of net loads considering the effects of best management practices (BMPs), and evaluation of water quality levels-of-service. The model uses GIS coverages of soils and land use to calculate pollutant loads. Pollutant removals are estimated by evaluating BMP coverage and removal efficiencies. A list of removal efficiencies for standard BMPs is supplied with the model, and user-specified BMPs are allowed. Finally, water quality levels of service are calculated and the GIS subbasin coverage is updated to include an attribute for water quality level-of-service.

INTRODUCTION

Nestled on the eastern shores of Tampa Bay, Hillsborough County covers about 900 square miles of land and 25 square miles of inland water area. Organized in 1934 as Florida's 19th County, Hillsborough has enjoyed growth and a population increase synonymous with that experienced by the rest of Florida. Despite the rapid growth rate, about 60% of the County remains either undeveloped or in agricultural use. The remaining 40% consists of urbanized land. With this increased growth and development, there have been many challenges for the County to provide and maintain the services required to meet the needs of its expanding citizenry.
During the El Nino rains of 1997 - 1998, large areas in Hillsborough County, especially in the Northwest, experienced street and structural flooding for an extended period of time. With over 50 inches of rain falling in a 4-month period (following a wet rainy season), El Nino proved to be the ultimate test for the effectiveness of the County's stormwater infrastructure.

Flood investigations during El Niño have generated more than three hundred (300) stormwater neighborhood projects. The need to accelerate the stormwater master planning of the entire county was also recognized. Such master plans would be managed as a group standardizing methodologies countywide. They would also allow for solutions to be implemented for the regional problems, while more effectively solving the localized problems.

Through discussions with staff in various County departments and with personnel from state agencies, it was quickly recognized that these plans could, and should, do more than solve flood problems. With $96 million approved by the Board of County Commissioners for an accelerated 5 year stormwater program, the objectives of these new plans came into fruition. One of the objectives is to establish a Water Quality Level of Service in the basins throughout the county. The Pollutant Loading and Removal Model was developed to serve this purpose.

Model Input Data

The Pollutant Loading and Removal Model has three main components: calculation of gross pollutant loads, estimation of net loads based on existing treatment, and evaluation of water quality levels-of-service. GIS coverages of land use and soils are used together with drainage basin delineations to determine runoff characteristics. Gross pollutant loads for each subbasin are calculated as the product of the runoff volume and the stormwater event mean concentrations (EMC) for each chemical of interest. The EMCs are based on measurements taken during stormwater characterization studies performed by Hillsborough County, and later submitted as part of the County's National Pollutant Discharge Elimination System (NPDES) permit. Net pollutant loads are estimated by evaluating removal from existing stormwater treatment within each sub-basin. A water quality level-of-service is then determined based on a comparison of existing net loads to a benchmark condition represented by the pollutant load produced by a typical land use in the area, in this case low/medium density residential.

Land Use

Land use composition within a sub-basin determines the extent of impervious areas, which in turn determines the volume of runoff expected from these basins and subbasins within the watershed. The 1995 land use coverages prepared by the SWFWMD were used herein to evaluate land use in each watershed. These coverages are based on the Florida Land Use and Cover Classification System (FLUCCS).
For pollutant loading estimates, land use categories were aggregated to correspond with the Hillsborough County NPDES permit. Major non-natural land use categories evaluated for pollutant loading included:

- low/medium density residential
- high density residential
- light industrial
- agricultural
- commercial
- institutional
- highway/utility
- recreational
- openland, and
- extractive (mining)/disturbed.

**Soil Characteristics**

For hydrologic analyses, a standard method of soils classification is the hydrologic soils group. Soils are grouped into four hydrologic soil groups A through D, which are commonly used to estimate infiltration rates and soil moisture capacities. Runoff volume calculations are based on the application of runoff coefficients by soil and land use type. The values assigned to the runoff coefficients were based on those obtained from NPDES permit studies conducted in Hillsborough County. Most of the coefficients, listed by land use, can be found in the FDOT drainage manual.

**Basin Delineations**

For purposes of comparing hydrologic, hydraulic, and runoff water quality characteristics of the different areas, each watershed is divided into sub-basins. Sub-basins may be aggregated to an intermediate, or basin, level to evaluate particular areas or reaches of interest within a watershed.

**Pollutant Concentrations**

The chemicals of interest for pollution load analysis were those required for NPDES permitting for stormwater discharges, as listed in Table 1. The annual amount of constituent mass that is washed-off from each basin during rainfall events was calculated as the product of the annual runoff volume times the corresponding event mean concentration (EMC). The EMC is the mean concentration of a chemical parameter expected in the stormwater runoff discharged from a particular land use category during a typical storm event. The calculated constituent mass represents the pollution load.

For watershed analyses in Hillsborough County, the EMC values reported in the County's NPDES permit applications for stormwater discharges and supporting documents were used if available. For land use categories or parameters not reported by Hillsborough County, EMC data

147

McConnell, Araj, and Jones
For pollutant loading estimates, land use categories were aggregated to correspond with the Hillsborough County NPDES permit. Major non-natural land use categories evaluated for pollutant loading included:

- low/medium density residential
- high density residential
- light industrial
- agricultural
- commercial
- institutional
- highway/utility
- recreational
- openland, and
- extractive (mining)/disturbed.

**Soil Characteristics**

For hydrologic analyses, a standard method of soils classification is the hydrologic soils group. Soils are grouped into four hydrologic soil groups A through D, which are commonly used to estimate infiltration rates and soil moisture capacities. Runoff volume calculations are based on the application of runoff coefficients by soil and land use type. The values assigned to the runoff coefficients were based on those obtained from NPDES permit studies conducted in Hillsborough County. Most of the coefficients, listed by land use, can be found in the FDOT drainage manual.

**Basin Delineations**

For purposes of comparing hydrologic, hydraulic, and runoff water quality characteristics of the different areas, each watershed is divided into sub-basins. Sub-basins may be aggregated to an intermediate, or basin, level to evaluate particular areas or reaches of interest within a watershed.

**Pollutant Concentrations**

The chemicals of interest for pollution load analysis were those required for NPDES permitting for stormwater discharges, as listed in Table 1. The annual amount of constituent mass that is washed-off from each basin during rainfall events was calculated as the product of the annual runoff volume times the corresponding event mean concentration (EMC). The EMC is the mean concentration of *a chemical parameter expected in the stormwater runoff discharged from a particular land use category during a typical storm event. The calculated constituent mass represents the pollution load.

For watershed analyses in Hillsborough County, the EMC values reported in the County's NPDES permit applications for stormwater discharges and supporting documents were used if available. For land use categories or parameters not reported by Hillsborough County, EMC data
from other studies in Florida were evaluated and used if appropriate. EMC values were available for many land uses for numerous pollutants including five-day biological oxygen demand (BOD.), total suspended solids (TSS), total kjeldahl nitrogen (TKN), nitrite plus nitrate (NO₂+NO₃), total nitrogen (TN), total and dissolved phosphorous (TP and TDP), oil and grease (O&G), cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn). EMC values used to estimate pollutant loads are summarized in Table 1. A comparison of these values to other Florida and national studies is provided in the following paragraphs.

BOD, data found in Hillsborough County samples tend to be lower, or similar, than those found in other areas in Florida, except for agriculture. The agriculture EMC for BOD5 is

148 McConnell, Araj, and Jones
Table I - Event Mean Concentration (EMC Values by Land Use)

<table>
<thead>
<tr>
<th>Land Use</th>
<th>BOD5</th>
<th>TSS</th>
<th>TKN</th>
<th>NO2 +NO3</th>
<th>TN</th>
<th>TP</th>
<th>Oil and Grease</th>
<th>Cd</th>
<th>Cu</th>
<th>Pb</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low/Medium Density Residential</td>
<td>1e</td>
<td>19</td>
<td>1.082</td>
<td>0.281</td>
<td>1.363</td>
<td>0.401</td>
<td>0.282</td>
<td>1.08</td>
<td>0.001</td>
<td>0.013</td>
<td>0.008</td>
</tr>
<tr>
<td>High Density Residential</td>
<td>2.6</td>
<td>29</td>
<td>1.368</td>
<td>0.679</td>
<td>2.047</td>
<td>1.337</td>
<td>0.552</td>
<td>0.73</td>
<td>0.001</td>
<td>0.047</td>
<td>0.006</td>
</tr>
<tr>
<td>Light Industrial</td>
<td>2.87</td>
<td>18.2</td>
<td>2.088</td>
<td>0.187</td>
<td>2.275</td>
<td>0.332</td>
<td>0.187</td>
<td>3.663</td>
<td>0.001</td>
<td>0.024</td>
<td>0.0055</td>
</tr>
<tr>
<td>Agricultural</td>
<td>18.3</td>
<td>12.7</td>
<td>2.167</td>
<td>0.803</td>
<td>2.97</td>
<td>2.349</td>
<td>1.223</td>
<td>0.5</td>
<td>0.013</td>
<td>0.041</td>
<td>0.0025</td>
</tr>
<tr>
<td>Commercial</td>
<td>2.62</td>
<td>36.5</td>
<td>2.071</td>
<td>0.171</td>
<td>2.378</td>
<td>0.305</td>
<td>0.182</td>
<td>0.793</td>
<td>0.001</td>
<td>0.014</td>
<td>0.0025</td>
</tr>
<tr>
<td>Office</td>
<td>2.717</td>
<td>9.33</td>
<td>1.083</td>
<td>0.603</td>
<td>1.686</td>
<td>0.253</td>
<td>0.132</td>
<td>0.5</td>
<td>0.001</td>
<td>0.021</td>
<td>0.005</td>
</tr>
<tr>
<td>Commercial, Retail</td>
<td>2.6685</td>
<td>22.915</td>
<td>1.645</td>
<td>0.387</td>
<td>2.032</td>
<td>0.279</td>
<td>0.157</td>
<td>0.6465</td>
<td>0.001</td>
<td>0.0175</td>
<td>0.00375</td>
</tr>
<tr>
<td>Institutional</td>
<td>2.6685f</td>
<td>22.915f</td>
<td>1.645f</td>
<td>0.387f</td>
<td>2.032f</td>
<td>0.279f</td>
<td>0.157f</td>
<td>0.6465f</td>
<td>0.001f</td>
<td>0.0175f</td>
<td>0.00375f</td>
</tr>
<tr>
<td>Highway/Utility</td>
<td>24a</td>
<td>261a</td>
<td>2.99a</td>
<td>1.14a</td>
<td>4.13a</td>
<td>0.12a</td>
<td>0.3d</td>
<td>0.4d</td>
<td>0.04a</td>
<td>0.103a</td>
<td>0.96a</td>
</tr>
<tr>
<td>Recreational</td>
<td>3-8b</td>
<td>11.1b</td>
<td>2.09b</td>
<td>0.508b</td>
<td>2.598g</td>
<td>0.05b</td>
<td>0.134c</td>
<td>0.9d</td>
<td>0.007b</td>
<td>0.041b</td>
<td>0.0056b</td>
</tr>
<tr>
<td>Open Land Extractive</td>
<td>3.8f</td>
<td>11.1f</td>
<td>2.09f</td>
<td>0.03c</td>
<td>2.598g</td>
<td>0.00c</td>
<td>0.134f</td>
<td>0.9f</td>
<td>0.0003c</td>
<td>0.001c</td>
<td>0.001c</td>
</tr>
<tr>
<td>(Mining)/Disturbed</td>
<td>28.94c</td>
<td>13.2c</td>
<td>3.5c</td>
<td>0.03c</td>
<td>3.53g</td>
<td>0.194c</td>
<td>0.134e</td>
<td>0.9d</td>
<td>0.0003c</td>
<td>0.001c</td>
<td>0.001c</td>
</tr>
<tr>
<td>Upland Forest</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
</tr>
<tr>
<td>Wetland Forest</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
</tr>
<tr>
<td>Wetland Non-Forested</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
</tr>
</tbody>
</table>

Note:
NPDES parameters: BOD5, COD, TSS, TDS, TKN, NO3+NO2, TP, DP, O&G; cadmium, copper, lead, zinc.
All EMC values without footnotes were obtained from samples collected for the Hills Co. NPDES Permit Application (1993).
For parameters not detected in all samples, EMCs were calculated using in-half the reporting limit for nondetects.
"BDL" - indicates below detection limits for all Hills Co. samples collected for a particular land use.
For pollutants not reported by Hills Co. (1993), additional sources were used as noted:
b. Literature value reported as EMC in Hillsborough Co. 1994.
c. Calculated value from Sarasota County stormwater samples.
d. Orange County, 1993.
e. Surrogate based on 1/2 DL for values reported as BDL.
f. EMCs for open land use were assumed to be less than or equal EMCs for recreational land use.
g. Total nitrogen (TN) estimated as the sum of NH3 + organic-N (TKN) and oxidized-N (NO2+NO3).
h. EMCs for upland forest, wetland forest, and non-forested wetland were assumed to zero for benchmark comparisons.
EMCs reported as representative of agricultural land use were used for all subcategories of agricultural land use (e.g., pastures, crops, and groves).

approximately five times larger than other values reported in Florida. In general, Hillsborough County agricultural land use EMCs for a number of parameters, tend to be much higher than those reported elsewhere in Florida. For most parameters, these elevated EMCs increase estimated load calculations significantly where agricultural land use is found.
Nitrogen from residential land uses tends to be higher in Florida and Hillsborough County than nationally due to the increased application of lawn fertilizer by homeowners and golf course managers. Slightly higher TKN and TP values for multi-family sites may reflect more intensive landscape maintenance for these land uses. Commercial land uses also have nitrogen values that are higher than national averages. This may reflect primarily atmospheric deposition, as studies in Florida have shown that commercial sites produce elevated nitrogen loads even if little green area is present. Phosphorous runoff tends to be lower in Florida than the U.S. average, although data from Hillsborough County studies differs somewhat. Phosphorous runoff from residential and commercial land uses are higher than Florida average, while runoff from industrial land uses are similar to Florida and national averages. As with nitrogen, elevated loads from multi-family land uses could reflect more intensive landscape maintenance.

The Hillsborough County data indicate that total nitrogen and total phosphorus EMCs for the agricultural land use are 74 and 586 percent higher, respectively, than that for low/medium family residential uses. The total nitrogen EMC is similar to that found for other locations in Florida. However, the EMC for total phosphorus is six times as high as the average EMC found for various agricultural sites in Florida. This situation makes agriculture one of the main contributors of nutrient loadings.

TSS data for Hillsborough County are comparable to other Florida locations and lower than U.S. averages. TSS results from soil erosion, with construction sites a major contributor and agricultural practices. Additional primary sources of TSS include vehicle emissions and atmospheric deposition. BOD data for Hillsborough County is somewhat low relative to other locations in Florida and across the U.S. Low levels of organic matter may reflect the low organic matter typically present in Florida soils.

Lead data for Hillsborough County are lower than other locations in Florida and across the U.S. Relatively low lead concentrations may reflect concentrations may reflect fate and transport characteristics of the particular systems sampled and/or decreased emissions due to the use of unleaded gasoline. Copper data for Hillsborough County are higher than other locations in Florida, but similar to the nationwide average. Relatively high values were observed for residential land uses. Transportation-related activities, particularly releases from brake linings, have been identified as primary sources for copper. Copper is also a common element in algacides and fungicides, and many fertilizers contain copper. Zinc data are much lower for Hillsborough County and Florida in general than the rest of the U.S. Sources of zinc include industrial processes, transportation-related activities, atmospheric deposition and fertilizers. Relatively low zinc concentrations may reflect fate and transport characteristics of the particular systems sampled and/or the presence of fewer industrial-processing facilities in Hillsborough County than other parts of the U.S.

Existing Stormwater Treatment

The type and coverage of best management practices (BMPs) providing pollutant removal needs to be determined to estimate net loads from each basin. BMP type and coverage data is
developed for each aggregate land use for each sub-basin based on interpretation of aerial photos and entered into the model input data set.

**Loading and Level-of-service Calculations**

The model uses the EPA Simple Method (U.S. EPA 1992) to calculate pollutant loads. The runoff characteristics discussed above were used with EMC values for particular land uses to calculate gross pollutant loads. All EMCs, runoff coefficients, and other lookup values required were incorporated into lookup tables provided with the Hillsborough County model. In the model, the average annual runoff expected from each specific land use/soils polygon, as determined from the GIS, is calculated as the product of the rainfall amount times the corresponding runoff coefficient. A correction factor of 0.9 is used to account for the numerous small rainfall events (possibly less than 0.1 inches) that do not result in any runoff. The total volume of runoff for a sub-basin is then determined by aggregating the calculated runoff for each polygon within that basin. Each sub-basin's contribution in terms of stormwater runoff discharges were calculated as average annual runoff flow. The average annual rainfall in the Tampa Bay area, which amounts to 51.4 inches, was used to calculate expected annual pollution loads.

According to the Simple Method, non-point source pollutant loads are calculated using the following formula:

\[
L_1 = (0.227)(P)(CF)(Rv_1)(C_1)(A_1)
\]

where

- \( L_1 \) = annual pollutant load per basin (lb/yr)
- \( P \) = annual average precipitation (in/yr)
- \( Rv_1 \) = weighted average runoff coefficient based on impervious area
- \( C_1 \) = event mean concentration of pollutant (mg/L)
- \( A_1 \) = catchment area contributing to outfall (acres)
- \( CF \) = correction factor for storms that do not produce runoff
  (assumed \( CF=0.9 \), 10 percent of storms do not produce runoff)

**Levels-of-Service**

In order to effectively manage stormwater pollution in Hillsborough County, water quality levels-of-service criteria were established as part of this study to allow comparison of existing or proposed conditions to pollutant loading goals. For comparison purposes, pollutant loads based on runoff from single family (low to medium density) residential land use were selected as the standard for comparison. In this manner, the calculation of pollutant loads is consistent with the concept of standard residential unit (SRU) used for stormwater utility assessments.
The procedure applied to each sub-basin consisted of the following steps:

1. Calculate the net pollutant load for each chemical of interest based on actual land use composition and treatment levels.
2. Calculate the gross pollutant load for that same chemical, assuming that 100 percent of area is developed for low/medium residential land uses.
3. Calculate the ratio net load/gross load.
4. Apply the criteria described below to determine the LOS for the sub-basin.

LOS criteria A through F were defined based on the following ranges:

- **LOS A**, net load equivalent to 20% or less of untreated single family residential. A LOS equal to A for a sub-basin would indicate the presence of undisturbed natural systems, or areas supplied with treatment systems capable of removing pollution levels to those representing natural systems. Areas where typical land uses (residential) exhibit stormwater treatment levels above the minimum required per 62-40.432(5) F.A.C. (Water Policy) would also receive LOS A.

- **LOS B**, net load equivalent to between 20 and 40% of untreated single family residential areas. A LOS equal to B would indicate the presence of treatment systems showing removal efficiencies consistent with those representing adequately designed and maintained conditions.

- **LOS C**, net load equivalent to between 40 and 70% of untreated single family residential areas. A LOS equal to C would indicate the presence of treatment systems showing removal efficiencies consistent with those representing average to poorly maintained conditions.

- **LOS D**, net load equivalent to between 70 and 100% of untreated single family residential areas. A LOS equal to D would indicate minimal treatment of sub-basin discharges.

- **LOS F**, net load equal to or greater than 100% of untreated single family residential areas. A LOS equal to F would indicate no treatment for sub-basin discharges, or the presence of extensive areas of land uses producing larger pollution loads per unit area than typical residential land uses.

**SAMPLE RESULTS**

Water quality levels-of-services have been developed for several Hillsborough County watersheds. Summary results for one of these watersheds, Double Branch Creek Watershed, is presented herein. The Double Branch Creek Watershed comprises a total of approximately 13,588 acres. Developed land use is primarily agricultural (3,266 acres or 24%), low density residential (120 acres or 9%), and high density residential (780 acres or 6%). Approximately 40 percent of the watershed consists of natural communities including upland forest (18 82 acres or 14%), wetlands (3,123 acres or 23%) and open water (791 acres or 6%). The remainder includes open land (1,256 acres or 9%), recreational (657 or 5%), and highway/utility (405 acres or 3”/o) land uses, with other developed land uses (extractive, light industrial, and institutional) contributing less than one percent.
A summary of pollutant loads from sub-basins within the Double Branch Creek Watershed and LOS based on a comparison of these loads to the residential benchmark are provided in Tables 2 and 3, respectively.

### Table 2

**Summary of Net Pollutant Loads - Double Branch Creek**

<table>
<thead>
<tr>
<th>Area</th>
<th>Volume</th>
<th>BOD5</th>
<th>TSS</th>
<th>TKN+NO3+NO2</th>
<th>TN</th>
<th>TP</th>
<th>TDP</th>
<th>Oil &amp; G</th>
<th>Cd</th>
<th>Cu</th>
<th>Pb</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>(acres)</td>
<td>(acre-feet)</td>
<td>(lbs/yr)</td>
<td>(lbs/yr)</td>
<td>(lbs/yr)</td>
<td>(lbs/yr)</td>
<td>(lbs/yr)</td>
<td>(lbs/yr)</td>
<td>(lbs/yr)</td>
<td>Obs/yr</td>
<td>(lbs/yr)</td>
<td>(lbs/yr)</td>
<td>(lbs/yr)</td>
</tr>
<tr>
<td>Total</td>
<td>13588</td>
<td>13940</td>
<td>25966</td>
<td>108766</td>
<td>47750</td>
<td>16684</td>
<td>64435</td>
<td>29772</td>
<td>16156</td>
<td>21020</td>
<td>161</td>
<td>161</td>
</tr>
<tr>
<td>Number</td>
<td>161</td>
<td>161</td>
<td>161</td>
<td>161</td>
<td>161</td>
<td>161</td>
<td>161</td>
<td>161</td>
<td>161</td>
<td>161</td>
<td>161</td>
<td>161</td>
</tr>
<tr>
<td>Min</td>
<td>0.02</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.000</td>
</tr>
<tr>
<td>Max</td>
<td>464.47</td>
<td>314.79</td>
<td>10073</td>
<td>52583</td>
<td>1260</td>
<td>660.76</td>
<td>2026</td>
<td>10.50</td>
<td>28.69</td>
<td>183.66</td>
<td>81.95</td>
<td>0.000</td>
</tr>
<tr>
<td>Mean</td>
<td>84.40</td>
<td>86.59</td>
<td>1613</td>
<td>6756.9</td>
<td>103.6</td>
<td>184.92</td>
<td>100.35</td>
<td>130.56</td>
<td>6.17</td>
<td>15.57</td>
<td>10.57</td>
<td>88.88</td>
</tr>
</tbody>
</table>

### Table 3

**Summary of Sub-Basin Levels-of-Service - Double Branch Creek**

<table>
<thead>
<tr>
<th>LOS (count)</th>
<th>BOD, TSS, TKN, NO3, TN, TP, TDP, Oil &amp; Grease, Cd, Cu, Pb, Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3, 21, 7, 7, 38, 23, 28, 4, 12, 43, 31</td>
</tr>
<tr>
<td>B</td>
<td>3, 38, 11, 10, 7, 21, 70, 11, 7, 31, 21</td>
</tr>
<tr>
<td>C</td>
<td>4, 33, 19, 26, 13, 16, 36, 4, 13, 15, 37</td>
</tr>
<tr>
<td>D</td>
<td>10, 10, 46, 37, 12, 16, 10, 6, 17, 10, 6</td>
</tr>
<tr>
<td>F</td>
<td>141, 59, 68, 88, 91, 85, 17, 136, 112, 62, 66</td>
</tr>
<tr>
<td>No. Sub-Basins</td>
<td>161, 161, 161, 161, 161, 161, 161, 161, 161, 161</td>
</tr>
<tr>
<td>Overall Watershed</td>
<td>161, 161, 161, 161, 161, 161, 161, 161, 161, 161</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LOS (percent)</th>
<th>BODs, TSS, TKN, NO3, TN, TP, TDP, Oil &amp; Grease, Cd, Cu, Pb, Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2%, 13%, 4%, 4%, 24%, 14%, 17%, 2%, 7%, 27%, 19%</td>
</tr>
<tr>
<td>B</td>
<td>2%, 24%, 7%, 6%, 4%, 13%, 43%, 7%, 4%, 19%, 13%</td>
</tr>
<tr>
<td>C</td>
<td>2%, 20%, 18%, 12%, 8%, 10%, 22%, 2%, 8%, 9%, 23%</td>
</tr>
<tr>
<td>D</td>
<td>6%, 6%, 29%, 23%, 7%, 10%, 6%, 4%, 11%, 6%, 4%</td>
</tr>
<tr>
<td>F</td>
<td>88%, 37%, 42%, 55%, 45%, 57%, 53%, 11%, 84%, 70%, 39%, 41%</td>
</tr>
</tbody>
</table>

Overall LOS for many parameters were “D” or “F” indicating discharge over untreated residential land use and/or minimal treatment within much of the watershed. These results also suggest that much of the pollutant load may be assimilated by natural wetlands and waterbodies. Several important parameters, however, including TSS, oil and grease, lead, and zinc, attained LOS "C" or higher in the majority of basins, indicating low discharge and/or adequate treatment for these parameters. TSS, oil and grease, lead, and zinc, attained LOS "C" or above in more than 80% of basins. As shown in Table 3, LOS were “D” or “F” in greater than 80-90% of sub-basins for three parameters BOD5, copper, and cadmium. Low overall LOS values in Double Branch Creek may result from the lack of adequate treatment in areas with agricultural runoff.
CONCLUSIONS

The pollutant loading and removal model is a valuable aid to assist in water quality assessments in Hillsborough County. The model provides the county with the ability to establish water quality levels-of-service. Water quality levels-of-service may in turn be used to guide development and management actions. Reducing nonpoint source quality data to a more simplified grading scheme to represent water quality status will facilitate policy and regulatory decision-making.