7. CONCLUSIONS AND RECOMMENDATIONS

Agricultural and urban fringe land uses were modeled with a combination of AGNPS options and auxiliary procedures. A number of auxiliary procedures were developed to enhance model input to, and model output from, the AGNPS 5.0 model. On an event basis, auxiliary procedures were created to assign values to selected parameters using either annual average or time-variable values, and to use GIS functionality to automate the creation of complex-formatted AGNPS input files. On a monthly basis, auxiliary procedures were developed to aggregate event output, to supplement aggregated monthly output with baseflow and septic system loads, and to process sequential storms with automated parameter updating.

Four sets of modeled runoff and loads were produced by the auxiliary procedures developed in this study, two on a composite period, and two on a monthly basis, for comparison with corresponding observed data from the historical monitoring record at the Bull Run watershed in northern Virginia. The paired observation comparisons between monitored and modeled output were conducted using a wide array of summary statistics, correlation, graphs, goodness-of-fit measures and hypothesis tests. Nonparametric statistics were used for the analysis as the data were not normally distributed and a small number of data points were available for the monthly output comparisons.

7.1 Conclusions

The following conclusions can be drawn from the work performed in this study:

- A variety of GIS functions were modified and/or developed for generating many of the spatial parameters required by the AGNPS 5.0 model. These included the watershed boundary, flow direction, AGNPS cell number, receiving cell number, slope shape factor, channel slope, and channel length/cell data layers. Additional layers were generated for use with the monthly supplemental modeling: a pseudo-streams layer and a layer of unique surface drainage areas for each stream cell. These functions provided consistency in value assignment, eliminated errors which could normally be induced by use of DEM elevation data, and reduced the time and effort required to manually determine and input cell-by-cell values.

- Existing procedures and methodology were modified to incorporate temporal variability into some of the AGNPS input parameters. These parameters included event EI, AMC, seasonal N fertilizer availability, bi-weekly RUSLE C-factors, the time-variable RUSLE K-factor, and time-variable SCS curve numbers (CN) for cropland. Except for the procedures used to calculate event EI and seasonal N fertilizer availability, all of the above time-variable methodology are used in existing models and procedures to distribute annual values of these parameters throughout the year. The use of the empirical EI equation was one of the more dubious inputs to the model, especially in light of differences produced between monitored and modeled runoff. The seasonal N fertilizer availability routine, although a crude approximation, intuitively provided a more realistic measure of N availability as influenced by crop uptake.

- The representation of urban fringe land uses was weaker than originally planned. The failure of the COD component of the model to produce output at the watershed outlet, the error in the non-feedlot point source option preventing incorporation of a buildup/washoff function for impervious areas, and the unavailability of historical disturbed areas and construction sites, all diminished the impact of the urban fringe in the modeling results. Urban fringe land uses were represented, however, with three land use classes - rural residential, lawns, and urban forested, related attributes, and monthly septic system loads.

- A large amount of time was required to develop the 3 data layers assembled in this study - parcel boundaries, land use, and septic systems. Even though all the parcel data was received in digital form, a wide variety of transformations and data manipulation was required to create the raster layer used in this study. The land use history was imprecise, though, once again, a huge effort was involved in investigating what was available, and in the attempted construction of land use history over the 16-year period. Even though much data was available through localities, standard naming conventions, even for such common entities as tax parcels, varied widely between counties and between agencies within counties, making attribute assignment by tax parcel a very complicated procedure.

- Additional GIS functions were successfully developed to utilize a combination of spatial, attribute, default, event-specific and user-optional data for creating the complex-formatted AGNPS 5.0 input files.

- Anywhere from 109 to 335 storms were processed at a time during various stages of development, debugging and final runs. The procedures developed for sequential storm processing consistently updated all parameters from storm-to-storm and allowed for unassisted batch processing for a list of storms.

- Monitored runoff and loads did not appear to correspond with storms monitored at a nearby rain gauge some distance from the watershed. Although preliminary modeling and the Thiessen weighting procedure were used to find the best neighboring rain gauge, the extent of the mis-match only became evident in the analysis of the final modeling runs. Therefore, modeling based on the mis-matched rainfall renders any comparisons between monitored and modeled parameters inconclusive.

- Although modeled output cannot be compared with monitored output in this case, it is possible to give some observations about the relative functioning of the alternative auxiliary procedures for each time basis:

- ♦ A larger difference was anticipated between the modeled output from the alternative parameterization procedures than actually occurred, because the nature of distributed parameters was overlooked. Distributed parameters fluctuate around an annual average. When a large enough number of events are modeled at various times throughout the year, some of the distributed parameter values will be higher, and some will be smaller than the annual average, so a uni-directional increase or decrease in modeled output will not happen as a result of incorporating time-variable parameters, as with the AG1cp procedure.

- ♦ The auxiliary monthly simulation procedure, AG2mn, resulted in a uni-directional increase in runoff and loads of TN and TP, because its nature was to add in sources not included in the alternative monthly modeling procedure, AG1mn.

- Error in modeled erosion was introduced through the use of a regression equation, rather than breakpoint rainfall data, to calculate event EI, a measure of rainfall energy intensity.

- A comparison of composite period modeled vs. observed mean concentrations revealed highly variable patterns in the modeled data corresponding with low runoff events, most probably resulting from a mismatch of rainfall with runoff events, so that modeled events did not correspond with events producing the observed runoff and loads. For high runoff events, however, the model performed very well in simulating concentrations, even though runoff and loads varied from the observed conditions.

- Lumping composite period output, when a rainfall event coincided with the day where one period ended and another one began, artificially inflated the range of modeled composite period data, but did not affect the outcome of the hypothesis tests due to the large number of data points.

- A procedure for indexing multiple NPS pollutants - TN, TP, and SS - has been outlined, based on the maximum sub-index score for each parameter using rating curves of both unit area load and mean monthly concentration. Though currently untested, this procedure has potential for use as a holistic tool for watershed targeting, addressing monthly NPS variations, local low flow concerns with habitat, and downstream concerns with high flow loads.

- Because of uncertainties in watershed rainfall distribution, the comparison between the monitored data and the modeled output from this study was inconclusive. However, there were several indications that the AGNPS model was performing as intended. The AGNPS model produced runoff from the 109 storms simulated in the range of 0-55% with an average of 40.7%, consistent with the average runoff rate of 38% calculated from long-term OWML data on Bull Run. Also the comparison of mean monthly concentrations showed that the model performed better for larger storms than for smaller storms, as originally designed.

- The non-feedlot point source option in AGNPS was shown to perform incorrectly. Instead of allowing the input of flow and pollutant concentrations at a point, the input flow and pollutants were repeatedly added to all downstream cells.

- A sensitivity analysis using incremental increases in rainfall with the TR-55 and geomorphic options within AGNPS revealed a spike in the pattern of sediment output and associated nutrients at lower levels of rainfall, that was also dependent on the antecedent moisture category (AMC). Thresholds were defined by AMC, and storms below those thresholds were removed from the analysis, to eliminate this source of error.

7.2 Recommendations

Based on the research and analysis performed in this study, the following recommendations can be made for future work with the AGNPS model and use of the NPSP index:

- When using historical data for modeling and subsequent model evaluation, numerous assumptions can be avoided and the degree of uncertainty decreased, by selecting a study site where both rainfall and runoff have been monitored concurrently on site. Further study also needs to be done on identifying and modeling prevailing rainfall distributions within a watershed.

- The consistent overprediction of TP with event output from AGNPS indicates the need for critical review, and possibly calibration, of the default parameters used within AGNPS for modeling total phosphorus.

- The continuous simulation version of AGNPS should be evaluated for use with the index when it becomes available, since developers have promised to fix the known hydrograph step error which has been shown to incorrectly estimate sediment yield by approximately 10%. This version is also to include a buildup/washoff option for impervious areas. This was one of the procedures that was to be used with this study for simulating urban fringe areas, and input through the non-feedlot point source option. Since an error was uncovered with that option, the buildup/washoff functions were not implemented with this study’s model input preparation procedures. The non-feedlot point source option could be useful for modeling other aspects of urban fringe areas, and should be corrected in the continuous simulation version of AGNPS.

- The limitation presented by the use of TR-55 methodology should be investigated further, especially as this is the recommended method for larger watersheds. If, indeed, smaller storms cannot be simulated with this methodology, the continuous simulation version of AGNPS will also run into problems, as modeling smaller storms will be essential for continuous simulation.

- Use of USGS or similar watershed delineation procedures are essential for developing AGNPS input files for larger watersheds. Use of these procedures ensures that the boundary is defined and flow directions in all cells are congruent so that all cells within the watershed drain to the watershed outlet. With hand delineated boundaries, cells are often encountered around the perimeter which do not drain to the outlet. The AGNPS model checks for this condition, and if found, the model will not run!

- When comparing modeled runoff and loads with monitored runoff and loads, it is essential that the rainfall and runoff be monitored at the same point, or at least that the rain gauge be somewhere inside the watershed. Because of the sensitivity of loading to runoff, it is also recommended that breakpoint data be used to calculate event EI rather that using empirical equations, even if developed for the same site.

- The seasonal N fertilizer procedure should be revised to include both N and P fertilizers, to use specific uptake curves for corn and wheat, and to base uptake rates on the amount of fertilizer applied and on the yield potential to allow excess fertilizer for leaching after harvest.