USING GEOGRAPHICAL INFORMATION SYSTEM (GIS)-BASED WATERSHED CHARACTERISTICS TO PREDICT STREAM VISUAL

ASSESSMENT SCORES

By

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A thesis submitted to the

Graduate School-New Brunswick

Rutgers, The State University of New Jersey

in partial fulfillment of the requirements

for the degree of

Master of Science

Graduate Program in

Environmental Science

written under the direction of

Dr. Christopher Obropta

and approved by

New Brunswick, New Jersey

May, 2008

ABSTRACT OF THE THESIS

Using Geographical Information System (GIS)-based Watershed Characteristics to Predict Stream Visual Assessment Scores

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The Stream Visual Assessment Protocol (SVAP) was designed as a cost-effective measurement of stream condition that can be used by non-scientific individuals with minimal training. It is intended as a preliminary assessment to determine problem areas where further study is needed. Although the SVAP is a simple assessment, resources are still required to train staff and volunteers on the protocol and to spend days in the field collecting data. However, if existing data can be used to obtain comparable stream health information without requiring field work, the cost associated with these resources can be reduced. This research investigated whether models can be created using previously collected SVAP data and GIS-based watershed characteristics to evaluate stream conditions to eliminate field work.

Using GIS, characteristics such as basin area and stream size were calculated for the areas draining into SVAP assessment locations. Digital data was used to determine characteristics based on land use/cover and soils. Statistical models were created using SVAP data from the Ramapo watershed in northeastern New Jersey. Models significant at $\alpha = 0.10$ or lower were applied to the Wanaque watershed to determine whether the SVAP scores can be predicted in another location. While the regression models generally explained a high amount of variance in the Ramapo SVAP scores, the SVAP scores for Wanaque could not be accurately predicted from the test models.

ACKNOWLEDGMENTS

I would like to thank my advisor, Christopher Obropta, for his continued support. I am grateful to all the members of my committee, Christopher Obropta, John Reinfelder, and Christopher Uchrin, for their time and assistance. A special thank you goes to Rob Miskewitz for his professional guidance throughout the entire process. I would also like to thank Steve Yergeau, Mehran Niazi, Sean Walsh, and Katie Giacalone for their technical knowledge and counsel and all of my other colleagues from the Water Resources Program, including Greg Rusciano, Sandra Goodrow, Cheryl Burdick, Josef Kardos, Elaine Rossi, and Lisa Evrard for their support. I would also like to extend my appreciation to Martha Rajaei for her procedural guidance and support. And finally I would like to thank my friends and family for their encouragement.

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INTRODUCTION

Rapid assessment protocols are often used as a precursor to in-depth sampling and analysis. These procedures generally provide preliminary information on stream conditions in order to target problem areas that demand more intensive study. The advantages to these assessments are that they are not time-intensive and expend fewer resources than more comprehensive analyses. However they still require work in the field collecting information, as well as subsequent evaluation, and can not replace the indepth study that follows.

A variety of assessment protocols have been developed that take into account the biological, chemical and physical aspects of stream health. Biological indices focus on aquatic macroinvertebrate and fish communities, which are easily affected by stream contamination or alteration, as indicators of riparian health (Sawyer et al., 2004). Two commonly used methods are the Index of Biotic Integrity (IBI) and the River Invertebrate Prediction and Classification System (RIVPACS) (Gergel et al., 2002). Chemical indices reflect water quality attributes, which are often indicators of point source and non-point source pollution from stormwater runoff. They may include measurements of pH, temperature, turbidity, concentration of metals, or the presence of other polluting chemicals (Ibid). Water quality sampling is more costly and time consuming than rapid assessments (Peterson, 2006).

Physical habitat assessments have become more prevalent over the past 20 years and have become well accepted by state and federal agencies in the United States (Bjorkland et al., 1999). These methods take into account the physical condition of the stream channel and extend into the riparian area (Gergel et. al, 2002). Studies have also begun to expand beyond the immediate riparian zone to include the influence of the surrounding watershed. These studies use aerial imagery, field results and data from geographical information systems (GIS) to measure the effects of land use and other landscape indicators (Gergel et al., 2002).

Regional factors, such as land use, topography and climate, must also be considered, so assessments need to be adapted to local conditions. Unfortunately, this also leads to a variety of assessment methods and collected data (Somerville and Pruitt, 2004). Often, different assessments are measured against each other to evaluate their effectiveness and to determine the most effective set of stream health indicators. Biological assessments are frequently used to determine physical and chemical stressors, as well as the influence from the broader landscape, as macroinvertebrate and fish assemblages are easily influenced by physical habitat conditions, water chemistry and broader watershed characteristics. (Gergel et al., 2002).

LITERATURE REVIEW

Biological Assessments

Sawyer et al. (2004) compared macroinvertebrate habitat to physical habitat, water chemistry and land use in a watershed in Alabama. Physical habitat data was collected using the US EPA's Rapid Bioassessment Protocol and Ohio's Qualitative Habitat Evaluation Index and a comparison of these methods found them to be highly correlated at r = 0.80. Land use percentages were calculated for the catchment area surrounding each sampling point using GIS to delineate the areas. Sawyer et al., (2004) used principal component analysis (PCA) to group variables, and then correlated them with biological data to determine which factors relate to community structure. Macroinvertebrate and fish assemblages were found to correlate the most strongly with physical habitat factors, with stream width and catchment area correlating to EPT The chemical factors of ammonia and turbidity negatively richness (r = 0.588). correlated with macroinvertebrate diversity (r = -0.358). Percent agriculture was the only land use factor that correlated with biological indices, correlating with sensitive EPT taxa (r = 0.452). While Sawyer et al. obtained the physical habitat factors through field study, this research will show how these measurements can also be calculated using hydrologic modeling in GIS.

Kennen (1999) compared macroinvertebrate community to watershed characteristics in order to evaluate relationships with impairment levels. GIS was used to calculate catchment areas and land use was determined from aerial photography. Regression analysis showed that impairment most significantly related to amount of urban land, amount of forested land, and total flow of municipal effluent. The resulting regression equation showed a rank correlation of 0.684. Although the study did not include physical habitat characteristics, it does show that land use data can be use to evaluate stream health.

Kokes et al. (2006) evaluated modeling software that uses reference data from the Czech Republic to predict macroinvertebrate assemblages from watershed characteristics. To use this software, physical stream data were collected from sample sites in the field or obtained using GIS data layers, and forward selection analysis determined the best set of predictors from the data. The predictors selected were: distance from source, stream order, altitude, longitude, latitude, slope and catchment area with a total variance of 85%. These variables would be entered into the system to predict macroinvertebrate assemblages and the results are used to assess stream conditions for water management projects. Again, many of the predictor variables that Kokes et al. collected in the field can also be determined using GIS software.

Conversely, Norton et al. (2002) tested a model that uses biological data to predict physical and chemical stream conditions to simplify how biological indices can be used to support water management initiatives. Principal component analysis narrowed a set of 18 measured physical and chemical variables to 6 factors, and multiple linear regression models were created for each factor. The models for all of the variables were significant at α = 0.05 but explained little variance in the data, though the stream chemistry models were stronger than the physical models. The model for the chemical variables TSS, Fe and BOD explained the most variability at r² = 0.34 and the model for the physical variables riffle quality, substrate quality and embeddedness explained the least, at r² = 0.10. Rogers et al. (2002) used macroinvertebrate data to evaluate impacts from chemical and physical factors such as metal contamination and habitat conditions, and to measure the importance of studying these factors together. They found that biological conditions were significantly dependent on physical habitat at a 95% confidence level, with the regression model accounting for 30% of the variability of biological conditions. By adding in the metal contaminant variables the model was able to explain 49% of the variability of macroinvertebrate assemblages. The authors also note that some sites that exhibited high physical habitat scores scored low for biological condition due to metal contamination. This suggests that one kind of data alone may not be sufficient to provide accurate stream conditions, and multiple factors combined may be better indicators of biological stress.

The characteristics that impact stream health are complex and often interrelated (Gergel et al., 2002). These studies have shown that relationships can be found between biological data and physical and chemical stream conditions, in addition to conditions in the broader watershed. These results can be used to streamline how information is collected for preliminary evaluation by focusing on the indicators that require the fewest resources. For instance, in Sawyer et al. (2004) and Kokes et al. (2006), some of the physical habitat factors that correlated most strongly were physical parameters, such as catchment area and stream length or width, which can also be determined using GIS applications. Land use composition, which can also be determined using GIS, was also found to be significant (Sawyer et al., 2004 and Kennan, 1999). Establishing a set of indicators that can be generated in the office would help to simplify the preliminary evaluation.

Predicting Physical and Chemical Habitat Information

Research on whether stream health information can be predicted from broad watershed characteristics such as land use has varied by data type and analytical methods. In an early study using GIS, Richards and Host (1994) compared macroinvertebrate assemblages and physical habitat information with land use data from the U.S. Geological Survey. GIS was used to overlay the land use information with manually delineated watershed boundaries and stream habitat was assessed for the reach above a sample point for each area. Pearson correlations were used to compare stream habitat variables to macroinvertebrate data collected from the sample points to determine which stream characteristics influence the macroinvertebrate structure. The physical habitat variables that had significant correlations ($\alpha \leq 0.10$) were embeddedness, substrate size, amount of woody debris, algal abundance, stream width, percent run, percent shade and These habitat variables were then compared to the land use data, and sinuosity. significant correlations were found between embeddedness and percent agriculture (r =0.63, $\alpha = 0.05$), as well as substrate size and urban development (r = 0.55, $\alpha = 0.10$). These results support that it is possible to determine relationships between land use data and stream assessment information.

Amis et al. (2007) compared a combination of physical, chemical and biological parameters to land use and land cover variables to create a GIS-based model for predicting stream integrity. Physical characteristics were measured and weighted by the author's determination of relative impact, and include: bank erosion, channel modification, vegetation decrease, flooding, flow modification and bed modification. The study area was delineated based on variations in geology, natural vegetation and altitude, and therefore varied in how many assessment sites were found in each study area. This information was layered with land use and population density data and these parameters were assigned weights based on their perceived impacts. Linear statistical models were created at different spatial scales to determine relationships between the data sets. The models predicted stream integrity from the land use/land cover variables with 77% accuracy. The extent of cover by natural vegetation was found to be a strong predictor at all scales although its contribution to variability was not noted by the authors. One interesting aspect of this study was that the spatial differences were taken into consideration. The land use/land cover data were calculated for various distances from the stream to determine if spatial scale would affect the ability for land use to predict stream health. The results showed that the larger catchment areas were more effective at predicting stream health, supporting that the collective influences of a watershed are representative of stream health.

Snyder et al. (2005) used linear regression to determine whether stream health rankings could be predicted using land use and land cover information. Stream health was determined by a combination of biological data and physical stream data ranked from poor to excellent. Land use and land cover data were calculated using satellite imagery to determine percent tree cover, percent impervious surface area and percent crop. Slope and flow path were also calculated by delineating the watershed in GIS. Logistic regression models showed impervious surface area to be the most important predictive variable, contributing 33% of the variance in stream health conditions. Percent tree cover was also significant at $\alpha = 0.05$ but contributed very little to the variance (2%). Some studies have focused only on impervious surface data to explore its effects on stream health. Cianfrani et al. (2006) evaluated total impervious area to determine relationships with stream width, depth, pools, sediment size, large woody debris, embeddedness and sinuosity. Impervious area was calculated using aerial photography and categorized based on the percent of impervious area. Stream characteristics were measured in the field. Statistical analysis showed that total impervious area was significantly correlated with the amount of large woody debris ($\alpha = 0.05$), sinuosity ($\alpha =$ 0.10) and, at higher levels of impervious area, pool depth ($\alpha = 0.05$).

In another study focusing on impervious surface, Ourso & Frenzel (2003) investigated percent impervious surface as an indicator of urbanization effects on stream health. Impervious area was calculated using satellite imagery and compared to stream habitat, macroinvertebrate, and water chemistry data collected in the field, as well as land use data from satellite imagery and aerial photography. Physical characteristics that correlated with percent impervious area at $\alpha = 0.05$ were sinuosity (r = -0.844), percent bank erosion (r = -0.681) and percent reach > 20% embedded (r = 0.587). Although the specific stream characteristics differed between this study and that of Cianfrani et al., both reflect the effects of runoff from impervious surfaces and reinforce its effectiveness as a predictor of stream health. Ourso & Frenzel question the accuracy of their results due to their low coefficients of determination, attributing them to the subjectivity of erosion and embeddedness assessments and the unreliability of sinuosity measurements for shorter stream segments. However, if the subjectivity of field assessments is questionable, then further study on using GIS-based data to assess streams would be useful.

Some research on GIS as a predictor of stream health focuses only on chemical conditions. Peterson & Urquhart (2005) used GIS to develop a statistical model to predict dissolved organic carbon (DOC) from watershed characteristics that were calculated in GIS or accessed from GIS-based datasets. DOC was related to percent open water, percent wetlands, percent rock type and mean minimum temperature, with 72% of the variability explained by the model. A lack of consistency of the model across study regions indicates that different models may be needed in different geographical areas. The authors were also concerned that the model does not account for changes in water quality due to local factors, such as point sources of organic inputs, which would not be represented in overall land use information. However, the authors were confident in the model's general accuracy when predicting DOC from watershed characteristics.

Zampella et al. (2007) found relationships between GIS-based land use data obtained from the New Jersey Department of Environmental Protection (NJDEP) and chemical data using both graphical analysis and statistical modeling. Using regression analysis at $\alpha = 0.05$, urban land was found to be a significant predictor of pH ($r^2 = 0.75$), specific conductance ($r^2 = 0.68$) and chloride ($r^2 = 0.83$). Upland agriculture was found to be a significant predictor of calcium ($r^2 = 0.65$) and magnesium ($r^2 = 0.67$). The study also stressed the importance of including both urban land and upland agriculture variables to analyze water quality, as each was a major predictor variable for different models.

Santos-Roman et al. (2003) used GIS and remote sensing data to derive variables such as channel length, drainage area, slope, shape, change in land cover, climate and geology in order to develop statistical models that predict water quality conditions in 15 basins in Puerto Rico. Using multivariate analysis and stepwise regression at $\alpha = 0.15$, they found that water quality can be predicted consistently, with the most significant predictor as forest rate of change (p = 0.0004). Other significant parameters were percent of limestone (p = 0.0408), annual rainfall (p = 0.0407) and watershed shape (p = 0.0208).

Both of these studies found that using GIS information such as land use, climate and rock type is accurate enough to predict water quality information. However the ability of GIS to predict chemical water quality does not demonstrate its ability to predict other aspects of stream health, such as physical conditions. However, it does provide a foundation that can help target further area of research.

GIS and Statistical Analysis

As these studies have shown, using GIS to analyze data can be an effective way to predict stream assessment results. GIS data is often available from state or other local agencies and is becoming increasingly easier to obtain through free Internet downloads. Additional watershed information can also be generated using hydrological modeling applications in GIS software. GIS-based applications allow the overlay of different categories of data to compare within the same geographical area. For instance, Boggs et al. (2001) were able to use GIS-derived data and data linked in GIS from soil and land use maps to generate the variables needed for a modification of the revised universal soil loss equation (RUSLE) to determine erosion risk on a watershed scale.

Using statistical analysis, relationships between GIS-based data and fieldcollected data can be investigated. Many studies use correlation analysis to find relationships between datasets, which may suggest a cause and effect, such as a change in water chemistry causing a change in fish population. Another commonly used statistical method is regression analysis, which provides a statistical model that can be used to predict results based on a fixed set of variables. The use of GIS to predict stream conditions should not be considered as an absolute replacement for field work, but it could become an effective way to provide the information used in the early planning stages of restoration projects. If field assessment data can be predicted from GIS-based data, it can reduce the amount of preliminary field work needed.

With the availability of numerous means of assessing stream conditions, it is difficult to determine the most effective method. Dale and Beyeler (2001) examined characteristics that would make effective ecological indicators. Their criteria included that indicators should be easily measured, responsive to stress in a predictable manner, and should integrate key gradients across ecological systems. In 2004 the US Environmental Protection Agency (EPA) and the US Army Corps of Engineers (USACE) co-funded a review of physical stream assessments used across the country (Somerville and Pruitt, 2004). The methods were studied to identify the assessment types most suitable to evaluate stream health based on the conditions set forth by the Clean Water Act. Forty-five methods were reviewed based on a survey that was sent to a combination of regulatory and non-regulatory agencies, and results varied based on complexity of the protocol and relevance to the Clean Water Act. The objectives for the different assessments also varied, and no single variable was commonly cited by the respondents. Some of the qualities suggested by the study as important for a thorough assessment are objectivity, data management and appropriate training.

To use an assessment method for statistical analysis, it would need to be based on quantitative rankings that can be easily compared to other numeric watershed characteristics. The flexibility to measure stream health elements either individually or as part of a total score would be useful in determining the most effective model. As a result this research will examine the Stream Assessment Visual Protocol and its ability to be predicted by watershed characteristics.

Stream Assessment Visual Protocol

The Stream Assessment Visual Protocol (SVAP) was developed by the Natural Resources Conservation Service (NRCS) and the U.S. Department of Agriculture as a rapid visual assessment of stream physical habitat (USDA, 1998). It is intended for non-scientists, such as riparian landowners and local volunteers, and requires minimal training (Bjorkland et al., 1999). Physical stream elements are qualitatively rated from 1-10, and the scores of each element are averaged for an overall score for the site. The assessment scores can be used to find the location of impaired streams to target for further study in the development of conservation and restoration programs.

The effectiveness of the SVAP has been measured in a few studies. During its development, the SVAP was tested at 182 sites and compared to a variety of assessment procedures, including the Index of Biotic Integrity (IBI) and state-specific protocols (USDA, 1998). Most of the procedures compared well with the SVAP, and those that were considered poor were attributed to the level of experience, draft of the protocol in use or regional differences in stream types (Bjorkland et al., 1999). Precision was also tested during development by comparing SVAP results from trained individuals who independently assessed the same reach, and the coefficient of variation was 8.8 percent for the overall stream score (USDA, 1998). In the study by the EPA and USACE, the SVAP was among the assessments reviewed. Although the overall suitability score was low, this was in reference to the Clean Water Act guidelines which are not the intended

use for the SVAP evaluations (Gerger et al., 2002). The SVAP scored well in the level of effort and level of expertise categories, which is important in a method designed to be cost-effective and user-friendly.

A study by Ward et al. (2003) evaluated the SVAP in comparison with two other visual assessments: The US EPA's Habitat Assessment Field Data Sheet (HAFDS) and the US Department of Interior Bureau of Land Management's Proper Functioning Data on channel width, depth, slope, substrate and Condition (PFC) assessment. vegetation, was collected on site as the other assessments were conducted. This information was compared to each assessment type using regression analysis to determine how these stream characteristics affect assessment scores, and SVAP scores were found to be affected by entrenchment, slope, substrate size, percent run and canopy. The SVAP correlated well with the HAFDS (r = 0.81), as the elements measured by the two procedures are very similar. The SVAP and PFC had a weaker correlation (r = 0.54), but the scoring method and type of information assessed for the PFC differed more. Rosgen Stream Morphological Classifications were also determined for each reach and compared to the assessments to determine if stream class affects the outcome of the assessment. Results showed that there is a difference in average SVAP score for different stream class, and care should be taken when comparing SVAP scores from different stream environments.

One study by Teels et al. (2006) used the SVAP and IBI to measure the response to riparian buffer establishment. Drainage areas were delineated for each sample site and overlaid with GIS land use. Both methods were successful in showing an improvement in stream health following the buffer establishment. As part of the study, IBI scores were compared to the SVAP, which was considered to represent "local" stream conditions, and to land use, which was considered to reflect broader stream conditions. SVAP scores were shown to correlate strongly with IBI scores (r = 0.70) while land use showed weaker negative correlations with IBI scores (r = -0.38). The results indicate that GIS-generated land use data may lack the detail needed to evaluate biological stream conditions as effectively as stream assessments. But as some correlation was found, this does not eliminate GIS as a means to collect preliminary assessment data in order to target locations for more detailed assessments.

Studies that compare stream assessments based on numerical ranking have shown that their results correlate strongly and the SVAP is no exception (Bjorkland et al., 1999 Ward et al., 2003, Teels et al., 2006). Physical stream assessment and GIS-based data have also been effective in predicting other stream health conditions (Sawyer et al., 2004, Kennen, 1999, Kokes et al., 2006). Few studies have used GIS data to predict physical stream assessment information. Amis et al. (2007) developed a statistical model to predict stream health characteristics from land use data, however the variables used were not part of any particular assessment valuation so the reusability for specific management initiatives would be limited. It should also be noted that this study took place in South Africa, so the available data, as well as regional conditions, would be very different from those studied in the US. Snyder et al. (2005) predicted a specific set of stream health rankings which were restricted to classifications of excellent, good, fair, poor and unknown, and which may be to vague to be effective in aiding decisions when targeting restoration. This research will test the hypothesis that statistical models can be developed to predict specific stream assessment rankings from GIS-based data that can be reused on a regular basis to support management strategies for stream health restoration. This study will evaluate a set of variables found in GIS-based data sets or that can be generated in GIS using hydrological modeling applications. Because landscape metrics have been correlated to stream habitat conditions at both the catchment and riparian levels (Gergel et al., 2002), variables will include land use characteristics for the immediate drainage area as well as the collective upstream areas for each assessment location. This data will be compared to SVAP data that was collected in the field, and regression analysis will be used to create statistical models that will be tested to predict SVAP scores from another watershed. If the SVAP data can be reasonably predicted by the models, this research will demonstrate that preliminary stream conditions can be assessed using GIS analysis of watershed characteristics and can streamline the preliminary stream assessment process.

METHODS

Study Area

The area selected for this study was the 238 square mile Watershed Management Area 3 (WMA3) in New Jersey. WMA3 is part of the Passaic River Basin, which spans northern New Jersey and parts of New York. Approximately 80 percent of WMA3 is in the Highlands Physiographic Province. The watershed consists of 58% forest, 25% urban and 17% water and wetlands based on 2002 NJDEP Land Use/Land Cover data. The population of WMA3 is over 244,000 residents, according to 2000 Census data.

WMA3 consists of four watersheds: Pequannock, Pompton, Ramapo and Wanaque (Figure 1). For this study, the 48 square mile Ramapo watershed was evaluated to obtain the data to build the statistical models. The Wanaque watershed, which is 79 square miles, was used for the data to validate the models. The Ramapo watershed is 44% forest which makes up most of the land to the west of the Ramapo River, 40% urban, generally found to the east of the river, and 11% water and wetlands. The Wanaque watershed is mostly undeveloped with 70% forest land, 14% urban and 15% water and wetlands. Both rivers feed into the Pompton River with drainage areas extending into New York.

Assessment Data Collection

Assessment data were collected by the Rutgers Cooperative Research & Extension Water Resources Program and TRC Omni Environmental Corporation as part of an overall restoration plan for WMA3. Streams were assessed using the SVAP between March 2002 and September 2002. These assessments are performed by visually studying segments of the stream and rating up to 15 riparian separate elements by

assigning them a numerical rating. The number of elements evaluated may vary as not all are applicable at each assessment site. The individual elements are averaged for a total assessment score to prioritize further action. Low scores indicate impacted conditions and high scores generally represent a healthy stream; the numerical definition of low and high may vary based on location and study goals (NRCS 1998).

SVAP scores were determined for 69 reaches in the Ramapo watershed and 81 reaches in the Wanaque watershed. Physical stream elements were rated from 1-10, and the scores of each element were averaged for an overall score for the site. GPS coordinates were taken for each SVAP location which allowed the data to be imported into ArcGIS as point locations in a shape file for spatial GIS analysis.

Individual elements that were assessed were bank stability, barriers to fish movement, canopy cover, channel condition, hydrologic alteration, instream fish cover, invertebrate habitat, nutrient enrichment, presence of pools, riffle embeddedness, riparian zone and water appearance. Manure presence was not evaluated as the watershed is less than 1% agricultural and no known livestock use occurs near the streams. Salinity was also not applicable as the streams in WMA3 are freshwater. Macroinveterbrate data were not collected as part of this study. Some of the sites did not assess all of the elements based on applicability at each site. For instance, riffle embeddedness is only measured if riffles are present, and canopy cover is not evaluated if the active reach width is greater than 50 feet. Table 1 shows the number of reaches evaluated for each element.

Digital Data Collection

The Ramapo watershed was delineated using the EPA's Better Assessment Science Integrating point and Nonpoint Sources (BASINS) software system, with ESRI's ArcView 3.3, in order to determine the subbasin area that drains to each SVAP point. Digital elevation models (DEMs) and stream network data were obtained from the NJDEP for the NJ portion (NJDEP Web site, 2007) and from the New York State Department of Conservation (NYSDC) for the NY portion (CUGIR Web site, 2007). The Ramapo SVAP points were used as the outlets to generate 69 separate drainage basins (Figure 2). The following data were generated for each basin: area, cumulative area (sum of upstream basin area), reach length, reach width, reach depth and basin slope. Because assessments are limited by access to the stream, the SVAP data points were not evenly dispersed throughout the watershed and drainage areas ranged from 0.1 hectares to 831 hectares.

The drainage basins were overlain with land use and land cover information (NJDEP 2002 Land Use/Land Cover for NJ, NJDEP Web site, 2007; and USGS 1990 Land Use/Land Cover for NY, CUGIR Web site, 2007) to determine land use type using Anderson Level I classifications (NJDEP, 2007), as well as impervious surface areas, for each drainage basin. Calculated land use variables include forest area, urban area, wetland/water area, percent forest, percent urban, percent wetland/water, impervious surface area, and percent impervious surface. Agriculture and barren land data were not used in the analysis as they make up less than 1% of the study area. A STATSGO soils data layer included in BASINS was used to obtain the drainage basin hydrologic soil group and erodibility factor. In order to use them in statistical analysis, hydrologic soil group letters were converted to numbers, where A = 1, B = 2, C = 3 and D = 4. The land use and soils data were spatially intersected, and SCS curve numbers were calculated for each basin based on Anderson Level II classifications and the dominant hydrologic soil

group for each basin. Composite variables for the entire drainage area for each basin were also included by calculating the total upstream area in the watershed that drains into each lower basin. A total of 26 basin characteristics were determined. Table 2 shows the variables with their sources.

Statistical Analysis

Principal Component Analysis

Principal component analysis (PCA) was used to determine if any similarities exist between the basins that would affect the ability to predict stream conditions. PCA is a statistical method that transforms variables into a new set of components, the first of which explains the most variance in the data with each successive component explaining a smaller portion of the remaining variability (Kim et al., 2006). A scatter plot of the first two components can visually show groupings between the data (Burns et al., 1997). These clusters can indicate similar traits between variables that can be useful in data analysis.

The Ramapo data for each subbasin were imported into the SAS statistical software application for PCA analysis. The results showed that the first component accounted for 66.25% of the variance and the second component accounted for 26.03%. The first two components were graphed on a scatter plot, with the first component on the x axis and the second component on the y axis. The plotted results showed two clear groupings, with 7 points scattered outside of these clusters. Analysis of the clusters revealed that one set of points consisted of basins that were primarily comprised of urban land use (% urban > 28) and the second cluster consisted of basins primarily comprised of forest land use (% forest > 50). Points not found within either cluster were either

comprised of a greater water/wetland area (%water/wetland > 20) or were significantly small (less than 0.01% of watershed area). Figure 3 shows the results of the PCA plot. The groupings indicated that similar traits may exist between basins with the same predominant land use. As a result, the basins were also split into two data sets to create separate regression models based on predominant land use type: basins with greater than 50% forest (n = 31) and the basins with greater than 28% urban (n = 31). The seven outliers from the PCA analysis were excluded from these models.

Regression Analysis

Multiple linear regression analysis was used to develop models to predict SVAP scores from watershed characteristics. The models have the general form:

$$Y_{i} = \beta_{0} + \beta_{1}X_{1} + \beta_{2}X_{2} + \ldots + \beta_{p-1}X_{p-1} + \varepsilon_{i}$$
(1)

where Y_i are the SVAP scores, β_0 is the y-intercept, $\beta_1, \dots, \beta_{p-1}$ are the regression coefficients of the p explanatory variables, X_1, \dots, X_{p-1} are the values of the p explanatory variables, and ε_i is the error that is unexplained by the model (SAS Institute, 2003; Norton et al., 2002). Using SAS, the SVAP score was entered as the dependant variable, and the watershed characteristics were entered as independent variables. Because the number of independent variables cannot exceed the number of observations, or basins with SVAP data, some of the models were built without including all of the watershed characteristics. For those models, different combinations of basin characteristics were tried until the best fit was found. Backward elimination determined the best set of predictor variables, including only variables that were significant at $\alpha = 0.05$. If no predictor variables were found to be significant at $\alpha = 0.05$, a significance level of $\alpha =$ 0.10 was used instead. Initial model runs using the Wanaque data resulted in predictions of abnormally large positive and negative SVAP scores, far outside the range of 1 to 10. This could be a result of the fact that some of the predictor variables were in units with a broad range of areas and lengths. For instance, the Ramapo drainage areas ranged from 2 to 831 hectares, and the cumulative drainage areas ranged from 31 to 12234 hectares. The Wanaque drainage areas ranged from 0.05 to 6363 hectares, with cumulative drainage areas ranging from 18 to 19984 hectares. To normalize the disparity in variables the units were converted to percentages.

The drainage basin area and cumulative area variables were converted to percentages of the watershed area, and the reach length and cumulative length variables were converted to percentages of the total stream length in the watershed. Other areabased variables (impervious surface area, composite surface area, forest area, urban area and water/wetland area) were removed because percentage variables already existed for these factors. The data were recalculated for both the Ramapo and Wanaque watersheds.

Principal component analysis was conducted on the new Ramapo variable calculations to see if any changes occurred. While the groupings were less distinct in the new analysis, there was still a separation between the more forested drainage areas and those with more urban area (Figure 4). The new data were divided based on this new analysis, with one set for % Forest > 41 (n = 37) and one set for % Urban > 43 (n = 35). Because the area data were normalized, there were no outliers due to drainage area size. In addition, because the results were not clearly clustered the new analysis did not isolate the basins with higher wetland area. As a result, all drainage basins are included in the

new analysis. Since there was less of a distinction between the forested and urbanized basins, four basins were included in both the Forest and Urban analyses.

Model Prediction Ability

Drainage basins were delineated for 81 SVAP data points in the Wanaque watershed (Figure 5), and watershed characteristics were determined using the same methods as with the Ramapo data. These results were used to run the regression models to determine whether they can predict the data for another watershed.

The Nash-Sutcliffe model efficiency coefficient was used to assess the ability of the model to predict SVAP scores. The model predictions and SVAP scores from the Wanaque watershed were compared using the Nash-Sutcliff equation:

$$E = 1 - \frac{\sum_{i=1}^{n} (O_i - P_i)^2}{\sum_{i=1}^{n} (O_i - \bar{O})^2}$$
(2)

where O_i is the observed SVAP score, P_i is the score predicted by the model, and \overline{O} is the mean observed SVAP score (Krause et al., 2005). Efficiencies can range from 1 to $-\infty$. An efficiency of E = 1 represents a prediction that perfectly matches the observed data. An efficiency of E = 0 signifies that the predictions are as accurate as the mean of the SVAP scores. Efficiencies less than zero indicate that the mean of the observations would be a better predictor than the model. Observed versus predicted results were plotted for each model and a 1:1 line was applied to represent an efficiency of E = 1.

RESULTS

Ramapo Regression Analysis

Regression models were created for each SVAP element as well as the score averaged from the categories, and all models were significant at $\alpha = 0.05$. The coefficient of determination (\mathbb{R}^2) for these models ranged from 0.16 to 0.93. Regression models were also created for the data that were split into two sets based on the PCA results. The R-squared results for these 39 regression models are shown in Table 3, where **n** is the number of observations based on the number of assessments conducted. Statistical models were created using the coefficients derived from the regression analysis. A list of the regression model equations is found in Table 4.

Model Prediction Ability

Data from the Wanaque watershed were inserted into the regression models to determine whether they can predict SVAP scores in another watershed. As with the Ramapo data, these were arranged into three sets: all basins, greater than 50% forest, and greater than 28% urban. Because the Wanaque watershed is more forested than the Ramapo watershed (70% vs. 44% respectively), there were more than double the number of basins used in the Forest equations (maximum of n = 62) than in the Urban equations (maximum of n = 23), however some of the basins are included in both sets of models because they have large percentages of both forest and urban land.

Due to the abnormally large values predicted from the original regression models, new regression analysis was conducted using the normalized Ramapo variables to generate a new set of prediction models. All but five of the models were significant at α = 0.05. Three of those were significant at α = 0.10 and the regression analysis did not result in any significant coefficients for the Riffle Embeddedness scores for all basins and basins > 28% urban. The new R-squared values are shown in Table 5 and the model equations are shown in Table 6.

The revised Wanaque data were inserted into the new regression models. While these results were less erratic than the models that were run before the data were normalized, there were still some models that resulted in predictions outside the range of SVAP scores from 1 to 10. A Nash-Sutcliffe model efficiency coefficient (E) was calculated for the predicted and observed SVAP scores. The results are shown in Table 7. All E values are less than zero, indicating that the models were unable to predict the SVAP scores more accurately than the mean of the observed SVAP scores. The observed versus predicted plots can be found in Figure 6. Models with E values less than -3 were not included in the graphical analysis, eliminating most of the models with results that predicted results outside of the scoring range of 1 to 10.

DISCUSSION

The negative efficiency results show that the regression models were not successful in predicting the SVAP scores. Two of the regression models did not have any significant predictor variables and 22 models predicted results outside of the SVAP score range of 1-10. The models that included all basins were better at predicting the scores, with most E values between 0 and -2, two at about -7 and one low efficiency value of - 127. The forest and urban datasets on the other hand each had several E values that were lower than -100.

The scatter plots for most of the models indicate that they tend to under-predict the high SVAP scores and over-predict the low scores. For instance, if we look at the model with the highest *E* value and use it to target for assessment only the areas with predicted scores of 6.0 or lower, our assessment would neglect four locations with lower actual scores of 4.5, 5.5 and 6.0 (see Figure 7). Increasing the predicted score to 8.0 to account for over-estimated predictions would result in the assessments of all locations, even those with scores up to 10.0. When predicting stream health conditions from a model, some under-prediction is acceptable because the main drawback would be that some sites might be assessed with favorable conditions. Although resources would be expended unnecessarily, there would still be fewer resources spent than if all sites were investigated as if there was no model used. However, the drawback from over-prediction is much more substantial, because the result would be that sites that are impacted would not be studied. If impaired sites are neglected, not only would potential sources of impairment be ignored, but resources could also be wasted in areas that may not be the primary source of stress. To avoid these consequences, more accurate predictions would be needed before these models could be useful in reducing SVAP assessments.

Several factors were considered in an effort to determine why the models were not effective in predicting accurate SVAP scores. In a study by Peterson & Urquhart (2006), regression model testing indicated that data from some geographical areas fit the model better than others, suggesting that regional differences could affect the reusability. However their model was tested across the entire state of Maryland. The Wanaque watershed is adjacent to the Ramapo watershed and similar in physical characteristics, so there should be limited geographical differences that would influence the ability to predict assessment scores.

In general, the models that were created using more observations predicted better than those that were derived using a smaller sample size. For instance, the models created using all of the basins (n = 69) were more accurate at predicting SVAP scores than those using only forest basins (n = 37) or those using only urban basins (n = 35). The SVAP elements that had data for every basin (Average Score, Bank Stability, Channel Condition, Riparian Zone) also predicted better than those with fewer observations (Instream Fish Cover, Invertebrate Habitat, Nutrient Enrichment, Riffle Embeddedness), which in most cases was contrary to the high R^2 results in the regression models (see Tables 3 & 5). This could be the result of overfitting the model, where the sample size is too small in relation to the amount of predictor variables, resulting in a model that gives overly optimistic model results yet fails to replicate results with other datasets (Babyack, 2004). According to Babyack, an accurate model requires a minimum of 10 observations per predictor variables, which in this study would require 210 observations. However, the Ramapo dataset only contained a maximum of 69 observations and in some cases the input variables had to be reduced so as to not exceed the number of observations. This inverse relationship between numbers of observations and model R-squared values is shown in Figure 8. This overfitting could explain why some of the model R^2 results were so high, especially for the smaller datasets, and why these models were much less successful in predicting the SVAP scores with the test data.

The optimistically high regression model R^2 results could also be due to the intercorrelation between some of the variables (Richards, 1931). According to Richards, if the intercorrelation between independent variables is high, for instance if they consist of factors that add up to greater than 95 percent, they will result in unusually high coefficients. As a result, the outputs of the model could vary much more than if only one of the intercorrelated variables were used. The Ramapo and Wanaque land use data calculated for the analysis includes percentages forest, urban and water/wetland that in most subbasins add up to 100 percent. The redundant inclusion of all three of these variables in the analysis may be a cause of the inability to generate models that can successfully predict new data.

To establish whether the models represented a reliable relationship between the SVAP data and the predicted variables, regression analysis was also performed on the Wanaque dataset (n = 81), as well as a combination of the Ramapo and Wanaque data (n = 150) for the Average SVAP Score data. If the Ramapo data is representative of the larger watershed, the same predictor variables should consistently appear in the other models. In Norton et al. (2002), regression models were created to predict physical and chemical conditions from macroinvertebrate habitat. Regression models were built from a

complete data set (n = 179) but in order to test the data a separate set of regression models were created out of a random subset of the data (n = 143) with the remaining data used to test the models (n = 36). These models were not published, however the authors state that the results between the two sets of models were similar. For the Ramapo model the predictor variables were: composite width, composite depth, and percent forest. The Wanaque model also included percent forest as a predictor, but no others were selected. The model for the combined Ramapo and Wanaque dataset selected percent area and percent urban as significant predictor variables. Because each model produced different sets of predictor variables, the validity of these models as accurate predictors is questionable.

Few studies that attempt to create statistical models to predict stream conditions provide any validation that the model is able to successfully predict other data samples. Amis et al. (2007) developed a statistical model that predicted 79% of the variance in stream health conditions based on watershed characteristics from only 22 basins. Their test model also compared the predictions with the same observations used to create the data models, so it is difficult to know whether their model would be successful with another set of data. Snyder et al. (2005) also created a regression model to predict stream health rankings but did not test the model on another dataset. However, they explained the model variance using an adjusted R^2 value, which estimates how well the model would predict a new set of data (Babyak, 2004). Their model explained the variation in the predicted rankings 35% of the time, with impervious surface area accounting for 33% of the variation. Although Kokes et al. (2006) developed modeling software with variables that explain 85% of the variation in macroinvertebrate assemblages, they do not produce any test results, although they do state that the model has been in use since 2001. Other studies using regression analysis to predict macroinvertebrate populations from other stream and watershed characteristics have generally not attempted to develop a reusable equation to predict other populations. Kennen (1999) also created regression equations to predict macroinvertebrate community impairment from land use and water quality data, but only to establish relationships between the data and not to reproduce results on other data sets. Rogers et al. (2002) created a regression model that explained 49% of the variance in biological conditions but only with the goal of showing the combined effects of physical and chemical data, and not to reproduce the prediction results.

Studies focusing on predicting water quality data using regression analysis tend to include more support for reusability, but with varying results. Zampella et al. (2007) developed a model from 25 sample sites using data for "altered" land use, or % urban and % agriculture, and the model explained 80% of the variability of water quality data. They tested the model using sample data from 18 other sites, and found no significant change ($\alpha = 0.05$) between the observed and predicted data except for the pH values, which were generally predicted higher than the observed values. Peterson & Urquhart (2006) created a regression model that explained 72% of the variation in DOC concentrations from percent water, wetland vegetation, rock type and temperature. They tested the model by generating 3083 predictions for the entire state of Maryland and analyzing the distribution of the results. They found that the model seemed to underpredict the DOC, as 90% of the predictions were low according to Maryland Department of Natural Resources standards, and it should be used as a conservative estimate rather than a predictor of absolute results. Santos-Roman et al. (2003) analyzed water quality data using regression analysis, however the model equations only calculate scores that classify the watersheds into land-use based water quality categories from the cluster analysis, and do not actually predict any specific conditions.

Despite the fact that several studies have attempted to create statistical models to predict stream health conditions, few have been able to accomplish more than establishing relationships between different types of characteristics. Although the Ramapo regression models did not successfully predict the Wanague SVAP scores, the models were evaluated to see which variables contributed the most variance in SVAP score by reviewing the partial R^2 generated in SAS. For instance, the Average Score model for all basins explained 39% of the variation in SVAP scores, and 25% was explained by the composite reach width parameter. Composite reach depth and percent forest, the other significant variables in the model, explained only 6% and 8% of the variance respectively. Other variables that contributed to more than half of the variance of scores for all basins were cumulative area for Barriers to Fish Movement (34%), erodability for both Instream Fish Cover (33.5%) and Pools (20.4%), and cumulative reach length for Water Appearance (39.2%). For the models where Forest > 41%, composite percent impervious surface contributed to more than half of the variation in the Average Score (32.2%) and Water Appearance (36.6%) models. In the regression models with Urban > 43%, cumulative reach length contributed to most of the variation in the Water Appearance model (42%).

Other studies have identified similar parameters that can be used as indicators of stream health. Sawyer et al. (2004) also found reach width and subbasin area to be related to stream health in their study of macroinvertebrate composition. Snyder et al. (2005) established percent impervious surface as a significant variable in predicting stream health rankings, and in studies by Cianfrani et al. (2006) and Ourso & Frenzel (2003), impervious surface was correlated strongly with stream habitat conditions.

Although the models were not able to predict specific SVAP scores, the variables that were selected in the regression analysis reflect a logical relationship with the stream conditions that were assessed. Considering the models with the two highest efficiencies, bank stability and riparian zone, we can determine a relationship between the parameters included in the model and the SVAP element (Table 6a). The predicted bank stability score would be negatively influenced by an increase in percent urban area, supporting the fact that an increase in urban land can cause an increase in runoff entering the stream which can lead to bank erosion (Corbett, 1997). The predicted riparian zone score is positively related to percent forest, which considers that the reduction of forest land can include the area adjacent to the stream. This demonstrates that the relationship of the variables in the models can be used as general indicators of stream conditions which could aid in the prioritization of assessment locations.

CONCLUSION

Although the regression models appeared to explain a high amount of the variability in the SVAP scores, they were not successful in predicting scores from another data set. Some SVAP elements were predicted more accurately than others, but the high R-squared results could be a result of overfitting the models due to small dataset sizes. Few studies have been able to create models that can successfully predict stream health conditions on new sets of data, however many use model results as general indicators of stream health. While this would not allow the elimination stream health assessments, it can help in setting priorities of which sites to evaluate first.

Recommendations for Future Study

Future study should include increasing the data set size to prevent overfitting of the model. The goal of maintaining a 10 to 1 ratio between observations and predictor variables was recommended by Babyak (2004) so evaluating the predictive strength of 21 watershed characteristics would require at least 210 sample sites for regression analysis, plus additional sites to test whether the model can predict other datasets. However, breaking up the sites into smaller categories, such as high percent forest and high percent urban, would require an even greater initial sample size.

Further analysis should also be conducted in geographically different areas, such as a region with dominant agriculture use, to determine if the results would improve based on those conditions. Since no significant agricultural areas were in the study area for this research, the effect of agricultural land use on stream assessments could not be determined. The presence of agriculture can dramatically affect several of the SVAP scores, such as nutrient enrichment due to the presence of excess phosphorus, riffle whether better predictions can be produced under these conditions.

REFERENCES

- Amis, M.A., Rouget, M. Balmford, A., Thuiller, W., Kleynhans, C.J., Day, J., Nel, J., 2007. Predicting Freshwater habitat integrity using land-use surrogates. *Water SA*. 22(2): 215-221.
- Babyak, M.A., 2004. What you see may not be what you get: A brief, nontechnical introduction to overfitting in regression-type models. *Psychosomatic Medicine*. 66: 411-421.
- Bjorkland, R., Pringle, C.M., Newton, B., 2001. A Stream Visual Assessment Protocol (SVAP) for riparian landowners. *Environ. Monit. Assess.* 68: 99-125.
- Boggs, G., Devonport, C., Evans, K., Puit, P., 2001. GIS-based rapid assessment of erosion risk in a small catchment in the wet/dry tropics of Australia. *Land Degrad. Develop.* 12: 417-434.
- Burns, W.A., Mankiewicz, P.J., Bence, A.E., Page, D.S., Parker, K.R., 1997. A principal-component and least-squares method for allocating polycyclic aromatic hydrocarbons in sediment to multiple sources. *Environ. Toxicol. Chem.* 16(6): 1119-1131.
- Cianfrani, C.M., Hession, W.C., Rizzo, D.M., 2006. Water imperviousness impacts on stream channel condition in southeastern Pennsylvania. J. of the American Water Resources Association. 42(4): 941-956.
- Corbett, C.W., Wahl, M., Porter, D.E., Edwards, D., Moise, C., 1997. Nonpoint source runoff modeling: A comparison of a forested watershed and an urban watershed on the South Carolina coast. J. of Experimental Marine Biology and Ecology. 213(1): 133-149.
- Cornell University Geospatial Information Repository (CUGIR), 2007, http://cugir.mannlib.cornell.edu.
- Dale, V.H., Beyeler, S.C., 2001. Challenges in the development and use of ecological indicators. *Ecological Indicators*. 1: 3-10.
- Gergel, S.E., Turner, M.G., Miller, J.R., Melack, J.M., Stanley, E.H., 2002. Landscape indicators of human impacts to riverine systems. *Aquat. Sci.*, 64: 118-128.
- Kennen, J.G., 1999. Relation of Macroinvertebrate Community Impairment to Catchment Characteristics in New Jersey Streams. J. of the American Water Resources Association. 35(4): 939-955.

- Kim, M., Kennicutt II, M.C., Qian, Y., 2006. Molecular and stable carbon isotopic characterization of PAH contaminants at McMurdo Station, Antarctica. *Marine Pollution Bulletin.* 52: 1585-1590.
- Kokes, J., Zahradkova, S., Nemejcova, D., Hodovsky, J., Jarkovsky, J., Soldan, T., 2006. The PERLA system in the Czech Republic: a multivariate approach for assessing the ecological status of running waters. *Hydrobiologia*. 566: 343-354.
- Krause, P., Boyle, D.P., Base, F., 2005. Comparison of different efficiency criteria for hydrological model assessment. *Advances in Geosciences*. 4: 89-97.
- New Jersey Department of Environmental Protection (NJDEP), 2007, http://www.nj.gov/dep/gis.
- Norton, S.B., Cormier, S.M., Smith, M., Jones, R.C., Schubauer-Berigan, M., 2002. Predicting levels of stress from biological assessment data: Empirical models from the eastern Corn Belt plains, Ohio, USA. *Environ. Toxicol. Chem.* 21: 1168-1175.
- Ourso, R.T., and Frenzel, S.A., 2003. Identification of linear and threshold responses in streams along a gradient of urbanization in Anchorage, Alaska. *Hydrobiologia*. 501: 117-131.
- Peterson, E.E., and Urquhart, N.S., 2006. Predicting water quality impaired stream segments using landscape-scale data and a regional geostatistical model: A case study in Maryland. *Environ. Monit. Asses.* 121: 615-638.
- Richards, C., and Host, G., 1994. Examining land use influences on stream habitats and macroinvertebrates: A GIS approach. *Water Resources Bulletin*. 30(4): 729-738.
- Richards, H. I., 1931. Analysis of the spurious effect of high intercorrelation of independent variables on regression and correlation coefficients. J. of the American Statistical Association. 26(173): 21-29.
- Rogers, C.E., Brabander, D.J., Barbour, M.T., Hemond, H.F., 2002. Use of physical, chemical, and biological indices to assess impacts of contaminants and physical habitat alteration in urban streams. *Environ. Toxicol. Chem.* 21(6): 1156-1167.
- Santos-Roman, D.M., Warner, G.S., Scatena, F., 2003. Multivariate analysis of water quality and physical characteristics of selected watersheds in Puerto Rico. *J. of the American Water Resources Association*. 39(4): 829-839.

SAS Institute, 2003. Regression Analysis. SAS/STAT User's Guide. Cary, NC.

- Sawyer, J.A., Stewart, P.M., Mullen, M.M., Simon, T.P., Bennett, H.H., 2004. Influence of habitat, water quality, and land use on macro-invertebrate and fish assemblages of a southeastern coastal plain watershed, USA. *Aquatic Ecosystem Health & Management*, 7(1): 85-99.
- Snyder, M.N., Goetz, S.J., Wright, R.K., 2005. Stream health rankings predicted by satellite derived land cover metrics. J. of the American Water Resources Association. 41(3): 659-677.
- Somerville, D.E. and B.A. Pruitt. 2004. Physical Stream Assessment: A Review of Selected Protocols for Use in the Clean Water Act Section 404 Program. September 2004, Prepared for the U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Wetlands Division (Order No. 3W-0503-NATX). Washington, D.C. 213 pp.
- Teels, B.M., Rewa, C.A., Myers, J., Aquatic condition response to riparian buffer establishment. 2006. *Wildlife Society Bulletin.* 34(4): 927-935.
- Ward, T.A., Tate, K.W., Atwill, E.R., Lile, D.F., Lancaster, D.L., McDougald, N., Barry, S., Ingram, R.S., George, H.A., Jensen, W., Frost, W.E., Phillips, G.G., Markegard, Larson, S., 2003. A comparison of three visual assessments for riparian and stream health. J. of Soil and Water Conservation. 58(2): 83-88.
- U.S. Department of Agriculture's Natural Resources Conservation Service, 1998. Stream Visual Assessment Protocol. NWCC-TN-99-1. National Water and Climate Center, Portland, OR.
- U.S. Department of Agriculture's Natural Resources Conservation Service, 1986. Urban Hydrology for Small Watersheds. 210-VI-TR-55, Second Ed., Conservation Engineering Division, Washington, DC.
- Zampella, R.A., Procopio, N.A., Lathrop, R.G., Dow, C.L., 2007. Relationship of landuse/ land-cover patterns and surface-water quality in the Mullica River basin. J. of the American Water Resources Association. 43(3): 594-603.

	Number of Sites	
SVAP Element	Evaluated	
Bank Stability	69	
Barriers to Fish Movement	43	
Canopy Cover	45	
Channel Condition	69	
Hydrologic Alteration	62	
Instream Fish Cover	39	
Invertebrate Habitat	24	
Nutrient Enrichment	41	
Pools	52	
Riffle Embeddedness	25	
Riparian Zone	69	
Water Appearance	68	

 Table 1. SVAP elements measured in the Ramapo watershed.

Variable	Source
Drainage basin Area	BASINS delineation results
Cumulative Area	BASINS delineation results
Reach Length	BASINS delineation results
Cumulative Reach Length	Sum of upstream reach lengths
Reach Width	BASINS delineation results
Composite Reach Width	Length-weighted average of upstream reach widths
Reach Depth	BASINS delineation results
Composite Reach Depth	Length-weighted average of reach upstream depths
Curve Number	SCS Curve Number table (from USDA TR-55) using hydrologic soil group from soils layer and Anderson Level II classifications from NJDEP and NYSDC land use/land cover data. Results were area-weighted and summed for each drainage basin.
Composite Curve Number	Area-weighted sum of upstream curve numbers
Erodibility Factor	EPA STATSGO soils layer data
Composite Erodibility	Area-weighted sum of erodibility factor
% Impervious Surface	NJDEP and NYSDC land use/land cover data
Composite % Impervious	Composite impervious surface area divided by total cumulative
Surface	area
Impervious Surface Area	NJDEP and NYSDC land use/land cover data
Composite Impervious Surface Area	EPA
Hydrologic soil group	From STATSGO soils component layer data, converted to
	numbers 1-4 and area weighted for each drainage basin
Composite Hydrogroup	Sum of area-weighted hydrologic soil group numbers
Slope	BASINS delineation results
Composite Slope	Area weighted average of slope
Forest Area	NJDEP and NYSDC land use/land cover data
Urban Area	NJDEP and NYSDC land use/land cover data
Water/Wetland Area	NJDEP and NYSDC land use/land cover data
% Forest	Forest Area divided by Basin Area
% Urban	Urban Area divided by Basin Area
% Water/Wetland	Water/Wetland Area divided by Basin Area

Table 2. Predictor variables measured in the regression models and how they wereobtained for analysis.

	Al	Basins	% F	orest > 50	% L	Jrban > 28
	n	R^2	n	R^2	n	R ²
SVAP Average Score	69	0.5847	31	0.9513	31	0.6877
SVAP Bank Stability	69	0.1612	31	0.8434	31	0.6569
SVAP Barriers to Fish	43	0.6144	20	0.9957	17	0.9155
SVAP Canopy Cover	45	0.3138	19	0.9999	20	0.9999
SVAP Channel Condition	69	0.2851	31	0.9350	31	0.9293
SVAP Hydrologic Alteration	62	0.4692	29	0.9973	15	0.9940
SVAP Instream Fish Cover	39	0.9282	19	0.9977	28	0.9999
SVAP Invertebrate Habitat	24	0.8715	11	0.9999	9	0.9802
SVAP Nutrient Enrichment	25	0.6944	15	0.9723	19	0.9781
SVAP Pools	52	0.8847	27	0.8199	19	0.9999
SVAP Riffle Embeddedness	25	0.8871	13	0.8933	10	0.9999
SVAP Riparian Zone	69	0.2969	31	0.2503	31	0.7012
SVAP Water Appearance	68	0.5362	30	0.9736	31	0.3307
All models are significant at α = 0.0	5.					

Table 3. R-squared values for the regression models developed using the Ramapodata before it was normalized.

					Reg	ression eq	uations by	Regression equations by SVAP element	nent					
			-	Barriers	(ī	Instream	Hydro-	-	Nutrient		Riffle	i	Water
		Average Score	Bank Stability	to Fish Mvmnt	Canopy Cover	Channel Condition	Fish Cover	logic Alteration	Inverte-brate Habitat	Enrich- ment	Pools	Embedd- edness	Riparian Zone	Appear- ance
	Intercept	4.95524	7.25993	14.6782	7.96321	2.02079	-75.8857	5.60959	4.63892	-6.3917	14.02	6.84361	5.43578	6.31817
	Subbasin Area							0.00215						
	Cumulative Area			-0.00557	-0.0003							-0.0059		
	Reach Length						-0.00074					-0.00119		
	Cumulative Reach													
	Length	-0.0003							-0.00157		0.0001	0.000659		-0.0001
	Reach Width	2.40139		8.29189			4.98154		19.56541			0.52274		0.33283
	Composite Reach Width	-2 7445				-0.26704	-5 61412	-1 56266	-10 66561		-4 ROR1			
	Reach Denth	-37 260		-130 564		101010	-110.85	00400.1	-368 87608	-1 0708	- 000			
	Comnosite Reach	207.20-		- 100.001 -			- 10.02		000/0000-	-1.3230				
sjue	Depth	36.5106					125.443	20.2845	402.85084		75.596			
bioi	Curve Number							0.0362				-0.06036		
iiəd	Composite CN							-0.04715			-0.0241			
აე .	Erodability	6.2047					-12.5885		68.72414					
iəte	Composite Erodability					12.84472			-58.17884		-15.12	8.61885		
rame	Impervious Surface (%)		-0.034						-0.09154		-0.055	0.09624		
вq	Composite IS (%)						0.22091			0.10126		-0.18806		
	Impervious Surface													
	(acres)	202 I U.U		0.04/08			G/LU.U				0.0293	100100		
	Composite IS (acres)			-0.00543			-0.00/23							
	Hydrologic soil group						-2.12331	-2.92662		-2.8785	1.4185	2.09028		
	Composite Hydrogroup							3.10094		6.89564	-1.9562			
	Slope							0.02111			-0.0226	-0.03511		-0.032
	Composite Slope													
	Forest Area	4.1E-07										7.55E-07		
	Urban Area	-1E-06		-3.4E-06			-2.8E-06		-0.00000255		-3E-06			
	Water/ Wetland Area						8.7E-06		0.00000926	2.1E-06				
	% Forest	1.15045				2.4676	93.1611			2.82301			2.64521	3.96198
	% Urban						91.0955					-5.02449		
	% Water/ Wetland						91.367	4.01133	-15.39449					

${}_{ m J}_{ m J}$ able 4a. Regression model equations for all basins using the Ramapo data before the unit-based variables were normalized

percentages.

	regression equations by avait element	SVAP element	
		Forest	Urban
		Average Score Average Score	Average Score
-	Intercept	141.39693	10.95588
0)	Subbasin Area	0.01263	
	Cumulative Area	-0.0155	-2.9E-04
	Reach Length		
	Cumulative Reach Length		
	Reach Width	20.6634	
	Composite Reach Width	-20.40127	
	Reach Depth	-268.56013	
_	Composite Reach Depth	275.27165	-6.0324
_	Curve Number	0.09983	
l]]] O	Composite CN	-0.17956	
	Erodability		30.03071
	Composite Erodability	19.15028	-20.04969
	Impervious Surface (%)	-1.02234	
-	Composite Impervious Surface (%)		
	Impervious Surface (acres)	0.1921	0.01296
	Composite Impervious Surface (acres)	-0.0095	
∣┻	Hydrogroup		
	Composite Hydrogroup	6.50186	-2.82065
	Slope	0.03177	0.06352
	Composite Slope		
	Forest Area		0.00000178
	Urban Area	-0.00002253	-1.7E-06
>	Water/ Wetland Area		
<u>م</u>	% Forest	-153.02805	
\$	% Urban	-122.45869	
~	% Water/ Wetland	-155.85964	

Table 4b. Regression model equations for basins with % Forest > 50 and % Urban > 28 using the Ramapo data before the unit-based variables were normalized as percentages.

Average Barriers Canopy Channel Fish Hydro- Coorer 5.89429 7.4062 12.78903 7.95808 2.66916 0.33666 7.46588 $()$ 5.89429 7.4062 12.78903 7.95808 2.66916 0.33666 7.46588 $()$ -3.14184 -3.18857 -3.66916 0.33666 7.46588 $()$ -3.14184 -3.18857 -0.30895 -0.34669 $()$ -0.8753 -3.14184 -3.18857 -0.30895 -0.34869 $()$ -0.8753 -0.30895 -0.34869 -0.34869 $()$ -0.8753 -0.30895 -0.34869 $()$ -0.31857 -0.30895 -0.34869 $()$ -0.30895 -12.306 -0.34869 $()$ -0.30895 -12.306 -0.34869 $()$ -13.8627 -12.306 -0.34869 $()$ -13.66 -12.306 -12.306 $()$ -13.8627 -12.306 -12.306						Regres	Regression equations by SVAP element	ons by SV	AP elemen						
Average Bank to Fish Canopy Channel Fish logic Intercept 5.89429 7.4062 12.78903 7.95608 2.66916 0.33666 7.46588 Subulation 5.89429 7.4062 12.78903 7.95608 2.66916 0.33666 7.46588 Subulative Area (%) Eucnulative Area (%) -3.14184 -3.18857 - 2.46588 Cumulative Area (%) - -3.14184 -3.18857 - - 4.6588 Reach Length (%) - - -3.14184 -3.18857 - - - Cumulative Area (%) - - -3.14184 -3.18857 - - - Cumulative Area (%) -					Barriers			nstream	Hydro-		Nutrient		Riffle		Water
Score Stability Mvmt Cover Cover Alteration Intercept 5.89429 7.4062 12.78903 7.95608 2.66916 0.33666 7.45588 Subbasin Area (%) -3.14184 -3.14184 -3.14584 -7.45588 Subbasin Area (%) -3.14184 -3.14184 -3.1657 7.45588 Cumulative Reach -0.8753 -3.14184 -3.1857 - - Length (%) -0.8753 -3.14184 -3.1857 - - Commonie Reach -0.8753 - - - - - Nidth -0.8753 - - - - - - Reach Width -			Average	Bank	to Fish	Canopy	Channel	Fish	logic	brate	Enrich-		Embedd-	Embedd- Riparian Appear-	Appear-
Intercept 5.89429 7.4062 12.78903 7.56916 0.33666 7.46588 Subbasin Area (%) Cumulative Area (%) -3.14184 -3.18857 - -3.14684 Cumulative Area (%) - -3.14184 -3.18857 - -3.14384 Cumulative Reach - - -3.14184 -3.18857 - - Cumulative Reach - - - -3.14184 -3.18857 - - Cumulative Reach -<			Score	Stability	Mvmnt	Cover	Condition	Cover	Alteration	Habitat	ment	Pools	edness	Zone	ance
Subbasin Area (%) Subbasin Area (%) 3.14184 3.18857 Cumulative Area (%) -3.14184 -3.14184 -3.14184 -3.1857 Reach Length (%) - -3.14184 -3.14184 -3.18557 Cumulative Reach -		Intercept	5.89429	7.4062	12.78903	7.95808	2.66916	0.33666	7.46588	-79.4118	-1.30615	8.46918	N/A	5.57943	6.02236
Cumulative Area (%) · · · · · · · · · · · · · · · · · · ·		Subbasin Area (%)									31.73733				
Reach Length (%) Image Ima Image Image		Cumulative Area (%)			-3.14184	-3.18857					12.80145				
Cumulative Reach Image: Mark Mark Mark Mark Mark Mark Mark Mark		Reach Length (%)										-33.4462			
Length (%) Length (%) Length (%) Length (%) Notesting (%)		Cumulative Reach													
Reach Width -0.30895 -0.34869 Vidth -0.8753 -0.34869 -0.34869 Width -0.8753 -0.34869 -0.34869 Reach Depth -0.8753 -0.34869 -0.34869 Reach Depth 13.8625 -0.34869 -0.34869 Depth 13.8625 -0.34869 -0.34869 Composite Reach 13.8625 -0.34869 -0.34869 Depth 13.8625 -0.5 -0.34869 -0.34869 Composite Reach 13.8625 -0.5 -0.34869 -0.34869 Depth 13.8625 -0.5 -0.34869 -0.34869 Composite Reach 13.8625 -0.5 -1.5 -1.2 Composite Routous -1.6.7097 9.4107 -1.3 -1.3 Impervious Surface (%) -1.3 9.4107 -1.3 -3.57722 -1 Mydrologic soil group -1.3 -3.57722 -3.57722 -1 Stope (%) -1.3976 -1 -1.3576 -1 -1		Length (%)								-117.394		46.00714			-12.35
Composite Reach -0.30895 -0.30895 -0.34869 Width -0.8753 -0.34869 -0.34869 Reach Depth 13.8625 -0.34869 -0.34869 Depth 13.8625 -0.34869 -0.34869 Depth 13.8625 -0.34869 -0.34869 Depth 13.8625 -0.34869 -0.34869 Depth 13.8625 -0.24869 -0.34869 Composite Reach 13.8625 -0.34869 -0.34869 Depth 13.8625 -0.4678 -0.4678 Curve Number -0.46 -0.46 -12.306 Composite CN -16.7097 9.4107 -12.306 Erodability Factor -16.7097 9.4107 -12.306 Impervious Surface (%) -16.7097 9.4107 -12.306 Motologic soil group -13.7722 -3.57722 -3.57722 Motologic soil group -1.39776 -3.57722 -3.57722 Slope (%) -1.39776 -1.33776 -3.57722 Motologic soil group		Reach Width								20.68503		-4.25242			0.45333
Width -U.3053 -U.3053 -U.30695 -U.30695 -U.30695 Reach Depth 13.8625 -U.30625 -U.30695 -U.30695 -U.30695 Composite Reach 13.8625 - -U.3075 -U.30695 -U.30695 Curve Number - -16.7097 -16.7097 -12.306 - Composite CN - -16.7097 9.4107 - - Erodability Factor - -16.7097 9.4107 - - Composite CN - -16.7097 9.4107 - - - Matrice (%) - -12.306 - - - - - Surface (%) - - -16.7097 9.4107 -	S														
Reach Depth Reach Depth 13.8625 1 <th1< th=""> 1<!--</th--><th>au</th><th></th><th>-0.8/53</th><th></th><th></th><th></th><th>-0.30895</th><th></th><th>-0.34869</th><th>-31.0520</th><th></th><th></th><th></th><th></th><th></th></th1<>	au		-0.8/53				-0.30895		-0.34869	-31.0520					
Composite Reach 13.8625 13.8625 6 6 Depth 13.8625 13.8625 13.8625 13.8625 13.8625 13.8625 13.8625 13.8625 13.8625 13.8625 13.8625 13.8625 13.8625 14.07 13.8625 14.07 12.306 14.07 14.316 14.07 14.316 14	əiə									-410.952	-24.5436	66.37307			
Depth 13.8625 13.8625 13.8625 13.8625 13.8625 13.8625 13.8625 13.8625 13.8625 13.8625 14.0000 14.0000 14.0000	iffe														
Curve Number Curve Number Curve Number Curve Number Curve Number Composite CN -12.306 N Composite CN -16.7097 -16.7097 9.4107 -12.306 N Erodability Factor -16.7097 9.4107 -12.306 N Composite Erodability -1 -12.306 N N Impervious Surface (%) -1 0.14316 N N Varlace (%) -1 -1 0.14316 N N Varlace (%) -1 -1 0.14316 N N N Varlace (%) -1 -1 0.14316 N N N N N Varlace (%) -1 -1 -1 0.14316 N <th>00</th> <th></th> <th>13.8625</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>626.9561</th> <th>18.52966</th> <th></th> <th></th> <th></th> <th></th>	00		13.8625							626.9561	18.52966				
Composite CN Image: Sector Image: Se) 1 6										0.0659				
Erodability Factor -16.7097 -16.7097 -12.306 -12.306 Composite Erodability N 9.4107 -12.306 N Impervious Surface (%) N 9.4107 9.4107 N Impervious Surface (%) N 9.4107 N N Composite Impervious N N 9.4107 N N Surface (%) N N N N N N N N Composite Impervious N	əjəi										-0.08838				
Composite Erodability Impervious Surface (%) 9.4107 9.4107 Impervious	ue.				-16.7097			-12.306				-13.7449			
Impervious Surface (%) Impervious	16 9 1						9.4107								
violus 0.14316 roup -3.57722 roup -3.57722 group -3.57722 group -3.57722 noup -3.57772 noup -1.5665 -1.5665 -1.5665															
roup 0.14316 roup 0.14316 sint -3.57722 agroup -1.5665 agroup -2.50 agroup -2.50 -2.50		Composite Impervious													
roup -3.57722 ogroup -3.57722 -3.57722 ogroup -3.57722 -3.57722 ogroup -1.5665 -1.5665 -1.5665 0 -1.5665 -1.5665 -1.5665		Surface (%)						0.14316		0.19682	0.23028				
ogroup 6.12116 (%) 1.39776 1.39776 2.54068 3.54477		Hydrologic soil group						-3.57722			-5.7936				
(%) 1.39776 2.54068 3.54477 -1.5665 -1.5665 2.54068 3.54477		Composite Hydrogroup						6.12116			7.74154				
(%) 1.39776 2.54068 3.54477 1.39776 -1.5665 2.54068 3.54477		Slope (%)									0.03146				-0.0308
1.39776 2.54068 3.54477 -1.5665 -1.5665 -1.5665		Composite Slope (%)									-0.03839				
-1.5665		% Forest	1.39776				2.54068	3.54477		77.34496	7.04071			2.36902	3.90849
		% Urban		-1.5665						68.07802					
4.9080		% Water/Wetland					5.13		4.9685	68.55001					

Table 6a. Regression model equations for all basins using the Ramapo data after the unit-based variables were normalized as percentages.

	All	Basins	% F	Forest > 41	% U	rban > 43
	n	R^2	n	R ²	n	R ²
SVAP Average Score	69	0.3926	37	0.4219	35	0.5219
SVAP Bank Stability	69	0.1704	37	0.6194	25	0.3707
SVAP Barriers to Fish	43	0.4883	26	0.9712 0.9273	21	0.9999
SVAP Canopy Cover	45	0.3213	24	$(\alpha = 0.10)$	23	0.9320
SVAP Channel Condition	69	0.3390	37	0.5019 0.6463	35	0.3718
SVAP Hydrologic Alteration	62	0.2293	34	(α = 0.10)	30	0.6114
SVAP Instream Fish Cover	39	0.6423	21	0.9998	19	0.9999
SVAP Invertebrate Habitat	24	0.8490	13	0.9999	21	0.9427
SVAP Nutrient Enrichment	25	0.8201	20	0.9992	23	0.9751
SVAP Pools	52	0.4133	32	0.1811	22	0.9991
SVAP Riffle Embeddedness	25	N/A	16	0.9982 0.1916	10	N/A
SVAP Riparian Zone	69	0.2382	37	(α = 0.10)	35	0.5894
SVAP Water Appearance	68	0.5557	36	0.5316	35	0.5540
All models are significant at α = 0.0 significant coefficients remaining in			erwise. Ite	ems marked N/A o	did not ha	ve any

Table 5. R-squared values for the regression models developed using the Ramapodata after the unit-based variables were normalized as percentages.

Protect Number Entities Numer File Numer Entities Ruttient Ruttien Ruttient Ruttient Ruttient Ruttien Ruttien <th <="" th=""><th></th><th></th><th></th><th></th><th></th><th>Regres</th><th>sion equati</th><th>ons by SV</th><th>Regression equations by SVAP element</th><th>L L</th><th></th><th></th><th></th><th></th><th></th></th>	<th></th> <th></th> <th></th> <th></th> <th></th> <th>Regres</th> <th>sion equati</th> <th>ons by SV</th> <th>Regression equations by SVAP element</th> <th>L L</th> <th></th> <th></th> <th></th> <th></th> <th></th>						Regres	sion equati	ons by SV	Regression equations by SVAP element	L L					
Average Baility Correction Embodic Repaired Embodic Repaired Embodic Repaired Embodic Repaired Remotic					Barriers			Instream	Hydro-	Inverte-	Nutrient		Riffle		Water	
Intercept 6.2387 7.0506 -1050.8 6.3071 0.5387 7.0506 $1.050.8$ 6.3071 $1.42.1729$ 3.742 Subbasin Area (%) 7.0506 57.132 6.2387 7.0506 57.132 $6.27.581$ $3.27.18$ 3.7178 $3.77.293$ $3.77.292$ $3.77.292$ $3.77.292$ $3.77.292$ $3.77.292$ $3.77.292$ $3.77.292$ $3.77.292$ $3.77.292$			Average Score	Bank Stability	to Fish Mvmnt	Canopy Cover	Channel Condition	Fish Cover	logic Alteration	brate Habitat	Enrich- ment	Pools	Embedd- edness	Riparian Zone	Appear- ance	
Subbasin Area (%) $= 575.123$ 575.123 527.533 12.15878 50.148 $= 0.1$ $= 0.0781$ 447.201 3.00143 $= 27.533$ 12.15878 $= 57.133$ $= 57.133$ $= 57.133$ $= 57.133$ $= 57.133$ $= 57.133$ $= 57.133$ $= 57.133$ $= 57.133$ $= 57.132$ $= 57.1524$ </th <th></th> <th>Intercept</th> <th>6.23897</th> <th>7.05069</th> <th>-1050.85</th> <th>26.30672</th> <th>0.91809</th> <th>673.2326</th> <th>-5.94129</th> <th>14.3311</th> <th>4725.008</th> <th></th> <th>142.17299</th> <th>_</th> <th>5.56054</th>		Intercept	6.23897	7.05069	-1050.85	26.30672	0.91809	673.2326	-5.94129	14.3311	4725.008		142.17299	_	5.56054	
Cumulative Area (%) 4.67408 4.07701 3.30143 8.27.538 1.2168 -920.48 -910.41 -910.48 -910.48 <th></th> <th>Subbasin Area (%)</th> <th></th> <th></th> <th>575.1923</th> <th></th> <th></th> <th>274.5605</th> <th></th> <th>561.149</th> <th></th> <th></th> <th></th> <th></th> <th></th>		Subbasin Area (%)			575.1923			274.5605		561.149						
Reach Length (%) -11.718 -51.718 -51.728 $-17.5.223$ $-17.5.223$ -33.73953 -57.132 -35.2387 -37.52 -57.132 </th <th></th> <th>Cumulative Area (%)</th> <th>4.67408</th> <th></th> <th>-400.797</th> <th>-447.207</th> <th>3.30143</th> <th>-827.538</th> <th>12.15878</th> <th>-920.48</th> <th></th> <th></th> <th></th> <th></th> <th></th>		Cumulative Area (%)	4.67408		-400.797	-447.207	3.30143	-827.538	12.15878	-920.48						
Cumulative Reach length (%)<		Reach Length (%)	-41.578	-51.7478	-548.566	-515.213	-47.9222	-175.252	-33.73953	-322.13	-57.132				-49.8345	
Rach With Composite Reach I <th></th> <th>Cumulative Reach Lenoth (%)</th> <th></th> <th></th> <th>455,9337</th> <th>499.5897</th> <th></th> <th>215.4604</th> <th></th> <th>-25,107</th> <th>26.78854</th> <th></th> <th></th> <th></th> <th></th>		Cumulative Reach Lenoth (%)			455,9337	499.5897		215.4604		-25,107	26.78854					
Composite Reach i i ····································		Reach Width						41.33974	-0.36051	90.8253	-4.58947	0.4988				
Reach Depth 10.363 -107.04 -105.368 -107.04 -105.368 -107.04 -105.368 -107.12601 10.3668 305.78713 305.7871 306.78713 305.7871 306.78713 305.7871 306.7871 306.7823 2.35.712 14.14882 30.7752 306.7763 30.7752 30.7752 307.7752 307.7752 307.7752 307.7752 307.7752 307.7752 307.7753 307.7753 307.723 307.723 307.723 307.723 307.723 307.723 307.723 307.723 307.723 307.723 377.12271 377.12271 <	sju							-32.2155		-75.108	6.54316					
Composite Reach -12.2801 105.7353 95.67352 438.0379 1360.66 -91.0907 96.668 -571.5264 Depth 0.02715 -0.38847 -0.3817 -0.02506 -0.16156 -0.13171 Curve Number 0.02715 -0.3883 0.33287 -0.03936 0.28647 -0.2523 -0.01451 -0.13171 Curve Number 0.02715 21.223 116.288 -0.33287 -0.02506 -0.13171 - Composite CN -0.0451 0.28083 0.33287 -0.03936 0.28647 -0.2523 -0.13171 - Composite Erodability Factor 0.0451 15.26764 40.19623 34.4405 30.1752 - -0.1371 Erodability Factor 0.0451 15.2764 40.19623 34.4405 30.1752 - -0.1371 Impervious Surface (%) 0.22243 216.28632 15.26764 40.19623 -0.14489 - -0.1075 Impervious Surface (%) - 0.7833 - -0.2523 -0.14408 -	əici			10.3363	-107.04	-105.898		-497.848		-1442.5	67.94868		305.78713		5.444	
Curve Number 0.02715 -0.38647 -0.41913 0.1466 -0.02506 -0.16156 -0 -0 13171 - Composite CN 0.0451 0.28983 0.33287 -0.03336 0.238647 -0.2523 -0.13171 -0.13171 - - -0.13171 - - -0.13171 - - -0.13171 - - -0.13171 - - -0.13171 - - -0.13171 - - -0.13171 - - -0.13171 - - -0.13171 - - -0.13171 - - -0.13171 - - -0.13171 - - -0.13171 - - -0.13171 - - -0.13171 - - -0.10761 - -0.10761 - - -0.10761 - -0.10761 - -0.10761 - -0.10761 - -0.10761 - -0.10761 - -0.10761 - -0.10761 - -0.10761 -0.10761	ffsoJ	_		-12.2801	105.7353	1		438.0379		1360.65	-91.0907					
Composite CN 0.0451 0.28983 0.33287 0.03336 0.28647 0.2523 0.2533 0.13171 0.13171 Erodability Factor 1.1 1.1 1.1723 1.17823 $2.0.3382$ $2.3.5152$ $1.4.14882$ $0.2.523$ $1.00.51155$ $1.00.51155$ Composite Erodability $1.3.9725$ 21.223 -16.285 52.7075 52.56764 40.19623 34.46405 30.1752 0.23336 2.54774 14.7696 Umbervious 0.78355 21.223 -16.285 52.7075 52.7075 52.8777 0.17489 0.17489 0.1769 0.10769 Umbervious 0.2242 0.28432 2.1807 0.68183 0.68183 0.68183 0.63275 0.17489 0.3336 1.87901 Umbervious 0.2242 0.23442 27.21121 28.65412 2.18807 2.87471 0.3336 1.87901 Umbervious 0.2242 0.28432 -0.1493 0.68376 0.17489 0.17489 1.87901 Umbervious 0.2242 0.28442 2.18807 2.18807 0.63376 0.17489 1.87901 Umbervious 0.2242 0.28442 2.1121 28.65412 2.18807 2.87471 0.3936 1.87901 Umbervious 0.2242 0.28442 0.08694 0.17489 0.17489 0.07966 0.07969 Umbervious 0.2242 0.11286 0.11286 0.01864 0.05597 0.07966 0.07966 Umbervious <td< th=""><th>19i</th><th>-</th><th>0.02715</th><th></th><th>-0.38647</th><th>-0.41913</th><th></th><th>0.1466</th><th>-0.02817</th><th></th><th>-0.02506</th><th></th><th>-0.16156</th><th></th><th>0.03347</th></td<>	19i	-	0.02715		-0.38647	-0.41913		0.1466	-0.02817		-0.02506		-0.16156		0.03347	
Frodability Factor	ອແ	-	-0.0451		0.28983	0.33287	-0.03936	-0.28647		-0.2523			-0.13171		-0.04747	
Composite Erodability 13.9725 21.223 -16.285 52.7075 15.26764 40.19623 34.46405 30.1752 30.1752 30.1754 1 Impervious Surface (%) 0.78355 52.7075 15.26764 40.19623 -0.17489 0.73336 255403 1.87901 Impervious Surface (%) 0.2242 0.25493 0.78355 2.18807 0.63275 0.17489 0.13185 1.87901 Hydrologic soil group 0.2242 0.25493 0.68183 0.63275 2.87471 3.51189 1.87901 Hydrologic soil group 0.2242 0.25493 0.68183 0.66312 2.18807 0.63275 2.87471 3.51189 1.87901 Hydrologic soil group 0.2242 0.25493 49.3364 40.2543 2.18807 2.87471 3.51189 12.98311 Hydrologic soil group 0.2242 0.25493 2.12121 28.65412 2.18607 0.13656 12.98311 Composite Hydrogroup 0.12128 49.1361 0.18654 0.18654 0.07569 0.0729	ie ie				61.77823	26.23682		-23.5152	-14.14882				109.51155			
6) 0.78355 () 0.85059 ()	sq.		13.9725	21.223	-116.285	-52.7075	15.26764	40.19623	34.46405	30.1752			-254.0744		15.2379	
• 0.2242 0.25493 0.68183 0.63275 0.63275 0.19185 0.19185 1 0 3.98442 27.21121 28.65412 2.18807 2.87471 3.51189 1 0 -5.2738 -49.3364 -40.2543 2.18807 2.87471 3.51189 1 0 -5.2738 -49.3364 -40.2543 2.18807 2.87471 0.19185 -3 0 -5.2738 -49.3364 -40.2543 2.18807 2.87471 0.05594 1 0 -5.2738 -49.3364 -0.14191 0.18654 0.18654 0.05597 -3 -3 0 -0.11286 -0.14191 0.18654 0.05597 0.05594 7 -3 1 1156.869 38.40574 0.078689 -4716.03 -4716.03 7 1 1147.439 33.8033 -6.05868 -641.812 -4707.98 -4707.98 7		Impervious Surface (%)			0.78355			-0.85059	-0.17489		-0.33936			-0.107		
ID 3.98442 27.21121 28.65412 2.18807 2.87471 3.51189 1 ID -5.2738 -49.3364 -40.2543 2.18807 2.3125 3.99753 -3 ID -5.2738 -49.3364 -40.2543 0.18654 2.3125 3.99753 -3 ID -0.11286 -0.14191 0.18654 0.05597 0.05594 -3 ID 1156.869 38.40574 6.68.899 0.05597 -4716.03 -4716.03 ID 1147.439 33.8033 -6.05868 -641.812 -4707.98 -4710.55 -4707.98		Composite Impervious Surface (%)	-0.2242	-0.25493		0.68183		0.63275			0.19185		1.87901		-0.2709	
Index outpoint -5.2738 -49.3364 -40.2543		Hydrologic soil group		3.98442	27.21121	28.65412	2.18807		2.87471		3.51189		12.98311			
(%) -0.11286 -0.14191 0.18654 0 0.05594 0 (%) 0 -0.11286 -0.14191 0.18654 0.05597 0.05594 0 (%) 0 0.07848 0.07848 0.05597 0.01065 0 0.01065 0 (%) 1156.869 38.40574 -668.899 -668.899 -6716.03 -4716.03 0 (%) 1147.439 33.8033 -6.05868 -641.812 -64707.98 -4707.98 0 (%) 1121.288 1121.288 -665.219 5.35971 -4711.55 0		Composite Hydrogroup		-5.2738	-49.3364	-40.2543				2.3125	-3.99753		-37.12271			
(%) 0.05597 0.01065 0.01065 (%) 1156.869 38.40574 -668.899 -4716.03 (%) 1147.439 33.8033 -605868 -641.812 -4707.98 (%) 1121.288 -6.05868 -641.812 -4707.98 -4711.55		Slope (%)			-0.11286	-0.14191		0.18654			0.05594		0.07293			
1156.869 38.40574 -668.899 -668.899 1147.439 33.8033 -6.05868 -641.812 1121.288 -1121.288 -652.219 5.35971		Composite Slope (%)				0.07848			0.05597		-0.01065		0.07906			
1147.439 33.8033 -6.05868 -641.812 - 1121.288 -652.219 5.35971 -		% Forest			1156.869	38.40574		-668.899			-4716.03					
1121.288 -652.219 5.35971		% Urban			1147.439	33.8033	-6.05868	-641.812			-4707.98					
		% Water/Wetland			1121.288			-652.219	5.35971		-4711.55					

Table 6b. Regression model equations for basins with % Forest >41 using the Ramapo data after the unit-based variables were normalized as percentages.

Partients Barriens Barriens Instream Hydro- logic Inv Average Barriens to Fish Conorp Conorp Fish logic In Intercept 10.0867 5.24474 115.729 57.3509 8.57382 60.29012 9.45614 -25 Score Stability Mvmit Cover 60.29012 9.45614 -25 Subbasin Area (%) 10.0867 5.24474 115.729 57.3509 8.57382 60.29012 9.45614 -25 Subbasin Area (%) 10.0867 5.24474 115.729 47.383 120.7586 -26.8259 -27 Cumulative Reach -0.9437 221.948 68.2544 4.59846 24.82281 -23 Reach Width -0.9437 -123.903 177.28 -120.7586 -70 -70 Composite Reach 13.3903 -147.28 -4.59846 24.82281 -23 Reach Width -0.94476 -123.23 -0.54894 3.07999 -70	Barriers Barriers Cal Bank to Fish Cal Stability Mvmnt Co 5.24474 115.729 57 -42.629 -459.228 -4 -43.3347 -221.948 68 43.3347 -221.948 68 -139.9996 17 -17	Instream Fish fition Cover 7382 60.29012	Hydro-	verte-				101-101
Average Bank to Fish Canopy Cannol Fish logic Score Stability Mvmnt Cover Score Stability Mvmt Intercept 10.0867 5.2474 115.729 57.3509 8.57382 60.29012 9.45614 Subbasin Area (%)	Bank to Fish Canopy Stability Mvmnt Cover 5.24474 115.729 57.3509 -42.629 -459.228 -423.856 -42.629 -459.228 -423.83 43.3347 -221.948 68.2544 124.9293 -147.28 -139.996 178.283					Riffle		water
Intercept 10.0867 5.24474 115.729 57.3509 8.57382 60.29012 9.45614 Subbasin Area (%) -42.629 -459.228 -433.856 -26.82529 Cumulative Area (%) -42.629 -459.228 -423.83 120.7586 -26.82529 Reach Length (%) -42.629 -459.228 -423.83 120.7586 -26.82529 Reach Length (%) - 124.9293 -147.28 -4.59846 24.82281 Cumulative Reach -0.9437 124.9293 -147.28 -4.59936 -78.8283 Reach Width -0.9437 124.9293 -147.28 -4.59366 -4.59366 Width -0.9437 -133.906 178.283 -0.54891 3.07999 Reach Depth -13.3903 3427.672 -147.28 -0.54891 3.07999 Reach Depth -13.3903 3427.672 -39.0671 3.07999 Composite Reach 13.3903 3427.672 -39.0671 -0.36033 Depth Composite Reach 13.3903 178.248	5.24474 115.729 57.3509 -114.462 483.856 -42.629 -459.228 -423.83 43.3347 -221.948 68.2544 124.9293 -147.28 -139.996 -139.996 178.283		Iogic	brate Enrich- Habitat ment	Pools	Embedd- R edness	Riparian Zone	Appear- ance
Subbasin Area (%)	-114.462 483.856 -42.629 -459.228 -43.3347 -423.83 43.3347 -221.948 68.2544 124.9293 -147.28 -139.996 178.283	120 7586	9.45614	9		-	2.36289	5.11709
Cumulative Area (%) -42.629 -45.629 -56.82529 Reach Length (%) -42.63 -26.82529 Cumulative Reach -42.633 -26.82549 Length (%) -33347 -221.948 68.2544 -4.59846 Length (%) -139.993 147.28 -4.59846 24.82281 Reach Width -0.9437 -271.948 68.2544 -4.59846 24.82281 Reach Width -0.9437 -272.148 -3.054891 3.07999 -4.59846 24.82281 Reach Width -0.9437 -2722.14 178.283 -0.54891 3.07999 -1.676 Composite Reach -0.9437 -2722.14 $-2.722.14$ $-2.630.671$ $-2.6.8253$ Reach Depth 0.9437 -2722.14 -2722.14 $-2.630.33$ -2.6677 $-2.66.2281$ Composite Reach 13.3903 3427.672 -2722.14 -0.54891 3.07999 $-2.66.2767$ Depth 13.3903 3427.672 -1.676 -123.16 -1.676 -123.16 -12.636 $-2.722.14$ $-2.722.14$ -2.64891 Composite Reach 13.3903 3.16464 48.2279 -0.36033 -0.36033 -0.36033 Depth 13.2689 3.16464 48.2279 -0.26033 -0.36033 -0.36033 Composite CN -13.2689 3.16464 48.2279 -0.36033 -0.36033 -0.36033 Composite Inpervious Surface (%) $-1.3.2683$ 3.16464 48.2279 -0.23415 -0.23415	-42.629 -459.228 -42.629 -459.228 -423.83 -423.83 -423.83 -423.83 -121.948 68.2544 124.9293 -147.28 -139.996 178.283	120 7586		72.1553				
Reach Length (%)	43.3347 -221.948 68.2544 124.9293 -147.28 -139.996 178.283	120 7586	-26.82529	69.0501	1 -137.904			
Cumulative Reach 43.3347 221.948 68.2544 4.59846 24.82281 Length (%) 124.9293 147.28 4.59846 24.82281 Reach Width 124.9293 147.28 4.59846 24.82281 Composite Reach -0.9437 124.9293 147.28 4.59846 24.82281 Width -0.9437 124.92996 178.283 -0.54891 3.079999 24.82281 Width -0.9437 -139.996 178.283 -0.54891 3.07999 24.82281 Width -0.9437 2722.14 273.9671 3.07999 29.6771 Depth 13.3903 3427.672 2.350671 3.0671 24.82281 Composite Reach 13.3903 3427.672 2.36.671 28.0671 28.0671 Depth 13.3903 3.427.672 2.49753 2.60733 2.60333 Composite Reach 13.3665 -126.341 48.2279 2.036071 2.60676 Composite CN 13.2665 12.49753 2.62767 2.60676	43.3347 -221.948 68.2544 124.9293 -147.28 -139.996 178.283	120.1000		42.4364	4 -139.265			
Reach Width 124.9293 -147.28 0.54891 3.07999 Composite Reach -0.9437 -139.996 178.283 -0.54891 3.07999 Width -0.9437 -139.996 178.283 -0.54891 3.07999 - Width -0.9437 -139.096 178.283 -0.54891 3.07999 - Reach Depth -13.3903 3427.672 -2722.14 - -39.0671 - Composite Reach 13.3903 3427.672 - -39.0671 - - Depth 13.3903 3427.672 - -0.36033 - - Composite Reach 13.3903 33.16464 48.2279 - - 0.36767 - Composite CN 13.2689 33.16464 48.2279 - 0.36033 - - Impervious Surface (%) 13.2689 33.16464 48.2279 - 0.11519 - - Impervious Surface (%) 13.2689 33.16463 - 0.23415 <t< th=""><th>124.9293 -147.28 -139.996 178.283</th><th>-4.59846</th><th>24,82281</th><th>-230.032</th><th>612.299</th><th></th><th></th><th>-13,525</th></t<>	124.9293 -147.28 -139.996 178.283	-4.59846	24,82281	-230.032	612.299			-13,525
Composite Reach -0.9437 -139.996 178.283 -0.54891 3.079999 - Width -0.9437 -0.9437 -139.996 178.283 -0.54891 3.079999 - Reach Depth -0.9437 -2722.14 -2722.14 - </th <th>-139.996 178.283</th> <th></th> <th></th> <th>37.13054 -3.51019</th> <th>'</th> <th></th> <th></th> <th>0.48964</th>	-139.996 178.283			37.13054 -3.51019	'			0.48964
Reach Depth -2722.14 -				-51.138	57.9469			
Composite Reach 13.3903 3427.672 >>>>>>>>>>>>>>>>>>>>>>>>>>>>	-2722.14			-704.948	1152.17			
Curve Number -0.18691 -0 0.04555 -0 -0 Composite CN -0.49753 -0.49753 -0.36033 -0		-39.0671		995.7501	-1250.33			
Composite CN .0.49753 .0.36033 .0.11519 .0.3603 .0.3156 .0.30433 .0.11519 .0.3603 .0.31365 .0.30433 .0.31365 .0.30433 .0.31365 .0.33765 .0.33765 .0.33765 .0.333755 .0.30689 .0.0748 .4.41304 .0.23415 .0.23415 .0.23415 .0.23415 .0.23415 .0.20689 .0.0748 .4.41304 .0.20689 .0.0748 .4.41304 .0.20689 .0.0748 .4.41304 .0.20689 .0.0748 .0.20748 .0.20748 .0.20748 <t< th=""><th>-0.18691</th><th>0.04555</th><th></th><th>0.19561</th><th>1 -0.09878</th><th></th><th></th><th></th></t<>	-0.18691	0.04555		0.19561	1 -0.09878			
Erodability Factor .49.7565 .125.34 17.46455 .8.62767 Composite Erodability 13.2689 33.16464 48.2279 Impervious Surface (%) 13.2689 33.16464 48.2279 Impervious Surface (%) 0.30433 0.11519	-0.49753	-0.36033		0.18833	3 -0.4544			
Composite Erodability 13.2689 33.16464 48.2279 1 1 1 Impervious Surface (%) 0.30433 0.11519 1	-125.34			-44.2594	4 -176.181		19.5871	
0 0.30433 0.11519 0.33765 0.30482 0.11519 -1.676 -1.2436 3.70777 -1.676 -1.2436 3.70777 33.14834 17.87922 2.84882	33.16464 48.227			42.7677	7 307.019		-16.823	
0.33765 -0.4882 -0.23415 -4.41304 -1.676 -1.2436 3.70777 -2.8107 -3.00689 -6.00748 -4.41304 33.14834 33.14834 17.87922 2.84882 1	0.30433	0.11519			0.59448			
-1.676 -1.2436 3.70777 -2.8107 -3.00689 -6.00748 -4.41304 33.14834 33.14834 2.84882 2.84882		-0.23415		0.41067 1.10498	8 -0.76906			
p 33.14834 17.87922 2.84882	-1.2436 3.70777 -2.8107		-4.41304	-7.64183	3 -6.6788		-3.5058	
	33.14834	17.87922	2.84882	13.75237			4.72796	
Slope (%) 0.05804 0.08718	0.0871				-0.45055			
Composite Slope (%) 0.83712 0.20836 -0.34851 0.0		-0.34851		0.08757 0.32787	7 0.16627		-0.0885	
% Forest 4.08357 -297.869 -20.71 5.17851 -48.1201 5.28778 199	-297.869 -20.71	-	5.28778	199.0632	-70.3549		6.81111	4.38368
% Urban -261.062 -34.495 -58.4227 1	-34.46	-58.4227		196.69 -15.5974	4 -108.624			
% Water/Wetland -271.896 -57.4853 182	-271.896	-57.4853		182.8803 -13.5364	4 -167.755			

Table 6c. Regression model equations for basins with % Urban >43 using the Ramapo data after the unit-based variables were normalized as percentages.

	All Basins	% Forest > 41	% Urban > 43
	E	E	E
SVAP Average Score	-0.309	-1.707	-0.601
SVAP Bank Stability	-0.206	-2.566	-0.931
SVAP Barriers to Fish	-0.208	-77.499	-90.841
SVAP Canopy Cover	-0.270	-116.296	-76874.606
SVAP Channel Condition	-0.458	-0.791	-0.457
SVAP Hydrologic Alteration	-0.388	-1.984	-1.114
SVAP Instream Fish Cover	-0.704	-935.117	-12.865
SVAP Invertebrate Habitat	-127.213	-6102.408	-18.889
SVAP Nutrient Enrichment	-6.995	-17766.772	-74.913
SVAP Pools	-6.955	-4.173	-163.967
SVAP Riffle Embeddedness	N/A	-718.303	NA
SVAP Riparian Zone	-0.081	-1.391	-1.616
SVAP Water Appearance	-1.467	-1.879	-1.403
Items with N/A did not have models.			

Table 7. Nash-Sutcliffe model efficiency coefficient (E) for observed vs.predicted SVAP scores. A negative E value signifies that the mean SVAPscore is better at predicting SVAP scores than the model.

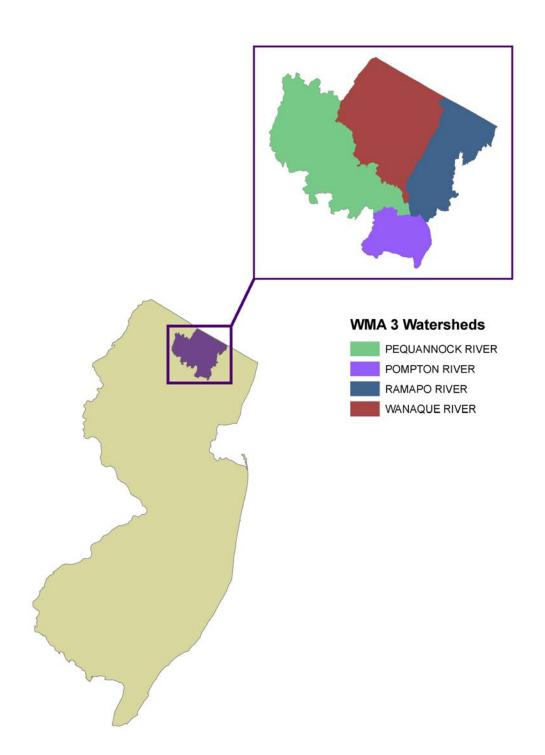


Figure 1. Location of Watershed Management Area (WMA) 3

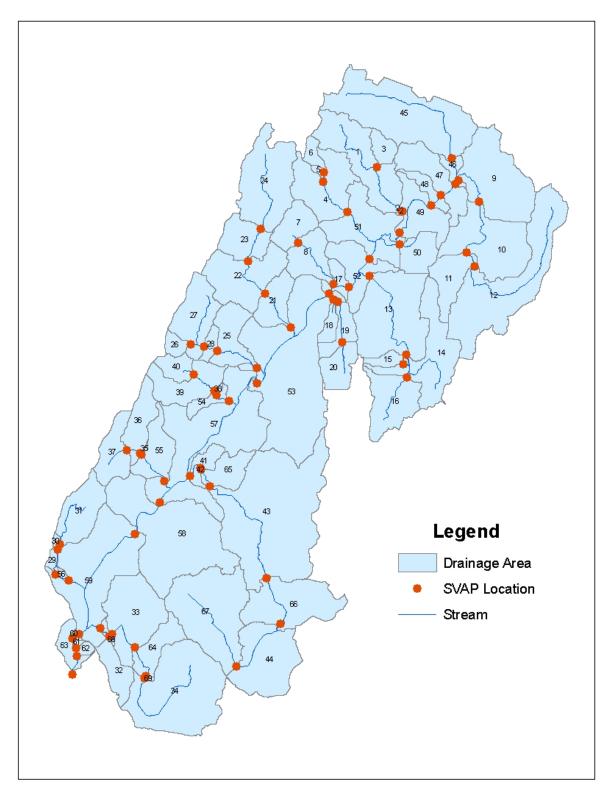


Figure 2. Map of Ramapo watershed and drainage area for each SVAP location.

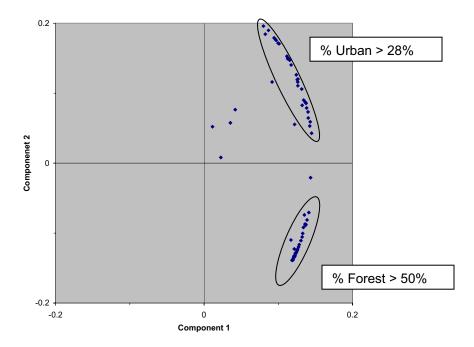


Figure 3. Principal Component Analysis: Ramapo subbasins before unit-based data were normalized as percentages. Results revealed subbasin clusters based on percentage of land use.

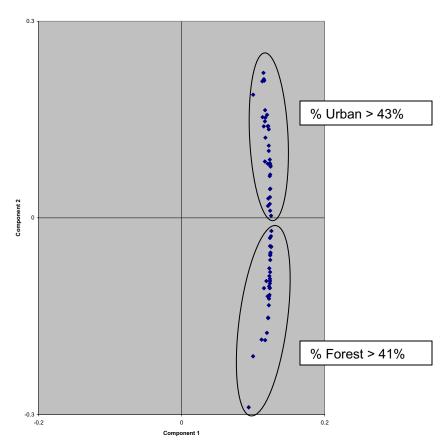


Figure 4. Principal Component Analysis: Ramapo subbasins after unit-based data were normalized as percentages. Subbasin clusters based on percentage of land use were still apparent.

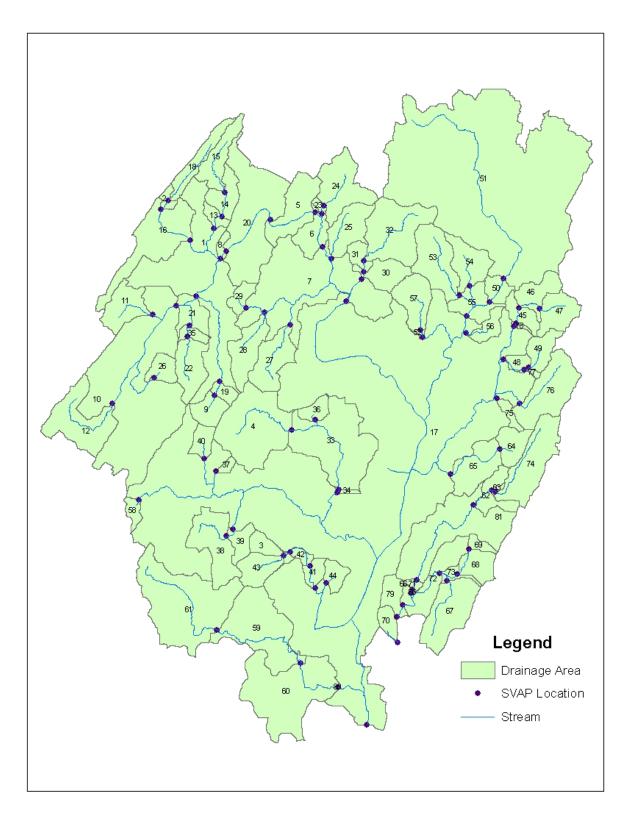
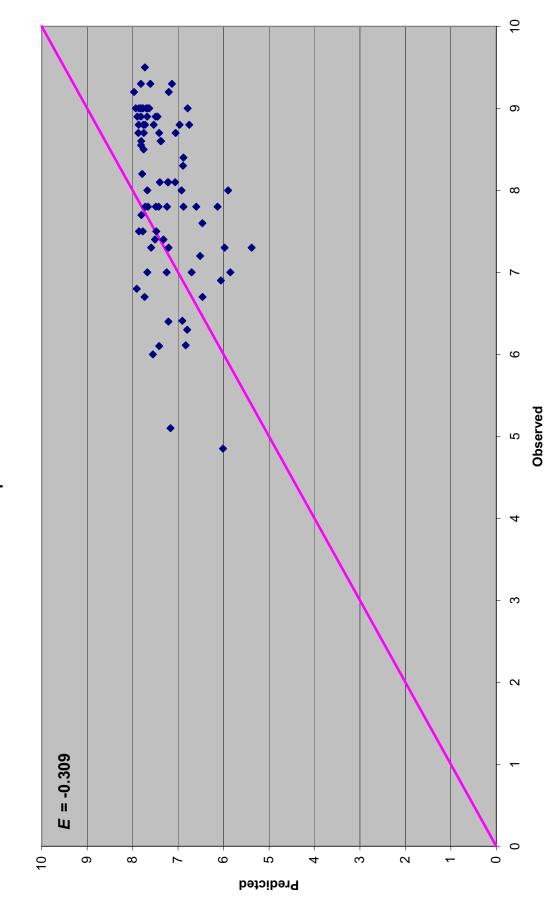
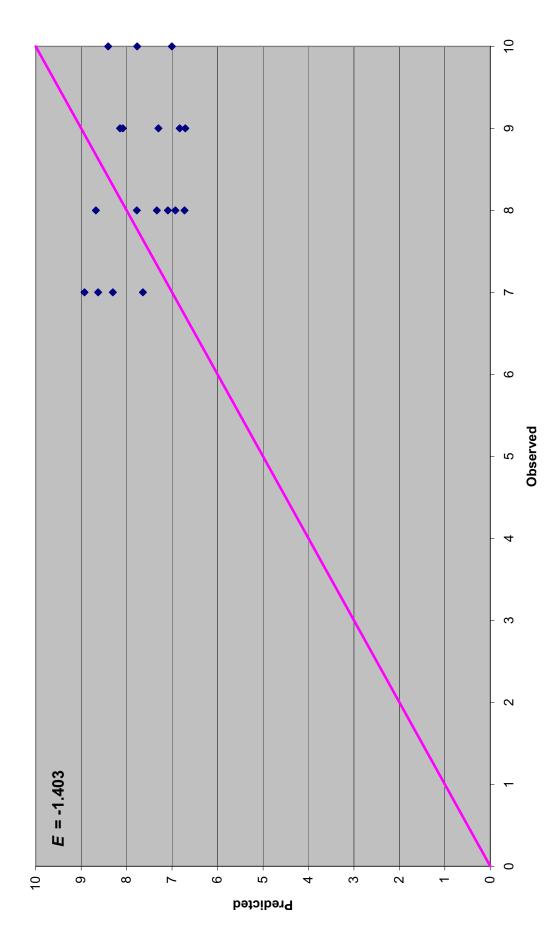


Figure 5. Map of Wanaque watershed and drainage area to each SVAP location.









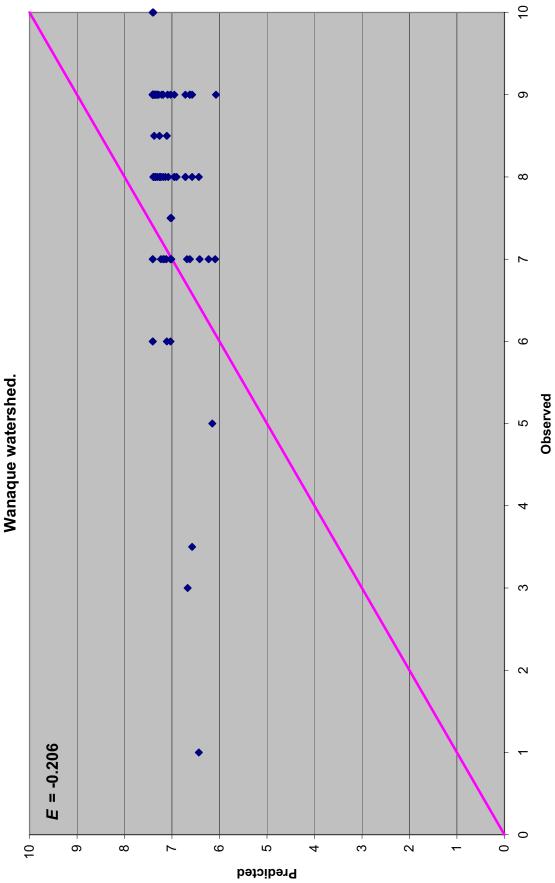
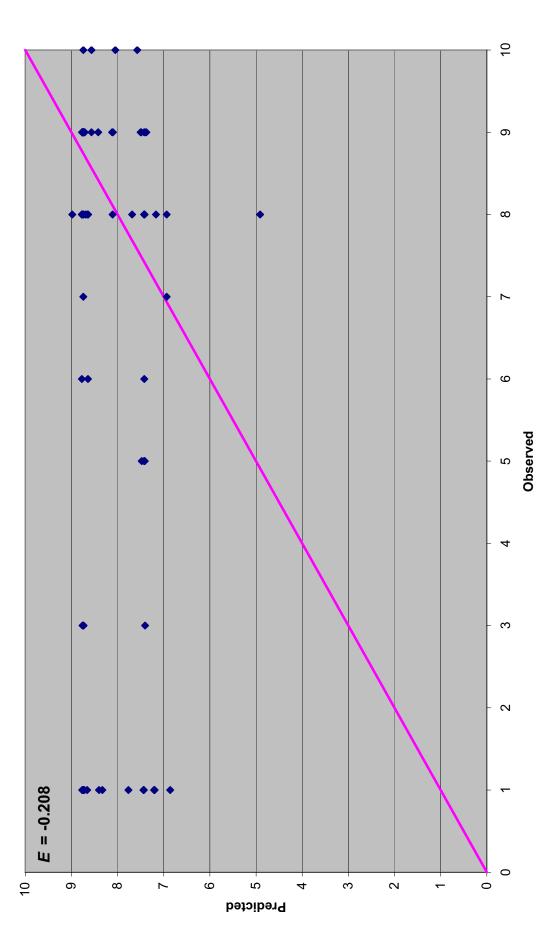
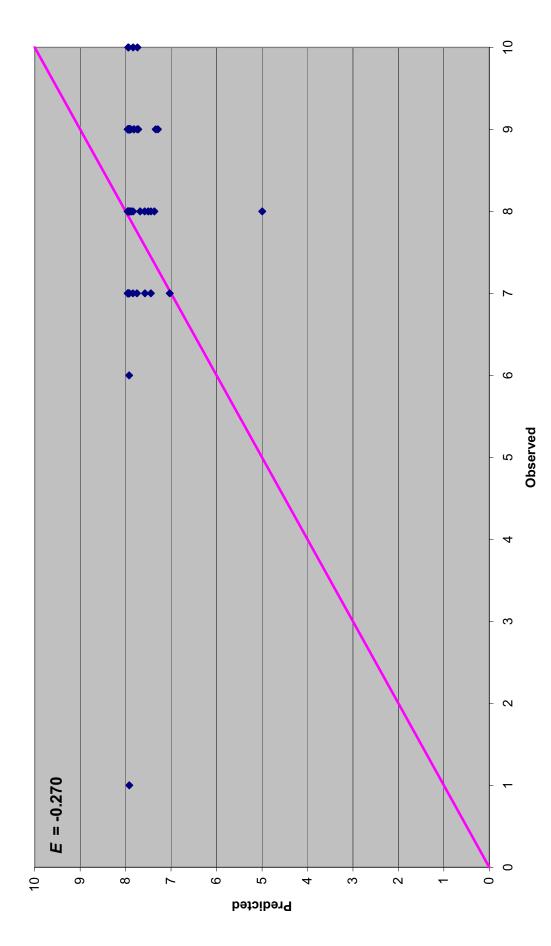


Figure 6b. Plot of predicted versus observed Bank Stability SVAP scores for

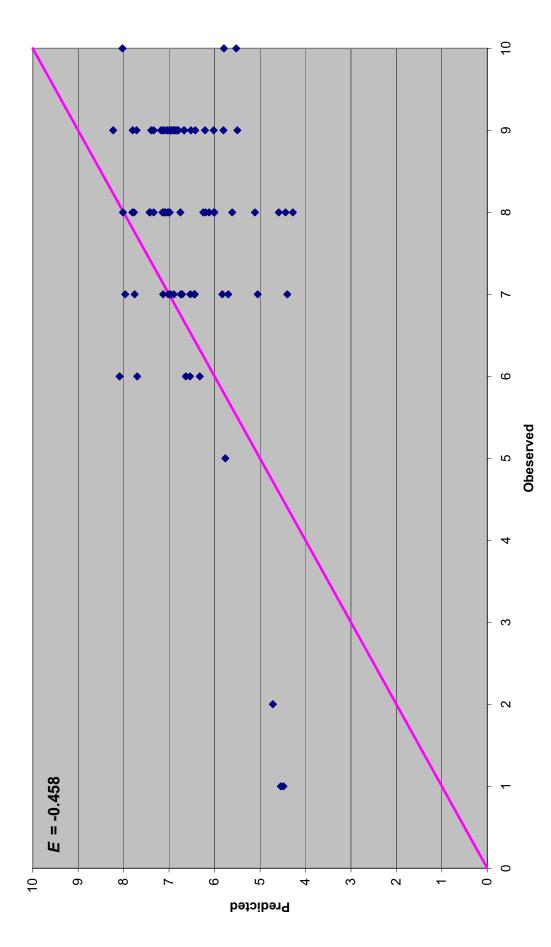




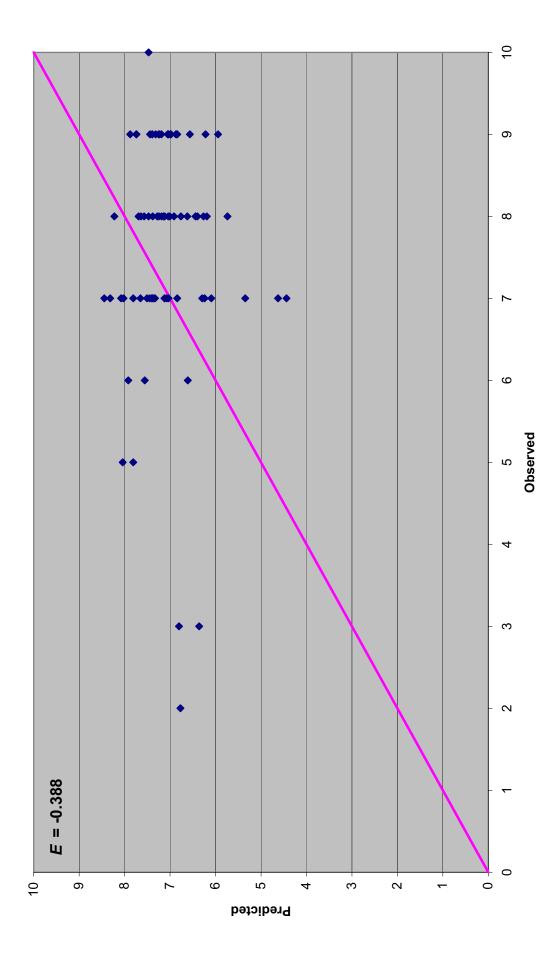


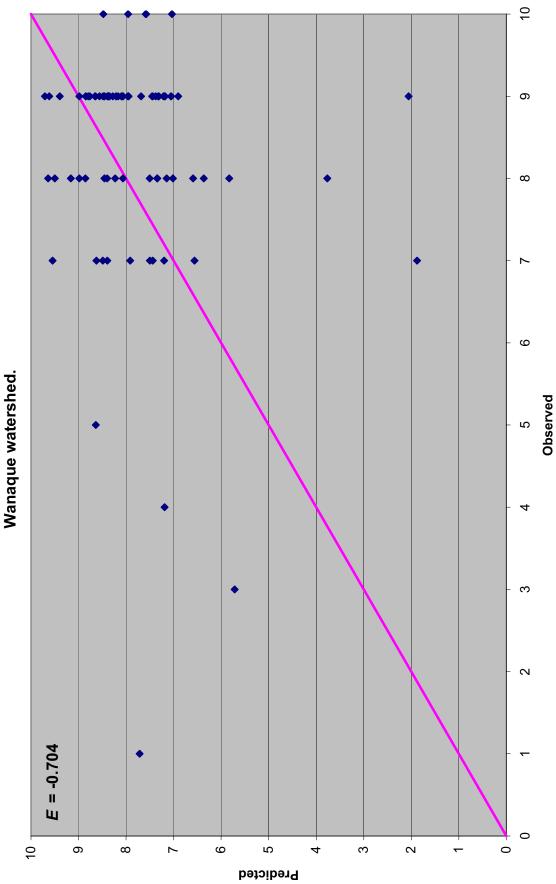






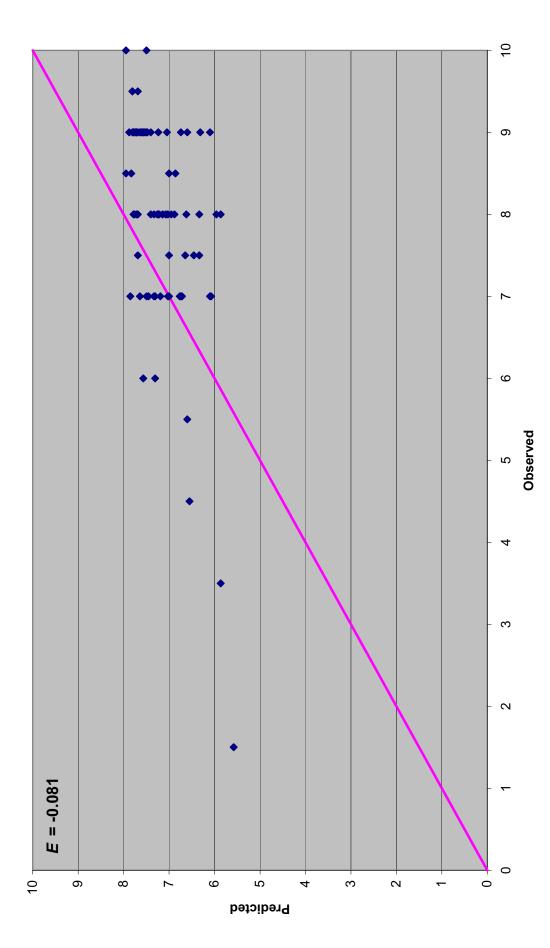












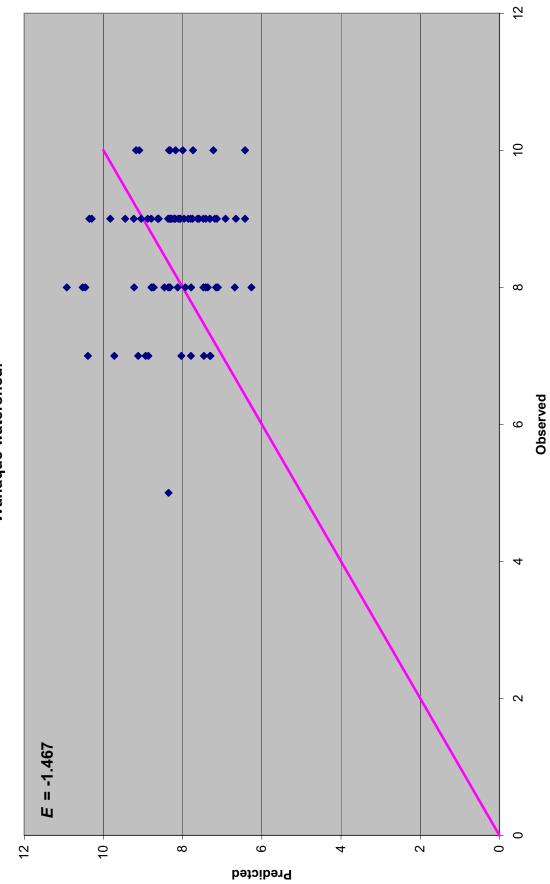
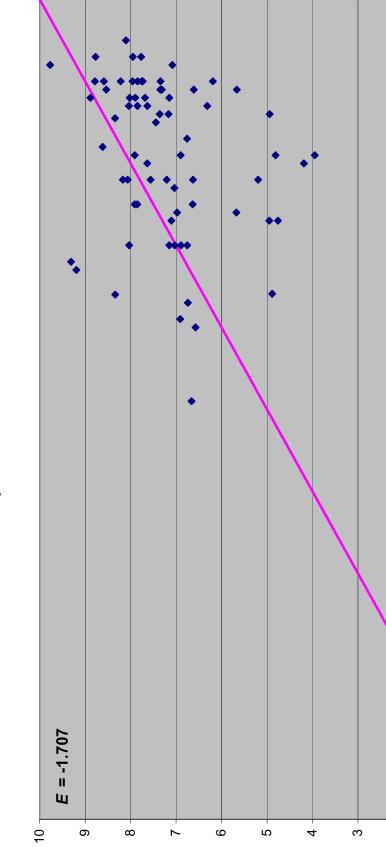


Figure 6i. Plot of predicted versus observed Water Appearance SVAP scores for Wanaque watershed.





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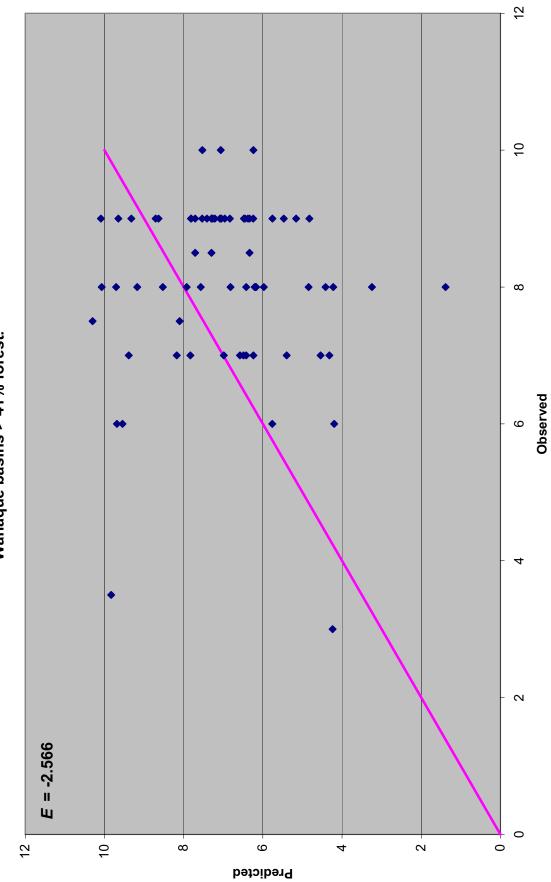
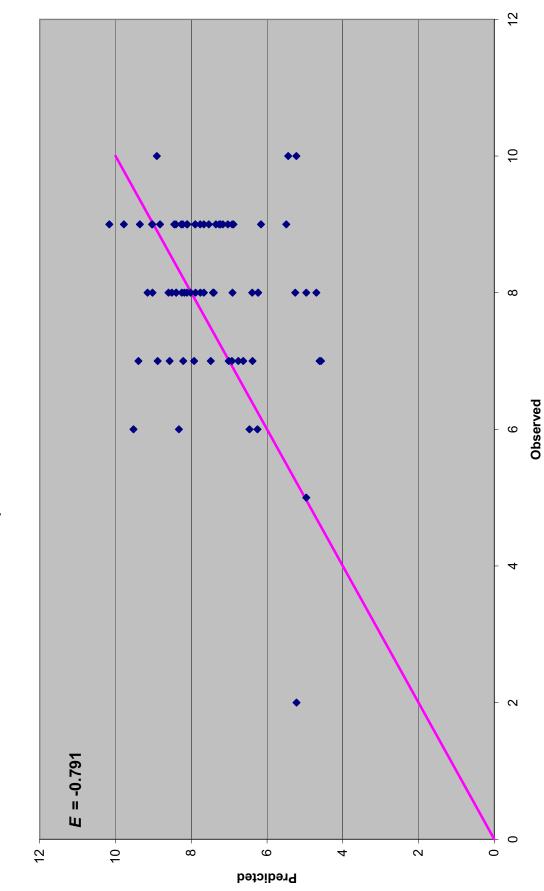
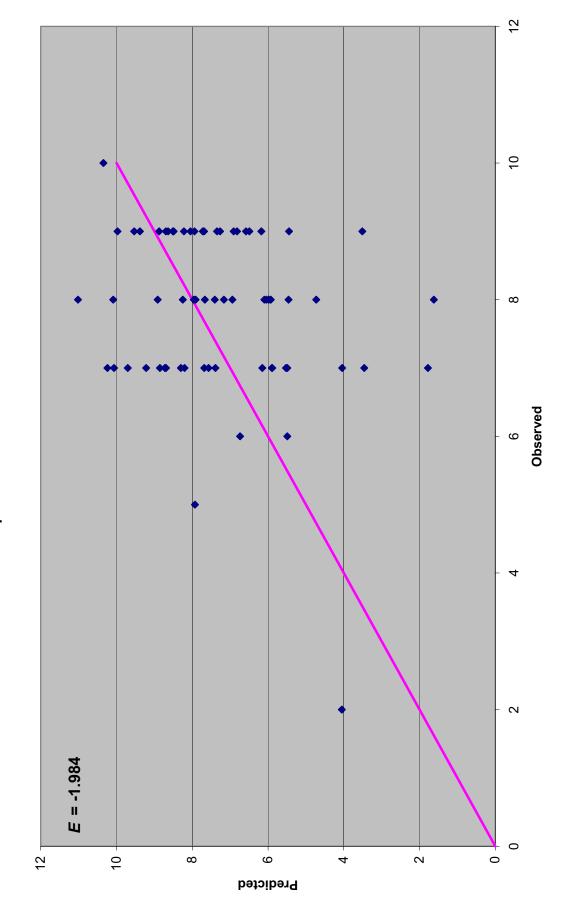


Figure 6k. Plot of predicted versus observed Bank Stability SVAP scores for Wanaque basins > 41% forest.

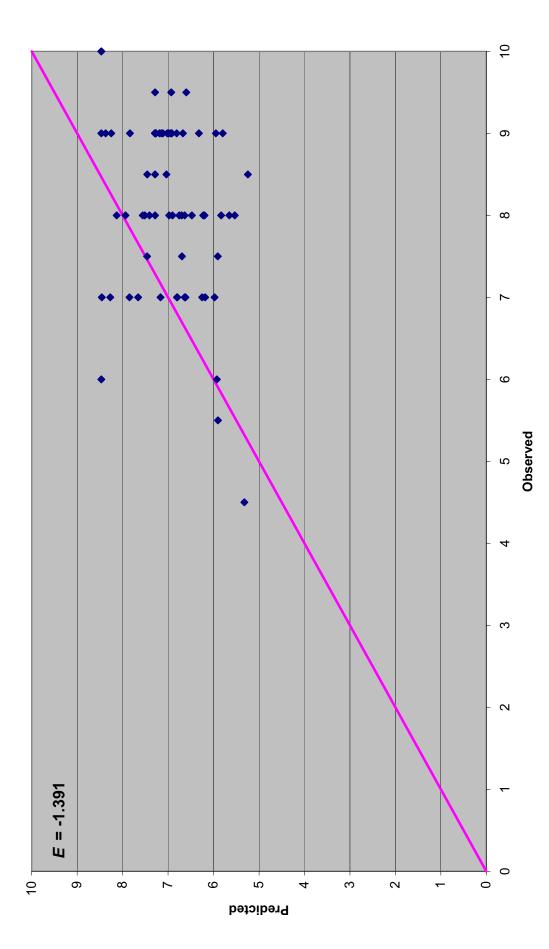












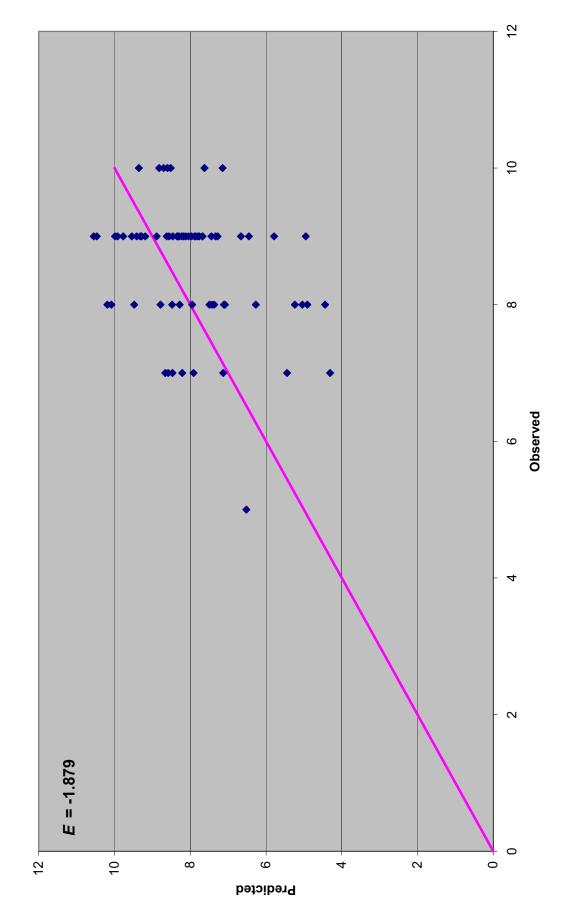
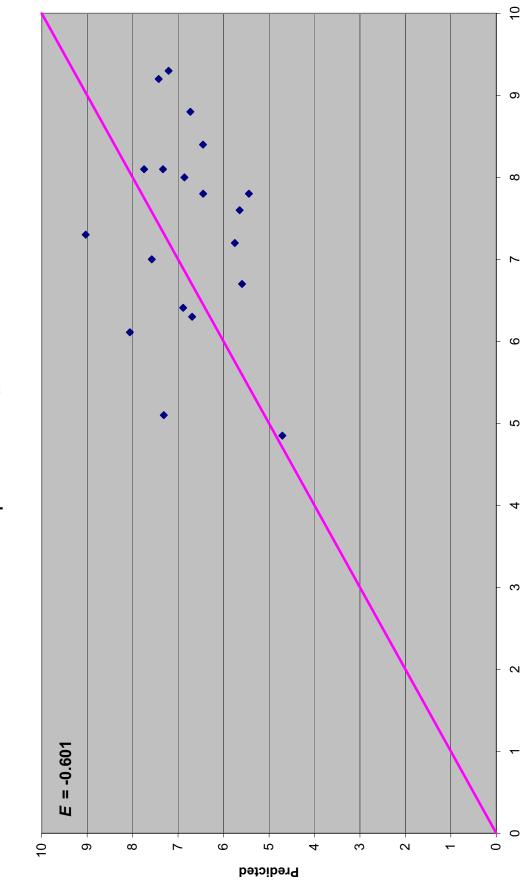


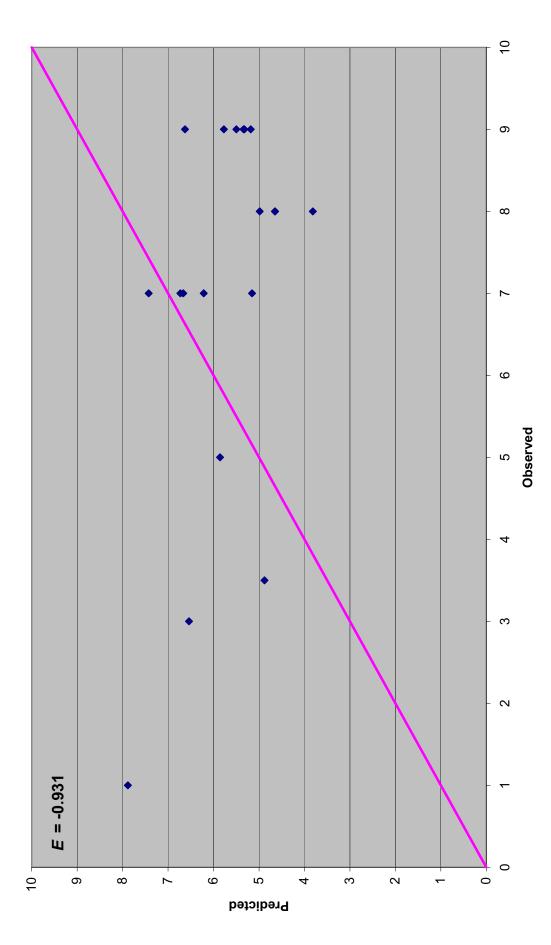
Figure 6o. Plot of predicted versus observed Water Appearance SVAP scores for Wanaque basins > 41% forest.





Observed







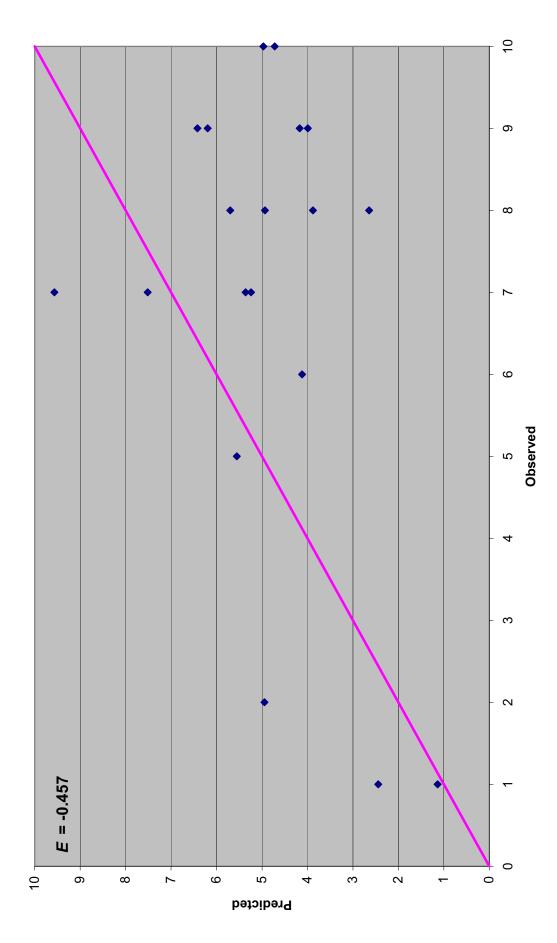
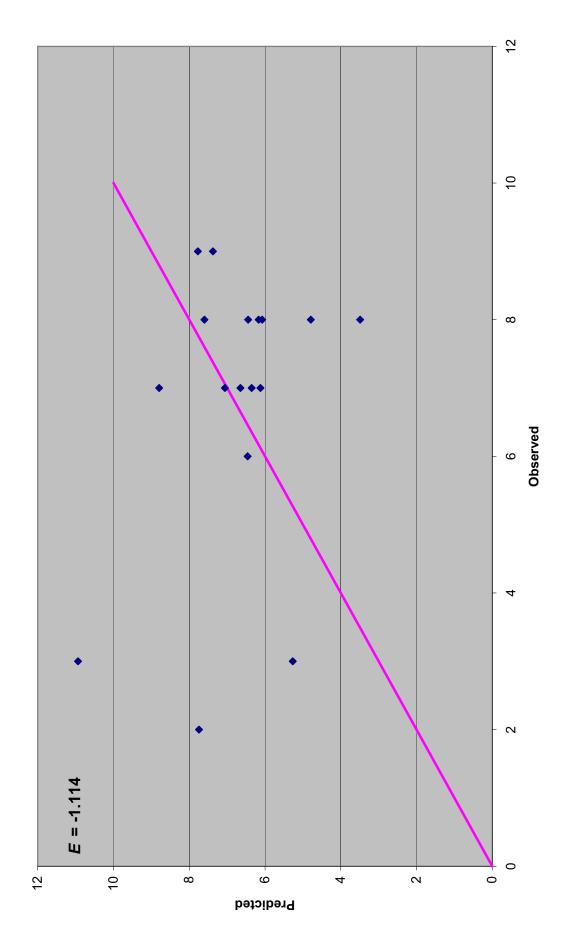
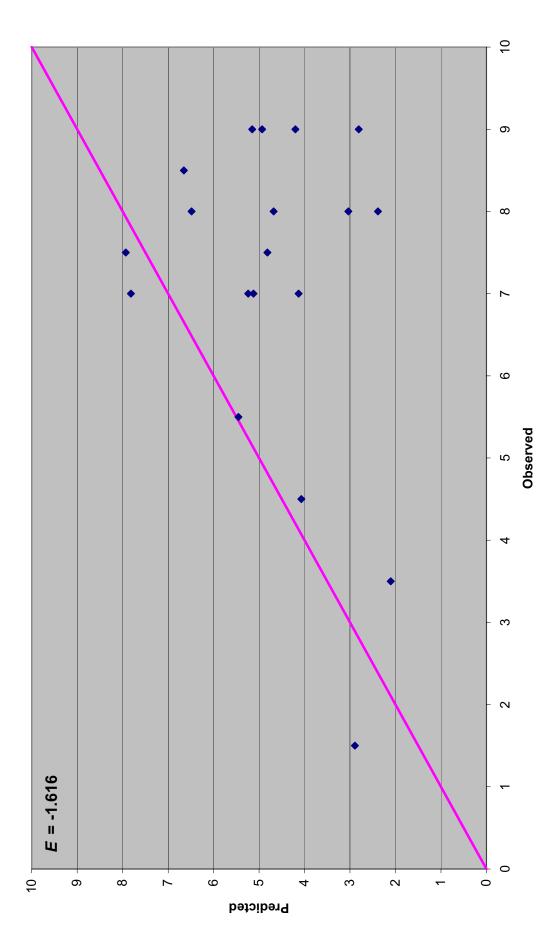


Figure 6s. Plot of predicted versus observed Hydrologic Alteration SVAP scores for Wanaque basins > 43% urban.







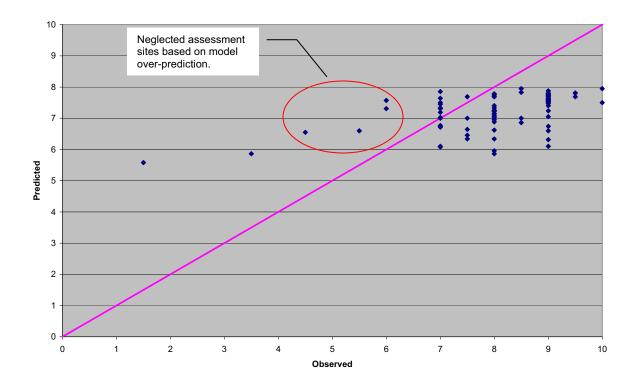


Figure 7. Regression model over-prediction. If only sites with predicted scores less than 6 are targeted, four sites with actual scores of 6 or below would be neglected.

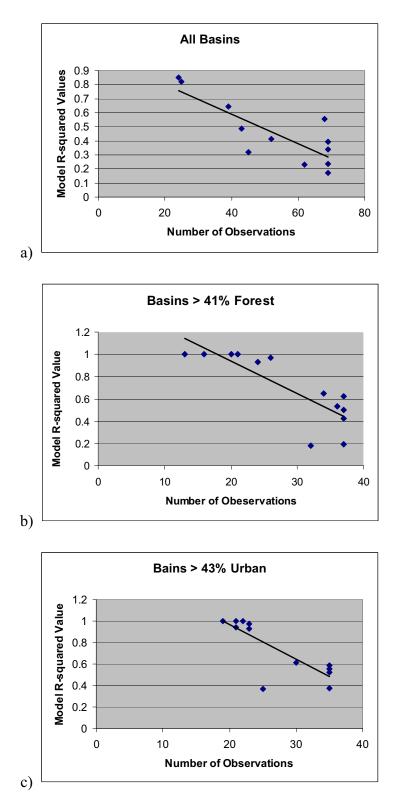


Figure 8. Inverse relationship between numbers of observations and model R-squared values for a) All basin data, b) basins greater than 41 percent forest, and c) basins greater than 43 percent urban.

APPENDIX

						SVAP	SVAP	SVAP			SVAP		SVAP
	Average	SVAP	SVAP	SVAP	SVAP	Water	Nutrient	Barriers to	SVAP		Inverte-	SVAP	Riffle
Sub-	SVAP	Channel	C	Riparian		Appear-	Enrich-	Fish		SVAP	brate	Canopy	Embedded
basin	Score	Condition	Alteration	Zone	Stability	ance	ment	Movement	Fish Cover	Pools	Habitat	Cover	ness
-	7.50		9	80						8			0
7	7.60			œ	4.5		8	8	8	œ			8
e	8.60			8			80			o		8	8
4	7.90		2	6			80	8	8	8		8	8
5	7.50		7	6						œ			7
9	7.00			4		2	2	10		4		7 10	0
2	8.10			8	8.0			8		6		6 0	7
œ	7.90			œ	8.0		80	8		7			8
ດ	6.70			7		8		8	8	8		8	Ø
10	6.50			9	6.0		0	0	0	7		0 7	0
-	7.40			7				8	8	8			8
12	6.60			9				0				0 7	7
13	7.00			8			80			0			0
14	6.80			9		2		0	0	7			0
15	7.20			7	6.0			0		8			0
16	6.90			7	6.0				0				0
17	7.90			8						8		8	8
18	7.40			8				0	0	8			8
19	7.10			7				9					8
20	7.60			7				0	8				0
21	6.60	2	9	7		8	0	0				0	0
22	9.10			10				6	6	6		6 6	6
23	6.80			7						8			8
24	7.30			7						8		0	0
25	8.05			8			0	0	0	8			0
26	8.30			8	7.0			0		о		ග ග	8
27	7.25			7		8	0						8
28	8.30			80				0	0	8			8
29	4.80		5	4	5.0			0	0	0		0 0	0
30	5.00			4				0		0		0 0	0
31	5.20			5		9			0				0
32	6.70			7			7	7		7			9
33				2									0
34	7.40		7	8	9				0			8	7
35	8.00			8		0	0	0		ດ			0

Appendix A: SVAP data collected for the Ramapo Watershed. A zero indicates no score was recorded. Page 1 of 2

						SVAP	SVAP	SVAP		SVAP		SVAP
	Average	SVAP	SVAP	SVAP	SVAP	Water	Nutrient	iers to	SVAP	Inverte-	SVAP	Riffle
Sub-	SVAP	Channel	C	Riparian	Bank	Appear-	Enrich-	Fish		brate	Canopy	Embedded
basin	Score	Condition	Alteration	Zone	Stability	ance	ment	Movement	Fish Cover Pools	Habitat	Cover	ness
36	8.10	8	8	8		6	8	5	6	6 6	0	0
37	7.30		8	7	7.0	6	0	9	0	0	0	0
38	7.00			7	6.0		0	0	2 0	2 0		0
39	9.10	6		6	9.0	10	0	0	0	6 6	0	0
40	9.10		6	6	9.0	10		6	9 10			0
41	6.50			9		2	7	2		0		0
42	7.10	9	2	9	7.0	8	8	8	2 0	0	0	0
43	5.55		5	9	4.5	7	7 7	0	0 0	0		0
44	6.70			7	6.5		0	0	0	0	0	0
45	7.40		2	8	7.0	8	0	0	0	0	0	0
46	7.00		2	7	6.0		0	0	0	0		0
47	7.35			7	7.0		6	0	0	0		0
48	7.00			9	6.0			8		8 7		7
49	6.90		∞	5	8.0		5	0	8	8		0
50	6.60			7	6.0		0	2		7 7		7
51	7.00			7	0.9			0		2 0		0
52	6.50		9	7	6.0		7	7		8		0
53	7.75	7		8			8 0	8		8	0	0
54	7.45			7	0.7		0	8	8	8 7		7
55	7.05		9	9	7.0		8	6	9	8		0
56	6.97			7	6.5	2		8	0	8	7	7
57	7.00			7	7.0			8	0	8 0		0
58	6.50			9				8		0		0
59	6.25		9	7		2	7	3	7 C	0 0	0	0
60	4.80			5	4.5			1		6 7		0
61	4.60			9				1		9 2	8	0
62	3.60			5	6.5	-		1	2	0 6		0
63	3.40	1	0	5		~		1	4 C	0 2		0
64	6.90			80	7.5	8	0	5	0	0		0
65	5.00			3	5.0	6) 4	10	3	3 3	10	0
99	3.32	5	3	3				1		2		0
67	7.10			4	8.0	6) 8	9	5 2		10	0
68	8.40			6	8	10	10	1			9	10
69	8.90	10	0	10	8.5	6	10	10	8	6 10		6

Appendix A: SVAP data collected for the Ramapo Watershed. A zero indicates no score was recorded. Page 2 of 2

Drainage% DrainageCumArea (ha)AreaLe290.05950.0000299.05990.0000235.77070.01938.81840.000731.25900.000731.25900.000731.25900.00082100.79780.010431.25900.0026100.79780.010431.25900.00260100.79780.010431.25900.00260100.79780.010433.04660.002733.04660.002733.04660.00271126.64390.01104275.78820.022633.04660.0027126.63330.0027126.63340.0027187.54400.007835.36360.0027187.54400.007835.36340.0026533.04660.0027187.54400.00144275.78820.0027187.54400.00173187.54410.00265187.54410.0013187.54940.00113187.64940.01148320.58940.0027181.18230.01148320.58940.00265181.18230.0013181.18230.0114830.28030.0114830.28030.0114830.28030.0113158.24120.001395.94410.0027895.94410.002895.94410.0013195.94410.0028 <td< th=""><th>%</th><th>%</th><th></th><th></th><th>Cumulative</th><th></th><th>Composite</th><th></th></td<>	%	%			Cumulative		Composite	
Area (ha) Area Le 290.0595 0.0237 0.0237 290.0595 0.0237 0.0237 0.0999 0.00001 49.8846 0.0026 49.88184 0.00013 8.8184 0.0001 235.7707 0.01933 8.8184 0.0001 31.2590 0.0026 0.0026 100.7578 31.2590 0.00082 0.0104 1 31.2590 0.00260 0.0037 1 349.8011 0.02260 100.0260 1 317.8430 0.01044 1 1 349.8011 0.02260 1 1 340.41307 0.01044 1 1 317.8430 0.02255 1 1 317.8430 0.00277 1 1 404.4194 0.0037 1 1 317.8430 0.00265 1 1 317.8456 0.0027 1 1 3187.5440 0.0026 1 1	Cumulative Cumulative	tive Cumulative	Reach	% Reach	Reach	Reach	Reach	Reach
290.0595 0.0237 290.0595 0.0020 49.8846 0.0001 8.8184 0.0007 8.8184 0.0007 8.8184 0.0006 31.2590 0.0026 100.7978 0.0103 8.8184 0.0007 8.8184 0.0006 126.9734 0.0104 31.2590 0.0026 126.9734 0.0104 317.8430 0.0260 317.8430 0.0260 317.8430 0.0260 317.8430 0.0104 317.8430 0.0260 317.8430 0.0260 317.8430 0.0260 126.6439 0.0104 317.8430 0.0225 330.466 0.0027 187.5440 0.0026 71.9656 0.0026 71.9656 0.0026 71.9656 0.0026 71.9656 0.0026 71.9656 0.0026 71.9656 0.0016	Length Area (ha)	na) Area	Length (m)	Length	Length (m)	Width (m)	Width (m)	Depth (m)
0.0999 0.0000 49.8846 0.0041 235.7707 0.0193 8.8184 0.0007 8.8184 0.0007 8.8184 0.0007 8.8184 0.0007 31.2590 0.0026 100.7978 0.0104 31.2590 0.0026 100.7978 0.0104 349.8011 0.0286 317.8430 0.0104 349.8011 0.0286 317.8430 0.0104 317.8430 0.0260 126.6439 0.0104 317.8430 0.0260 126.6439 0.0104 317.8430 0.0260 187.5440 0.0331 275.7882 0.0027 33.0466 0.0037 33.0466 0.0037 35.3636 0.0026 71.9656 0.0027 37.95634 0.0026 71.9656 0.0026 71.9656 0.0026 71.9656 0.0026	0.0447 339.9440	9440 0.0278	3955.0872	0.0442	4000.4128	2.6880	2.4183	0.2121
49.8846 0.0041 235.7707 0.0193 8.8184 0.0007 8.8184 0.00026 31.2590 0.0026 100.7978 0.0104 100.7978 0.00022 100.7978 0.0104 100.7978 0.01041 100.7978 0.01041 317.8430 0.0260 317.8430 0.0260 126.6439 0.010417 349.8011 0.0260 126.6439 0.010417 510.1307 0.0417 510.1307 0.0417 510.1307 0.0275 126.6439 0.0027 187.5440 0.0027 187.5440 0.0027 275.7882 0.0027 187.5440 0.0078 187.5440 0.0078 187.5440 0.0078 187.5440 0.0078 187.5444 0.0078 187.5494 0.0078 170.6567 0.0078 126.7337 0.0114 320.5894 0.0262 137.6494 0.0114 320.5894 0.0026 128.737 0.0114 320.5894 0.0026 126.7337 0.0114 320.5894 0.0026 126.7337 0.0114 320.5894 0.0026 126.7337 0.0114 126.7337 0.0114 126.7337 0.0013 126.7337 0.0013 126.8393 0.0013 126.8393 0.0113 $160.$	0.0448 340.0439	0.0278 0.0278	9.9934	0.0001	4010.4062	2.6885	2.4184	0.2121
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	0.0005	49.8846 0.0041	45.3256	0.0005	45.3256	0.8499	0.8499	0.0984
8.8184 0.0007 31.2590 0.0026 100.7978 0.0082 100.7978 0.0082 126.9734 0.0104 349.8011 0.0286 347.8430 0.0260 317.8430 0.0260 126.6439 0.0104 510.1307 0.0417 510.1307 0.0275 510.1307 0.0417 725.7882 0.0225 33.0466 0.0027 187.5440 0.0153 44.9211 0.0027 187.5440 0.0078 71.9656 0.0027 71.9656 0.0027 35.3636 0.0027 187.5440 0.0113 250.3915 0.0078 95.7644 0.0078 110.8945 0.0078 320.5894 0.0205 137.6494 0.0114 320.5894 0.0207 181.1823 0.0114 32.6871 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 95.9441 0.0114 $95.03.1799$ 0.0411	0.0181 275.8481	3481 0.0225	1238.0107	0.0138	1624.5339	2.3713	2.1234	0.1951
31.2590 0.0026 100.7978 0.0082 126.9734 0.0104 126.9734 0.0104 349.8011 0.0286 317.8430 0.0260 317.8430 0.0260 317.8430 0.0260 317.8430 0.0260 317.8430 0.00260 317.8430 0.0104 510.1307 0.0104 510.1307 0.0225 33.0466 0.0225 33.0466 0.0027 187.5440 0.0153 71.9656 0.0029 71.9656 0.0020 71.9656 0.0020 71.9656 0.0020 71.9656 0.0020 71.9656 0.0014 71.9656 0.0020 71.9656 0.0016 71.9657 0.0014 71.9658 0.00113 71.9650 0.00113 71.9650 0.00113 7260.3915 0.0113 250.3915 0.0113 126.7837 0.0113 250.3803 0.0113 7.5501 0.00262 160.6393 0.0113 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 <t< td=""><td>0.0043</td><td>40.0774 0.0033</td><td>8 297.0844</td><td>0.0033</td><td>386.5232</td><td>0.7453</td><td>0.6648</td><td>0.0902</td></t<>	0.0043	40.0774 0.0033	8 297.0844	0.0033	386.5232	0.7453	0.6648	0.0902
100.79780.0082126.97340.0104 349.8011 0.0260 349.8011 0.0260 317.8430 0.0260 317.8430 0.0260 126.6439 0.0104 510.1307 0.0417 510.1307 0.0417 510.1307 0.0104 510.1307 0.0104 510.1307 0.0104 510.1307 0.0104 74.9211 0.0027 187.5440 0.0153 35.3636 0.0029 71.9656 0.0029 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.00713 71.9656 0.00713 71.9656 0.00713 71.9656 0.0014 71.9656 0.0013 71.9656 0.0013 71.9656 0.0016 71.9656 0.0013 71.9656 0.0013 71.9656 0.0013 71.9656 0.0013 71.9656 0.0013 726.3803 0.0113 75.601 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 <	0.0010	31.2590 0.0026	89.4388	0.0010	89.4388	0.6421	0.6421	0.0816
126.9734 0.0104 349.8011 0.0286 317.8430 0.0260 317.8430 0.0260 317.8430 0.0260 126.6439 0.010417 510.1307 0.0417 510.1307 0.0417 510.1307 0.0417 510.1307 0.0225 33.0466 0.0027 33.0466 0.0027 187.5440 0.0153 44.9211 0.0029 71.9656 0.0029 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9650 0.0114 7260.3915 0.0114 322.6871 0.0027 181.1823 0.0113 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 95.9441 0.0131 95.9422 0.0228 95.031799 0.0411	0.0033 100.7978	7978 0.0082	298.6520	0.0033	298.6520	1.2962	1.2962	0.1304
349.8011 0.0286 317.8430 0.0260 126.6439 0.0104 510.1307 0.0417 510.1307 0.0417 510.1307 0.0331 275.7882 0.0331 275.7882 0.0027 187.5440 0.0337 33.0466 0.0027 187.5440 0.0027 71.9656 0.0029 71.9656 0.0029 71.9656 0.0029 71.9656 0.0029 71.9656 0.0026 71.9656 0.0029 71.9656 0.0026 71.9656 0.0026 71.9656 0.0026 71.9656 0.0026 71.9657 0.0104 7250.3915 0.0104 322.6871 0.0027 181.1823 0.0113 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 95.9441 0.0013 95.9441 0.0013 95.9441 0.00131 950.1799	0.0238 227.7712	712 0.0186	1835.3146	0.0205	2133.9666	2.1139	1.7520	0.1807
317.8430 0.0260 126.6439 0.0104 510.1307 0.0417 510.1307 0.0417 510.1307 0.0331 275.7882 0.0331 275.7882 0.0225 33.0466 0.0027 187.5440 0.0027 187.5440 0.0029 71.9656 0.0029 71.9656 0.0029 95.7644 0.0078 110.8945 0.0078 71.9656 0.00209 71.9656 0.00209 71.9656 0.00209 71.9657 0.0014 35.3634 0.00104 71.9656 0.00205 110.8945 0.00114 320.5894 0.0205 137.6494 0.0113 32.6871 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 95.9441 0.0013 95.9441 0.0013 95.03.1799 0.0411	0.1009 1304.4187	1187 0.1066	1396.1913	0.0156	9032.1342	6.0234	4.5536	0.3632
126.6439 0.0104 510.1307 0.0417 510.1307 0.0417 404.4194 0.0331 275.7882 0.0225 33.0466 0.0027 187.5440 0.0153 35.3636 0.0029 71.9656 0.0059 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9657 0.0104 7250.3915 0.0104 250.3915 0.01037 137.6494 0.0104 137.6494 0.0113 126.7837 0.01037 320.5894 0.0262 137.6494 0.0113 250.3179 0.0013 7.5501 0.0027 160.6393 0.0131 95.9441 0.0013 95.9441 0.0078 95.9441 0.0078 95.9441 0.0013 95.9442 0.0013 95.0411 0.0078 95.0411 0.00411	0.0853	3176 0.0780	~	0.0233	7635.9429	4.9944	4.0151	0.3205
510.1307 0.0417 404.4194 0.0331 275.7882 0.0331 275.7882 0.0331 275.7882 0.0225 33.0466 0.0027 187.5440 0.0153 35.3636 0.0029 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.00718 71.9656 0.00148 71.9656 0.00104 732.6871 0.01104 320.5894 0.0113 32.6871 0.0113 75601 0.0025 181.1823 0.0113 7.5501 0.0013 7.5501 0.0078 7.5501 0.0078 7.5501 0.0078 95.9441 0.0078 95.9441 0.0131 95.9412 0.0411	0.0620 636.7746	746 0.0520	494.2343	0.0055	5547.3630	3.9172	3.5263	0.2726
404.4194 0.0331 275.7882 0.0225 33.0466 0.0027 187.5440 0.0153 187.5440 0.0153 44.9211 0.0037 35.3636 0.0029 71.9656 0.0059 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.0659 0.0078 71.0564 0.0078 71.0567 0.0071 250.3915 0.0104 250.3915 0.0205 126.7837 0.0104 250.3915 0.0205 137.6494 0.0113 320.5894 0.0205 137.6493 0.0205 137.6494 0.0113 32.6871 0.0262 137.6493 0.0113 75.611 0.0025 75501 0.0013 75501 0.0013 75501 0.0013 75503 0.0131 95.9441 0.0078 9503.1799 0.	0.0565 510.1307	1307 0.0417	5053.1287	0.0565	5053.1287	3.4292	3.4292	0.2495
275.7882 0.0225 33.0466 0.0027 187.5440 0.0153 44.9211 0.0037 35.3636 0.0029 71.9656 0.0029 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.9656 0.0078 71.0657 0.0014 35.36345 0.00104 250.3915 0.0104 250.3915 0.0104 322.6871 0.0205 137.6494 0.0113 32.6871 0.0148 32.6871 0.0027 181.1823 0.0148 7.5501 0.0026 158292 0.0131 7.5501 0.0013 7.5501 0.0016 160.6393 0.0131 95.9441 0.0131 95.03.1799 0.0411	0.0837 900.7983	7983 0.0736		0.0361	7487.8168	4.8235	3.6144	0.3132
33.0466 0.0027 187.5440 0.0153 44.9211 0.0037 35.3636 0.0029 71.9656 0.0059 95.7644 0.0078 110.8945 0.0078 71.9656 0.0078 71.9656 0.0078 71.0657 0.0078 71.0678 0.0078 71.0678 0.0078 71.0844 0.0104 320.5894 0.0262 137.6494 0.0113 320.5893 0.0113 320.5894 0.0262 137.6494 0.0113 32.6871 0.0027 181.1823 0.0113 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 95.9441 0.0078 95.031799 0.0411	0.0475 496.3788	3788 0.0406	3 2497.1597	0.0279	4253.8862	3.3735	2.6293	0.2468
187.5440 0.0153 44.9211 0.0037 35.3636 0.0029 71.9656 0.0059 71.9656 0.0059 95.7644 0.0078 10.8945 0.0078 110.8945 0.0091 250.3915 0.0205 126.7837 0.0104 220.5894 0.0262 137.6494 0.0113 320.5894 0.0162 137.6494 0.0113 32.6871 0.0113 32.6871 0.0027 181.1823 0.0113 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 7.5501 0.0013 $7.503.1799$ 0.0411	0.0017	33.0466 0.0027	151.4692	0.0017	151.4692	0.6638	0.6638	0.0835
44.9211 0.0037 35.3636 0.0029 71.9656 0.0059 95.7644 0.0078 110.8945 0.0078 110.8945 0.0091 250.3915 0.00091 250.3915 0.0104 126.7837 0.0104 320.5894 0.0262 137.6494 0.0113 320.5893 0.0113 320.5894 0.0262 137.6494 0.0113 32.6871 0.0262 137.6493 0.0113 32.6871 0.0262 137.6494 0.0113 32.6871 0.0262 156.6871 0.0027 160.6393 0.0131 95.9441 0.0078 95.9441 0.0078 95.9442 0.0411	s 0.0179 187.5440	5440 0.0153	1605.2573	0.0179	1605.2573	1.8813	1.8813	0.1672
35.3636 0.0029 71.9656 0.0059 95.7644 0.0078 110.8945 0.0091 250.3915 0.0091 250.3915 0.0205 126.7837 0.0104 320.5894 0.0262 137.6494 0.0113 32.6871 0.0262 137.6494 0.0113 32.6871 0.0262 137.6494 0.0113 32.6871 0.0025 137.6494 0.0113 32.6871 0.0026 158292 0.0131 15.8292 0.0131 15.8293 0.0131 95.9441 0.0078 95.9441 0.0078 95.9442 0.0131 95.9441 0.0131 95.9342 0.0228 95.031799 0.0411	0.4012 45	2429 0.3705		0.0077	35909.3913	12.7185	4.7242	0.5977
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	0.0041	35.3636 0.0029	367.8958	0.0041	367.8958	0.6914	0.6914	0.0858
95.7644 0.0078 95.7644 0.0078 110.8945 0.0091 250.3915 0.0205 126.7837 0.0104 320.5894 0.0262 137.6494 0.0113 320.5893 0.0113 320.5894 0.0262 137.6494 0.0113 32.6871 0.0277 181.1823 0.0148 30.2803 0.0025 15.8292 0.0013 7.5501 0.0013 7.5501 0.0013 95.9441 0.0078 95.9441 0.0228 95.9441 0.0131 95.03.1799 0.0411	0.0241 167.7300	7300 0.0137	1214.4727	0.0136	2155.8403	1.7594	1.4725	0.1599
110.8945 0.0091 250.3915 0.0205 126.7837 0.0104 320.5894 0.0262 137.6494 0.0113 32.6871 0.0113 32.6871 0.01148 32.6871 0.0027 181.1823 0.01148 30.2803 0.0113 15.8292 0.0013 15.8292 0.0013 7.5501 0.0006 160.6393 0.0131 95.9441 0.0078 278.8242 0.0411 503.1799 0.0411	0.0105	95.7644 0.0078	941.3676	0.0105	941.3676	1.2569	1.2569	0.1278
250.3915 0.0205 126.7837 0.0104 320.5894 0.0104 320.5894 0.0113 320.5894 0.0113 32.6871 0.0277 32.6871 0.0027 32.6871 0.0013 32.5803 0.0148 30.2803 0.0013 15.8292 0.0013 7.5501 0.0006 160.6393 0.0131 95.9441 0.0078 278.8242 0.0411 503.1799 0.0411		3591 0.0661	1315.2393	0.0147	6369.7886	4.5212	3.4271	0.3000
126.7837 0.0104 320.5894 0.0262 320.5894 0.0262 137.6494 0.0113 32.6871 0.0027 181.1823 0.0148 30.2803 0.0137 15.8292 0.0013 15.8292 0.0013 7.5501 0.0016 160.6393 0.0131 95.9441 0.0078 503.1799 0.0411		7646 0.0570	1400.0365	0.0156	5054.5493	4.1382	3.2532	0.2828
320.5894 0.0262 137.6494 0.0113 32.6871 0.0113 32.58871 0.0027 181.1823 0.0148 30.2803 0.0013 15.8292 0.0013 7.5501 0.0006 160.6393 0.0131 95.9441 0.0078 503.1799 0.0411	0.0408 447.3731	3731 0.0366	1090.8280	0.0122	3654.5128	3.1695	2.7579	0.2367
137.6494 0.0113 32.6871 0.0027 32.6871 0.0025 181.1823 0.0148 30.2803 0.0125 15.8292 0.0013 7.5501 0.0016 160.6393 0.0131 95.9441 0.0078 278.8242 0.0228 503.1799 0.0411		5894 0.0262	2563.6848	0.0286	2563.6848	2.5951	2.5951	0.2072
32.6871 0.0027 181.1823 0.0148 30.2803 0.0148 30.2803 0.0013 15.8292 0.0013 7.5501 0.0006 160.6393 0.0131 95.9441 0.0078 278.8242 0.0228 503.1799 0.0411	0.0420 3	7991 0.0312	14	0.0159	3756.7249	2.8820	2.2362	0.2222
181.1823 0.0148 30.2803 0.0025 30.2803 0.0013 15.8292 0.0013 7.5501 0.0006 160.6393 0.0131 95.9441 0.0078 278.8242 0.0228 503.1799 0.0411	0.0002	32.6871 0.0027	21.1993	0.0002	21.1993	0.6595	0.6595	0.0831
30.2803 0.0025 15.8292 0.0013 7.5501 0.0006 160.6393 0.0131 95.9441 0.0078 278.8242 0.0228 503.1799 0.0411	s 0.0214 213.8694	3694 0.0175	1890.9278	0.0211	1912.1271	2.0355	1.8252	0.1762
15.8292 0.0013 7.5501 0.0006 160.6393 0.0131 95.9441 0.0078 278.8242 0.0228 503.1799 0.0411	0.0261 244.1497	1497 0.0200	423.5700	0.0047	2335.6971	2.2039	1.8722	0.1858
7.5501 0.0006 160.6393 0.0131 95.9441 0.0078 278.8242 0.0228 503.1799 0.0411	0.0329 184.0186	0.0150 0.0150	780.6151	0.0087	2941.3660	1.8600	1.7289	0.1659
160.6393 0.0131 95.9441 0.0078 278.8242 0.0228 503.1799 0.0411	0.0241 168.1894	1894 0.0137	160.6054	0.0018	2160.7509	1.7623	1.7166	0.1601
95.9441 0.0078 278.8242 0.0228 503.1799 0.0411	0.0223 160.6393	3393 0.0131	2000.1455	0.0223	2000.1455	1.7144	1.7144	0.1571
278.8242 0.0228 503.1799 0.0411	0.0740			0.0042	6626.8992	5.1189	4.0145	0.3258
503.1799 0.0411	0.0660	3354 0.0732		0.0131	5908.9638	4.8060	3.8932	0.3124
	0.0399		35	0.0399	3574.5651	3.4011	3.4011	0.2481
35 2.1971 0.0002 0.0	0.0134 244.8388	3388 0.0200	64.1001	0.0007	1196.4695	2.2076	1.8267	0.1860

Appendix B: Ramapo Watershed variables for the 69 subbasins determined using GIS. Page 1 of 6

Drainage Normange		Subbasin		%		%			Cumulative		Composite	
Area Ional Length Area Ional Ional <thi< th=""><th>Sub-</th><th>Drainage</th><th>% Drainage</th><th>Cumulative</th><th>Cumulative</th><th>Cumulative</th><th>Reach</th><th>% Reach</th><th>Reach</th><th>Reach</th><th>Reach</th><th>Reach</th></thi<>	Sub-	Drainage	% Drainage	Cumulative	Cumulative	Cumulative	Reach	% Reach	Reach	Reach	Reach	Reach
113.2143 0.0008 0.0127 2.26417 0.0198 499.4372 0.0004 113.2684 2.1627 1.8223 132.2184 0.0013 0.0163 2.22.384 0.0193 175.3683 0.0014 1.32.364 2.0157 1.8223 155.415 0.0014 0.15206 0.00449 168.894 0.0016 1475.666 2.0331 1.7524 56.5205 0.00449 168.804 0.0065 1486.5150 7.7386 5.6956 54.1689 0.0040 0.1271 192.4825 0.1465 192.4825 0.1465 3.2446 5.5244 531.7860 0.0123 193.685.447 0.1541 141.2834 0.4463 3.2469 3.541 531.7860 0.0124 0.1541 141.2844 0.4663 3.541 3.554 531.7860 0.0124 0.1541 141.2844 0.461 3.651 4.455 531.7860 0.0166 171.7864 0.1541 141.2864 3.696 3.641 531.7860	basin	Area (ha)	∢	Length	Area (ha)	Area	Length (m)	Length	Length (m)	Width (m)	Width (m)	Depth (m)
122.2184 0.0101 0.0201 0.0165 122.2184 0.0101 122.2184 0.0165 14522 14523 158.4125 0.0003 0.0166 2.22.2688 0.0019 186.1084 0.0969 130.2681 0.9643 1.7575 66.5206 0.0049 0.0146 218.3228 0.0179 86.1084 0.0969 130.2681 0.9643 1.7575 66.5206 0.0049 0.0141 1330.7882 0.1475 52.3272 0.0061 1.7575 831.7788 0.0031 0.1218 1326.4286 0.1495 53.3471 0.0431 1.7554 831.7788 0.0036 0.1147 1330.7883 0.1495 34.12.8884 3.4893 3.4983 31.8801 0.0138 0.1356 0.1324 134.7655 0.2344 3.4983 3.4983 31.72204 0.1387 0.1383 0.13246 0.1493 3.4574 3.4564 31.772391 0.1383 0.1383 0.1455 2.3347147 7.3663 4.6442 <th>36</th> <th>119.4233</th> <th></th> <th>0.0127</th> <th>242.6417</th> <th>0.0198</th> <th>409.4372</th> <th>0.0046</th> <th>1132.3694</th> <th>2.1957</th> <th>1.8232</th> <th>0.1853</th>	36	119.4233		0.0127	242.6417	0.0198	409.4372	0.0046	1132.3694	2.1957	1.8232	0.1853
3.3356 0.003 0.0165 2.22.2684 0.0182 1/0.5266 2.0631 1/524 61.306 0.0149 0.63.206 0.0147 66.306 0.0447 66.306 0.0447 66.306 0.0447 66.306 0.0447 66.306 0.0447 66.306 0.0447 66.306 0.0447 66.306 0.0447 66.306 0.0447 66.306 0.0447 66.306 0.0447 66.306 0.0447 66.306 0.0447 66.306 0.0446 0.5534 0.5534 8.31.7788 0.0043 0.1456 351.4770 0.0433 195.2066 0.2314 0.3468 0.3617 7.4619 7.3524 2.93.266 0.0043 0.156 0.1446 393.1476 0.0443 14.7645 0.361 2.93.266 0.0043 0.156 0.1446 393.1477 0.4413 2.964 4.365 2.93.267 0.1466 314.765 0.0045 144.745 0.966 4.205 0.5524 2.93.27231 0.1261	37	123.2184	0.0101	0.0081	123.2184	0.0101	722.9322	0.0081	722.9322	1.4622	1.4622	0.1413
158 120 0.0146 218,3228 0.0175 868 1.575 65 2506 0.0044 0.1238 16.8587 0.0045 1.46.8516 7.318 5.6895 54,1687 0.0044 0.1238 1905.4826 0.1515 52.3821 0.0065 1.486.5150 7.318 5.6895 54,1687 0.0080 0.1147 1830.7882 0.1486 5.1372 5.0111 5.6318 527.5280 0.0431 0.1267 1830.7865 0.1486 5.7317 0.0065 14.865.506 5.7381 527.5280 0.0431 0.1467 1830.7865 0.1660 5.73175 0.0064 1415.2664 7.3475 527.5280 0.01661 6.1660 0.1660 5.73175 0.0064 1415.2663 4.3698 47.441 0.0028 0.1660 5.73175 0.0045 14.152.9646 7.4174 57.7723 0.0021 0.0127 9.60176 0.0238 4.744 157.7731 0.0123 9.0175	38	3.3356		0.0165	222.2684	0.0182	170.5988	0.0019	1473.5669	2.0831	1.7624	0.1789
60.5206 0.0049 0.0047 50.5206 0.0044 0.158 55.2408 0.0044 0.158 55.2408 0.0045 7.1808 0.0954 0.0544 0.55284 0.21168 0.0046 0.1147 1830.7882 0.1431 1830.7882 0.1439 3831.0470 0.0433 17.2081 0.00561 7.3820 5.5284 527.3285 0.0026 0.1147 1830.7882 0.1431 837.1775 0.0033 4.2070 3.5493 57.3731 0.0126 0.1581 0.503.60 0.1431 4.12.864 0.0933 4.12.864 4.3051 166.8611 0.0136 0.1581 0.01341 0.1584 0.0136 4.12.864 4.3051 166.8611 0.0139 0.1581 0.01431 4.12.864 0.0433 4.12.864 4.3051 185.7421 0.0129 0.1581 0.01431 4.12.864 0.0433 4.12.864 4.442 165.811 0.0129 0.1581 4.12.8465 0.0121 2.567.781 7.4619	39	158.4122		0.0146	218.9328	0.0179	886.1094	0.0099	1302.9681	2.0643	1.7575	0.1779
54,1689 0.0004 0.1283 1980.6616 0.1617 52.3321 0.0006 1146.65150 7.7388 5.6895 831.7788 0.0660 0.1118 1830.4826 0.1675 52.3321 0.0005 1.6117 5.3574 831.7788 0.0660 0.1118 1830.4870 0.1686 1956.2066 0.353.471 5.6193 5.3542 533.7788 0.0023 0.1581 130.7803 0.0431 141.72.844 0.0015 5.7471 7.810 3.3499 517.0316 0.1581 130.73058 0.1661 5.31.775 0.0004 1415.2964 7.8558 4.5968 517.233 0.0013 0.1681 2.078.6530 0.3981 134.7683 1.2823 4.5968 517.233 0.0011 0.0012 0.0012 144.744 1.807.835 4.5968 517.233 0.0012 0.1641 2.373.481 0.3356 0.3657 1.7341 5283 0.0013 0.0014 4.152.5964 7.8659 4.5968	40	60.5206		0.0047	60.5206	0.0049	416.8587	0.0047	416.8587	0.9544	0.9544	0.1063
0.2197 0.0000 0.11218 1926.4926 0.1575 5.2.3921 0.0006 10504.0542 7.6111 5.6318 233.2552 0.02431 0.01431 1350.7882 0.02431 0.531.7387 5.7.3829 5.5.324 233.2552 0.02431 0.01431 1650.7882 0.1446 533.1475 0.00433 4412.8884 3.4969 5.5.348 31.9980 0.01581 0.15617 1863.9447 0.1524 537.1755 0.00431 415.554 3.4969 31.9980 0.01381 0.1651 1863.9447 0.1524 537.1755 0.00431 415.554 4.566 157.7231 0.0139 0.1651 207.6650 0.1691 3.214.755 0.0021 2.357.843 4.3665 157.7231 0.0122 0.274 257.4400 0.237.41 7.4614 7.4614 157.7231 0.0122 0.274 257.4200 0.237.41 7.4615 4.7465 259.1300 0.0121 0.274 257.4200 0.227.41 2.460.550 <td>41</td> <td>54.1689</td> <td></td> <td>0.1283</td> <td>1980.6616</td> <td>0.1619</td> <td>582.4608</td> <td>0.0065</td> <td>11486.5150</td> <td>7.7388</td> <td>5.6895</td> <td>0.4292</td>	41	54.1689		0.1283	1980.6616	0.1619	582.4608	0.0065	11486.5150	7.7388	5.6895	0.4292
831.7788 0.0680 0.1147 183.0.7882 0.1430 183.0.7882 0.1430 183.0.7882 0.1331 15.2081 5.5284 5.5284 232.5852 0.0431 0.0423 717.2091 0.0686 1995.2096 0.0223 177.2091 3.5482 3.4893 3.4893 572.580 0.0431 0.04323 717.2091 0.0523 717.2091 9.653.417 7.4619 4.3051 747.581 0.0136 0.1561 2.003.9058 0.1610 0.1581 2.0038 4.556.40 3.657 99.0700 0.0081 0.1581 2.0198 0.991.455 0.0015 1.412.29646 7.855 4.566.9 17.7231 0.0012 9.10170 0.9148 0.9143 0.0015 4.556.9 4.566.9 7142 0.0112 0.2274 3710.4682 0.3281 1.412.2964 4.745 4.744 7142 0.0112 0.0221 9.470615 0.0012 8.40569 4.5650 7142 0.0112 0.0122	42	0.2197	0000.0	0.1218	1926.4926	0.1575	52.3921	0.0006	10904.0542	7.6111	5.6318	0.4245
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	43	831.7788			1830.7882	0.1496	3931.0470	0.0439	10270.9159	7.3820	5.5284	0.4159
527.5280 0.0431 0.0433 527.5280 0.0431 0.0433 527.5280 0.0431 7.1683 3.4989 3.4989 31.9890 0.0136 0.1561 1863.3447 0.1524 13.77345 0.0015 13.579.7871 7.4619 3.4984 3.4989 16.571 1863.3447 0.1567 0.1689 399.1495 0.0015 13.579.781 7.4619 4.6744 157.7231 0.0129 0.1581 2078.6530 0.1689 399.1495 0.0021 296.070 4.6744 990700 0.0021 0.0072 299.0700 0.0081 640.5961 0.073 4.6743 149.2842 0.0123 0.2743 2764.260 0.2485 366.4071 0.033 1.2828 4.7988 783.3424 0.0640 0.5823 610.1370 0.2485 366.4071 0.033 1.2828 4.7988 783.3424 0.0640 0.5823 610.1370 0.2485 366.4071 0.033 1.28289 1.7393 1.7395	44	293.2852				0.0586	1995.2096	0.0223	1995.2096	4.2070	3.5342	0.2859
31.9880 0.0026 0.1517 1863.9447 0.1524 134.7645 0.0015 13579.7871 7.4619 4.3051 166.8611 0.0136 0.1581 2030.8038 0.1660 573.1775 0.0004 14122.9646 7.8558 4.5968 157.7241 0.0129 0.2754 2576.4200 0.2106 1791.4555 0.0072 640.5597 1.2828 4.5968 99.0700 0.0021 0.2105 1321.4825 0.0015 5033.7163 1.2828 4.5968 259.1301 0.0122 0.2704 0.5664 147.5769 0.5366 4.7988 4.7988 7440.200 0.0331 0.2716 200.3865 0.0151 5467.0709 10.3402 4.7988 78803 0.0631 0.2216 0.0348 566.471 0.0022 2383.7463 1.7365 78913 0.0141 0.0326 0.0151 2461.590 0.015 3383.7463 1.7365 78013 0.0166 0.0123 141.282.064771 0.0023 141.7326	45	527.5280		0.0493		0.0431	4412.8884	0.0493	4412.8884	3.4989	3.4989	0.2528
166.8611 0.0136 0.1581 2030.8058 0.1660 573.175 0.0064 14152.9646 7.8558 4.5968 47.8472 0.0039 0.1626 2078.6530 0.1699 399.1465 0.0045 14552.1141 7.9663 4.6744 99.0700 0.0081 0.0072 39.0700 0.0081 640.5957 0.0072 29.0709 10.3402 4.6744 99.070 0.0081 0.0072 39.0700 0.0081 640.5957 0.0072 269.0709 10.3402 4.7842 99.070 0.0081 0.0212 0.2745 3210.4682 0.2015 247.3463 12.2858 4.7988 7890 0.0014 0.0212 0.2512 6710.370 0.5865 3407.3346 1.937.3809 2.1731 7800 0.0013 0.0142 0.0251 372.2816 0.0381 141.3537 2.3084 7.398 7800 0.0014 0.255 372.2816 0.0052 3407.3346 1.9033 1.7355 7800 0	46	31.9980	0.0026		1863.9447	0.1524	134.7645	0.0015	13579.7871	7.4619	4.3051	0.4189
47.8472 0.0039 0.1626 2078.6530 0.1699 399.1495 0.0045 14552.1141 7.9663 4.6744 157.7231 0.0129 0.2274 2576.4200 0.2106 1791.4955 0.0201 20384.0158 9.0615 4.6452 299.1300 0.0212 0.2745 23210.4822 0.2203 16.49557 4.7843 4.7383 299.1300 0.0212 0.2745 3210.4887 0.0218 24567.0709 10.32253 4.7988 299.1300 0.0212 0.3896 4260.5506 0.3482 1028.8586 0.0115 3303.7463 12.2538 4.7988 783.3424 0.00212 0.3896 4260.5506 0.3482 1028.8566 0.012 2307.3346 16.0277 56509 783.3424 0.0021 0.0225 5710.1370 0.0213 464.2540 0.0022 1397.3346 1.9033 1.7391 77.206 0.0021 0.0216 260.1887 0.0202 1347.3346 1.0033 1.7357 7.22589 0.0163 164.25402 0.0072 1097.3346 1.0033 1.7357 $7.266.9999$ 0.0048 191.2191 0.0153 574.5202 7.0273 7.0273 $7.266.9999$ 0.0481 12150.1802 0.9051 141.3286 0.0111 8115.7537 2.2944 7.3952 $7.866.9999$ 0.0048 12150.0990 10973 87991.29309 2.1023 7.4277 586.98999 0.00212	47	166.8611			2030.8058	0.1660	573.1775	0.0064	14152.9646	7.8558	4.5968	0.4335
157.7231 0.0129 0.2274 2576.4200 0.2106 1791.455 0.0200 20354.0158 9.0615 4.6452 99.0700 0.0081 0.0072 399.0700 0.0081 640.5597 1.2828 1.2828 149.2842 0.00212 0.3696 420.5506 0.3485 360.4071 0.0398 5212.0480 1.2828 4.7884 149.2842 0.0021 0.3696 420.5567 0.0215 3464.2540 0.015 2465.073 12.2538 4.7884 149.2842 0.0031 0.0255 372.2816 0.0121 22896 1.8391 2.1731 7.2081 0.00164 0.5833 565.4562 0.0571 2390.2346 2.1733 2.1751 7.2081 0.0104 0.0255 372.2816 0.0121 2306.476 2.355 2.1751 7.2081 0.01021 2988.7670 0.8335 565.4552 0.0571 2390.2791 7.1731 7.2091 0.0121 266.467 0.0385 565.4552 0.0571	48	47.8472			2078.6530	0.1699	399.1495	0.0045	14552.1141	7.9663	4.6744	0.4376
99.0700 0.0081 0.0072 99.0700 0.0081 0.0072 99.0700 1.2828 1.2828 1.2828 259.1300 0.0212 0.2745 3210.4682 0.2624 1947.9615 0.0015 24567.0709 10.3402 4.7848 149.2842 0.00122 0.23823 710.1370 0.5483 556.0.137 0.0021 32837.803 12.2538 4.7988 78003 0.0031 0.2216 260.187 0.5483 566.4565 0.0052 13037.809 2.3723 4.7988 78003 0.0031 0.2216 260.187 0.0214 465.9686 0.0052 13037.810 2.3378.09 2.3734 1.9033 1.7355 72.006 0.0046 0.381 191.2191 0.0156 465.9686 0.0057 13033 1.7355 1.3367 72.006 0.0046 0.3861 191.2191 0.0156 1411.3286 0.0157 12902279 7.0258 74.8137 0.0048 0.888.7670 0.8888.7690 2.65.7670 2.	49	157.7231	0.0129		2576.4200	0.2106	1791.4955	0.0200	20354.0158	9.0615	4.6452	0.4768
259.1300 0.0212 0.2745 3210.4682 0.2624 1947.9615 0.0218 24567.0709 10.3402 4.7844 149.2842 0.0122 0.3696 4260.5506 0.3482 1028.8586 0.0115 3303.7463 12.2538 4.7986 783.3424 0.0640 0.5823 6710.1370 0.5485 3560.4071 0.0025 1937.8209 2.2895 1.8391 717.4428 0.00142 0.0215 372.2816 0.00213 464.2546 0.0052 1373.346 $1.937.3209$ 2.1731 7127.4066 0.0026 0.3121 1912.191 0.0126 100.3462 $0.3887.761$ 0.0213 464.25462 0.0057 3407.3346 $1.933.769$ 7127.4066 0.00462 0.8154 1912.191 0.0167 1293.64562 0.0157 72990.2791 2.0387 2.1731 765.5281 0.0440 0.8841 1216.11059 0.8963 1411.3285 0.0141 8815.7937 22.9794 7.3952 488.6190 0.0399 0.9844 1216.11059 0.9940 305.3633 0.0021 8890.4264 2.0233 7.0926 4.8137 0.00012 0.9987 1216.11059 0.9941 305.3633 0.0021 8815.7637 22.9494 7.4014 4.8161 0.00022 0.00021 1216.11059 0.9933 1216.11059 0.9033 1216.11059 0.9936 4.8161 0.00021 0.00021 0.00021 0.9962 21	50	99.0700	0.0081	0.0072	99.0700	0.0081	640.5597	0.0072	640.5597	1.2828	1.2828	0.1295
149.2842 0.0112 0.3696 4260.5506 0.3482 1028.856 0.0115 33083.7463 12.2538 4.7988 783.3224 0.0640 0.5823 6710.1370 0.5485 3560.4071 0.0038 57120.0480 16.0927 5.6509 37.8033 0.0014 0.5823 6710.1370 0.5485 366.4071 0.0052 1937.8209 2.8387 2.1731 37.8033 0.0014 0.0255 377.2066 0.0334 191.2191 0.0156 346.566 3407.3346 1.9033 1.7555 566.5281 0.0462 0.8312 10475.7569 0.8055 1411.3285 0.0151 2290.2791 2.0233 7.0926 586.5899 0.0480 0.8312 10475.7569 0.8931 367.9123 0.0411 8115.7537 2.9349 7.4014 586.5899 0.0048 0.8312 10475.7569 0.9933 274.6777 0.0014 281.6769 7.3952 586.5924 0.1105 0.118 8115.7537 2.29449 7.4014 <td>51</td> <td>259.1300</td> <td></td> <td></td> <td>3210.4682</td> <td>0.2624</td> <td>1947.9615</td> <td>0.0218</td> <td>24567.0709</td> <td>10.3402</td> <td>4.7844</td> <td>0.5207</td>	51	259.1300			3210.4682	0.2624	1947.9615	0.0218	24567.0709	10.3402	4.7844	0.5207
783.3424 0.0640 0.5823 6710.1370 0.5485 3560.4071 0.0398 52120.0480 16.0927 5.6509 37.8903 0.0031 0.0216 260.1587 0.0213 464.2540 0.0052 1337.8209 2.2895 1.8391 127.4428 0.0104 0.0255 372.2816 0.0304 1083.9695 0.0121 2280.4390 2.8387 2.1731 7.2006 0.0031 191.2191 0.0156 465.9686 0.0052 3407.3346 1.9033 1.7355 565.5281 0.01480 0.3312 191.2191 0.0156 465.9686 0.0057 2401.607 2.1033 1.7355 586.3899 0.0048 0.3883 1411.3285 0.0031 8815.767 7.0926 7.3952 488.6190 0.00393 12161.1059 0.3933 12161.1059 0.3963 7.4014 7.0926 7.4014 488.6190 0.0004 0.9884 12161.1059 0.3963 214.672 0.0331 7.4014 7.4014 <td< td=""><td>52</td><td>149.2842</td><td></td><td></td><td>4260.5506</td><td>0.3482</td><td>1028.8586</td><td>0.0115</td><td>33083.7463</td><td>12.2538</td><td>4.7988</td><td>0.5831</td></td<>	52	149.2842			4260.5506	0.3482	1028.8586	0.0115	33083.7463	12.2538	4.7988	0.5831
37.8903 0.0031 0.0216 260.1587 0.0213 464.2540 0.0052 1937.8209 2.2895 1.8391 127.4428 0.0104 0.0256 372.2816 0.0304 1083.9695 0.0121 2280.4390 2.8387 2.1731 7.2006 0.0006 0.0381 191.2191 0.0156 465.9686 0.0052 3407.3346 1.9033 1.7355 565.5281 0.0482 0.8154 988.7670 0.8083 5165.4552 0.0577 72990.2791 20.3084 6.2657 586.5289 0.0480 0.8312 10475.7669 0.8563 1411.3285 0.0071 2990.2791 2.0324 7.3952 586.9899 0.0480 0.8312 10475.75690 0.9933 3679.9123 0.0118 74401.6076 2.0233 7.0926 $4.88.6190$ 0.0034 0.9875 12161.1059 0.9933 274.6727 0.0031 88195.7897 7.4014 $4.11.4011$ 0.0004 0.9933 12161.1059 0.9935 274.6727 0.0031 88950.4264 7.4014 $6.16.5112$ 0.0933 12161.1059 0.9936 10007 8951.3818 23.0747 7.4028 $5.8.7529$ 0.0012 8995.7897 23.9869 7.4074 7.5028 $4.14.4011$ 0.0006 0.9023 1261.5123 0.0024 8951.3818 7.4074 7.4074 0.0004 0.9933 12161.1059 0.9564 7.4074 7.4074	53	783.3424	0.0640	0.5823	6710.1370	0.5485	3560.4071	0.0398	52120.0480	16.0927	5.6509	0.6993
127.4428 0.0104 0.0255 372.2816 0.0304 1083.9695 0.0121 2280.4390 2.8387 2.1731 7.2006 0.0006 0.0381 191.2191 0.0156 465.9686 0.0052 3407.3346 1.9033 1.7355 565.5281 0.0462 0.8154 988.7670 0.8083 5165.4562 0.0577 72990.2791 20.3084 6.2657 565.5281 0.0480 0.8312 10475.7569 0.8083 5165.4562 0.0577 72990.2791 20.3084 6.2657 586.9899 0.0480 0.8312 10475.7569 0.8933 3111.3285 0.0118 8115.7537 22.9794 7.3952 4.8137 0.0039 0.9844 12150.1802 0.9933 274.6727 0.0031 8815.7897 22.9949 7.4014 4.8137 0.0004 0.9875 12154.9939 0.99336 274.6727 0.0031 $8891.3.9309$ 7.4023 4.8137 0.0012 0.99933 12175.5070 0.99936 374.6727 0.0024 $8991.3.9309$ 7.4022 4.4011 0.0012 0.99933 12175.5070 0.99952 218.1412 0.0024 $8991.3.9309$ 7.4022 6.1120 0.0012 0.0048 1.0000 12234.2599 1.0076 $8991.3.9309$ 7.4022 6.1120 0.0012 0.0048 $8991.3.9309$ 22.9918 7.4092 6.1120 0.0004 0.0012 0.0004 89913.9309 7.4022	54	37.8903		0.0216	260.1587	0.0213	464.2540	0.0052	1937.8209	2.2895	1.8391	0.1906
7.2006 0.0066 0.0381 191.2191 0.0156 465.9686 0.0057 3407.3346 1.9033 1.7355 565.5281 0.0462 0.8154 988.7670 0.8083 5165.4562 0.0577 72990.2791 20.3084 6.2657 586.9899 0.0480 0.8312 10475.7569 0.8653 1411.3285 0.0157 72990.2791 20.3084 6.2657 586.9899 0.0480 0.8312 10475.7569 0.8863 411.3285 0.0157 72990.2791 21.0233 7.0926 488.6190 0.0399 0.9844 12150.1802 0.9933 3679.9123 0.0041 88115.7537 22.9794 7.3052 4.8137 0.0004 0.9875 12154.9939 0.9935 274.6727 0.0031 88390.4264 7.4014 4.8137 0.0004 0.9877 12154.9939 0.9935 274.6727 0.0031 8891.57897 7.4023 4.8115 0.0007 0.9933 12175.5070 0.9935 218.1412 0.0024 8891.39309 23.0822 7.4072 4.4011 0.0012 0.9933 12175.5070 0.9952 218.1412 0.0024 8891.39309 23.0082 7.4072 4.8167 0.00078 0.9933 1275.5070 0.9024 8913.39309 23.0747 7.5028 4.8013 0.0078 0.0078 999.0094 0.01574 5807.462 0.0065 $3.42.3239$ 3.4803 4.8167 0.0078 <	55	127.4428		0.0255	372.2816	0.0304	1083.9695	0.0121	2280.4390	2.8387	2.1731	0.2199
565.52810.04620.8154988.76700.80835165.45620.057772990.279120.30846.2657586.98990.04800.831210475.75690.85631411.32850.015874401.607621.02337.0926488.61900.03990.987412150.18020.99313679.91230.041188115.753722.97947.39524.81370.00040.987512154.99390.9935274.67270.003188390.426422.98497.40146.11200.00050.993312161.10590.9935274.6720.003188695.789722.99187.402614.40110.00120.993312175.50700.9952218.14120.00348895.789722.99187.407258.75290.000481.000012234.25991.0000597.45090.00678951.38187.40267.427758.75290.00780.00524616.51120.05641107.38570.01244734.34293.48037.403295.48470.00780.12121926.27290.1574580.74620.01244734.34293.48033.663195.48470.00780.01244734.34293.865.78972.16677.40767.607895.48470.00780.0124107.38570.01244734.34293.48033.480395.48470.00780.0124107.38570.01244734.34293.68167.407695.48470.00780.02300.07811659.15580.0124	56	7.2006			191.2191	0.0156	465.9686	0.0052	3407.3346	1.9033	1.7355	0.1685
586.98990.04800.831210475.75690.85631411.32850.015874401.607621.02337.0926488.61900.033990.984412150.18020.99313679.91230.041188115.753722.97947.39524.81370.00040.987512154.93390.9935274.67270.003188390.426422.98497.40146.11200.00050.9903312161.10590.9940305.36330.003488695.789722.99187.402614.40110.00120.9903312175.50700.9952218.14120.002488913.930923.00827.427758.75290.00481.000012234.25991.0000597.45090.001289511.381823.07477.502858.75290.00780.0078816.51120.05041107.38570.01244734.34293.48033.480395.48470.00780.0078999.00940.1574580.74620.01267.61065.631695.48470.0078999.00940.1574580.74620.01267.61065.631695.48470.0078999.00940.05041107.38570.01266.33.86393.480395.48470.0078999.00940.05171659.15580.01267.41065.631695.48470.0078999.00940.05741659.15580.01265.13253.9688423.92390.0230423.92390.033472685.50350.03002685.50353.0688	57	565.5281			9888.7670	0.8083	5165.4562	0.0577	72990.2791	20.3084	6.2657	0.8166
488.6190 0.0399 0.9844 12150.1802 0.9931 3679.9123 0.0411 88115.7537 22.9794 7.3952 4.8137 0.0004 0.9875 12154.9939 0.9935 274.6727 0.0031 88390.4264 22.9849 7.4014 6.1120 0.0005 0.9909 12161.1059 0.9940 305.3633 0.0031 8895.7897 22.9948 7.4014 7.4.011 0.0012 0.9903 12175.5070 0.9952 218.1412 0.0024 88913.3309 23.0082 7.4022 58.7529 0.0048 1.0000 12234.2599 1.0000 597.4509 0.0067 89511.3818 23.0747 7.5028 710.7148 0.0078 0.1212 1926.2729 0.1574 580.7462 0.0124 4734.3429 3.8420 3.4803 95.4847 0.0078 999.0094 0.1574 580.7462 0.0124 4734.3429 3.8420 3.4803 95.488003 0.0230 0.231.6 7.6106 5.1326 3.0688 3.0688 <td>58</td> <td>586.9899</td> <td></td> <td>0.8312</td> <td>10475.7569</td> <td>0.8563</td> <td>1411.3285</td> <td>0.0158</td> <td>74401.6076</td> <td>21.0233</td> <td>7.0926</td> <td>0.8356</td>	58	586.9899		0.8312	10475.7569	0.8563	1411.3285	0.0158	74401.6076	21.0233	7.0926	0.8356
4.81370.00040.987512154.99390.9935274.67270.003188390.426422.98497.40146.11200.00050.990912161.10590.9940305.36330.003488695.789722.99187.409214.40110.00120.993312175.50700.9940305.36330.002488913.930923.00827.409258.75290.00120.993312175.50700.9952218.14120.002488913.930923.07877.409258.75290.00481.000012234.25991.0000597.45090.006789511.381823.07477.5028110.71480.00780.0529616.51120.05041107.38570.01244734.34293.48037.480395.48470.00780.12121926.27290.1574580.74620.01868511.381823.07477.502895.48470.00780.12121926.27290.1574580.74620.0186851.32633.4803281.80030.02300.023090.0304423.92390.033471659.15580.01856339.86895.13253.9851423.92390.0301423.92390.033472685.50350.03085.13253.98513.98563.30570.00030.0698898.64110.0735341.90780.00386250.87164.81663.89663.30570.00030.041352.39210.00063626.95723.41173.4012	59	488.6190	0.0399	0.9844	12150.1802	0.9931	3679.9123	0.0411	88115.7537	22.9794	7.3952	0.8867
6.11200.00050.990912161.10590.9940305.36330.00348695.789722.99187.409214.40110.00120.993312175.50700.9952218.14120.002488913.930923.07827.427758.75290.00141.000012234.25991.0000597.45090.002488913.930923.07477.502858.75290.00481.000012234.25991.0000597.45090.006789511.381823.07477.502895.48470.00780.0529616.51120.05041107.38570.01244734.34293.84203.480395.48470.00780.12121926.27290.1574580.74620.006510851.66217.61065.6316281.80030.02300.0708999.00940.08171659.15580.01856339.86895.13253.9851281.80030.02300.0300423.92390.03472685.50350.01856339.86895.13253.98513.30570.00030.0698898.64110.0735341.90780.00386250.87164.81663.89663.30560.00020.00020.0405505.79650.041352.39210.00063626.95723.41173.4012	60	4.8137	0.0004	0.9875	12154.9939	0.9935	274.6727		88390.4264	22.9849	7.4014	0.8868
14.4011 0.0012 0.9933 12175.5070 0.9952 218.1412 0.0024 88913.9309 23.0082 7.4277 58.7529 0.0048 1.0000 12234.2599 1.0000 597.4509 0.0067 89511.3818 23.0747 7.5028 710.7148 0.0078 0.0529 616.5112 0.0504 1107.3857 0.0124 4734.3429 3.8420 3.4803 95.4847 0.0078 0.1212 1926.2729 0.1574 580.7462 0.0124 4734.3429 3.8420 3.4803 95.4847 0.0078 0.1212 1926.2729 0.1574 580.7462 0.0124 4734.3429 3.8420 3.4803 281.8003 0.0230 0.1212 1926.2729 0.1574 580.7462 0.0126 5.6316 5.6316 281.8003 0.0233 0.02347 0.659.1558 0.0185 6339.8689 5.1325 3.9851 423.923239 0.0347 2685.5035 0.0330 2685.5035 3.0688 3.0688 3.9668	61	6.1120		0.9909	12161.1059	0.9940	305.3633	0.0034	88695.7897	22.9918	7.4092	0.8870
58.75290.00481.000012234.25991.0000597.45090.006789511.381823.07477.5028110.71480.00900.0529616.51120.05041107.38570.01244734.34293.84203.480395.48470.00780.12121926.27290.1574580.74620.016510851.66217.61065.6316281.80030.02300.0708999.00940.08171659.15580.01856339.86895.13253.9851423.92390.03470.0307423.92390.03472685.50350.03002685.50353.06883.06883.30570.00030.0698898.64110.0735341.90780.00386250.87164.81663.89662.61660.00020.0405505.79650.041352.39210.00063626.95723.41173.4012	62	14.4011	0.0012	0.9933	12175.5070	0.9952	218.1412	0.0024	88913.9309	23.0082	7.4277	0.8874
110.7148 0.0090 0.0529 616.5112 0.0504 1107.3857 0.0124 4734.3429 3.8420 3.4803 95.4847 0.0078 0.1212 1926.2729 0.1574 580.7462 0.0065 10851.6621 7.6106 5.6316 281.8003 0.0230 0.0708 999.0094 0.0817 1659.1558 0.0185 6339.8689 5.1325 3.9851 423.9239 0.0347 0.0347 2685.5035 0.03300 2685.5035 3.0688 3.0688 3.0688 3.3057 0.0003 0.0347 0.0347 2685.5035 0.03300 2685.5035 3.0688 3.0688 3.0688 3.3057 0.0003 0.00038 898.6411 0.0735 341.9078 0.0038 6250.8716 4.8166 3.8966 2.6166 0.0002 0.0405 505.7965 0.0413 52.3921 0.0006 3626.9572 3.4117 3.4012	63	58.7529		1.0000	12234.2599	1.0000	597.4509	0.0067	89511.3818	23.0747	7.5028	0.8891
95.48470.00780.12121926.27290.1574580.74620.006510851.66217.61065.6316281.80030.02300.0708999.00940.08171659.15580.01856339.86895.13253.9851423.92390.03472685.50350.03002685.50353.06883.06883.06883.30570.00030.0698898.64110.0735341.90780.00386250.87164.81663.89662.61660.00020.0405505.79650.041352.39210.00063626.95723.41173.4012	64	110.7148		0.0529	616.5112	0.0504	1107.3857	0.0124	4734.3429	3.8420	3.4803	0.2691
281.8003 0.0230 0.0708 999.0094 0.0817 1659.1558 0.0185 6339.8689 5.1325 3.9851 423.9239 0.0347 0.0347 2685.5035 0.0300 2685.5035 3.0688 3.8066 3.8066 3.8066 3.2066 3.2012 0.00002 0.0405 505.7965 0.0413 52.3921 0.0006 3626.9572 3.4117 3.4012 3.4012 3.4012 3.4012 3.4012 3.4012 3.4012 3.4012 3.4012	65	95.4847	0.0078	0.1212	1926.2729	0.1574	580.7462	0.0065	10851.6621	7.6106	5.6316	0.4245
423.9239 0.0347 0.0300 423.9239 0.0347 2685.5035 0.0300 2685.5035 3.0688 <	99	281.8003	0.0230	0.0708	999.0094	0.0817	1659.1558	0.0185	6339.8689	5.1325	3.9851	0.3264
3.3057 0.0003 0.0698 898.6411 0.0735 341.9078 0.0038 6250.8716 4.8166 3.8966 2.6166 0.0002 0.0405 505.7965 0.0413 52.3921 0.0006 3626.9572 3.4117 3.4012	67	423.9239		0.0300	423.9239	0.0347	2685.5035	0.0300	2685.5035	3.0688	3.0688	0.2317
2.6166 0.0002 0.0405 505.7965 0.0413 52.3921 0.0006 3626.9572 3.4117 3.4012	68	3.3057		0.0698	898.6411	0.0735	341.9078	0.0038	6250.8716	4.8166	3.8966	0.3129
	69	2.6166		0.0405	505.7965	0.0413	52.3921	0.0006	3626.9572	3.4117	3.4012	0.2486

Appendix B: Ramapo Watershed variables for the 69 subbasins determined using GIS. Page 2 of 6

Sub- temposite Composite basin Composite b										Composite	
Reach CN Evolability indexivous Impervious Surface		Composite		Composite		Composite		Composite	Impervious	Impervious	
Depth (m) Area Wt.) Area Wt.) (nonsidence) (nonsidence) (nonsidence) (nonsidence) (acres) <	Sub-	Reach	CN	CN	Erodability	Erodability	Impervious	Impervious	Surface	Surface	Hydrogroup
0.1954 76 79 0.31 0.26 0.45 0.65 3.2422 0.1954 66 79 0.37 0.00 0.06 0.65 3.2483 0.1789 92 0.24 0.24 0.02 0.00 0.000 0.000 0.0935 92 0.24 0.24 0.02 0.00 0.000 0.000 0.01304 93 0.24 0.24 0.02 0.00 0.000 0.000 0.01364 79 0.37 0.01 3.7.95 34.71 18 2.7.83 0.1055 53 55 0.31 0.10 3.7.95 34.77 34.91 18 7.7.94 0.2495 71 71 1.75 0.3 3.0.52 34.57 34.91 17.7.3040 36 0.2540 72 0.33 0.16 7.7.2 52.7.471 5 57.7.471 5 0.2540 71 7.12 1.5.57 1.5.7.7 1.7.7	basin	Depth (m)	(Area Wt.)	(Area Wt.)	(tons/acre)	(tons/acre)	Surface (%)	Surface (%)	(acres)	(acres)	(Area Wt.)
0.1954 66 79 0.37 0.00 0.00 0.00 0.000 0.0384 92 92 0.24 0.21 0.02 0.000 0.000 0.000 0.0385 92 0.24 0.24 0.24 0.02 0.000 0.000 0.000 0.1304 93 0.24 0.24 0.24 0.02 0.000 0.000 0.000 0.1304 93 0.23 0.21 0.01 0.000 0.000 0.000 0.000 0.1304 79 86 0.31 0.10 37.35 234.31 183.3534 35 0.2540 71 61 71 0.33 0.05 34.47 31.30 107.8794 44 0.2540 71 71 0.33 0.05 34.47 31.30 107.8794 44 0.2540 71 1.78 0.33 0.25 24.43 71.2 25.433 52.433 52.433 53.63 52.433 <t< th=""><th>~</th><th>0.1954</th><th>76</th><th>62</th><th>0.31</th><th>0.26</th><th>0.45</th><th>0.65</th><th>3.2462</th><th>5.4311</th><th>2.8310</th></t<>	~	0.1954	76	62	0.31	0.26	0.45	0.65	3.2462	5.4311	2.8310
0.00904 92 0.24 0.24 1.78 2.1649 0.1789 92 93 0.24 0.02 0.00 0.000 0.1789 92 93 0.24 0.02 0.00 0.000 0.000 0.0816 94 94 0.24 0.24 0.02 0.00 0.000 0.000 0.1804 79 86 0.31 0.24 0.24 0.02 0.00 0.000 0.000 0.1804 75 61 0.31 0.21 0.23 0.29 37.95 33.51 287.924 73 0.2495 54 53 0.31 0.31 0.31 0.31 0.35 33.53 287.924 73 0.2540 77 61 17.76 15.74 33.55 74.13 33.55 74.13 33.55 74.13 33.55 74.13 74.13 74.14 74.14 74.14 74.14 74.14 74.13 74.14 74.14 74.14 <td< th=""><th>2</th><th>0.1954</th><th>99</th><th>62</th><th>0.37</th><th>00.0</th><th>00.00</th><th>0.65</th><th>0.0000</th><th>5.4311</th><th>1.9990</th></td<>	2	0.1954	99	62	0.37	00.0	00.00	0.65	0.0000	5.4311	1.9990
01789 92 0.24 0.21 0.02 0.1257 0.0835 94 94 0.24 0.24 0.05 0.00 0.000 0.1564 93 0.24 0.24 0.24 0.24 0.00 0.000 0.000 0.1564 79 95 0.31 0.24 0.24 0.24 0.24 0.00 0.000 <	e	0.0984	92	92	0.24	0.24	1.78	1.78	2.1849	2.1849	2.9930
0.0835 92 93 0.24 0.05 0.00 0.000 0.1844 79 94 94 0.37 0.24 0.00 0.000 0.000 0.1864 79 86 0.37 0.24 0.00 0.000 0.000 0.1864 79 86 0.37 0.21 0.09 38.72 34.91 188.3944 38 0.1564 73 0.3 0.06 34.47 31.50 107.8794 44 0.2495 54 53 0.33 0.15 17.76 16.94 177.3040 34.57 0.2495 54 53 0.33 0.15 17.76 16.34 177.3040 34.57 0.2460 711 711 712 55.7471 5 55.7471 5 0.1416 66 68 0.33 0.14 12.77 55.7471 5 0.1416 66 68 0.33 0.14 12.77 12.57 52.7432	4	0.1789		92	0.24	0.21	0.02	0.02	0.1257	0.1257	3.0000
0.0816 94 94 0.24 0.24 0.00 0.000 0.000 0.1304 93 93 0.24 0.24 0.00 0.000 0.000 0.1584 79 86 0.31 0.10 37.95 34.91 188.3394 92 0.1584 75 0.33 0.30 30.52 34.37 31.30 1078799 47 0.2540 72 0.33 0.30 30.52 31.30 1078799 47 0.2540 72 0.33 0.15 17.76 16.24 177.3040 36 0.2540 72 0.33 0.33 17.76 16.26 137.798 46 0.2640 71 712 712 7327 3133 107879 31 0.2640 71 16.26 68 0.33 0.21 17.3040 36 0.2640 71 71 12.57 12.51 12.57 12.51 12.51 12.51 12.51 <td>S</td> <td>0.0835</td> <td></td> <td>93</td> <td>0.24</td> <td>0.05</td> <td></td> <td>00.0</td> <td>0.0000</td> <td>0.0000</td> <td>2.9490</td>	S	0.0835		93	0.24	0.05		00.0	0.0000	0.0000	2.9490
01304 93 024 0.24 0.00 0.000<	9	0.0816	94	94	0.24	0.24		00.0	0.0000	0.0000	2.9960
0.1584 79 86 0.37 0.21 0.00 0.000 0.000 0.2995 25 47 0.33 0.09 38.75 34.91 18.3394 95 0.2763 54 55 0.33 0.06 34.47 31.30 107.8799 47 0.2764 54 54 0.33 0.06 34.47 31.30 107.8799 47 0.2540 72 0.33 0.06 34.47 31.30 107.8799 47 0.2540 72 0.33 0.16 34.47 31.30 107.8799 47 0.2540 72 0.33 0.35 0.33 0.35 33.55 33.55 33.55 33.55 33.55 33.57 34.37 52.7471 52 46 46 47 31.05 52.7471 52 46 46 47 46 46 46 47 46 46 47 46 46 47 47 47 46	7	0.1304		93	0.24	0.24		0.00	0.0000	0.0000	3.0000
0.2996 25 47 0.33 0.09 38.72 34.91 188.3394 96 0.2761 65 54 55 0.31 0.06 37.95 31.52 297.2234 72 0.2540 54 54 54 0.30 0.30 30.52 33.52 297.234 74 0.2540 72 70 0.33 0.15 17.76 16.94 177.3040 36 0.2569 71 61 61 61 7 30.52 30.52 315.31 34.33.31 34.33.31 34.33.33 34.33.31 34.33.33 34.33	∞	0.1584		86	0.37	0.21	00.0	00.0	0.0000	0.0000	2.8430
	ი	0.2995		47	0.33			34.91	188.3394	937.6745	2.3240
0.2541 69 57 0.33 0.06 34.47 31.30 107.8799 44 0.2495 54 54 0.30 0.33 30.52 33.5318 34 0.2590 71 67 0.33 0.15 17.7304 36 0.20535 71 67 0.33 0.17 198 177.304 38 0.02540 71 67 0.33 0.15 17.12 5.5493 16 0.0855 61 61 0.33 0.33 12.57 7.12 5.7471 5 0.1416 66 0.33 0.33 12.57 12.57 5.5493 16 0.1416 669 0.3 0.33 0.33 12.57 12.57 5.7471 5 0.2397 90 0.31 0.04 0.31 0.076 16.77 0.8488 16 0.2400 71 12.57 12.57 12.57 52.7471 5 0.2140 <td< td=""><td>10</td><td>0.2762</td><td></td><td>55</td><td>0.31</td><td>0.10</td><td></td><td>33.52</td><td>297.9234</td><td>749.3352</td><td>2.1530</td></td<>	10	0.2762		55	0.31	0.10		33.52	297.9234	749.3352	2.1530
0.2495 54 0.30 0.33 0.15 17.75 30.52 343.5318 34 0.2540 72 70 0.33 0.15 17.75 16.94 177.3040 38 0.2550 71 61 0.33 0.157 19.87 16.54 177.3040 38 0.0855 71 71 12.57 12.57 7.12 5.5433 0.1672 61 61 0.33 0.33 12.51 12.57 5.5433 0.1672 61 61 61 0.33 0.33 12.57 12.57 5.5433 0.1278 63 63 0.33 0.33 0.33 12.57 5.57471 5 0.2387 902 0.33 0.33 0.33 12.57 12.573 15 0.1281 63 0.33 0.33 0.33 12.57 12.533 15 0.2281 0.33 0.31 0.21 0.21 0.23 12.56669 5 <td>1</td> <td>0.2541</td> <td></td> <td>57</td> <td>0.33</td> <td></td> <td></td> <td>31.30</td> <td>107.8799</td> <td>451.4117</td> <td>2.7020</td>	1	0.2541		57	0.33			31.30	107.8799	451.4117	2.7020
0.2540 72 70 0.33 0.15 17.76 16.94 177.3040 36 0.2059 71 67 0.30 0.17 19.87 16.73 0.32 7.12 5.5493 112.57 5.5493 112.57 5.5493 112.57 5.5493 112.57 5.5493 112.57 5.5493 112.57 5.5493 112.57 5.5493 112.57 5.5493 112.57 5.5493 112.57 5.5493 112.57 12.57 12.57 12.57 12.57 12.57 12.57 12.57 12.57 12.57 12.57 12.57 112.57 12.57 112.57 12.512 12.51 12.57	12	0.2495		54	0.30			30.52	343.5318	343.5318	2.6210
0.2059 71 67 0.30 0.017 19.87 16.26 132.7998 15 0.0835 71 71 0.28 7.12 7.12 5.5433 1 0.0856 63 0.33 0.03 0.72 7.12 5.5433 1 0.1672 61 61 63 0.33 0.03 0.72 7.783 1 0.1278 63 63 0.33 0.03 0.72 10.31 22.6699 3 0.1278 69 69 0.33 0.01 0.02 8.50 8.50 8.538 16 17.782 0.1278 69 69 0.24 0.02 0.07 0.078 0.566 3 0.2397 783 0.24 0.21 0.21 0.27 0.783 16.77 0.7653 0.2387 91 67 0.24 0.24 0.21 0.26 0.7653 0.2387 92 0.24 0.24 0.24	13	0.2540		70	0.33			16.94	177.3040	368.4002	2.9100
	14	0.2059		67	0.30		19.87	16.26	132.7998	191.0961	2.6040
0.1672 61 61 0.33 0.33 12.57 12.57 52.7471 5 0.2974 29 57 0.37 0.00 0.76 16.77 0.8488 16 0.2974 29 57 0.33 0.33 0.03 0.33 9.02 9.02 16.77 0.8488 165 0.0858 63 63 0.33 0.14 12.57 16.77 0.8488 165 0.1416 66 68 0.33 0.14 12.72 10.31 22.6069 3 0.1420 64 0.0 90 0.24 0.00 0.07 0.1661 3 0.2397 93 90 0.24 0.07 0.26 0.1661 3 0.2156 81 86 0.31 0.11 0.24 0.07 0.7653 3 0.2156 81 86 0.34 0.24 0.07 0.7654 1.2553 3 0.2164 0.24	15	0.0835		71	0.28			7.12	5.5493	5.5493	2.9170
0.2974 29 57 0.37 0.00 0.76 16.77 0.8488 165 0.0858 63 63 0.33 0.33 0.33 9.02 7.7832 7.7832 0.1416 66 68 0.33 0.14 12.72 10.31 22.6069 3 0.1416 66 68 0.33 0.14 12.72 10.31 22.6069 3 0.1248 74 88 0.31 0.04 0.07 0.765 3.6538 0.2397 90 90 90 0.24 0.09 0.07 0.7653 3.6538 0.2450 91 90 0.24 0.07 0.24 0.07 0.7653 3.6538 0.1657 81 86 0.31 0.11 0.36 0.1061 3.6568 3.6538 0.2167 81 87 87 0.24 0.23 0.1061 0.7653 3.6526 3.6526 3.6526 3.6526 3.6526 3.65	16	0.1672		61	0.33			12.57	52.7471	52.7471	2.5990
	17	0.2974		57	0.37			16.77	0.8488	1630.8367	
0.1416 66 68 0.33 0.14 12.72 10.31 22.6063 3 0.1278 69 69 0.31 0.028 8.50 8.50 8.6538 8.5538 0.1278 69 69 0.28 0.28 0.28 8.50 8.6538 8.5538 0.2480 74 88 0.31 0.04 0.21 0.07 0.5862 8.538 0.2397 90 90 0.24 0.07 0.07 0.05862 8.538 0.2317 90 90 0.24 0.07 0.07 0.0653 0.1061 0.7653 0.2156 81 87 0.24 0.07 0.24 0.07 0.7653 0.1061 0.7653 0.1856 81 87 87 0.24 0.20 0.10 0.763 0.1661 3 0.2072 81 87 0.24 0.20 0.21 0.2256 0.18 3 3 3 2 3	18	0.0858		63	0.33			9.02	7.7832	7.7832	
0.1278 69 69 0.28 0.28 8.50 8.50 8.6538 8.6538 0.2480 74 88 0.31 0.04 0.21 0.07 0.5862 0.5862 0.2480 74 88 0.31 0.04 0.21 0.07 0.5862 0.1061 0.2397 90 90 0.24 0.07 0.07 0.5862 0.1061 0.2156 93 90 0.24 0.07 0.26 0.1061 0.2072 89 89 0.24 0.07 0.21 0.7553 0.21856 81 87 87 0.24 0.20 0.00 0.000 0.1620 89 89 0.24 0.21 0.21 1.2253 2 0.1649 94 89 0.24 0.21 0.21 1.2253 2 0.1640 94 89 0.24 0.21 0.21 0.184 3 0.1640 91 0.24	19	0.1416		68	0.33		-	10.31	22.6069	S	3.2700
0.2480 74 88 0.31 0.04 0.21 0.07 0.5862 0.2397 90 90 0.24 0.09 0.07 0.5862 0.1061 0.2397 90 90 0.24 0.07 0.5862 0.1061 0.2156 93 90 0.24 0.07 0.565 0.1061 0.2072 89 87 0.24 0.07 0.265 0.1061 0.2072 89 87 0.24 0.24 0.26 0.00 0.000 0.1856 81 87 0.24 0.26 0.10 1.2253 0.1620 89 0.24 0.26 0.12 0.26 1.2753 0.1620 89 0.24 0.25 0.10 0.5526 1.2753 0.1649 94 88 0.24 0.02 0.12 0.1767 1.2753 2 0.1580 66 88 0.24 0.02 0.12 1.373 2 2	20	0.1278		69	0.28			8.50	8.6538	8.6538	3.5000
0.2397 90 90 0.24 0.09 0.024 0.05 0.1061 0.2156 93 90 0.24 0.07 0.24 0.07 0.7653 0.2156 93 90 0.24 0.07 0.261 0.7653 0.21856 81 86 0.31 0.11 0.24 0.00 0.000 0.1856 81 86 0.31 0.11 0.26 0.21 1.2253 0.1856 81 86 0.31 0.11 0.36 0.00 0.000 0.1850 87 0.24 0.23 0.12 0.21 1.2253 0.1620 89 0.24 0.20 0.12 0.1875 0.1630 96 88 0.24 0.01 7.36 6.18 0.1571 86 0.24 0.01 7.36 6.18 1.3723 0.1572 90 0.16 7.30 10.1649 1.3723 0.1571 86	21	0.2480		88	0.31			0.07	0.5862	1.4576	2.7700
0.2156 93 90 0.24 0.07 0.24 0.07 0.7653 0.2072 89 89 0.24 0.24 0.00 0.000 0.000 0.1856 81 86 0.31 0.11 0.36 0.01 1.2253 0.1856 81 86 0.31 0.11 0.36 0.00 0.000 0.1856 81 87 0.24 0.24 0.20 0.12 1.2253 0.1620 89 0.24 0.24 0.20 0.12 0.000 0.000 0.1649 94 89 0.24 0.23 0.12 0.12 1.2553 0.1649 94 88 0.24 0.03 0.12 0.167 1.6556 0.1571 86 84 0.24 0.03 0.12 1.736 1.01649 0.1572 96 0.15 7.90 0.164 1.33 1.5.02 45.8059 0.1572 87 0.13 <	22	0.2397		06	0.24		0.02	0.05	0.1061	0.8714	2.9970
0.2072 89 89 0.24 0.24 0.00 0.000 0.000 0.1856 81 86 0.31 0.11 0.36 0.21 1.2253 0.1856 81 86 0.31 0.11 0.36 0.00 0.000 0.1856 81 87 0.24 0.24 0.26 0.12 1.2253 0.0831 87 89 0.24 0.20 0.12 0.10 0.000 0.1620 89 89 0.24 0.25 0.12 0.10 0.1675 0.1649 94 89 0.24 0.03 0.25 0.12 1.373 0.1570 90 86 0.24 0.01 7.36 6.18 1.373 0.1571 86 87 0.24 0.01 7.36 6.13 1.373 0.1572 87 0.13 1.33 1.326 1.373 1.373 0.2481 7.3 0.24 0.24 0.24 <td>23</td> <td>0.2156</td> <td></td> <td>06</td> <td>0.24</td> <td></td> <td>0.24</td> <td>0.07</td> <td>0.7653</td> <td>0.7653</td> <td>2.9940</td>	23	0.2156		06	0.24		0.24	0.07	0.7653	0.7653	2.9940
0.1856 81 86 0.31 0.11 0.36 0.21 1.2253 0.0831 87 0.24 0.24 0.00 0.000 0.0000 0.1620 89 87 0.24 0.24 0.20 0.12 0.107 0.1620 89 89 0.24 0.20 0.12 0.10 0.000 0.1649 94 89 0.24 0.20 0.12 0.12 0.1875 0.1572 90 86 0.24 0.03 0.25 0.12 0.1875 0.1572 90 86 0.24 0.02 26.12 7.90 10.1649 0.1571 86 0.24 0.02 26.12 7.90 10.1649 0.1572 90 16.13 7.36 6.13 24.2875 0.1572 87 0.24 0.23 19.33 15.02 45.8059 0.2162 87 0.43 0.43 13.22 164.0730 164.0730 <t< td=""><td>24</td><td>0.2072</td><td></td><td>89</td><td>0.24</td><td>0.24</td><td></td><td>00.0</td><td>0.0000</td><td>0.0000</td><td>3.0000</td></t<>	24	0.2072		89	0.24	0.24		00.0	0.0000	0.0000	3.0000
0.0831 87 87 0.24 0.24 0.00 0.00 0.000 <td>25</td> <td>0.1856</td> <td></td> <td>86</td> <td>0.31</td> <td>0.11</td> <td>0.36</td> <td>0.21</td> <td>1.2253</td> <td>1.9654</td> <td>2.8960</td>	25	0.1856		86	0.31	0.11	0.36	0.21	1.2253	1.9654	2.8960
0.1620 89 89 0.24 0.20 0.12 0.10 0.5526 0.1649 94 89 0.24 0.03 0.25 0.10 0.5526 0.1580 66 84 0.24 0.03 0.25 0.12 0.1875 0.1571 86 84 0.24 0.01 7.36 6.18 1.3723 0.1571 86 86 0.24 0.01 7.36 6.13 1.3723 0.1571 86 86 0.24 0.01 7.36 6.13 1.3723 0.2762 87 68 0.24 0.01 7.36 6.13 24.2875 0.2762 87 68 0.43 0.04 19.33 15.02 45.8059 0.2481 73 73 16.77 14.59 115.5120 1 0.2481 73 0.43 0.43 0.43 0.43 13.22 164.0730 0.2481 73 0.43 0.24 <	26	0.0831		87	0.24	0.24	00.00	00.0	0.0000	0.0000	3.0000
0.16499489 0.24 0.03 0.25 0.12 0.1875 0.1580 66 84 0.24 0.02 26.12 7.90 10.1649 0.1572 90 86 0.24 0.02 26.12 7.90 10.1649 0.1571 86 86 0.24 0.02 6.13 6.13 24.2875 0.1572 87 68 0.24 0.024 6.13 6.13 24.2875 0.2762 87 68 0.43 0.04 19.33 15.02 45.8059 0.2707 50 66 0.42 0.13 16.77 14.59 115.5120 0.2481 73 0.43 0.43 0.43 0.34 0.38 0.0133 0.1632 94 84 0.24 0.00 0.24 0.38 0.0133	27	0.1620		89	0.24	0.20	0.12	0.10	0.5526	0.5526	2.9950
0.1580 66 84 0.24 0.02 26.12 7.90 10.1649 0.1572 90 86 0.24 0.01 7.36 6.18 1.3723 0.1571 86 0.24 0.01 7.36 6.13 24.2875 0.1571 86 0.24 0.01 7.36 6.13 24.2875 0.2702 87 68 0.43 0.04 19.33 15.02 45.8059 0.2707 50 66 0.43 0.043 0.13 16.77 14.59 115.5120 0.2481 73 0.43 0.43 0.43 13.22 164.0730 0.1632 94 84 0.24 0.00 0.24 0.38 0.0133	28	0.1649	94	89	0.24	0.03		0.12	0.1875	0.7401	2.9940
0.1572 90 86 0.24 0.01 7.36 6.18 1.3723 0.1571 86 86 0.24 0.01 7.36 6.18 1.3723 0.1571 86 86 0.24 0.24 1.373 54.2875 0.2707 87 68 0.43 0.04 19.33 15.02 45.8059 0.2707 50 66 0.42 0.13 16.77 14.59 115.5120 0.2481 73 73 0.43 0.43 0.43 13.22 164.0730 0.1632 94 0.24 0.00 0.24 0.03 0.33 0.0133	29	0.1580	99	84	0.24	0.02		7.90	10.1649	35.8247	2.9850
0.1571 86 86 0.24 0.24 6.13 24.2875 0.2762 87 68 0.43 0.04 19.33 15.02 45.8059 0.2707 50 66 0.42 0.13 16.77 14.59 115.5120 0.2707 50 66 0.42 0.13 16.77 14.59 115.5120 0.2481 73 73 0.43 0.43 13.22 164.0730 0.1632 94 0.24 0.00 0.24 0.013 13.22 164.0730	30	0.1572	06	86	0.24	0.01	7.36	6.18	1.3723	25.6598	3.0000
0.2762 87 68 0.43 0.04 19.33 15.02 45.8059 0.2707 50 66 0.42 0.13 16.77 14.59 115.5120 0.2707 73 73 0.43 0.13 16.77 14.59 115.5120 0.2481 73 0.43 0.43 0.43 13.22 164.0730 0.1632 94 84 0.24 0.00 0.24 0.38 0.0133	31	0.1571	86	86	0.24	0.24		6.13	24.2875	24.2875	2.9950
0.2707 50 66 0.42 0.13 16.77 14.59 115.5120 0.2481 73 0.43 0.43 13.22 164.0730 0.1632 94 84 0.24 0.00 0.24 0.013	32	0.2762		68	0.43			15.02	45.8059	368.4289	2.9990
0.2481 73 73 0.43 0.43 13.22 13.22 164.0730 0.1632 94 84 0.24 0.00 0.24 0.38 0.0133	33	0.2707		99	0.42			14.59	115.5120	322.2024	2.9670
0.1632 94 84 0.24 0.00 0.24 0.38 0.0133	34	0.2481		73	0.43			13.22	164.0730	164.0730	3.0010
	35	0.1632	94	84	0.24	00.0	0.24	0.38	0.0133	2.2810	3.0000

Appendix B: Ramapo Watershed variables for the 69 subbasins determined using GIS. Page 3 of 6

									Composite	
	Composite		Composite		Composite		Composite	Impervious	Impervious	
Sub-	Reach	CN	CN	Erodability	Erodability	Impervious	Impervious	Surface	Surface	Hydrogroup
basin	Depth (m)	(Area Wt.)	(Area Wt.)	(tons/acre)	(tons/acre)	Surface (%)	Surface (%)	(acres)	(acres)	(Area Wt.)
36	0.1630	86	84	0.24	0.12	22.0	0.38	2.2678	2.2678	2.9960
37	0.1413	82	82	0.24	0.24	00.00	00.0	0.0000	0.0000	3.0000
38	0.1584	10	84	0.37	0.01	0.26	0.24	0.0214	1.3305	2.0000
39	0.1581	84	86	0.31	0.22	0.26	0.24	1.0057	1.3092	2.9640
40	0.1063	89	89	0.24	0.24	0.20	0.20	0.3035	0.3035	2.9880
41	0.3453		62	0.37	0.01	24.33	17.63	32.4500	859.0717	1.9930
42	0.3429	73	63	0.37	00.0	34.99	17.44	0.1899	826.6217	2.0000
43	0.3386	58	62	0.36	0.16	21.59	16.73	442.0915	753.0728	2.4500
44	0.2539	99	63	0.41	0.17	9.23	12.22	65.8422	65.8422	2.7140
45	0.2528	27	27	0.29	0.29	5.83	5.83	26.1546	26.1546	2.4750
46	0.2884		41	0.37	0.01	26.17	26.53	20.6209	984.4501	1.9960
47	0.3003		42	0.30	0.02	20.47	26.04	84.4070	1068.8571	2.4100
48			43	0.30	0.01	34.69	26.23	40.9685	1109.8256	2.2880
49	0.2998	48	48	0.30	0.02	11.17	21.94	43.5203	1158.7769	2.4160
50	0.1295	71	71	0.33	0.33	26.66	26.66	64.3763	64.3763	2.9420
51	0.3020	55	53	0.30	0.02	2.08	18.60	13.3331	1236.6120	2.4280
52	0.3017	46	56	0.29	0.01	6.78	17.83	24.9757	1629.9879	2.1250
53	0.3270	54	63	0.30	0.03	4.64	12.19	89.7909	1763.0946	2.7130
54			79	0.31	0.04	1.39	0.41	1.3046	2.6351	2.4210
55		72	80	0.31	0.10	1.73	0.84	5.4367	7.7177	2.7890
56	0.1584	59	83	0.31	0.01	34.83	8.91	6.1973	42.0220	2.8250
57	0.3489	42	62	0.30	0.02	16.19	12.77	226.2951	2858.8142	2.2950
58		62	62	0.33	0.02	21.78	13.28	315.9032	3174.7175	2.4250
59	0.3851	59	63	0.38	0.02	18.30	13.55	220.8588	3806.0271	2.5000
60			63	0.43	00.00	46.46	13.57	5.5257		3.0000
61	0.3856		63	0.43	0.00	51.16	13.59	7.7268		3.0000
62			63	0.40	0.00	32.64	13.61	11.5839	3830.8634	2.9910
63			63	0.40	0.00		13.72	51.7458	3882.6093	2.4080
64	0.2519	72	73	0.43	0.08	15.23	13.61	41.4042	206.6904	2.9820
65			63	0.33	0.02	31.16	17.44	73.3590	826.4318	2.9590
99			65	0.40	0.11	13.85	12.68		310.9813	2.7710
67		61	61	0.40	0.40	~	14.28	149.5495	149.5495	2.4890
68		82	99	0.43	00.0		14.56	0.4205	322.6229	3.0000
69	0.2481	81	73	0.43	00.0	18.76	13.25	1.2132	165.2862	3.0000

Appendix B: Ramapo Watershed variables for the 69 subbasins determined using GIS. Page 4 of 6

Sub-	Composite	Velocity	Composite Velocity		Composite	Forest Area	Urban Area	Water/Wetland			%Water/
basin	basin Hydrogroup	(m/s)	(m/s)	Slope (%)	Slope (%)	(ha)	(ha)	Area (ha)	%Forest	%Urban	wetland
-	2.85	2.490083	2.39463	57.1047	55.7632	254.6878275	6.835226857	28.53641483	0.8781	0.0236	0.0984
2	2.85	1.70581	2.3944676	26.8008	55.7546	0.065150463	0.034718518	0	0.6524	0.3476	0.0000
З	2.99	1.692535	ŀ	47.9625	47.9625	37.67301452	5.956768385	6.144917354	0.7569	0.1197	0.1235
4	3.00	2.493376	2.398393	60.0133	59.1257	213.0176716	4.617894318	18.12513817	0.9035	0.0196	0.0769
5	2.99	2.009975	1.6501827	73.7979	53.9039	8.6686	0	0	1.0000	0.0000	0.0000
9	3.00	1.543203	1.5432035	48.2916	48.2916	29.0302	0	2.188873226	0.9299	0.0000	0.0701
7	3.00	2.347788	2.3477877	71.2543	71.2543	95.73403964	0.056648417	5.007074721	0.9498	0.0006	0.0497
ω	2.91	2.575122	2.4898156	67.1283	68.9542	118.492966	0	8.320666388	0.9344	0.0000	0.0656
6	2.44	1.670411	1.5794031	21.4581	20.0948	23.19350877	165.6903034	7.945499724	0.1178	0.8416	0.0404
10		1.710258	1.5426881	23.0171	19.5953	32.1424383	274.8393631	10.69144111	0.1012	0.8652	0.0337
11	2.64	1.617975	1.4535694	21.5820	17.8873	31.51488137	89.4518408	4.703830058	0.2488	0.7063	0.0371
12		1.410783		16.9701	16.9701	92.10064676	329.0743375	27.08883777	0.2022	0.7224	0.0595
13	2.75	1.508704	1.4296229	18.0062	17.5711	140.046278	207.5205161	56.48923406	0.3466	0.5136	0.1398
14		1.312674	1.3483417	14.7585	17.2166	70.5543518	163.2829577	36.25469171	0.2609	0.6038	0.1341
15	2.92	0.940923	0.9409229	17.5184	17.5184	12.6509983	17.48175181	1.396668449	0.4012	0.5545	0.0443
16		1.395855		20.7781	20.7781	50.1227948	106.574324	13.1505145	0.2951	0.6275	0.0774
17		2.625428	2.0665586	53.8283	35.6297	28.13380629	1.473971158	15.31329032	0.6263	0.0328	0.3409
18	3.01	1.345512		34.8195	34.8195	11.46829329	20.67102295	2.784866507	0.3284	0.5919	0.0797
19		1.978773	-	43.1023	41.1341	33.46273433	37.05701817	1.395900908	0.4653	0.5153	0.0194
20		1.736663		39.6551	39.6551	71.02902939	17.74714405	6.947419028	0.7420	0.1854	0.0726
21		3.180051	2	80.8956	61.8993	108.1788613	0.948941355	1.547002367	0.9774	0.0086	0.0140
22		2.859265	2.599656	66.5659	58.8802	232.983197	4.483287087	12.70531398	0.9313	0.0179	0.0508
23	3.00	2.612944	2.4439011	59.5685	54.5786	109.755946	8.718090461	8.049975937	0.8675	0.0689	0.0636
24	3.00	2.374949		52.6052	52.6052	258.8285019	2.708102795	59.05281202	0.8074	0.0084	0.1842
25		2.852677		73.1623	63.9152	125.699475	4.589902489	7.270157254	0.9138	0.0334	0.0529
26		1.715112		58.5083	58.5083	29.01704326	1.584868479	2.085205823	0.8877	0.0485	0.0638
27		2.340009		56.3523	56.6818	154.4909915	10.08005454	16.32163972	0.8540	0.0557	0.0902
28		2.708704		72.9686	58.7018	28.65585768	1.517862553	0.046633495	0.9482	0.0502	0.0015
29		1.648428	1.9554498	29.1402	42.4749	5.197636058	10.55170229	0	0022.0	0.6700	0.0000
30		2.204227	1.9807123	53.4304	43.7299	6.020571533	1.529523449	0	0.7974	0.2026	0.0000
31	3.00	1.969727	1.9697266	43.2740	43.2740	132.3041269	25.35635625	2.699140019	0.8250	0.1581	0.0168
32	2	1.84078		26.5679	24.8125	21.54581103	71.78178379	2.576587874	0.2247	0.7485	0.0269
33		1.930639		29.5088	24.6881	72.8985977	144.2822884	61.53346675	0.2616	0.5177	0.2208
34		1.545416	~	20.4140	20.4140	144.6912076	174.6551737	180.5786564	0.2882	0.3479	0.3597
35	3.00	2.009643	1.971845	45.8122	42.3260	1.962009801	0.035788858	0.199318929	0.8930	0.0163	0.0907

Appendix B: Ramapo Watershed variables for the 69 subbasins determined using GIS. Page 5 of 6

Sub-	Composite	Velocity	Composite Velocity		Composite	Forest Area	Urban Area	Water/Wetland			%Water/
basin	basin Hydrogroup	(m/s)	(m/s)	Slope (%)	Slope (%)	(ha)	(ha)	Area (ha)	%Forest	%Urban	wetland
36	3.00		1.9714098	38.9471	38.9471	95.40002673	8.378010954	15.48549973	0.7999	0.0702	0.1298
37	3.00	1.794087	1.7940874	43.9519	52.6988	88.27069148	3.507607888	31.4400497	0.7164	0.0285	0.2552
38	2.96	2.076784	2.1739468	54.7648	52.8321	2.744148188	0.173085236	0.418390549	0.8227	0.0519	0.1254
39	2.97	2.314302	2.1750608	47.731	47.731	143.1471998	6.925047244	7.960428886	8506.0	0.0438	0.0504
40	2.99	1.753473	1.7534726	31.0510	27.4399	48.61820775	6.702807812	4.959901524	0.8065	0.1112	0.0823
41	2.56	2.022383	1.86799	5.1242	27.3384	5.916399995	38.06305592	9.999728458	0.1096	0.7051	0.1853
42	2.57	0.821494	1.8633888	28.6199	27.3754	0	0.219711759	0	0.0000	1.0000	0.0000
43	2.55	1.940645		36.1525	28.6420	175.4170621	596.1192023	52.10200119	0.2117	0.7193	0.0629
44	2.58	2.110711	1.8369874	58.4162	58.4162	91.27786597	142.0669782	55.21620952	0.3163	0.4923	0.1914
45	2.48	2.624218		11.5773	30.7942	130.6805423	36.55992556	14.22571666	0.7204	0.2016	0.0784
46	2.44	1.234467	1.9439077	38.5743	31.4335	0.330219972	22.03579326	9.519808226	0.0104	0.6911	0.2986
47	2.44	2.254246	1.9721207	35.7153	31.5320	64.17930402	95.90969279	6.772097076	0.3846	0.5748	0.0406
48	2.43	2.169348	1.9772396	26.0470	34.3932	10.50264673	33.01524286	4.279404843	0.2197	0.6907	0.0895
49	2.49	1.850819	2.053157	25.0943	25.0943	46.40900346	68.40301053	37.93812297	0.2943	0.4338	0.2406
50	2.94	1.389202	1.3892019	53.4965	37.7732	36.85150141	48.29236168	6.943835119	0.3771	0.4941	0.0710
51				42.1790	33.6563	170.5980901	35.13947053	53.22270777	0.6588	0.1357	0.2055
52	2.57	2.329261	2.0161787	47.4318	41.9161	74.17963223	41.89999366	33.09467141	0.4973	0.2809	0.2219
53				59.6856	53.7164	514.9976026	168.9122548	78.18853451	0.6577	0.2157	0.0998
54		2.469249		54.5126	46.4849	28.58783548	7.00066523	2.271830086	0.7551	0.1849	0.0600
55		2.455638		4.8440	41.0579	109.6940152	12.3745992	5.374192553	0.8607	0.0971	0.0422
56		0.675781	1.9243054	51.2997	40.0357	0	7.197889554	0.002663995	0.0000	0.9996	0.0004
57	2.65	2.460487	2.1875884	32.7674	39.6284	237.2842187	273.9134115	53.16126032	0.4196	0.4843	0.0940
58	2.64	1.958712	2.1737442	32.2056	38.1396	218.6479644	319.8641625	43.92309524	0.3725	0.5449	0.0748
59	2.67	1.921562	2.1277577	27.8655	38.1355	125.6202104	269.8617785	92.83738181	0.2573	0.5526	0.1901
60	2.67	1.787294	2.1276107	33.3321	38.1331	1.014505986	2.752681057	1.046497854	0.2108	0.5718	0.2174
61	2.67	1.954723	2.127501	58.9824	38.1578	0.94805335	3.703914064	1.460014239	0.1551	0.6060	0.2389
62	2.67	2.599981	2.1280885	13.4874	38.0393	3.771640207	9.952933592	0.636585706	0.2626	0.6930	0.0443
63	2.67	1.242844	2.12437	31.6104	22.5079	2.408974523	48.54461267	7.799334484	0.0410	0.8263	0.1327
64	3.00	1.953661	1.6276183	26.6803	27.3409	50.91302477	51.4700423	7.151741033	0.4627	0.4677	0.0650
65		1.874559	1.8634704	20.4785	26.3392	10.34446931	81.55574059	3.364811319	0.1086	0.8561	0.0353
99	2.63	1.616498	1.7849028	23.4459	23.4459	38.27518396	221.9046008	19.21256127	0.1370	0.7942	0.0688
67				7.5581	24.6251	86.52725062		48.66466551	0.2042	0.6794	0.1148
68				40.0189	20.5154	2.545958908		0	0.7702	0.2298	0.0000
69	3.00	2.164635	1.5492532	12.3400	20.4500	1.08201941	1.284577075	0.249970824	0.4135	0.4909	0.0955

Appendix B: Ramapo Watershed variables for the 69 subbasins determined using GIS. Page 6 of 6

Avorage Subbasin Source Channel Intertex Material Source Material Intertex Material Intertex Material Intertex Intertex Interex Intertex Interex									Barriers					
SXAP Channel Hydrologic Riparian Bank Appear- ment Enrich- ment Move- ment Fish brate Caropy caros Caropy caros 700 10 More- 320 10 More- 320 10 More- 320 Fish Move- 320 Fish Fish Fish Move- 320 Fish Fish Move- 320 Fish Fish Fish Fish Fish Fish Fish<		Average					Water	Nutrient	to Fish	Instream		Inverte-		Riffle
Score Condition Alteration Zone Stability anct Cover Pools Hability Cover Cover Pools Hability Cover			Channel	Hydrologic	Riparian	Bank	Appear-	Enrich-	Move-	Fish		brate	Canopy	Embedd-
700 10 0 0.0	Subbasin		Condition	Alteration	Zone	Stability	ance	ment	ment	Cover	Pools	Habitat	Cover	edness
9200 10 10 9	1	7.00	8	8	8.0	8.0	6	6		6	6	7		9
9100 9 910 920 90 910	2		10	10	9.0	9.0	10	10		൭	6	6		6
9.30 8 7 7.0	က		0	б	9.0	9.0	6	6		б	6	6		6
880 8 80 70<	4		Ø	7	7.0	7.0	8	7		2	2	2		7
300 8 7 80 80 7.5 80 7.5 9 <t< td=""><td>5</td><td></td><td>Ø</td><td>8</td><td>8.0</td><td>7.0</td><td></td><td>6</td><td></td><td>6</td><td>6</td><td>6</td><td></td><td>8</td></t<>	5		Ø	8	8.0	7.0		6		6	6	6		8
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	9		ω	7	8.0	8.0	8	8		໑	б	6		0
7.50 8 7 8.0 8.0 7 7 8.0 9 </td <td>2</td> <td></td> <td>0</td> <td>б</td> <td>8.0</td> <td>7.5</td> <td></td> <td>6</td> <td></td> <td>б</td> <td>6</td> <td>6</td> <td></td> <td>6</td>	2		0	б	8.0	7.5		6		б	6	6		6
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8.80 9 8 9.0 9.0 9 8 9 9 9 9 9	37		თ	ດ	8.0	9.0		6		ດ	o	6		6
	38	σ	6	8	9.0	0.6	о	8		6	0	6		6

Appendix C: SVAP data collected for the Wanaque Watershed. A score of zero indicates no score recorded. Page 1 of 2

								Barriers					
	Average					Water	Nutrient	to Fish	Instream		Inverte-		Riffle
	SVAP	Channel	Hydrologic	Riparian	Bank	Appear-	Enrich-	Move-	Fish		brate	Canopy	Embedd-
Subbasin	Score	Condition	Alteration	Zone	Stability	ance	ment	ment	Cover	Pools	Habitat	Cover	edness
39	8.00	ω	∞	9.0	9.0	6	6	Ø	6	o	6	б	ω
40	8.90	6	0	8.5	8.0	0	0	∞	0	0	0	7	0
41	9.00	ω	2	8.0	8.0	6	8	-	6	80	8	80	8
42	8.80	2	2	6.0	6.0	8	8	Ø	8	2	8	80	7
43	9.50	0	o	10.0	9.0	6	6	Ø	10	6	6	10	0
44	9.00	2	7	8.0	8.0	8	7	9	8	8	2	8	7
45	7.80	б	ດ	9.0	9.0	6	6	ດ	0	o	6	o	0
46	8.90		7	9.0	9.0	6	6	~	6	6	6	б	0
47	7.80	0	ດ	9.0	9.0	6	6	ດ	0	ი	6	o	0
49	9.00	0	ດ	9.0	9.0	6	6	ດ	6	ი	6	o	0
50	7.00	8	8	_ ·	8.5	8	6	8	6	6	8	6	0
51	8.00	0	ග		9.0	6	6	0	6	о	6	б	∞
53	8.60		Ø		8.0	6	6	6	6	6	8	6	ω
54	9.00	ω	0		9.0	6	6	о	6	о	6	б	0
55	7.30	6	0	9.5	9.0	10	7	7	5	~	0	7	10
56	7.80	ω	2		8.0	8	8	-	7	8	8	80	ω
57	8.90	9	9	7.0	7.0	5	9	-	7	2	2	2	9
59	8.70	6	6	8.0	8.0	6	6	1	8	8	6	2	8
60	8.30	6	0	9.0	10.0	10	10	0	10	10	6	10	0
61	7.40	8	2	9.0	8.0	6	8	L	6	6	8	8	8
64	6.10		2	7.0	7.0	8	8	8	8	8	2	8	2
67	7.80	2	8	7.0	7.0	8	8	8	8	8	8	8	8
68	7.30	9	8	7.0	6.0	8	8	6	8	8	6	8	8
70	7.30	2	0	9.5	10.0	7	7	3	8	0	0	6	0
74	7.50	6	6	10.0	0.0	6	8	8	6	6	6	10	6
75	8.10	6	0	9.5	9.0	0	0	8	8	0	0	6	0
76	7.70	8	6	8.0	8.0	6	8	8	6	6	6	6	6
27	8.70	8	8	8.0	8.0	8	8	9	6	6	8	6	8
78	7.50	6	6	8.0	9.0	6	6	6	6	6	6	6	6

					_							
	Subbasin	% Drainade		%	%	% Reach	Cumulative	% Cumulative				
Sub-	Drainage	Area	Cumulative	Cumulative	Reach Le		Reach	Reach	Reach	Composite	Reach	Compostie
basin	Area (ha)		Area	Area	Length		Length	Length	Width	Reach Width	Depth	Reach Depth
	1 764.792	2 0.035553	3454.2921	0.160580	5199.99 0.	0.044881	22576.0896	0.194854	10.8045	4.190671032	0.5362	0.262460493
	2 24.9568	3 0.001160	131.7946	0.006127	378.449 0.	0.003266	2800.9644	0.024175	1.5224	1.366547498	0.1452	0.135080831
.,	3 60.9788	3 0.002835	167.4471	0.007784	277.095 0.	0.002392	1372.554	0.011847	1.7576	1.423827343	0.1598	0.138649891
V	4 422.248	3 0.019629	422.248	0.019629	2955.24 0.	0.025507	2955.2373	0.025507	3.0615	3.0615	0.2313	0.2313
(1)	5 194.4212	2 0.009038	4184.4602	0.194524	1813.18 0.	0.015650	27116.9372	0.234046	12.122	5.47363005	0.5789	0.313999659
	6 100.9756	0.004694	4520.0934	0.210126	354.825 0.	0.003062	29184.8612	0.251895	12.6963	5.362941697	0.597	0.309541834
	7 746.077	0.034683	6260.7665	0.291045	2445.31 0.	0.021105	41449.7435	0.357753	15.4371	5.163799573	0.6801	0.299208326
5	8 21.2617	0.000988	3475.5538	0.161569	314.349 0.002713	.002713	22890.4389	0.197567	10.8444	4.28204521	0.5375	0.266237549
റ	9 83.8684	t 0.003899	83.8684	0.003899	630.56 0.005442	.005442	630.5603	0.005442	1.1608	1.1608	0.1212	0.1212
10	0 1121.3374	1 0.052128	1597.0542	0.074242	297.939 0.002572	.002572	5015.4456	0.043288	6.8011	2.300084038	0.3938	0.187193989
11	1 141.9011	0.006597	141.9011	0.006597	1549.42 0.013373	.013373	1549.4212	0.013373	1.5914	1.5914	0.1495	0.1495
12	267.7136	3 0.012445	267.7136	0.012445	2914.91 0.025159	.025159	2914.9088	0.025159	2.3291	2.3291	0.1928	0.1928
13	34.3842	2 0.001598	258.4859	0.012016	624.853 0.005393	.005393	3700.0109	0.031935	2.2806	1.772527499	0.1901	0.160048773
14	4 94.9137	0.004412	224.1017	0.010418	861.265 0.	0.007434	3075.1575	0.026542	2.0934	1.669290241	0.1795	0.153942545
15	5 129.188	3 0.006006	129.188	0.006006	2213.89 0.019108	.019108	2213.8929	0.019108	1.5043	1.5043	0.144	0.144
16	3 310.8562	2 0.014451	442.6508	0.020578	1776.34 0.015332	.015332	4577.3057	0.039507	3.1494	2.058429303	0.2357	0.174128689
17	7 6363.48	3 0.295820	19984.5195	0.929023	10027.7 0.	0.086549	99482.2075	0.858631	30.9746	7.375828627	1.082	0.368235024
18	3 106.8378	3 0.004967	106.8378	0.004967	2422.52 0.	0.020909	2422.5156	0.020909	1.3422	1.3422	0.1335	0.1335
19	9 35.5826	0.001654	119.451	0.005553	499.373 0.	0.004310	1129.9337	0.009752	1.4352	1.282070886	0.1396	0.129331867
20	514.4852	2 0.023917	3990.039	0.185485	2413.32 0.	0.020829	25303.7575	0.218397	11.7808	4.997230866	0.568	0.295017818
21	1 92.1873	3 0.004286	1868.9123	0.086880	778.893 0.	0.006723	5794.3386	0.050011	7.4738	2.995551015	0.4194	0.218407843
22	2 147.264	1 0.006846	147.264	0.006846	1685.13 0.	0.014544	1685.1278	0.014544	1.6272	1.6272	0.1518	0.1518
23	3 13.1125			0.010909	301.221 0.	0.002600	1713.0991	0.014786	2.152	2.091918296	0.1829	0.179438503
24				0.010299	1411.88 0.	0.012186	1411.8781	0.012186	2.0791	2.0791	0.1787	0.1787
25	5 150.4098		15	0.006992		0.014803	1715.1078	0.014803	1.648	1.648	0.1531	0.1531
26				0.003073	253.177 0.	0.002185	253.1768	0.002185	1.0063	1.0063	0.1102	0.1102
27				0.008012	2414.47 0.	0.020839	2414.4701	0.020839	1.7883	1.7883	0.1616	0.1616
28	3 153.9051	0.007155	153.9051	0.007155	1703.82 0.	0.014706	1703.816	0.014706	1.6709	1.6709	0.1545	0.1545
29				0.002435	417.21 0.	0.003601	417.2098	0.003601	0.8752	0.8752	0.1004	0.1004
30				0.021642		0.002535	3568.9712	0.030804	3.2462	2.638480569	0.2405	0.209368614
31					367.035 0.	0.003168	3275.3188	0.028269	2.7765	2.583994798	0.2167	0.206577494
32				0.014566	2908.28 0.	0.025101	2908.2837	0.025101	2.5597	2.5597	0.2053	0.2053
33	3 467.6775	5 0.021741	940.1386	0.043704	3657.05 0.	0.031564	6890.5943	0.059473	4.9489	3.974013079	0.3186	0.272277146

Appendix D: Wanaque Watershed variables for the 81 subbasins determined using GIS . Page 1 of 9

	Subbasin	% Drainage		% Cumulative		% Reach	Cumulative	% Cumulative				
Sub- basin	Drainage Area (ha)	Area	Cumulative Area	Area	Reach Length	Length	Reach Length	Reach Length	Reach Width	Composite Reach Width	Reach Depth	Compostie Reach Depth
34	10.1765	0.000473	950.3151	0.044177	130.624	0.001127	7021.2181	0.060600	4.9809	3.992745356	0.32	0.273164989
35	32.4069	0.001507	179.6709	0.008352	489.38	0.004224	2174.5078	0.018768	1.8335	1.673628481	0.1643	0.154613165
36	50.2132	0.002334		0.002334	278.307	0.002402	278.3073	0.002402	0.8533	0.8533	0.0987	0.0987
37	17.8962	0.000832	17.8962	0.000832	14.99	0.000129	14.99	0.000129	0.4595	0.4595	0.0653	0.0653
38	223.7022	0.010399	223.7022	0.010399	1599.68	0.013807	1599.6822	0.013807	2.0912	2.0912	0.1794	0.1794
39	62.6566	0.002913	2	0.013312	397.015	0.003427	1996.6973	0.017233	2.4251	2.157591306	0.198	0.183098348
40	57.6932	0.002682	57.6932	0.002682	594.31	0.005129	594.3102	0.005129	0.9274	0.9274	0.1043	0.1043
41				0.011185	856.415	856.415 0.007392	3399.7335	0.029343	2.1846	1.785648923	0.1847	0.160839613
42	26.2451	0.001220	193.6922	0.009004	1170.76	1170.76 0.010105	2304.2744	0.019888	1.918	1.997797026	0.1694	0.17393203
43	106.4683	0.004949	106.4683	0.004949	1095.46	1095.46 0.009455	1095.4591	0.009455	1.3394	1.3394	0.1333	0.1333
44	54.6772	0.002542	54.6772	0.002542	331.409	331.409 0.002860	331.409	0.002860	0.898	0.898	0.1021	0.1021
45	67.3703	0.003132	296.4953	0.013783	618.289	618.289 0.005336	2387.5032	0.020607	2.4763	1.959434658	0.2008	0.170880984
46	104.3211	0.004850	229.125	0.010651	833.709	833.709 0.007196	1769.214	0.015270	2.1215	1.778805147	0.1811	0.160425152
47	124.8039	0.005802	124.8039	0.005802	935.505	935.505 0.008074	935.5046	0.008074	1.4734	1.4734	0.142	0.142
48	34.8936		128.1195	0.005956	862.685	862.685 0.007446	1892.3301	0.016333	1.4968	1.326266595	0.1435	0.132220018
49	85.0568		85.0568	0.003954	830.782	0.007170	830.7824	0.007170	1.1706	1.1706	0.1219	0.1219
50	58.3623		2587.1663	0.120270	945.057	0.008157	9450.5312	0.081568	9.0842	8.972960047	0.4776	0.473730002
51	2528.804		2528.804	0.117557	8505.47	0.073411	8505.4745	0.073411	8.9606	8.9606	0.4733	0.4733
52	6.002	0.000279	151.9577	0.007064	267.102	0.002305	1571.0615	0.013560	1.6581	1.62523253	0.1537	0.151625033
53	221.8547	0.010313	221.8547	0.010313	2496.84	0.021550	2496.8417	0.021550	2.0808	2.0808	0.1788	0.1788
54	143.9384		143.9384	0.006691	1281.61	0.011062	1281.6094	0.011062	1.6051	1.6051	0.1504	0.1504
55	112.9397		ဗ္ဂ	0.142525	972.612	0.008395	14201.5943	0.122574	10.0583	7.170645736	0.5112	0.39526469
56				0.002765	908.66	0.007843	908.6595		0.9445	0.9445	0.1056	0.1056
57	-		-	0.006785	1303.96	0.011254	1303.96		1.6185	1.6185	0.1512	0.1512
58				0.001633	224.201	0.001935	224.2011	0.001935	0.6886	0.6886	0.0855	0.0855
59				0.044527	4330.87	0.037380	8661.1676		5.0045	4.337393382	0.321	0.291001951
60			-	0.067605	2135.39	0.018431	10796.5593	0.093185	6.4295	4.751179569	0.3793	0.308465933
61	ഹ			0.026556	4330.3	0.037375	4330.3022		3.6702	3.6702	0.261	0.261
62	တ			0.016493	904.373	0.007806	4019.8591		2.7578	2.38709095	0.2157	0.195775809
63			N	0.012265	168.883	0.001458	3115.4861		2.3088	2.279480431	0.1916	0.189992153
64					452.334		452.3336	0.003904	1.2378	1.2378	0.1265	0.1265
65	17	0.008111	267.8335	0.012451	2261.29	0.019517	2713.6213	0.023421	2.3297	2.147691163	0.1928	0.181748451
99	2.0473	0.000095	833.3008	0.038738	116.491	0.001005	8396.9679	0.072474	4.6033	3.51633444	0.3036	0.250808365

Appendix D: Wanaque Watershed variables for the 81 subbasins determined using GIS . Page 2 of 9 $\,$

Sub- Drai basin Area 67 24 68 9 69 2 69 2 70 70		Subbasin % Drainage		%		% Reach	% Reach Cumulative	Gumulative				
Ā	Drainage	Area	Cumulative	Cumulative	Reach	Length	Reach	Reach	Reach	Composite	Reach (Reach Compostie
	Area (ha)		Area	Area	Length)	Length	Length	Width	Reach Width Depth		Reach Depth
	244.2948	0.011357	244.2948	0.011357	2275.21	2275.21 0.019637	2275.2125	0.019637	2.2046	2.2046	2.2046 0.1858	0.1858
	91.1786	0.004239	118.5922	0.005513	996.028	996.028 0.008597	1011.0178	0.008726	1.429	1.416610857 0.1392	0.1392	0.138285196
	27.4135	0.001274	27.4135	0.001274	14.99	14.99 0.000129	14.99	0.000129	0.5934	0.5934	0.0775	0.0775
	46.598	0.002166	46.598	0.002166	561.464	561.464 0.004846	561.4641	0.004846	0.8158	0.8158	0.0958	0.0958
71 1	14.6006	0.000679	831.2535	0.038643	363.606	363.606 0.003138	8280.4769	0.071469	4.5965	3.501042844	0.3033	0.250065684
72 18	184.7441	0.008588	1408.9945	0.065500	841.278	841.278 0.007261	9238.2458	0.079735	6.3086	3.77061121	0.3745	0.262072304
73 2	28.0626	0.001305	390.9496	0.018174	450.117	450.117 0.003885	3736.3471	0.032248	2.9232	2.077947656	0.2243	0.177581059
74 25	257.9466	0.011991	257.9466	0.011991	2946.6	2946.6 0.025432	2946.6035	0.025432	2.2778	2.2778	0.1899	0.1899
75	30.07	0.001398	30.07	0.001398	14.99	14.99 0.000129	14.99	0.000129	0.6273	0.6273	0.6273 0.0804	0.0804
76 25	256.8182	0.011939	256.8182	0.011939	2212.95	2212.95 0.019100	2212.9494	0.019100	2.2718	2.2718	2.2718 0.1896	0.1896
77	8.1691	0.000380	93.2259	0.004334	198.863	198.863 0.001716	1029.645	0.008887	1.2368	1.183385673 0.1264	0.1264	0.122769117
78	6.6012	0.000307	303.0966	0.014090	124.77	124.77 0.001077	2512.273	0.021683	2.5092	1.986738264	0.2026	0.172456281
2 62	71.2152	0.003311	1480.2097	0.068811	431.343	431.343 0.003723	12974.5929	0.111984	6.4981	3.283167896	0.382	0.237741011
80	0.0499	0.000002	1454.3242	0.067607	9.9934	9.9934 0.000086	10806.5527	0.093271	6.4296	4.752731695	0.3793	0.308531437
81 46	461.8752	0.021471	816.653	0.037964	3897.01	3897.01 0.033635	7916.871	0.068331	4.5479	3.450730709	0.3011	0.247620739

Appendix D: Wanaque Watershed variables for the 81 subbasins determined using GIS . Page 3 of 9 $\,$

Sub-		Composite	Frodibility	Comp Erodabilitv	Impervious	Composite Impervious	Impervious	Composite Impervious		Composite	
basin	CN	CN calc	(tons/acre)		Surface %	Surface %	Surface Acres	Surface Acres	Hydrogroup # Hydrogroup	Hydrogroup	Slope (%)
-	68.13	67.56073	0.31999999	0.319514394	9.3418	7.28598038	176.4376987	621.8989194	с С	2.99999991	36.7083
2	73	62.380633	0.31999999	0.319999993	0	0	0	0	с С	e	64.5331
S	68.15	64.35408	0.23999999	0.239999995	3.125	1.137278706	4.705624663	4.705624663	с С	e	64.4135
4	64.09	64.09	0.27999999	0.279999994	0.3571	0.357032402	3.725186138	3.725186138	с С	c	40.2541
5	70.7	66.733448	0.27999999	0.317740622	2.8462	8.132586697	13.66935243	840.8932932	с С	2.99999993	63.8417
9	67.88	66.806277	0.23999999	0.311968101	0.9375	7.549655938	2.339162781	843.232456	e	2.99999993	63.182
7	66.97	67.146958	0.27999999	0.299912065	7.1402	6.827251876	131.6335918	1056.200035	n	2.99999995	57.8683
8	79.56	67.634136	0.31999999	0.319517365	20.7576	7.367975491	10.86970047	632.7686198	с С	2.99999991	19.0593
6	60.16	60.16	0.29999999	0.299999993	5.7692	5.752710333	11.9218488	11.9218488	n	n	40.9983
10	66.02	66.57292	0.31999999	0.319999973	8.9521	7.474654656	246.673106	294.973861	с С	2.99999981	48.5887
11	64.4	64.4	0.31999999	0.319999993	1.8333	1.832655156	6.425978386	6.425978386	с С	c	62.4161
12	72.75	72.75	0.31999999	0.319999993	4.9627	4.903936025	32.44053258	32.44053258	с С	ĉ	55.6323
13	61.36	66.622968	0.31999999	0.319999993	0	0.038188825	0	0.24391915	e	e	58.9954
14	70.48	67.430472	0.31999999	0.319999993	0.1042	0.044048183	0.24391915	0.24391915	с С	e	65.9038
15	65.19	65.19	0.31999999	0.319999993	0	0	0	0	n	e	63.2574
16	67.85	66.221554	0.31999999	0.319999993	0.8871	0.616675421	6.745134868	6.745134868	3	3	69.7695
17	64.85	65.627827	0.29666666	0.270429409	8.7999	6.812998753	1383.579226	3364.377854	2.948197205	2.95760671	45.8976
18	59.9	59.9	0.31999999	0.319999993	0	0	0	0	n	e	47.4878
19	62.86	60.964288	0.31999999	0.305957683	7.5	6.273203171	6.59435228	18.51620108	С	3	31.2885
20	59.15	66.540171	0.31999999	0.319579596	15.303	8.390217299	194.4553209	827.2239407	3	2.99999992	25.6795
21	62.1	59.952194	0.31999999	0.289236277	23.0667	7.52455503	52.51628251	347.4901435	S	2.71159016	12.9104
22	89.39	89.39	0.31999999	0.319999993	16.0313	16.00520625	58.24124003	58.24124003	3	3	39.6246
23		67.6		0.239999995	0	0	0	0	3	3	98.6197
24	68.67	68.67	0.23999999	0.239999995	0	0	0	0	3	3	71.5153
25	70.95	70.95	0.23999999	0.239999995	0	0	0	0	3	3	70.151
26	55.6	55.6	0.31999999	0.319999993	5.7759	5.775901253	9.434244015	9.434244015	3	3	28.0227
27	68.78	68.78	0.25999999	0.259999994	7.2059	7.205899634	30.68836521	30.68836521	З	3	53.8499
28		71.68	0.31999999	0.319999993	7.5694	7.558105244	28.74343661	28.74343661	3	3	44.3611
29	70.77	70.77	0.31999999	0.319999993	12.1698	12.16979507	15.75157524	15.75157524	3	3	29.5296
30	69.	9		0.239999995	2.3333	0.534661431	6.150610326	6.150610326	3	3	51.7152
31	73	.99		0.239999995	0	0	0	0	3	3	72.5266
32	65.16		0.23999999	0.239999995	0	0	0	0	ε	3	57.8726
33	69.49	66.840895	0.23999999	0.257965371	5.3779	3.15822574	62.14603002	73.36818886	3	3.00000032	53.074

Appendix D: Wanaque Watershed variables for the 81 subbasins determined using GIS . Page 4 of 9

<u> </u>		(tons/acre) 0.23999999			,					
	66.80 85.71 63.84 66.11		(tons/acre)	Surface %	Surface %	Surface Acres	Surface Acres	Hydrogroup # Hydrogroup		Slope (%)
	85.77 63.84 66.19	-	0.257772988	16.3636	3.286910194	3.815976767	77.18416563	c	3.00000032	89.7524
	63.89 66.19		0.319999993	17.8571	16.32235183	14.22458206	72.46582209	S	e	25.9335
	63.8 ⁽ 66.1 ⁽	3 0.23999999	0.239999995	6.087	6.042202628	7.49697271	7.49697271	ĉ	n	66.2339
	63.8t 66.15	5 0.27999999	0.279999994	7.1429	6.644643091	2.938361522	2.938361522	e	e	50.1223
	63.8 66.1	9 0.23999999	0.239999995	3.4524	3.443923729	19.03691301	19.03691301	S	e	38.9422
	66.19	5 0.23999999	0.239999911	2.7273	3.287122073	4.222527486	23.25944049	c	2.999999895	41.6621
		3 0.27999999	0.279999994	9.1026	9.102601098	12.97665877	12.97665877	e	e	50.1371
		0.23999999	0.239999995	0	1.156528119	0	6.876098249	S	c	38.6305
42 73.	73.29 48.055993	0.23999999	0.166211831	3.4091	1.436670572	2.170473586	6.876098249	Э	2.07764794	41.2712
43 62	62.18 62.18	8 0.23999999	0.239999995	0	0	0	0	Э	e	65.4851
44 64.	64.82 64.82	2 0.23999999	0.239999995	2.5	2.494521525	3.370282207	3.370282207	e	e	53.0758
45 63.	63.21 56.985789	9 0.23999999	0.239999995	0.9375	4.549273179	1.560675711	33.32978985	3	3	50.1195
46 64.	64.47 55.155666	5 0.23999999	0.239999995	5.75	5.6112534	14.88265612	31.76911413	3	ε	50.368
47 47.	47.37 47.37	7 0.23999999	0.239999995	5.4762	5.475674987	16.88645801	16.88645801	3	3	48.5304
48 78.	78.08 71.619416	5 0.23999999	0.239999995	9.6875	5.213908612	8.338410087	16.50636314	3	3	33.9735
49 68.	68.75 68.75	5 0.23999999	0.239999995	3.3333	3.278645474	6.890904691	6.890904691	3	3	61.3741
50 68.	68.81 70.911499	9 0.23999999	0.206487712	0.9091	5.01544783	1.311042962	320.6319588	3	3.10722115	67.612
51 70.	70.96 70.96	5 0.20571428	0.205714281	5.1724	5.110218279	319.3209159	319.3209159	3.109695711	3.10969571	59.9566
52 72.	72.42 68.405101	1 0.23999999	0.239999995	25	10.69377785	3.707742277	40.15379663	3	3	33.8204
53 71.	71.24 71.24	4 0.23999999	0.239999995	1.3158	1.321050525	7.242038127	7.242038127	Э	e	61.6571
54 73.	73.18 73.18	8 0.23999999	0.239999995	0	0	0	0	3	3	69.8713
	68.67 70.959201		0.211720574	12.5	4.7868115	34.7670243	362.6410213	3	3.09047883	34.869
			0.239999995	12.25	12.25000567	18.00469779	18.00469779	3	3	34.3961
57 68.	68.24 68.24	4 0.23999999	0.239999995	10.1786	10.10547456	36.44605435	36.44605435	3	3	61.9358
58 70.	70.19 70.19		0.319999933	15	14.31818716	12.42667262	12.42667262	3	3	29.474
	68.37 65.877055		0.23999997	0.2174	3.633371995	2.052204285	85.99503106	3	2.99999969	49.1155
60 57.	57.22 62.921834		0.239999978	7.5874	4.890951134	89.76187485	175.7569059	3	2.99999979	38.9707
61 64.	64.19 64.19		0.239999995	6.1022	5.946821948	83.94282677	83.94282677	3	3	42.2013
62 71.	71.96 69.105579		0.239999927	9.0323	4.894661905	20.28089316	42.90934452	3	2.99999915	46.9755
			0.239999995	12.5	3.471042132	1.804516833	22.62845135	£	e	38.7355
64 63.			0.239999995	6.25	6.231280842	14.37289945	14.37289945	З	e	52.618
			0.239999995	25.9756	19.07781215	111.8872242	126.2601236	3	З	35.1774
66 8(80.5 69.897408	3 0.23999999	0.27602767	44.5238	12.53152065	2.252377308	258.034822	C	2.9945606	11.8083

Appendix D: Wanaque Watershed variables for the 81 subbasins determined using GIS . Page 5 of 9

CN CN calc (tons/acre) Ions/acre) Surface % Surface % Surface Acres Surface	Sub-		Composite	Composite Erodibility	Comp Erodability I	Impervious	Composite Impervious	Impervious	Composite Impervious		Composite	
66.866.80.23999990.239999954.50624.45637439826.9010132726.9010132773.6174.0491380.239999990.2399999512.714313.2358600128.437543538.786539775.5175.510.2399999990.2399999515.2778061410.348996210.348996275.5175.510.2399999990.230519.264719.2646898122.1820685522.1820685583.1469.8712950.239999990.27611640221.08713.455778997.425638956255.782444774.1351.0581450.239999990.27611640221.08713.2452727997.425638956255.782444774.1351.0581450.239999990.23999999513.29799.15445068860.68885927318.723681374.1169.5229810.2399999990.23999999512.89477.7233116758.92245384974.6100068274.1169.5229810.2399999990.2399999953.33333.26708351520.8239345220.8239345275.8775.870.2399999990.23999999519.0909019.0908841914.1850939514.1850939567.9867.9867.9867.980.2399999990.2399999952.71432.66256467816.8965761316.8965761375.8775.870.2399999990.2399999956.42863.5457156361.2770483578.16795304873.969.2012790.2399999990.2399999956.42863.545716361.2770483578.16795304873.969.185	basin		CN calc	(tons/acre)	_	Surface %	Surface %	Surface Acres	Surface Acres	Hydrogroup #	Hydrogroup	Slope (%)
73.6174.049138 0.23999999 0.239999999 12.7143 13.23586001 28.4375435 38.7865397 75.51 75.51 75.51 0.239999999 0.239999995 15.27780614 10.3489962 10.3489962 68.57 68.57 0.305 0.305 0.305 19.2647 19.2647 19.26468981 22.18206855 22.18206855 83.14 69.871295 0.23999999 0.276116402 21.087 12.45272799 7.425638956 255.7824447 74.13 51.058145 0.23999999 0.239999933 12.8947 7.723311675 8.922453849 74.61000682 74.14 69.522981 0.239999999 0.239999995 12.8947 7.723311675 8.922453849 74.61000682 74.1 69.522981 0.239999999 0.239999995 12.0909 9.154450688657613 14.18509395 14.18509395 75.87 75.87 75.87 0.239999999 0.239999995 19.09088419 14.18509395 14.18509395 67.98 67.98 0.239999999 0.239999995 5.72143 2.662564678 16.89657613 16.89657613 75.87 75.87 0.239999999 0.239999995 0.239999995 0.239999995 0.239999995 0.239999995 0.239999995 67.98 67.98 67.98 0.2399999995 0.239999995 0.2743879 14.18509395 14.18509395 75.87 75.87 0.2399999995 0.239999995 0.239999995 0.239999995 0.239999995 <td>67</td> <td></td> <td></td> <td>0.23999999</td> <td>0.239999995</td> <td>4.5062</td> <td>4.456374398</td> <td>26.90101327</td> <td>26.90101327</td> <td>c</td> <td>n</td> <td>53.6047</td>	67			0.23999999	0.239999995	4.5062	4.456374398	26.90101327	26.90101327	c	n	53.6047
75.51 75.51 0.2399999 0.23999995 15.2778 15.27780614 10.3489962 10.3489962 10.3489962 10.3489962 10.3489962 10.3489962 10.3489962 10.3489962 10.3489962 10.3489962 10.3489962 10.3489962 10.3489962 10.3489962 10.3489962 22.18206855 22.182053656 26.161000682 22.182053649 16.18000395	68			0.23999999	0.239999792	12.7143	13.23586001	28.4375435	38.7865397	e	2.99999747	64.787
68.5768.570.3050.3050.3050.30519.264719.2646898122.1820685522.1820685583.1469.8712950.239999990.27611640221.08712.452727997.425638956255.782444774.1351.0581450.3050.23999993312.89477.7233116758.92245384974.6100068274.169.5229810.239999990.23999993312.89477.7233116758.92245384974.6100068274.169.5229810.2399999990.2399999953.33333.26708351520.8239345220.8239345275.8775.870.2399999990.23999999519.090919.0908841914.1850939514.1850939567.9867.980.2399999990.2399999953.33333.26708351520.8239345220.8239345275.8775.870.2399999990.23999999519.0900819.0908841914.1850939514.1850939567.9867.980.2399999990.2399999956.42863.5457156361.2770483578.16795304873.969.2012790.23999999956.42863.5457156361.2770483578.16795304869.1857.2513510.23999999956.42863.5457156361.2770483578.16795304869.1857.2513510.2399999956.42863.5457156361.2770483578.16795304870.6766.9639090.2399999956.42863.5457156361.27704835733.32978985570.6766.9639090.2399999956.42863.5457156363	69		75.51	0.23999999	0.239999995	15.2778	15.27780614	10.3489962	10.3489962	ε	e	56.6258
83.1469.871295 0.2399999 0.276116402 21.087 12.45272799 7.425638956 255.7824447 74.13 51.058145 0.305 0.2303237861 13.2979 9.154450688 60.68885927 318.7236813 74.13 51.058145 0.305 0.239999933 12.8947 7.723311675 8.922453849 74.61000682 67.97 67.97 0.239999999 0.239999995 3.3333 3.267083515 20.82393452 20.82393452 67.98 67.97 0.239999999 0.239999995 3.3333 3.267083615 14.18509395 14.18509395 67.98 67.98 0.239999999 0.239999995 3.3333 3.267083419 14.185093395 14.18509395 67.98 67.98 0.239999999 0.239999995 5.7143 2.662564678 16.89657613 16.89657613 75.87 0.239999999 0.239999995 6.4286 3.545715636 1.277048357 8.167953048 69.18 57.251351 0.239999999 0.239999995 6.4286 3.545715636 1.277048357 8.167953048 69.18 57.251351 0.239999995 6.4286 3.545715636 10.277048357 8.167953048 69.91 57.251351 0.239999999 0.239999995 6.4286 3.5457156367 33.32978985 69.91 62.922074 0.239999995 0.239999995 6.43607972 39.3797895 69.94096 0.2399999995 0.239999995 0.2399999978 0.20564490	70		68.57			19.2647		22.18206855	22.18206855	2.153383237	2.15338324	16.0889
74.13 51.058145 0.305 0.203237861 13.2979 9.154450688 60.68885927 318.7236813 318.7236813 74.13 51.05814 0.23999999 0.239999933 12.8947 7.723311675 8.922453849 74.61000682 67.97 67.97 0.239999999 0.23999995 3.3333 3.267083515 20.82393452 20.82393452 75.87 75.87 0.239999999 0.239999995 19.0909 19.09088419 14.18509395 14.18509395 67.98 67.98 0.239999999 0.239999995 2.7143 2.662564678 16.89657613 16.89657613 73.9 69.201279 0.239999999 0.239999995 2.7143 2.662564678 16.89657613 16.89657613 73.9 69.201279 0.239999999 0.239999995 6.4286 3.545715636 1.277048357 8.167953348 69.18 57.251351 0.2399999995 6.4286 3.545715636 1.277048357 8.167953048 70.67 66.963909 0.2399999915 0.2658848004 18.1731 10.	71	83.14		0.23999999	0.276116402	21.087		7.425638956	255.7824447	S	2.9945472	17.4315
74.1 69.522981 0.23999999 0.239999933 12.8947 7.723311675 8.922453849 74.61000682 67.97 67.97 0.239999999 0.239999995 3.3333 3.267083515 20.82393452 20.82393452 75.87 75.87 0.239999999 0.239999995 19.09098419 14.18509395 14.18509395 75.87 75.87 75.87 0.2399999999 0.239999995 19.09088419 14.18509395 14.18509395 67.98 67.98 0.2399999999 0.239999995 2.7143 2.662564678 16.89657613 16.89657613 73.9 69.201279 0.2399999999 0.239999995 6.4286 3.545715636 1.277048357 8.167953048 73.9 69.201279 0.239999999 0.239999995 6.4286 3.545715636 1.277048357 8.167953048 70.67 66.963909 0.2399999995 6.4286 3.545715636 1.277048357 8.167953048 70.67 66.963909 0.2399999995 0.2399999955 6.4286 3.545715636767 33.32978985 70.67 66.963909 0.2399999995 0.2399999978 18.1731 10.755387918 31.97970927 393.336881 69.91 62.922074 0.239999999 0.239999978 18.0056 12.3073842 205.4474612 248.3568057 70.04 69.63406 0.3305 12.3073842 205.4474612 248.3568057	72				0.203237861	13.2979		60.68885927	318.7236813	2.995381876	2.16377627	47.6165
67.9767.970.239999990.239999953.33333.26708351520.8239345220.8239345275.8775.870.239999990.2399999519.090919.0908841914.1850939514.1850939567.9867.980.2399999990.2399999952.71432.66256467816.8965761316.8965761373.969.2012790.2399999990.2399999956.42863.5457156361.2770483578.16795304870.6766.9639090.23999999150.23999999150.445019217033.3297898570.6766.9639090.2399999990.239999991518.173110.7538791831.97970927393.33688170.6766.9639090.2399999990.239999997818.173110.7538791831.97970927393.335688170.0469.9162.9220740.239999997818.005612.3073842205.4474612248.3568057	73			0.23999999	0.239999933	12.8947	7.723311675	8.922453849	74.61000682	e	2.99999923	45.1735
75.87 75.87 0.23999999 0.23999995 19.0909 19.09088419 14.18509395 14.18509395 14.18509395 14.18509395 14.18509395 15.89 14.18509395 14.18509395 14.18509395 15.89 14.18509395 15.89 15.89 14.18509395 14.18509395 14.18509395 14.18509395 14.18509395 14.18509395 14.18509395 14.18509395 15.89 15.89 15.89 15.89 15.89 16.89 15.704835 16.89 15.704835 8.167953048 16.89 16.	74		67.97	0.23999999	0.239999995	3.3333		20.82393452	20.82393452	S	e	61.7718
67.98 67.98 0.23999999 0.23999995 2.7143 2.662564678 16.89657613 175.7630752 69.91 62.922074 0.2399999978 18.0756 12.3073842 20.006169289 175.7630752 70.04 69.63406 0.305 0.276762079 18.0056 12.3073842 205.4474612 248.3568057	75		75.87	0.23999999	0.239999995	19.0909	19.09088419	14.18509395	14.18509395	e	e	42.0047
73.9 69.201279 0.23999999 0.23999995 6.4286 3.545715636 1.277048357 8.167953048 69.18 57.251351 0.239999999 0.239999915 0 4.45019217 0 33.32978985 70.67 66.963909 0.236848004 18.1731 10.75387918 31.97970927 393.3336881 69.91 62.922074 0.2399999978 5 4.890954991 0.006169289 175.7630752 69.91 62.922074 0.2399999978 5 4.890954991 0.006169289 175.7630752 70.04 69.63406 0.305 0.276762079 18.0056 12.3073842 205.4474612 248.3568057	76			0.23999999	0.239999995	2.7143	2.662564678	16.89657613	16.89657613	ε	e	65.8835
69.18 57.251351 0.23999999 0.239999915 0 4.45019217 0 33.32978985 70.67 66.963909 0.305 0.256848004 18.1731 10.75387918 31.97970927 393.3336881 69.91 62.922074 0.239999997 0.239999978 5 4.890954991 0.006169289 175.7630752 70.04 69.63406 0.305 0.276762079 18.0056 12.3073842 205.4474612 248.3568057	77			0.23999999	0.239999995	6.4286	3.545715636	1.277048357	8.167953048	e	e	64.8639
70.67 66.963909 0.305 0.256848004 18.1731 10.75387918 31.97970927 393.336881 69.91 62.922074 0.23999999 0.239999978 5 4.890954991 0.006169289 175.7630752 70.04 69.63406 0.305 0.276762079 18.0056 12.3073842 205.4474612 248.3568057	78			0.23999999	0.239999915	0	4.45019217	0	33.32978985	S	2.99999901	52.9626
69.91 62.922074 0.23999999 0.239999978 5 4.890954991 0.006169289 70.04 69.63406 0.305 0.276762079 18.0056 12.3073842 205.4474612 205.4474612	79				0.256848004	18.1731		31.97970927	393.3336881	2.161216767	2.85202655	27.7042
70.04 69.63406 0.305 0.276762079 18.0056 12.3073842 205.4474612	80		62.922074	0.23999999	0.239999978	5		0.006169289	175.7630752	3	2.99999979	44.1732
_	81	70.04			0.276762079	18.0056		205.4474612	248.3568057	2.9901864	2.99444935	52.2591

Appendix D: Wanaque Watershed variables for the 81 subbasins determined using GIS . Page 6 of 9
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		Forest		Wetland/			
Sub-	Composite	area	Urban	Water			Wetland/
basin	% Slope	(ha)	Area (ha)	Area (ha)	Forest %	Urban %	Water %
1	47.884512	461.56	186.91	93.48	0.6	0.24	0.122229
2	50.7155206	24.86	0	0	~	0	0
e	65.0948581	54.69	1.45	4.33	0.9	0.02	0.07
4	40.2541	356.84	11.13	54.28	0.85	0.03	0.12855
5	45.7493245	180.2	7.15	7.05	0.93	0.04	0.036261
9	47.5550091	93.91	0	7.07	0.93	0	0.070017
7	50.0394874	573.88	64.66	83.28	0.77	0.09	0.111624
8	47.7081738	4.37	15.9	0.93	0.21	0.75	0.043741
o	40.9983	55.73	11.59	16.28	0.66	0.14	0.194114
10	50.1467762	618.16	328.09	157.48	0.55	0.29	0.140439
11	62.4161	123.23	0.76	17.01	0.87	0.01	0.119872
12	55.6323	186	65.21	10.2	0.69	0.24	0.0381
13	63.6621964	28.74	0	5.45	0.84	0	0.16
14	64.3782287	91.47	0	3.27	0.96	0	0.03
15	63.2574	115.36	0	13.79	0.89	0	0.106744
16	64.0963789	279.12	2.92	23.3	0.9	0.01	0.074954
17	48.7869185	3820.89	938.63	1535.7	0.6	0.15	0.24133
18	47.4878	86.27	0	18.89	0.81	0	0.17681
19	38.1059012	21.36	3.37	7.59	0.6	0.09	0.213307
20	44.8677438	164.69	109.48	240.07	0.32	0.21	0.466622
21	43.4890896	11.2	40.75	33.46	0.12	0.44	0.362957
22	39.6246	85.99	46.47	9.9	0.58	0.32	0.067226
23	73.0298746	11.32	0	1.38	0.86	0	0.11
24	71.5153	208.89	0	12.59	0.94	0	0.06
25	70.151	146.08	0	4.21	0.97	0	0.03
26	28.0227	31.62	16.72	17.75	0.48	0.25	0.268524
27	53.8499	148.81	11.68	11.84	0.86	0.07	0.07
28	44.3611	121.06	21.81	7.38	0.79	0.14	0.047952
29	29.5296	38.56	9.33	4.3	0.74	0.18	0.08
30	57.8919761	101.43	0.57	4.67	0.95	0.01	0.043748
31	59.729639		0	0	-	0	0
32	57.8726		0	33.82	0.9	0	0.11
33	48.0190314	346.06	79.82	33.93	0.74	0.17	0.07255

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		Forest		Wetland/			
Sub- basin	Composite % Slope	area (ha)	Urban Area (ha)	Water Area (ha)	Forest %	Urban %	Wetland/ Water %
34	48.4659354	6.26	2.01	1.15	0.62	0.2	0.11
35	37.1551622	7.22	20.48	4.5	0.22	0.63	0.138859
36	66.2339	35.59	4.52	6.49	0.71	0.09	0.129249
37	50.1223	12.59	3.46	0.6	0.7	0.19	0.033527
38	38.9422	188.18	4.1	29.09	0.84	0.02	0.13
39	39.5373126	50.85	3.33	8.48	0.81	0.05	0.135341
40	50.1371	38.02	16.6	3.1	0.66	0.29	0.05
41	57.3358367	43.86	0	2.67	0.93	0	0.06
42	35.2284252	18.48	6.68	0.0	0.7	0.25	0.02
43	65.4851	88.53	0	16.12	0.83	0	0.15
44	53.0758	44.74	3.36	6.46	0.82	0.06	0.118148
45	49.5380335	56.61	1.72	9.05	0.84	0.03	0.134332
46	49.3670632	83.51	8.48	12.78	0.8	0.08	0.12
47	48.5304	76.54	13.97	34.26	0.61	0.11	0.274511
48	54.1340073	17.2	17.35	0.06	0.49	0.5	0
49	61.3741	65.68	12.24	5.73	0.77	0.14	0.067367
50	60.1292935	51.68	3.3	3.39	0.89	0.06	0.058085
51	59.9566	2323.98	110.03	49.84	0.92	0.04	0.019709
52	60.8253026	1.34	3.72	0.95	0.22	0.62	0.16
53	61.6571	200.03	6.85	11.3	0.9	0.03	0.05
54	69.8713	125.69	16.92	4.7	0.87	0.12	0.03
55	59.7666951	71.04	32.77	8.65	0.63	0.29	0.07659
56	34.3961	48.38	10.42	0.55	0.81	0.18	0.01
57	61.9358	130.01	4.11	10.79	0.89	0.03	0.07
58	29.474	11.19	17.41	4.9	0.32	0.5	0.139509
29	44.9918895	357.09	0.1	24.32	0.92	0	0.06291
60	42.9364626	314.91	50.96	110.29	0.63	0.1	0.222162
61	42.2013	415.47	62.3	75.53	0.73	0.11	0.132219
62	57.5967431	44.33	39.96	6.59	0.49	0.44	0.07
63	61.2	2.51	3.09	0.24	0.43	0.53	0.04
64	52.618		21.95	14.56	0.61	0.24	0.155979
65		53.99	87.45	32.89	0.31	0.5	0.188495
66	53.8219975	0.33	1.72	0	0.16	0.84	0

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Sub-	Composite	Forest area	Urban	Wetland/ Water			Wetland/
basin	% Slope	(ha)	Area (ha)	Area (ha)	Area (ha) Area (ha) Forest % Urban %	Urban %	Water %
67	53.6047	165.65	45.31	26.99	0.68	0.19	0.110481
68	62.9004212	66.17	22.3	2.08	0.73	0.24	0.02
69	56.6258	12.04	14.57	0.8	0.44	0.53	0.03
70	16.0889	23.51	21.66	1.42	0.5	0.46	0.030473
71	53.9254733	1.7	12.41	0.16	0.12	0.85	0.01
72	38.0745141	75.56	98.04	9.15	0.41	0.53	0.05
73	55.8193042	12.5	14.04	-	0.45	0.5	0.035635
74	61.7718	229.77	3.65	17.98	68.0	0.01	0.069704
75	42.0047	16.33	13.19	0.56	0.54	0.44	0.02
76	65.8835	232.76	1.69	17.46	0.91	0.01	0.067986
77	61.6799005	7.68	0.36	0	0.94	0.04	0
78	49.6126015	6.2	0	0.34	0.94	0	0.051506
29	50.9855567	26.35	44.33	0.54	0.37	0.62	0.007583
80	42.936505	0	0.04	0.01	0	0.8	0.2
81	54.5779273	197.06	214.84	47.51	0.43		0.47 0.102863

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