TMDL for Saltlick Pond #9
West Virginia

U.S. Environmental Protection Agency
Region 3
1650 Arch Street
Philadelphia, PA 19103

July 5, 2000

CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY

The objective of this study was to summarize the background information, analyze load reductions, and document a Total Maximum Daily Load (TMDL) for siltation. The West Virginia Division of Environmental Protection (WVDEP) has identified Saltlick Pond #9 (designated code WV_LK(L)-95-(1)) for aquatic life impairment due to siltation, as reported in the 1998 303(d) list of water-quality-limited waters (WVDEP 1998). WVDEP has determined that the aquatic life use designation (Class B1 for warm water fishery) has been impaired by siltation.

The West Virginia standards and listing practices were reviewed to develop a numeric target which will meet the water quality standard. Siltation has no specific water quality criterion; however, elevated inputs of sediment have been demonstrated to cause impairment of the support of aquatic life and recreational uses of the pond. The endpoint for the development of a TMDL for siltation of Saltlick Pond #9 is based on the evaluation of the total sediment load delivered to the pond, as indicated by the average accumulation rate of sediment in selected critical locations, allowing for a 40 year life span for the pond.

To evaluate the relationship between the sources, their loading characteristics, and the resulting conditions in the pond, a combination of analytical tools were used. Assessments of the nonpoint source loading into the pond were developed for Saltlick Pond #9 watershed using the Generalized Watershed Loading Function (GWLF) computer program (Haith et al., 1992). GWLF provided estimates of sediment transported to the pond from individual land use categories. The pond sedimentation rate was calculated based on sediment trap efficiency (Chow, 1953). The results of the watershed and reservoir models were compared with observed water quality data, literature values, previous studies, and reservoir conditions to evaluate the models' performance.

TMDLs are composed of the sum of individual waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and natural background levels. The period from 1990 to 1995 was used to evaluate the source loading under a range of climatic conditions. There are no relevant point sources in the watershed so the WLA is zero. The resulting load allocation from nonpoint sources consists of a 36 percent reduction of sediment load to address siltation problems.

The loads are described as average annual load reductions, which is typically appropriate for reservoirs and impoundments. The margin of safety has been addressed through an explicit portion of the TMDL load. The load reductions can be achieved through a combination of land use and restoration practices such as erosion and sediment control practices, forest management, and stream restoration.

1 INTRODUCTION

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions. By following the TMDL process, states can establish water quality-based controls to reduce pollution from both point and nonpoint sources and to restore and maintain the quality of their water resources (USEPA, 1991).

The West Virginia Division of Environmental Protection (WVDEP) has determined that the aquatic life use designation of Saltlick Pond #9 has been impaired by siltation. The United States Environmental Protection Agency (USEPA) conducted this study to analyze the sediment loading to the pond and to establish a TMDL that will restore and maintain the quality of Saltlick Pond #9 for the uses designated by West Virginia.

This report presents the background information, analysis, and TMDL that address the designated use impairment of Saltlick Pond #9. The report is organized as follows:

- Section 2 - A description of the waterbody and the impairments listed by West Virginia as required under Section 303(d) of the Clean Water Act
- Section 3 - A presentation of the essential information that characterizes the impaired waterbody and watershed
- Section 4 - A description of the applicable water quality standards and the selection of TMDL endpoints to achieve the standards and to meet the designated uses
- Section 5 - An assessment of the water quality data and information pertinent to developing TMDLs
- Section 6 - An assessment of the sources of pollutants pertinent TMDL allocation
- Section 7 - A description of the modeling process used to develop the TMDL
- Section 8 - Allocation of the load reduction to sources
- Section 9 - A discussion of reasonable assurance and implementation techniques
- Section 10 - Monitoring recommendations

This report also provides a description of the waterbody and associated pollution sources, provides a summary of water quality monitoring data, and describes the analytical approach used to develop the TMDL. The report specifically addresses each of the elements of a TMDL, including the following:

1.	Describe waterbody, pollutant of concern, pollutant sources, and priority ranking	(Section 2)
2.	Describe applicable water quality standards and numeric water quality targets	(Section 4)
3.	Loading capacity- linking water quality and pollutant sources	(Section 8)
4.	Load allocations (LAs)	(Section 8)
5.	Wasteload allocations (WLAs)	(Section 8)
6.	Margin of safety (MOS)	(Section 8)
7.	Seasonal variation	(Section 8)
8.	Reasonable assurance for implementation	(Section 9)

2 PROBLEM STATEMENT

A general description of the impaired waterbody, Saltlick Pond #9, and the causes for its listing on the 303(d) list are presented in this section.

The Saltlick Pond #9 watershed is located within the Little Kanawha River hydrologic cataloging unit (05030203). The land area of the watershed is approximately 2,528 hectares (6,240 acres) contained solely within Braxton County. Runoff from the watershed flows into Saltlick Pond #9 from Saltlick Creek. Water discharged from the pond continues in Saltlick Creek to the Little Kanawha River 13 miles downstream. The pond is used for recreational activities such as fishing and picnicking. Boating using electric motors only are permitted on the pond. The pond's watershed is primarily rural, and the main land uses are forest and hay/pasture.

WVDEP listed Saltlick Pond #9 on the 1998 303(d) list for not meeting its designated uses. The waterbody is given a high priority for TMDL development. The pond (designated code LK(L)-95-(1) was listed for siltation (WVDEP, 1998). The impairment, from the West Virginia Primary Waterbody List, is presented in Table 2.1.

The water quality use that is impaired is aquatic life. The primary source column provides the "general source descriptions, if confirmed" (WVDEP, 1998). WVDEP had not determined the source of the pond impairment at the time of the 303(d) listing..

West Virginia considers ponds to be impaired by siltation if sediments are visually observed to accumulate to a depth approaching the pond normal pool elevation.

Table 2.1. Water quality impairment of Saltlick Pond #9 pursuant to section 303(d) of the Clean Water Act

Waterbody Name	Stream Code	Use Affected	Pollutant	Primary Source	Area Affected
Saltlick Pond #9	LK(L)-95-(1)	Aquatic Life	Siltation	Undetermined	15 acres

3 ENVIRONMENTAL SETTING

The environmental setting provides a description of the features of the watershed that contribute to the impairment of Saltlick Pond #9. This section presents the environmental information that will be used in subsequent sections.

3.1 Pond Characteristics

3.1.1 Physical Characteristics

Based on discussions with WVDEP personnel, historical information regarding the Saltlick Pond #9 was collected. The pond was constructed at an elevation of 880 feet in 1967 by the Elk Soil Conservation District and is maintained by the State Soil Conservation Service.

The pond consists of the flooded Saltlick Creek stream valley. Records available from the WVDNR show that Saltlick Pond #9 is the most upstream of a series of ponds along Saltlick Creek.

Table 3.1. Saltlick Pond #9 dimensions (USDA SCS, 1965)

	Surface Area		Mean Pond Depth (m)		Maximum Pond Depth	
Pond Name	(hectares)	(acres)	(meters)	(feet)	(meters)	(feet)
Saltlick Pond #9	6.6	16.2	1.5	5	4.9	16

Based on the available bathymetric and physical characteristics data obtained from the 1965 design report (USDA SCS, 1965), several physical characteristics of Saltlick Pond #9 have been derived and are presented in Table 3.2. The pond surface area extends over approximately 6.6 hectares (16.2 acres). The pond is shallow with a maximum depth of 4.9 meters (16 feet) and a mean depth of 1.5 meters (5 feet). The overall storage volume of the pond at normal pool is about 118,400 cubic meters (96 acre-feet) and drains a watershed area totaling 2,528 hectares (6,240 acres).

Table 3.2. Description of the physical characteristic of Saltlick Pond #9

Characteristics	Original Value (1967)	References
Pond volume (cubic meters)	118,500	Dam Inspection Report (1981)
Surface area (hectares)	6.6	
Drainage area (hectares)	2,528	
Mean depth (meters)	1.5	Smithson, West Virginia Small Impoundment Fishing Guide
Maximum depth (meters)	4.9	
Length (meters)	1,021	Measured from map
Mean width (meters)	64.3	

3.1.2 Morphometric Characteristics

The 1967 bathymetric analysis (summarized in Table 3.3) shows that the ratio of mean to maximum depth is close to 0.3, indicating moderately steep side slopes. As the pond continues to lose capacity to siltation, sediment deposits around the inflow point and shores reduce the slopes at pond entrance areas.

The ratio of the drainage area to pond surface area is about 383. The watershed area is very large in comparison with the pond surface areas which indicates that the watershed sediment loading could have a significant impact on the pond water quality. Since the drainage watershed is large in comparison to the impoundment area, making the pond very sensitive to increased loading, especially in the areas surrounding the pond.

The ratio of the length of Saltlick Pond #9 to its mean width (15.9) indicates that the length of the pond is the dominant process. The pond tends to act more like a wide river than a deep pond.

Table 3.3. Morphometric parameters of Saltlick Pond #9

Characteristics	Original Value (1967)
Mean to max depth ratio	0.31
Drainage area to surface area ratio	383
Length to mean width ratio	15.9

3.1.3 Hydrologic Characteristics of the Pond

A key hydrologic parameter of Saltlick Pond #9 was determined based on estimates of streamflow rates and volumetric characteristics of the impoundment. The pond residence time, calculated as pond volume over the annual flow rate is approximately one week. This short residence time is typical for ponds with a large drainage area-to-pond surface area ratio. In ponds with short residence times, a significant portion of the sediment load is transported farther into the impoundment beyond the transition to deeper water.

3.2 Watershed Characteristics

The Saltlick Pond #9 watershed is 2,528 hectares (6,240 acres). The watershed soils are dominantly hydrologic soil groups B and C (USDA, 1993). The soil series include Allegheny, Conemaugh, Mononghela, Mohoning, and Sandstone (USACE, 1981). Based on an evaluation of watershed size the estimated sediment delivery ratio of 0.18, that is 18 percent of the eroded soil reaches the pond based on long-term average annual loading analysis (Vanoni, 1975).

3.2.1. Available Land Use Coverage

The land use/land cover conditions were based on the Gap 2000 Land Use coverage data. The 26 land use/land cover classifications contained in the Gap 2000 data are presented in Table 3.5 and Figure 3.1.

Table 3.4. WV GAP2000 Land Use/Land Cover Categories

GAP Land Use ID	Label
1	Shrubland
2	Woodland
3	Surface water
4	Major highways
5	Major powerlines
6	Populated area – mixed land cover
7	Low intensity urban
8	Moderate intensity urban
9	Intensive urban
10	Row crop agriculture
11	Pasture/grassland
12	Barren land – mining, construction
13	Planted grassland
14	Conifer plantation
15	Floodplain forest
16	Forested wetland
17	Shrub wetland
18	Herbaceous wetland
19	Surface water (combine with class #3)
20	Cove hardwood forest
21	Diverse/mesophytic hardwood forest
22	Hardwood/conifer forest
23	Oak dominant forest
24	Mountain hardwood forest
25	Mountain hardwood/conifer forest
26	Mountain conifer forest

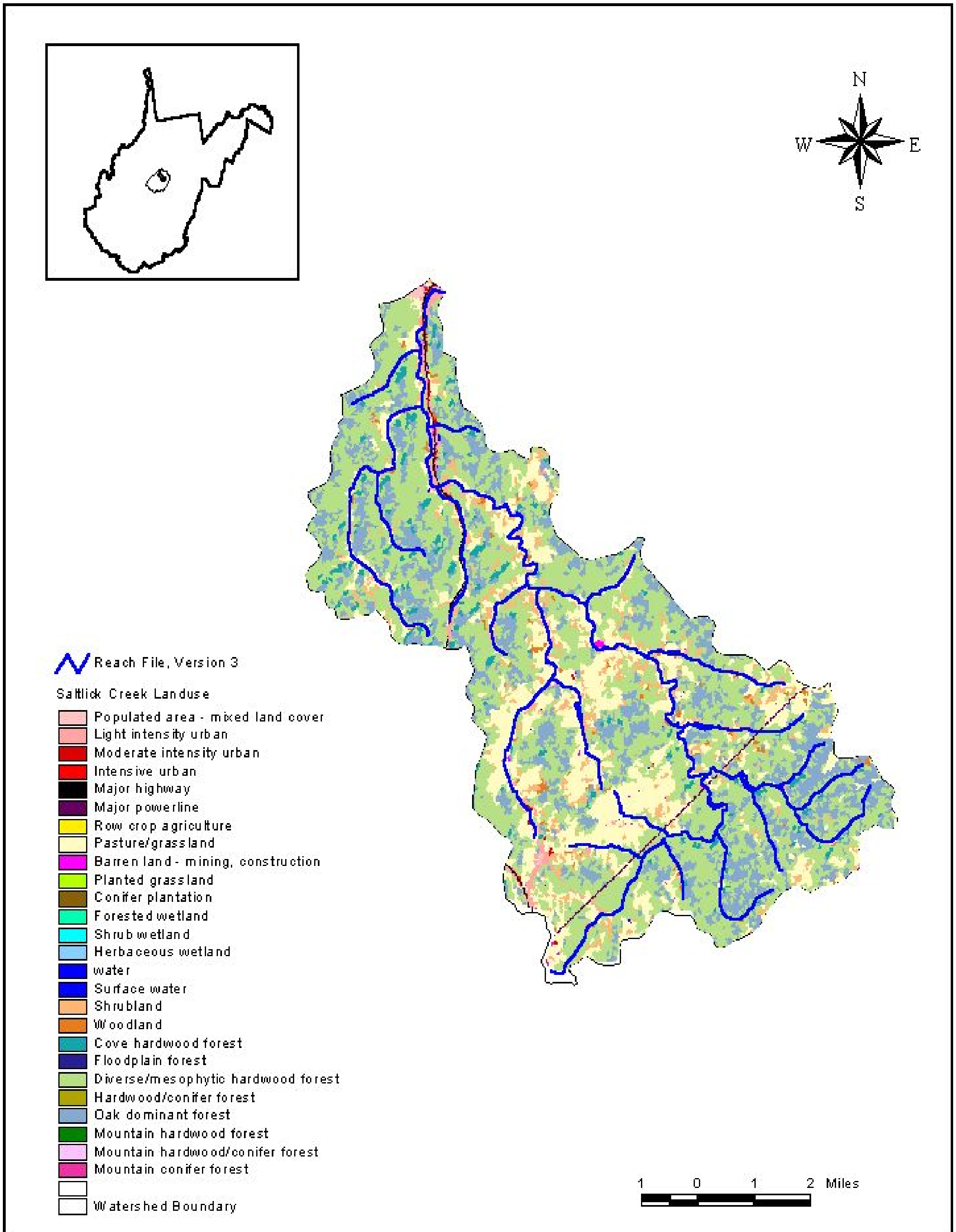

Figure 3.1
SaltLick Creek
Landuse Distribution
(Gap 2000 land use /land cover)

Map Projection: Albers Equal Area GRS 80

Data Sources: West Virginia DEP

3.2.2. Land Use Reclassification

The reclassification scheme applied to the GAP 2000 land use/land cover is presented in Table 3.6. The first column of this table shows the general land use categories such as forest, agriculture and urban built up. The second column shows GAP 2000 land uses that fall under these general categories. For example, cropland and pastureland fall under agriculture, therefore, it was divided into two subcategories as shown in the third column of the table. In summary, based on reclassification of the WV GAP 2000 land use, forestland was subdivided into 3 categories, agricultural land uses were subdivided into 2 categories, roads were subdivided into two categories, and urban built up areas, barren land, wetlands, and water areas were not subdivided, each on was kept as a separate category. The resulting land use coverage is shown in Figure 3.2

Table 3.5. Representative land use classes applied in the simulation

General Land Use Category	Gap Land Use	Description [a]	Modeling Land Use Designation
Forest	Mountain conifer forest Mountain hardwood/conifer forest Mountain hardwood forest Oak dominant forest Hardwood/conifer forest Diverse/mesohytic hardwood forest Cove hardwood forest	Well Established forest areas	Forest_1
	Woodland	Intermediate forest areas-wooded areas without mature canopy forest cover	Forest_2
	Shrubland Major powerlines	Natural highland scrubland or reverting agricultural fields with woody vegetation. Powerline right-of-ways	Forest_3
Agriculture	Row crop agriculture	Includes row crops such as corn and soybeans	Ag_1
	Planted grassland	Includes pastureland, hay fields, old fields, abandoned farms, and other herbaceous land cover areas (excluding wetlands).	Ag_2
Urban Builtup	Low intensity urban Moderate intensity urban Intensive urban Populated area – mixed land cover	Rural developed areas Concentrated residential, commercial, industrial, and institutional areas in which a significant portion of the land area may be undeveloped. Dense residential, commercial, industrial, and city core areas in which the majority of the land is developed Rural or lightly developed areas	Urban

General Land Use Category	Gap Land Use	Description [a]	Modeling Land Use Designation
Roads	Major highways	Paved	Road_1
		Unpaved	Road_2
Barren land	Barren land – mining, construction	Uunvegetated lands resulting from construction, timbering, mining, or other activities.	Br
Wetlands	Forested wetland Shrub wetland Herbaceous wetland Floodplain forest	Forested, shrub, and hebaceous land cover derived from National Wetlands Inventory (NWI) Bottom land forest	Wet
Water	Surface water	Open water, including lakes large ponds and rivers	Wat

[a] Adapted from WV GAP 2000 land use description

3.2.3. Land Use Distribution and Areas

Table 3.7 presents the distribution of the land segment used in the watershed model to estimate sediment loading.

Table 3.6. Watershed land use distributions

General Land Use Classes	TMDL Land Use Classes	Land Use Distribution in Watershed	
		Hectares	Percent
Forest	Forest_1	1,655	65.5%
	Forest_2	15	0.6%
	Forest_3	127	5.0%
Agriculture	Ag_1	0	0.0%
	Ag_2	673	27.1%
Urban Builtup	Urban	27	1.1%
Roads	Road_1	0	0.0%
	Road_2	16	0.2%
Barren Land	Br	4	0.2%
Wetlands	Wet	0	0.0%
Water	Wat	12	0.5%
Total		**2,528**	**100.0%**

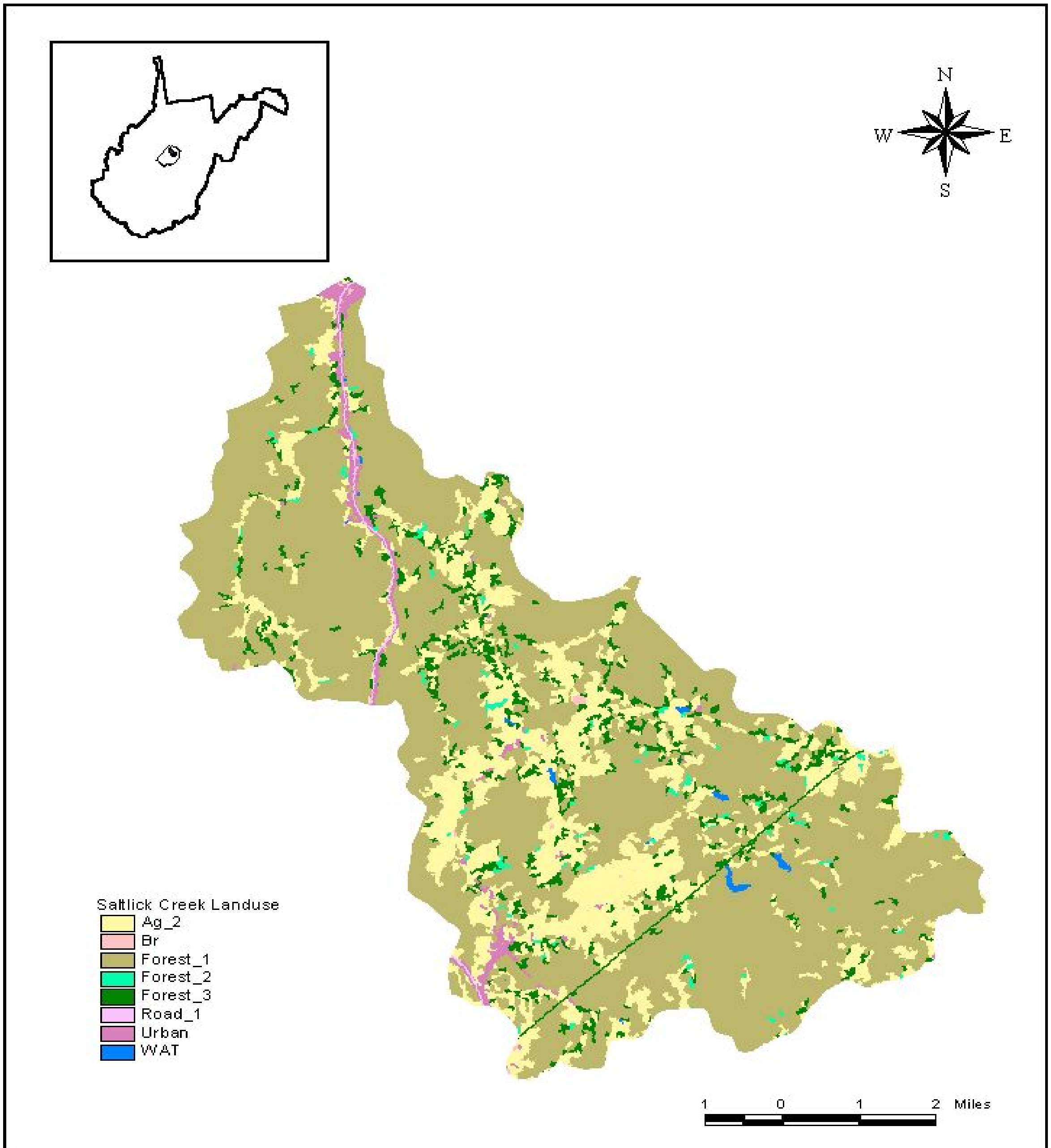

Figure 3.2 Salitlick Creek Landuse Distribution Modeling Landuse Designation	Map Projection: Albers Equal Area, GRS 80 Data Sources: West Virginia DEP

4 WATER QUALITY STANDARDS AND TMDL ENDPOINT

4.1 Water Quality Standards

The state water quality standards include water use categories, antidegradation criteria, numeric criteria, and narrative descriptions of conditions in waters of the state. The relevant water use categories for Saltlick Pond #9 is propagation and maintenance of fish and other aquatic life (Category B-1). No special exceptions or use designations are identified for Saltlick Pond #9.

In addition to impairing aquatic life, the siltation of Saltlick Pond #9 has raised citizen concern about fishing and recreation uses.

4.2 Sediment Endpoint and Target Limit

Saltlick Pond #9 is listed as impaired due to siltation on West Virginia's 1998 303(d) list. Siltation is the excessive accumulation of sediment in a reservoir or pond. This accumulation of sediment can impair the water uses of the pond, such as fish and other aquatic life and recreation. Siltation can adversely affect aquatic life by creating thick mud deposits, filling habitat, and increasing turbidity. Siltation impairs recreational uses by reducing access and storage capacity, and by degrading the aesthetic character of the pond.

The state has no numeric criteria related to siltation in ponds. The relevant narrative conditions specify the following:

> §46-1-3.3.2 No sewage, industrial wastes or other wastes present in any of the water of the State shall cause therein or materially contribute to any of the following conditions thereof:
> ...
> c. Deposits or sludge banks on the bottom.
> ...
> i. Any other condition ... which adversely alters the integrity of the waters of the State including wetlands; no significant adverse impact to the chemical, physical, hydrologic, or biological components of aquatic ecosystems shall be allowed. (Title 46, Series 1, Requirements Governing Water Quality Standards)

In the absence of numeric criteria for pond siltation in West Virginia, a numeric limit was selected for the development of the Saltlick Pond #9 siltation TMDL. This numeric limit was selected to be protective of the pond uses and to serve as a target for identifying achievement of water quality standards associated with the pond listing. The selection of this numeric limit was based on the following considerations:

- The selected endpoint, expressed as a long-term sedimentation rate for Saltlick Pond #9, is consistent with the causes of the pond listing. Excessive siltation is reported by the state as the main cause of the pond impairment.

- The long-term annual siltation rate should not be excessive and should allow for a reasonable life span of the pond before deposits become evident at normal pool elevations or create barrier to recreational uses. For small impoundments such as Saltlick Pond #9 a minimum 50-year life span is selected as a target and is used in derivation of siltation rate limit for this TMDL, assuming the lake is at its initial storage capacity, which can be achieved through dredging of existing deposits.

- Siltation does not occur uniformly over the entire pond bottom. Selected locations within the pond experience high siltation rates compared to other locations within the pond. The selected locations are the areas most likely to create barriers for recreational uses. Specifically for Saltlick Pond #9, characterized by a small area (6.6 hectares) and a shallow depth (1.5 meters mean depth), the high siltation locations are assumed to correspond to 35,500 cubic meters (28.8 acre-feet) volume of the pond.

Based on the above considerations regarding the life span of the impoundment and the siltation volume (or critical volume), a long-term average annual siltation rate limit of 1.79 cm per year was calculated and established as the numeric target for this siltation TMDL.

5 WATER QUALITY ASSESSMENT

This section provides an inventory and analysis of the available water quality data for Saltlick Pond #9, its tributary (Saltlick Creek), and the watershed.

5.1 Inventory of Available Water Quality Monitoring Data

Limited water quality monitoring activities have been conducted for Saltlick Pond #9 and its inflows. WVDEP seasonal water quality sampling of Saltlick Pond #9 and its inflow (Saltlick Creek) from summer and fall 1996 (a total of 2 sampling events) were reviewed. Data include the monitoring of nutrients, metals, temperature, suspended solids, and other water quality parameters. In addition, field notes were available from a watershed assessment survey conducted on 11/9/99.

5.2 Analysis of Water Quality Monitoring Data for Saltlick Pond #9

The available water quality monitoring data related to siltation are presented on Table 5.1. The conclusions from the review of the data are as follows:

- Suspended solids concentrations in the lake and inflow are low, suggesting that siltation problem is due mainly to the transport of large particles to the pond that settle out of the water column quickly. (The elevated bottom value measured on 9/5/96 is most likely due to disturbance of the bottom during sampling.)
- The relatively deep secchi depth further supports the hypothesis that the particles contributing to siltation do not remain suspended in the water column.

Table 5.1. Summary of WVDEP pond sampling observations of siltation: Saltlick Pond #9, 1996

Physical-Chemical Characteristic	Units	Date	Surface	Bottom	Inflow
Suspended Solids	mg/L	6/13/96	5	6	<5
		9/5/96	<5	18	<5
Secchi Depth	m	Summer 96	1.89	–	–

Field notes from a watershed assessment survey conducted on 11/9/99 suggest that activity in the watershed during the previous two to three years may have contributed significantly to siltation in the pond.

> “We spoke with some ‘old-timers’ in the area who stated that up until about three years ago they thought the lake was in good shape. There was lots of wildlife (beavers, ducks, etc.) in the area and ‘pretty good’ fishing.
> “But about two years ago a crew moved in and replaced the gas line that runs across the hills and across Carpenter Creek. They rebuilt what had up until then [been] a jeep trail and turned it into what is now a 1+ lane fairly passable dirt road. From the time the crew started on the gas line and road, the residents noted a heavy increase in silt and sand flowing into the creeks and the lake and a definite drop in the quality of fishing.

"One resident also said that about two years ago landowners on both sides of the lake logged their properties and this also caused lots of dirt and mud to run into the lake." (WV DEP, 1999)

In conclusion, monitoring data suggest that suspended sediment in the water column of the Saltlick Pond #9 does not represent a water quality problem. However, high loadings transported during storm events are believed to be the primary contributor to lake siltation, especially based on evidence that watershed disturbances have recently contributed to increased sediment availability. Assessment of long term average sediment loading can appropriately be used to evaluate siltation rate in this pond.

6 SOURCE ASSESSMENT

6.1 Assessment of Point Sources

Several databases were reviewed to determine if permitted or regulated point source discharges were present within the watershed. The databases reviewed were obtained primarily from the USEPA mainframe system. In addition to review of available databases, local agencies, including WVDEP and USEPA Region 3 were contacted by telephone. The following database systems were searched:

- Permit Compliance System for permitted industrial or municipal facilities
- Hazardous and solid waste facilities
- Abandoned mines
- Oil and gas wells
- Toxic release inventory

No point sources were identified in the watershed.

6.2 Assessment of Nonpoint Sources

Nonpoint sources of pollutants within the watershed can generally be associated with the different types of land uses and land activities within the watershed. For example, sediment loadings can originate from agriculture, silviculture, and road construction activities. Expansion of residential and commercial/industrial areas can also cause an increase in stormwater flows and sediment loads through soil erosion and sediment transport.

The primary land uses within the Saltlick Pond #9 watershed are pasture and forest with smaller areas of residential and transportation land uses. The land uses within the watershed are presented in Table 6.1.

Table 6.1. Watershed land use distributions

General Land Use Classes	TMDL Land Use Classes	Land Use Distribution in Watershed	
		Hectares	Percent
Forest	Forest_1	1,655	65.5%
	Forest_2	15	0.6%
	Forest_3	127	5.0%
Agriculture	Ag_1	0	0.0%
	Ag_2	673	27.1%
Urban Builtup	Urban	27	1.1%
Roads	Road_1	0	0.0%
	Road_2	16	0.2%
Barren Land	Br	4	0.2%
Wetlands	Wet	0	0.0%
Water	Wat	12	0.5%
Total		**2,528**	**100.0%**

6.3. Representation of Potential Sources in the Development of Loading Estimation

The representation of the nonpoint sources in the loading model was determined based on the available data and considering the differences among the various categories of sources.

Sediment

The sediment sources represented in the model are shown in Table 6.2.

Table 6.2. The sediment sources simulated in the loading model.

Sources Simulated	Characteristics
Forest_1	Well Established forest areas
Forest_2	Intermediate forest areas-wooded areas without mature canopy forest cover
Forest_3	Natural highland scrubland or reverting agricultural fields with woody vegetation. Powerline right-of-ways
Ag_2	Includes pastureland, hay fields, old fields, abandoned farms, and other herbaceous land cover areas (excluding wetlands).
Urban-pervious	Concentrated residential, commercial, industrial, and institutional areas in which a significant portion of the land area may be undeveloped. Rural developed areas Rural or lightly developed areas
Urban-impervious	Dense residential, commercial, industrial, and city core areas in which the majority of the land is developed.
Roads_2	Unpaved
Br	Unvegetated lands resulting from construction, timbering, mining, or other activities.
Wat	Open water, including lakes large ponds and rivers

7 MODELING AND ANALYSIS SUMMARY

Based on a review of the available data, listed pollutants, and pond characteristics the following approach was identified. The analysis is presented and described for sediment loading to the pond.. In-pond analysis of the trap efficiency is described. The silt accumulation estimates are used to compare with the identified threshold for siltation.

7.1 Sediment Loading Model

The loading evaluation requires the simulation of annual loading of sediment to the reservoir. The GWLF model was used to estimate sediment loading from the land. The model provides monthly and annual estimates of sediment yield to the reservoir, taking into consideration soil characteristics and land use information. Setup, analysis, and model testing were based on the standard practice for GWLF model setup, using literature values for soil and practice related parameters. Insufficient monitoring information is available to compare predictions to observed tributary loadings. Table 7.1 presents the sediment loading estimates for Saltlick Pond #9 based on a simulation period of 1990-1995.

Table 7.1. Sediment loading estimates by source

Source	Mean Existing Sediment Loading (metric tons/year)
Forest_1	172.7
Forest_2	3.1
Forest_3	793.2
Ag_2	1,428.2
Urban-pervious	<1
Urban-impervious	<1
Roads_2	290.0
Br	77.3
Wat	0
Total	**2764.5**

7.2 Lake Sediment Analysis

The sediment accumulation to the Saltlick Pond #9 is assessed using trap efficiency calculations. Trap efficiency refers to the ability of ponds and reservoirs to retain a portion of the sediment loading. This efficiency is expressed as the percent of sediment retained compared to total incoming sediment. The key factors that affect the efficiency of ponds/reservoirs to trap sediment include sediment particle size distribution, the pond hydraulic residence time, and the design and operation of the reservoir outlets. Brune's method for estimating ponds and reservoirs trap efficiency was developed based on analysis of numerous reservoir siltation studies (Chow, 1953). The method establishes a graphical relationship between the sediment trap efficiency and the ratio of the reservoir available storage capacity to the total annual inflow. This relationship has been extensively used to estimate siltation rates, reservoir life span, and other engineering parameters used in economic feasibility studies of reservoirs.

Using an approximate volume of 118,400 cubic meters (96 acre-feet) and an estimated annual inflow from GWLF model of 11,776,000 cubic meters (9,547 acre-feet), the trap efficiency of Saltlick Pond #9 is estimated at 60 percent. The siltation rate is estimated at 2.8 cm/year for Saltlick Pond #9, occurring on 60% of the total lake surface area (Table 7.2). This allocation assumes that the pond is at an initial capacity or is dredged to a capacity of 118,400 cubic meters (96 acre-feet).

Table 7.2. Estimated sediment loadings to Saltlick Pond #9

Mean Sediment Loading (metric tons/yr)	Siltation (metric tons/yr)	Accumulation Rate (cm/yr)
2,764.5	1658.7	2.8

8 TMDL

The load estimation model and the pond trap efficiency analysis were used to derive the TMDL for Saltlick Pond #9. The results of the TMDL analysis for siltation are presented in this section.

8.1 Sediment

The sediment allocation was based on the long-term average siltation rate as an endpoint and a numeric limit of 1.79 cm per year. Table 8.1 provides the computed mean siltation rate for the pond for two different conditions: (1) initial condition; (2) a loading scenario that extends the life of the reservoir from 32 to 50 years. The table also compares the life span of the pond under these two conditions.

Table 8.1. Siltation of Saltlick Pond #9

	Initial Condition	Loading Scenario for 50 Year Reservoir Lifespan
Mean Annual Load (metric tons)	2,764.5	1,769.4
Siltation Rate (cm)	2.80	1.79
Fill Time (years)[a]	32	50
Loading scenario for 50 year reservoir lifespan corresponds to a 36% load reduction (see Table 8.2)		

[a]based on a critical siltation volume of 35,500 cubic meters (28.8 acre-feet)

Table 8.2 summarizes the sediment load allocation scheme corresponding to an overall reduction of 36%, which will extend the timespan of the pond from 32 to 50 years.

Table 8.2. Saltlick Pond #9 Sediment TMDL

Source	Existing Sediment Loading (metric tons)	Percent Reduction	Load Allocation (metric tons)	Comments
Forest_1	172.7	0%	172.7	
Forest_2	3.1	0%	3.1	
Forest_3	793.2	46%	428.4	
Ag_2	1,428.2	27%	1,042.6	
Urban-pervious	<0.1	0%	0	
Urban-impervious	<0.1	0%	0	
Roads_2	290.0	80%	58.0	
Br	77.3	80%	15.5	
Wat	0	0%	0	
Total Load	**2,764.5**	**∑ Load Allocation**	**1,720.3**	
Load Reduction = 1,000.4(36%)		**Waste Load Allocation**	**0**	**No point sources**
		Margin of Safety	**44.2**	**2.5% of Load Allocation**
TMDL = Loading Capacity = 1,764.2				

Margin of Safety: An explicit margin of safety was calculated as a percentage of the loading capacity (2.5%). The selected margin of safety is consistent with the level of uncertainty identified in performing the TMDL analysis.
Seasonality: The analysis considered seasonality in the loading through the simulation of monthly loadings. The evaluation of sediment impacts in the reservoir was considered for the long-term average annual conditions. The allocation is presented as an annual average loading consistent with the impairment of the reservoir and the expression of the load reduction required to achieve water quality standards.
Critical Condition: The critical conditions for the sediment TMDL are selected to evaluate the long-term siltation impairments observed in the pond.

Margin of Safety

The margin of safety for this TMDL was expressed as an explicit number, calculated as a percentage of the total loading capacity. A 2.5 percent margin of safety was selected to reflect the uncertainty in the modeling analysis and the selection of the TMDL endpoint. Other implicit conservative assumptions provide an additional margin of safety. Specific conservative assumptions include:

- The endpoint for the reservoir is defined based on a 50 year lifespan for a selected volume of the pond assuming dredging to allow for 96 acre-feet capacity.

- The loadings calculated by the nonpoint source model (GWLF) were derived using conservative assumptions in the selection of soil erosion factors. The use of conservative assumptions in developing the loading model results in relatively high loads and slightly larger required load reductions.

Seasonality

The sediment analysis considered seasonality in the loading through the simulation of monthly watershed loadings based on historic precipitation records. The evaluation of sediment impacts in the reservoir was considered for the average annual conditions representing the response to long term, cumulative siltation. The TMDL and load allocation are presented as annual average loading consistent with the type of impairment (siltation) and waterbody type (reservoir). Reduction of the average annual load is expected to result in achievement of water quality standards.

Critical Condition

The critical conditions for the sediment TMDL are selected to evaluate the type of impairment (siltation) and the type of waterbody (reservoir). Protection of the pond condition requires the control of long term loadings and accumulation of sediment. The pond condition is evaluated based on mean siltation rates, in selected locations, in response to long-term annual loading and trapping of sediments in the reservoir.

Background Conditions

The TMDL load allocation should include, when possible as a separate allocation, the natural background loading of the pollutant. For sediment natural background is included as an allocation to the forest loadings. Note that the forest category also includes some loads due to forestry activities, which are in addition to the naturally occurring runoff and erosion from forested areas. The monitoring data were insufficient to separate natural forest loadings from other forest sources.

9 REASONABLE ASSURANCE FOR IMPLEMENTATION

9.1 Management Practices

There are a number of best management practices that can be adopted to minimize the sediment loadings in accordance with the identified TMDL and load reduction targets. The sediment TMDL identifies load allocations and reductions from forest land, agricultural operations, and roads. Some of the management practices that can be used to achieve the identified load reductions include:

Forestry management: forestry practices including preharvest planning, streamside area management and buffers, road construction/reconstruction/management, timber harvest management, site preparation, erosion and sediment control, and forest regeneration.

Agricultural management: Agricultural management practices can reduce erosion and sediment delivery. Typical practices include conservation tillage, terraces, crop rotations, and stream buffers. Fencing or alternative water supplies can assist in reducing the time when livestock are in or near streams. Trampling of stream corridors can increase erosion and turbidity.

Roads: Sediment loads can be reduced through ongoing management of roads and stream crossings, erosion and sediment control practices during road construction, road grading or removal of abandoned roads.

9.2 West Virginia Nonpoint Source Programs

The West Virginia Division of Environmental Protection-Office of Water Resources, as the lead agency for West Virginia's nonpoint source program, coordinates with other cooperating state agencies to address nonpoint source impacts, develop and implement best management practices reducing pollutant loads for agricultural, silvicultural, and construction activities. Activities in the various categories include education, technical assistance, financial assistance, research, regulatory and enforcement.

Silviculture

The Division of Forestry administers several state and federally funded programs that relate to water quality protection and improvement. These include programs that provide technical and financial assistance, education and enforcement of state regulations. In coordination between the Office of Water Resources and the Division of Forestry, the Logging Sediment Control Act is enforced. Under the West Virginia Logging Sediment Control Act, all logging operations are required to be registered with the Division of Forestry and are to be in compliance with all regulations and laws of the state. Timber harvesting operators are required to protect the environment through the judicious use of silvicultural best management practices adopted by the Division of Forestry to minimize soil erosion and sedimentation.

The West Virginia Division of Forestry may be reached at (304) 558-2788.

Agriculture

In cooperation with the West Virginia Soil Conservation Agency, agricultural nonpoint source problems are addressed through state and federal assistance programs to develop and apply best management practices. When water quality problems emanate from agricultural activity, the Division of Environmental Protection relies on the Soil Conservation Agency to contact and work with the landowner to correct problems. The two prominent areas of direct assistance provided to the agricultural community are technical and financial assistance that involve the following:

a. Agriculture erosion control conservation planning and BMP implementation with land users,
b. Manage NPS demonstration projects and coordinate with assisting agencies to carry out this management program.

For additional information on agricultural best management practices, you may contact the West Virginia Soil Conservation Agency at (304) 558-2204.

Road Maintenance

It is recommended that the dirt road in the watershed be maintained through better design, surfacing or grading, and control of sediment trails and headcuts.

Construction

The West Virginia Nonpoint Source Program for construction activity involves coordination with the State Soil Conservation Agency and Office of Environmental Enforcement to provide education, technical assistance, compliance assistance and regulatory enforcement to minimize sediment and other pollutants' impacts on surface and ground water resources.

For construction sites of less than 3 acres, voluntary Sediment Control Plans are prepared and submitted by the developer to one of the 14 Soil Conservation Districts in the State. They are reviewed by a Nonpoint Source Technician for adequacy to control sediment runoff during the period of construction. Construction sites of less than 3 acres are not subject to the Stormwater NPDES permitting process in West Virginia. Therefore, it is the responsibility of the developer to work with the local SCD to submit sediment and erosion control plans. Approved erosion and sediment control plans are forwarded to the Nonpoint Source Program at the Office of Water Resources, where upon agency approval, provides protection in the event a violation of the turbidity water standard should occur while the plan is being properly implemented.

For additional information on construction sites which are less than three acres contact the WVDEP - Office of Water Resources, at (304) 558-2108.

Construction activities involving greater than 3 acres require a Stormwater NPDES Permit from the Office of Water Resources. The Permit Section may be contacted for additional information at (304) 558-4086.

10 MONITORING AND SURVEYS

Continued monitoring of water column suspended sediment and the inflow at the entrance of the pond is highly recommended. In addition, periodic bathymetric surveys of the pond should be performed to evaluate changes in lake capacity. These bathymetric surveys can be performed every five to ten years. The results of this monitoring and surveys will allow assessment of the efficiency of nonpoint source controls in the watershed and evaluate how the controls are meeting the endpoints of the TMDL.

11 REFERENCES AND RELEVANT LITERATURE

Carlson, R., and J. Simpson. 1996. *A Coordinator's Guide to Volunteer Lake Monitoring Methods*. North American Lake Management Society.

Chapra, S.C. 1997. *Surface Water Quality Modeling*. McGraw-Hill, New York.

Chow, Ven Te (Editor-in-chief). 1953. *Handbook of Applied Hydrology.*

Haith, D.A., L.L Shoemaker. 1987. Generalized watershed loading functions for stream flow nutrients. *Water Resources Bulletin* 23(3): 471-478.

Haith, D.A., R. Mandel, and R.S. Wu. 1992. *Generalized Watershed Loading Functions, Version 2.0, User's Manual.* Cornell University, Ithaca, NY.

NRCS. 1996. Technical Report Number 55. 214-VI-TR-55, 2nd edition. Natural Resources Conservation Service, Hydrology Program.

USACE. 1981. *Saltlick Creek, Structure No. 9, Braxton County, West Virginia.* Phase I Final Report, National Dam Inspection Program, August 1981.

USDA. 1993. *State Soil Geographic Data Base (STATSGO) Data Users' Guide.* Miscellaneous Publication 1492. U.S. Department of Agriculture.

USDA SCS. 1965. *Saltlick Creek Watershed Design Report, Dam No. 9, Braxton County, West Virginia.* January 1965.

USEPA. 1991. *Guidance for Water Quality-based Decisions: the TMDL Process.* EPA440-4-91-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

Vanoni, Vito, editor. Reprinted 1977. *Sedimentation Engineering.* ASCE Task Committee.

WVDEP. 1999. *Division of Environmental Protection, Watershed Assessment Program.* Field survey notes, 11/9/99.

WVDEP. 1998. *West Virginia Water Quality Assessment*, 305(b) Report, 1998. West Virginia Department of Environmental Protection, Charleston, WV.

WVDEP. 1998. *1998 303(d) List of Impaired Streams*. Office of Water Resources, West Virginia Department of Environmental Protection, Charleston, WV.

WVDNR. 1983. *West Virginia Small Impoundment Fishing Guide.* West Virginia Department of Natural Resources.