IMPACT OF RUNOFF POLLUTION

8/25/02 – 9/2/02

ON

SWIFT CREEK RESERVOIR
CHESTERFIELD COUNTY, VIRGINIA

Genito Road Causeway 9/5/02; Photo by Silver Cloud Aviation

Causeway 10/17/02 Photo by T.A. Pakurar

Abstract

Pollution from construction runoff for the week ending 9/2/02 is shown to be massive and not budgeted for in the watershed management plan. The runoff contains high amounts of phosphorus and fine silt. The state erosion and sediment control (ESC) laws are intended to protect downstream properties from construction runoff pollution. These laws are not being rigorously enforced nor do they adequately deal with the finely-divided, phosphorus-containing sediment found in the watershed. A cap of 500 acres in Swift Creek Watershed under construction at any one time is required to protect the reservoir. Alternatively "anionic PAM" technology is recommended to help stabilize soils containing high amounts of fine silt. A simple visual inspection of the runoff water is suggested to see if the installed ESC measures are adequate. The pollution continues after the rains of 10/15-16/02.

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Hands Across the Lake

November 12, 2002

IMPACT OF RUNOFF POLLUTION ON SWIFT CREEK RESERVOIR

Report Contents

Purpose:

This report provides an analysis of how the runoff event 8/25-9/2/02 impacted Swift Creek Reservoir in Chesterfield County. The reservoir provides about 1/3 of the county's drinking water. No attempt was made to assess blame, restoration costs, or fee distribution for restoration for this event.

What Happened

- After 5.4" of rain fell on the watershed for the week ending 9/2/02, highly visible rivers of mud flowed down Little Tomahawk Creek and Tomahawk Creeks into and discolored the 50-acre section of Swift Creek Reservoir north of Genito Road Causeway.

- Mud plumes were seen south of the causeway and were visible across from Sunday Park (~3 miles away) on 9/5/02.

- County photos of Little Tomahawk and Tomahawk Creeks show significant silt and sediment deposits for approximately 15,000' north of the reservoir; Little Tomahawk Creek was clear of sediment deposits further north.

Hands Across the Lake Concerns:

- High Nutrient Loads
- Reduced storage volume
- Stream Impairment
- Higher water treatment costs
- Low oxygen for fish
- Altered Biodiversity

Summary

An erosive plume of sediment was photographed entering the main reservoir September 5, 2002. Chesterfield County's position is that the sediment posed no threat to the public health. Hands Across the Lake (HAL) is in agreement with this statement. But there are concerns about the environmental health of the reservoir.

The quantity of runoff pollution entering Swift Creek Reservoir was calculated using the county's monitoring data and published calculation methods for the watershed. The pollution causes were investigated with the help of experts from the Chesterfield Utilities and Water Quality Sections, State experts from Virginia Department of Conservation and Recreation (DCR), Department of Transportation (VDOT) and Department of Health (VDH).

The following facts have been brought out in the investigation:

- About 5.44 inches of rain fell at the Addison-Evans Water Production & Laboratory Facility (AEWPLF) during the period 8/25-9/2/02. The rainfall averaged 3/4 inch per day; maximum rainfall was 1.93 inches during any 24-hour period. VDOT measured 8" rain at the Route 288 construction site.

- The sediment discolored about 50 acres of the reservoir north of Genito Road Causeway. Plumes entered the main body of the reservoir from the culvert under Genito Road and discolored a visible strip of the reservoir ~3 miles away at Sunday Park. The reservoir north of Genito Road was similarly discolored in May 2002 and again on 10/17/02.

- County monitoring data indicate that approximately 400 lbs. of phosphorus and 1,400,000 lbs. of sediment entered Swift Creek Reservoir during the runoff events 8/25-9/2/02 from Tomahawk and Little Tomahawk Creeks. County photos show the pollutants were washed from ~80 acres of construction sites up to 3 miles north of the reservoir.

- The phosphorous exported during this event is ~40 lbs. per acre per year and is ~180X higher than the 0.22 limit for new developments in the watershed. The county Watershed Management Plan for Swift Creek Reservoir does not address this source of pollution.

- Sediment visibility four days after a rain event suggests the runoff contain high amounts of fine silt, clay or colloidal soils. This fine silt contains most of the phosphorus pollution.

- State Erosion and Sediment Control Laws (ESC) are designed to protect properties downstream of construction from runoff pollution. These laws are not being rigorously enforced nor do they adequately deal with the finely divided, phosphorus-containing sediment found in this watershed. The aerial photos of construction sites near the reservoir and the DCR report (9/5/02) investigating the route 288 site show numerous violations of the ESC laws.

- HAL's concern is that if the pollution from this event is indicative of that for the entire watershed, then runoff pollution from just 500 acres under construction (less than 2% of the watershed) is sufficient to destroy the reservoir. The phosphorus in such runoff (20,000 lbs. per year) would take the in-lake concentration over the legal maximum (0.05 mg/l) as mandated by county ordinance.

- County monitoring data is used to confirm that most phosphorus is transported by attachment to the sediment particles. A relationship of phosphorus amounts to the amount of total suspended solids is presented. High phosphorus amounts are usually accompanied by high sediment visibility in mildly discolored runoff water.

- A simple visual check is suggested as a test to see if the erosion or sediment controls are adequate for the site. If any discoloration is evident in the runoff water, then the phosphorus content is above the concentration required to protect the reservoir. The county ordinance limits the in-lake phosphorus concentration to 0.05 mg/l maximum. The EPA sets the same limit for tributaries of drinking water reservoirs [19].

- DCR officials recommend strict adherence to stabilization procedures defined in the erosion control laws to keep finely divided sediment "fines" from entering sediment basins and property downstream. The technology defined in DCR Technical Bulletin 2 (anionic PAM) may be needed to keep the fines contained on the owner's property.

Recommendations

- HAL recommends a county watershed management committee be formed and address ordinance changes needed for watershed protection during construction.

- HAL recommends a 500-acre cap on construction activities in the watershed. Any property without permanent stabilization or working best management practices (BMPs) would be considered under construction for the purposes of this cap. A developer could opt-out of the cap if he uses measures that prevent a slightly discolored run-off from exiting his property.

- HAL recommends new zoning scenarios be deferred for up to twelve months until such time as the necessary changes to the Upper Swift Creek Plan and Watershed Management Plan are adopted to protect the reservoir.

- HAL recommends construction activity should be held responsible for restoration costs if sediment leaves the owners property.

DISCUSSION

Health and Safety Issues:

There was no health or safety issue with the water supply from the water plant. The annual audit samples and quarterly water quality samples met all regulated requirements. Virginia Department of Health concurred that no additional sampling was required.

Water Plant Costs:

There was no noticed increase in treatment costs during the 2 weeks following the runoff event.

Higher production costs are still of concern to HAL since high costs were cited to close the water production facility at Falling Creek Reservoir. At that time twelve feet of silt was at the base of the dam.

Hydrology (Water Volumes)

Three different scenarios were used to estimate the water volumes discharged to the reservoir during the runoff events. Each scenario methodology is described in various watershed reports [8, 9, 10-15, and 1]:

Scenario 1 used the measured data from the monitoring stations on Little Tomahawk and Tomahawk Creeks. Since the meter on Tomahawk Creek was plugged for the storm event 8/28-8/29, its flow was estimated by using that measured at Little Tomahawk Creek and assuming equal rainfall per square miles. Scenario 1 underestimates the total water flow because some of the detailed daily hydrology won't be available until after year-end when the overall water budget for the reservoir is reconciled.

Scenario 2 used the rainfall measured at the Water Plant (5.44 inches) and the runoff coefficient for the creek reported in 1992 by Smock [9]. The runoff coefficient is the percentage of rain contributed to the creek flow versus being absorbed in the ground. A higher runoff factor is expected if there is more impervious area (more development). For example Smock reported [9] that the more heavily developed sections of the watershed had a runoff factor of 0.31 (31%) in 1992.

Scenario 3 used the rainfall measured at the Route 288-construction site (8.0 inches).

Sample calculations are shown in Appendix A and details are on the HAL website [20]. The creek watershed area and runoff factors are shown in Table 1, and the calculated flow volumes in cubic meters are shown in Table 2 below:

Table 1: Watershed Drainage Areas and Runoff to Rainfall Factors

Creek	Total Drainage Area, square miles	Runoff to rainfall factor [Ref. 9]
Tomahawk	**5.52**	**0.25**
Little Tomahawk	**2.98**	**0.22**

Table 2: Water Volumes for Tomahawk and Little Tomahawk Creeks, 8/25-9/2/02

Creek	Scenario 1 (metered)	Scenario 2 (5.44 inches rain)	Scenario 3 (8.0 inches rain)
Tomahawk Creek, m^3	190,262	493,874	726,285
Little Tomahawk, m^3	108,600	234,626	345,038
Total, m^3	**298,861**	**728,499**	**1,071,323**

There are considerable differences in the flow volumes and these differences need to be reconciled with the USGS water budget for the runoff event if it is available. The monitoring data is adjusted to account for the area not metered due to the placement of the monitoring stations. Excessive storm silt plugged the Tomahawk Creek sampling tubes on 8/28-8/29. An additional 6501 cubic meters of flow was recorded on the totalizer for Little Tomahawk Creek but not used in the calculations.

Although the differences should to be resolved, the conclusions in this report are valid for any scenario considered. The range of data is presented to give the reader an estimate of the accuracy of the calculation procedures.

Phosphorus Loads Importance

Phosphorus loads are important to the long-term viability of the reservoir as a drinking water source. According to Katherine Leitch [1]:

"As excess phosphorus enter a water body, a process of enrichment known as eutrophication occurs, the results of which are increased productivity of plant life and water quality degradation. Some common symptoms of an eutrophic lake are anaerobic bottom water (low oxygen) algal blooms, prolific aquatic plants, increased populations of bottom dwelling fish, and iron and manganese in the water column. "

"The influx of excess phosphorus to the reservoir starts a cycle of water-quality degradation that is difficult to break. Algae utilize the nutrient for growth, and when the algae die they settle to the bottom of the reservoir. The organisms that degrade the dead algae exert an oxygen demand that removes oxygen from the water, and if the bottom is anaerobic, a

reducing environment is created and phosphorus that is incorporated in the sediments can be released into the water column. Mixing of this released phosphorus starts the process all over again, as algae can then use the phosphorus previously bound to the sediments. The process is called ‘internal loading’ or ‘internal fertilization.’”

“If the water body is a drinking water supply, eutrophication can cause problems during the treatment process. Algae can cause taste and odor problems, clog filters and their extracellular products, if chlorinated, can create trihalomethanes (THMs) or other disinfection by-products (DBPs). Trihalomethanes are believed to be carcinogenic and are by-products of reactions between chlorine and organic matter. Controls on THMs and DBPs are expected to be tighter in the future, and compliance will be more difficult for water utilities that rely on eutrophic source waters. This rule will make the quality of the source water even more important.” [1]

This past summer the Virginia Department of Conservation and Recreation (DCR) has classified Swift Creek Reservoir and Swift Creek Tributary as impaired because of low oxygen near the lake/stream bottom.

Total Phosphorus Calculations

Phosphorus concentrations were measured during the runoff event using automatic flow-weighted sampling techniques. Concentrations in Little Tomahawk Creek reached 0.444 mg/l which is 4x higher than the maximum recommended by the US Environmental Protection Agency (EPA) for waters flowing into drinking water reservoirs. In addition the measured concentration was 9x higher than the 0.05 mg/l maximum level mandated by ordinance for the reservoir.

Total Phosphorus loads were calculated using each of the three flow estimates just discussed. The same measured phosphorous concentrations were used in each scenario.

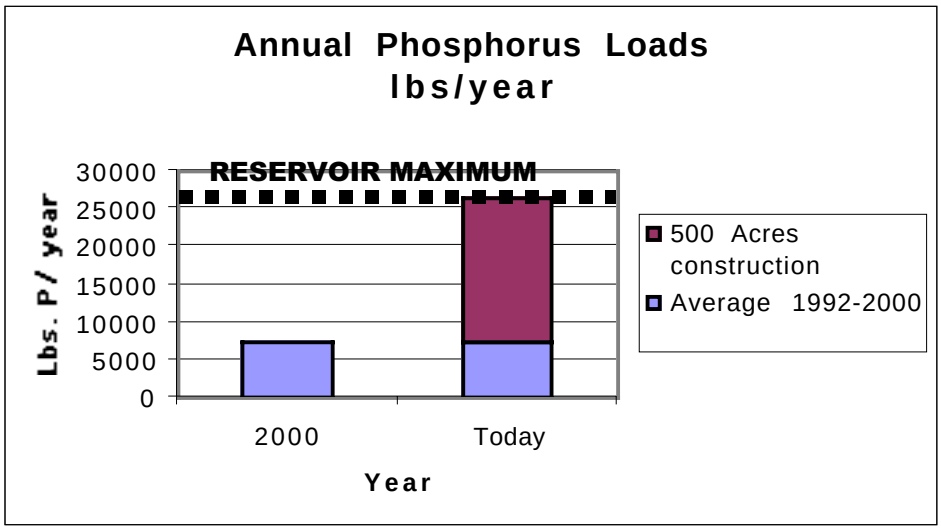
Table 3: Phosphorus Loads, lbs. for Tomahawk and Little Tomahawk Creeks 8/25-9/2/02

Flow Calculation	Tomahawk Creek	Little Tomahawk Creek	Total
Scenario 1	**95**	**81**	**176**
Scenario 2	**248**	**175**	**423**
Scenario 3	**364**	**258**	**622**
Average	**236**	**171**	**407**
Median	**248**	**175**	**423**
Percent, %	**50**	**50**	**100**

The median values are reported in the summary. The phosphorus amounts are huge when compared to the expected annual tributary phosphorus loads of 400-600 lbs. per year. Any value between 176 and 622 pounds per week is of concern to the reservoir.

Annual phosphorus export coefficients were calculated based on 80 Acres of construction and 43.1" of annual rainfall. These ranged from 17-62 lbs./acre/year with a median value of 42 lbs./acre/year.

Chart 1: Annual Phosphorus Loads



HAL's concern is that if the pollution from this event is indicative of that for the entire watershed, then runoff pollution from just 500 acres under construction (less than 2% of the watershed) is sufficient to destroy the reservoir. The phosphorus in such runoff (20,000 lbs. per year) would take the in-lake concentration over the legal maximum (0.05 mg/l) as mandated by county ordinance.

Reduced Storage Volume:

Sediment visibility days after the runoff event indicate very fine particle size (like flour). According to the US Geological Survey ([2], the fine particles have a high surface to volume ratio and carry the bulk of phosphorus transport.

The mud discolored the reservoir north of Genito Road and was seen in the main reservoir as far south as Sunday Park 4 days after it stopped raining. This observation strongly suggests that the sediment particles were extremely fine like the consistency of flour and have high phosphorus content [2].

Sediment loads were calculated for each of the flow scenarios previously discussed. Sediment concentrations were measured at the monitoring stations. Total pounds of sediment are presented in Table 4 below:

Table 4: Total Suspended Solids, lbs. for Tomahawk and Little Tomahawk Creeks 8/25-9/2/02

Flow Calculation	Tomahawk Creek	Little Tomahawk Creek	Total
Scenario 1	151,732	461,700	613,302
Scenario 2	393,860	997,400	1,391,261
Scenario 3	579,206	1,467,000	2,045,972
Average	375,000	975,000	1,350,000
Median	393,860	997,400	1,390,000
Percent, %	28	72	100

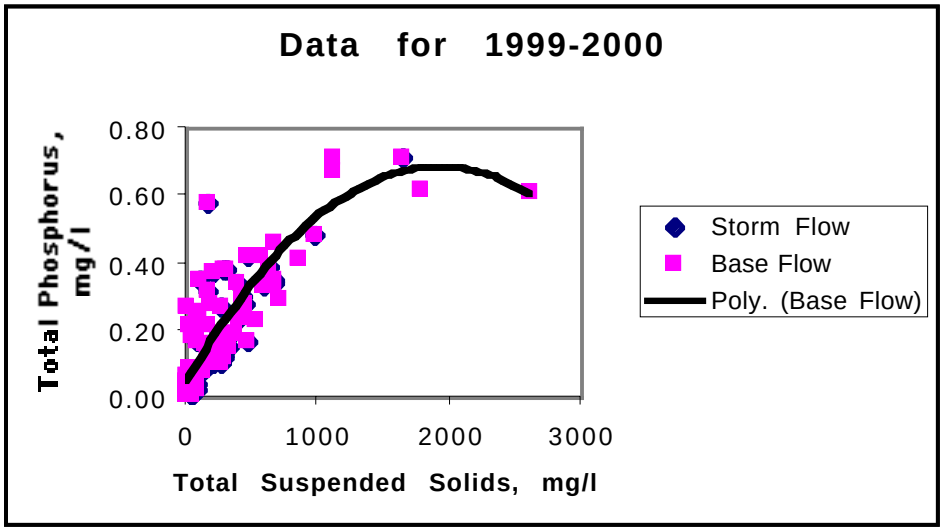
The median value of 1,400,000 lbs. is reported in the summary. The storage volume loss of 700 cubic meters is estimated from the maximum sediment load (2,046,000 lbs.)

The following is an attempt to calculate what it would cost to replace the sediment that was washed away and compare it to the cost for erosion and sediment controls. First let us assume the cost to excavate and transport this dirt is $3.13/ cubic meter. Using the maximum sediment load calculated in scenario 3, total cost would be 2,001,000 lbs./ 3000 lbs./cubic meter x $3.13 = $2100. The dollar amount is small compared to the cost of the sediment control measures at the Woolridge Road intersection of Route 288 and Little Tomahawk Creek ($118,000). So sediment control cannot be economically justified based on dirt costs alone. It stresses the need to plan erosion and sediment control as part of a phased construction plan; it's too expensive to do it later. If one considers the lost value of a drinking water supply or the cost to restore tributaries and affected portions of the reservoir, then economic justification might be achieved.

Relationship of Total Phosphorus Quantity to Total Suspended Solids

The tributary data for 1999-2000 is plotted in Figure 1 below:

Figure 1: Phosphorus Quantity vs. Amount of Sediment



The relationship shows that if one can see or measure the amount of sediment flowing in muddy runoff discharge, then the amount of phosphorus can be predicted.

The phosphorus limit for Swift Creek Reservoir is 0.05 mg/l maximum. The EPA [19] recommends that phosphorus levels in tributaries be below 0.01 mg/l maximum.

This limit is reached at ~100 mg/l. Total Suspended Solids. In other words, if one can visibly see the muddy color in storm water runoff, then the concentration of phosphorus is too high. Muddy runoff therefore can be interpreted as an early warning signal that the phosphorus levels may be too high and that the erosion and sediment control measures are not working.

One of the most significant conclusions of this report is that a little bit of runoff discoloration is bad. And the more finely divided the clay particles, the more phosphorus they contain. And that is bad and requires extra measures to bring under control.

Erosion & Sediment Control Measures (ESC)

The state erosion and sediment control laws are intended to protect properties downstream of construction activities from runoff pollution. These laws are not being rigorously enforced nor do they adequately deal with the finely divided, phosphorus-containing sediment found in the watershed.

These bold statements are based on a series of observation made during the storms 8/25-9/2/02, aerial photographs made on 9/5/02 and subsequent discussions with state officials aware of the problems. Let me list the observations:

- Rainfall for the week averaged 3/4 inch/day at the water plant. Maximum rainfall was 1.9" in any 24-hour period. Erosion and sediment control laws require sediment basins be designed to handle 8-inches of rain/24 hours (a 25-year storm).

- Hotel Construction site, Old Hundred Road and Hull Street Road: No sediment basin was in place prior to clearing the trees. Aerial photos show a muddy pond, but closer inspection showed there was no piping to make that pond work like a sediment (silt) basin. The sediment basin not completed until the week of September 15 after neighbors complained of muddy water contaminating their property and the reservoir. The damage was already done by that time.

- Summer Lake Development (675 homes) on Otterdale Road at Otterdale Creek: The resource protection area (RPA) along Otterdale Creek was cleared to construct sewer pipes (a legal clearing). The required sediment basins, however, were not evident. Muddy water was photographed streaming down the silt fences into the Otterdale Road culvert and on into the creek which feeds the reservoir a few hundred yards away.

- Swift Creek Village (Commonwealth Center Phase III ~188 acres), Hull Street Road at Swift Creek: Trees and ground cover were removed in early spring. No erosion control or ground stabilization was visible in aerial photos 9/5, but state law requires ground stabilization within seven days of reaching final grade. Department of Conservation and Recreation (DCR) inspector commented "Surely some portion of this site was not under active construction and requires stabilization." Richard McElfish, Director of Environmental Engineering, deferred comment on the above three sites until he could see HAL's written report.

- Route 288 construction (15,000 ft. north of reservoir): Aerial photo published in September Issue of *The Village Mill* showed extensive discoloration of 50 acres of the reservoir north of Genito Road Causeway. Mud plumes were still visible in main reservoir four days after the rain stopped. This suggests that the sediment is finely divided (called fines) and contains excessive phosphorus. The erosion and sediment control plan for the project did not meet state requirements. Ironically, after a similar

pollution event in May, VDOT spent approximately $118,000 to correct the sediment problem. The correction measures were still not adequate on 9/2. On 9/5 the DCR issued a letter to VDOT listing violations to minimum standards 4,5,6,7 & 11. The DCR gave VDOT a "Qualified Compliance" letter on 9/25 after retention devices and ground stabilization improvements were made. A total of 380 lbs. of phosphorus and 1,400,000 lbs. of sediment were released into the reservoir during the week ending 9/2. Additional silt is still clogging the Little Tomahawk and Tomahawk Creek tributaries.

- This past spring, the DCR conducted a program review of the Chesterfield County erosion and sediment control (ESC) program. This review listed all of the areas that the County is not meeting the requirements of the state ESC laws and recommended corrective actions.

The problem of finely divided sediment or "fines" is an important one to consider. First there is a strong correlation between sediment content (color intensity of muddy water) and phosphorus content. David Mau (US Geological Survey) has published data [2] showing that fines contain most of the phosphorus. This data agrees with data from our reservoir-monitoring program. The observations of particles being visible four days after a rain event raises serious questions about BMP design for our area; many BMPs have a two-hour retention such that the fine sediments and phosphorus will proceed through into the reservoir.

HAL believes this has happened with the August-September runoff incident. Tomahawk and Little Tomahawk Creeks each had about half of the phosphorus, yet Tomahawk Creek had only 26% of the sediment. Tomahawk Creek appears to have deposited most of the sediment in Woods Lake adjacent to Otterdale Road just south of Route 288 construction. The lightweight fines passed through this lake and carried the phosphorus to the reservoir.

The event analysis showed:

- The contractor believed he was in compliance with all state erosion and sediment control laws.
- The contractor installed additional runoff controls that were beyond those required by existing law to keep control of his sediment.
- These extra measures worked for the storm events subsequent to the event under investigation.

The fine sediment particles visible in the reservoir carry most of the phosphorus. Fine sediment particles need to be controlled with erosion control measures. Enforce existing laws:

Any denuded area requires soil stabilization within seven (7) days:

- of reaching final grade
- Or if not at final grade, then if dormant longer than 30 days.

The intent of Section 4VAC50-30-40 of Virginia Erosion & Sediment Control Regulations, item 19 is stated in the preamble: "Properties and waterways downstream from development sites shall be protected from sediment deposition, erosion and damage due to increases of volume, velocity and peak flow rate of stormwater runoff…."

A list of minimum criteria is listed to "satisfy" the intent of the law. There is no check or test downstream of the construction activity to see if the intent of the ECS is met. There is no corrective action taken if the control measures are not working. A new standard is clearly called for. One such standard might be "Zero sediment downstream of a construction site." If you can see the sediment, the phosphorus levels are too high.

Construction activity should be held responsible for restoration costs if sediment leaves the owners property. Current penalties are limited to $2000 per occurrence in civil court.

The intent of the state sediment control laws needs to be enforced in order to control phosphorus. Soil stabilization procedures need to be enforced to prevent finely divided sediment particles from entering the reservoir. (These carry the most phosphorus.)

Sediment control procedures need to be enforced with some needed test to see if the controls are working. Visual standards (if you see any sediment it contains too much phosphorus) or turbidity standards should be considered. Tougher standards may be required for a drinking water watershed. New technology (e.g. DCR Technical Bulletin 2) may be required for fines control.

References:

1. Leitch, Katherine McArthur, Masters Thesis, Virginia Polytechnic Institute & State University, Blacksburg, VA, August 1998, "Estimating Tributary Phosphorus Loads Using Flow-Weighted Composite Storm Sampling."

2. Mau, David P., U.S. Geological Survey (USGS) Water-Resources Investigation Report 01-4085 (2001). Copies of this report are available from the USGS Information Services, Box 25286, Federal Center, Denver CO 80225-0286, or call 1-888-ASK-USGS. David Mau's e-mail address is **dpmau@usgs.gov**.

3. Mau, David P., News Release US Department of the Interior and US Geological Survey, "Science and Community Involvement are Keys to Preserving Water Resources of Lake Olathe, August 5, 2002.

4. Davies, Karl, Term Paper for Forestry 528: Forest Hydrology, University of Massachusetts, Amherst, "The Effects of Vegetation Removal on Water Quality: Implications for Management of Municipal Watersheds in the Northeastern United States," May 1984.

5. VA Department of Conservation and Recreation (DCR), Virginia Erosion and Sediment Control Regulations, Minimum Standards, Section 4VAC50-30-40.

6. Ibid. "Erosion and Sediment Control Law, Regulations and Certification Regulations" (1999).

7. McCutcheon, John, DCR, Memorandum to Chris Burgess, VDOT Environmental Specialist, "Recommended Improvements to ESC Measures at Woolridge Road Interchange, Route 288," 9/5/02.

8. Smock, Leonard A and Silvia B. Gazzera, Department of Biology, University of Richmond, Richmond, VA, "Hydrologic and Water Quality Characteristics of the Swift Creek Reservoir Watershed 1992-1993 (1993).

9. *Ibid.* 1991-1992 (1992)

10. Grizzard, T.J., R.C. Hoehn and K.A. McArthur, "Hydrologic and Water-Quality Characteristics of Swift Creek Watershed and Reservoir," Virginia Tech Department of Civil Engineering and the Occoquan Watershed Monitoring Laboratory, Manassas, VA (1994).

11. *Ibid.* (1995)

12. *Ibid.* (1996)

13. Cloe, W. Weedon, Stephanie R. Feaser, Carmen F. Hein-Harmon, David Sirois, and George DuVal, "Hydrologic and Water Quality Characteristics of the Swift Creek Reservoir Watershed 2000" Published by Chesterfield Department of Utilities, January 2002.

14. *Ibid.* for 1998, revised July 2000.

15. *Ibid.* for 1997, December 1999.

16. CH2MHill, consultants, Watershed Management Plan for Swift Creek Reservoir, 2000.

17. DCR Erosion & Sediment Control Technical Bulletin 2, "Application of Anionic Polyacrylamide for Soil Stabilization and Storm Water Management, July 2002. **http://www.dcr.state.va.us/sw/e&s.htm**

18. Reidy-Puckett, Denise, Atlanta *Building News*, July 2002, pp. 16-18, "Lowering NTUs Has Developers Baffled."

19. EPA 1986, "*Quality Criteria for Water*," EPA 440/5-86-001, U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, DC.

20. HAL website for updated photos and information:
http://handsacrossthelake.tripod.com

Appendix 1: Data and Sample Calculations

Utilities Department Monitoring Data

Sample calculations

APPENDIX 2 - Investigation Methodology:

Photographic Evidence was obtained:

20. May 2002 – VA Department of Forestry, aerial photos of construction activity and reservoir north of Genito Road.
21. May 2002 - Chesterfield County Water Quality Section – Little Tomahawk and Tomahawk Creeks north of the Reservoir.
22. 8/29/02 – Chesterfield County Water Quality Section – Little Tomahawk Creek north of the Reservoir.
23. 9/5/02 – John Ficklin, Silver Cloud Aviation – aerial photos of reservoir area
24. 10/17/02 – T.A. Pakurar – aerial photos
25. 10/17/02 – Dean Hawthorne, Dean Hawthorne Photography – Aerial photos of Swift Creek Reservoir and Tributaries.

Data and expert opinions were first obtained, then validated from the following officials:

- Chesterfield County Utilities
- Chesterfield County Engineering
- Chesterfield County Water Quality Section
- Chesterfield County Department of Transportation
- Virginia Department of Health (VDH)
- Virginia Department of Conservation and Recreation (DCR)
- Virginia Department of Transportation (VDOT)
- Hands Across the Lake Staff Biologist

Note: All departments except VDH, DCR and HAL Biologist were present at county meeting 9/3/02 organized by Hon. Art Warren and Pete Stith from Chesterfield County.

Reference data was obtained from

- US Geological Survey (USGS)
- US Environmental Protection Agency (EPA)
- Chesterfield County Utilities Department (Monitoring Data)

Appendix 3 - Notes grouped by department or agency 9/16/02

1. Chesterfield Board of Supervisors

- Set phosphorus limits as key reservoir management strategy (1997)
- In lake maximum = 0.05 mg/l
- Limit runoff phosphorus from new residential development to 0.22 lb./ac./yr.
- Upper Swift Creek Plan (1991; Plan amended in 2000 to lower density from 2.2 to 2.0 DU/Ac. in the watershed; corrected plan map 2002): set density, ratios of commercial to residential development.

2. Observations

- 5.44" rain fell at Water Treatment Plant 8/25-9/02/02.
- Muddy water entered Little Tomahawk Creek from various construction projects including the VDOT 288 project and discolored the 50 acre reservoir section north of Genito Rd.
- Plumes of muddy water broke through the Genito Road causeway and entered the main reservoir.
- On 9/5/02, John Ficklin of Silver Cloud Aviation, took aerial photographs of the lake and recorded his visual sightings.
- Photos 1 & 2 are taken from the reservoir looking north across the Genito Rd. Causeway. The mud plumes extend into reservoir more than 1/2 mile.
- The mud is very visible a week after it rained.
- Photo 3 shows the view from the Woodlake shoreline looking north. The plume extends across the reservoir (~1 mile) and is spread by the west shoreline.
- Photo 4 shows the mud plume heading south along the Woodlake shoreline for approximately 3 miles and is very visible from the air near Sunday Park.
- Color photos are presented on the HAL website: http://handsacrossthelake.tripod.com
- According to photographer John Ficklin, the mud plume was more visible from the air than in the photos.
- County photos show excessive mud/ silt/ sediment buildup for ~15,000' north of the reservoir along Little Tomahawk Creek. The creek was clear north of Rt. 288.

3. HAL concerns

- Second major incident (May, Aug)
  - Major quantity of mud (silt and sediment) entered reservoir (Aug)
  - High nutrient loads (phosphorus)
  - Higher water treatment costs
  - Reduced storage volume
  - Low oxygen (impairment)
  - Altered biodiversity of tributaries

4. Chesterfield County Utilities

- 5.4" rain fell at treatment plant 8/25-9/02.
- No safety problem
- No need for extra testing (w/VDH)
- No higher costs seen through mid September except for manganese control due to reservoir turnover.

5. Chesterfield County Water Quality

- Mud coming from VDOT route 288 construction.
- Just a little mud in reservoir
- Photographic evidence of sediment buildup on Little Tomahawk Creek for ~15,000 ft. north of reservoir.
- Focus on tributary
- May have to classify tributary as "impaired"

6. VDOT

- Quick response to county/ citizen concerns for Little Tomahawk Creek.
- Goal – keep all silt on VDOT property
- VDOT not the only source of mud in reservoir.
- E&S designed to handle 1" rain/24 hrs.
- Hydraulics designed to handle 25-year storm (8" rain/24hours.)
- Current E&S at Little Tomahawk Creek (LTC) field designed
- E&S Cost $118K at LTC as of 9/19/02
- Have done more than required by law.
- Overwhelmed by 8" rain in short period of time.
- Not involved w/ 288 crossing Tomahawk Creek
- Rain event 9/15 totaled 0.5" – controls worked perfectly; no mud left site
- Cost for regular excavation and transport ~1 mile = $ 3.13 /cubic meter
- Weekly photo documentary environmental status reports sent in September.

7. DCR

- Mud most likely came from multiple sources.
- Mud visibility 9/5 suggests very fine sediment (like flour)
- Only way to "eliminate fines" from runoff is erosion control (soil stabilization).
- Since there were no phased E&S plans, there was no design to show how SWB#5A was to be used as a sediment basin before the entire curb and gutter and storm drains were complete.
- The slopes at 288 were fairly well stabilized and held up well under the heavy rains. There was almost no stabilization in any of the temporary channels; these unstabilized areas contributed a lot of sediment.
- Preferred diverting upstream water from Little Tomahawk Creek (LTC) around sediment basin. Sediment removal is more difficult when LTC enters sediment basin and mixes with road runoff because of higher volumes of water to treat.

- USGS study (#8 below) applies to VA.

8. **USGS**

- Fine silt particles carry significantly more nutrient loads than coarse particles due to high surface to volume ratio. (data from David Mau, report 01-4085, 1998)
- Quoted 0.1 mg/l as EPA maximum phosphorus concentrations in flowing surface water into drinking water reservoirs. The non-enforceable standard was set to reduce accelerated eutrophication and excessive algal growth.