

**Sediment Contaminants at Dillsboro Reservoir:  
Report on Site Assessment and Sediment Analyses**



**U.S. Fish and Wildlife Service  
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## **Sediment Contaminants at Dillsboro Reservoir: Report on Site Assessment and Sediment Analyses**

### **Abstract:**

Potential removal of Dillsboro Dam, located on the Tuckasegee River near Sylva (Jackson County), North Carolina, has caused some concern for the potential mobilization of sediment-associated contaminants accumulated behind the dam in Dillsboro Reservoir. We used the framework of the U.S. Environmental Protection Agency / U.S. Army Corps of Engineers technical guidance manual on disposal of dredged material in inland waters to evaluate this issue.

A tier 1 review of existing information indicated no major pollutant sources or contaminant concerns upstream of the dam. The review also indicated that sediments within the reservoir might have low potential to accumulate contaminants from a physical standpoint, being comprised primarily of sand and gravel. Finally, it appears that watershed land uses upstream and downstream of the reservoir are similar and that any mobilized sediments from behind the dam may merely subject downstream areas to the same sources of contaminants to which they have been historically exposed. While no major concerns were noted in the review of existing information, new data were collected to support management decisions (tier 2).

Six sediment samples from within the reservoir and four samples downstream were collected in June 2003 and analyzed for elemental contaminants. None of the sediment samples from within the reservoir or downstream exceeded probable effects concentration screening values, indicating no obvious concern. Over 80 percent of the sediment sample results were also less than threshold effects screening values, indicating they are unlikely of toxicological significance. Slightly less than 20 percent of the sample results fell between the screening values and they were further evaluated by comparing their magnitude to the geometric mean of the screening values. Only two values (both for nickel) exceeded the geometric mean of the screening values. The highest nickel concentration (41.5 ug/g dry weight) was from a downstream sediment sample near Dillsboro gage, and the average of the four downstream samples (27.4 ug/g dry weight) exceeded the average concentration of the six samples collected within the reservoir (21.8 ug/g dry weight). Accordingly, the nickel concentrations behind the dam should not be a concern relative to movement downstream where concentrations are slightly higher.

Our review of existing data and an on-site assessment (tier 1) and results of sediment chemistry (tier 2) indicated no significant sediment contamination. This assessment is limited to the toxicological properties of the sediments evaluated. It does not address the potential physical impacts of sediment mobilization.

## Preface

To assess the sediments at Dillsboro Reservoir, the U.S. Fish and Wildlife Service assisted Duke Energy in a review of existing information on potential pollutant sources to reservoir sediments. The review of historic information (U.S. Fish and Wildlife Service, *Sediment Contaminants at Dillsboro Reservoir: A Site Assessment and Recommendations*) was released in draft in June 2003. That draft formed the foundation for sediment sampling, analyses, and interpretation to evaluate the issue with additional site-specific data. Following collection of new data in late June 2003, a draft report on Dillsboro Reservoir sediment chemistry was circulated for review and comment in July 2003 (U.S. Fish and Wildlife Service, *Preliminary Evaluation of Sediment Chemistry Data for Dillsboro Reservoir*). The current document is the final report of the U.S. Fish and Wildlife Service on the sediment evaluation project; it is a compilation of material from the previous two draft reports as well as new material gleaned from reviews of those drafts.

A Sediment Evaluation report summary was included in the Draft Dillsboro Environmental Assessment / Biological Assessment. Reviewers of the Draft Environmental Assessment included the U.S. Fish and Wildlife Service, U.S. Forest Service, North Carolina Wildlife Resources Commission, North Carolina Division of Water Resources, North Carolina Division of Water Quality, Eastern Band of the Cherokee Indians, Jackson County Soil and Water District, Western North Carolina Alliance, Town of Dillsboro, and Duke Power.

Steve Johnson (Duke Power) provided valuable project coordination, and Jon Knight (Devine Tarbell & Associates, Inc.) assisted with study design and sample collection. Scott Fletcher (Devine Tarbell & Associates, Inc.), Jon Knight, Steve Johnson, Jeff Lineberger (Duke Power), John Wishon (Duke Power) and Sara Ward (U.S. Fish and Wildlife Service) reviewed earlier versions of this document. Jim Dwyer (U.S. Fish and Wildlife Service) assisted with interpretation of sediment chemistry results. Their contributions are appreciated.

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# **Sediment Contaminants at Dillsboro Reservoir: Final Report on Site Assessment and Sediment Analyses**

## **Introduction**

Potential removal of Dillsboro Dam, located on the Tuckasegee River near Sylva (Jackson County), North Carolina, has caused at least some concern for the potential mobilization of sediments accumulated behind the dam in Dillsboro Reservoir (Figure 1 and 2). Sediments can accumulate contaminants, and at high concentrations those contaminants can be an in-place concern as well as a concern upon sediment mobilization. To assess the sediments at Dillsboro Reservoir, the U.S. Fish and Wildlife Service (Service) assisted Duke Energy (the dam owner and operator) in a review of existing information on pollutant sources potentially affecting reservoir sediment quality at Dillsboro (tier 1). The Service also recommended additional sediment sampling, analyses, and interpretation to evaluate the issue with current, site-specific data (tier 2). This document is the final report of the Service on the sediment evaluation project; it is a compilation of material from previous drafts as well as new material gleaned from reviews of those drafts.

## **Methods**

There are no regulations or standards that dictate the approach to be used in evaluating potential sediment contamination at a dam removal site. However, determining the need for any contaminant sampling, and the design of any needed sampling effort, can certainly benefit from well-established procedures aimed at guiding an evaluation of the potential for contaminant-related impacts from sediments proposed for dredging. The joint U.S. Environmental Protection Agency and U.S. Army Corps of Engineers technical guidance manual on evaluation of dredged sediment (USEPA/USACE 1998) was used to determine an appropriate level of effort to address this issue.

The USEPA/USACE Inland Testing Manual employs a tiered approach to evaluation of the potential for contaminated sediment impacts. Evaluations start with a tier 1 assessment (using readily available existing information to assess the potential for a contaminated sediment concern) and proceeding in a step-wise fashion through tiers 2 (surface water and sediment chemistry), tier 3 (toxicity testing) and tier 4 (bioaccumulation testing) only to the extent necessary to address the issue (i.e., all assessments start with tier 1, they may end there or proceed to higher tiers if additional data are necessary to guide the management decision). The Service conducted tier 1 and tier 2 assessments for the Dillsboro Reservoir project.

### *Tier 1 Methods: Compilation of Existing Information*

The potential for contaminants to have been introduced to the sediments behind the Dillsboro Dam was initially addressed by examining existing information. This information included relevant sources of contamination, pathways of contaminant transport, the physical nature of the sediments behind the dam, and the chemical and physical nature of the sediments downstream that may be impacted by any mobilization of sediments from behind the dam. Potential sources of contamination include urban and agricultural runoff, industrial and municipal wastewater

discharges, riparian fill, spills of oil or chemicals, releases from landfills or hazardous waste sites, and mineral extraction / refinement practices. In general, absence of pollutant sources would indicate little need for aggressive work to characterize any potential contaminants. Likewise, any proposed sampling should be guided by identification of a specific issue from this review.

To complete the tier 1 assessment, we examined files and databases maintained by State and federal natural resource management agencies. We also contacted individuals familiar with the reservoir, its operations, local land-use, and water quality.

### *Tier 2 Methods: Sediment collection, analyses and interpretation*

#### *Sample locations:*

Management factors considered in determining the number and placement of samples included the historical review indicating limited known contaminant concerns and the intent of the sampling (which is to provide current analytical data to support the inference of low contaminant burdens based on historical data). Physical factors considered include the area of potentially affected sediments behind the dam, bathymetry, distribution of sediments, and extent of sediment shoaling, scour, and mixing.

Samples stations were targeted to two types: 1) quiescent areas, such as inside channel bends and nearshore depositional areas adjacent to the dam where fine-grained sediments (which have the greatest potential to accumulate contaminants) are most likely to settle; and, 2) sediment beds typical of the impounded reach that area likely to move once the dam is removed (and which therefore have the greatest potential to affect areas downstream).

#### *Sample collection:*

Sediment samples were collected June 23 and 24, 2003, by the Service and an independent contractor for Duke Energy. Collections were made with a stainless-steel petite Ponar grab. At each site, two to six grabs of the top 5 to 10 cm of sediment were collected and composited to form one sample per site. The composite of the grab samples was homogenized by stirring with a stainless-steel spoon in a stainless-steel bucket. Debris (e.g., sticks, leaves, rocks bigger than ~1 cm<sup>3</sup>) were removed during homogenization. Collection equipment was thoroughly cleaned (ambient water rinse, detergent and water scrub, distilled / demineralized water rinse, 10% nitric acid rinse, and a final rinse with distilled / demineralized water) before sampling at the first site and between sites. Three (one for metals, one for organic carbon and grain size, and one for archival) 500-mL aliquots of sediment were placed into series 320 I-Chem glass jars with Teflon-lined lids. Samples were stored in a cooler on ice (~4 degrees C) in the field and stored frozen (< 0 degrees C) upon reaching the Service lab in Raleigh on June 24<sup>th</sup>. All samples were collected, transported and stored under chain of custody (Appendix A).

### *Chemical Analyses:*

The 10 sediment samples were delivered to Research Triangle Institute (RTI), Research Triangle Park, NC on June 30, 2003. Samples were wet-homogenized, freeze-dried, dry-homogenized and digested/extracted in concentrated nitric acid using microwave heating. Elemental contaminants were analyzed by inductively coupled plasma mass spectrometry (ICP-MS), inductively coupled plasma atomic emission spectrometry (ICP-AES) and cold vapor atomic absorption (CVAA). The instrumentation consisted of a ThermoElemental X7 ICP-MS, a Perkin-Elmer 4300 Optima ICP-AES and a Leeman Labs PS200 automated mercury analyzer (CVAA). Sediment particle sizes were determined by sieve series, and percent organic carbon was determined by loss on ignition.

Analyses were accompanied by batch-specific quality control / quality assurance samples. An additional aliquot of two sediments were taken to prepare duplicate and matrix spikes and digested/extracted alongside real samples. In addition, an aliquot of National Institute of Standards and Technology (NIST) Standard Reference Material (SRM) 2709 (River Sediment) and a reagent blank were prepared for analysis.

## **RESULTS**

### *Tier 1 Results: Compilation of Existing Information*

We examined the following databases or lists of contaminant concerns (with the source of the data listed in parentheses):

National Priorities List (Superfund Sites)	(USEPA)
Inactive Hazardous Waste Sites	(NC Division of Waste Management)
Old Landfills	(NC Division of Waste Management)
Active Solid Waste Permits	(NC Division of Waste Management)
CERCLIS Sites	(USEPA)
NPDES (surface water discharge) Permits	(NC Division of Water Quality)
Sewage Sludge Land Application Sites	(USEPA)
Registered Confined Animal Feeding Operations	(USEPA)

Active and abandoned solid or hazardous waste facilities are a potential source of contamination if they are located in the watershed and have had a release to the environment. To address this potential, a records search was conducted in October and November 2002. A search of State databases and files revealed no National Priorities List (Superfund) or Inactive Hazardous Waste Sites listed in Jackson County. Two sites were identified on the Old Landfills list, but neither of these (the Cashiers Refuse Disposal Site and the Sylva Dump on Montieth Branch, a tributary of Scott Creek) are in the watershed of Dillsboro Reservoir. The only active solid waste site in the County is the Scott Creek C&D Transfer Station (1172 Mineral Springs Road in Sylva); there is no discharge associated with this solid waste transfer facility. One CERCLIS Site was listed for the County, the Nantahala Abandoned PCB Transformer Site (River Road, Dillsboro). An examination of the file for this facility (11/14/02, NC Division of Waste Management, Central Files, Raleigh) indicates the site was a pole and transformer storage yard where one PCB-

containing transformer was discovered by an employee, removed, tested, and properly disposed of with State and federal agency oversight in 1999. On-site examination revealed no evidence of leakage or other PCB-containing transformers. The Nantahala Abandoned PCB Transformer Site received a "No Further Remedial Action Planned" status from U.S. EPA in 1999. Based on this review, there were no chemicals of concern identified from active or inactive solid waste or hazardous waste sites.

Surface water discharges of wastes are also a potential source of contaminants. As of October 2002, there were six facilities with permitted discharges to the surface waters upstream of Dillsboro Reservoir (Table 1). Three additional facilities are located in the vicinity of Dillsboro Reservoir (Tuckasegee Water and Sewer Authority-Sylva Plant, Jackson County Board of Education-Scott Creek School, and Ensley Adult Care). These facilities are all small (0.0063 to 0.6 million gallons per day) and, more importantly for this assessment, discharge to Blanton Branch or Scott Creek that are hydrologically down gradient of the Dillsboro Reservoir (i.e., any contaminant concerns from these facilities would not impact the reservoir). Note also that Scotts Creek School has recently been taken off line (Kevin Barnett, NCDWQ, pers. comm. 2003). The Tuckasegee Water and Sewer Authority facility discharging to the Tuckasegee River upstream of Dillsboro Reservoir was the only major facility identified. State files indicate this facility has been well-operated with a compliance rate of >90% in their aquatic toxicity monitoring (NC Division of Water Quality 2000).

Other water quality information was available from the North Carolina Division of Water Quality's basinwide assessment report (NC Division of Water Quality 2000). Pages 30 and 31 of that document indicate that water quality ratings (as determined by the diversity, richness and tolerances of aquatic organisms collected in standardized sampling) for the Tuckasegee River at Dillsboro (off SR 1378) have been good to excellent since sampling began in the mid-1980's. Page 14 of that document indicates the Division conducted no fish tissue contaminant monitoring in the basin between 1994 and 1999 because there were no known contaminant issues to be addressed. Page 57 of the basinwide assessment report presents results of water quality sampling conducted at the only Tuckasegee River station (#G8600000, well downstream of the Dillsboro Reservoir); water quality was generally good with the only exceedences of State standards being associated with turbidity (4 of 50 samples exceeding the State standard of 25 NTUs with a maximum of 110 NTU), fecal coliform (4 of 50 sample exceeding the standard of 200 MPN/100ml with a maximum of 690 MPN/100ml), iron (9 of 54 samples exceeding the standard of 1000 ug/l with a maximum concentration of 7400 ug/l), and copper (11 of 54 samples exceeding the action level of 7 ug/l with a maximum concentration of 17 ug/l). None of the 5-year average concentrations or 75<sup>th</sup> percentile concentrations for these parameters exceeded the State standards or action levels. Based on this review, there were no significant concerns identified from surface water sources, with the possible exception of slightly elevated and infrequent exceedence of action levels for iron and copper.

In addition to file and record reviews, telephone calls to staff familiar with water and land quality issues in the vicinity were also made in order to identify any other potential contaminant concerns that should be considered. The surface water quality staff of the North Carolina Division of Water Quality's Asheville Regional Office indicated that high pH wastes (caustics) historically discharged from the Jackson Paper facility should be addressed (Kevin Barnett, pers. comm. 2002). The facility discharged paper processing wastewater to the Tuckasegee River until the late 1980's when they implemented a water recycling protocol. Examination of aerial photographs from the time the mill was operational indicate the discharge was actually to Scotts

Creek which enters the Tuckasegee River just downstream of the Dillsboro Dam (Figure 3). Accordingly, this facility should not have had an impact on sediment quality within the reservoir, but it may well have impacted downstream sediments.

Mining activities in Jackson County were characterized for their potential to impact sediments. Staff in the Department of Geosciences at Western Carolina University (Steve Yurkovich, pers. comm. 2003) and previously collected reference material (Williams 1987) indicate mining activities may have contributed sediments to the Tuckasegee River historically and the formations, which attracted mining efforts, may yet produce sediments and leachates.

- Kaolin - Mined in the county from 1888 to the mid-1920s, it appears that the largest deposits and processing plant were located at Hogrock Mountain on Little Savannah Creek with mention of processing also at Dillsboro. Those pits were filled in after the clay was removed. Other smaller deposits were found upstream of Dillsboro Dam.
- Mica - Mined in the county until 1962, nearly 90 mines and prospects are found within the county and the largest of these operated through WWI and WWII. Some 10-15 of the largest operations lasted to the end. Both scrap and sheet mica was extracted. Most of these were hillside operations that removed the soil layer to expose the ore. A few were underground mines.
- Copper - Prospects were worked on Green's Creek, Cullowhee Mountain (above the Tuckasegee Nursery at Moody Bridge), Wayehutta Creek, and Wolf Creek. The largest and most promising was at Cullowhee Mountain. Accounts suggest that a 30 ton copper smelter and a 10 ton lixiviation plant were constructed in about 1908 and a 40 ton copper furnace installed by 1910. Large cuts, shafts and tunnels were cut. The mine was abandoned after 1912, reopened in 1917, then closed. From 1929 to 1932 copper ore was mined here and shipped to Ducktown for processing. Mining ended shortly after 1932. Generally the ore is pyrite or chalcopyrite (Fe and FeCu sulfides). The mines, trenches and tunnels are still there. They are often filled with water that is green-blue in color from the copper.
- Dunite - This igneous rock, though rare, is common in Jackson County. It is composed of the minerals olivine, pyroxene, and chromite (in small amounts). The olivine has a density 50% greater than feldspar and quartz so is likely to settle to the stream bottom quickly. Because of the presence of the mineral chromite, chromium concentrations should be expected to be higher downstream from these deposits. Also, the dunites contain some nickel that might also be in water or sediments. As dunites become metamorphosed, minerals such as talc, serpentine, and anthophyllite are produced. Anthophyllite in these deposits may be converted into asbestos.
- Large deposits of dunite cross the Tuckasegee just above Webster Bridge (much of Webster is underlain by this rock), cross again near where Ashe Settlement Road intersects NC 107, continues up Cane Creek Road and a large quarry is located at the head of Cane Creek at Chestnut Gap. Remains of old mines can still be observed in Cowan Valley Estates. Other locations of dunite on the upper Tuckasegee are on Caney Fork (Judaculla Rock) and supposedly up Speedwell Road. Dr. Jerry Miller, WCU, has

analyzed the geochemistry of the sediments at the reservoir below the powerhouse on the West Fork. The sediment there had an anomalously high chromium concentration.

Site-specific sediment chemistry data are very limited but informative. Sampling by Duke Power was completed on October 4, 2001. Samples were collected about 125 feet upstream of the dam in midstream at a depth of 5 to 6 feet by repeatedly inserting a hand held corer into the sediment. Due to corer refusal, only 5 to 6 inches of sediment was obtained during each attempt; this material was mixed to form a single composite sample which was analyzed for metals, volatiles, semivolatiles, organochlorine pesticides, polychlorinated dibenzodioxins (dioxins), and polychlorinated dibenzofurans (furans). Volatile organics, semivolatile organics (with the exception of a low concentration of benzoic acid), organochlorine pesticides, and dioxins / furans were all less than the laboratory reporting limits. Sediment metal concentrations were below the detection limits for silver, arsenic, lead and selenium. Low levels of chromium, copper and mercury were detected. Cadmium was detected at 4.6 ug/g dry weight, a concentration at which effects to sensitive benthos may occur (MacDonald et al. 2000).

Beyond potential pollutant sources, review of existing data also addressed pathways between contaminant sources and sediments of interest, and the areas potentially affected if contaminated sediments were mobilized. These factors include things like impoundment bathymetry, flows, watershed hydrology and land uses, sediment and soil types, and sediment deposition rates. Many contaminants preferentially bind to organic matter and fine-grained (silt or clay) sediments. While a dam is expected to allow fine material to settle and potentially accumulate in shoaling areas, much of the substrate in the area of the Dillsboro dam is sandy, with little potential for contaminant accumulation. In the State's sampling of the benthic community in 1999, the substrate at the Tuckasegee River at Dillsboro (off SR 1378) was 40 to 50 % sand and gravel.

Important reservoir physical parameters were recently assessed as part of hydropower facility re-licensing studies. Recent bathymetry data are available and mapped in Figure 2. The draft "sediment issues for the Dillsboro project" summary (Duke Energy 2003) provides the following details on sediment composition, transport, and accumulation:

- The Dillsboro Project only generates electricity when there is sufficient flow in the river and flows in excess of 284 cubic feet per second are spilled. There is negligible useable storage for electric generation and, consequently, there is no need for dredging sediments from the reservoir.
- Bathymetric surveys were conducted in June 2001. Sediment samples were collected from transects established at points 1/5th, 2/5th, 3/5th and 4/5th along the midline of the impoundment from the dam to the headwater area. At each transect, grab samples were taken at 4 equidistant points across the impoundment. Particle size was determined.
- The bathymetry and particle size data show that the reservoir is similar to a river with a sandy-silt bed. Sediment translocation within and transport through the reservoir are dependent on the river flows. During periods of lower flows (roughly less than half bankfull) there is sediment deposition, and during high flows (roughly bankfull or greater) there is sediment mobilization and transport through and out of the reservoir.

- Sediment carried by the Tuckasegee River is highly mobile and composed of suspended sands and silts which are deposited on the falling limb of the hydrograph in backwater areas, but are easily re-suspended and moved during high flow events. Based on the bathymetric maps, the general form of the channel bed upstream of the dam remained unchanged. Material deposited behind the dam is very fine grained (generally less than 1 mm) and is of such a composition that it is easily re-suspended during high flows. There is no decrease in particle size from upstream to downstream near the dam, which would have indicated coarse particles aggrading due to backwater effects of the dam. Particle sizes along the length of the reservoir indicate that deeper areas have 1 mm particles, and shallower areas have essentially very fine, suspendable particles less than 0.1 mm. During high flows, observations upstream and downstream of the dam indicated the presence of large amounts of suspended materials; as flows dropped, this material was not stored in the main channel except in backwaters and deep pools.
- The river channel width is confined which limits lateral migration; thus, only the channel bed can change in response to flow changes. Scouring occurs at set points in the reservoir, such as in bends and in constricted areas. The extent of scouring changes in relation to flow and the incoming sediment loads. Since the flow is unregulated and, considering the present sediment accumulation within the reservoir, there will be little net increase of sediment storage.
- Sediment in the system consists of suspended silts and sands that deposit only when stopped by downstream controls. Sediment accumulation is not occurring at the dam face due to the shear stress at the unit intakes. The elevation of the bottom of the intake opening determines the depth of sediment accumulation at the dam, and acts as the “base level”. The funneling effect of water where flow enters the intake opening causes an increase in the water velocity in the forebay area. The increased flow velocity and shear stress causes erosion of any deposited sediment and the sediments are transported downstream. Headward (upstream) migration of the deposited sediments continues, creating a channel within the sediments.
- This channel is evident from the bathymetric data, and the depth of the channel approximately equals the depth of the intake. There is no delta formation (i.e., indicating excessive sediment availability) downstream of Dillsboro dam. There appears to be a balance between sediment delivered to this area and the ability of the river to move this material.
- Sediment particle size data indicate potential shoaling areas that can be targeted for sediment analyses, particularly in the shallow areas along the shoreline.

A summation of the tier 1 review of existing information indicates that no major contaminant concerns were identified. The cadmium concentration of the one composite sediment sample collected in 2001 may merit additional attention. The periodic exceedences of the State action level for copper in surface water may merit additional attention. The review also indicated that the material behind the dam might have low potential to accumulate contaminants from a physical standpoint, being comprised primarily of sand and gravel. Finally, it appears that watershed land uses upstream and downstream of the reservoir are similar and that any mobilized

sediments from behind the dam may merely subject downstream areas to the same sources of contaminants to which they have been historically exposed. While no major concerns were noted in the review of existing information, it was recommended that new data be collected to support management decisions. Those data will focus on inorganic contaminants to address the copper and cadmium issues identified above and the mining history of the area.

### *Tier 2 Results: Sediment collection, analyses and interpretation*

Table 2 lists sediment collection locations which are also depicted in Figure 4. The complete report from RTI is reprinted in Appendix B and summarized here. Laboratory blank, duplicate, SRM and spike data were reviewed, and they demonstrate very good lab performance on this batch of samples relative to analytical precision and accuracy.

Figure 5 (with sub-figures a-h for each element) is a comparison of the elemental contaminant results to freshwater sediment quality guidelines (MacDonald et al. 2000). These consensus-based threshold effects guidelines were established to provide lower bound concentrations below which adverse effects to sensitive aquatic organisms should not occur (Threshold Effects Concentrations, or TECs) and an upper range of concentrations above which adverse effects to sediment dwelling organisms may be expected (Probable Effects Concentrations, or PECs).

Eighty-one percent of all values evaluated were less than the TECs (i.e., presumed to be toxicologically insignificant). This category included all the data for arsenic, lead and mercury. Further, no samples exceeded the PECs for any elemental contaminant (i.e., no samples of obvious concern).

To evaluate the <20 percent of sample results that fell between the TECs and PECs for cadmium (n=1), chromium (n=3), copper (n=3), nickel (n=5) and zinc (n=3), we computed a geometric mean of the TECs and PECs for each element and defined it as a “median effects concentration”, or “MEC”. From Figure 5, it is apparent that only two sediment sample results for nickel exceeded these MECs. The two samples exceeding the MECs were collected at station D4 from within the reservoir, and DG1 from the Dillsboro gage area downstream of the dam (which had the highest overall nickel concentration). None of the few samples that exceeded the TECs for cadmium, chromium, copper and zinc exceeded the MECs, and most of the results were still relatively close to the TECs for these elements.

Because none of the samples indicate a toxicological concern, a statistical comparison of sediments within Dillsboro Reservoir to downstream sediments was not conducted.

## **Discussion**

There are no federal or North Carolina sediment quality criteria or standards, but the recent freshwater sediment quality guidelines of MacDonald et al. (2000) are very useful. The State of Florida recently recommended these for use as guidance in many of their programs, including evaluation of dredged material and risk assessment of contaminated sites (MacDonald et al. 2003). In a review by experts on sediment assessment, sediment quality guidelines like those used here were found to offer good utility in site assessment (Wenning and Ingersoll 2002).

From Figure 5, it is apparent that none of the sediment samples from within the reservoir or downstream exceeded the PECs, indicating no sediment contaminant concentrations of obvious concern. Over 80 percent of the sediment sample results were also less than the TECs, indicating they are unlikely of toxicological significance.

Slightly less than 20 percent of the sample results fell between the TEC and PEC, and they were further evaluated by comparing their magnitude to the geometric mean of the TEC and PEC for that element. If the TEC is thought of as a threshold below which no adverse effects are expected to occur, and the PEC is the likely effects concentration, the geometric mean of these two is an estimate of the concentration where adverse effects may begin to be observed. This “median effects concentration” or “MEC”, while not a construct of the original guidelines, appears useful as an initial screen of data in the middle category. We note also that this approach is consistent with how the U.S. Environmental Protection Agency summarizes chronic toxicity data in their water quality criteria program (Stephan et al. 1985). In that guidance, the geometric mean of a No Observed Effect Concentration and Lowest Observed Effect Concentration for a compound of interest can be used as a Maximum Allowable Toxicant Concentration, again with the idea that the lowest concentration of interest is somewhere between the no effect and likely effect concentrations.

In our application of the MECs, only two values (both for nickel) exceeded these levels. The highest nickel concentration (41.5 ug/g dry weight) was from a downstream river sample near Dillsboro gage, and the average of the four downstream samples (27.4 ug/g dry weight) exceeded the average concentration of the six samples collected upstream of the dam (21.8 ug/g dry weight). Accordingly, the nickel concentrations behind the dam should not be a concern relative to movement downstream where concentrations are slightly higher. Although nickel was found to be somewhat elevated relative to the screening level, nickel is a metal with little affinity for aquatic bioaccumulation, biomagnification, and mobilization in sediments (Connell and Miller 1984). Nickel also has only slight to moderate aquatic toxicity (USEPA 1986), and the concentrations observed in surface water quality monitoring of the Tuckasegee River, typically less than a 10 ug/l detection limit (NCDWQ 2000), are lower than values toxic even to very sensitive aquatic organisms (USEPA 1986, Keller and Zam 1991).

Concentrations of cadmium were generally low. None of our six samples upstream of the dam approached the concentration of the moderately elevated cadmium detected in the single 2001 composite sediment sample.

This assessment included all the priority pollutant metals / metalloids. Note that this does not address some of the elements reported by the lab, like barium, beryllium and vanadium, for which there are few relevant comparison values. This is likely not a significant limitation because there was no known source to the stream indicating enrichment of these relatively rare elements in our tier 1 assessment.

A value of one-half the method detection limit was used for the graphs in Figure 5 in the few instances of values reported as lower than detection. This should not influence the data interpretation because the detection limits were sensitive relative to the screening guidelines.

This assessment is limited to the toxicological properties of the sediments evaluated. It does not address the potential physical impacts of sediment mobilization.

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Table 1. National Pollutant Discharge Elimination System (NPDES) facilities upstream of the Dillsboro Dam.

<b>Facility Name</b>	<b>Volume</b>	<b>Receiving stream</b>
<b>Major facilities</b>		
Tuckasegee Water and Sewer Authority	1.5 MGD	Tuckasegee River
<b>Minor Facilities</b>		
Western Carolina University WTP	0.0005 MGD	Tuckasegee River
Singing Water Camping Resort*	0.0075 MGD	Trout Creek
Trillium Links and Village*	0.02 MGD	UT to Thorpe Lake
Jackson Co. BOE (Blue Ridge School)*	0.01 MGD	Hurricane Creek
Whiteside Estates* #	0.1 MGD	Grassy Camp Creek
* note - all of these facilities are in Tuckasegee River headwaters and located upstream of either the Tuckasegee Lake Dam and / or Glenville Lake Dams 1 and 2		
# this facility was not constructed and has never been operated		

Table 2. June 2003 sediment collection sites within Dillsboro Reservoir and downstream areas.

Sample #	Date Collected	Description
D1	06/23/03	Reservoir sample (35° 21.542N / 83° 14.839W) Depositional area on left bank in 1 to 2-feet of water depth
D2	06/23/03	Reservoir sample (35° 21.727N / 83° 14.792W) Typical reservoir sediments (coarse sand) in 5 to 6-feet of water depth
D3	06/23/03	Reservoir sample (35° 21.899N / 83° 14.821W) Depositional area on right bank
D4	06/23/03	Reservoir sample (35° 21.9532N / 83° 14.906W) Depositional area on left bank in 1 to 2-feet water depth (below sign line)
D5	06/23/03	Reservoir sample (35° 21.997N / 83° 14.947W) Typical reservoir sediments (coarse sand / gravel) in 8 to 9-foot water depth
D6	06/23/03	Reservoir sample (35° 21.994N / 83° 14.957W) Depositional area on right bank (shoal behind boom log)
Barkers Creek 1 (BC1)	06/24/03	Downstream sample (35° 23.114N / 83° 17.502W) Depositional area, right bank at Tuckasegee Outfitters in 1-foot water depth
Barkers Creek 2 (BC2)	06/24/03	Downstream sample (35° 23.114N / 83° 17.502W) River channel at BC1, coarse sand in 2 to 3-feet water depth
Dillsboro Gage 1 (DG1)	06/24/03	Downstream sample (35° 21.976N / 83° 15.492W) Depositional area, right bank shoal at Dillsboro Gage, 0.5-foot water depth
Dillsboro Gage 2 (DG2)	06/24/03	Downstream sample (35° 21.976N / 83° 15.489) River channel at DG1, coarse sand in 2 to 3-feet water depth

Figure 1. Dillsboro Reservoir and vicinity.

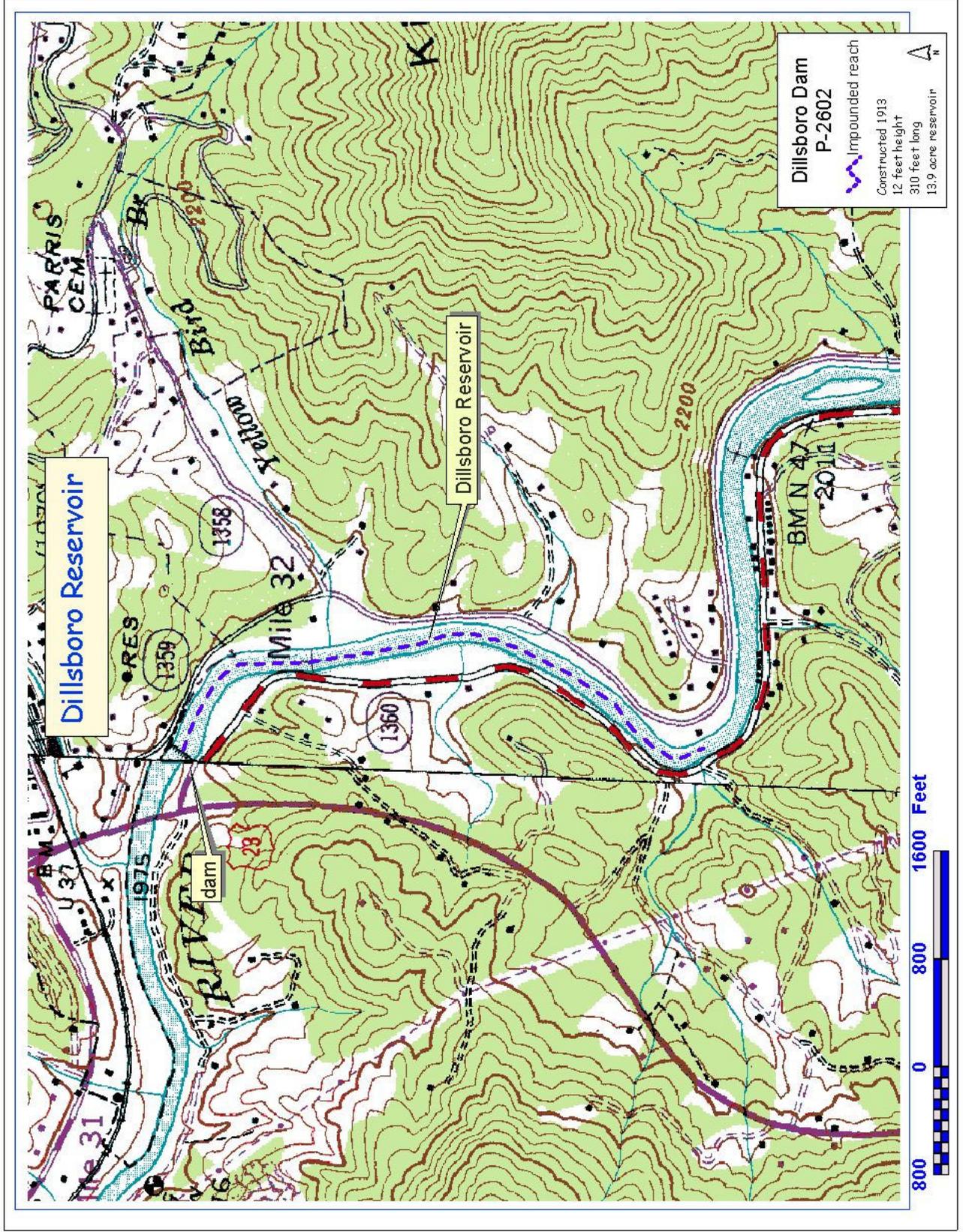


Figure 2. Dillsboro Reservoir bathymetry.

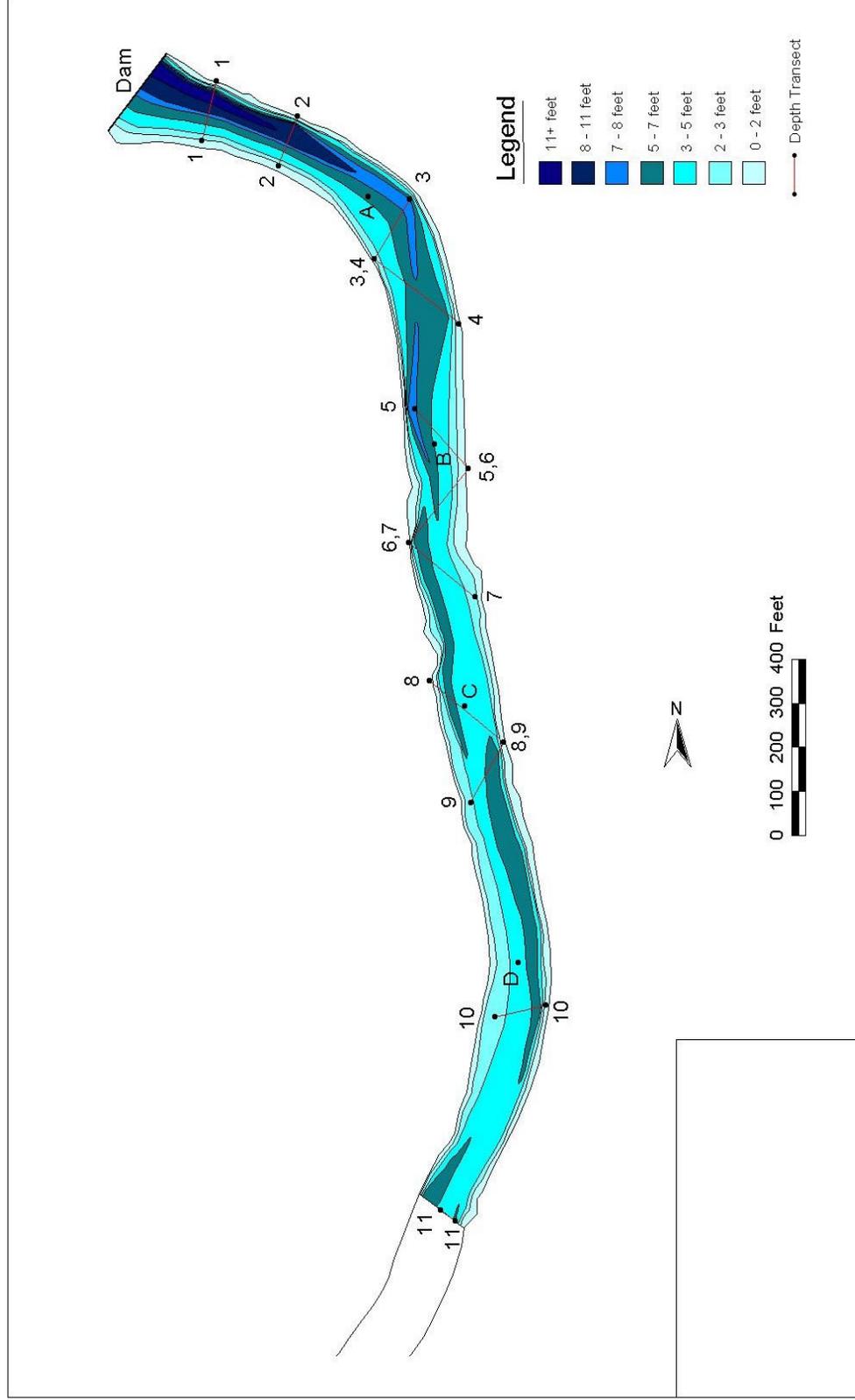


Figure 3. 1967 aerial photograph of mixing zone of Scotts Creek downstream of Dillsboro Dam.



Figure 4. June 2003 Dillsboro Reservoir sediment sampling sites.

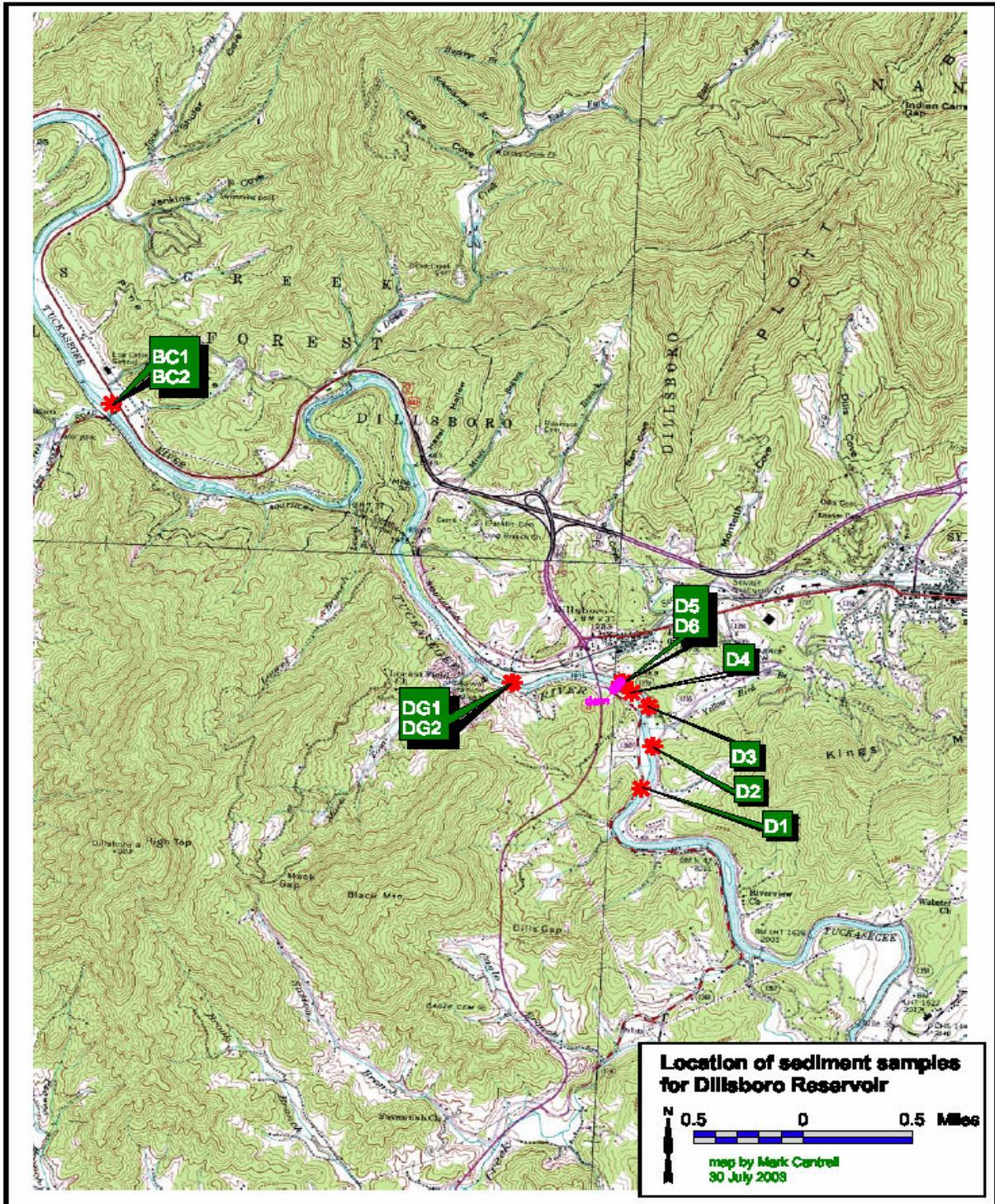


Figure 5 (a-h). Elemental contaminant concentrations of sediments collected within the Dillsboro Reservoir (D1, D2, D3, D4, D5 and D6) and downstream of the reservoir (DG1, DG2, BC1 and BC2). For each element, results are compared to threshold effects concentration (TEC) guidelines of MacDonald et al. (2000) -- values below which adverse effects to sensitive aquatic organisms should not occur, and probable effects concentrations (PECs) -- values above which adverse effects to sediment dwelling organisms may be expected (MacDonald et al. 2000). Some figures also have a “median effects concentration” (MEC), the geometric mean of the TEC and PEC, for reference.

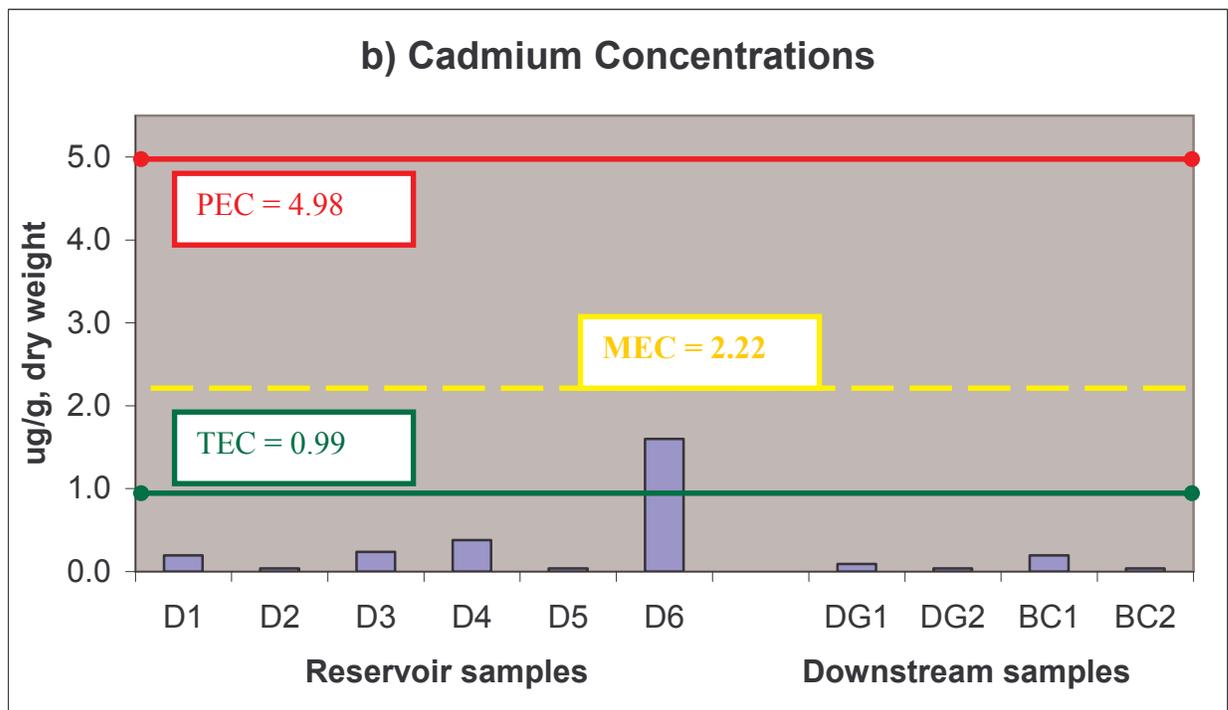
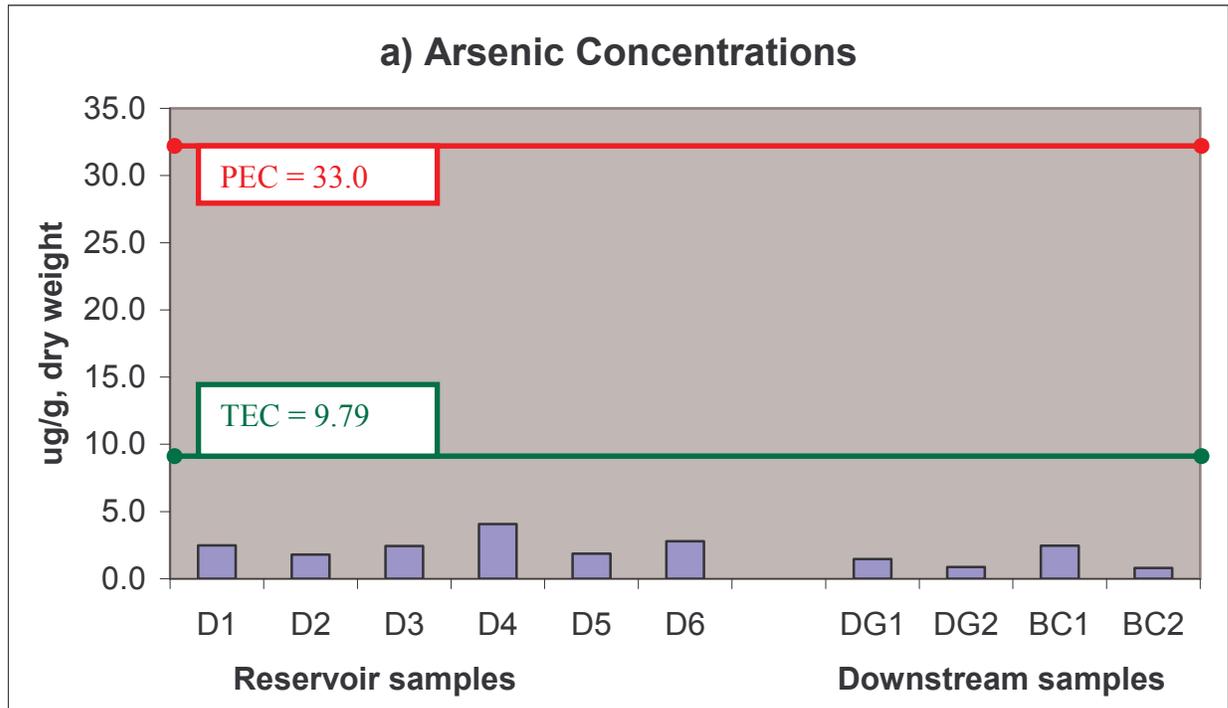


Figure 5 (cont.)

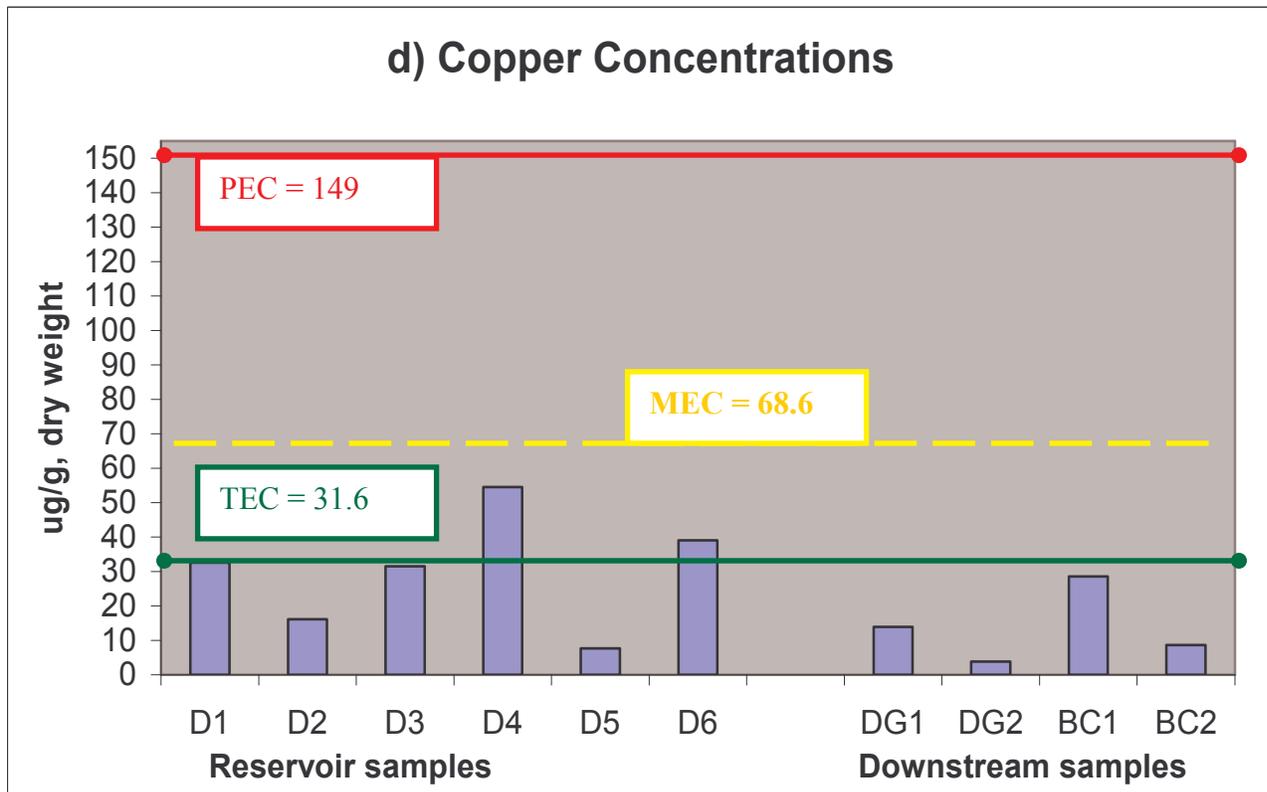
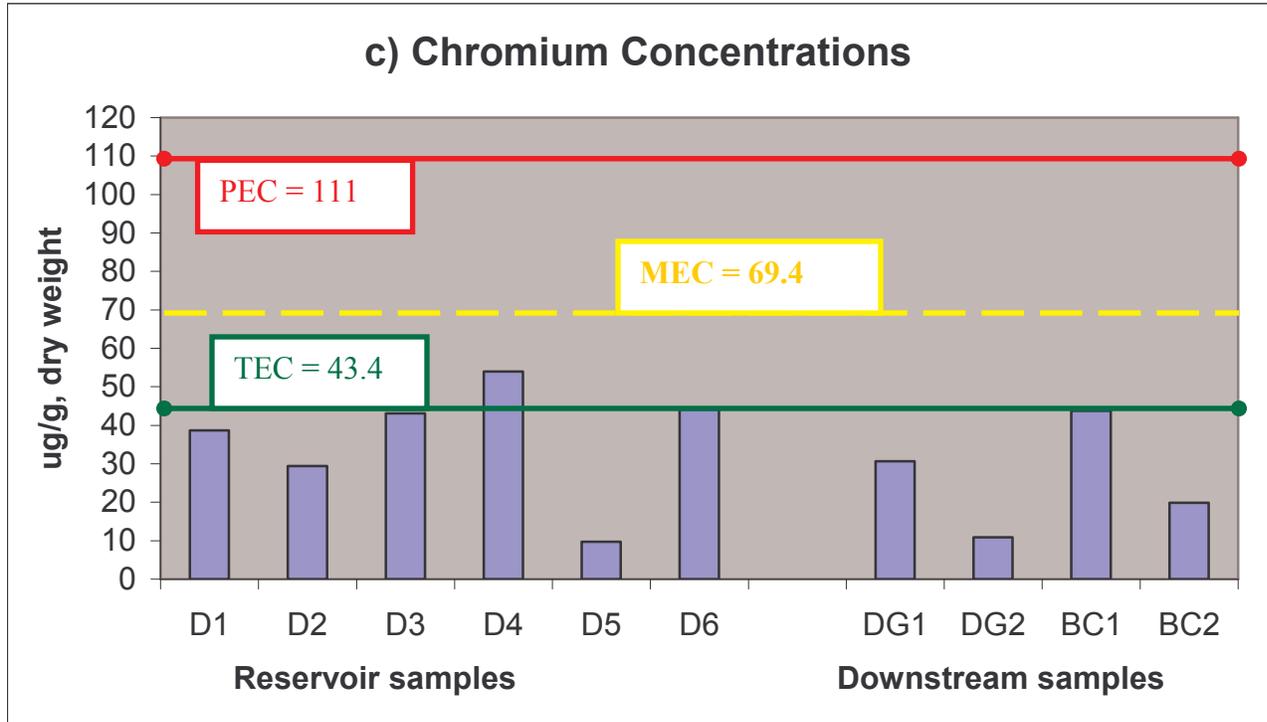


Figure 5 (cont.)

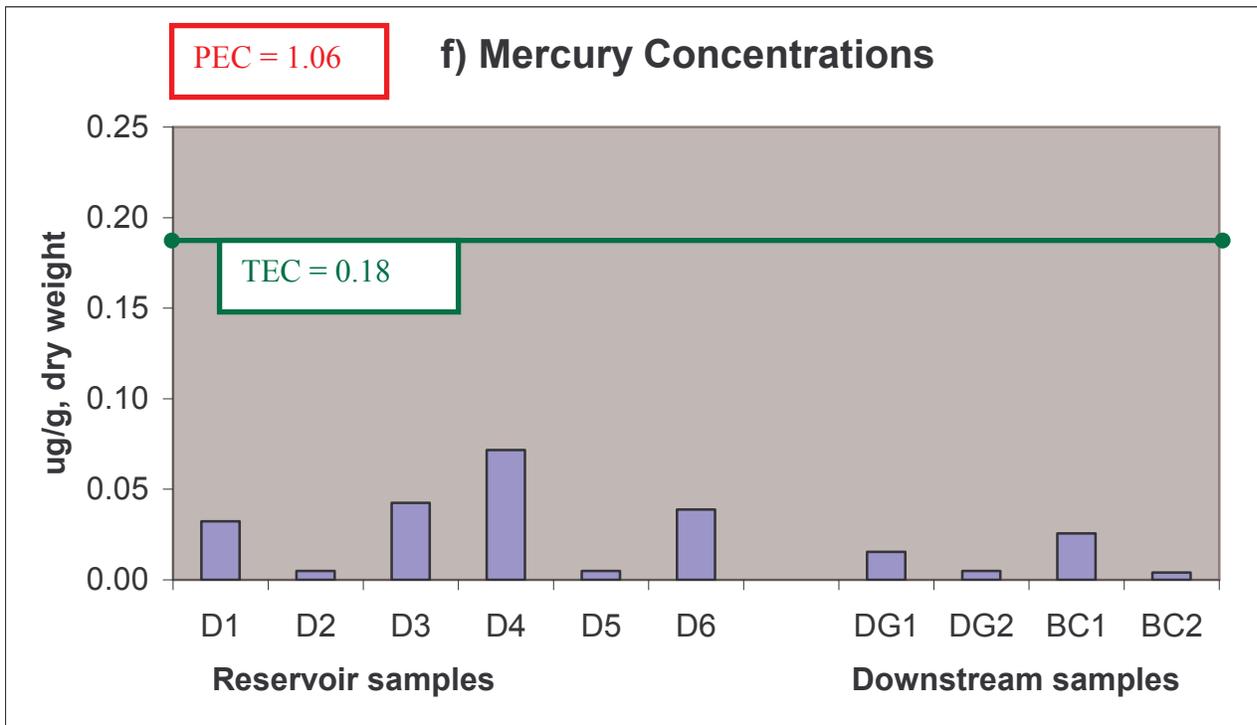
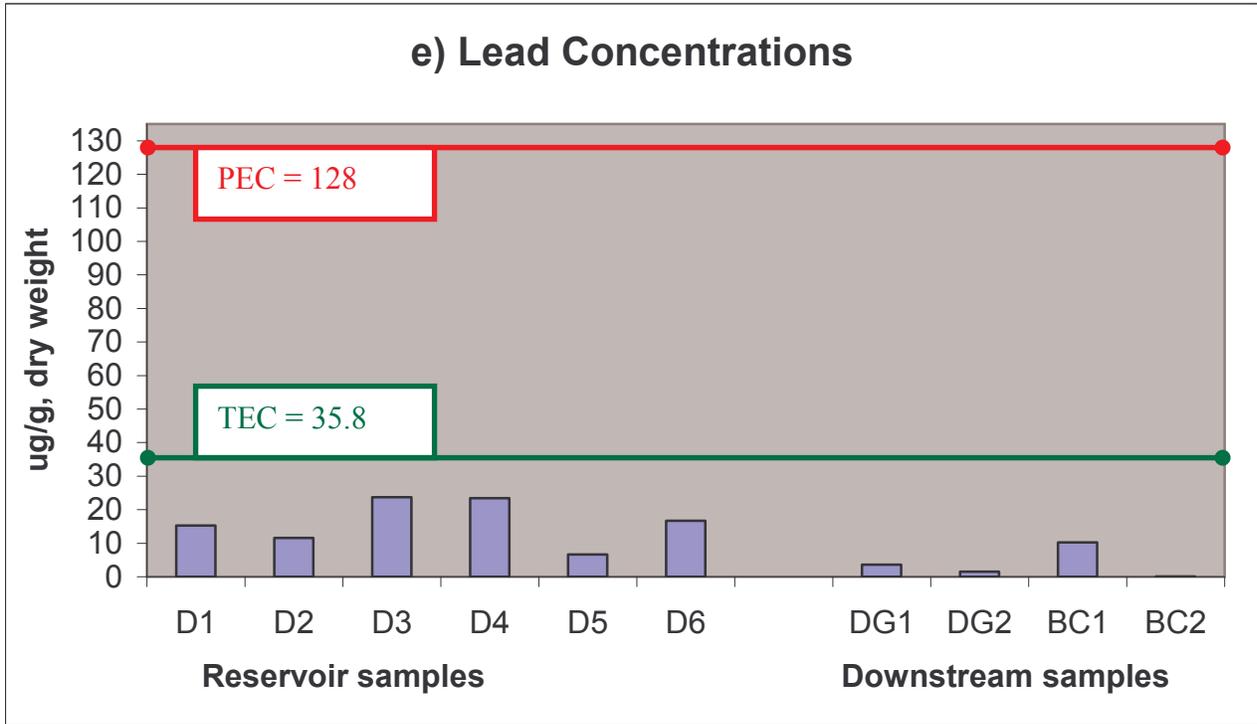
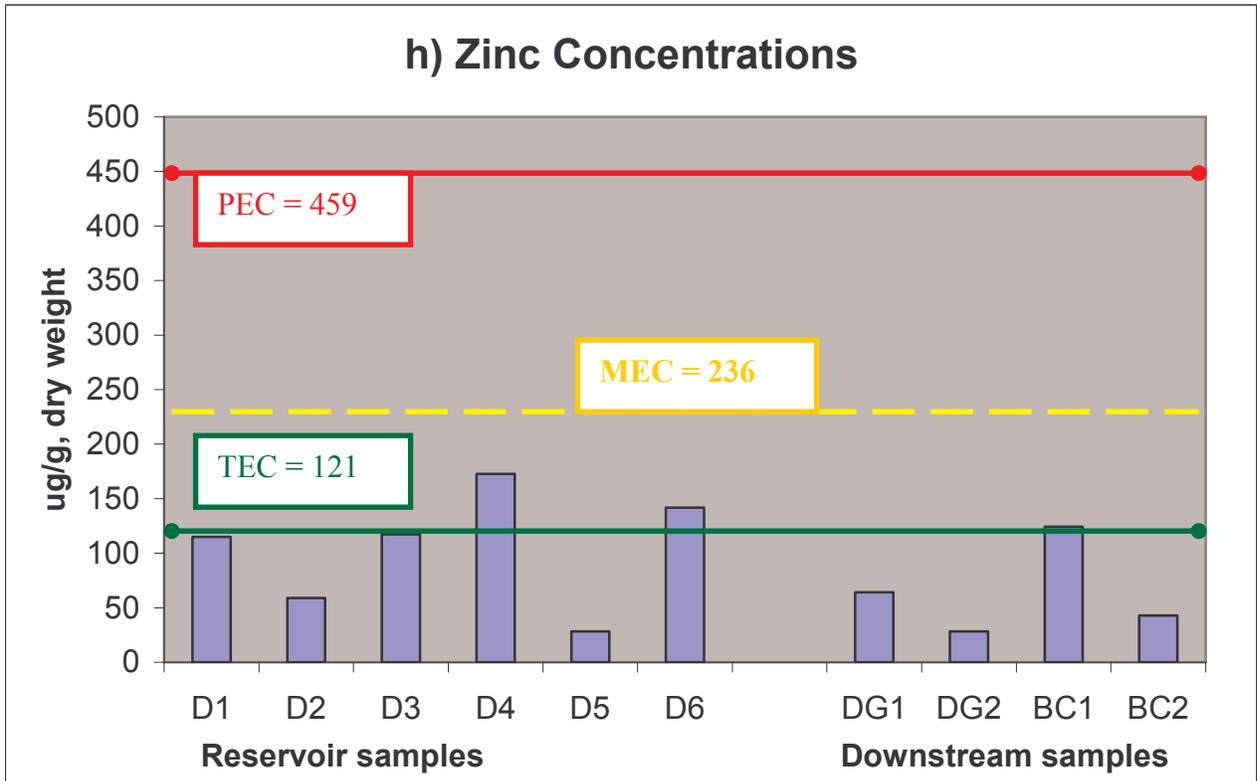
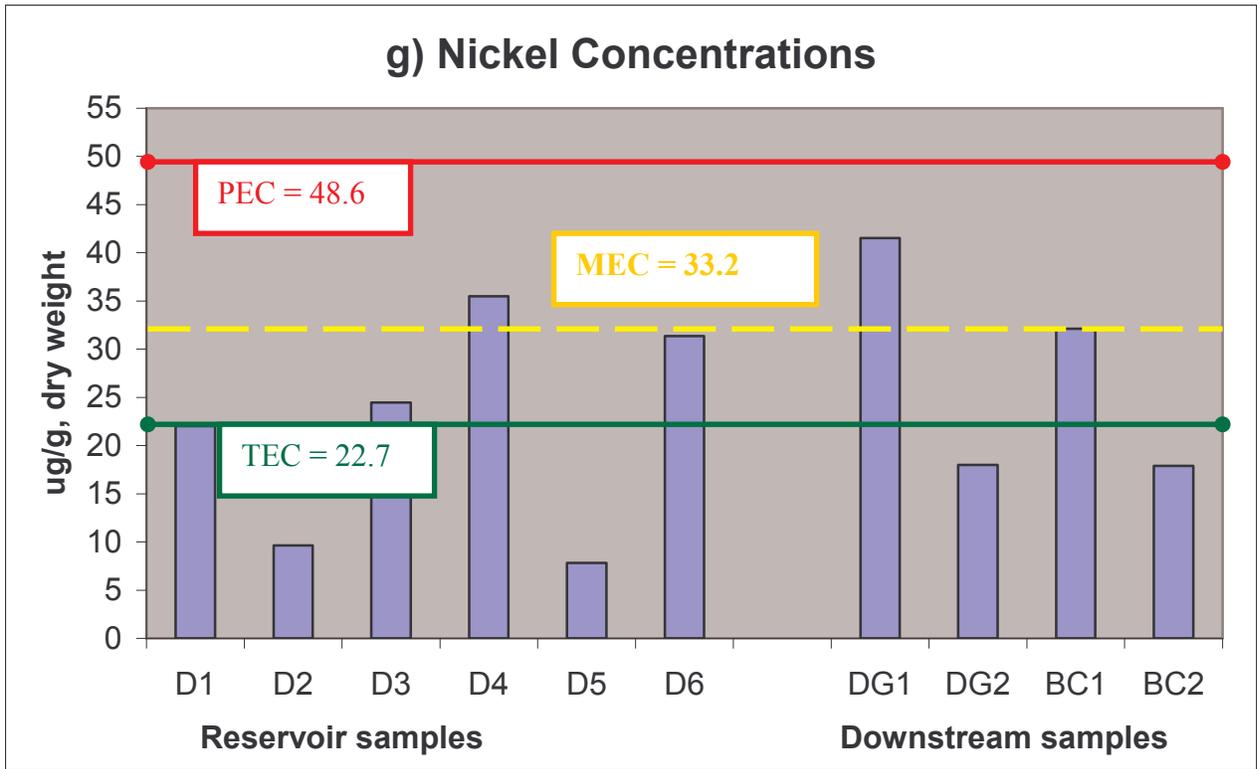


Figure 5 (concluded)



# Appendix A. Chain of Custody for June 2003 Sediment Samples

DEPARTMENT OF THE INTERIOR U. S. FISH AND WILDLIFE SERVICE DIVISION OF LAW ENFORCEMENT			<b>CHAIN OF CUSTODY RECORD</b>		FILE NO. INV-
DATE AND TIME OF SEIZURE: <i>June 23, 24 - 2003</i>		DISTRICT:	EVIDENCE/PROPERTY SEIZED BY: <i>Collected by Tom Augspurger - Ecologist</i>		
SOURCE OF EVIDENCE/PROPERTY (person and/or location): <input checked="" type="checkbox"/> TAKEN FROM: <input type="checkbox"/> RECEIVED FROM: <input type="checkbox"/> FOUND AT: <i>Sediment samples from Tuckasegee River - within impaired reach of Dillsboro Reservoir and downstream</i>			CASE TITLE AND REMARKS: <i>Dillsboro Reservoir Sediment Assessment - Duke Power</i>		
ITEM NO.	DESCRIPTION OF EVIDENCE/PROPERTY (include Seizure Tag Numbers and any serial numbers):				
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
<i>each sample consists of three (3), 500 gram glass I-chem jars of homogenized sediment from a single site (i.e. three replicates per each of the 10 locations)</i>					
ITEM NO.	FROM: (PRINT NAME, AGENCY)	RELEASE SIGNATURE:	RELEASE DATE	DELIVERED VIA:	
<i>1 through 10 (2 jars per sample of the 3 available)</i>	<i>Tom Augspurger U.S. Fish and Wildlife Serv.</i>	<i>Tom Augspurger</i>	<i>06/30/03</i>	<input type="checkbox"/> U.S. MAIL <input checked="" type="checkbox"/> IN PERSON <input type="checkbox"/> OTHER:	
	TO: (PRINT NAME, AGENCY)	RECEIPT SIGNATURE:	RECEIPT DATE		
	<i>Sara Ward U.S. Fish and Wildlife Serv.</i>	<i>Sara Ward</i>	<i>06/30/03</i>		
ITEM NO.	FROM: (PRINT NAME, AGENCY)	RELEASE SIGNATURE:	RELEASE DATE	DELIVERED VIA:	
<i>1 through 10 (2 jars per sample of 3 available)</i>	<i>Sara Ward U.S. Fish and Wildlife Serv.</i>	<i>Sara Ward</i>	<i>6/30/03</i>	<input type="checkbox"/> U.S. MAIL <input checked="" type="checkbox"/> IN PERSON <input type="checkbox"/> OTHER:	
	TO: (PRINT NAME, AGENCY)	RECEIPT SIGNATURE:	RECEIPT DATE		
	<i>David Binstock RTI</i>	<i>David Binstock</i>	<i>6/30/03</i>		
ITEM NO.	FROM: (PRINT NAME, AGENCY)	RELEASE SIGNATURE:	RELEASE DATE	DELIVERED VIA:	
				<input type="checkbox"/> U.S. MAIL <input type="checkbox"/> IN PERSON <input type="checkbox"/> OTHER:	
	TO: (PRINT NAME, AGENCY)	RECEIPT SIGNATURE:	RECEIPT DATE		

ADDITIONAL TRANSFERS ON REVERSE SIDE

FORM 3-2063 (9/81)

## Appendix B. Analytical Data Report for June 2003 Sediment Samples

July 15, 2003

Mr. Tom Augspurger  
U.S. Fish and Wildlife Service  
Box 33726  
Raleigh, NC 27601

Dear Mr. Augspurger

Please find the analytical report for the analysis of 10 Duke Power sediment samples for trace elemental content. Samples were digested/extracted in concentrated nitric using microwave heating and analyzed using a combination of inductively coupled plasma atomic emission spectrometry (ICP-AES) and inductively coupled plasma mass spectrometry (ICP-MS) for all metals but mercury and cold vapor atomic absorption (CVAA) for mercury. Please call me at 919-541-6897 if you have any questions.

Sincerely

Peter M. Grohse

Program Manager - Trace Metals Analysis  
RTI International  
3040 Cornwallis Rd. - Building 6  
Research Triangle Park, NC 27709

# TECHNICAL REPORT

**Client:** Duke Power

**RTI Project No.:** 08224.001.003

**Date:** 7-15-03

***By***

Peter M. Grohse.  
Research Triangle Institute  
Post Office Box 12194  
3040 Cornwallis Road  
Research Triangle Park, NC 27709

(919) 541-6897  
pmg@rti.org

**Submitted to:**

Tom Augspurger  
Box 33726  
U.S. Fish and Wildlife Service  
Raleigh, NC 27601  
Phone 919-856-4520

## **INTRODUCTION**

Ten (10) sediment samples were received for analysis on June 30, 2003. An analysis for aluminum (Al), arsenic (As), boron (B), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb), selenium (Se), strontium (Sr), vanadium (V) and zinc (Zn) was performed by inductively coupled plasma mass spectrometry (ICP-MS) and inductively coupled plasma atomic emission spectrometry (ICP-AES) and mercury by cold vapor atomic absorption (CVAA).

## **PREPARATION**

Samples were wet-homogenized, freeze-dried, dry-homogenized and digested in digested/extracted in concentrated in nitric using microwave heating.

## **QUALITY CONTROL**

An additional aliquot of two sediments were taken to prepare duplicate and matrix spikes and digested/extracted alongside real samples. In addition, an aliquot of NIST SRM 2709 (River Sediment) and a reagent blank were prepared for analysis.

## **MEASUREMENT**

Sample and QC extracts/digests were analyzed as noted in the introduction. The instrumentation consisted of a ThermoElemental X7 ICP-MS, a Perkin-Elmer 4300 Optima ICP-AES and a Leeman Labs PS200 automated mercury analyzer.

## **RESULTS**

Moisture content is provided in Table 1. Trace metal results are presented in Table 2 and are expressed in  $\mu\text{g/g}$  on a dry weight basis. Laboratory blank, duplicate, SRM and spike data are presented in Table 3 and are also expressed in  $\mu\text{g/g}$  dry weight. Note that the digestion actually provides a strong leach, which will only fully recover elements such as As, Cd, possibly Cu, Hg, possibly Ni, Pb, Se and Zn.

## **SAMPLE CUSTODY**

Remaining samples will be stored for one year after submission of the report.

**Table 1 - Sample Information**

<b>Sample ID</b>	<b>Sample Matrix</b>	<b>Rec'd Wt (g)</b>	<b>% Moisture</b>
<b>D1</b>	Soil/Sediment	49.2	48.5
<b>D2</b>	Soil/Sediment	48.2	52.5
<b>D3</b>	Soil/Sediment	44.0	60.6
<b>D4</b>	Soil/Sediment	41.4	74.4
<b>D5</b>	Soil/Sediment	61.8	75.1
<b>D6</b>	Soil/Sediment	48.9	64.9
<b>Barkers Creek 1</b>	Soil/Sediment	53.8	56.6
<b>Barkers Creek 2</b>	Soil/Sediment	71.5	34.8
<b>Dillsboro Gage1</b>	Soil/Sediment	71.2	34.1
<b>Dillsboro Gage2</b>	Soil/Sediment	64.9	29.9

**Table 2 - Sample Data in µg/g, Dry Weight<sup>a</sup>**

Sample ID	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn
Barkers Creek 1	22970	2.45	0.60	258	0.94	0.19	43.7	28.5	38,071	0.026	9,181	514
Barkers Creek 2	7466	0.80	<0.25	59.9	0.40	<0.08	19.9	8.6	15,524	0.004	3,371	316
D1	21908	2.5	0.68	214	0.75	0.20	38.7	32.6	33,165	0.032	6,946	473
D2	12483	1.8	0.28	74.6	0.59	<0.08	29.4	16.1	25,498	<0.01	2,266	297
D3	22535	2.4	0.74	215	0.86	0.24	43.1	31.6	34,627	0.043	7,075	475
D4	35590	4.1	1.09	318	1.21	0.38	54.0	54.6	49,051	0.072	9,460	581
D5	9761	1.9	<0.25	25.8	0.50	<0.08	9.8	7.7	9,380	<0.01	1,414	114
D6	28586	2.8	6.34	261	5.769	1.599	44.1	39.1	39,152	0.039	8,103	599
Dillsboro Gage1	12483	1.47	0.27	137	0.50	0.09	30.7	13.9	22,745	0.015	8,057	308
Dillsboro Gage2	4131	0.88	<0.25	32.4	0.27	<0.08	10.9	3.9	11,015	<0.01	3,145	234
MDL	10	0.5	0.25	0.25	0.1	0.08	0.5	0.5	10	0.01	10	0.5
Method	ICP-AES	GFAA	ICP-MS	ICP-AES	ICP-MS	ICP-MS	ICP-AES	ICP-AES	ICP-AES	CVAA	ICP-AES	ICP-AES

Sample ID	TOC (%)	Grain Size		
		Sand	Silt	Clay
Barkers Creek 1	12.3	93.0	6.85	0.01
Barkers Creek 2	0.23	99.7	0.46	0.01
D1	1.73	86.8	13.0	0.06
D2	0.45	99.3	0.32	0.09
D3	2.16	82.3	17.4	0.11
D4	4.14	91.4	8.3	0.02
D5	0.41	99.1	0.88	<0.01
D6	7.81	86.2	13.7	0.10
Dillsboro Gage1	14.8	98.1	2.01	0.01
Dillsboro Gage2	0.060	99.6	0.23	<0.01
MDL	0.004%	<0.01	<0.01	<0.01
Method		Sieving/Suspension/Gravimetry		

Sample ID	Mo	Ni	Pb	Se	Sr	V	Zn
Barkers Creek 1	0.25	32.1	10.3	<0.3	10.8	79.6	124
Barkers Creek 2	<0.2	17.9	<0.25	<0.3	3.1	26.6	43.0
D1	0.27	22.0	15.2	0.72	9.0	71.5	115
D2	0.24	9.6	11.6	<0.3	3.7	42.6	59
D3	0.30	24.5	23.7	<0.3	11.0	71.5	117
D4	0.36	35.5	23.5	0.61	14.7	102	173
D5	0.26	7.8	6.7	<0.3	2.1	17.2	28.4
D6	1.69	31.4	16.7	0.5	13.7	80.0	142
Dillsboro Gage1	0.24	41.5	3.6	<0.3	7.3	47.8	64.3
Dillsboro Gage2	<0.2	18.0	1.5	<0.3	2.4	17.3	28.4
MDL	0.2	0.5	0.25	0.3	0.5	0.5	1.0
Method	ICP-MS	ICP-AES	ICP-AES	GFAA	ICP-AES	ICP-AES	ICP-AES

<sup>a</sup> Except where noted

**Table 3 - QC Sample Results in µg/g, Dry Weight<sup>d</sup>**

QC ID	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg
D3	22535	2.43	0.74	215	0.86	0.24	41.8	31.6	34627	0.043
Duplicate	23819	2.46	0.67	216	0.86	0.24	41.8	30.5	35090	0.035
% RPD	5.5	1.2	9.8	0.4	0.2	1.9	0.1	3.2	1.3	20.2
D4	21650	4.06	0.2 <sup>a</sup>	318	0.5 <sup>a</sup>	0.1 <sup>a</sup>	50.0	54.6	49051	<0.01
Spiked D4	35590	41.8	15.1	720	16.0	14.1	411	461	53495	1.48 <sup>a</sup>
Spike Added	400	37.6	15.4	400	15.4	15.4	400	400	4000	1.7
% Recovery	c	100	96	100	101	91	90	102	c	87.1
SRM Result	1.80%	14.8	25.5	377	0.84	0.46	46.99	35	27171	1.38
SRM Value <sup>b</sup>	2%-3.1%	17.7	N/A	N/A	N/A	0.38	60-115	26-40	2.5%-3.3%	1.40
Reagent Blank	<1.0	<0.5	<0.25	<0.25	<0.1	<0.08	<0.5	<0.5	<10	<0.01
<b>MDL</b>	10	0.5	0.25	0.25	0.1	0.08	0.5	0.5	10	0.01

a Sample D5; b NIST 2709 Sediment, consensus leach value; c Spike to background ratio<<1

d TOC in % units N/A - NIST Value

QC ID	Mg	Mn	Mo	Ni	Pb	Se	Sr	V	Zn	TOC
D3	7075	475	0.30	24.5	23.7	<0.3	11.0	71.5	117	1.73
Duplicate	7074	482	0.23	25.6	17	<0.3	11.5	71.0	121	1.91
% RPD	0.0	1.3	25.6	4.6	35.2	N/A	4.5	0.8	3.1	9.9
D4	9460	581	0.52 <sup>a</sup>	35.5	23.5	0.61	14.7	102	173	
Spiked D4	13273	1000	12.91	1246	1210	34.8	409	484	564	
Spike Added	4000	400	15.4	1200	1200	37.6	400	400	400	
% Recovery	c	105	81	101	99	91	99	96	98	
SRM Result	11691	518	0.30	75	12	1.05	99	43	96	
SRM Value <sup>b</sup>	1.2%-1.5%	360-600	N/A	65-90	12-18	1.57	100-112	51-70	87-120	
Reagent Blank	<10	<0.5	<0.2	<0.5	<0.25	<0.3	<0.5	<0.5	<1.0	
<b>MDL</b>	10	0.5	0.2	0.5	0.25	0.3	0.5	0.5	1.0	0.004%

a Sample D5; b NIST 2709 Sediment, consensus leach value; c Spike to background ratio<<1;

d TOC in % units N/A - NIST Value

**Sample**

Sample ID											
D4	0.266	50	0.5	10	Al	34,537	43,303				
D4	0.266	50	0.5	10	As						
D4	0.266	50	0.5	10	B	82.1	453.8				
D4	0.266	50	0.5	10	Ba	318	720				
D4	0.266	50	0.5	10	Be	<0.1	387				
D4	0.266	50	0.5	10	Cd	2.7	402				
D4	0.266	50	0.5	10	Cr	54.0	442				
D4	0.266	50	0.5	10	Cu	54.6	461				
D4	0.266	50	0.5	10	Fe	49,051	53,495				
D4	0.266	50	0.5	10	Mg	9,460	13,273				
D4	0.266	50	0.5	10	Mn	581	1000				
D4	0.266	50	0.5	10	Mo	1.4	315				
D4	0.266	50	0.5	10	Ni	35.5	1246				
D4	0.266	50	0.5	10	Pb	23.5	1210				
D4	0.266	50	0.5	10	Se						
D4	0.266	50	0.5	10	Sr	14.7	409				
D4	0.266	50	0.5	10	V	102	484				
D4	0.266	50	0.5	10	Zn	173	564				
D4 SPIKE	0.266	50	0.5	10	Al	43,303		8,766	4000		
D4 SPIKE	0.266	50	0.5	10	As						
D4 SPIKE	0.266	50	0.5	10	B	453.8		372	400		
D4 SPIKE	0.266	50	0.5	10	Ba	720		402	400		
D4 SPIKE	0.266	50	0.5	10	Cd	402		399	400		
D4 SPIKE	0.266	50	0.5	10	Cr	442		388	400		
D4 SPIKE	0.266	50	0.5	10	Cu	461		406	400		
D3 DUPLICATE	0.269	50	0.5	10	Hg						
NIST 2709	0.268	50	0.5	10	Hg						
NIST 2709	0.268	50	0.5	10	Mg	11,691	12,000-15,000				
NIST 2709	0.268	50	0.5	10	Mn	518	360-538				
NIST 2709	0.268	50	0.5	10	Mo	0.9					
NIST 2709	0.268	50	0.5	10	Ni	74.8	65+				
NIST 2709	0.268	50	0.5	10	Pb	11.7	12-18				
NIST 2709	0.268	50	0.5	10	Se		1.6				
NIST 2709	0.268	50	0.5	10	Sr	98.9	100-112				
NIST 2709	0.268	50	0.5	10	V	43.2	35+				
NIST 2709	0.268	50	0.5	10	Zn	95.8	100+				