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Assessment of Environmental Contaminants in Muddy River Fishes, Clark County, Nevada.

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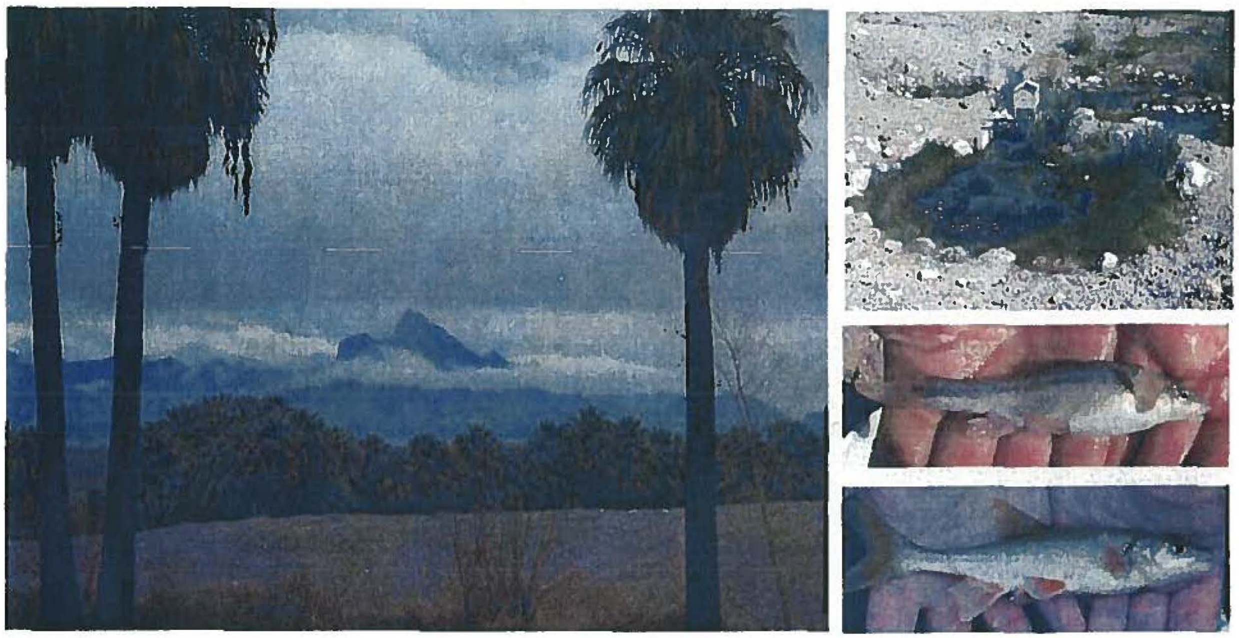

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U.S. Fish and Wildlife Service
Mission Statement

"Our mission is working with others to conserve, protect, and enhance the nation's fish, wildlife, and plants and their habitats for the continuing benefit of the American people."

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On the Cover (clockwise from left): Warm Springs area of Moapa Valley looking east towards Mormon Peak, Playboy Spring (a.k.a. Peterson East), Moapa speckled dace (*Rhinichthys osculus moapae*), Virgin River chub (*Gila seminuda*).

ABSTRACT

In 2002 the U.S. Fish and Wildlife Service (Service) Southern Nevada Field Office initiated a study to identify environmental contaminant impacts to native fish of the Muddy River, Clark County, Nevada. Potential sources of pollution include a coal-fired power plant, dairy cattle operation, agriculture, and irrigation return flows. The Muddy River Ecosystem provides habitat for at least eight rare aquatic species including the endangered Moapa dace (*Moapa coriacea*). Between February 2002 and April 2003, over five hundred fish were surveyed for external health. Overall fish condition was good and incidence of external lesions, parasites, and physical anomalies were low in representative fish species. A total of sixty non-native fish were collected at six stations throughout the Muddy River and submitted for inorganic (trace metal) analysis. Three of the fish were also analyzed for organic (organochlorine) compounds. Species sampled include one common carp (*Cyprinus carpio*), two bluegill (*Lepomis macrochirus*), nineteen blue tilapia (*Oreochromis aurea*), and 38 black bullhead catfish (*Ictalurus melas*). Chemical residues recovered in whole body fish were compared to National Contaminant Biomonitoring Program (NCBP) data as well as threshold toxicity values in published literature. Of the nineteen trace elements tested, only molybdenum was not detected in any fish sample. Most concentrations were within background levels, however, mercury (range non-detect - 0.28 parts per million wet weight (ppm ww), $\bar{x} = 0.097$) and selenium (range 0.21 - 1.2 ppm ww, $\bar{x} = 0.654$) are potential contaminants of concern. While levels detected appear to be below thresholds associated with acute toxicity, sublethal chronic effects to the long-term health and survival of endemic fish is unknown. Mercury is a known endocrine disruptor and of particular concern as an environmental toxin due to its ability to bioaccumulate in the food chain. All organochlorine compounds (OCs) tested were below the lower detection limit, with the exception of p,p' DDE (maximum value 0.029 ppm ww), which was within the expected range of concentrations based on historical DDT use. Our study confirms that Muddy River fish are being exposed to and accumulating certain trace metals. In the absence of species specific toxicity information for native fish, only general inferences can be made about the possible effects of trace metals detected based on comparisons to threshold toxic affect levels for other fish species. Results indicate mercury and selenium may pose a slight risk to native fish even at low levels. If trace metal concentrations in surrogate non-native fish are a good estimator of levels in native fish, our study did not find evidence of gross contamination. We conclude that contaminants pose a relatively small risk to native fish compared to documented threats from habitat modification and predation by non-native species. To achieve maximum benefit for recovery of endemic fish, we recommend resource managers place a higher priority on removal of exotic species and habitat restoration while continuing to monitor the abundance, health and distribution of native fish.

PREFACE

This report summarizes the analytical results of fish samples collected from the Muddy River, Clark County, Nevada. Analytical work for this investigation was completed under Patuxent Analytical Control Facility Catalog Number 1180001 - Purchase Orders No. 94420-03-Y315 (Inorganics) and 94420-03-Y314 (Organochlorines).

Questions, comments, and suggestions related to this report are encouraged. Written inquires should refer to Report Number 200210008 (FFS #: 14320A-1130-1F38) and be directed to:

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1. INTRODUCTION

Many native species of fish in the southwestern United States are in decline due to habitat modification, introduction of non-native species, and degraded water quality. The Muddy River, which originates approximately 50 miles northeast of the city of Las Vegas in Moapa Valley, Clark County, Nevada, flows southeast from numerous natural springs at its headwaters, to the Overton Arm of Lake Mead National Recreation Area on the Colorado River (a distance of 25 miles) (Figure 1). River flows are diverted along the way to irrigate crops, provide cooling for the Reid Gardner Power Plant, and provide a source of drinking water for the communities of Logandale, Moapa, and Overton. The Muddy River is formed by thermal springs that flow at a constant 32° Celsius from carbonate aquifers, creating a biologically diverse ecosystem characterized by high rates of species endemism. The endangered Moapa dace (*Moapa coriacea*) is restricted to the upper portions of the Muddy River and is limited to less than an estimated 1,000 individuals. In 1979, the Moapa Valley National Wildlife Refuge was established to protect the Moapa dace, securing three of the seven major spring sources on 106 acres of land. The Muddy River population of the Virgin River chub (*Gila seminuda*), a species listed as endangered in the Virgin River, may also be listed as endangered in the Muddy River in the near future. The Muddy River provides habitat for two other endemic fishes: the Moapa White River springfish (*Crenichthys baileyi moapae*) and Moapa speckled dace (*Rhinichthys osculus moapae*); and a variety of endemic aquatic invertebrates. These species are threatened by habitat loss, exotic species, de-watering, alteration of spring flows, and degradation of water quality. Previous studies have documented the decline in the distribution and abundance of endemic fishes in the Muddy River, attributable to habitat alteration and destruction, and the introduction of non-native aquatic species (Deacon and Bradley 1972; Cross 1976; Scoppettone et al. 1992, 1993, 1996). Following the introduction of tilapia in 1995, chub numbers in the Warm Springs area of the Muddy River declined from an estimated 8,000 to less than 2 individuals by 1997 (USGS 2004). In addition to tilapia, other non-native species are known to predate on various life stages of native fish, including bullhead catfish, sunfish (*Lepomis macrochirus*), crayfish (*Procambarus sp.*), softshell turtle (*Trionyx spiniferus*), and bullfrogs (*Rana catesbeiana*). The invasive Tamarisk (*Tamarix* sp.) tree has become the dominant riparian vegetation throughout large portions of the Muddy River, forming a dense monoculture that constrains natural flow and light regimes.

2. OBJECTIVES

The purpose of this investigation was to examine the relationship between biological and chemical characteristics of the Muddy River. Specifically, to determine if water quality is a limiting factor in fish abundance and diversity through the following:

- assessment of overall fish health and condition;
- collection of basic water chemistry;
- identification and characterization of trace metal uptake in fish;
- evaluation of contaminant risks to recovery of native fish; and
- identification and implementation of corrective measures in areas where water quality and/or fisheries are impaired.

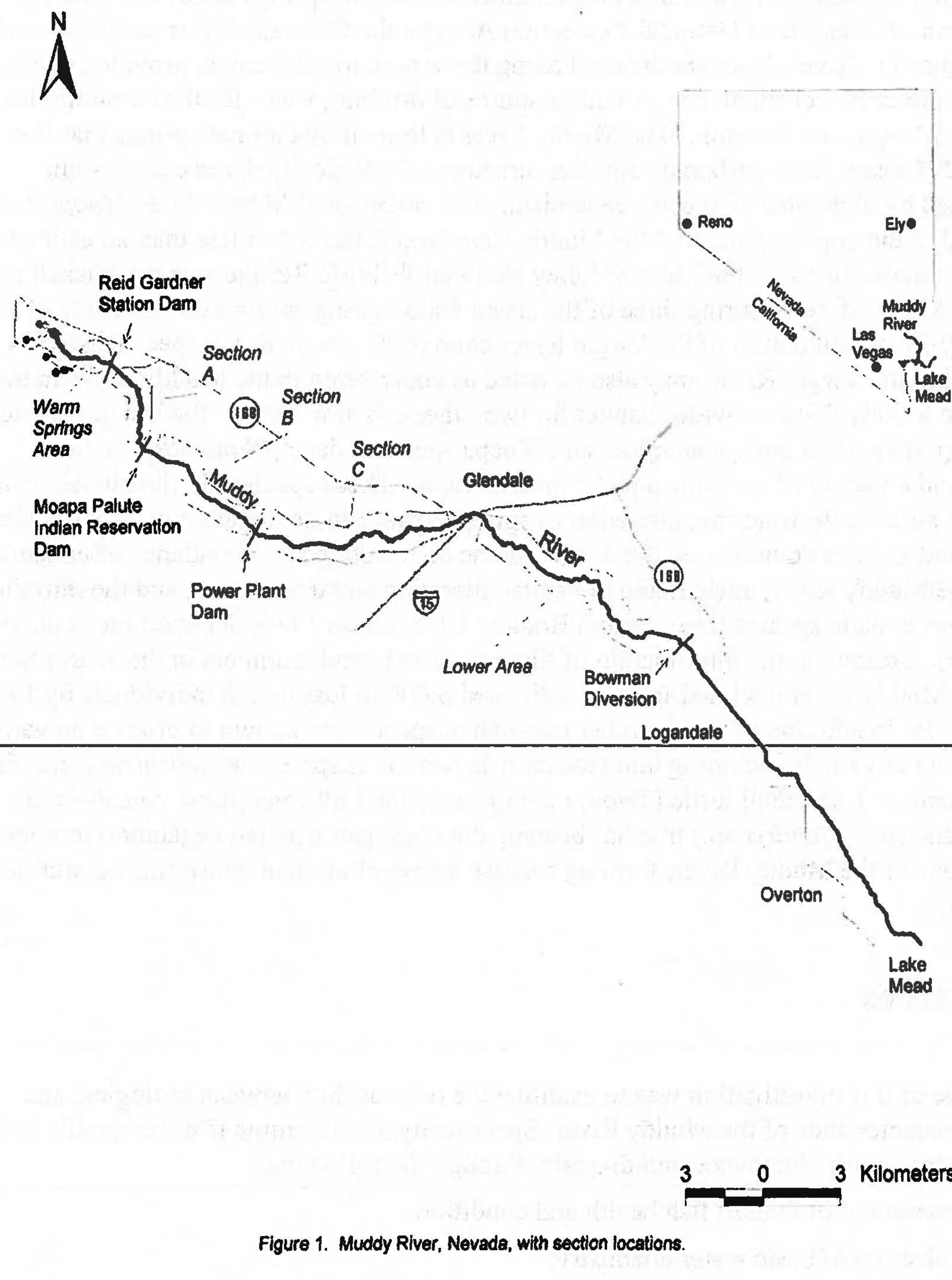

Figure 1. Muddy River, Nevada, with section locations.

3. METHODS

3.1 Fish Collections

Fish were collected in May 2002 and March 2003. Net success was lower in 2002 (Table 1) because 2003 samples (Table 2) were collected in cooperation with ongoing work by the U.S. Geological Survey (USGS) - Biological Resource Division, Western Fisheries Research Center, Reno, Nevada. Hoop nets were deployed overnight along representative reaches of the river until the desired number of samples was achieved. A minimum of five individual fish were collected for contaminant analysis and not less than 50 fish were assessed for health at each of six sites. Global positioning system (GPS) coordinates for sample sites are listed in Table 3. We attempted to collect a single species of fish throughout all sample stations to facilitate between site comparisons, but were unable to collect our target species of black bullhead catfish at the Warm Springs area, which is farthest upstream and served as our reference site. Blue tilapia (*Oreochromis aurea*) were our second species of choice and were collected throughout the system, with the exception of the Overton area. Additional non-native fish species encountered during sampling include common carp (*Cyprinus carpio*), shortfin molly (*Poecilia mexicana*), mosquitofish (*Gambusia affinis*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), red shiner (*Cyprinella lutrensis*), and fathead minnow (*Pimephales promelas*). With the exception of smaller species that numbered in the hundreds (e.g., shiner and molly), each fish was weighed, measured, and examined externally. Fish to be analyzed for contaminants were placed in an individual plastic bag on ice and frozen upon returning from the field. Basic water chemistry was measured at each site using a Hydrolab® Datasonde multiprobe instrument (Table 4). Field quality control and quality assurance measures followed Patuxent Analytical Control Facility (PACF)(1990) and American Public Health Association (1985) guidelines.

3.2 Laboratory Analytical Methods

Whole body fish samples were submitted to PACF contract labs for chemical analysis. All samples met the 10 gram minimum weight requirement. Quality control and assurance measures were approved by the PACF.

3.2.1 Organochlorines - Analyses performed by the Mississippi State Chemical Laboratory (MSCL) included percent lipid, percent moisture, and an organochlorine scan for the following 22 compounds in whole body fish: aldrin, *alpha* BHC, *alpha* chlordane, *beta* BHC, *cis*-nonachlor, *delta* BHC, dieldrin, endrin, *gamma* BHC, *gamma* chlordane, HCB (hexachlorobenzene), heptachlor epoxide, mirex, *o,p'*-DDD, *o,p'*-DDE, *o,p'*-DDT, oxychlordane, *p,p'*-DDD, *p,p'*-DDE, *p,p'*-DDT, Total PCB, toxaphene, and trans-nonachlor. See Appendix A for additional information.

3.2.2 Trace Elements - Analyses performed by Laboratory and Environmental Testing, Inc., included percent moisture and the following 19 trace elements in whole body fish: aluminum, arsenic, boron, barium, beryllium, cadmium, chromium, copper, iron, mercury, magnesium, manganese, molybdenum, nickel, lead, selenium, strontium, vanadium, and zinc. See Appendix B for additional information.

Table 1. FWS Net Success for Muddy River Sampling 2002

Site	speckled dace[1]	chub[1]	red shiner	large mouth bass	fat head minnow	molly	bluegill	carp	tilapia	mosquito fish	bb catfish
1 - Warm Springs (Reference)									23 (5)		
2 - Paiute Reservation	22	28				176			23 (3)	3	1 (1)
3 - Power Plant /Dairy	27	55				14			6 (4)	1	2 (1)
4 - Glendale	6	31				>23			2	11	5 (5)
5 - Bowman Reservoir		5						3 (2)	2 (1)		32 (4)
6 - Overton			63	1	4		84 (2)			1	7* (4)
Totals	55	119	63	1	4	>213	84	3	56	16	47

native fish species.

b is black bullhead (catfish)

ɔne of seven catfish collected at Site 6 was a young channel catfish, the rest were black bullhead.

) number of fish kept for metals analysis is shown in parentheses, all others were released.

ample sites are listed 1 - 6 from an upstream to downstream direction (i.e., farthest downstream site is Overton).

Table 2. FWS and USGS Combined Net Success for Muddy River Sampling 2003

Site	Virgin River chub[1]	speckled dace[1]	tilapia	molly	mosquitofish	bb catfish
1 - Warm Springs (Reference)	0	0	2	117	12	0
1 - Warm Springs (Reference)	0	0	0	47	2	0
1 - Warm Springs (Reference)	0	0	0	11	3	0
Perkins Ranch[2]	0	1	0	18	7	0
Perkins Ranch[2]	0	0	0	11	3	0
Perkins Ranch[2]	0	17	0	12	2	0
2 - Paiute Reservation	28	81	7 (5)	28	5	0
2 - Paiute Reservation	12	113	1	20	2	0
2 - Paiute Reservation	22	92	1	16	1	0
3 - Power Plant	13	62	0	0	0	0
3 - Power Plant	72	60	1 (1)	0	0	0
3 - Power Plant	12	27	1	0	1	1 (1)
3 - Dairy	1	22	0	1	0	3 (3)
3 - Dairy	6	21	1	0	0	4 (4)
3 - Dairy	13	1	0	0	1	1 (1)
4 - Glendale	26	0	0	0	0	5 (5)
4 - Glendale	21	0	0	0	2	1 (1)
4 - Glendale	18	0	0	0	0	4 (4)
5 - Bowman Reservoir	17	0	0	1	0	3 (3)
5 - Bowman Reservoir	15	0	0	0	0	0
5 - Bowman Reservoir	14	1	0	0	0	2 (1)
Totals	**290**	**498**	**14**	**282**	**41**	**24**

[1] native fish species

[2] Fish sampling in 2003 was conducted cooperatively with USGS using their site nomenclature, which is the same as FWS with the exception of the Perkins Ranch.

bb is black bullhead (catfish)

Red shiner and common carp were also encountered during sampling, but were not tabulated.

( ) number of fish kept for metals analysis is shown in parentheses, all others were released.

Sample sites are listed 1 - 5 from an upstream to downstream direction (i.e., farthest downstream site is Bowman Reservoir).

Table 3. GPS Coordinates for Sample Locations on Muddy River, Nevada

Site	Latitude	Longitude
1 - Warm Springs (Reference)	36 N 43 ' 33 "	-114 E 43 ' 39 "
2 - Paiute Reservation	36 N 39 ' 58 "	-114 E 39 ' 30 "
3 - Power Plant / Dairy	36 N 39 ' 13 "	-114 E 37 ' 18 "
4 - Glendale	36 N 39 ' 48 "	-114 E 34 ' 12 "
5 - Bowman Reservoir	36 N 37 ' 15 "	-114 E 29 ' 57 "
6 - Overton - Site A	36 N 35 ' 36 "	-114 E 28 ' 33 "
6 - Overton - Site B	36 N 33 ' 17 "	-114 E 26 ' 36 "

Coordinates were recorded using a Garmin emap handheld GPS unit (NAD83).
Sample sites are listed 1 - 6 from an upstream to downstream direction (i.e., farthest downstream site is Overton).

Table 4. Muddy River Water Quality Data

Date	Site	Dissolved Oxygen (mg/L)	pH (std. units)	Temperature (°Celsius)	Conductivity (microSiemens per centimeter (µS/cm)
37431	1 - Warm Springs (Reference)	5.2	7.56	31.98	1058
2-26-2003*	2 - Paiute Reservation	8.63	8.36	24.45	1105
37431	3 - Power Plant / Dairy	10.72	8.66	30.01	1121
37431	4 - Glendale	8.8	8.55	29.03	1340
37431	5 - Bowman Reservoir	8.59	8.4	25.11	1463
37431	6 - Overton Site A	4.46	7.79	24	2277
37431	6 - Overton Site B	9.04	8.1	21.96	3432

***due to difficulties in gaining access to the Moapa Reservation in 2002, water quality data for this site was taken in 2003.**

Water quality data were measured with a Hydrolab® DataSonde Multiprobe.

Sample sites are listed 1 - 6 from an upstream to downstream direction (i.e., farthest downstream site is Overton).

4. RESULTS AND DISCUSSION

4.1 Fish Health and Condition

Environmental stress can affect growth rate and general condition of fish. Fulton's condition factor (K) provides a relative measure of nutritional state or "well being" of individual fish and populations using a formula to compare a fish's length to its weight (Anderson and Gutreuter 1983). Fish total length in millimeters (mm), weight in grams (g), and K are reported for 2002 samples (Table 5) and 2003 samples (Table 6). Fish were generally found to be in good health throughout the study area. Incidence of external lesions, parasites, and physical anomalies were low. Approximately one in every nine fish exhibited some form of health problem, some of which was attributable to net stress or net induced predation (e.g., softshell turtle). Documented health issues included tumors, leeches, damaged fins (e.g., bitten, torn, missing, or eroded), fin rot, redness around the mouth or fin area, bite marks, and a single bullhead catfish with a protruding lower jar. K values were > 1.0 for all sixty fish submitted for contaminant analysis, indicating good nutritional state, with K ranging from 1.05 to 2.11 in 2002 (mean 1.57) and from 1.02 to 1.88 in 2003 (mean 1.38). No patterns were observed in K when compared between species or by sample locations.

4.2 Water Chemistry

Basic water chemistry was measured once per site using a Hydrolab® Datasonde Multiprobe instrument (Table 4). Dissolved oxygen was variable and ranged from 4.5 milligrams per liter (mg/L) to 10.7 mg/L. Some fish become stressed when dissolved oxygen drops below 5.0 mg/L and most fish cannot survive at concentrations below 3 mg/L dissolved oxygen. Temperatures decreased in a downstream direction, as would be expected with a thermal spring-fed system (range 32 - 22 °Celsius from Warm Springs to Overton, respectively). Muddy River pH ranged from neutral to slightly buffered or alkaline (range 7.6 to 8.7 standard units). Conductivity increased in a downstream direction (range 1058 - 3472 microSiemens per centimeter (μS/cm)), likely due to agriculture surface and subsurface drainage. The carbonate aquifer that provides the source water for the Muddy River is naturally high in salts and minerals, as indicated by relatively high conductivity in the Warm Springs area (1058 μS/cm). However, the lower stream segments are influenced by agriculture drainage that is contributing to increases in dissolved solids and may be limiting certain aquatic species. The Power Plant/Dairy site had the highest dissolved oxygen and pH values. We suspect that nutrient rich run-off or irrigation drain water is contributing to algal growth and increased photosynthesis in this stream segment, which may be causing diurnal fluctuations in dissolved oxygen and increased alkalinity levels. Additional water quality sampling, including 24 hour Hydrolab® profiles and nutrients in water (e.g., nitrogen, phosphorus) would be necessary to verify these initial results. Fluctuations in dissolved oxygen and conductivity data indicate that adjacent land uses are affecting water quality in the Muddy River. Levels for measured parameters would not be expected to cause direct mortality in native fish, but could influence abundance and distribution in sensitive species. See Table 4 for additional information.

4.3 Trace Elements

There are several potential sources of trace elements along the Muddy River, including natural geologic deposits, irrigation drain water, and coal combustion. Irrigation water applied to soils can leach salts and trace elements, such as selenium and arsenic, from the soil. Byproducts of coal combustion (e.g., fly ash) may contain aluminum, arsenic, boron, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, vanadium, and zinc. Most trace metals have the potential to be toxic when taken up in excess by aquatic organisms.

Concentrations for 19 trace elements analyzed in whole body fish were generally low. Table 7 lists the analytical results in parts per million wet weight (ppm ww) and Table 8 presents the same data in parts per million dry weight (ppm dw). Boron, beryllium, cadmium, molybdenum, nickel, and vanadium were less than the detection limit in more than half of the samples. Only molybdenum was not detected in any fish sample. Trace elements that were not detected in less than half the samples were assigned the value of one-half of the detection limit for statistical purposes. Between site comparisons were hampered by our inability to collect a single fish species throughout the study area. Results were compared to NCBP data (Schmitt and Brumbaugh 1990) and threshold toxicity values in published literature. The NCBP database tracked temporal and geographic trends in trace element and organochlorine concentrations in composite samples of whole fish collected at 112 riverine stations throughout the United States from 1976-1984. We used the NCBP results for comparative purposes only. The geometric mean and 85th percentile concentrations reported in the NCBP have no regulatory significance or meaning with respect to potential hazards to fishery resources (May and McKinney 1981), but serve as reference points to distinguish elevated contaminant concentrations in fish.

Concentrations of aluminum, arsenic, barium, copper, iron, magnesium, and strontium were consistently higher in tilapia compared to catfish. Lead, boron, nickel, and zinc were also generally higher in tilapia than catfish, although some catfish were elevated as well. Only mercury was higher in catfish than tilapia. Chromium, selenium, and manganese levels were variable and without distinct patterns among species or by location. Beryllium and cadmium concentrations were at or below the lower detection limit in all samples and were not considered further in our evaluation. Between species differences in trace element concentrations are most likely due to changes in food availability, diet, or natural and anthropogenic sources between locations, which in turn affects elemental transport and uptake. Therefore, differences in diet composition between our surrogate species (i.e., catfish, tilapia) and native fish species of concern (dace, springfish, and chub) in this study should be taken into consideration when interpreting results. For instance, catfish are generally considered to be omnivorous scavengers while tilapia are described as filter feeders that consume zooplankton, aquatic vegetation, and invertebrates in their native habitat (Spataru and Zorn 1978). However, tilapia in the Muddy River have adjusted their diet and compete for available food items with native fish, including predation of native fish (USGS 2004). La Rivers (1962) reports that Moapa dace feed primarily on small arthropods and vegetation, while Virgin River chub are omnivores, preferring aquatic insects and small fish.

Tilapia appear to exhibit preferential uptake of aluminum, arsenic, copper, iron, and several other metals compared to catfish. Trace elements that were elevated only in tilapia (i.e., aluminum, arsenic, barium, copper, iron, magnesium, strontium) from the Warm Springs area are believed to be of natural origin and were removed from consideration as contaminants of concern. For example, aluminum concentrations were higher in tilapia (geometric mean 722 ppm dry wt) compared to catfish (geometric mean 89 ppm dry wt). The geometric mean for copper (1.04 ppm ww) was slightly higher than the NCBP geometric means (0.65 - 0.82 ppm ww) and right at the NCBP 85th percentile (1.0 ppm ww), but again, appears only elevated in tilapia. Limited sediment sampling (n = 3) by the Service in 1994 appears to confirm natural sources for copper with values dropping from 21.2 ppm dry wt at Warm Springs, 13.3 ppm dry wt in Glendale, and 8.3 ppm dry wt at Overton. Sampling of invertebrates in 1994 also showed a drop in copper concentrations from Warms Springs to Overton (7.6 ppm dry wt. and 1.8 ppm dry wt., respectively).

Chromium concentrations were variable throughout the study area. Sixteen (8 catfish, 8 tilapia) of sixty samples exceeded Eisler's (1986) recommended threshold of 4.0 ppm dw for evidence of chromium contamination. The highest concentration was in a single catfish from the Overton area (32 ppm dw). Again, elevated levels in tilapia from the headwaters seem to indicate natural sources.

Lead concentrations (geometric mean 0.06 ppm ww) were below the NCBP geometric means of 0.11 - 0.28 ppm ww and the NCBP 85th percentile concentration of 0.22 ppm ww. Lead concentrations in whole body fish exceeding 0.5 ppm ww have the potential to harm fish reproduction and survival (Walsh *et al.* 1977). Five tilapia (range 0.3 - 0.48 ppm ww) and one catfish (0.32 ppm ww) approached this threshold. Lead data did not show a trend other than being generally higher in tilapia.

The mercury geometric mean (0.08 ppm ww) was less than the NCBP geometric means (0.10 - 0.12 ppm ww) and the NCBP 85th percentile value of 0.17 ppm ww. Whole-body concentrations associated with sublethal and lethal effects in adults are estimated at 5 ppm ww for brown trout and 10 ppm ww for rainbow trout (Wiener and Spry 1996). No fish exceeded these reported effect levels or the FDA human consumption advisory level of 1 ppm ww for commercial fish. EPA recently reduced the human health mercury fish criteria to 0.30 ppm ww (U.S. EPA, 1998) for "at risk" consumers, which includes children and expectant mothers. Only three fish in our study approached this guideline with a maximum value of 0.28 ppm ww. To our knowledge, subsistence fishing does not occur on the Muddy River. Mercury in all tilapia was at or below the lower detection limit, indicating their diet limits the uptake of mercury or a lack of mercury contamination in the Warm Springs area. Mercury levels in catfish were below national averages but certain samples were elevated near the power plant/dairy stream segment. Emissions from coal combustion are known to release mercury into the environment, however, additional sampling of environmental media would be necessary for complete source characterization. Given the relatively low concentrations overall, a follow-up investigation is not currently planned. While mercury levels do not appear to exceed wildlife toxicity thresholds, sublethal effects to the long-term health and survival of endemic fish is unknown. Mercury, a known endocrine disruptor and neurotoxin, is of particular concern due to its ability to biomagnify in the food chain.

Selenium concentrations were variable throughout the watershed. The geometric mean of 0.62 ppm ww was slightly higher than the NCBP means (0.42 - 0.48 ppm ww), but did not exceed the NCBP 85th percentile of 0.73 ppm ww. However, eleven of sixty samples were greater than or equal to the 4 ppm dw regarded as the whole body threshold for adverse effects in fish (Skorupa *et al* 1996). Selenium toxicity varies by species and little is known about the sensitivity of native fish to selenium. Selenium remains a potential contaminant of concern due to its ability to strongly bioaccumulate and documented reproductive effects in fish and wildlife.

The zinc geometric mean of 20.5 ppm ww was comparable to the NCBP means (21.4 - 23.8 ppm ww) and below the NCBP 85th percentile of 34.2 ppm ww. Zinc concentrations in fish showed no apparent trends except that levels were generally higher in tilapia compared to catfish.

4.4 Organochlorines

With the exception of the DDT metabolite *p,p'*-DDE, all 22 organochlorine compounds tested in three whole body fish were below the lower detection limit (i.e., non-detect (ND))(Table 9). Concentrations of *p,p'*-DDE in two black bullhead catfish and one common carp were 0.029 ppm ww, 0.012 ppm ww, and non-detect, respectively. These values are well below the NCBP geometric mean DDE concentration of 0.19 ppm ww (Schmitt *et al* 1990).

Although the use of DDT was banned in the United States in 1972 due to health concerns and injury to wildlife, it continues to be sold internationally as an inexpensive and effective pesticide, primarily for control of mosquito-borne malaria in third world countries. DDT is a very stable and persistent compound in the environment, with a half-life between 2 - 15 years (U.S. EPA 1989). DDT and its metabolites have been detected in wildlife throughout North America and even remote areas of Antarctica. DDE residues detected in Muddy River fish were low and are believed to be from historical use.

5. CONCLUSIONS

• The condition and health of native Muddy River fish were good, as indicated by robust K values and low incidence of physical anomalies during external examination of over 500 fish.

• Basic water chemistry measurements (pH, dissolved oxygen, temperature, and conductivity) were largely within ranges tolerated by most fish species. Fluctuations in dissolved oxygen and conductivity data indicate that adjacent land uses are affecting water quality and may influence the abundance and distribution of sensitive fish species.

• Concentrations for 19 trace elements analyzed in whole body non-native fish were generally low. Selenium values varied throughout the study area and were slightly elevated compared to NCBP averages. Eleven of sixty samples exceeded the selenium toxicity threshold of 4 ppm dw in whole body fish. Mercury values were generally lower than NCBP mean values, however, some samples were elevated in the vicinity of the coal-fired power plant. For these reasons and

due to their ability to bioaccumulate in the aquatic food chain, selenium and mercury remain potential contaminants of concern.

• Environmental contaminants do not appear to pose significant risks to native fish inhabiting the Muddy River at this time. A higher priority should be placed on addressing documented threats to recovery of native fish, such as removal of exotic species and habitat restoration.

Table 5. Muddy River Whole Body Fish Samples Submitted for Trace Element Analysis - 2002

Date	FWS Sample #	Site	Species	Weight (g)	Total Length (mm)	K
37391	MR1-14	1 - Warm Springs (Reference)	tilapia	45	134	1.87
37391	MR1-15	1 - Warm Springs (Reference)	tilapia	35.4	128	1.69
37391	MR1-16	1 - Warm Springs (Reference)	tilapia	52.8	151	1.53
37391	MR1-17	1 - Warm Springs (Reference)	tilapia	36.4	129	1.7
37391	MR1-18	1 - Warm Springs (Reference)	tilapia	45.9	145	1.51
37390	MR2A-9	2 - Paiute Reservation	tilapia	33	120	1.91
37390	MR2A-10	2 - Paiute Reservation	tilapia	52	140	1.9
37390	MR2A-11	2 - Paiute Reservation	tilapia	57.4	150	1.7
37391	MR2A-26	2 - Paiute Reservation	BB catfish	347	280	1.58
37390	MR3-16	3 - Power Plant / Dairy	BB catfish	256.4	275	1.23
37391	MR3-61	3 - Power Plant / Dairy	tilapia	172.5	211	1.84
37391	MR3-62	3 - Power Plant / Dairy	tilapia	128.6	187	1.97
37391	MR3-63	3 - Power Plant / Dairy	tilapia	92.2	170	1.88
37391	MR3-64	3 - Power Plant / Dairy	tilapia	78.1	164	1.77
37390	MR4-14	4 - Glendale	BB catfish	235.5	255	1.42
37391	MR4-38	4 - Glendale	BB catfish	151.5	228	1.28
37431	MR4-46	4 - Glendale	BB catfish	322.1	284	1.41
37431	MR4-47	4 - Glendale	BB catfish	243.2	265	1.31
37431	MR4-48	4 - Glendale	BB catfish	150	232	1.2
37388	MR5B-4	5 - Bowman Reservoir	BB catfish	145	220	1.36
37388	MR5B-6	5 - Bowman Reservoir	BB catfish	120	214	1.22
~~37388~~	~~MR5B-7~~	~~5 - Bowman Reservoir~~	~~tilapia~~	~~145~~	~~190~~	~~2.11~~
37388	MR5B-1★	5 - Bowman Reservoir	common carp	120	204	1.41
37389	MR5B-40	5 - Bowman Reservoir	BB catfish	194.3	232	1.56
37389	MR5A-41	5 - Bowman Reservoir	BB catfish	169.8	253	1.05
37390	MR6A-31	6 - Overton Site A	BB catfish	345.8	271	1.74
37390	MR6A-32★	6 - Overton Site A	BB catfish	371.3	297	1.42
37431	MR6A-36	6 - Overton Site A	BB catfish	62.1	173	1.2
37431	MR6A-39	6 - Overton Site A	BB catfish	165	241	1.18
37390	MR6A10	6 - Overton Site A	blugill	53.6	138	2.04
37389	MR6B47	6 - Overton Site B	blugill	35.1	122	1.93
	Total Samples = 31					

sample submitted for organochlorine scan in addition to trace elements analysis.

. is Fulton's condition factor. Values were calculated using the formula K = [(100,000) (W)] / L3, where W is weight in grams and L is total length in millimeters.

B = black bullhead catfish.

ample sites are listed 1 - 6 from an upstream to downstream direction (i.e., farthest downstream site is Overton).

Table 6. Muddy River Whole Body Fish Samples Submitted for Trace Element Analysis - 2003

Date	FWS Sample #	Site	Species	Weight (g)	Total Length (mm)	K
37678	03MR2-1	2 - Paiute Reservation	tilapia	53.2	155	1.43
37678	03MR2-2	2 - Paiute Reservation	tilapia	55.7	153	1.56
37678	03MR2-3	2 - Paiute Reservation	tilapia	41.2	130	1.88
37678	03MR2-4	2 - Paiute Reservation	tilapia	41.2	130	1.88
37678	03MR2-5	2 - Paiute Reservation	tilapia	32	120	1.85
37683	03MR3-1	3 - Power Plant / Dairy	tilapia	19.5	104	1.73
37683	03MR3-2	3 - Power Plant / Dairy	BB catfish	205.6	250	1.32
37684	03MR3-3	3 - Power Plant / Dairy	BB catfish	225.1	257	1.33
37684	03MR3-4	3 - Power Plant / Dairy	BB catfish	231.4	252	1.45
37684	03MR3-5	3 - Power Plant / Dairy	BB catfish	174.7*	243	1.22
37684	03MR3-6	3 - Power Plant / Dairy	BB catfish	268.8	274	1.31
37684	03MR3-7	3 - Power Plant / Dairy	BB catfish	196.3	260	1.12
37684	03MR3-8	3 - Power Plant / Dairy	BB catfish	249.6	262	1.39
37684	03MR3-9	3 - Power Plant / Dairy	BB catfish	104.2	195	1.41
37684	03MR3-10	3 - Power Plant / Dairy	BB catfish	180.6	238	1.34
37685	03MR4-1★	4 - Glendale	BB catfish	350.7	293	1.39
37685	03MR4-2	4 - Glendale	BB catfish	173.9	250	1.11
37685	03MR4-3	4 - Glendale	BB catfish	232.8	252	1.45
37685	03MR4-4	4 - Glendale	BB catfish	169.8	242	1.2
37685	03MR4-5	4 - Glendale	BB catfish	284.2	286	1.21
37685	03MR4-6	4 - Glendale	BB catfish	201.5	255	1.22
37685	03MR4-7	4 - Glendale	BB catfish	113	211	1.2
37685	03MR4-8	4 - Glendale	BB catfish	246.7	266	1.31
37685	03MR4-9	4 - Glendale	BB catfish	198.9	240	1.44
37686	03MR5-1	5 - Bowman Reservoir	BB catfish	155.8	235	1.2
37686	03MR5-2	5 - Bowman Reservoir	BB catfish	193.1	240	1.4
37686	03MR5-3	5 - Bowman Reservoir	BB catfish	90.3	207	1.02
37686	03MR5-4	5 - Bowman Reservoir	BB catfish	200.2	240	1.45
37686	03MR5-5	5 - Bowman Reservoir	BB catfish	222.4	260	1.27

Total Samples 29

catfish had underbite (lower jaw protruding) which may have hampered its forage success, resulting in lower body weight.

sample submitted for organochlorine scan in addition to trace elements analysis.

: is Fulton's condition factor. Values were calculated using the formula K = [(100,000) (W)] / L3, where W is weight in grams and L is total length in millimeters.

:B = black bullhead catfish.

ample sites are listed 1 - 5 from an upstream to downstream direction (i.e., farthest downstream site is Bowman Reservoir).

Table 7. Trace Metals in Whole Body Fish Collected from the Muddy River 2002 - 2003 (ppm wet weight)

Sample	Species	% Moist.	Al	As*	B	Ba	Be	Cd	Cr*	Cu	Fe	Hg*	Mg	Mn	Mo	Ni	Pb*	Se	Sr	V	Zn
MR1-14	Tilapia	75.3	380	1.1	1.5	4.5	0.04	ND	3	3.1	327	0.01	903	5.9	ND	1.2	0.48	0.78	92.4	0.84	35.7
MR1-15	Tilapia	79.6	215	1.2	1	3	0.02	0.02	1.6	1.1	204	0.01	705	5.2	ND	0.59	0.42	0.69	101	0.5	45
MR1-16	Tilapia	78.3	332	1.3	1.7	3.3	0.03	0.02	1.6	4.3	274	0.01	1070	5.9	ND	0.64	0.33	0.44	104	0.73	44.8
MR1-17	Tilapia	78.1	282	1.8	1	2.5	0.02	ND	0.9	2.4	229	0.01	827	5	ND	0.35	0.27	0.68	104	0.66	43.4
MR1-18	Tilapia	81.1	79.9	0.97	0.8	1.4	ND	ND	0.39	2.6	77.3	0.01	531	3.1	ND	0.1	0.2	0.76	109	0.37	37.4
MR2A-10	Tilapia	76.2	337	0.84	2.8	3.3	0.03	ND	1	2	246	0.01	877	6.4	ND	0.43	0.18	0.63	109	0.58	30.8
MR2A-11	Tilapia	82.2	165	0.68	1.5	2.5	ND	ND	0.41	4.2	127	0.01	654	3.8	ND	0.2	0.18	0.61	135	0.34	33.5
MR2A-26	BBcatfish	77	15	0.1	0.5	1.2	ND	ND	3.7	1.2	50.6	0.22	343	2.1	ND	0.4	0.025	0.41	50.2	ND	25.7
MR2A-9	tilapia	74.6	658	2.4	1.7	5.87	0.05	ND	1.8	3.4	480	0.015	1260	10.5	ND	0.78	0.32	0.78	116	1.1	43.2
MR3-16	BBcatfish	79.9	3.5	0.02	ND	0.64	ND	ND	0.2	1	23	0.17	334	2.1	ND	ND	0.13	0.37	44.2	ND	21.8
MR3-61	Tilapia	80.1	149	0.92	1.5	1.7	ND	ND	0.49	1.1	114	0.03	466	3.3	ND	0.2	0.09	0.95	76	0.32	20.7
MR3-62	Tilapia	76.1	65	0.57	0.5	0.68	ND	0.03	0.33	1.3	56.6	0.01	382	1.7	ND	ND	0.05	0.92	42.4	0.2	18.4
MR3-63	Tilapia	77.7	6.8	0.56	ND	0.44	ND	ND	0.61	1	20	0.03	314	0.95	ND	ND	0.02	0.85	44.2	ND	14.5
MR3-64	Tilapia	77.6	8.7	0.6	ND	0.43	ND	ND	0.38	1.7	19	0.03	326	1.7	ND	0.2	0.02	0.52	46.2	ND	15.8
MR4-14	BBcatfish	79.9	18	0.06	ND	0.59	ND	ND	0.2	0.54	31	0.095	327	2.6	ND	ND	0.04	0.54	33.7	ND	15.3
MR4-38	BBcatfish	80.2	11	0.16	ND	0.54	ND	ND	0.2	0.72	30	0.13	354	3.1	ND	ND	0.04	0.57	54.2	ND	23.5
MR4-46	BBcatfish	78.2	8.9	0.05	ND	0.46	ND	ND	1.2	0.72	32	0.15	299	1.6	ND	0.2	0.08	0.46	26.6	ND	15.7
MR4-47	BBcatfish	80.1	4.3	0.08	ND	0.5	ND	ND	1.3	0.86	28	0.12	306	2.6	ND	0.1	0.05	0.51	29.9	ND	17.2
MR4-48	BBcatfish	77.3	10	0.025	ND	0.29	ND	ND	0.32	0.98	27	0.06	274	2.2	ND	ND	0.025	0.5	18	ND	16
MR5A-41	BBcatfish	82.4	25	0.15	ND	0.57	ND	ND	0.51	1.2	47.2	0.11	332	1	ND	ND	0.1	0.48	31.7	0.09	16.6
MR5B-1	carp	77.2	88.9	0.22	ND	2.9	ND	ND	0.2	0.9	71.5	0.03	497	2.3	ND	ND	0.22	0.75	90.8	0.2	60.2
MR5B-4	BBcatfish	79.3	25	0.04	ND	0.48	ND	ND	0.46	0.52	32	0.11	314	2	ND	ND	0.16	0.51	34.9	ND	14.4
MR5B-40	BBcatfish	79.4	16	0.1	ND	0.38	ND	ND	0.3	0.55	28	0.04	256	1.3	ND	ND	0.02	0.71	18.8	ND	15.3
MR5B-6	BBcatfish	77.6	144	0.19	ND	1.1	ND	ND	0.46	0.72	111	0.05	377	4.1	ND	ND	0.32	0.86	26.8	0.2	17
MR5B-7	Tilapia	77.3	397	1	1	3	0.02	0.03	1.4	3.5	311	0.01	616	12.3	ND	0.5	0.3	0.96	53.9	0.74	16.5
MR6A-31	BBcatfish	81.2	16	0.1	ND	0.58	ND	ND	5.9	1	82.5	0.09	324	2.1	ND	0.82	0.06	0.37	35.9	ND	13.2
MR6A-32	BBcatfish	81.8	11	0.06	ND	0.76	ND	ND	0.045	1	16	0.093	344	2.3	ND	ND	0.02	0.21	53.1	ND	15.6
MR6A-36	BBcatfish	80.9	27	0.39	ND	0.89	ND	ND	0.2	0.64	33	0.063	357	7.1	ND	ND	0.06	0.56	62.5	0.3	20.6
MR6A-39	BBcatfish	80.9	7.6	0.1	ND	0.19	ND	ND	0.2	0.66	28	0.1	289	1.8	ND	ND	0.02	0.42	21.2	ND	15.4
MR6A10	blugill	71.6	3.6	0.1	ND	0.5	ND	ND	0.05	0.36	12	0.095	404	6.3	ND	ND	0.03	1	38.7	ND	19.1
MR6B47	blugill	73.6	34	0.35	ND	1.3	ND	ND	0.2	0.49	31	0.09	424	35.2	ND	ND	0.025	0.91	67.8	0.1	24.1
03MR2-1	Tilapia	82	372	0.76	1.6	2.8	0.03	ND	0.87	4.7	250	0.01	819	7.3	ND	0.38	0.2	0.66	129	0.69	29.8
03MR2-2	Tilapia	77.8	161	0.71	1.5	1.8	ND	ND	0.48	0.68	120	0.01	527	3.9	ND	0.2	0.13	0.65	84	0.5	31.5
03MR2-3	Tilapia	79.5	256	0.47	1.7	2.4	0.03	ND	0.71	4.4	186	0.01	713	6	ND	0.2	0.19	0.84	92.7	0.48	30.8
03MR2-4	Tilapia	78.4	262	0.45	2.6	2.4	0.02	ND	0.65	3.4	185	0.02	770	6.2	ND	0.3	0.19	0.75	102	0.51	32.1
03MR2-5	Tilapia	79	231	0.86	1	2.8	0.02	ND	1.8	0.72	208	0.01	847	5.1	ND	0.4	0.14	0.61	124	0.51	36.4
03MR3-1	Tilapia	76.7	97.5	1.2	1	2.2	ND	ND	0.39	1.2	82.2	0.01	544	3.1	ND	0.2	0.07	0.7	105	0.2	30
03MR3-10	BBcatfish	81.9	24	0.15	ND	0.4	ND	ND	0.38	0.62	38	0.04	257	1.3	ND	ND	0.04	0.54	13.4	ND	15.6
03MR3-2	BBcatfish	81.8	7.7	0.1	ND	0.36	ND	ND	0.35	0.64	27	0.09	267	0.95	ND	ND	0.02	0.83	21.2	ND	13.4
03MR3-3	BBcatfish	81.4	7.9	0.02	ND	0.32	ND	ND	0.1	0.52	17	0.11	257	0.89	ND	ND	0.02	0.6	16.9	ND	13.1
03MR3-4	BBcatfish	81.5	13	0.06	ND	0.48	ND	ND	0.3	0.84	25	0.1	276	2.4	ND	ND	0.02	0.62	23.7	ND	15.6
03MR3-5	BBcatfish	82.4	21	0.1	ND	0.49	ND	ND	0.31	0.56	33	0.065	269	1.3	ND	ND	0.02	0.52	21	ND	17.2
03MR3-6	BBcatfish	78.9	18	0.08	0.8	0.77	ND	ND	3	0.98	50.6	0.1	357	2.4	ND	0.1	0.02	0.58	41.6	ND	20.1
03MR3-7	BBcatfish	82.9	17	0.08	ND	0.94	ND	ND	0.3	0.89	44.5	0.19	278	1.4	ND	ND	0.04	0.44	25	0.09	14.5
03MR3-8	BBcatfish	77.8	11	0.05	ND	0.92	ND	ND	5.4	0.69	59.4	0.072	376	3.2	ND	0.2	0.05	0.58	60.7	0.1	19.5
03MR3-9	BBcatfish	80.3	27	0.16	ND	0.43	ND	ND	0.37	0.65	42.7	0.05	279	1.4	ND	ND	0.02	0.9	14.2	ND	16.6
03MR4-1	BBcatfish	80.9	19	0.05	0.6	1.1	ND	ND	0.05	0.84	31	0.28	374	2.1	ND	ND	0.06	0.39	59.5	ND	21.9
03MR4-2	BBcatfish	84.8	25	0.06	0.4	1.1	ND	ND	0.38	1.2	33	0.21	310	2.7	ND	ND	0.04	0.34	41.6	0.1	15.4
03MR4-3	BBcatfish	81.4	30	0.24	0.4	0.86	ND	0.02	0.35	1	41	0.096	307	2.5	ND	ND	0.04	0.75	30.8	0.09	18.3
03MR4-4	BBcatfish	83.2	46	0.099	ND	0.58	ND	ND	0.38	0.7	50.7	0.066	276	2.2	ND	ND	0.19	0.46	13.1	0.1	13.3
03MR4-5	BBcatfish	78.2	6.6	0.02	ND	0.36	ND	ND	2.1	0.66	33	0.18	337	2.2	ND	ND	0.02	0.57	42.3	ND	18.3
03MR4-6	BBcatfish	81.3	30	0.13	ND	0.54	ND	ND	0.5	0.65	42.4	0.087	297	1.8	ND	ND	0.04	0.93	20.5	0.1	14.7
03MR4-7	BBcatfish	80.7	32	0.17	ND	0.39	ND	ND	0.37	0.74	41.2	0.05	253	1.6	ND	ND	0.02	0.9	11.6	ND	13.1
03MR4-8	BBcatfish	81.8	27	0.29	ND	0.69	ND	ND	0.3	0.75	35	0.06	293	1.6	ND	ND	0.02	0.9	21.2	ND	14.2
03MR4-9	BBcatfish	81.3	38	0.29	ND	0.53	ND	ND	0.54	0.74	45.5	0.067	296	2.1	ND	ND	0.04	1.2	17.9	0.1	15.3
03MR5-1	BBcatfish	80.6	26	0.1	0.6	1.1	ND	ND	0.3	0.81	34	0.073	290	1.8	ND	ND	0.02	0.75	25.1	ND	16.9
03MR5-2	BBcatfish	81.9	10	0.07	ND	0.52	ND	ND	0.2	0.9	25	0.1	271	1.5	ND	ND	0.02	0.53	21.1	ND	15.1
03MR5-3	BBcatfish	79.2	25	0.05	0.5	1.1	ND	ND	0.41	0.76	36	0.092	451	4.7	ND	ND	0.14	0.56	70.5	0.1	23.3
03MR5-4	BBcatfish	80.5	20	0.09	ND	0.77	ND	ND	0.1	0.97	29	0.12	283	1.4	ND	ND	0.02	0.72	24.5	ND	13.9
03MR5-5	BBcatfish	80.5	27	0.07	ND	0.56	ND	ND	0.32	0.91	38	0.14	300	1.9	ND	ND	0.05	0.72	27.2	ND	19.1
GeoMean			35.14	0.19		0.91			0.47	1.04	54.43	0.05	396.36	2.74			0.06	0.62	42.24		20.5
SE			134.1	0.48		1.16			1.17	1.11	95.73	0.06	226.91	4.73			0.11	0.2	35.24		10.22
Detection limit			.5 - .9	.03 - .06	.3 - .6	.03 - .06	.02 - .03	.02 - .03	.09 - .1	.05 - .09	.3 - .6	.02 - .03	.3 - .6	.08 - .1	.3 - .6	.09 - .1	.03 - .06	.03 - .06	.03 - .06	.08 - .01	.09 - .1

ote: Geometric mean and standard deviation (SE) have been rounded to two decimal places and were not calculated for analytes where greater than or equal to one-half of the sample values were non-detect (ND).
less than one-half of the arsenic data (4 datum), chromium (3 datum), mercury (15 datum), lead (21 datum) were below the detection limit, therefore geometric mean and standard deviation were calculated using one-half of the detection limit.

Table 8. Trace Metals in Whole Body Fish Collected from the Muddy River 2002 - 2003 (ppm dry weight)

Sample	Fish species	% Moist.	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg*	Mg	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
MR1-14	Tilapia	75.3	1540	4.3	6.1	18	0.2	ND	12	12	1330	0.05	3660	24	ND	4.9	1.9	3.2	374	3.4	145
MR1-15	Tilapia	79.6	1050	6	5	15	0.1	0.1	7.8	5.4	999	0.05	3450	25	ND	2.9	2.1	3.4	493	2.5	220
MR1-16	Tilapia	78.3	1530	6.1	7.8	15	0.1	0.1	7.6	20	1260	0.05	4900	27	ND	2.9	1.5	2	478	3.4	206
MR1-17	Tilapia	78.1	1290	8.2	4	11	0.1	ND	4.1	11	1050	0.05	3770	23	ND	1.6	1.2	3.1	474	3	198
MR1-18	Tilapia	81.1	422	5.1	4	7.6	ND	ND	2.1	14	409	0.05	2810	16	ND	0.7	1.1	4	577	2	198
MR2A-10	Tilapia	76.2	1420	3.5	12	14	0.1	ND	4.2	8.2	1030	0.05	3690	27	ND	1.8	0.77	2.7	458	2.4	129
MR2A-11	Tilapia	82.2	930	3.8	8.5	14	ND	ND	2.3	24	714	0.05	3680	22	ND	1	1	3.4	759	1.9	188
MR2A-26	BBcatfish	77	66	0.5	2	5.4	ND	ND	16	5	220	0.94	1490	9.2	ND	1.7	0.2	1.8	218	ND	112
MR2A-9	tilapia	74.6	2590	9.3	6.7	23.1	0.2	ND	7	13	1890	0.05	4950	41	ND	3.1	1.3	3.1	458	4.4	170
MR3-16	BBcatfish	79.9	18	0.2	ND	3.2	ND	ND	1	5.1	110	0.85	1660	10	ND	ND	0.63	1.9	220	ND	109
MR3-61	Tilapia	80.1	750	4.6	7.3	8.4	ND	ND	2.5	5.7	571	0.1	2340	17	ND	0.9	0.5	4.8	382	1.6	104
MR3-62	Tilapia	76.1	270	2.4	2	2.8	ND	0.1	1	5.5	235	0.05	1590	7	ND	ND	0.2	3.8	176	0.7	76.3
MR3-63	Tilapia	77.7	31	2.5	ND	2	ND	ND	2.7	4.5	90	0.1	1410	4.3	ND	ND	0.2	3.8	198	ND	65.3
MR3-64	Tilapia	77.6	39	2.7	ND	1.9	ND	ND	1.7	7.8	83	0.1	1460	7.8	ND	1	0.2	2.3	207	ND	70.7
MR4-14	BBcatfish	79.9	91	0.3	ND	2.9	ND	ND	1	2.7	160	0.47	1630	13	ND	ND	0.2	2.7	168	ND	76.4
MR4-38	BBcatfish	80.2	57	0.83	ND	2.7	ND	ND	0.8	3.6	150	0.64	1780	16	ND	ND	0.2	2.9	273	ND	118
MR4-46	BBcatfish	78.2	41	0.2	ND	2.1	ND	ND	5.5	3.3	150	0.69	1370	7.5	ND	0.8	0.4	2.1	122	ND	71.7
MR4-47	BBcatfish	80.1	22	0.4	ND	2.5	ND	ND	6.4	4.3	140	0.6	1540	13	ND	0.7	0.2	2.6	150	ND	86.5
MR4-48	BBcatfish	77.3	44	0.2	ND	1.3	ND	ND	1	4.3	120	0.3	1200	9.5	ND	ND	0.2	2.2	79.3	ND	70.5
MR5A-41	BBcatfish	82.4	140	0.83	ND	3.2	ND	ND	2.9	6.8	269	0.65	1880	5.7	ND	ND	0.63	2.7	180	0.5	94.6
MR5B-1	carp	77.2	390	0.95	ND	13	ND	ND	0.7	3.9	313	0.1	2180	10	ND	ND	0.95	3.3	398	0.7	264
MR5B-4	BBcatfish	79.3	120	0.2	ND	2.3	ND	ND	2.2	2.5	160	0.55	1520	9.6	ND	ND	0.79	2.5	169	ND	69.5
MR5B-40	BBcatfish	79.4	78	0.5	ND	1.9	ND	ND	1	2.7	130	0.2	1240	6.3	ND	ND	0.2	3.5	91.5	ND	74.4
MR5B-6	BBcatfish	77.6	642	0.86	ND	4.9	ND	ND	2.1	3.2	493	0.2	1680	18	ND	ND	1.4	3.8	119	1	75.6
MR5B-7	Tilapia	77.3	1740	4.4	5	13	0.1	0.1	6.1	15	1360	0.05	2700	53.7	ND	2.2	1.3	4.2	236	3.2	72.3
MR6A-31	BBcatfish	81.2	84	0.5	ND	3.1	ND	ND	32	5.5	440	0.48	1730	11	ND	4.4	0.3	2	191	ND	70.6
MR6A-32	BBcatfish	81.8	60	0.3	ND	4.2	ND	ND	0.5	5.6	87	0.51	1890	13	ND	ND	0.2	1.1	292	ND	85.5
MR6A-36	BBcatfish	80.9	140	2	ND	4.7	ND	ND	1	3.4	170	0.33	1860	37	ND	ND	0.3	2.9	327	1	108
MR6A-39	BBcatfish	80.9	40	0.5	ND	1	ND	ND	1	3.4	150	0.55	1510	9.2	ND	ND	0.2	2.2	111	ND	80.2
MR6A10	blugill	71.6	13	0.4	ND	1.8	ND	ND	0.5	1.3	44	0.33	1420	22	ND	ND	0.2	3.6	136	ND	67
MR6B47	blugill	73.6	130	1.3	ND	4.9	ND	ND	0.7	1.9	120	0.34	1610	134	ND	ND	0.2	3.4	257	0.5	91.3
03MR2-1	Tilapia	82	2070	4.2	8.6	15	0.2	ND	4.9	26	1390	0.05	4550	40	ND	2.1	1.1	3.7	717	3.8	165
03MR2-2	Tilapia	77.8	726	3.2	6.6	8	ND	ND	2.2	3.1	542	0.05	2380	18	ND	1	0.6	2.9	379	2.2	142
03MR2-3	Tilapia	79.5	1250	2.3	8	12	0.1	ND	3.5	22	908	0.05	3470	29	ND	1	0.91	4.1	452	2.3	150
03MR2-4	Tilapia	78.4	1210	2.1	12	11	0.1	ND	3	16	857	0.1	3570	29	ND	1	0.86	3.5	474	2.4	149
03MR2-5	Tilapia	79	1100	4.1	6	14	0.1	ND	8.7	3.4	994	0.05	4040	25	ND	1.9	0.64	2.9	591	2.4	174
03MR3-1	Tilapia	76.7	419	5	5	9.6	ND	ND	1.7	5.2	353	0.05	2340	13	ND	0.7	0.3	3	454	1	129
03MR3-10	BBcatfish	81.9	130	0.82	ND	2.2	ND	ND	2.1	3.4	208	0.2	1420	7	ND	ND	0.2	3	74.1	ND	86.3
03MR3-2	BBcatfish	81.8	42	0.6	ND	2	ND	ND	1.9	3.5	150	0.49	1470	5.2	ND	ND	0.2	4.6	117	ND	73.5
03MR3-3	BBcatfish	81.4	42	0.2	ND	1.7	ND	ND	0.8	2.8	92	0.58	1380	4.8	ND	ND	0.2	3.2	90.7	ND	70.5
03MR3-4	BBcatfish	81.5	69	0.3	ND	2.6	ND	ND	1	4.6	140	0.55	1490	13	ND	ND	0.2	3.4	128	ND	84.6
03MR3-5	BBcatfish	82.4	120	0.6	ND	2.8	ND	ND	1.7	3.2	190	0.37	1530	7.6	ND	ND	0.2	2.9	120	ND	98
03MR3-6	BBcatfish	78.9	83	0.4	4	3.6	ND	ND	14	4.7	239	0.49	1690	11	ND	0.6	0.2	2.7	197	ND	95.1
03MR3-7	BBcatfish	82.9	100	0.5	ND	5.5	ND	ND	1.5	5.2	260	1.1	1620	8.1	ND	ND	0.2	2.6	146	0.5	84.7
03MR3-8	BBcatfish	77.8	49	0.2	ND	4.1	ND	ND	24	3.1	266	0.32	1690	15	ND	0.7	0.2	2.6	272	0.6	87.4
03MR3-9	BBcatfish	80.3	140	0.81	ND	2.2	ND	ND	1.9	3.3	217	0.3	1420	7.1	ND	ND	0.2	4.6	71.9	ND	84.1
03MR4-1	BBcatfish	80.9	98	0.2	3	5.6	ND	ND	0.5	4.4	160	1.5	1960	11	ND	ND	0.3	2.1	311	ND	115
03MR4-2	BBcatfish	84.8	160	0.4	3	7	ND	ND	2.5	7.7	217	1.4	2040	18	ND	ND	0.3	2.3	274	0.6	101
03MR4-3	BBcatfish	81.4	160	1.3	2	4.6	ND	0.1	1.9	5.6	221	0.52	1650	14	ND	ND	0.2	4.1	166	0.5	98.4
03MR4-4	BBcatfish	83.2	270	0.6	ND	3.5	ND	ND	2.2	4.2	301	0.39	1640	13	ND	ND	1.1	2.7	77.9	0.6	79.3
03MR4-5	BBcatfish	78.2	30	0.2	ND	1.6	ND	ND	9.7	3	150	0.84	1540	10	ND	ND	0.2	2.6	194	ND	84
03MR4-6	BBcatfish	81.3	160	0.69	ND	2.9	ND	ND	2.7	3.5	227	0.46	1590	9.8	ND	ND	0.2	5	109	0.5	78.8
03MR4-7	BBcatfish	80.7	160	0.86	ND	2	ND	ND	1.9	3.9	213	0.3	1310	8.1	ND	ND	0.2	4.7	59.9	ND	68
03MR4-8	BBcatfish	81.8	150	1.6	ND	3.8	ND	ND	1	4.1	190	0.32	1610	9.1	ND	ND	0.2	4.9	117	ND	78.3
03MR4-9	BBcatfish	81.3	210	1.5	ND	2.9	ND	ND	2.9	3.9	244	0.36	1590	11	ND	ND	0.2	6.2	95.6	0.7	81.6
03MR5-1	BBcatfish	80.6	130	0.5	3	5.5	ND	ND	1.5	4.2	170	0.38	1490	9.4	ND	ND	0.2	3.9	129	ND	86.9
03MR5-2	BBcatfish	81.9	56	0.4	ND	2.9	ND	ND	0.9	5	140	0.57	1500	8.4	ND	ND	0.2	2.9	117	ND	83.5
03MR5-3	BBcatfish	79.2	120	0.3	2	5.3	ND	ND	2	3.6	180	0.44	2160	23	ND	ND	0.66	2.7	338	0.6	112
03MR5-4	BBcatfish	80.5	100	0.5	ND	3.9	ND	ND	0.7	5	150	0.59	1450	7.3	ND	ND	0.2	3.7	126	ND	71.4
03MR5-5	BBcatfish	80.5	140	0.3	ND	2.9	ND	ND	1.6	4.7	190	0.73	1530	9.6	ND	ND	0.3	3.7	139	ND	97.8
GeoMean			172.7	0.96		4.47			2.34	5.12	267.87	0.24	1947.66	13.47			0.37	3.07	207.66		100.8
SE			590.3	2.11		5.02			5.62	5.47	414.45	0.33	973.33	18.3			0.47	0.93	168.93		44.95
Detection limit			3	0.2	2	0.2	0.1	0.1	0.5	0.3	2	0.1	2	0.5	2	0.5	0.2	0.2	0.2	0.5	0.5

Note: Geometric mean and standard deviation (SE) are rounded to two decimal places and were not calculated for analytes where greater than or equal to one-half of the sample values were non-detect (ND).
* less than one-half the mercury data were below the detection limit. Therefore geometric mean and standard deviation were calculated using one-half of the detection limit (i.e., 0.05)

Table 9. Organochlorines in Three Whole Body Fish from the Muddy River 2002 - 2003

Analyte	Parts per million wet weight				Parts per million dry weight			
	Detection Limit	03MR4-1 BBcatfish	MR5B-1 Ccarp	MR6A-32 BBcatfish	Detection Limit	03MR4-1 BBcatfish	MR5B-1 Ccarp	MR6A-32 BBcatfish
% moisture		81.6	78.1	81.7		81.6	78.1	81.7
% lipid		0.896	0.974	0.573		0.896	0.974	0.573
HCB	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
alpha BHC	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
alpha chlordane	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
gamma chlordane	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
oxychlordane	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
cis-nonachlor	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
trans-nonachlor	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
heptachlor epoxide	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
beta BHC	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
delta BHC	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
gamma BHC	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
dieldrin	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
endrin	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
toxaphene	0.05	ND	ND	ND	.228-.273	ND	ND	ND
mirex	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
o,p'-DDD	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
o,p'-DDE	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
o,p'-DDT	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
p,p'-DDD	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
p,p'-DDE	0.002	0.029	ND	0.012	.009 - .01	0.158	ND	0.0656
p,p'-DDT	0.002	ND	ND	ND	.009 - .01	ND	ND	ND
PCB - total	0.01	ND	ND	ND	.04 - .05	ND	ND	ND

ND is non-detect, indicating samples were below the lower detection limit
BB is black bullhead catfish. Ccarp is common (asian) carp.

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APPENDIX A

ORGANOCHLORINES

Analytical Laboratory
Mississippi State Chemical Laboratory (MSCL)
Mississippi State, MS

An electronic version of the MSCL report, including raw data, analytical methods, and quality control / quality assurance, is available from the U.S. Fish and Wildlife Service Southern Nevada Field Office upon request.

APPENDIX B

TRACE ELEMENTS

Analytical Laboratory
Laboratory and Environmental Testing, Inc. (LET)
Columbia, MO

An electronic version of the LET report, including raw data, analytical methods, and quality control / quality assurance, is available from the U.S. Fish and Wildlife Service Southern Nevada Field Office upon request.