USING EXISTING DATA FROM THE MIDDLE RIO GRANDE TO SCREEN WATER QUALITY RISKS TO RIO GRANDE SILVERY MINNOW

ISC Contract PSA-550-P552-0013

MRGESACP Contract 04-FG-40-2264

VOLUME 1 – FINAL REPORT

A Report Prepared by

Tetra Tech EM Inc.

Michael D. Marcus [1, 2], Sean Covington [3], and Natalie Smith [1]

[1] Tetra Tech EM Inc.
6121 Indian School Road NE
Albuquerque, New Mexico 87110
(505) 881-3188x116
[2] mike.marcus@ttemi.com

[3] NewFields LLC
117 Riverview Road
Liberty Hill, Texas 78642
(512) 778-9119

Report Prepared for

New Mexico Interstate Stream Commission

Nic Medley and Elizabeth W. Zeiler

New Mexico Interstate Stream Commission
Bataan Memorial Building, Room 101
Don Gaspar Avenue
Post Office Box 25102
Santa Fe, New Mexico 87504-5102
(505) 827-5811

19 December 2005

ACKNOWLEDGEMENTS

The New Mexico Interstate Stream Commission (NMISC) and Tetra Tech EM Inc. submitted a proposal to the Middle Rio Grande Endangered Species Act Collaborative Program (Program). The Science Subcommittee, with support of the Program, accepted the proposal and the contract was subsequently awarded under Grant Agreement No. 04-FG-40-2264 on September 2004 by the U.S. Bureau of Reclamation (Reclamation) as part of the Program.

We thank the NMISC staff for their comment review that has helped improve this report: Elizabeth Zeiler, Nic Medley, Beiling Liu, Peter Wilkinson, and Rolf Schmidt-Peterson. We also thank the Program for sponsoring this project; the U.S. Fish and Wildlife Service (USFWS), NMISC, and Reclamation for sharing the study results from the USFWS 2002-2003 sampling study on the Middle Rio Grande (MRG) of New Mexico; and Reclamation, NMISC, and the U.S. Army Corps of Engineers for sharing the historical MRG water quality dataset compiled through the Upper Rio Grande Water Operations Environmental Impact Statement Project.

It has been hypothesized that water quality impairments have posed adverse impacts to the Rio Grande silvery minnow (RGSM) population. This project used extensive and diverse existing water quality datasets available for the MRG to, for the first time, examine the data in their entirety. It is our hope that the ecological risk screening presented in the following report will provide guidance to future Program objectives and activities aimed at the recovery of the RGSM. This project would not have occurred without the foresight and commitment of the Program.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

Section **Page**

LIST OF FIGURES

Figure **Page**

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF APPENDIX TABLES

LIST OF APPENDIX TABLES (CONTINUED)

Table **Appendix A**

Table **Appendix B**

ACRONYMS AND ABBREVIATIONS

ACQUIRE	AQUatic Toxicity Information REtrieval
ACR	acute to chronic ratio
AMV	acute maximum value
AERA	aquatic ecological risk assessment
AET	apparent effects threshold
ASV	acute screening value
AWQC	ambient water quality criteria
AWWTP	Albuquerque Southside Water Reclamation Plant
$BaSO_4$	barium sulfate
BHC	benzene hexachloride
BOD	biological oxygen demand
CCC	criterion continuous concentration (chronic effects)
CCME	Canadian Council of Ministers of the Environment
CMC	criterion maximum concentration (acute effects)
COPC	contaminants of potential concern
COPEC	chemicals of potential ecological concern
CSV	chronic screening value
DCPA	Dimethyl 2,3,5,6-Tetrachloroterephthalate
DEQ	Department of Environmental Quality
DO	dissolved oxygen
EIS	Environmental Impact Statement
EPC	exposure point concentrations
ERED	Environmental Residue Effects Database
ER-L	effects range–low
ER-M	effects range-median
ESB	Ecotoxicological Screening Benchmarks
FCV	final chronic value
FDEP	Florida Department of Environmental Protection
FHM	Fathead minnow
GLWQI	Great Lakes Water Quality Initiative
HAZMAT	hazardous materials
HCN	hydrogen cyanide
HQ	hazard quotient
LER	lowest effect residue
MDL	method detection limit

ACRONYMS AND ABBREVIATIONS (CONTINUED)

MEK	methyl ethyl ketone or 2-butanone
MENVIQ/EC	Ministere de l'Environnement du Quebec et Environnement Canada
MRG	Middle Rio Grande
N	nitrogen
NA	not available
ND	not detected
NEC	no effects concentration
NER	no effects residue
NH_3	ammonia
NMED	New Mexico Environment Department
NMISC	New Mexico Interstate Stream Commission
NOAA	National Oceanic and Atmospheric Administration
NOEC	no-observed effects concentration
NOEL	no-observed effects level
NYCRR	New York Code of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
ORNL	Oak Ridge National Laboratory
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbons
PBT	persistent bioaccumulative and toxic
PCB	polychlorinated biphenyl
PEC	probable effect concentration
PEC-Q	PEC quotients
PhAC	pharmaceuticals
Program	Middle Rio Grande Endangered Species Act Collaborative Program
QA/QC	quality assurance/quality control
Reclamation	U.S. Bureau of Reclamation
RGSM	Rio Grande Silvery Minnow
RPA	reasonable and prudent alternative
RRWWTP	Rio Rancho Wastewater Treatment Plant
SAV	secondary acute value
SCV	secondary chronic value
SETAC	Society of Environmental Toxicology and Chemistry
SMAV	species-mean acute value
SQG	sediment quality guidelines
SSc	Science Subcommittee
TEC	threshold effect concentration

ACRONYMS AND ABBREVIATIONS (CONTINUED)

TMDL	total maximum daily load
TRV	toxicity reference value
UET	upper effects threshold
URGWOPS	Upper Rio Grande Water Operations
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOCs	Volatile organic compounds
WAD	weak-acid dissociable
WHO	World Health Organization
WWTP	wastewater treatment plant

USING EXISTING DATA FROM THE MIDDLE RIO GRANDE TO SCREEN WATER QUALITY RISKS TO RIO GRANDE SILVERY MINNOW

ISC Contract PSA-550-P552-0013

MRGESACP Contract 04-FG-40-2264

EXECUTIVE SUMMARY

The U.S. Fish and Wildlife Service (USFWS) listing of Rio Grande silvery minnows (RGSMs, *Hybognathus amarus*) as an endangered species cited adverse water quality as a likely contributor to their population declines in the Middle Rio Grande (MRG) (USFWS 1994). Claims continue to be made that degraded water quality adversely impacts the population numbers of RGSMs and their recovery potentials. In contrast, a 1999 analysis by the New Mexico Environment Department (NMED 2001) of the water quality in the MRG between the Pueblos of Santa Ana and Isleta found no evidence that adverse water quality was impairing aquatic life. Commonly cited evidence of water quality directly impacting fish in the MRG is limited to a few examples in localized, limited segments of the MRG. At present, direct cause-effect linkages are lacking and indirect and hypothetical relationships predominate relative to the claim that poor chemical or physical water quality has contributed to the decline of the RGSM population in the MRG.

Due to remaining uncertainties, there is a need for additional assessment of how water quality conditions may be adversely affecting the survival, recruitment, health, population size, and recovery potential of RGSMs in the MRG. Toward addressing this need, two datasets of existing sampling and assessment data from the MRG were compiled and assessed in this project following the ecological risk assessment guidance established by the U.S. Environmental Protection Agency (USEPA 1992a, 1998). First, the most recent dataset assessed was collected by the USFWS in 2002 to 2003; this study was supported by the MRG Endangered Species Act Collaborative Program (Program) and the New Mexico Interstate Stream Commission (NMISC). The second and older dataset assessed, which included the period from 1985 to 2000, was originally compiled through the Upper Rio Grande Water Operations (URGWOPS) Environmental Impact Statement (EIS) project and this dataset was made available by the U.S. Bureau of Reclamation (Reclamation), the U.S. Army Corps of Engineers (USACE), and the NMISC.

Data quality assessment found essentially the entire USFWS dataset appropriate for use in this risk assessment. The data quality assessment identified various issues with the URGWOPS data, but judged the dataset appropriate for use in ecological risk screening conducted by this project. Overall, however, the USFWS data were deemed to include more recent data of higher and more consistent

quality. As such, management decisions for the MRG based on results from this ecological risk assessment should place greater weight on findings from the USFWS dataset, while viewing the assessment of the URGWOPS data as having important secondary supportive value for planning.

For this ecological risk assessment, water quality criteria values established under state and tribal authorities for the MRG and updated aquatic life criteria from the USEPA were compiled with additional risk assessment benchmarks for water, sediment and tissue concentrations for chemicals not included in the water quality criteria. This compilation produced a comprehensive set of aquatic ecological risk screening benchmarks. Chemicals were identified as constituents of potential concern (COPCs) whenever their concentrations in water, sediment, or fish tissue samples from the MRG exceeded their associated ecological risk screening benchmarks.

Also, the toxicity profile for RGSMs was compiled, which was largely based on the use of fathead minnows (FHMs) as their toxic-response surrogate. This compiled profile allowed this assessment to focus more directly on potential effects of MRG water quality to RGSMs. To date, comparative toxicity studies indicated that in general, FHMs are an appropriate surrogate for RGSMs in terms of sensitivities to toxicants (Buhl 2002; Lusk 2005). Buhl (2002) reported that mixtures of some chemical toxicants at concentrations similar to levels reported for the Rio Grande produced greater than additive effects when compared with results that were obtained for those constituents individually, so that the single concentration criterion included in state and tribal criteria for the MRG may be inadequate for projecting potential water quality effects on RGSMs. Even under these circumstances, FHMs appear to be a reasonable surrogate species for RGSMs in evaluating potential toxicity relationships based on these comparative results (Buhl 2002, 2003).

The risk screening benchmarks were used to assess water quality results for surface water, sediment, and fish tissue contained in the USFWS and URGWOPS datasets. The 2002-2003 USFWS water quality study includes 15,600 analytical records for 189 analytes in samples collected from 14 sites; each location was sampled during two or four individual sampling events (USFWS 2004). The URGWOPS dataset holds over 250,000 chemical and physical measurement records for 414 parameters collected between 1947 and 2000 during more than 38,400 individual sampling events. For this water quality risk assessment project, the URGWOPS dataset was trimmed to include only data collected between 1985 and, in most cases, 2000 from the main channel of the Rio Grande between the confluence with the Rio Chama and a sampling location upstream of Elephant Butte Reservoir.

Spatial and temporal relationships derived from these data are evaluated and reported. Tier I and Tier II screening risk assessments were performed to evaluate water quality risks. A primary conclusion from this risk assessment is that there is no clear “smoking gun” COPC that can be singled out as an agent likely to have produced significant MRG-wide historical impacts to RGSMs. Nor can any COPC be targeted as currently impairing the recovery of RGSMs along the length of the MRG. The sample analysis results indicate various isolated episodes during which elevated concentrations of one or more COPCs could have caused localized impacts to aquatic life and RGSM. These episodes may be related to natural conditions, stormwater runoff or other inflow events, upsets in the operation of wastewater treatment systems, or, perhaps, illegal discharges. Although some data appear to be of poor reliability (particularly in the URGWOPS dataset), no discernible temporal or spatial patterns were detected within the datasets, including any elevated concentration persisting at any one site.

Considering the three environmental media assessed, the exposure pathways, and the extended collection period for the water quality data, this lack of a clear "big ticket" COPC was not expected. In addition, native populations of FHMs in the MRG — the species commonly accepted as the toxicity surrogate for RGSMs and used in this report as such — have not displayed a similar decline accompanying the decline as the RGSM populations and, instead, have persisted as one of the most abundant species along the MRG (Reclamation 2003). Therefore, this assessment would not support the hypothesis that water quality effects have been the most important limiting factor affecting this fish, even though potentially limiting water quality conditions may have locally impacted RGSMs in the MRG at some times in the past.

This risk assessment supports the hypothesis that a collection of chemicals in the river's water, sediment, and biotic media may pose a risk due to cumulative impacts. This relationship appears strongest in the earlier data and appears to continue into the present, although to a markedly lesser extent. This relationship is exemplified in the results for trace elements. Even considering the various uncertainties (measurement frequencies, data quality, and applicability of TRVs used as risk benchmarks) and the findings that concentrations for most metals in most samples are less than the risk screening threshold values, this analysis suggests that a large number of chemicals in the river's water, sediment, and biotic media cumulatively may be problematic. Determining whether the remaining sources of these conditions are man-caused, natural, or more likely a mix of both, requires additional sampling and analysis.

As such, it is reasonable to conclude that water quality impacts to aquatic life, likely including RGSMs, have occurred in the past and may occur in the future, whenever elevated concentrations of toxic chemicals recur. Whether these impacts product direct mortality of RGSMs in the MRG cannot be specifically answered by this assessment. At least sublethal impacts, however, undoubtedly contribute to the overall conditions of environmental stress in the MRG, which could lead to declines in the population of RGSMs and other aquatic life.

Based on the assessment presented in this report, it is recommended that a monitoring program be initiated to assess whether exceedances of water quality criteria or of other risk screening criteria presented in this report occur with regularity for any specific chemical and any specific location or for a specific reach. If regular exceedances of chemicals at locations are identified, additional chemical and site specific studies should be implemented to, first, assess the nature and magnitude of the risk and, if any risks of impacts appear to be persistent and sufficiently large, then identify likely natural or man-caused sources leading to these conditions. Table ES-1 presents priority and monitoring recommendations based on relative risk estimates and additional considerations from the scientific literature for COPCs identified in surface water, sediment, and fish tissue. Again, due to the generally higher and more consistent quality of the USFWS data, assessment results obtained though analysis of that dataset were weighted more heavily in forming these recommendations.

We recommend that a routine monitoring program include quarterly sampling and assessment of surface water, quarterly sampling of sediment, and annual sampling of fish tissues, emphasizing RGSM, when possible, to refine the base of understanding for the fate of COPCs and their effects. Sampling locations should include a distribution of sites appropriately selected to add information about point and nonpoint source areas. Targeted studies might focus on characterizing the potential concentration and distribution of contaminated sediment along the MRG, including the fate of COPCs at downstream locations. Laboratory studies could investigate the potential toxic responses of RGSMs exposed to sediments and benthic algae from the MRG. Other laboratory studies might specifically develop site-specific toxicological criteria for RGSMs to allow specific quantification of potentials for impact related to COPCs. They can also evaluate the nature of most probable impacts (such as mortality and reproductive effects) through field studies to better target key assessment parameters for potential impacts from COPCs.

Specific sampling sites would best be selected by a separate workgroup of Program representatives with expertise in water quality assessment. Selected sites should focus on MRG reaches and sampling locations that best address current scientific priorities for the Program, as constrained by the budgets available to address these issues. As general guidance, these sites should include locations where previous data collection has occurred to allow at least some continuity with existing information to allow for trend analysis. Examples include the sites included in the USFWS studies and those proposed for study in the FY06 Request for Proposals for water quality studies. In general, some selected sites should focus on locations where "worse-case" water quality conditions are anticipated, sample collections at these sites could be conducted using coupled upstream-downstream sampling sites to allow comparative assessments of potential effects. Ideally, a minimum of triplicate samples should be collected from each

Table ES-1. MRG COPCs and Recommendations for Future Monitoring

Analytes/Parameters	Surface Water		Sediment		Tissue	
	Priority	Monitoring Frequency	Priority	Monitoring Frequency	Priority	Monitoring Frequency
Trace Elements - SW to include total and dissolved measurements, sediment and tissue to include total measurements						
Aluminum	low	1-5	low	1-5	low	1-5
Arsenic	low	1-5	**high**	**quarterly**	low	1-5
Barium	low	1-5	low	1-5	low	1-5
Beryllium	low	1-5	low	1-5	low	1-5
Cadmium	low	1-5	**high**	**quarterly**	low	1-5
Chromium	low	1-5	**high**	**quarterly**	low	1-5
Cobalt	low	1-5	**high**	**quarterly**	low	1-5
Copper	low	1-5	low	1-5	low	1-5
Iron	low	1-5	low	1-5	low	1-5
Lead	low	1-5	**high**	**quarterly**	low	1-5
Lithium	low	1-5	low	1-5	low	1-5
Manganese	low	1-5	low	1-5	low	1-5
Mercury	**high**	**quarterly**	**high**	**quarterly**	**high**	**annual**
Nickel	low	1-5	**high**	**quarterly**	low	1-5
Selenium	**high**	**quarterly**	**high**	**quarterly**	**high**	**annual**
Silver	low	1-5	low	1-5	low	1-5
Tin	low	1-5	low	1-5	low	1-5
Uranium	**high**	**quarterly**	**high**	**quarterly**	low	1-5
Vanadium	low	1-5	low	1-5	low	1-5
Zinc	low	1-5	**high**	**quarterly**	low	1-5
Nutrients						
Total Ammonia as nitrogen	**high**	**quarterly**	low	1-5	NA	NA
Common Anions						
Cyanide	low	1-5	**high**	**quarterly**	NA	NA
Volatile and Semi-volatile Organic Compounds (VOCs)						
Acetone	low	1-5	**high**	**quarterly**	low	1-5
Benzidine	low	1-5	low	1-5	low	1-5
Bis(2-ethylhexyl) phthalate	low	1-5	low	1-5	low	1-5
Chloroform (trichloromethane)	low	1-5	low	1-5	low	1-5
Hexachlorobutadiene	low	1-5	low	1-5	low	1-5
Polycyclic Aromatic Hydrocarbons (PAHs)						
1-Methylnaphthalene	NA	NA	low	1-5	NA	NA
Acenapthene	NA	NA	low	1-5	NA	NA
Acenapthylene	NA	NA	low	1-5	NA	NA
Anthracene	NA	NA	low	1-5	NA	NA
Benzo(a)anthracene	NA	NA	low	1-5	NA	NA
Benzo(a)pyrene	NA	NA	low	1-5	NA	NA
Benzo(b)fluoranthene	NA	NA	low	1-5	NA	NA
Benzo(ghi)perylene	NA	NA	low	1-5	NA	NA
Benzo(k)fluoranthene	NA	NA	low	1-5	NA	NA
Chrysene	NA	NA	low	1-5	NA	NA
Dibenzo(a,h)anthracene	NA	NA	low	1-5	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	low	1-5	NA	NA
Total PAHs	NA	NA	low	1-5	NA	NA
Petroleum Hydrocarbons						
None	low	1-5	low	1-5	low	1-5
Herbicides and Other Pesticides						
2,4-D	low	1-5	low	1-5	low	1-5
2-Chlorophenol	low	1-5	low	1-5	low	1-5
alpha-Endosulfan	low	1-5	**high**	**quarterly**	low	1-5
Azinphos-methyl	low	1-5	low	1-5	low	1-5
beta-Endosulfan	low	1-5	**high**	**quarterly**	low	1-5
Chlordane	low	1-5	**high**	**quarterly**	low	1-5
Chlorpyrifos	low	1-5	low	1-5	low	1-5
Diazinon	low	1-5	low	1-5	low	1-5
Dieldrin	low	1-5	**high**	**quarterly**	low	1-5
Dinoseb	low	1-5	low	1-5	low	1-5
Endrin	low	1-5	**high**	**quarterly**	low	1-5
Heptachlor	low	1-5	**high**	**quarterly**	low	1-5
Heptachlor epoxide	low	1-5	**high**	**quarterly**	low	1-5
Methyl parathion	low	1-5	low	1-5	low	1-5
Mirex	low	1-5	low	1-5	low	1-5
p,p'-DDD	low	1-5	**high**	**quarterly**	low	1-5
p,p'-DDE	low	1-5	**high**	**quarterly**	low	1-5
p,p'-DDT	low	1-5	**high**	**quarterly**	low	1-5

Table ES-1. MRG COPCs and Recommendations for Future Monitoring (Continued)

Analytes/Parameters	Surface Water		Sediment		Tissue	
	Priority	Monitoring Frequency	Priority	Monitoring Frequency	Priority	Monitoring Frequency
Parathion	low	1-5	low	1-5	low	1-5
Toxaphene	low	1-5	**high**	**quarterly**	low	1-5
Explosives						
2,4-Dinitrotoluene	low	1-5	low	1-5	low	1-5
2,6-Dinitrotoluene	low	1-5	low	1-5	low	1-5
Pharmaceuticals						
none	low	1-5	low	1-5	low	1-5
Polychlorinated Biphenyls (PCBs)						
Aroclor 1254	low	1-5	low	1-5	low	1-5
Aroclor 1221	low	1-5	low	1-5	low	1-5
Aroclor 1242	low	1-5	low	1-5	low	1-5
Aroclor 1248	low	1-5	low	1-5	low	1-5
Total PCBs	low	1-5	low	1-5	low	1-5

Notes:
NA = Not applicable to the media or not analzyed
monitoring frequency of 1-5 indicates yearly or higher frequency

sampling local to allow for enhanced statistical data analysis. Often, however, such sampling designs are prevented due to cost constraints. For such conditions, it is preferable, rather than sampling using single grab samples, to collect triplicate samples, and then mix the samples to form a composite, which is then subsampled to obtain the sample volumes required for analysis. The triplicate samples tend to be based, most often, on spatial distribution or, less often, on temporal distribution of the collected samples. For example, if the sampling site is intended to characterize channel conditions, then samples would be collected at locations across the channel; if they are to characterize pool conditions, then they are collected at three locations across the pool; and if they are intended to characterize conditions during an event, then they would be collected at three or more times during the event. Such studies, as guided by the results produced by this risk assessment, would lead to refining the understanding of water quality relationships and potential impacts to RGSMs and aquatic life in the MRG.

The Introduction to this report, Section 1, includes information on project justification, statement of need, and project goals and objectives. Section 2 is devoted to providing an introduction to ecological risk assessment and includes a generalized schematic of the structure of an ecological risk assessment. The general methods used in the ecological risk assessment for the MRG are presented in Section 3. Results from the water quality risk screening are presented in Section 4; this section includes additional detail on some methods used and a limited discussion of some results obtained to aid the reader in understanding the assessment at the time the results are presented. The results section is organized to present findings grouped first by the two major datasets assessed (USFWS and URGWOPS) and then by medium analyzed (surface water, sediment, and fish tissue). The newer USFWS data are characterized first to place the most emphasis on the most recent water quality results and higher quality information available; the older URGWOPS dataset appears to have a lower overall quality and consistency, in terms of its value in this ecological risk assessment, but provides supportive information of historical relevance. Section 5 then reviews the uncertainties inherent in this risk assessment, many of which are common to all risk assessments. The discussion is primarily organized to characterize risk by groups of similar chemical constituents (metals, common anions, and organic constituents). Future priorities for MRG water quality assessment are presented in Section 6. Then, the entire assessment is summarized, with risk management recommendations made in Section 7. The intent of this organization is to provide a more integrated presentation of risks associated with multiple chemicals in multiple media across the two datasets, leading to specific assessment priorities for future studies.

1.0 INTRODUCTION

The U.S. Fish and Wildlife Service (USFWS 1994) listing of Rio Grande silvery minnows (RGSMs, *Hybognathus amarus*) as an endangered species cited adverse water quality as a likely contributor to their population declines in the Middle Rio Grande (MRG). There continue to be claims of degraded water quality adversely impacting population numbers of RGSMs and their recovery potentials in the MRG. In contrast, a 1999 analysis by the New Mexico Environment Department (NMED 2001) of the water quality in the MRG between the Pueblos of Santa Ana and Isleta found no evidence that adverse water quality was impairing aquatic life. Commonly cited evidence of water quality directly impacting fish in the MRG is limited to a few examples related to relatively rare municipal wastewater treatment plant failures leading to locally elevated concentrations of chlorine and ammonia, and examples linked presumably to low concentrations of dissolved oxygen (DO) in overbank areas and in select stormwater discharges; both kinds of events appear to be related to the decay of terrestrial leaf litter and other organic materials in stagnant water. Such water quality impacts have occurred in localized, limited segments of the MRG.

At present, direct cause-and-effect linkages are lacking, and indirect and hypothetical relationships predominate relative to the claim that poor chemical or physical water quality has contributed to the decline of the RGSM population in the MRG. In fairness, however, the difficulty must be acknowledged in documenting direct water quality impacts leading to fish kills in rivers, such as the MRG, where localized fish kills can often go unobserved and undocumented. Similarly, it is also commonly difficult, to link either short-term acute or long-term chronic effects on aquatic populations in the wild to any single environmental cause or set of causes, including water quality. Consequently, the general lack of documented, cause-and-effect impacts specifically linking water quality to declining fish populations cannot directly lead to the conclusion that these events are not occurring. At the same time, documentation of widespread or periodic fish kills correlated to specific prevailing or episodic water quality conditions, if they were observed, would lend support to such cause-and-effect linkages.

In total, these relationships pointed to the need for additional assessment of how potentially adverse water quality conditions may be affecting the survival, recruitment, health, population size, and recovery potential of RGSMs in the MRG. There exist extensive and diverse datasets on past and recent water quality conditions in the MRG that have not been systematically assessed. Much of the older data collected by various agencies have been compiled into a single database as part of the Upper Rio Grande Water Operations (URGWOPS) Environmental Impact Statement (EIS) project. The U.S. Bureau of Reclamation (Reclamation), the U.S. Army Corps of Engineers (USACE), and the New Mexico Interstate

Stream Commission (NMISC) funded development of this database. Recent data that add to this characterization were collected by the USFWS (2004) under funding from the MRG Endangered Species Act Collaborative Program (Program) and by the NMISC. Specifically, the potential for impacts from the individual water quality constituents reported in these datasets have not been evaluated in an integrated assessment. Similarly, the potentials have not been assessed for cumulative adverse water quality impairments and risks to either aquatic life, in general, or RGSMs, specifically, across the multiple chemical constituents and multiple environmental media using these data. Therefore, to improve on the understanding of the relationship of RGSMs to water quality conditions in the MRG, the project reported here applied ecological risk assessment techniques to evaluate and quantify the probability that water quality, as characterized in the USFWS and URGWOPS datasets, has posed significant adverse risks and produced probable impacts to the RGSM population in the MRG. The assessment was designed to identify chemical toxicants of potentially greatest concern and further narrow the range of those toxicants through an ecological risk assessment to determine a focus for future water quality sampling and other appropriate studies through which remaining uncertainties can be best resolved.

1.1 Project Justification

To help clarify the uncertain role of water quality in the MRG, the Middle Rio Grande Endangered Species Act Collaborative Program (Program) established a scientific priority to identify and characterize potential water quality impacts on RGSMs in the MRG upstream from Elephant Butte Reservoir (Figure 1). This priority intended to specifically addresses the second of two water quality elements included under the Reasonable and Prudent Alternative (RPA) defined in the March 2003 Biological Opinion (BO; USFWS 2003):

> *Action agencies, in coordination with parties to the consultation, shall provide funding for a comprehensive water quality assessment and monitoring program in the Middle Rio Grande to assess water quality impacts on the silvery minnow. This assessment and monitoring program should use available data from all sources.*

1.2 Statement of Need

A systematic evaluation of the existing water quality dataset is needed to assess the potential that specific water quality impacts have occurred or may be occurring. Where potentials for impacts are indicated, the specific water quality constituents of concern should be identified and needs for additional study prioritized. The results from the assessment presented in the following sections provide direction and focus for future sampling and analysis needed to improve the understanding of the influence of water quality on RGSMs in the MRG. The results from this project are intended to enhance the effectiveness

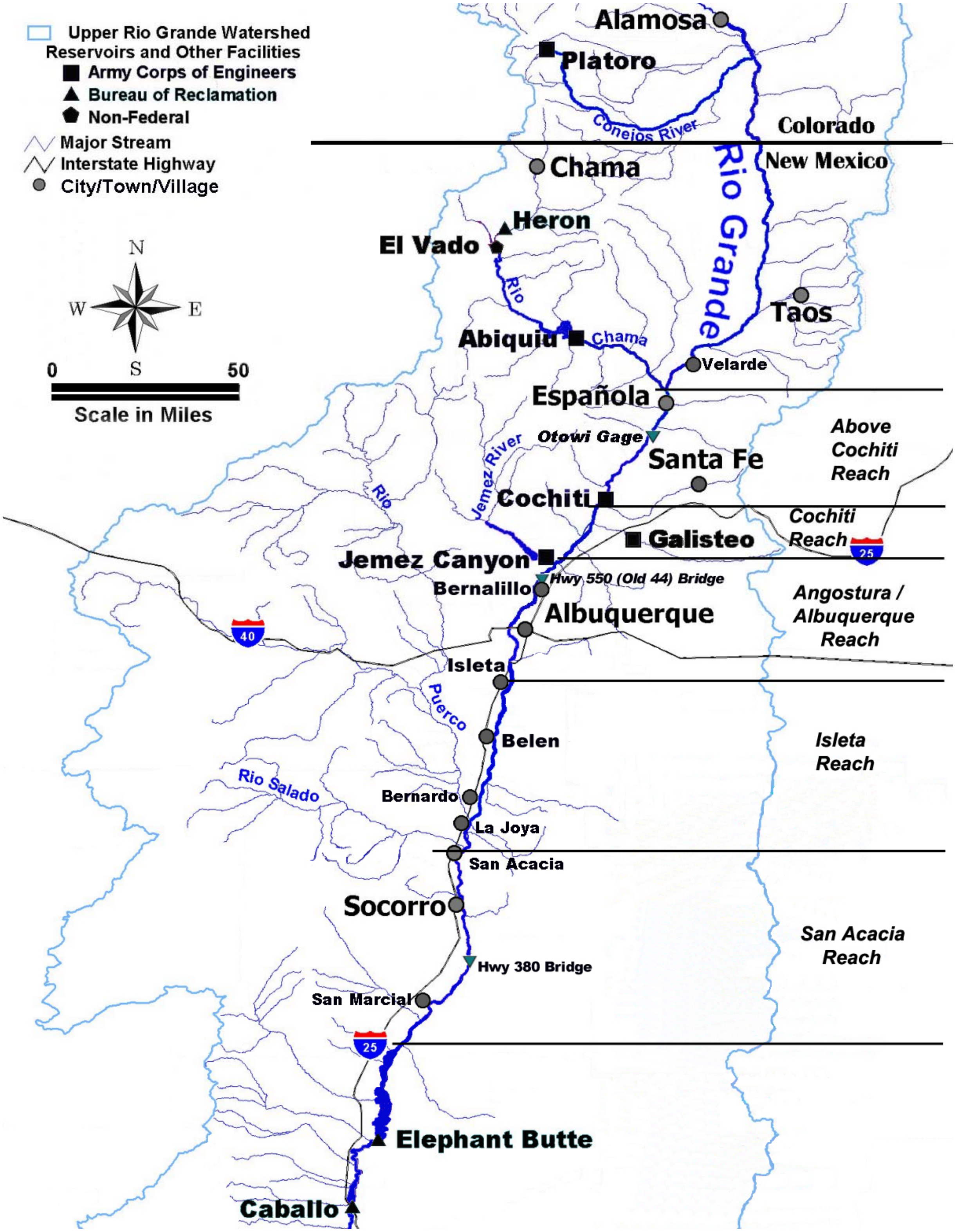


Figure 1. Middle Rio Grande, NM, Showing Divisions for Individual River Reaches

and cost-efficiencies of future water quality studies in the MRG by helping to focus future priority assessments and identify chemicals of concern for the MRG.

1.3 Project Goals and Objectives

The overall goal of this study is to aid in the conservation and recovery of the endangered RGSMs by assessing whether the quality of surface water in the MRG might have produced and has the marked potential to continue to produce negative population-level or localized impacts on the survival, growth, and reproduction of RGSMs.

Available water quality data from the URGWOPS and USFWS datasets were assessed during this study to identify contaminants of potential concern (COPCs) for the MRG. This assessment used existing data in an ecological risk assessment to evaluate the probability that water quality in the MRG has impaired aquatic life, in general, or RGSMs, in particular. Where significant adverse impacts or data gaps are identified, additional data collection and study are recommended. The project follows the U.S. Environmental Protection Agency's (USEPA 1998) guidance for ecological risk assessment.

Objectives of this project include defining a problem formulation, largely through developing a conceptual model and developing hypotheses on the relationships of water quality to RGSMs. The primary hypothesis of interest to this project is that,

> ***Adverse water quality conditions have existed and appear to continue to produce conditions of high risk and potential population-level impacts adversely affecting aquatic life and the recovery of RGSMs in the MRG.***

Additional project objectives include:

- Develop aquatic life and the RGSM exposure profiles for use in identifying COPCs in the MRG
- Characterize potential effects related to the identified COPCs
- Characterize ecological risk associated with water quality in the MRG
- Recommend water quality constituents of priority for future assessments

2.0 ENVIRONMENTAL RISK ASSESSMENT

Ecological risk assessment is defined in the federal guidance (USEPA 1992a, 1998) as a process that evaluates the likelihood that adverse ecological effects are occurring or may occur as a result of exposure to one or more stressors. Also, established procedures for ecological risk assessment provide methods of projecting effects from single or multiple chemicals. For example, ecological risk assessment can use available information collected to characterize past water quality conditions to assess the likelihood that certain adverse effects might have occurred in the past. In addition, risk assessment also can project the potential effects, should the aquatic community undergo prolonged future exposure to a specified set of single or multiple chemicals.

Previous characterizations suggesting linkages between declining RGSM populations and adverse water quality in the MRG have primarily relied on limited comparisons of water quality monitoring data to national water quality criteria and to State and Tribal water quality standards. These criteria and standards provide only a limited set of chemical analytes to project potential cause and effect relationships. A larger source of information that can be used in assessing potential effects on aquatic life from an expanded (but still limited) chemical list is available in the form of established screening and assessment benchmarks used in aquatic ecological risk assessment (see Section 3.2.1.1). Risk assessment procedures also provide established methods for projecting effects from single and multiple chemicals.

Risk assessment projects typically involve dedicated sampling and analysis to produce data of sufficient and known quality to support reliable assessments. Of particular importance in designing these projects are sampling and analysis methods that are capable of producing data with minimum detection limits (MDLs) for each chemical assessed that are sufficiently below the corresponding benchmark criteria. At the same time, many risk assessment projects, including this one, evaluate data collected outside the project but compiled with a similar scope. The quality of externally collected data cannot always be directly or completely assessed, however. Therefore, qualitative decisions on whether to use externally generated data must be made based on the intrinsic characteristics of the data — for example, who collected and analyzed the data and when. The quality of the data used in a risk assessment is a major factor in defining the uncertainty in the resulting conclusions.

This ecological risk assessment of water quality in the MRG exclusively screened source data collected in other studies. As such, it had no control over whether the MDLs used in those datasets were sufficiently sensitive to allow reasonable comparisons to applicable risk benchmarks. In later stages of ecological risk assessments, sampling programs are generally designed to include sampling site distributions and sampling frequencies sufficient to allow hypothesis testing. However, it is not always practical or feasible to design sampling programs that can provide sufficient numbers of samples to meet all assumptions required for many statistical analyses, particularly when the assessments include larger geographic areas. Such investigations often depend on the use of existing data to complete the assessment.

Figure 2 shows a general, conceptualized framework for ecological risk assessment and management, as presented by USEPA (1992a, 1998). Most risk assessment reports include separate chapters for each of the stages shown in the large ecological risk assessment box on Figure 2. To aid readers unfamiliar with risk assessment, this report only generally follows that organization. Instead, the balance of Section 2 is devoted to providing an introduction to ecological risk assessment, as shown in Figure 2. This introduction is intended to guide readers to where in the report additional information is presented for each topic in the figure. The general methods used in the ecological risk assessment for the MRG are presented in Section 3. Results from the water quality risk screening are presented in Section 4; this section includes additional detail on some methods used and limited discussions of the results obtained to aid the reader in understanding the assessment at the time the results are presented. The results section is organized to present findings grouped first by the two major datasets assessed (USFWS and URGWOPS) and then by medium analyzed (surface water, sediment, and fish tissue). The newer USFWS data are characterized first to place the most emphasis on the most recent water quality and higher quality information available; the older URGWOPS dataset appears to have a lower overall quality and consistency, in terms of its value in this ecological risk assessment, but provides supportive information of historical relevance. Section 5 then reviews the uncertainties inherent in this risk assessment, many of which are common in all risk assessments. The discussion is primarily organized to characterize risk by groups of similar chemical constituents (for example, metals, common anions, and organic constituents). Future priorities for MRG water quality assessment are presented in Section 6. Then, the entire assessment is summarized, with risk management recommendations made in Section 7. The intent of this organization is to provide a more integrated presentation of risks associated with multiple chemicals in multiple media across the two datasets, leading to specific assessment priorities for future studies.

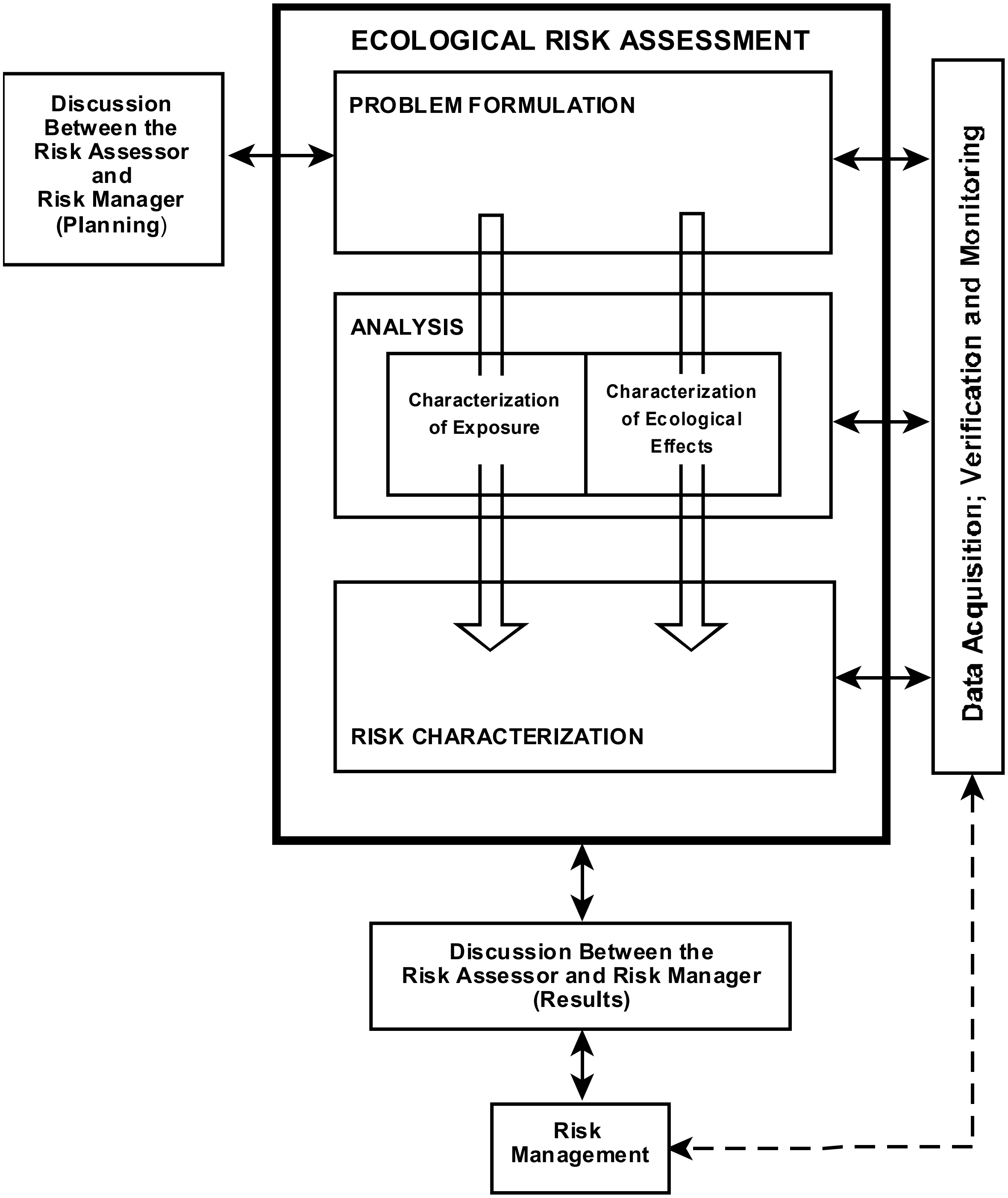


Figure 2. Framework for Ecological Risk Assessment and Management (based on USEPA 1992a)

2.1 Problem Formulation

Most ecological risk assessment follows guidance by USEPA (1992a, 1998). The first step in the USEPA risk assessment process is problem formulation, during which the development and refinement of preliminary hypotheses takes place. The hypotheses are referring to why ecological effects have occurred, or may occur, as a result of the activities assessed. This first step provides the foundation for the entire assessment. During problem formulation, the objectives for the risk assessment are also defined and refined, the nature of the problem is evaluated, and a plan for analyzing data and characterizing risk is developed. This step includes characterizing the ecosystem of concern, the stressors that will be assessed, the nature of the effects, the assessment and measurement endpoints included, and the conceptual model that sets forth likely linkages between potential stressors and receptor responses. Problem formulation typically results in three products: (1) assessment endpoints that adequately reflect management goals and the ecosystem they represent, (2) conceptual models that describe key relationships between a stressor and assessment endpoint, and (3) an analysis plan.

Therefore, the nature of the ecosystem must be described in this phase. The historical range of RGSMs included the Rio Grande from near the Gulf of Mexico upstream to the confluence of the Rio Grande with the Rio Chama in New Mexico. Over its more recent history, this river has been impaired by a host of culturally induced changes. Natural channel flows and bed forms have been altered considerably. Both historical and recent information indicates that the channel can include sometime prolonged intervals of drying. Overall, flows are now heavily regulated, and the water quality of the river has changed to reflect cultural development in the basin.

Potentially adverse water quality alterations resulting from these changes may affect RGSMs and other aquatic life through a diversity of pathways. The contrast between the predominant 1-year life expectancy presently observed for RGSMs in the MRG and the typical multi-year (3 years and longer) life expectancy documented in captivity suggests that increased cumulative risks from various factors in the MRG, possibly including water quality, may be contributing to the reduced life expectancy.

Potential water-quality related effects on RGSMs include direct toxic responses from total or dissolved concentrations of chemicals in the water that enter the body with food or across the gills. Significant concentrations of chemicals can also enter the body when contaminated food and the associated sediment are ingested. Indirect effects on RGSMs can result from factors that reduce production of food for RGSMs, such as algae, diatoms, and small planktonic invertebrates. Direct toxic effects can be short-term acute or long-term chronic. Short-term, acutely toxic responses that result in mortality can be correlated with suddenly elevated chemical concentrations in surface waters. These episodes could include runoff of chemicals from urban areas during storm or snowmelt or during operational failures at wastewater treatment facilities, spills, ruptured pipelines, or accidental releases from industrial facilities. Extensive and multi-species mortalities could result if these events produce acutely toxic concentrations of chemicals in the receiving water (for example, high concentrations of chlorine, ammonia, or heavy metals). Chronic toxicities are associated with sublethal effects on populations, including slowed growth rates, reduced reproductive success, and shortened life expectancies. The remainder of this section discusses the three products of the problem formulation stage.

2.1.1 Assessment Endpoints

Assessment endpoints are explicit expressions of the actual environmental values to be protected (USEPA 1998). Definition of these endpoints is critical to the problem formulation process because the endpoints are used to structure the assessment to address management concerns and are central to development of the conceptual model. Criteria used to select assessment endpoints include (1) how well they target susceptible ecological entities, (2) whether they are measurable ecosystem characteristics, (3) whether they are susceptible to known or potential stressors, and (4) whether they adequately represent management goals. To increase the likelihood that the risk assessment will be used in management decisions, assessment endpoints are more effective when they also reflect societal values and management goals. Ecological resources are considered susceptible when they are sensitive to a stressor and are, or may be, exposed. Susceptibility can often, but not always, be identified early in problem formulation. Risk assessors use best professional judgment to select the most likely candidates.

Assessment endpoints selected for this risk assessment include (1) potential effects on the entire aquatic community in the MRG (i.e., including RGSMs, the community of which it is a part, and the biological resources on which it potentially relies), and (2) potential effects specifically on RGSMs individually. Assessment effects for RGSMs were largely represented using fathead minnows (FHMs) as a surrogate species. A toxicant response surrogate is needed because a very limited dataset exists on responses by RGSMs to toxicants (in part because it is listed by federal and state agencies as an endangered species, with major constraints limiting motilities to individuals of the species), while an abundant response dataset exists for FHMs. As discussed below, laboratory studies show FHMs to be an appropriate response species for RGSMs. Use of surrogate species is consistent with USEPA guidance and helps in identifying the potentially most sensitive life stages of RGSMs. Assessment endpoints encompassing different levels of ecological organization (in this case, populations of RGSMs and FHMs and the generalized aquatic communities) allow assessment of risks from differing perspectives, potentially improving weight-of-evidence support for likely relationships identified in the data.

Potential effects assessed include both short-term acute (over periods of hours to a few days) and long-term chronic (weeks to months) exposure. Short-term acute exposure scenarios allow for the assessment of potential individual and localized population-level mortality effects, while chronic exposure scenarios allow for assessment of longer-term effects on survival, growth, and reproduction, which could include localized or system-wide effects. This analysis projects the potential effects on the RGSMs/FHMs at the population level and at the MRG aquatic community level using available data on water, sediment, and tissue quality responses that were compiled for use in assessing risk potentials in the MRG.

2.1.2 Conceptual Model

The conceptual model in the problem formulation step includes two components: a visual representation and a written description of hypothesized relationships between potential stressors and ecological receptors that might be exposed (USEPA 1998). The model may represent various relationships, including ecosystem processes that affect receptor responses and exposure scenarios that qualitatively link land use to stressors. Primary, secondary, and tertiary exposure pathways may be described, as well as their co-occurrence along exposure pathways. Conceptual models for ecological risk assessments are based on existing information about stressors, potential exposures, and predicted effects. The complexity of the conceptual model depends on the number of stressors, the number of assessment endpoints, the nature of effects, and the characteristics of the ecosystem. The conceptual model may account for one of the most important sources of uncertainty in a risk assessment. For example, the risk characterization may misrepresent actual risks if important relationships are missed or specified incorrectly. Uncertainty arises from lack of knowledge about how the ecosystem functions, failing to identify and relate temporal and spatial parameters, omitting stressors, or overlooking secondary effects.

Based on the data available to assess these pathways and sources, data gaps are identified during the analysis. These gaps for the MRG are highlighted and reviewed in the results, discussion, and conclusion sections. Specifically, potential adverse water quality conditions may affect RGSMs through a diversity of chemical stressors and exposure pathways. Figure 3 presents a diagram of the conceptual model for the MRG hypothesizing how water quality may affect conservation and recovery of RGSMs through potential pathways for stressors to affect the RGSM population and the aquatic community in the MRG. Potential water quality effects are shown to primarily originate from industrial, municipal, and agricultural sources. Since most industrial and municipal sources are commonly combined and treated concurrently in municipal treatment systems along the MRG, they are conceptually shown in a combined box on Figure 3. These sources can produce multiple potential water quality stressors from point and nonpoint source discharges. The primary release mechanisms hypothesized on the figure for these

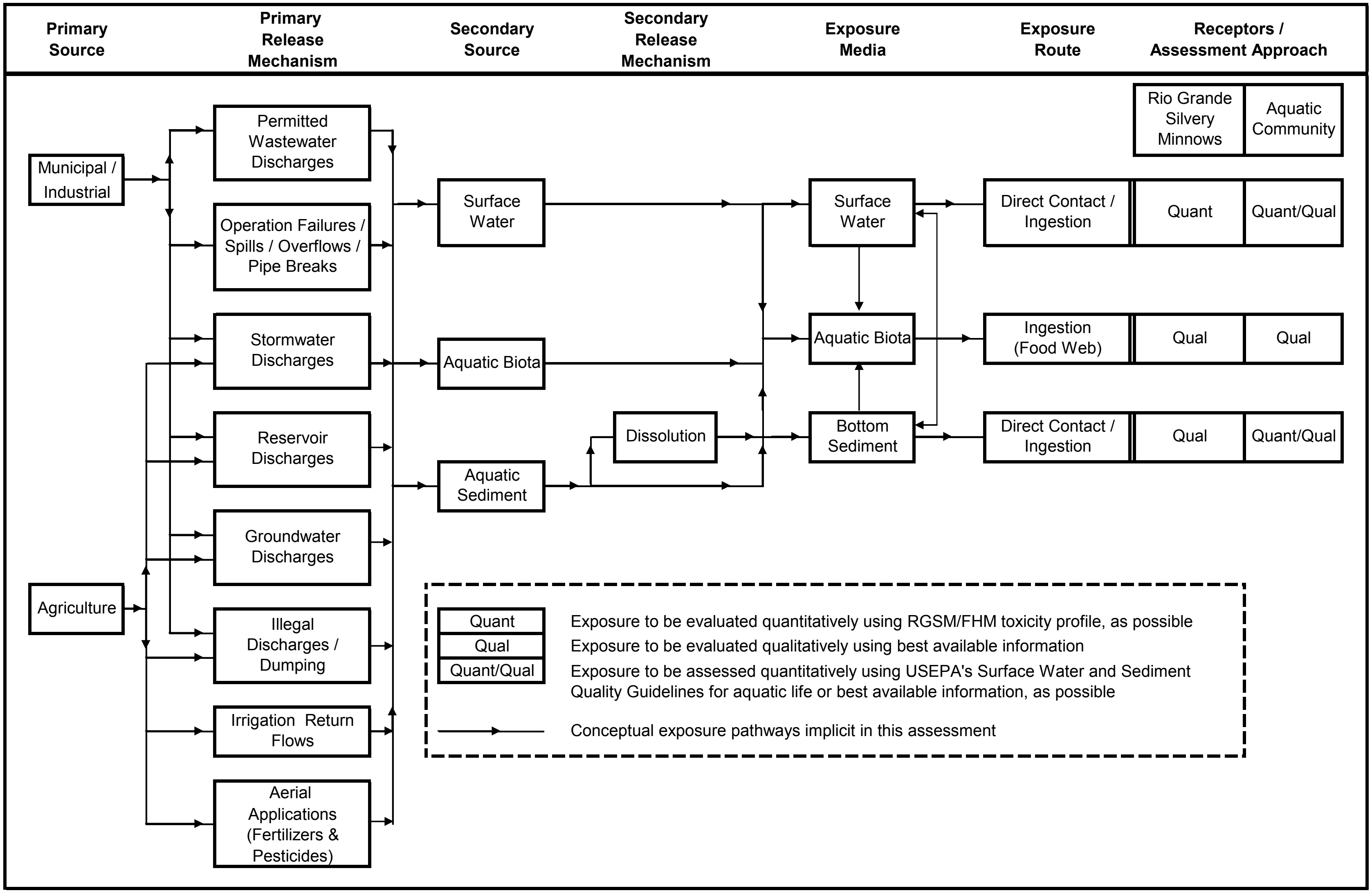


Figure 3. Conceptual Exposure Model for Rio Grande Silvery Minnows and the Aquatic Community

stressors include discharges of wastewater, storm water, and groundwater; discharges from reservoirs; illegal dumping; irrigation return flows; and aerial application of pesticides and herbicides. Secondary sources that may contribute to exposure include redistribution within and between the three environmental media represented — surface water, aquatic sediment, and aquatic biota. Of particular note, aquatic sediment can exchange absorbed and adsorbed chemicals through dissolution, redistributing chemicals to surface water, biota, and even back to the bottom sediment.

All direct and indirect routes of exposure hypothesized can be considered as potential complete pathways because little information exists on adverse water quality impacts on RGSMs. Direct effects may be acute or chronic. These effects include direct toxic responses from total or dissolved concentrations of chemicals in the water that enter the bodies of RGSMs and other aquatic organisms with food or across the gills. Acutely toxic episodes could include runoff of substances from urban areas during storms or snowmelt, or during operational failures at wastewater treatment facilities. Routes of exposure at the community level include direct contact or ingestion without accumulation, bioaccumulation, or biomagnification. Significant concentrations of chemicals also can enter the body when the fish ingest contaminated food or sediment (through absorption and adsorption). Indirect effects on RGSMs can also result from adverse water quality that reduces the production of food for RGSMs, such as algae, diatoms, and small planktonic invertebrates.

2.1.3 Analysis Plan

The analysis plan is the final stage of problem formulation. During analysis planning, risk hypotheses are evaluated to determine how they will be assessed using available and new data. The plan includes the assessment design, data needs, measures, and methods for conducting the analysis phase of the risk assessment. The analysis plan specifies pathways and relationships identified during problem formulation to be pursued during the analysis phase. The hypotheses considered more likely to contribute to risk are targeted. Where data are few and new data cannot be collected, it may be possible to extrapolate from existing data. Extrapolation allows use of data collected from other locations or organisms where similar problems exist.

The assessment of water quality risks along the MRG includes a systematic evaluation of all existing data on water quality compiled from the main channel of the MRG between the confluence with Rio Chama and the Elephant Butte Reservoir. The area of study for this project is segmented into five river reaches:

- Above Cochiti Reach, between the confluence with Rio Chama and Cochiti Reservoir
- Cochiti Reach, between Cochiti Reservoir and the Angostura diversion dam

- Angostura/Albuquerque Reach, between the Angostura and Isleta diversion dams
- Isleta Reach, between the Isleta and San Acacia diversion dams
- San Acacia reach, between the San Acacia diversion dam and the Elephant Butte Reservoir

The MRG data compiled during this project are compared to available Federal, State, and Tribal water quality criteria and standards as well as to established risk screening benchmarks for concentrations in water, sediment, and fish tissue. Together, these data are used to assess probable relationships of RGSMs and the aquatic community to chemicals detected in the MRG.

The exposure and effect of these chemicals on RGSMs and the aquatic community are characterized through sequential analyses using Tier I and Tier II risk assessment procedures. The two steps produce, first, a preliminary highly conservative risk screening of all assessed chemicals to identify the initial set of COPCs; and then a more-refined assessment of those COPCs to produce a more-realistic assessment of probable risk relationships. Chemicals detected in the MRG water, sediment, or fish tissue samples at concentrations that exceed water quality criteria are characterized as COPCs (also called *chemicals of potential ecological concern*, or *COPECs*, in some ecological risk assessments). The risks associated with the COPCs using the assessment (risk screening) endpoints are quantified by the various measurement endpoints (such as the number of times the risk screening criteria were exceeded, estimates of maximum probable risks [hazard quotients {HQs}], and maximum likely risks). The results lead to a "line-of-evidence" or "weight-of-evidence" analysis of how adverse water quality conditions potentially relate to RGSMs and other aquatic life along this river. Individual COPCs are evaluated for their potential to affect these resources. Spatial and temporal relationships defined in the existing water quality data are evaluated for indications of significant impairment from COPCs (individually and in combination) that may be correlated to release mechanisms, events, or river features.

2.2 Analysis Phase

The analysis phase brings together the two primary components of risk assessment — exposure and effects characterizations — as well as their relationships to characteristics of the ecosystem and is the step between problem formulation and risk evaluation. At the beginning of the analysis phase, the data are examined to ensure that they can be used to evaluate the conceptual model developed in problem formulation. The data should be examined for both usability and quality. The objective of this phase is to prepare the data to be able to predict ecological responses to stressors under exposures of interest. This step produces the information summaries and profiles on response effects due to exposures to stressors by the target receptors of concern. These profiles provide the basis for estimating and describing risks. The quality of the data should also be factored in when describing associated risk.

This assessment of water quality risk in the MRG relies on use of the URGWOPS and USFWS datasets. These data together provide an extensive characterization of water quality conditions in the MRG at diverse sampling locations over several decades, as discussed in Section 3.

Both the URGWOPS EIS and the USFWS datasets were incorporated into a Microsoft Access database and formatted to allow querying to produce information needed to access quantifiable risks to RGSMs and the aquatic community along the MRG. Again, this assessment depends only on existing data; no new sampling was completed as part of this project. These data were assessed for their usability in conducting a risk assessment (USEPA 1992b) using four data criteria or classification categories:

- *Category 1* – data that are not useable because information is insufficient
- *Category 2* – useable data having information for sample date, location, and units, but lacking information on sampling or analytical procedures
- *Category 3* – useable data having Category 2 information, plus sampling and analytical procedures, but lacking quality assurance/quality control (QA/QC) information
- *Category 4* – useable data, including all Category 3 information plus data flags and supporting QA/QC information to indicate that QC procedures were used

Uncertainty is a constant concern throughout the analysis phase (USEPA 1998). Sources of uncertainty that arise in estimating a parameter's true values primarily include variability, uncertainty about a quantity's true value, and data gaps. (The term *variability* here describes the heterogeneity for each variable, i.e., chemical parameter, in the dataset.) Uncertainty about a parameter's true value may include its magnitude, location, or time of occurrence. The objective of uncertainty characterization in risk assessment is to describe and, where possible, to quantify what is known and not known about both exposures and effects in the system assessed. Understanding the sources of uncertainty can help to increase the credibility of assessments by explicitly describing quantitatively, when possible, or qualitatively, if necessary, the magnitude and direction of uncertainties. Uncertainties characterized during the analysis phase are used during the risk characterization phase when risks are estimated to help describe the confidence in the lines of evidence used. Any remaining uncertainty can often be reduced by additional sample collections and measurements. As such, understanding the nature of the remaining uncertainties can help in identifying requirements for any future sampling and analysis plans. (Section 5 provides a detailed consideration of uncertainty related to risk assessments in general and this assessment of the MRG in particular.)

2.2.1 Environmental Characterization and Exposure Profiles

Exposure is the degree of contact between a stressor and a receptor. The potential for exposure includes information on where, when, and at what concentrations the COPCs posing risk might occur. Ecological risk assessment also requires projecting where the exposure conditions for the potential environmental stressors may intercept organisms in the environment. The ability to accurately profile these potentials in ecological risk assessment depends on the ability to correctly measure or otherwise define interacting stressor sources, exposure concentrations, ecosystem patterns, and habitat use. Exposure profiles can include analyses that project environmental distributions for stressors and the extent and pattern of contact or co-occurrence with key receptors. Summary exposure profiles identify the receptors (species populations, for example) and describe the courses stressors take from the source to the receptor (the exposure pathway) and the spatial and temporal extent and intensity of co-occurrence or contact. Profiles also describe the variability and uncertainty of the projected exposure estimates, including conclusions about the likelihoods that exposure will occur.

The exposure profile is combined with an effects profile to estimate risks. The exposure profile, to be useful, should be compatible with the stressor response relationship generated in the effects characterization (see the next subsection).

2.2.2 Characterization of Potential Ecological Effects

Characterizing potential ecological effects requires linking likely responses by biological receptors to environmental stressors and assessing how these responses change over varying stressor concentration levels (USEPA 1998). The stressor-response relationships used in an assessment depend on the scope and nature of the ecological risk assessment as defined in problem formulation and reflected in the analysis plan. For example, early screening tiers often require only point estimates of effects (such as the value that is lethal to 50 percent of the test population, the LC_{50}) to compare with point estimates from stressors. Tiers used early in the process often include predetermined point effects benchmarks to answer whether a potential risk exists. Tiers used later in the process commonly require alternative assessment benchmarks to better address management questions that change from “yes-no” to “what, where, and how great is the risk?”

Water quality criteria established under State and Tribal standards along the MRG and updated aquatic life criteria from the USEPA were compiled to characterize potentials for ecological effects for this risk assessment for the MRG. Additional risk assessment benchmarks for water, sediment and tissue concentrations for chemicals not included in the Federal, State, or Tribal criteria also were compiled, as described in Section 4.1.1. This compilation produced a comprehensive set of risk screening benchmarks that were used to determine potentials for impairments of RGSMs and aquatic life in the MRG. Chemicals were identified as COPCs whenever their concentrations in water, sediment, or fish tissue exceeding their associated ecological risk screening benchmarks.

The Federal, State, and Tribal water quality-based criteria are weighted toward the most sensitive species tested and then adjusted to protect an estimated 95 percent of the aquatic community (USEPA 1994). Toxicity profiles for RGSMs, using FHMs as their surrogate, were also compiled to focus this assessment of water quality more directly on potential effects on RGSMs. To date, comparative toxicity studies indicated that, in general, FHMs are an appropriate surrogate for RGSMs in terms of sensitivities to toxicants (Buhl 2002; Lusk 2005). Mixtures of these compounds at concentrations similar to levels reported for the Rio Grande produced greater than additive effects when compared with results that were obtained for the constituents individually, so that the single concentration criteria used by NMED may be inadequate for projecting potential water quality effects in the Rio Grande (Buhl 2002). In total, however, FHMs appear to be a reasonable surrogate species for RGSMs in evaluating potential toxicity relationships based on these comparative results (Buhl 2002, 2003).

FHMs are commonly used in aquatic toxicity testing: most water quality criteria for aquatic life developed by USEPA include results from toxicity tests using FHMs. Additionally, a considerable dataset on the toxicant response by FHMs is available from other well-known and readily available existing data compilations, including the AQUatic Toxicity Information REtrieval (ACQUIRE) dataset. Toxicity response data for RGSMs and FHMs available from these sources were compiled to create a toxicity response profile for RGSMs and FHMs in relation to COPCs identified in the MRG water quality database. (In the end, resources available to this project were insufficient to allow distinguishing among the range of threshold effects, including effects on growth, mortality, or reproduction, in defining the toxicity profile or assessing risk.) Toxicity data for an identified COPC that are not available for RGSMs and FHMs are noted as a data gap in this MRG assessment. As part of this overall effort, the relative sensitivities of RGSMs and FHMs relative to other aquatic life species included in the USEPA criteria-setting documents were also compiled, where available, and reported.

2.3 Risk Characterization

Risk characterization is the final phase of ecological risk assessment. Completing risk characterization clarifies the relationships between stressors, effects, and ecological entities and is intended to lead to conclusions regarding the occurrence of exposures and the adversity of existing or anticipated effects. Both the Tier I and Tier II risk assessments, as described in the subsequent subsections, were used in this assessment.

2.3.1 Tier I Screening-Level Risk Assessments

When appropriate data are available to quantify exposure and effects estimates, the simplest approach for comparing the estimates is a ratio (or quotient), expressed as an exposure concentration divided by an effects concentration (USEPA 1998). In Tier I screening-level assessments, quotients are commonly used to characterize risks for chemical stressors where reference or benchmark toxicity values are available. This method has the advantage of being an efficient, inexpensive means of identifying high- or low-risk situations that can lead to management decisions without the need for further information. Quotients also can be used to integrate the risks across multiple chemical stressors. In this document, quotients for the individual constituents in a mixture are generated by dividing each exposure level by a corresponding toxicity endpoint (for example, the acute or chronic water quality criteria, the LC_{50}, the concentration where effects appear in 50 percent of the test organisms [EC_{50}], or the concentration or level where no effects were observed [NOEC or NOEL]). The resulting quotients also can be summed to project total potential risks. Although the toxicity of a chemical mixture may be greater than or less than predicted from the toxicities of the individual constituents, the method of adding quotients assumes that toxicities are additive or approximately additive. This assumption may be most applicable when the modes of action of chemicals in a mixture are similar, but less applicable when the modes of action are dissimilar. Additive or near-additive interactions are common among many toxicants (USEPA 1998).

The quotient method involves calculating hazard quotients (HQ) to project maximum probable risks for potential toxicants in the environment. That is, these ratios are computed from the concentration of the chemical divided by the respective toxicity reference value (risk screening benchmarks). The hazard quotient is defined to equal:

$$HQ = \frac{Dose}{TRV}$$

Where:

HQ = Hazard quotient; maximum probable risk (non-dimensional)

$Dose$ = Site- or sample-specific chemical concentration for exposure of receptors

TRV = Chemical- or receptor-specific toxicity reference value (risk screening benchmark concentration)

A value of 0.3 for this ratio was defined during an expert workshop as an appropriate decision criterion for selecting individual COPCs to include in the Tier II cumulative risk assessment (Parkhurst and others 1996). Potentially additive risks for the chemicals can be calculated by adding the HQs for each constituent of concern for chemicals with HQ greater than or equal to 0.3; when this sum is greater than 1.0, cumulative toxic risks can be projected as likely. Use of this approach is most valuable where there are no individual HQs that exceed 1.0 or only a few slightly above. Estimation of additive risks becomes of secondary concern, however, when many calculated of HQs for individual chemicals exceed 1.0 (as was found during the assessment of the MRG datasets).

Risk characterization to estimate maximum probable risks for chemicals detected in the MRG samples and to define priority COPCs for the MRG were based on the risk screening benchmarks compiled for water, sediment, and tissue, as discussed above. These benchmarks provide the core of the published threshold action levels appropriate to protect RGSMs and their ecological resources. Data gaps were identified where detectable concentrations of chemicals were reported, but appropriate benchmarks were lacking. A number of limitations restrict application of the quotient method. Although quotients can address whether risks are high or low, quantitative information is not produced to assess incremental risks over changing exposure conditions. For example, LC_{50} values derived from a 96-hour laboratory test using constant exposure levels may not be appropriate to assess effects on reproduction from pulsed exposures over shorter or longer intervals. In addition, the quotient method may not always be appropriate for predicting secondary effects (such as loss of food resources). Finally, the quotient method does not explicitly incorporate uncertainty (for example, the uncertainty created by extrapolation of results from tested species in the laboratory to the species or community in the environment).

Chemicals with a maximum probable risk ratio above 1.0 for the maximum sample concentration in the MRG samples are identified as COPCs and carried forward for Tier II cumulative risk screening. The data are summarized for each key COPC identified to help characterize temporal and spatial trends in chemical concentrations in the samples. The measurement endpoints used as screening benchmarks, and the magnitudes and frequencies that these screening benchmarks were exceeded by sample results in the datasets are presented and summarized in Section 4.

2.3.2 Tier II and Cumulative Risk Assessments

Tier II risk assessments were conducted to provide a more definitive and quantitative basis for assessing risk as well as an evaluation of whether additional assessments of the COPC may reduce any remaining levels of uncertainty.

This project intended to use the Water Environment Research Foundation’s Aquatic Ecological Risk Assessment (AERA) model (Parkhurst and others 1996). However, this modeling approach was deemed to be unnecessary after the MRG datasets were compiled and earlier steps of the risk analysis indicated the potential for high risks associated with various chemical constituents, as discussed in subsequent sections. These high levels of apparent risk would largely "swamp out" the incremental subtleties that may be revealed through the AERA model. In addition, the chemicals in the MRG water quality dataset dwarf the limited list of chemicals presently included in this model for risk projections. (Recalibrating the AERA model to include all chemicals of potential concern in the MRG could become a large, separate project). This modeling approach could be applied in the future on data from a focused study specifically designed to be assessed through this model.

Instead, results computed for maximum probable risk are presented for the Tier I assessments. Then specific Tier II assessments were used for each medium, as discussed in Section 3. Since significant single-chemical and single-medium risks were identified, multiple constituent cumulative effects were not assessed. These probable risk values (HQs) may be simply added individually for any or all groups of chemicals of interest to estimate cumulative risks across the selected chemicals.

2.4 Recommendations, Reporting, and Risk Management

This MRG water quality risk assessment includes all chemical and physical constituents in the datasets that have the potential for producing toxic responses and have measured results from data of sufficient quality to allow assessment. Data summaries are provided to help characterize temporal and spatial relationships shown in the data for each constituent projected to pose likely risks to RGSMs or the MRG aquatic community. Constituents that may be of concern but where data are insufficient for reasonable assessment are identified as candidates for additional sampling and assessment in future studies.

When making decisions regarding ecological risks, risk managers generally must consider social, economic, political, or legal constraints in combination with risk assessment results (USEPA 1998). In some cases, managers may use risk assessment results as part of an ecological cost-benefit analysis or other environmental assessments. Risk managers also often consider alternative strategies for addressing risks, including risk mitigation or relative risk comparisons. Furthermore, risk managers often consider and incorporate public opinion and political demands into decisions. Collectively, all these factors might render very high risks acceptable or very low risks unacceptable.

General guidelines exist to aid risk managers with the interpretation of risk assessment results (Wenzel and others. 1996). In general, based on established professional risk interpretation and management guidance, potential ecological effects associated with the maximum probable risk projections can be defined as follows:

1. Maximum Probable Risk less than 1: No significant risk
2. Maximum Probable Risk greater than 1 and less than 10: Small potential for adverse effects

3. Maximum Probable Risk greater than 10 and less than 100: Significant potential for adverse effects
4. Maximum Probable Risk greater than 100: Expected adverse effects

Finally, the concern regarding risk in the MRG focuses on a federal- and state-listed endangered species. As such, the second category may be the most appropriate benchmark breakpoint for defining risks of concern to RGSMs.

3.0 METHODS

The project team first identified and compiled existing analytical data on water quality for the MRG to establish the exposure profile for the MRG. Concurrently, the team identified and compiled appropriate risk screening benchmarks that were used to assess the occurrence of water quality exceedances in the MRG. The following subsections describe the methods through which these tasks were accomplished.

3.1 Compilation of Environmental Data

This assessment considered two primary data sources: (1) results from the USFWS 2002-2003 sampling study funded by the Program, and (2) an extensive compilation of historical data assembled through the URGWOPS EIS project. No additional sample collection or analysis was part of this project. The following sections characterize each dataset.

3.1.1 U.S Fish and Wildlife Service 2002-2003 Dataset

The 2002-2003 USFWS study on water quality in relation to RGSMs and their habitat contained more than 15,600 analytical results across as many as 189 unique analytes in samples collected from 14 sites, each including two to four individual sampling events (USFWS 2004). Tables from the USFWS report, available as individual Excel worksheets, were reformatted, compiled into a single spreadsheet, and imported into Microsoft Access. In addition, data were subsequently sorted to produce three separate media databases, one each for water, sediment, and tissue.

The results presented include detectable concentrations as well as non-detected concentrations (in other words, concentrations less than the MDL) for many chemical analytes. If an analyte (i.e., chemical) was detected in any one sample, then one-half of the MDL was used to "fill" the concentrations for all other analyses for chemical where a "non-detectable concentration" was indicated in the dataset. This *data augmentation* procedure thus assumes the compound was present in the river and in all samples at low concentrations (averaging 0.5 times the MDL) whenever at least one of the samples exhibited a value greater than the MDL. For example, if out of 38 measurements for an analyte at least one was reported as greater than the MDL, then the remaining 37 results for that analyte were "filled" to show a concentration of one-half the MDL for each of the sample's remaining analytical results. (Note that the MDL can vary among individual analyses conducted on different samples or at different times. Also, this data augmentation technique can result in the insertion of values that exceed risk screening criteria.). Where the analyses for an analyte resulted in no detections in any samples of a medium for an analyte, all "non-detect" (ND) results presented by USFWS were converted to "null" values (i.e., blanks) for all results for the analyte. This procedure assumes that the analyte is not present in the MRG, at least in any detectable or ecologically meaningful concentrations, and that any risk via this parameter is insignificant. This procedure was separately applied for the water, sediment, and tissue data.

Exposure profile results by medium for the MRG, computed and presented as part of this risk assessment, include the lists of the chemicals analyzed in the USFWS study; the number of analyses for each analyte in each medium; the number of samples with concentrations above the MDL by medium; and the minimum, average, and maximum concentration per analyte in each medium (including data augmented under the rules defined above for the ND results reported in the original USFWS dataset).

3.1.2 URGWOPS EIS Dataset

The URGWOPS EIS project compiled an extensive dataset that included greater than 250,000 individual analytical results. Reservoir operations and discharge flow alternatives that would affect the MRG were the primary focus of this EIS. The U.S. Geological Survey (USGS) compiled this database under contract to Reclamation from a variety of organizations, including the USGS itself, USEPA, the U.S. Forest Service, Reclamation, USACE, and the New Mexico Environment Department (NMED). The data include more than 38,400 individual sampling events yielding over 250,000 analytical results and physical analyses for 414 parameters. The data were collected between 1947 and 2000 from sites along the Rio Grande and associated tributaries, drains, ditches, outfalls, and reservoirs along and adjoining the URGWOPS project area in New Mexico, southern Colorado, and northwestern Texas. The database contains data for water, sediment, and various biota samples.

After permission had been obtained to use the data from the lead agency managers of the URGWOPS EIS project, the dataset was exported by the USGS into a set of flat-field text files and then supplied to the project team. These records were then organized and imported to form a set of relational database files to allow data management using Microsoft Access. Based on concerns related to the quality of older data and variety of analytical methods used over the years, the dataset was trimmed to include only results for samples collected on or after January 1, 1985. These data were further trimmed to include results only for samples collected from the Rio Grande between its confluence with Rio Chama and upstream of Elephant Butte Reservoir (latitude 36.066 N to 33.153 N). Due to intractabilities found in the latitude-longitude characterization of the site locations field, the final set of sites was culled to include sites only located within the five reaches of the MRG described in Section 2.1.3 (see Figure 1).

Evaluation of data for sites along the irrigation system and for tributaries to the Rio Grande is beyond the scope of this project. The resulting dataset was then separated into three databases (water, sediment, and biota). Thus, the second set of exposure profile results for the MRG, computed and presented by medium as part of this risk assessment, includes the chemicals included in the URGWOPS database; the number of analytical results presented for each analyte in each medium; the number of samples with detected concentrations by medium; and the minimum, average, and maximum concentration for each analyte in each medium.

MDLs were not reported in the URGWOPS dataset; however, based on data qualifiers and visual review of the data, the reported values for many analytes exceeding screening benchmarks appeared to be due to overly high MDLs. It was then assumed for analytes that had reported a value exceeding screening criteria with a data qualifier of "<" or ">" the value was an MDL and not an actual concentration. (See Section 3.1.3 for further discussion of data qualifiers.) For many chemicals, there were several values flagged to suggest multiple MDLs, and often the dataset included many more data entries of values equal to these that were unflagged. For these, it was assumed that all unflagged values in the dataset for each analyte that were equal to the assumed minimum MDL value, flagged as indicated above, were also values at the minimum MDL. Data augmentation, as discussed for the USFWS data, was not applied to the URGWOPS data. It was assumed that all reported values equal to the assumed minimum MDLs are MDLs, and that the lack of data qualifiers is due to differences in data reporting from multiple sources. A limitation of this method is that the reported values in the URGWOPS dataset lacking data qualifiers, but that had apparent MDL flags in the database for equal values, were not counted as MDL exceedances, potentially biasing characterizations of MDL exceedances in this assessment of the URGWOPS dataset. There were no data reported as ND.

The exposure profile results for MRG water quality analyzed in the URGWOPS dataset, as presented in Section 4.4.1, include the lists of the chemicals; the number of analyses for each analyte; the number of samples with concentrations above the screening benchmark; the number of samples with reported values that are assumed to be MDLs and exceed the screening benchmark; the assumed MDL range that exceeds the screening benchmarks; and the minimum, average, and maximum concentration per analyte in water.

3.1.3 Data Usability

Data in each dataset were evaluated for usability before they were used for risk screening. The evaluation of usability was primarily based on data completeness and the level of QA/QC associated with each dataset using the categories defined in Section 2.2.

The QA/QC procedures for the USFWS dataset included 100 percent review and verification. The environmental sample data that did not meet QA/QC criteria were reported in the dataset with qualifiers or data flags. The flags indicated data that were noncompliant, but they were considered usable for the purposes of the USFWS study. A full description of the data qualifier codes for the USFWS dataset can be reviewed in the USFWS (2004) water quality report. The entire USFWS dataset was classified as Category 4 data for the purpose of this study as well.

Inconsistent information was included in the URGWOPS dataset to assess QA/QC. While some QA/QC qualifiers were paired with some data for most data, there was little to no basis for assessing the QA/QC level. Therefore, where possible, the URGWOPS dataset was primarily divided into two data usability categories, based on the QA/QC qualifiers:

URGWOPS Data QA/QC Qualifiers	Definition	Data Usability Category
3	Approved for transfer	Category 3
A	QA/QC information not reported	Category 2
H	Laboratory and field values "In Review"	Category 2
I	Laboratory and field values "In Review"	Category 3
U	Analyzed, not detected	Category 2
M	Presence verified, not quantified	Category 3
E	Estimated value	Category 2
<	Less than value listed	Category 2
>	More than value listed	Category 2

A selection of entries in the URGWOPS database included blanks for the analytical results; most are accompanied by a data flag indicating that the chemical's "presence [was] verified, not quantified." As such, these entries were classified as Category 1 data. All Category 1 entries were deleted from the data analysis. No Category 4 data were identified in the URGWOPS dataset.

3.2 Identification, Compilation, and Use of Risk Screening Benchmarks

This subsection describes the methods whereby risk-screening benchmarks were selected for use in assessing water quality data for the MRG. Separate sets of benchmarks were compiled for each of the three environmental media assessed: surface water, sediment, and fish tissue. In addition, the project team compiled an additional set of species-specific benchmarks using the limited set of toxicity data available for RGSMs, as supplemented with the more extensive set of toxicity data available for FHMs. The following subsections also include information on the application of these benchmarks and introduce general cautions for their interpretation; additional information intended to aid interpretation of specific benchmarks is included in Sections 4 and 5.

3.2.1 Surface Water Benchmarks

A primary source of benchmark information used in risk assessment for aquatic life is the national water quality criteria for aquatic life developed by the USEPA. Development of these criteria is based on a process outlined by Stephan and others (1985) and USEPA (1994), and involves both acute and chronic toxicity testing with at least one species of freshwater animal in each of at least eight different families:

(1) The family Salmonidae in the class Osteichthyes (commonly, rainbow trout is used)

(2) A second family in the class Osteichthyes, preferably a commercially or recreationally important warmwater species, such as bluegill or channel catfish

(3) A third family in the phylum Chordata (may be in the class Osteichthyes or may be an amphibian; often FHMs are included here or in the above category)

(4) A planktonic crustacean such as a cladoceran or copepod

(5) A benthic crustacean (ostracod, isopod, amphipod, or crayfish)

(6) An insect (mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, or midge)

(7) A family in a phylum other than Arthropoda or Chordata, such as Rotifera, Annelida, or Mollusca

(8) A family in any order of insect or any phylum not already represented (often tests with algae or less often with aquatic plants are included here)

A fundamental limitation of these methods for deriving water quality criteria for arid Western waters is also discussed by USEPA (1994). That is, the list of acceptable species for developing criteria includes at least several taxa that are not typically found in many waters in the West and that are rarely found in any ephemeral waters of the West. For example, one requirement is for test data to include species from the family Salmonidae, a group that does not occur in the MRG, but one that often helps to drive the national criteria. Also, the toxicity test waters commonly used in exposures intending to assess relationships to aquatic species typically have very low concentrations of dissolved minerals; i.e., many tests are conducted using water from the upper Great Lakes. Yet, regulatory standards established by Native American Tribes and the State of New Mexico for toxic substances are primarily based on the national criteria developed under these guidelines and test conditions. Regionally derived criteria are needed, which would be developed using native western taxa and water quality conditions with higher dissolved mineral concentrations to improve specificity to arid Western waters.

The national criteria are designed to be protective of 95 percent of the aquatic species. That is, chemical concentrations in surface waters that are below the national criteria levels are considered to be protective of most aquatic resources across the nation. Conversely, chemical concentrations that exceed these water quality standards and criteria are commonly taken to indicate that risks to the aquatic community are present. The USEPA recognizes, however, that these national criteria may be over or under protective over local or regional areas. Specifically, site-specific factors, some of which occur over regional scales, can modify a parameter's potential toxicity. For example, copper in excess of the standard in the presence of high concentrations of dissolved solids or organic matter is minimally bioavailable and thus is not toxic, even when it exceeds its criterion. Therefore, these elevated concentrations must be individually evaluated during risk assessments and in the context of the environment, target organism, and characteristics of the aquatic community.

3.2.1.1 Benchmark Identification and Compilation

Water quality benchmarks or toxicity reference values (TRVs) for specific chemicals detected in the MRG were compiled from a variety of sources, including the following

- NMED "Standards for Interstate and Intrastate Surface Waters," amended July 15, 2005 (NMED 2005)
- Pueblo of Isleta Surface Water Quality Standards (2002)
- Water Quality Code of the Pueblo of Santa Clara (1995)
- Pueblo of Sandia Water Quality Standards (2000)
- San Juan Pueblo Water Quality Standards (1998)
- EPA's National Recommended Ambient Water Quality Criteria (AWQC) (2002)
- Michigan Department of Environmental Quality (DEQ) 2005 update of water quality values to protect humans, wildlife, and aquatic life (i.e. their Rule 57 procedures)
- Oak Ridge National Laboratory (ORNL 1996), Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota
- Revised Canadian Environmental Quality Guidelines (Canadian Council of Ministers of the Environment 1996)
- New York Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations (New York State Department of Environmental Conservation 1999)
- A Compendium of Working Water Quality Guidelines for British Columbia (Nagpal and others 2001)

3.2.1.2 Benchmark Application and Interpretation

TRVs used to assess risks to aquatic life in the MRG were selected using the following priority order: state or tribal standards applicable within the assessment area, federal criteria, Tier II criteria, other state and USEPA regionally derived standards or criteria, and Canadian criteria. TRVs for use both Tier I and Tier II risk screening were selected first based on the lowest tribal or New Mexico state standards. If appropriate criteria for a chemical in the MRG were not available from these water quality standards, the lowest of USEPA's AWQC were used. In many cases, AWQC also were not available for chemicals detected in the MRG. In that case, Tier II TRVs compiled by the Michigan DEQ (2002) were used; this set of TRVs is thoroughly evaluated and regularly updated, making it the single best and most current source of information on toxicity-based effects thresholds. Where Michigan DEQ criteria were lacking, ORNL Tier II toxicological benchmarks were used; the ORNL benchmarks are an older compilation, but have a long history of use. Both the Michigan and ORNL compilations include secondary acute and chronic values that are derived much like AWQC but that do not meet the eight-family requirements to derive an AWQC value. These Tier II values are derived according to the Great Lakes Water Quality Initiative Approach (GLWQI) and tend to be highly conservative because they are based on fewer toxicity tests than the number of tests used to derive criteria. A safety factor is applied to the criteria based on the number of families included in deriving the value to make up for the lack of toxicity data, meaning that the fewer the families used, the higher the safety factor. USEPA Region 4 acute and chronic ecological screening values were used next where an appropriate ORNL Tier II criterion for a chemical was not available. These criteria are based on relatively few toxicity studies (in many cases, a single acute study). The acute response data, the lowest acute LC_{50} or EC_{50} if more than one study is available, is divided by 10 to obtain the chronic value.

Additional sources to address other MRG chemicals that lacked screening criteria from the above sources included (1) Canadian environmental quality guidelines, (2) New York State Department of Environmental Conservation (NYSDEC) standards, and (3) British Columbia guidelines. These sources were consulted only for specific compounds where available criteria were not identified after review of the above sources; thus, only the criteria needed from these sources were compiled during this assessment. Finally, lack of criteria for analytes detected in the MRG in any of these sources is indicated in the results as a data gap.

All screening criteria compiled for aquatic life are presented in the results section tables, with the TRV used in Tier I screening shown in bold. Chronic effects values are selected for use as screening TRVs for this risk assessment because they represent a conservative threshold to define low- or no-effects concentrations based on extended exposure to protect the propagation of aquatic life. Continuous exposure of organisms over an extended period can affect survival, growth, reproduction, and internal physiological and biochemical processes. For three risk screening benchmarks defined, only acute toxicity TRVs were available (aldrin, bis[2-ethylhexyl]pthalate, and silver). For these three chemicals, their acute TRVs were each divided by 10 to estimate their chronic TRVs.

TRVs for arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc include consideration of ambient water hardness. Increasing hardness for these metals correlates with lower toxicity, whereas decreasing hardness results in increased toxicity. Mathematical equations that describe these relationships have been developed as part of the national criteria to integrate the influence of hardness in defining the criteria, and these equations are integrated in state and tribal water quality standards. The median hardness (175 mg/L) calculated using the data collected during the USFWS 2002 and 2003 studies was used as a representative and conservative value that could be used to derive hardness-based TRVs because multiple hardness values were collected over different flow conditions at each sample location.

In recent years, USEPA's position has evolved to acknowledge that the dissolved forms of metals typically represent the more biologically available and more toxic fraction. Historically, however, the national criteria for metals were expressed as total or total recoverable metals. To accommodate this shift, USEPA has derived and published conversion factors to define the relationship between total recoverable and dissolved metals. Risk screening criteria for the following metals in the MRG are therefore expressed as dissolved rather than total recoverable concentrations: arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. Appropriate conversion factors are available from USEPA only for these metals. In some instances, to aid in the assessment of MRG data reported as total concentrations, the conversion formula was modified to allow back-calculation of the TRV for some of the reported metal concentrations. Many volatile and semivolatile organic compounds and herbicides or pesticides were reported in the URGWOPS dataset in both the total and dissolved forms. Typically, these compounds and their screening criteria are reported only as total concentrations; therefore, lacking any better alternative, the screening criteria for the total concentrations of these analytes were also applied to assess reported dissolved concentrations.

Several TRVs are pH-dependent. The acute and chronic benchmarks for aluminum from USEPA AWQC (1988) for example, are for waters where pH levels are within the specified range of 6.5 to 9. The criteria are not mathematically derived values based on pH; rather, they are empirically derived from laboratory and field studies and apply to the range of 6.5 to 9. The combined pH range from the datasets is 6.6 to 9.7. This criterion is considered conservative for waters with a pH higher than 9.

Pentachlorophenol is also pH dependent, and a pH of 6.7 was used for the calculation of criteria as a worst-case exposure scenario for this assessment.

The criterion for ammonia (NH_3) depends both on pH and temperature, as well as on the presence or absence of a specific sensitive trout and salmon species. For the assessment of the MRG, a pH of 8.4 at 30°C, the absence of salmonid species, and the presence of early life stages were used as a worst-case scenario to select the screening benchmark for total ammonia. The acute toxicity of ammonia, as un-ionized ammonia, has been shown to increase as pH decreases, and aquatic toxicity also increases as temperature increases. So, as the temperature increases and pH decreases, total ammonia toxicity increases. Screening benchmark selection and applicability in identifying COPCs is examined individually in subsequent sections.

3.2.2 Sediment Benchmarks

Numerous chemical-specific benchmarks for sediment are available in the literature. Toxicity-based benchmarks were available for many of the chemicals detected in the MRG. Methods for establishing sediment benchmarks vary widely based on the species used, exposure regimes, endpoints, and interpretation of data. Most sediment benchmarks are derived based on responses of aquatic invertebrate taxa, including amphipods, midges, mayflies, oligochaetes, daphnids, various bivalves, and bacteria. These organisms are selected primarily because they live in intimate contact with sediments and because control of exposures can be both precise and accurate during testing, making interpretation of results straightforward. Measurement endpoints used in the exposure tests range from survival, growth, body deformities, and reproduction, to more subtle effects such as changes in biochemical biomarkers, for example, luminescence. Testing can include field or laboratory exposures of organisms to individual chemicals or chemical mixtures. Ecological risk assessment benchmarks derived from the measurement endpoints used in the testing are commonly based on varying levels of effects. In addition, they often include an uncertainty factor to accommodate the issues related to widespread application of a benchmark that is based on a single species or only a few species.

Besides the variations noted in generating data used for deriving benchmarks, approaches to interpreting the results differ as well. Some assessments define benchmarks using a 15th percentile value for a low- or no-effect benchmark and an 85th percentile for high effects. Others are more conservative and consider a concentration protective only at a 95 percent confidence level (in other words, they define protection at the individual versus the population level). Example threshold levels include effects range–low (ER-L), apparent effects threshold (AET), and upper effects threshold (UET).

Collectively, these values, and others like them, are commonly referred to as sediment quality guidelines (SQGs). MacDonald and others (2000) indicate that the numerical SQGs for any substance can differ by several orders of magnitude, depending on the derivation procedure and the intended use. Despite the wide range of benchmark values, derivation procedures, and endpoints, there has been an ongoing effort over the last 5 to 8 years to develop SQGs that are consensus-based (see for example MacDonald and others 2000, Ingersoll and others 1996). The goal of these efforts is to integrate the various studies conducted to date and to develop a two-tiered benchmark approach that includes a backing in real data from multiple field and laboratory studies. This approach produces benchmarks that are broad-based, more accurate in the level of toxicity, and better correlated to effects.

3.2.2.1 Benchmark Identification and Compilation

There are several different methods for deriving sediment benchmarks, and there is variability in the endpoints and responses used. Each approach has certain advantages and limitations that influence their application in the assessment process for sediment (MacDonald and others 2000). The disadvantage of using these benchmarks to assess risks to RGSMs is that benchmarks for sediment quality have been developed based on the response of invertebrates to chemicals in bottom sediments. Therefore, sediment benchmarks are applicable to concentrations of chemicals in sediments.

The literature reviewed in developing benchmarks used in the assessment of the MRG included the following documents:

- Hellyer and Balog (1999) – Derivation, strengths, and limitations of sediment ecotoxicological screening benchmarks (ESBs)
- MacDonald and others (2000) – Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems
- Washington Department of Ecology (1995) – Washington Sediment Management Standards
- Buchman (1999) – NOAA Screening Quick Reference Tables
- Jones and others (1997) – Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision
- Ingersoll and others (1996) – Calculation and evaluation of sediment effects concentrations for the amphipod *Hyallela azteca* and the midge *Chironomus riparius*
- EPA (1999a) – Region 6 Screening-Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities
- Florida Department of Environmental Protection (2003) – Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters: Technical Report
- EPA (2003) – Region 5 RCRA Ecological Screening Levels

- MacDonald and others (1999) – A Compendium of Environmental Quality Benchmarks

SQGs for the MRG were compiled from MacDonald and others (2000) for several metals, including arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. SQGs for 10 individual polycyclic aromatic hydrocarbons (PAHs) and total PAH were also available from MacDonald and others (2000). The SQGs were identified for the following individual PAHs: anthracene, fluorine, naphthalene, phenanthrene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and pyrene. SQGs were available from MacDonald and others (2000) for total polychlorinated biphenyls (PCBs) and several organochlorine pesticides: chlordane, dieldrin, sum DDD, sum DDE, sum DDT (where the sum is equal to the total of the isomers for the compound), total DDTs (where the total is equal to the sum of DDD, DDE, and DDT), endrin, heptachlor epoxide, and lindane. Values presented in MacDonald and others (2000) are based on sediment dry weight.

The SQGs used for the MRG were augmented with values in MacDonald and others (2003), which were developed for the Florida Department of Environmental Protection. Additional sediment screening values were compiled from other sources listed earlier in this subsection.

Although the terms threshold effects concentration (TEC) and probable effects concentration (PEC) were used throughout the assessment, not all values used (unless from MacDonald and others 2000) were derived as consensus-based effects levels. For example, values from USEPA Region 5 were largely based on an equilibrium partitioning approach for deriving numeric sediment screening values from water quality effects data. These screening effects levels were included in the TEC category. Although they are not formally derived as TECs via the process of MacDonald and others (2000), they are, like the TECs, the best screening benchmarks available.

3.2.2.2 Benchmark Application and Interpretation

SQGs are not formally derived criteria. Nonetheless, TECs and PECs derived following the process outlined in MacDonald and others (2000) have been generally found to offer useful predictive potentials. More often than not, concentrations in sediment that are less than the TECs have been found not to produce toxic responses, whereas concentrations in sediment that exceed the PECs are generally found to be toxic.

SQGs presented in MacDonald and others (2000) were selected as the primarily source for screening benchmarks used in this assessment of the MRG because their SQGs are comprehensive, are consensus-based with regard to effects, and their predictive value is relatively high. (So, for example, toxicity is projected more often when the assessment benchmark is exceeded, and “no effects” are projected more often when it is not exceeded.) This assessment therefore presents TECs and PECs from the literature. Harmful effects on sediment-dwelling organisms are not expected at concentrations below the TEC; harmful effects on sediment-dwelling organisms are expected to occur more frequently at concentrations above the PEC.

Concentrations of chemicals detected in MRG sediments that fall below the TEC or its equivalent indicate very low to no potential for adverse effects. The detected chemicals that exceed their PECs indicate that potential effects are probable and are identified in the results as COPCs. Effects are more uncertain in the area between the TEC and the PEC and range from very low expected occurrence of effects on highly likely occurrence of effects. MacDonald and others (2000) and a more recent study by Field and others (2002) point out that even at the TEC, not all samples predicted to be non-toxic are non-toxic; similarly, not all samples predicted to be toxic at the PEC are toxic.

3.2.3 Tissue Benchmarks

Data for residues in fish tissue can be reported for concentrations of chemicals in whole body fish or for individual organ tissues. These data are included in both the USFWS and URGWOPS datasets. The implications of these residues were evaluated by comparing the concentrations measured for MRG fish to criteria defined using effects relationships for concentrations in fish tissue compiled from published reports of results from various laboratory and field studies.

3.2.3.1 Benchmark Identification and Compilation

Tissue residue effects data were extracted primarily from two databases:

- Jarvinen, A.W., and G.T. Ankley. 1999. Linkage of effects on tissue residues: Development of a comprehensive database for aquatic organisms exposed to inorganic and organic chemicals. Society of Environmental Toxicology and Chemistry (SETAC) Press, Pensacola, Florida.
- USACE. 2003. Environmental Residue Effects Database (ERED).

Both databases compiled effects data for aquatic organisms (including fish, invertebrates, and algae) exposed to a number of chemicals. This assessment used only tissue residue effects data from fish as risk assessment criteria. A hierarchy of tissue effects data was established in the criteria definition process because the emphasis of this assessment is on RGSMs, using FHMs as a suitable surrogate:

1. When whole-body residue data were available for FHMs, these data were preferentially selected for use as screening benchmarks.
2. If data for FHMs were not available, tissue data from warmwater fish species were used.
3. If either of these data types was not available, then tissue residue data for a salmonid or other referenced freshwater fish species were used.

4. Tissue residue effects data from marine species were selected only if alternative tissue residue data, as indicated above, were not available.

All of the fish tissue data available from the two datasets for the MRG are for whole-body samples of fish. Therefore, effects data for whole body residue concentrations were used when available to complete the MRG assessment. Tissue-specific residue data (for gill, liver, or muscle tissue, for example) were used only if no whole-body data were available. The preferred endpoints for this assessment were growth or reproductive effects (or both); survival data were used if data for growth or reproductive effects were not available. In addition, results from longer-term exposures were preferentially selected over short-term exposures in developing the MRG assessment criteria.

3.2.3.2 Benchmark Application and Interpretation

Chemicals can bioaccumulate, bioconcentrate, and biomagnify. Although several of the chemicals evaluated for the MRG can biomagnify (which is the progressive buildup of a chemical through the food chain), the primary focus of assessing fish tissues is to evaluate the chemicals that bioaccumulate and bioconcentrate. Bioaccumulation refers to the net accumulation over time of metals (or other persistent substances) within an organism from both biotic (other organisms) and abiotic (soil, air, and water) sources. Bioconcentration is the accumulation of a chemical in tissues of a fish or other organism to levels greater than are found in the surrounding environment. Chemical concentrations reported in the MRG fish tissues can be the result of exposure via water, sediment, or the prey consumed. The dietary pathway for some chemicals, such as selenium, can be a much more important exposure route, in terms of toxicity, than is exposure through water. However, estimating doses of chemicals in fish by their individual exposure route is poorly understood. In addition, adequate models to describe these relationships, such as have been developed for wildlife, are largely not available. Thus, measured effects from laboratory or field studies are compared to evaluate potential ecological effects on fish based on measured tissue residues. These field studies evaluated specific endpoints such as survival, growth, reproduction, or other physiological or biochemical endpoints.

Tissue residue effects data for adult and early life stage fish were compiled separately, when available, because chemicals that accumulate in tissues can lead to differing levels of effects (depending on the life stage of the fish). Both the no effects residue (NER) and lowest effect residue (LER) concentrations were compiled for comparisons, when available, for each endpoint and life stage.

Qualitative comparisons of MRG fish tissue data used a variety of criteria defined from the fish tissue residue effects data. Risk screening criteria were defined from the literature review for 54 chemicals in tissue residues. Maximum tissue residue concentrations reported in each of the MRG datasets were compared with the corresponding lower value from the adult and early life stage residue effects values to assess maximum probable effects relationships in fish tissue. With regard to the chemicals measured in fish tissues from the USFWS and URGWOPS datasets, suitable tissue residue effects data could not be found to develop assessment criteria for 11 chemicals (barium, boron, cobalt, lithium, manganese, molybdenum, strontium, tin, titanium, dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA), and Nonachlor).

The defined criteria available for residue effects were used across all related metabolites or isomers for the chemical for several parameters where residue effects levels were available to define screening criteria for some metabolites or some isomers, but not others. Therefore, for example, alpha-, beta-, gamma-, and delta-hexachlorocyclohexane (BHC) tissue concentrations were assessed using effects relationships reported for gamma BHC.

Fish tissue residue effects data are typically reported on a wet-weight basis. Because much of the fish tissue data from both the USFWS (2004) and URGWOPS datasets were reported on a dry-weight basis, the tissue TRVs were converted to dry weight using an assumed dry/wet conversion factor of 0.2 (Jarvinen and Ankley 1999).

3.2.4 RGSM/FHM Benchmarks

This ecological risk assessment is driven by the need to evaluate potential water quality effects on RGSMs in the MRG. Questions arise, however, as to whether the screening criteria compiled for this study, as based on potential effects on aquatic life in general, are sufficiently protective of RGSMs in particular. Therefore, data were separately reviewed and compiled to develop species-specific screening benchmarks appropriate for RGSMs to better assess potential effects on RGSMs. As introduced first in Section 2.1.1, this set of benchmark criteria assumed that FHMs are reasonable surrogates to evaluate potential water quality effects on RGSMs (Buhl 2002; Lusk 2005).

The RGSMs/FHMs criteria set was developed using information available for both species to create a toxicity response profile for RGSMs and FHMs as related to chemicals detected in the MRG. Toxicity response data for both species were compiled from Buhl (2002). In addition, response data for FHMs were compiled from USEPA AWQC (Table A1) documents and the AQUIRE on-line database, which is part of the ECOTOX (ECOTOXicology) database (USEPA 2005).

Buhl (2002) provides the only known study that reported toxicity testing information for RGSMs. This study also evaluated the suitability of using FHMs as a surrogate for RGSMs through comparative short-term and long-term toxicity tests. Chemicals compared included arsenic, total residual chlorine, copper, and ammonia. In compiling information from that report, this report presents results that show the most sensitive species tested, the RGSM and FHM ratios, as well as the specific toxicity response values for each analyte tested.

Screening benchmarks for FHMs were also compiled from USEPA's chemical-specific AWQC documents for priority pollutants (Table A1) with a note that not all of the USEPA's criteria documents were available for use in this project. Most of these documents include specific toxicity testing results for FHMs. The species-mean acute and chronic values for FHMs and the acute to chronic ratio were compiled from these documents. Only acute or chronic test results were reported for some analytes, however. Appropriate screening values were calculated for these analytes if an acute to chronic ratio was provided; the acute value was divided by 10 to obtain the chronic value for risk screening if information on this ratio was lacking. (For completeness in the screening table, if only a chronic value was available, it was multiplied by 10 to obtain an acute value.) Data from the compiled information available in the criteria documents are presented for each analyte on the most sensitive species tested, the relative ranking of FHM sensitivity to analyte exposure among the reported taxa, species-mean acute and chronic values, and acute-to-chronic ratios.

Additional screening benchmarks for FHMs were compiled from the AQUIRE database. This database contains data on aquatic toxicity that include freshwater, marine, and estuarine exposures to animal and plant species. Chemical exposure must be through water, diet, injection, or skin for data to be included in this dataset; sediment studies are not included unless a pore (or overlying) water concentration is provided. The database includes studies dating back to 1915, but the majority of the data encompass test results reported from 1970 to the present. The aquatic data were used historically to estimate the toxicity of chemicals that lack toxicity data based on similarities in chemical structure and to project toxicant activity potentials, anticipating that water quality criteria could be defined based on these structure-activity relationships. To this end, the database has focused on encoding standard calculated test endpoints, such as the LC_{50}, that can be used to compare toxic effects across species, chemicals, and endpoints.

Constraints on the data to be used for MRG risk assessment were necessary because of the structure of the database. Stephan and others (1985) defined an acceptable acute toxicity test value for FHMs as derived from 96-hour EC_{50} or LC_{50} tests; this requirement is consistent with the other MRG risk screening benchmark criteria that have been compiled. Therefore, all of the FHM toxicity testing data for 96-hour EC_{50} and LC_{50} values were queried from the AQUIRE database for use in this assessment. When the database query yielded multiple EC_{50} and LC_{50} values for an analyte, the geometric mean of these values was calculated. Only data from 7-day NOELs or 28- to 32-day NOELs were selected for chronic toxicity values, and the geometric mean for each analyte was again calculated when the data query produced multiple values for an analyte. Chronic toxicity test data were selected based on the recommendations in the USEPA GLWQI and in Stephan and others (1985) that chronic tests be of 28- to 32-day duration. The 7-day short-term chronic test results were also included because USEPA supports them as an appropriate test for assessing potential chronic effects on this species. In comparison to acute toxicity results, markedly fewer chronic values for analytes are available from the AQUIRE dataset.

The difference between information from USEPA AWQC documents and AQUIRE is that FHM testing reported in the USEPA documents is subject to review to ensure that the testing was in accordance with applicable guidelines. Conversely, requirements for entry into AQUIRE are not equally rigorous. In addition, information in the AQUIRE database is updated more frequently and consequently is more recent. As a result, information in AQUIRE on toxicity testing can vary significantly from the USEPA AWQC toxicity relationships for some chemicals.

The most sensitive risk screening benchmark for RGSMs and FHMs was identified after all available toxicity response values for RGSM/FHM were compiled from the above sources. That value for each analyte was then compared with the aquatic-life screening benchmark to evaluate which of the two provided greater sensitivity for screening potential effects in the MRG. Several additional risk screening benchmarks for analytes resulted from the RGSM and FHM compilation where no aquatic-life benchmark had been previously identified.

3.3 Risk Screening

The first step with regard to characterizing risk in the MRG is estimating the representative exposure point concentrations (EPCs) for chemicals in the environmental media to which receptors may come into contact. The steps in the risk screening are discussed in the subsections that follow.

3.3.1 Tier I Risk Screening

As discussed in Section 3.1, analytical results compiled from the existing datasets for surface water, sediment, and biological tissue samples were used to estimate separate EPCs for the MRG by individual analyte and medium. In the Tier I risk assessment for the MRG, these EPCs are compared with risk screening benchmarks. These benchmarks have been compiled and defined through the steps described in Section 3.2. This approach produces the most conservative assumptions of exposure and effects, consistent with USEPA risk assessment guidance (USEPA 1998). The maximum concentrations of chemicals in sediment, surface water, and tissue that exceed the screening-level effects values are carried forward as COPCs to the next steps in the risk assessment.

3.3.2 Tier II Risk Screening: Derivation of Exposure Point Concentrations

The second risk screening tier sometimes called *baseline risk assessment* in Superfund assessments, refines EPCs for each COPC to which a receptor may be exposed in each medium. As suggested in guidance (USEPA 1998), site-wide EPCs in abiotic and biotic exposure media can be represented by the 95 percent upper confidence limit (UCL) on the mean of the concentrations reported for each analyte. EPCs for the MRG are based on the 95 percent UCL derived in this ecological risk assessment using a statistical software package, ProUCL (USEPA 2004), which evaluates the distribution of each input dataset and calculates representative upper-bound concentrations. ProUCL was developed to test the normality or lognormality of a data distribution and to compute a conservative and stable upper confidence limit of the population mean (USEPA 2004). ProUCL provides recommendations for 95 percent UCLs for (1) normally distributed datasets, (2) lognormally distributed datasets, and (3) datasets that are neither normal nor lognormal (nonparametric data). The ProUCL calculations are consistent with recommendations in USEPA (2004) guidance for calculating exposure point concentrations at hazardous waste sites.

The resulting 95 percent UCL concentrations derived for each parameter as output from Pro UCL are presented in the tables in the results section. The maximum value was used as the EPC if the 95 percent UCL exceeded the maximum detected value. Most COPCs that remain after this step in the assessment are assigned the highest priorities for continuing water quality assessment project support by the Program.

4.0 WATER QUALITY RISK SCREENING

The following subsections present the risk screening benchmarks compiled for the aquatic community and RGSMs in the MRG; characterize a selection of potential ecological effects associated with chemicals detected in the MRG; describe the exposure-point estimates projected using the analytical results compiled for samples collected from the MRG; report the levels of risk projected for chemical concentrations found in MRG water, sediment, and tissue; and identify priority COPCs that are candidates for future sampling and assessment.

4.1 Risk Screening Benchmarks

The following subsections briefly introduce the risk screening benchmarks contained in the accompanying tables that have been compiled to assess risks to aquatic life from chemicals in MRG water, sediment, and fish tissue, and risks to RGSMs specifically from chemicals in water.

4.1.1 Benchmarks to Assess Potential Water Constituent Effects on Aquatic Life

Conservative risk screening benchmarks, based on potentially adverse effects related to chronic chemical exposure, were compiled for chemicals detected in surface water samples from the MRG in either the UWFWS or the URGWOPS datasets, as discussed in Section 3.2.1. The compiled results for 184 surface-water risk benchmarks are presented in Table 1. This table includes the candidate screening values compiled from each source reviewed. The specific benchmark selected for each chemical across the various sources is shown in **bold** on the table under the source for the value. All screening benchmark criteria selected are also compiled in the second column of the table.

Organisms require certain concentrations of trace elements to maintain normal healthy physiological and biochemical processes. Included among these essential nutrients are calcium, magnesium, potassium, copper, iron, manganese, selenium, and zinc. However, there is a sometimes fine (and often a not-so-fine) line between chemical concentrations needed for health maintenance and concentrations that produce toxicity. Fish (like any other organism) are naturally able to regulate the concentrations of essential trace elements. However, if the exposure to and accumulation of trace elements exceeds their internal regulatory functions, excess residual concentrations in tissue can become toxic and detrimental to normal functions. Other trace elements, such as mercury, cadmium, and arsenic, are not included among the essential nutrients; excessive accumulation of these trace elements can cause adverse effects in fish. Mercury is currently classified as persistent, bioaccumulative, and toxic (PBT) by USEPA due to its wide range of effects and distribution in the environment.

Table 1. Benchmark Basis Used to Screen Risk to Aquatic Life for Contaminants in Water

Analyte	Screening Criteria	Units	NMAC 20.6.4		Lowest Tribe Aquatic Water Quality Criteria[a]		Lowest Tribe Aquatic Water Quality Criteria Reference	EPA 2002 Water Quality Criteria		Michigan Rule 57 Tier II values (Rev. 2/1/2005)		Oakridge values (Rev. 1996)				Canadian Environmental Quality Guidelines (Rev. 1996)[b]	British Columbia (Rev. 2001)[b]	NYSDEC (Rev. 1999)[b]	
												Tier II Values		*Region IV*					
			Acute (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)	Pueblo	CMC (ug/L)	CCC (ug/L)	AMV (ug/L)	FCV (ug/L)	SAV (ug/L)	SCV (ug/L)	ASV (ug/L)	CSV (ug/L)	Chronic (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)
1,1,1-Trichloroethane (total)	**89**	ug/L	--	--	--	--	--	--	--	800	**89**	200	11	5,280	528	--	--	--	--
1,1,2,2-Tetrachloroethane (total)	**380**	ug/L	--	--	--	--	--	--	--	910	**380**	2,100	610	932	240	--	--	--	--
1,1,2-Trichloro-1,2,2-trifluoroethane (total)	**32**	ug/L	--	--	--	--	--	--	--	280	**32**	--	--	--	--	--	--	--	--
1,1,2-Trichloroethane (total)	**500**	ug/L	--	--	--	--	--	--	--	2,800	**500**	5,200	1,200	3,600	940	--	--	--	--
1,1-Dichloroethane (total)	**740**	ug/L	--	--	--	--	--	--	--	6,600	**740**	830	47	--	--	--	--	--	--
1,1-Dichloroethene (total)	**130**	ug/L	--	--	--	--	--	--	--	1,200	**130**	450	25	3,030	303	--	--	--	--
1,2,3-Trichlorobenzene (total)	**8**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	**8**	--	--	--
1,2,4-Trichlorobenzene (total)	**30**	ug/L	--	--	--	--	--	--	--	100	**30**	700	110	150	44.9	24	--	--	--
1,2,4-Trimethylbenzene (total)	**17**	ug/L	--	--	--	--	--	--	--	150	**17**	--	--	--	--	--	--	--	--
1,2-Dibromoethane	**0.006**	ug/L	--	--	--	--	--	--	--	--	**0.006**	--	--	--	--	--	--	--	--
1,2-Dichlorobenzene (total)	**13**	ug/L	--	--	--	--	--	--	--	120	**13**	260	14	158	15.8	0.70	--	--	--
1,2-Dichloroethane (total)	**2,000**	ug/L	--	--	--	--	--	--	--	8,200	**2,000**	8,800	910	11,800	2,000	100	--	--	--
1,2-Dichloroethene (total)	**1,100**	ug/L	--	--	--	--	--	--	--	9,600	**1,100**	--	--	--	--	--	--	--	--
1,2-Dichloropropane (total)	**230**	ug/L	--	--	--	--	--	--	--	2,000	**230**	--	--	5,250	525	--	--	--	--
1,2-Diphenylhydrazine (total)	**2.7**	ug/L	--	--	--	--	--	--	--	--	--	--	--	27	**2.7**	--	--	--	--
1,3,5-Trimethylbenzene (total)	**45**	ug/L	--	--	--	--	--	--	--	410	**45**	--	--	--	--	--	--	--	--
1,3-Dichlorobenzene (total)	**28**	ug/L	--	--	--	--	--	--	--	100	**28**	630	71	502	50.2	150	--	--	--
1,3-Dichloropropene (total)	**0.055**	ug/L	--	--	--	--	--	--	--	--	--	0.99	**0.055**	--	--	--	--	--	--
1,4-Dichlorobenzene (total)	**16**	ug/L	--	--	--	--	--	--	--	100	**16**	180	15	112	11.2	26	--	--	--
2,4,6-Trichlorophenol (total)	**5**	ug/L	--	--	--	--	--	--	--	39	**5**	--	--	32	--	--	--	--	--
2,4-D (total)	**220**	ug/L	--	--	--	--	--	--	--	1,400	**220**	--	--	--	--	--	--	--	--
2,4-Dichlorophenol (total)	**19**	ug/L	--	--	--	--	--	--	--	160	**19**	--	--	202	36.5	--	--	--	--
2,4-Dimethylphenol (total)	**380**	ug/L	--	--	--	--	--	--	--	1,300	**380**	--	--	212	21.2	--	--	--	--
2,4-Dinitrophenol (total)	**19**	ug/L	--	--	--	--	--	--	--	130	**19**	--	--	62	6.2	--	--	--	--
2,4-Dinitrotoluene (total)	**310**	ug/L	--	--	--	--	--	--	--	--	--	--	--	3,100	**310**	--	--	--	--
2-Butanone (MEK;ethyl methyl ketone; total)	**2,200**	ug/L	--	--	--	--	--	--	--	20,000	**2,200**	240,000	14,000	--	--	--	--	--	--
2-Chloroethyl vinyl ether (total)	**3,540**	ug/L	--	--	--	--	--	--	--	--	--	--	--	35,400	**3,540**	--	--	--	--
2-Chlorophenol (total)	**24**	ug/L	--	--	--	--	--	--	--	210	**24**	--	--	438	43.8	--	--	--	--
2-Hexanone	**99**	ug/L	--	--	--	--	--	--	--	--	--	1,800	**99**	--	--	--	--	--	--
2-Methyl-4,6-dinitrophenol (total)	**2.3**	ug/L	--	--	--	--	--	--	--	--	--	--	--	23	**2.3**	--	--	--	--
2-Nitrophenol (total)	**3,500**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	**3,500**	--	--	--	--
3,3'-Dichlorobenzidine (total)	**4.5**	ug/L	--	--	--	--	--	--	--	41	**4.5**	--	--	--	--	--	--	--	--
4-Bromophenyl phenyl ether (total)	**1.5**	ug/L	--	--	--	--	--	--	--	--	--	--	**1.5**	--	--	--	--	--	--

Table 1. Benchmark Basis Used to Screen Risk to Aquatic Life for Contaminants in Water (continued)

Analyte	Screening Criteria	Units	NMAC 20.6.4		Lowest Tribe Aquatic Water Quality Criteria[a]		Lowest Tribe Aquatic Water Quality Criteria Reference	EPA 2002 Water Quality Criteria		Michigan Rule 57 Tier II values (Rev. 2/1/2005)		Oakridge values (Rev. 1996)				Canadian Environmental Quality Guidelines (Rev. 1996)[b]	British Columbia (Rev. 2001)[b]	NYSDEC (Rev. 1999)[b]	
												Tier II Values		*Region IV*					
			Acute (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)	Pueblo	CMC (ug/L)	CCC (ug/L)	AMV (ug/L)	FCV (ug/L)	SAV (ug/L)	SCV (ug/L)	ASV (ug/L)	CSV (ug/L)	Chronic (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)
4-Chloro-3-methylphenol (total) (3-Methyl-4-chlorophenol)	**7.4**	ug/L	--	--	--	--	--	--	--	67	**7.4**	--	--	3	0.3	--	--	--	--
4-Isopropyltoluene (total)	**20**	ug/L	--	--	--	--	--	--	--	180	**20**	--	--	--	--	--	--	--	--
4-Methyl-2-pentanone	**170**	ug/L	--	--		--	--	--	--	--	--	2,200	**170**	--	--	--	--	--	--
4-Nitrophenol (total)	**60**	ug/L	--	--		--	--	--	--	540	**60**	1,200	300	828	82.8	--	--	--	--
Acenaphthene (total)	**38**	ug/L	--	--	--	--	--	--	--	100	**38**	--	--	170	17	5.8	--	--	--
Acetone (total)	**1,700**	ug/L	--	--	--	--	--	--	--	15,000	**1,700**	28,000	1,500	--	--	--	--	--	--
Acrolein (total)	**2.1**	ug/L	--	--	--	--	--	--	--	--	--	--	--	6.8	**2.1**	--	--	--	--
Acrylonitrile (total)	**66**	ug/L	--	--	--	--	--	--	--	590	**66**	--	--	755	75.5	--	--	--	--
Alachlor (total)	**11**	ug/L	--	--	--	--	--	--	--	150	**11**	--	--	--	--	--	--	--	--
Aldicarb (total)	**1**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	**1**	--	--	--
Aldrin (total)	**3**	ug/L	3	--	**3**	--	Sandia San Juan Santa Clara	3	--	0.15	0.017	--	--	3	0.30	--	--	--	--
Alkalinity, as $CaCO_3$ (dissolved)	**20,000**	mg/L as CaCO3	--	--	--	--	--	--	**20,000**	--	--	--	--	--	--	--	--	--	--
alpha-Endosulfan (total)	**0.056**	ug/L	0.22	0.056	0.22	**0.056**	Sandia	0.22	0.06	--	--	--	--	0.22	0.06	--	--	--	--
Aluminum (dissolved)	**87**	ug/L	750	**87**	750	**87**	Isleta Sandia - acute Santa Clara	--	--	--	--	--	--	750	**87**	--	--	--	--
Aluminum (total)	**87**	ug/L	--	--	--	--	--	750	**87**	--	--	--	--	--	--	--	--	--	--
Ammonia (total) as nitrogen**	**0.475**	mg/L as N	3.88	0.475	3.88	**0.475**	Isleta Sandia San Juan	3.88	0.475	0.21	0.053	--	--	--	--	19	--	--	--
Anthracene (total)	**0.73**	ug/L	--	--	--	--	--	--	--	--	--	13	**0.73**	--	--	0.012	--	--	--
Antimony (total)	**240**	ug/L	--	--	--	--	--	--	--	1,100	**240**	180	30	1,300	160	--	--	--	--
Aroclor 1221 (total)	**0.28**	ug/L	--	--	--	--	--	--	--	--	--	5	**0.28**	0.2	0.014	--	--	--	--
Aroclor 1232 (total)	**0.58**	ug/L	--	--	--	--	--	--	--	--	--	10	**0.58**	0.2	0.014	--	--	--	--
Aroclor 1242 (total)	**0.053**	ug/L	--	--	--	--	--	--	--	--	--	1.2	**0.053**	0.2	0.014	--	--	--	--
Aroclor 1248 (total)	**0.081**	ug/L	--	--	--	--	--	--	--	--	--	1.4	**0.081**	0.2	0.014	--	--	--	--
Aroclor 1254 (total)	**0.033**	ug/L	--	--	--	--	--	--	--	--	--	0.6	**0.033**	0.2	0.014	--	--	--	--
Aroclor 1260 (total)	**94**	ug/L	--	--	--	--	--	--	--	--	--	1,700	**94**	0.2	0.014	--	--	--	--
Arsenic (total)	**150**	ug/L	--	--	--	--	--	--	--	340	150	--	--	--	--	5.0	--	--	--
Arsenic (dissolved)	**150**	ug/L	340	150	340	**150**	Isleta San Juan	340	150	340	150	--	--	--	--	5.0	--	--	--

Table 1. Benchmark Basis Used to Screen Risk to Aquatic Life for Contaminants in Water (continued)

Analyte	Screening Criteria	Units	NMAC 20.6.4		Lowest Tribe Aquatic Water Quality Criteria[a]		Lowest Tribe Aquatic Water Quality Criteria Reference	EPA 2002 Water Quality Criteria		Michigan Rule 57 Tier II values (Rev. 2/1/2005)		Oakridge values (Rev. 1996)				Canadian Environmental Quality Guidelines (Rev. 1996)[b]	British Columbia (Rev. 2001)[b]	NYSDEC (Rev. 1999)[b]	
												Tier II Values		*Region IV*					
			Acute (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)	Pueblo	CMC (ug/L)	CCC (ug/L)	AMV (ug/L)	FCV (ug/L)	SAV (ug/L)	SCV (ug/L)	ASV (ug/L)	CSV (ug/L)	Chronic (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)
Atrazine (total)	**7.3**	ug/L	--	--	--	--	--	--	--	50	**7.3**	--	--	360	190	1.8	--	**--**	**--**
Azinphos-methyl (total)	**0.005**	ug/L	--	--	--	--	--	--	--	--	**--**	--	--	--	--	--	--	**--**	**0.005**
Barium (total)*	**793.6**	ug/L	--	--	--	--	--	--	--	2,264	**793.6**	110	4	--	--	--	--	--	--
Benzene (total)	**200**	ug/L	--	--	--	--	--	--	--	890	**200**	2,300	130	530	53	370	--	--	--
Benzidine (total)	**0.1**	ug/L	--	--	--	--	--	--	--	--	--	--	--	250	25	--	--	0.1	**0.1**
Benzo[a]anthracene (total)	**0.027**	ug/L	--	--	--	--	--	--	--	--	--	0.49	**0.027**	--	--	0.018	--	--	--
Benzo[a]pyrene (total)	**0.014**	ug/L	--	--	--	--	--	--	--	--	--	0.24	**0.014**	--	--	0.015	--	--	--
Benzyl alcohol (total)	**8.6**	ug/L	--	--	--	--	--	--	--	--	--	150	**8.6**	--	--	--	--	--	--
Beryllium (dissolved)	**5.3**	ug/L			130	**5.3**	Santa Clara	--	--	--	--	--	--	--	--	--	--	--	--
Beryllium (total)*	**5.3**	ug/L	--	--	130	**5.3**	Sandia	--	--	88.59	9.85	32	0.7	16	0.53	--	--	--	--
beta-Endosulfan (total)	**0.056**	ug/L	0.22	**0.056**	0.22	**0.056**	Sandia	0.22	**0.056**	--	--	--	--	0.22	0.056	--	--	--	--
Bis(2-chloroethyl) ether (total)	**2,380**	ug/L	--	--	--	**--**	--	--	--	--	--	--	--	23,800	**2,380**	--	--	--	--
Bis(2-ethylhexyl) adipate (total) [Di(2-ethylhexyl) adipate]	**4.6**	ug/L	--	--	--	--	--	--	--	41	**4.6**	--	--	--	--	--	--	**--**	**--**
Bis(2-ethylhexyl) phthalate (total) [Di(2-ethylhexyl) phthalate]	**285**	ug/L	--	--	--	--	--	--	--	**285**	--	27	3	1110	<0.3	16	--	--	0.6
Boron (total)	**1,900**	ug/L	--	--	--	--	--	--	--	16,000	**1,900**	30	1.6	--	750	--	--	**--**	**--**
Bromacil (total)	**5**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	**5.0**	**--**	--	--
Bromoform (Tribromomethane; total)	**320**	ug/L	--	--	--	--	--	--	--	--	**--**	2,300	**320**	2,930	293	**--**	**--**	**--**	**--**
Bromomethane (methyl bromide) (total)	**35**	ug/L	--	--	--	--	--	--	--	320	**35**	--	--	1100	110	--	--	**--**	**--**
Bromoxynil	**5.0**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	**5.0**	**--**	--	--
Cadmium (dissolved)*	**0.36**	ug/L	3.47	**0.36**	3.67	0.38	Isleta	3.47	0.36	7.82	3.38	--	--	--	--	--	--	--	--
Cadmium (total)*	**0.41**	ug/L	3.77	**0.41**	3.77	**0.41**	Isleta	3.8	0.4	8.5	3.8	--	--	1.79	0.66	0.017	--	--	--
Carbaryl (total)	**0.2**	ug/L	--	--	--	**--**	--	--	--	--	--	--	--	--	--	**0.2**	**--**	--	--
Carbofuran (total)	**1.8**	ug/L	--	--	--	**--**	--	--	--	--	--	--	--	--	--	1.8	**--**	10	**1**
Carbon tetrachloride (total) (Tetrachloromethane)	**89**	ug/L	--	--	--	--	--	--	--	800	**89**	180	9.8	3,520	352	13.3	--	--	--
Chlordane (total)	**0.0043**	ug/L	2.4	0.0043	2.4	**0.0043**	Sandia Isleta San Juan Santa Clara	2.400	0.004	0.27	0.029	--	--	2.4	**0.0043**	--	--	--	--
Chloride (dissolved)	**230**	mg/L	--	--	860	**230**	Santa Clara	860	230	--	--	--	--	860	230	--	--	--	--
Chlorine (total residual) (total)	**3**	mg/L	19	11	19	**3**	Sandia Isleta-chronic	19.00	11.00	19	--	--	--	19	11	--	--	--	--
Chlorobenzene (total)	**47**	ug/L	--	--	--	--	--	--	--	420	**47**	1,100	64	1,950	195	1.3	--	**--**	5

Table 1. Benchmark Basis Used to Screen Risk to Aquatic Life for Contaminants in Water (continued)

Analyte	Screening Criteria	Units	NMAC 20.6.4		Lowest Tribe Aquatic Water Quality Criteria[a]		Lowest Tribe Aquatic Water Quality Criteria Reference	EPA 2002 Water Quality Criteria		Michigan Rule 57 Tier II values (Rev. 2/1/2005)		Oakridge values (Rev. 1996)				Canadian Environmental Quality Guidelines (Rev. 1996)[b]	British Columbia (Rev. 2001)[b]	NYSDEC (Rev. 1999)[b]	
												Tier II Values		*Region IV*					
			Acute (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)	Pueblo	CMC (ug/L)	CCC (ug/L)	AMV (ug/L)	FCV (ug/L)	SAV (ug/L)	SCV (ug/L)	ASV (ug/L)	CSV (ug/L)	Chronic (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)
Chloroethane (total)	**1,100**	ug/L	--	--	--	--	--	--	--	10,000	**1,100**	--	--	--	--	--	--	--	--
Chloroform (Trichloromethane; Total)	**170**	ug/L	--	--	--	--	--	--	--	1,300	**170**	490	28	2,890	289	1.8	--	--	--
Chloromethane (methyl chloride) (total)	**5,500**	ug/L	--	--	--	--	--	--	--	--	--	--	--	55,000	**5,500**	--	--	--	--
Chlorothalonil (total)	**0.18**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	**0.18**	--	--	--
Chlorpyrifos (total)	**0.041**	ug/L	--	--	0.083	**0.041**	Isleta Sandia San Juan Santa Clara	0.083	0.041	0.027	0.002	--	--	0.083	0.041	0.0035	--	--	--
Chromium (dissolved)*	**117.2**	ug/L	901.0	**117.2**	901	**117.2**	Isleta	--	--	901	117.2	--	--	--	--	--	--	--	--
Chromium (total)*	**136.3**	ug/L	2851.4	**136.3**	2851.4	**136.3**	Isleta	--	--	2851.4	136.3	--	--	--	--	--	--	--	--
Chromium III (dissolved)*	**59.68**	ug/L	--	--	901	117.2	Sandia Isleta	901.04	**59.68**	--	--	--	--	--	--	--	--	--	--
Chromium III (total)*	**69.40**	ug/L	--	--	--	--	--	2851.38	**69.40**	--	--	--	--	--	--	--	--	--	--
Chromium IV (dissolved)	**10.58**	ug/L	--	--	15.71	**10.58**	Sandia Isleta	16	11	--	--	--	--	--	--	--	--	--	--
Chromium IV (total)	**11.20**	ug/L	--	--	--	--		16.29	**11.20**	--	--	--	--	--	--	--	--	--	--
cis-1,2-Dichloroethene (total)	**620**	ug/L	--	--	--	--	--	--	--	5,500	**620**	--	--	--	--	--	--	--	--
Cobalt (total)	**100**	ug/L	--	--	--	--	--	--	--	370	**100**	1,500	23	--	--	--	--	--	--
Copper (dissolved)*	**14.45**	ug/L	22.77	**14.45**	22.77	**14.45**	Isleta San Juan Sandia	22.77	14.45	22.77	14.45	--	--	--	--	--	--	--	--
Copper (total)*	**15.05**	ug/L	23.72	**15.05**	23.72	**15.05**	Isleta	23.72	15.05	23.72	15.05	--	--	9.22	6.54	--	--	--	--
Cyanide, free	**5.2**	ug/L	--	--	22	**5.2**	Sandia	22	5.2	22	5.2	--	--	22	5.2	5	--	--	--
Cyanide (total)	**5.2**	ug/L	--	--	22	**5.2**	San Juan Santa Clara	--	--	--	--	--	--	--	--	--	--	--	--
Demeton	**0.1**	ug/L	--	--	--	--	--	--	**0.1**	--	--	--	--	--	--	--	--	--	0.1
Diazinon (total)	**0.0963**	ug/L	--	--	--	--	--	0.1925	**0.0963**	0.064	0.004	0.17	0.043	--	--	--	--	--	--
Dibenzofuran (total)	**4**	ug/L	--	--	--	--	--	--	--	36	**4**	66	3.7	--	--	--	--	--	--
Dicamba (total)	**10**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	**10**	--	--	--
Dieldrin (total)	**0.0019**	ug/L	0.24	**0.056**	0.24	**0.0019**	Sandia San Juan Santa Clara - chronic	0.240	0.056	0.24	0.056	--	--	2.5	0.0019	--	--	--	--
Diethyl phthalate (total)	**110**	ug/L	--	--	--	--	--	--	--	980	**110**	1,800	210	5,210	521	--	--	--	--

Table 1. Benchmark Basis Used to Screen Risk to Aquatic Life for Contaminants in Water (continued)

Analyte	Screening Criteria	Units	NMAC 20.6.4		Lowest Tribe Aquatic Water Quality Criteria[a]		Lowest Tribe Aquatic Water Quality Criteria Reference	EPA 2002 Water Quality Criteria		Michigan Rule 57 Tier II values (Rev. 2/1/2005)		Oakridge values (Rev. 1996)				Canadian Environmental Quality Guidelines (Rev. 1996)[b]	British Columbia (Rev. 2001)[b]	NYSDEC (Rev. 1999)[b]	
												Tier II Values		***Region IV***					
			Acute (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)	Pueblo	CMC (ug/L)	CCC (ug/L)	AMV (ug/L)	FCV (ug/L)	SAV (ug/L)	SCV (ug/L)	ASV (ug/L)	CSV (ug/L)	Chronic (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)
Dimethyl phthalate (total)	**330**	ug/L	--	--	--	--	--	--	--	--	--	--	--	3,300	**330**	--	--	--	--
Di-n-butyl phthalate (total)	**9.7**	ug/L	--	--	--	--	--	--	--	38	**9.7**	190	35	94	9.4	19	--	--	--
Dinoseb (total)	**0.48**	ug/L	--	--	--	--	--	--	--	4.8	**0.48**	--	--	--	--	0.05	--	--	--
Endrin (total)	**0.036**	ug/L	0.086	0.036	0.086	**0.036**	Sandia San Juan	0.086	0.036	0.086	0.036	--	--	0.180	0.0023	--	--	--	9.7
Ethylbenzene (total)	**18**	ug/L	--	--	--	--	--	--	--	160	**18**	130	7.3	4,530	453	90	--	--	--
Fluoranthene (total)	**1.6**	ug/L	--	--	--	--	--	--	--	14	**1.6**	--	--	398	39.8	0.04	--	--	--
Fluoride (total)	**3.52**	mg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	17.6	**3.52**
Heptachlor epoxide (total)	**0.0038**	ug/L	0.52	**0.0038**	0.52	**0.0038**	Sandia Santa Clara	0.520	0.0038	--	--	--	--	0.520	0.004	--	--	--	--
Heptachlor (total)	**0.0038**	ug/L	0.52	**0.0038**	0.52	**0.0038**	Sandia San Juan Santa Clara	0.520	0.0038	0.42	0.07	0.125	0.007	0.520	0.004	--	--	--	--
Hexachlorobenzene (total)	**12**	ug/L	--	--	--	--	--	--	--	--	--	210	**12**	--	--	--	--	--	--
Hexachlorobutadiene (total)	**1**	ug/L	--	--	--	--	--	--	--	7	**1**	--	--	9	0.93	1.3	--	--	--
Hexachlorocyclopentadiene (total)	**0.07**	ug/L	--	--	--	--	--	--	--	--	--	--	--	0.7	**0.07**	--	--	--	--
Hexachloroethane (total)	**8**	ug/L	--	--	--	--	--	--	--	70	**8**	--	--	98	9.8	--	--	--	--
HMX (total)	**250**	ug/L	--	--	--	--	--	--	--	2,300	**250**	--	--	--	--	--	--	--	--
Iron (total)	**1,000**	ug/L	--	--	--	**1,000**	Sandia Isleta San Juan	--	1,000	--	--	--	--	--	1,000	300	--	--	--
Isophorone (total)	**1,300**	ug/L	--	--	--	--	--	--	--	4,600	**1,300**	--	--	11,700	1,170	--	--	--	--
Lead (dissolved)*	**4.6**	ug/L	183.16	7.14	118.1	**4.6**	Isleta	153.2	5.7	167.6	18.8	--	--	33.78	1.32	--	--	--	--
Lead (total)*	**6.5**	ug/L	--	--	166.5	**6.5**	Isleta	166.5	6.5	236.3	26.5	--	--	--	--	--	--	--	--
Lindane (total) (Hexachlorocyclohexane)	**0.08**	ug/L	0.95	--	0.95	**0.08**	San Juan Sandia, Isleta - acute Santa Clara - chronic	0.95	--	0.95	0.07	--	--	2	0.08	0.01	--	--	--
Linuron (dissolved)	**7.0**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	**7.0**	--	--	--
Lithium (total)	**96**	ug/L	--	--	--	--	--	--	--	870	**96**	260	14	--	--	--	--	--	--
Malathion (total)	**0.1**	ug/L	--	--	--	**0.1**	Sandia San Juan	--	0.1	--	--	--	--	--	0.01	--	--	--	--
Manganese (total)*	**3,155**	ug/L	--	--	--	--	--	--	--	6,807	**3,155**	2,300	120	--	--	--	--	--	--
Mercury (dissolved)1	**0.77**	ug/L	1.4	**0.77**	--	--	--	1.19	0.65	1.4	0.77	--	--	--	--	--	--	--	--

Table 1. Benchmark Basis Used to Screen Risk to Aquatic Life for Contaminants in Water (continued)

Analyte	Screening Criteria	Units	NMAC 20.6.4		Lowest Tribe Aquatic Water Quality Criteria[a]		Lowest Tribe Aquatic Water Quality Criteria Reference	EPA 2002 Water Quality Criteria		Michigan Rule 57 Tier II values (Rev. 2/1/2005)		Oakridge values (Rev. 1996)				Canadian Environmental Quality Guidelines (Rev. 1996)[b]	British Columbia (Rev. 2001)[b]	NYSDEC (Rev. 1999)[b]	
												Tier II Values		*Region IV*					
			Acute (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)	Pueblo	CMC (ug/L)	CCC (ug/L)	AMV (ug/L)	FCV (ug/L)	SAV (ug/L)	SCV (ug/L)	ASV (ug/L)	CSV (ug/L)	Chronic (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)
Mercury (total)	**0.012**	ug/L	--	--	1.4	**0.012**	Sandia San Juan - acute Santa Clara - chronic	1.40	0.77	--	--	--	1.3	2.4	0.123	--	--	--	--
Methyl parathion (total)[2]	**0.008**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.065	**0.008**
Methyl tert-butyl ether (total) (MTBE)	**730**	ug/L	--	--	--	--	--	--	--	6,500	**730**	--	--	--	--	10,000	--	--	--
Methylene chloride (Dichloromethane;total)	**940**	ug/L	--	--	--	--	--	--	--	8,500	**940**	26,000	2,200	19,300	1,930	98.1	--	--	--
Metolachlor (total)	**7.8**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	**7.8**	--	--	--
Metribuzin (total)	**1.0**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	**1.0**	--	--	--
Mirex (total)	**0.001**	ug/L	--	--	--	**0.001**	Sandia San Juan	--	0.001	--	--	--	--	--	0.001	--	--	--	--
Molybdenum (total)	**800**	ug/L	--	--	--	--	--	--	--	7,200	**800**	16,000	370	--	--	73	--	--	--
Naphthalene (total)	**13**	ug/L	--	--	--	--	--	--	--	100	**13**	190	12	230	62	1.1	--	--	--
Nickel (dissolved)*	**83.5**	ug/L	751.8	**83.5**	751.8	**83.5**	Sandia Isleta San Juan	751.8	83.5	751.8	83.5	--	--	--	--	--	--	--	--
Nickel (total)*	**83.7**	ug/L	753.3	**83.7**	753.3	**83.7**	Isleta	753.3	83.7	753.3	83.7	--	--	789	87.71	--	--	--	--
Nitrobenzene (total)	**220**	ug/L	--	--	--	--	--	--	--	1,000	**220**	--	--	2,700	270	--	--	--	--
N-Nitrosodiphenylamine (total)	**58.5**	ug/L	--	--	--	--	--	--	--	--	--	3,800	210	585	**58.5**	--	--	--	--
p,p'-DDD (total)	**0.001**	ug/L	1.100	**0.001**	--	--	--	--	--	--	--	0.190	0.011	0.064	0.0064	--	--	--	--
p,p'-DDE (total)	**0.001**	ug/L	1.100	**0.001**	--	--	--	--	--	--	--	--	--	105	10.5	--	--	--	--
p,p'-DDT (total)	**0.001**	ug/L	1.1	**0.001**	1.1	**0.001**	Sandia Isleta San Juan	1.1	0.001	0.029	0.0032	--	0.013	1.1	0.001	--	--	--	--
Parathion (total)	**0.013**	ug/L	--	--	0.065	**0.013**	Sandia San Juan Santa Clara	0.065	0.013	0.065	0.013	--	--	0.065	0.013	--	--	--	--
PCBs (total)	**0.014**	ug/L	--	0.014	2.0	**0.014**	Sandia - acute Isleta -acute Santa Clara - chronic San Juan	--	0.014	--	--	--	0.14	--	--	--	--	--	--

Table 1. Benchmark Basis Used to Screen Risk to Aquatic Life for Contaminants in Water (continued)

Analyte	Screening Criteria	Units	NMAC 20.6.4		Lowest Tribe Aquatic Water Quality Criteria[a]		Lowest Tribe Aquatic Water Quality Criteria Reference	EPA 2002 Water Quality Criteria		Michigan Rule 57 Tier II values (Rev. 2/1/2005)		Oakridge values (Rev. 1996)				Canadian Environmental Quality Guidelines (Rev. 1996)[b]	British Columbia (Rev. 2001)[b]	NYSDEC (Rev. 1999)[b]	
												Tier II Values		*Region IV*					
			Acute (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)	Pueblo	CMC (ug/L)	CCC (ug/L)	AMV (ug/L)	FCV (ug/L)	SAV (ug/L)	SCV (ug/L)	ASV (ug/L)	CSV (ug/L)	Chronic (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)
Pentachlorophenol (total)	**4.24**	ug/L	--	--	6.45	**4.24**	San Juan - acute# Sandia - acute# Santa Clara - chronic#	19	15	--	--	--	--	--	--	0.5	--	--	--
pH (total), field	**6.6-9**	**---**	6.6-9	--	--	--	--	--	6.5-9	--	--	--	--	--	--	--	--	--	--
Phenanthrene (total)	**2.4**	ug/L	--	--	--	--	--	--	--	21	**2.4**	--	--	--	--	0.4	--	--	--
Phenol (total)	**450**	ug/L	--	--	--	--	--	--	--	3,400	**450**	--	--	1,020	256	4	--	--	--
Picloram (total)	**46**	ug/L	--	--	--	--	--	--	--	290	**46**	--	--	--	--	29	--	--	--
Pyrene (total)	**0.025**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	**0.025**	--	--	--
RDX (dissolved)	**85**	ug/L	--	--	--	--	--	--	--	400	**85**	--	--	--	--	--	--	--	--
Selenium (dissolved)	**1.84**	ug/L	19.92	4.61	19.92	**1.84**	Sandia Isleta - acute San Juan Santa Clara	--	4.61	--	--	--	--	--	--	--	--	--	--
Selenium (total)	**2**	ug/L	20	5	20	**2**	SandiaIsleta - acute San JuanSanta Clara	--	5	62[3]	5[3]	--	--	20	5	1	--	--	--
Silver (dissolved)*	**8.42**	ug/L	**8.42**	--	--	--	Sandia Isleta San Juan	8.4	--	--	--	--	--	--	--	--	--	--	--
Silver (total)	**9.03**	ug/L	9.91	--	**9.03**	--	Sandia Isleta San Juan	9.91	--	0.54	**0.06**	--	--	1.23	0.01	0.1	--	--	--
Silvex (total)	**30**	ug/L	--	--	--	--	--	--	--	270	**30**	--	--	--	--	--	--	--	--
Simazine (total)	**10**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	**10**	--	--	--
Strontium (total)	**8,300**	ug/L	--	--	--	--	--	--	--	75,000	**8,300**	15,000	1,500	--	--	--	--	--	--
Styrene (total)	**160**	ug/L	--	--	--	--	--	--	--	1,400	**160**	--	--	--	--	72	--	--	--
Tebuthiuron (total)	**1.6**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	**1.6**	--	--	--
Tetrachloroethene (total)	**190**	ug/L	--	--	--	--	--	--	--	1,400	**190**	830	98	528	84	--	--	--	--
Tetrahydrofuran (total)	**11,000**	ug/L	--	--	--	--	--	--	--	74,000	**11,000**	--	--	--	--	--	--	--	--
Thallium (total)	**10**	ug/L	--	--	--	--	--	--	--	78	**10**	110	12	--	--	0.8	--	--	--
Tin (total)	**73**	ug/L	--	--	--	--	--	--	--	--	--	2,700	**73**	--	--	--	--	--	--
Titanium	**100**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**100**	--	--
Toluene (total)	**140**	ug/L	--	--	--	--	--	--	--	840	**140**	120	9.8	1,750	175	2.0	--	--	--

Table 1. Benchmark Basis Used to Screen Risk to Aquatic Life for Contaminants in Water (continued)

Analyte	Screening Criteria	Units	NMAC 20.6.4		Lowest Tribe Aquatic Water Quality Criteria[a]		Lowest Tribe Aquatic Water Quality Criteria Reference	EPA 2002 Water Quality Criteria		Michigan Rule 57 Tier II values (Rev. 2/1/2005)		Oakridge values (Rev. 1996)				Canadian Environmental Quality Guidelines (Rev. 1996)[b]	British Columbia (Rev. 2001)[b]	NYSDEC (Rev. 1999)[b]	
												Tier II Values		*Region IV*					
			Acute (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)	Pueblo	CMC (ug/L)	CCC (ug/L)	AMV (ug/L)	FCV (ug/L)	SAV (ug/L)	SCV (ug/L)	ASV (ug/L)	CSV (ug/L)	Chronic (ug/L)	Chronic (ug/L)	Acute (ug/L)	Chronic (ug/L)
Toxaphene (total)	**0.0002**	ug/L	0.73	**0.0002**	0.73	**0.0002**	Sandia San Juan Santa Clara	0.73	0.0002	0.15	0.005	--	--	0.73	0.00025	--	--	--	--
trans-1,2-Dichloroethene (total)	**140**	ug/L	--	--	--	--	--	--	--	14,000	**1,500**	--	--	13,500	1,350	--	--	--	--
Triallate (dissolved)	**0.24**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	**0.24**	--	--	--
Trichloroethene (total)	**200**	ug/L	--	--	--	--	--	--	--	1,800	**200**	440	47	--	--	--	--	--	--
Trifluralin (total)	**0.2**	ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	**0.2**	--	--	--
Uranium (natural) (total)	**2.6**	ug/L	--	--	--	--	--	--	--	--	--	46.0	**2.6**	--	--	--	--	--	--
Vanadium (total)	**12**	ug/L	--	--	--	--	--	--	--	110	**12**	280	20	--	--	--	--	--	--
Vinyl chloride (total)	**930**	ug/L	--	--	--	--	--	--	--	8,400	**930**	--	--	--	--	--	--	--	--
Xylenes (total)	**35**	ug/L	--	--	--	--	--	--	--	310	**35**	230	13	--	--	--	--	--	--
Zinc (dissolved)*	**170.29**	ug/L	189.81	188.27	188.02	**170.29**	Santa Clara	189.81	188.27	189.81	188.27	--	--	--	--	--	--	--	--
Zinc (total)	**192.51**	ug/L	192.51	**192.51**	--	--	--	192.51	192.51	192.51	192.51	--	--	65.04	58.91	30	--	--	--

Notes:

Bold values are those criteria values used in the screening process

* Calculated values using a hardness of 175 mg/L

** Ammonia values determined using a pH of 8.4 and a temperature of 30 deg. C.

[a] Criteria was evaluated from Isleta, Sandia, San Juan, and Santa Clara Pueblos

[b] Values listed do not represent all available benchmarks for the specified guidelines; data shown were included to supplement data gaps

[1] Dissolved mercury was calculated by multiplying total mercury concentrations by the Federal Standard conversion factor of 0.85

[2] Acute value applies to methyl parathion only; chronic value applies to sum of parathion and methyl parathion.

[3] Michigan value for selenium includes selenium plus inorganic salts

-- = no value

CMC = acute

CCC = chronic

SAV = Secondary acute value

SCV = Secondary chronic value

ACV = Acute maximum value

FCV = Final chronic value

ASV = Acute screening value

CSV = Chronic screening value

This assessment used the lowest of the state or tribal criteria for selenium in water as a TRV. However, the new *Draft Aquatic Life Water Quality Criteria for Selenium – 2004* indicates that the species-mean acute value (SMAV) for FHMs is 2,209 µg/L for selenite and 11,346 µg/L for selenate. FHMs rank six out of 28 in sensitivity for selenite and seven out of 18 for selenate. The most sensitive organism for selenite is the amphipod while the most sensitive organism for selenate is the cladoceran (water fleas). New selenium criteria for chronic effects are based on tissue residues because of evidence that suggests that effects are largely based on dietary intake rather than aqueous exposure. Potential chronic effects caused by selenium should be evaluated based on fish tissue residues in light of the latest state of the science.

4.1.2 Benchmarks to Assess Potential Sediment Constituent Effects on Aquatic Life

Table 2 presents the compiled TECs and PECs that were used as SQGs to assess the USFWS and URGWOPS data values and sources from which these values were obtained. Compiling these benchmarks followed the approach described in Section 3.3.2. TECs and PECs are not available for all chemicals; only a screening-level value is available in many cases, which is commonly used as an equivalent to a TEC. The values compiled in Table 2 can be viewed as useful tools to focus assessment needs and priorities for potential future investigations.

4.1.3 Benchmarks to Assess Potential Tissue Constituent Effects to Aquatic Life

Benchmarks for tissue residue effects are presented in Table 3 on a wet-weight basis, as indicated in Section 3.3.3. This table is organized by chemical parameter with no-effects and lowest-effects residue values for both adults and early life stages of fish, as information is available. Generally, the early life stages of a fish are the more sensitive; thus, the tissue residue values for this age category are typically lower.

These chemicals can be assigned priority for future assessments where tissue residues measured in MRG fish samples exceed the effects concentrations compiled in Table 3. The tissue residue effects levels presented in the table are generally based on a single species and results from a single study; as such, these relationships are useful principally only for screening.

In contrast to the other values in the table, the selenium benchmark results from a more comprehensive evaluation process that led to USEPA's recent draft of a tissue-based chronic criterion (USEPA 2004). Thus, this selenium benchmark for tissue concentrations has value beyond screening.

Table 2. Sediment Quality Guideline Screening Values Used to Screen Risk to Aquatic Life for Contaminants in Sediment

Parameter	Synonym	TEC	PEC	Unit
1,1,1-Trichloroethane		170		ug/kg
1,1,2,2-Tetrachloroethane		850		ug/kg
1,1,2-Trichloroethane		518		ug/kg
1,1-Dichloroethane		0.575		ug/kg
1,1-Dichloroethene		19.4		ug/kg
1,2,4-Trichlorobenzene		5062		ug/kg
1,2-Dichlorobenzene		294		ug/kg
1,2-Dichloroethane		260		ug/kg
1,2-Dichloroethene (total)				
1,2-Dichloropropane		333		ug/kg
1,2-Dimethylnaphthalene				
1,3,5-Trinitrobenzene				
1,3-Dichlorobenzene				
1,3-Dinitrobenzene				
1,4-Dichlorobenzene		318		ug/kg
1,6-Dimethylnaphthalene				
1-Hexanol, 2-ethyl-				
1-Methyl-9H-fluorene				
1-Methylnaphthalene		130		ug/kg
1-Methylphenanthrene		204	1170	ug/kg
1-Methylpyrene				
1-Octanol				
2,2'-Biquinoline				
2,3,6-Trimethylnaphthalene				
2,4,5-T				
2,4,6-Trinitrotoluene				
2,4-D		0.038		ug/kg
2,4-Dimethylphenol		6.21		ug/kg
2,4-Dinitrotoluene		14.4		ug/kg
2,6-Dimethylnaphthalene				ug/kg
2,6-Dinitrotoluene		39.8		ug/kg
2-Amino-4,6-dinitrotoluene				
2-Butanone (MEK)				
2-Chloronaphthalene		417		ug/kg
2-Chlorophenol		31.9		ug/kg
2-Ethylnaphthalene				
2-Fluorobiphenyl				
2-Hexanone		58.2		ug/kg
2-Methylanthracene				
2-Methylnaphthalene		70	670	ug/kg
2-Nitrotoluene				
3,5-Dimethylphenol				
3-methylheptyl acetate				
3-Nitrotoluene				
4-Amino-2,6-dinitrotoluene				

Table 2. Sediment Quality Guideline Screening Values Used to Screen Risk to Aquatic Life for Contaminants in Sediment (continued)

Parameter	Synonym	TEC	PEC	Unit
4-Bromophenyl				
4-Chloro-3-methylphenol				
4-Chlorophenyl				
4H-Cyclopenta[def]phenanthrene				
4-Methyl-2-pentanone		25.1		ug/kg
4-Nitrotoluene				
9,10-Anthraquinone				
9H-Fluorene				
Acenaphthene		6.7	89	ug/kg
Acenaphthylene		5.9	130	ug/kg
Acetic acid, 2-ethylhexyl este				
Acetone		8.7		ug/kg
Acridine		1000		ug/kg
Aldrin		2	160	ug/kg
Alpha radioactivity				
alpha-BHC	alpha-HCH	6		ug/kg
alpha-Endosulfan	Endosulfan I			
Alpha-pinene				
Aluminum		25519	59572	mg/kg
Americium-241				
Ammonia				
Ammonia as N				
Ammonia plus N				
Anthracene		57.2	845	ug/kg
Antimony		150	200	mg/kg
Arsenic		9.79	33	mg/kg
Azobenzene				
Barium		20	60	mg/kg
Benzene		57		ug/kg
Benzene, 1,4-bis(1-methylethyl)				
Benzo[a]anthracene	Benzo(a)anthracene	108	1050	ug/kg
Benzo[a]pyrene	Benzo(a)pyrene	150	1450	ug/kg
Benzo[b]fluoranthene	Benzo(b)fluoranthene	27.2	4000	ug/kg
Benzo[c]cinnoline				
Benzo[g,h,i]perylene	Benzo(ghi)perylene	290	3800	ug/kg
Benzo[k]fluoranthene	Benzo(k)fluoranthene	27.2	4000	ug/kg
Benzyl n-butyl phthalate		1970		ug/kg
Beryllium				
beta-BHC	beta-HCH	5		ug/kg
Beta-pinene				
Bicyclo[3.1.1]hept-2-ene, 3,6,				
Bis(2-chloroethoxy)methane				
Bis(2-ethylhexyl) phthalate		180	2600	ug/kg

Table 2. Sediment Quality Guideline Screening Values Used to Screen Risk to Aquatic Life for Contaminants in Sediment (continued)

Parameter	Synonym	TEC	PEC	Unit
Bismuth				
Boron				
Bromide				
Bromodichloromethane				
Bromoform		650		ug/kg
Bromomethane				
C8-Alkylphenol				
Cadmium		0.99	4.98	mg/kg
Calcium				
Carbazole			1600	ug/kg
Carbon (total)				
Carbon disulfide		23.9		ug/kg
Carbon tetrachloride		1200		ug/kg
Carbophenothion				
Cerium				
Chlordane	Chlordane (technical)	3.2	18	ug/kg
Chloride				
Chlorobenzene		820		ug/kg
Chloroethane				
Chloroform		0.4		ug/kg
Chloromethane				
Chloroneb				
Chromium		43.4	111	mg/kg
Chrysene		166	1290	ug/kg
cis-1,2-Dichloroethene				
cis-1,3-Dichloropropene				
cis-Chlordane				
cis-Nonachlor				
cis-Permethrin				
Cobalt		50		mg/kg
Copper		31.6	149	mg/kg
Cyanide, Total		0.1		mg/kg
Cyclohexane, 1-methyl-4-(1-met				
Cyclohexene, 4-methyl-1-(1-met				
DCPA				
delta-BHC	delta-HCH	71500		ug/kg
Diazinon		0.38		ug/kg
Dibenzo[a,h]anthracene	Dibenzo(a,h)anthracene	33	140	ug/kg
Dibenzothiophene				
Dibromochloromethane				
Dicamba				
Dieldrin		1.9	62	ug/kg
Diethyl phthalate		630		ug/kg
Dimethyl phthalate		160		ug/kg
Dimethyl sulfide				
Di-n-butyl phthalate			43	ug/kg

Table 2. Sediment Quality Guideline Screening Values Used to Screen Risk to Aquatic Life for Contaminants in Sediment (continued)

Parameter	Synonym	TEC	PEC	Unit
Di-n-octyl phthalate		40600		ug/kg
Disulfide, dimethyl				
Dodecane, 1-iodo				
Eicosane				
Endosulfan I		2.9		ug/kg
Endosulfan II		14		ug/kg
Endosulfan sulfate		34.6		ug/kg
Endrin		2.2	210	ug/kg
Endrin aldehyde		480		ug/kg
Ethion				
Ethylbenzene		175		ug/kg
Europium				
Fluoranthene		423	2230	ug/kg
Fluorene		77.4	536	ug/kg
Fluoride				
Gage				
Gallium				
Gold				
Gross alpha radioactivity				
Gross beta radioactivity				
Heneicosane				
Heptachlor		0.6	10	ug/kg
Heptachlor epoxide		2.5	16	ug/kg
Hexachlorobenzene		20	240	ug/kg
HMX				
Holmium				
Indeno(1,2,3-cd)pyrene	Indeno[1,2,3-cd]pyrene	78	3800	ug/kg
Inorganic carbon				
Iron		188400	247600	mg/kg
Isodrin		55.2		ug/kg
Isophorone		2400		ug/kg
Isoquinoline				
Lanthanum				
Lead		35.8	128	mg/kg
Lead-210				
Lindane	gamma-BHC (Lindane)	2.4	5	ug/kg
Lithium				
Magnesium				
Malathion		0.67		ug/kg
Manganese		631	1184	mg/kg
Mercury		0.18	1.06	mg/kg
Methanethiol				
Methoxychlor		19		ug/kg
Methyl parathion		7.2		ug/kg
Methylene chloride		500		ug/kg

Table 2. Sediment Quality Guideline Screening Values Used to Screen Risk to Aquatic Life for Contaminants in Sediment (continued)

Parameter	Synonym	TEC	PEC	Unit
Mirex		11	800	ug/kg
Moisture				
Moisture (for all other analyses)				
Moisture (for VOC analyses)				
Molybdenum				
m-Xylene & p-Xylene		25		ug/kg
Naphthalene		176	561	ug/kg
Naphthalene, 1,6,-dimethyl				
Naphthalene, 2,3-dimethyl-				
Neodymium				
n-Hexane Ext. Material				
Nickel		22.7	48.6	mg/kg
Niobium				
Nitrate				
Nitrate-Nitrite				
Nitrite				
Nitrobenzene		145		ug/kg
Nitroglycerin				
N-Nitrosodi-n-propylamine				
N-Nitrosodiphenylamine				
o,p'-DDD	2,4'-DDD	16	43	ug/kg
o,p'-DDE	2,4'-DDE	9	15	ug/kg
o,p'-DDT	2,4'-DDT			ug/kg
o,p'-Methoxychlor				
Octadecane				
Organic carbon				
Orthophosphate				
Oxychlordane				
o-Xylene		25		ug/kg
p,p'-DDD	4,4'-DDD	3.54	8.51	ug/kg
p,p'-DDE	4,4'-DDE	1.42	6.75	ug/kg
p,p'-DDT	4,4'-DDT	1.19	4.77	ug/kg
p,p'-Ethyl-DDD				
p,p'-Methoxychlor				
Parathion		0.81		ug/kg
p-Cresol				
Pentachloroanisole				
Pentachloronitrobenzene				
PETN				
Phenanthrene		204	1170	ug/kg
Phenanthridine				
Phenol			48	ug/kg
Phosphate as P, Ortho				
Phosphorus				

Table 2. Sediment Quality Guideline Screening Values Used to Screen Risk to Aquatic Life for Contaminants in Sediment (continued)

Parameter	Synonym	TEC	PEC	Unit
Picloram				
Plutonium-238				
Plutonium-239				
Polonium-210				
Polychlorinated naphthalenes				
Potassium				
Pyrene		195	1520	ug/kg
Quinoline				
Radium-226				
Radium-228				
RDX				
Scandium				
Selenium				
SGT-HEM (Petroleum Hydrocarbons)				
Silver		1	2.2	mg/kg
Silvex		675		ug/kg
Sodium				
Strontium				
Styrene		254		ug/kg
Sulfate				
Sulfur				
Sum DDD		4.9	28	ug/kg
Sum DDE		3.2	31	ug/kg
Sum DDT		4.2	63	ug/kg
Tantalum				
Terphenyl-d14				
Tetrachloroethene		1600		ug/kg
Tetradecane				
Tetryl				
Thallium				
Thorium				
Thorium-230				
Thorium-232				
Tin				
Titanium				
Toluene		890		
Total DDT		5.3	570	ug/kg
Total Kjeldahl Nitrogen				
Total organic carbon				
Total PAH		1600	23000	ug/kg
Total PCB	PCBs	60	680	ug/kg
Total phosphorus				
Toxaphene		0.1	32	ug/kg
trans-1,2-Dichloroethene				
trans-1,3-Dichloropropene				

Table 2. Sediment Quality Guideline Screening Values Used to Screen Risk to Aquatic Life for Contaminants in Sediment (continued)

Parameter	Synonym	TEC	PEC	Unit
trans-Chlordane				
trans-Nonachlor				
trans-Permethrin				
Trichloroethene				
Tridecane				
Unknown				
Uranium				
Uranium-234				
Uranium-235				
Uranium-238				
Vanadium				
Vinyl chloride		202		ug/kg
Xylenes (total)		25		ug/kg
Ytterbium				
Yttrium				
Zinc		121	459	mg/kg

Notes:

PEC = Probable Effects Concentration defined as the concentration above which adverse effects are expected to occur more often than not.

TEC = Threshold Effects Concentration defined as the concentration below which adverse effects are not expected to occur.

TEC and PECs are terms used to identify low or no screening levels and upper or probable levels of effects. Not all values presented in this table are TECs and PECs as derived by MacDonald et al. 2000.

Table 3. Fish Tissue Residue Effects Levels used to Screen Used to Screen Risk to Aquatic Life for Contaminants in Fish Tissue

		Adult Life Stages		Early Life Stages			
Parameter	**Units**	**NER**	**LER**	**NER**	**LER**	**Source**	**Comment**
Endrin aldehyde	ug/kg	10000	10000			Jarvinen and Ankley 1999	Fathead minnow, 300 d exposure, combined water and diet, survival, technical grade endrin
Endrin ketone	ug/kg	10000	10000			Jarvinen and Ankley 1999	Fathead minnow, 300 d exposure, combined water and diet, survival, technical grade endrin
gamma-BHC (Lindane)	ug/kg	30650	47650			Jarvinen and Ankley 1999	Fathead minnow exposure (304 days) based on survival;
gamma-Chlordane	ug/kg	8300	83000			Parrish et al. 1976	96 hour, marine; pinfish survival; NOEC from uncertainty factor of 10
Heptachlor	ug/kg	88650				Jarvinen and Ankley 1999	Fathead minnow 276 day exposure, water, survival no effect for larvae to adult period, eviscerated carcass
Heptachlor epoxide	ug/kg	88650				Jarvinen and Ankley 1999	Fathead minnow 276 day exposure, water, survival no effect for larvae to adult period, eviscerated carcass
Hexachlorobenzene	ug/kg			232500		Jarvinen and Ankley 1999	Fathead minnow whole body, 28 day exposure, survival and growth endpoints
Iron	mg/kg			1250		USACE 2004	Egg mortality and hatching success, common carp no effect concentration
Lead	mg/kg			131	221	USACE 2004	FHM juveniles in water exposure, biochemical endpoint
Lipids	%						
Lithium	mg/kg						No tissue residue-effects data available.
Magnesium	mg/kg						
Manganese	mg/kg						No tissue residue-effects data available.
Mercury	ug/kg	54500		54500		Jarvinen and Ankley 1999	336 day fathead minnow exposure larvae to adult, survival and growth endpoints
Mercury	ug/kg	500	1950			Beckvar et al. 2005	MeHg exposure in food, fathead minnow
Methoxychlor	ug/kg	12500		3550		Jarvinen and Ankley 1999	Yearling Brook trout, diet exposure, 30 days, surivival and growth endpoints; Fingerling rainbow trout,water exposure, survival no effects.
Mirex	ug/kg	645000		645000		Jarvinen and Ankley 1999	Fathead minnow whole body, 120 day exposure, reproduction endpoint
Moisture	%						
Molybdenum	mg/kg						No tissue residue-effects data available.
Nickel	mg/kg	515				Jarvinen and Ankley 1999	No whole body data available, common carp 15 day exposure, gill residue
Nonachlor							No tissue residue-effects data available.
Oxychlordane	ug/kg						Chlordane metabolite, use threshold for chlordane
PCBs	ug/kg			3600	36000	Fisher et al. 1994	Egg exposure, Atlantic salmon

Table 3. Fish Tissue Residue Effects Levels used to Screen Used to Screen Risk to Aquatic Life for Contaminants in Fish Tissue (continued)

Parameter	Units	Adult Life Stages		Early Life Stages		Source	Comment
		NER	LER	NER	LER		
Potassium	mg/kg						
Selenium	mg/kg	8		8		USEPA 2004	Chronic criterion for whole body fish residue (7.91 ug/g dw)
Selenium (FHM)	mg/kg	5.7	7			USACE 2004	FHM growth, ingestion exposure
Silver	mg/kg			0.3		Jarvinen and Ankley 1999	Bluegill survival and growth, no effect, 180 day exposure
Sodium	mg/kg						
Sodium (FHM)	mg/kg						
Sodium (Red Shiner)	mg/kg						
Strontium	mg/kg						No tissue residue-effects data available.
Thallium	mg/kg			13.6		USACE 2004	Bluegill no effect concentration, survival,
Tin	mg/kg						No tissue residue-effects data available.
Titanium	mg/kg						No tissue residue-effects data available.
Toxaphene	ug/kg	5000-13500	16500	2000	5000	Jarvinen and Ankley 1999	FHM adult exposure 295 days, whole body residue, growth endpoint; FHM fry exposure 30 days, whole body residue, growth endpoint
Uranium	mg/kg		0.2			Buet and others 2005	Trout gills - 10 days of exposure to 500 µg/L uranium; endpoint is reduction in antioxidant enzyme activity
Vanadium	mg/kg	28.7		12	15.6	Jarvinen and Ankley 1999	Adult Flagfish, 96 day exposure, whole body, survival, growth, reproduction endpoints; Larval Flagfish, 28 day exposure, whole body, survival endpoint.
Zinc	mg/kg			170	200	Jarvinen and Ankley 1999	Larvae to adult Flagfish, 100 day exposure, whole body, growth endpoint

Notes:

1. Tissue residues and residue effects levels are presented on a dry weight basis.

2. Tissue residues were primarily extracted from one of two primary databases:

Jarvinen, A.W. and G.T. Ankley. 1999. Linkage of effects to tissue residues: Development of a comprehensive database for aquatic organisms exposed to inorganic and organic chemicals. Society of Environmental Toxicology and Chemistry (SETAC) Press, Pensacola, Florida.

USACE. 2003. Environmental Residue Effects Database. US Army Corps of Engineers. http://el.erdc.usace.army.mil/ered/Index.cfm

3. When fathead minnow whole body residue data were available, these data were preferentially selected for use. If fathead minnow data were not available, warm water fish species tissue data were considered, if these types of data were not available, then tissue residues for a salmonid or other freshwater species were selected.

4. Marine species were selected only if alternatives tissue residue data as indicated above were not available.

Table 3. Fish Tissue Residue Effects Levels used to Screen Used to Screen Risk to Aquatic Life for Contaminants in Fish Tissue (continued)

5. Whole body residues were selected for this evaluation; tissue specific residues were only used if no whole body data were available.
6. Growth and/or reproduction endpoints were preferred endpoints for this assessment, although survival data were used if growth and/or reproduction endpoint data were not available.
7. Longer term exposures were preferentially selected over short-term exposures.
8. Shaded parameters were not considered as potentially toxic bioaccumulators and were not evaluated.

LER = Lowest effect residue

NER = No effects residue

4.1.4 Benchmarks to Assess Potential Water Constituent Effects to RGSM/FHM

Overall, both RGSMs and FHMs appear relatively similar in their sensitivities to aquatic toxicants, as discussed in Section 2.3.2. Table A2 shows the specific toxic responses by RGSMs and FHMs, which were compiled as discussed in Section 3.3.4 using data from Buhl (2002). RGSMs appeared more sensitive to copper than FHMs, whereas FHMs appeared slightly more sensitive to chlorine and ammonia. The RGSM to FHM ratio for arsenic indicates that FHMs are almost twice as sensitive to arsenic as RGSMs.

Most information presented in Table A2 was compiled on FHMs from USEPA's freshwater aquatic life criteria documents (shown in Table A1) and from USEPA's AQUIRE online database. (Not all criteria documents listed in Table A1 include toxicity test results for FHM. In addition, not all were available for this report.) Table A2 presents information extracted from USEPA's AWQC, including the most sensitive aquatic species, the relative ranking of FHMs in the assessment, and the species-mean acute, species-mean chronic, and acute-to-chronic ratio for FHM, as presented in each of the criteria documents. The table presents the mean acute and chronic values for the toxicity testing results using FHMs presented in the AQUIRE dataset. Section 3.3.4 describes the steps used to develop conservative chronic screening benchmarks derived for each of the analytes. Table A2 shows that where more than one species was included in the analysis used to establish the AWQC, FHMs were never the most sensitive species tested. Furthermore, it rarely was included among the top third of the most sensitive species tested. This relationship provides weight-of-evidence support to suggest that FHMs, and therefore RGSMs as its toxicological surrogate, are reasonably well protected by the national aquatic life criteria for most potential aquatic contaminants.

The second column of Table A2 lists the aquatic life screening benchmarks from Table 1 to allow additional assessment of this hypothesis. General aquatic life benchmarks for nine analytes appear to provide potentially insufficient protection for RGSMs and FHMs. This information is presented in Table 4. These analytes included, for example, dissolved arsenic (a factor of 40 times), un-ionized ammonia (4 times), total benzene (20 times), total residual chlorine (260 times), dissolved copper (578 times), total hexachlorobenzene (12 times), dissolved mercury (3 times), dissolved silver (14 times), and dissolved zinc (1.4 times). Considerable uncertainty is associated with the information in the AQUIRE database because the values are not subject to toxicity testing guidelines for water quality.

The aquatic life benchmarks shown in Table A2 appear to be sufficiently protective for 71 analytes. In addition, five benchmarks were defined for RGSMs and FHMs for analytes that otherwise lacked aquatic life screening benchmarks. These benchmarks were for 1,2,3-trichloropropane,

Table 4. Comparison of Toxicity Responses Where the Reported Water Quality Screening Benchmarks that may not be Protective for Rio Grande Silvery Minnows and Fathead Minnows

Analyte	Table 1 Screening Benchmarks	RGSM/FHM Toxic Responses (Buhl 2002)				EPA AWQC Criteria					EPA AQUIRE		Comment
		Most Sensitive Taxa RGSM or FHM	RGSM Mean Acute (ug/L)	RGSM Mean Chronic (ug/L)	RGSM/FHM Ratio	Most Sensitive Taxa	FHM Ranking	FHM Mean Acute (ug/L)	FHM Mean Chronic (ug/L)	FHM ACR	FHM Mean Acute (ug/L)	FHM Mean Chronic (ug/L)	
Arsenic (dissolved)	150	Fathead	34.3	3.43	1.92	--	--	--	--	--	9,900	990	--
Ammonia (unionized)**	0.475	Fathead	1.12	0.112	1.11	--	--	--	--	--	--	--	--
Benzene (total)	200	--	--	--	--	Rainbow trout Salmo galrdner	3/7	33,000	3,300	NA	22,095.76	10.2	--
Chlorine (total residual) (total)	3	Fathead	0.115	0.0115	1.01	--	--	--	--	--	--	--	--
Copper (dissolved)*	14.45	RGSM	0.25	0.025	0.64	Cladoceran	18/43	96	6.2	15.48	1,200.98	28.3	Used 1995 Update - 2003 Draft did not have data
Hexachlorobenzene (total)	12	--	--	--	--	--	--	--	--	--	10	1	--
Mercury (dissolved)[1]	0.77	--	--	--	--	Midge	12/28	150/168	<0.23/<0.26	>646.2-652.2	--	--	As mercuric chloride (Mercury II) 2 values given
Silver (dissolved)*	8.42	--	--	--	--	Daphnia	9/18	11.34	0.83	13.66	5.78	0.578	1987 - Draft
Zinc (dissolved)*	188.27	--	--	--	--	Cladoceran	17/36	3,830	678.60	5.644	1,365.01	136.5	1995 Update

Notes:
* Calculated values using a hardness of 175 mg/L

** Ammonia values determined using a pH of 8.4 and a temperature of 30 deg. C.

[a] Criteria was evaluated from Isleta, Sandia, Santa Clara and San Juan Pueblos
[1] Dissolved mercury was calculated by multiplying total mercury concentrations by the Federal Standard conversion factor of 0.85

-- = no value

ACR = Acute to chronic ratio

FHM = Fathead minnow

NA = Not available

RGSM = Rio Grande Silvery Minnow

2,4-dinitro-6-methylphenol, 2,6-dinitrotoluene, 9H-fluorene, and bromobenzene. Ambient MRG concentrations reported for these five chemicals were less than the screening benchmarks. Screening benchmarks could not be defined for 104 chemicals reported as detected in the MRG.

The RGSM- and FHM-specific criteria may provide greater protection for a limited set of chemicals in the MRG than the more general aquatic life TRV. Still, each of these analytes was targeted as a COPC for the MRG during initial screening using the aquatic life benchmarks. (Arsenic was identified as a COPC during screening of sediment; Section 5.1 discusses the potential for arsenic toxicity in the MRG. Its context in risk management is discussed in Section 6).

4.2 Assessment Sites and Evaluation Period

The next two subsections provide brief introductions to the distribution and sampling interval included in this assessment for the 14 sites in the USFWS study and the 79 sites along the MRG assessed from the URWOPS dataset (Table 5).

4.2.1 USFWS Data

USFWS collected samples at 14 sites between July 2002 and September 2003 in three reaches of the MRG (Table 6), as follows:

- 5 sampling stations in the Angostura Reach
- 5 sampling stations in the Isleta Reach
- 4 sampling stations in the San Acacia Reach

The 14 locations along the MRG included two sites downstream of wastewater treatment plant discharges and one site downstream of an irrigation return drain and riverside drain. Sampling data were collected during a total of 38 sampling events. Table 5 shows the number of sampling sites by reach of the MRG where water quality, sediment, and tissue were sampled.

4.2.2 URGWOPS Data

The URGWOPS dataset includes water quality data from 79 sampling sites over five reaches of the MRG:

- 15 sampling stations in the Above Cochiti Reach
- 10 sampling stations in the Cochiti Reach
- 36 sampling stations in the Angostura Reach
- 12 sampling stations in the Isleta Reach
- 6 sampling stations in the San Acacia Reach

Table 5. Number of Sites by River Reach in the URGWOPS and USFWS Datasets*

River Reach	USFWS			URGWOPS		
	Water Quality	Sediment	Tissue	Water Quality	Sediment	Tissue
Above Cochiti	0	0	0	15	3	0
Cociti	0	0	0	10	5	0
Angostura	5	5	5	36	3	2 (+3)
Isleta	5	5	5	12	2	0
San Acacia	4	4	4	6	2	0 (+1)

Notes:
* Sampling stations within a reach not located on the Rio Grande River are showm in parentheisis

Table 6. Water-Quality Monitoring Sites in the USFWS 2002-2003 Dataset

Site Number	Site name	Latitude/Longitude	Times Sampled
1	Rio Rancho Waste Water Treatment Plant Outfall #2	351535N 1064040W	2
2	Rio Grande at La Orilla	350921N 1064014W	4
3	Rio Grande at Barelas	350446N 10646231W	2
4	Albuquerque Waste Water Treatment Plant Outfall	350103N 1064016W	2
5	Rio Grande at Los Padillas	345747N 1064113W	4
6	Rio Grande at Isleta below Railroad Bridge	350103N 1064040W	2
7	Rio Grande at Los Lunas	344907N 1064243W	4
8	Rio Grande at Abeytas	342701N 1064809W	2
9	Lower San Juan Irrigation Drain	342214N 1065026W	2
10	Rio Grande at La Joya	341846N 10651141W	4
11	Rio Grande at Lemitar	341051N 1065302W	2
12	Rio Grande below Arroyo del Tajo	340227N 1065154W	4
13	Rio Grande at San Pedro	335427N 1065109W	2
14	Rio Grande at North Boundary Bosque del Apache	335234N 1065058W	2

Table 7 presents location information for sites used from the URGWOPS dataset. Semiannual hydrogeological data for sites in each reach were collected between January 1985 and September 1999. Samples were collected throughout each reach between January 1985 and September 1999; however, sampling frequency at the locations was sporadic. Stations were not sampled consistently in each reach over time. Additionally, analytical suites were not consistent throughout each reach, sampling station, or time period, primarily due to the various data sources that have been compiled into the dataset. The significant irregularities of the dataset will be discussed in subsequent sections. Table 5 shows the distribution of surface water quality, sediment, and tissue samples within each reach.

Table 7. MRG Sites Included in Risk Screening for the URGWOPS Dataset

Site Name and Reach *	Site Identification Code (STAID)
MRG SITES ABOVE COCHITI REACH	
RIO GRANDE @ SAN JUAN PUEBO @ HWY 74 BRIDGE	360358106043410
RIO GRANDE ABV THE PECOS R,RIO GRANDE @ SAN JUAN P	360358106043401
RIO GRANDE ABOVE SAN JUAN PUEBLO, NM	8281100
RIO GRANDE ABV. ESPANOLA @ VALDEZ BRIDGE	360027106042010
RIO GRANDE ABOVE ESPANOLA STP	355912106041701
RIO GRANDE 300YDS BELOW ESPANOLA WWTP OUTFALL	355907106043010
RIO GRANDE BELOW ESPANOLA STP	**355851106044001**
RIO GRANDE AT SANTA CLARA, NM	8291600
RIO GRANDE ABV THE PECOS R,RIO GRANDE AT OTOWI BRI	355229106083001
RIO GRANDE AT OTOWI BRIDGE	**355229106083002**
RIO GRANDE AT OTOWI BRIDGE, NM	8313000
RIO GRANDE UPPER ABV PECOS R,WEST OF STATE RD 509	**352237107482101**
RIO GRANDE NEAR WHITE ROCK, N. MEX.	**355009106092710**
RIO GRANDE ABOVE WHITE ROCK STP	**354912106104001**
RIO GRANDE,RIO GRANDE BELOW WHITE ROCK STP	**354810106113201**
MRG SITES WITHIN COCHITI REACH	
RIO GRANDE AT COCHITI, NM	**8314500**
RIO GRANDE AT COCHITI DAM OUTFALL	353705106192410
RIO GRANDE,RIO GRANDE AT COCHITI DAM OUTFALL	353705106192401
RIO GRANDE BELOW COCHITI DAM, NM	8317400
RIO GRANDE BELOW SANTA FE RIVER	353628106185410
RIO GRANDE ABV GALISTEO CREEK-RECHECK LATLON	353456106164911
RIO GRANDE AT SAN FELIPE N BOUNDRY	353253106222710
RIO GRANDE AT SAN FELIPE PUEBLO	352639106262310
RIO GRANDE AT SAN FELIPE, NM	8319000
RIO GRANDE BELOW SAN FELIPE LAGOONS	352502106272810
MRG SITES WITHIN ANGOSTURA REACH	
RIO GRANDE AT ANGUSTURA HDG,NM	**352247106295400**
RIO GRANDE AT ANGOSTURA DIVERSION DAM	352245106294001
RIO GRANDE BELOW ANGOSTURA DIVERSION WORKS	352245106294010
RIO GRANDE AT HWY 44 AT BERNALILLO, NM	**351921106332710**
RIO GRANDE HWY 44 BERNALILLO,NM	351920106332710
RIO GRANDE ABOVE HWY 44 BRIDGE	351919106332310
RIO GRANDE AT US HIGHWAY 44 BRIDGE	351919106332310
UPPER RIOGRANDE,RIO GRANDE AT US HWY 44 BRIDGE	351919106332301
RIO GRANDE AT BERNALILLO WWTF DISCHARGE	351759106331210
RIO GRANDE NEAR BERNALILLO, NM	**8329500**
RIO GRANDE UPSTREAM FROM RRU WWTF#2 DISCHARGE	**351523106353710**
UPPER RIO GRANDE,RIO GRANDE US FROM RRU WWTF#2 DIS	351523106353701
RIO GRANDE ABOVE RIO RANCHO WWTF #3	351658106354910
RIO GRANDE ABOVE RRU WWTF #3 DISCHARGE	**351658106354910**
RIO GRANDE ABOVE RIO RANCHO WWTF #2	351523106353710
RIO GRANDE ABOVE ALAMEDA BRIDGE	351151106383010
RIO GRANDE AT ALAMEDA BRIDGE (CORRALES BRIDGE)	351151106383010
UPPER RIO GRANDE,RIO GRANDE AT ALAMEDA BRIDGE (COR	351151106383001
RIO GRANDE NR ALAMEDA, NM	8329928

Table 7. MRG Sites Included in Risk Screening for the URGWOPS Dataset (continued)

Site Name and Reach *	Site Identification Code (STAID)
RIO GRANDE AT CENTRAL AVE BRIDGE	**350521106404801**
RIO GRANDE AT ALBUQUERQUE, NM	8330000
RIO GRANDE,RIO GRANDE AT BRIDGE AVE	**350411106393701**
RIO GRANDE UPPER ABV PECOS R,CITY OF ALBERQUERQUE	**350500106390001**
RIO GRANDE ABOVE RIO BRAVO BRIDGE	350137106402110
RIO GRANDE AT RIO BRAVO BRIDGE	350137106402110
UPPER RIOGRANDE,RIO GRANDE AT RIO BRAVO BRIDGE	350137106402101
RIO GRANDE AT RIO BRAVO BRIDGE NEAR ALBUQUERQUE,NM	8330150
RIO GRANDE ABOVE I-25 BRIDGE	345658106404910
RIO GRANDE AT INTERSTATE 25 BRIDGE	345658106404910
RIO GRANDE RIVER AT INTERSTATE 25 BRIDGE	345658106404901
UPPER RIO GRANDE ABV PECOS R,RIO GRANDE R AT INTER	345658106404902
RIO GRANDE ABOVE ISLETA DIVERSION	345423106410610
RIO GRANDE AT ISLETA PUEBLO (HWY 147 BRIDGE)	345423106410610
RIO GRANDE,RIO GRANDE AT ISLETA PUEBLO	**345423106410601**
RIO GRANDE, UPPER,RIO GRANDE AB ISLETA DAM	**345422106410501**
RIO GRANDE AT ISLETA, NM	8331000
MRG SITES WITHIN ISLETA REACH	
RIO GRANDE RIVER AT ISLETA DIVERSION DAM	**345423106410501**
RIO GRANDE RIVER AT LOS LUNAS BRIDGE	344816106430001
RIO GRANDE AT LOS LUNAS BRIDGE	344816106430210
RIO GRANDE,RIO GRANDE AT LOS LUNAS	**344816106430201**
RIO GRANDE,LOS LUNAS	**344803106430901**
RIO GRANDE AT BELEN (309 BRIDGE)	343910106441510
RIO GRANDE,RIO GRANDE AT BELEN	343910106441501
RIO GRANDE NEAR BOSQUE NM AT BRIDGE	343242106454610
RIO GRANDE,RIO GRANDE NR BOSQUE	343242106454601
RIO GRANDE FLOODWAY NEAR BERNARDO, NM	8332010
RIO GRANDE NR BERNARDO, NM	8332000
RIO GRANDE AT BERNARDO BRIDGE (US HWY 60)	342057106511710
MRG SITES WITHIN SAN ACACIA REACH	
RIO GRANDE FLOODWAY AT SAN ACACIA, NM	8354900
RIO GRANDE AT SAN ANTONIO	335510106510202
RIO GRANDE SOCORRO MAIN CANAL AT ESCONDIDA	**340734106533801**
RIO GRANDE UPPER ABV PECOS R,RIO GRANDE FLOODWAY A	**334200106564501**
RR BRDG 1 MI S OF SAN MARCIAL,RIO GRANDE	**334110106591001**
RIO GRANDE FLOODWAY AT SAN MARCIAL, NM	8358400

Notes:
* Stations shown in bold do not have exceedances of water quality

4.3 U.S. Fish and Wildlife Service 2002-2003 Dataset

USFWS (2004) documented the data collection effort for the data used in this assessment. The following sections draw from and expand on the initial summaries presented in the report.

4.3.1 Water Constituents

The USFWS dataset included 189 different water quality analytes (Table 8). Assessment benchmarks available for 162 analytes could be evaluated through risk assessment. Of these analytes, concentrations above the MDL in at least one sample were found for 51 chemicals. The USFWS dataset included 27 physical and conventional water quality constituents that are not considered potentially toxic to aquatic life.

4.3.1.1 Environmental and Exposure Profile Characterization

The most recent and most consistent characterization of the overall physical and chemical water quality conditions in the MRG is available from the 2002-2003 USFWS study. Table A3 lists the 189 analytes assessed in the study, the number of samples analyzed during the study, the number of samples with detectable concentrations, the range (minimum and maximum concentrations), and the average concentration for each. As discussed in Section 3.1.1, estimations of average exposure conditions include filling non-detected concentrations with one-half the MDL whenever at least a single sample for the analyte held a detectable concentration of the chemical. Table 9 summarizes the analytes with sample concentrations that exceeded screening benchmarks. The MDL for mercury exceeded its respective screening benchmark. The exposure profile concentrations compiled in this table provide the average and the potentially worse case (maximum) exposure conditions for aquatic life, as defined in the USFWS dataset.

4.3.1.2 Risk Characterization

<u>Tier I screen based on maximum concentrations for analytes</u>

As described in Section 3.3.1.2, a conservative risk screening to estimate maximum probable risk to aquatic life for that chemical in the MRG was first conducted by computing the ratio of the maximum concentration for a chemical in the MRG reported by USFWS to the corresponding risk screening benchmark for the chemical (compare Table 1 and Table A3). Maximum probable risks exceeded 1.0 in Tier I screening for the six analytes shown on Table 9. A detailed listing of concentration, date, and location for these six analytes is presented in Appendix B, Table B1. The following text briefly summarizes these screening results. In addition, this screening identified as data gaps screening benchmarks for 14 analytes for which USFWS reported detectable concentrations, thus preventing calculation of the maximum probable risk. The bottom rows of this table also show 27 additional physical and conventional water quality constituents assessed during the USFWS study. While these are not potentially toxic constituents that can be addressed in risk assessments, they do contribute to the water quality conditions affecting aquatic life in the MRG and are presented for completeness.

Table 8. List of 189 Unique Analytes in the USFWS 2002-03 Water Quality Assessment*

Parameter Name			
1,1,1-Trichloroethane	Bromoform	Ethylbenzene	Progesterone
1,1,2,2-Tetrachloroethane	Bromomethane	Famphur	Propazine
1,1,2-Trichloroethane	Cadmium	Fensulfothion	Propoxyphene
1,1-Dichloroethane	Caffeine	Fenthion	Protroptyline
1,1-Dichloroethene	Calcium	Fluoride	Prozac
1,2-Dichloroethane	Carbon disulfide	Hardness, as CaCO3	RDX
1,2-Dichloroethene (total)	Carbon tetrachloride	HMX	Ronnel
1,2-Dichloropropane	Carbonate, as CO3	Imipramine	Selenium
1,3,5-Trinitrobenzene	Chemical oxygen demand (COD)	Iron	Setraline
1,3-Dinitrobenzene	Chloride	Lead	Silanol, tri methyl-
1,4 dichlorobenzene	Chlorobenzene	Lithium	Silica
2,4,5-T	Chloroethane	Magnesium	Silver
2,4,5-TP (Silvex)	Chloroform	Malathion	Simazine
2,4,6-Trinitrotoluene	Chloromethane	Manganese	Sodium
2,4-D	Chlorpyrifos	MCPA	Specific conductance - unfiltered
2,4-DB	Cholesterol	MCPP	Strontium
2,4-Dinitrotoluene	Chromium	Medroxyprogesterone	Styrene
2,6-Dinitrotoluene	cis-1,2-Dichloroethene	Megestrol Acetate	Sulfate
2-Amino-4,6-dinitrotoluene	cis-1,3-Dichloropropene	Menstranol	Sulfotepp
2-Butanone (MEK)	Cobalt	Mercury	Tamoxifen
2-Hexanone	Copper*	Merphos	Tetrachloroethene
2-Nitrotoluene	Coumaphos	Methyl parathion	Tetrachlorvinphos (Stirophos)
3-Nitrotoluene	Cyanide, Total	Methylene chloride	Tetryl
4-Amino-2,6-dinitrotoluene	Cyclotetrasiloxane, octamethyl	Mevinphos	Thallium
4-Methyl-2-pentanone	Dalapon	Molybdenum	Thionazin
4-Nitrotoluene	DCAA	m-Xylene & p-Xylene	Tin
6 alpha-Methylprednisolone	Demeton (total)	Naled	Titanium
Acetic acid, 2-ethylhexyl este	Desipramine	Nickel	Tokuthion
Acetone	Dextro-Norgestrel	Nitrate	Toluene
Alkalinity, as CaCO3	Diazinon	Nitrate-Nitrite	Total dissolved solids
Aluminum	Dibromochloromethane	Nitrite	Total Kjeldahl Nitrogen
Amitriptyline	Dicamba	Nitrobenzene	Total phosphorus
Ammonia as N	Dichlorprop	Nitroglycerin	Total suspended solids
Anilazine	Dichlorvos	Nordoxepin	trans-1,2-Dichloroethene
Antimony	Dimethoate	Norethindrone	trans-1,3-Dichloropropene
Arsenic	Dinoseb	Norethynodrel	Trichloroethene
Atrazine	Diphenylmethane	Nortriptyline	Trichloronate
Azinphos-methyl	Discharge, instantaneous	O,O,O-Triethyl phosphorothioate	Trimipramine maleate
Barium	Dissolved oxygen	o-Xylene	Turbidity
Benzene	Dissolved oxygen, saturation	Paroxetine	Uranium
Beryllium	Disulfoton	Perchlorate	Vanadium
Beta-Estradiol	Doxepin	PETN	Vinyl chloride
Bicarbonate, as HCO3	Enthynl Estradiol	pH - unfiltered	Water temperature
Biochemical oxygen demand (BOD)	EPN	Phenytoin	Xylenes (total)
Bolstar	Equilin	Phorate	Zinc
Boron	Estrone	Phosphate as P, Ortho	
Bromide	Ethoprop	Potassium	
Bromodichloromethane	Ethyl parathion	Prednisone	

Notes:

[*] One additional analyte was classified as unknown

Table 9. Summary and Risk Screening of Water Quality Data Included in the USFWS 2002-03 dataset with Sample Concentrations Exceeding Aquatic Life Screening Criteria

Analytes/Parameters[1]	Units	Number of Analyzed Sample Results	Number of Samples with Detected Concentrations	Maximum Concentration (measured)	Minimum Concentration (measured or estimated[2])	Average Concentration (measured and estimated[2])	MDL[3] - Min	MDL[3] - Max	Aquaitc Life Risk Screening Criteria (from Table 1)	Maximum Probable Risk = Max Conc. Criteria
Trace Elements										
Aluminum (total)	ug/L	37	21	1500.00	10.00	72.86	20	20	87	17.2
Lithium (total)	ug/L	38	38	180.00	18.00	65.42	2.1	2.1	96	1.9
Mercury (total)	ug/L	38	11	0.06	0.01	0.02	0.015	0.028	0.012	4.6
Uranium (natural) (total)	ug/L	38	38	4.10	0.83	2.78	0.0015	0.0015	2.6	1.6
Vanadium (total)	ug/L	38	38	19.00	3.30	6.24	0.07	0.07	12	1.6
Common anions										
Cyanide (total)	mg/L	38	17	0.06	0.00	0.01	--	0.0039	0.0052	12.1

Notes:

[1] If not specified, assume analytes and results are reported as total.

[2] For analytes with at least 1 detectable concentration, concentrations for analyses lacking detectable concentrations are estimate to be 0.5 the MDL for the analysis

[3] MDL = Method detection limit

-- = dash or blank cell in orignal FWS tables (i.e., not measured or not reported)

Trace Elements. A total of 29 trace elements were detected in the USFWS samples at concentrations above the MDLs (Table A3); five of these (aluminum, lithium, mercury, uranium, and vanadium) were detected at concentrations that exceeded their respective risk screening benchmark (Table 9). However, the MDL range for mercury analysis was 0.015-0.028 μg/L, which was greater than the screening criteria of 0.012 μg/L.

Aluminum was detected in 21 of 37 samples analyzed and exceeded the risk benchmark in two samples, with concentrations of 290 μg/L and 1,500 μg/L, yielding a maximum probable risk of 17.2 and indicating a significant potential for adverse effects. The maximum probable risks for the other four analytes were less than 10, indicating a small potential for adverse effects. All 38 USFWS surface water samples contained detected concentrations of lithium, uranium, and vanadium. Mercury was detected in 11 of 38 samples analyzed and exceeded the risk benchmark in all 11 samples; however, the MDL for mercury was above the risk screening criteria.

Volatile Organic Compounds (VOCs). A total of 41 VOCs were included in the analytical suite; 28 were not detected at concentrations above the reporting limits. Of the 13 VOCs detected, seven had not been assigned TRVs and six were at concentrations below their TRVs.

Common Anions. Bromide, chloride, and total cyanide are anions with potential toxicity to aquatic life. All three analytes were detected. No established screening benchmark was identified for bromide, and all detected concentrations of chloride were less than the established risk screening benchmark. Total cyanide was detected in 29 of 38 samples analyzed, with a maximum probable risk of 12.1 and a significant potential for adverse impacts.

Herbicides and Other Pesticides. Included in the analysis were 11 herbicides and 32 pesticides. Atrazine was the only herbicide detected with a maximum concentration below its risk screening benchmark. Of the 32 pesticides, reported concentrations were above the detection limits only for dalapon and ethoprop; however, risk screening benchmarks were not available for either of these analytes. Although neither chlorpyrifos nor demeton had concentrations exceeding their MDLs, the MDL concentrations both exceeded the established benchmarks, so risk cannot be assessed.

Explosives. For the 13 explosives analyzed, detectable concentrations were reported only for 2,4,6-trinitrotoluene and 2-nitrotoluene; a risk screening benchmark has not been established for either compound.

Pharmaceuticals. A total of 29 pharmaceuticals were analyzed. Of these, only cholesterol was detected at a concentration above the analytical reporting limits. Although the presence of cholesterol in the MRG indicates likely anthropogenic contamination, cholesterol is not considered an aquatic toxicant and, therefore, is not a contaminant of interest for this risk assessment. Additionally, no TRV is available for cholesterol.

Tier II screen based on 95 percent UCL concentrations for COPCs

A Tier II risk screening was conducted based on the risk associated with the 95 percent UCL of the analytical results for each of the six chemicals included in the USFWS dataset that were identified as COPCs in Tier I risk screening (aluminum, lithium, mercury, uranium, vanadium, and cyanide) (Table 10). The 95 percent UCL exceeded the screening benchmarks only for aluminum, mercury, and uranium. The 95 percent UCL probable risk for each of the three was less than 10, indicating only a small potential for adverse effects. Although the potential for adverse effects from total cyanide in Tier I screening was 12.12, its 95 percent UCL probable risk is only 0.008.

4.3.1.3 Reach-specific Summary

The following subsections summarize the distribution of the three COPCs, aluminum, mercury, and uranium, along the Angostura, Isleta, and San Acacia Reaches, the three reaches addressed by the USFWS study. Details related to the relationships discussed below are presented in Appendix Table B1, with some of these results more specifically highlighted below.

Angostura Reach

For reference, the following table lists the locations of the USFWS sampling sites in the Angostura Reach that are discussed in this subsection.

FWS Site Number	Sites in the Angostura Reach	Latitude/Longitude	Times sampled
1	Rio Rancho Waste Water Treatment Plant Outfall #2	351535N 1064040W	2
2	Rio Grande at La Orilla	350921N 1064014W	4
3	Rio Grande at Barelas	350446N 10646231W	2
4	Albuquerque Waste Water Treatment Plant Outfall	350103N 1064016W	2
5	Rio Grande at Los Padillas	345747N 1064113W	4

The concentration of aluminum exceeded its risk benchmark of 87 µg/L in one sample at Los Padillas on October 31, 2002. The site is located at the southern end of the reach and downstream of the Albuquerque Southside Water Reclamation Plant (USFWS Site AWWTP). This value appears to be an isolated occurrence in the data for this site. Analytical results before and after the October 31, 2002, sampling event are several orders of magnitude lower. Aluminum is a major soil-forming mineral and elevated concentrations of aluminum are often attributed to natural conditions; however, insufficient data are available to determine a source of elevated aluminum in the MRG. It is important to recognize,

Table 10. Tier II Risk Screening of Tier I Surface Water COPCs Based on 95 percent UCL of Detected and Estimated Sample Concentrations in the USFWS 2002-2003 Dataset

Parameter	Statistical Method	95% UCL Value	Criteria	Probable Risk
Aluminum	**99% Chebyshev (Mean, Sd) UCL**	**474.96**	**87**	**5.46**
Aluminum - no outlier	95% Chebyshev (Mean, Sd) UCL	68.39	87	0.79
Lithium	95% H-UCL	76.00	96	0.79
Lithium - no outlier	Student's-t UCL	64.96	96	0.68
Mercury	**95% Chebyshev (Mean, Sd) UCL**	**0.03**	**0.012**	**2.18**
Uranium	**Mod-t UCL (Adjusted for skewness)**	**3.00**	**2.6**	**1.15**
Vanadium	Mod-t UCL (Adjusted for skewness)	7.25	12	0.60
Cyanide, Total	95% Chebyshev (Mean, Sd) UCL	0.01	5.2	0.003

Notes:
COPC = Contaminants of potential concern
Sd = Standard deviation
UCL = Upper confidence limit

however, that aluminum tends to be toxic only in higher alkaline or acidic water quality conditions not occurring in the MRG.

The concentration of mercury exceeded its risk benchmark of 0.012 µg/L in only the last sample collected at La Orilla in February 29, 2003. This sampling site is at the north end of the reach and downstream of the Rio Rancho Wastewater Treatment Plant (RRWWTP). No detectable concentration was measured during three prior sampling events (July 26, 2002; November 1, 2002; and December 19, 2002). Available sampling information for RRWWTP for August 8, 2002, and January 20, 2002, also indicates non-detectable concentrations. However, it should be noted that the MDL was higher than the risk screening benchmark for mercury.

Uranium was detected at concentrations that exceed its risk benchmark in seven samples collected from the three consecutive sampling stations in the Angostura reach. No results that exceeded the benchmark were observed in the samples collected at the outfalls at AAWWTP or RRWWTP. Uranium exceeded the benchmark screening concentration at La Orilla on three dates (November 1, 2002: 3.10 µg/L; December, 19, 2002: 4.00 µg/L; and February 28, 2003: 3.80 µg/L). One sample collected at Barelas on January 17, 2003, exceeded the benchmark. The concentration of uranium did not exceed its benchmark in any of three sampling locations during the July 2002 sampling. (The pattern displayed in these results, plus that found for the other reaches, tends to point to likely natural watershed sources producing diffuse input to the MRG). Three samples collected as Los Padillas exceeded the uranium benchmark (October 31, 2002: 3.20 µg/L; December 18, 2002: 3.50 µg/L; and February 27, 2003: 3.30 µg/L).

Isleta Reach

The following table lists the locations of the USFWS sampling sites in the Isleta Reach that are discussed in this subsection.

FWS Site Number	Sites in the Isleta Reach	Latitude/Longitude	Times sampled
6	Rio Grande at Isleta below Railroad Bridge	350103N 1064040W	2
7	Rio Grande at Los Lunas	344907N 1064243W	4
8	Rio Grande at Abeytas	342701N 1064809W	2
9	Lower San Juan Irrigation Drain	342214N 1065026W	2
10	Rio Grande at La Joya	341846N 10651141W	4

Aluminum was not detected at concentrations that exceeded its risk benchmark at any of the five sampling stations in the Isleta Reach.

Mercury was detected at three consecutive sampling stations, including Los Lunas, Abeytas, and La Joya. The concentration of mercury did not exceed its MDL at the northernmost sampling station (Rio Grande at Isleta below Rail Road Bridge) or at the Lower San Juan Irrigation Drain, located between the Abeytas and La Joya sampling stations. Mercury was detected at Los Lunas at concentrations that exceeded its risk benchmark on three occasions (July 24, 2002: 0.033 µg/L; October 30, 2002: 0.055 µg/L; and February 26, 2003: 0.022 µg/L). Mercury exceeded its risk benchmark in one sample from Abeytas (January 16, 2003: 0.029 µg/L) and in one sample from La Joya (February 25, 2003: 0.022 µg/L). Again, the MDL for mercury exceeded the risk screening benchmark.

Uranium was detected at concentrations that exceeded the benchmark risk value in 11 samples at all four sampling stations in the Isleta Reach and in the Lower San Juan Irrigation Drain. Uranium concentrations exceeded the screening benchmark twice below the Rail Road Bridge (August 7, 2002: 2.80 µg/L; and February 28, 2003: 3.60 µg/L); in three samples from Los Lunas (October 30, 2002: 3.10 µg/L; February 26, 2003: 3.10 µg/L; and December 27, 2002: 3.30 µg/L); one sample from Abeytas (January 16, 2003: 3.20 µg/L); two samples from the San Juan Drain (January 27, 2003: 2.80 µg/L; and August 5, 2002: 3.20 µg/L); and all four samples from La Joya (July 23, 2002: 2.80 µg/L; September 10, 2002: 2.80 µg/L; December 13, 2002: 3.30 µg/L; and February 25, 2003: 3.30 µg/L). (Again, the pattern displayed in these results, plus that found for the other reaches, tends to point to likely natural watershed sources producing diffuse input to the MRG.)

<u>San Acacia Reach</u>

The following table lists the locations of the four USFWS sampling sites in the San Acacia Reach discussed in this subsection.

FWS Site Number	Sites in the San Acacia Reach	Latitude/Longitude	Times sampled
11	Rio Grande at Lemitar	341051N 1065302W	2
12	Rio Grande below Arroyo del Tajo	340227N 1065154W	4
13	Rio Grande at San Pedro	335427N 1065109W	2
14	Rio Grande at North Boundary of Bosque del Apache	335234N 1065058W	2

Aluminum concentration exceeded its risk benchmark in one sample from San Pedro. The San Pedro sampling station is located in the central part of the San Acacia Reach.

Detected concentrations of mercury exceeded its risk benchmark at the three consecutive southern sampling stations in the San Acacia Reach, but mercury was not detected above MDLs at the northernmost sampling station, Lemitar. The MDL for mercury exceeded the risk screening benchmark. Concentrations of mercury exceeded the benchmark in two samples collected at the Arroyo del Tajo (July 22, 2002: 0.04 µg/L; and February 24, 2002: 0.033 µg/L), one sample at San Pedro (January 14, 2003: 0.023 µg/L), and two samples from the North Boundary of Bosque del Apache sampling site (January 13, 2003: 0.026 µg/L; and August 19, 2002: 0.055 µg/L).

Uranium exceeded the screening benchmarks in eight samples, including three sampling stations in the San Acacia Reach: five samples from Lemitar (September 9, 2002: 2.70 µg/L; December 12, 2002: 3.20 µg/L; February 24, 2002: 3.20 µg/L; July 22, 2002: 3.30 µg/L; and January 15, 2003: 3.00 µg/L); two samples from San Pedro (October 24, 2002: 2.70 µg/L; and January 14, 2003: 3.10 µg/L); and one sample from the North boundary of Bosque del Apache site (January 13, 2003: 3.00 µg/L). The pattern displayed in these results, plus that found for the other reaches, tends to point to likely natural watershed sources producing diffuse input to the MRG.

4.3.2 Constituents in Sediment

As indicated in Section 4.4.1, 38 sediment samples were collected from 14 locations during the USFWS study conducted in 2002 and 2003. Sediment samples were analyzed for common anions, total cyanide, nutrients, trace elements, total mercury, total organic carbon, VOCS, PAHs, total petroleum hydrocarbons, moisture, and grain size. Table 11 lists all chemicals analyzed in sediment samples.

Table 11. List of Unique Sediment Parameters/Analytes Included in the USFWS 2002-2003 Dataset.

Parameter	Type	Parameter	Type
1,1,1-Trichloroethane	VOCs	Dimethyl sulfide	VOCs
1,1,2,2-Tetrachloroethane	VOCs	Disulfide, dimethyl	VOCs
1,1,2-Trichloroethane	VOCs	Dodecane, 1-iodo	VOCs
1,1-Dichloroethane	VOCs	Eicosane	VOCs
1,1-Dichloroethene	VOCs	Endosulfan I	Pesticides
1,2-Dichloroethane	VOCs	Endosulfan II	Pesticides
1,2-Dichloroethene (total)	VOCs	Endosulfan sulfate	Pesticides
1,2-Dichloropropane	VOCs	Endrin	Pesticides
1,3,5-Trinitrobenzene	Explosives	Endrin aldehyde	Pesticides
1,3-Dinitrobenzene	Explosives	Ethylbenzene	VOCs
1-Hexanol, 2-ethyl-	VOCs	Fluoranthene	PAHs
1-Methylnaphthalene	PAHs	Fluorene	PAHs
1-Octanol	VOCs	Fluoride	Common anions
2,4,6-Trinitrotoluene	Explosives	gamma-BHC (Lindane)	Pesticides
2,4-Dinitrotoluene	Explosives	Heneicosane	VOCs
2,6-Dinitrotoluene	Explosives	Heptachlor	Pesticides
2-Amino-4,6-dinitrotoluene	Explosives	Heptachlor epoxide	Pesticides
2-Butanone (MEK)	VOCs	HMX	Explosives
2-Hexanone	VOCs	Indeno(1,2,3-cd)pyrene	PAHs
2-Methylnaphthalene	PAHs	Iron	Trace elements
2-Nitrotoluene	Explosives	Lead	Trace elements
3-methylheptyl acetate	VOCs	Lithium	Trace elements
3-Nitrotoluene	Explosives	Magnesium	Trace elements
4,4'-DDD	Pesticides	Manganese	Trace elements
4,4'-DDE	Pesticides	Mercury	Trace elements
4,4'-DDT	Pesticides	Methanethiol	VOCs
4-Amino-2,6-dinitrotoluene	Explosives	Methoxychlor	Pesticides
4-Methyl-2-pentanone	VOCs	Methylene chloride	VOCs
4-Nitrotoluene	Explosives	Moisture	General chemistry
Acenaphthene	PAHs	Moisture (for all other analyses)	General chemistry
Acenaphthylene	PAHs	Moisture (for VOC analyses)	General chemistry
Acetic acid, 2-ethylhexyl ester	VOCs	Molybdenum	Trace elements
Acetone	VOCs	m-Xylene & p-Xylene	VOCs
Aldrin	Pesticides	Naphthalene	PAHs
alpha-BHC	Pesticides	Naphthalene, 1,6,-dimethyl	VOCs
Alpha-pinene	VOCs	Naphthalene, 2,3-dimethyl-	VOCs
Aluminum	Trace elements	n-Hexane Ext. Material	TPHs
Ammonia as N	Nutrients	Nickel	Trace elements
Anthracene	PAHs	Nitrate	Common anions
Antimony	Trace elements	Nitrate-Nitrite	Nutrients
Arsenic	Trace elements	Nitrite	Common anions
Barium	Trace elements	Nitrobenzene	Explosives
Benzene	VOCs	Nitroglycerin	Explosives
Benzene, 1,4-bis(1-methylethyl)	VOCs	Octadecane	VOCs
Benzo(a)anthracene	PAHs	Orthophosphate	Common anions
Benzo(a)pyrene	PAHs	o-Xylene	VOCs
Benzo(b)fluoranthene	PAHs	PETN	Explosives

Table 11. List of Unique Sediment Parameters/Analytes Included in the USFWS 2002-2003 Dataset (continued).

Parameter	Type	Parameter	Type
Benzo(ghi)perylene	PAHs	Phenanthrene	PAHs
Benzo(k)fluoranthene	PAHs	Phosphate as P, Ortho	Common anions
Beryllium	Trace elements	Potassium	Trace elements
beta-BHC	Pesticides	Pyrene	PAHs
Beta-pinene	VOCs	RDX	Explosives
Bicyclo[3.1.1]hept-2-ene, 3,6,	VOCs	Selenium	Trace elements
Boron	Trace elements	SGT-HEM (Petroleum Hydrocarbons)	TPHs
Bromide	Common anions	Silver	Trace elements
Bromodichloromethane	VOCs	Sodium	Trace elements
Bromoform	VOCs	Strontium	Trace elements
Bromomethane	VOCs	Styrene	VOCs
Cadmium	Trace elements	Sulfate	Common anions
Calcium	Trace elements	Tetrachloroethene	VOCs
Carbon disulfide	VOCs	Tetradecane	VOCs
Carbon tetrachloride	VOCs	Tetryl	Explosives
Chlordane (technical)	Pesticides	Thallium	Trace elements
Chloride	Common anions	Tin	Trace elements
Chlorobenzene	VOCs	Titanium	Trace elements
Chloroethane	VOCs	Toluene	VOCs
Chloroform	VOCs	Total Kjeldahl Nitrogen	Nutrients
Chloromethane	VOCs	Total organic carbon	General chemistry
Chromium	Trace elements	Total phosphorus	Nutrients
Chrysene	PAHs	Toxaphene	Pesticides
cis-1,2-Dichloroethene	VOCs	trans-1,2-Dichloroethene	VOCs
cis-1,3-Dichloropropene	VOCs	trans-1,3-Dichloropropene	VOCs
Cobalt	Trace elements	Trichloroethene	VOCs
Copper	Trace elements	Tridecane	VOCs
Cyanide, Total	Common anions	Unknown	VOCs
Cyclohexane, 1-methyl-4-(1-met	VOCs	Uranium	Trace elements
Cyclohexene, 4-methyl-1-(1-met	VOCs	Vanadium	Trace elements
delta-BHC	Pesticides	Vinyl chloride	VOCs
Dibenzo(a,h)anthracene	PAHs	Xylenes (total)	VOCs
Dibromochloromethane	VOCs	Zinc	Trace elements
Dieldrin	Pesticides		

Notes:
Yellow highlighted parameters are not considered to be toxics
PAHs = Polycyclic aromatic hydrocarbons
TPHs = Total petroleum hydrocarbons
VOCs = Volatile organic compounds

Table 12. Summary Statistics of the Sediment Screening Effort Included in the USFWS 2002-2003 Dataset

Criteria	Count
Number of analytes measured	161
Number of analytes measured not considered as toxics	17
Number of analytes considered as COPCs	144
Number of COPCs detected	86
Number of COCPs as non detects	58
Number of COPCs with SQGs	81
Number of COPCs without SQGs	63
Number of COPCs detected with SQGs	47
Number of COPCs detected without SQGs	39
Number of COPCs detected with SQGs that exceed TEC	33
Number of non detects with SQGs	34
Number of non detects without SQGs	24
Number of non detects with SQGs exceed TEC	11

4.3.2.1 Environmental / Exposure Profile Characterization

During the USFWS study, sediment samples were analyzed for 161 analytes (Table 12). Not all parameters were analyzed at the same frequency, and some chemicals were analyzed only once. Of the 161 parameters analyzed, 144 were considered initially as exhibiting potentially toxic properties that can be assessed through this risk assessment. Of these, 86 analytes had detected concentrations above MDLs. SQGs were available for 81 of the 114 chemicals analyzed and 47 of the 86 chemicals detected. Table 13 shows the chemical parameters that were detected but for which SQG are lacking for comparison.

4.3.2.2 Risk Characterization

<u>Tier I Screen based on benchmark screening values</u>

Table A4 presents the results of the initial Tier I screening of maximum sediment concentrations compared with the available sediment screening benchmarks (SQGs). Table 14 presents a summary of the analytes with sample concentrations that exceeded TEC screening benchmarks. Thirty-three detected parameters exceeded the lowest screening-level (TEC) SQGs, while maximum potential risk quotients for 25 parameters exceeded 1.0. PAHs and metals were the primary COPCs with potential risks greater than 1.0. Of these, arsenic, barium, cadmium, chromium, copper, lead, manganese, nickel, silver, and zinc exceeded the PEC. Dibenzo(a,h)anthracene was the only organic parameter that exceeded its PEC. TEC- and PEC-based hazard quotients substantially greater than 1.0, based on their maximum concentration, were found for arsenic, cadmium, chromium, cobalt, copper, lead, silver, and zinc.

Table 13. Detected Sediments Chemicals that Lack Sediment Quality Guideline Screening Values in the USFWS 2002-2003 Dataset

Type	Parameter
Common Anions	Chloride
Common Anions	Fluoride
Nutrients	Ammonia as N
TPH	n-Hexane Ext. Material
TPH	SGT-HEM (Petroleum Hydrocarbons)
Trace elements	Beryllium
Trace elements	Boron
Trace elements	Lithium
Trace elements	Molybdenum
Trace elements	Selenium
Trace elements	Strontium
Trace elements	Thallium
Trace elements	Tin
Trace elements	Titanium
Trace elements	Uranium
Trace elements	Vanadium
VOCs	1,2-Dichloroethene (total)
VOCs	1-Hexanol, 2-ethyl-
VOCs	1-Octanol
VOCs	2-Butanone (MEK)
VOCs	3-methylheptyl acetate
VOCs	Acetic acid, 2-ethylhexyl ester
VOCs	Alpha-pinene
VOCs	Benzene, 1,4-bis(1-methylethyl)
VOCs	Beta-pinene
VOCs	Bicyclo[3.1.1]hept-2-ene, 3,6,
VOCs	Cyclohexane, 1-methyl-4-(1-met
VOCs	Cyclohexene, 4-methyl-1-(1-met
VOCs	Dimethyl sulfide
VOCs	Disulfide, dimethyl
VOCs	Dodecane, 1-iodo
VOCs	Eicosane
VOCs	Heneicosane
VOCs	Methanethiol
VOCs	Naphthalene, 1,6,-dimethyl
VOCs	Naphthalene, 2,3-dimethyl-
VOCs	Octadecane
VOCs	Tetradecane
VOCs	Tridecane

Notes:
TPHs = Total petroleum hydrocarbons
VOCs = Volatile organic compounds

Table 14. Summary and Screening of Sediment Data Included in the USFWS 2002-2003 Dataset with Sample Concentrations Exceeding TEC Benchmarks

				Screening Criteria										
Parameter	Unit	Samples Analyzed (#)	Detects (#)	Maximum Detected Concentration	Minimum Detected Concentration	Average Concentration	Min of MDL	Max of MDL	TEC	PEC	Exceed TEC (#)	Exceed PEC (#)	TEC Risk Quotient	PEC Risk Quotient
1,1-Dichloroethane	ug/kg	38					0.26	2.6	0.575		24			
1-Methylnaphthalene	ug/kg	38	17	150	4.2	26.58	0.057	180	130		1		1	
4,4'-DDD	ug/kg	38	1	0.73	0.015	2.76	0.03	46	3.54	8.51	7	3	0	0.1
4,4'-DDE	ug/kg	38	6	4.5	0.0295	3.63	0.059	58	1.42	6.75	18	4	3	0.7
4,4'-DDT	ug/kg	38			0.08	3.74	0.16	63	1.19	4.77	19	7		
Acenaphthene	ug/kg	38	6	46	2.25	11.47	0.039	100	6.7	89	14	0	7	0.5
Acenaphthylene	ug/kg	38	1	19	0.07	23.95	0.14	320	5.9	130	37	2	3	0.1
Acetone	ug/kg	38	21	51	0.7	13.47	1.4	12	8.7		20		6	
Aldrin	ug/kg	38					0.22	36	2	160	10	0		
alpha-BHC	ug/kg	38	2	0.73	0.0305	2.07	0.061	33	6		3		0.1	
Aluminum	mg/kg	38	38	38000	350	11106.58	2.4	6.6	25519	59572	5	0	1	0.6
Anthracene	ug/kg	38	4	77	1.5	8.77	3	68	57.2	845	2	0	1	0.1
Antimony	mg/kg	38	22	83	0.00175	2.30	0.0033	6.9	150	200	0	0	0.6	0.4
Arsenic	mg/kg	38	38	2600	0.8	71.27	0.019	26	9.79	33	1	1	266	79
Barium	mg/kg	38	38	150000	0.16	4076.64	0.028	36	20	60	35	31	7500	2500
Benzo(a)anthracene	ug/kg	38	3	190	0.095	17.10	0.19	130	108	1050	2	0	2	0.2
Benzo(a)pyrene	ug/kg	38	17	350	0.027	21.89	0.054	47	150	1450	1	0	2	0.2
Benzo(b)fluoranthene	ug/kg	38	14	330	2.35	31.08	4.5	100	27.2	4000	8	0	12	0.08
Benzo(k)fluoranthene	ug/kg	38	7	250	0.26	20.56	0.52	61	27.2	4000	5	0	9	0.06
beta-BHC	ug/kg	38			0.025	2.18	0.05	36	5		4			
Cadmium	mg/kg	38	38	79	0.02	2.18	0.0016	2.1	0.99	4.98	1	1	80	16
Chlordane (technical)	ug/kg	38					0.22	330	3.2	18	17	8		
Chloroform	ug/kg	38	1	0.73	0.155	0.60	0.31	5.9	0.4		26		2	
Chromium	mg/kg	38	38	11000	2.1	299.75	0.021	27	43.4	111	1	1	253	99
Chrysene	ug/kg	38	12	300	0.07	26.15	0.14	63	166	1290	2	0	2	0.2
Cobalt	mg/kg	38	38	5000	1.3	136.08	0.0014	1.8	50		1		100	
Copper	mg/kg	38	38	8500	1.7	231.75	0.017	23	31.6	149	1	1	269	57
Cyanide, Total	mg/kg	38	31	1.2	0.06	0.30	0.1	0.23	0.1		32		12	
Dibenzo(a,h)anthracene	ug/kg	38	9	210	0.0395	15.69	0.079	120	33	140	3	1	6	2
Dieldrin	ug/kg	38	1	0.74	0.155	2.09	0.31	32	1.9	62	9	0	0.39	0.01
Endosulfan I	ug/kg	38					0.15	49	2.9		9			
Endosulfan II	ug/kg	38					0.061	55	14		3			
Endrin	ug/kg	38					0.11	54	2.2	210	12	0		
Fluorene	ug/kg	38	1	13	0.09	17.36	0.18	230	77.4		2		0.17	
gamma-BHC (Lindane)	ug/kg	38					0.075	32	2.4	5	8	5		
Heptachlor	ug/kg	38					0.057	41	0.6	10	19	3		
Heptachlor epoxide	ug/kg	38	3	6.8	0.02	2.08	0.04	29	2.5	16	10	0	3	0.4
Indeno(1,2,3-cd)pyrene	ug/kg	38	10	270	1.3	24.44	2.6	280	78	3800	4	0	3	0.07
Lead	mg/kg	38	38	8100	1.9	220.12	0.0048	6.3	35.8	128	1	1	226	63
Manganese	mg/kg	38	38	240000	74	6624.16	0.026	35	631	1184	4	2	380	203
Methoxychlor	ug/kg	38	2	0.5	0.095	5.94	0.19	100	19		3		0.03	
Nickel	mg/kg	38	38	8000	1.9	219.38	0.015	20	22.7	48.6	2	1	352	165
Silver	mg/kg	38	38	66	0.021	1.83	0.0026	3.5	1	2.2	1	1	66	30
Toxaphene	ug/kg	38					0.056	1300	0.1	32	37	16		
Zinc	mg/kg	38	38	35000	9.6	953.09	0.4	530	121	459	1	1	289	76

Notes:

If a parameter was measured as greater than detection, but not in all analyses, then 1/2 of the MDL was used for subsequent non-detected values for a parameter.

If a parameter was measured as less than detection for all of its respective analyses, the parameter was considered not present.

MDL = Method detection limit

PEC = Probable effects concentration

TEC = Threshold effects concentration

Table 15 lists the analytes that were not detected, but had MDLs exceeding the SQGs identified. Most of these chemicals were organochlorine pesticides. Additionally, Table 15 shows those chemicals that were infrequently detected and had MDL results reported for non-detectable measurements that were greater than the SQGs. It is possible that data augmentation (see Section 3.1.1) generated additional exceedances for some chemicals where there were "non-detectable" concentrations and the MDL was more than twice the risk screening benchmark. Overall, based on the conservative screening approach used, PAHs and metals in sediments may pose a risk to benthic invertebrates in MRG sediments. In addition, the MDLs for several oranochlorine pesticides also exceeded the TEC screening values.

High potential risk quotients were found for several of the parameters listed above based on the maximum concentration, even when compared with the less conservative PEC. Still, the TEC was repeatedly exceeded throughout the MRG sampling locations for several parameters, including cyanide, several PAHs, barium, aluminum, and acetone. Table A5 lists the locations where samples for the various parameters exceeded the TEC. Cyanide, for example, exceeded the TEC value at all locations during one

or more sample periods. Cyanide lacks a PEC value, however, which prevents a determination of whether cyanide in sediments would exceed an upper potential effects level.

For total DDT, the TEC was exceeded at least once at nearly all MRG locations with the exception of RRWWTP, AWWTP, and Isleta (Table 16). The sum of DDT compounds, however, did not exceed the PEC for total DDT at any location. DDT and its metabolites are persistent organochlorines; their use has been banned in the U.S. since the mid 1970s. Thus, the occurrence of these pesticides is likely related to its long half-life and slow degradation rate or continuous atmospheric deposition of DDT transported from areas of current use outside of the U.S. Based on these data, there appears to be a small potential for risk to aquatic benthic invertebrates from DDT in sediment; however, based on the PEC-based risk quotients, the risks are likely low, if present at all. The primary potential risks posed by DDT compounds may be to upper trophic level organisms because DDT compounds can biomagnify through the food chain. Modeling of food chain transfers from the aquatic community to avian or mammalian receptors would need to be conducted to assess whether or not the concentrations of DDT compounds in aquatic media (i.e., sediments, benthos, and or fish) are sufficiently elevated to pose a risk to avian and/or mammalian receptors. However, modeling the trophic transfer of potential bioaccumulative and biomagnifying compounds to avian and mammalian receptors is outside the scope of this ecological risk assessment which was focused on assessing potential risks to aquatic receptors.

For total PAHs, the sum TEC screening level of 1600 mg/kg was exceeded once in a sample from Los Lunas; all other TEC-based probable risks were less than 1.0 (Table 17). All PEC-based risk quotients for total PAHs were less than 1.0, and all PEC based risk quotients were 0.1 or less for

Table 15. Chemicals with MDLs Greater than Sediment Quality Guideline Screening Benchmarks in the USFWS 2002-2003 Dataset

Type	Parameter
Common Anions	Cyanide, Total
PAHs	Benzo(a)anthracene
PAHs	Benzo(b)fluoranthene
PAHs	Benzo(k)fluoranthene
PAHs	Dibenzo(a,h)anthracene
PAHs	Fluorene
Pesticide	4,4'-DDD
Pesticide	4,4'-DDE
Pesticide	**4,4'-DDT**
Pesticide	**Aldrin**
Pesticide	**alpha-BHC**
Pesticide	beta-BHC
Pesticide	**Chlordane (technical)**
Pesticide	Dieldrin
Pesticide	**Endosulfan I**
Pesticide	**Endosulfan II**
Pesticide	**Endrin**
Pesticide	**gamma-BHC (Lindane)**
Pesticide	**Heptachlor**
Pesticide	Heptachlor epoxide
Pesticide	Methoxychlor
Trace Element	Arsenic
Trace Element	Barium
Trace Element	Cadmium
Trace Element	Cobalt
Trace Element	Lead
Trace Element	Manganese
Trace Element	Silver
Trace Element	Zinc
VOCs	**1,1-Dichloroethane**
VOCs	1-Methylnaphthalene
VOCs	Acenaphthene
VOCs	Acenaphthylene
VOCs	Acetone
VOCs	Anthracene
VOCs	Chloroform
VOCs	Chrysene
VOCs	Indeno(1,2,3-cd)pyrene
VOCs	**Toxaphene**

Notes:
Bold values indicates all analyzed samples had an MDL greater than sediment quality guidelines
PAH = Polycyclic aromatic hydrocarbon
VOC = Volatile organic compound

Table 16. Risk Screening of total DDT compounds for Rio Grande Sediments in the USFWS 2002-2003 Dataset

Station Name	Date	Result (ug/kg)	TEC (ug/kg)	PEC (ug/kg)	TEC Probable Risk	PEC Probable Risk
FWS-1-RRWWTP	08-Aug-02	0.615	5.3	570	0.1	0.001
FWS-1-RRWWTP	30-Jan-03	4	5.3	570	0.8	0.007
FWS-2-La Orilla	26-Jul-02	0.54	5.3	570	0.1	0.0009
FWS-2-La Orilla	01-Nov-02	19.5	5.3	570	4	0.03
FWS-2-La Orilla	19-Dec-02	6.45	5.3	570	1	0.01
FWS-2-La Orilla	28-Feb-03	5.05	5.3	570	1	0.009
FWS-3-Barelas	22-Aug-02	1.605	5.3	570	0.3	0.003
FWS-3-Barelas	17-Jan-03	8.75	5.3	570	2	0.02
FWS-4-AWWTP	06-Aug-02	0.6	5.3	570	0.1	0.001
FWS-4-AWWTP	29-Jan-03	3.95	5.3	570	0.7	0.007
FWS-5-Los Padillas	25-Jul-02	0.62	5.3	570	0.1	0.001
FWS-5-Los Padillas	31-Oct-02	83.5	5.3	570	20	0.1
FWS-5-Los Padillas	18-Dec-02	4.35	5.3	570	0.8	0.008
FWS-5-Los Padillas	27-Feb-03	0.82	5.3	570	0.2	0.001
FWS-6-Isleta	07-Aug-02	4.95	5.3	570	0.9	0.009
FWS-6-Isleta	28-Jan-03	4.05	5.3	570	0.8	0.007
FWS-7-Los Lunas	24-Jul-02	0.57	5.3	570	0.1	0.001
FWS-7-Los Lunas	30-Oct-02	75.5	5.3	570	10	0.1
FWS-7-Los Lunas	17-Dec-02	4.15	5.3	570	0.8	0.007
FWS-7-Los Lunas	26-Feb-03	0.89	5.3	570	0.2	0.002
FWS-8-Abeytas	12-Sep-02	10	5.3	570	2	0.02
FWS-8-Abeytas	16-Jan-03	14.5	5.3	570	3	0.03
FWS-9-LSJD	05-Aug-02	0.605	5.3	570	0.1	0.001
FWS-9-LSJD	27-Jan-03	30	5.3	570	6	0.05
FWS-10-La Joya	23-Jul-02	0.585	5.3	570	0.1	0.001
FWS-10-La Joya	10-Sep-02	1.075	5.3	570	0.2	0.002
FWS-10-La Joya	13-Dec-02	17.15	5.3	570	3	0.03
FWS-10-La Joya	25-Feb-03	0.82	5.3	570	0.2	0.001
FWS-11-Lemitar	21-Aug-02	1.635	5.3	570	0.3	0.003
FWS-11-Lemitar	15-Jan-03	8.55	5.3	570	2	0.02
FWS-12-Arroyo del Tajo	24-Feb-02	0.855	5.3	570	0.2	0.002
FWS-12-Arroyo del Tajo	22-Jul-02	8.8	5.3	570	2	0.02
FWS-12-Arroyo del Tajo	09-Sep-02	2.335	5.3	570	0.4	0.004
FWS-12-Arroyo del Tajo	12-Dec-02	0.1245	5.3	570	0.02	0.0002
FWS-13-San Pedro	14-Jan-03	10.35	5.3	570	2	0.02
FWS-13-San Pedro	26-May-03	0.235	5.3	570	0.04	0.0004
FWS-13-San Pedro	27-May-03	0.72	5.3	570	0.1	0.001
FWS-13-San Pedro	28-May-03	0.265	5.3	570	0.05	0.0005
FWS-13-San Pedro	May-03	1.22	5.3	570	0.2	0.002
FWS-14-NB BdA	19-Aug-02	1.23	5.3	570	0.2	0.002
FWS-14-NB BdA	13-Jan-03	45	5.3	570	8	0.08

Notes:
Total DDx compounds are the sum of analytical results for DDD, DDE, and DDT.
At FWS-13, DDX compounds were analyzed on three different dates. Here they are summed for a May 2003 value.
PEC = Probable effects concentration
TEC = Threshold effects concentration

Table 17. Risk Screening of total PAHs for Rio Grande Sediments in the USFWS 2002-2003 Dataset.

Station Name	Date	Result (ug/kg)	TEC (ug/kg)	PEC (ug/kg)	TEC Probable Risk	PEC Probable Risk
FWS-1-RRWWTP	08-Aug-02	694	1600	23000	0.4	0.03
FWS-1-RRWWTP	30-Jan-03	155.5	1600	23000	0.1	0.007
FWS-2-La Orilla	26-Jul-02	104.35	1600	23000	0.07	0.005
FWS-2-La Orilla	01-Nov-02	730.5	1600	23000	0.5	0.03
FWS-2-La Orilla	19-Dec-02	273	1600	23000	0.2	0.01
FWS-2-La Orilla	28-Feb-03	116.95	1600	23000	0.07	0.005
FWS-3-Barelas	22-Aug-02	82.05	1600	23000	0.05	0.004
FWS-3-Barelas	17-Jan-03	223.3	1600	23000	0.1	0.01
FWS-4-AWWTP	06-Aug-02	2085	1600	23000	1	0.09
FWS-4-AWWTP	29-Jan-03	69.1	1600	23000	0.04	0.003
FWS-5-Los Padillas	25-Jul-02	261.35	1600	23000	0.2	0.01
FWS-5-Los Padillas	31-Oct-02	1469	1600	23000	0.9	0.06
FWS-5-Los Padillas	18-Dec-02	113.95	1600	23000	0.07	0.005
FWS-5-Los Padillas	27-Feb-03	60.65	1600	23000	0.04	0.003
FWS-6-Isleta	07-Aug-02	1192.5	1600	23000	0.7	0.05
FWS-6-Isleta	28-Jan-03	68.05	1600	23000	0.04	0.003
FWS-7-Los Lunas	24-Jul-02	63.25	1600	23000	0.04	0.003
FWS-7-Los Lunas	30-Oct-02	3127.5	1600	23000	**2**	0.1
FWS-7-Los Lunas	17-Dec-02	85.4	1600	23000	0.05	0.004
FWS-7-Los Lunas	26-Feb-03	65.35	1600	23000	0.04	0.003
FWS-8-Abeytas	12-Sep-02	79	1600	23000	0.05	0.003
FWS-8-Abeytas	16-Jan-03	150.05	1600	23000	0.09	0.007
FWS-9-LSJD	05-Aug-02	59.5	1600	23000	0.04	0.003
FWS-9-LSJD	27-Jan-03	132.75	1600	23000	0.08	0.006
FWS-10-La Joya	23-Jul-02	287	1600	23000	0.2	0.01
FWS-10-La Joya	10-Sep-02	118.85	1600	23000	0.07	0.005
FWS-10-La Joya	13-Dec-02	74.3	1600	23000	0.05	0.003
FWS-10-La Joya	25-Feb-03	59.3	1600	23000	0.04	0.003
FWS-11-Lemitar	21-Aug-02	339.2	1600	23000	0.2	0.01
FWS-11-Lemitar	15-Jan-03	95.35	1600	23000	0.06	0.004
FWS-12-Arroyo del Tajo	24-Feb-02	62.5	1600	23000	0.04	0.003
FWS-12-Arroyo del Tajo	22-Jul-02	485.5	1600	23000	0.3	0.02
FWS-12-Arroyo del Tajo	09-Sep-02	88.45	1600	23000	0.06	0.004
FWS-12-Arroyo del Tajo	12-Dec-02	243.9695	1600	23000	0.2	0.01
FWS-13-San Pedro	14-Jan-03	192.75	1600	23000	0.1	0.008
FWS-13-San Pedro	05-Jul-03	3.15	1600	23000	0.002	0.0001
FWS-13-San Pedro	06-Jul-03	9.5	1600	23000	0.006	0.0004
FWS-13-San Pedro	07-Jul-03	2.1	1600	23000	0.001	0.00009
FWS-13-San Pedro	08-Jul-03	4	1600	23000	0.003	0.0002
FWS-13-San Pedro	09-Jul-03	1.45	1600	23000	0.0009	0.00006
FWS-13-San Pedro	10-Jul-03	3.15	1600	23000	0.002	0.0001
FWS-13-San Pedro	11-Jul-03	2.1	1600	23000	0.001	0.00009
FWS-13-San Pedro	12-Jul-03	1.85	1600	23000	0.001	0.00008
FWS-13-San Pedro	13-Jul-03	1.95	1600	23000	0.001	0.00008
FWS-13-San Pedro	14-Jul-03	3.7	1600	23000	0.002	0.0002
FWS-13-San Pedro	15-Jul-03	7	1600	23000	0.004	0.0003
FWS-13-San Pedro	16-Jul-03	7	1600	23000	0.004	0.0003
FWS-13-San Pedro	17-Jul-03	1.85	1600	23000	0.001	0.00008
FWS-13-San Pedro	18-Jul-03	9.5	1600	23000	0.006	0.0004
FWS-13-San Pedro	19-Jul-03	2.65	1600	23000	0.002	0.0001
FWS-13-San Pedro	20-Jul-03	5.5	1600	23000	0.003	0.0002
FWS-13-San Pedro	21-Jul-03	23	1600	23000	0.01	0.001
FWS-13-San Pedro	22-Jul-03	2.65	1600	23000	0.002	0.0001
FWS-13-San Pedro	Jul-03	92.1	1600	23000	0.06	0.004
FWS-14-NB BdA	19-Aug-02	70.15	1600	23000	0.04	0.003
FWS-14-NB BdA	13-Jan-03	141.9	1600	23000	0.09	0.006

Notes:
PEC = Probable effects concentration
TEC = Threshold effects concentration

individual PAHs. PAHs are therefore an unlikely source of risk to benthic macroinvertebrates based on the USFWS sample results.

TECs and PECs for two groups of chemicals are available that are based on the sum total (not individual) concentrations of the individual chemicals in the group: total DDT (the sum of DDD, DDE, and DDT) and PAHs. These two groups of compounds are evaluated relative to group benchmarks in Tables 18 and 19.

Tier II Screen based on cumulative assessment of PECs

The Tier I screening allowed for the separation of the chemical concentrations in sediments into two primary groups: (1) those that likely do not pose a potential risk, and (2) those that deserve further consideration as part of a Tier II cumulative assessment. Several chemical groups in MRG sediments were evaluated to assess the potential for cumulative effects, including total DDT compounds, PAHs, organochlorine compounds, and metals. Total DDT and PAH compounds were found to pose small or no risk to aquatic benthic invertebrates; however, their contribution to overall cumulative effects were evaluated along with the organochlorine compounds and metals in a Tier II assessment. Specifically, total DDT compounds were collectively evaluated together with other organochlorine compounds for potential cumulative effects because of their persistence in the environment.

Potential cumulative effects in sediments were evaluated through the use of a mean PEC-quotient (PEC-Q) as described in MacDonald and others (2000). As reported in Section 3.3.2.2, the use of mean PEC-Qs has been validated using a number of datasets as an appropriate mechanism to assess potential cumulative effects. A mean PEC-Q is derived from the summation of individual PEC-Qs divided by the number of results that were summed (in other words, a mean value of all PEC-Qs). Table 18 shows the mean PEC-Qs derived for organochlorine compounds. Reliable PEC values have been derived and identified for the MRG for organochlorine pesticides that include chlordane, dieldrin, DDD, DDE, DDT, endrin, heptachlor epoxide, and lindane. At least one of the sampling events rather than periods at all USFWS sites included a mean PEC-Q greater than 0.12; there is a low incidence of toxicity below this value.

Based on the guidelines in USEPA (2000) and MacDonald and others (2003), where mixtures occur, mean PEC-Qs of 0.12 and 0.63 are recommended as SQGs for assessing sediments. Less than 10 percent chronic toxicity is indicated for a mean PEC-Q of 0.12, while greater than 50 percent toxicity is suggested for a mean PEC-Q of 0.63 or higher. Minimal potential for toxicity is expected for those mean PEC-Qs less than or equal to 0.12, and risks are expected to be negligible.

Table 18. Mean PEC Quotients for selected Organochlorine Pesticides in the USFWS 2002-2003 Dataset

Station Name	Date	Sum PEC HQ	Count	Mean PEC-Q	TOC (g/kg)
FWS-1-RRWWTP	08-Aug-02	0.3	8	0.038	1.2
FWS-1-RRWWTP	30-Jan-03	1.3	8	0.16	1.1
FWS-2-La Orilla	26-Jul-02	0.27	8	0.033	2.5
FWS-2-La Orilla	01-Nov-02	6.3	8	0.79	6.1
FWS-2-La Orilla	19-Dec-02	2.4	8	0.31	6.7
FWS-2-La Orilla	28-Feb-03	1.6	8	0.21	4.6
FWS-3-Barelas	22-Aug-02	0.44	8	0.055	2.3
FWS-3-Barelas	17-Jan-03	2.9	8	0.36	3.5
FWS-4-AWWTP	06-Aug-02	0.3	8	0.037	1
FWS-4-AWWTP	29-Jan-03	1.3	8	0.16	0.62
FWS-5-Los Padillas	25-Jul-02	0.31	8	0.038	4.9
FWS-5-Los Padillas	31-Oct-02	27	8	3.4	11
FWS-5-Los Padillas	18-Dec-02	1.5	8	0.19	1.8
FWS-5-Los Padillas	27-Feb-03	0.27	8	0.033	0.74
FWS-6-Isleta	07-Aug-02	0.97	8	0.12	8
FWS-6-Isleta	28-Jan-03	1.3	8	0.16	0.295
FWS-7-Los Lunas	24-Jul-02	0.28	8	0.035	0.74
FWS-7-Los Lunas	30-Oct-02	25	8	3.1	21
FWS-7-Los Lunas	17-Dec-02	1.5	8	0.19	2.7
FWS-7-Los Lunas	26-Feb-03	0.29	8	0.036	0.87
FWS-8-Abeytas	12-Sep-02	3.2	8	0.41	7.8
FWS-8-Abeytas	16-Jan-03	4.7	8	0.59	22
FWS-9-LSJD	05-Aug-02	0.3	8	0.037	0.68
FWS-9-LSJD	27-Jan-03	9.8	8	1.2	15
FWS-10-La Joya	23-Jul-02	0.29	8	0.036	4.4
FWS-10-La Joya	10-Sep-02	0.35	8	0.044	14
FWS-10-La Joya	13-Dec-02	3.8	8	0.47	6.4
FWS-10-La Joya	25-Feb-03	0.27	8	0.033	0.91
FWS-11-Lemitar	21-Aug-02	0.47	8	0.059	9
FWS-11-Lemitar	15-Jan-03	2.8	8	0.35	4.6
FWS-12-Arroyo del Tajo	24-Feb-02	0.28	8	0.035	2
FWS-12-Arroyo del Tajo	22-Jul-02	4.3	8	0.54	7.8
FWS-12-Arroyo del Tajo	09-Sep-02	0.54	8	0.068	7.3
FWS-12-Arroyo del Tajo	12-Dec-02	0.058	8	0.0073	8.8
FWS-13-San Pedro	14-Jan-03	3.4	8	0.42	6.6
FWS-13-San Pedro	13-May-03	0.11	1	0.055	
FWS-13-San Pedro	15-May-03	0.007	1		
FWS-13-San Pedro	19-May-03	0.0015	1		
FWS-13-San Pedro	21-May-03	0.11	1		
FWS-13-San Pedro	23-May-03	0.018	1		
FWS-13-San Pedro	26-May-03	0.028	1		
FWS-13-San Pedro	27-May-03	0.11	1		
FWS-13-San Pedro	28-May-03	0.056	1		
FWS-14-NB BdA	19-Aug-02	0.43	8	0.054	2.3
FWS-14-NB BdA	13-Jan-03	9.8	8	1.2	8.6

Notes:

respective PEC).
The Mean PEC-Q is Sum PEC-Q divided by the number of analyses and analytes for a location.

Organochlorine pesticides for which reliable PEC values have been derived and are included in this analysis:
chlordane, dieldrin, DDD, DDE, DDT, Endrin, Heptachlor epoxide, and Lindane

At FWS-13-San Pedro Location, the individual analyses from several sampling events in May 2003 were used to arrive at a Mean PEC-Q
Mean PEC-Qs < 0.1 to 0.12 are considered to have a low incidence of toxicity.
Shaded cells are those PEC-Qs that exceed 0.12.

Table 19. Cumulative Mean PEC-Qs for Total PAHs, Select Organochlorine Pesticides, and Select Metals in the USFWS 2002-2003 Dataset

Station Name	Date	Sum PEC HQ	Count	Mean PEC-Q
FWS-1-RRWWTP	08-Aug-02	0.21	8	0.026
FWS-1-RRWWTP	30-Jan-03	0.22	8	0.028
FWS-2-La Orilla	26-Jul-02	0.56	8	0.070
FWS-2-La Orilla	01-Nov-02	0.48	8	0.060
FWS-2-La Orilla	19-Dec-02	0.81	8	0.101
FWS-2-La Orilla	28-Feb-03	0.62	8	0.078
FWS-3-Barelas	22-Aug-02	0.26	8	0.033
FWS-3-Barelas	17-Jan-03	0.36	8	0.046
FWS-4-AWWTP	06-Aug-02	0.53	8	0.066
FWS-4-AWWTP	29-Jan-03	0.41	8	0.051
FWS-5-Los Padillas	25-Jul-02	0.32	8	0.040
FWS-5-Los Padillas	31-Oct-02	1.2	8	0.156
FWS-5-Los Padillas	18-Dec-02	0.2	8	0.025
FWS-5-Los Padillas	27-Feb-03	0.15	8	0.018
FWS-6-Isleta	07-Aug-02	0.62	8	0.078
FWS-6-Isleta	28-Jan-03	0.26	8	0.033
FWS-7-Los Lunas	24-Jul-02	0.28	8	0.035
FWS-7-Los Lunas	30-Oct-02	1.2	8	0.151
FWS-7-Los Lunas	17-Dec-02	0.3	8	0.038
FWS-7-Los Lunas	26-Feb-03	0.22	8	0.028
FWS-8-Abeytas	12-Sep-02	1.4	8	0.178
FWS-8-Abeytas	16-Jan-03	1	8	0.130
FWS-9-LSJD	05-Aug-02	0.33	8	0.041
FWS-9-LSJD	27-Jan-03	0.8	8	0.100
FWS-10-La Joya	23-Jul-02	0.43	8	0.054
FWS-10-La Joya	10-Sep-02	0.81	8	0.101
FWS-10-La Joya	13-Dec-02	0.48	8	0.060
FWS-10-La Joya	25-Feb-03	0.18	8	0.023
FWS-11-Lemitar	21-Aug-02	0.62	8	0.077
FWS-11-Lemitar	15-Jan-03	0.53	8	0.066
FWS-12-Arroyo del Tajo	24-Feb-02	0.51	8	0.063
FWS-12-Arroyo del Tajo	22-Jul-02	1.1	8	0.143
FWS-12-Arroyo del Tajo	09-Sep-02	1	8	0.127
FWS-12-Arroyo del Tajo	12-Dec-02	0.64	8	0.079
FWS-13-San Pedro	10-Nov-02	0.097	1	0.083
FWS-13-San Pedro	13-Nov-02	0.02	1	
FWS-13-San Pedro	14-Nov-02	0.12	1	
FWS-13-San Pedro	16-Nov-02	0.065	1	
FWS-13-San Pedro	17-Nov-02	0.07	1	
FWS-13-San Pedro	20-Nov-02	0.2	1	
FWS-13-San Pedro	27-Nov-02	0.085	1	
FWS-13-San Pedro	28-Nov-02	0.0094	1	
FWS-13-San Pedro	14-Jan-03	0.74	8	0.092
FWS-14-NB BdA	19-Aug-02	550	8	69.369
FWS-14-NB BdA	13-Jan-03	0.93	8	0.116

Notes:
The Sum PEC-Q is the sum of PEC-Qs for each parameter (analytical result for each parameter
The Mean PEC-Q is Sum PEC-Q divided by the number of analyses and analytes for a location.
Metal Parameters used in this analysis are those for which reliable PECs have been developed,
At FWS-13-San Pedro Location, the individual analyses from several sampling events in May 2003
Mean PEC-Qs < 0.1 to 0.12 are considered to have a low incidence of toxicity.
Shaded cells are those PEC-Qs that exceed 0.12.

Assessment of PEC-Qs in the MRG included metals for which reliable PECs have been developed; these metals include arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. The mean PEC-Qs for metals were consistently less than 0.12 at several sites (Table 19). However, at least one sample from the Los Padillas, Los Lunas, Abeytas, Arroyo del Tajo, and North Boundary of Bosque del Apache sites all yielded mean PEC-Qs greater than 0.12. Mean PEC-Qs were only slightly higher than 0.12 for all but one of these locations. A single very high PEC-Q was calculated for the North Boundary of Bosque del Apache site. In general, except for one sample that had a PEC-Q of 0.156 from Los Padillas, the potential incidence of toxicity posed by the cumulative metals evaluated is confined to the lower reaches of the MRG.

A total mean PEC-Q was derived for each site and sampling date to evaluate all three chemical groups collectively (Table 20). This assessment included PEC-Qs for PAHs, organochlorine pesticides and metals. Mean PEC-Qs of less than or equal to 0.12 were calculated for locations RRWWTP, AWWTP, and Isleta, and thus risks are expected to be negligible. The incidence of cumulative toxicity, based on the chemical parameters evaluated, is potentially greater than 10 percent for all other locations. The mean PEC-Qs at three locations were sufficiently elevated to suggest that the incidence of toxicity is greater than 50 percent: the Los Padillas, Los Lunas, and North Boundary of Bosque del Apache sites. The mean PEC-Q at the Los Padillas and Los Lunas sites is driven by organochlorine pesticide concentrations, while the mean PEC-Q is driven by metals, primarily zinc, at the North Boundary of Bosque del Apache site.

This assessment of potential cumulative risks to benthic macroinvertebrates exposed to COPCs in MRG sediments indicates that some risks are present and potentially elevated at several locations. Concentrations of organochlorine pesticides are the likely risk drivers that pose the most risks to benthic receptors. Mean PEC-Qs for metals indicate that cumulative exposure to metals at most sites does not pose a potential risks and the incidence of toxicity caused by metals (evaluated using this procedure) is low. Not all chemicals found to exceed the TEC were included in this analysis; thus, other COPCs may also contribute to potential risks. The chemicals that are not included in this analysis were omitted because they lacked reliable PECs; this methodology works only for chemical parameters where reliable PECs were available (MacDonald and others 2000; 2003).

In addition to the parameters shown to exceed PECs and that contribute to potential cumulative risks, cyanide, barium, aluminum, manganese, and acetone also require additional assessment to assess their actual risk in the MRG. Cyanide was detected in almost all samples of MRG sediments. Its continued presence in sediments suggests strong metal-cyanide complexes that do not easily or readily

Table 20. Cumulative Mean PEC-Qs for Total PAHs, Select Organochlorine Pesticides, and Select Metals in the USFWS 2002-2003 Dataset

Station Name	Date	PEC-Q Total PAHs	Sum PEC-Q Organochlorine Pesticides	Sum PEC-Q Metals	Total Mean PEC-Q	Potential Incidence of Toxicity
FWS-1-RRWWTP	08-Aug-02	0.03	0.30	0.21	0.03	<10%
FWS-1-RRWWTP	30-Jan-03	0.007	1.31	0.22	0.09	<10%
FWS-2-La Orilla	26-Jul-02	0.005	0.27	0.56	0.05	<10%
FWS-2-La Orilla	01-Nov-02	0.03	6.32	0.48	0.40	>10% and <50%
FWS-2-La Orilla	19-Dec-02	0.01	2.44	0.81	0.19	>10% and <50%
FWS-2-La Orilla	28-Feb-03	0.005	1.65	0.62	0.13	>10% and <50%
FWS-3-Barelas	22-Aug-02	0.004	0.44	0.26	0.04	<10%
FWS-3-Barelas	17-Jan-03	0.01	2.86	0.36	0.19	>10% and <50%
FWS-4-AWWTP	06-Aug-02	0.09	0.30	0.53	0.05	<10%
FWS-4-AWWTP	29-Jan-03	0.003	1.30	0.41	0.10	<10%
FWS-5-Los Padillas	25-Jul-02	0.01	0.31	0.32	0.04	<10%
FWS-5-Los Padillas	31-Oct-02	0.06	27.26	1.25	1.68	>50%
FWS-5-Los Padillas	18-Dec-02	0.005	1.53	0.20	0.10	<10%
FWS-5-Los Padillas	27-Feb-03	0.003	0.27	0.15	0.02	<10%
FWS-6-Isleta	07-Aug-02	0.05	0.97	0.62	0.10	<10%
FWS-6-Isleta	28-Jan-03	0.003	1.32	0.26	0.09	<10%
FWS-7-Los Lunas	24-Jul-02	0.003	0.28	0.28	0.03	<10%
FWS-7-Los Lunas	30-Oct-02	0.1	24.69	1.21	1.53	>50%
FWS-7-Los Lunas	17-Dec-02	0.004	1.52	0.30	0.11	<10%
FWS-7-Los Lunas	26-Feb-03	0.003	0.29	0.22	0.03	<10%
FWS-8-Abeytas	12-Sep-02	0.003	3.25	1.42	0.28	>10% and <50%
FWS-8-Abeytas	16-Jan-03	0.007	4.72	1.04	0.34	>10% and <50%
FWS-9-LSJD	05-Aug-02	0.003	0.30	0.33	0.04	<10%
FWS-9-LSJD	27-Jan-03	0.006	9.79	0.80	0.62	>10% and <50%
FWS-10-La Joya	23-Jul-02	0.01	0.29	0.43	0.04	<10%
FWS-10-La Joya	10-Sep-02	0.005	0.35	0.81	0.07	<10%
FWS-10-La Joya	13-Dec-02	0.003	3.79	0.48	0.25	>10% and <50%
FWS-10-La Joya	25-Feb-03	0.003	0.27	0.18	0.03	<10%
FWS-11-Lemitar	21-Aug-02	0.01	0.47	0.62	0.06	<10%
FWS-11-Lemitar	15-Jan-03	0.004	2.79	0.53	0.20	>10% and <50%
FWS-12-Arroyo del Tajo	24-Feb-02	0.003	0.28	0.51	0.05	<10%
FWS-12-Arroyo del Tajo	22-Jul-02	0.02	4.32	1.14	0.32	>10% and <50%
FWS-12-Arroyo del Tajo	09-Sep-02	0.004	0.54	1.01	0.09	<10%
FWS-12-Arroyo del Tajo	12-Dec-02	0.01	0.06	0.64	0.04	<10%
FWS-13-San Pedro	14-Jan-03	0.008	3.37	0.74	0.24	>10% and <50%
FWS-13-San Pedro	2003	0.004	0.44	0.67	0.07	<10%
FWS-14-NB BdA	19-Aug-02	0.003	0.43	554.95	32.67	>50%
FWS-14-NB BdA	13-Jan-03	0.006	9.84	0.93	0.63	>50%

Notes:
Where mixtures occur – mean PEC-Q of 0.12 and 0.63 are recommended as SQAGs for assessing sediments. <10% chronic toxicity below mean PEC-Q of 0.12 and >50% toxicity above mean PEC-Q of 0.63.
Shaded cells are those PEC-Qs that exceed 0.12.
PAHs = Polycyclic aromatic hydrocarbons
PEC-Q = Probable effects concentration quotient

decompose, similar to HCN in water. The toxicity of metal-cyanide complexes is not well understood or documented.

The barium TRVs were based on values from the USEPA (1977), which compiled values for evaluating sediments in Great Lakes harbors. Barium tends to form highly insoluble complexes with sulfate and carbonate. Few, if any, literature sources examine barium in sediments and the studies available are largely focused on marine sediments because barite is the primary component in drilling mud used in offshore oil and gas exploration. Dr. Scott Carr (2002, Texas A&M Marine Ecotoxicology Research Station) reported that barium is a relatively inert and nontoxic element. He sampled sediments in the vicinity of oil exploration platforms with barium concentrations as high as 25 percent, with no toxicity directly attributable to barium observed. There are reports in the literature, however, of barium, disrupting or mimicking calcium-mediated physiological processes (for example, spicule formation in sea urchins and digestive gland epithelia in grass shrimp). Overall, barium in aquatic systems is not considered very toxic. Barium exhibits low solubility in freshwater systems and is preferentially complexed with sulfate to form barium sulfate ($BaSO_4$). This complex has low to no bioavailability. Precipitation of barium sulfate to the sediments would result in high barium concentrations; however, it is likely not bioavailable.

TRVs for aluminum and manganese were compiled from Ingersoll and others (1996) and were based on 28-day *Hyallela azteca* survival, growth, and sexual maturation where bulk total sediments were analyzed. The ER-L and effects range-median (ER-M) guidelines were derived for each of these parameters. In addition, the investigators derived a no effects concentration (NEC), which was defined as the maximum concentration of a chemical in a sediment that did not significantly adversely affect the specific response (survival, growth, or maturation). This value was similar to the AET, in which no adverse effect is expected for a particular response if the chemical concentration is below the AET.

The NEC derived for aluminum from the *Hyallela azteca* 28-day tests and used to derive the TRVs for aluminum was 73,160 mg/kg. The derived NEC value for manganese is 4,460 mg/kg. Research by Ingersoll and others (1996) indicates that the ER-M and NECs, rather than the ER-L, should be used to predict toxicity of samples because of the lower Type I error (false positives) associated. Assuming that the NEC is a better predictor of no effects, no measured MRG sediment concentrations of aluminum exceed the NEC value. Similarly, all but one manganese concentration exceeds the NEC. It is highly probable that neither of these parameters poses a risk to benthic invertebrates. Still, continued monitoring and assessment of these two metals may help to more accurately define their concentrations for a more accurate determination of risks.

Elevated concentrations of acetone and indications of risk in the USFWS sediment samples are enigmatic, as this chemical is highly volatile and rapidly biodegradable. Acetone, which is a VOC, is a common laboratory contaminant, as indicated in USFWS (2004). It occurs naturally as a biodegradation product of sewage, solid wastes, and alcohols, and as an oxidation product of humic substances (World Health Organization [WHO] 1998). Acetone in an aquatic system is predominantly found in water, rather than in sediment, because it is a relatively volatile compound and because of its high water solubility and low sediment adsorption coefficient (WHO 1998). Acetone may be present in sediments as a result of biodegradation; however, it is not clear whether the concentration measured is a result of actual concentrations or is an artifact of laboratory contamination.

Thus, based on this assessment of sediment chemistry and the availability of SQGs to screen measured concentrations of COPCs in sediments, metals at select locations and organochlorine pesticides would require additional investigations to assess their true risk in the MRG. Future evaluation of cyanide complexes should also be considered. No SQGs were available for several metals (Table 13) and the potential incidence of toxicity was elevated for those where SQGs were available. Organochlorine pesticides were found to pose a potential risk both individually and cumulatively. Additional assessment to required to resolve the actual risks posed.by PAHs would appear to be of minimal concern.

4.3.3 Tissue Constituents

Based on the data presented in the USFWS report, 54 parameters were measured from Rio Grande fish tissues from 14 sites. At most sites, parameters were measured in composited samples of available fish tissues, or the individual species listed in Table A6; however, as indicated above, not all parameters were measured at all sites. Samples of only FHMs and only red shiners were submitted for separate analysis; these samples were collected from a select number of stations, primarily Los Lunas and Arroyo del Tajo. These samples of FHMs and red shiners allow assessment of whether different species accumulated chemicals at different rates. This information could aid in understanding how these two species may contribute to tissue residues observed in the composite samples assessed.

4.3.3.1 Environmental / Exposure Profile Characterization

Table A6 presents the results of the fish tissues analyzed during this study, along with a comparison of those tissue concentrations to tissue residue effects values. Summary statistics are provided to illustrate the range of measured concentrations in tissue for each parameter, with no-detect values subject to data augmentation procedures discussed in Section 3.2.3. The MDLs used in the USFWS studies appear adequate for the parameters where tissue residue effects values were available. Table 21 presents a summary of analytes were maximum sample concentrations exceeded risk screening benchmarks.

The USFWS (2004) fish tissue analysis included 29 samples collected from 14 sites along the MRG. The samples were analyzed for trace elements, total mercury, pesticides, moisture, and lipids. The UFSWS characterized the results for trace elements, total mercury, moisture, and lipids as “variable.” Concentrations of pesticides detected above the laboratory established reporting limit and/or the MDLs were found for 4,4’-DDD, 4,4’-DDE, alpha-chlordane, beta-BHC, dieldrin, endrin, endrin aldehyde,

Table 21. Summary of Fish Tissue Residue Concentrations in the USFWS 2002-2003 Dataset with Sample Concentrations Exceeding Screening Benchmarks

Parameter	Units	Number of Samples Analyzed	Count of Detects	Max of Detects	Min of Result (MDL/2)	Average of Result (MDL/2)	Min of MDL	Max of MDL	Adult Life Stages		Early Life Stages		Max Value Exceeds Screening Value	Count of Samples Exceeding Screening Value
									NER	LER	NER	LER		
Aluminum	mg/kg	22	21	610	6.5	140.11		13	42.65			<40	**Yes**	21
Aluminum (FHM)	mg/kg	5	5	790	41	434.20		12					**Yes**	4
Aluminum (Red Shiner)	mg/kg	4	4	350	28	152.50		18					**Yes**	2
Chromium	mg/kg	20	20	2	0.22	0.62		34	0.9	0.9			**Max > NER = LER**	4
Chromium (FHM)	mg/kg	4	4	1.9	0.36	1.07		0.13					**Max > NER = LER**	2
Chromium (Red Shiner)	mg/kg	4	4	1.5	0.29	0.78		0.2					**Max > NER = LER**	2
Mercury	ug/kg	21	21	1300	0.09	119.23		170	500	1950			**Max > NER < LER**	1
Mercury (FHM)	ug/kg	5	5	120	15	56.00		24					**No**	
Mercury (Red Shiner)	ug/kg	4	4	220	52	139.75		35					**No**	
Selenium	mg/kg	20	20	10	0.24	1.41		18	8		8		**Yes**	1
Selenium (FHM)	mg/kg	4	4	2.7	0.29	1.43		0.072	5.7	7			**No**	
Selenium (Red Shiner)	mg/kg	4	4	2.9	0.2	1.70		0.11					**No**	
Zinc	mg/kg	20	20	230	19	69.50		130			170	200	**Yes**	3
Zinc (FHM)	mg/kg	4	4	130	23	66.00		0.5					No	
Zinc (Red Shiner)	mg/kg	4	4	300	31	152.25		0.74					**Yes**	2

Notes:

Tissue data were reported on a dry weight basis. Effects residue concentrations were reported on a wet weight basis. Wet weight benchmarks were adjusted to dry weight using the following:

Dry weight = (wet weight conc)/(1-(%moisture/100). % moisture was assumed to be 80%

FHM = Fathead minnow

LER = Lowest effect residue

MDL = Method detection limit

NER = No effects residue

gamma-BHC (lindane), and methoxychlor. The frequency of detection was low. In fact, most of the organochlorine pesticides were detected only once, if at all. The DDT metabolite DDD was detected most frequently and had the highest measured concentration across all of the pesticides.

All of the 30 trace elements analyzed in fish tissues were detected. All are naturally occurring, and several trace elements are essential nutrients for proper fish health. There is no clear trend to suggest that one species accumulated either more or less of the chemicals analyzed in FHMs and red shiners across both the pesticides and trace elements.

Concentrations of aluminum, mercury, selenium, and silver as trace element markers were compared spatially across the 14 sample locations to evaluate if there were any trends in fish tissue concentrations (i.e., increasing or decreasing) across sampling locations. No apparent spatial trends emerged (Figure 4). Concentrations of each trace element in tissues also tended to fluctuate over time at a location, and there does not appear to be a time of the year when concentrations were consistently higher; however, the temporal data series is limited.

4.3.3.2 Risk Characterization - Screening based on tissue residue effects values

Tier I Screening based on tissue residue effects values

Comparison of the maximum concentration for a parameter to a tissue residue effects value shows that five trace elements (aluminum, chromium, mercury, selenium, and zinc) in Rio Grande fish tissue exceeded the residue effects levels (Table 21). Table A7 lists the sites where each of the trace elements exceeded its effects value.

Tier II Screening based on 95 percent UCL values

Using the maximum concentration as a basis for assessing risk is the most conservative screening that can be conducted; therefore, the 95 percent UCL for each of the parameters that exceeded the Tier I screening values was also derived. Table 22 shows the 95 percent UCLs for these parameters and how they compare to the screening tissue effects values. Because the 95 percent UCL is based on the distribution of all of the data, it is assumed to be a reasonable maximum exposure concentration that can be used to gauge potential risks. Of the five parameters where the maximum tissue residue concentrations exceeded their respective tissue residue effects levels, concentrations of aluminum, chromium, and mercury based on their 95 percent UCL concentrations exceeded their respective tissue residue effects levels as well.

Based on the fish tissue residues measured for organochlorine pesticides and trace elements, aluminum, chromium, and mercury pose a risk to Rio Grande fish, based on accumulated residues when the 95 percent UCL is used as a reasonable maximum fish tissue concentration. Uncertainties remain

Table 22. Comparison of the 95 percent UCL Fish Tissue Residue Concentrations to Tissue Residue Effects Values for the USFWS 2002-2003 Dataset

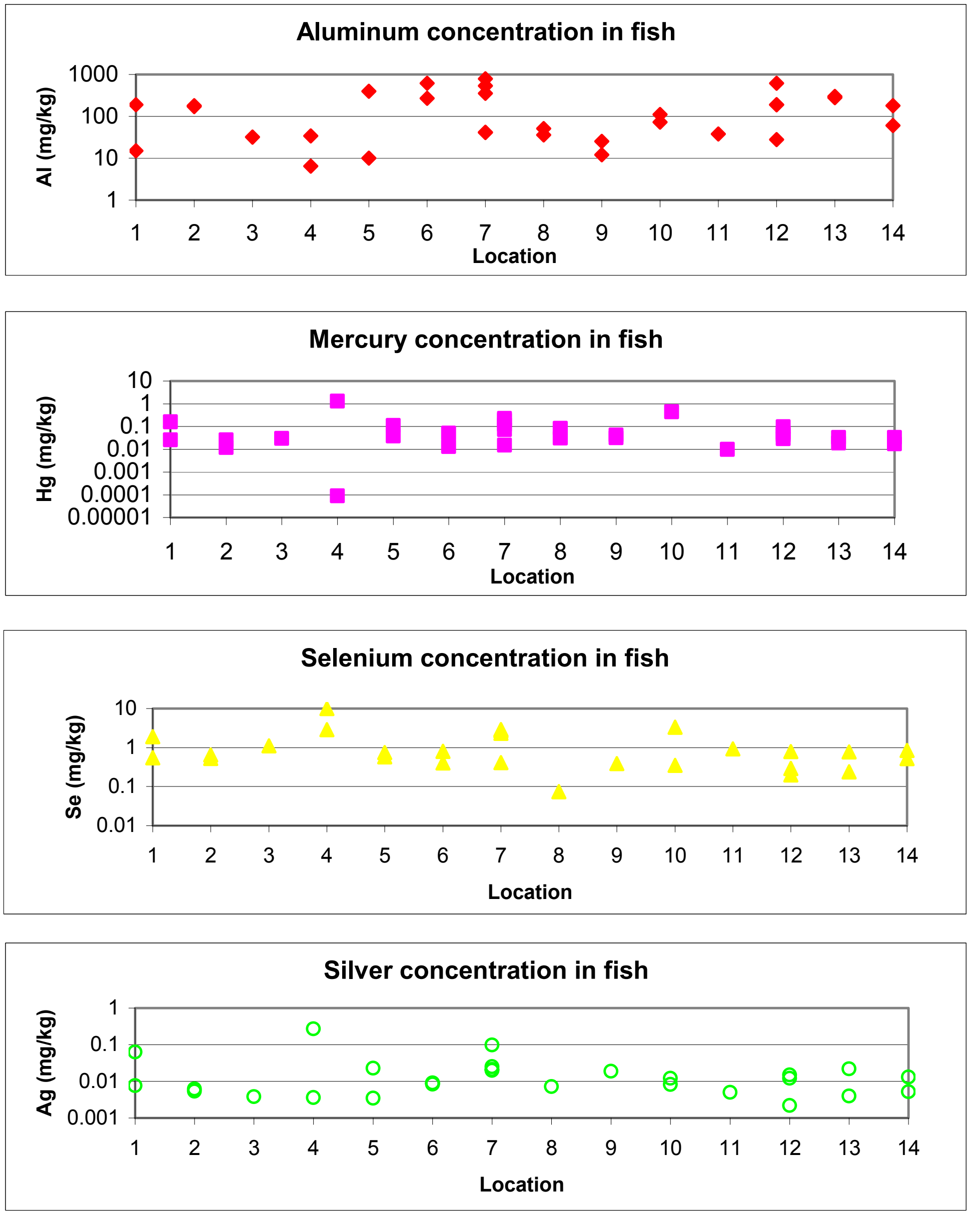
Parameter	Units	Number of Samples Analyzed	Max of Detects	95% UCL	Adult Life Stages		Early Life Stages		95% UCL Exceeds Screening Value	Source
					NER	LER	NER	LER		
Aluminum	mg/kg	31	790	278.9	42.65			40	**Yes**	Jarvinen and Ankley 1999
Chromium	mg/kg	28	2	1.15	0.18	0.18			**Yes**	USACE 2004
Mercury	ug/kg	30	1300	549.71	500	1950			**Yes**	Beckvar et al. 2005
Selenium	mg/kg	28	10	2.12	7.9		7.9		**No**	USEPA 2004
Zinc	mg/kg	28	300	141.2			170	200	**No**	Jarvinen and Ankley 1999

Notes:
Maximum values were used when the 95% UCL derived was greater than the maximum value.
Tissue data and Residue Effects values are reported on a dry weight basis.
LER = Lowest effect residue
NER = No effects residue
UCL = Upper confidence limit

regarding actual risk indicated by the tissue concentrations reported; these uncertainties include applicability of the screening benchmarks used, the specific pathway for potential exposure, the form in which the metal is present, and applicability of species sampled.

Residue effects levels for aluminum in tissue are based on trout exposures. Gensemer and Playle 1999 conducted an extensive review of aluminum toxicity on aquatic organisms. They report that aluminum is a gill toxicant that is affected by calcium and dissolved organic matter, which make it less bioavailable at the gill surface. Although extensive, the review acknowledges that much of the available research has been conducted on aluminum exposures in soft water conditions with low pH. Neither of these conditions exists in the Rio Grande. The aluminum concentrations measured from fish collected at most sites were many times higher than the tissue residue effects concentrations. This difference suggests that the actual effects level of aluminum accumulation in fish tissues is much higher under the conditions in the Rio Grande, but how much higher is uncertain.

Like aluminum, the tissue residue effects level for chromium used to screen Rio Grande fish was derived from limited data. The endpoint was based on decreases in microsomal enzyme activity in liver, kidney, and gill tissue and increases in mitochondrial activity in the kidney of rainbow trout. These sublethal chronic responses are likely overly conservative. For example, in another study reported in the ERED (USACE 2003), the NECs of chromium based on residues in gill, kidney, and liver ranged from 2.14 to 2.18 mg/kg and were based on different biochemical endpoints. Jarvinen and Ankley (1999) report a data record for rainbow trout based on 180-day exposure. Chromium concentrations were 3.48 mg/kg in kidney, 1.98 mg/kg in liver, and 0.58 mg/kg in muscle. These measurements were all indicated to have no effects on survival. Based on the most sensitive measurement, chromium would still exceed



Locations:

1	FWS-1-RRWWTP	8	FWS-8-Abeytas
2	FWS-2-La Orilla	9	FWS-9-LSJD
3	FWS-3-Barelas	10	FWS-10-La Joya
4	FWS-4-AWWTP	11	FWS-11-Lemitar
5	FWS-5-Los Padillas	12	FWS-12-Arroyo del Tajo
6	FWS-6-Isleta	13	FWS-13-San Pedro
7	FWS-7-Los Lunas	14	FWS-14-NB BdA

Figure 4. Tissue Residue Concentrations in Fish from 14 Rio Grande Locations

the residue effects value; however, using the upper effects residue value, it is indicated that none of the chromium levels in fish would exceed the residue effects data.

The tissue residue effects values for mercury cited in Beckvar and others (2005) are based on FHM exposure to methylmercury via the diet pathway. The endpoint was reproduction. In the same report, data from another study found an NER of 0.79 and LER of 0.86 mg/kg. Both studies used the same exposure route, chemical form, and endpoints. The NER was 0.69 mg/kg and the LER was 1.2 mg/kg in another study from the same report with a growth endpoint and mercury chloride exposure via water. Again, the range of potential endpoints, metals species used in exposures, and exposure routes all affect the concentrations that are considered to pose no or low effects based on the body burdens measured. Except for the excessively high concentration of mercury measured in the samples from location FWS-4, all other concentrations of mercury were similar to or less than the LER used for screening these data.

The preceding discussion is not intended to suggest that risks are not present to fish in the MRG based on measured tissue residues of chemicals. Rather, it is meant to suggest that there are uncertainties associated with the use of non-site-specific data. Additional investigations may be warranted for the parameters identified as posing a potential risk that focus on RGSMs or the surrogate species, FHMs, to evaluate whether concentrations measured in tissues of these species are associated with adverse effects.

4.4 URGWOPS EIS 1985-2000 Dataset

The URGWOPS dataset includes analytical results for water, sediment, and fish tissues. Sampling locations, sampling frequencies, and parameters analyzed were generally inconsistent throughout the dataset. Nevertheless, the dataset included samples collected along multiple locations in each reach from January 1985 to September 1999 (for surface water and tissue), and to October 2000 (for sediment). The following subsections summarize this information.

4.4.1 Water Constituents

The URGWOPS dataset provides results on 414 water quality analytes (Table 23). Detectable concentrations were found for all analytes in at least one sample. Of the 414 analytes, 339 were potentially toxic contaminants of interest. The remaining 75 analytes consisted of physical and conventional water quality constituents that are not considered potentially toxic to aquatic life.

Table 23. List of 516 Unique Analytes included in the URGWOPS 1985-2000 Dataset

Parameter Name
1,1,1,2-Tetrachloroethane, total
1,1,1-Trichloroethane, total
1,1,2,2-Tetrachloroethane, total
1,1,2-Trichloro-1,2,2-trifluoroethane, total
1,1,2-Trichloroethane, total
1,1-Dichloroethane, total
1,1-Dichloroethene, total
1,1-Dichloropropene, total
1,2,3-Trichlorobenzene, total
1,2,3-Trichloropropane, total
1,2,4-Trichlorobenzene, total
1,2,4-Trimethylbenzene, total
1,2-Dibromo-3-chloropropane, total
1,2-Dibromoethane, total
1,2-Dichlorobenzene, total
1,2-Dichloroethane, total
1,2-Dichloropropane, total
1,2-Diphenylhydrazine, total
1,3,5-Trimethylbenzene, total
1,3,5-Trinitrobenzene, dissolved
1,3-Dichlorobenzene, total
1,3-Dichloropropane, total
1,3-Dichloropropene, total
1,3-Dinitrobenzene, dissolved
1,4-Dichlorobenzene, total
1-Naphthol, dissolved
2,2-Dichloropropane, total
2,4,5-T, dissolved
2,4,5-T, total
2,4,6-Trichlorophenol, total
2,4-D, dissolved
2,4-D, total
2,4-DB, dissolved
2,4-DB, total
2,4-Dichlorophenol, total
2,4-Dimethylphenol, total
2,4-Dinitrophenol, total
2,4-Dinitrotoluene, dissolved
2,4-Dinitrotoluene, total
2,6-Diethylaniline, dissolved
2,6-Dinitrotoluene, dissolved
2,6-Dinitrotoluene, total
2-Amino-4,6-dinitrotoluene, dissolved
2-Chloro-4-isopropylamino-6-amino-s-triazine, dissolved
2-Chloroethyl vinyl ether, total
2-Chloronaphthalene, total
2-Chlorophenol, total
2-Chlorotoluene, total
2-Methyl-4,6-dinitrophenol, dissolved
2-Methyl-4,6-dinitrophenol, total
2-Nitroaniline, total
2-Nitrophenol, total
2-Nitrotoluene, dissolved
3,3'-Dichlorobenzidine, total
3,5-Dichlorobenzoic acid, total
3-Hydroxy carbofuran, dissolved
3-Hydroxycarbofuran, total
3-Nitroaniline, total
3-Nitrotoluene, dissolved
4-Amino-2,6-dinitrotoluene, dissolved
Ethylbenzene, total
Fecal coliform, M-FC MF (0.45 micron) method
Fecal coliform, M-FC MF (0.7 micron) method
Fecal streptococci, azide-dextrose-ethyl-violet azide
Fecal streptococci, KF streptococcus MF method
Fenuron, dissolved
Fluometuron, dissolved
Fluoranthene, total
Fluoride, total
Fluoride, dissolved
Fonofos, dissolved
Fonofos, total
gamma-Chlordane, total
Gross alpha radioactivity 2-sigma combined uncertainty
Gross alpha radioactivity, dissolved, natural
Gross alpha radioactivity, total, natural
Gross beta radioactivity 2-sigma combined uncertainty
Gross beta radioactivity, dissolved, Cs-137
Gross beta radioactivity, dissolved, Sr-90/Y-90
Gross beta radioactivity, total, Sr-90/Y-90
Hardness
Heptachlor epoxide, total
Heptachlor, total
Hexachlorobenzene, total
Hexachlorobutadiene, total
Hexachlorocyclopentadiene, total
Hexachloroethane, total
HMX, dissolved
Indeno[1,2,3-cd]pyrene, total
Iron, dissolved
Iron, total
Isophorone, total
Isopropylbenzene, total
Lead, dissolved
Lead, total
Lindane, dissolved
Lindane, total
Linuron, dissolved
Lithium, dissolved
Lithium, total
Magnesium, dissolved
Magnesium, total
Malathion, dissolved
Malathion, total
Manganese, dissolved
Manganese, total
MCPA, dissolved
MCPB, dissolved
Mercury, dissolved
Mercury, total
Merphos, total
Methiocarb, dissolved
Methiocarb, total
Methomyl, dissolved
Methomyl, total
Methyl parathion, dissolved
Methyl parathion, total
Methyl tert-butyl ether, total (MTBE)
Methyl trithion, total
Methylene blue active substances, total

Table 23. List of 516 Unique Analytes included in the URGWOPS 1985-2000 Dataset (continued)

Parameter Name	
4-Bromophenyl phenyl ether, total	Metolachlor, dissolved
4-Chloro-3-methylphenol, total (3-Methyl-4-chlorophenol)	Metolachlor, total
4-Chlorophenyl phenyl ether, total	Metribuzin, dissolved
4-Chlorotoluene, total	Metribuzin, total
4-Isopropyltoluene, total	Mirex, total
4-Nitrophenol, total	Molinate, dissolved
4-Nitrotoluene, dissolved	Molybdenum, dissolved
9H-Fluorene, total	Molybdenum, total
Acenaphthene, total	m-Xylene plus p-xylene, total
Acenaphthylene, total	Naphthalene, total
Acetochlor, dissolved	Napropamide, dissolved
Acetone, total	n-Butylbenzene, total
Acifluorfen, dissolved	Neburon, dissolved
Acifluorfen, total	Nickel, dissolved
Acrolein, total	Nickel, total
Acrylonitrile, total	Nitrate, dissolved
Alachlor, dissolved	Nitrate, dissolved, as nitrogen
Alachlor, total	Nitrate, total, as nitrogen
Aldicarb sulfone, dissolved	Nitrite plus nitrate, dissolved
Aldicarb sulfone, total	Nitrite plus nitrate, total
Aldicarb sulfoxide, dissolved	Nitrite, dissolved
Aldicarb sulfoxide, total	Nitrite, dissolved, as nitrogen
Aldicarb, dissolved	Nitrite, total, as nitrogen
Aldicarb, total	Nitrobenzene, dissolved
Aldrin, total	Nitrobenzene, total
Alkalinity, dissolved	N-Nitrosodimethylamine,total
Alpha radioactivity 2-sigma combined uncertainty	N-Nitrosodi-n-propylamine, total
Alpha radioactivity counting error, total	N-Nitrosodiphenylamine, total
Alpha radioactivity, dissolved	Noncarbonate hardness, dissolved, field
Alpha-emitting isotopes of radium, dissolved	Noncarbonate hardness
alpha-Endosulfan, total	Noncarbonate hardness, total, field
alpha-HCH, dissolved	Noncarbonate hardness, total, lab
alpha-HCH, total	Norflurazon, dissolved
alpha-HCH-d6, surrogate, dissolved	n-Propylbenzene, total
Aluminum, total	o,p'-DDD, total
Aluminum, dissolved	o,p'-DDE, total
Americium-241 2-sigma combined uncertainty, dissolved	o,p'-DDT, total
Americium-241 counting error, total	Oil and grease, total
Americium-241, dissolved	Organic carbon, dissolved
Americium-241, total	Organic carbon, total
Ametryn, total	Organic nitrogen, dissolved
Ammonia (un-ionized), total	Organic nitrogen, total
Ammonia plus organic nitrogen, dissolved	Orthophosphate, dissolved
Ammonia plus organic nitrogen, dissolved, modified	Orthophosphate, total
Ammonia plus organic nitrogen, total	Oryzalin, dissolved
Ammonia plus organic nitrogen, total, modified	Oxamyl, dissolved
Ammonia, dissolved as NH4	Oxamyl, total
Ammonia, dissolved as nitrogen	o-Xylene, total
Ammonia as NH4, total	p,p'-DDD, total
Ammonia, total as nitrogen	p,p'-DDE, dissolved
Anthracene, total	p,p'-DDE, total
Antimony, total, EPA contract	p,p'-DDT, total
Antimony, total	p,p'-Ethyl-DDD, total
Antimony, dissolved	p,p'-Methoxychlor, total
Aroclor 1016, total	Parathion, dissolved
Aroclor 1221, total	Parathion, total
Aroclor 1232, total	PCBs, total
Aroclor 1242, total	Pebulate, dissolved
Aroclor 1248, total	Pendimethalin, dissolved

Table 23. List of 516 Unique Analytes included in the URGWOPS 1985-2000 Dataset (continued)

Parameter Name	
Aroclor 1254, total	Pentachlorophenol, total
Aroclor 1260, total	pH, total, field
Arsenic, dissolved	pH,total, laboratory
Arsenic, total	Phenanthrene, total
Atrazine, dissolved	Phenol, total
Atrazine, total	Phenolic compounds, total
Azinphos-methyl, dissolved	Phorate, dissolved
Azinphos-methyl, total	Phorate, total
Barium, dissolved	Phosphate, total
Barium, total	Phosphorus, dissolved
BDMC, total	Phosphorus, dissolved, modified jirka method
Benfluralin, dissolved	Phosphorus, total
Bentazon, dissolved	Phosphorus, total
Benzene, total	Phosphorus, total, modified jirka method
Benzidine, total	Picloram, dissolved
Benzo[a]anthracene, total	Picloram, total
Benzo[a]pyrene, total	Plutonium-238 2-sigma combined uncertainty, dissolved
Benzo[b]fluoranthene, total	Plutonium-238 counting error, total
Benzo[g,h,i]perylene, total	Plutonium-238, dissolved
Benzo[k]fluoranthene, total	Plutonium-238, total
Benzyl alcohol, total	Plutonium-239 counting error, total
Benzyl n-butyl phthalate, total	Plutonium-239 plus plutonium-240 2-sigma combined uncertainty
Beryllium, dissolved	Plutonium-239 plus plutonium-240, dissolved
Beryllium, total	Plutonium-239, total
Beta radioactivity 2-sigma combined uncertainty	Polychlorinated naphthalenes, total
Beta radioactivity counting error, total	Potassium, dissolved
beta-Endosulfan, total	Potassium, total
beta-HCH, total	Prometon, dissolved
Bicarbonate, dissolved, incremental titration	Prometon, total
Bicarbonate, total, fixed endpoint (pH 4.5)	Prometryn, total
Bicarbonate, total, incremental titration	Propachlor, dissolved
Biochemical oxygen demand, total	Propachlor, total
Bis(2-chloroethoxy)methane, total	Propanil, dissolved
Bis(2-chloroethyl) ether, total	Propargite, dissolved
Bis(2-chloroisopropyl) ether, total	Propazine, total
Bis(2-ethylhexyl) adipate, total [Di(2-ethylhexyl) adipate]	Propham, dissolved
Bis(2-ethylhexyl) phthalate, total [Di(2-ethylhexyl) phthalate]	Propoxur, dissolved
Boron, dissolved	Propoxur, total
Boron, total	Propyzamide, dissolved
Bromacil, dissolved	Propyzamide, total
Bromacil, total	Pyrene, total
Bromide, dissolved	Radium-226 2-sigma combined uncertainty, dissolved
Bromobenzene, total	Radium-226, dissolved, radon method
Bromochloromethane, total	Radium-226, total
Bromodichloromethane, total	Radium-228 2-sigma combined uncertainty, dissolved
Bromomethane, total (methyl bromide)	Radium-228 counting error, total
Bromoxynil, dissolved	Radium-228, dissolved
Butachlor, total	Radium-228, total
Butylate, dissolved	RDX, dissolved
Cadmium, dissolved	sec-Butylbenzene, total
Cadmium, total	Selenium, total
Calcium, dissolved	Selenium, dissolved
Calcium, total	Silica, dissolved
Calcium, total, recoverable	Silicon, dissolved
Carbaryl, dissolved	Silicon, total
Carbaryl, total	Silver, dissolved
Carbofuran, dissolved	Silver, total, EPA contract
Carbofuran, total	Silver, total

Table 23. List of 516 Unique Analytes included in the URGWOPS 1985-2000 Dataset (continued)

Parameter Name	
Carbon-14	Silvex, dissolved
Carbonate, dissolved, incremental titration	Silvex, total
Carbonate, total, fixed endpoint (pH 8.3)	Simazine, dissolved
Carbonate, water, total, incremental titration	Simazine, total
Carbonate, total	Simetryn, total
Carbon dioxide, total	Sodium, dissolved
Carbophenothion, total	Sodium, water, percent in equivalents of major cations
Chemical oxygen demand, high level, total	Sodium, total
Chloramben methyl ester, dissolved	Specific conductance, non-temperature corrected
Chloramben, total	Specific conductance, total, field
Chlordane, total	Specific conductance, total, laboratory
Chloride, dissolved	Specific conductance, total
Chlorine (total residual), total	Strontium, dissolved
Chlorobenzene, total	Strontium, total
Chloroethane, total	Strontium-90 2-sigma combined uncertainty, dissolved
Chloromethane, total (methyl chloride)	Strontium-90, dissolved
Chlorothalonil, dissolved	Styrene, total
Chlorothalonil, total	Sulfate, dissolved
Chlorpyrifos, dissolved	Sulfate, dissolved, uncorrected
Chlorpyrifos, total	Sulfate, total
Chromium, total	Tebuthiuron, dissolved
Chromium, dissolved	Tebuthiuron, total
Chrysene, total	Temperature
cis-1,2-Dichloroethene, total	Terbacil, dissolved
cis-1,3-Dichloropropene, total	Terbacil, total
cis-Chlordane, total	Terbufos, dissolved
cis-Permethrin, dissolved	Terbuthylazine, dissolved
Clopyralid, dissolved	tert-Butylbenzene, total
Cobalt, dissolved	Tetrachloroethene, total
Cobalt, total	Tetrachloromethane, total (carbon tetrachloride)
Copper, dissolved	Tetrahydrofuran, total
Copper, total	Thallium, total
Cyanazine, dissolved	Thallium, dissolved
Cyanazine, total	Thiobencarb, dissolved
Cyanide, free, total	Thorium-230 2-sigma combined uncertainty, dissolved
Cyanide, dissolved	Thorium-232 counting error, total
Cyanide, total, EPA contract	Thorium-232, total
Cyanide, total	Tin, dissolved
Dacthal monoacid, dissolved	Tin, total
Dalapon, total	TNT, dissolved
DCPA, dissolved	Toluene, total
delta-HCH, total	Total nitrogen, dissolved
Diazinon, dissolved	Total nitrogen, total
Diazinon, total	Toxaphene, total
Dibenzo[a,h]anthracene, total	trans-1,2-Dichloroethene, total
Dibenzofuran, total	trans-1,3-Dichloropropene, total
Dibromochloromethane, total	trans-Chlordane, total
Dibromomethane, total	trans-Permethrin, total
Dicamba, dissolved	Triadimefon, total
Dicamba, total	Triallate, dissolved
Dichlobenil, dissolved	Tribromomethane, total
Dichlorodifluoromethane, total	Tribuphos, total
Dichloromethane, total (methylene chloride)	Trichloroethene, total
Dichlorprop, dissolved	Trichlorofluoromethane, total
Dichlorprop, total	Trichloromethane, total (chloroform)
Dieldrin, dissolved	Triclopyr, dissolved
Dieldrin, total	Trifluralin, dissolved
Diethyl phthalate, total	Trifluralin, total
Dimethyl phthalate, total	Tritium 2-sigma combined uncertainty, total
Di-n-butyl phthalate, total	Tritium, total

Table 23. List of 516 Unique Analytes included in the URGWOPS 1985-2000 Dataset (continued)

Parameter Name	
Di-n-octyl phthalate, total	Uranium (natural) 2-sigma combined uncertainty
Dinoseb, dissolved	Uranium (natural), dissolved
Dinoseb, total	Uranium (natural), total
Dissolved oxygen, total	Uranium, dissolved, extraction fluorometric method
Disulfoton, dissolved	Uranium-234 2-sigma combined uncertainty, dissolved
Disulfoton, total	Uranium-234 counting error, total
Diuron, dissolved	Uranium-234, dissolved
Endosulfan sulfate, total	Uranium-234, total
Endrin aldehyde, total	Uranium-235 2-sigma combined uncertainty, dissolved
Endrin ketone, total	Uranium-235, dissolved
Endrin, total	Uranium-238 2-sigma combined uncertainty, dissolved
EPTC, dissolved	Uranium-238 counting error, total
EPTC, total	Uranium-238, dissolved
Escherichia coli, m-TEC MF method	Uranium-238, total
Esfenvalerate, dissolved	Vanadium, total
Ethalfluralin, dissolved	Vanadium, dissolved
Ethalfluralin, total	Vinyl chloride, dissolved
Ethion, total	Vinyl chloride, total
Ethoprop, dissolved	Xylenes, total
Ethoprop, total	Zinc, dissolved
Ethyl methyl ketone, total (2-Butanone)	Zinc, total

4.4.1.1 Environmental / Exposure Profile Characterization

Table A8 presents environmental summaries for each of the 414 analytes, including number of samples with detectable concentrations, and maximum, minimum, and average concentrations from the URGWOPS database. This information characterizes the broad range of environmental conditions existing in the MRG over the sampling period.

The examination points to several uncertainties in the data. The results for many of the chemicals in the database show patterns of a single or a few repeating values across the majority of the reported results. These values are typically whole numbers and are often associated with remarks and QA/QC codes that suggest the value reported may be the MDL or have some functional relationship to the MDL. In addition, there are possible duplicated entries of the same data. In these cases, it is possible that results for field duplicates were collected and reported for individual sampling stations; however, the likelihood that the results would be identical, as contained in the database, is low. Without a confirmation effort that would require a data-point-by-data-point review, the results contained in this dataset can only be used at face value for this assessment or as an assumed MDL.

Table 24 presents a summary of risk screening of water quality data in the URGWOPS dataset. In addition to summary statistics, this table presents information about the number of samples with reported values that are assumed to be MDLs and exceed the screening benchmark and the assumed MDL range that exceeds the screening benchmarks. The analytes that are not shaded in Table 24 indicate that

Table 24. List of 70 Analytes in the URGWOPS 1985-2000 Dataset for Water Quality with Sample Concentrations Exceeding Aquatic Life Screening Criteria

Analytes/Parameters	Units	Aquaitc Life Risk Screening Criteria (see Table 1)	Maximum Probable Risk = Max Conc. / Criteria	Number of Samples (reported)	Total Number of Exceedances	Number of MDL Exceedance	Assumed MDL Range Exceeding Screening Criteria	Maximum Concentration (reported)	Minimum Concentration (reported)	Average Concentration (reported)
Trace elements										
Aluminum (dissolved)	**ug/L**	**87**	**21.84**	**303**	**116**	**78**	**100-200**	**1,900**	**1**	**77.693**
Aluminum (total)	**ug/L**	**87**	**1494.25**	**122**	**122**	**--**	**--**	**130,000**	**170**	**6,265.902**
Barium (total)*	**ug/L**	**793.58**	**4.91**	**89**	**6**	**--**	**--**	**3,900**	**100**	**197.753**
Beryllium (total)	ug/L	5.3	18.87	73	18	17	50-100	100	1	71.315
Beryllium (dissolved)*	ug/L	5.3	18.87	278	57	57	10-100	100	0.5	6.994
Cadmium (dissolved)*	**ug/L**	**0.36**	**77.78**	**360**	**360**	**354**	**1**	**28**	**1**	**1.094**
Cadmium (total)*	ug/L	0.41	24.39	165	165	163	1-10	10	1	1.158
Chromium (total)*	**ug/L**	**136.29**	**2.35**	**170**	**3**	**--**	**--**	**320**	**1**	**13.217**
Copper (dissolved)*	ug/L	14.44701213	6.92	362	103	99	50-100	100	1	29.101
Copper (total)*	**ug/L**	**15.05**	**39.87**	**164**	**85**	**64**	**20-100**	**600**	**1**	**49.957**
Iron (total)	**ug/L**	**1000**	**240.00**	**91**	**70**	**--**	**--**	**240,000**	**200**	**8,135.714**
Lead (dissolved)*	ug/L	4.602131471	21.73	357	102	99	5-100	100	1	2.454
Lead (total)*	**ug/L**	**6.5**	**107.69**	**115**	**70**	**33**	**5-10**	**700**	**0.5**	**19.991**
Manganese (total)*	**ug/L**	**3,154.70**	**1.68**	**87**	**1**	**--**	**--**	**5,300**	**40**	**243.333**
Mercury (dissolved)[1]	ug/L	0.77	6.49	138	2	1	5	5	0.1	0.216
Mercury (total)	**ug/L**	**0.012**	**183.33**	**267**	**267**	**237**	**0.02-0.5**	**2**	**0.02**	**0.298**
Nickel (dissolved)*	ug/L	83.4964758	11.98	298	298	210	1-1,000	1,000	1	41.210
Nickel (total)*	**ug/L**	**83.74771895**	**2.39**	**75**	**75**	**70**	**10-100**	**200**	**3**	**93.440**
Selenium (dissolved)	**ug/L**	**1.844**	**5.42**	**227**	**342**	**333**	**0.5-5**	**10**	**1**	**2.626**
Selenium (total)	**ug/L**	**2**	**6.50**	**342**	**91**	**86**	**5-10**	**13**	**0.5**	**2.437**
Silver (dissolved)*	ug/L	8.422552635	11.87	306	306	302	0.2-100	100	0.2	24.222
Silver (total)	ug/L	9.03	110.74	133	133	133	1-1,000	1,000	1	51.714
Tin (total)	ug/L	73	13.70	67	67	64	100-1,000	1,000	100	149.254
Uranium (natural) (total)	**ug/L**	**2.6**	**2.31**	**16**	**16**	**13**	**2-5**	**6**	**2**	**2.563**
Vanadium (total)	ug/L	12	8.33	179	50	24	1-100	100	2.8	15.256
Zinc (total)	**ug/L**	**192.51**	**12.47**	**156**	**156**	**89**	**10-100**	**2,400**	**10**	**80.256**
Volatile Organic Compounds										
1,2-Dibromoethane (total)	ug/L	0.006	166.67	1	1	1	1	1	1	1.000
1,3-Dichloropropene (total)	ug/L	0.055	54.55	1	1	1	3	3	3	3.000
Benzidine (total)	ug/L	0.1	10.00	1	1	1	1	1	1	1.000
Hexachlorobutadiene (total)	ug/L	1	1.00	1	1	1	1	1	1	1.000
Polychlorinatedbiphenyls										
Aroclor 1221 (total)	ug/L	0.28	1.79	2	2	2	0.5	0.5	0.5	0.500
Aroclor 1242 (total)	ug/L	0.053	9.43	4	4	4	0.5	0.5	0.5	0.500
Aroclor 1248 (total)	ug/L	0.081	6.17	4	4	4	0.5	0.5	0.5	0.500
Aroclor 1254 (total)	ug/L	0.033	30.30	4	4	4	1	1	1	1.000
PCBs (total)	ug/L	0.014	7.14	49	49	49	0.1	0.1	0.1	0.100
Herbicides										
Dinoseb (total)	ug/L	0.48	1.67	2	2	2	0.2-0.8	0.8	0.2	0.500
Pesticides										
alpha-Endosulfan (total)	ug/L	0.056	8.93	53	1	1	0.5	0.5	0.01	0.022
Azinphos-methyl (total)	ug/L	0.005	20.00	2	2	2	0.1	0.1	0.1	0.100

Table 24. List of 70 Analytes in the URGWOPS 1985-2000 Dataset for Water Quality with Sample Concentrations Exceeding Aquatic Life Screening Criteria (continued)

Analytes/Parameters	Units	Aquaitc Life Risk Screening Criteria (see Table 1)	Maximum Probable Risk = Max Conc. / Criteria	Number of Samples (reported)	Total Number of Exceedances	Number of MDL Exceedance	Assumed MDL Range Exceeding Screening Criteria	Maximum Concentration (reported)	Minimum Concentration (reported)	Average Concentration (reported)
beta-Endosulfan (total)	ug/L	0.056	178.57	4	4	4	0.1-10	10	0.1	2.575
Chlordane (total)	ug/L	0.0043	23.26	48	48	48	0.1	0.1	0.1	0.100
Chlorpyrifos (total)	ug/L	0.041	1.22	20	20	20	0.01-0.05	0.05	0.01	0.012
Diazinon (dissolved)	**ug/L**	**0.004[1]**	**17.56**	**34**	**34**	**14**	**0.002**	**0.072**	**0.002**	**0.012**
Diazinon (total)	ug/L	0.004	25.00	51	51	41	0.01-0.1	0.1	0.01	0.016
Dieldrin (total)	ug/L	0.0019	5263.16	53	53	53	0.01-10	10	0.01	0.204
Endrin (total)	ug/L	0.036	2.78	53	53	53	0.01-0.1	0.1	0.01	0.017
Heptachlor (total)	ug/L	0.0038	13.16	53	53	53	0.01-0.5	0.05	0.01	0.013
Heptachlor epoxide (total)	ug/L	0.0038	131.58	53	53	53	0.01-0.5	0.5	0.01	0.022
Methyl parathion (total)[2]	ug/L	0.008	6.25	50	50	50	0.01-0.5	0.05	0.01	0.011
Mirex (total)	ug/L	0.001	10.00	48	48	48	0.01	0.01	0.01	0.010
p,p'-DDD (total)	ug/L	0.001	100.00	54	54	54	0.01-0.1	0.1	0.01	0.017
p,p'-DDE (dissolved)	ug/L	0.001[1]	5.45	34	34	34	0.006	0.006	0.006	0.006
p,p'-DDE (total)	ug/L	0.001	100.00	54	54	54	0.01-0.1	0.1	0.01	0.017
p,p'-DDT (total)	ug/L	0.001	100.00	54	54	54	0.01-0.1	0.1	0.01	0.017
Parathion (total)	ug/L	0.013	3.85	50	50	50	0.01-0.5	0.05	0.01	0.011
Toxaphene (total)	ug/L	0.0002	5000.00	53	53	53	0.07-1	1	0.07	0.982
Common anions										
Cyanide (dissolved)	mg/L	0.0052[1]	1.92	10	10	10	0.01	0.01	0.01	0.010
Cyanide (total)	mg/L	0.0052	19.23	139	139	139	0.01-0.02	0.1	0.01	0.012
Cyanide, free	mg/L	0.0052	3.85	40	40	40	0.01-0.1	0.02	0.01	0.011
Nutrients										
Ammonia as nitrogen** (dissolved)	**mg/L as N**	**0.475[1]**	**4.21**	**302**	**302**	**110**	**0.01-0.02**	**2**	**0.01**	**0.093**
Ammonia as nitrogen** (total)	**mg/L as N**	**0.475**	**12.63**	**552**	**552**	**217**	**0.01-0.11**	**4.5**	**0.9**	**2.700**
Ammonia plus organic nitrogen (dissolved)	**mg/L as N**	**0.475[1]**	**3.58**	**171**	**171**	**69**	**0.1-0.2**	**6**	**0.01**	**0.250**
Ammonia plus organic nitrogen (total)	**mg/L as N**	**0.475**	**52.63**	**737**	**737**	**31**	**0.1-0.2**	**1.7**	**0.1**	**0.298**
Ammonia plus organic nitrogen (total) (modified)	**mg/L as N**	**0.475**	**9.47**	**2**	**2**	**1**	**0.9**	**25**	**0.1**	**0.917**

Notes:

[1] = Screening criteria used is for total analyte

* = Calculated values using a hardness of 175 mg/L

-- = No screening criteria available for analyte

🟩 Exceedance
🟧 Max Concentration Due to Max MDL Range
⬜ All Exceedances Due to MDL

MDL = Method detection limit

the exceedances of the risk screening criteria are due to an assumed MDL being greater than the risk screening criteria. The analytes that are shaded in Table 24 indicate chemicals where the maximum concentration is the same as the maximum assumed MDL. The chemicals shown in **bold** and shaded in Table 24 indicate the compounds where there were exceedances of the screening criteria due to assumed sample concentrations.

4.4.1.2 Risk Characterization

<u>Tier I Screening based on benchmark screening values</u>

The Tier I screening assessment of the URGWOPS dataset identified 63 analytes as COPCs that pose a maximum probable risk exceeding 1.0 for the MRG (Table 24). Each of these analytes is shown in bold on the table. Table B2 in Appendix B presents a detailed listing of concentrations, sampling dates, and sampling locations for each of these 63 COPCs. The following paragraphs summarize the results from the Tier I screening assessment by chemical group.

Trace Elements. The URGWOPS dataset includes 27 trace elements (Table A8) with measurement data for both the total and dissolved forms. Of the 27 elements, maximum concentrations in surface water exceed the risk screening benchmark for 17 analytes. These analytes are shown in Table 24. In some cases, both the total and dissolved forms exceeded the benchmarks. Benchmark values are not available for 21 analytes and are identified in the table as data gaps.

Of the 17 analytes that exceed the risk screening benchmarks, total aluminum, total iron, total lead, total mercury, and total silver HQs were greater than 100. The results for the dissolved forms of lead, mercury, and silver also exceeded benchmarks. However, the maximum probable risk associated with the analytes was 0.1 or lower for the maximum probable risk for the total form; therefore decreasing the potential for adverse effects. In addition, the exceedances for silver were due to the assumed MDL being greater than the screening criteria. A benchmark for dissolved iron was not available.

The maximum probable risk exceeded 10 for dissolved aluminum, total and dissolved beryllium, total and dissolved cadmium, total copper, dissolved lead, dissolved nickel, total tin, and total zinc. The exceedances for dissolved beryllium are attributed to an assumed MDL range between 10 and 100 µg/L being greater than the risk screening criteria of 5.3 µg/L. In addition, the maximum reported concentrations for total beryllium, total cadmium, dissolved lead, dissolved nickel, and total tin are identical to the maximum MDLs for these analytes.

The maximum probable risk exceeded 1.0 for total barium, total chromium, dissolved copper, total manganese, dissolved mercury, total nickel, dissolved selenium, total selenium, total uranium, and vanadium. The maximum reported concentrations for dissolved copper, dissolved mercury, and vanadium are identical to the maximum MDL for these analytes.

Neither the total nor the dissolved forms of arsenic were detected at concentrations exceeding the established benchmarks. Concentrations were below benchmarks for total concentrations (no benchmarks were available for the dissolved form) of antimony, boron, cobalt, fluoride, lithium, molybdenum, and strontium.

Dissolved concentrations of arsenic, cadmium, cobalt, fluoride, magnesium, manganese, nickel, sodium, strontium, and vanadium exceeded the total concentrations. This occurs in datasets when total and dissolved metals are not collected as matched pairs. When matched pairs of total and dissolved data for an analyte are collected and the dissolved concentration is higher than the total concentration, it is a strong indication of analytical error. The maximum concentrations of total and dissolved forms were identical for antimony, boron, molybdenum, and tin, as presented in Table A8.

VOCs. A total of 88 VOCs were analyzed, 51 of which were detected at concentrations above the analytical reporting limits. Of the 51 for which TRVs were available, concentrations for only four analytes (1,2-dibromomethane, 1,3-dichloropropene, benzidine, and hexachlorobutadiene) exceeded the TRVs, and only a single sample analytical result for each exceeded the risk screening benchmarks. The maximum probable risk for 1,2- dibromomethane was 167, indicating expected adverse effects, while the maximum probable risk for 1,3-dichloropropene was 55, benzidine 10, and hexachlorobutadiene 1.0. However, these VOC exceedances are attributed to an assumed MDL for each analyte exceeding the respective screening benchmark. The majority of the 88 VOCs were analyzed only once or twice, with the exception of 2-chloro-4-isopropylamino-6-amino-s-triazine (34 analysis), and polychlorinated naphthalene (48 analysis). No TRVs are available for these two analytes.

Common Anions. Chloride, total residual chlorine, and total and dissolved free cyanide are anions of interest with potential toxicity to aquatic life. Both chloride and total residual chlorine were reported at concentrations less than the screening benchmarks. Total, dissolved, and free forms of cyanide were all detected at concentrations that exceed the benchmarks. The maximum probable risk for dissolved cyanide was 1.92, for total cyanide was 19.32, and for free cyanide was 3.85.

PAHs and Methylene Blue Active Substances. Two PAHs and methylene blue active substances, an organic compound, were analyzed in a single sampling event as part of the URGWOPS dataset. The PAH acenapthalene was detected at a concentration below its TRV; no benchmark was available for acenapthalene. Methylene blue active substances were also detected, but no benchmark was available.

PCBs and Aroclors. A total of five out of the seven Aroclors exceeded the benchmarks. These included Aroclor 1221, Aroclor 1242, Aroclor 1248, Aroclor 1254, and total PCBs. The maximum probable risk for Aroclor 1254 was 30, indicating a significant potential for adverse effects. The maximum probable risk for Aroclor 1221 (1.79), Aroclor 1242 (9.43), Aroclor 1248 (6.17), and total PCBs (7.14) were less than 10, indicating a small potential for adverse effects. The concentrations of Aroclor 1232 and Aroclor 1260 were less than the risk screening benchmarks. The Aroclor exceedances were attributed to an assumed MDL exceeding their respective screening benchmarks.

Herbicides. Out of the 35 herbicides analyzed as part of the study, concentrations of only dinoseb exceeded its risk screening benchmark. Its maximum probable risk was 1.67, indicating a small potential for adverse effects; however, this assessment is based on only two samples and the assumed MDL was greater than the risk screening criteria. Risk screening benchmarks were not available for 30 herbicides. Concentrations of the remaining 16 herbicides were below benchmarks.

Other Pesticides. The URGWOPS dataset included analytical results for 90 pesticides. Both the unfiltered (total) and filtered (dissolved) phases were analyzed for some of these chemicals, likely to understand pesticide absorption onto particulates (Table A8). Typically, pesticides are analyzed in total form because established criteria are based on total pesticide concentrations; the benchmarks for total concentrations were applied to both total and dissolved pesticides. Of the 90 pesticides, 19 were detected at concentrations exceeding the benchmarks (Table 21). Seven pesticides indicated a maximum probable risk of 100 or higher: dieldrin, toxaphene, beta-endosulfan, heptachlor epoxide, p, p'-DDD (total), p, p'-DDE (total), and p, p'-DDT (total). The exceedances for five of these pesticides (excluding dieldrin and toaxaphene) were due to the assumed MDL exceeding the respective screening criteria.

The maximum probable risk was 10 or higher for azinphos-methyl (total), chlordane, diazinon (dissolved), diazinon (total), heptachlor (total), and mirex (total). The exceedances for total azinphos-methyl, total chlordane, total heptachlor, and total mirex were due to assumed MDLs being higher than risk screening benchmarks. The maximum concentration for total diazinon was identical to the maximum MDL. Concentrations of dissolved diazinon exceeded the MDL range and screening benchmarks in 20 out of 34 samples (Table 24). The dissolved diazinon concentrations were higher than the total diazinon concentrations; typically, the dissolved form of an analytes is 1/10 the concentration of the total form.

The maximum probable risk was 1 or higher for alpha endosulfan, chloropyrifos (total), endrin (total), methyl parathion, p, p'-DDE (dissolved), and parathion (total). The exceedances for these six analytes were due to assumed MDLs being higher than risk screening benchmarks.

The dissolved forms of azinphos-methyl, clorophyrifos, dieldrin, methyl parathion, and parathion did not exceed the established risk benchmarks. The dissolved forms of alpha-endosulfan, beta-endosulfan, chlordane, endrin, heptachlor, heptachlor epoxide, mirex, and toxaphene were not analyzed. A total of 19 pesticides were detected at concentrations below TRVs, and no benchmarks were available for the remaining 71.

Explosives. Out of the six explosives reported in the URGWOPS dataset, three were at concentrations less than risk screening benchmarks: 2,4-dinitrotoluene, 4-nitrophenol, and nitrobenzene. Screening benchmarks are not available for the three other explosives: 2,6-dinitrotoluene, 2-nitroaniline, and 3-nitroaniline.

Nutrients. Eight different forms of ammonia where analyzed as nutrients of potential interest. Out of the six analytes for which benchmarks were available, five — including total and dissolved ammonia as N and total and dissolved ammonia plus organic nitrogen — had concentrations that exceeded the maximum MDL and risk screening benchmarks. Un-ionized ammonia and dissolved ammonia plus organic nitrogen were detected at concentration below benchmark concentrations.

Tier II Risk Screening Based on 95 percent UCLs

A Tier II risk screening was conducted on the 68 COPCs that exceeded risk benchmarks during the Tier I screening. Concentrations used in this assessment were based on the 95 percent UCL for a parameter. Of the 68 analytes, factors such as limited sample numbers or highly skewed data distributions prevented calculation of the 95 percent UCL values for 15 analytes. For example, no 95 percent UCLs could be calculated for the VOCs because the dataset included only a single entry. The 95 percent UCL for total lead likewise was not calculated because the majority of the data included repeating whole numbers and data flags that indicated MDLs and not actual water quality concentrations. 95 percent UCLs were not derived for the following: 1,2-dibromoethane, total cobalt, total lead, 1,3-dichloropropene, Aroclor-1254, Aroclor-1221, Aroclor-1248, azinphos-methyl (total), ammonia plus organic nitrogen, benzidine (total), dissolved beryllium, chlordane, mirex (total), dinoseb, hexachlorobutadiene, and PCBs (total). The 95 percent UCL values could not be calculated and Tier II risks could not be completed for any VOCs or acenaphthalene. The results of the Tier II screening are shown on Table 25 and are summarized in the following paragraphs by analyte groupings.

Trace Elements. The Tier II risk screening using the 95 percent UCL yielded risks of less than 1.0 for five of the COPCs defined in the Tier I screening: total barium, total chromium, total manganese, total zinc, and total mercury. The maximum probable risk for dissolved mercury, however, increased from 6.49 to 31.89 when calculated using the 95 percent UCL, likely related to high data variability.

Table 25. Tier II Risk Screening of Tier I Surface Water COPCs Based on 95 percent UCL of Detected Sample Concentrations in the URGWOPS 1985-2000 Dataset

Parameter	Statistical Method	95 UCL Value	Criteria	Probable Risk
alpha-Endosulfan (total)	**95% Chebyshev (Mean, Sd) UCL**	**0.06**	**0.056**	**1.11**
Aluminum (total)	**95% H-UCL**	**7,045.09**	**87**	**80.98**
Aluminum (dissolved)	97.5% Chebyshev (Mean, Sd) UCL	132.30	87	1.52
Silver (total)	**99% Chebyshev (Mean, Sd) UCL**	**134.81**	**9.03**	**14.93**
Silver (dissolved)	99% Chebyshev (Mean, Sd) UCL	48.17	8.42	**5.72**
Zinc (total)	97.5% Chebyshev (Mean, Sd) UCL	183.95	192.51	0.96
Vanadium (total)	**97.5% Chebyshev (Mean, Sd) UCL**	**84.61**	**12**	**7.05**
Uranium (natural) (total)	**Mod-t UCL (Adjusted for skewness)**	**3.12**	**2.6**	**1.20**
Toxaphene, unfiltered	**Student's-t UCL**	**1.01**	**0.002**	**505.92**
Tin (total)	**95% Chebyshev (Mean, Sd) UCL**	**250.96**	**73**	**3.44**
Silvex (total)	95% Chebyshev (Mean, Sd) UCL	0.05	30	0.002
Selenium (dissolved)	**95% Chebyshev (Mean, Sd) UCL**	**2.90**	**1.84**	**1.58**
Selenium (total)	**95% Chebyshev (Mean, Sd) UCL**	**3.23**	**2**	**1.61**
Parathion (total)	Mod-t UCL (Adjusted for skewness)	0.01	0.013	0.94
p,p'-DDT (total)	**95% Chebyshev (Mean, Sd) UCL**	**0.03**	**0.001**	**30.96**
p,p'-DDE (total)	**95% Chebyshev (Mean, Sd) UCL**	**0.03**	**0.001**	**30.96**
p,p'-DDD (total)	**95% Chebyshev (Mean, Sd) UCL**	**0.03**	**0.001**	**30.96**
Nickel (total)	**95% Chebyshev (Mean, Sd) UCL**	**107.57**	**83.7**	**1.29**
Nickel (dissolved)	**99% Chebyshev (Mean, Sd) UCL**	**83.28**	**83.5**	**1.00**
Methyl parathion (total)	**Mod-t UCL (Adjusted for skewness)**	**0.01**	**0.008**	**1.53**
Mercury (total)	95% Chebyshev (Mean, Sd) UCL	0.37	0.77	0.47
Mercury (dissolved)	**95% Chebyshev (Mean, Sd) UCL**	**0.38**	**0.012**	**31.89**
Manganese (total)	95% Chebyshev (Mean, Sd) UCL	535.32	3,155	0.17
Lead (total)	**97.5% Chebyshev (Mean, Sd) UCL**	**66.41**	**6.5**	**10.22**
Lead (dissolved)	95% Chebyshev (Mean, Sd) UCL	3.72	4.6	0.81
Iron (total)	**95% H-UCL**	**7,368.94**	**1,000**	**7.37**
Heptachlor (total)	**Mod-t UCL (Adjusted for skewness)**	**0.02**	**0.0038**	**4.10**
Heptachlor epoxide (total)	**95% Chebyshev (Mean, Sd) UCL**	**0.06**	**0.0038**	**16.32**
Endrin (total)	95% Chebyshev (Mean, Sd) UCL	0.03	0.036	0.87
Dieldrin (total)	**97.5% Chebyshev (Mean, Sd) UCL**	**1.38**	**0.0019**	**726.44**
Diazinon (total)	95% Chebyshev (Mean, Sd) UCL	0.03	0.0963	0.28
Diazinon (dissolved)	99% Chebyshev (Mean, Sd) UCL	0.04	0.0963	0.43
Cyanide (total)	Mod-t UCL (Adjusted for skewness)	0.01	5.2	0.003
Cyanide, free (total)	Mod-t UCL (Adjusted for skewness)	0.01	5.2	0.002

Table 25. Tier II Risk Screening of Tier I Surface Water COPCs Based on 95 percent UCL of Detected Sample Concentrations in the URGWOPS 1985-2000 Dataset (continued)

Parameter	Statistical Method	95 UCL Value	Criteria	Probable Risk
Copper (total)	**97.5% Chebyshev (Mean, Sd) UCL**	**82.18**	**15.05**	**5.46**
Copper (dissolved)	97.5% Chebyshev (Mean, Sd) UCL	43.06	14.45	2.98
Chromium (total)	97.5% Chebyshev (Mean, Sd) UCL	30.83	136.3	0.23
Chlorpyrifos (dissolved)	Mod-t UCL (Adjusted for skewness)	0.005	0.041	0.11
Cadmium (total)	**Mod-t UCL (Adjusted for skewness)**	**1.29**	**0.41**	**3.15**
Cadmium (dissolved)	**Mod-t UCL (Adjusted for skewness)**	**1.23**	**0.36**	**3.42**
beta-Endosulfan (total)	**Highly Skewed Data/Max Detected Value Used**	**10.00**	**0.056**	**178.57**
Beryllium (total)	**97.5% Chebyshev (Mean, Sd) UCL**	**103.16**	**5.3**	**19.46**
Barium (total)	95% Chebyshev (Mean, Sd) UCL	399.75	793.6	0.50
Ammonia as nitrogen (total)	97.5% Chebyshev (Mean, Sd) UCL	0.40	0.475	0.85
Ammonia as NH4 (total)	97.5% Chebyshev (Mean, Sd) UCL	0.75	--	--
Ammonia as nitrogen (dissolved)	97.5% Chebyshev (Mean, Sd) UCL	0.18	0.475	0.37
Ammonia as NH4 (dissolved)	97.5% Chebyshev (Mean, Sd) UCL	0.32	--	--
Ammonia plus organic nitrogen (total)	**95% Chebyshev (Mean, Sd) UCL**	**1.18**	**0.475**	**2.48**
Ammonia plus organic nitrogen (dissolved)	95% Chebyshev (Mean, Sd) UCL	0.38	0.475	0.81
Ammonia (un-ionized) (total)	95% Chebyshev (Mean, Sd) UCL	0.03	0.475	0.06

Notes:
COPC = Contaminants of potential concern
Sd = Standard deviation
UCL = Upper confidence limit

Similarly, the potential risk increased from 18.87 to 19.46 for total beryllium, likely for the same reason. The potential risks decreased markedly for total aluminum, total and dissolved cadmium, total copper, total iron, dissolved nickel, total and dissolved silver, and total tin. Potential risks decreased only slightly for dissolved aluminum, dissolved copper, dissolved lead, total nickel, total and dissolved selenium, total uranium, and total vanadium.

Common Anions. Tier II screening found total and free cyanide to have potential risks of less than 1.0 using the 95 percent UCL concentration.

Herbicides and Other Pesticides. Tier II screening indicated potential risks of less than 1.0 for the 95 percent UCL concentration of total and dissolved diazinon, chlorophyrifos, endrin, and parathion. The maximum probable risk and the 95 percent UCL were identical for beta endosulfan. The potential risk for alpha-endosulfan increased from 8.93 to maximum probable risk to 11.07 using the 95 percent UCL concentration. Tier II screening indicated a marked decrease in risk for total dieldrin, toxaphene, and total heptachlor epoxide, while only slight risk decreases for total p,p’-DDD, total p,p’-DDE, total p,p’-DDT, total heptachlor, and total methyl parathion.

4.4.1.3 Reach-Specific Summary

The analytes that exceeded risk screening benchmarks at each station in the four reaches are presented in Table B2 of Appendix B. No distinct patterns or trends could be identified in the data for each reach. Comparisons among sampling stations within a specific reach were difficult because suites of analytes that had been assigned screening benchmarks were not consistent throughout all of the sampling stations. Additionally, uncertainty was associated with most of the URGWOPS data, as discussed in Section 4.4. The following summarizes patterns of elevated levels for the COPCs that posed high risks with likely impacts as identified in the Tier I screening.

Total barium was detected in 89 samples at concentrations ranging from 100 to 3,900 μg/L. Of these, six samples exceeded maximum MDLs and risk screening criteria. Highest concentrations were identified at three locations in the Cochiti and Angostura Reaches in 1988 and 1995. The maximum concentration was detected at the Rio Grande at U.S. Highway 44 Bridge in 1988. Additional elevated levels were detected at Rio Grande at Angostura Diversion Dam in 1988 and the Rio Grande at Pueblo of San Felipe Northern Boundary in 1995. No correlation or trends were identified in the distribution of the data for barium. The maximum probable risk for barium is 4.91 for water quality. Risk associated with barium and water quality was eliminated during Tier II screening.

Dieldrin was detected in 53 samples at concentrations ranging from 0.01 to 10 μg/L. These elevated levels occurred in each reach. The maximum concentration of 10 μg/L was detected in a sample collected in the Cochiti Reach at the northern boundary of the Pueblo of San Felipe lands in 1995. Only three separate values, of 0.01, 0.1, and 10 µg/L, were reported for the 53 samples; therefore, a series of repeated values is seen throughout the reach through time. Data qualifiers (other than those identified during data augmentation) indicate that these results may be MDLs and not actual water concentrations. If the reported value is the MDL; the lowest MDL of 0.01 µg/L was still greater than its risk screening benchmark of 0.004 µg/L.

Similarly, the results for toxaphene indicated that the reported values are assumed to be MDLs. A total of 53 samples were analyzed for toxaphene. Of these, 52 samples were reported with a result of 1 µg/L, and the result for the remaining sample was 0.07 µg/L. Both of the analytical results are higher than its risk screening benchmark of 0.0002 µg/L.

Ammonia in various forms exceeded the risk screening benchmarks in all reaches. The benchmarks were exceeded at all stations in the URGWOPS dataset for ammonia, except for two in the Angostura Reach: Rio Grande at U.S. Highway 44 Bridge at Bernalillo and Rio Grande near Alameda.

4.4.2 Sediment Constituents

Sediment data reported in the URGWOPS database included samples for chemicals in bed sediment and suspended sediment. Only the data for bed sediment are discussed in this section. Sediment data were available for 15 locations along the river and included common anions, nutrients, trace elements, total mercury, total organic carbon, PAHs, VOCs, SVOCs, pesticides, radioisotopes, total petroleum hydrocarbons, and moisture. Table 26 lists the 163 chemicals analyzed in sediment samples.

4.4.2.1 Environmental / Exposure Profile Characterization

Data were available for 163 parameters (Table 27). Seven of those parameters were not considered potentially toxic, leaving 155 chemicals to evaluate using available SQGs. SQGs were available for only 76 chemicals. No SQGs were identified for 79 chemicals (Table 28).

4.4.2.2 Risk Characterization

<u>Tier I Screening based on benchmark screening values</u>

Table A9 presents the data for each chemical measured in bed sediments from the URGWOPS dataset. The dataset includes five or fewer results for all but a very small number of analytes. A substantially larger number of results were available for arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, and zinc. Of the 76 chemicals for which SQGs were available, 26 exceeded the screening-level TEC. Analytes with sample concentrations that exceeded their respective

Table 26. Unique Sediment Parameters/Analytes Reported for Bed Sediment in the URGWOPS 1985-2000 Dataset

Parameter	Type	Parameter	Type
1,2,4-Trichlorobenzene	VOC	Gross alpha radioactivity	Radio-isotope
1,2-Dichlorobenzene	VOC	Gross beta radioactivity	Radio-isotope
1,2-Dimethylnaphthalene	VOC	Heptachlor	Pesticide
1,3-Dichlorobenzene	VOC	Heptachlor epoxide	Pesticide
1,4-Dichlorobenzene	VOC	Hexachlorobenzene	VOC
1,6-Dimethylnaphthalene	VOC	Holmium	Trace Element
1-Methyl-9H-fluorene	VOC	Indeno[1,2,3-cd]pyrene	PAH
1-Methylphenanthrene	VOC	Inorganic carbon	General Chemistry
1-Methylpyrene	VOC	Iron	Trace Element
2,2'-Biquinoline	VOC	Isodrin	Pesticide
2,3,6-Trimethylnaphthalene	VOC	Isophorone	VOC
2,4,5-T	Pesticide	Isoquinoline	VOC
2,4-D	Pesticide	Lanthanum	Trace Element
2,4-Dimethylphenol	VOC	Lead	Trace Element
2,4-Dinitrotoluene	VOC	Lindane	Pesticide
2,6-Dimethylnaphthalene	VOC	Lithium	Trace Element
2,6-Dinitrotoluene	VOC	Magnesium	Trace Element
2-Chloronaphthalene	VOC	Malathion	Pesticide
2-Chlorophenol	VOC	Manganese	Trace Element
2-Ethylnaphthalene	VOC	Mercury	Trace Element
2-Methylanthracene	PAH	Methyl parathion	Pesticide
3,5-Dimethylphenol	VOC	Mirex	Pesticide
4-Chloro-3-methylphenol	VOC	Molybdenum	Trace Element
4H-Cyclopenta[def]phenanthrene	VOC	Naphthalene	PAH
9,10-Anthraquinone	VOC	Neodymium	Trace Element
9H-Fluorene	VOC	Nickel	Trace Element
Acenaphthene	PAH	Niobium	Trace Element
Acenaphthylene	VOC	Nitrobenzene	Explosive
Acridine	VOC	N-Nitrosodi-n-propylamine	VOC
Aldrin	Pesticide	N-Nitrosodiphenylamine	VOC
alpha-Endosulfan	Pesticide	o,p'-DDD	Pesticide
alpha-HCH	Pesticide	o,p'-DDE	Pesticide
Aluminum	Trace Element	o,p'-DDT	Pesticide
Ammonia	Nutrient	o,p'-Methoxychlor	Pesticide
Anthracene	PAH	Organic carbon	General Chemistry
Antimony	Trace Element	Oxychlordane	Pesticide
Arsenic	Trace Element	p,p'-DDD	Pesticide
Azobenzene	VOC	p,p'-DDE	Pesticide
Barium	Trace Element	p,p'-DDT	Pesticide
Benzo[a]anthracene	PAH	p,p'-Ethyl-DDD	Pesticide
Benzo[a]pyrene	PAH	p,p'-Methoxychlor	Pesticide
Benzo[b]fluoranthene	PAH	Parathion	Pesticide
Benzo[c]cinnoline	VOC	PCBs	VOC
Benzo[g,h,i]perylene	PAH	p-Cresol	VOC
Benzo[k]fluoranthene	PAH	Pentachloroanisole	VOC
Benzyl n-butyl phthalate	VOC	Pentachloronitrobenzene	VOC

Table 26. Unique Sediment Parameters/Analytes Reported for Bed Sediment in the URGWOPS 1985-2000 Dataset (continued)

Parameter	Type	Parameter	Type
Beryllium	Trace Element	Phenanthrene	PAH
beta-HCH	Pesticide	Phenanthridine	VOC
Bis(2-chloroethoxy)methane	VOC	Phenol	VOC
Bis(2-ethylhexyl) phthalate	VOC	Phosphorus	Trace Element
Bismuth	Trace Element	Picloram	Pesticide
Boron	Trace Element	Polychlorinated naphthalenes	VOC
C8-Alkylphenol	VOC	Potassium	Trace Element
Cadmium	Trace Element	Pyrene	PAH
Calcium	Trace element	Quinoline	VOC
Carbazole	VOC	Radium-226	Radio-isotope
Carbophenothion	Pesticide	Radium-228	Radio-isotope
Cerium	Trace Element	Scandium	Trace Element
Chloroneb	Pesticide	Selenium	Trace Element
Chromium	Trace Element	Silver	Trace Element
Chrysene	PAH	Silvex	Pesticide
cis-Chlordane	Pesticide	Sodium	Trace Element
cis-Nonachlor	Pesticide	Strontium	Trace Element
cis-Permethrin	Pesticide	Sulfur	General Chemistry
Cobalt	Trace Element	Tantalum	Trace Element
Copper	Trace Element	Thorium	Trace Element
DCPA	Pesticide	Thorium-230	Radio-isotope
Diazinon	Pesticide	Thorium-232	Radio-isotope
Dibenzo[a,h]anthracene	PAH	Tin	Trace Element
Dibenzothiophene	VOC	Titanium	Trace Element
Dicamba	Pesticide	Toxaphene	Pesticide
Dieldrin	Pesticide	trans-Chlordane	Pesticide
Diethyl phthalate	VOC	trans-Nonachlor	Pesticide
Dimethyl phthalate	VOC	trans-Permethrin	Pesticide
Di-n-butyl phthalate	VOC	Uranium	Trace Element
Di-n-octyl phthalate	VOC	Uranium-234	Radio-isotope
Endrin	Pesticide	Uranium-238	Radio-isotope
Ethion	Pesticide	Vanadium	Trace Element
Europium	Trace Element	Ytterbium	Trace Element
Fluoranthene	PAH	Yttrium	Trace Element
Gallium	Trace Element	Zinc	Trace Element
Gold	Trace Element		

Note:
Unique parameters were included if the analysis indicated it was for bed sediments
Yellow highlighted parameters are not considered to be toxics
PAHs = Polycyclic aromatic hydrocarbons
VOCs = Volatile organic compounds

Table 27. General Summary Statistics of the Sediment Screening for the URGWOPS 1985-2000 Dataset

Criteria	Count
Number of analytes measured(1)	163
Number of analytes measured not considered as toxics	8
Number of analytes considered as COPCs	155
Number of COPCs with SQGs	76
Number of COPCs without SQGs	79
Number of COPCs that exceed TEC	26
Number of COPCs that exceed the TEC with < 5 samples	17
Number of COPCs that exceed the TEC with > 5 samples	8

(1) Number measured in bed sediments of mainstem Rio Grande locations
COPCs - Chemicals of potential concern

TEC values are summarized in Table 29. Of the 26 parameters that exceeded the TECs, concentrations of six exceeded PECs: barium, cadmium, lead, nickel, silver, and toxaphene.

The following discussion focuses on those chemicals for which sufficient data are available to allow an assessment. The TEC risk quotient for iron was less than 1.0 and for arsenic, chromium, copper, and manganese equaled 1.0, indicating unlikely individual risks from these chemicals to benthic invertebrates in sediments. TEC risk quotients were 10 or less for cadmium, cobalt, lead, mercury and zinc. In turn, the PEC risk quotient for cadmium was 2, cobalt lacked a PEC, and the risk quotient for lead was 1.2, for mercury 4.1, and for zinc 0.9 (Table 29). Thus, of the chemicals with adequate data to assess risks, cadmium, cobalt, lead, mercury, and zinc would appear to be likely candidates for future monitoring efforts for evaluating potential individual or cumulative risks.

Maximum concentrations for barium in sediment exceeded its PEC (risk quotient = 9.8); however, the number of measurements for barium was low (n=5); as discussed in Section 4.3.2.2, barium is highly insoluble and is considered non-toxic. Nickel exceeded its PEC (risk quotient = 3.1), but again, the number of measurements was low (n=5), and only two exceed the TEC or PEC. Similarly, silver exceeded its PEC (risk quotient = 68.2), yet the number of samples was low (n=5) and, of those, three exceeded the TEC and PEC. All of the toxaphene measurement data (n=5) exceeded the TEC, while only results for two samples exceeded the PEC (risk quotient = 6.3). Of the parameters that exceeded the PEC but had limited data, nickel, silver and toxaphene may also deserve further consideration in future monitoring efforts.

Table 28. List of Parameters Measured in Sediments Lacking Sediment Quality Guidelines in the URGWOPS 1985-2000 Dataset

Type	Parameter
SVOC	1,2-Dimethylnaphthalene
SVOC	1,3-Dichlorobenzene
SVOC	1,6-Dimethylnaphthalene
SVOC	1-Methyl-9H-fluorene
SVOC	1-Methylpyrene
SVOC	2,2'-Biquinoline
SVOC	2,3,6-Trimethylnaphthalene
Pesticide	2,4,5-T
SVOC	2,6-Dimethylnaphthalene
SVOC	2-Ethylnaphthalene
SVOC	2-Methylanthracene
SVOC	3,5-Dimethylphenol
SVOC	4-Chloro-3-methylphenol
SVOC	4H-Cyclopenta[def]phenanthrene
SVOC	9,10-Anthraquinone
SVOC	9H-Fluorene
Nutrient	Ammonia
SVOC	Azobenzene
SVOC	Benzo[c]cinnoline
Trace element	Beryllium
SVOC	Bis(2-chloroethoxy)methane
Trace element	Bismuth
Trace element	Boron
SVOC	C8-Alkylphenol
SVOC	Carbazole
SVOC	Carbophenothion
Trace element	Cerium
Pesticide	Chloroneb
Pesticide	cis-Nonachlor
Pesticide	cis-Permethrin
Pesticide	DCPA
SVOC	Dibenzothiophene
Pesticide	Dicamba
SVOC	Di-n-butyl phthalate
Pesticide	Ethion
Trace element	Europium
Trace element	Gallium
Trace element	Gold
Radio-isotope	Gross alpha radioactivity
Radio-isotope	Gross beta radioactivity
Trace element	Holmium
SVOC	Isoquinoline
Trace element	Lanthanum
Trace element	Lithium
Trace element	Molybdenum

Table 28. List of Parameters Measured in Sediments Lacking Sediment Quality Guidelines in the URGWOPS 1985-2000 Dataset (Continued)

Type	Parameter
Trace element	Neodymium
Trace element	Niobium
SVOC	N-Nitrosodi-n-propylamine
SVOC	N-Nitrosodiphenylamine
Pesticide	o,p'-DDT
Pesticide	Oxychlordane
Pesticide	p,p'-Ethyl-DDD
SVOC	p-Cresol
SVOC	Pentachloroanisole
SVOC	Pentachloronitrobenzene
SVOC	Phenanthridine
SVOC	Phenol
Pesticide	Picloram
SVOC	Polychlorinated naphthalenes
SVOC	Quinoline
Radio-isotope	Radium-226
Radio-isotope	Radium-228
Trace element	Scandium
Trace element	Selenium
Trace element	Strontium
Trace element	Tantalum
Trace element	Thorium
Radio-isotope	Thorium-230
Radio-isotope	Thorium-232
Trace element	Tin
Trace element	Titanium
Pesticide	trans-Nonachlor
Pesticide	trans-Permethrin
Trace element	Uranium
Radio-isotope	Uranium-234
Radio-isotope	Uranium-238
Trace element	Vanadium
Trace element	Ytterbium
Trace element	Yttrium

Notes:
SVOCs = Semi-volatile organic compounds

Table 29. Summary and Risk Screening of Sediment Data Collected and Reported for Samples in the URGWOPS 1985-2000 Dataset with Sample Concentrations Exceeding TEC Benchmarks

Parameter	Count	Minimum Value	Maximum Value	# Exceed TEC	TEC	# Exceed PEC	PEC	TEC risk Quotient	PEC Risk Quotient
2,4-D	1	0.1	0.1	1	0.038			2.63	
2,4-Dinitrotoluene	2	50	50	2	14.4			3.47	
2,6-Dinitrotoluene	2	500	500	2	39.8			12.56	
2-Chlorophenol	2	50	50	2	31.9			1.57	
Acenaphthene	2	50	50	2	6.7	0	89	7.46	0.56
Acenaphthylene	2	50	50	2	5.9	0	130	8.47	0.38
Arsenic	58	1	12	1	9.79	0	33	1.23	0.36
Barium	5	40	590	5	20	4	60	29.50	9.83
Benzo[b]fluoranthene	2	32	50	2	27.2	0	4000	1.84	0.01
Benzo[k]fluoranthene	2	8	50	1	27.2	0	4000	1.84	0.01
Bis(2-ethylhexyl) phthalate	2	19	460	1	180	0	2600	2.56	0.18
Cadmium	58	0.3	10	56	0.99	9	4.98	10.10	2.01
Chromium	58	1	48	2	43.4	0	111	1.11	0.43
Chrysene	2	18	50	0	166	0	1290	0.30	0.04
cis-Chlordane	2	1	1	0	3.2	0	18	0.31	0.06
Cobalt	60	1	150	2	50			3.00	
Copper	58	1	33	1	31.6	0	149	1.04	0.22
Diazinon	1	0.2	0.2	0	0.38			0.53	
Dibenzo[a,h]anthracene	2	50	50	2	33	0	140	1.52	0.36
Dieldrin	5	0.1	1	0	1.9	0	62	0.53	0.02
Diethyl phthalate	2	14	50	0	630			0.08	
Dimethyl phthalate	2	16	50	0	160			0.31	
Di-n-octyl phthalate	2	47	50	0	40600			0.001	
Endrin	5	0.1	2	0	2.2	0	210	0.91	0.01
Fluoranthene	2	26	50	0	423	0	2230	0.12	0.02
Heptachlor	5	0.1	1	2	0.6	0	10	1.67	0.10
Heptachlor epoxide	5	0.1	1	0	2.5	0	16	0.40	0.06
Hexachlorobenzene	2	1	1	0	20	0	240	0.05	0.004
Indeno[1,2,3-cd]pyrene	2	5	50	0	78	0	3800	0.64	0.01
Iron	58	10	15000	0	188400	0	247600	0.08	0.06
Isodrin	2	1	1	0	55.2			0.02	
Isophorone	2	50	50	0	2400			0.02	
Lead	58	1.3	150	3	35.8	1	128	4.19	1.17
Lindane	5	0.1	1	0	2.4	0	5	0.42	0.20
Malathion	1	0.2	0.2	0	0.67			0.30	
Manganese	58	35	680	1	631	0	1184	1.08	0.57
Mercury	58	0.01	0.74	3	0.18	0	1.06	4.11	0.70
Methyl parathion	1	0.2	0.2	0	7.2			0.03	
Mirex	5	0.1	1	0	11	0	800	0.09	0.001
Naphthalene	2	50	50	0	176	0	561	0.28	0.09
Nickel	5	11	150	2	22.7	2	48.6	6.61	3.09
Nitrobenzene	2	50	50	0	145			0.34	
o,p'-DDD	2	1	1	0	16	0	43	0.06	0.02
o,p'-DDE	2	1	1	0	9	0	15	0.11	0.07
o,p'-Methoxychlor	2	5	5	0	19			0.26	
p,p'-DDD	5	0.1	1	0	3.54	0	8.51	0.28	0.12
p,p'-DDE	5	0.1	1	0	1.42	0	6.75	0.70	0.15
p,p'-DDT	5	0.1	2	2	1.19	0	4.77	1.68	0.42
p,p'-Methoxychlor	5	0.1	5	0	19			0.26	
Parathion	1	0.2	0.2	0	0.81			0.25	
PCBs	5	1	100	2	60	0	680	1.67	0.15
Phenanthrene	2	16	50	0	204	0	1170	0.25	0.04
Pyrene	2	18	50	0	195	0	1520	0.26	0.03
Silver	5	0.1	150	3	1	3	2.2	150.00	68.18
Silvex	1	0.1	0.1	0	675			0.0001	
Toxaphene	5	10	200	5	0.1	2	32	2000.00	6.25
trans-Chlordane	2	1	1	0	3.2	0	18	0.31	0.06
Zinc	58	4	400	2	121	0	459	3.31	0.87

Notes:

PEC = Probable effects concentration

TEC = Threshold effects concentration

4.4.2.3 Reach-Specific Summary

Table A10 shows the locations where TECs for each parameter were exceeded. The table also indicates where measured concentrations are less than the reported values for most of the data. These data also indicate that detection limits for many parameters may have been too high to allow risk assessment. Because of the uncertainties related to these data, they should be viewed cautiously in assessing risks to the MRG sediments and benthic macroinvertebrates.

4.4.3 Tissue Constituents

Information on the data included in the URGWOPS dataset is presented in Section 3.1.2. Despite the overall size of this database, the availability of data for residues in fish tissue was limited. Therefore, as indicated in Section 3.1.2, the following tissue analysis includes results for samples collected from water bodies connected but outside of the MRG channel. (In contrast, all sample data assessed here for water and sediment came from samples collected within the Rio Grande channel.) Analytical results for trace elements were available for six sample locations, while data for organic parameters (primarily pesticides and herbicides) were from five locations. There is no information, other than what is presented in the database, on data collection methods, samples, or analysis methods because the database was compiled from several sources.

Analytical results for 22 trace elements in “fish tissues” (not defined in the database, so fish tissues could be fillets, whole body, or organ specific tissues) and 28 organic compounds (principally pesticides) in whole body fish were found for the limited URGWOPS fish tissue data. All data provided for fish tissue are assessed as presented because information in the database was unclear about detection limits. Additionally, uncertainties in the tissue residue effects values relative to the URGWOPS tissue data are similar to those expressed previously for the USFWS data. Moreover, additional uncertainties arise in the URGWOPS dataset based on the limited quantity of the data over the time period, as well as the limited information about collection, analysis, and sample composition. These data and a risk characterization are presented, but should be viewed cautiously.

4.4.3.1 Environmental / Exposure Profile Characterization

Tables 30 and 31 summarize the results of the fish tissue data available in the URGWOPS dataset, along with a comparison of those tissue concentrations to tissue residue effects values. Summary information is limited to the number of analyses for each chemical and the minimum and maximum concentrations reported for each. Of the 22 trace elements with results, no tissue residue risk-screening benchmarks were available for seven. Of the 28 organic chemicals with available data, tissue residue effects values were available for only three. Various isomers or metabolites (such as DDx compounds)

Table 30. Fish Tissue Residues in the URGWOPS 1985-2000 Dataset (tissue type unknown)

Parameter	Units	Count	Minimum	Maximum	Adult Life Stages NER	Adult Life Stages LER	Early Life Stages NER	Early Life Stages LER	Max Value Exceeds Screening Value	Source
Aluminum	mg/kg	6	1	9	42.65			40	No	Jarvinen and Ankley 1999
Antimony	mg/kg	6	0.2	1.3			25		No	Jarvinen and Ankley 1999
Arsenic	mg/kg	6	0.2	1.8	9			11.2-58.5	No	Jarvinen and Ankley 1999
Barium	mg/kg	6	0.1	0.3					Data Gap	No tissue residue-effects data available.
Beryllium	mg/kg	6	0.2	1.8			25.65		No	USACE 2004
Boron		6	0.6	1.7					Data Gap	No tissue residue-effects data available.
Cadmium	mg/kg	6	0.4	2.6			0.18	1.75	**Yes**	Jarvinen and Ankley 1999
Chromium	mg/kg	6	0.5	0.7	0.9	0.9			No	USACE 2004
Cobalt		6	0.2	0.9					Data Gap	No tissue residue-effects data available.
Copper	mg/kg	6	32	340			38.1	60.5	**Yes**	USACE 2004
Iron	mg/kg	6	350	1300			1250		**Yes**	USACE 2004
Lead	mg/kg	6	0.2	1.3			131	221	No	USACE 2004
Manganese	mg/kg	6	3.9	13					Data Gap	No tissue residue-effects data available.
Mercury	mg/kg	6	0.2	0.6	0.5	1.95			**Yes**	Beckvar et al. 2005
Molybdenum	mg/kg	6	1.2	2.9					Data Gap	No tissue residue-effects data available.
Nickel	mg/kg	6	0.2	1.7	515				No	Jarvinen and Ankley 1999
Selenium	mg/kg	6	2.7	53	7.9		7.9		**Yes**	USEPA 2004
Silver	mg/kg	6	0.2	1.6			0.3		**Yes**	Jarvinen and Ankley 1999
Strontium	mg/kg	6	0.2	1.4					Data Gap	No tissue residue-effects data available.
Uranium	mg/kg	6	0.2	0.2		0.2			No	Buet and others 2005
Vanadium	mg/kg	6	0.2	1.1	28.7		12	15.6	No	Jarvinen and Ankley 1999
Zinc	mg/kg	6	82	370			170	200	**Yes**	Jarvinen and Ankley 1999

Notes:

Tissue data and residue effects data are presented on a dry weight basis.

Yellow highlighted rows are for those parameters where maximum tissue concentrations exceed the effects thresholds

LER = Lowest effect residue

NER = No effects residue

Table 31. Fish Tissue Residues in the URGWOPS 1985-2000 Dataset (whole body tissues)

Parameter	Units	Count	Minimum	Maximum	Adult Life Stages		Early Life Stages		Max Value Exceeds Screening Value	Source
					NER	LER	NER	LER		
o,p'-DDD	mg/kg	5	0.025	0.025	205	563.5	34	120	No	Beckvar et al. 2005
o,p'-DDE	mg/kg	5	0.025	0.025					No	Beckvar et al. 2005
o,p'-DDT	mg/kg	5	0.025	0.03					No	Beckvar et al. 2005
Aldrin	mg/kg	5	0.025	0.025			1.8		No	Jarvinen and Ankley 1999
alpha-HCH	mg/kg	5	0.025	0.025	30.65	47.65			No	Jarvinen and Ankley 1999
beta-HCH	mg/kg	5	0.025	0.025	30.65	47.65			No	Jarvinen and Ankley 1999
Lindane	mg/kg	5	0.025	0.04	30.65	47.65			No	Jarvinen and Ankley 1999
cis-Chlordane	mg/kg	5	0.025	0.035	8.3	83			No	Parrish et al. 1976
trans-Chlordane	mg/kg	5	0.025	0.025	8.3	83			No	Parrish et al. 1976
cis-Nonachlor	mg/kg	5	0.025	0.025					Data Gap	No tissue residue-effects data available.
DCPA	mg/kg	5	0.025	0.025					Data Gap	No tissue residue-effects data available.
delta-HCH	mg/kg	5	0.025	0.025	30.65	47.65			No	Jarvinen and Ankley 1999
Dieldrin	mg/kg	5	0.025	0.025			1.8		No	Jarvinen and Ankley 1999
Endrin	mg/kg	5	0.025	0.025	10	10			No	Jarvinen and Ankley 1999
Heptachlor	mg/kg	5	0.025	0.025	88.65				No	Jarvinen and Ankley 1999
Heptachlor epoxide	mg/kg	5	0.025	0.025	88.65				No	Jarvinen and Ankley 1999
Hexachlorobenzene	mg/kg	5	0.025	0.035			232.5		No	Jarvinen and Ankley 1999
Mirex	mg/kg	5	0.025	0.025	645		645		No	Jarvinen and Ankley 1999
o,p'-Methoxychlor	mg/kg	5	0.025	0.025	12.5		3.55		No	Jarvinen and Ankley 1999
Oxychlordane	mg/kg	5	0.025	0.025	8.3	83			No	Parrish et al. 1976
p,p'-DDD	mg/kg	4	0.025	0.175	205	563.5	34	120	No	Beckvar et al. 2005
p,p'-DDE	mg/kg	5	0.08	0.55	205	563.5	34	120	No	Beckvar et al. 2005
p,p'-DDT	mg/kg	5	0.025	0.14	205	563.5	34	120	No	Beckvar et al. 2005
p,p'-Methoxychlor	mg/kg	5	0.025	0.025	12.5		3.55			Jarvinen and Ankley 1999
PCBs	mg/kg	5	0.25	2.05			3.6	36	No	Fisher et al. 1994
Pentachloroanisole	mg/kg	5	0.025	0.025			61.5		No	Jarvinen and Ankley 1999
Toxaphene	mg/kg	5	1	1		16.5	2	5	No	Jarvinen and Ankley 1999
trans-Nonachlor	mg/kg	5	0.025	0.045					Data Gap	No tissue residue-effects data available.

Notes:

Tissue data and residue effects data reported on a dry weight basis.

LER = Lowest effect residue

NER = No effects residue

were measured for several organic parameters in fish tissues; risk-screening benchmarks for the residue concentrations were not always available for each of the isomers or metabolites. Therefore, where risk-screening benchmarks were available for one of the isomers or metabolites, but not for others in the same group of compounds, then the available benchmarks were used for other isomers or metabolites. Limited data availability precluded any evaluations of spatial or temporal trends for tissue data in the URGWOPS dataset.

4.4.3.2 Risk Characterization Screening Based on Tissue Residue Effects Values

Comparison of the maximum concentration for a trace element to its tissue residue effects value shows that seven trace elements from the URGWOPS dataset exceeded the risk-screening benchmarks: cadmium, copper, iron, mercury, selenium, silver, and zinc (Table 30). As shown in Table 31, none of the fish tissue residues for organic parameters exceeded the tissue residue effects values.

The Tier II risk assessment using calculated 95 percent UCL concentrations for trace elements resulted in little change in the risk projections. Only iron and mercury concentrations, based on the 95 percent UCLs, were found to be lower than the tissue residue effects levels. Risks posed by cadmium, copper, selenium, silver, and zinc were predicted based on 95 percent UCL concentrations (Table 32).

Cadmium in fish tissue exceeded the screening criterion in each of the six samples. The tissue residue effects value for cadmium was based on bluegill sunfish. Cadmium exceeded the NER as well as the LER, suggesting that cadmium in tissues may pose a risk to fish; however, the small sample size is problematic. USFWS data found no risks predicted for cadmium based on residue concentrations in fish tissue.

Copper risks are predicted based on a maximum concentration (340 mg/kg); however, copper in all other samples analyzed ranged from 32 to 84 mg/kg. These values still exceed the screening criterion. Similar to cadmium, however, the USFWS copper in fish tissue data did not exceed the copper screening levels.

The draft selenium chronic criterion is based on effects on bluegill sunfish. The actual range of bluegill chronic values was largely based on field and laboratory exposures. Different forms of selenium are present under different environmental conditions. For example, selenate, the less toxic form, predominates under aerobic conditions commonly found in flowing waters, whereas selenite, which tends to be more toxic, predominates in standing waters where conditions may trend toward anaerobic. Only one of the six tissue residue values exceeded the screening criterion for total selenium, while the remaining concentrations were all lower than the criterion. Similar to cadmium and copper, selenium was not predicted to pose a risk to fish based on fish tissue residues measured in the USFWS dataset.

Table 32. Comparison of the 95 percent UCL Fish Tissue Residue Concentrations to Tissue Residue Effects Values for the URGWOPS 1985-2000 Dataset

Parameter	units	Number of Samples Analyzed	Maximum Number of Detects	95% UCL	Adult Life Stages		Early Life Stages		95% UCL Exceeds Screening Value	Source
					NER	LER	NER	LER		
Cadmium	mg/kg	6	2.6	2.025			0.18	1.75	**Yes**	Jarvinen and Ankley 1999
Copper	mg/kg	6	340	340			38.1	60.5	**Yes**	USACE 2004
Iron	mg/kg	6	1300	871			1250		No	USACE 2004
Selenium	mg/kg	6	53	53	7.9		7.9		**Yes**	USEPA 2004
Silver	mg/kg	6	1.6	1.3			0.3		**Yes**	Jarvinen and Ankley 1999
Zinc	mg/kg	6	370	370			170	200	**Yes**	Jarvinen and Ankley 1999

Notes:
Maximum values were used when the 95% UCL derived was greater than the maximum value.
Residue Effects values are reported on a wet weight basis
LER = Lowest effect residue
NER = No effects residue

Silver in fish tissues from the URGWOPS dataset exceeded the screening criterion in all samples. The residue effects value, however, which was based on an NER value for bluegill sunfish, was not exceeded in samples collected as part of the USFWS dataset.

Zinc residues in fish exceeded the tissue residue effects screening values at three of the stations evaluated in the URGWOPS dataset. Although effects data for the FHM were not identified for tissue residues, the no-effects data for the three fish species presented in Jarvinen and Ankley (1999) indicate that NECs for residues in each of the fish varied widely. McGeer and others (2003) found that zinc does bioaccumulate in aquatic biota, but there is an inconsistent relationship between exposure concentration and whole-body concentration of zinc. In fact, most species did not show significant increases in zinc accumulation when exposure levels increased, even when concentrations reached levels that would be predicted to cause chronic effects. This finding suggests that adverse effects related to zinc exposure are independent of whole-body accumulation.

4.4.3.3 Location-Specific Summary

Table A11 shows at which sampling locations trace elements exceeded the screening criteria. Cadmium, copper, silver, and zinc exceeded screening values only for sites within the channel of MRG (recall that a limited quantity of fish tissue data were available and that additional fish tissue data from tributaries were also considered). The fact that cadmium, copper, and silver exceeded the screening criteria at most, if not all, of the stations evaluated may suggest that these concentrations are elevated as a result of regional geological factors.

5.0 ASSESSMENT UNCERTAINTIES

Ecological risk assessments require assumptions and extrapolations in each step of the assessment that lead to uncertainty in risk prediction and affect projections of true exposure and risk at any site. Accordingly, the key assumptions and uncertainties discussed in the following sections that have the greatest influence on ecological risk assessments include the following:

- Use of existing data
- Assumptions regarding exposure probability
- Sampling uncertainty and data gaps (uncertainty about spatial distribution of contamination as a consequence of limitations in sampling a site)
- Uncertainty in the selection of COPCs
- Uncertainty in the natural (seasonal or annual) variability in the species, populations, communities, and ecosystems in question, as well as uncertainty about individual sensitivity to COPCs
- Uncertainty in risk characterization using laboratory-based toxicity values and the HQ approach
- Uncertainty in models and parameters used to estimate risk potentials
- Uncertainty in assessing background COPC concentrations that may relate to calculated risk potentials (incremental risk)

5.1 Use of Existing Data

Two data sets were used in this risk assessment to evaluate potential COPCs in water, sediments, and fish tissues. In addition, highly conservative assumptions were applied in completing this screening assessment; this practice is typical for early tiers of ecological risk assessment to help ensure that all appropriate COPCs are targeted by the assessment. The assessment rated the USFWS data in the data usability evaluation as moderately high quality data. Much of the URGWOPS data were rated as marginal or low quality data due to missing information about quality assurance, poor coordinate information, poor analytical data flagging, inadequate sample numbers, and needed backup information that allows for a correct use and interpretation of the data. As such, while the URGWOPS data were used to screen chemicals, much more emphasis is placed on the USFWS data. The uncertainties associated with the URGWOPS data should not preclude their use, but the weight placed on results of analyses from the URGWOPS data should be viewed cautiously.

5.2 Probabilities of Exposure

This risk assessment is based on several assumptions that create a worst case scenario, permitting a conservative assessment of risk for the given sampled conditions. These assumptions are as follows:

- The RGSM populations have been and will be ubiquitously distributed through the MRG, wherever samples included in this assessment have been collected.
- The probability of prolonged chronic exposure for resident RGSMs is likely and equal for all chemicals reported at the times and locations sampled; that is, individual RGSMs are assumed to be present where and when water quality sampling occurred, and the conditions noted at the sampling time persist with the associated RGSMs and aquatic life for prolonged intervals.

If instead of the above-listed assumptions it is assumed that RGSMs or key aquatic community components are not ubiquitously distributed or not necessarily present at the times and locations the samples were collected, then potential exposure to the conditions sampled might not exist, potential hazards might not occur, and ecological risk might be low. Exposure potential must exist for risk to be present.

5.3 Sampling and Analysis Uncertainties

Potentially major sources of uncertainty can be attributable to biased sampling or biased analysis, as highlighted in the two following subsections.

5.3.1 Biased Sampling

Uncertainty in the exposure concentrations can occur, for example, by preferentially locating sample sites where contamination is either present or not present, or by using other subjective criteria to guide selection of sample collection locations. Sample locations used to estimate risks in this MRG assessment probably were based on some combination of (1) existing or historical data collection locations, (2) location accessibility, and (3) locations where the potential for risk effects was likely due to point or non-point discharge in the vicinity. Although these factors likely created some bias, the sites collectively included in this assessment from both the USFWS and the URGWOPS datasets provided values both near the maximum (worse case) and the range thought to be representative of conditions appropriate for calculating 95 percent UCL values. As a result, it is unlikely that the bias had any significant adverse effect on this risk assessment.

5.3.2 Biased Analysis

Analytical data can include measurement error and sampling error as primary sources of uncertainty. The USFWS dataset included an extensive QA/QC program, as documented in the USFWS report (2004). This review of the USFWS data did not reveal any significant quality issues that would misdirect the assessment. Similar QA/QC documentation was not available for the data in the URGWOPS dataset; however, most of the data included in this assessment were produced by government agencies such as the U.S. Geological Survey or the NMDEQ. These agencies would be expected to use appropriate, state-of-the-science analytical and QA/QC procedures. Therefore, any analytical bias included with this assessment is likely minimal and unlikely to adversely affect the final projection of risk.

5.4 Data Gaps

Typically, a data gap is the absence of an element necessary to fully evaluate that parameter. For example, there are undoubtedly hundreds of thousands of chemicals in the MRG for which the samples have not been analyzed. Any one of these chemicals can be considered a data gap. Additionally, not all chemicals included in Table A1, the list of chemicals gathered from available criteria, have been analyzed in samples from the MRG. These can also be considered data gaps. This project has not attempted to address such questions, nor their merit. Instead, this project had focused on analytical results available for the MRG, to learn what knowledge these results convey and what the analysis of these results indicate, and to determine data gaps to drive future sampling plans.

In this case, the suite of analytical tests that were performed on the samples collected is considered to be very extensive and to cover to a very large extent the range of contaminants that could be introduced into the river at repeated intervals through normal operations and in any significant quantities. This being said, the fact that a time series was not available for most analytes is a data gap.

Another data gap of interest for this assessment includes the availability of analytical results for chemicals detected in measurable quantities, but that lack benchmarks to judge their biological or environmental significance. Developing appropriate benchmark data for many of these chemicals listed would require multiple short- and long-term toxicity tests with multiple species to fill these data gaps. This effort would be significant in terms of cost.

As part of the USEPA priority pollutant program, the chemicals thought to pose the greatest risk to the nation’s aquatic life have been identified and assessments have been completed or are being developed. These chemicals are among those listed on Table A1. Beyond that list, only limited federal, state, or private benchmark development studies can be expected. Furthermore, new benchmark criteria become available slowly and sporadically to add to the sources used to build Tables 1, 2, and 3. Thus, the data gaps identified in many of the tables of this document are likely to remain data gaps into the future.

Sampling and chemical analysis for indicator chemicals or chemicals of interest that lack assessment benchmarks could continue to enable evaluation of concentration trends. However, assessment of their biological significance will likely continue to remain uncertain for some time. As such, future sampling and analysis for most chemicals lacking assessment benchmarks should be limited to frequencies of once every few years or longer. These data could then be used to look at long term trends of concentration increases or decreases. To answer the question of whether localized accumulations of chemicals in this list may have environmental significance, specific studies involving intensive sampling would have to be conducted. These studies would have to be coupled with laboratory and field studies intended to determine the biological meaning of the concentrations found. Beyond infrequent or special focused assessment strategies, more frequent or "shotgun" sampling and analysis of analytes that lack assessment benchmarks can be generally viewed as having questionable merit.

5.4.1 Uncertainties Associated with COPC Selection

COPCs for each medium assessed (surface water, sediment, and fish tissue) were identified from among the chemicals in the datasets. The question remains whether additional COPCs would have been identified if results for more analytes were available. For surface water risk evaluation, Table 8 lists 189 chemicals assessed using the USFWS data and Table 23 lists 516 chemicals assessed using the URGWOPS data. Other tables list the chemicals assessed in sediment and tissue for both studies. These tables show that the most analytes were evaluated for the surface water risk assessment, fewer for sediment, and even fewer for tissue. Availability of assessment benchmarks, and thus the ability to interpret the biological meaning, followed the same trend for these three environmental media. For these reasons, despite the considerable number of records available for the MRG, relatively few COPCs were identified through this risk assessment. For example, only 51 of 189 (27 percent) of the surface water analytes included in the USFWS study were at concentrations above the detection limits (Table A3); 14 of those 51 analytes (27 percent) lacked benchmarks and thus could not be used to interpret their biological meaning (Table A3); and six (13 percent) of the 37 analytes for which benchmarks were available were identified as COPCs in the Tier I screening (Table 9). Of these six, only three remained after the Tier II risk screening, and these posed only relatively low risks to aquatic organisms in conservative chronic surface water exposure scenarios (Table 10). Additional risk assessment based on the more time-extensive data series of the URGWOPS dataset, as well as the assessment of sediment and tissue results from both datasets, expanded the COPC list, as discussed in Section 5.3.

It is reasonable to conclude that the selection of the analytes for which samples were analyzed to create the two datasets was based on their perceived relatively high likelihood of occurrence and impact in the MRG. Although not impossible, it is unlikely that that a more extensive analyte list would yield any new COPCs.

5.4.2 Receptor-Specific Uncertainties

Species, life histories, and behavioral differences can also affect sensitivities to natural factors. To the extent possible, this MRG risk assessment attempted to incorporate differences in life history, and an RGSM/FHM screening benchmark was specifically developed to address concerns that the more generally and widely applied aquatic life criteria were insufficiently sensitive for RGSM. The results indicate that they were sufficiently sensitive (see Section 4.1.4).

Although uncertainty remains in terms of the effect of these relationships on the overall applicability of this risk assessment for the individual life history stages of the RGSM, the study has attempted to include highly conservative assumptions with each step. Therefore, this risk assessment is adequate, in terms of the goals of this project, to identify assessment priorities for future studies.

5.5 Risk Characterization Uncertainties

There are several and varying levels of uncertainty associated with the process of risk characterization. This section identifies the major risk characterization components as well as uncertainties that apply, regardless of the ecosystem component for which the risks are being evaluated. Generic uncertainty issues are discussed first in the following subsections, followed by evaluations of specific uncertainties that apply to aquatic ecosystems and terrestrial wildlife.

5.5.1 Potential Exposure Conditions

Uncertainty with regard to the natural (seasonal or annual) variability and exposure regimes for the species, populations, communities, and ecosystems is an important issue. Concerns regarding variability can be minimized for many aquatic assessments by including sampling for low-flow and high-flow events. Seasonal shifts in flow patterns and their effects, as well as their effects on the distribution and fate of COPCs, are typically known. Natural variability can be captured by assessing multiple sampling events distributed over one or more annual cycles. For this assessment, the two MRG datasets include a diversity of sampling locations, seasonality, and discharges over an extended interval from 1985 to 2003.

Uncertainty is present in the calculation of potential exposure conditions for environmental characterizations based on maximum concentrations (for the Tier I screening assessment) and the reasonable maximum exposure concentration (95 percent UCL of the mean for Tier II assessment) using the available data. The applicability of these values is limited by typical factors associated with analytical data as well as the locations of the samples and the number of samples collected. If the sample results dataset is limited, representative concentrations of a parameter may not be appropriately identified, and the calculation of the 95 percent UCL (based on the assumption that data are normally distributed) is compromised.

When calculating potential exposure conditions from sampling data, one-half of the reported detection limit was used for non-detect results in the calculation of the UCL values. Any statistical approach that uses non-detected concentrations is associated with some uncertainty, because actual concentrations may be very close to the detection limit, or may be much lower than the detection limit. The uncertainty will increase with the number of non-detect values, but this uncertainty may be less relevant if the non-detect concentration is less than the reasonable maximum exposure concentration.

The uncertainty that applies to all data is related to the ability to measure a representative field concentration. This uncertainty, in turn, depends on several factors, including the sampling medium, the form or phase of the chemical measured, and the presence of other chemicals in the sample that could affect the analysis of the target chemical. These factors are addressed to the extent possible through good analytical laboratory procedures (through calculation of sample-specific quantitation limits) and by specifying rigorous sampling procedures in the field sampling plans, followed by appropriate implementation under a quality assurance program. However, the inherent magnitude of concentration variability for chemicals along the MRG for the media sampled remains uncertain.

5.5.2 Toxicity

In general, risk assessments are built on toxicity information gained from laboratory and other controlled experiments. This information is then used to extrapolate conditions likely to exist in the natural environment. Laboratory information often does not provide complete linkages for these extrapolations, however. Consequently, assessment factors are often used to compensate for the uncertainties inherent in the extrapolation (Warren-Hicks and Moore 1998). According to Calabrese and Baldwin (1993), uncertainties arise when extrapolations are made for the following:

- Acute to chronic endpoints
- One life stage to the entire life cycle
- Individual effects on effects at the population level or higher
- One species to many species
- Laboratory to field conditions
- One to all exposure routes

- Direct to indirect effects
- One ecosystem to all ecosystems
- One location or time to others

The net effect of these uncertainties may result in either an overestimate or underestimate of risk, depending on site-specific conditions, the types of receptors included in the evaluation, the chemicals of concern, and the species of concern.

5.5.3 Bioavailability

The bioavailability of a COPC creates uncertainty in the risk characterization process. This uncertainty can affect the potential exposure conditions used to estimate bioavailable forms (such as dissolved metals in solution) as well as the toxicity endpoints used to derive risk assessment benchmarks.

Bioavailability and ecotoxicity of chemicals are linked to their concentrations and the forms they take (USEPA 1999b). The toxicity of a contaminant is controlled by the following factors:

- Its environmental concentration
- Site-specific chemistry (especially through ionic solubility and speciation, if a metal or metalloid)
- The physical matrix in which the contaminant is found
- The uptake pathways into a target organism from the physical matrix

All of these factors help to determine the exposure matrix for organisms in the field. Assessment of ecological risks and the potential adverse effects of a contaminant require an understanding of the exposure matrix that may lead to actual uptake by a receptor species. The USEPA has highlighted this complex of factors in its Biotic Ligand Model (USEPA 1999b).

5.5.4 Benchmark Uncertainty

The benchmarks or TRVs used as comparison points for chemical concentrations to make determinations of risk or no risk are based on potentially many well-defined studies or possibly on a single study. The basis and data that go into the values used for TRVs in an ecological risk assessment have varying levels of uncertainty. As discussed above, all the factors affecting uncertainties of toxicity also affect the uncertainties of the benchmarks used to derive risk estimates. By providing a range of benchmarks, the uncertainty associated with the HQ approach likely decreases, because true effects, and therefore risks, are likely found within the range.

6.0 FUTURE PRIORITIES FOR MRG WATER QUALITY ASSESSMENTS

This project screened the risks to RGSMs and other aquatic life in the MRG based on two sets of existing water quality data. Of these, the USFWS dataset included data collected in 2002-2003 and the data quality assessment found essentially the entire dataset appropriate for use in this risk assessment. The URGWOPS dataset used in this risk assessment spanned 1985-2000; the data quality assessment identified various issues with these data, but judged the data set to be useable in this ecological risk screening, albeit with caution. Overall, however, the USFWS data were deemed to include more recent data of higher and more consistent quality. As such, this assessment places greater weight on the USFWS dataset for planning needs, while viewing the URGWOPS data as having important secondary supportive value for planning. The following subsections summarize the specific water quality risks identified in this assessment and characterize the basis for proposing priorities for future water quality studies.

6.1 Trace Elements

Overall, the following discussion focuses on several metals identified through this assessment as posing a potential risk to aquatic receptors in one or more of the media sampled (Table 33). Not all of the risks predicted for individual metals in each of the media evaluated are expected to result in observed risks to RGSM. Uncertainties in the screening benchmarks used to predict risks, the number of samples available, and the quality of measurement data (in some cases, detection limits that are higher than effect thresholds) contribute to the uncertainty in predicted versus actual risks. A number of trace elements were measured for all of the media but no effects threshold values were available. These are considered data gaps in this assessment. No risk predictions could be made for these trace elements as a result.

Cumulative risk from metals in surface water and sediments is likely present at some sites at some times in the MRG. While cumulative risk was assessed for sediment, it was not specifically assessed in this study for surface waters. This is because many metals have HQs greater than 1 in surface water and summing probable risks greater than 1.0 and often much greater than 1.0 would result in a cumulative probable risk greater than 1.0; consequently, no knowledge is gained in completing such an exercise.

For metals in sediment, cumulative risk is present, albeit small, while individual risks to benthic receptors may be overpredicted based on the Tier I screening assessment due to the assumptions required. The trace elements arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc were evaluated in a Tier II cumulative assessment for sediments to assess the potential for this mixture of metals to pose a risk to benthic receptors. Collectively, for the metals evaluated risks were found at locations FWS-5, 7, 8,

Table 33. MRG COPCs and Recommendations for Future Monitoring

Analytes/Parameters	Surface Water		Sediment		Tissue	
	Priority	Monitoring Frequency	Priority	Monitoring Frequency	Priority	Monitoring Frequency
Trace Elements - SW to include total and dissolved measurements, sediment and tissue to include total measurements						
Aluminum	low	1-5	low	1-5	low	1-5
Arsenic	low	1-5	**high**	**quarterly**	low	1-5
Barium	low	1-5	low	1-5	low	1-5
Beryllium	low	1-5	low	1-5	low	1-5
Cadmium	low	1-5	**high**	**quarterly**	low	1-5
Chromium	low	1-5	**high**	**quarterly**	low	1-5
Cobalt	low	1-5	**high**	**quarterly**	low	1-5
Copper	low	1-5	low	1-5	low	1-5
Iron	low	1-5	low	1-5	low	1-5
Lead	low	1-5	**high**	**quarterly**	low	1-5
Lithium	low	1-5	low	1-5	low	1-5
Manganese	low	1-5	low	1-5	low	1-5
Mercury	**high**	**quarterly**	**high**	**quarterly**	**high**	**annual**
Nickel	low	1-5	**high**	**quarterly**	low	1-5
Selenium	**high**	**quarterly**	**high**	**quarterly**	**high**	**annual**
Silver	low	1-5	low	1-5	low	1-5
Tin	low	1-5	low	1-5	low	1-5
Uranium	**high**	**quarterly**	**high**	**quarterly**	low	1-5
Vanadium	low	1-5	low	1-5	low	1-5
Zinc	low	1-5	**high**	**quarterly**	low	1-5
Nutrients						
Total Ammonia as nitrogen	**high**	**quarterly**	low	1-5	NA	NA
Common Anions						
Cyanide	low	1-5	**high**	**quarterly**	NA	NA
Volatile and Semi-volatile Organic Compounds (VOCs)						
Acetone	low	1-5	**high**	**quarterly**	low	1-5
Benzidine	low	1-5	low	1-5	low	1-5
Bis(2-ethylhexyl) phthalate	low	1-5	low	1-5	low	1-5
Chloroform (trichloromethane)	low	1-5	low	1-5	low	1-5
Hexachlorobutadiene	low	1-5	low	1-5	low	1-5
Polycyclic Aromatic Hydrocarbons (PAHs)						
1-Methylnaphthalene	NA	NA	low	1-5	NA	NA
Acenapthene	NA	NA	low	1-5	NA	NA
Acenapthylene	NA	NA	low	1-5	NA	NA
Anthracene	NA	NA	low	1-5	NA	NA
Benzo(a)anthracene	NA	NA	low	1-5	NA	NA
Benzo(a)pyrene	NA	NA	low	1-5	NA	NA
Benzo(b)fluoranthene	NA	NA	low	1-5	NA	NA
Benzo(ghi)perylene	NA	NA	low	1-5	NA	NA
Benzo(k)fluoranthene	NA	NA	low	1-5	NA	NA
Chrysene	NA	NA	low	1-5	NA	NA
Dibenzo(a,h)anthracene	NA	NA	low	1-5	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	low	1-5	NA	NA
Total PAHs	NA	NA	low	1-5	NA	NA
Petroleum Hydrocarbons						
None	low	1-5	low	1-5	low	1-5
Herbicides and Other Pesticides						
2,4-D	low	1-5	low	1-5	low	1-5
2-Chlorophenol	low	1-5	low	1-5	low	1-5
alpha-Endosulfan	low	1-5	**high**	**quarterly**	low	1-5
Azinphos-methyl	low	1-5	low	1-5	low	1-5
beta-Endosulfan	low	1-5	**high**	**quarterly**	low	1-5
Chlordane	low	1-5	**high**	**quarterly**	low	1-5
Chlorpyrifos	low	1-5	low	1-5	low	1-5
Diazinon	low	1-5	low	1-5	low	1-5
Dieldrin	low	1-5	**high**	**quarterly**	low	1-5
Dinoseb	low	1-5	low	1-5	low	1-5
Endrin	low	1-5	**high**	**quarterly**	low	1-5
Heptachlor	low	1-5	**high**	**quarterly**	low	1-5
Heptachlor epoxide	low	1-5	**high**	**quarterly**	low	1-5
Methyl parathion	low	1-5	low	1-5	low	1-5
Mirex	low	1-5	low	1-5	low	1-5
p,p'-DDD	low	1-5	**high**	**quarterly**	low	1-5
p,p'-DDE	low	1-5	**high**	**quarterly**	low	1-5
p,p'-DDT	low	1-5	**high**	**quarterly**	low	1-5

Table 33 MRG COPCs and Recommendations for Future Monitoring (Continued)

Analytes/Parameters	**Surface Water**		**Sediment**		**Tissue**	
	Priority	**Monitoring Frequency**	**Priority**	**Monitoring Frequency**	**Priority**	**Monitoring Frequency**
Parathion	low	1-5	low	1-5	low	1-5
Toxaphene	low	1-5	**high**	**quarterly**	low	1-5
Explosives						
2,4-Dinitrotoluene	low	1-5	low	1-5	low	1-5
2,6-Dinitrotoluene	low	1-5	low	1-5	low	1-5
Pharmaceuticals						
none	low	1-5	low	1-5	low	1-5
Polychlorinated Biphenyls (PCBs)						
Aroclor 1254	low	1-5	low	1-5	low	1-5
Aroclor 1221	low	1-5	low	1-5	low	1-5
Aroclor 1242	low	1-5	low	1-5	low	1-5
Aroclor 1248	low	1-5	low	1-5	low	1-5
Total PCBs	low	1-5	low	1-5	low	1-5

Notes:
NA = Not applicable to the media or not analzyed
monitoring frequency of 1-5 indicates yearly or higher frequency

12, and 14. The potential incidence of toxicity is likely low for all FWS locations except FWS-14. Barium, aluminum, and manganese were also identified as trace elements in sediments that may pose a risk individually; however, supporting data from the source document used to obtain the TRVs for aluminum and manganese support the conclusion that neither element is likely a contributor to risk in the MRG (Ingersoll and others 1996). Cumulatively, metals in sediments evaluated using the mean PEC-Q for Rio Grande sediments may pose a small risk to benthic receptors.

Trace elements as a suite of parameters should remain on the priority list for future studies. The rationale is several-fold: (1) in water and sediments, potential cumulative risks are present; (2) metals have multiple potential sources and are likely to be continuously loaded to the MRG from these sources; (4) the older data (URGWOPS) indicate that metals had historical concentrations that might have posed larger risks than indicated for the more recent data collected by the USFWS, and additional assessment is needed to assess the validity of this trend; and (4) the magnitude and frequency of occasional elevated levels is not adequately understood. It is likely cost–effective to continue monitoring most trace elements in total because results for many of the trace elements can be determined via a single analytical method that can simultaneously assess a suite that includes most metals, and costs for metals analyses from many (but not all) laboratories can be the same for one or many metals. Monitoring can be justified as long as detection limits are set to allow for effective comparison of these elements to effects thresholds.

The complex mixture of trace elements in surface water and sediments and the potential for cumulative toxicity in these media suggest that ambient toxicity testing may be an effective mechanism to assess whether MRG surface water or sediments are toxic. If toxicity is identified, then evaluation procedures could be used to narrow the list of potential trace elements that may be causing it. No SQGs are available for a number of trace elements and the mean PEC-Q for a suite of metals indicates a small but present risk for cumulative toxicity. As a result, future investigations should continue to include a suite of trace elements in sediment analysis coupled with toxicity testing and benthic community assessments to verify whether predicted risks are actual risks. This approach does not indicate directly whether concentrations of trace elements in sediments pose a risk to RGSM; however, understanding whether trace element concentrations are toxic to benthic invertebrates would provide important information with regard to understanding potential exposure routes and chemicals that pose a risk to RGSMs via secondary exposures.

6.1.1 Chemical-Specific Monitoring Recommendations and Interpretive Guidance for Trace Metals

Table 33 presents priority and monitoring recommendations based on relative risk estimates and additional considerations presented below for each medium evaluated through this assessment. A number of trace elements were detected across all media, as expected, given that trace elements are naturally occurring. The purpose of the following discussion is to focus on the trace elements that may pose a risk individually, based on the quality and quantity of data used in the analysis. Following is a summary and evaluation of the trace element COPCs across each of the media evaluated. Again, due to the generally higher and more consistent quality of the USFWS data, assessment results obtained though analysis of this dataset are weighted more heavily in the following discussion than relationships identified in the URGWOPS dataset.

Aluminum – Concentrations of aluminum in all media equaled or exceeded effects thresholds in the USFWS dataset, while they exceeded water quality thresholds only in the URGWOPS dataset; however, based on the best available information, aluminum should not be considered a COPC of significance in the MRG. The 2004 National Recommended Water Quality Criteria (USEPA 2004) states the following regarding surface water concentrations:

> "*(1) The value of 87 ug/l is based on a toxicity test with the striped bass in water with pH= 6.5-6.6 and hardness <10 mg/L. Data in "Aluminum Water-Effect Ratio for the 3M Plant Effluent Discharge, Middleway, West Virginia" (May 1994) indicate that aluminum is substantially less toxic at higher pH and hardness, but the effects of pH and hardness are not well quantified at this time. (2) In tests with the brook trout at low pH and hardness, effects increased with increasing concentrations of total aluminum even though the concentration of dissolved aluminum was constant, indicating that total recoverable is a more appropriate measurement than dissolved, at least when particulate aluminum is primarily aluminum hydroxide particles. In surface waters, however, the total recoverable procedure might measure aluminum associated with clay particles, which might be less toxic than aluminum associated with aluminum hydroxide. (3) USEPA is aware of field data indicating that many high quality waters in the U.S. contain more than 87 ug aluminum/L, when either total recoverable or dissolved is measured.*"

Additionally, Ingersoll and others (1996), however, defined a no-effects value for aluminum in sediment (73,160 mg/kg) that is much higher than MRG sediment concentrations. Based on this information, aluminum in sediments does not pose a risk to benthic invertebrates. Aluminum is recognized as a gill toxicant, but this relationship results from research that has been conducted at low water hardness, low total organic carbon, and low pH, conditions not found in the MRG. Therefore, chemical conditions in the MRG and the geochemistry of aluminum suggest that aluminum in surface water and sediment does not pose a risk in the MRG. Uncertainty in the tissue residue effects data suggests that aluminum in tissue (specifically the gill) that may cause adverse effects and a better understanding of the relationship between tissue residues of aluminum and toxic effects is necessary before aluminum can be dismissed totally as a COPC with regard to RGSM. As such, trend monitoring at 1-5 year intervals should continue for aluminum in water, sediment, and fish tissues at sampling sites along the MRG.

Arsenic – This metal was not identified as a COPC in the surface water samples for either dataset that would pose potential risk to aquatic life in MRG surface waters. The low HQ calculated for sediment in the URGWOPS dataset and the high HQ calculated for the USFWS dataset indicate a small and a high risk, respectively. However, the high HQ calculated for the USFWS data is based on a single hit. Arsenic in sediments, however, does contribute to potential cumulative metal effects on benthic invertebrates. No tissue risks are predicted. Therefore, 1-5 year trend monitoring is recommended for arsenic in surface water and fish tissue along the MRG, while sediment sampling and analysis should be included as part of a quarterly monitoring program.

Barium **–** Through the initial evaluation, barium was identified as posing a potential risk based on concentrations in sediment. However, barium chemistry (Section 4.4.2.2) in surface waters and sediments indicated that the bioavailability of barium is low because of complexation with sulfate. Consequently, barium is not likely to pose a risk to aquatic receptors and is included as a low priority COPC that should be included in trend monitoring over 1-5 year intervals.

Beryllium – Risks were predicted for total beryllium in surface waters from the URGWOPS data but not from the USFWS data. Detection limits used in the URGWOPS dataset are too high for effective use of these data. No SQGs for beryllium were found. Beryllium is not predicted to pose a risk based on fish tissue residues. Therefore, beryllium is not likely to pose a risk to aquatic receptors and is included as a low priority COPC that should be included in trend monitoring over 1-5 year intervals.

Cadmium – Based on the fact that data for total and dissolved cadmium from the URGWOPS dataset indicated that a small risk is present for surface waters and the fact that USFWS data indicated no apparent risk posed by cadmium, this metal is currently considered as not posing a marked risk in surface water. It is doubtful that cadmium is a risk issue in sediments based on the URGWOPS data because of the probability that detection limits that are too high prevent accurate assessment of these data relative to the SQGs. Only one measurement of cadmium in USFWS sediments data exceeded the TEC; but, cadmium in sediments does contribute to potential cumulative effects on benthic invertebrates. Thus, cadmium is retained as a higher priority risk issue for sediments. No risks were identified for cadmium in fish tissues based on the USFWS data, but fish tissues data from URGWOPS were elevated above the risk screening criteria. Therefore, lower priority 1-5 year trend monitoring is recommended for cadmium in surface water and fish tissue along the MRG, while sediment sampling and analysis should be included as part of a quarterly monitoring program.

Chromium – This metal was not detected in surface waters at concentrations that pose a risk. However, chromium was elevated in sediments and tissues when compared with screening levels in these media. Sediment concentrations of chromium exceeded the TEC only once in USFWS data, indicating that all remaining measurements in sediments were less than the no-effects threshold even though a maximum exposure in sediments had occurred. URGWOPS data suggest that a small risk is present (this could be because of the longer temporal period of the measurement data), but only two measurements exceeded the TEC. Chromium in sediment is consequently not expected to pose a risk in benthic invertebrates due to limited exceedances of the TEC. But the cumulative analysis of metals indicates that chromium may contribute to additive toxicity in the sediment. Residues of chromium in fish tissue analyzed during the USFWS study exceeded the residue effects levels based on the 95 percent UCLs. The risk from chromium may be a function of the tissue residue effects level selected, given that data for trout were used for the tissue TRV. Therefore, lower priority 1-5 year trend monitoring is recommended for chromium in surface water and fish tissue along the MRG, while sediment sampling and analysis should be included as part of a quarterly monitoring program.

Cobalt – In the URGWOPS dataset, two out of 60 measurements of cobalt exceeded the screening level value, while in the USFWS dataset, one in 38 measurements of this metal exceeded the screening criterion. Low HQs from both datasets for cobalt in surface water suggest low potential for risk in the MRG. Only one measurement of cobalt in USFWS sediment data exceeded the TEC and in the URGWOPS sediment data, only two values exceeded the TEC. The lowest cleanup goal identified as a site-specific PEC was 80 mg/kg at the Blackbird Mine in Idaho, where cobalt was one of the primary COPCs (USEPA 2003b). A large proportion of the cobalt measurements collected for sediments are less than this PEC and the TEC. Thus, cobalt in sediments is not likely a risk issue. Tissue residue screening benchmarks are not available for cobalt. In summary, lower priority 1-5 year trend monitoring is recommended for cobalt in surface water, sediments, and fish tissue along the MRG.

Copper – Copper in surface waters was not identified as posing risk based on USFWS data, but older URGWOPS data indicated that copper may have posed a small risk in the past. Sediment copper concentrations reported for the USFWS dataset exceeded the TEC once; the URGWOPS dataset also showed that the TEC was exceeded once. Thus, both datasets indicated a low potential for risk. Copper in tissues collected for the USFWS study did not exceed the tissue TRV but this TRV was exceeded by concentrations in the URGWOPS data for two samples. In total, the criteria for copper was infrequently exceeded in all three media. Because of the strong influence of water quality conditions (particularly hardness and alkalinity) on the bioavailability of copper, it is probable that risks from copper are low, and likely lower than indicated by the probable risks calculated based on the URWOPS dataset. Additionally, a new criterion for copper has been proposed by USEPA that uses the biotic ligand model (BLM). If future data become available to apply using this model, it should be used to derive a site-specific or region-specific copper criterion for the MRG. Based on available information, however, only lower priority 1-5 year trend monitoring is recommended for copper in surface water, sediment, and fish tissue along the MRG.

Iron – Concentrations of iron in surface water were not identified as posing risks based on the site-wide 95 percent UCL for USFWS data. They also did not exceed the screening levels for sediments or tissues. Concentrations of iron based on 95 percent UCLs from the URGWOPS data exceeded the criterion for surface water, while iron in sediments was less than the TEC. Tissue data were limited, but based on the 95 percent UCLs for iron in fish tissues from the URGWOPS data, no risks were predicted, although the maximum concentration was higher than residue effects levels. Thus, the older water quality data suggest that iron concentrations may pose a small risk, while the more recent FWS dataset across three media indicate that iron is not considered to pose a risk in the MRG. Therefore, only lower priority 1-5 year trend monitoring is recommended for iron in surface water, sediment, and fish tissue along the MRG.

Lead – Risks due to total lead concentration were identified based on the longer-term URGWOPS data, while risks based on dissolved lead were not predicted for either dataset. Both datasets indicated risks from sediment lead concentrations, but the prediction is based on one sample from the USFWS dataset and three samples from the URGWOPS dataset, which suggests that elevated concentrations are sporadic. Lead does, however, contribute to potential cumulative effects for metals in sediments. Tissue residues from both datasets agree that no risks are predicted. Based on these data, lead poses only a low-level risk in the MRG. Therefore, only lower priority 1-5 year trend monitoring is recommended for lead in surface water and fish tissue along the MRG, while sediment sampling and analysis should be included as part of a quarterly monitoring program.

Lithium – Lithium did not exceed water quality thresholds, and no sediment quality thresholds were available. No residue effects values for lithium in tissue were available. Lithium was detected in sediments and tissue, but the lack of screening values does not allow for interpretation of the data. Given the inability to assess potential risks associated with lithium, only lower priority 1-5 year trend monitoring is recommended for lithium in surface water, sediment, and fish tissue along the MRG.

Manganese – Minimal risks were predicted for manganese in surface waters based on data from both datasets. For sediments, only one measurement for manganese from the USFWS dataset exceeded the NEC (Ingersoll and others 1996) while no URGWOPS data exceeded the NEC. No effects data for tissue residue for manganese were found. Apparently minimal risks from manganese concentrations exist in the MRG. Therefore, only lower priority 1-5 year trend monitoring is recommended for manganese in surface water, sediment, and fish tissue along the MRG.

Mercury and Selenium – Mercury and selenium are considered here together because of their similar fate, transport, and exposure routes to aquatic organisms. Both may form methylated organic species, which tend to be more bioavailable than the inorganic forms. In-stream chemical conditions govern the predominant species of these chemicals, and diet is an important exposure route for aquatic organisms. Of the trace elements, mercury and selenium are potentially of greatest concern, not because the HQs are high, but because both are COPCs that bioaccumulate and biomagnify in the food chain.

Surface water data indicate that mercury exceeds its chronic criterion based on total mercury in the USFWS dataset and dissolved mercury in surface water in the URGWOPS dataset. Selenium in USFWS surface water data did not exceed the chronic criterion, but exceeded the criterion in the URGWOPS dataset.

Mercury concentrations in USFWS sediment samples did not exceed the TEC, but URGWOPS concentration data exceeded the TEC in the 3 of 58 measured concentrations. No benthic effects values for selenium were found. However, Van Derveer and Canton (1997) proposed low (2.5 mg/kg) and upper (4.0 mg/kg) effects levels for selenium in sediments for western streams based on effects on fish and birds. The average concentration of selenium in sediments in the USFWS dataset (8.49 mg/kg) exceeds these effects values. Sediment data for selenium were limited in the URGWOPS dataset, but the maximum concentration did not exceed the lower effects value described in this paragraph.

Both mercury and selenium were detected in USFWS fish tissues at concentrations greater than the tissue residue effects values. However, only mercury, based on the 95 percent UCL, continued to indicate risks based on concentrations in fish tissue. Tissue data from the URGWOPS dataset were limited and only selenium exceeded the tissue residue effects values based on the 95 percent UCL concentrations.

Selenium and mercury should be considered as high priority COPCs until future data suggest otherwise. This recommendation is based on the fact that both of these two trace elements bioaccumulate, and despite low concentrations in water and or sediment, they pose risk through the food chain to upper trophic level organisms such as fish and birds. Therefore, higher priority quarterly monitoring for both selenium and mercury in both surface water and sediment, and annual monitoring in fish tissue are recommended.

Nickel – Dissolved nickel did not exceed the surface water quality criterion based on the site-wide 95 percent UCL for USFWS surface water data. The same statistics for URGWOPS data indicated that nickel concentrations were equal to the criterion for chronic exposure to the dissolved form of the metal. Thus, risks from nickel in surface water are low. Nickel concentrations exceeded the TEC twice in the USFWS dataset and also in the URGWOPS dataset. Tier II risk assessment indicated that nickel could contribute to cumulative toxicity in the sediment. The PEC for nickel was also exceeded by data from both datasets. No tissue residue values were exceeded for either dataset. Therefore, lower priority 1-5 year trend monitoring is recommended for nickel in surface water and fish tissue along the MRG, while sediment sampling and analysis should be included as part of a quarterly monitoring program.

Silver – The concentrations of silver in surface water reported in the USFWS dataset did not exceed the chronic risk-screening criterion for silver. The value was exceeded in the URGWOPS dataset, indicating low risk. Risk calculated for silver in USFWS sediments is based on a single measurement. Likewise, risk predicted based on URGWOPS data is from limited data with poor detection limits. Risk due to concentrations of silver in sediments is not expected to be as high as predicted based because of the size of the dataset. USFWS tissue residue data indicate no risks to fish. Limited data from URGWOPS, however, indicate that tissue residues exceeded the effects criterion. Additional assessment is appropriate to better characterize actual risks associated with silver. Therefore, only lower priority 1-5 year trend monitoring is recommended for silver in surface water, sediment, and fish tissue along the MRG.

Tin – Tin was not identified as posing a risk in surface waters based on the USFWS data. In the URGWOPS data, projected risk was low based on the 95 percent UCL. However, the minimum detection limit for tin in the URGWOPS dataset exceeded the screening criterion. No SQGs or tissue residue effects levels for tin were found. While risks from tin exposure in water appear low, additional analysis will help to better characterize its actual risk. However, only lower priority 1-5 year trend monitoring is recommended for tin in surface water, sediment, and fish tissue along the MRG.

Uranium – Uranium concentrations exceeded surface water quality criteria, although the site-wide HQ based on the 95 percent UCL was low (1.15). A recent study by Dias and others (2005) examined uranium effects on aquatic midge larvae via sediment exposure; growth effects were observed at a concentration of 2.97 mg/kg, which is considerably lower than the average concentration reported for the MRG (19.34 mg/kg). Consequently, benthic effects that result from uranium are possible and additional assessment appropriate. Based on tissue residues, uranium accumulation in fish tissue poses little, if any, risk. Including uranium in the quarterly sampling program for surface water and sediment and in the 1-5 year trend monitoring for fish tissues will help to clarify the potential risk of uranium in the MRG.

Vanadium – Vanadium did not exceed water quality thresholds in USFWS data based on the site-wide 95 percent UCL, but URGWOPS concentrations did exceed the screening concentrations. Uncertainty is created by the fact that MDLs were often higher than the screening value in the URGWOPS dataset. No sediment quality thresholds were available. Vanadium did not exceed the tissue residue effects value. Vanadium would appear to pose low risk to aquatic life resources in the MRG. Therefore, only lower priority 1-5 year trend monitoring is recommended for vanadium in surface water, sediment, and fish tissue along the MRG.

Zinc – Zinc was not detected in surface water samples of either dataset at concentrations that indicated the presence of risk. However, sediment concentrations indicated risk in both datasets. Tissue sample results in the URGWOPS dataset indicated risk, which was not found in the USFWS dataset. However, sediment concentrations of zinc exceeded the TEC and PEC only once in USFWS data, suggesting that all remaining measurements in sediments were less than the no-effects threshold, even though a maximum exposure of this parameter in sediments has occurred. Tissue residue concentrations in the USFWS dataset did not exceed the residue effects levels based on the 95 percent UCLs, while concentrations in the URGWOPS dataset exceeded the same residue effects level. These elevated levels may be a function of the tissue residue effects level selected, given that an appropriate residue effect level was not found for a species more applicable to the MRG. Thus, there is uncertainty in risk estimates for zinc in fish tissues. Given low concentrations in water and most sediment samples, it is concluded that zinc should be considered a moderate to low priority for future investigations. Therefore, lower priority 1-5 year trend monitoring is recommended for zinc in surface water and fish tissue along the MRG; sediment sampling and analysis should be included as part of a quarterly monitoring program.

6.2 Nutrients

Although several forms of ammonia were assessed in both datasets, un-ionized ammonia is the most relevant form associated with assessing toxic risks; the most recent criteria from the USEPA are based on total ammonia due to the potential toxicity of ammonium under some environmental conditions. Potential risks posed by ammonia in surface waters were not predicted based on data from either dataset using site-wide 95 percent UCLs. Ammonia is also a potential nutrient of importance, especially for algal production. Also, ammonia continues to be a concern in municipal wastewater treatment plant discharges, especially during intervals of treatment upset. Continued assessment of ammonia in surface water on a quarterly basis is recommended through this assessment, especially at sites downstream from municipal treatment works. Sampling and analysis of ammonia in sediment or tissue can be recommended only as part of lower priority 1-5 year trend monitoring program.

6.3 Common Anions

No established risk screening or aquatic life water quality criteria value is available for total cyanide. Until one is available, however, USEPA (1984) recommends applying the criterion for free cyanide to data obtained through the analytical method for total cyanide. This criterion may be overly protective when applied to the free cyanide results. Even so, cyanide in MRG surface water samples was not predicted to pose a risk based on site-wide 95 percent UCLs from either dataset.

Cyanide concentrations in the USFWS sediment analysis data exceeded the screening benchmark. Moran (1998) indicates that cyanide tends to react readily with hundreds of chemical that then lead to breakdown compounds. These compounds tend to be less toxic than the original cyanide, but many are known to be toxic to aquatic organisms and can persist in the environment for significant durations. Therefore, quarterly monitoring of cyanide in sediment is recommended through this assessment. Sampling and analysis of ammonia in water or tissue can be recommended only as part of lower priority 1-5 year trend monitoring.

6.4 VOCs

In surface water samples, a number of VOCs and SVOCs were identified as COPCs in both of the datasets. Although a large number of these compounds were analyzed, many had only a single analysis. Others of these compounds had adequate numbers of samples analyzed, but many of these lack appropriate effects criteria. If a compound was not reported as detected in the datasets, it was not considered further. In the USFWS dataset no VOCs or SVOCs exceeded screening benchmarks, where benchmarks were available. In the URGWOPS dataset, only maximum concentrations could be compared with benchmarks, when available, because only one or two measurements were available for most of these compounds. Concentrations for only benzidine and hexachlorobutadiene exceeded the screening criteria, based on a single analysis for each. In total, the limited availability of toxicity thresholds for this group of chemicals suggests that, while baseline data can be generated, assessment of potential toxicity to aquatic life may lag until sufficient testing data are available.

In USFWS sediment data, acetone and chloroform were identified as exceeding sediment screening criteria with indications of low risk. As discussed above, the source of this acetone is uncertain, and acetone may be present in the sediment results as a result of natural biodegradation in the sediment or due to an artifact of laboratory contamination. Resolution of this uncertainty would require additional analysis. As also discussed above, the reported detection of chloroform in sediment is surprising, as it is highly volatile (WHO 1994). VOCs and SVOCs were not assessed in fish tissues.

One out of two bis(2-ethylhexyl) phthalate URGWOPS sample results from sediment analyses were identified as exceeding screening levels. This compound is a common plasticizing agent and is often measured in environmental samples.

Based on the lack of surface water and sediment ecological risk screening criteria for a large number of VOCs and SVOCs, these compounds are considered as a group to be of interest, but of lower priority. Therefore, except for acetone, sampling and analysis of VOCs and SVOCs in surface water, sediment, and tissue can be recommended only as part of lower priority 1-5 year trend monitoring; acetone concentrations in sediment should be monitored as part of the quarterly sediment monitoring program, at least until the mechanism or source for the acetone can be resolved.

6.5 Polycyclic Aromatic Hydrocarbons

PAH concentrations were analyzed in sediment in the USFWS dataset, and in water and sediment in the URGWOPS dataset. Concentrations in fish tissues have not been assessed. For sediment samples, several of these compounds were found at concentrations that exceeded TECs for individual chemicals in both datasets. In Tier II screening, however, the sum TEC screening level for total PAHs was exceeded only once, at FWS-7, with all other TEC-based HQs less than 1.0. Additionally, all PEC-based HQs for total PAHs were less than 1.0, and all PEC-based HQs were 0.1 or less. PAHs are therefore not likely posing a risk to the benthic community. URGWOPS data were of little utility in assessing PAHs because of MDLs exceeding screening benchmarks and limited numbers of compounds analyzed. Therefore, based on available information, PAHs in MRG sediments, based on the USFWS data, appear to pose minimal risk. Sampling and analysis of PAHs in surface water, sediment and tissue can be recommended only as part of lower priority 1-5 year trend monitoring.

6.6 Total Petroleum Hydrocarbons

Total petroleum hydrocarbons (TPHs) were measured in sediments collected by the USFWS. However, SQGs are not available for TPHs. As TPHs are composed of both gasoline- and diesel-range organics (which includes both volatile and semivolatile fractions), common surrogates to assess the potential for risks posed by TPH include PAHs and benzene, toluene, ethylbenzene, and xylene (BTEX). As discussed above, a sample concentration from only one location was found to exceed this threshold, while some individual PAHs exceeded screening level TEC benchmarks based on a total PAH benchmark. BTEX compounds were all found to be less than SQGs in the separate VOC assessments. Using these two chemical groups as surrogates for TPH, this class of compounds does not appear to pose a risk in MRG sediments. No TPH compounds were analyzed in water or tissues. Therefore, sampling and analysis of TPHs in surface water, sediment or tissue can be recommended only as part of a lower priority 1-5 year trend monitoring program.

6.7 Herbicides and Other Pesticides

Pesticides and herbicides measured in USFWS surface water samples were all found to be less than detection or less than screening-level criteria, when available. Sediments from this dataset indicated potential risks posed by heptachlor epoxide and p,p’-DDE when compared with screening-level benchmarks. However, further analysis of sediments, focused on organochlorine pesticides, found that potential toxicity to benthos may be occurring based on the cumulative assessment of chlordane, dieldrin, DDD, DDE, DDT, endrin, heptachlor epoxide, and lindane. Most of these compounds were reported as not detected; however, varying detection limits were often greater than the screening level benchmarks. These compounds are exceptionally persistent in the environment with long half-lives.

Organic compounds such as DDT and other organochlorine compounds, among others, are toxic to fish at varying concentrations in tissues. USEPA currently classifies several chemicals as persistent, bioaccumulative, and toxic (PBT) because of their wide range of effects and distribution in the environment. Some of these chemicals include DDT and its metabolites, aldrin, dieldrin, chlordane, toxaphene, and mercury, among many others. PBTs not only pose a risk to fish, but to higher trophic levels through biomagnification. Even though several of these compounds were determined to pose a risk based on a cumulative assessment of sediments, no pesticides were observed in USFWS fish tissue samples above the tissue residue effects values.

The URGWOPS dataset provided a much larger list of herbicides and pesticides for assessment; however, while the list of compounds analyzed was extensive, many of the available analyses were conducted only once or twice. In some cases, water quality criteria or benchmarks to assess effects were not available. Most of the compounds identified as posing potential risk are organochlorines. The minimum value reported for several of these compounds (assumed to be a detection limit, but not verified) was greater than the screening value. Organochlorine pesticides and herbicides were found in sediments at concentrations in URGWOPS samples that exceeded sediment screening levels; however, these elevated levels are based on a few analyses, often five or less. Despite the low number of results, the presence of some of these compounds, such as toxaphene, at concentrations that far exceed the screening levels suggests that further investigation may be warranted to delineate the nature and extent of pesticide contamination.

Collectively, the two datasets indicate that pesticides and herbicides are or have been present at concentrations that individually and cumulatively may pose a risk to aquatic receptors in both water and sediments. Further analysis of pesticides and herbicides is therefore warranted. Priority should be given to compounds that are persistent, while compounds with shorter half-lives deserve a lower priority for future investigation of concentrations in water, sediment, and fish tissue. Therefore, except for the pesticides and herbicides indicated differently in Table 33, sampling and analysis of pesticides in surface water, sediment or tissue can be recommended only as part of a lower priority 1-5 year trend monitoring program. As indicated by the 11 pesticides and herbicides highlighted in Table 33, a higher priority quarterly sampling and analysis program for total concentrations in sediment should be conducted for dieldrin, toxaphene, beta-endosulfan, heptachlor epoxide, p,p'-DDD, p,p'-DDE, p,p'-DDT, alpha-endosulfan, chlordane, heptachlor, and endrin.

6.8 Explosives

Chemical compounds that are considered explosives were seldom detected in either dataset, or no screening levels were available to assess potential effects in surface waters. No risk was predicted based on the available data for surface water. Risk was predicted for 2,4-dinitrotoluene (HQ of 3.5) and 2,6-dinitrotoluene (HQ of 12.6) in sediments samples from the URGWOPS dataset. Again, however, only two results for each of these compounds were available for evaluation. No analytical results were available for concentrations of explosives in fish. As a group, explosives are a low priority for further assessment in surface waters and sediments. Therefore, at most, sampling and analysis of explosives in surface water, sediment or tissue can be recommended only as part of lower priority 1-5 year trend monitoring.

6.9 Pharmaceuticals

Ten sampling sites were investigated for the presence of 39 pharmaceuticals, including 28 non-antibiotic pharmaceuticals and 10 antibiotics. Pharmaceutical compounds were analyzed in surface water samples collected by USFWS. None of these compounds were measured as greater than the detection limits. No data are available on pharmaceuticals in sediment or fish tissue.

This group of compounds is of low priority for future investigations in terms of potential impacts to RGSM. Periodic sampling and assessments of water, sediment, and tissues at selective locations, however, and at infrequent intervals, would allow the establishment of any trend information for general water quality assessment. Therefore, sampling and analysis of pharmaceuticals in surface water, sediment or tissue can be recommended only as part of lower priority 1-5 year trend monitoring.

6.10 PCBs

Aroclor and total PCBs were only analyzed in water samples included in the URGWOPS dataset. The Tier I assessment indicated the presence of low risks associated with maximum concentrations of four Aroclor compounds plus total PCBs. However, the quality of these data was insufficient to calculate 95 percent UCLs to allow Tier II risk assessments. Aroclor analyses each included a maximum of four analytical results; total PCB analyses were apparently all conducted using MDLs that exceeded both the ambient water concentrations and the TRVs used to screen their risks in the MRG. Additional sampling and analysis would be necessary to complete an assessment of their risk magnitude and potentials for impact in the MRG. Therefore, sampling and analysis of PCBs in surface water, sediment or tissue can be recommended only as part of lower priority 1-5 year trend monitoring.

7.0 SUMMARY AND RISK MANAGEMENT RECOMMENDATIONS

This risk assessment was performed on water quality data collected from the MRG between the Rio Chama and Elephant Butte Reservoir between 1985 and 2003 to produce an integrated assessment of risk to aquatic life in general and to RGSMs in particular. For this assessment, analytical results for water, sediment, and tissue samples from two existing datasets were screened against state-of–the-science compilations of effects assessment criteria. The USFWS dataset included data collected in 2002-2003 and the data quality assessment found essentially the entire dataset appropriate for use in this risk assessment. The URGWOPS dataset spanned 1985-2000; the data quality assessment identified various issues with these data, but judged the data to be appropriate for use in ecological risk screening. Overall, however, the USFWS dataset was deemed to include more recent data of higher and more consistent quality. As such, this assessment places greater weight on the USFWS datat for planning needs, while viewing the URGWOPS data as having important secondary supportive value for planning. Spatial and temporal relationships derived from these data are evaluated and reported. Tier I and Tier II screening risk assessments were performed to evaluate potential risks. Risk-screening benchmarks were compiled from a diversity of sources to provide aquatic TRVs for the assessments. In addition, a new benchmark compendium was developed to compare the sensitivity of aquatic life criteria to the RGSM criteria. This comparison largely depended on the use of FHM responses to toxicants as a surrogate indicator for potential toxic sensitivities to RGSM. COPCs are identified with their potential for risks to aquatic life and RGSM; in addition, data gaps were identified. The assessment has produced a weight-of-evidence analysis of the relationship of water quality conditions to RGSM in the MRG. This final section summarizes the assessment and briefly highlights the priorities for future work. The expectation is that by clarifying the impact of water quality on the RGSM, appropriate management actions can be taken to contribute to the recovery of RGSMs in the MRG.

A primary conclusion after this risk assessment is that there is no clear "smoking gun" COPC that can be singled out as an agent likely to have produced significant MRG-wide historical impacts to RGSM. Nor can any COPC be targeted as currently impairing the recovery of RGSMs along the length of the MRG.

The sample analysis results indicate various isolated episodes during which elevated concentrations of one or more COPCs could have caused localized impacts to aquatic life and RGSM. These episodes may be related to natural conditions, stormwater runoff or other inflow events, or to upsets in the operation of wastewater treatment systems, or perhaps, illegal discharges. Although some data appear to be of poor reliability (particularly in the URGWOPS dataset), no discernible temporal or spatial patterns were detected within the data, including any elevated concentrations persisting at any one site.

Considering the three environmental media assessed, the exposure pathways, and the extended collection period for the water quality, this lack of a clear “big ticket” COPC was not expected. In addition, native populations of FHMs in the MRG — the species commonly accepted as the toxicity surrogate for RGSM and used in this report as such — have not displayed a decline similar to that of RGSM populations and instead persist as one of the most abundant species along the MRG (Reclamation 2003). Therefore, this assessment would not support the hypothesis that water quality effects have been the most important limiting factor affecting this fish, even though adverse water quality conditions may have locally impacted RGSMs in the MRG at some times in the past, as described below.

Based on the analysis conducted in this risk assessment, there is evidence that suggests the potential for cumulative effects of chemicals that, individually, may pose small or no risks. This relationship appears strongest in the URGWOPS dataset and appears to continue into the present, although to a markedly lesser extent. This relationship is exemplified in the results for trace elements. Even considering the various uncertainties (measurement frequencies, data quality, and applicability of TRVs used as risk benchmarks) and the findings that concentrations for most metals in most samples are less than the risk screening threshold values, this analysis suggests that a large number of chemicals in the river’s water, sediment, and biotic media cumulatively may be problematic. Determining whether the remaining sources of these conditions are man-caused, natural, or most likely, a mix of both, requires additional sampling and analysis.

As such, it is reasonable to conclude that water quality impacts to aquatic life, likely including RGSM, have occurred in the past and may occur in the future, whenever elevated concentrations of toxic chemicals recur. Whether these impacts product direct mortality of RGSMs in the MRG cannot be specifically answered by this assessment. At least sublethal impacts, however, undoubtedly contribute to the overall conditions of environmental stress in the MRG, which could lead to declines in the population of RGSMs and other aquatic life.

The COPCs identified in this study are the constituents of particular interest. Specifically, the assessment of the URGWOPS dataset showed that many COPCs were detected in the MRG between 1985 and 2000. The COPCs included several metals with identifiable risks in both surface water and sediment. Surface water risks are identified in the USFWS dataset for aluminum, mercury, and uranium. COPCs in the USFWS dataset for sediment included aluminum, barium, arsenic, chromium, cobalt, copper, lead, manganese, nickel, silver, zinc, and cadmium. Tissue COPCs included aluminum, chromium, and mercury. As a group, metals appear to pose marked risks and likely environmental stress in the MRG. Section 5 discussed various reasons to suspect that this assessment for the MRG was overly conservative in attributing high risks to several of these metals, including aluminum and barium. Nevertheless, the remaining metal COPCs in the MRG that may be posing risks, particularly in sediment, point to the need to continue assessment of metals to better define their relationship to potential impacts to RGSMs and aquatic life (see Table 33). Although metals were found in water and sediments at concentrations that indicate a potential for impact, concentrations in fish tissue were of only marginal concern. For those found, the tissue concentrations of mercury and selenium should continue to be monitored on an annual basis because of their ability to bioaccumulate through the aquatic food chain. Other metals in fish tissues may be monitored with a lower priority and frequency.

We recommend that a routine monitoring program might include quarterly sampling and assessment of surface water, quarterly sampling of sediment, and annual sampling of fish tissues, emphasizing RGSM, when possible, to refine the base of understanding with regard to the fate of metals and their effects. Parameters to include in such a program are listed in Table 33. Sampling locations should include a distribution of sites appropriately selected to add information about point and nonpoint source areas. Targeted studies might focus on characterizing the potential concentration and distribution of contaminated sediment along the MRG, including the fate of metals at downstream locations. Laboratory studies could investigate the potential toxic responses of RGSMs exposed to sediments and benthic algae from the MRG. Other laboratory studies might specifically develop site-specific toxicological criteria for RGSMs to allow specific quantification of potentials for impact related to metal COPCs. They can also evaluate the nature of most probable impacts (such as mortality and reproductive effects) through field studies to better target key assessment parameters for potential impacts from metals.

Specific sampling sites would best be selected by a separate workgroup of Program representatives with expertise in water quality assessment. Selected sites should focus on MRG reaches and sampling locations that best address current scientific priorities for the Program, as constrained by the budgets available to address these issues. As general guidance, these sites should include locations where previous data collections have occurred to allow at least some continuity with existing information to allow for trend analysis. Examples include the sites included in the USFWS studies and those proposed for study in the FY06 Request for Proposals for water quality studies. In general, some selected sites should focus on locations where "worse-case" water quality conditions are anticipated; collections at these sites could be conducted using coupled upstream-downstream sampling sites to allow comparative assessments of potential effects. Ideally, a minimum of triplicate samples should be collected from each sampling locale to allow for enhanced statistical data analysis. Often, however, such sampling designs are prevented due to cost constraints. For such times, it is preferable, rather than sampling using single grab samples, to collect triplicate samples and then mix the samples to form a composite. This composite sample can then be subsampled to obtain the sample volumes required for analysis. Triplicate samples used to form composite samples tend to be based, most often, on spatial distribution or, less often, on temporal distribution of the collected samples. For example, if the sampling site is intended to characterize a channel condition, then samples would be collected at locations across the channel; if they are to characterize pool conditions, then they would be collected at three locations across the pool; and if they are intended to characterize conditions during an event, then they would be collected at three or more times during the event.

Although ammonia associated with organic compounds is indicated as a possible risk when screened using the ammonia benchmarks, in this form, it is primarily associated with decaying biomass (for example, proteins) and is thus not toxic. The risk screening of total and dissolved ammonia in samples from both datasets does not indicate that it poses a significant risk. However, the concern remains that ammonia (and free chlorine) continues to be a significant localized risk to aquatic life in the MRG due to wastewater treatment plant upsets. Therefore, a periodic assessment of the significance of such upsets and the associated impacts continues to have merit. Ammonia could be assessed as part of a routine surface water-monitoring program as an option, but the results of this assessment did not indicate that this parameter is of key concern. It is a potential important nutrient that can stimulate algal growth.

Concentrations of cyanide in sediment in the USFWS dataset indicated moderate risks. Section 5 indicates that this projection is likely overly conservative. Therefore, cyanide could be included in a routine quarterly sediment-sampling program to better quantify its presence and distribution in the MRG. Laboratory feeding studies using RGSMs could also assess the potential implications of cyanide in sediment and the toxicity of metal cyanide complexes. Any such studies must recognize that total cyanide includes free cyanide, weak-acid dissociable (WAD) cyanide, plus the relatively non-toxic iron-cyanide complexes that, under most environmental conditions, are unlikely to dissociate into toxic free cyanide. New Mexico State and Tribal criteria have been established for WAD cyanide, which includes the toxicologically and environmentally important forms of cyanide, including free cyanide and moderately and weakly complexed metal-cyanides. Therefore, cyanide assessments in the MRG should focus on the analysis of WAD cyanide.

Evaluation of VOCs, PAHs, herbicides and other pesticides, and PCBs identified a few COPCs, particularly in the URGWOPS dataset. The relative high concentrations of herbicides and other pesticides in this dataset is puzzling because many of the compounds in this group, as well as the other groups of organics listed above, are hydrophobic (“water hating”) in nature. Thus, they would more typically be found associated with sediment accumulations. Although the USFWS dataset also included a number of results for herbicides and pesticides, as well as for other organic chemical compounds, relatively few detects were recorded in the water samples and fewer COPCs were identified through the risk assessment. More detections and COPCs were identified for sediment samples. However, few risks remained associated with VOCs and SVOCs in the Tier II cumulative assessments of sediment chemicals. Some risks were predicted for individual PAHs, but based on the USFWS data, total PAHs were not found to pose a risk to benthic receptors.

A considerable difficulty in assessing risk is the lack of toxicity data for use in defining risk screening benchmarks and water quality criteria. Although a large number of analytes were quantified using analytical methods for TPHs, explosives, and pharmaceuticals, relatively few TRVs have been developed for use as screening benchmarks for these analytes. An equally important key to more effective assessment of risk, including potential cumulative risk, is the collection of data with adequate detection limits relative to a chemical's toxicity threshold for a media. In the case of organochlorine pesticides in sediments, the whole class of chemicals could have been dismissed because they were reported as non-detect. However the availability of appropriate screening-level criteria indicated that risks and effects might be occurring at the detection limits reported. The lack of assessment criteria cannot be used as the basis for excluding periodic assessments of these analytes in the MRG, but provides a useful basis for justifying their reduced frequency of monitoring and assessment. Periodic assessments would allow development of datasets that could be used for future assessments of long-term concentration trends. These datasets would also provide a useful basis for potential future screening efforts, should screening values become available later on.

Many of these low-level contaminants may very well be contributing to aquatic ecological impacts in the MRG. At this time, most of these chemical groups are not recommended for inclusion in a quarterly routine monitoring program. Instead, it would appear more appropriate that these chemical groups evaluated through a long-term assessment program; with assessment sites selected based on available data to allow trend assessment. Sample collection activities would be performed at intervals of 1 to 3 years to establish trends.

In general, future water quality assessment projects for the MRG should include three types of studies:

1. A routine water quality-monitoring program, with sampling at standardized sampling sites on a quarterly basis. This routine program would assess the dynamics of COPCs and conventional pollutants of concern in water and sediment. This program would also include tissue sampling at the sampling sites, with a single set of samples collected during low-flow conditions in the fall. The number of sampling sites and their location would be selected using a statistical methodology to enhance the ability for extrapolation of the results.

2. A long-term trend-monitoring program, conducted at intervals of 1 to 5 years. Such a program would have the goal of tracking any patterns in distribution along the Rio Grande of concentrations for a large suite of chemicals, and would be conducted in part to assess whether new COPCs may be appearing in the river. The number of sampling sites and their location would be selected using a statistical methodology to enhance the ability for extrapolation of the results. Such studies should also include options to allow synoptic sampling of sites selected while in the field to allow the assessment of potential "worse-case" water quality conditions. Analysis of chemicals that lack corresponding effects criteria would provide only baseline or trend information. That is, only limited interpretation in terms of potential negative or positive effects on RGSM, FHM, or the aquatic community would be possible from these data. Should appropriate effects information become available in the future, trend-monitoring data could be interpreted for possible past effects.
3. Laboratory studies to better define toxic relationships of RGSMs (or FHMs, as its surrogate) to the COPCs identified. As suggested above, these studies could develop site-specific toxicological criteria for RGSMs in the MRG to allow specific quantification of potentials for impact related to COPCs. They would also determine the nature of most probable impacts (such as mortality or reproductive effects) as potentially observed in field studies, to better target key assessment parameters for potential impacts from metals.

The list of priority COPCs presented in Table 33 establishes the chemicals recommended for future water quality sampling and assessment. These chemicals form the priority list to be included in routine monitoring studies conducted, during which samples are collected at regular quarterly intervals. They also should be targeted in focused studies aimed to identify potential site-specific MRG relationships. Those COPCs of lower priority could be included only in lower-frequency assessments to track longer-term trends in chemical concentrations. These assessments could focus on lower-flow conditions in late summer and fall, when in-stream concentrations of contaminants would be typically highest. These studies could also focus at sites or in MRG reaches where past concentrations were greatest to assess potential worst-case conditions. Such studies, as guided by the results produced by this risk assessment, would lead to refining the understanding of water quality relationships and potential impacts to RGSM and aquatic life in the MRG.

8.0 LITERATURE CITED

Barrick, R., S. Becker, L. Brown, H. Beller, and R. Pastorok. 1988. Sediment Quality Values Refinements:1988 Update and Evaluation of Puget Sound AET. Volume 1. Prepared for the Puget Sound Estuary Program, Office of Puget Sound.

Beckvar, N.,T.M. Dillon, and L.B. Read. 2005. Approaches for Linking Whole-Body Fish Tissue Residues of Mercury or DDT to Biological Effects Thresholds. Environmental Toxicology and Chemistry, Vol. 24, No. 8, pp. 2094–2105.

Bergman, H.L. and E.J. Doward-King. 1997. *Reassessment of Metals Criteria for Aquatic Life Protection: Priorities for Research and Implementation*. Proceedings of the Pellston Workshop on Reassessment of Metals Criteria for Aquatic Life Protection, 10-14 February 1996. Society of Environmental Toxicology and Chemistry (SETAC) Press. Pensacola, FL.

Bestgen, K.R., and S.P. Platania 1991. Status and conservation of the Rio Grande silvery minnow, Hybognathus amarus. Southwestern Naturalists 36(2):225-232.

Bolton, H.S., R.J. Breteler, B.W. Vigon, J.A. Scanlon, and S.L. Clark. 1985. National perspective on sediment quality. Battelle. Prepared for USEPA Contract No. 68-01-6986. Washington Environmental Program Office. Washington, District of Columbia.

Buchman, M.F. 1999. NOAA Screening Quick Reference Tables (SquiRT), NOAA HAZMAT Report 99-1, Seattle, WA, Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration, 12 pages.

Buhl, K.J. 2002. The Relative Toxicity of Inorganic Contaminants to the Rio Grande Silvery Minnow (Hybognathus amarus) and Fathead Minnows (Pimephales promelas) in Water Quality Simulating that in the Rio Grande, New Mexico. Report to the USFWS, New Mexico Ecological Services Office, Albuquerque, NM.

Buhl, K.J. 2003. Abstracts for the SETAC Meeting. Toxicological Evaluation of Municipal Effluents to the Rio Grande Silvery Minnow. U.S. Geological Survey, Yankton, SD.

Buet, A., S. Barillet, and V. Camilleri. 2005. Changes in Oxidative Stress Parameters in Fish as Response to Direct Uranium Exposure. Radioprotection, Suppl. 1, vol. 40, S151-S155.

Calabrese, E.J., and Baldwin, L.A. (1993). *How to Conduct an Ecological Risk Assessment*. Lewis Publishers.

Canadian Council of Ministers of the Environment (CCME). 1999. Canadian environmental quality guidelines. Winnipeg, Manitoba.

Carr, S. 2002. Texas A&M Marine Ecotoxicology Research Station, personal communication via e-mail, November 2002.

Cubbage, J., D. Batts, and S. Briedenbach. 1997. Creation and analysis of freshwater sediment quality values in Washington State. Environmental Investigations and Laboratory Services Program. Washington Department of Ecology. Olympia, Washington.

Dias, V., B. Ksas, V. Camilleri and J.M. Bonzom. 2005. Sublethal effects of sediment-associated uranium on Chironomus riparius (Diptera: Chironomidae) larvae. Radioprotection, Suppl. 1, vol. 40, S191-S197.

Environment Canada. 1996. Revision Canadian Environmental Quality Guidelines http://www.ec.gc.ca/ceqg-rcqe/

Field, L.J., D.D. MacDonald, S.B. Norton, C.G. Ingersoll. 2002. Predicting Amphipod Toxicity from Sediment Chemistry Using Logistic Regression Models. Environ. Toxicol. Chem., 21, 9, 1993-2005.

Fisher JP, Spitsbergen JM, Bush B, Jahan-Parwar B. 1994. Effect of embryonic PCB exposure on hatching success, survival, growth and developmental behavior in landlocked Atlantic salmon, Salmo salar. In: Gorsuch JW, Dwyer FJ, Ingersoll CG, La Point TW, eds, Environmental toxicology and risk assessment. Vol 2. ASTM STP 1216. American Society for Testing and Materials, Philadelphia PA, pp 298-314.

Florida Department of Environmental Protection (FDEP). 1994. Approach to the Assessment of Sediment Quality in Florida Coastal Waters, Volume 1. Development and Evaluation of Sediment Quality Guidelines. Prepared for Florida Department of environmental Protection, Office of Water Quality, Tallahassee, FL., by MacDonald Environmental Sciences Ltd. Ladysmith, British, Columbia.

Gensemer, R.W. and R.C. Playle. 1999. The Bioavailability and Toxicity of Aluminum in Aquatic Environments. Critical Reviews in Environmental Science and Technology, 29(4): 315-450.

Hellyer, G.M. and G.E. Balog. 1999. Derivation, Strengths and Limitations of Sediment Ecotoxicological Screening Benchmarks (ESBs), U.S. EPA-New England Regional Laboratory, Lexington, MA.

Ingersoll, C.G., P.S. Haverland, E.L. Brunsun, T.J. Canfield, F.J. Dwyer, C.E. Henke, N.E. Kemble, D.R. Mount, R.G. Fox. (1996) Calculation and evaluation of sediment effects concentrations for the amphipod Hyallela azteca and the midge Chironomus riparius. J. Great Lakes Res. 22: 602-623.

Jarvinen, A.W., and G.T. Ankley. 1999. Linkage of effects to tissue residues: Development of a comprehensive database for aquatic organisms exposed to inorganic and organic chemicals. Society of Environmental Toxicology and Chemistry (SETAC) Press, Pensacola, Florida.

Jones, D.S., G. W. Suter II, and R.N. Hull. 1997. Toxicological Benchmarks For Screening Contaminants Of Potential Concern For Effects On Sediment Associated Biota: 1997 Revision. ES/ER/TM-95/R4

Lusk, J.D. 2005. Discussion Draft on an Approach for Identifying Protective Water Quality Criteria for Silvery Minnow Habitat. United States Fish and Wildlife Service.

MacDonald, D.D., R.S. Carr, F.D. Calder, E.R. Long, and C.G. Ingersoll. 1996. Development and evaluation of sediment quality guidelines for Florida coastal waters. Ecotoxicology 5:253-278.

MacDonald, D.D, T. Berger, K. Wood, J. Brown, T. Johnsen, M.L. Haines, K. Brydges, M.J.MacDonald, S.L. Smith, and D.P. Shaw. 1999. A Compendium of Environmental Quality Benchmarks. Prepared for Environment Canada, Vanvouver, BC.

MacDonald, D., C. Ingersoll, and T. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch Environ Contam Toxicol 39: 20-21

MacDonald, D.D., C.G. Ingersoll, D.E. Smorong, R.A. Lindskoog, G. Sloane and T. Biernacki. 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters: Technical Report. Prepared for the Florida Department of Environmental Protection.

MacDonald and U.S. Geological Survey (USGS). 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters, Technical Report. http://www.cerc.usgs.gov/pubs/sedtox/SQAGs_for_Florida_Inland_Waters_01_03.pdf

McGeer,J.C., K.V. Brix, J.M. Skeaff, D.K. Deforest, S.I. Brigham, W.J. Adams, and A. Green. 2003. Inverse Relationship Between Bioconcentration Factor and Exposure Concentration for Metals: Implications for Hazard Assessment of Metals in the Aquatic Environment. Environmental Toxicology and Chemistry, Vol. 22, No. 5, pp. 1017–1037.

MENVIQ/EC (Ministere de l'Environnement du Quebec et Environnement Canada). 1992. Interim criteria for quality assessment of St. Lawrence River sediment. ISBN 0-662-19849-2. St. Lawrence Action Plan. St. Lawrence Center and Ministere de l'Environnement du Quebec. Quebec City, Quebec.

Menzie-Cura& Associates Inc. (Menzie) 1996. An Assessment of the Risk Assessment Paradigm for Ecological Risk Assessment. Prepared for the Commission on Risk Assessment and Risk Management Chelmsford, MA. January 10.

Michigan Department of Environmental Quality (DEQ) 2005. State of Michigan DEQ Update of Water Quality Values to Protect Humans, Wildlife, and Aquatic Life. Rule 57 Water Quality Guidelines. http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728-11383--,00.html

Moran, R.E. 1998. Cyanide In Mining: Some Observations on the Chemistry, Toxicity and Analysis of Mining-Related Waters. Mineral Policy Center, Washington, D.C.

Nagpal N.K., L.W. Pommen, and . L.G. Swain. 2001. A Compendium of Working Water Quality Guidelines for British Columbia. August 23. http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/working.html

New Mexico Environment Department (NMED). 2005. Water Quality Standards for Interstate and Intrastate Surface Waters, NMAC 20.6.4.1. NMED, Santa Fe, NM. Revised July 15.

NMED. 2001. Middle Rio Grande Total Maximum Daily Load (TMDL) for Fecal Coliform. NMED, Santa Fe, NM.

New York State Department of Environmental Conservation. 1999. State of New York 6 New York Code of Rules and Regulations Part 703: Surface Water and Groundwater Quality Standards and Groundwater Effluent. http://www.dec.state.ny.us/website/regs/part703.html

Oak Ridge National Laboratory (ORNL). 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota. Oak Ridge, TN. http://www.esd.ornl.gov/programs/ecorisk/benchmark_reports.html

Parkhurst, B.R., W. Warren-Hicks, R.D. Cardwell, J. Volosin, T. Etchinson, J.B. Butcher, and S.M. Covingtion. 1996. Aquatic Ecological Risk Assessment: A Multi-Tiered Approach. Report D53011. Water Environment Research Federation, Alexandria, VA

Parrish PR, Schimmel SC, Hansen DJ, Patrick JM, Jr, Forester J. 1976. Chlordane: effects on several estuarine organisms. J Toxicol Environ Health 1:485-494.

Persaud, D., R. Jaagumagi, and A. Hayton. 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Water Resources Branch. Ontario Ministry of the Environment. Toronto, Ontario. 27 pp.

Pueblo of Isleta. 2002. Pueblo of Isleta Surface Water Quality Standards. Pueblo of Isleta, New Mexico. Revised March 18.

Pueblo of Sandia. 2000. Pueblo of Sandia Water Quality Standards. Pueblo of Sandia, New Mexico. Revised October.

Pueblo of San Juan. 1998. San Juan Pueblo Water Quality Standards. San Juan Pueblo, New Mexico. Revised March 11.

Pueblo of Santa Clara. 1995. Water Quality Code of the Pueblo of Santa Clara. Pueblo of Santa Clara. Amended March 24.

Singh, A., A.K. Singh, and R.W. Maichle. 2004. ProUCL, Version 3.0. EPA/600/R04/079.

Smith, S.L., D.D. MacDonald, K.A. Keenleyside, C.G. Ingersoll, and L.J. Field. 1996. A Preliminary Evaluation of sediment Quality Assessment Values for Freshwater Ecosystems. Journal of Great Lakes Research 22(3):624-638.

Stephan, C.E., D.I. Mount, D.J. Hansen, J.H. Gentile, G.A. Chapman, and W.A. Brungs. 1985. Guidelines for deriving numerical national water quality criteria for the protection of aquatic organisms and their uses. EPA 822/R-85-100. USEPA, Washington, DC.

Stortelder, P.B., M.A. van der Gaag, and L.A. van der Kooij. 1989. Perspectives for water organisms. An ecotoxicological basis for quality objectives for water and sediment. Part 1. Results and calculations. DBW/RIZA Memorandum N. 89.016a. (English Version August, 1991). Institute for Inland Water Management and Waste Water Treatment. Lelystad, Netherlands.

Traina, SJ, and V. Laperche. 1999. Contaminant bioavailability in soils, sediments, and aquatic environments. Proc. Nat. Acad. Sci. 96:3365-3371

U.S. Army Corps of Engineers. 2003. Environmental Residue Effects Database (ERED). U.S. Army Corps of Engineers. http://el.erdc.usace.army.mil/ered/Index.cfm

U.S. Bureau of Reclamation (Reclamation). 2003. Rio Grande silvery minnow Population Monitoring 2003. http://www.usbr.gov/uc/albuq/rm/rg/#data

U.S. Environmental Protection Agency (USEPA). 1977. Guidelines for the pollution classification of the Great Lakes Harbor Sediments. U.S. Environmental Protection Agency, Region V. Chicago, Il.

USEPA. 1984. Ambient Water Quality Criteria for Cyanide. EPA 440/5-84-028. USEPA, Office of Water, Regulations, and Standards, Washington, DC.

USEPA. 1986. Water Quality Criteria (Gold Book). EPA-440/5-86-001.USEPA, Office of Water, Regulations, and Standards, Washington, DC.

USEPA. 1988. Ambient Water Quality Criteria for Aluminum. EPA#: 440/5-86-008.USEPA, Office of Water, Regulations, and Standards, Washington, DC.

USEPA. 1992a. Framework for Ecological Risk Assessment. Risk Assessment Forum. EPA/630/R-92/001. Washington, DC.

USEPA. 1992b. Guidance for Data Usability in Risk Assessment. Publication 9285.7-09A, Office of Emergency and Remedial Response, EPA, Washington, DC.

USEPA. 1994. Water Quality Standards Handbook. EPA 823-B-74-005a.. Office of Water, Washington, DC.

USEPA. 1996a. ECO Update: Ecotox Thresholds. Office of Solid Waste and Emergency Response (OSWER). EPA 540/F-95/038

USEPA. 1996b. Assessment and Remediation of Contaminated Sediments (ARCS) Program. Great Lakes National Program Office, Chicago, Illinois. EPA 905-R96-008.

USEPA. 1997. The incidence and severity of sediment contamination in surface waters of the United States. Volume 1: National sediment quality survey. EPA 823-R-97-006. Office of Science and Technology (4305). Washington, DC.

USEPA. 1998. Guidelines for Ecological Risk Assessment - Final. EPA/630/R-95/002F. Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, DC.

USEPA. 1999a. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. EPA 530-D-99-001A.

USEPA. 1999b. Biotic Ligand Model of the Acute Toxicity of Metals. U.S. Environmental Protection Agency, Office of Science and Technology. Draft Report

USEPA. 2002. National Recommended Ambient Water Quality Criteria. Office of Water, Washington, DC. http://www.epa.gov/waterscience/criteria/wqcriteria.html

USEPA. 2003a. Region 5 RCRA Corrective Action Ecological Screening Levels. Office of Water, Washington, DC. http://www.epa.gov/reg5rcra/ca/edql.htm

USEPA. 2003b. Blackbird Mine Superfund Site Record of Decision, Lemhi County, Idaho. Prepared By USEPA, Region 10.

USEPA. 2004. ProUCL Version 3.0 User Guide. EPA/600/R04/079. Office of Water, Washington, DC. http://www.epa.gov/nerlesd1/tsc/images/proucl3.pdf

USEPA. 2004. Draft Aquatic Life Water Quality Criteria for Selenium – 2004. EPA-822-D-04-001, Office of Water, Washington, DC.

USEPA. 2005. ECOTOX (ECOTOXicology) database. http://www.epa.gov/ecotox/

U.S. Fish and Wildlife Service (USFWS). 1994. Final rule: Endangered and Threatened Wildlife and Plants; Final Rule to List the Rio Grande Silvery Minnow as an Endangered Species. Federal Register 59 FR 36988.

USFWS. 2003. Biological and Conference Opinions on the Effects of Actions Associated with the Programmatic Biological Assessment of Bureau of Reclamation's Water and River Maintenance Operations, Army Corp's of Engineers; Flood Control Operation, and Related Non-Federal Actions on the Middle Rio Grande, New Mexico. March 17.

USFWS. 2004. Hydrologic and Biologic Data for the Water-Quality Assessment in Relation to Rio Grande Silvery Minnow Habitats. Middle Rio Grande, New Mexico. New Mexico Ecological Services Office, Albuquerque, NM. July.

Van Derveer, W.D., and S.P. Canton. 1997. Selenium Sediment Toxicity Thresholds and Derivation of Water Quality Criteria for Freshwater Biota of Western Streams. Environmental Toxicology and Chemistry, Vol. 16, No. 6, pp. 1260–1268.

Warren-Hicks, W.J., and D.R.J. Moore. 1998. Uncertainty Analysis in Ecological Risk Assessment. Proceedings of the Pellston Workshop on Uncertainty Analysis in Ecological Risk Assessment, 23-28 August 1995. SETAC Press. Pensacola, FL.

Washington State Department of Ecology. 1995. Sediment Quality Chemical Criteria, WAC 173-204-320. http://www.ecy.wa.gov/programs/tcp/smu/sed_chem.htm

Wentsel, R.S., LaPoint, T.W., Simini, M., Checkai, R.T., Ludwig, D., and Brewer, L., 1996. Tri-Service Procedural Guidelines for Ecological Risk Assessments, U.S. Army Edgewood Research, Development, and Engineering Center, Aberdeen Proving Ground, Maryland.

World Health Organization (WHO). 1994. Environmental Health Criteria 163 – Chloroform. International Programme on Chemical Safety. Geneva, Switzerland.

WHO. 1998. Environmental Health Criteria 207 - Acetone. International Programme on Chemical Safety. Geneva, Switzerland.