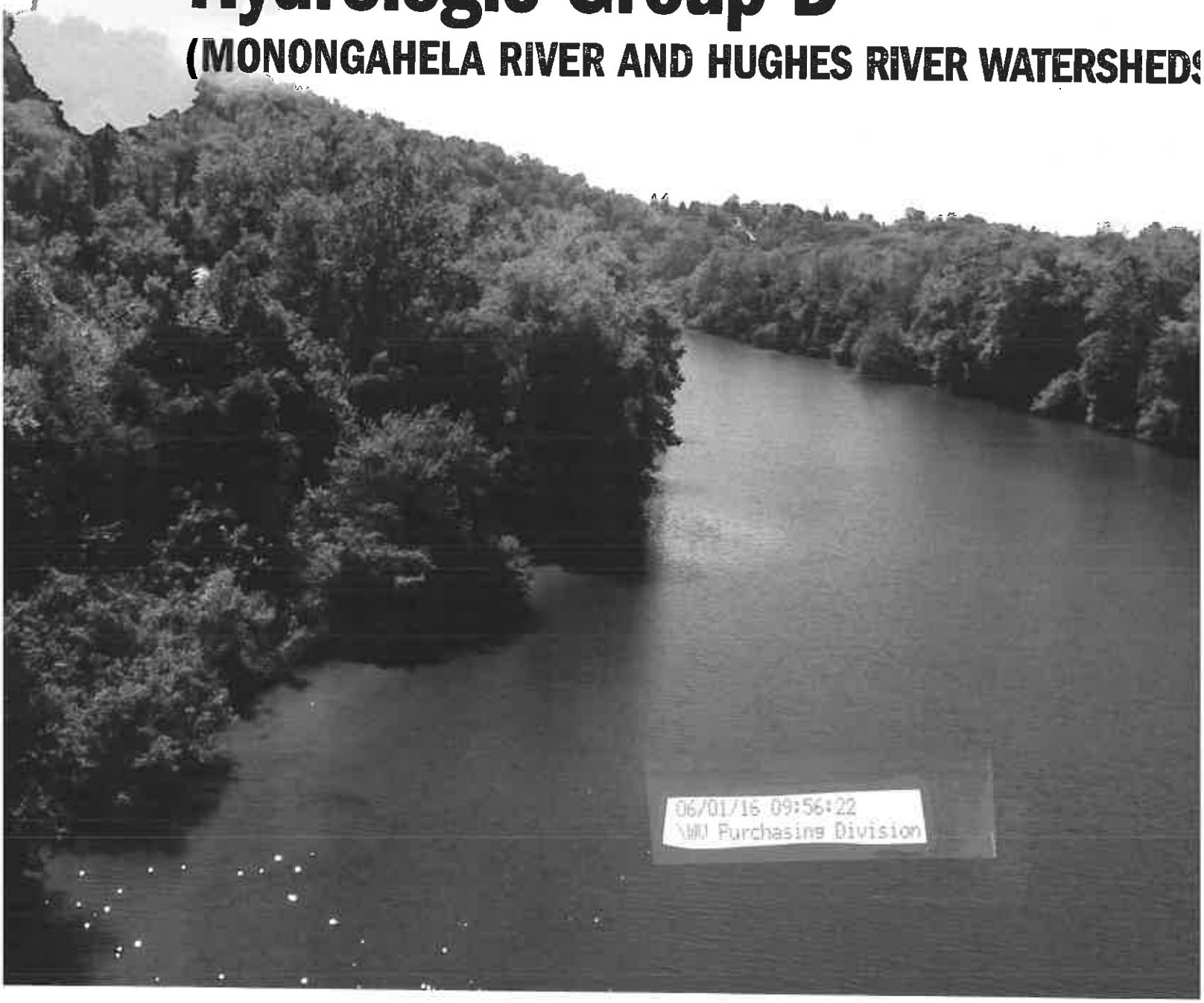
BUYER: BETH A. COLLINS, SENIOR BUYER
SOLICITATION NO.: DEP1600000014
BID OPENING DATE: June 1, 2016
BID OPENING TIME: 1:30 PM, EST
FAX NUMBER: 304-720-2334

Expression of Interest

Total Maximum Daily Loads Development Contract:

Hydrologic Group D

(MONONGAHELA RIVER AND HUGHES RIVER WATERSHEDS



TETRA TECH

SUBMITTED TO:
Department of Administration,
Purchasing Division
2019 Washington Street East
Charleston, WV 25305-0130

SUBMITTED BY:
Tetra Tech, Inc.
803 Quarrier Stre
Suite 400
Charleston, WV 2

TETRA TECH

Mindy S. Ramsey
Director

June 1, 2016

Ms. Beth Collins
WV Purchasing Division
2019 Washington Street, East
Charleston, WV 25305

EOI#:	DEP1600000014
Title:	Expression of Interest-Total Maximum Daily Loads Development Contract: Hydrologic Group D (Monongahela River and Hughes River Watersheds).
Opening Date:	June 1, 2016
Opening Time:	1:30 PM

Dear Ms. Collins:

Tetra Tech, Inc. is pleased to submit our proposal in response to West Virginia Department of Environmental Protection's Expression of Interest number DEP1600000014 for the Total Maximum Daily Loads (TMDLs) Development Contract: Hydrologic Group D (Monongahela River and Hughes River Watersheds). We have worked closely with the WVDEP's TMDL Program for over 10 years as it has grown into one of the nation's premier TMDL programs.

We hope that our proposal and qualifications demonstrate our significant experience and continued commitment to providing high quality TMDL support for West Virginia. Our experience in developing TMDLs and the tools that streamline the TMDL development process is unmatched by any other firm. We emphasize the use of TMDLs in supporting the broader environmental programs of the state and answering practical watershed planning questions. This approach to TMDL development requires that we not presume the use of a specific approach or set of modeling tools, but that we instead select or develop necessary tools that answer the appropriate management questions depending upon the watershed, pollutant sources, and policy. With that in mind, Section I of our submission includes a proposed methodology for developing Monongahela River TMDLs that will meet the expressed requirement to integrate model output from past TMDL projects into a receiving waters model.

In our proposal, we have identified a core group of staff, all of whom have extensive TMDL development experience, and many who have directly supported West Virginia for more than 10 years. I will serve as the Project Manager located in our Charleston Office to facilitate communication and maximize our efficiency in meeting project needs.

We appreciate the opportunity to present our qualifications to West Virginia and we look forward to providing support for this project. If you should have any questions, please feel free to contact me at 304-414-0054 x 100.

Sincerely,

Mindy S. Ramsey

Tetra Tech, Inc.
[illegible] Quarrier Street, Suite 400
Charleston, WV 25301
Tel 304.414.0054 Fax 304.720.2334 www.tetratech.com

Purchasing Divison
2019 Washington Street East
Post Office Box 50130
Charleston, WV 25305-0130

State of West Virginia
Centralized Expression of Interest
02 — Architect/Engr

Proc Folder: 211814

Doc Description: EOI:TMDL development for Monogahela & Hughes River watershed

Proc Type: Central Contract - Fixed Amt

Date Issued	Solicitation Closes	Solicitation No	Version
2016-04-26	2016-06-01 13:30:00	CEOI 0313 DEP1600000014	1

BID RECEIVING LOCATION

BID CLERK
DEPARTMENT OF ADMINISTRATION
PURCHASING DIVISION
2019 WASHINGTON ST E
CHARLESTON WV 25305
US

VENDOR

Vendor Name, Address and Telephone Number:

FOR INFORMATION CONTACT THE BUYER

Beth Collins
(304) 558-2157
beth.a.collins@wv.gov

Signature X [signature] **FEIN #** **DATE** 5/25/2016

All offers subject to all terms and conditions contained in this solicitation

ADDITIONAL INFORMATION:

The West Virginia Purchasing Division, for the Agency, the West Virginia Department of Environmental Protection, is soliciting Expressions of Interest for professional mapping and design services for the TMDL Development Contract: Hydrologic Group D (Monongahela River and Hughes River Watersheds), per the attached bid requirements and specifications.

INVOICE TO	SHIP TO
ENVIRONMENTAL PROTECTION OFFICE OF AML&R 601 57TH ST SE CHARLESTON WV25304 US	ENVIRONMENTAL PROTECTION OFFICE OF AML&R 601 57TH ST SE CHARLESTON WV 25304 US

Line	Comm Ln Desc	Qty	Unit Issue
1	Water testing services		

Comm Code	Manufacturer	Specification	Model #
81100000			

Extended Description :

** DATES OF SERVICE ESTIMATED FOR BIDDING PURPOSES **
TMDL development for impaired streams in the Monongahela River and Hughes River watersheds.

SCHEDULE OF EVENTS

Line	Event	Event Date
1	Tech Question Deadline at 5:00 PM, EST	2016-05-17

ADDITIONAL TERMS AND CONDITIONS

See attached document(s) for additional Terms and Conditions

WEST VIRGINIA DEPARTMENT OF ENVIRONMENTAL PROTECTION
TMDL VENDOR QUALIFICATION QUESTIONNAIRE — Attachment A

PROJECT NAME	DATE (DAY, MONTH, YEAR)	FEIN
TMDL Development Hydrologic Group D Monongahela River and Hughes River Watersheds	01, June, 2016	954148514

1. FIRM NAME	2. HOME OFFICE BUSINESS ADDRESS	3. FORMER FIRM NAME
Tetra Tech, Inc.	10306 Eaton Place, Suite 340 Fairfax, VA 22030	N/A

4. HOME OFFICE TELEPHONE	5. ESTABLISHED (YEAR)	6. TYPE OWNERSHIP
(703) 385-6000	1966	~~Individual~~ **Corporation** ~~Partnership~~ ~~Joint Venture~~

7. PRIMARY TMDL DEVELOPMENT OFFICE: ADDRESS/ TELEPHONE/ PERSON IN CHARGE/ NO.OF TMDL DEVELOPMENT PERSONNEL IN OFFICE

803 Quarrier Street, Suite 400 / (304) 414-0054 / Mindy Ramsey, Director / 5 TMDL development personnel in office
Charleston, WV 25301

8. NAMES OF PRINCIPAL OFFICERS OR MEMBERS OF FIRM	8a. NAME, TITLE, & TELEPHONE NUMBER - OTHER PRINCIPALS
Andrew Parker, PE, Vice President	Jon Ludwig, Program Manager, (703) 385-1973

9. PERSONNEL BY DISCIPLINE

1	CONTRACT ADMINISTRATOR(S)	6	WATERSHED ANALYST(S)	—	OTHER (LIST BELOW)
2	PROGRAM MANAGER(S)	4	SOILS SPECIALIST(S)	—	_____
2	PROJECT MANAGER(S)	3	TECHNICAL EXPERT(S)	—	_____
1	QA/QC MANAGER(S)	3	TECHNICAL WRITER(S)	—	_____
4	BIOLOGICAL ANALYST(S)	3	OUTREACH SPECIALIST(S)		
2	MODEL DEVELOPER(S)	6	SENIOR WATER RESOURCE ENGINEER(S)		

37 TOTAL PERSONNEL

Note: If needed, Tetra Tech has over 50 additional highly qualified staff to support this project.

10. DO YOU NEED ADDITIONAL EMPLOYEES TO FULFILL THE REQUIREMENTS OF THIS CONTRACT? X NO

11. OUTSIDE KEY CONSULTANTS/SUB-CONSULTANTS ANTICIPATED TO BE USED. Attach "TMDL Vendor Qualification Questionnaire".		
NAME AND ADDRESS: **NOT APPLICABLE**	SPECIALTY: **NOT APPLICABLE**	WORKED WITH BEFORE _____ Yes **NOT APPLICABLE** _____ No
NAME AND ADDRESS:	SPECIALTY:	WORKED WITH BEFORE _____ Yes _____ No
NAME AND ADDRESS:	SPECIALTY:	WORKED WITH BEFORE _____ Yes _____ No
NAME AND ADDRESS:	SPECIALTY:	WORKED WITH BEFORE _____ Yes _____ No
NAME AND ADDRESS:	SPECIALTY:	WORKED WITH BEFORE _____ Yes _____ No
NAME AND ADDRESS:	SPECIALTY:	WORKED WITH BEFORE _____ Yes _____ No
NAME AND ADDRESS:	SPECIALTY:	WORKED WITH BEFORE _____ Yes _____ No
NAME AND ADDRESS:	SPECIALTY:	WORKED WITH BEFORE _____ Yes _____ No

12. A. Is your firm experienced in development of TMDLs for total recoverable metals?

YES

12.A.1 Provide names and number of projects.

Tetra Tech began developing TMDLs in WV in 1998 initially supporting USEPA Region 3 and has directly worked with WVDEP since 2002 to develop various technical approaches for total recoverable metals TMDLs throughout WV. For EPA and WVDEP, Tetra Tech has developed **2,597** EPA approved total recoverable metals TMDLs in 29 WV projects (includes multiple watersheds for some task orders). In addition, Tetra Tech has developed hundreds more in other states and EPA Regions. The table below displays the total recoverable metals TMDLs approved or under development through task orders for WVDEP since 2002.

WV Hydrologic Group	Status	Total Recoverable Metals TMDLs
A (Upper Kanawha & Upper Ohio North Watersheds);	USEPA Approved	63
B (Coal River, Lower Kanawha & North Branch Potomac Watersheds);	USEPA Approved	139
C (Gauley River Watershed);	USEPA Approved	60
D (New River & Little Kanawha Watersheds);	USEPA Approved	17
E (Upper Ohio South, Dunkard Creek, Camp Creek & Youghiogheny Watersheds)	USEPA Approved	32
B2 (Elk River & Lower Kanawha Watersheds)	USEPA Approved	406
C2 (Middle Ohio North & Middle Ohio South Watersheds)	USEPA Approved	299
D2 (Monongahela Watershed)	USEPA Approved	140
E2 (West Fork Watershed)	USEPA Approved	300
A3 (Upper Kanawha, Upper Ohio North, South Branch Potomac, & Shenandoah)	USEPA Approved	75
B3 (Tygart Valley River Watershed)	Under Development	231
TOTAL WEST VIRGINIA TMDLS DEVELOPED FOR WVDEP (SINCE 2002)		**1762**

A detailed description of Tetra Tech's TMDL experience is described in **Section 3** of the proposal that accompanies this questionnaire.

12.A.2 Provide an example TMDL for total recoverable metals.

Two (2) USEPA approved total recoverable metals TMDL projects are provided as examples (on CD-ROM) in **Appendix A** of the proposal that accompanies this questionnaire. The two projects include:

- Total Maximum Daily Loads for Selected Streams in the Upper Ohio South Watershed, West Virginia
- Total Maximum Daily Loads for Selected Streams in the Elk River Watershed, West Virginia

12.A.3 Provide a detailed description of the methodology to develop a total recoverable metals TMDL as per EOI.

A detailed description of the total recoverable metals TMDL methodology is presented in **Section 1** of the proposal that accompanies this questionnaire.

12. B. Is your firm experienced in development of TMDLs for pH/dissolved metals?

YES

12.B.1 Provide names and number of projects.

Tetra Tech began developing TMDLs in WV in 1998 initially supporting USEPA Region 3 and has directly worked with WVDEP since 2002 to develop various technical approaches for pH/dissolved metals TMDLs throughout WV. For EPA and WVDEP, Tetra Tech has developed 729 EPA approved pH/dissolved aluminum TMDLs in 25 WV projects (includes multiple watersheds for some task orders). In addition, Tetra Tech has developed hundreds more in other states and EPA Regions. The table below displays the pH/dissolved metals TMDLs approved or under development through task orders for WVDEP since 2002.

WV Hydrologic Group	Status	pH/Dissolved Metals TMDLs
A (Upper Kanawha & Upper Ohio North Watersheds)	USEPA Approved	80
B (Coal River, Lower Kanawha & North Branch Potomac Watersheds)	USEPA Approved	91
C (Gauley River Watershed)	USEPA Approved	75
D (New River Watershed)	USEPA Approved	9
E (Upper Ohio South, Dunkard Creek , Camp Creek & Youghiogheny Watersheds)	USEPA Approved	14
B2 (Elk River, Lower Kanawha Watersheds)	USEPA Approved	44
D2 (Monongahela Watershed)	USEPA Approved	50
E2 (West Fork Watershed)	USEPA Approved	12
A3 (Upper Kanawha, Upper Ohio North, South Branch Potomac, & Shenandoah)	USEPA Approved	11
B3 (Tygart Valley River Watershed)	Under Development	83
C3 (Meadow River, Rocky Marsh Run, Warm Spring Run)	Under Development	7
TOTAL WEST VIRGINIA TMDLS DEVELOPED FOR WVDEP (SINCE 2002)		**476**

A detailed description of Tetra Tech's TMDL experience is described in **Section 3** of the proposal that accompanies this questionnaire.

12.B.2 Provide an example TMDL for pH/dissolved metals.

Two (2) USEPA approved total recoverable metals TMDL projects are provided as examples (on CD-ROM) in **Appendix A** of the proposal that accompanies this questionnaire. The two projects include:

- Total Maximum Daily Loads for Selected Streams in the Upper Ohio South Watershed, West Virginia
- Total Maximum Daily Loads for Selected Streams in the Elk River Watershed, West Virginia

12.B.3 Provide a detailed description of the methodology to develop a pH/dissolved metals TMDL as per EOI.

A detailed description of the pH/dissolved metals TMDL methodology is presented in **Section 1** of the proposal that accompanies this questionnaire.

12.C. Is your firm experienced in development of TMDLs for fecal coliform bacteria?

YES

12.C.1 Provide names and number of projects.

Tetra Tech began developing TMDLs in WV in 1998 initially supporting USEPA Region 3 and has directly worked with WVDEP since 2002 to develop various technical approaches for fecal coliform TMDLs throughout WV. For EPA and WVDEP, Tetra Tech has developed **1128** EPA approved fecal coliform TMDLs in 23 WV projects (includes multiple watersheds for some task orders). In addition, Tetra Tech has developed hundreds more in other states and EPA Regions. The table below displays the fecal coliform TMDLs approved or under development through task orders for WVDEP since 2002.

WV Hydrologic Group	Status	Fecal Coliform Bacteria TMDLs
A (Upper Kanawha & Upper Ohio North Watersheds)	USEPA Approved	54
B (Coal River, Lower Kanawha & North Branch Potomac Watersheds)	USEPA Approved	102
C (Gauley River & Potomac Direct Drains Watersheds)	USEPA Approved	54
D (New River, Greenbrier River, James River & Little Kanawha Watersheds)	USEPA Approved	128
E (Upper Ohio South, Dunkard Creek, Camp Creek & Youghiogheny Watersheds)	USEPA Approved	101
B2 (Elk River, Lower Kanawha & North Branch Potomac Watersheds)	USEPA Approved	192
C2 (Middle Ohio North & Middle Ohio South Watersheds)	USEPA Approved	164
D2 (Monongahela Watershed)	USEPA Approved	65
E2 (West Fork Watershed)	USEPA Approved	175
A3 (Upper Kanawha, Upper Ohio North, South Branch Potomac, & Shenandoah)	USEPA Approved	52
B3 (Tygart Valley River Watershed)	Under Development	117
C3 (Meadow River, Rocky Marsh Run, Warm Spring Run)	Under Development	19
TOTAL WEST VIRGINIA TMDLS DEVELOPED FOR WVDEP (SINCE 2002)		**1223**

A detailed description of Tetra Tech's TMDL experience is described in **Section 3** of the proposal that accompanies this questionnaire.

12.C.2 Provide an example TMDL for bacteria.

Three (3) USEPA approved fecal coliform bacteria TMDL projects are provided as examples (on CD-ROM) in **Appendix A** of the proposal that accompanies this questionnaire. The three projects include:

- Total Maximum Daily Loads for Selected Streams in the Upper Ohio South Watershed, West Virginia
- Total Maximum Daily Loads for Selected Streams in the Elk River Watershed, West Virginia
- Total Maximum Daily Loads for Selected Streams in the North Branch Potomac River Watershed, West Virginia

12.C.3 Provide a detailed description of the methodology to develop a fecal coliform bacteria TMDL as per EOI.

A detailed description of the fecal coliform bacteria TMDL methodology is presented in **Section 1** of the proposal that accompanies this questionnaire.

12. D. Is your firm experienced in biological stressor identification and development of TMDLs for biological impairments?

YES

12.D.1 Provide names and number of projects.

Tetra Tech began developing TMDLs in WV in 1998 initially supporting USEPA Region 3 and has directly worked with WVDEP since 2002 to develop various technical approaches for biological TMDLs throughout WV. For EPA and WVDEP, Tetra Tech has developed **437** EPA approved biological TMDLs in 18 WV projects (includes multiple watersheds for some task orders). In addition, Tetra Tech has developed several more in other states and EPA Regions. See Table III-1 of the proposal. The table below displays the biological TMDLs approved for WVDEP since 2002. Development of biological TMDLs has been suspended; however, biological stressor identification has been performed for streams in D2, E2, and A3 watershed groups, and are under development for B3 to identify if pollutant TMDLs may address biological impacts.

WV Hydrologic Group	Status	Biological TMDLs	Biological Stressor Identification
A (Upper Kanawha & Upper Ohio North Watersheds)	USEPA Approved	45	45
B (Coal River, Lower Kanawha & North Branch Potomac Watersheds)	USEPA Approved	48	48
C (Gauley River & Potomac Direct Drains Watersheds)	USEPA Approved	35	35
D (New River & James River Watersheds)	USEPA Approved	25	25
E (Upper Ohio South, Dunkard Creek , Camp Creek & Youghiogheny Watersheds)	USEPA Approved	51	51
B2 (Elk River, Lower Kanawha & North Branch Potomac Watersheds)	USEPA Approved	95	95
C2 (Middle Ohio North & Middle Ohio South Watersheds)	USEPA Approved	77	77
D2 (Monongahela Watershed)			50
E2 (West Fork Watershed)			175
A3 (Upper Kanawha, Upper Ohio North, South Branch Potomac, & Shenandoah)			36
B3 (Tygart Valley River Watershed)			53
TOTAL WEST VIRGINIA TMDLS DEVELOPED FOR WVDEP (SINCE 2002)		**376**	**690**

A detailed description of Tetra Tech's TMDL experience is described in **Section 3** of the proposal that accompanies this questionnaire.

12.D.2 Provide an example stressor identification evaluation along with the associated biological TMDL.

Three (3) USEPA approved biological TMDLs and their associated stressor identification evaluations are provided as examples (on CD-ROM) in **Appendix A** of the proposal that accompanies this questionnaire. The three projects include:

- Total Maximum Daily Loads for Selected Streams in the Upper Ohio South Watershed, West Virginia
- Total Maximum Daily Loads for Selected Streams in the Elk River Watershed, West Virginia
- Total Maximum Daily Loads for Selected Streams in the North Branch Potomac River Watershed, West Virginia

12.D.3 Provide a detailed description of the methodology to be used to identify bio stressors per EOI.

A detailed description of the biological stressor identification process and biological TMDL methodology is presented in **Section 1** of the proposal that accompanies this questionnaire.

12. E. Describe you firm's management plan that supports personnel and project activities within the organization and coordinates with the WVDEP to achieve timely TMDL development within budgetary constraints as per EOI.

Working directly with WVDEP for 13 years, Tetra Tech has demonstrated the ability to manage and coordinate highly technical TMDL development activities within project budgets and timelines. Our exceptional performance includes:

- $7.9M/15 task orders
- Deadlines met
- No budget overruns/requested change orders
- Constantly developing tools to improve efficiency/reduce costs

A detailed description of Tetra Tech's management capabilities and available resources to support this project is presented in **Section 2** of the proposal that accompanies this questionnaire.

12. F. Describe your firm's experience with the LSPC/MDAS or equivalent modeling system in TMDL development. Provide names and number of projects for which this type of modeling system was employed.

Tetra Tech developed the LSPC/MDAS model specifically for TMDL development in West Virginia. Tetra Tech has modeled 29 individual USGS 8 Digit Hydrologic Unit Codes in West Virginia using LSPC/MDAS, and over 70 projects using LSPC/MDAS in various states throughout the country. A detailed description of Tetra Tech's familiarity with LSPC/MDAS model can be found in **Section 1** and three examples that demonstrate successful application of LSPC/MDAS are provided in **Appendix A** of the proposal that accompanies this questionnaire.

13. PERSONAL HISTORY STATEMENT OF PRINCIPALS AND ASSOCIATES **RESPONSIBLE FOR TMDL DEVELOPMENT PROJECTS** (Insert additional copies as necessary)

NAME & TITLE (Last, First, Middle Int.)	YEARS OF EXPERIENCE		
	In EPA-approved TMDL development	In TMDL-related projects	With modeling system(s), e.g., LSPC, MDAS, etc…
Parker, Andrew	18	18	18

Brief Explanation of Responsibilities

Mr. Parker will provide contractual oversight for the WVDEP contract, ensure that adequate staff and resources are dedicated, and provide technical review and direction to maintain quality and consistency of performance. He will work closely with the management team to allocate resources and identify work teams for performance of specific projects.

EDUCATION (Degree, Year, Specialization) M.E., 1996, Environmental Engineering
B.S., 1995, Civil Engineering

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS	REGISTRATION (Type, Year, State)
American Society of Civil Engineers	Engineer in Training, 1996, Virginia

13. PERSONAL HISTORY STATEMENT OF PRINCIPALS AND ASSOCIATES **RESPONSIBLE FOR TMDL DEVELOPMENT PROJECTS**

NAME & TITLE (Last, First, Middle Int.)	YEARS OF EXPERIENCE		
	In EPA-approved TMDL development	In TMDL-related projects	With modeling system(s), e.g., LSPC, MDAS, etc…
Ludwig, Jon, C.	15	15	15

Brief Explanation of Responsibilities

Mr. Ludwig will support Ms. Ramsey and Mr. Parker in assigning staff, monitoring individual task orders, and representing Tetra Tech in selected technical matters. Mr. Ludwig, working from our Fairfax, VA, office, will coordinate closely with Ms. Ramsey and WVDEP Project Managers to ensure that projects are meeting all technical and schedule objectives.

EDUCATION (Degree, Year, Specialization) M.S., 1997, Environmental Pollution Control
B.S., 1995, Environmental Science

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS	REGISTRATION (Type, Year, State)
American Water Resource Association. Water Environment Federation.	None

13. PERSONAL HISTORY STATEMENT OF PRINCIPALS AND ASSOCIATES **RESPONSIBLE FOR TMDL DEVELOPMENT PROJECTS**

NAME & TITLE (Last, First, Middle Int.)	YEARS OF EXPERIENCE		
	In EPA-approved TMDL development	In TMDL-related projects	With modeling system(s), e.g., LSPC, MDAS, etc…
Ramsey, Mindy	5	5	4

Brief Explanation of Responsibilities

Ms. Ramsey is the director of Tetra Tech's Charleston, WV office and will serve as the local day-to-day point of contact to WVDEP and will work closely with the WVDEP Project Manager to maintain clear, focused direction of the project. She will work closely with the Program Manager and Deputy Project Manager to staff projects and maintain communication between all parties.

EDUCATION (Degree, Year, Specialization) M.S., 2002, Biological Sciences
B.S., 1996, Biology

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS	REGISTRATION (Type, Year, State)
None	None

13. PERSONAL HISTORY STATEMENT OF PRINCIPALS AND ASSOCIATES **RESPONSIBLE FOR TMDL DEVELOPMENT PROJECTS**

NAME & TITLE (Last, First, Middle Int.)	YEARS OF EXPERIENCE		
	In EPA-approved TMDL development	In TMDL-related projects	With modeling system(s), e.g., LSPC, MDAS, etc…
Smith, Jonathan, P.E.	8	8	8

Brief Explanation of Responsibilities

Mr. Smith will support Mr. Ludwig and Ms. Ramsey in assigning staff, monitoring individual task orders, and representing Tetra Tech in selected technical matters.

EDUCATION (Degree, Year, Specialization) B.S., 1995, Biological & Agricultural Engineering

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS	REGISTRATION (Type, Year, State)
American Public Works Association, NC Chapter. Envirocert International.	Professional Engineer, 2011, West Virginia #19285 Certified Professional in Erosion and Sedimentation Control, 2005, North Carolina #4111 Certified Professional in Storm Water Quality, 2010, North Carolina #0048

13. PERSONAL HISTORY STATEMENT OF PRINCIPALS AND ASSOCIATES **RESPONSIBLE FOR TMDL DEVELOPMENT PROJECTS**

NAME & TITLE (Last, First, Middle Int.)	YEARS OF EXPERIENCE		
	In EPA-approved TMDL development	In TMDL-related projects	With modeling system(s), e.g., LSPC, MDAS, etc…
Bai, Sen, PhD, PE	11	11	11

Brief Explanation of Responsibilities

Dr. Bai will provide leadership for all tasks associated with hydrodynamic grid-based water quality modeling in large rivers under this contract, coordinating technical tasks closely with the Project Manager. Dr. Bai will formulate technical approaches for incorporating previously approved TMDL baseline and allocated conditions as inputs for developing new fecal coliform or metals TMDLs for the Monongahela River or other large receiving waters.

EDUCATION (Degree, Year, Specialization) Ph.D., 2004, Environmental Engineering
M.S., 1997, Environmental Chemistry
B.S., 1994, Environmental Planning and Management

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS	REGISTRATION (Type, Year, State)
American Society of Limnology and Oceanography. American Geophysical Union.	Professional Engineer, 2009, Virginia #0402045241

13. PERSONAL HISTORY STATEMENT OF PRINCIPALS AND ASSOCIATES **RESPONSIBLE FOR TMDL DEVELOPMENT PROJECTS**

NAME & TITLE (Last, First, Middle Int.)	YEARS OF EXPERIENCE		
	In EPA-approved TMDL development	In TMDL-related projects	With modeling system(s), e.g., LSPC, MDAS, etc…
Beckman, John, F.	9	9	9

Brief Explanation of Responsibilities

Mr. Beckman will provide leadership for all tasks associated with bacteria TMDLs under this contract, coordinating technical tasks closely with the Project Manager. Mr. Beckman will work closely with WVDEP TMDL staff to refine technical approaches for WV Fecal Coliform Bacteria TMDLs. He will also lead subwatershed delineation and hydrology calibration tasks.

EDUCATION (Degree, Year, Specialization) M.E.M., 1998, Environmental Management
B.A., 1994, Biology

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS	REGISTRATION (Type, Year, State)
Southern Appalachian Botanical Society.	None

13. PERSONAL HISTORY STATEMENT OF PRINCIPALS AND ASSOCIATES **RESPONSIBLE FOR TMDL DEVELOPMENT PROJECTS**

NAME & TITLE (Last, First, Middle Int.)	YEARS OF EXPERIENCE		
	In EPA-approved TMDL development	In TMDL-related projects	With modeling system(s), e.g., LSPC, MDAS, etc…
Mellors, Christina, E.	12	12	12

Brief Explanation of Responsibilities

Ms. Mellors will lead all tasks associated with Total Metals/Sediment TMDLs under this contract, coordinating closely with the Project Manager and Mr. Matsuzuru to continue to evolve the technical representation of the total metals and sediment in the MDAS model. She will work to develop highly detailed technical approaches to incorporate mining permits and erosion-related sediment sources in the MDAS model.

EDUCATION (Degree, Year, Specialization) M.S., 1998, Environmental Science
B.S., 1995, Chemical Engineering

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS None

REGISTRATION (Type, Year, State) None

13. PERSONAL HISTORY STATEMENT OF PRINCIPALS AND ASSOCIATES **RESPONSIBLE FOR TMDL DEVELOPMENT PROJECTS**

NAME & TITLE (Last, First, Middle Int.)	YEARS OF EXPERIENCE		
	In EPA-approved TMDL development	In TMDL-related projects	With modeling system(s), e.g., LSPC, MDAS, etc…
Wandling, Julie, A.	5	13	5

Brief Explanation of Responsibilities

Ms. Wandling will lead all data development tasks under this contract and will coordinate and communicate with the Project Manager, the various TMDL leads, and WVDEP staff to develop the most recent and accurate watershed data necessary to construct the TMDL models. She will also participate in subwatershed delineation tasks and in developing the permit summary report.

EDUCATION (Degree, Year, Specialization) B.S., 1998, Biology

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS None

REGISTRATION (Type, Year, State) None

13. PERSONAL HISTORY STATEMENT OF PRINCIPALS AND ASSOCIATES **RESPONSIBLE FOR TMDL DEVELOPMENT PROJECTS**

NAME & TITLE (Last, First, Middle Int.)	YEARS OF EXPERIENCE		
	In EPA-approved TMDL development	In TMDL-related projects	With modeling system(s), e.g., LSPC, MDAS, etc…
Zhang, Hua, Ph.D.	7	10	12

Brief Explanation of Responsibilities

Dr. Zhang will support Mr. Matsuzuru and Ms. Christina Mellors with tasks associated with Dissolved Metals/pH TMDLs under this contract to provide technical solutions for dissolved metals/acidity and total metals/sediment TMDLs.

EDUCATION (Degree, Year, Specialization) Ph.D., 2006, Soil Science
M.S., 2002, Soil Science
B.S., 1999, Environmental Management

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS of America. American Geophysical Union Soil Science Society

REGISTRATION (Type, Year, State) None

13. PERSONAL HISTORY STATEMENT OF PRINCIPALS AND ASSOCIATES **RESPONSIBLE FOR TMDL DEVELOPMENTS PROJECTS**

NAME & TITLE (Last, First, Middle Int.)	YEARS OF EXPERIENCE		
	In EPA-approved TMDL development	In TMDL-related projects	With modeling system(s), e.g., LSPC, MDAS, etc…
Zheng, Lei, Ph.D.	10	10	15

Brief Explanation of Responsibilities

Dr. Zheng's work will focus on identifying environmental stressors impairing biological condition of macroinvertebrates in West Virginia streams to help the WVDEP develop Total Maximum Daily Loads for biologically impaired streams.

EDUCATION (Degree, Year, Specialization) Ph.D., 2003, Ecology, Evolutionary Biology, and Behavior
M.A., 1991, Botany
B.S., 1988, Botany

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS None

REGISTRATION (Type, Year, State) None

14. PROVIDE A LIST OF SOFTWARE AND EQUIPMENT AVAILABLE IN THE PRIMARY OFFICE WHICH WILL BE USED TO COMPLETE TMDL DEVELOPMENT SERVICES

Desktop Access Data Processing Hardware	Quantity
High Capacity Network Server	1
IBM-Compatible PC	4
Notebook/Laptop IBM-Compatible PC	4
Windows 2003/2008 Internet Server with FTP and Web Site support	1
Xerox Work Centre 7535 Printer/Copier	1

Database Software*

- Oracle /10i/11g
- Microsoft Office 2003/2007/2010
- Microsoft Project 2003/2007/2010
- MS Office One Note 2007
- MS SharePoint

*Note: The Charleston office can access additional software licenses from the Tetra Tech Network.

GIS Development and Data Processing Hardware and Software	Quantity
IBM-Compatible Workstation/Laptop	8
40TB Mass Storage (accessed via Tetra Tech Network)	4
CD/DVD Writers	2
ESRI ArcGIS Desktop Advanced 10.2	5
ESRI ArcGIS Desktop Standard 10.2	5
ESRI ArcGIS Desktop Basic 10.2	5
ESRI ArcGIS 3D Analyst	1
ESRI Spatial Analyst 10	5
ArcGIS for Server Enterprise 10	1

15. CURRENT PROJECTS/ACTIVITIES IN WHICH YOUR FIRM IS PRESENTLY INVOLVED

PROJECT NAME, TYPE AND LOCATION	NAME AND ADDRESS OF OWNER	NATURE OF YOUR FIRM'S RESPONSIBILITY	ESTIMATED PROJECT COST	PERCENT COMPLETE
TMDL Development for WV Group C3 Watershed (Meadow River, Rockymarsh Run and Warm Spring Run)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	Prime Contractor - TMDL Development Lead	$272,471	30%
TMDL Development for WV Group B3 Watershed (Tygart Valley River)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	Prime Contractor - TMDL Development Lead	$574,954	90%
EPA Region 3 - TMDL development and related support in West Virginia, Pennsylvania, Delaware, Maryland and Virginia; Chesapeake Bay TMDL and WIP development support	USEPA Region 3, 1650 Arch Street, Philadelphia, PA 19103	Prime Contractor	$4,131,322	82%
Minnesota PCA - TMDL development and related support in Minnesota (e.g., TMDL development, modeling, implementation planning)	Minnesota Pollution Control Agency, 520 Lafayette Road North, St. Paul, MN 55155	Prime Contractor	$2,015,070	61%
EPA Region 5 - TMDL development and related support in Illinois, Indiana, Michigan, Ohio, Minnesota, and Wisconsin(e.g., TMDL development, TMDL implementation plans, methodologies for permitting Great Lakes nutrient dischargers, Section 319 support)	USEPA Region 5, 77 West Jackson Blvd, Chicago, IL 60604	Prime Contractor	$4,521,643	81%
EPA Region 8 - TMDL development and related support in Montana (e.g., TMDL development, monitoring, water quality modeling)	USEPA Region 8, Montana Office, Federal Building, 10 W. 15th Street, Suite 3200, Helena, MT 59626	Prime Contractor	$2,723,600	84%
EPA Region 10 - TMDL development and related support in Alaska, Washington, Oregon and Idaho (TMDL development, TMDL model peer review, TMDL review/revision)	USEPA Region 10, 1200 6th Ave, Suite 900, Seattle, WA 98101	Prime Contractor	$1,755,163	90%
EPA Region 9 - TMDL development and related support in California, Arizona, and Hawaii; NPDES permit development (individual, general, and stormwater) in California and Arizona; and water quality standards support in California (natural conditions, use attainability, and whole effluent toxicity training)	USEPA Region 9, 75 Hawthorne Street, San Francisco, CA 94105	Prime Contractor	$10,929,417	71%

15. CURRENT PROJECTS/ACTIVITIES IN WHICH YOUR FIRM IS PRESENTLY INVOLVED (Continued)

PROJECT NAME, TYPE AND LOCATION	NAME AND ADDRESS OF OWNER	NATURE OF YOUR FIRM'S RESPONSIBILITY	ESTIMATED PROJECT COST	PERCENT COMPLETE
City of Calgary - Bow River Total Loading Objectives Assessment	City of Calgary, Water Centre, 625 25 Ave SE, Calgary, AB T2G	Prime Contractor	$441,652	46%
City of San Diego - TMDL and implementation plan development (TMDL reviews, TMDL development, modeling, and assessment) in numerous inland and coastal waters in San Diego	City of San Diego, Storm Water Department, 9370 Chesapeake Drive, Suite 100, San Diego, CA 92123	Prime Contractor	$5,217,660	51%

TOTAL NUMBER OF PROJECTS: 10

TOTAL ESTIMATED PROJECT COSTS: $30,576,882

16. CURRENT ACTIVITIES ON WHICH YOUR FIRM IS SERVING AS A SUB-CONSULTANT TO OTHERS

PROJECT NAME, TYPE AND LOCATION	NATURE OF FIRMS RESPONSIBILITY	NAME AND ADDRESS OF OWNER	ESTIMATED COMPLETION DATE	ESTIMATED PROJECT COST $0.00	
				ENTIRE PROJECT	YOUR FIRM'S RESPONSIBILITY
Not Applicable, Tetra Tech not currently serving as sub-consultant					
	Not Applicable				
		Not Applicable			
			Not Applicable		
				Not Applicable	
					Not Applicable

17. COMPLETED WORK WITHIN LAST 5 YEARS IN WHICH YOUR FIRM WAS THE DESIGNATED FIRM OF RECORD

PROJECT NAME, TYPE AND LOCATION	NAME AND ADDRESS OF OWNER	ESTIMATED PROJECT COST	YEAR	EPA APPROVED?
TMDL Development for WV Group A3 Watershed (Upper Kanawha, Upper Ohio North, South Branch Potomac, and Shenandoah)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	$565,866	2015	Yes
TMDL Development for WV Group E2 Watershed (West Fork River)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	$574,954	2014	Yes
TMDL Development for WV Group D2 Watershed (Tributaries of the Monongahela River)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	$536,524	2014	Yes
TMDL Development for WV Group C2 Watersheds (Middle Ohio North & South Watersheds)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2346	$594,995	2013	Yes
TMDL Development for WV Group B2 Watershed (North Branch Potomac, Elk, and Lower Kanawha)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2346	$657,990	2011	Yes
TMDL Development for WV Group A2 (Cheat)	USEPA Region 3, 1650 Arch Street, Philadelphia, PA 19103; WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2346	$586,912	2010	Yes
EPA Region 2 - TMDL development in New Jersey, Puerto Rico and U.S. Virgin Islands; monitoring to support TMDL development in U.S. Virgin Islands	USEPA REGION 2, 290 Broadway, New York, NY 10007-1866	$212,444	2008-2012	Yes
EPA Region 3 - TMDL development and related support in West Virginia, Pennsylvania, Delaware, Maryland and Virginia; Chesapeake Bay TMDL and WIP development support	USEPA Region 3, 1650 Arch Street, Philadelphia, PA 19103	$8,541,368	2009-2013	Yes
EPA Region 4 - TMDL development in South Carolina, Florida, Kentucky, North Carolina and Alabama; TMDL model training; hydrodynamic and water quality modeling for TMDL development	USEPA Region 4, 61 Forsyth Street SW, Atlanta, GA 30303	$2,380,672	2008-2014	Yes
EPA Region 5 - TMDL development and related support in Illinois, Indiana, Michigan, Ohio, Minnesota, and Wisconsin(e.g., TMDL development, Category 4b assessments, nutrient TMDL target development, TMDL modeling training, TMDL development training)	USEPA Region 5, 77 West Jackson Blvd, Chicago, IL 60604	$2,646,948	2009-2013	Yes

17. COMPLETED WORK WITHIN LAST 5 YEARS IN WHICH YOUR FIRM WAS THE DESIGNATED FIRM OF RECORD (Continued)				
PROJECT NAME, TYPE AND LOCATION	NAME AND ADDRESS OF OWNER	ESTIMATED PROJECT COST	YEAR	EPA APPROVED?
EPA Region 6 - TMDL development in Louisiana and Arkansas; TMDL development for dissolved oxygen (DO), nutrient, and turbidity impairments in the Grand Lake O' the Cherokees Watershed, which includes the Neosho River, the Spring River, and the Elk River in Arkansas, Kansas, Missouri, and Oklahoma	USEPA Region 6, Fountain Place, Suite 1200, 1445 Ross Avenue, Dallas, TX 75202	$1,394,494	2008-2013	Yes
EPA Region 8 - TMDL development and related support in Montana (e.g., TMDL development, modeling, 303d assessments, monitoring, Category 4b assessments)	USEPA Region 8, Montana Office, Federal Building, 10 W. 15th Street, Suite 3200, Helena, MT 59626	$3,112,418	2009-2013	Yes
EPA Region 9 - TMDL development and related support in California, Arizona, and Hawaii (e.g., TMDL development, model development, impaired waters assessment, public meetings, and training); NPDES permit development (individual, general, and stormwater) in California and Arizona; and water quality standards support in California (natural conditions, use attainability, and whole effluent toxicity training)	USEPA Region 9, 75 Hawthorne Street, San Francisco, CA 94105	$7,171,837	2009-2013	Yes
EPA Region 10 - TMDL development and related support in Alaska, Washington, Oregon and Idaho (TMDL development, TMDL model peer review, TMDL review/revision)	USEPA Region 10, 1200 6th Ave, Suite 900, Seattle, WA 98101	$3,305,346	2008-2013	Yes
EPA Region 1 - TMDL development support for Lake Champlain	USEPA Region 1, 5 Post Office Square, Boston, MA 02109-3912	$920,106	2010-2014	Yes
Montana DEQ - TMDL and model development	Montana Department of Environmental Quality, 1520 E. Sixth Avenue, P.O. Box 200901, Helena, MT 59620	$110,010	2007-2012	Yes
City of San Diego – TMDL development (TMDL reviews, TMDL development, modeling, and assessment) in numerous inland and coastal waters in San Diego; monitoring to support TMDL development for coastal streams; development of TMDL implementation plans	City of San Diego, Storm Water Department, 9370 Chesapeake Drive, Suite 100, San Diego, CA 92123	$2,126,880	2009-2012	Yes

18. COMPLETED WORK WITHIN LAST 5 YEARS ON WHICH YOUR FIRM HAS BEEN A SUB-CONSULTANT TO OTHER FIRMS (INDICATE PHASE OF WORK FOR WHICH YOUR FIRM WAS RESPONSIBLE)

PROJECT NAME, TYPE AND LOCATION	NAME AND ADDRESS OF PRIMARY FIRM	ESTIMATED PROJECT COST OF YOUR FIRM'S PORTION	YEAR	EPA APPROVED?	CLIENT NAME AND ADDRESS
Not Applicable, Tetra Tech has not been sub-consultant to other firms					
	Not Applicable				
		Not Applicable			
				Not Applicable	
					Not Applicable

19. Use this space to provide any additional information or description of resources supporting your firm's qualifications to perform work for the WVDEP's TMDL Program.

Since the late 1990's, Tetra Tech has developed more than 5,000 approved TMDLs throughout West Virginia, initially supporting USEPA to meet strict consent decree deadlines. Since 2002, Tetra Tech has worked closely with WVDEP's TMDL Program to provide highly technical and innovative solutions, including the Mining Data Analysis System (MDAS), which have helped WVDEP's TMDL Program become a national leader in TMDL development. Over 3,600 of the TMDLs have been developed directly supporting WVDEP with more than 450 TMDLs currently under development.

20. The foregoing is a statement of facts.

Signature: _____ Title: Director Date: MAY 25, 2016

Printed Name: Jon C. Ludwig

RFQ No. DEP1600000014

STATE OF WEST VIRGINIA
Purchasing Division

PURCHASING AFFIDAVIT

MANDATE: Under W. Va. Code §5A-3-10a, no contract or renewal of any contract may be awarded by the state or any of its political subdivisions to any vendor or prospective vendor when the vendor or prospective vendor or a related party to the vendor or prospective vendor is a debtor and: (1) the debt owed is an amount greater than one thousand dollars in the aggregate; or (2) the debtor is in employer default.

EXCEPTION: The prohibition listed above does not apply where a vendor has contested any tax administered pursuant to chapter eleven of the W. Va. Code, workers' compensation premium, permit fee or environmental fee or assessment and the matter has not become final or where the vendor has entered into a payment plan or agreement and the vendor is not in default of any of the provisions of such plan or agreement.

DEFINITIONS:

"Debt" means any assessment, premium, penalty, fine, tax or other amount of money owed to the state or any of its political subdivisions because of a judgment, fine, permit violation, license assessment, defaulted workers' compensation premium, penalty or other assessment presently delinquent or due and required to be paid to the state or any of its political subdivisions, including any interest or additional penalties accrued thereon.

"Employer default" means having an outstanding balance or liability to the old fund or to the uninsured employers' fund or being in policy default, as defined in W. Va. Code § 23-2c-2, failure to maintain mandatory workers' compensation coverage, or failure to fully meet its obligations as a workers' compensation self-insured employer. An employer is not in employer default if it has entered into a repayment agreement with the Insurance Commissioner and remains in compliance with the obligations under the repayment agreement.

"Related party" means a party, whether an individual, corporation, partnership, association, limited liability company or any other form or business association or other entity whatsoever, related to any vendor by blood, marriage, ownership or contract through which the party has a relationship of ownership or other interest with the vendor so that the party will actually or by effect receive or control a portion of the benefit, profit or other consideration from performance of a vendor contract with the party receiving an amount that meets or exceed five percent of the total contract amount.

AFFIRMATION: By signing this form, the vendor's authorized signer affirms and acknowledges under penalty of law for false swearing (*W. Va. Code* §61-5-3) that neither vendor nor any related party owe a debt as defined above and that neither vendor nor any related party are in employer default as defined above, unless the debt or employer default is permitted under the exception above.

WITNESS THE FOLLOWING SIGNATURE:

Vendor's Name: Tetra Tech, Inc.

Authorized Signature: _____ Date: 5/25/2016

State of Virginia

County of Fairfax, to-wit:

Taken, subscribed, and sworn to before me this 25 day of May, 2016.

My Commission expires Sept. 30, 2017.

AFFIX SEAL HERE

NOTARY PUBLIC _____

ANGELA KAY MARCIANO
NOTARY PUBLIC
REGISTRATION # 7233114
COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES
SEPTEMBER 30, 2017

STATE OF WEST VIRGINIA
Purchasing Division

PURCHASING AFFIDAVIT

MANDATE: Under W. Va. Code §5A-3-10a, no contract or renewal of any contract may be awarded by the state or any of its political subdivisions to any vendor or prospective vendor when the vendor or prospective vendor or a related party to the vendor or prospective vendor is a debtor and: (1) the debt owed is an amount greater than one thousand dollars in the aggregate; or (2) the debtor is in employer default.

EXCEPTION: The prohibition listed above does not apply where a vendor has contested any tax administered pursuant to chapter eleven of the W. Va. Code, workers' compensation premium, permit fee or environmental fee or assessment and the matter has not become final or where the vendor has entered into a payment plan or agreement and the vendor is not in default of any of the provisions of such plan or agreement.

DEFINITIONS:

"Debt" means any assessment, premium, penalty, fine, tax or other amount of money owed to the state or any of its political subdivisions because of a judgment, fine, permit violation, license assessment, defaulted workers' compensation premium, penalty or other assessment presently delinquent or due and required to be paid to the state or any of its political subdivisions, including any interest or additional penalties accrued thereon.

"Employer default" means having an outstanding balance or liability to the old fund or to the uninsured employers' fund or being in policy default, as defined in W. Va. Code § 23-2c-2, failure to maintain mandatory workers' compensation coverage, or failure to fully meet its obligations as a workers' compensation self-insured employer. An employer is not in employer default if it has entered into a repayment agreement with the Insurance Commissioner and remains in compliance with the obligations under the repayment agreement.

"Related party" means a party, whether an individual, corporation, partnership, association, limited liability company or any other form or business association or other entity whatsoever, related to any vendor by blood, marriage, ownership or contract through which the party has a relationship of ownership or other interest with the vendor so that the party will actually or by effect receive or control a portion of the benefit, profit or other consideration from performance of a vendor contract with the party receiving an amount that meets or exceed five percent of the total contract amount.

AFFIRMATION: By signing this form, the vendor's authorized signer affirms and acknowledges under penalty of law for false swearing (*W. Va. Code* §61-5-3) that neither vendor nor any related party owe a debt as defined above and that neither vendor nor any related party are in employer default as defined above, unless the debt or employer default is permitted under the exception above.

WITNESS THE FOLLOWING SIGNATURE:

Vendor's Name: Tetra Tech, Inc.

Authorized Signature: _____ Date: 5/25/2016

State of Virginia

County of Fairfax, to-wit:

Taken, subscribed, and sworn to before me this 25th day of May, 2016

My Commission expires Sept. 30, 2017

AFFIX SEAL HERE

NOTARY PUBLIC _____

ANGELA KAY MARCIANO
NOTARY PUBLIC
REGISTRATION # 7233114
COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES
SEPTEMBER 30, 2017

CERTIFICATE OF LIABILITY INSURANCE

DATE(MM/DD/YYYY) 01/08/2016

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER Aon Risk Insurance Services West, Inc. Los Angeles CA Office 707 Wilshire Boulevard Suite 2600 Los Angeles CA 90017-0460 USA	CONTACT NAME: PHONE (A/C. No. Ext): (866) 283-7122 FAX (A/C. No.): (800) 363-0105 E-MAIL ADDRESS:
INSURED Tetra Tech, Inc. 10306 Eaton Place, Suite 340 Fairfax VA 22030 USA	INSURER(S) AFFORDING COVERAGE — NAIC # INSURER A: National Union Fire Ins Co of Pittsburgh — 19445 INSURER B: The Insurance Co of the State of PA — 19429 INSURER C: AIG Europe Limited — AA1120841 INSURER D: INSURER E: INSURER F:

COVERAGES **CERTIFICATE NUMBER:** 570060924150 **REVISION NUMBER:**

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS. **Limits shown are as requested**

INSR LTR	TYPE OF INSURANCE	ADDL INSD	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
A	X COMMERCIAL GENERAL LIABILITY CLAIMS-MADE X OCCUR X X,C,U Coverage GEN'L AGGREGATE LIMIT APPLIES PER: POLICY X PRO-JECT X LOC OTHER:			GL3372258	10/01/2015	10/01/2016	EACH OCCURRENCE DAMAGE TO RENTED PREMISES (Ea occurrence) MED EXP (Any one person) PERSONAL & ADV INJURY GENERAL AGGREGATE PRODUCTS - COMP/OP AGG	$2,000,000 $1,000,000 $10,000 $2,000,000 $1,000,000 $1,000,000
A	AUTOMOBILE LIABILITY X ANY AUTO ALL OWNED AUTOS SCHEDULED AUTOS X HIRED AUTOS X NON-OWNED AUTOS			CA 3194397	10/01/2015	10/01/2016	COMBINED SINGLE LIMIT (Ea accident) BODILY INJURY (Per person) BODILY INJURY (Per accident) PROPERTY DAMAGE (Per accident)	$1,000,000
C	X UMBRELLA LIAB X OCCUR EXCESS LIAB CLAIMS-MADE DED X RETENTION $100,000			TH1500079	10/01/2015	10/01/2016	EACH OCCURRENCE AGGREGATE	$1,000,000 $1,000,000
B B B B	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY ANY PROPRIETOR / PARTNER / EXECUTIVE OFFICER/MEMBER EXCLUDED? (Mandatory in NH) Y/N: N — N/A If yes, describe under DESCRIPTION OF OPERATIONS below			WC014267906 WC014267908 WC014267907 WC014267912	10/01/2015 10/01/2015 10/01/2015 10/01/2015	10/01/2016 10/01/2016 10/01/2016 10/01/2016	X PER STATUTE OTH-ER E.L. EACH ACCIDENT E.L. DISEASE-EA EMPLOYEE E.L. DISEASE-POLICY LIMIT	 $1,000,000 $1,000,000 $1,000,000

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (ACORD 101, Additional Remarks Schedule, may be attached if more space is required)

Evidence of Insurance.
Stop Gap Coverage for the following states: OH, WA, WY.

CERTIFICATE HOLDER

Tetra Tech Inc.
10306 Eaton Place, Suite 340
Fairfax VA 22030 USA

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE

Aon Risk Insurance Services West Inc.

Holder Identifier :

Certificate No : 570060924150

CERTIFICATIONAND SIGNATURE PAGE

By signing below, or submitting documentation through wvOASIS, I certify that I have reviewed this Solicitation in its entirety; that I understand the requirements, terms and conditions, and other information contained herein; that this bid, offer or proposal constitutes an offer to the State that cannot be unilaterally withdrawn; that the product or service proposed meets the mandatory requirements contained in the Solicitation for that product or service, unless otherwise stated herein; that the Vendor accepts the terms and conditions contained in the Solicitation, unless otherwise stated herein; that I am submitting this bid, offer or proposal for review and consideration; that I am authorized by the vendor to execute and submit this bid, offer, or proposal, or any documents related thereto on vendor's behalf; that I am authorized to bind the vendor in a contractual relationship; and that to the best of my knowledge, the vendor has properly registered with any State agency that may require registration.

TETRA TECH, INC
(Company)

JON C. LUDWIG, DIRECTOR
(Authorized Signature) (Representative Name, Title)

703-385-1973 (Phone) 703-385-6007 (Fax) 5/25/2016
(Phone Number) (Fax Number) (Date)

ADDENDUM ACKNOWLEDGEMENT FORM
SOLICITATION NO.:

Instructions: Please acknowledge receipt of all addenda issued with this solicitation by completing this addendum acknowledgment form. Check the box next to each addendum received and sign below. Failure to acknowledge addenda may result in bid disqualification.

Acknowledgment: I hereby acknowledge receipt of the following addenda and have made the necessary revisions to my proposal, plans and/or specification, etc.

Addendum Numbers Received:
(Check the box next to each addendum received)

☐ Addendum No. 1	☐ Addendum No. 6
☐ Addendum No. 2	☐ Addendum No. 7
☐ Addendum No. 3	☐ Addendum No. 8
☐ Addendum No. 4	☐ Addendum No. 9
☐ Addendum No. 5	☐ Addendum No. 10

I understand that failure to confirm the receipt of addenda may be cause for rejection of this bid. I further understand that any verbal representation made or assumed to be made during any oral discussion held between Vendor's representatives and any state personnel is not binding. Only the information issued in writing and added to the specifications by an official addendum is binding.

TETRA TECH, INC
Company

Authorized Signature

5/25/2016
Date

NOTE: This addendum acknowledgement should be submitted with the bid to expedite document processing.

Expression of Interest to Provide Professional Engineering Services for Total Maximum Daily Loads in the Monongahela River and Hughes River Watersheds

EOI Number 0313 DEP1600000014

Submitted by:

Tetra Tech, Inc.
803 Quarrier Street
Suite 400
Charleston, West Virginia 25301

Submitted to:

Department of Administration, Purchasing Division
2019 Washington Street East
Charleston, WV 25305-0130

Contents

I. Approach and Methodology

Tetra Tech has played a substantial role in Total Maximum Daily Load (TMDL) development in West Virginia, initially supporting U.S. Environmental Protection Agency (USEPA) to meet strict consent decree deadlines for more than 400 waters impaired by acid mine drainage (AMD) throughout the state. Since 2002, Tetra Tech has worked closely with West Virginia Department of Environmental Protection (WVDEP) through Purchase Order Nos. DEP12147, DEP13860, DEP15231, DEP15530, DEP15990, and DEP16550 to undergo a successful transition from a supporting role in the USEPA TMDL development efforts into full programmatic responsibility. During this time, WVDEP and Tetra Tech have found a unique way to integrate large-scale, watershed based TMDLs with fine-scale, highly technical methodologies that produce implementable TMDLs in a cost-effective manner. By coupling these TMDL development efforts with a fully-integrated watershed management program, West Virginia's has grown into one of the nation's premier TMDL programs. The scope and magnitude of these TMDLs has required WVDEP to set very aggressive schedules for the projects to be developed simultaneously. It is critical that these schedules are maintained as new TMDL projects begin each year, increasing the workload as the program cycles through the five hydrologic groups.

Supporting WVDEP's TMDL development efforts for over 10 years, Tetra Tech has successfully met aggressive project schedules while maintaining project budgets. Tetra Tech has completed over 3,000 USEPA approved TMDLs in West Virginia, in addition to over 450 TMDLs currently under development, while working directly for WVDEP. The success in meeting aggressive schedules and workloads is due to the exemplary efforts of Tetra Tech staff (shown in Section II.C) and our proven approach for effective project management (described in Section II.D).

Successfully completing the work directive within project timelines and budgets will require that several pollutant specific TMDL methodologies be developed simultaneously. Careful organization of the many detailed analyses associated with the methodologies is critical to meet project timelines and budgets. In the following sections, we have included TMDL methodology descriptions for total recoverable metals, dissolved metals/acidity, and bacteria impairments that contain each of the technical components listed in this solicitation. In addition, a description for stressor identification in streams with biological impacts is provided in order to demonstrate our extensive experience to perform this task if requested. An organization flowchart for the entire TMDL development process is included at the end of this section.

I.A. Data Development

Tetra Tech has been working with WVDEP for over 10 years to build efficiencies in the transfer and use of watershed data. A tremendous amount of data is required to build fine-scale watershed models that take into account all potential point and nonpoint pollutant sources. Tetra Tech modelers have developed database and spreadsheet tools to speed the transfer of data concerning mining and non-mining permits that are incorporated as point sources in the TMDL model. Likewise, GIS tools and protocols have been cooperatively developed to efficiently apply nonpoint source information such as streambank erosion and agricultural source tracking to modeled subwatersheds. Pre-TMDL water quality monitoring data must be systematically applied to calibrate models accurately. Tetra Tech modelers are also adept at using publicly available physiographic datasets like USGS topographic maps, stream gage data, and landuse coverages to build the most hydrologically representative watershed models possible.

Tetra Tech uses data from all available sources to develop TMDLs. Relevant data encompass physical, chemical, biological, and demographic characteristics of TMDL watersheds. Information concerning both disturbed and undisturbed streams in TMDL watersheds is significant. At the very beginning of the TMDL development process, an exhaustive search will be made to solicit all available data from all watershed stakeholders. Table I.A-1 lists various TMDL stakeholders matched with a summarized overview of the type of data they contribute. Stakeholders who contribute their data become cognizant of the TMDL process, which can lead to increased understanding of the long-term goals and regulatory implications of TMDL implementation.

Table I.A-1. TMDL Stakeholder Data Contributions

Stakeholder	Data Type
Cities and Counties	▪ 911 addressable structures and roads ▪ POTW effluent data ▪ MS4 areas ▪ CSO
Mining industry	▪ 308 water quality monitoring data
Multi-Resolution Land Characteristics Consortium National Land Cover Database (NLCD 2006)	▪ Landuse and land cover
National Oceanic and Atmospheric Administration, National Climatic Data Center (NOAA-NCDC)	▪ Meteorological station locations ▪ Rainfall ▪ Temperature ▪ Wind speed ▪ Dew point ▪ Humidity ▪ Cloud cover
U.S. Army Corps of Engineers	▪ Lakes and Dams ▪ Dam discharge data
U.S. Department of Agriculture (USDA), Natural Resources Conservation Service	▪ Soils surveys ▪ State Soil Geographic Database (STATSGO) ▪ Soil Survey Geographic Database (SSURGO)
U.S. Census Bureau (2011)	▪ Political Boundaries ▪ Cities/populated places ▪ TIGER Roads ▪ Population change ▪ Demographics and Economic Activity
USDA Forest Service	▪ Timber harvest data
U.S. Environmental Protection Agency	▪ STORET water quality database ▪ Water quality monitoring station locations ▪ Federal standards and regulations ▪ Clean Air Interstate Rule (atmospheric deposition)

Stakeholder	Data Type
U.S. Geological Survey (USGS)	▪ Cataloging Unit boundaries (HUC) ▪ Historical Stream Flow Record (daily averages) ▪ Topographic maps (topo quads) ▪ Digital Orthophoto Quarter Quadrangle (DOQQ) ▪ Digital elevation maps (DEM) ▪ National Elevation Dataset (NED) ▪ National Hydrologic Dataset Stream Reach (NHD)
WVDEP	▪ Applicable water quality standards ▪ Nonpoint Source Management Plans ▪ OWRNPDES data (non-mining) ▪ HPU data (mining NPDES) ▪ Abandoned mining coverage and data ▪ Discharge Monitoring Report data ▪ Oil and gas operations coverage ▪ Marcellus Shale operations coverage ▪ Section 303(d) list of impaired water bodies ▪ Water quality monitoring station locations ▪ TMDL source tracking data ▪ Sewered area and septic zones ▪ Best management practices ▪ Pre-TMDL monitoring data ▪ Streambank erosion study data ▪ Impaired Streams
West Virginia Division of Forestry	▪ Timber harvest data ▪ Burned areas ▪ Skid roads and landings
West Virginia Division of Natural Resources (DNR)	▪ Wildlife information
West Virginia University	▪ Roads

Data retrieval from stakeholders is only the beginning of the data development process. Tetra Tech will review all raw data for accuracy. Suspect data will be identified through an exhaustive QA/QC process that includes the identification of spatial, temporal, and statistical outliers as they pertain to impaired streams and TMDL watersheds. Tetra Tech will use Microsoft® Access databases to manage the large volume of data to be received from existing WVDEP databases as well as other sources of information. For over 10 years, Tetra Tech has worked extensively with WVDEP databases including the Watershed Assessment Branch database (WABbase), and has the demonstrated skill to transfer and manipulate data in a Microsoft® Access database environment.

The following sections describe in detail all of the data used to develop TMDLs.

I.A.1. Subwatershed Delineation

Subwatershed delineation refers to the subdivision of the watershed into smaller, discrete subwatersheds for modeling and analysis. The subdivision of the subject watersheds will be scaled to the extent and size of the impaired stream segments such that only one impaired stream segment is contained in an individual subwatershed unit. An example subwatershed delineation is provided in Appendix A.

Before delineation is begun, the location, stream name, stream code and impairment status of all streams will be verified. Any stream whose impairment status is questionable will be considered to be impaired for the purpose of the delineation so that the delineation is as inclusive as possible. The location of pre-TMDL monitoring stations and other water quality monitoring stations will also be verified prior to delineation to maximize spatial symmetry between monitoring stations and modeled stream reaches.

The subdivision of watersheds will begin with the 12 digit hydrological unit (HUC) watersheds. In order to represent watershed loadings and the resulting concentrations of pollutants of concern, each watershed will be divided into hydrologically connected subwatersheds. Model subwatershed boundaries are derived from topographic hydrologic boundaries. The delineation will incorporate detail from 1:24,000 scale USGS topographic maps, stream connectivity (from USGS's National Hydrography Dataset [NHD] stream coverage), the impairment status of modeled streams, and monitoring station locations. The subwatershed delineation is not only a key step in the creation of the model, but also establishes a geographic framework useful for assigning load reductions and developing future TMDL implementation efforts.

Upon completion of the subwatershed delineation, the subwatershed units will then be labeled with project name, final stream name, stream code, TMDL watershed name, major stream grouping (HUC 8, HUC 10, HUC 12), GNIS ID, GNIS name, and will be assigned a subwatershed identification number. Subwatersheds will be numbered sequentially from the most downstream subwatershed unit to the headwaters. The subwatershed network connectivity is also generated at this time and included in the attributes of the subwatershed delineation shapefile. The connectivity identifies the immediate downstream subwatershed for each subwatershed unit and is the basis by which the stream network is represented in the model for the routing of pollutants, therefore it is crucial that the connectivity be free from error in order for the model to run properly. Next, the areas for each subwatershed unit will be calculated in square meters and acres. A modeled reach consisting of one representative stream segment for each subwatershed unit will also be generated at this time. The modeled reach is used to calculate stream channel properties for configuration of the Mining Data Analysis System (MDAS) model. The process of labeling the subwatersheds and generating the modeled reach also serves as a review to ensure that the impaired streams are labeled correctly, that the structure of the stream network is preserved in the delineation, and that each impaired segment has been isolated.

The subwatershed delineation deliverable will be submitted in a CD directory with shapefiles compatible with the latest version of ArcGIS, representing the subwatershed delineation, TMDL watersheds, impaired streams, modeled reach, and NHD streams reach coverage. If necessary, a revised WAB monitoring station location shapefile will be included if discrepancies in monitoring station location data are discovered during the subwatershed delineation process. A separate document detailing any questionable or conflicting information encountered during the review of the stream reach and monitoring station shapefiles and impairment listings will be submitted along with the subwatershed delineation. Table I.A-2 lists the shapefiles that may be included in the subwatershed delineation deliverable.

Table I.A-2. Subwatershed Delineation Spatial Data

Shapefile	Description
Subwatershed Delineation	Spatial representation of the subwatershed delineation. The attributes table will include the project name, TMDL watershed name, subwatershed ID number, downstream sub ID number, area in square meters, area in acres, GNIS ID, GNIS name, final stream name, WV stream code, and WV NHD stream code.
Streams	Spatial representation of all digitized streams in the watershed. Coverage originates from WVDEP's most up to date version of NHD Stream Reach. The attributes table will include stream name, WV stream code, and NHD stream code.
Impaired Streams	WVDEP's latest NHD stream reach file modified to highlight impaired streams. The attribute table will contain fields that indicate all pollutants for which each stream is impaired as determined by the TMDL work directive list. The attribute table will also include the impaired stream name, NHD stream code, WV stream code, and trout designation.

Shapefile	Description
Modeled Reach	Spatial representation of the modeled reach. The attributes tables will include the subwatershed ID number, downstream subwatershed ID number, WV NHD stream code, final stream name, WV Code, hydrologic unit code categories (HUC 8, HUC 10, and HUC 12), watershed name, and length of reach segment in meters.
TMDL Watershed Boundary	Spatial representation of the TMDL watershed boundaries. The attribute table will contain the TMDL watershed name.

I.A.2. NPDES Permit Summary Report

It is crucial that permitted point sources be represented correctly in the model in order to develop a defensible TMDL. To that end, a Permit Summary Report will be submitted to WVDEP that identifies and characterizes the NDPES data associated with permitted point sources in each watershed. Tetra Tech works collaboratively with WVDEP to spatially review the latest OWRNPDES GIS coverages (outlets and permits shapefiles) against the subwatershed delineation, streams layer, and the aerial images. The OWRNPDES GIS coverages are then joined to the subwatershed delineation to tag each outlet with the appropriate modeled subwatershed number to facilitate processing using the Permit Summary Report Database developed by Tetra Tech. This database generates the permit sub type tables that will be used to enter permit details for the outlets. Once all data gaps are resolved, Tetra Tech will coordinate a meeting with WVDEP representatives to thoroughly review the data and determine the modeling methodology for each outlet. The meeting will result in the approval of the Permit Summary Report Database which then will be used to create the final Permit Summary Report Excel Spreadsheets, which will consist of a mining-related permit summary spreadsheet, and a non-mining related permit summary spreadsheet. These summaries will be submitted on a CD in a Microsoft® Excel filterable spreadsheet format. An example Permit Summary Report is provided in Appendix A.

WVDEP Division of Mining and Reclamations' hpu.shp GIS coverage will be used to determine the location of the mining-related NPDES permitted outlets. The effluent type, permit limits and discharge data for these outlets can be acquired from West Virginia's ERIS database system. However, additional information is needed to characterize the mining activities for representation in the model. Tetra Tech has created a customized interactive spreadsheet tool to aid WVDEP Division of Water and Waste Management (DWWM) personnel in the collection of mining-related permit data. This enables SMCRA Article 3 mining permit details to be related back to NPDES permits at the outlet level for representation in the model. This tool is used to generate a comprehensive list of the mining-related NPDES permitted outlets in the watershed, including permit number, permit type, outlet ID, outlet location (latitude and longitude), effluent type code, effluent limits, total and disturbed drainage area (for precipitation induced discharges), and continuous flow data (for pumped or constant discharges). This information provides the basis for representing mining related discharge flows as either pumped or precipitation-driven in the model.

WVDEP's OWRNPDES GIS coverages (outlets and permits shapefiles) will be used to determine the locations of the non-mining permitted sources; and detailed permit information such as discharge characteristics, permit limits and discharge data will be obtained from WVDEP's ERIS database. Tetra Tech has created a customized database tool to aid WVDEP DWWM personnel in querying the OWRNPDES GIS coverage to break out the permit types into tables as follows: HAU, IND POTW, IND Other, IND POTW Collection, Sewage General, Car Wash, Groundwater Remediation, Water Treatment Plants, IND Industrial, Solid Waste Landfill Applications, Stormwater Industrial GP, Construction Stormwater GP (this information comes from the OWRNPDES Permits shapefile coverage), Mining

Bathhouse Outlets, and WVDOH+MUN. These two datasets will be combined to generate the non-mining related permit summary list, which will provide the permit number; facility name; responsible party; permit type; outlet ID; outlet location (latitude and longitude); the watershed in which the outlet is located; outlet status (open/closed); the start and end dates for the outlet; and the parameters of interest for which limits are found, including flow, chemical concentrations and pH.

The Permit Summary Report will not only provide a comprehensive list of the permitted point sources in a subwatershed but also will identify any data gaps in the detailed permit information necessary to accurately represent the outlets in the model. Tetra Tech will work with WVDEP to obtain any missing information. Tetra Tech has a great deal of experience querying WVDEP's ERIS database, which it has access to through a virtual private network connection from its Charleston, WV office. This enables Tetra Tech to verify any questionable permit information in real time. For example, Tetra Tech reviews each major facility's permit in ERIS to better understand the outlet details, wastewater characteristics, and to identify questions to discuss with the WVDEP NPDES permit writers.

Significant details are frequently absent from the permit's outlet information in ERIS. For example, a stormwater outlet may actually be internal in nature, contributing its stormwater to another outlet of its permit, or even a completely different permit. Tetra Tech's knowledge of the NPDES permitting process and the WVDEP's ERIS database aid in identifying these data gaps to properly model each outlet. Discharge limits are helpful for identifying the parameters of concern, the average concentrations discharged, and the flow of each outlet (design or measured). In many cases, outfalls with stormwater contributions will discharge to a sedimentation pond. These outlets are often comingled with process water, non- contact cooling water, and sometimes even sanitary wastewater. The flow of the outlet is not monitored at its point of discharge to the pond, but at the outlet of the pond to the receiving stream. Discharge monitoring reports may be used to determine how often the ponds themselves have been reported to discharge, making it possible to derive the average monthly flow discharged to the stream. In some cases, sedimentation ponds may not discharge unless there is a large rain event, which means the outlet is characterized as stormwater and should be considered precipitation-driven. Likewise, an outlet may have monthly flows reported with limitations (non-benchmark values). In this situation, wastewater flows may not be best represented as stormwater. In this case, it would be best to employ a continuous flow, which can be derived by using an average of the reported average monthly flow data, or from the flow capacity of the treatment structure as identified in the permittee's application.

I.A.3. Pollutant Source Report

Working closely with WVDEP and interested stakeholders, Tetra Tech will develop an accurate and detailed assessment of all possible pollutant sources in these watersheds. The results of this assessment will be presented in a Pollutant Source Report. The Pollutant Source Report is the starting point for MDAS model configuration. All of the datasets required for model setup are represented in the Pollutant Source Report: from the subwatershed delineation to the pollutant sources to the meteorological data that drives the model. Preparing the Pollutant Source Report not only provides a spatial representation of the source information available pertaining to the subject watershed but also provides an opportunity to systematically format all of the data required for model configuration and to identify any data gaps that need to be filled. An example Pollutant Source Report is provided in Appendix A.

Tetra Tech has extensive knowledge of the datasets available pertaining to potential pollutant sources throughout West Virginia and neighboring states. Tetra Tech staff have cultivated professional relationships with the staff of WVDEP and other organizations who can provide further details regarding sources. Most notably are the WVDEP personnel responsible for watershed source tracking and those with knowledge of permit details and the ERIS database system. Tetra Tech has worked closely with WVDEP source tracking personnel in order to streamline the data collection process so that the

appropriate type and amount of source data is collected. This provides for greater efficiency in gathering source data within the time constraints of WVDEP's TMDL development schedule.

After the Permit Summary Report Excel Spreadsheets have been reviewed, Tetra Tech will begin to prepare the Pollutant Source Report. Once complete, Tetra Tech will coordinate a meeting with WVDEP representatives to thoroughly review the data and approve the information as the final deliverable. The Pollutant Source Report will be submitted in a CD directory containing an ArcGIS project that spatially represents the potential sources of stream impairments in the watershed. A separate project will be created for each watershed and each project will contain a separate view for each impairment type (metals, bacteria, or other impairment). Within each view, shapefiles will be presented that represent potential point and nonpoint pollutant sources, watershed physiographic data, and monitoring data required for modeling. The shapefiles are primarily statewide coverages that Tetra Tech processes using GIS, clipping by watershed and then labeling features with the identifying information for the individual subwatershed unit in which they are located. These shapefiles will be represented with appropriate symbols in the view legend and physical and observed details will be presented in the attributes table associated with each shapefile. A descriptive document (or legend) will also be submitted with the Pollutant Source Report that explains in detail the contents of each project, view, and shapefile.

I.A.4. Watershed Physiographic Data

Tetra Tech builds MDAS models using GIS shapefiles that represent watershed physiographic features such as topographic elevation and stream networks. These features provide a geographic framework within which the pollutant sources can be viewed and assessed. Shapefiles will include the subwatershed delineation, reach network, and impaired reaches. The inclusion of features such as towns and road networks will help to orient reviewers and TMDL implementers. Soil type classification will be included to identify areas within the watershed that may have different soil properties and thus, different hydrologic properties. The landuse grid, which serves to provide the user with an overview of the land cover and to what degree the land is disturbed in the watershed, is the basis for creating the modeled landuse categories and calculating associated areas for model input. NLCD 2011 (Jin et al., 2013) is the most up to date landuse grid coverage available for the state of West Virginia, and the EOI specifies NLCD 2011 or equivalent. Table I.A-3 lists the shapefiles describing watershed physical features that may be included in the Pollutant Source Report.

Table I.A-3. Pollutant Source Report Spatial Data

Shapefile	Description
Subwatershed Delineation	Created by the subwatershed delineation process described in Section I.A.1. The attribute table will include the project name, TMDL watershed name, subwatershed ID number, downstream sub ID number, area in square meters, area in acres, GNIS ID, GNIS name, final stream name, WV stream code, and WV NHD stream code.
Stream Reach	Spatial representation of all digitized streams in the watershed. The coverage will originate from most up to date version of NHD Stream Reach shapefile. The attribute table will includes stream name, WV stream code, and NHD stream code.
Impaired Streams	WVDEP's latest NHD Stream Reach file modified by Tetra Tech to highlight all of the impaired water bodies in the watershed. The attribute table will contain fields that indicate all pollutants for which each stream is impaired as determined by the TMDL work directive list. The attribute table will also include project name, TMDL watershed name, impaired stream name, NHD stream code, WV stream code, and trout designation.
Roads	Based on previous experience, the wv_roads.shp coverage from WCMS is incomplete. This coverage will be supplemented with the TIGER/line files from the U.S. Census Bureau (2011) and unmapped jeep trails found on the topographical maps and aerial photos.
Towns	Includes locations and names of town and municipalities in the watershed. Coverage originates from wvppl.shp in WCMS.
Soils	Soil classification by type (MUID), represented as polygons. Coverage originates from USGS STATSGO database.
Landuse – NLCD 2006/2011	This is a grid coverage of the National Land-Cover Database. The coverage is comprised of 30x30 meter grid cells each identified by landuse category.
911 Coverages (if available)	Coverages are based on information collected through the 911 emergency response mapping initiatives. The point coverages include all buildings and structures on a countywide basis. Tetra Tech may use this coverage update the modeled landuse to reflect population growth.

I.A.5. Monitoring Data

To develop a valid model, a variety of monitoring data is required. Meteorological data such as precipitation, wind speed, potential evapotranspiration, cloud cover, temperature, and dewpoint drive model hydrology. Each subwatershed unit is assigned a weather station based on proximity, which requires that weather stations outside of the subject watershed be identified. Depending upon the size of the watershed and distance to the nearest weather station, grid-based weather data products may be used to develop MDAS model weather input files for TMDL modeling. For previous TMDL projects, the Parameter-Elevation Regressions on Independent Slopes Model (PRISM) and the North American Land Data Assimilation System (NLDAS-2), both publicly available weather datasets, provided reliable spatial data on which to build multiple weather files. Using multiple weather files provided more accurate variability for large watersheds. Both datasets combine rain gauge data with radar observations to predict hourly weather parameters such as precipitation, solar radiation, wind, and humidity. USGS flow gages provide stream flow measurements that are used as a target in model hydrology calibration. If an appropriate USGS flow gage does not exist in the watershed, a reference watershed approach will be used for hydrology calibration. This requires identifying and analyzing data from USGS gage stations outside of the watershed, and sometimes outside of West Virginia. Pre-TMDL monitoring stations provide water quality data that is used as a target in model water quality calibration. Monitoring data provided by the WVDEP Division of Mining and Reclamation is used to characterize mining sources. Spatial representation of the various types of monitoring stations in the Pollutant Source Report will allow Tetra

Tech and WVDEP to determine whether sufficient monitoring data exists and to identify any data gaps that need to be filled before modeling proceeds.

Tetra Tech is continually looking for ways in which monitoring data can be better integrated into the TMDL model setup process. Tetra Tech has worked with WVDEP to improve the spatial representation of pre-TMDL monitoring station locations; to include more detailed field notes in the WAB sampling data; and to begin assessing streambank erosion potential for aid in sediment and metals modeling. Tetra Tech has worked with WVDEP in the past to clarify data inconsistencies and augment monitoring datasets, and will continue to do so going forward. Table I.A-4 lists the shapefiles that describe monitoring data sources that may be included in the Pollutant Source Report.

Table I.A-4. Pollutant Source Report Water Quality Monitoring Data

Shapefile	Description
WAB Stations	Includes locations of all WAB instream monitoring stations. The attribute table will include the station ID, stream name, stream code, and location coordinates. Coverage is based on latest WAB stations shapefile provided by WVDEP. The attribute table will include the station ID, stream name, stream code, and location coordinates.
WAB Samples	Includes locations of all WAB instream WAB samples. The attribute table will include the station ID, Sample ID, stream name, stream code, location coordinates, collection dates, and monitoring results.
Additional Monitoring Stations	Includes locations of additional water quality monitoring stations provided by various stakeholder groups such as: permittees, watershed groups, environmental groups, or other data sources. The attribute table will include the permit #, stream name, stream code, and location coordinates.
Additional Monitoring Samples	Includes the locations of all other water quality monitoring samples provided to the WVDEP by permittees or other sources, if applicable. The attribute tables will include the data provider, stream name, stream code, location coordinates, collection dates, and monitoring results.
Weather Stations	Includes locations of weather stations (including precipitation gages and surface airways stations) within and surrounding the watershed. The attribute table will include the station name and ID, period of record, elevation, and location.
USGS Gage Stations	Includes locations of the USGS gages within or surrounding the project watersheds. The attribute table will include the gage ID, station name, period of record, flow rate, drainage area, and location.

I.A.6. Potential Point Sources

I.A.6.a. Fecal Coliform Point Sources

The most significant fecal coliform point sources are the permitted discharges from sewage treatment plants. These facilities (including publicly and privately owned treatment works, combined sewer overflows, home aeration units, sewage package plants, WVDOH municipal sewage plants, and mine bathhouses) are regulated by NPDES permits. Permits require effluent disinfection and compliance with strict fecal coliform limitations (200 counts/100 milliliters [average monthly] and 400 counts/100 ml [maximum daily]). However, noncompliant discharges and collection system overflows can contribute loadings of fecal coliform bacteria to receiving streams. WVDEP's OWRNPDES GIS coverage shows the locations of NPDES permitted sources of fecal coliform bacteria. Tetra Tech will obtain the most up to date version of this coverage for inclusion in the Pollutant Source Report.

Tetra Tech is aware that new permits may be issued between the time that the Pollutant Source Report is submitted and the model is fully calibrated. Tetra Tech will work closely with WVDEP to establish a means by which significant permits are included in the calibrated model. Table I.A-5 lists the shapefiles that describe point sources that may be included in the Pollutant Source Report.

Table I.A-5. Pollutant Source Report Permitted Point Source Data

Shapefile	Description
OWR Non-Mining NPDES Outlets	Includes a summary of the fecal coliform related permit limit information for each of the OWRNPDES permit outlets. Coverage originates from the latest OWRNPDES.shp and permit information retrieved from ERIS by WVDEP. The attribute table includes the permit, outlet, and the permit details for modeling purposes such as: design flow, land cover information and areas, and permit limits.
CSO Outlets	Locations of the NPDES permitted facilities that have CSO outlets. Coverage originated from latest OWRNPDES.shp. Where applicable, delineation of MS4s versus CSO drainage areas.
MS4 Permits	Coverage includes the areas associated with Municipal Separate Storm Sewer Systems.

I.A.6.b. Metals Point Sources

Metals point sources are classified by the mining- and non-mining-related permits issued by WVDEP. Untreated mining-related discharges from deep, surface, and other mines typically have low pH values (i.e., they are acidic) and contain high concentrations of metals (iron, aluminum, and manganese). For this reason, mining-related activities are commonly issued NPDES discharge permits that contain effluent limits for total iron, total manganese, nonfilterable residue, and pH. Most permits also include effluent monitoring requirements for total aluminum. Similarly, facilities that forfeited their bonds and abandoned operations can be a significant source of metals and low-pH. These facilities become the responsibility of the WVDEP Special Reclamation and are issued NPDES permits. WVDEP maintains a spatial coverage of the mining-related NPDES permit outlets. Tetra Tech will obtain the most up to date version of this coverage for inclusion in the Pollutant Source Report.

WVDEP DWWM controls water quality impacts from point source discharges from non-mining activities through the issuance of NPDES permits. WVDEP's OWRNPDES GIS coverages (permits and outlets shapefiles) show the locations of these sources. Non-mining point sources of metals may include the wastewater discharges from water treatment plants and industrial manufacturing operations. In addition, the discharges from construction activities that disturb more than one acre of land are legally defined as point sources. The sediment introduced from such discharges can contribute metals. All other non-mining NPDES permits (i.e., the wastewater discharges) must discharge at a pH between 6.0 and 9.0. Based on the types of activities and the minimal flow of most of these discharges, these permitted non-mining sources are usually believed to be negligible, however, they will be included in the pollutant source summary and the model.

Tetra Tech is aware that new permits may be issued between the time that the Pollutant Source Report is submitted and the model is fully calibrated. Tetra Tech will work closely with WVDEP to establish a means by which significant permits are included in the calibrated model. Table I.A-6 lists the shapefiles that describe point sources that may be included in the Pollutant Source Report.

Table I.A-6. Pollutant Source Report Permitted Point Source Data

Shapefile	Description
OWR Non-Mining NPDES Outlets	Includes a summary of the metals related non-mining permit limit information for each of the OWRNPDES permit outlets. Coverage originates from the latest OWRNPDES.shp and permit information retrieved from ERIS by WVDEP. The attribute table includes the permit, outlet, and the permit details for modeling purposes such as: design flow, disturbed areas, land cover information and areas, and permit limits.
Mining NPDES Outlets	Summarizes the mining-related NPDES outlets. The attribute table includes the permit, outlet, effluent type and the permit information for each outlet. Coverage originates from the latest hpu.shp and from information provided by WVDEP DWWM in the interactive tool Tetra Tech has developed to collect mining outlet information.
Bond Forfeiture Sites	Includes locations and status of bond forfeiture sites. Coverage created based on information from the Office of Special Reclamation in WVDEP Division of Land Restoration.
Permitted Mining Areas	Includes area coverage of the surface mining operations. Coverage originates from the latest perbd.shp provided by WVDEP.
Valley Fills	Includes area coverage of valley fills from mountaintop removal coal operations. Coverage originates from the latest vallf.shp provided by WVDEP.

I.A.7. Potential Nonpoint Sources

I.A.7.a. Fecal Coliform Nonpoint Sources

In addition to permitted sources, non-permitted (nonpoint) sources contribute fecal coliform bacteria loads to impaired streams in a watershed. The nonpoint fecal coliform sources in a watershed are represented differently in the model depending on their type and behavior. Potential nonpoint fecal coliform sources include wildlife, grazing livestock, residential/urban runoff and failing septic systems.

Frequently, nonpoint sources are characterized by build-up and wash-off processes. On the land surface, fecal coliform bacteria accumulate over time and wash off during rain events. As the runoff transports the sediment over the land surface, more fecal coliform bacteria are collected and carried to the stream. While the concentrations of bacteria are increasing, some bacteria are also dying. The net loading into the stream is determined by the local watershed hydrology. Nonpoint sources are represented in the model as land-based runoff from the landuse categories. Fecal coliform accumulation rates (in number per acre per day) can be calculated for each landuse based on all sources contributing fecal coliform bacteria to the land surface. Wildlife and grazing livestock contribute to landuses in the watershed such as forest, grassland, pasture and urban/residential. Failing septic systems, straight pipes conveying raw sewage, and wildlife contribute fecal coliform bacteria to residential/urban lands. These contributions are a nonpoint source via the build-up and wash-off of coliform bacteria from both pervious and impervious surfaces in industrial areas, on paved roads, and in residential areas. Direct discharges from livestock may be a significant source of bacteria in receiving streams, depending on the number of livestock with stream access in the watershed.

Failing septic systems represent non-permitted (nonpoint) sources that can contribute fecal coliforms to receiving water bodies through surface or subsurface flow. Fecal coliform contributions from failing septic system and discharges will be represented in the model by flows and concentrations, which will be quantified on the basis of the following information:

- Areas not served by public sewer.
- Number of failing septic systems in each subwatershed.

- Estimated population served by the septic systems (calculated from census data, source tracking information provided by the WVDEP and 911 coverages).
- An average daily discharge in gallons of wastewater/person/day.
- Estimated septic effluent concentration reaching the stream.

Tetra Tech will review the nonpoint source data it receives before including it in the Pollutant Source Report and transform the data where necessary to enhance spatial representation. Table I.A-7 lists the shapefiles that describe nonpoint sources that may be included in the Pollutant Source Report.

Table I.A-7. Pollutant Source Report Nonpoint Source Data

Shapefile	Description
Landuse – NLCD 2011	This is a grid coverage of the National Land-Cover Database. The coverage is comprised of 30x30 meter grid cells. The NLCD 2011 will be loaded to show each of the landuses identified in the NLCD coverage.
911 coverages	These are coverages provided by WVDEP based on information collected through the 911 initiatives. The point coverage includes all buildings and structures on a countywide basis. May be used to provide house counts in unsewered areas and to update residential landuse in areas that have recently undergone significant residential development.

I.A.7.b. Metals and Sediment Nonpoint Sources

In addition to point sources, nonpoint sources can contribute to water quality impairments related to metals and pH. Abandoned mine lands (AML) contribute AMD, which produces low pH and high metals concentrations in surface and subsurface water. Also, land disturbing activities that introduce excess sediment are additional nonpoint sources of metals. Previous modeling efforts have revealed that certain sediments contain high levels of aluminum and iron - and to a lesser extent, manganese (Watts et al. 1994). Land disturbance can increase sediment loading to impaired waters, and the control of sediment-producing sources might be necessary to meet water quality criteria for metals during high-flow conditions. Potential sediment-related nonpoint sources of metals are forestry operations, oil and gas operations, Marcellus shale operations, roads, agriculture, and barren lands.

Tetra Tech will thoroughly review the nonpoint source data it receives before including it in the Pollutant Source Report and transform the data where necessary to enhance spatial representation. Table I.A-8 lists the shapefiles that describe nonpoint sources that may be included in the Pollutant Source Report.

On July 12, 2011, Acting Governor Earl Ray Tomblin signed an executive order to make the WVDEP establish emergency rules to regulate Marcellus Shale operations until long term rules can be developed. On August 22, 2011, these emergency rules were codified in Title 35 CSR Series 8. Because shale gas drilling operations are a relatively new nonpoint source for West Virginia, Tetra Tech worked in coordination with WVDEP Office of Oil and Gas to characterize permits for current TMDL development. It is important to differentiate Marcellus wells from regular oil and gas wells because of the increased size of the land disturbance from Marcellus well pad construction. Well pad size and land disturbance information have been gathered to characterize sediment and metals contributions. Tetra Tech will continue to work with WVDEP to best represent oil and gas wells.

Table I.A-8. Pollutant Source Report Nonpoint Source Data

Shapefile	Description
AML Portals (WVDEP)	Includes locations of AML portals. Coverage originates from the latest aml_pnt.shp.

Shapefile	Description
AML Highwall	Includes locations of AML highwalls. Coverage originates from the latest aml_line.shp.
AML Area	Includes locations and areas of AML surface disturbances. Coverage originates from the latest aml_poly.shp.
Oil and Gas Wells	Includes locations and status of oil and gas well operations. Coverage originates from the latest oog.shp.
Marcellus Shale Wells	Includes the locations and status of the Marcellus Shale drilling operations. Coverage originates from the latest ERIS Wells.shp
Harvested Forest	Includes locations of forest harvest operations. The attributes table includes the registration number, start date, end date, landing (areas) haul road (acres), total logging area (acres) and calculated radius (meters). Coverage created based on the coordinates from the harvested forest information provided by WV Division of Forestry.
Burned Forest	Includes locations of burned forest areas. The attributes table includes date of burn, total area burned (acres), and the calculated radius. Coverage created based on the coordinates from burned forest information provided by WV Division of Forestry.

I.A.8. WVDEP Source Tracking

As part of its preparation for TMDL development, WVDEP staff conduct site visits to all impaired streams to identify any previously unknown pollutant sources in the watersheds and to collect additional data needed for source characterization and model setup. In fecal coliform impaired streams, the source tracking efforts by WVDEP DWWM may identify additional sources such as unpermitted discharges and failing septic systems, or gather supplemental information such as sewer coverages, failing septic data, pasture areas and livestock counts. In metals impaired streams, the source tracking efforts by WVDEP DWWM and the Office of Abandoned Mine Lands and Reclamation may identify additional AML sources (discharges, seeps, portals, culverts, refuse piles, diversion ditches, and ponds). Field data, such as GPS locations, water samples, and flow measurement can be collected to locate these sources and characterize their impact on water quality. Tetra Tech works closely with WVDEP source tracking personnel in order to streamline the data collection process so that the appropriate type and amount of data are collected. When necessary, Tetra Tech personnel have accompanied WVDEP source tracking personnel in the field to assist with the identification and characterization of sources. Tetra Tech's involvement in the source tracking process is important to source characterization as it leads to enhanced data collection and more accurate representation in MDAS. Table I.A-9 lists the shapefiles that describe source tracking data that may be included in the Pollutant Source Report.

Table I.A-9. Pollutant Source Report Source Tracking Data

Shapefile	Description
Septic Zones	Coverage created by WVDEP from the source tracking efforts. The coverage includes seasonal flow and septic system failure rates for separate zones within the watershed.
Sewered Areas	Coverage created by WVDEP and includes the aerial coverage of local PSDs
Sewage Overflow Events	Coverage created from information provided on the source tracking data spreadsheet created by WVDEP. Attributes include the locations and sewage overflow events.
Agricultural Source Tracking Sites	Coverage created from the potential fecal coliform bacteria sources that were identified during WVDEP source tracking efforts. The attribute table includes the

Shapefile	Description
	category for the source, a description of the type of source, size and runoff potential.
AML Seeps Source Tracking	Coverage created from the sample locations taken during WVDEP source tracking efforts. The attribute table includes the site description and the analytical results for each sample.
MS4 Permits	This coverage includes areas/outlets associated with Municipal Separate Storm Sewer Systems (MS4).
AML Disturbances Source Tracking	Coverage created from the identified AML areas during WVDEP source tracking efforts. The attribute table includes the site description of each AML, associated PADS#, and ranks the runoff potential.
Sediment Source Tracking	Coverage created from the potential sediment sources identified during WVDEP source tracking efforts. The attribute table includes rankings of potential sediment impacts for the following sources: AML, Oil-Gas, Unmapped Roads, Agriculture, Metal Hydroxides, Bank Erosion, and Residential areas.

I.B. Modeling Approach

Relative to the Monongahela River Watershed, to support the TMDL development of fecal coliform bacteria and total iron, it is critical to understand where the pollutant sources are coming from, how they are transported overland, and their fate and transport once they reach the main stem of the river. An integrated watershed and receiving water modeling approach is necessary to answer these questions. A watershed model will simulate the runoff and loadings of bacteria and total iron from various sources throughout the watershed. In addition, sediment transport will need to be simulated given the total iron content of sediment.

The watershed model will generate flow and pollutant loadings, which can be readily input to the main channel of the Monongahela River where the receiving water model will simulate the mixing, die-off of bacteria, settling and resuspension as well as adsorption and desorption of total iron. The receiving water model will integrate model output for previous TMDL projects (e.g., the Monongahela River tributaries, West Fork River, and Tygart Valley River watersheds) as boundary conditions. The following sections discuss the selection of the appropriate watershed and receiving water models and how they will be developed.

TMDL development for the Hughes River Watershed will be accomplished with a watershed model only.

I.B.1. Watershed Modeling

I.B.1.a. Model Selection

The selection criteria for a specific watershed model should be based on technical, regulatory, and stakeholder-specified considerations. Given Tetra Tech's experience addressing these considerations in West Virginia's watersheds, MDAS is proposed for watershed modeling. MDAS was developed by Tetra Tech and USEPA specifically for TMDL application in West Virginia to facilitate large scale, data intensive watershed modeling applications. MDAS is particularly applicable to support TMDL development for areas affected by AMD and other point and nonpoint pollution sources. MDAS is non-proprietary model, and its code is open for inspection. Modification of the model and/or additional model development can easily be done in-house, as Tetra Tech developed and maintains the model code. The system integrates the following:

- Graphical interface
- Data storage and management system
- Dynamic watershed model
- Data analysis/post-processing system

The MDAS graphical interface supports basic GIS functions, including electronic geographic data importation and manipulation. Key geographic datasets include stream networks, landuse, flow and water quality monitoring station locations, weather station locations, and permitted facility locations. The data storage and management system functions as a database and supports storage of all data pertinent to TMDL development, including water quality observations, flow observations, and Discharge Monitoring Reports (DMRs) from permitted facilities, as well as stream and watershed characteristics used for modeling.

The dynamic watershed model simulates nonpoint source flow and pollutant loading as well as instream flow and pollutant transport, and it is capable of representing time-variable point source contributions. This component is most critical to TMDL development because it provides the linkage between source

contributions and instream response. It is capable of simulating flow; the behavior of sediment, total recoverable metals, bacteria, nutrients, pesticides, and other conventional pollutants including chlorides and sulfates; temperature; and pH for pervious and impervious lands and for water bodies.

A relational Microsoft® Access database serves as the framework for watershed data management. A key advantage of MDAS' development framework is that it has no inherent limitations in terms of modeling size or upper limit of model operations imposed by architecture. In addition, the Microsoft® Visual C++ programming architecture allows for seamless integration with modern-day, widely available software such as Microsoft® Access and Excel (Figure I.B-1). Another key advantage of MDAS is that it can be customized to fit West Virginia's individual TMDL development needs.

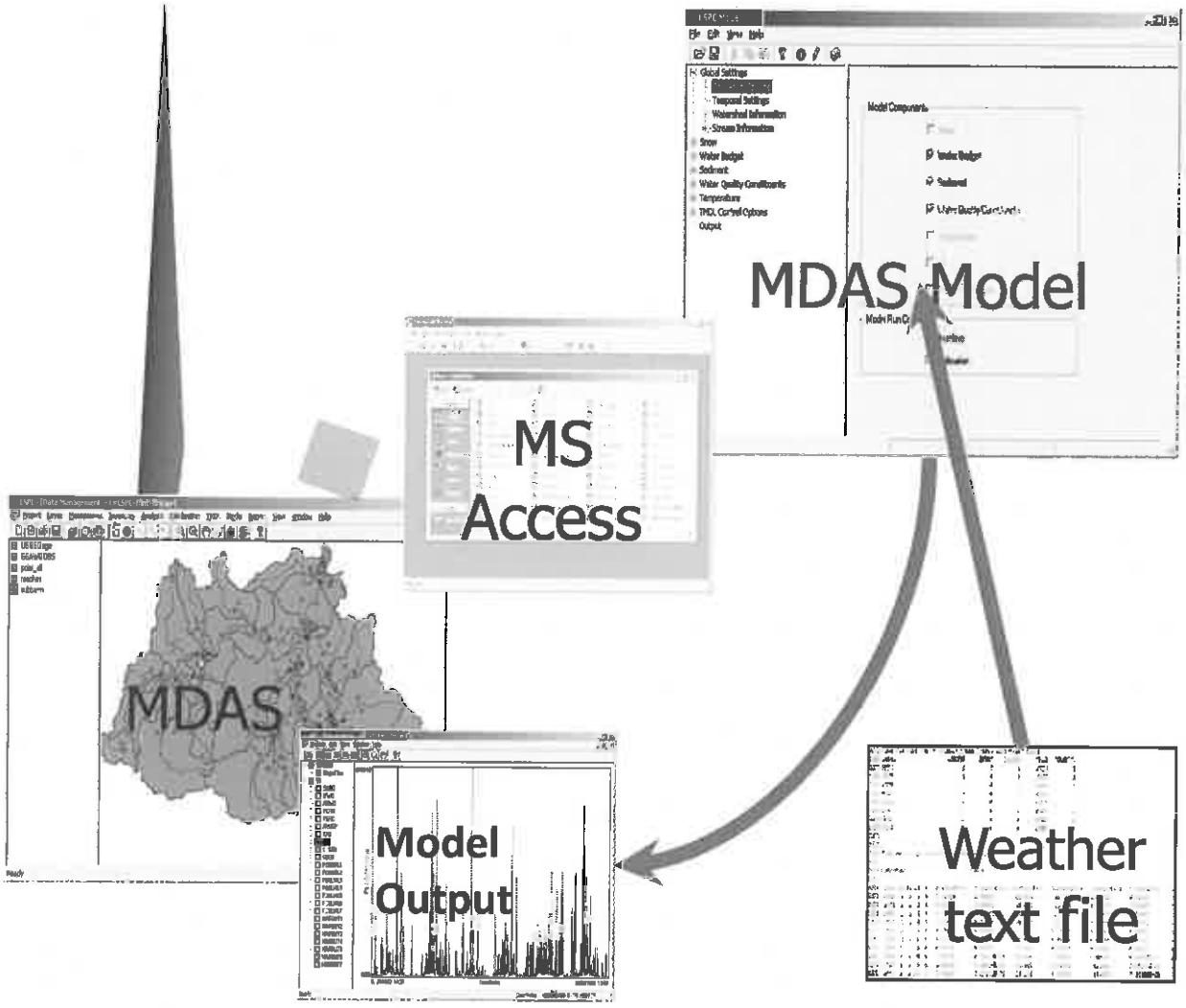


Figure I.B-1. MDAS Model Features

Advantages to choosing MDAS as the watershed model for this project include:

- Simulates watershed hydrology using hourly local meteorological data.
- Presents no inherent limitations regarding the size and number of subwatersheds and streams that can be modeled at any given time.

- Simulates all of the necessary pollutants on land and instream under a range of flow conditions.
- Is calibrated for existing conditions, while it can be modified to allow for baseline and allocation scenarios.
- Applies to rural and urban watersheds.
- Because of the small time-step, it can be used to evaluate compliance with varying water quality criteria, including exposure duration and exceedance frequency components.
- MDAS allows for representation of loading processes for both point and nonpoint sources as either precipitation-driven or constant discharge, as appropriate.
- MDAS allows for representation of pollutant build-up/wash-off rates and/or representative event mean concentrations (EMCs) for various landuse categories.
- Stream network connectivity allows for instream transfer of pollutants from upstream to downstream watersheds.
- MDAS has a unique graphical interface which supports GIS functions.
- MDAS allows for representation of instream dissolved metals.
- Easy to use post-processing tools allow for presentation of allocations in a user-friendly manner.
- A comprehensive modeling framework using the proposed MDAS approach facilitates the development of TMDLs not only for this project, but also for potential future projects to address other impairments throughout the modeled watersheds.
- Allows for customization of algorithms and sub-routines to accommodate the particular needs of the project.
- Time-variable nature of the modeling will enable a straightforward evaluation of the cause-effect relationship between source contributions and waterbody response and direct comparison with relevant water quality criteria.
- Proposed modeling tools are free and publicly available. This is advantageous for distributing the model to interested stakeholders and among government agencies.
- Approved by the USEPA for use in TMDLs.
- Model includes both surface runoff and baseflow (groundwater) conditions.
- Provides storage of all geographic, modeling, and point source permit data in a Microsoft® Access database and text file formats to provide for efficient manipulation of data.
- Provides post-processing and analytical tools designed specifically to support TMDL development and reporting requirements.

I.B.1.b. Watershed Model Configuration

I.B.1.b.1 Fecal Coliform Model Setup

During model setup Tetra Tech will format the subwatershed, stream reaches, and point source data for input into MDAS. Meteorological conditions are the driving force for nonpoint source transport processes in watershed modeling. Hourly precipitation, temperature, dew point, evapotranspiration, cloud cover, and other relevant weather data will be obtained for those stations inside and around the watersheds of concern. The available weather data will be analyzed for completeness, and if any periods of time are missing from the preferred station, best available data from neighboring stations will be used to fill data gaps. Once the weather datasets are complete, MDAS air files will be prepared to run the model. Weather data will be validated during hydrology calibration. Tetra Tech modelers will use the same MDAS air file for all pollutant models, whether fecal coliform, metals, or ionic stress.

The model will be configured using the MDAS model database to simulate modeled point and nonpoint pollutant sources, as well as general hydrologic characteristics of the modeled subwatersheds and TMDL streams. Development of the modeled landuse from GIS coverages is the next step in model setup. The

modeled landuse will be developed taking into account the sources of the pollutants of concern. The fecal coliform modeled landuse will start with a base landuse GIS shapefile such as the NLCD 2011. This coverage will be modified to incorporate WVDEP source tracking information. For instance, areas of high concentrations of livestock (agricultural intensity) or fecal runoff potential; differences between grasslands versus pastures; new residential development; and other nonpoint pollutant sources not described on the original coverage will be taken into account. A roads analysis will also be performed using polylines from sources such as TIGER, WVRoads, and USGS topographic maps. Roads will be classified as either paved or unpaved. In addition, an analysis of the percent imperviousness of urban/residential areas will be performed. MS4 areas that occur in TMDL watersheds will be delineated using information obtained from WVDEP, WVDOH, and local city engineers.

Besides precipitation-driven discharges, other direct discharges are modeled. In the case of the fecal coliform modeling, failing septic systems, NPDES permitted outlets with fecal coliform discharges, CSOs, and other special cases (e.g., Sanitary Sewer Overflows (SSOs) or known sludge piles) will be modeled.

Upon completion of landuse manipulation and point source input configuration, additional information required for model setup will be prepared, including inputs of reach geometry and routing, watershed physical information (e.g. slopes, length of overland flow, elevation), and weather station assignment for each subwatershed. Assignment of point sources to reaches will also be prepared for addition to the MDAS database. Finally, Tetra Tech will provide technical transfer of all models, modeling tools, and data used during the development of the TMDLs. Nothing in the models, modeling tools, databases, etc., will be restricted in its distribution.

I.B.1.b.2 Total Metals and Sediment Model Setup

To explicitly model nonpoint sources in the sediment and metals impaired watersheds, additional landuses need to be represented in the model beyond the modified fecal landuse described in I.B.1.b. These landuses will represent both point and nonpoint precipitation-driven sources. With each hydrologic group, Tetra Tech has worked to create a customized landuse set that represents the sources within the subject watersheds and will continue to do so for this project; for example Tetra Tech most recently collaborated with WVDEP personnel to determine how best to represent Marcellus Shale gas wells in watersheds where they represent a significant landuse. The metals modeled landuses for TMDLs that Tetra Tech has developed for WVDEP typically include the following: conventional oil and gas wells, unpaved roads, burned forests, harvested forest / skid roads, revoked mines, and AML highwall.

Precipitation-driven point sources within the metals model are typically related to mining activities and stormwater permits. Information from WVDEP's permit databases and spreadsheets will be used to develop the permitted landuse coverage. Besides precipitation-driven discharges, other direct discharges will be modeled such as AML seeps, pumped discharges from mines, and non-mining NPDES permits

In addition to anthropogenic sources, metals and sediment contributions from groundwater and streambank erosion will also be considered in the modeling process. In the case of naturally occurring parameters, such as manganese, aluminum and iron, groundwater contributions will be modeled according to the individual characteristics of the land and its corresponding area.

Tetra Tech has worked with WVDEP to develop a method to consistently assess bank erosion potential at the subwatershed level using a qualitative assessment of vegetative cover and soil characteristics (e.g., erodibility). The qualitative vegetative cover assessment is based on the 2011 National Agriculture Imagery Program aerial photography. Each subwatershed is assigned a qualitative value between 1 and 3, with 1 being the best observed bank vegetative cover and 3 having the least coverage. Tetra Tech and

WVDEP have found that while vegetative cover is one of the most important factors controlling bank stability, soils characteristic data available through SSURGO may provide additional insight into the streambank erosion rates that can be applied to all subwatersheds. Tetra Tech will use these data to further refine the subwatershed representation in the model.

Upland sediment loading is simulated based on the mathematical description of the soil detachment process and the sediment transport along the surface slopes. Spatial variation of the soil erodibility will be included in the model using the information retrieved from statewide soils database. Statistical analyses using pre-TMDL monitoring data collected throughout the subject watersheds will be performed to establish the correlation between metals loads and sediment loads and to evaluate spatial variability. The results will then be applied to the sediment-producing landuses during the water quality calibration phase of the MDAS.

I.B.1.b.3 pH and Dissolved Metals Model Setup

As noted in previous work for WVDEP, the majority of water quality impairment relates to mine drainage and bacterial contamination. The development of TMDLs is needed to address the typical stressors and water quality impairment due to pH, metal toxicity, and sedimentation in the Group D3 watersheds. Specifically, TMDL modeling capabilities will address water quality criterions for iron, aluminum, manganese, selenium, and pH. The modeling must address low flow, mean flow, and storm peaks at multiple locations throughout the basin and permit a comparison of model output with observed data from representative water quality monitoring stations. The TMDL model will determine instream dissolved metals and pH due to total metal inputs from point and nonpoint sources, with prescribed pollutant allocations to result in compliance with water quality criteria. The need to regulate and manage the environmental impacts from mining requires methods that encompass the inherent complexity of the myriad chemical interactions in the environmental media.

We propose to utilize an updated version of the MDAS model for TMDL development for dissolved metals and pH. The updates included coupling MDAS with the USEPA's watershed Loading Simulation Program in C++ (LSPC) (USEPA 2009) to dynamically simulate dissolved ions that influence pH. The LSPC/MDAS model will simulate complex loading processes within the watersheds and advanced chemical reactive transport processes within the streams and, thus, include the complex interactions between the land, the atmosphere, and surface and groundwater. For example, the LSPC/MDAS model will include sediment sources, atmospheric deposition, streambank erosion, and landuse source attributes and the affected instream chemical dynamics that result in observed water quality for dissolved metals and pH.

The model possesses the following capabilities that will provide a scientifically sound representation of the watershed loading and transport system and a sound development of TMDLs and allocation scenarios:

- Simulate hydrologic variations due to time variable weather patterns and the related transient saturation or unsaturated condition of the surface/subsurface
- Simulate time variable chemical loadings from various sources in the watershed
- Simulate geochemical interactions within a stream channel
- Provide model results with a broad range of spatial and temporal scales
- Evaluate source loading abatement scenarios for water quality control/management design

The conceptualization of the LSPC/MDAS model (Figure I.B-2) illustrates the relationship of the land processes and loading mechanisms that leads to the calculated edge of stream condition at various locations within the watershed. The edge of stream condition is transferred into the MDAS model for

subsequent instream calculations. The modeling for instream metals, including iron, aluminum, and manganese, along with pH, requires a comprehensive approach for simulating the interactions between dissolved, adsorbed, and precipitated chemical species that necessarily includes the simulation of major ions (e.g., calcium, sulfate, carbonate). The stream components in MDAS include the dominant processes regulating the interactions and transport of major ions, metals, adsorbing materials, and mineral phases. Reactions between the water column and the streambed are represented along with the reactions governing the distribution of dissolved and particulate chemicals. Significant chemical species for TMDL development in the subject watersheds will be included in the MDAS database with a chemical system based on major ions, iron, aluminum, manganese, adsorption/desorption to oxides and clays, precipitated chemicals, and mineral phases.

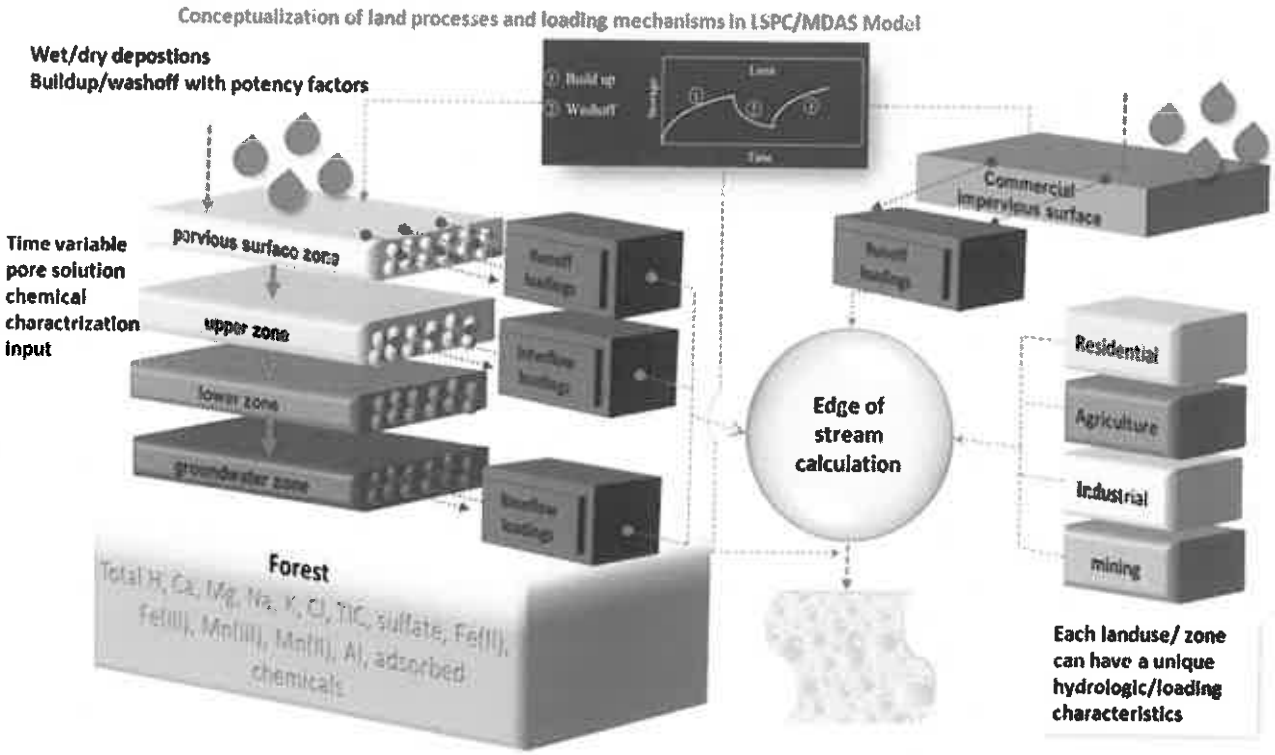


Figure I.B-2. Land components of LSPC-MDAS model

MDAS's geochemical reactions within the channel are based on thermodynamics and chemical kinetics. The foundation, based on MINTEQA2/MINEQL, is an equilibrium calculation for the major reactions that define the chemical composition of the stream reach during a given time step. Most speciation reactions are fast relative to the time step and the equilibrium assumption is reasonable. However, for certain reactions, such as the oxidation of ferrous iron to ferric iron or the adsorption of metals on iron oxyhydroxides, reactions may be limited by the kinetics, and not necessarily reach equilibrium. The major limitation of the equilibrium approach is mitigated in MDAS by incorporating simultaneous equilibrium and kinetic (non-equilibrium) calculations within the same computational time step, leading to more precise spatial and temporal representations of non-equilibrium solution conditions for certain processes. To simulate and attain realistic stream chemical conditions, the model includes a variety of chemical reactions to support various stream conditions affected by anthropogenic or natural sources:

- Chemical speciation, including trace metals

- Acid/base chemical reactions and pH simulations
- CO_2 gas degassing/ingassing kinetics in rivers and lakes
- Redox kinetics including potential photoreduction/microbial oxidation
- Kinetic mineral precipitation/dissolution
- Adsorption/desorption based on diffuse double layer (DDL) modeling
- Cation adsorption/desorption on clay surfaces represented by cation exchange capacity
- Aging/burial of active/inactive sediment layers related to sediment deposition from the water column and scour from the stream bed

The precipitation/dissolution and the adsorption/desorption reactions both occur in the water column and streambed sediments. The heat loading into the stream from land and point sources is also considered and can be simulated. The resulting stream temperature is used for all temperature-dependent chemical reactions occurring within the stream. The stream components represented in MDAS are shown in Figure I.B-3.

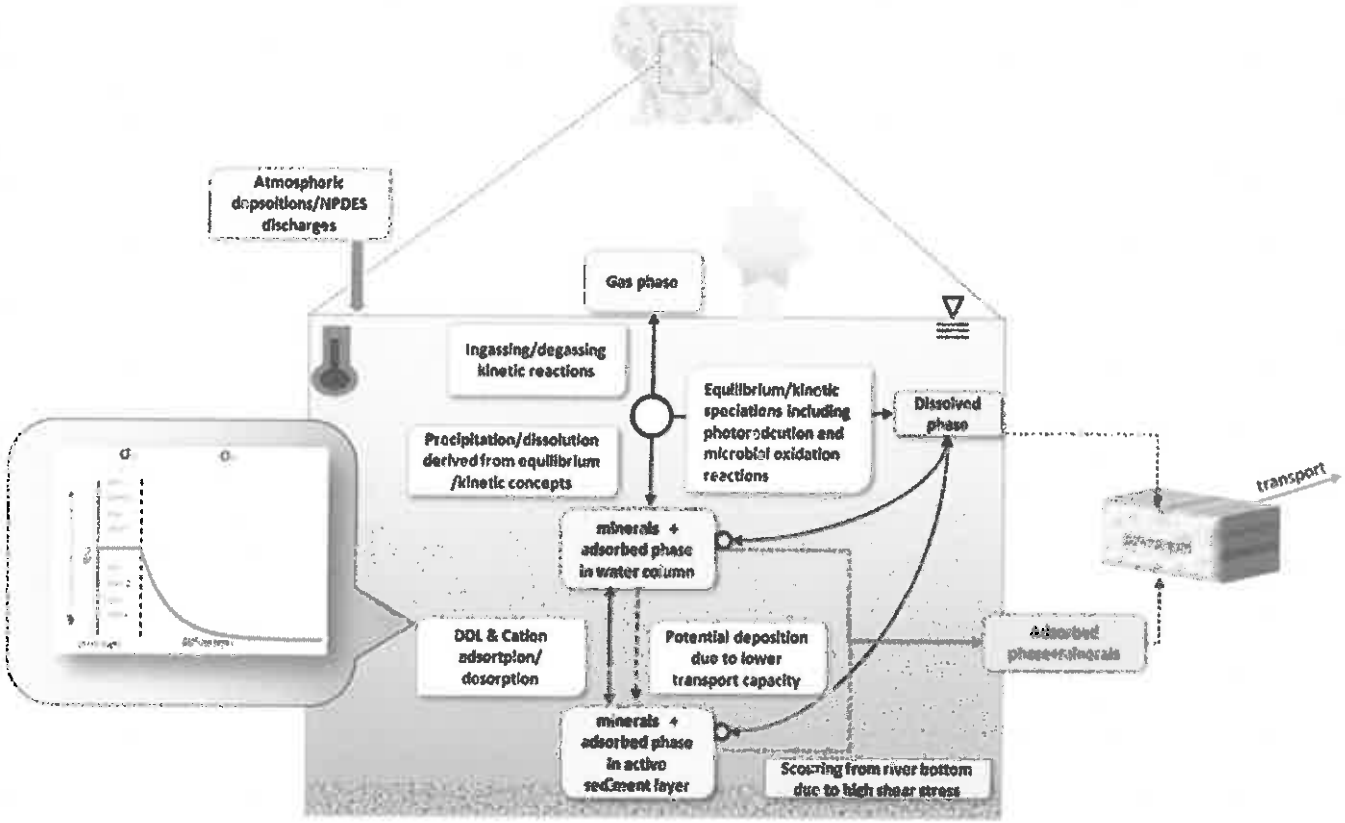


Figure I.B-3. Stream components in MDAS

This capability of LSPC/MDAS and our experience in model development/application will assure WVDEP that Tetra Tech is capable of meeting, fulfilling, and exceeding required TMDL development functions for pH and dissolved metals. Modification of the model and/or additional model development can be done in-house, as Tetra Tech developed and maintains the model code. MDAS is a non-proprietary model, and its code is open for inspection.

I.B.1.b.4 Sediment-Metals Relationship

Previous TMDL modeling by Tetra Tech for WVDEP indicates that the relatively high iron content of the soils in the West Virginia watersheds is a significant factor in iron water quality criterion non-attainment. Closely related to clay deposits, iron in soils can become mobilized through precipitation-induced runoff and eventually be delivered to streams. Iron can also become entrained in stream waters via erosion processes that worsen as stream energy (discharge) increases. Therefore, modeled extreme precipitation events or a series of significant storms may result in elevated instream TSS and non-attaining iron concentrations.

Iron loads are delivered to the tributaries with surface runoff, subsurface flows, and direct point sources. Sediment-producing landuses and bank erosion are also sources of iron because iron is associated with sediment. MDAS provides mechanisms for representing all of these various pathways of pollutant delivery. A detailed water quality analysis will be performed using statistically-based load estimates with observed flow and instream monitoring data. The confidence in the calibration process increases with the quantity and quality of the monitoring data.

Iron and TSS concentrations from pre-TMDL monitoring will be used to develop a metals-sediment correlation. Statistical analyses using monitoring data collected in the subject watersheds will be performed to establish the correlation between metals loads and sediment loads and to evaluate spatial variability. The results will be then applied to the sediment-producing landuses during the water quality calibration phase of MDAS. An example result of the correlation analysis is shown in Figure I.B-4.

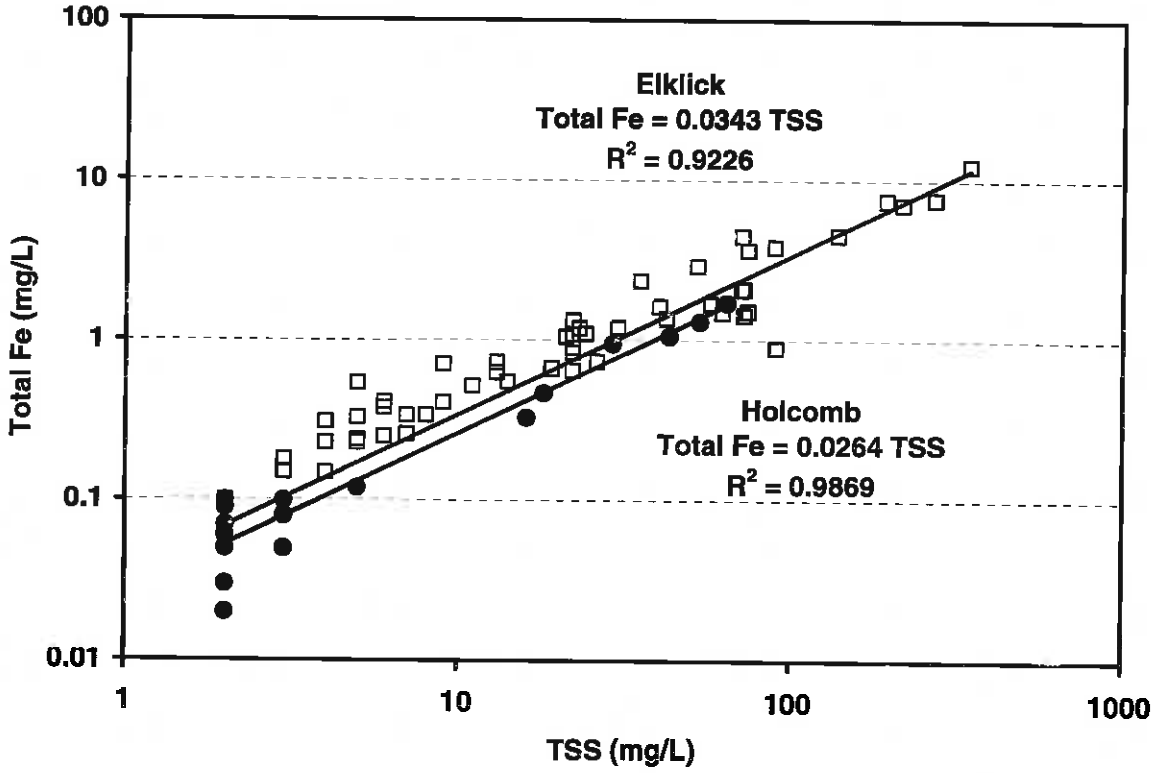


Figure I.B-4. Metals-sediment correlation

Sediment will be simulated based on the mathematical description of the soil detachment process and the sediment transport along the surface slopes. Spatial variation of the soil erodibility will be included in the model using the information retrieved from the soil database. In addition, non-sediment-related iron land-based sources will be modeled using average concentrations for the surface, interflow and groundwater portions of the water budget.

I.B.1.b.5 Streambank Erosion

The MDAS streambank erosion model is a function of stream flow and bank stability. The bank erosion algorithms of MDAS are based on the scour erosion algorithms of HSPF. The bank erosion rate per unit area is defined as a function of: bank flow volume above a specified threshold, the bank erodible area, the coefficient of scour for the bank soil, and an optional exponent for non-linearity. The streambank soil matrix is assumed to be unlimited, and bank scour is defined uniquely for each stream segment. Each stream segment will have a user-specified flow threshold above which streambank erosion may occur. The bank scouring process is a power function dependent on high-flow events, defined as exceeding the flow threshold. The coefficient of scour for the bank soil can be determined by calibration, where modeled bank erosion sediment loads are compared with loads calculated from the pin study and kber values are adjusted iteratively. Streambank erosion is represented as a unique source independent of other upland-associated erosion sources.

The wetted perimeter and reach length represent ground area covered by water (Figure I.B-5). The erodible wetted perimeter is equal to the difference between the actual wetted perimeter and wetted perimeter during threshold flow conditions. The bank erosion rate per unit area is multiplied by the erodible perimeter and the reach length to obtain the estimate of sediment mass eroded corresponding to the stream segment. The erodible perimeter changes for each flow value, and accounts for bank area exposed to flowing water (which is available for erosion). The bank erosion flow threshold limits the bank erosion process to instances when that flow is exceeded (extreme events).

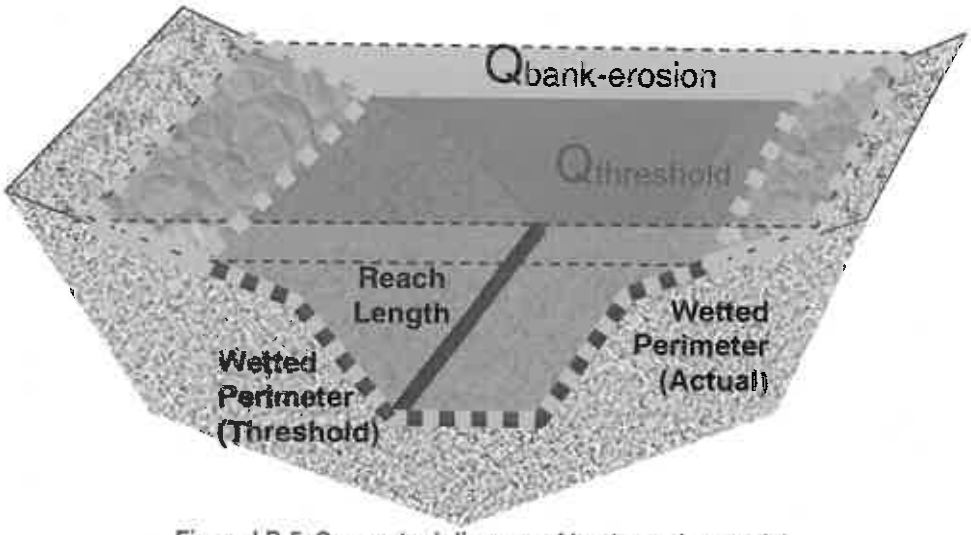


Figure I.B-5. Conceptual diagram of bank erosion model

The WVDEP erosion data from source tracking studies performed for past TMDL projects will provide Tetra Tech modelers with a possible range of streambank erosion contributions to stream sediment loads. Quantitative results from representative stream reaches will be used in conjunction with the qualitatively

assessed values of vegetative cover to capture spatial variation in bank stability across the entire watershed. Stream sediment loading rates obtained from the assessments will be used as calibration endpoints for adjusting the MDAS stream bank erosion parameter for the accurate simulation of streambank sediment loading throughout the watershed.

I.B.1.c. Watershed Model Calibration

I.B.1.c.1. Hydrology Calibration

After the MDAS model is configured, model calibration will be performed. Model calibration will be focused on two main areas: hydrology and water quality. Pollutant concentrations are strongly influenced by stream flow. High flows and low flows can dilute or intensify instream concentrations of modeled pollutants. Strongly predictive hydrologic calibration allows the MDAS model to accurately calculate pollutant time-step instream concentrations and yearly average loads. Therefore, in TMDL model development it is critical to calibrate hydrologic models so that they closely predict observed stream flow observations.

To begin the hydrology calibration process, Tetra Tech will use the best available weather and land cover data as core model inputs. Gaps in weather data completeness will be addressed using statistical methods, including Meteorological Data Analysis and Preparation Tool (MetADAPT) software available from the USEPA Region 4 TMDL Toolbox. Tetra Tech will also obtain USGS gaging station data for streams in TMDL watersheds. Instantaneous flow measurements collected during pre-TMDL monitoring and WAB stream surveys will also be used when appropriate. In the event that USGS gaging stations are not present in the TMDL watershed, model hydrology will be calibrated to a nearby watershed with similar weather patterns and landuse characteristics. Model parameters will initially be set to the best available literature values within scientifically accepted ranges.

Hydrologic calibration will be achieved by adjusting model parameters so that model output matches observed stream flow within an acceptable range of variability. Upon completion of hydrology calibration, Tetra Tech will submit a hydrology calibration deliverable featuring a statistical analysis of model output goodness-of-fit under a variety of seasonal conditions and flow regimes. The MDAS hydrology algorithm follows a strict conservation of mass, with various compartments available to represent different aspects of the hydrologic cycle and maintenance of the annual water balance. Sources of water are direct rainfall or snowmelt. Potential sinks from a land segment are total evapotranspiration, flow to deep groundwater aquifers, and outflow to a stream reach. From the reach perspective, sources include land outflow (runoff and baseflow), direct precipitation, or flow routed from upstream reaches. Sinks include surface evaporation, mechanical withdrawals, or reach outflow. Tetra Tech also has the capability to develop model algorithms to capture the specific dynamics of snow accumulation, evaporation, and meltwater runoff. Snow is an important hydrologic variable to consider, especially when modeling high elevations in West Virginia watersheds.

A well-calibrated model can predict stream flow over a wide range of climatic conditions and seasonal changes, including base flow and storm events. Tetra Tech will select calibration time periods based upon an examination of annual precipitation variability and the availability of observed precipitation and streamflow data. The period will be determined to represent a range of hydrologic conditions: low, mean, and high flow. Calibration for these conditions is necessary to ensure that the model will accurately predict a range of conditions over time periods beyond the calibration time period.

Key considerations in the hydrology calibration will include the overall water balance, the high flow-low flow distribution, storm event flows, and seasonal variation. At least two criteria for goodness-of-fit will be used for calibration: graphical comparison and the relative error method. Calibration will be performed

on a reasonable number of subwatersheds to insure adherence to scientific principles. Graphical comparisons are extremely useful for judging the results of model calibration; time-variable plots of observed versus modeled flow provide insight into the model's representation of storm hydrographs, baseflow recession, time distributions, and other pertinent factors often overlooked by statistical comparisons. The model's accuracy will primarily be assessed through interpretation of the time-variable plots. The relative error method will be used to support the goodness-of-fit evaluation through a quantitative comparison. A small relative error indicates a better goodness-of-fit for calibration.

After calibrating hydrology at multiple locations, independent sets of hydrologic parameters will be developed and applied to the remaining subwatersheds in the basin. A validation of these hydrologic parameters will be made through a comparison of model output to observed data at additional locations in the watershed. The validation locations are expected to represent larger watershed areas and essentially validate application of the hydrologic parameters derived from the calibration of smaller subwatersheds. Validation will be assessed in a similar manner to calibration.

Tetra Tech has successfully calibrated hydrology in over 20 different MDAS models in West Virginia watersheds. In fact, Tetra Tech has prior experience calibrating hydrology in the Monongahela River watershed for a past TMDL project. Tetra Tech has developed calibration spreadsheet tools customized to interpret MDAS model output. Sample output from one of these tools is presented in Figure I.B-6. Calibration tools give Tetra Tech modelers the capability to achieve model calibration in a comprehensive and highly efficient manner. Customized calibration analysis also facilitates technical review by WVDEP staff and USEPA TMDL reviewers. Hydrology calibration results will be presented on a CD containing calibration tools described above and will contain worksheets that represent the observed data and modeled output, with graphs and tables designed to assess the goodness-of-fit of the calibration, and a statistical analysis of the calibration. Daily, monthly, and annual flow volumes will be considered. An example of the hydrology calibration deliverable from West Virginia Hydrologic Group C2 TMDL is presented in Appendix A.

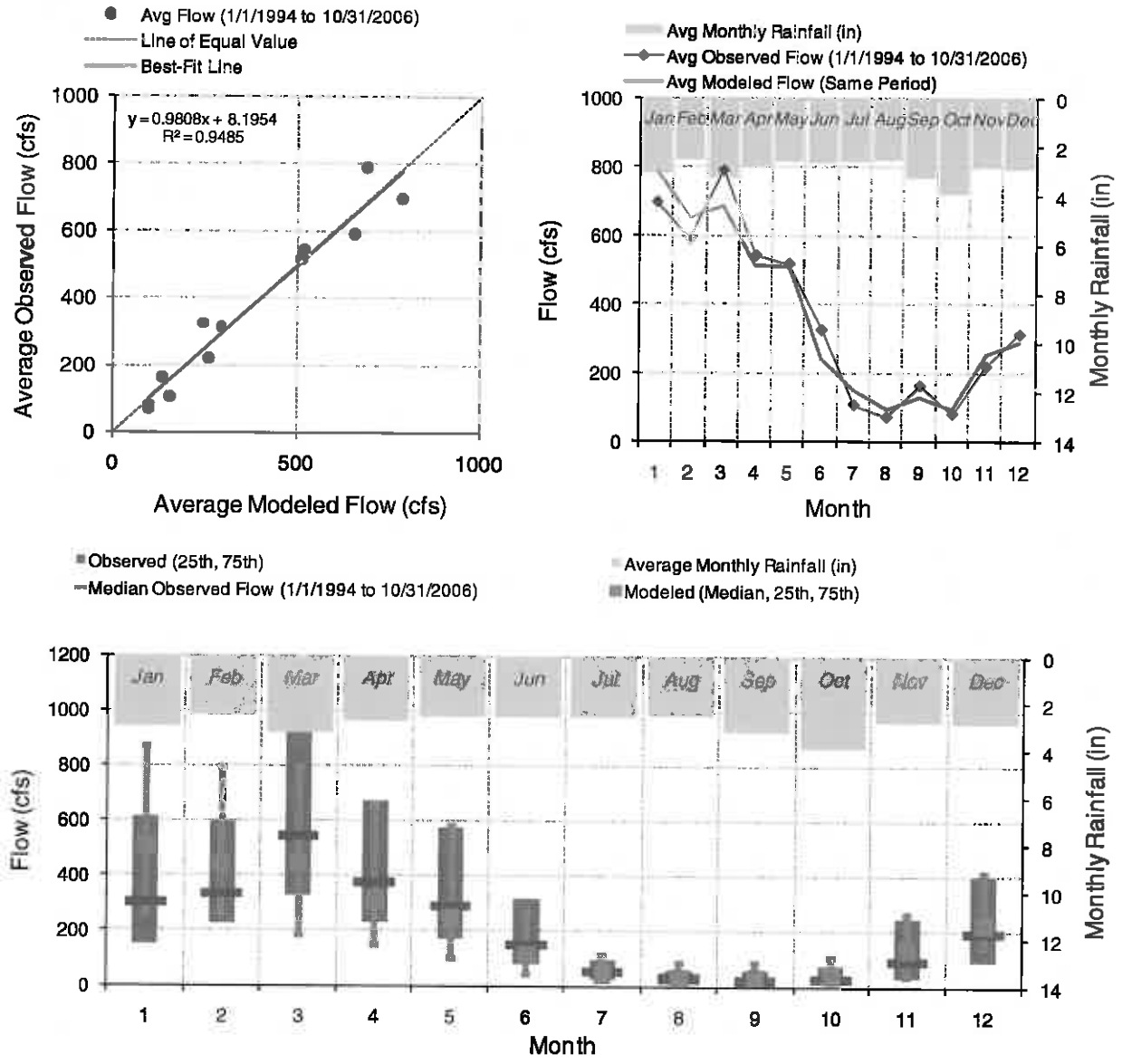


Figure I.B-6. Example Hydrology Calibration Spreadsheet Tools

I.B.1.c.2. Model Water Quality Calibration

After hydrology calibration is finalized, water quality calibration for all pollutants of concern will be performed at multiple locations throughout the watersheds. Water quality calibration refers to the adjustment or fine-tuning of modeling parameters related to water quality to reproduce instream observations. Available monitoring data in the watershed will be identified and assessed for application to calibration. Monitoring stations with data that represent a range of hydrologic conditions, source types, and pollutants will be selected. The time-period for water quality calibration will be selected based on the availability of the observed data and their relevance to the current conditions in the watershed. The period should include various wet and dry conditions.

In the broadest sense, calibration will consist of executing the watershed model, comparing time series water quality output with available water quality observation data, and adjusting water quality parameters

within a reasonable range. The main objective of the water quality calibration will be to best simulate low-flow, mean-flow, and storm events at representative water quality monitoring stations throughout the watershed. Upon completion of the calibration at selected locations, the calibrated dataset containing parameter values for modeled sources and pollutants will be complete. This dataset will be applied to areas for which calibration data are not available.

Water Quality Calibration results will be presented on a CD and will contain worksheets that represent the observed data and modeled output, with graphs and tables designed to assess the goodness-of-fit of the calibration, and a statistical analysis of the calibration. Calibration will be performed on a significant number of watersheds to ensure the scientific validity of the process. An example of the water quality calibration deliverable from the West Virginia Hydrologic Group B2 TMDL project is presented in Appendix A.

I.B.1.c.3. Fecal Coliform Water Quality Calibration

The water quality parameters that will be adjusted to obtain a calibrated model are the build-up and wash-off of fecal coliform bacteria from the subwatershed acreages associated with fecal coliform producing landuses. The direct load estimates from failing septic systems can also be adjusted for fecal coliform concentration. Landuse-specific parameters that are relevant for calibration of fecal coliform bacteria are the build-up rate and wash-off limit parameters. Essentially, the build-up relates to the rate at which the amount of fecal coliform (in counts per acre) accumulates on the land surface every day during dry conditions. The wash-off parameters are used to guide the model in the relative rate of detachment and transport of the accumulated mass from the land segment to the stream during runoff conditions. This is generally expressed as inches of runoff that would be required to mobilize certain percent of the stored mass on the surface. Starting values for these parameters will be taken from previous models, literature, peer-recommended ranges, and Tetra Tech's Fecal Coliform Loading Estimation Spreadsheet. Background values will be derived from storm sampling events in undisturbed locations.

Septic discharges will be modeled as direct discharges to the reaches, with estimated flows and concentrations. Flow values will be estimated using unsewered house counts and septic failure rates. Tetra Tech has also worked with WVDEP staff to improve failing septics analysis by incorporating 911 emergency response GIS data to identify unsewered homes in TMDL watersheds. Septic concentrations will be calculated using fecal coliform loads derived from low-flow instream water quality data for locations only affected by septics during low flow conditions. These calculated loads will then be applied to the estimated septic flows, to obtain an average septic discharge concentration.

After initial parameter values have been established, the model will be run, and comparisons will be made with observed fecal coliform water quality data for several representative locations in the watershed. The fecal coliform bacteria calibration will be focused on matching trends identified during the water quality analysis. Daily average instream fecal coliform bacteria concentrations from the MDAS model will be compared directly with observed data collected during WVDEP's pre-TMDL monitoring efforts as shown in Figure I.B-7.

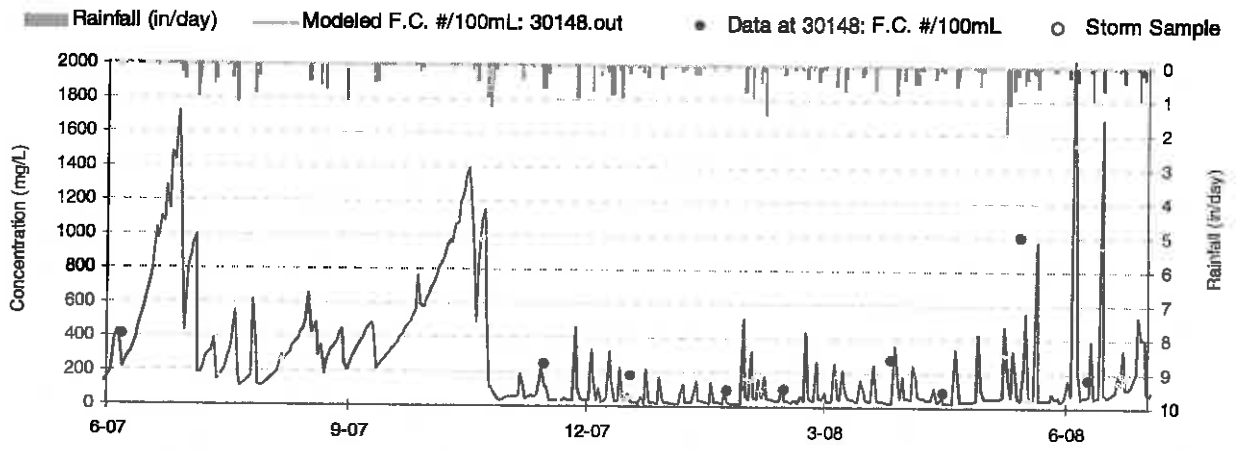


Figure I.B-7. Fecal coliform concentration: model output vs. observed data

I.B.1.c.4. Metals Water Quality Calibration and Iron-Sediment Relationship

The first step in the metals water quality calibration is the determination of the sediment-metals relationship, which may vary throughout the subject watershed. Potency factors are region-specific parameters that account for the pounds of a particular metal generated for each ton of sediment produced. The values for the potency factors will be determined by analysis of TSS and metals data. Land-based sediment calibration consisted of adjusting the coefficient in the sediment wash-off equation (KSER) for each landuse. The landuses will be parameterized according to their sediment-producing capabilities. In addition to the sediment-generated metals, any additional non-sediment related loading will be estimated. Parameters that are used are SOQC, IOQC, and AOQC. These define the concentration of non-sediment related metals by landuse for surface runoff, interflow, and groundwater, respectively.

To establish reasonable ranges of values for use in the metals water quality calibration for mining landuses, DMR and storm monitoring data will be analyzed. Metals loading for sediment producing landuses will be assumed to be exclusively dependent on the sediment loads and their potency factors. Reasonable water quality parameters for AML will be derived from statistical analysis of AML water quality data from source tracking efforts. Parameters for background conditions will be based on observed water quality data from undisturbed monitored locations. Starting values for other non-monitored sources will be taken from previous models, literature, and peer-recommended ranges.

The approach taken to calibrate water quality will focus on matching trends identified during the water quality analysis. Hourly instream concentrations from the model will be compared directly with observed data. Observed data from WVDEP's pre-TMDL monitoring efforts and data submitted by various mining companies throughout the watershed will be used for calibration. The objective will be to best simulate the metals concentration and loading at low flow, mean flow, and storm peaks at representative water quality monitoring stations. The representative stations will be selected based on location and loading source type.

I.B.1.c.5. pH and Dissolved Metals Water Quality Calibration

Historical mining activities are an important consideration in the development of dissolved aluminum and pH TMDLs. AMD is drainage that flows from open or deep mines and coal refuse piles. The formation of

AMD is a function of geology, hydrology, and mining technologies used at the site. It tends to be highly acidic and to contain high concentrations of dissolved metals. These metals remain dissolved until the pH of the water increases to the level at which the metals precipitate out. AML seeps will be modeled as direct, continuous-flow sources in the model. AML and other land-based sources will be modeled using representative average concentrations for the surface, interflow and groundwater portions of the water budget.

Atmospheric deposition data will be obtained from the USEPA Office of Air Quality Planning and Standards at Research Triangle Park, North Carolina. The data are a result of air quality modeling in support of the CAIR. The data include concentrations of sulfate and nitrogen oxides in wet and dry deposition. For the technical information on these data, see the Technical Support Document for the Final Clean Air Interstate Rule—Air Quality Modeling (USEPA, 2005c). National Atmospheric Deposition Program (NADP) monitoring data will be also used to characterize the extent of atmospheric deposition in the watershed. Atmospheric deposition inputs and parameters will be calibrated using monitoring data from streams without impact of AMD or other significant sources of acidity load.

To simulate the biogeochemical process across the watershed and instream waters, the chemical reaction parameters will be calibrated using the comprehensive water quality monitoring data. The monitoring stations on streams without influence of AMD will be identified first to calibrate the atmospheric deposition module of the MDAS model. After the chemical reaction parameters will be calibrated to water quality data in those background or reference subwatersheds, water flow and chemistry data of AMD seeps will be added in the model as point source time series. The MDAS model will be further calibrated to the water quality data observed in the subwatersheds influenced by those AMD sources.

I.B.2. Receiving Water Modeling

I.B.2.a. Model Selection

After the flow and pollutants enter the river from different sources, various processes occur in rivers. For fecal coliform bacteria and iron, the major processes include:

- Flow
- Heat transport
- Transport of fecal coliform, iron, and sediment
- Die-off of fecal coliform
- Adsorption and desorption of iron on suspended sediment

A deterministic model is needed to simulate these processes to better understand water quality conditions in rivers. Multiple computer models have been developed to simulate water quality in rivers and the most suitable model needs to be selected for water quality simulation in the Monongahela River. Following factors need to be considered:

- A model from public domain
- Three dimensional simulation capability
- A model with integrated hydrodynamics and sediment/water quality capability

A number of public domain water quality models are available that contain the basic framework for river model development such as WASP, CE-QUAL-W2, or the latest version of HEC-RAS. WASP is a pure water quality model that requires transport calculation information provided from other models such as Environmental Fluid Dynamics Code (EFDC). Functionally, the WASP model does not offer more than the EFDC water quality module that is based on the CE-QUAL-ICM, which was developed by U.S. Army Corp of Engineers (USACE). The CE-QUAL-W2 model assumes lateral complete mix and is only

suitable for narrow streams and lakes. The previous versions of HEC-RAS could only support 1-D representation of the channel. The latest version of HEC-RAS introduced 2-D representation. Among these models, only EFDC is able to simulate three dimensional hydrodynamics and water quality, and it is an integrated model which does not need external linkage between hydrodynamics and water quality.

The EFDC model is a public domain hydrodynamic and water quality modeling system developed by Tetra Tech. Tetra Tech continues to maintain and enhance the model with primary external support from USEPA. The EFDC is readily available to the general public at http://www.epa.gov/ceampubl/swater/efdc/index.htm. EFDC is unique among current surface water modeling systems in that it incorporates fully 3-D hydrodynamics, salinity, temperature, sediment, toxic contaminant, and eutrophication simulation capabilities in a single internally linked framework. The EFDC model's hydrodynamic simulation capabilities are similar to models such as CH3D-WES, DELFT3D, and ECOM-POM. EFDC incorporates state of the art sediment and adsorptive toxic contaminate fate and transport formulations. Its eutrophication module is based on CE-QUAL-ICM and is capable of representing primary production and nutrient cycling at multiple levels.

The EFDC model also includes a wide range of simulation capabilities for incorporating flow control and navigational structures including culverts, pressure conduits, spillways, weirs, dams and pumping operations as well as time-dependent barriers appropriate for representing lock operations. The operation of the various flow linkages and controls can be specified in a time varying manner or their operation can be controlled by simulation variables such as water surface elevation. The EFDC modeling system also includes a variety of pre- and post-processing, and decision support tools that will greatly improve linkage capabilities.

Tetra Tech developed a simplified 1D version of EFDC for the Monongahela River in 2002 and has extensively validated all components of the EFDC model over the course of the model's 20-year existence, as evidenced by over 120 applications, 20 peer-reviewed journal articles, and 25 peer-reviewed conference papers. Many major EFDC applications have been reviewed by independent scientific panels, including applications for the USEPA's Total Maximum Daily Load (TMDL) and Superfund programs and the State of Florida's Comprehensive Everglades Restoration Plan. Tetra Tech has applied EFDC applied to develop models for simulating sediment transport, fecal coliform bacteria and metals in many rivers throughout the US.

Hydrodynamic and sediment transport model state variables include:

- Water surface elevation
- Horizontal velocity components
- Water temperature
- Dye or other conservative tracer
- Inorganic sediment (minimum of two size classes)
- Sorptive contaminant (minimum of two)

Water quality state variables include:

- Water column algae (up to three classes)
- Immobile benthic algae (periphyton)
- Rooted plants (macrophyte)
- Organic carbon (one to three classes)
- Organic nitrogen (one to three classes)
- Ammonia (NH4)
- Nitrite+Nitrate (NOx)
- Organic phosphorous (one to three classes)
- Orthophosphate (PO4)

- Dissolved oxygen (DO)
- Bacteria
- Metals

In summary, EFDC is a generic 3-D integrated hydrodynamics and sediment transport/water quality model that is the most suitable model for simulating the sediment and metals transport as wells as the fate and transport of fecal coliform bacteria.

I.B.2.b. Receiving Water Model Configuration

To develop the Monongahela River hydrodynamics and water quality model, a variety of supporting data are needed to configure the model domain and external forces of the domain. Model configuration involves setting up the model computational grid using available geometric/bathymetric data, designating the model's state variables, setting boundary conditions and initial conditions. This section summarizes the configuration process and key components of the model. The receiving water model usually requires significantly more computer resources and runs much slower than watershed models. The model simulation period will be a subset of the watershed modeling period. All time-series output including flow, water temperature, sediment, bacteria, and total iron will be processed for the same time period.

I.B.2.b.1 Grid Generation

EFDC is a numerical model and governing equations for hydrodynamics and water quality kinetics are solved numerically using finite difference methods. The model domain needs to be divided into small segments (computational cells) to apply finite difference methods. Model grid generation, will create the computational cells and define average bottom elevations for each of the cells. The study area is approximately 38 miles long from the confluence of the West Fork River and Tygart Valley Rivers to the West Virginia –Pennsylvania border. To develop the model grid, ESRI GIS software ArcMap will be used together with the ESRI's online topography map and satellite image to define the channel boundary. Once the channel boundary is defined, grid generation tools such as the Tetra Tech's GEFDC will be used to create the grid. In general, straight sections of the channel will have relatively coarse resolution and sections with complex shoreline will have relatively fine resolution. Using the satellite images, a channel shoreline GIS will be created and 2-D curvilinear grid will be developed.

EFDC supports all 1-D, 2-D, and 3-D configurations of waterbodies. The Monongahela River is separated to four pools (Point Marion, Morgantown, Hildebrand, and Opekiska) associated with lock and dam structures. It is anticipated that the river will have deep portions and 3-D configuration is needed. The 3-D configuration is achieved by first conducting grid generation on the 2-D horizontal plane, and then dividing the water column in the vertical direction to multiple layers. After the horizontal grid is finalized, the average bottom elevation will be estimated using cross section data from U.S. Army Corps of Engineers existing HEC-2 models that were surveyed for flood studies. It is not expected that all grid cells will have bathymetry data to determine the average bottom elevation and therefore, bathymetry data gaps will need to be filled. For the channel portions with available data, average bottom elevations will be computed in ArcMap directly. Interpolation and extrapolation will be necessary to assign average bottom elevation to each cell without bathymetry data.

An example of curvilinear grid is shown below in Figure I.B-8.

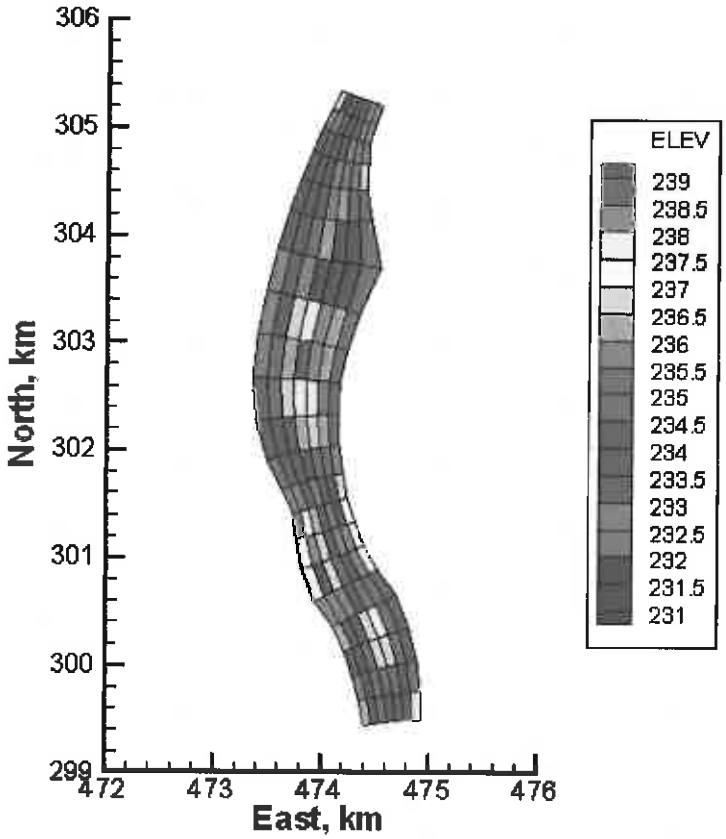


Figure I.B-8. An example of curvilinear orthogonal grid for EFDC

I.B.2.b.2 Boundary Conditions

The flow and water quality conditions are driven by the external forces and internal processes. Boundary conditions represent the external forcing factors. To run the model, boundary conditions require specification. These forcing factors are critical components in the modeling process and have direct implications on the quality of model performance. External forcing factors include a wide range of dynamic information for Monongahela River:

- Weather conditions as surface boundary conditions
- Watershed inputs of flow, heat, sediment, bacteria, and iron
- Point source inputs of flow, heat, sediment, bacteria, and iron
- Downstream boundary conditions

Weather conditions directly impact the hydrodynamics and water temperature in the river. Weather stations will be explored from various sources including NOAA weather service to identify the stations nearby the river. The EFDC model requires air pressure, air temperature, dew point temperature or relative humidity, rainfall, evaporation, solar radiation, cloud cover and wind. Evaporation can be calculated from EFDC's internal evaporation algorithm which uses wind and temperature information. Solar radiation can be calculated using well-establish clear sky solar radiation algorithm such as the one used in the CE-QUAL-W2 model if observation data are not available. The raw weather data will be reviewed first to identify any outlier values and missing gaps. After that, data will be cleaned and gaps will be filled in with different approaches depending on the gaps for example short time period gaps or long term data missing. Then the data will be used to prepare to the EFDC input files aser.inp and wser.inp for the weather conditions.

The Monongahela River mainly receives the flows and pollutant runoff from the West Fork and Tygart Valley Rivers as well as tributaries and direct runoff inputs from the local drainage areas. Two options can be used to represent the flows entering the Monongahela River. If observed flow data are available at or near the mouths of the West Fork River, Tygart Valley Rivers and any tributaries entering the Monongahela River, data can be used because they are the most reliable information. For any other flow inputs without monitoring data, the watershed model results from previous TMDL studies (West Fork River TMDLs, Tygart Valley River TMDLs and Monongahela Tributaries will be used for the flow boundary conditions. If flow data are only available within the West Fork and Tygart watersheds and the flow gages are far upstream of their confluence, watershed model results of flow will be used as the flow boundary conditions.

Based on our previous TMDL development experience for WVDEP, it is not anticipated that water temperature, suspended sediment, bacteria, and iron data will be available on a daily basis from pre-TMDL monitoring sites. The watershed model results will be used as boundary conditions for these parameters. Watershed model results will be processed and formatted into EFDC input files.

In addition to the watershed contributions, point sources directly discharging to the Monongahela River will be represented. Similar to watershed contributions, daily time series flow and pollutants are needed to specify the boundary conditions from point sources. Tetra Tech will work with WVDEP during the permit summary report process to develop appropriate daily time series boundary conditions for point sources directly discharging to the Monongahela River.

It is common for boundary condition data to be incomplete. Various reasons can cause data gaps. For example, sensor malfunction can cause erroneous or missing data and water quality parameters may be only collected during certain periods. The EFDC model runs on sub-daily time steps and requires daily boundary conditions for dynamic simulation. To develop a robust water quality model, data gaps need to be filled appropriately.

Different approaches may be applied to interpolate or extrapolate the limited available data for different data gap patterns. Multiple options are available to fill these type of data gaps for model configuration. Below is a list of example data-filling approaches:

- Linear interpolation can be used to fill short term data missing values;
- Monthly average and long-term values can be used to fill the data gaps with long-term data missing values;
- Regression can be used if the data with gaps are correlated well with other data;
- Missing data can be filled using proven algorithms such as the clear sky solar radiation algorithm to fill the missing solar radiation data;
- Missing data can be filled with derivations from other related parameters;
- Missing data can be filled by patching data from other stations. This approach is usually applied to fill missing air temperature or precipitation data;
- When limited data reveal low concentrations of certain contaminants in the watershed, low concentrations can be assigned to fill the missing data gaps;
- For values at detection limits, 50% of the detection limits can be used to represent the actual concentrations
- If none of the abovementioned approaches are suitable to the fill the gaps of a certain type of data, values can be determined during calibration.

After data gap filling, these data will be converted to EFDC input files.

In addition to the abovementioned boundary conditions, four lock and dams structures divide the river into four pools. When water flows through the dams/spillways, the structures determine how fast the water can pass them. The first three dams/spillways (Opekiska, Hildebrand, and Morgantown) will be considered as internal boundary locations while the Point Marion lock and dam will establish the downstream boundary location. Data from the U.S. Army Corps of Engineers will be used to develop depth/elevation-discharge curves that will mimic the routing of water through the dams/spillways. Corresponding upstream and downstream model grids will be identified for these boundary locations. No water quality boundary conditions are needed for these locations because the model will calculate the water quality constituents and route them through the dams/spillways.

I.B.2.b.3. Initial Conditions

EFDC requires specification of initial conditions to start the model run. The Monongahela River is pooled due to the construction of the dams/spillways. The initial water surface elevation is important to maintain the overall water balance and to ensure correct simulation of the water surface elevation during the entire modeling period. The initial water surface elevations will use the actual observed data on the first day of the modeling period. If no water surface elevation data are available, it is planned to use the full pool level to start the model simulation.

The model allows for constant or spatially varying initial conditions for all model state variables. The influences of initial conditions disappear quickly given the strong external forces (flows from the West Fork and Tygart Valley Rivers); therefore, constant initial conditions will be specified. For the remaining initial conditions, water temperature will be assigned to 20°C uniformly, and all the water quality constituents will be set to 0.1 mg/L.

I.B.2.c. Receiving Water Model Calibration

Once the Monongahela River model is configured, model testing can be performed. Specifically, model testing includes a second check on model configurations to ensure the model runs stably throughout the modeling period. After testing is complete, model calibration is performed. The first step is to evaluate the hydrodynamic results by comparing the modeled water surface elevation with observed data. Water temperature representing river thermodynamics is then verified and water quality rates and constants are adjusted by comparing model output directly to observed data.

I.B.2.c.1 Calibration of Hydrodynamics

The water surface elevation change represents the flow conditions and flow balance in the river. Modeled water surface elevation will be compared against the observed water surface elevation. Both graphic comparisons and statistics will be used to evaluate the model performance of hydrodynamic simulation. The water balance is mainly driven by inflows, precipitation, evaporation, and flow routing through the dams/spillways. Relevant parameters and spillway configurations can be adjusted until modeled water surface elevation agree with the observed data.

Water temperature is also an important indicator for hydrodynamics simulation, especially for 3-D simulation. Similar to the water surface elevation, model results will be compared against data both graphically and using statistics. Coefficients related to heat transport can be adjusted until modeled water temperature agree with data.

I.B.2.c.2 Calibration of Fecal Coliform Bacteria

Die-off is the main mechanism of fecal coliform bacteria once they are discharged to the river. Calibration of fecal coliform bacteria will be to determine the die-off rate. Fecal coliform bacteria in the

Monongahela River will be heavily related to the loadings of the bacteria from all the sources. Therefore, in addition to adjusting the die-off rate, it may be necessary to trace back to the output of previously developed watershed models.

Modeled fecal coliform bacteria will be compared against data. Fecal coliform bacteria levels may vary significantly in the river depending on the actual sources of the bacteria. Both graphic comparison and statistics will be used to support the calibration.

I.B.2.c.3 Calibration of Suspended Sediment

Through years of TMDL development, it has been documented by WVDEP and Tetra Tech that sediment associated iron is a significant contributor to total iron impairments throughout the Monongahela watershed. To accurately simulate the fate and transport of iron, it is necessary to simulate the transport of sediment through the river. Sediments are supplied from the watershed and instream erosional processes and are carried by surface runoff or river flow. Given the lock and dam structures, the Monongahela River is pooled and will be deeper than a natural channel. Therefore water velocity will be lower because the gravitational force due to the natural channel slope has been eliminated resulting in a reduced velocity within the pool. When velocity is low, suspended sediment will settle and deposit to the bottom, and there will be a reduction in the potential for sediment erosion. Therefore, settling is expected to be a significant factor in sediment transport process in the Monongahela River. Settling velocities of suspended sediment vary significantly depending on particle size. The watershed model will provide sand, silt, and clay to the EFDC model. In EFDC model, sediments are divided into cohesive (fine particles) and non-cohesive (coarse particles) sediments. The difference of cohesive and non-cohesive sediments in freshwater system is minimal except that the non-cohesive coarse sediment will have bed load transport pushed forward by river flow. For a pooled river like the Monongahela, the difference will be only on the settling velocities. Sand will be distributed to non-cohesive sediment, and silt and clay will be modeled as cohesive sediments. Settling velocities will be adjusted iteratively during model calibration and model results will be compared against pre-TMDL monitoring data using both graphical comparison and statistics.

I.B.2.c.4 Calibration of Total Iron

Model calibration for total iron will be conducted after sediment calibration is complete. As with sediment, iron levels are heavily related to the external loadings from the West Fork, Tygart Valley Rivers and direct tributaries of the Monongahela River. At the same time, the iron attached to the sediment particles will settle to the river bottom along with the sediments. The attachment of iron to the sediment particles follow adsorption and desorption mechanic. Equilibrium adsorption is assumed in the EFDC model and partition coefficients of iron to all three types of sediments (sand, silt, and clay) will be estimated. Model results will be compared against pre-TMDL monitoring data and the partition coefficients will be adjusted iteratively until model results agree well with data. In addition to the adjustment of partition coefficients, it is highly possible that the settling velocities of the suspended sediments will be further fine-tuned to achieve better performance of the model for total iron simulation.

I.B.3. Biological Stressor Identification

Beginning in the TMDL Group A, Tetra Tech collaborated with WVDEP biologist to establish a methodology to effectively identify significant stressors to biological communities. Biological TMDLs were developed for TMDL Groups through C2. WVDEP has suspended biological TMDL development while investigating their impairment listing methodology. However, Tetra Tech has continued to provide stressor identification (SI) support for WVDEP to evaluate and arrive at the causative stressors for which specific pollutants TMDL may resolve impacts indicated through biological monitoring data. Table I.B-1 provides a summary of previous TMDL Groups with the number of streams that have been evaluated by

the SI process to date. WVDEP may request that the stressor identification continue and expand the analysis to include other biological assemblages. The following section describes the existing stressor identification methodology, Tetra Tech will use if requested. Tetra Tech will work closely with the WVDEP to make necessary modification to the stressor identification process to include indices data from any biological assemblage of concern, including benthic macroinvertebrates and fish communities if data are available. Technical Experts, listed in Section II.C. Personnel, such as Jeroen Gerritsen, have lead or contributed to biological indices, TMDL development, impairment and implementation studies that utilize multiple data sources including fish communities. These experiences will enable Tetra Tech to build upon the existing SI framework to include the best available data in decision making and future TMDL development.

Review and Modify Stressor Threshold Values, Stressor-Response Estimation

In order to begin the stressor identification process, Tetra Tech would recommend reviewing the associations between candidate stressors and biological metrics, and to infer thresholds of biological impairment for each stressor based on current data. Working with WVDEP biologists, Tetra Tech will use the reference approach and the stressor-response relationships between biological metrics and candidate stressors to infer thresholds of biological response to stressors. The large West Virginia dataset will enable Tetra Tech to examine the biological patterns along a particular gradient of interest.

Table I.B-1. Number of Evaluated Biological SI Streams by Group

TMDL Group	Total Number of SI Streams
A	45
B	48
C	35
D	25
E	51
A2	25
B2	95
C2	77
D2	50
E2	138
A3	36
B3	53
TOTAL	**628**

I.B.3.a. Data Analysis and Review from WABbase

To begin the SI process, Tetra Tech will review data sources, most importantly, WVDEP's WABbase, warehoused in an Oracle platform with a Microsoft® Access relational database interface. Guided by the comprehensive SI conceptual model, which represents all potential causes and sources of stress leading to potentially impacted biological assemblages, Tetra Tech will identify all WABbase data that are available to inform our analysis of the likelihood of each candidate cause potentially impacting biological assemblages based on genus or species-level taxonomy in each stream.

Building on our experience working with WABbase and WVDEP biologists, Tetra Tech will conduct a thorough review of each data element in WABbase and construct and test queries that select and export potentially pertinent data related to biological stress. These queries will capture data from all geographic locations that were sampled on biologically assessed streams. For each the queried dataset will combine all available data relating to biological community conditions, water quality, physical habitat, and geographic data.

As part of the data review, Tetra Tech will conduct multiple quality assurance and quality control steps to assure the completeness and accuracy of data used for the SI analysis. Tetra Tech will review all station location information for sites within the biologically assessed watersheds and subwatersheds for consistency and accuracy. Tetra Tech will continue to work with WVDEP to resolve any data quality issues that arise during the review of the data.

I.B.3.b. Stressor Conceptual Model

During extensive experience working with WVDEP to develop USEPA-approved TMDLs and conduct stressor identification, Tetra Tech has developed a comprehensive conceptual model of candidate causes of biological impact (Figure I.B-9). This conceptual model provides the linkage between potential impact causes, their sources, and the pathway by which each stressor can impact the biological community. Sources, impairment causes, and the resulting effects of the biological community depend on the stream or watershed in question. In some cases, biological degradation can be linked to a single stressor; in other situations, multiple stressors are responsible. This conceptual stressor pathway model will be reviewed based on consultation with WVDEP and updated as necessary to capture additional potential sources of concern particular to the watersheds in each TMDL development group.

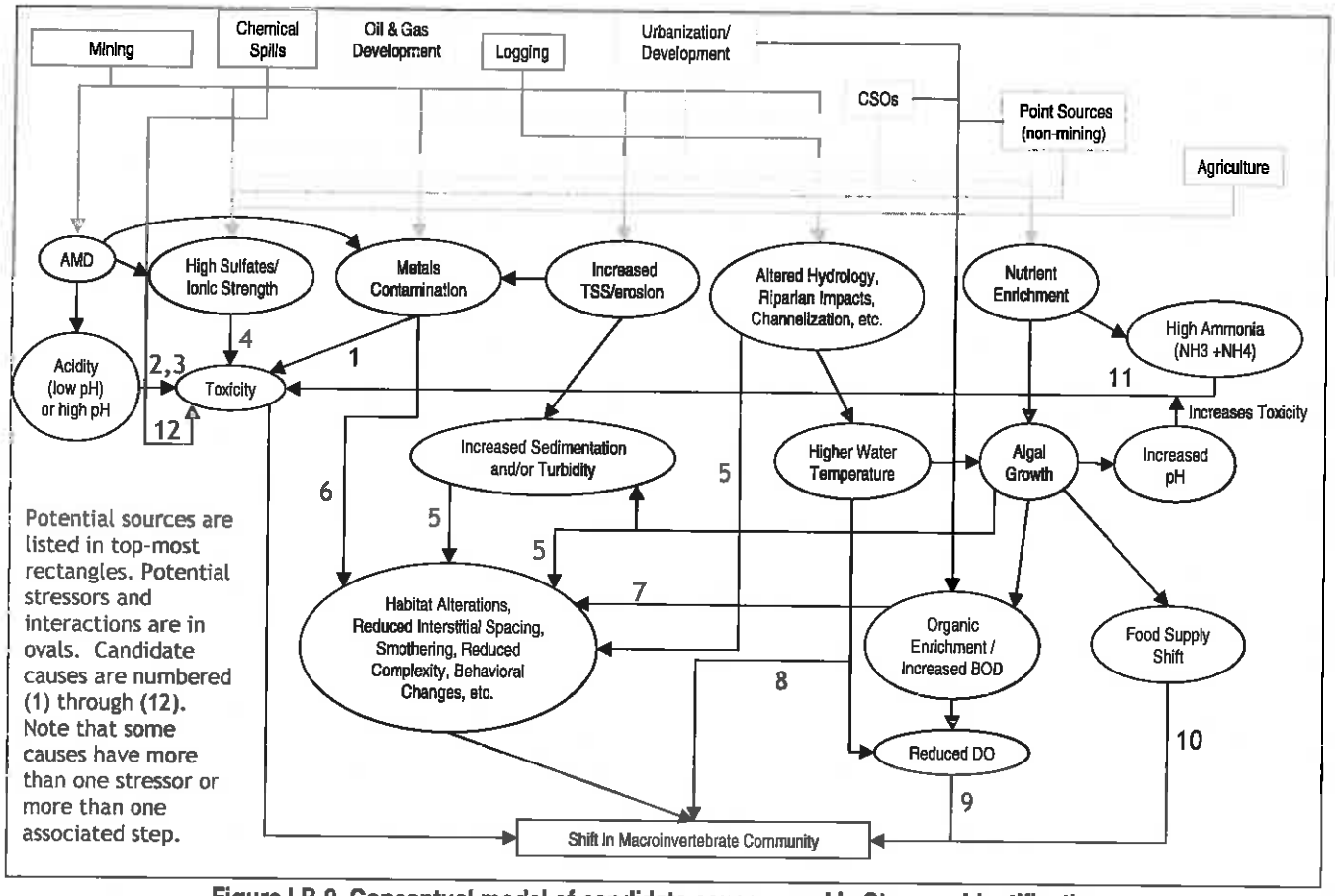


Figure I.B-9. Conceptual model of candidate causes used in Stressor Identification

Tetra Tech will schedule and organize a biological SI meeting with WVDEP to review and discuss the details of the strength of evidence approach. This meeting will enable WVDEP and Tetra Tech to discuss the biological assemblages and for WVDEP to approve or modify the stressor threshold values and conceptual model. The meeting also allows Tetra Tech to have a better understanding of the types of causative stressors that may be responsible for the biological community in particular watersheds.

Customized SI Database

During the preparation and review of analytical data the enormous volume of information can become overwhelming. To assist in the decision making and strength of evidence process of past SI projects, Tetra Tech developed a Microsoft® Access database to house all the data and create summary tables. The database builds from the chemistry, biological data, rapid bioassessment protocol data and sampler comments provided by WVDEP. Subsequent queries format the data and begin to evaluate and normalize the data against water quality criteria and threshold values. Once the data has been normalized using a 1-6 scale for each parameter averages can be calculated by stream and by sampling station. The database has been designed so that it can be included into WVDEP's WABbase and can be modified and expanded to incorporate changes in water quality criteria, updated threshold criteria, or expanded to include additional water quality parameters in the future. Database features include, but are not limited to:

- Quality control to compare the work directive list to the WAB sample data to ensure that sample data and work directive list correspond to each other.

- Summary results for the biologically assessed streams on the work directive list, including other identified impairments.
- A table to record the significant biological stressors for each assessed stream as determined by the strength of evidence and best professional judgment from the WVDEP and Tetra Tech biologists during the SI Workshop.

The final SI deliverable consists of the compilation of data review, analysis, summarizing data, organizing a strength-of-evidence approach and the culmination of a best professional judgment decision made in collaboration between WVDEP and Tetra Tech biologists. Tetra Tech will work with the WVDEP to further improve the decision making process.

The SI results will be incorporated into a biological section for each TMDL report and the technical report. An example of the SI summary database for Hydrologic Group C2 (Middle Ohio River North and South Watersheds) is included in Appendix A, SI Database folder.

I.C. Model Allocations

Tetra Tech, with the help and guidance of WVDEP, will develop allocations that meet and exceed required TMDL components. Tetra Tech will simulate baseline loading conditions, define endpoints for the pollutants of concern, establish limits of source loading alternatives, and consider critical conditions in the allocation process. Following WVDEP's direction, Tetra Tech will utilize a strategy that accounts for and accomplishes a realistic prioritization of pollutant sources with allowable deviation after sensitivity analysis of sources and flow conditions. Allocations will be performed to meet pollutant specific water quality criteria, including an explicit margin of safety (MOS) (WVDEP typically assigns a 5% MOS). Allocations will target load reductions for the most significant sources whereby allocations to precipitation-induced sources will not be more stringent than concentrations of equivalent pollutants resulting from background conditions, and allocations to point sources will not be more stringent than numerical water quality criteria. Final allocations will be presented with pollutant sources identified as to whether they are considered load allocations (LAs) or waste load allocations (WLAs).

WVDEP will be asked to provide a general allocation order, which will guide Tetra Tech in making the necessary reductions to meet fecal coliform endpoints in the priority sequence that WVDEP establishes for each watershed. To aid in the development of allocations, Tetra Tech will provide WVDEP with a baseline output viewer tool that it has developed for making rapid comparisons between baseline (un-reduced) and allocated (reduced) model scenarios. An example of an output viewer tool is included in Appendix A.

I.C.1 Fecal Coliform Allocations

The fecal coliform TMDL endpoint will be based on the instantaneous acute water quality criterion where not more than 10 percent of all samples taken in a given month can exceed 400 counts/100mL and the chronic 30-day geometric mean of 200 counts/100mL, minus an explicit margin of safety. The approach to allocations to fecal coliform bacteria sources will start with a universal 100% reduction to untreated human sewage sources (failing septics). Using the watershed approach (headwaters will be analyzed first, with pollutant loads transferred to downstream watersheds), Tetra Tech will reduce land-based fecal sources following WVDEPs allocation strategy to meet the TMDL endpoint. Loads from CSOs will be reduced in a manner consistent with the waste water treatment system's Long Term Control Plan. Loads from MS4 communities will be identified in allocation tables and summarized by municipal jurisdiction. Tetra Tech will provide WVDEP with a filterable spreadsheet with modeled unit area loading results by subwatershed and landuse.

I.C.2 Metals Allocations

The total iron TMDL endpoint for warm-water streams will be based on the chronic 4-day average of 1.5 mg/L minus an explicit margin of safety (MOS) (WVDEP typically assigns a 5% MOS). The endpoint for trout streams will be derived in the same manner, but using the chronic 4-day average of 1.0 mg/L.
If, under the most stringent and unachievable allocation scenarios, modeling output does not ensure troutwater criterion attainment, Tetra Tech will work closely with WVDEP to propose phased implementation of the TMDLs under which the source allocations necessary to universally achieve an interim iron water quality target. The approach to allocations for total recoverable metals sources will be guided by WVDEP's allocation order. Tetra Tech will make necessary reductions to meet metals endpoints in the priority sequence that WVDEP establishes for each watershed. Using the watershed approach, Tetra Tech will reduce metals sources (including sediment-related metals sources) using WVDEP's allocation strategy to meet the TMDL endpoints. Given the established total iron/sediment relationship described in Section I.B.5, total iron TMDLs will serve as a surrogate for biologically impacted streams where sedimentation is determined as a stressor. Tetra Tech will verify that sediment loadings resulting from total iron TMDLs are equal or more protective than a traditional sediment TMDL using the reference watershed approach. Tetra Tech will assist WVDEP in the selection of the reference watershed when presented with a list of potential streams.

After completion of the initial allocation run, Tetra Tech will submit preliminary results, and ask WVDEP to review and directs changes. Tetra Tech will update the allocations according to WVDEP's input. Finally, allocation databases will be prepared with model output from baseline and allocation conditions. These databases will have queries that automatically prepare and format TMDL related allocation tables. The resulting allocations will be presented on a CD as filterable spreadsheets that identify pollutant-specific and subwatershed-specific baseline and TMDL loadings for individual point sources and categories of point sources.

I.C.3 pH and Dissolved Metals Allocations

The allocation approach will focus on reducing metals concentrations and increasing pH by assigning buffering capacity (alkalinity) using the MDAS model to meet metals water quality criteria; and then verifying that the resultant pH under these conditions would be in compliance with pH criteria.
As general steps of the allocation process, substantive sources (e.g., seeps) of total iron will be reduced first. This step will be taken because, depending on the stream's buffering capacity, existing instream dissolved iron concentrations could significantly reduce pH. Once the model results indicate the achievement of the iron criterion, dissolved aluminum and pH model results will be evaluated under the reduced iron loadings condition. If model results predict non-attainment of the pH and dissolved aluminum criteria, alkalinity additions will prescribed and total aluminum will be reduced from specific point and nonpoint sources.
For subwatersheds with acidic atmospheric deposition sources and low watershed buffering capacity and no AML sources, acidity load reductions will be prescribed (via alkalinity addition) to the extent necessary to attain pH criteria at the subwatershed outlet. For subwatersheds with historical mining sources present, the predicted acid loads from atmospheric deposition will be first offset by alkalinity addition then the total aluminum loading from AMLs will be reduced to the extent necessary to attain dissolved aluminum water quality criteria.

For subwatersheds with active mining sources and AML present, the aluminum loadings from AML sources will be reduced until compliance with criteria will be attained, or to the maximum practical extent. If further reductions will be necessary or in subwatersheds with active mining point sources and no AML, the point source loadings will be reduced until criteria will be attained.

I.D. TMDL Report Development

I.D.1. Report Outline

For each TMDL watershed, Tetra Tech will develop a comprehensive TMDL report package that provides technical information sufficient to meet or exceed federal regulatory (40 CFR 130) requirements and USEPA Region III guidance for TMDL approval. The report package will list impaired streams, identify pollutant sources, and enumerate the pollutant reductions needed to achieve state water quality criteria for each of the impaired segments. Reports will also be designed to be useful resources for TMDL implementation efforts by responsible agencies and programs. The TMDL report package will consist of a general report with appendices, a technical report with appendices, and an interactive ArcGIS project that displays TMDL results in a spatial format. Report appendices will be in standard file formats such as Microsoft® Excel spreadsheets and Adobe PDF files that do not require special hardware or software to view. The entire report package will be presented in digital form on a CD-ROM. This format allows for cost-effective distribution of the report to state agency personnel, stakeholders, and the concerned public. This format also allows for easy uploading to the WVDEP website. Example TMDL packages are provided in Appendix A.

Tetra Tech has produced TMDL reports for the WVDEP for more than 10 years. Through multiple drafts of each TMDL report, a report format has evolved that successfully meets both client expectations and USEPA regulatory requirements. Report structure and contents of the public report, technical report, and interactive ArcGIS project are discussed in detail below.

The general report will consist of a main section, allocation Microsoft® Excel spreadsheet appendices and a supporting ArcGIS project. The main section will describe the overall TMDL development process for the TMDL watershed, identify impaired streams, and outline the source assessment of pollutants and biological stressors. It will also describe the modeling process and TMDL allocations. The general report will list measures that will be taken to ensure that the TMDLs are met. The TMDL report will also include spreadsheets that provide detailed source allocations and reductions associated with successful TMDL scenarios. The contents of the general report will consist of information organized into sections shown below. Report design will be flexible to accommodate the impairments found in each TMDL watershed. Relevant sections describing impairment-specific TMDLs will be added or deleted as necessary.

The technical report will describe in detail the methodology Tetra Tech uses to develop TMDLs. Information in the technical report will satisfy all USEPA regulatory requirements for review, thus leading to final TMDL approval. Emphasis will be placed on providing a thorough explanation of MDAS watershed model setup, calibration, and post-allocation output. Biological SI process will also be described.

The technical report will also have appendices that provide supplementary graphs and spreadsheets that document the methodology described in the technical report. Appendices to the technical report will be provided as needed to describe relevant watershed features and document model development. The number of appendices is expected to be approximately twelve, based on the appendices needed for previously completed West Virginia TMDLs. Past technical report appendices have included the following information:

- Stream impairment and previous TMDL no longer effective
- Bank Vegetation Cover Scores
- TSS/Metals correlation spreadsheet

- Modeled landuse tables for fecal coliform and metals
- Failing septic analysis
- NPDES permit descriptions
- Harvested and burned forest areas
- Modeled road descriptions
- Model water quality and hydrology calibration results
- Water quality data (chemical and biological)
- SI summary information
- Sediment reference stream information

The interactive GIS application will be in an ArcGIS project format. The ArcGIS project will allow the user to view spatial data in detail, magnify features of interest, and identify attributes of individual features. This project will be included on the report CD-ROM.

The spatial data featured in the ArcGIS project will be organized as in Table I.C-1. Topographic maps and stream coverages will orient users, and help them find impaired streams and TMDL watersheds. Features such as AML highwalls and bond forfeiture sites will show pollutant sources.

Table I.C-1. Example of Interactive GIS Project Shapefiles

Watershed Coverages	▪ Pre-TMDL Monitoring Sites ▪ MDAS modeled subwatersheds ▪ Impaired Streams ▪ Streams ▪ NLCD 2006 Landuse ▪ USGS 100K Topographic Map
Metals TMDL Coverages	▪ Bond Forfeiture Sites ▪ AML Discharges ▪ AML Areas ▪ AML Highwalls ▪ Valley Fill Areas ▪ Mining NPDES Outlets
Fecal TMDL Coverages	▪ Fecal POTW Discharges ▪ Agricultural Intensity ▪ Agricultural Runoff Potential ▪ MS4 Areas
Sediment TMDL Coverages	▪ Oil and Gas Wells ▪ Marcellus Shale Wells ▪ Logging Operations ▪ Burned Forest

I.D.2. Preliminary Draft TMDL Report

Tetra Tech has worked closely with WVDEP TMDL staff for over 10 years to edit TMDL reports to client specifications. After modeling all impaired streams in the TMDL watershed, Tetra Tech will generate a preliminary draft TMDL report. This report will be submitted to WVDEP in digital format on CD-ROM, or via a restricted-access Internet ftp site. The preliminary draft report will consist of a complete report outline with supporting text and appendices, minus any report text of regulatory nature that is the responsibility of WVDEP.

Tetra Tech will receive WVDEP comments on the preliminary draft report during the period of time between the report submittal and the draft deliverable due date. Excellent communication between Tetra Tech and WVDEP has increased efficiency in the report editing process. Tetra Tech's local presence in Charleston, WV allows Tetra Tech technical staff to work face-to-face with the WVDEP client to execute last-minute document edits when necessary. Tetra Tech will make WVDEP edits and prepare a draft report to be distributed for public comment.

I.E. Status Report and Other Meetings

In addition to providing bi-monthly progress reports, Tetra Tech will hold project status meetings on a regular basis, either in-person at WVDEP headquarters, or via conference call. When complex issues arise, Tetra Tech has found that the fastest route to resolution entails visiting WVDEP's offices for an in person meeting. Meeting face to face provides both parties with an opportunity to review pertinent data and facilitates discussion. For the same reasons, project deliverables will be handed over in person. Tetra Tech will contact the WVDEP staff member(s) responsible for reviewing the deliverable to set up a meeting, during which the deliverable will be presented and discussed. This will facilitate WVDEP's review of the deliverables and keep the project running on schedule.

With each TMDL project, Tetra Tech makes staff available to tour the project watershed. Not only do the tours provide the modelers with intimate knowledge of the physical characteristics of the watershed and pollutant sources, it also provides an opportunity to identify new sources or those that need further investigation.

I.F. Public Participation Meetings

Tetra Tech will assist WVDEP with coordinating and facilitating public meetings to explain TMDL development. Tetra Tech will be available to participate in these meetings at any time and any location necessary during the TMDL process. The meetings will be designed to broaden the public's and stakeholders' understanding of the TMDL development process. Tetra Tech will prepare visual aids such as slides and customized ArcView projects for the presentations, when needed. Personnel who are intimately involved with the various aspects of TMDL development will be available to explain model components, model development, source characterization, data development, model results for both baseline and TMDL conditions and the impacts of various potential allocation scenarios. Tetra Tech has an extraordinary amount of experience in presenting our work in a public forum. Tetra Tech's presence and understanding of the concerns related to TMDL development from both a regulatory and affected party perspective will help facilitate interaction between stakeholders and WVDEP.

Tetra Tech will also be available for public meetings to discuss draft TMDL results at any time and any location necessary, providing the same services and support required for the stakeholder input meetings described above. Personnel who are intimately involved with TMDL development will be available to provide detailed information regarding the substantive components of the TMDL and to take comments from concerned stakeholders. Tetra Tech will work with WVDEP in order to provide meetings that are informative and will facilitate stakeholder involvement. Prior experience in such meetings gives Tetra Tech an understanding of the types of comments and questions that will be posed at meetings concerning draft TMDL documents and enables them to help orient stakeholders and facilitate comments on the draft TMDL.

Tetra Tech will also provide support to WVDEP during the public review and comment period by answering any technical questions posed by stakeholders and addressing any revisions to the draft TMDL as a result of stakeholder input. Policy questions or issues will be addressed by WVDEP and included in the documents once provided in electronic format to Tetra Tech.

I.G. Response to Public Comment

I.G.1. Address Comments

Tetra Tech will receive and address individual public comments on the draft report. Public comments will be incorporated into the final document. Tetra Tech is experienced in addressing comments from a wide spectrum of West Virginia stakeholders, from industry to local watershed groups. Tetra Tech is fully prepared to defend its technical approach and TMDL results to any watershed stakeholder. Tetra Tech will prepare a responsiveness summary that will address stakeholder questions, and point to changes in the document that resulted from those questions. Tetra Tech will also provide detailed explanations to those comments that did not lead to revisions to the TMDL report. Questions or comments pertaining to state policy will be addressed by WVDEP and provided to Tetra Tech in electronic format to be included in the TMDL document response summary.

I.G.2. Final Draft TMDL Report

Upon conclusion of the editing process, Tetra Tech will submit a final draft TMDL report suitable for USEPA review and TMDL approval. This final draft report will incorporate all comments from watershed stakeholders, plus any additional comments from WVDEP. The report will be submitted in digital format on CDROM. Submittal date will be determined by the project timetable.

I.G.3. TMDL Records Retention

Tetra Tech will provide a complete administrative record for each TMDL watershed on CD-ROM to WVDEP and the USEPA upon receipt of the USEPA's final approval letter and decision rational documentation. Tetra Tech will archive all files pertaining to TMDL development and retain them for a minimum of five years. Files will be stored electronically and will be available upon request within 10 days of receiving such a request from WVDEP.

I.G.4. Schedule

Tetra Tech recognizes the need for a detailed schedule due to the relatively short timeframe in which the TMDLs are to be developed. Tetra Tech will work closely with WVDEP at the beginning of the TMDL process to develop a timeline and deliverable schedule for the steps outlined in Sections I.A,I.B, I.C, and I.D that will lead to a valid, defensible TMDL that can be approved in a timely manner. Tetra Tech has extensive experience developing TMDLs within a very short period of time and has developed a methodology for achieving that efficiently. The TMDL process is primarily a series of steps that build upon each other, leading to interim deliverables. This process begins with the review of the work directive and ends with the issuance of final reports (Figure I.G-1). Although the TMDL process is primarily cumulative in nature, throughout the process there are a number of tasks that can be worked on while interim deliverables are being reviewed. Tetra Tech technical personnel will be available to meet with WVDEP as they review and provide comment on all interim deliverables. This provides for a constant flow of work throughout the contract period and maximizes efficiency throughout the review process.

An important aspect of the schedule is the review and QA/QC of datasets as they are introduced into the process. Tetra Tech recognizes that it will be working with statewide datasets, which, due to their large size, are bound to contain inconsistencies and random error. Because the TMDL development process is cumulative in nature, any errors that are not immediately identified will be propagated to each successive step in the process. Given the technical complexity and the timeframe within which these TMDLs are to be developed, having to go back and correct errors, no matter how minor, could result in future deadlines not being met. Therefore, Tetra Tech will spend the time necessary to assist WVDEP in identifying and correcting any errors in its datasets as TMDL development proceeds in order that the final product is delivered on time.

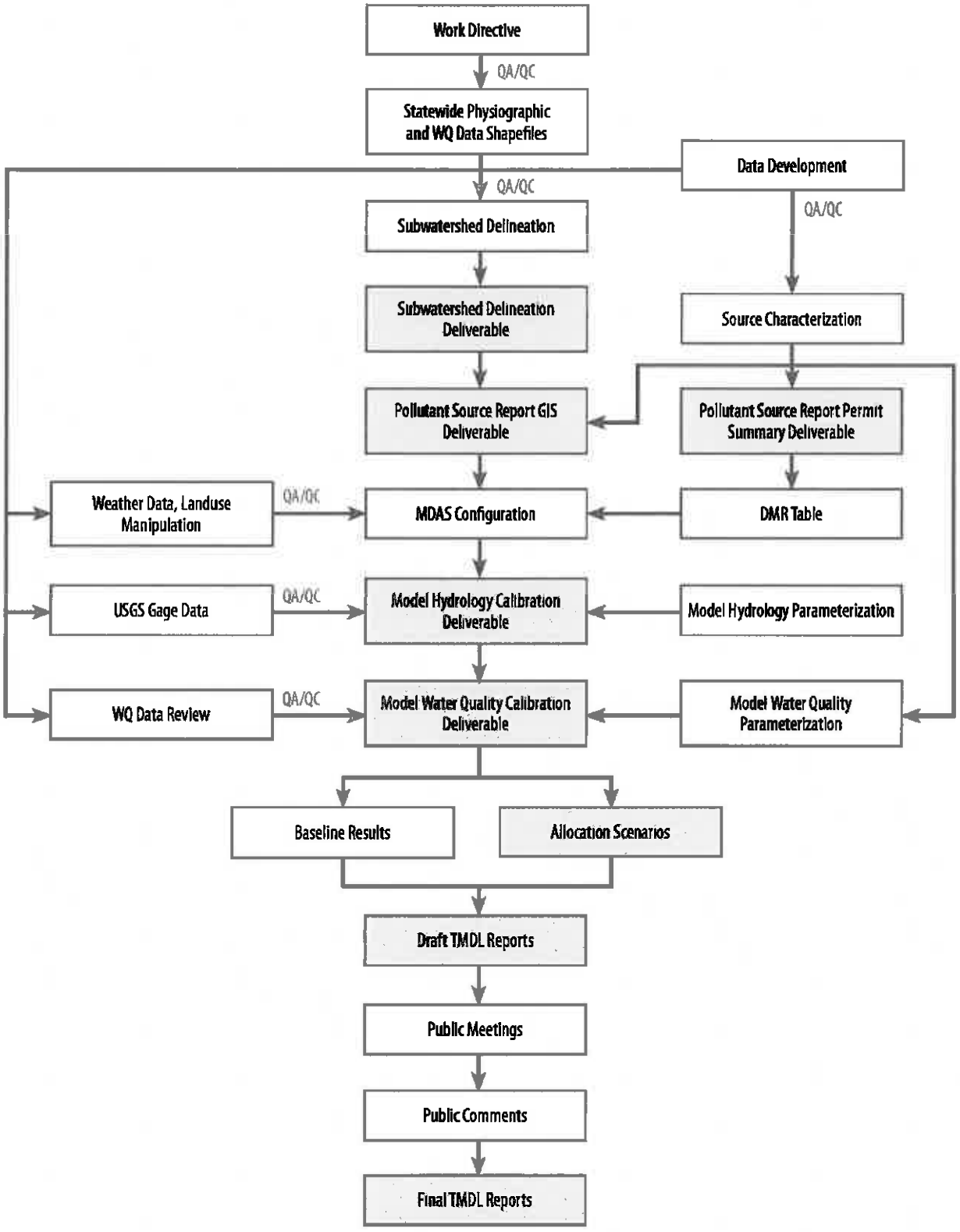


Figure I.G-1. TMDL Development Process Flowchart

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II. Management and Resources

As requested in the Expression of Interest (EOI), this section discusses Tetra Tech's management capabilities and available resources to support this project. Specifically, this section presents information on the following:

- **Organization**—discusses Tetra Tech's history and background, including services, size and office locations.
- **Resources**—describes hardware, software and other resources available to support this project.
- **Personnel**—presents the experience and qualifications of the proposed Tetra Tech team.
- **Project Management**—describes Tetra Tech's approach to project management.

II.A. Organization

Tetra Tech, Inc.

Founded in 1966, Tetra Tech, Inc. is a leading provider of specialized environmental management consulting and technical services. We develop innovative, successful, and cost-effective solutions to complex environmental problems for public and private clients. Tetra Tech's success is a result of several factors, starting with technical skills in a wide range of disciplines and including a commitment to open, honest communication about project performance with clients, which fosters partnerships that enable us to meet fast-track schedules and stay within budget. Tetra Tech's vision for growth and diversification to meet clients' needs has been another key to our success. As environmental policies and regulations have changed the ways our clients do business, Tetra Tech has hired national experts and acquired firms that are knowledgeable in those areas and has put their skills to work. The result is that today, as a publicly owned company, we have 350 offices with over 13,000 employees worldwide. More important than our size, however, is that Tetra Tech is rated consistently by the industry as one of the most financially stable, top-quality environmental engineering firms. This year marked the ***twelfth*** consecutive year in which Tetra Tech was ranked 1st in the top U.S. water firms by *Engineering News-Record*. Tetra Tech also was ranked #1 in Water Supply, Water Treatment, Solid Waste, Environmental Management, Environmental Science, and Environmental Consulting. In addition, *Engineering News-Record* ranked Tetra Tech #3 in their "Environmental Firms in International Markets", #6in their "The Top 200 Environmental Firms" and #7 overall in their "The Top 500 Design Firms" issues.

Key Environmental Services of Tetra Tech's Water Resource Center

- TMDL Development
- Watershed Management
- Physical, Chemical and Biological Monitoring
- Stormwater Assessment and Management
- Watershed Modeling
- Hydrodynamic and Water Quality Modeling
- Environmental Tool and Systems Development

Tetra Tech was originally founded to provide engineering services related to waterways, harbors and coastal areas. Our reputation as a national leader in the water resources arena was forged through our early coastal water quality efforts and was solidified in the early 1980s when we established the Water Resources Center and were awarded the first in a series of national watershed assessment and management contracts with the USEPA Office of Water. For over 20 years the Water Resources Center has supported USEPA's watershed and water quality programs, through multiple contract re-competes. In fact, we have never lost a contract with USEPA in which we were the incumbent contractor—a direct indicator of the consistent high quality of our products and our ability to identify and implement evolving technologies and trends. In addition to our national role in developing watershed and water quality management tools and practices, the Water Resources Center has been asked by other federal agencies (e.g., U.S. Army Corps of Engineers [USACE]), more than 40 states, and numerous local and municipal agencies to provide technical assistance in designing and implementing watershed and water quality related programs and plans for their waters. In response to these requests, the Water Resources Center has grown from a core staff of 40 professionals in 1992 to more than 100 professional scientists and engineers in 2013. These staff are located in offices across the United States, but all report to central management in the Center's headquarters in Fairfax, Virginia. Our growth and office diversification has been a direct result of the increased requests for our services and demonstrates our ability to adapt to our clients' needs. For example, the Center opened our Charleston, West Virginia, office in July 2002 to provide local support to WVDEP in the development of TMDLs. Since then, Tetra Tech management and technical staff have contributed to more than $7.9 million worth of work directly for WVDEP, resulting in more than 3,600 approved TMDLs in addition to over 450 ongoing TMDLs.

Our Charleston, West Virginia office will be the primary office for this project and will be supported by staff in our Fairfax, Virginia; Owings Mills, Maryland; Cleveland, Ohio; and San Diego, California offices, as necessary. Table II-A-1 summarizes the office locations expected to support this project and the associated number of employees. Resources and equipment available to support this project are described in the following section (II.B. Resources).

Table II-A-1. Tetra Tech Offices

Office Location	Number of Employees
Charleston, West Virginia	7
Fairfax, Virginia (excluding offices listed in this table)	100
Owings Mills, Maryland	25
Atlanta, Georgia	24
Research Triangle Park, North Carolina	15
San Diego, California	14
Cleveland, Ohio	11

II.B. Resources

This section provides information on the support services and equipment capabilities for the offices proposed to support this project.

The Fairfax, Virginia office has five contract administrators dedicated to tracking the financial status of contracts and ensuring Tetra Tech meets all contractual requirements. Activities of the contracts management staff include accessing and distributing weekly financial reports to the Tetra Tech Project Manager, issuing subcontractor agreements, tracking and administering subcontracts, and generating and submitting progress reports and invoices. We also have several administrative support staff who perform a variety of administrative duties, such as answering phones, arranging conference calls and package delivery, processing expense reports and invoices, and photocopying.

Tetra Tech has several accounts with overnight delivery services to ensure timely delivery of important products. We have accounts with Federal Express, United Parcel Service and DHL.

Tetra Tech maintains an account with Verizon services for our teleconferencing and web conferencing needs. Teleconferencing and web conferencing for an unlimited number of attendees can be arranged immediately using Microsoft® Skype for Business.

Tetra Tech maintains state-of-the-art computing facilities, equipment, and software (Tables II-B-1 through II-B-7) to support our clients' needs for project management, information management, data and geospatial analysis, database management, mathematical modeling, literature searches, Internet access, file maintenance and storage, document production, and graphics generation.

Tetra Tech's printing and reproduction resources are listed in Table II-B-1. Tetra Tech also has extensive document and graphics production capabilities. For example, our Fairfax, VA office maintains a fully equipped publications and graphics department with six full time staff, skilled in both PC and Macintosh systems. Our desktop publishing and graphics specialists consistently produce high-quality environmental reports, brochures, posters, handbooks, documents, and multimedia products. Tetra Tech's publications and graphics department has the capability to generate multicolor or black-and-white maps, graphs, presentation charts, viewgraphs, 36-inch-wide color posters, and other audiovisual materials using a wide range of type styles and page formats. We have expertise in developing and maintaining Internet-ready documents and functional, database-driven web sites for USEPA and other federal agencies. We are capable of producing layout, coding, scripting, graphics, production/editing, database setup, and output reports for the Internet.

Tetra Tech's computer hardware and systems capabilities are also listed in Table II-B-1. Tetra Tech uses electronic communication systems to facilitate data transmission, e-mail, and Internet access. We maintain intra-office and Internet connectivity and an Internet Server that hosts a File Transfer Protocol (FTP) site and a World Wide Web (www) site. Tetra Tech maintains full 24-channel T1 direct access to the Internet for rapid and reliable external electronic communications in all of its offices, including the Charleston, WV location.

Software applications used by Tetra Tech for statistical, database and web development are listed in Table II-B-2, for computer programming are listed in Table II-B-3, for GIS development and data processing are listed in Table II-B-4 and for environmental modeling are listed in Table II-B-5.

Our GIS resources include fully equipped GIS and computer-aided design (CAD) laboratories. Desktop GIS is widely used by our scientists and engineers on a daily basis to support our projects. More intensive

GIS processing is achieved using ESRI's ArcGIS Desktop Standard, Basic and Advanced Version 10, customized MapObjects applications, and dedicated systems. Tetra Tech also uses a variety of database platforms and software tools. Our broad information technology expertise includes proficiency in Oracle and Microsoft SQLServer, MS Access databases; operating systems such as VMware, Linux and Windows; and programming languages C++, Visual Basic, Java, .NET, ArcView Avenue, and Arc/Info AML. Tetra Tech also utilizes virtual server operating systems and cloud computing using VMware Esx Server.

Other support functions include Tetra Tech's accounts with numerous online information services, including GIS data repositories, and personnel with familiarity and experience searching a wide variety of databases, including USEPA's STORET and U.S. Geological Survey (USGS) National Water Information System (NWIS). We also have easy access to a host of major national libraries, including USGS, U.S. Department of Agriculture (USDA), USEPA, National Oceanic and Atmospheric Administration (NOAA), and a large number of academic and public libraries. Tetra Tech also can connect directly to the mainframe at USEPA's National Computer Center in Research Triangle Park, NC, with desktop access provided through a cluster controller. Tetra Tech has extensive experience using the expansive processing and storage resources available at USEPA's computer center. Furthermore, Tetra Tech has direct access to WVDEP's ERIS database through a virtual private network connection from their Charleston, WV office, enabling Tetra Tech to verify any questionable permit information in real time.

Table II-B-2. Desktop Access Data Processing Hardware

Equipment	Quantity
High Capacity Network Server	20
IBM-Compatible PC	40
Macintosh PC (Power Mac, etc.)	1
Notebook/Laptop IBM-Compatible PC	68
Windows 2003/2008 Internet Server with FTP and Web Site Support	12
Linux Internet Server with FTP and Web Site Support	15
Hewlett-Packard DesignJet 5000 Color Plotter (60" wide)	1
Xerox ColorCube Printers / Copiers	2
Xerox WorkCenter Printer / Copiers	3

Table II-B-3. Statistical, Database, and Web Development Software Packages

Database Software	Statistical Software	Web Development Software
▪ Oracle 11g/12g ▪ MySQL ▪ Postgres ▪ MSSQL Server/Enterprise 2012/2015 ▪ Microsoft Office 2013 ▪ Microsoft Project 2013 ▪ Microsoft Visio 2008/2010 ▪ Microsoft Visual Studio 2013/2015 ▪ MS Visual Studio Ultimate 2013/2015 ▪ MS Office One Note 2013 ▪ MS SharePoint 2013	▪ Statistica 6.1 ▪ Mathematica	▪ Dreamweaver MX CS6 ▪ Macromedia Studio MX ▪ Lotus Domino Lotus Notes ▪ Fireworks ▪ Adobe Flash CS5/CS6 ▪ Adobe Photoshop CS6 ▪ Oracle Jdeveloper ▪ Drupal

Table II-B-4. Programming Language Compilers

Compilers		
▪ Intel Visual Fortran Compiler ▪ Sun Java Studio	▪ Pascal 7.0, DOS and Windows ▪ Visual C++ 5.0, 6.0 ▪ Visual Studio v6.0 ▪ Visual Studio 2010, 2012, 2013, 2015 ▪ Borland C++ 4.5 ▪ Visual Basic 5.0	▪ Visual Source Café ▪ SPARC Works C++ ▪ Visual KAP Parallel Computing ▪ Oracle JBuilder ▪ Python

Table II-B-5. GIS Development and Data Processing Hardware and Software

Equipment	Quantity
IBM-Compatible Workstation/Laptop	285
40TB Mass Storage	4
Overland Tape Drive LTO-4 20TB	1
CD/DVD Writers	20
ESRI ArcGIS Desktop Advanced 10.2	7
ESRI ArcGIS Desktop Standard 10.2	24
ESRI ArcGIS Desktop Basic 10.2	7
ESRI ArcGIS 3D Analyst	1
ESRI Spatial Analyst 10	16
ArcGIS for Server Enterprise 10	2

Table II-B-6. Environmental Computer Models and Systems used by Tetra Tech

Model Category	Model Name
Ecological	IFIM, HEP
Watershed Runoff	HSPF, NPSM, LSPC, MDAS, SWMM, HEC-1, TR-20, PSURM, WSTT, GWLF, AGNPS, P8, SWAT
Thermal Fate	EFDC, TRANQUAL, HSPF, DISPER, ELA
River Hydraulics	HEC-2, HEC-RAS, WSPRO, FESWMS-2DH, DAMBREAK, DWOPER, UNET
Hydrodynamics	EFDC, CAFE, TEA, CE-QUAL-W2, TABS-2, FESWMS-2DH, DYNHYD5, MIT-DNM, RMA
Discharge Plume	CORMIX, USEPA Plume Models
Mixing Zone	CORMIX, EFDC, TEA/ELA, CAFE/DISPER
Eutrophication	QUAL2E, WASP, CE-QUAL-W2, CE-QUAL-RIV1, RIVHW, EFDC, BATHTUB, LAKE2K
Toxic Fate	TOX15, SMPTOX, RIVRISK, AMMTOX, TOXCALC
Sediment Transport and Scour	TABS-2, STUDH, HEC-6, QUASED, HEC-RAS, EFDC
Ground Water	MODFLOW, MOC, PLASM, Random Walk, GLEAMS

II.C. Personnel

Tetra Tech will administer the proposed contract from the Charleston, WV office of Tetra Tech's TMDL and Water Resources Center. Figure II-C-1 shows the proposed program management organization. It features a core management team of dedicated senior managers who have clearly defined management roles to ensure timely, high-quality, cost-effective performance under the contract. In addition, it shows the staffing plan of key Technical Leads, who will guide support staff in the completion of each aspect of the TMDL development.

Our Project Manager, Mindy Ramsey, and key Technical Leads will be located in the Charleston, WV office, and other management staff (Program and Deputy Program Manager) will be located in our Fairfax, VA, office. For more than 10 years, the Charleston office has worked on West Virginia TMDL projects, fostering close working relationships with key WVDEP personnel. As demonstrated during this time, we can draw upon our extensive technical expertise and resources from offices throughout the country (Cleveland, OH; Fairfax, VA; Owings Mills, MD; Atlanta, GA; Research Triangle Park, NC; and San Diego, CA) to support the WVDEP TMDL program seamlessly and in an efficient, cost-effective manner. Nearly 40 staff have contributed to the innovative technical approaches and designs for more than 5,000 West Virginia TMDLs that have been completed or are currently under development through WVDEP contracts. The Project Manager will have the authority to allocate and commit these additional staff to the WVDEP TMDL projects.

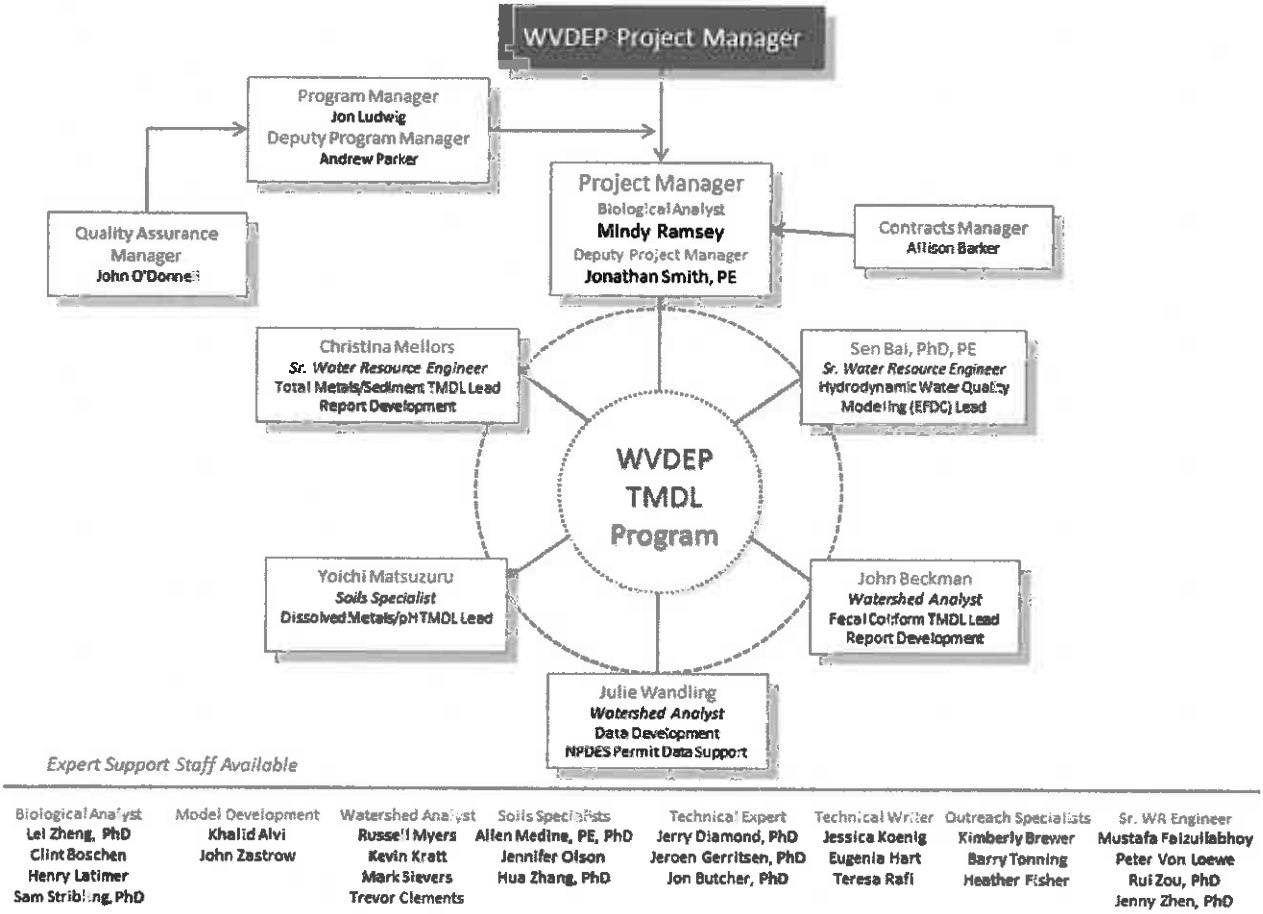


Figure II-C-1. Organization of the Proposed Tetra Tech Team

Core Management Team

Brief descriptions of the roles and qualifications of each member of the Core Management Team follow.

Jon Ludwig, Program Manager

For 10 years, Mr. Ludwig successfully managed five large WVDEP TMDL contracts that contain very aggressive project schedules that progressed simultaneously, leading to timely, high-quality, and cost-effective performance. His leadership and energy have produced highly technical and innovative solutions that have helped WVDEP's TMDL Program become a national leader in TMDL development and have resulted in over 4,500 USEPA approved TMDLs. Mr. Ludwig has over 15 years of experience providing technical and management in all areas of water resources and TMDL development and has collaborated with WVDEP's TMDL Program Manager for over 13 years, developing practical solutions for complex programmatic TMDL issues. Mr. Ludwig will provide leadership through programmatic and technical guidance to ensure WVDEP's TMDL Program continues as the national leader in TMDL development.

Mindy Ramsey, Project Manager and Biological SI Lead

Ms. Ramsey is the Director of Tetra Tech's Charleston, WV office and will provide the local day-to-day point of contact to WVDEP and will work closely with the WVDEP Project Manager to maintain clear, focused direction of the project. She will work closely with the Program Manager, Mr. Jon Ludwig, to staff projects and maintain communication between all parties. She has supported biological TMDL development, document revision, and allocations; and has overseen the approval for the C2 and D2 watershed group TMDLs. Ms. Ramsey lead the USEPA approved TMDL projects for the E2 and A3 watersheds. She is currently leading the B3 and C3 watershed group TMDL development efforts and is responsible for staff planning, reporting progress, and invoicing.

Allison Barker, Contract Administrator

Ms. Barker will be responsible for financial reports, contract administration, and cost control. She has served as the Contract Administrator for the six previous WVDEP TMDL contracts (Purchase Order No. DEP12147, DEP13860, DEP15231 DEP15530, DEP15990, DEP16379, and DEP 16550) and has done so since the project's inception. Ms. Barker is the Contracts Group Manager and a senior contract administrator in Tetra Tech's Fairfax office. She has been extensively involved in negotiating and managing all levels and types of federal and private sector contracts and subcontracts.

Sen Bai, PhD, PE, Hydrodynamic Water Quality Modeling Lead

Sen Bai will be responsible for leading multi-dimensional grid-based modeling efforts for TMDL development in large rivers with multiple major tributaries. Dr. Bai is an environmental engineer/modeler providing technical and project management support to federal, state, and municipal clients in the areas of water quality modeling, watershed modeling, hydrodynamic modeling, watershed management, and TMDL development and implementation. Dr. Bai has extensive experience addressing nutrients and eutrophication, enteric bacteria, and sediment transport and has served as lead modeler for more than 30 waterbodies and watersheds, including lakes, rivers, reservoirs, bays and coastal area in the United States and internationally (Canada, Slovenia) using CE-QUAL-W2, EFDC, WASP, LSPC, and HSPF. Dr. Bai will lead the integration of model output from previous TMDL projects (e.g., West Fork River, Tygart Valley River, Monongahela River Tributaries) into the receiving water model as boundary conditions for the Monongahela River main steam TMDL.

John Beckman, Fecal Coliform Bacteria TMDL Lead

Mr. Beckman will provide leadership for all tasks associated with bacteria TMDLs under this contract, coordinating technical tasks closely with the Project Manager. He is a watershed analyst with over 18 years of experience specializing in TMDL development, water quality modeling, data management, GIS analysis, technical writing, and field investigations. Mr. Beckman has worked closely with WVDEP TMDL staff over the last 9 years developing and refining technical approaches for WV Fecal Coliform

Bacteria TMDLs, including characterizing and developing model inputs for failing septic systems, agricultural sources, and various MS4 and CSO communities.

Yoichi Matsuzuru, Dissolved Metals/pH TMDL Lead
Mr. Matsuzuru will lead all tasks associated with Dissolved Metals/pH TMDLs if needed under this contract and will work closely with the Project Manager and Deputy Project Managers to provide technical solutions for dissolved metals/acidity issues that may occur. He will also work closely with Ms. Christina Mellors developing and refining technical approaches with the total metals/sediment TMDLs. Mr. Matsuzuru has extensive experience in constructing watershed water quality models, and is a specialist in developing mathematical models to characterize pollutant transport and chemical reactions. He has led development of chemical reactive transport model codes, as well as the acid rain module in the Mining Data Analysis System (MDAS). He has been extensively involved in TMDL technical development activities throughout the U.S. Most recently, Mr. Matsuzuru has led the development of aluminum and pH TMDLs for selected streams in the Hydrologic Groups, D2, E2, A3, and B3. He will continue to support model development which will be applied to streams impacted by pH and dissolved metals.

Christina Mellors, Total Metals/Sediment TMDL Lead
Ms. Mellors will lead all tasks associated with Total Metals/Sediment TMDLs under this contract, coordinating closely with the Project Manager and Mr. Yoichi Matsuzuru to continue to evolve the technical representation of the total metals and sediment in MDAS model. Over the past 12 years, she has led total metals/sediment related TMDL projects in WV, working closely WVDEP staff to develop highly detailed technical approaches for representation of mining permits and sediment sources in the MDAS model. She served as the technical lead for the total metals/sediment TMDLs in the Gauley River watershed, which was WVDEP's initial pilot project for representing the dynamic linkage of total iron and sediment in the MDAS model. Ms. Mellors is a Senior Water Resources Engineer and has contributed technically to virtually all of the WV TMDL projects that Tetra Tech has completed since 2002.

John O'Donnell, Quality Assurance Manager
Mr. O'Donnell will be responsible for all QA activities for the contract, including the implementation and maintenance of the Quality Assurance Project Plan (QAPP). He is Quality Assurance Manager for the Fairfax, VA group offices, serving as Quality Assurance Officer for contracts in the Fairfax office and for Tetra Tech's Biological Research Facility. He has developed office-wide quality assurance program and quality systems and tools to meet quality assurance requirements of diverse contracts in the Fairfax Group offices.

Andrew Parker, Deputy Program Manager
Mr. Parker will support Mr. Ludwig and Ms. Ramsey in assigning staff, monitoring individual task orders, and representing Tetra Tech in selected technical matters. Mr. Parker, working from our Fairfax, VA office, will coordinate closely with Mr. Ludwig, Ms. Ramsey and WVDEP Project Manager to ensure that projects are meeting all technical and scheduled objectives. Mr. Parker is a senior environmental engineer with more than 19 years of experience providing technical and management support to federal, state, regional, municipal, and private clients in the areas of watershed and receiving water modeling, watershed and water quality assessment, water resource planning, and TMDL development.

Jonathan Smith, PE, Deputy Project Manager
Mr. Smith will support Mr. Ludwig and Ms. Ramsey in assigning staff, monitoring individual task orders, and representing Tetra Tech in selected technical matters. He has 19 years of experience in water resources engineering, specializing in stormwater management. Mr. Smith is a professional engineer licensed in West Virginia, as well as a Certified Professional in Stormwater Quality, a Certified

Professional in Erosion and Sedimentation Control, and a LEED-Accredited Professional. He is an expert in stormwater management with the ability to plan, manage, and implement stormwater-related projects for municipal and private clients. As a project manager, Mr. Smith has extensive experience in supplying clients with project deliverables and supervising technical staff. He has completed design and construction oversight for more than 20 stormwater BMPs, including stormwater wetlands, bioretention areas, green roofs, pervious pavement practices, innovative wet ponds, level spreaders, media filters, and a number of water quality retrofits of existing BMPs.

Julie Wandling, Data Development & NPDES Permit Support

Ms. Wandling will lead all data development tasks under this contract and will coordinate and communicate with the Project Manager, the various TMDL leads, and WVDEP staff to develop the most recent and accurate watershed data necessary to construct the TMDL models. Working for WVDEP's Wasteload Allocation program for over 8 years, she has extensive experience with the intricacies of the various NPDEP permits and WVDEP's permit database (ERIS). Over the past 6 years, she has utilized this valuable experience assisting WVDEP TMDL staff to streamline the permit data retrieval process and facilitate efficient data transfer to Tetra Tech. Ms. Wandling is a watershed analyst with a breadth of knowledge and experience in TMDLs, NPDES permitting, antidegradation implementation, and low flow estimating statistics.

Other Key Staff

Table II-C-1 summarizes the qualifications of the key staff identified for supporting this project. This table includes all the required fields identified in the EOI (i.e., titles, education, and work experience). Relevant experience in total recoverable metals, dissolved metals and acidity, bacteria, sediment, and biological TMDLs and associated skills is identified for each of the selected staff. The selected staff have been assigned within the following professional categories:

- Contract Adminstrator
- Program Manager
- Project Manager
- Quality Assurance/Quality Control Manager
- Biological Analyst
- Model Developer
- Watershed Analyst
- Soils Specialist
- Technical Expert
- Technical Writer
- Outreach Specialist
- Senior Water Resource Engineer

The Technical Experts who are identified provide specialized skills in toxicology, modeling, database management, or statistics. Direct experience with TMDL work in West Virginia is indicated in the table by a circle (●). Nearly 40 of the proposed staff have TMDL related experience in West Virginia and the majority of staff members identified have at least 5 years of experience working on TMDL projects.

> ***Through these highly qualified and dedicated staff members we bring to WVDEP the continuity and quality of support they need to meet the challenges of the upcoming TMDL schedules.***

Focused resumes for the proposed staff are also provided in Appendix B of the proposal.

Table II-C-1. Summary of Experience and Skills of Proposed Staff

				TMDL Development				Watershed Assessment			Modeling & Data Management					Stressor Identification			Training & Outreach		Regulatory Guidance		
Staff	Proposed Role	Highest Degree	Total Years Experience	Total Recoverable Metals TMDLs	Dissolved Metals/pH TMDLs	Bacteria TMDLs	Sediment TMDLs	Pollutant Source Tracking	Biological Assessment	Water Quality Sampling & Analysis	Data Development & GIS	Watershed/Water Quality Modeling	In-stream/Dissolved Metals Modeling	Model System Development	Sediment/Metals Relationship (Fe/TSS)	Conceptual Model Design	Biological Diagnostic/Statistical Modeling	Biological Index/Metric Development	Training/Technology Transfer	Public Outreach	QAPP Development	Water Quality Standards/UAA	Permitting
Jon Ludwig	Deputy Project Manager	MS	17	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Mindy Ramsey	Project Manager	MS	13	●	●	●	●	●	●	●	●				●		●			●		●	
John Beckman	Watershed Analyst	MEM	18	●	●	●	●	●	□	□	●	●	●		●		●		□	●	□		
Christina Mellors	Senior WR Engineer	MS	18	●		●	●				●	●	●	●	●	●			□	●			□
Andrew Parker	Deputy Program Manager	ME	19	●	●	●	●	□		□	●	●	●	●			□		●	●	●	●	□
Jonathan Smith, PE	Deputy Project Manager	BS	19					□		□	□	□		□		□			□	□			□
Julie Wandling	Watershed Analyst	BS	15	●	●	●	●	●		◐	●	◐							●	●		●	●
Yoichi Matsuzuru	Soils Specialist	MEM	16	●	●	●				●	◐	◐	◐	◐		●			□			◐	
Sen Bai	Senior WR Engineer	PhD	16			□	□	□		□	□	□		□		□			□				
Khalid Alvi	Model Development	MS	14	●	●	●	●	□	□	□	□	□	□	□		□							
Allison Barker	Contracts Manager	JD	16	●	●	●	●																
Clint Boschen	Biological Analyst	MS	18		□	●	●	●	●	●	●	●		●		●	●	□	□	□	□	□	□
Kimberly Brewer	Outreach Specialist	MRP	31																	●		●	●
Jonathan Butcher, PH	Technical Expert	PhD	30	□	□	□	□	□	□	□	□	□	□	□		□	□	□	□	□	□	□	□
Trevor Clements	Watershed Analyst	MEM	31			□	□	□		□		□				□			●	□		□	□
Jerry Diamond	Technical Expert	PhD	31						●	●						□	□	□			□	□	□

Staff	Proposed Role	Highest Degree	Total Years Experience	TMDL Development				Watershed Assessment			Modeling & Data Management					Stressor Identification			Training & Outreach		Regulatory Guidance		
				Total Recoverable Metals TMDLs	Dissolved Metals/pH TMDLs	Bacteria TMDLs	Sediment TMDLs	Pollutant Source Tracking	Biological Assessment	Water Quality Sampling & Analysis	Data Development & GIS	Watershed/Water Quality Modeling	In-stream/Dissolved Metals Modeling	Model System Development	Sediment/Metals Relationship (Fe/TSS)	Conceptual Model Design	Biological Diagnostic/Statistical Modeling	Biological Index/Metric Development	Training/Technology Transfer	Public Outreach	QAPP Development	Water Quality Standards/UAA	Permitting
Mustafa Faizullabhoy, PE	Senior WR Engineer	MS	15	☐	☐	☐	☐		☐		●	●	●	☐		☐			☐				
Heather Fisher	Outreach Specialist	MEM	15			☐	☐		☐		☐	☐							☐	☐			
Jeroen Gerritsen	Technical Expert	PhD	34						●		●					●	●	●	●		☐	☐	
Eugenia Hart	Technical Writer	MS	15	●		●	☐				●	●							☐				
Jessica Koenig	Technical Writer	BA	18			●	☐	☐	☐	☐	●	●	●						☐	☐	☐	☐	
Kevin Kratt	Watershed Analyst	MEM	19	☐	☐	☐	☐	☐	☐	☐	☐	☐				☐			☐	☐		☐	☐
Henry Latimer	Biological Analyst	MS	17	☐	☐			☐	☐	☐						☐					☐	☐	☐
Allen Medine, PE	Soils Specialist	PhD	36	☐	☐			●	☐	☐	●	●	●	●	●		☐		☐	☐	☐	☐	☐
Russell Myers	Watershed Analyst	MS	4					☐	☐	☐	☐												
John O'Donnell	Quality Assurance Manager	BS	31							●											●		
Jennifer Olson	Soils Specialist	MS	18			☐	☐	☐	☐	☐	☐	☐							☐	☐			☐
Teresa Rafi	Technical Writer	MA	18	●		●	●			●	●	●							☐	☐			☐
Mark Sievers	Watershed Analyst	MS	15	☐	☐	☐	☐	●		☐	●	☐		☐					☐		☐		
James Stribling	Biological Analyst	PhD	29						☐	☐	☐					☐	☐	☐	☐	☐	☐		
Barry Tonning	Outreach Specialist	MA	32					☐	☐	☐									●	●	☐	●	●
Peter von Loewe	Senior WR Engineer	MS	15	☐	☐	☐				☐	☐	☐	☐	☐					☐		☐		

Staff	Proposed Role	Highest Degree	Total Years Experience	TMDL Development				Watershed Assessment			Modeling & Data Management					Stressor Identification			Training & Outreach		Regulatory Guidance		
				Total Recoverable Metals TMDLs	Dissolved Metals/pH TMDLs	Bacteria TMDLs	Sediment TMDLs	Pollutant Source Tracking	Biological Assessment	Water Quality Sampling & Analysis	Data Development & GIS	Watershed/Water Quality Modeling	In-stream/Dissolved Metals Modeling	Model System Development	Sediment/Metals Relationship (Fe/TSS)	Conceptual Model Design	Biological Diagnostic/Statistical Modeling	Biological Index/Metric Development	Training/Technology Transfer	Public Outreach	QAPP Development	Water Quality Standards/UAA	Permitting
John Zastrow	Model Development	MS	17								□			□					□				
Hua Zhang	Soils Specialist	PhD	13	●	●	□	●	●	□	●	●	●	●	●	●	●	●	□	□				
Jenny Zhen	Senior WR Engineer	PhD	15				●			□	●	●		●									
Lei Zheng	Biological Analyst	PhD	16						□	□	□		●				●	●					
Rui Zou	Senior WR Engineer	PhD	16		□	□	□				□	□		□							□		

● Experience in West Virginia □ General experience

II.D. Project Management

Supporting WVDEP's TMDL development efforts, Tetra Tech has a long history of successfully meeting aggressive project schedules while staying within project budgets. The scope and magnitude of the TMDL program requires WVDEP to set very aggressive project schedules that progress simultaneously. It is critical that these schedules are maintained because new projects begin each year, incrementally increasing the workload as the TMDL program cycles through the five hydrologic groups. This success is not only due to the exceptional performance of key technical staff, but is also the product of strong leadership provided by our core management team. The stability and continuity of our management team has led to timely, high-quality, and cost-effective performance under this contract. Tetra Tech will maintain this successful management structure. Our Program Manager, Jon Ludwig, will continue to provide corporate visibility and national leadership in water resources. Technical oversight will be provided by Deputy Program Manager, Mr. Andrew Parker and Deputy Project Manager, Mr. Jonathan Smith, PE. Ms. Mindy Ramsey will continue to serve as the Project Manager as with the past four TMDL projects. She will continue to draw upon the guidance and knowledge of the management team and WVDEP's Project Manager to solve complex programmatic and technical issues to continually improve WVDEP's TMDL Program. Further details regarding our comprehensive management plan is discussed in Section II.D.2

II.D.1. Unique Capabilities offered by the Tetra Tech Team

Tetra Tech would like to highlight four of the unique capabilities we offer WVDEP in meeting the requirements of the TMDL program:

- Experience in managing contracts of similar size and scope
- Breadth of technical skills needed in addressing all facets of the TMDL program
- Ability to mobilize resources to meet quick response requirements and manage large projects
- Experience with similar highly technical projects (project symbiosis)

- Many firms have had experience in development of single TMDL projects, but Tetra Tech has direct experience from the past six WV TMDL contracts and with several other contracts similar to this WVDEP solicitation in size and scope (e.g., USEPA, Georgia Environmental Protection Division (EPD), and City of San Diego, CA). To address the challenge of meeting the WVDEP TMDL deadlines, the selected firm must be able to address multiple projects concurrently while maintaining schedules and cost controls. The selected firm will need to have the capacity and trained staff to meet this challenge successfully. Over the past 10 years, Tetra Tech has successfully demonstrated the ability to meet these challenges by maintaining overall schedules and budgets while simultaneously managing large TMDL projects across multiple Hydrologic Groups. Other Tetra Tech clients include USEPA Regions 1, 3, 4, 5, 6, 8, 9, 10, and City of San Diego, CA.

The experience gained from managing these past and current contracts will be used to ensure that we have staff qualified to provide support across all of the technical service areas and to provide WVDEP with effective mechanisms for project tracking and management. In addition, WVDEP will have easy access to the very latest technical tools and information developed under these contracts. Tetra Tech believes that every client's needs should be addressed on a project-by-project basis. This individual attention to clients and our production of the highest quality technical work are demonstrated by our continued ability to successfully compete on contracts that are follow-on to work initially done by Tetra Tech.

Summary of Related Skills to Support TMDL Development

Table II-D-1 summarizes the key aspects of the Tetra Tech team's unique qualifications and abilities that will enable us to successfully and effectively meet WVDEP's TMDL and watershed management objectives.

Table II-D-1. Summary of Tetra Tech's Qualifications and Experience

Service Offered	Meeting the Objectives of WVDEP
Public Outreach	▪ Numerous staff trained and dedicated to ensuring that the public and stakeholders have a role in watershed and water quality studies (including TMDLs) ▪ Wrote the popular guide *Getting in Step: A Guide to Effective Outreach in Your Watershed* ▪ Tetra Tech's in-house conference planning department regularly plans and coordinates seminars and conferences for technology transfer purposes. ▪ Experience in TMDL public meetings and training in WV ▪ Technical staff routinely present or facilitate meetings to discuss technical approaches, issues, results, and other options
Water Quality Assessment	▪ Current staff have developed, conducted, and maintained numerous monitoring networks for state and local agencies across the nation ▪ Staff have developed and taught numerous courses on monitoring and data analysis and interpretation methods
Watershed Modeling	▪ Over 70 qualified staff available to support watershed modeling using all public domain models ▪ Staff include developers of numerous watershed models (GWLF, LSPC) and project-specific model interfaces ▪ Staff have provided training in watershed modeling in all 10 USEPA Regions and numerous states ▪ Current staff authored USEPA's *Compendium of Models for TMDL Development* ▪ Proposed staff involved in the design, development, and maintenance/update of USEPA's BASINS and the next generation modeling toolbox
Water Quality Modeling	▪ Over 50 qualified staff available to support water quality modeling for all waterbody types ▪ Staff includes the developers of LSPC/MDAS and EFDC ▪ Staff have developed materials and provided training in water quality modeling principles and application ▪ Developed a toolbox of watershed and water quality models for USEPA Region 4
Watershed Management Measures	▪ Staff have developed and maintain a library (and database) of BMP efficiencies ▪ Staff also include experts in treatment technologies and their efficiencies ▪ Staff includes national experts in permit writing
GIS	▪ National leader in the development of GIS-based systems and model interfaces ▪ Tetra Tech staff designed and developed systems including BASINS, Watershed Characterization System (WCS), MDAS, and others ▪ All staff fluent in the use of ArcGIS ▪ Staff are familiar with all WV and regional/national data layers

Service Offered	Meeting the Objectives of WVDEP
Monitoring Support	▪ Nationally recognized experts in bioassessment and nutrient criteria monitoring plan development ▪ Tetra Tech staff developed the Rapid Bioassessment Protocols ▪ Numerous staff with extensive field monitoring experience for all pollutant and waterbody types ▪ All staff support QAPP development and development of SOPs
Other skills and capabilities we offer that are relevant to scope of work	
Water Quality Standards Evaluations/Toxicity Testing	▪ All staff have a comprehensive understanding of water quality standards ▪ Tetra Tech staff conduct an impairment confirmation analysis prior to initiating TMDL development–this is part of the Tetra Tech SOP for TMDL development ▪ Tetra Tech staff are nationally-recognized experts on toxicity testing and analysis, including support for the development site-specific criteria ▪ Tetra Tech staff have developed a Use Attainability Analyses (UAA) and guidance
Maintenance of an Administrative Record	▪ Tetra Tech staff develop and maintain an administrative record for all TMDL and NEPA projects ▪ Tetra Tech has developed internal SOPs for the content and format of all administrative record documents
Depth of Staff	▪ Tetra Tech Team has over 100 staff with relevant experience available to support WVDEP ▪ More than 100 additional staff can be made available if needed to support WVDEP ▪ Tetra Tech has unmatched staff depth across all task areas
Permit Support - Permit Writing and Training	▪ Tetra Tech has nationally-recognized experts in Permit Writing and in teaching USEPA's Permit Writer's Course ▪ Tetra Tech staff are currently writing permits for several states, including Alaska, California, and Arizona
System Development	▪ Tetra Tech staff are developing numerous modeling and GIS systems to support state and local TMDL and watershed management programs ▪ Tetra Tech employs several programmers and database administrators to support our water resources division–this allows our engineers and scientists to focus on conceptual design and testing

Ability to Mobilize Resources and Manage Large Technical Projects

The following examples of recent and current projects are provided to demonstrate how Tetra Tech mobilizes technical personnel to provide federal and state program support.

Support for Chesapeake Bay TMDL Development

Tetra Tech has provided a wide range of technical and managerial support to USEPA Region 3 and the Chesapeake Bay Program Office (CBPO) related to TMDL development efforts for the Chesapeake Bay. Tetra Tech has participated in steering committee and technical team meetings to address critical elements throughout the TMDL development process and has fulfilled numerous tasks related to research, data gathering, statistical analysis, reporting, public outreach, and information technology needs. One of Tetra Tech's key roles has been to lead documentation of the TMDL. To meet this need, Tetra Tech has prepared the overall report outline, written sections of the report, edited technical sections written by CBPO staff, and completed a number of white papers addressing key considerations.

Tetra Tech has supported the development of Watershed Implementation Plans (WIPs) for the states and the District of Columbia as well as configuration of a TMDL Tracking and Accountability System (TAS).

WIP support has been provided directly to each state for state-wide WIPs as well as local, higher resolution WIPs, with the objective being to identify measures and milestones to comply with TMDL allocations.

Over a 4 year period, Tetra Tech supported WVDEP with various WIP activities including detailed analyses of model output, development of a model output viewer tool, development of management scenarios to evaluate using the model, confirmation of nonpoint and point source representation in the CBPO model, and stakeholder meeting support. Tetra Tech has also participated in planning discussions with WVDEP to determine how stormwater retrofit and offset strategies can be applied to meet the nutrient load reductions prescribed by the Chesapeake Bay TMDL. Currently, Tetra Tech is developing the West Virginia BMP and Land-use Tracking System which allows for BMP tracking (including mobile capabilities) and reporting to BayTAS using the National Environmental Information Exchange Network (NEIEN). This system will provide an online framework for WVDEP to track and monitor post construction stormwater best management practices (BMPs) and land use changes. In addition, the system will allow the West Virginia Department of Agriculture to store and track non-cost share agricultural BMP data.

Manganese Permitting Analysis for Coal River Watershed, WV

Tetra Tech supported WVDEP in the development of metals TMDL development for the Coal River watershed. During the course of TMDL development, USEPA approved a revision to the West Virginia Water Quality Standards that altered the zone of applicability of the manganese water quality criterion for the public water supply designated use. The criterion is now applicable only in the five-mile zone upstream of known public or private water supply intakes used for human consumption. The revision resulted many request letters from coal companies to "back-slide" their current manganese effluent limits to technology-based limits. At the request of WVDEP, Tetra Tech conducted a comprehensive analysis to determine the cumulative effect of this backsliding at various downstream locations in the Coal River watershed where the revised manganese criterion is applicable.

Using the calibrated watershed model that was constructed for TMDL development (MDAS), Tetra Tech ran alternate scenarios to provide solutions and guidance as to which areas of the Coal River watershed could sustain manganese technology-based effluent limits while maintaining compliance with water quality criteria in the effective zones. Results were summarized into graphical displays in an easy to use format so that WVDEP DMR permit writers can address the above mentioned request letters and issue/re-issue permits quickly and efficiently. ***This project was completed simultaneously with TMDL development without additional funding.***

Los Angeles County Regional Model Development

For all coastal watersheds of Los Angeles County, Tetra Tech supported the Los Angeles County Department of Public Works (LACDPW) in the development of a comprehensive watershed management decision support system to assist in water quality improvement planning. This system is based on previously developed HSPF/LSPC models developed by USEPA and the Ventura County Watershed Protection Division to support previous TMDL development and watershed planning efforts, with expanded capability added to address LACDPW planning needs. The system provides:

- Dynamic simulation of watershed hydrology and transport of multiple pollutants
- Evaluation of storm size and return frequencies for identification of management targets
- Dynamic simulation of BMP processes, including both distributed LID and centralized facilities
- Optimization of the most cost-effective combination and designs of BMPs to meet management objectives and achieve water quality improvement

- Load reduction quantification to support TMDL implementation efforts
- Cost estimates for County-wide water quality improvement planning

To achieve these goals, Tetra Tech linked the watershed models to dynamic, process-based BMP models and locally derived BMP cost functions that have evolved through several piloting and testing efforts of SCCWRP, City of Los Angeles, Dr. Bowman Cutter (formerly at UC Riverside), and LACDPW. USEPA Region 9 provided a match to LACDPW's investment in development of the tools, promoting buy-in from regulators. USEPA Region 9 supports the development of such tools that can be used to support TMDL implementation efforts, and has worked collaboratively with LACDPW to include the use of these tools for MS4 permit implementation. Currently, Tetra Tech is utilizing this modeling system to support several MS4 co-permittees to prioritize and optimize BMP implementation efforts.

NPDES Permit Support

Tetra Tech is currently working on a wide range of projects that support various states in permit data collection (including site visits), reasonable potential analysis (RPA) preparation, draft permit development, public comment response, and administrative tasks associated with final permit adoption. Tetra Tech staff have played lead roles in developing key USEPA guidance that affect watershed- and water quality-based decision making, including the *Technical Support Document for Water Quality-Based Toxics Control,* the *Guidance for Water Quality-based Decisions: The TMDL Process,* and the *Watershed-Based NPDES Permitting Implementation Guidance*. Tetra Tech has also served as USEPA's contractor administering and delivering the NPDES Permit Writers Training Course.

Project Symbiosis

Over the past several years, Tetra Tech has supported several highly technical TMDL and watershed management projects similar to those in West Virginia. This provides symbiotic benefits, as technical approaches and tools that are developed for one project, are shared among our other high-end projects to benefit one another. This is possible because several key Tetra Tech staff are involved in these state-of-the-art projects, and there is continuous communication between the project managers of these high-end projects. Lessons learned from one project can, and indeed are, applied to other projects to make them more technically defensible. Two key projects that have benefited West Virginia's TMDL development are the Lake Tahoe and Milwaukee TMDLs, which are described below.

Watershed Management in the Lake Tahoe Basin

Tetra Tech has supported numerous agencies over the past 9 years in developing a watershed modeling framework to support management of the Lake Tahoe Basin and TMDL development to address declining clarity in the lake. The project resulted in a calibrated watershed model, representing source loading at the landuse level and also spatially around the Lake Tahoe basin, to support contributing watershed BMP implementation and dynamic linkage to the Lake Clarity Model. Its design readily enables allocation and TMDL implementation through BMP placement and optimization techniques. Tetra Tech has also supported the Nevada Division of Environmental Protection and Lahontan Regional Water Quality Control Board in fine-tuning the Lake Tahoe Watershed Model and conducting preliminary allocation simulations to support TMDL development. Fine-tuning of the existing model included revision of runoff concentrations by landuse and incorporation of new streambank erosion estimates. Tetra Tech also performed an analysis of imperviousness data that resulted in a series of informative maps indicating pervious percentages by land capability class within major watersheds and intervening zones, by hydrologic transfer area, and by Lake Tahoe Watershed Model subwatersheds.

Milwaukee Metropolitan Sewerage 2020 Facility Plan

Tetra Tech has supported a landmark long-range watershed-based planning effort for the MMSD. One purpose of the planning effort is to identify improvements needed for MMSD wastewater treatment

facilities to accommodate growth and protect water quality through the year 2020. Tetra Tech has worked with the Modeling Team to build a comprehensive modeling system with linked sewer system models, watershed models, and a nearshore/harbor lake model. The models are now being used by planners to evaluate the potential water quality benefits of a range of implementation measures, such as sewer separation, additional CSO and SSO controls, and both traditional and innovative (e.g., low impact development) BMPs. Tetra Tech also developed a Water Quality Index to distill the vast amount of modeling output into information that can be more easily digested by decision makers. This allows the various planning alternatives to be ranked and prioritized. Tetra Tech also created a Web-accessible Model Viewer to make model output more accessible and functional. The Viewer allows users to evaluate modeling output at various points in the watershed and for different pollutants and scenarios. The Viewer ensures that all planners have access to the same information in the same format so that they can make the most informed decisions.

II.D.2. Project Management Plan

Tetra Tech's proposed project organization and management approach to support WVDEP in the service areas presented in the EOI are based on the development of clearly defined staff roles to ensure timely, high-quality, and cost-effective performance under the contract. The roles of the key personnel presented in section II.C of this proposal include the Program Manager, Project Manager, Deputy Project Manager, QA Manager, and individual leads for technical areas. This Core Management Team will maintain overall responsibility for the day-to-day activities of our technical staff, whose skills and availability greatly exceed that necessary to support WVDEP. The relevant experience and skills of each of the key personnel are outlined in Section II.C and resumes for all staff are included in Appendix B. This section outlines our approach to project organization and management, including:

- Use of Subcontractors
- Cost Control
- Schedule Control
- Project Tracking

II.D.3. Use of Subcontractors

Tetra Tech is proud of the outstanding business relationships we have formed with companies that have a proven ability to provide timely and excellent technical support to our projects. However, because we have staff with expertise in all of the technical service areas, we do not anticipate the need to use subcontractor support under this contract.

Should the need arise to secure the support of other qualified subcontractors, either to provide quick response support or to provide a unique expertise, we will not hesitate to enlist their services. Successful standard procedures are in place to facilitate identification and management of the subcontractors.

II.D.4. Cost Control

Financial control will be ensured by means of Tetra Tech's formalized and computerized management information system, which provides the Tetra Tech Program Manager and Project Manager, with up-to-date (weekly) fiscal information for the project. A principal advantage of this system is that it enables managers to obtain financial data quickly and in sufficient detail for proper decision making. The system is designed to provide both the client and Tetra Tech management with full visibility on the current status and progress of each work item. It identifies potential problem areas before they can jeopardize the success of the project by causing work delays or cost overruns. Weekly charges to each task are provided

to the Tetra Tech Program Manager and Project Manager. These weekly (Tetra Tech internal) computer printouts include the names and number of hours of staff charging to the contract, computer usage, subcontractors' charges, and purchase commitments.

II.D.5. Schedule Control

Time and schedule control can be a problem as a result of changing priorities that might result from a lack of information, new information, or changes in monitoring activities. Conflicts between workload requests by different programs might also cause some difficulty in scheduling. In the past, these problems have been worked out by contract officers and Tetra Tech by coordinating planning activities. By remaining flexible and maintaining frequent communication with client management and technical staff, we have been able to accommodate changes, substitutions, and reasonable new requests. Tetra Tech has identified staff with availability that exceeds that expected under this contract, ensuring that we can accommodate potential workload surges or new priority efforts. Although Tetra Tech has the benefit of the largest TMDL staff in the country and can therefore adjust to variable workloads and schedule constraints, adherence to the planning process results in a more uniform level of effort and allows better performance.

Scheduling of work is important to all projects. Project schedules are developed by the Tetra Tech Project Manager and Technical Leads to define the pathways necessary to meet each project's key milestones and deliverables. These schedules include charts to identify project milestones and delivery dates. This information is shared with the members of the project team to make them aware of when their input is needed by other members of the team. The Tetra Tech Project Manager holds regular conference calls, and requires at a minimum monthly reports from Technical Leads. Regular reporting identifying existing and potential problems, and allows for early initiation of corrective actions.

II.D.6. Project Tracking

Tetra Tech has set up a contract management system that performs the necessary financial and performance tracking, and develops progress reports. This contract management system is used for all Tetra Tech contracts of similar size, type, and scope. The system is equally suited to both small and large task order contracts of all types. Tetra Tech has adapted its tracking and reporting systems to meet the needs of the previous WVDEP TMDL contracts, and intends to maintain, and where appropriate adapt, its tracking and reporting systems to meet the needs of this WVDEP TMDL Support Contract.

Tetra Tech will conform to the EOI reporting requirements through the efforts of dedicated contract management support staff in Fairfax whose job descriptions include fulfilling the tracking and reporting requirements of the contract. These personnel are a contract specialist, Allison Barker, who will report to the Program Manager, Jon Ludwig, and Project Manager, Mindy Ramsey on all matters regarding contract administration. The job performance ratings of the contract specialists are tied directly to Tetra Tech's contract management performance under the contract. The dedicated contract management staff will conduct the following activities to ensure strict conformance with the West Virginia contract requirements:

- Operate and maintain a computerized (Microsoft® Excel-based) internal tracking system. This system is linked to Tetra Tech's corporate contract accounting system (CODA) to allow weekly inputs of direct labor, other direct costs (ODC), and subcontractor charges, as well as all indirect costs. Reports generated from the inputs are distributed to the Project Manager and Program Manager on Wednesday following the Sunday close of week. This allows each Project Manager

to know, on a real-time basis, how much each staff member is working on each project and track progress toward meeting project milestones.

- Maintain an internal project status tracking system (Microsoft® Excel-based) that tracks, for each project, period of performance, WVDEP Project Manager, and Project Manager, applicable telephone numbers, dollar and LOE amount of original project assignment and each amendment, date received from WVDEP, work plan due date and actual date submitted to WVDEP, date of receipt of approval by WVDEP, and comment column for any unusual conditions or problems.
- In conjunction with the Tetra Tech Program Manager and Project Manager, issue formal letters to designated Tetra Tech or subcontractor Project Managers and request a complete work plan, cost estimates, and schedule and reporting requirements.
- Maintain a filing system for all incoming documentation (work plans, completion reports, monthly reports, technical reports) and all correspondence.
- Prepare a detailed work plan and budget (by task) to guide the execution and assess the technical progress of each task.

Tetra Tech is flexible in reporting formats and procedures and will be happy to discuss any modifications that may be desired.

Difficulties and Resolution

In supporting a large contract we are always prepared to address administrative and technical difficulties. In our current and past contracts, we have successfully anticipated potential difficulties and prevented them during initial planning phases. The experienced Technical Leads assigned from the Project Team will address potential problems in the work plan; if problems arise once the work has begun, they will be addressed immediately. Difficulties and their resolution will be brought to the immediate attention of the Tetra Tech Program Manager and Project Manager, and WVDEP Project Manager.

Difficulties encountered and steps taken to solve them will be an important subject of the bi-monthly progress reports to WVDEP, as well as the monthly periodic review meetings and telephone discussions with the WVDEP Project Manager. If any modification of the work schedule is required, WVDEP will be involved as soon as the need is recognized.

Frequent communication will occur among the WVDEP Project Manager and the Tetra Tech Program Manager, Project Manager and Technical Leads. With these contacts, and by comparing progress on a project against milestones described in the work plan, the Project Manager will become aware, at an early stage, of any difficulties that might require corrective action. Corrective action could include:

- Discussions with the WVDEP Project Manager to negotiate modification in scope, schedule, or deliverables.
- Securing additional commitments of staff time to devote to the assignment.
- Retaining outside consultants to review problems in specialized technical areas.
- Restricting expenditures in any task area.
- Making adjustments in staff.

The Tetra Tech Program Manager or Project Manager may exercise the authority to replace a Technical Lead or staff member if it is in the best interest of the project. Such action will be taken only with the explicit approval of the WVDEP Project Manager. Because Tetra Tech offers in-depth experience and skills, an equally qualified staff replacement can be found for almost any professional involved in a work

assignment. Tetra Tech has gained a great deal of experience in addressing the limited number of difficulties that have arisen during past TMDL contracts. Solutions have been developed for most of the difficulties that might be expected under this contract. Specific difficulties that have needed attention and their resolution are described below.

Estimating Required Level of Effort

It is often difficult to estimate the level of effort required to complete a task because all of the information to be collected or reviewed is not available at the time estimates are required. Whenever possible, a preliminary review of available data and data quality will be made to provide a better estimate of required effort. In addition, Tetra Tech has kept careful records of both estimated and actual time required to complete work assignments of similar type and scope to those expected on this contract. This record allows reasonable estimates despite uncertainties.

Effective Project Management and Communication

Our experience with contracts of similar size and scope to the WVDEP EOI has convinced us that the successful development and administration of work assignments depends on effective communications and interactions among the key project positions: the WVDEP Project Manager, the Tetra Tech Program Manager, Project Manager, and Technical Leads. Effective communications among this group can greatly facilitate and expedite the issuance of project requests, the review of work plans, and the authorization to proceed.

If awarded the contract, the Tetra Tech Program Manager and Project Manager will seek a meeting with the WVDEP Project Manager to facilitate contract administration and communication protocols.

Communication with WVDEP during Projects

During the conduct of the project, the appropriate Technical Lead will have the primary day-to-day contact with designated WVDEP technical staff. WVDEP is able to work directly with the person conducting or supervising the project. This results in a much more efficient system than having a single-point contact with only the Program Manager or Project Manager. Any difficulties or problems are reported to the Project Manager for resolution. Multiple points of communication will be provided for coordination between the Tetra Tech Team and WVDEP. The Tetra Tech Project Manager communicates directly with the WVDEP Project Manager and each WV project manager regarding schedules, work assignments, and progress. For example, prior to initiating a scheduled activity, the Project Manager checks with the appropriate WVDEP Project Leader to ensure that there have not been any changes in circumstances or priorities and to verify any special concerns. If there are changes, a discussion is held as soon as possible to modify planned activities. All changes will be properly documented and transmitted in writing to WVDEP. The Project Manager will maintain a procedure of contacting the WVDEP Project Manager at least monthly to ensure that all concerns and problems are addressed or, ideally, are avoided through early detection. In addition, the Project Manager or Deputy Project Manager will be available within one hour's notice to facilitate communication on all contract issues.

In addition to the proposed management procedures, the success or failure of the management of this work depends on the relationships, interactions, and communications between the WVDEP Project Manager, the WVDEP Project Leaders, and the Tetra Tech Project Manager, Deputy Project Manager, and Technical Leads. Tetra Tech envisions in person meetings and/or phone calls on a weekly (or more frequent) basis, periodic technical memoranda, and at least monthly meetings with the WVDEP Project Manager and Tetra Tech Project Manager, in addition to the standard bi-monthly progress reports. This

type of communication is absolutely required in order to involve the WVDEP Project Manager and Project Leaders as true participants in the technical work. Additionally, solid working relationships have already been established by Tetra Tech staff and WVDEP staff, facilitating technical discussions about project activities between Tetra Tech and WVDEP technical personnel. When complex issues arise, Tetra Tech has found it most effective to schedule in person meetings at WVDEP's offices to resolve the issues quickly and efficiently.

Control Mechanisms

Quality Control

Strict adherence to Tetra Tech's Quality Management Plan (QMP) guarantees a high quality of technical performance. Quality control is achieved by Tetra Tech in four ways: careful definition of work assignments to ensure that the project team understands WVDEP's needs, careful selection of staff, monitoring of technical progress and budgetary performance on a continual basis, and review of analyses and reports as necessary in response to critique and comment from the WVDEP Project Manager or other designated person. Team meetings and internal peer review are used to exert quality control based on the professional standards of team members.

Organizational Conflict of Interest Plan

Tetra Tech and each member of its staff are committed to complying fully with the requirements set forth in Subpart 9.5 of the Federal Acquisition Regulations (FAR) regarding COI for all work Tetra Tech performs for state, federal, and other clients. This subpart defines COI as follows:

Because of activities performed or relationship established with other persons, either (1) a person is unable to render impartial assistance or advice to a client, (2) a person's objectivity in performing work for a client is or might be impeded, or (3) a person has an unfair competitive advantage.

Tetra Tech, its employees, and any subcontractors are required to fully comply with contract-specific COI requirements. The Tetra Tech Organizational Conflict of Interest Plan includes the following sections: Corporate Structure; COI Screening Process; Procedures to Avoid, Mitigate, or Neutralize Potential COI; Certifications; Responsibilities; Training; and Subcontractor COI Identification.

All Tetra Tech employees receive training on how to identify actual or potential organizational and personal COI situations, and when and how to disclose such information. In addition, each employee receives a copy of this COI plan along with orientation materials. Tetra Tech also regularly disseminates information concerning COI issues to its employees through "brown bag" seminars, interoffice conference calls, and memoranda. Tetra Tech conducts annual COI awareness training for all employees that includes review of certification language and of any changes that may have occurred in Tetra Tech's COI plan. This training is conducted as part of Tetra Tech's "Code of Business Conduct" awareness training and certification program. Certification that all employees have read and understand the contents of the current code and plan is retained by Tetra Tech.

Tetra Tech will place the COI flow-down clauses in each subcontract document. If requested by the client, the subcontractor must prepare and follow an appropriate COI plan. Tetra Tech will require that the subcontractor certify that it has prepared and is following its COI plan. Each subcontractor will verbally notify Tetra Tech of any actual or potential COI within 2 working days of receipt of a project order. In addition, each subcontractor must disclose specific COI circumstances to the client.

Management of Personnel Resources

We have structured our proposed team specifically to provide the most highly qualified individuals in the nation to WVDEP. Information on how key personnel resources are organized in "work teams" is presented in the organization chart in Section II.C of this proposal. The information presented in Section II.C clearly demonstrates that Tetra Tech already has identified the highly qualified in-house staff and experts necessary to perform the major requirements of the technical service areas. Personnel have been assigned to each work team based on their experience and familiarity with the technical or program issues to be addressed.

Awareness of West Virginia's Priorities

To provide the strongest Technical Leads and key staff on each work assignment, the Tetra Tech Project Manager will work closely with WVDEP to maintain a clear understanding of the contract mission priorities and the schedules in each program area. The Project Manager's ability to project and plan for the work to be performed under the contract will facilitate the smooth initiation and conduct of the assignments when we receive them. The management team of Andrew Parker, Jon Ludwig, and Mindy Ramsey has worked successfully with WVDEP managers in the past and has access to a significant resource pool that can easily accommodate shifts in priority and facilitate assignment of the team's personnel to high-priority, complex assignments.

Monitoring Staff Availability

The Tetra Tech Project Manager will maintain an awareness of staff availability for key project components. She also will monitor schedules for work closely to evaluate the best options for allocating resources. Frequent contact with the Technical Leads will be an additional mechanism to permit optimum allocations of resources and flexibility and to follow project progress.

We have also established (and demonstrated through the past WV TMDL contract mechanisms) the ability to work closely with satellite offices and clients through the use of high speed internet access including FTP sites, project intranet and Internet sites, and email. Close client contact is also maintained through the use of frequent meetings at WVDEP's offices for project updates, and transfer of materials.

III. Qualifications and Experience

Described in this section is Tetra Tech's experience in supporting West Virginia and many other states in TMDL development, with particular emphasis on total recoverable metals, dissolved metals/pH, bacteria, and biological TMDLs. Tetra Tech has supported West Virginia in TMDL development since 1997 through pilot studies, training, methods development, and TMDL studies throughout the state. West Virginia's program has grown into a national leader by integrating large-scale programmatic watershed management concepts with fine-scale, highly technical methodologies that produce implementable TMDLs in a cost-effective manner. Tetra Tech is privileged to have supported West Virginia throughout this program evolution, and we look forward to supporting West Virginia as their TMDL program continues to grow towards successful implementation and watershed restoration.

The West Virginia and national experience shown here is the product of the effort of key Tetra Tech staff listed in Section II.C. We have proposed staff who have worked on the projects described, nearly 30 of whom have worked directly on West Virginia projects. The experience presented is particularly relevant to the West Virginia TMDL program because it demonstrates the continuity of support we offer to WVDEP. Key staff proposed for this project have long-standing working relationships with WVDEP. Over the past 13 years, our Program Manager, Mr. Jon Ludwig, has worked closely with WVDEP's Program Manager to solve many complex programmatic and technical issues to continually improve WVDEP's TMDL Program. Tetra Tech staff in our local Charleston office have worked closely with WVDEP staff to develop new and innovative ways to further strengthen the scientific validity and defensibility of the TMDLs. Based on this experience, we have a unique and comprehensive understanding of WVDEP expectations, recognition of their mission, and respect for their understanding of the waters of the state and their dedication to environmental stewardship.

III.A. Duration of Experience

Tetra Tech is the national leader in the calculation of TMDLs, as well as development of watershed management plans and TMDL implementation plans. Tetra Tech has been a vital, constructive partner to numerous states and USEPA in their efforts to move the TMDL program from an early, narrower focus on point source wasteload allocations to today's more holistic watershed approach. Because we have supported states and USEPA in their implementation of the TMDL program since the early 1980s, Tetra Tech thoroughly understands the web of technical, legal, administrative, and social issues that influence the program and can affect its success. Over the past 17 years, we have developed more than 7,200 TMDLs across the United States for all waterbody types and pollutants.

Because of the extent of our involvement, there are few technical issues that we have not encountered, considered, and developed successful solutions to address. In addition, the litigious and controversial nature of many TMDLs requires that our staff have the ability to develop credible approaches and present and defend our approaches and results to regulators and stakeholders in a public forum. We have provided scientifically based analyses and successfully defended our technical conclusions in spite of significant public scrutiny and expert academic and consultant reviews. Our comprehensive national support to the TMDL program over the past decade has included developing the first TMDL guidance document (1991); developing a suite of tools (such as BASINS) designed to aid TMDL developers in performing tasks more efficiently; and developing numerous technical support documents, including primary authorship of the USEPA protocols for developing TMDLs for nutrients, sediment and pathogens. The depth and breadth of our experience over the past decade has allowed us to assemble and train a pool of national experts skilled in all aspects of the TMDL program. We have personnel with unmatched expertise in all activities associated with TMDL analyses, including watershed characterization, data analysis and processing, source assessment, watershed and water quality modeling, allocation analyses, water quality monitoring, implementation plan development and stakeholder facilitation.

III.B. Quantity/Quality of Past Projects

Over the past 13 years, Tetra Tech has developed more than 4,500 TMDLs throughout West Virginia, initially supporting USEPA to meet strict consent decree deadlines (and subsequently assisting WVDEP with its own program. Over 3,000 of these TMDLs have been developed directly supporting WVDEP over the past 10 years, and there are over 450 TMDLs currently under development. These projects have resulted in watershed models that cover over 92 percent of the state, as illustrated in Figure III-1 in Section III.C. Through these diverse projects, Tetra Tech has compiled an incredible depth of West Virginia-specific resources, literature and data that can be used to further strengthen the scientific validity and defensibility of future TMDL development efforts. Tetra Tech's West Virginia TMDL development experience is illustrated in Table III-1.

Table III-1. Tetra Tech's West Virginia TMDL Experience

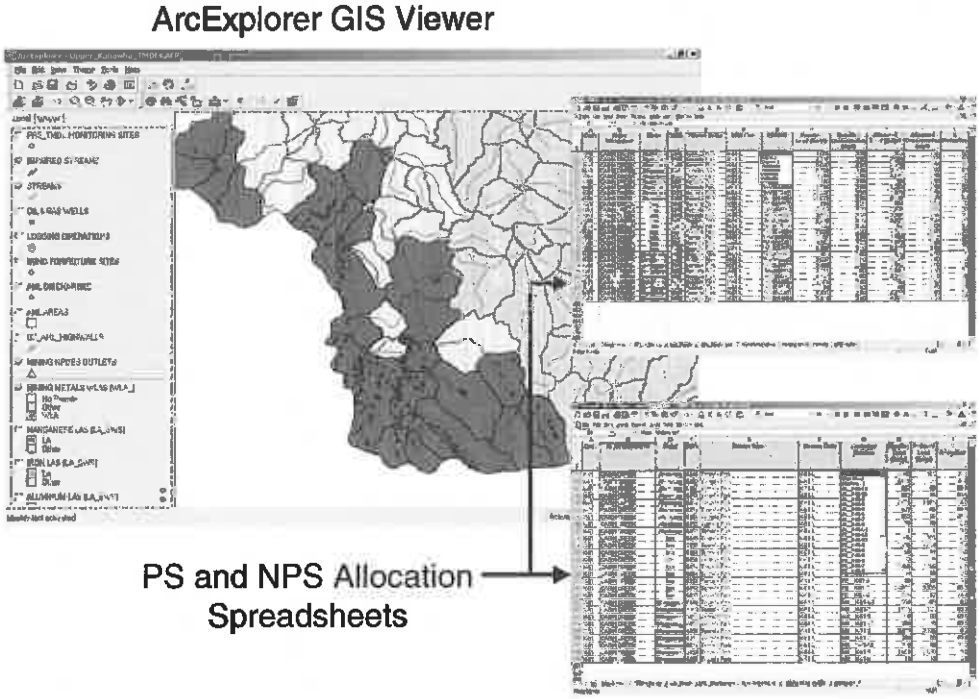
Year or Hydrologic Group	Status	Number of Streams	Total Recoverable Metals	Dissolved Metals	Acidity/pH	Bacteria	Biological	Sediment	Chloride/ selenium*
Developed for USEPA									
1998	USEPA Approved	9	3	0	0	5	0	4	
1999	USEPA Approved	6	4	4	0	0	0	3	
2000	USEPA Approved	7	12	0	0	0	0	1	
2001	USEPA Approved	183	447	0	96	0	0	0	
2002	USEPA Approved	147	396	0	69	2	0	0	
2004	USEPA Approved	58	121	12	17	2	36	0	
2010 (A2)	USEPA Approved	99	83	66	79	32	25	7	
TOTAL		**509**	**1066**	**82**	**261**	**41**	**61**	**15**	
Developed for WVDEP									
A	USEPA Approved	106	63	50	30	54	45	16	
B	USEPA Approved	190	139	53	38	102	48	25	
C	USEPA Approved	125	60	31	44	54	35	26	
D	USEPA Approved	136	17	5	4	128	25	20	
E	USEPA Approved	114	32	6	8	101	51	37	
B2	USEPA Approved	476	406	19	25	192	95	66	
C2	USEPA Approved	173	299	0	0	164	77	65	
D2	USEPA Approved	99	140	25	25	65			9
E2	USEPA Approved	202	300	6	6	175			3
A3	USEPA Approved	80	75	6	6	52			29
B3	Under Development	174	86	33	50	117			
C3	Under Development	26			7	19			

Year or Hydrologic Group	Status	Number of Streams	Total Recoverable Metals	Dissolved Metals	Acidity/pH	Bacteria	Biological	Sediment	Chloride/ selenium*
TOTAL		**1901**	**1726**	**233**	**243**	**1233**	**376**	**255**	**41**
TOTAL WEST VIRGINIA TMDLS		**2410**	**2828**	**315**	**504**	**1264**	**437**	**270**	**41**

*Began tracking chloride and selenium separately in D2. Previous isolated counts were included in total recoverable metals.

As demonstrated throughout this proposal, Tetra Tech and WVDEP have worked closely together to identify and create unique ways to integrate large-scale, watershed based TMDLs with fine-scale, highly technical methodologies that produce "implementable" TMDLs in a cost-effective manner. This watershed based approach to TMDL development is comprehensive and typically includes all known impairments in a watershed. TMDL development includes a multi-faceted modeling approach to address total recoverable metals, dissolved metals, acidity (pH), and bacteria impairments.

Tetra Tech and WVDEP also have designed the "TMDL on CD" concept where all relevant TMDL information (TMDL reports and appendices, technical documentation, and supporting data) is included on a CD-ROM. To further improve the "usability" of the TMDLs, Tetra Tech and WVDEP developed a series of interactive tools to provide TMDL implementation guidance. These tools are designed to simplify and assist "implementers" (nonpoint source staff and permit writers) in using the TMDLs to develop watershed plans and issue/renew permits. An interactive ArcGIS project allows the user to explore the spatial relationships of the source assessment data, as well as further details related to the data. Users are also able to "zoom in" on streams and other features of interest. In addition, spreadsheet tools (in Microsoft® Excel format) were developed to provide the data used during the TMDL development process, and the detailed source allocations associated with successful TMDL scenarios. These tools provide guidance for selection of implementation projects as well as for permit issuance and are also included on the TMDL Project CD. To date, these concepts have been applied for completed and approved TMDL projects in Hydrologic Groups A, B, C, D, E, A2, B2, C2, D2, E2, and A3; and are currently under development for Hydrologic Groups B3 and C3.



We have included the TMDL Project CDs for Elk River, North Branch Potomac, and Upper Ohio South watersheds as examples in Appendix A.

Table III-3 summarizes the pollutant specific TMDLs for the each of these example projects.

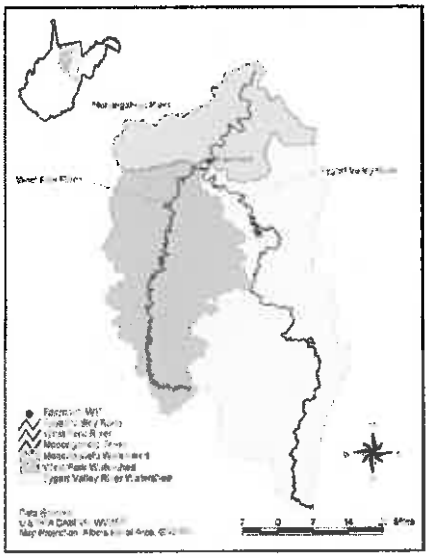
Table III-3. West Virginia Pollutant-specific TMDLs for Example TMDLs Presented in Appendix A

Watershed	Number of Streams	Dissolved Aluminum	Total Iron	Total Manganese	pH	Chlorides	Biological	Bacteria	Sediment
Elk River Watershed	195	16	189	0	20	0	44	79	24
North Branch Potomac Watershed	22	0	0	0	0	0	8	22	0
Upper Ohio South Watershed	75	1	29	1	1	4	20	66	12
TOTAL	**292**	**17**	**218**	**1**	**21**	**4**	**72**	**167**	**36**

To further demonstrate our TMDL development experience, we have included the following descriptions of several related projects.

Mining TMDLs for Tygart River Watershed West Virginia
Client: USEPA Region 3

In response to court ordered schedules for TMDL establishment, Tetra Tech developed TMDLs for mining-related impairments due to metals (iron, aluminum, manganese) and pH in West Virginia, in close coordination with WV DEP and EPA Region 3. TMDLs were developed for the Buckhannon, Tygart, Cheat, Elk, Monongahela, Stony, Tug, Dunloup, West Fork and Guyandotte watersheds. The effort involved development of innovative modeling techniques to address a variety of case specific requirements related to water quality criteria, water use designations, source pollution conveyance methods, and permitting. To incorporate these multiple facets, Tetra Tech developed a comprehensive modeling and analysis system - MDAS (Mining Data Analysis System). Tetra Tech also provided support for public meetings, technical meetings and training sessions to help support public acceptance of the new methods.



Tetra Tech developed mining related TMDLs for the Tygart Valley River Watershed. Tetra Tech took the technical lead in most areas, including recommending targeted stream monitoring, managing permit information, analyzing abandoned mine land data, developing a model, defining a consistent allocation procedure, developing TMDL reports, and presenting the TMDL results to the public. TMDLs resulting from the approach were technically defensible, approved by EPA, and consistent with WV permitting processes.

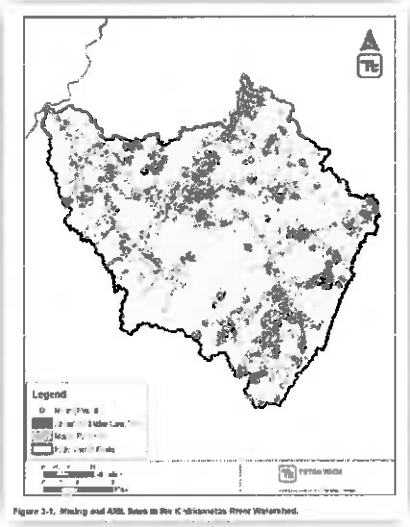
Using MDAS, Tetra Tech simulated instream flow and water quality conditions throughout the Tygart Valley River watershed for a 6 year period. The watershed modeling process involved the segmentation of the watershed into 1007 hydrologic subunits; compilation of meteorological, land use, stream and land use specific hydrology and pollutant data; calibration of MDAS/HSPC hydrology and water quality; and generation of nonpoint source and in stream flows and pollutant loadings. Many of the impaired segments were small nested tributaries and had various water use designations that require specific acute and chronic numeric criteria. Over 300 permitted mining discharges, in multiple phases of reclamation (exhibiting various water quality conditions) were represented as point sources that simulated characteristics of precipitation driven discharges. Final TMDL allocations were assigned to more than 1,000 subwatersheds and over 80 individual mining facilities and resulted in the development of over 150 individual TMDLs for the watershed. The MDAS model also provided a basis for permit analyses which ultimately will support future re mining and growth issues as they arise.

Ohio River Bacteria TMDL Development
Client: USEPA Region 5

Tetra Tech is currently in the process of supporting USEPA in the development of a bacteria TMDL for the Ohio River. The Ohio River Basin covers more than 200,000 square miles extending over six states, from east to west including West Virginia, Pennsylvania, Kentucky, Ohio, Indiana and Illinois. Based on the 2006 303(d) report, 475 miles are impaired for contact recreation by bacteria. Tetra Tech prepared a QAPP in accordance with USEPA guidance (including recommending a modeling approach and a means for comparing the multiple pathogen criteria); is helping Region 5 to facilitate a Ohio River Pathogen TMDL Coordinators Workgroup; and is compiling and assessing available data for the Ohio River as well as for important sources of bacteria such as tributaries, combined sewer overflows, sanitary sewer overflows and urban stormwater. Once all available data have been compiled and organized, Tetra Tech will be setting up and calibrating a hydrodynamic and water quality model of the river to support the TMDL. Tetra Tech also supported USEPA and the states in a series of six public kickoff meetings held in January 2009.

Metals TMDL Development for the Kiskiminetas-Conemaugh River Watershed, PA
Client: USEPA Region 3 and Pennsylvania Department of Environmental Protection

Stream reaches in the Kiskiminetas River and Conemaugh River watersheds in southwestern Pennsylvania are included on the state's 2008 Section 303(d) list due to various impairments, including metals, pH, and sediment. Tetra Tech developed TMDLs in the Kiskiminetas-Conemaugh River watershed to address the water quality problems associated with abandoned mine drainage, land erosion, bank modification, and various other causes. The coordinated efforts of Tetra Tech teams compiled information necessary for completing mining related TMDLs to satisfy Consent Decree deadlines for two eight digit HUC watersheds.



The project involved extensive efforts to gather NPDES permit information for thousands of municipal and industrial wastewater treatment facilities and mining facilities. GIS data related to abandoned mine lands were compiled and incorporated into a customized landuse coverage for use in setting up a Mining Data Analysis System (MDAS) model of the watershed. A substantial amount of available monitoring data in the watershed was identified and assessed for calibrating the hydrology, sediment, and water quality predictions of the MDAS model. Statistical analyses using pre-TMDL monitoring data collected throughout the Kiskiminetas-Conemaugh River watershed were performed to establish the correlation between metals loads and sediment loads and to evaluate spatial variability. The calibrated model provides the basis for simulating baseline conditions, which represent existing nonpoint source loadings and point sources loadings at permit limits.

Modeled subwatershed loadings were iteratively reduced to estimate the load reductions required to meet instream concentration targets

for total metals (iron, aluminum, and manganese). Iron reductions were used as a surrogate for sediment reductions and dissolved aluminum reductions were used as a surrogate for pH TMDLs. Streams placed on Pennsylvania's Section 303(d) list with a designated use of high quality or exceptional value are subject to additional protection pursuant to the state's anti-degradation policy. Long-term loads based on the TMDL allocations were identified, as well as median and maximum allowable daily loads. WLAs were assigned to permitted municipal, industrial, and mining facilities and municipal separate storm sewer systems (MS4s) that discharge in the watershed. LAs were assigned to nonpoint sources including drainage from abandoned mine lands.

Modeling and Monitoring for the Klamath and Lost River Basins
Client: USEPA Region 10 and USEPA Region 9

Tetra Tech led efforts to develop hydrodynamic and water quality models and conduct physical, chemical, and biological monitoring efforts in the Klamath and Lost River Basins to support TMDL development. The Klamath and Lost Rivers are included on Oregon and California's 303(d) lists for dissolved oxygen, nutrients, chlorophyll a, temperature, fecal coliform, pH, and ammonia. The Klamath River watershed covers an area of approximately 15,722 square miles in Oregon and California. The headwaters of the Klamath River originate in the Cascade Mountains and the river flows to the southwest toward its confluence with the Pacific Ocean. Downstream of Upper Klamath Lake the river contains a series of dams used for hydropower generation and flood control. The Lost River is a tributary to the Klamath River. Since the early 1900s, extensive flood diversion and irrigation facilities have been constructed throughout the Lost River basin. Modification of the natural hydrology has hydrologically-connected the Lost River to the Klamath River for the past century through a series of pumps, canals, drains, and impoundments.

Initial efforts focused on developing a comprehensive database of water quality data for the basin and summarizing historical and current conditions. After accessing, compiling, and analyzing a multitude of data records from federal, state, regional, local, and private entities, independent modeling approaches for the Lost and Klamath Rivers to meet TMDL requirements were proposed. A multiple-domain CE-QUAL-W2 model of the Lost River was developed and calibrated. The model includes 12 waterbodies, consisting of linked rivers and reservoirs from upstream to downstream. The system also includes the Klamath Wildlife Refuge and contributions from over 230,000 irrigated acres (via drains and canals) and dynamically simulates hydrodynamic and water quality processes (chemical and biological). Also developed was a dynamic modeling framework for the Klamath River composed of a series of one-dimensional RMA models for riverine segments, two-dimensional CE-QUAL-W2 models for impoundments, and a three-dimensional EFDC model for the estuary. Both modeling systems were peer-reviewed by modeling experts from federal agencies, academia, and private consulting firms.

To support calibration of both dynamic models, a series of physical, chemical, and biological sampling events (including SOD and macrophyte/periphyton monitoring) at over 30 independent sites were conducted. The calibrated models were used to evaluate a series of management scenarios for this highly contentious area. The primary focus of the management scenarios was to identify plausible options for achieving both Oregon and North Coast RWQCB water quality criteria. Lost River scenarios evaluated the impacts of agricultural land nutrient reductions and reservoir management on water quality conditions.

Scenarios for the Klamath River involved an evaluation of point source impacts, nonpoint source reductions, reductions from the upstream Upper Klamath Lake, and reservoir operations on water quality. The modeling and data collection effort required very close coordination with the states and USEPA to meet the needs of the many entities involved, including federal agencies, tribes, municipalities, private interest groups, landowners, and reservoir owners and operators.

Watershed Management in the Lake Tahoe Basin
Clients: University of California – Davis, Nevada Department of Environmental Protection, and California Lahontan Regional Water Quality Control Board

Tetra Tech supported UC–Davis, Lahontan Regional Water Quality Control Board (RWQCB), Nevada Division of Environmental Protection (DEP), U.S. Forest Service, and Tahoe Regional Planning Agency in developing a watershed modeling framework to support management of the Lake Tahoe Basin to address declining lake clarity. Tetra Tech integrated results from diverse studies in meteorologic data analysis, geographic information systems (GIS), best management practices (BMPs), stream sediment, and stormwater sampling into a comprehensive and customized watershed model of the basin using the Loading Simulation Program in C++ (LSPC). The model provides a platform for water quality management in the entire basin, evaluating the implications of management scenarios for urbanized and growing areas and managed forest regions. It will help the many parties involved make informed decisions before allocating funds to mitigate pollution and improve Lake Tahoe's clarity.

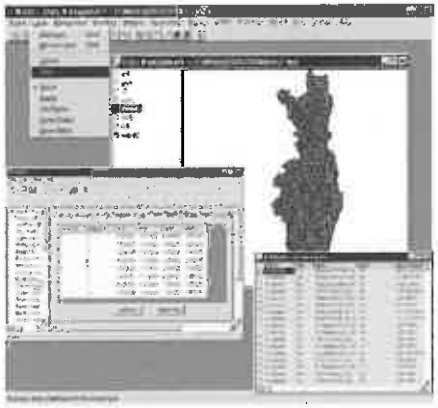
Tetra Tech used LSPC, a modeling framework developed by Tetra Tech for USEPA to support large, complex watershed modeling applications. Tetra Tech incorporated data from a number of concurrent research efforts, including a satellite-derived high-resolution impervious cover layer, site-specific stormwater monitoring data, and locally observed Snow Telemetry data to develop a representative hydrology and water quality model. In addition to detailed snow and hydrology prediction, algorithms relating land cover, slope, and pollutant loading provided a credible basis for generating representative sediment and nutrient loading estimates. The project resulted in a calibrated watershed model, representing source loading at the land use level and spatially around the basin, to support BMP implementation and dynamic linkage to the Lake Clarity Model. The Tahoe Research Group used the model to educate stakeholders on the impact of land use decisions on hydrology, water quality, and lake clarity.

The modeling effort concluded that the primary source category groups of clarity-reducing pollutants included: (1) urban runoff, (2) forest upland erosion, (3) atmospheric deposition, and (4) stream channel erosion. With more than $1.5 billion estimated as the cost to restore lake clarity, a premium is placed on developing informative decision support analyses. For each source category group, a team of local experts was assembled to take the lead on quantifying the nature of pollutant loading, identifying and evaluating a range of potential management options and quantifying potential pollutant removal benefits and associated capital and operations and maintenance costs.

Following this expert-led effort to characterize potential pollutant reduction opportunities and associated cost information for the primary sources identified, a meta-heuristic optimization technique was applied to evaluate the costs-benefits and selection trade-offs among controls associated with the various pollutant sources. This optimization approach helped to prioritize management actions from a basin-wide perspective. Tetra Tech supported the implementation effort by developing analytical approaches and tools for a comprehensive progress tracking and pollutant trading system. These tools support the computation of the project-specific benefit of BMP management, the assignment of load reduction credits, and the progressive tracking of implementation actions as they occur in the watershed. The overall effort delivered a comprehensive approach that quantitatively measures watershed actions in terms of progress toward meeting established load allocation targets

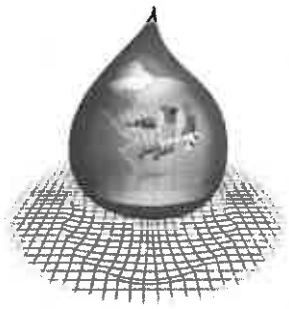
III.C. Water Quality Model Experience

Since its inception, Tetra Tech has developed and applied models to support informed environmental decision-making. We have focused on performing studies and implementing solutions that use the watershed as an analytical framework and are designed in close coordination with the client and appropriate stakeholder groups. By developing and applying modeling and analysis tools, we provide constructive and practical solutions to all types of water management issues. Tetra Tech has significant experience developing and applying linked modeling systems for the express purpose of TMDL development and implementation as well as watershed and water quality management, stormwater management, and source water protection. Although our experience with detailed modeling is unique, we promote the use of simple yet scientifically defensible methods to respond cost-effectively to the needs for watershed, water quality and water resources management, while providing easy-to-understand analyses to promote stakeholder and public involvement and acceptance.



To meet West Virginia's need to develop hundreds of TMDLs for mining-impaired waters, Tetra Tech developed the Mining Data Analysis System (MDAS). MDAS is developed around HSPF and includes graphics/visualization interfaces, data management/inventory/ analysis, nonpoint source modeling, and TMDL analysis and post-processing. Tetra Tech has since applied MDAS to develop thousands of TMDLs.

Tetra Tech modelers understand that there is not a one-size fits all approach for modeling to support watershed and water resources management. When deciding which model to apply, it is necessary to understand the local issues and consider any unique environmental features that affect watershed and water quality processes and conditions. The members of our staff are intimately familiar with all public domain models endorsed by USEPA and the USACE and have practical experience in each. Because our staff regularly supports modeling in most states, as well as model and interface development for USEPA, states and local municipalities, we thoroughly understand the strengths and limitations of available mathematical models and their ranges of application. In fact, Tetra Tech staff wrote USEPA's *Compendium of Tools for Watershed Assessment and TMDL Development* (EPA841-B-97-006), as well as the USEPA ORD's *TMDL Model Evaluation and Research Needs* (EPA/600/R-05/149), a review of more than 60 process-based models and an evaluation of their applicability, strengths and weaknesses. Because we "wrote the book" on models—twice—and we rely primarily on public domain models, we are able to provide our clients with unbiased model selection recommendations based on the strengths and limitations of available models—a practice unique to Tetra Tech.



Tetra Tech developed USEPA's Modeling Toolbox—a revolutionary modeling system that integrates watershed loading models, receiving water models, and database and visualization systems into a streamlined assessment package. The Toolbox provides users with the ability to dynamically simulate flow, transport and water quality processes in all types of surface water environments.

By designing and conducting thousands of modeling studies throughout the United States, Tetra Tech has unmatched experience in successfully applying watershed and water quality models to support the analysis of complex environmental problems and evaluate long-term management goals. We develop custom applications from simple to complex and for hydrodynamics, watershed, receiving water, groundwater, mixing zones and hydrology and hydraulics.

Tetra Tech combines our practical modeling experience with our understanding of our clients' needs and growing trends to create innovative modeling tools and systems that are more user-friendly and accessible. In the mid-1990s Tetra Tech developed for USEPA the BASINS modeling system—a powerful GIS-based system integrating national environmental datasets, analytical tools, and USEPA-supported watershed and receiving water models. Since then, Tetra Tech has developed a number of comprehensive modeling systems, model interfaces and supporting analytical tools. We have built a number of interfaces that link data, reporting, modeling and tracking needs as part of ongoing management systems. Because of our understanding of the environmental processes represented by models, our in-depth knowledge of available modeling systems and related data, and our technical capabilities for designing and developing tools, we have the unique ability to identify a need and design a tool or system to fulfill that need. In addition, we emphasize transferring modeling capabilities to users through the exclusive use of public domain modeling software, on-site model installation and training workshops, and continued phone- and Internet-based technical support and troubleshooting.

Working with WVDEP, Tetra Tech developed a high-resolution hydrology and water quality model (MDAS) for two small trout streams in WV to determine the range(s) of total iron concentrations that occur in viable trout waters as a result of precipitation induced runoff. Results are being used to support WVDEP's pursuit of coldwater fisheries water quality criterion revision.

A model is only as good as the data it is built on. Tetra Tech also recognizes that the model is only as good as the person who runs it. Our modelers not only have extensive experience with all types of models, they have a fundamental understanding of the physical, chemical and biological processes affecting watershed and waterbody conditions—allowing us to successfully apply any model in the context of real-world environmental conditions. This is essential for the responsible and accurate selection and application of models for watershed and water resource management. Our staff's extensive experience with all types of models also eliminates any learning curve, allowing us to more efficiently complete projects. Having run models for a wide range of climates, locations and challenging situations, we can also avoid common modeling pitfalls and mistakes and produce the best results in a cost-effective manner.

For all coastal watersheds of Los Angeles County, Tetra Tech developed a comprehensive watershed management decision support system based on previously developed HSPF/LSPC models to assist in water quality improvement planning. Specifically, the system provides:

- Dynamic simulation of watershed hydrology & transport of multiple pollutants
- Evaluation of storm size & frequencies for identification of management target
- Dynamic simulation of BMP processes, including both distributed LID & centralized facilities
- Optimization of the most cost-effective combination of BMPs design
- Load reduction quantification to support TMDL implementation
- Cost estimates for county-wide water quality improvement planning

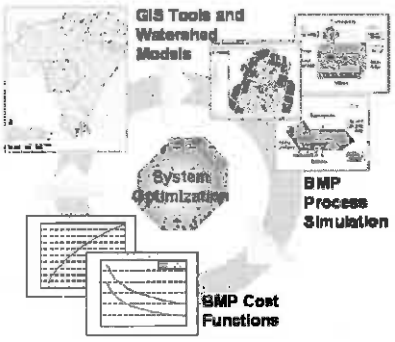


Figure III-1 illustrates the West Virginia basins where Tetra Tech has performed modeling to support TMDL development, resulting in watershed models that cover more than 92 percent of the state. Table III-4 also displays the models for which Tetra Tech has practical experience.

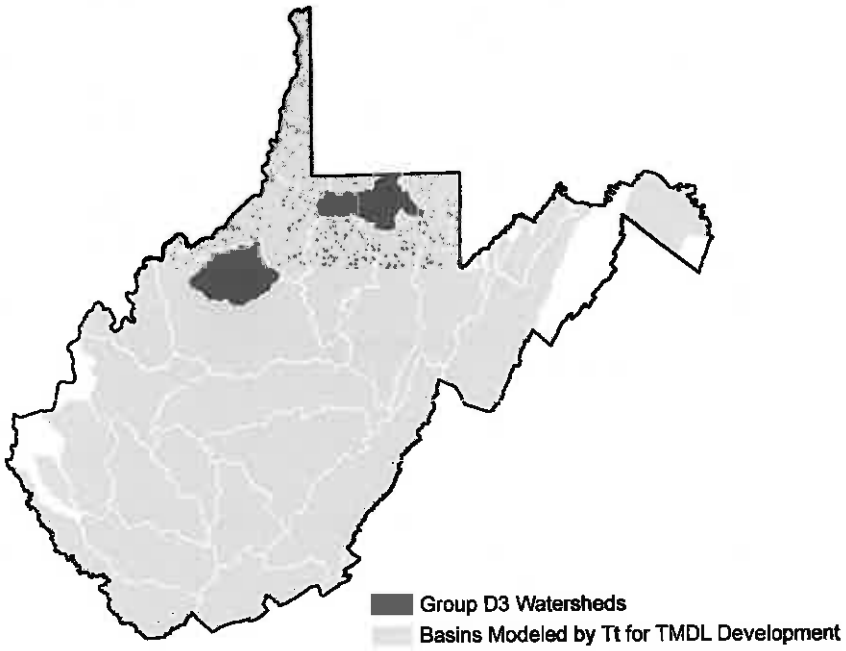


Figure III-1. West Virginia basins in which Tetra Tech has conducted watershed and water quality modeling

Table III-4. Environmental Computer Models and Systems Used by Tetra Tech

Model Category	Model Name
Ecological	IFIM, HEP
Watershed Runoff	HSPF, NPSM, LSPC, MDAS, SWMM, HEC-1, TR-20, PSURM, WSTT, GWLF, AGNPS, P8, SWAT
Thermal Fate	EFDC, TRANQUAL, HSPF, DISPER, ELA
River Hydraulics	HEC-2, HEC-RAS, WSPRO, FESWMS-2DH, DAMBREAK, DWOPER, UNET
Hydrodynamics	EFDC, CAFE, TEA, CE-QUAL-W2, TABS-2, FESWMS-2DH, DYNHYD5, MIT-DNM, RMA
Discharge Plume	CORMIX, USEPA Plume Models
Mixing Zone	CORMIX, EFDC, TEA/ELA, CAFE/DISPER
Eutrophication	QUAL2E, WASP, CE-QUAL-W2, CE-QUAL-RIV1, RIVHW, EFDC, BATHTUB, LAKE2K
Toxic Fate	TOX15, SMPTOX, RIVRISK, AMMTOX, TOXCALC
Sediment Transport and Scour	TABS-2, STUDH, HEC-6, QUASED, HEC-RAS, EFDC
Ground Water	MODFLOW, MOC, PLASM, Random Walk, GLEAMS

III.D. Entities for which Tetra Tech Has Developed TMDLs

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858-541-4328

TETRA TECH

Khalid Alvi, PE

Model Development

EDUCATION

M.S., Civil/Environmental Engineering, Asian Institute of Technology, Thailand, 1999

B.S., Civil Engineering, University of Engineering and Technology, Lahore, Pakistan, 1993

YEARS OF EXPERIENCE

Tetra Tech: 10

Total: 14

LICENSES/REGISTRATIONS

P.E., Professional Engineer, Commonwealth of Virginia, 2010

PROFESSIONAL AFFILIATIONS

American Society of Civil Engineers

AREAS OF EXPERIENCE

- Geographic information system (GIS) programming and analysis
- Watershed management
- Watershed modeling
- Stormwater modeling
- BMP/LID modeling
- Water quality modeling
- Pollutant source assessment
- Modeling tool development
- Model training

Mr. Alvi is a civil engineer with more than 10 years of experience in the field of water resources, including preparing system design documents, system requirement analysis, and model formulation and development. He has extensive experience in the development of GIS-based watershed and BMP modeling systems and works with computer programmers and watershed modelers to produce quality designs, applications and software for USEPA, states, and municipal agencies. He has led the development of BMP-Decision Support System and Watershed Information System for Prince George's County, MD, and was technical lead and project manager for development of a System for Urban Stormwater Treatment and Analysis INtegration (SUSTAIN)—a decision support system for the EPA's Office of Research and Development to develop, evaluate, optimize, select, and place BMPs based on cost and effectiveness. He also provides national technical support to EPA SUSTAIN and STEPL model users' communities and has conducted several hands-on-training courses on SUSTAIN and STEPL models across the country. Mr. Alvi's programming expertise includes: FORTRAN, C++, VBA, and GIS (ArcGIS, ArcView, MapWindow).

Project Experience

Los Peñasquitos, Mission Bay and San Dieguito Water Quality Improvement Plans (WQIPs), City of San Diego. Providing technical support on development of WQIPs for the Los Peñasquitos, Mission Bay and San Dieguito Watershed Management Areas (WMAs). Technical lead on modeling tasks. Reviewed and updated baseline watershed model to calibrate at the landuse level for wet weather analysis. Reviewed and updated the bacteria background concentration as needed to match with the observed values for dry weather analysis. Performed sensitivity analysis for non-structural BMPs such as downspout disconnection and street sweeping.

System for Urban Stormwater Treatment and Analysis INtegration (SUSTAIN), USEPA Office of Research and Development. Principal model developer and project manager for development of SUSTAIN, a decision support tool for evaluating, optimizing, and placing BMPs based on cost and effectiveness in watersheds of varying scale. Technical lead for developing of various system components and coordinating with USEPA project officer in managing the project. Providing technical support to the end users of the software. Also supported USEPA in conducting several informational and hands-on SUSTAIN training workshops around the United States.

Lake Champlain TMDL Development, USEPA Region 1. Principal tool developer for development of a linked framework of models to update the Lake Champlain phosphorus TMDL and support implementation planning in the 8,234-mi^2 watershed that drains nearly half the land area of Vermont and portions of northeastern New York and southern Quebec. Designed, programmed, and applied a BMP Scenario Tool that was linked to a recalibrated and refined BATHTUB model of Lake Champlain and a calibrated SWAT model of the basin to predict effects of BMP implementation in the watershed. Conducted web-based and in-person training seminars for USEPA Region 1 personnel on use of the tool.

STEPL User Group Support, USEPA Office of Water. Project manager for providing user support for Spreadsheet Tool for Estimating Pollutant Load (STEPL), which employs simple algorithms to calculate nutrient and sediment loads from different land uses and load reductions that would result from

implementation of various BMPs. Provided conceptual and specific model reviews, software upgrades, and hands-on training workshops across the country.

Web-based STEPL Model Development, Validation and Enhancement Analysis, USEPA Office of Water. Project coordinator for enhancement and conversion to a web-based platform of USEPA's STEPL spreadsheet-based BMP model. Worked with web-based tool development team and modelers to ensure accurate implementation of STEPL enhancements. Enhancements include improved rainfall-runoff hydrology by changing the long-term annual average rainfall to individual storms for computing the surface runoff and improved annual sediment load prediction by replacing the traditional Universal Soil Loss Equation (USLE) with the modified USLE equation that incorporates the runoff volume and peak for individual storm sizes.

Development of a Web-based Version of STEPL to Estimate Pollutant Loads in New York MS4 Jurisdictions. Technical Lead for developing a web application for NY DEC that can provide a decision-making framework and interface for users to evaluate effectiveness of various pollutant reduction activities in select New York MS4 jurisdictions. This application includes a user-friendly GIS-based watershed selection and several other mapping backgrounds, including street maps, aerial maps, watershed boundaries, and NHD streams.

Loading Simulation Program in C++ (LSPC). Principal model developer for LSPC, a watershed modeling system based on HSPF algorithms along with additional BMP algorithms, stream chemical reactions, stream bank erosion processes, and time-variable land use change simulation. Development lead and has contributed to the enhancement of LSPC modeling framework over the last 9 years. Implemented chemical reaction module to simulate the solute transport and transformation. Implemented BMP algorithms for disinfection units by introducing the pollutant concentration limit and load reduction controls. Implemented sediment transport algorithms. Implemented time-variable land use change simulation. Supporting and enhancing the model capabilities on a project basis.

Comprehensive Load Reduction Plans (CLRPs), City of San Diego, CA. Provided GIS programming and support for modeling of urban watershed and BMP processes to produce watershed-scale TMDL implementation plans. Developed hydrologic response units (HRUs) for land representation in LSPC watershed model of the San Diego River. Performed Management Settings analysis to model the watershed-scale management scenarios.

Watershed Model Development, Los Angeles County Department of Public Works. IT Lead for development of countywide watershed modeling system to identify pollutant reduction measures for urban runoff and stormwater quality improvements project. Led GIS data pre/post processing and updated/developed LSPC and BMPDSS.

SUSTAIN Case Study Applications. Conducted case study applications of SUSTAIN in Kansas City, MO, Louisville, KY, and Albuquerque, NM. For Kansas City and Louisville case studies, applied SUSTAIN to evaluate the use of green infrastructure for CSO mitigation. Calibrated SUSTAIN to existing models (InfoWorks, XP-SWMM) and modeled a variety of BMPs to determine cost-benefit relationships between green and grey infrastructure and identify the least-cost combinations of green and gray infrastructure to achieve regional overflow targets.

Watershed Information System (WIS), Prince George's County, MD. Principal system designer and project manager for this GIS-based system to facilitate and streamline data management, retrieval, and reporting capabilities to support development of Watershed Management Plans (WMPs) addressing EPA's 319 requirements. Prepared requirement analysis, and designed ArcGIS interface for the system. Assisted in developing spatial geodatabase, processing stream corridor assessment data, and processing other ArcGIS vector and raster datasets.

Watershed Model Preprocessing Tools, Fairfax County Stormwater Planning Division, VA. Developed a set of preprocessing tools using county GIS data to streamline watershed model inputs for developing watershed management plans for the county's 18 watersheds. Modified USEPA's STEPL model to include variable land use and automate data entry. Wrote/modified python language scripts for processing GIS data to extract required information from GIS layers for watershed model. Developed a standalone editing/modifying utility for SWMM5 input file to automate watershed parameter updates.

Grid Based Watershed Mercury Loading Model (GBMM), USEPA Region 4. Technical Lead on model formulation and development for GBMM that simulates spatial and temporal dynamics of mercury at the watershed level for both point and nonpoint sources. Designed ArcGIS interface and coded watershed processes using raster algebra library in visual C++ programming language. Helped manage the project tasks and worked closely with the ArcGIS programmer. Contributed in developing the technical design document and user's manual. Supported writing the technical conference paper/poster to disseminate the new grid-based modeling approach.

Sen Bai, PhD, PE

Senior Water Resource Engineer

EDUCATION

Ph.D., Environmental Engineering, University of Virginia, USA, 2004

M.S., Environmental Chemistry, Peking University, China, 1997

B.S., Environmental Planning and Management, Wuhan University, China, 1994

YEARS OF EXPERIENCE

Tetra Tech: 11

Total: 16

LICENSES/REGISTRATIONS

Professional Engineer, Virginia (# [redacted])

PROFESSIONAL AFFILIATIONS

American Society of Limnology and Oceanography

American Geophysical Union

Served as manuscript reviewer for:

- Estuaries and Coasts
- Journal of Coastal Research
- Journal of Environmental Science and Health, Part A Toxic/Hazardous Substances and Environmental Engineering
- Journal of Hydro-Environment Research
- Journal of Marine Systems
- Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management
- Water Environmental Research
- Water Research

AREAS OF EXPERIENCE

- Water quality modeling
- Watershed modeling
- Hydrodynamic modeling
- TMDL development

Dr. Sen Bai is an environmental engineer/modeler providing technical and project management support to federal, state, and municipal clients in the areas of water quality modeling, watershed modeling, hydrodynamic modeling, watershed management, point and nonpoint source pollution characterization and assessment, TMDL development and implementation. Dr. Bai has extensive experience addressing nutrients and eutrophication, enteric bacteria, and sediment transport and has served as lead modeler for more than 30 waterbodies and watersheds, including lakes, rivers, reservoirs, bays and coastal area in the United States and internationally (Canada, Slovenia) using CE-QUAL-W2, EFDC, WASP, LSPC, and HSPF. He has developed models to support water quality criteria development, TMDL development, and assessment of management practices. He is knowledgeable in numerical methods, is a skillful programmer, and has developed post processors for models such as W2, EFDC, and LSPC with Matlab, Excel VBA, FORTRAN, and Tecplot. He has also published journal and conference papers of his research work.

Project Experience

Frank Lake Water Quality Model Development. Served as lead modeler to support Alberta ESRD in developing an integrated hydrodynamic and water quality models for Frank Lake. Visual EFDC was used to develop the modeling system. A two dimensional grid was generated. Effluents from WWTPs were input to the model domain together with flow and loadings from the drainage basin, which were from the SWAT model of the watershed. The model simulates the complete cycles of nutrients and carbon with the dynamics of phytoplankton, periphyton, and macrophyte with sediment diagenesis activated to track the deposition and reaction of organic matter.

Linked Reservoir and River Water Temperature Simulation on the Stanislaus River, CA. For NOAA NMFS, developed water temperature models using EFDC for three linked reservoirs—New Melones Reservoir, Tulloch Reservoir, and Goodwin Reservoir— that flow into the Lower Stanislaus River, where the temperature is critical for protecting fish habitat. Developed linked models to simulate water temperature from the head reservoir to the river and to evaluate management practices.

Bacteria TMDL Updates, Washington, DC. Converted fecal coliform TMDL to *E. coli* TMDL. Reviewed previous models including Potomac, Anacostia, Rock Creek, Tidal Basin and Ship Channel. Converting the model input time series for fecal coliform to *E. coli* time series by applying a regression equation. Summarized daily and annual loadings of *E. coli* for DC waters to meet water quality standards.

Water Temperature and DO TMDL for Soos Creek Watershed, Washington. Developed HSPF model for water quality simulation in Soos Creek watershed and linked model results to Qual2Kw model for higher spatial resolution. Guided development of water temperature and DO simulations in Qual2Kw and application of linked models to develop TMDLs for temperature and dissolved oxygen.

Hydrodynamic and Water Quality Model Development of the Grand Lake o' the Cherokees, Oklahoma. Developed an EFDC water quality model, which receives watershed contributions of flow, sediment, and nutrients generated by a SWAT watershed model. The model simulates suspended sediment, DO, nutrients,

phytoplankton, and sediment diagenesis. The model results will support the development of TMDL to achieve DO criteria in the lake.

Hydrodynamic and Water Quality Model Development for Nutrient Criteria Development for Charlotte Harbor, Caloosahatchee Estuary, and Estero Bay, Florida. Developed hydrodynamic and water quality models of Charlotte Harbor, Caloosahatchee Estuary, and Estero Bay to support development of nutrient water quality criteria. The model uses flow generated by LSPC watershed model to drive hydrodynamic simulation using EFDC. EFDC-generated hydrodynamic information and LSPC-simulated nutrients from land are passed to WASP to simulate water quality, including nutrients, phytoplankton, DO, and light extinction coefficients.

Mispillion River and Cedar Creek Modeling, DE. For DNREC, served as lead modeler to develop a linked watershed and receiving water model to develop nutrient and bacteria TMDLs. Developed LSPC/HSPF model for overland washoff of nutrients and bacteria and in-stream dynamics. Enhanced the LSPC water quality module by adding a nitrogen preference function for impoundment algae simulation. Developed EFDC hydrodynamic and bacteria model for the tidal portion of the river. Linked LSPC to EFDC to conduct whole watershed modeling.

Watershed Modeling to Support CSO Planning in Milwaukee, WI. Served as lead watershed modeler to develop LSPC/HSPF hydrology simulation of Milwaukee River watershed. Designed and debugged the LSPC water quality module. Developed a mass conserve algorithm for material transport in streams with rapid flow change due to increased impervious land. Modeled sediment, nutrients, and algae dynamics in the watershed including both streams and lakes. Analyzed the CSO and SSO impacts on water quality in the Milwaukee River.

Bacteria Modeling for Christina River Basin to Support Bacteria TMDL Development, PA and DE. Evaluated the sources of fecal coliform and enterococci from land surface accumulation, cattle access to stream, and septic failure in Chester County, PA, and New Castle County, DE. Developed fecal coliform and enterococci models for Brandywine Creek. Simulated wash-off of fecal coliform and enterococci from land surface and in-stream fate and transport. Developed enterococci fate and transport model for tidal portion of Christina River and Brandywine Creek using EFDC framework. Modified EFDC to include die-off of enterococci from solar radiation and to include sediment-water partition of enterococci.

Lake Maumelle Hydrodynamic and Water Quality Modeling, AR. Developed a three-dimensional model using EFDC with generalized vertical coordinate (GVC) for Lake Maumelle, AR, to support development of a watershed management plan to protect this water supply source for the Little Rock region. Incorporated CE-QUAL-W2 heat flux and wind shear stress algorithms in the GVC version of EFDC. The model successfully reproduced the formation and disappearance of thermocline in the lake. Linked the model to an HSPF watershed model. Calculated time of travel to evaluate the impact of land development on the withdrawal intake for a water supply plant. Applied CE-QUAL-W2 to evaluate water quality under various development scenarios.

Three-dimensional Hydrodynamic and Water Quality Modeling for Salt River Bay, U.S. Virgin Islands. Developed a three-dimensional hydrodynamic EFDC model to support TMDL development. Applied the model to simulate the salt intrusion and flushing phenomenon in the bay area, to evaluate the effects of wind and tide and to analyze the impact of sediment oxygen demand on dissolved oxygen in the bay.

Sediment and Eutrophication Modeling for Lower Vermillion River, MN. Developed a vertically 2-dimensional model for simulating the suspended sediment and algae dynamics in the Lower Vermillion River to support TMDL development for sediment and nutrients. The modeling domain includes one main channel, three sloughes with three dikes, and seven lakes.

Fecal Coliform Fate and Transport Modeling in the Tidal Basin and Washington Channel, Washington, DC. Developed a fate and transport model for fecal coliform using EFDC to support TMDL development for DC DOH. Incorporated sediment-water partition capabilities for fecal coliform bacteria and the effects of sediment settling and re-suspension effects on fecal coliform into the EFDC code. Applied the model to simulate fecal coliform dynamics in the Tidal Basin and Washington Shipping Channel.

Water Quality Modeling of the Patuxent River Estuary, MD. Modeled hydrodynamics and eutrophication for Patuxent Estuary using the CE-QUAL-W2 for NOAA. Modified CE-QUAL-W2 version 3 code to include spatial variable longitudinal dispersion for the Patuxent Estuary. Developed a linking interface between CE-QUAL-W2 version 2 and WASP. Tested the linkage on the Patuxent Estuary. Modeled hypoxia and algal bloom under various land use change scenarios and evaluated the impact of fresh water inflow to algal bloom using the model.

TETRA TECH

Allison Barker

Contracts Manager

EDUCATION

J.D., Suffolk University Law School, 1998

B.A., English, University of Connecticut, 1995

YEARS OF EXPERIENCE

Tetra Tech: 15

Total: 16

LICENSES & CERTIFICATIONS

Certified Federal Contracts Manager

Member of National Contract Management Association (NCMA)

TRAINING

Contract Administration (seminar), National Contract Management Association

Government Contract Law (seminar) National Contract Management Association

Federal Acquisition Regulation (seminar) National Contract Management Association

AREAS OF EXPERIENCE

- State and Local Government Contracts

Ms. Barker is the Contracts Group manager and a senior contract administrator in Tetra Tech's Fairfax office. She has many years of contracts experience covering the full spectrum of contractual activities from proposal preparation through contract close out. She has been extensively involved in the following areas: proposal preparation; negotiating and managing all levels and types of federal and private sector contracts and subcontracts; all aspects of financial reporting; interfacing with contracting officers; supervising and training of junior personnel; and drafting of contracts, subcontracts, consultant agreements and teaming agreements. She has a thorough knowledge of the FAR and currently has her CFCM (Certified Federal Contracts Manager) certification.

Project Experience

Contract Aministrator. Currently serves as contract administrator for most of the Tetra Tech Fairfax office's commercial and state and local government contracts. Reviews all contracts for issues that need to be negotiated prior to signature. Prepares subcontracts as needed. Reviews all invoices submitted for accuracy on each project administered. Conducts monthly analysis of project status reports. Monitors all projects, tracking their budgets and costs incurred through weekly accounting reports to ensure there are no cost overruns and following the status of work plan due dates, stop work dates, and periods of performance. Trains new contracts department staff on all aspects of Tetra Tech's contract administration. Assists other contract administrators on Tetra Tech's large EPA CPFF contracts and where Tetra Tech is a subcontractor on EPA prime contracts. Reviews Tetra Tech outgoing invoices on contracts for accuracy before billing them to clients.

Responsible for the preparation of cost proposals. Reviews RFPs, coordinates with the technical staff, works with subcontractors, and reviews all cost information prior to processing it into a final proposal format.

Served as contract administrator for four multi year, multimillion-dollar CPFF contracts with the U.S. Environmental Protection Agency. Most contracts involved more than 8 major subcontractors and several consultants. Responsible for monitoring over 100 work assignments tracking their budgets and costs incurred through weekly accounting reports to ensure there are no cost overruns and following the status of work plan due dates, stop work dates, and periods of performance; and ensuring that all deadlines are met. Reviewed all contract modifications processed by EPA and coordinated frequently with EPA Contract Officers and Project Officers. Worked with work assignment task leaders to ensure that work plans and progress reports are submitted to EPA in a timely manner.

Prepared monthly financial reports for EPA on each work assignment, including dollars allocated, dollars spent per month, and dollars spent to date. Also worked with subcontractors on contract issues, contract ceilings, work plan approvals, monthly financial reports, status of work being conducted, and budget status. Reviews all subcontractor and vendor ODC invoices for accuracy prior to their being submitted to the accounts payable department. Reviewed and processed all Tetra Tech outgoing invoices on the contracts she managed for accuracy before the billing department sends them to EPA.

TETRA TECH

John Beckman

Watershed Analyst

EDUCATION

M.E.M., Environmental Management, Duke University, 1998

B.A., Biology, University of California – Santa Cruz, 1994

YEARS OF EXPERIENCE

Tetra Tech: 15

Total: 18

PROFESSIONAL AFFILIATIONS

Southern Appalachian Botanical Society

AREAS OF EXPERIENCE

- TMDL development
- Watershed modeling
- Water quality field studies
- Land use analysis and GIS
- Watershed data management
- Technical writing/editing
- Stream ecology and hydrogeomorphology surveys
- Botanical surveys

Mr. Beckman is an environmental scientist specializing in TMDL development and natural resources inventory. He has 18 years of professional experience performing scientific research, analysis, and large scale field surveys. Mr. Beckman leads Tetra Tech's statewide fecal coliform TMDL development efforts for the West Virginia Department of Environmental Protection. His duties include water quality modeling, data management, GIS analysis, technical writing, field investigations, and public outreach support. Mr. Beckman also has experience conducting stream ecology and botanical studies in the eastern United States.

Project Experience

TMDLs for Tygart Valley River Watershed, WV. 2014-present. For WVDEP, led fecal coliform TMDL development for watershed group B3. Gathered hydrologic data and built MDAS model. Calibrated MDAS water quality models for fecal coliform. Supported MDAS model setup for iron, aluminum, and beryllium. Developed model inputs for failing septic systems, MS4 areas, and agricultural sources. Developed estimates of streambank erosion in modeled streams. Calculated TMDL load allocations for fecal coliform, aluminum and pH TMDLs.

Source Water Protection Field Surveys, VA. 2013-2015. For the Virginia Department of Health, led field surveys to verify potential contaminant sources for drinking water systems in Albermarle and Rockbridge Counties. Wrote and edited source water protection plans. Performed time of travel analysis for Maury Service Authority source water intake.

Community Water System Source Water Protection Plan Updates, Clarksburg and Fairmont, WV. Clarksburg Water Board and City of Fairmont. 2014-present. Conducted data gathering meetings with drinking water plant operators, developed survey area maps using GIS, and performed field investigations to confirm known potential contaminant sources and identify new threats to drinking water in the West Fork and Tygart Valley River watersheds.

Nutrient TMDLs for Wissahickon Creek, PA. 2014. Developed phosphorus TMDL allocation inputs specific to 16 MS4 entities in the Wissahickon Creek watershed in eastern Pennsylvania. Ran load reduction scenarios in LSPC watershed model to generate inputs for EFDC receiving water modeling system.

TMDLs for South Branch Potomac, Upper Kanawha, and Upper Ohio North Watersheds, WV. 2013-2015. For WVDEP, led fecal coliform TMDL development for watershed group A3. Gathered hydrologic data and built MDAS model. Calibrated MDAS watershed models for hydrology and water quality. Developed model inputs for failing septic systems, MS4 areas, and agricultural sources. Modeled point-source permitted fecal coliform discharges. Developed TMDLs for selenium by allocating loads to active mining operations and historic acid mine drainage seeps.

TMDLs for West Fork River Watershed, WV. 2012-2014. For WVDEP, led fecal coliform TMDL development for watershed group E2. Built MDAS watershed model through analysis of hydrology, land cover, and elevation datasets. Conducted MDAS watershed model calibration for hydrology and water quality parameters. Performed iron-sediment correlation and streambank erosion calibration. Represented fecal coliform and iron point-source discharges in the MDAS model. Developed TMDL load allocations and pollutant reductions for fecal coliform sources.

TMDLs for Monongahela River Watershed, WV. 2011-2013. For WVDEP, led fecal coliform TMDL development for watershed group D2. Constructed a hydrologic model using GIS analysis and database techniques. Calibrated MDAS watershed models for hydrology and water quality. Developed model inputs for CSOs, failing septic systems, MS4 areas, and agricultural sources. Incorporated point-source permitted fecal coliform discharges into the watershed model. Developed TMDL load allocations and pollutant reductions for both point and nonpoint sources.

TMDLs for Middle Ohio North and South Watersheds, WV. 2010-2011. For WVDEP, led fecal coliform TMDL development for watershed group C2. Performed GIS analysis to delineate model subwatersheds and manage pollutant source data. Built and calibrated MDAS watershed models. Developed CSO and MS4 model inputs. Incorporated permitted fecal coliform discharges into the watershed model, and developed TMDL load allocations and pollutant reductions for both point and nonpoint sources.

Source Water Protection Field Surveys, WV. 2009-2011. For the West Virginia Department of Health and Human Resources, Source Water Assessment and Protection Program, led field surveys to verify potential contaminant sources for 100 drinking water systems. Served as primary point of contact for subcontractors and off-site field staff. Organized field data using GIS and MS Access databases.

Perennial Streams Survey, WV. 2010. Field botanist for USACE Huntington District project to assess hydrogeomorphology of headwater streams and vegetative characteristics of headwater riparian areas in southern West Virginia. Used field methods to determine canopy, shrub, and herbaceous percent cover and tree species. Surveyed bank angle, longitudinal profile, and streambank erosion. Used GPS to navigate to sites and record survey features.

TMDLs for Lower Kanawha Watershed, Elk River, and Patterson Creek, WV. 2009. For WVDEP, led fecal coliform TMDL development for watershed group B2. Used hydrologic and topographic GIS data to delineate model subwatersheds. Built and calibrated MDAS watershed models. Incorporated permitted discharges into the watershed model, and developed TMDL load allocations and pollutant reductions for both point and nonpoint sources. Met with wastewater treatment plant operators and city engineers to develop CSO and MS4 model inputs.

Trout Water Iron Modeling Project, WV. 2009. For WVDEP, supported model development efforts to investigate total iron concentrations in two trout streams, Elklick Run and Holcomb Run, both headwater streams in Gauley River Watershed. Performed fieldwork to collect soil samples and estimate streambank erosion. Set up watershed model, compiled meteorological data, and prepared preliminary draft report.

TMDLs for Cheat River Watershed, WV. 2008. For WVDEP, led fecal coliform TMDL development for impaired streams in the Cheat River Watershed (watershed group A2). Performed GIS analysis to delineate model subwatersheds and manage pollutant source data. Built and calibrated MDAS watershed models. Incorporated permitted discharges into the watershed model, and developed TMDL load allocations and pollutant reductions for both point and nonpoint sources. Attended public meetings to present TMDL results.

TMDLs for Upper Ohio South, Dunkard Creek, Youghiogheny Tributaries, and Camp Creek Watersheds, WV. 2007. For WVDEP, led fecal coliform TMDL development for watershed group E. Delineated model subwatersheds using GIS. Built and calibrated MDAS watershed models for hydrology and water quality. Modeled CSO point sources and MS4 areas. Incorporated permitted discharges into the watershed model, and developed TMDL load allocations and pollutant reductions for both point and nonpoint sources. Made figures and edited reports.

TMDLs for New River and Greenbrier River Watersheds, WV. 2006. For WVDEP, served as TMDL development team member for watershed group D. Participated in the Stressor Identification workshop for biological TMDLs. Used GIS to delineate model subwatersheds. Built and calibrated MDAS watershed models. Developed TMDL load allocations and pollutant reductions. Assisted with agricultural pollution source tracking field surveys in impaired watersheds.

TMDLs for Gauley River and Potomac Direct Drains Watersheds, WV. 2005. For WV DEP, served as TMDL development team member for watershed group C. Used watershed data to build MDAS models for fecal coliform and sediment. Performed hydrology calibration, water quality calibration, and load allocations for the Potomac Direct Drains watersheds models. Edited technical reports, and collected data for streambank erosion field studies.

TMDLs for Coal River, Lower Kanawha, and North Branch Potomac Watersheds, WV. 2005. For WVDEP, served as TMDL development team member for watershed group B. Performed GIS analysis to contribute to the pollutant source reports for the three TMDL watersheds. Produced ArcInfo GIS project displaying TMDL results as part of the public TMDL report. Edited text and made figures for the public and technical TMDL reports.

TETRA TECH

Clint Boschen

Biological Analyst

EDUCATION

M.S., Biological Sciences, Florida State University, 1996

B.S., Biology, Virginia Polytechnic Institute and State University (Virginia Tech), 1991

YEARS OF EXPERIENCE

Tetra Tech: 14

Total: 18

PROFESSIONAL AFFILIATIONS

Water Environment Federation

AREAS OF EXPERIENCE

- Clean Water Act support
- TMDL development
- Water Quality modeling
- Guidance development
- Water quality assessment
- Pollutant source assessment
- Watershed management
- Stormwater management
- Water quality monitoring and bioassessment

Mr. Boschen has more than 18 years of professional experience providing technical and program management support to federal, state, municipal, and local water resource agencies. He has extensive experience in the areas of stormwater management, water quality planning, stream and lake assessment, watershed/receiving water modeling studies, water quality and biological sampling, and wetland permitting. He is currently leading Tetra Tech's TMDL and watershed management support to the City of San Diego and other municipalities in the region. Mr. Boschen has experience with all aspects of the Clean Water Act, including wetland and stream protection programs (Sections 404 and 401), water quality standards, NPDES, and TMDLs. He has led or participated in complex TMDL and modeling projects to address biological impairments, metals, bacteria, toxic pollutants, sediment, dissolved oxygen, and nutrient enrichment. He also has extensive technical experience designing monitoring studies, developing and applying water quality and hydrologic models (LSPC, SWMM, GWLF, STEPL, etc.), performing water quality analyses, and providing technical training.

Project Experience

Biological TMDL Development for Streams in West Virginia. For the West Virginia Department of Environmental Protection (WVDEP), Project Manager for the development of biological TMDLs for streams in the Upper Ohio, Upper Kanawha, Lower Kanawha, Coal River, and North Branch Potomac watersheds in West Virginia. Coordinated stressor identification studies involving the analysis of available water quality, habitat, and biological data to determine the primary causes of impairment for each listed stream. Mr. Boschen also participated in stressor identification studies for the Gauley River and Potomac Direct Drains watersheds. Stressor identification incorporated statistical analyses of pollutant-biological response relationships, literature reviews, and additional data collection to help identify and evaluate candidate causes of biological impairment. Assisted in the development of novel statistical approaches and diagnostic tools that utilize biological data to help identify benthic community stressors (tolerance value and "dirty null" models). He coordinated the development of TMDLs for identified stressors (pollutants) using a reference watershed approach and selected water quality/watershed modeling systems (MDAS, GWLF, etc.). TMDLs were developed for excessive sedimentation, metals contamination, and acidity.

Chesapeake Bay TMDL Development. For EPA Region 3 and the Chesapeake Bay Program, provided TMDL technical and project management support. Member of several Chesapeake Bay workgroups, including the Reevaluation Technical Workgroup, the Modeling Sub-committee, and the Water Quality Steering Committee. Provided assistance to resolve key technical issues and identify TMDL development needs. Completed the development of documentation for the Chesapeake Bay Phase 5 watershed model and led the development of model documentation and technical support for VORTEX (system contains the Phase 5 watershed model input data).

Bacteria and Biological TMDL Development for Streams in Virginia. For EPA Region 3 and the Virginia Department of Environmental Quality (VADEQ), Project Manager for the development of TMDLs for impaired streams in the Potomac-Shenandoah, Tennessee-Big Sandy, Roanoke, and James River basins in Virginia. TMDLs were developed for fecal coliform, E. coli, and biological impairments to meet court-ordered deadlines. Bacteria TMDLs were developed using EPA's Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) system and Tetra Tech's Loading Simulation Program C++ (LSPC)

model. Excessive sedimentation and nutrient enrichment were identified as the primary causes of biological impairment based on Stressor Identification studies conducted by Tetra Tech. Various methods were used to quantify pollutant loads for biologically-impaired streams, including the Generalized Watershed Loading Functions (GWLF) model.

As-needed Monitoring Services, City of San Diego
Mr. Boschen leads Tt's monitoring, watershed, and water quality support to the City of San Diego in partnership with AMEC Environmental. Responsible for the development and execution of multiple task orders, contract management, and staffing. Key activities included critical Bio-objectives support, TMDL development activities and collaboration with EPA Region 9 and the San Diego Regional Board, and technical support to facilitate future adoption of dissolved metals SSOs and ASBS dilution studies.

Water Quality Improvement Plans (WQIPs). For the City of San Diego and other Responsible Agencies, supported the development of numeric goals and other components of the Los Peñasquitos, San Dieguito, Mission Bay, and San Diego Bay WQIPs. Also, led development of an updated model for the Los Peñasquitos watershed. The previous model was updated to incorporate recent monitoring data for calibration and additional BMP modeling capability to identify pollutant load reduction needs. Development of WQIPs is required under the recently issued San Diego MS4 permit. These plans consolidate MS4 permit reporting requirements and include identification priority water quality conditions, structural and nonstructural strategies, and implementation support.

Upper San Marcos Creek/Lake San Marcos Nutrient TMDL Analysis. For EPA Region 9 and the San Diego Regional Board, Project Manager for modeling support to address nutrient impairments for Upper San Marcos Creek and Lake San Marcos. A nutrient study is currently being conducted as part of a voluntary public agency effort, which includes the City of San Marcos, County of San Diego, City of Escondido, Caltrans District 11, Vallecitos Water District, and the San Marcos Unified School District. The first phase of the study includes development of a watershed model for the area that drains to Lake San Marcos to help characterize nutrient sources within the watershed and the linkage to potential impacts on water quality. Tetra Tech developed a watershed model using the Loading Simulation Program in C++ (LSPC) to estimate flow and nutrient contributions to the lake. Model results will be used to evaluate the relative impact of various eutrophication processes and develop a detailed implementation plan.

Famosa Slough Eutrophication Modeling and TMDL Support. For the City of San Diego, Project Manager for TMDL development in Famosa Slough to address eutrophic conditions, including modeling the small, coastal watershed, a 22-acre lagoon and a 10-acre channel that connects the lagoon with the tidal portion of the San Diego River. Managed development of watershed and receiving water models as part of the 2008 TMDL Phase I data compilation and model configuration effort for several lagoons in Southern California. Models included a linked watershed (HSPF) and receiving water (EFDC) modeling framework to quantify nutrient sources and eutrophication impacts. Managed later updates to the EFDC model to incorporate additional monitoring data and better represent eutrophication processes, including macroalgae and sediment components. Will manage application of models to develop TMDLs and identify management actions.

Santa Margarita Watershed River Modeling and TMDL Support. For EPA Region 9 and the San Diego Regional Board, Project Manager for developing TMDLs for the Santa Margarita River and Estuary to address nutrients/eutrophic conditions. This small estuary receives surface runoff from a relatively large watershed which includes portions of San Diego and Riverside counties. Managed development of watershed and receiving water models as part of the 2008 TMDL Phase I data compilation and model configuration effort for several lagoons in Southern California. Models included a linked watershed (HSPF) and receiving water (EFDC) modeling framework to quantify nutrient sources and eutrophication impacts. Managed recent updates to watershed model to incorporate additional data and extend the modeling period. Ongoing support includes refinements to the water quality calibration and continued collaboration with the watershed stakeholders to facilitate TMDL and implementation planning efforts.

Development of Comprehensive Load Reduction Plans for San Diego Watersheds. For the City of San Diego and regional MS4 copermittees, Project Manager for the development of Comprehensive Load Reduction Plans (CLRPs) for six watersheds in the San Diego region (San Diego River, San Dieguito, Penasquitos, Scripps, Tecolote, and Chollas). These plans address the bacteria impairments that were included in the recently approved TMDLs for San Diego Beaches and Creeks (February 2010). In addition, other TMDLs and 303(d) impairments were included to increase the effectiveness and efficiency of planning efforts, and to reduce the overall cost of implementation and compliance monitoring. Development of these plans occurred in phases to satisfy the regulatory requirements specified in the Bacteria TMDL and additional analyses and implementation planning requested by the Responsible Parties.

TETRA TECH

Kimberly Brewer, AICP

Outreach Specialist

EDUCATION

M.R.P., City and Regional Planning, University of North Carolina, 1985

B.A., Economics, Wake Forest University, 1981

YEARS OF EXPERIENCE

Tetra Tech: 17

Total: 31

LICENSES/REGISTRATIONS

American Institute of Certified Planners

PROFESSIONAL AFFILIATIONS

American Institute of Certified Planners

American Planning Association

AREAS OF EXPERIENCE

- Watershed management planning
- Conflict resolution/Facilitation
- Code and ordinance review/development
- Program implementation support
- Community outreach and involvement
- Training

Throughout her 31 years of water resources planning and management experience, Ms. Brewer has coupled technical and policy analysis with stakeholder facilitation/mediation to develop innovative, cost-effective watershed management and green design strategies. She has pioneered approaches for low-impact design, reviewed more than 35 local governments' ordinances and codes to strengthen LID and green infrastructure, and assisted in conducting numerous local watershed management studies and action plans incorporating LID. She was a co-author of the *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (USEPA, 2008) and a co-investigator and co-author for the joint Electric Power Research Institute (EPRI)/WERF project on Case Studies for the New Water Infrastructure Management Paradigm to help communities develop sustainable approaches to water management.

Project Experience

Chesapeake Bay TMDL Watershed Implementation Plan (WIP). Prince Georges County, MD. Assisted in developing WIP for Chesapeake Bay TMDL. Led analysis of budgets and costs, funding options, future growth and development impacts to be mitigated, and management strategies.

Third Fork Creek Watershed Plan. City of Durham, NC. Assisting in project to prepare a watershed management plan and implementation plan for restoring watershed function. Worked with City Coordinating Team to establish core watershed restoration goals, objectives, indicators, and benchmarks that will provide a consistent framework for conducting watershed assessments and management plans city-wide. Also established goals and objectives unique to Third Fork Creek. Assisted in critical lands protection analysis, riparian area management planning, and review of existing code, ordinances, criteria, policies, and procedures to support the City's restoration efforts.

Determining the Potential of Green Infrastructure to Reduce Overflows in Milwaukee, WI. Led research and co-authored Triple Bottom Line (TBL) analysis for the recommended green infrastructure practices determined to be most cost-effective. The purpose of the TBL analysis was to evaluate a broader range of social, economic, and environmental benefits, using quantifiable indicators such as job creation, increased property values, reduced infrastructure costs, reduced pumping costs, increased recreational opportunities, increased groundwater recharge, increased carbon sequestration, and reduced energy use/heat island effect. The analysis also determined the degree to which each green infrastructure practice contributed to these benefits.

Watershed Improvement Program, Athens-Clarke County (ACC), GA. Developed Watershed Improvement Program protocols using three diverse pilot watersheds. Working in partnership with ACC staff, developed protocols for monitoring, data review, watershed characterization, watershed and site-scale modeling, evaluation of BMPs, and development and evaluation of management strategies. Assisted ACC in establishing goals, objectives, indicators, and benchmarks that were used in watershed assessment and planning. Designed the Watershed Improvement Program protocols to provide a sound and consistent foundation for future watershed plans and CIP planning in the county.

Case Studies on New Water Paradigm. Co-investigator and co-author for research being sponsored by the Electric Power Research Institute (EPRI) and Water Environment Research Foundation (WERF) to propose a new paradigm for

water infrastructure management (drinking water, wastewater, and stormwater) that is based on sustainable principles. Recruited western and eastern case study communities and 24 expert advisory panelists, compiled background information on each community, arranged and led a three-day intensive retreat, and was primary author of final report defining goals, principals, and components of the new paradigm.

TMDL Implementation Plans, Los Angeles County. Lead planner in development of multi-pollutant TMDL implementation plans for Ballona Creek and Los Angeles River for Los Angeles County, which use a comprehensive, cost-effective, phased approach. Assisted in developing, evaluating, and documenting nonstructural and structural solutions for the watersheds, including LID techniques. Linked the Implementation Plan to other water resource objectives and planned water resources projects to achieve multiple benefits.

San Antonio LID Permitting Track. For the San Antonio River Authority and the City of San Antonio, currently developing a voluntary, stand-alone LID permitting track (LID Use Pattern Ordinance) that includes incentives, LID performance standards, site design strategies, construction activity requirements, and inspections and maintenance requirements. Worked with a staff stakeholder committee and design and engineering stakeholder committee to drafting language for the proposed ordinance. Currently assisting the City in moving the code through public, board, and city council review to adoption.

Model Post-Construction Ordinance for Spring River Watershed Region. For USEPA and Missouri DEQ, developed model post-construction code that encourages LID for local governments in the Spring River Watershed to assist the local governments in complying with their MS4 permit requirements. Worked with local government staff in identifying goals for the local code and implementation concerns and issues. Held training workshop for local government staff.

Green Infrastructure Training for EPA Region 7 Staff. To support EPA Region 7's efforts to encourage communities to use green infrastructure as they plan for sustainable infrastructure, designed and conducted a 1.5-day training workshop for EPA and state staff that administer a variety of water, waste, and air programs. The training included an overview of green infrastructure, case studies and lessons learned, local code reviews, integrating green infrastructure into state and federal programs, modeling and analysis, and a design/planning exercise.

LID Training for Local Governments and Designers. For Johnson County, Kansas and EPA Region 7, developed and conducted a one-day training workshop on LID, including principles of LID, the LID design process, LID practices, how LID is different than the current BMP design approach in the local governments, co-benefits of LID, case studies, common conflicts with existing codes, maintenance and monitoring, and a design exercise.

Green Infrastructure Code Review, City of Griffin, GA. Completed a detailed code, ordinance, stormwater design manual, and utility fee credit review to identify barriers and recommend revisions to strengthen implementation of green infrastructure. Worked closely with the Stormwater Utility to develop a list of preliminary options and recommendations for code revisions. Then facilitated a workshop with staff from the planning, parks, stormwater, and public works departments, the City Attorney, and members of the local Environmental Advisory Board. The workshop identified 20 priority action items for code revisions and areas that needed additional research.

Building Blocks for Sustainable Communities Technical Assistance. For USEPA Office of Sustainable Communities, helped develop community technical assistance tool *Linking Land Use and Water Quality*. Managed technical assistance to nine communities in using the tool and lead technical assistance in five communities. Assistance included community research, design of local workshops and community outreach for workshops, working with community staff to complete a code review using the tool checklist, tailoring presentation materials to local issues and goals, participating in on-site tour to review representative problem areas and green BMP opportunity sites, presentations to election officials, conducting all-day workshop with staff, elected officials and key stakeholders and developing high priority action plan, and writing a Next Steps Memo for the elected board's consideration.

Statewide Watershed Management Frameworks. Facilitated and provided technical assistance in designing statewide watershed management frameworks for Delaware, Georgia, Florida, Texas, Tennessee, and West Virginia. Technical assistance included evaluation and delineation of watershed management units, outlining stakeholder involvement needs and processes, a management cycle and schedule of activities, strategic monitoring and assessment, recommended prioritization method, and process for developing watershed management strategies and plans. Assistance also addressed transitional issues such as developing monitoring partnerships, designing an information management system to support basin management, and developing new organizational structures. Project Manager for Delaware, Tennessee, and West Virginia; Project Assistant for Georgia, Florida, and Texas.

TETRA TECH

Jonathan Butcher, PhD, PH

Technical Expert

EDUCATION

Ph.D., Civil and Environmental Engineering (Water Resources), Duke University, 1989

M.E.M., Water Resources, Duke University School of Forestry and Environmental Studies, 1984

B.A., Harvard College, 1973

YEARS OF EXPERIENCE

Tetra Tech: 16

Total: 30

LICENSES/REGISTRATIONS

Professional Hydrologist, Registered by the American Institute of Hydrology, 1995, Certificate #[redacted]

PROFESSIONAL AFFILIATIONS

American Institute of Hydrology (Registered Professional Hydrologist)

American Water Resources Association (Reviewer for JAWRA)

American Society of Civil Engineers (Reviewer for JEE)

American Geophysical Union

Water Environment Federation

North American Lake Management Society

Society of Environmental Toxicology and Chemistry

International Water Association

AREAS OF EXPERIENCE

- Climate change
- Clean Water Act support
- TMDL development
- Water quality modeling
- Hydrodynamic modeling
- Guidance development
- Water quality assessment
- Pollutant source assessment
- Environmental statistics
- Watershed management
- Ecological risk assessment

Dr. Butcher has 30 years of experience in watershed planning, risk assessment, water quality management, and the development, application, and communication of hydrologic, hydraulic, and water quality models. He is a nationally recognized expert in the application of HSPF, SWAT, and other watershed models and has worked with model developers to test, debug, modify, and improve modeling code. Dr. Butcher also has developed numerous lake, reservoir, and estuarine response models using WASP, EFDC, CE-QUAL-W2, and a variety of other tools and regularly develops comprehensive linked watershed and receiving water modeling systems. His comprehensive modeling and assessment projects including applications for TMDL development, source water protection, climate change analysis, and development of numeric water quality criteria.

Project Experience

Lake Maumelle Source Water Protection Plan. Central Arkansas Water, 6/05-11/07. Developed a linked watershed-reservoir modeling system using HSPF and CE-QUAL-W2. Identified application needs for modeling through a stakeholder objectives process and formal modeling QAPP. Applied calibrated/validated models to evaluate a variety of development scenarios and management strategies. Directed development of Site Evaluation Tool to analyze loading under different BMP combinations on newly developed sites and to support decisions on zoning and land management practices. Supported public hearings with expert testimony.

Malibu Biota/Sediment TMDL. EPA Region 9, 9/10-12/14. Led a project for EPA Region 9 to develop a TMDL to address impaired bioscores in Malibu Creek and Lagoon. Evaluating and assessing causes of poor bioscores is challenging due to the unique geology of the San Gabriel Mountains, which experience the highest uplift rates in California. Applied full CADDIS approach to stressor identification to identify inter-relationships of a variety of physical, habitat, and chemical stressors. Identified nutrient loads and habitat degradation associated with hydromodification and increased sediment transport as primary stressors. Wrote major sections of approved TMDL for nutrients and sediment transport capacity. Currently supporting development of TMDL implementation plans.

Jordan Lake TMDL Watershed Models. NC DWQ and Triangle J Council of Governments, 9/03-3/05, 8/12-ongoing. Led two projects to model watershed nutrient loads from a 1,700 square mile mixed use watershed to support development of TMDL for chlorophyll a. For the initial scoping model, combined sub-watershed estimates of nutrient load generation using the GWLF model with the stream transport/attenuation component of the USGS SPARROW model. Led follow-up project to create a detailed HSPF model of the watershed that allows assignment of loads to jurisdictional entities consistent with adopted TMDL and accompanying rules. Incorporated a representation of land use change and derivation of load allocations for 2000 and current conditions.

Jordan Lake Nutrient Response Model. Jordan Lake Project Partners, 12/00-9/03. Manager and lead modeler on a project for a consortium of utilities to create a calibrated response model for Jordan Lake in NC. This model met state's mandate to create a tool that can be used to derive alternative effluent limits to those prescribed in the Nutrient Sensitive Waters rule. Created a complex, three-dimensional hydrodynamic model using a modified version of the EFDC code. Hydrodynamic and temperature simulation output of this model is linked forward into a WASP water quality model to simulate nutrient species and algal response.

Received additional support from NC DWQ to develop a watershed model for the reservoir.

Gould Island Contaminated Sediment Evaluation. NAVSTA Newport, 12/09-1/12. Led a Tier 2 contaminated sediment evaluation of Gould Island, a former naval facility in Narragansett Bay, RI. Helped develop an EFDC tidal model and CGWAVE and STWAVE wave models of the area; these models were used to assess stability of

Milwaukee Metropolitan Sewer District (MMSD) 2020 Planning Study. MMSD, 6/04-11/07, 2/10-4/13Modeling lead for the MMSD 2020 study. Developed comprehensive watershed models for the Milwaukee area and supported TMDL development (1,100 mi^2). HSPF is used as the basic model framework; however, loading rates from individual land areas are tuned to replicate estimates developed using SWAT (for agricultural land) and SLAMM (for developed urban land), as directed by Wisconsin DNR.

Minnesota River TMDL Watershed Models. Minnesota PCA, 12/00-9/03, 3/06-12/09. Led two projects to develop HSPF models and complete TMDLs for the Minnesota River system, covering much of the southwest portion of the state (12,200 mi^2). Developed a set of nine linked models for major tributary basins and the Minnesota River mainstem. Created Special Actions modifications to simulate tile drainage within HSPF. **Global Change Hydrology Impacts.** USEPA ORD, 7/08-9/15. Technical and modeling lead for large-scale, multi-firm project to analyze the impacts of climate and land use change on hydrology and pollutant loading in 20 large river basins (approximately 20,000 mi^2 each) in all climatic regions of the US. Basins are simulated with HSPF and SWAT, with future impacts simulated in response to a variety of different NARCCAP downscaled climate.

Lake Champlain Nutrient TMDL. USEPA Region 1, 8/11-10/13. Supported USEPA in the reanalysis of the Lake Champlain nutrient TMDL, especially in regards to incorporating climate change into allocations as directed by court order. Supervised development of SWAT models of runoff and pollutant transport for the entire Champlain watershed. Developed methods to incorporate climate change scenarios into SWAT simulations by applying statistical transformations to historical meteorological time series - using either NARCCAP dynamically downscaled climate products or CMIP statistically downscaled climate products. Directed pilot application of climate scenarios to the La Platte watershed and modeling efforts to extend analysis to entire Champlain watershed.

Climate Change Impacts on Lakes. USEPA ORD, 10/12-9/14. Led an effort to evaluate potential climate impacts on lake thermal structure and mixing regimes. Developing one-dimensional model of lake mixing based on current NCAR CESM/CLM modeling system routines that provide a full simulation of temperature, radiative, and wind forcing, including sophisticated representation of ice and snow layers and the impact of black carbon and aerosol deposition on snow/ice thermal and optical properties.

South Fork Nooksack Temperature TMDL and Climate Change Analysis. USEPA ORD, 7/13-9/15. Technical lead for project integrating climate change into the temperature TMDL for the South Fork Nooksack River, an important salmon habitat in northwest Washington State. Worked with multiple climate scenarios that have been statistically downscaled by Washington's Climate Impacts Group (CIG) and used to produce broad-scale projections of hydrologic changes using the VIC model.

St. Louis, Cloquet, and Nemadji Watershed Models. Minnesota PCA, 2/13-12/15. Leading project to develop detailed, HUC-12 scale HSPF models of the St. Louis, Cloquet, and Nemadji watersheds near Duluth, MN. These watersheds include extensive hydropower development and open-pit taconite mining, which results in complex mixes of water withdrawals and discharges. The lower Nemadji is on lacustrine soils influenced by long-range artesian groundwater connections. Initial hydrology is completed, but will be further revised through integration with a MODFLOW groundwater model of the Nemadji.

Ventura River Hydrology Model, Ventura County WPD, CA. 3/08-6/11. Developed a detailed subhourly HSPF model of Ventura River watershed. Because model was initially used to support FEMA FIS determinations, focused on accurate prediction of flood peaks using 15-minute and 5-minute simulations.

Root River Watershed Models. EPA Region 5, 12/10-5/13. Led project to develop comprehensive watershed models of the Root River in the driftless area of southeastern Minnesota to support TMDLs and watershed management planning. This unglaciated area is characterized by karst and sinkhole plains. Models include HSPF at the watershed scale and SWAT at the local watershed scale. Both models were modified to address simulation of karst features. BMPs to control nitrogen export to the Gulf of Mexico are of particular interest. Also conducted GIS-based evaluation of potential wetland restoration sites.

TETRA TECH

J. Trevor Clements

Watershed Analyst

EDUCATION

M.E.M., Water Resource Systems Analysis, Duke University, 1983 (3-2 Program)

B.A., Political Science, Environmental Conservation, Augustana College, IL, 1982

Honors: summa cum laude, Phi Beta Kappa, Aristeia, Union Camp Fellowship

YEARS OF EXPERIENCE

Tetra Tech: 18

Total: 31

PROFESSIONAL AFFILIATIONS

American Water Works Association

Water Environment Federation

Association of Metropolitan Water Agencies

North Carolina Water Resources Association

AREAS OF EXPERIENCE

- Watershed management planning
- Community resiliency planning
- Watershed assessment
- Source water protection
- Stakeholder facilitation and public outreach
- Watershed management framework development
- Sustainable practices research
- Management plan and program implementation support
- Water quality modeling
- NPDES permitting support
- State and federal program evaluation and research
- Program, project and contract management

Trevor Clements has 31 years of experience in the assessment and management of water and is a national leader in comprehensive watershed management and integrated water planning incorporating sustainable and resilient practices. He has researched and developed triple-bottom line management approaches for communities to respond to change (water quality, climate, land use, population, social and economic), managed numerous modeling and watershed assessment analyses, prepared numerous watershed and stormwater management plans, supported facility and infrastructure planning, and supported many plan implementation programs including those for source water protection. He has achieved national recognition for his skills in facilitating intensive work group sessions and partner meetings, troubleshooting integrated management framework development and implementation barriers, facilitating stakeholder involvement, and refining watershed management program roles and procedures. Drawing on his experience, Mr. Clements has authored or co-authored multiple publications and technical guidance documents and is frequently asked to provide public presentations and keynote addresses regarding integrated water approaches.

Project Experience

Jordan Watershed Modeling and Jurisdictional Load Allocations. Project Manager for a coalition of the Triangle J Council of Governments, NC Division of Water Quality, and NC Nutrient Scientific Advisory Board to develop a hydrodynamic watershed model to more accurately estimate nutrient baseline loads and determine jurisdictional load allocations for TMDL implementation. Compiled data for 32 jurisdictions, applied advanced remote sensing to develop high resolution land use and land cover classifications, calibrated and corroborated hydrology and water quality components per model QAPP, and applied the model to establish baseline load allocations for each jurisdiction.

Northeast Creek Watershed Modeling Services. For City of Durham, managed project to calibrate and apply PCSWMM and WASP models to support jurisdictional load allocation for multiple TMDLs. Coordinated with City, NC Division of Water Resources, and adjoining jurisdictions to compile data and develop a modeling framework to support all parties. Also, under separate task, updated a WARMF model for the City of Durham portion of the Falls Lake watershed to improve jurisdictional load estimation.

North Carolina TMDL Support. Managed contract that supports the North Carolina Division of Water Quality in producing TMDLs. For all work orders, oversaw preparation of scoping memo outlining proposed approach, work plan development, and contract management. Provided senior technical consultation and quality assurance review for analysis and documentation.

North Carolina Surface Water Quality Modeling Program. Managed North Carolina's Surface Water Quality Modeling Program. Analyzed sources and impacts of conventional, toxic, and eutrophication-related parameters on water quality of streams, rivers, lakes, estuaries, and wetlands. Modeling applications included fate and transport studies, 303(d) list and TMDL development, NPDES wasteload allocations, environmental impact assessments, and basin-wide planning.

Integration of State Revolving Fund Programs and Watershed Protection. Coauthored report for EPA's Office of Water outlining incentives for and impediments to improved integration of State Revolving Fund (SRF) programs with watershed protection approaches. Seven states were interviewed as a part of

project research, and a briefing was conducted for EPA Office Directors and key program staff.

North Carolina DOT Significant Contributor Determination Protocols. For NCDOT and the North Carolina Division of Water Resources, facilitated a project to develop a protocol for determining whether NCDOT is a significant contributor for specific pollutants of concern when TMDLs are being developed. The decision invokes additional regulatory requirements and therefore both agencies want an accurate and practical means for making the decision. Conducted research, developed conceptual models, drafted protocols, facilitated joint meetings, and prepared final documentation.

North Carolina Basin Management Approach. Led design of the initial basinwide planning approach for the Water Quality Section of the NC Division of Environmental Management. Changed operational paradigm for assessment, NPDES and nonpoint source planning programs to be coordinated on management cycles within basin planning units. Represented North Carolina in negotiations with USEPA Region IV to obtain approval to revise its Continuing Planning Process to incorporate operational changes.

North Carolina Integrated Restoration Workshop. Lead facilitator for 2-day workshop bringing approximately 40 agency staff together from various Department of Natural Resources programs involved in environmental restoration to identify opportunities for enhanced coordination and leveraging of resources.

North Carolina Low Impact Development (LID) Guidebook. Provided senior QAQC and contract management for support to NC State University to develop case studies for the North Carolina Low Impact Development Guidebook.

Mecklenburg County McDowell Creek Watershed Study. Managed project for the Mecklenburg County Land Use and Environmental Services Agency to develop a watershed modeling system to support management decision-making. Project involved set-up and calibration of an HSPF watershed model, baseline assessment comparing existing conditions to project conditions for future land use, development of a site development evaluation model to evaluate effectiveness of stormwater BMPs, and development of pre- and post-processor software to link the modeling tools with the county's Watershed Information System.

Jordan Lake Nutrient Response Modeling. For a consortium of utilities, managed the development of a modeling framework to evaluate nutrient delivery to Jordan Lake and the lake response. The lake drains over 1600 square miles across 10 counties, and provides a water supply of over 100 MGD to local communities. The project involved linking regression models, FLUX models, an EFDC model of the lake hydrodynamics, and a WASP model of the lake water quality. The project partners worked with the State of North Carolina to use the modeling framework to establish a TMDL and to support development of a watershed-wide nutrient management strategy.

Georgia River Basin Management Partners Meeting. Facilitated meeting of 49 potential partners from local, state, and federal agencies for the Georgia Environmental Protection Division. Provided overview of proposed statewide framework and moderated discussion regarding potential partnership roles.

Georgia Basin Planning. Lead facilitator for design and implementation of statewide basin planning for the State of Georgia. Over 18 month period, facilitated team of agency program leads to define a new business paradigm integrating multiple clean water act programs to operate within a comprehensive basin management approach. Provided ongoing consultation to assist development of first round of basin plans.

Mississippi Staffing Analysis for Water Quality Management Program. For the State of Mississippi, developed and applied method for estimating level of effort and staffing needs for implementing a watershed management program that is capable of generating all required TMDLs over a court mandated time frame. Information generated by this study was used by the state General Assembly to authorize large increases in staff and funding for contractual support of the program. First analysis was completed in 1997. A draft update was completed in May 2004.

Mississippi Statewide Basin Planning. Facilitated executive team and program leads in developing and transitioning the Division of Environmental Quality to a statewide basin management program. Created a basin management cycle, program templates, and an implementation strategy including multi-stakeholder coordination forums.

Mississippi River Basin Water Quality Citizen Guides. Managed project to develop public-friendly information guides (about 32 pages each) regarding water quality assessment, impaired waters, TMDL development summaries, and watershed management strategies for priority watersheds. Individual Guides were prepared for the Yazoo River, Tombigbee-Tennessee Rivers, Pearl River, Pascagoula River, and Coastal Streams Basins.

TETRA TECH

Jerry Diamond, PhD

Technical Expert

EDUCATION

Ph.D., Ecology and Stream Biology, University of North Carolina, 1984

M.S., General Science, Stream Ecology, Oregon State University, 1976

B.A., Biology, cum laude, Case Western Reserve University, 1973

YEARS OF EXPERIENCE

Tetra Tech: 21

Total: 31

AREAS OF EXPERIENCE

- Water quality criteria and standards
- Use Attainability Analyses
- Water and sediment quality assessments
- Ecological risk assessments
- Environmental toxicology

Dr. Jerry Diamond is a Principal ecologist and a Director of ecotoxicology at Tetra Tech with over 30 years of experience in environmental toxicology, ecological risk assessments, water quality assessments, and criteria and standards. He has developed and managed over 300 environmental risk assessments involving a variety of chemicals and over 40 site-specific or region-specific criteria studies for a variety of chemicals including several metals and sulfate. He has been an invited peer reviewer of criteria data and analyses for US EPA, Environment Canada, and several States and he has designed and directed many studies under NPDES, and ESA. Dr. Diamond is an Editor of Aquatic Toxicology for the international journal *Environmental Toxicology and Chemistry,* and he has served frequently as an Expert Witness for the Department of Justice and EPA in ecology, ecotoxicology, and ecological risk assessment and was appointed as a Technical Expert by EPA's Office of Science and Technology regarding the development of water quality criteria.

Project Experience

Biological and Physicochemical Evaluation of North Branch Potomac River. Project leader for a large-scale study of the North Branch Potomac basin for the U.S. Army Corps of Engineers, Baltimore District, including both stream and reservoir sampling and analysis. Directed field sampling, quality assurance procedures, and final reporting of the study. Fish, plankton, and benthic sampling upstream, within, and downstream of reservoirs in West Virginia, Maryland, Pennsylvania, and New York were performed and related to aquatic chemistry and geophysical data. Evaluated water quality of the reservoirs and the ability of the reservoirs to mitigate upstream acid mine drainage. The modified sampling program and statistical analysis design developed in this project were used as a model for future studies of the North Branch and other large rivers in the Baltimore District.

Clinch River, VA Watershed Ecological Risk Assessment. Worked with an interagency workgroup in formulating the risk assessment, designing risk analyses, obtaining and collating data from a variety of sources, and conducting and presenting the risk analyses and risk characterization. Designed and implemented risk analyses and risk characterization for federally listed mussel and fish species in the basin and provided vulnerability analyses for certain known listed species sites. Provided statistical analyses of GIS data on native mussel, macro-invertebrate, and fish populations in the watershed, developed innovative methods for evaluating multiple stressor effects, and participated in public meetings. Used a variety of statistical approaches to define relationships between land use activities, instream habitat quality, and native mussels and fish. Results of analyses were presented in public workshops, international scientific conferences, peer-reviewed journal articles, and in an EPA report (EPA-600-R-01-050).

Natural Condition Standard Guidance Development and Training. Project Manager developing statistical approaches, QA/QC requirements, permit implementation, and other aspects of new guidance for natural condition-based water quality standards (NCBWQS) in Alaska, the first rigorous treatment of such standards anywhere in the U.S. Worked with ADEC and EPA Region 10 staff to identify concerns, technical issues, and to define defensible solutions regarding data requirements, associated QA necessary, and statistical treatment of water quality data. Assisted ADEC in developing the NCBWQS guidance document and address comments from stakeholders. Led a training workshop for ADEC staff in

using the NCBWQS approach, including development and presentation of a spreadsheet tool for calculating NCBWQS. Used data from streams in mining areas as case studies illustrating the use of the NCBWQS approach. Helped develop presentation materials for public workshops on the guidance and gave workshops in Fairbanks, Juneau, and Anchorage.

Recreational Use Attainability Analyses and Data Collection, Missouri, Iowa. Project Manager for EPA Region 7 and EPA-OST project supporting UAAs for over 200 sites in Iowa and Missouri. Developed a streamlined field protocol and UAA framework to clearly identify information/data needs for a given site, sufficiently document whether the use has existed or is attainable, and accompanying quality assurance protocols to support the administrative record. Used available state information and mapping information to help prioritize potential recreational opportunities at each site and streamline field survey and assessment work. Results were compiled in separate assessment reports for each site that the states used in their UAAs.

NEPA and EIS Sand and Gravel River Mining, Pittsburgh, PA. Project Manager of a large NEPA and EIS project that was used by the Pittsburgh District Army Corps of Engineers to determine whether permits should be reissued for commercial sand and gravel dredging in the Allegheny and upper Ohio Rivers. Duties included project management, preparation of technical documents, strategic planning, methodology development, stakeholder meeting facilitation, and addressing stakeholder comments. An ecological risk assessment framework was used to screen potential effects of various dredging scenarios on aquatic life and drinking water supplies and to focus field studies and additional data collection activities. Used GIS to map and analyze habitat effects on a variety of sensitive fish and endangered freshwater mussels in the study area. Designed the sampling program used by the dredging industry, Pennsylvania DEP, Army Corps, and West Virginia, Ohio, and Pennsylvania biologists to assess threatened and endangered mussel distribution in the Allegheny and Ohio Rivers. Collated and interpreted information in all resource areas (biological, economic, cultural, hydrological) and used multivariate analyses of mussel species, habitat, and spatial information to determine effects of dredging on mussel abundance and distribution. GIS analyses were used to project potential effects of different dredging scenarios (permit conditions) on fish species, including several state listed species.

Evaluation of Ecological Risks and Toxics Bioavailability Information, Coeur d'Alene Lake, ID. Expert witness and ecotoxicologist consultant for Department of Interior (DOI) and Bureau of Indian Affairs (BIA) for litigation regarding relicensing of Post Falls Dam, ID. Reviewed and evaluated documents prepared by the power company and its consultants, Coeur d'Alene Tribe and their consultants, technical literature pertaining to metal bioavailability, site-specific information developed by EPA for the Bunker Hill superfund site upstream and Coeur d'Alene River, and other relevant supporting materials supplied by the power company or Bureau of Indian Affairs. Synthesized available toxics information and qualitatively evaluated ecological risk potential due to project operations. Prepared direct testimony in the form of an expert report, which provided an expert opinion and scientific support regarding critical data and information gaps in assessing ecological risk due to project operations, and the need for additional monitoring during the next 50 year license period. Assisted DOI and BIA attorneys develop cross-examination strategies for power company expert witnesses. Testified at the hearing in Spokane, WA on behalf of DOI and BIA.

Review of National Water Quality Criteria. Reviewed recent toxicological data for USEPA as part of their revised selenium criteria development for aquatic life and wildlife. Invited peer reviewer of Environment Canada's methodology for national ammonia criteria development. Invited expert on ammonia toxicity and threshold development for City of Winnipeg and Saskatchewan Province study of the Red River, Canada. Reviewed toxicological data as part of EPA's reassessment of ammonia criteria. Participated in an international harmonization study directed by World Health Organization designed to compare and contrast the way in which different developed countries develop water quality criteria and risk assessment thresholds given the same data sets for different chemicals. Applied both Office of Water and Office of Pollution Prevention and Toxics (TSCA) methodologies to a range of chemicals including metals and various organic compounds having different amounts of relevant data available.

Development of Dissolved Oxygen Criteria for Terrebonne Basin, LA. Led dissolved oxygen criteria development for EPA Region 6 on behalf of Louisiana DEP for the Terrebonne Basin, a large coastal watershed with historic violations of the state DO standard. Reviewed and compiled existing water quality and biological information collected by LDEP, evaluated dissolved oxygen data on a daily and seasonal basis, and applied a natural condition methodology developed for Alaska DEC that relies on reference condition DO regimes to calculate criteria and allowable exceedance frequencies. Prepared the technical report and discussed finding and recommendations with EPA and the state.

Mustafa Faizullabhoy, PE

Senior Water Resource Engineer

EDUCATION

M.S., Civil and Environmental Engineering, Old Dominion University, 1998

B.E., Civil Engineering, Osmania University, India, 1995

YEARS OF EXPERIENCE

Tetra Tech: 13

Total: 15

LICENSES/REGISTRATIONS

Professional Engineer, Virginia, License No. [redacted]

State of Maryland Certificate of Training: Responsible Personnel in Erosion and Sediment Control, Green Card Certification, pursuant to the Environment Article §4-104.

PROFESSIONAL AFFILIATIONS

American Society of Civil Engineers

AREAS OF EXPERIENCE

- Watershed management
- Watershed modeling
- Climate Change
- Receiving water hydrodynamic and water quality modeling
- Reservoir management
- Water quality monitoring program design and implementation
- Information management system development

Mr. Faizullabhoy is a water resources/environmental engineer with more than 14 years of professional experience in the areas of water quality modeling, hydrologic and hydraulic modeling, and storm water management planning and design. He has developed and applied a variety of computational methodologies for water quality modeling. He specializes in the field of hydrodynamic modeling, surface water quality modeling, contaminant transport, data analysis and statistics, and environmental sustainability, with particular emphasis on lake and reservoir modeling. He has extensive experience implementing hydrologic and water quality models, including QUAL2K, BASINS, CE-QUAL-W2, EFDC, Visual Plumes, SHADE, LAKE2K, PHOSMOD, BATHTUB, EUTROMOD, WASP, GWLF and SWMM. Mr. Faizullabhoy's experience also includes spreadsheet and database programming for managing, analyzing, and summarizing large complex data sets. He has an in-depth understanding of environmental data and their scientific use for screening level analysis, as well as for more rigorous analysis using various modeling applications. He has also hands-on experience in spreadsheet/database programming, computer language programming (FORTRAN, Visual Basic), and geographic information systems (GIS).

Project Experience

Chesapeake Bay TMDL Support (2009–present). Provided on call support for USEPA for development of the Chesapeake Bay TMDL. Conducted an in-depth statistical analysis of the flow and water quality data to select a three-year critical period for the TMDL. Developed a spreadsheet tool for estimating potential nutrient and sediment load reduction under USEPA's proposed stormwater management strategy for the Chesapeake Bay watershed. Provided support for the development of the District of Columbia's WIP for the Chesapeake Bay TMDL. Reviewed and categorized several hundred comments received by USEPA as part of the Chesapeake Bay TMDL comment process. Comments from various academic, private citizens, state, environmental groups, local government, federal/tribes and industry and trade organizations were coded and categorized to inclusion in the SMART-C comment/response review system.

Stormwater BMP Site Searches and Concept Designs in Montgomery County. Provided general support to the Maryland State Highway Administration (SHA) to meet their Chesapeake Bay TMDL WIP and be compliant with their Phase I and II MS4 permit for all SHA roadway network and maintenance facilities that have associated stormwater discharge. The study involved conducting a desktop evaluation of SHA-owned roadways and facilities in the study area for potential new stormwater BMP sites (over 400 sites). Conducted a field investigation of 100 potential sites identified by the desktop evaluation to visually confirm drainage patterns and identify any site constraints.

Shenandoah River PCB TMDL, Virginia. For the USEPA Region 3 developed a customized steady state, sediment water column interaction model for PCB in the Shenandoah River, VA. The model used a time variable approach to model the Millville Reservoir in the WV downstream of the Shenandoah River to predict the concentration of PCB with time. This easy to use spreadsheet tool was used to evaluate various load reduction scenarios for the TMDL from various point sources into the Shenandoah River, and also evaluate the contribution of sediment as a source into the water column.

Total Maximum Daily Loads for Metals in Waters of Pullen Creek in Skagway, AK. Pullen Creek is a 1.5 mile long waterbody which run along the southern

boundary of the City of Skagway (an area with a long history of mining). The TMDL approach establishes a concentration-based allocation, representing the sediment quality. TMDLs were established for each individual metal that has been shown to exceed the TEL—cadmium, copper, lead and zinc.

Guidance Document for Approaches used in the Development of PCB TMDLs in the US (2008). For the U. S. USEPA Region 5 developed a Summary Report to provide state and USEPA TMDL practitioners, especially those within Region 5, with a comprehensive set of approaches to develop TMDLs that address PCBs impairments (Summary Report: Approaches for Development of PCB TMDLs). A comprehensive review of past USEPA-approved PCB TMDL reports was undertaken. Twenty TMDL reports were selected based on the scale, complexity, sources and year (more recent) of the TMDL studies that were undertaken and established. The report also provides guidance on the time and resources that can be a factor in the approach selection.

Roanoke River PCB Target Analysis and TMDL Support, Virginia (2008). For the U. S. USEPA Region 9 and Virginia Department of Environmental Quality assisted in the Roanoke River PCB TMDL development approach and data analysis. Used the guidelines outlined in the USEPA 2003 technical support document for development of bioaccumulation factors to developed species specific bioaccumulation factors (BAF) from observed PCB concentrations in fish tissue samples and nearby water column samples. Results were presented for both individual species and trophic levels. Water column targets for allowable PCB concentrations were derived by dividing the state's fish tissue criterion or screening threshold by some factor that represents the fish's ability to absorb and retain PCBs.

Schuylkill River PCB TMDL, Pennsylvania (2007). For the USEPA Region 3, provided technical support and developed a customized steady-state, sediment water column interaction model for PCB in the Schuylkill River, PA. A mass balance model of PCBs was developed for the stream segments assuming that the PCBs partition into the dissolved and particulate forms and considering the various interactions between the sediment layer and the water column. The Schuylkill River is a long river and has ten dams located along its main stem. The model took into account the effects of burial behind each dam by using a time to equilibrium time variable approach for the constant critical period flow.

Development of High resolution stream network layer using LiDAR data; Mid-Coast Basins, Oregon (2014-2015). For USEPA Region 10 and ODEQ developed a hydrologically conditioned, flow direction, and accumulation raster and stream layer. A high-resolution accurate stream network layer was needed for analysis of water quality status and trends and TMDL development in the Mid-Coast basins. This product will assist in assessment of watershed-level conditions at varying degrees of resolution and provide a framework to examine relationships between riparian/landscape conditions and water quality parameters, including temperature, dissolved oxygen, sediment, bacteria, and nutrient concentrations. Created Python scripts to automate the entire workflow to process the LiDAR data.

Quantitative Assessment of Temperature Sensitivity of the South Fork Nooksack River under Future Climates using QUAL2Kw (2013). For the U.S. Environmental Protection Agency (EPA) Region 10, Washington Department of Ecology, Nooksack Indian Tribe, and the Lummi Nation collaborated on a temperature TMDL for the South Fork Nooksack River (SFNR), in Washington State. EPA Region 10 and EPA's Office of Research and Development (ORD) and Office of Water (OW) launched a pilot research project to consider how projected climate change impacts could be incorporated into a TMDL and influence restoration plans. The pilot research project uses the temperature TMDL being developed for the SFNR as the pilot TMDL for climate change analysis.

Skykomish River Temperature Prescriptive TMDL Development (2012–2013). For USEPA Region 10 and Washington Department of Ecology modeled the influence of shade for the development of the Skykomish temperature TMDL. Used Washington Ecology's SHADE model that incorporates the use of available vegetation and topographic data to analyze existing and system potential shade. Modeled six waterbodies - the Skykomish River, Wallace River, Woods Creek, Olney Creek, Bear Creek and Beaver Creek. Derived tree height information from Light Detection and Ranging (LiDAR) data from the PSLC and Snohomish County. Conducted a detailed system potential tree height analysis of mature riparian vegetation using available literature, past studies, and soils data in the watershed.

Region 6 TMDLs (2006). For the U.S. Environmental Protection Agency, Region 6, managed and developed sixty four TMDLs for Fecal Coliform Bacteria, Chlorides, Sulfates, Total Dissolved Solids (TDS), Turbidity, Total Suspended Solids (TSS), Sedimentation, and Siltation for Selected Subsegments in the Terrebonne, Red River, and Sabine River Basins, in Louisiana. The project utilized a load duration approach to compute the TMDLs for each pollutant and its corresponding percent reduction for each subsegment in the subbasins. Created a customized spreadsheet template to automate and facilitate TMDL calculations and allocations.

TETRA TECH

Heather Fisher, AICP

Outreach Specialist

EDUCATION

M.E.M., Resource Economics and Policy, Nicholas School of the Environment, Duke University, 2002

B.A., Pre-professional Zoology and Environmental Studies, Chemistry Minor, Ohio Wesleyan University, 1999

Study abroad: Center for Sustainable Development, School for Field Studies, Atenas, Costa Rica, Fall 1998

YEARS OF EXPERIENCE

Tetra Tech: 13

Total: 15

LICENSES/REGISTRATIONS

American Institute of Certified Planners, 2007

PROFESSIONAL AFFILIATIONS

American Planning Association

American Institute of Certified Planners

AREAS OF EXPERIENCE

- TMDL development
- Guidance development
- Water quality assessment
- Pollutant source assessment
- Environmental statistics
- Watershed management and planning
- Implementation Planning
- Funding Source Identification
- Conservation and restoration planning
- Low Impact Development
- Vegetation design
- Stakeholder facilitation
- Landowner outreach
- Decision analysis
- Cost-benefit analysis
- NEPA socio-economics analysis

Ms. Fisher is an environmental scientist and certified planner with experience in water resources planning and management. She specializes in the economic aspects of watershed management, including cost-benefit analysis, socio-economic analyses, financial capability assessment, and other similar techniques. She has also led numerous watershed planning efforts that apply environmental, social, and economic indicators towards prioritization of management opportunities. She has also led development of multiple TMDLs throughout the country for a variety of pollutants. She is a co-author for USEPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (EPA 841-B-08-002) and regularly supports implementation planning and funding source identification, as well as public outreach and stakeholder facilitation. Her technical background includes data processing, statistics, spatial analysis, and information management. She has set up and calibrated watershed and lake models and has extensive GIS experience. Prior to joining Tetra Tech, Ms. Fisher evaluated the economic benefits of Low Impact Development (LID) for The Conservation Fund and worked as a research assistant for a wetlands valuation study at Duke University.

Project Experience

Bitterroot River and Lick Creek Metals TMDLs. Worked with USEPA Region 8 to develop lead and aluminum TMDLs for the Bitterroot River and Lick Creek, respectively. Led source assessment and linkage analysis, providing documentation of all data and information related to sources and an assessment of potential, unknown sources. Co-wrote TMDL documentation with USEPA.

Santa Clara Lakes TMDL Support. For USEPA Region 9, leading the development of BATHTUB modeling and TMDL report sections for three lake nutrient TMDLs in Los Angeles County. The three subject lakes exists along the San Andreas Fault and present a challenging case due to their unique geology and limited availability of lake and watershed data. Conducting an extensive research effort using both local contacts and literature searches to identify the best available information and develop a thorough understanding of these systems.

Red Lake/ Anton Road Ponds TMDL Development. Led the development of a technical approach and TMDL document for USEPA Region 10. Red Lake and two nearby ponds on Kodiak Island, AK receive leachate from a former Navy landfill. Elevated iron and manganese concentrations have been observed in Red Lake. Development of the technical approach involved the review of available data and techniques for estimating the TMDL. The data review also involved a comprehensive assessment of available data and recommendations for additional listing of impairments and future monitoring efforts.

Reasonable Assurance Support for USEPA OWM. Acted as Work Assignment Leader for Reasonable Assurance Work Assignment to support USEPA's investigation of the logistics and feasibility of applying more robust reasonable assurance to TMDLs. Led identification and summaries of 30 examples of typical, USEPA-approved TMDLs and the evaluation of achieving reasonable assurance. Coordinated level of effort estimates for adding robust reasonable assurance to 12 of these TMDL examples, selected by USEPA. Led development of a summary report on "good" examples of reasonable assurance, and coordinating the provision of technical assistance to regions for enhancing the application of reasonable assurance for ongoing TMDL development.

Reevaluation of Mid Snake/Upper Snake Rock Subbasin TMDL. For USEPA (Region 10), managed project for an independent and comprehensive review of

data and information available to support TMDL revisions for the Mid Snake/Upper Snake Rock Subbasin TMDL in Idaho. The overall data evaluation involved assessing the existing TMDL assumptions in achieving indicated target values and includes the assessment of critical flow, attenuation, and loading.

Clarks Creek DO TMDL. Provided project management, document organization and TMDL writing for the USEPA Region 10 and Washington Ecology in the development of an implementation-ready DO TMDL for Clarks Creek in Puyallup. This spring-fed tributary of the Puyallup River is an important spawning and rearing area for salmon, but is also threatened by low DO, caused in part by the overgrowth of waterweed (Elodea nuttallii) and sediment oxygen demand. Conditions that promote macrophyte growth include nutrient and sediment loads and the removal of riparian cover. Simulated DO deficit components using QUAL2Kw. A key objective of the DO TMDL is the development of a strategic implementation plan for attaining DO standards, including recommendations on specific locations and practices that will most effectively reduce stressors associated with urban stormwater, hatchery discharges, agricultural runoff, and instream/riparian improvements.

Watson Lake TMDL BATHTUB Modeling. For Arizona Department of Environmental Quality (ADEQ), managed project and led BATHTUB modeling for Watson Lake in Prescott, AZ to support the nutrient, chlorophyll a, and pH TMDL for the lake. Watson Lake is an artificial reservoir that provides wildlife habitat and recreational uses as well as providing water supply for downstream agriculture. Stakeholders within this watershed include the City of Prescott, Yavapai County, Yavapai-Prescott Tribe, non-profit organizations, and citizens. Recommended lake targets, led development of BATHTUB models, and evaluated management scenarios. This TMDL represents a unique, stakeholder-driven TMDL effort in which the initial public meeting garnered input from the community on potential management scenarios for the lake.

Invasive Species Investigation for USEPA OWM. Researched aquatic invasive species assessment methods, both locally and regionally applied. Wrote report sections and case studies on the 303d listing and TMDL development relating to aquatic invasive species. Supported document organization and revisions.

Los Angeles Waterbodies TMDLs. For USEPA Region 9, provided BATHTUB lake modeling and data analysis for the Los Angeles Area Lakes TMDLs development. TMDLs were developed for 10 lakes or lake systems impaired by algae, ammonia, chlordane, copper, DDT, eutrophication, lead, organic enrichment/low dissolved oxygen, mercury, odor, PCBs, pH and/or trash.

Illinois TMDL Implementation Plans, Illinois EPA. Provided expertise on cost estimates and cost-effectiveness for watershed-specific TMDL implementation plans. Developed cost-effectiveness analyses for multi-watershed, multi-parameter TMDLs. Researched and estimated the relative costs of nonpoint source BMPs, in-lake management techniques, shoreline stabilization, and stream restoration options..

Black River SWAT Model. Co-developed and calibrated a SWAT modeling application for the Black River drainage in the Ohio Corn Belt to support nutrient and sediment TMDL development. Assisted in modeling scenarios for the management of agricultural land and point sources in the watershed.

North Carolina TMDL Development. Co-developed fecal coliform and turbidity TMDLs for the East Fork of the Deep River and fecal coliform TMDLs for Richland, Muddy, and Newfound Creeks. Performed TMDL source assessments and flow duration analyses to estimate the existing and target loads. Interviewed local officials for information on sewer problems and local stormwater efforts.

Florida Inland Nutrient Criteria. Supported USEPA OST by conducting modeling analyses to evaluate downstream protection values for nutrients in streams to achieve lake nutrient criteria. Conducted BATHTUB model set-up and calibration to support nutrient criteria development for lakes with expedited delivery under litigation deadlines.

Mississippi Nutrient Criteria for Lakes. Performed data processing and calculations to support the development of lake nutrient criteria for the State of Mississippi. Applied Visual Basic macros and advanced Excel formulas to automate processing of large dissolved oxygen profile datasets.

California Nutrient Criteria Pilot Project. For USEPA Region 9, developed methods for estimating SWAT input parameters of natural vegetation in Southern California. Applied GAP co-dominant species associations to SWAT hydrologic response units (HRUs). Conducted SWAT modeling analysis of reference watersheds. Analyzed model output and stratification parameters in a regression analysis. Trained professionals on the above methods and the application of SWAT to Northern California.

TETRA TECH

Jeroen Gerritsen, PhD

Technical Expert

EDUCATION

Ph.D., Ecology, The Johns Hopkins University, Baltimore, 1978

M.S., Ecology, The Johns Hopkins University, Baltimore, 1976

B.S., Environmental Studies, Antioch College, Yellow Springs, OH, 1974

YEARS OF EXPERIENCE

Tetra Tech: 22

Total: 34

PROFESSIONAL AFFILIATIONS

North American Benthological Society

Ecological Society of America

Society for Environmental Toxicology and Chemistry

Estuarine Research Federation

North American Lake Management Society

AREAS OF EXPERIENCE

- Stressor identification research
- Stressor-response investigations
- Statistical data analysis
- Bioassessment and biocriteria development
- TMDL development
- Tool development
- Information management system development

Dr. Gerritsen has over 30 years of experience in aquatic environmental sciences, including basic and applied research, teaching, environmental assessment, and project management. His technical abilities include statistical design and analysis, systems ecology and modeling, ecological risk assessment, limnology, wetlands ecology, estuarine ecology, and plant-nutrient relationships. He has directed multidisciplinary investigations and has contributed technical expertise to impact assessment and regulatory review, effects of acidic deposition, and design and analysis of environmental monitoring programs. He has broad field experience in lakes of North America and Europe; in streams, wetlands, and estuaries of the continental United States; and in the North Atlantic Ocean.

Project Experience

Biological Criteria Development. For USEPA Office of Water, Project Manager for developing biological sampling and analysis methods to tier designated aquatic life uses in state and tribal water quality standards. He directed technical support and scientific input to develop sound scientific principles for establishing biological and disturbance gradients that would serve as a framework for tiered designations. These tiered uses reflect the biological quality attainable for a given system and eventually integrate biocriteria with water quality criteria. Tasks and subprojects have included the following:

- Served on technical expert panel and participated in workgroup and panel meetings that developed the Biological Condition Gradient (BCG), which in the scientific foundation for tiered aquatic life uses.
- Provided scientific documentation for support of concepts developed by the workgroup.
- Facilitated several regional and national workshops to test and evaluate the biological condition gradient developed by the technical expert panel.
- Developed methods to translate the conceptual model of the BCG to a quantitative assessment methodology using biological assessment data.
- Project manager for organizing and editing the USEPA guidance document on Tiered Aquatic Life Use (EPA-822-R-05-001). Tetra Tech scientists were principal authors of several key chapters on technical implementation of quantitative assessment in the TALU framework, and on development of the Generalized Stressor Gradient (GSG).

Continuing as Project Manager to provide technical leadership and support in regional projects and workshops to develop quantitative applications of the BCG, the GSG, and tiered aquatic life uses. Tasks currently underway include: application of the quantitative assessment methodology in New Jersey, New England, Pennsylvania, and Rocky Mountain region; conceptual development and application to estuaries; assessing state programs with respect to critical elements required for effective biomonitoring; definition and measurement of the stressor gradient in Southeastern states; and regional applications in each USEPA region.

A Stream Condition Index for West Virginia Wadeable Streams. Dr. Gerritsen directed the development of the West Virginia Stream Condition Index (2000) for West Virginia DEP and USEPA Region 3. Tetra Tech scientists analyzed West Virginia's early stream biomonitoring data (1996-98) to develop the first version of the WVSCI, currently used by West Virginia for bioassessment and biocriteria.

Stressor Identification Guidance Document. Project manager for preparing and editing the *Stressor Identification Guidance Document* (EPA/822/B-00/025) for identifying and evaluating stressors of aquatic systems, for USEPA Office of Research and Development (ORD). The guidance provides diagnostic approaches for using biological indicators in conjunction with other ecological data to identify and prioritize multiple stressors causing impairment. Member of the workgroup developing the guidance document, reviewed chapter drafts prepared by ORD scientists, and prepared draft case study chapter on the Presumpscot River. Tt assembled, revised, and edited the complete guidance document, made further revisions based on reviewers' comments, and prepared the final copy.

Identification of Stressors Causing Ecological Degradation in West Virginia Streams. As part of comprehensive TMDL development for impaired streams of West Virginia, directed the Stressor Identification, which used USEPA's Stressor Identification guidance, above. From benthic macroinvertebrate monitoring data, West Virginia DEP identified streams that were biologically impaired in West Virginia. Tetra Tech developed a conceptual model for ecological stream impairment in the region, and is evaluating the stressor-response hypotheses of the conceptual model. Using West Virginia's statewide monitoring database, directed the development of multivariate statistical models to assess the relative importance of stressors affecting the biological community. These were combined with site-specific information through techniques of ecological epidemiology identified in USEPA's Stressor Identification guidance to identify the stressors most likely to have caused the ecological degradation observed in each stream. Because of the large number of streams and large WV database, Tetra Tech was able to streamline many of the procedures in the SI Guidance.

Case Studies Identifying the Causes of Biological Impairment in Streams. Based on the strength of the stressor identification for the West Virginia TMDL program, was invited with WVDEP to participate in a writing workshop designed to evaluate applications of the USEPA's Stressor Identification (SI) guidance. At this workshop, case studies were analyzed, revised and used to document the use of SI for determining the causes of biological impairment in streams. Tetra Tech technical experts will contribute writing and editing of case study drafts developed during the workshop.

Assessment of Aquatic Effects of Mountaintop Mining in West Virginia. For an environmental impact statement on mountaintop mining /valley fill being developed by USEPA Office of Research and Development, integrated biological data collected by USEPA and coal mining companies in 5 watersheds. Using statistical quality control procedures, he determined the compatibility of the biological data sets collected by different agencies and consultants. Developed a statistical analysis plan approved by all (frequently contentious) participants (USEPA and the mining companies), and included procedures for taking into account the effects of confounding factors, such as seasonality, spatial autocorrelation, and the effects of other stressors not associated with coal mining (residential and agricultural runoff). Supervised the analysis of fish data to identify stressors and sources of stress on fish communities of West Virginia streams. Directed preparation and coauthored several chapters of the EIS being prepared by USEPA/ORD.

Statistical Methods for Biocriteria Development: Draft Guidance Document. Biological indexes developed by Tetra Tech and others require a variety of statistical tools to develop and calibrate the models. Directed preparation of a statistical methods guidance document targeted specifically at biomonitoring agencies of States and Tribes, to explain statistical methods used in indexes, requirements for different methods, and guidance on selecting the most appropriate methods for the specific situation of an agency. Tetra Tech developed several alternative biological indexes using both univariate and multivariate approaches, to be case study applications, using the same database, to guide readers through alternative approaches. Principal author of approximately half of the draft guidance document.

TETRA TECH

Eugenia Hart

Technical Writer

EDUCATION

M.S., Wetlands and Water Resources, State University of New York College of Environmental Science and Forestry, 2000

B.S., Natural Resources and Environmental Science, Purdue University, 1996

YEARS OF EXPERIENCE

Tetra Tech: 14

Total: 15

AREAS OF EXPERIENCE

- Clean Water Act support
- TMDL development and implementation
- Pollutant source assessment
- Water quality assessment
- Watershed management
- Watershed modeling
- Watershed characterization
- Technical writing

Ms. Hart is an environmental scientist with 15 years of professional experience. She provides general and technical support on projects for the USEPA's Total Maximum Daily Load (TMDL) Program under Clean Water Act section 303(d). These projects have included technical development of TMDLs and public outreach related to TMDL development, as well as development of guidance documents for TMDL development. She has participated in and managed the development of a variety of TMDLs for fecal coliform bacteria, nutrients, sediment, metals, and residue-impaired waterbodies, using watershed models including HSPF, LSPC, and GWLF. Ms. Hart also provides general and technical support for various projects related to watershed and water quality assessment and management, including watershed characterization, literature searches, research, data compilation and analysis, and technical writing.

Project Experience

Delaware Statewide Chesapeake Bay Watershed Implementation Plan (WIP) (USEPA Region 3; 4/2010–present). Providing support to Delaware's Department of Natural Resources and Environmental Control (DNREC) with the development of their WIP for the Chesapeake Bay nutrient and sediment TMDLs. Tasks to date have included mapping all industrial stormwater facilities in the Delaware portion of the Chesapeake Bay watershed in ArcGIS.

Chesapeake Bay Watershed TMDL Support (USEPA CBPO; 5/2014–present). Provided assistance to the EPA's Chesapeake Bay Program Office with collecting local land cover/ land use data at the county and municipal level for all six states in the Chesapeake Bay watershed. Also conducted a literature review to support development of more accurate loading rates for forested land uses to update the Chesapeake Bay Watershed Model. Reviewed over 200 journal articles and entered all available loading rates into a database and helped to summarize the information in a report submitted to the Bay Program.

Fourpole Creek TMDL Development, WV (USEPA Region 3). Supported TMDL development for the Fourpole Creek watershed in Huntington, West Virginia. The project included development of TMDLs for fecal coliform bacteria and aluminum impairments in an urban watershed. The aluminum impairment was associated with high levels of sediment entering the waterbody from highly urbanized areas and multiple construction sites in the watershed. The fecal coliform bacteria impairment was mainly due to urban sources including illicit sewer connections and septic failure. The project included setup and calibration of the MDAS watershed model as well as the development of TMDLs. Worked with EPA and West Virginia Department of Environmental Protection to develop an allocation scenario that would enable the fecal coliform bacteria loads from urbanized areas to be incorporated into a future MS4 permit for the City of Huntington.

Unnamed Tributary to the Monongahela River TMDLs, WV (USEPA Region 3). Supported the development of iron and manganese TMDLs for the Unnamed Tributary to the Monongahela River in West Virginia due to runoff from two adjacent Superfund sites. Worked with USEPA Region 3's Superfund division to gather water quality data collected by Superfund in the watershed. Developed iron and manganese TMDLs for the Unnamed Tributary based on the Superfund data.

Cheat River and Tygart Valley River TMDLs, WV (USEPA Region 3). Supported the development of mining TMDLs for the Cheat River and Tygart Valley River watersheds in West Virginia. Provided technical writing and editorial support for the draft and final documents. Developed a training manual for the Mining Data

Analysis System (MDAS) model used in TMDL development for the Tygart Valley River watershed. The MDAS is a system to support point and non-point source modeling for acid mine drainage leading to TMDL development. The training manual was used for a MDAS training session for EPA Region 3 and West Virginia Department of Environmental Protection.

TMDL Development for the Thompson TMDL Project Area, MT (USEPA Region 8; 6/2013–3/2014). Supported TMDL development for metals, nutrients and sediment in nine waterbodies in western Montana. Support included calculating the TMDLs as well as writing the supporting technical documents.

TMDL Development for Red Lake/Anton Road Pond, Cottonwood Creek, and Goldstream Creek, AK (USEPA Region 10; 7/2012–present). Supported USEPA Region 10 iron and manganese TMDL development in Red Lake and Anton Road Ponds in Kodiak, AK because of impairment due to a historic landfill. Also developed fecal coliform bacteria TMDL for Cottonwood Creek in Wasilla, AK using the simple method and currently developing technical approach for sediment TMDL for Goldstream Creek.

Nutrient Framework Elements (USEPA Headquarters; 10/2012). Reviewed all available state Nutrient Reduction Strategies for each Region 4 state and assessed the status of their development of nutrient criteria against USEPA's 2011 Stoner Memo, which contains the eight Recommended Elements of a State Framework for Managing Nitrogen and Phosphorus Pollution. Responded to a questionnaire developed by USEPA about each State's Nutrient Framework Status.

Lost River TMDLs, CA (USEPA Region 9). Supported EPA Region 9 in organizing their response to comments and editing and formatting the final TMDL report for nitrogen and BOD for the Lost River, California.

TMDL Development for San Diego Bay, CA (California Regional Water Quality Control Board; 2008). Supported the California Regional Water Quality Control Board San Diego Region's TMDL development for toxic pollutants (chlordane, lindane, PCBs, and PAHs) at the San Diego Bay Shoreline (i.e., mouths of Switzer, Chollas, and Paleta Creeks). Responsible for the technical writing of the TMDL reports.

TMDL Development for Louisiana River Basins (USEPA Region 6). Supported TMDL development for dissolved oxygen, fecal coliform bacteria, lead, chlorine, and turbidity in selected segments of the Mississippi River basin in Louisiana. Responsible for the technical writing and figures for three TMDL reports.

TMDL Development for Rio Culebrinas, PR (USEPA Region 2). Supported USEPA Region 2 and Puerto Rico Environmental Quality Board with the development of fecal coliform bacteria TMDLs for waterbodies in the Rio Culebrinas watershed in Puerto Rico. Responsible for the technical writing and figures for one TMDL report.

Development of Nutrient Endpoints for SE Pennsylvania (USEPA Region 3). Reviewed existing literature pertaining to the impact of nutrients and other limiting factors on algal growth in streams. This included obtaining many relevant journal articles from the University of Delaware Library as well as online. The purpose of the literature review is to support both the selection of numeric stream targets and development of appropriate modeling parameters to be used in simulating algal response to changes in water quality and other limiting factors.

TMDL Implementation Reviews (USEPA Region 10). Reviewed 5 TMDL implementation documents and/or TMDL documents each for the states of Idaho, Washington, and Oregon. The TMDL implementation plans were compared to the Nonpoint Source Watershed Plan requirements. A final report was developed that provided a summary of the strengths and weaknesses of the implementation plans, whether they met the requirements of the watershed plans, and how they compared to each other (i.e., state to state).

Temperature TMDL Development for the Pend Oreille River, ID, WA, Kalispel Indian Tribe (USEPA Region 10). Responsible for the technical writing of the temperature TMDL for the Pend Oreille River. This project entailed pulling background information from several available documents and creating one cohesive TMDL document that satisfied the TMDL requirements for the USEPA, the state of Idaho, the state of Washington, and the Kalispel Indian Tribe.

Wissahickon Creek Sediment TMDLs, PA (USEPA Region 3; 2003). Supported the development of sediment TMDLs for the Wissahickon watershed in Pennsylvania. The Wissahickon is a high profile watershed located partially in the city of Philadelphia. The high sediment loads to the watershed were mainly due to the large amounts of urban land in the watershed that contribute to higher in-stream flows due to the lack of vegetation in the watershed to slow runoff. Used ArcView software to create a GIS project for the watershed and used local GIS coverages to locate an adequate reference watershed for Wissahickon Creek because Pennsylvania currently does not have numeric criteria for sediment.

TETRA TECH

Jessica Koenig

Technical Writer

EDUCATION

B.A., Environmental Science, University of Virginia, 1996

YEARS OF EXPERIENCE

Tetra Tech: 17

Total: 18

AREAS OF EXPERIENCE

- TMDL development
- Watershed management
- Surface water quality assessment
- Development of water program guidance documents and training
- Project management

Ms. Koenig is an environmental scientist with over 18 years of professional experience providing general and technical support on projects for the EPA's total maximum daily load (TMDL) program. Ms. Koenig has managed and participated in the development of hundreds of TMDLs throughout the country, with approaches ranging from spreadsheet, mass-balance analyses to detailed hydrologic and water quality modeling. In addition to developing TMDLs, Ms. Koenig has provided extensive programmatic support for EPA and states, including development of national and state-specific guidance documents for TMDL development and related issues and development and presentation of TMDL training courses. She has supported EPA with key TMDL program issues, such as supporting EPA's response to comments on the *Proposed Revisions to the Water Quality Planning and Management Regulation* (40 CFR 130, August 23, 1999), developing guidance to support consistency with a DC District court ruling requiring daily loads in TMDLs, developing guidance and training to better integrate TMDLs with NPDES stormwater permits, and providing research and guidance support for challenging listing topics (e.g., invasive species). For the past 10 years, she has been managing technical support and development of TMDLs for EPA Region 10, including development of TMDLs in Alaska, Idaho, and Washington for a range of pollutants (nutrients, dissolved oxygen, fecal coliform, TSS, petroleum, sediment toxicity, metals, debris and seafood residue). Ms. Koenig has also managed several TMDLs in Idaho, Utah, Delaware, Florida, Virginia, Pennsylvania and West Virginia.

Project Experience

National TMDL Guidance Development. Has managed or supported development of all of the major EPA publications providing guidance to TMDL practitioners, as well as a number of state-specific guidance documents. Managing and serving as primary author of EPA's *Handbook for Developing Watershed TMDLs* and is a primary author of *TMDLs to Stormwater Permits Handbook* for EPA Region 5 and EPA Headquarters. Managed the development and was primary author of a technical document, *Options for Expressing Daily Loads in TMDLs*, on identifying daily load expressions for TMDLs developed with non-daily allocations (to be consistent with a recent court ruling that TMDLs that are not expressed as "daily" loads do not comply with the Clean Water Act). Developed and presented a webcast based on the guidance. Co-managed and served as primary author for the development of EPA's *Protocol for Developing Pathogen Total Maximum Daily Loads (TMDLs)* (EPA841-R-00-002). Also supported development of the sediment and nutrient protocols (EPA841-B-99-004, EPA841-B-99-007).

TMDL Training. Supported development of original Watershed 103: Training for TMDL Practitioners' through EPA's Watershed Academy. Recently updated training materials and presented the course to EPA Region 3 staff. The 2-day course included an overview of the TMDL program, TMDL elements, steps in the TMDL development process, modeling techniques, recommendations for reviewing TMDLs, and several region-specific case studies.

TMDL Development in Alaska. Managed the development of 40 percent of Alaska's approved TMDLs for EPA Region 10 and Alaska DEC and is currently managing the development of TMDLs for Dutch Harbor, Iliuliuk Harbor, Skagway Harbor, and Pullen Creek. Managed support to Alaska for review of listing methodologies and design of monitoring programs to evaluate impaired waters. Recent examples of projects include: Managing the development of TMDLs to address petroleum impairments in the bottom sediments of Dutch and Iliuliuk

Harbors in the Aleutian Islands and Skagway Harbor in Southeast Alaska. Managed development of TMDLs to address impairment by sediment and low interstitial dissolved oxygen in Jordan Creek in Juneau and impairments from metals accumulated in streambed sediments in Pullen Creek in Skagway. Managed the development of fecal coliform TMDLs for nine streams and three lakes in Anchorage. Also developed delisting document for bacteria for Cheney Lake. Managed development of a TMDL for fecal coliform in Pederson Hill Creek in Juneau using a load duration approach. Managed the development of residues and sediment toxicity TMDLs using site-specific qualitative assessment and supported the dissolved oxygen TMDL in Ward Cove using WASP. Managed development of a residues TMDL for Thorne Bay consistent with Ward Cove.

Watershed and TMDL Program Support for EPA Region 10. Has managed TMDL-related and watershed-related support for EPA Region 10 for the past 10 years. Support has included the management and development of dozens of TMDLs throughout Alaska, Idaho, and Washington. Managed several projects to design and implementation of monitoring programs to evaluate waterbody impairment and support TMDL development (e.g., Skagway Harbor, AK; Chena River basin, AK; Black Lake, ID; Coquille River, OR; northern Idaho microbial source tracking; Pend Oreille River/Lake, ID). Managed a review of state listing methodologies to support Alaska in developing their own methodologies for bacteria, turbidity and petroleum. Manages the development of Nonpoint Source Success Stories and documentation to meet National Water Program Guidance performance measures (WQ-10 and SP-12) for water quality improvement for all Region 10 states. Managed several projects to conduct expert third-party peer review of models developed by the states (e.g., Puget Sound, WA; Coquille River, OR; Lake Whatcom, WA). Managed the development of nutrient and sediment TMDLs for the Coeur d'Alene Tribe in northern Idaho. Developing a guidance document on using microbial source tracking to support TMDL development and implementation.

TMDL Guidance for California. Supported the development of *A Process for Addressing Impaired Waters in California*, a technical and programmatic guidance document developed for the State Water Resources Control Board. The document provides information on identifying and performing appropriate technical analyses and approaches and regulatory actions for addressing waters that do not meet support designated uses. Managed the development of a companion technical module for bacteria TMDLs that provides detailed information and "how-to" guidance relevant to developing TMDLs for the specific pollutants.

EPA ORD Model Review. For EPA ORD, coordinated the development of a comprehensive guidance document (*TMDL Model Evaluation and Research Needs*, EPA/600/R-05/149) on the applicability of models for TMDL development and implementation. Project involved the review of more than 60 process-based modeling systems used for TMDL development, including allocation of loads and evaluate of management practices. Managed the activities of more than 15 experts reviewing models for model capabilities and features, input/output, strengths and limitations, hardware/software requirements, supporting linkages, calibration considerations and associated uncertainty, and pre- and post-processing capabilities. Coordinated the development of factsheets for all models reviewed and managed the overall organization and production of the final document.

Development of EPA's Watershed Handbook. Served as a primary author of *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (EPA 841-B-08-002), which provides comprehensive information and guidance on developing and implementing watershed plans to restore and protect water quality. Authored several chapters including those on gathering data and information; data analysis to identify sources and causes; estimating pollutant loads; and setting goals and identifying necessary load reductions.

Utah TMDL Support. For EPA Region 8, managed the development of TMDLs and site-specific criteria for TDS in five streams in the Duchesne River watershed. Project included extensive data analysis for approximately and a field survey to identify and evaluate potential sources. The TMDLs were based on a statistical data analysis and load duration curves identifying allowable TDS loads under varying flow conditions and were used to identify potential management practices for each impaired subwatershed. Managed development of TDS TMDLs for salinity for Uinta River and Dry Gulch Creek using a similar approach. The Uinta and Duchesne TMDLs both involved extensive coordination with representatives from EPA Region 8, Utah DEQ, the Ute Indian Tribe, USFS, BLM, and local water conservancy districts and included support and presentations for multiple stakeholder and public meetings. Also managed the development of phosphorus and dissolved oxygen TMDLs for two reservoirs in Utah using GWLF and PHOSMOD to establish watershed nutrient loadings and simulate inlake nutrient and dissolved oxygen dynamics.

TETRA TECH

Kevin Kratt

Watershed Analyst

EDUCATION

M.E.M., Water Resources, Duke University, 1995

B.S., Business Economics, Miami University, 1992

YEARS OF EXPERIENCE

Tetra Tech: 19

Total: 19

PROFESSIONAL AFFILIATIONS

Water Environment Federation

Ohio Stormwater Association

Society of American Military Engineers

AREAS OF EXPERIENCE

- Clean Water Act support
- TMDL development
- Water quality modeling
- Guidance development
- Water quality assessment
- Pollutant source assessment
- Watershed management
- Stormwater management
- Implementation Planning

Kevin Kratt has been a project manager and water resources scientist at Tetra Tech for 19 years. Mr. Kratt is the company's coordinator for water resources projects in the Midwest, and is the director of the Cleveland, Ohio, Water Resources office. He provides technical and project management support for federal, state, and local government clients. Mr. Kratt's areas of expertise include watershed and water quality assessment, stormwater management, watershed and water quality modeling, and implementation planning. He has been supporting U.S. Environmental Protection Agency (USEPA) and Midwest states with total maximum daily load (TMDL) issues since the mid-1990's, and has most recently supported USEPA, U.S. Army Corps of Engineers (USACE), and local communities with implementation of the Great Lakes Restoration Initiative. Mr. Mr. Kratt is also involved with important national and regional TMDL issues, such as the efforts to better integrate TMDLs with National Pollutant Discharge Elimination System (NPDES) stormwater permits and TMDL implementation tracking.

Project Experience

Ohio River Pathogen TMDL Development (USEPA Region 5). Supported USEPA Region 5 with the development of pathogen TMDLs for the 900-mile Ohio River. Led a team of modelers and water resource scientists that prepared a project quality assurance project plan (QAPP), provided sampling recommendations, chose an appropriate technical approach, compiled and assessed data, and conducted two-dimensional modeling of the river.

Director of Tetra Tech's TMDL Activities in Region 5 (USEPA Region 5, 6/07 – present). Coordinates all Region 5 TMDL-related task orders under Region 5's Division of Water Contract as well as USEPA's National Watershed Contract. Through these contracts, managed or participated in the development of more than 1,000 approved TMDLs within the region. Works closely with USEPA, Tetra Tech project managers, and subcontractor staff to ensure all projects are completed in an efficient and cost-effective manner. The Region 5 contract was awarded to Tetra Tech through a competitive process in June 2007 and the contract has provided Region 5 with the ability to task important program efforts (27 task orders totaling $5M).

Director of Tetra Tech's TMDL Activities in Region 8 (USEPA Region 8, 6/08 – present). Coordinates all Region 8 TMDL-related task orders under the Region 8 Division of Water Contract. Through these contracts, manages or participates in the development of more than 150 approved TMDLs within the region. Works closely with USEPA, Tetra Tech project managers, and subcontractor staff to ensure all projects are completed in an efficient and cost-effective manner. The Region 8 contract was awarded to Tetra Tech through a competitive process in June 2008 and the contract has provided Region 8 with the ability to task important program efforts (19 task orders totaling $3M).

TMDLs to Stormwater Permits Handbook (USEPA Region 5). Supported USEPA's development of the TMDLs to Stormwater Permits Handbook for USEPA. The handbook contains information to give TMDL and stormwater permit writers a better understanding of (1) cross-program regulatory requirements and programmatic processes; (2) current efforts to establish better cross-program connections; and (3) opportunities to further improve how the TMDL and NPDES stormwater programs interact to address stormwater-related water quality impairments.

Ohio TMDL Support (USEPA Region 5). Provided technical and project management support to Ohio EPA for more than 20 TMDL and watershed studies throughout the state. Pollutants addressed by these TMDLs include metals, nutrients, pathogens, sediments, dissolved oxygen, and total dissolved solids. Models used to develop the TMDLs have included the Simple Method, BATHTUB, load duration curves, Generalized Watershed Loading Functions (GWLF), SWAT, and HSPF. Thoroughly familiar with Ohio's water quality standards and assessment process, including the use of fish and benthic macroinvertebrate biocriteria and the Qualitative Habitat Evaluation Index (QHEI), and has worked with Ohio EPA to develop quantitative relationships between water chemistry, habitat conditions, flow conditions, and the health of aquatic communities.

Nutrient Modeling to Protect Nearshore Waters of the Great Lakes (USEPA Region 5, 9/07 – 12/13). Served as project manager for this effort to assess appropriate modeling tools for determining nutrient waste load allocations and NPDES permits for direct and indirect dischargers to the Great Lakes. The goal of the overall project is to develop and provide a modeling tool for states on Lake Michigan (Phase 1) and other Great Lakes states (Phase 2) that will address mixing patterns in the nearshore areas and subsequently establish permit limits for direct and indirect point source dischargers to the Great Lakes to attain protection of nearshore waters.

Saginaw Bay Nutrient Load Analysis (USEPA Region 5). Served as project manager for this effort to conduct an analysis of the nitrogen, phosphorus, and sediment loads to Saginaw Bay. This project will advance the stated goals of the Great Lakes Restoration Initiative by providing information needed to target restoration efforts in Saginaw Bay watershed, specifically the identification and characterization of nutrient loads contributing to eutrophication of the bay.

West Fork White River TMDLs (Indiana Department of Environmental Management [IDEM]). Served as project manager for the development of E. coli TMDLs for the upper West Fork White River. The project included multiple phases including: data compilation, data analysis, methodology selection, detailed watershed and water quality modeling, preparation of TMDL documents and implementation plans, and public involvement. Applied the LSPC to evaluate the various sources of E. coli within the watershed, which included livestock operations, CSOs, and urban runoff. Used the LSPC model to evaluate various potential implementation scenarios that would allow water quality standards to be met. IDEM selected a final scenario and made allocations for the TMDL.

Wabash River TMDLs (USEPA Region 5). Served as project manager for the development of nutrient, temperature, and E. coli TMDLs for the Wabash River in Indiana and Illinois. The Wabash River watershed is extremely large (more than 11,700 square miles total) and impairments are associated with both agricultural and urban areas. There are more than 130 NPDES dischargers to the Wabash River, including a number of communities with CSOs. Set up and calibrated the CE-QUAL-RIV1 model for the Wabash River and then used it to identify appropriate load allocations.

Lake Michigan Shoreline TMDL (IDEM). Served as project manager for the development of an E. coli TMDL for the Indiana shoreline of Lake Michigan. This was the first TMDL developed and approved for one of the Great Lakes. Applied the three-dimensional Environmental Fluid Dynamics Code (EFDC) model to evaluate the effects of wind, waves, tributary loadings, and other factors on E. coli concentrations along the near shore and subsequent beach closures. Used the EFDC model to evaluate the degree to which existing sources of E. coli needed to be reduced to meet water quality standards during the summer recreational season. The most significant sources of E. coli were found to vary by beach, but included tributary loadings, seagulls, and failing nearshore septic systems.

Illinois TMDL Support (Illinois Environmental Protection Agency [IEPA]). Provided technical and project management support for more than 9 years for TMDL projects located throughout Illinois. Served as project manager for the development of more than 130 USEPA-approved TMDLs in Illinois, which represents 43 percent of the total number of statewide approved TMDLs as of May 27, 2010. Managed projects that led to the delisting of another 30 water body/pollutant combinations. Very familiar with the key issues affecting TMDL development within Illinois, such as the focus on using simple approaches, the characteristics of primarily agricultural watersheds, only developing TMDLs for pollutants with water quality standards, and TMDL pace issues.

Minnesota TMDL Support (Minnesota Pollution Control Agency [MPCA]). Provided project management support for the following TMDL projects: Lower Vermillion River, Groundhouse River, Minnehaha Creek/Lake Hiawatha, and Minnesota River. Supported MPCA on the Stormwater Nondegradation Analysis Project (SNAP) that provided information for the development of rules to ensure Minnesota's waters meet the standard of nondegradation. Supported MPCA to develop a case study evaluating the draft Nine Lakes TMDL in Minnesota, which focused on the integration of stormwater NPDES permitting issues and TMDL development.

TETRA TECH

Henry Latimer

Biological Analyst

EDUCATION

M.S., Biology, Aquatic Ecotoxicology, Virginia Polytechnic Institute and State University, 1999

B.S., Biology, Mary Washington College, 1995

YEARS OF EXPERIENCE

Tetra Tech: 11

Total: 17

PROFESSIONAL AFFILIATIONS

Society for Environmental Toxicology and Chemistry

AREAS OF EXPERIENCE

- Water quality criteria and standards
- Use attainability analyses
- Ecological risk assessment
- Whole effluent toxicity
- Toxicity identification evaluations
- Ecological assessment
- Biological evaluations, threatened and endangered species

Mr. Latimer is a Senior Scientist at Tetra Tech with over 17 years of experience using ecotoxicological tools to evaluate anthropogenic impacts on aquatic ecosystems. He has worked extensively in the evaluation of toxic effects of metals, organic compounds (e.g., PCBs and dioxin), and other stressors in both sediments and the water column on individuals and communities throughout the United States. This experience has included evaluation of the potential for bioaccumulation of mercury and selenium in ecosystems ranging from high elevation streams in the Columbia River Drainage containing migratory salmonids to lower elevation, warm-water systems. In assessing the ecological risk of organic toxins, he has modeled the site-specific dietary dose and bioaccumulation of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and dioxins in several species of freshwater fish. Mr. Latimer has developed, modified, and implemented aquatic water column (WET), and sediment toxicity test methods using numerous test species in both fresh and saltwater. He served as the Director of a large aquatic toxicology laboratory for four years prior to joining Tetra Tech and specializes in not only compliance testing, but also TIE/TRE investigations, research, and site-assessment. He has developed site-specific water quality criteria for a number of different metals using water-effects ratio, and non-resident species deletions procedures, as well as updates of USEPA guidance documents. Additionally, he has been extensively involved with reviewing and commenting on NPDES permits and compliance data from dischargers in states throughout the United States.

Project Experience

Bioaccumulation Assessments. Designed and implemented studies to investigate the potential, actual, or predicted bioaccumulation of selenium and mercury, PCBs, PAHs, or dioxins/furans in fish and aquatic invertebrates. These studies were performed in high altitude mountain streams containing migratory salmonids (Se and Hg), an Alaskan stream in the vicinity of a proposed mixing zone for effluent from a metal mine (Hg), in a Plains stream in Colorado receiving multiple inputs from oil refineries and municipal treatment plants (Se), and in the tidal Delaware river in the vicinity of a superfund site (PCBs, PAHs, dioxins/furans).

Sediment Toxicology. Designed and participated in studies to evaluate the potential toxic contribution of organic and inorganic compounds present in stream and reservoir sediments from site throughout the U.S. These studies used a number of different species of invertebrate and fish in both standard and research-grade whole sediment and sediment elutriate tests conducted both in the laboratory and in situ.

Whole Effluent Toxicity Testing. Used WET testing in evaluation of a wide variety of municipal and industrial discharges, as well as ambient conditions. Overseen and participated in testing with numerous different invertebrate, fish, and algae species in compliance testing, non-compliance investigations (e.g., TIE/TRE investigations), and research-grade freshwater and saltwater testing. Has provided technical oversight on well over 1,000 WET tests. Designed and implemented both manipulated- and synthetic-effluent studies to identify, isolate, and/or predict compounds responsible for toxicity observed in permitted discharges. Used site-specific information to recommend appropriate test methods and species for use in routine monitoring of industrial and municipal effluents. Also, participated in a meeting with other professionals involved in compliance WET testing with the US

USEPA in January 2001, to comment on proposed changes to WET testing methods prior to issuance of those new guidance documents.

Ecological Impact Assessment/Risk Assessment. In support of an ERA at a Superfund Site in Delaware, modeled bioaccumulation of PAHs, PCBs, and dioxins through the food web to fish receptors and compared predicted tissue residues to literature toxicity thresholds to assess risk. Participated in an ERA involving landfills draining to a stream system on an Air Force Base in Maryland for which the contaminants of concern included metals, PAHs, pesticides, and PCBs.

Mixing Zones. Has worked extensively in evaluating the potential ecological impact of mixing zones downstream of mining discharges in both Idaho and Alaska. Using modeled dilution ratios under various discharge and flow regimes, he predicted the concentrations of priority pollutants and the potential effects of the discharge at various points in the stream. Evaluated effect endpoints included avoidance behavior by trout and salmon (including Federally Threatened species), as well as toxicity to fish and invertebrates. Additionally, coauthored mixing zone guidance for permit writers for the states of Idaho and Alaska.

Site-specific Water Quality Criteria. Developed site-specific water quality criteria for aluminum, cadmium, copper, lead, selenium, and zinc through use of the non-resident deletion procedure, water-effects ratio methodology, and correction of USEPA water quality criteria documents. Several of these studies were supported by use attainability analyses (UAA), which Mr. Latimer developed and/or participated in.

Use Attainability Analysis. Conducted UAAs and studies in support of UAAs in both plains and high-altitude streams in Colorado. Has assisted USEPA Region 7 in development of primary contact recreational UAA protocols for Iowa and Missouri. Then managed the study to complete UAAs on more than 200 different streams in Iowa and Missouri.

NPDES Permit Review and Support. Has interpreted, reviewed, and commenting on NPDES permits for dischargers throughout the United States. This work has focused on whole effluent toxicity (WET) conditions and limits, pollutant limits, and mixing zones. Further, he has assisted State of California Regional Water Quality Control Boards in writing portions of specific permits and to craft language for general permits.

TETRA TECH

Jon Ludwig

Program Manager

EDUCATION

M.S., Environmental Pollution Control, The Pennsylvania State University, 1997

B.S., Environmental Science, Widener University, 1995

YEARS OF EXPERIENCE

Tetra Tech: 15

Total: 17

LICENSES/REGISTRATIONS

None

PROFESSIONAL AFFILIATIONS

American Water Resources Association

Water Environment Federation

AREAS OF EXPERIENCE

- Clean Water Act support
- TMDL development
- Water quality modeling
- Mining related water quality studies
- Hydrodynamic modeling
- Guidance development
- Water quality assessment
- Pollutant source assessment
- Environmental statistics
- Watershed management
- Ecological risk assessment
- Safe Drinking Water Act support
- Source water protection

Mr. Ludwig is a director of Tetra Tech's Water Resource Group located in Fairfax, VA and Charleston, WV. He supervises a team of engineers and scientists focusing on watershed planning and management, environmental model development and application, and environmental monitoring and assessment. He is a senior environmental scientist with over 16 years of experience providing technical and management support to federal, state, regional, and private clients in the areas of water resources, watershed and water quality assessment, watershed modeling, and Total Maximum Daily Load (TMDL) development. Mr. Ludwig has successfully managed large, multi-million dollar contracts with federal and state clients and is currently overseeing multiple large water resource projects with USEPA Regions 1,3,5,6, 7 and 8. Mr. Ludwig has managed more than 50 projects for federal, state, municipal, and private clients throughout the US and Canada. Working closely with WVDEP's TMDL Program Manager over the past 11 years, he has provided leadership and energy to produce highly technical and innovative solutions that have helped WVDEP's TMDL Program become a national leader in TMDL development.

Project Experience

Statewide West Virginia TMDL Development Support for WVDEP. Project manager over the past 10 years, supporting West Virginia Department of Environmental Protection (WVDEP) and U.S. Environmental Protection Agency Region 3 (EPA) to develop and fine-tune a TMDL methodology to address various water quality impairments in West Virginia, including biological, iron, manganese, dissolved aluminum, pH, fecal coliform bacteria, and sediment. Originally designed to meet aggressive consent decree deadlines, this innovative TMDL modeling approach was developed using the Mining Data Analysis System (MDAS) to simulate in-stream flow and water quality conditions (based on point and nonpoint contributions) throughout large watersheds. Efforts have resulted in development of more than 3,500 TMDLs in West Virginia using this methodology to meet strict consent decree deadlines, including 1,650 waterbodies and 8 different pollutants (including pH, aluminum, iron, manganese, chloride, selenium, siltation, and biological impairments).

Ohio River Bacterial TMDL. (2007-present). Currently serving as co-project manager supporting USEPA Region 5 in the development of a bacteria TMDL for the Ohio River. The Ohio River Basin covers more than 200,000 square miles extending over six states, from east to west including Pennsylvania, West Virginia, Ohio, Kentucky, Indiana and Illinois. Based on the 2006 303(d) report, 475 miles are impaired for contact recreation from by bacteria.

Re-Evaluation of the Cheat River Watershed TMDLs in West Virginia. (2006-2010). In support of WVDEP and USEPA EPA Region 3, served as project manager for re-evaluation of the Cheat River Watershed. Tetra Tech developed and calibrated MDAS water quality models for pH, total iron, dissolved aluminum, manganese and fecal coliform bacteria. The model dynamically simulated stream acidity results from multiple sources including acid precipitation caused by sulfur and nitrogen emissions, as well as acid mine drainage (AMD) with very high concentrations of sulfate and dissolved metals (Fe and Al) from abandoned coal mining sites in the region.

West Virginia Iron Troutwater Modeling Study. (2009-2010). In support of WVDEP, served as project manager for a high-resolution hydrology and water quality modeling study for two small trout streams in the Gauley River watershed,

WV. The MDAS model was applied to simulate in-stream flow and water quality conditions to determine the range(s) of total iron concentrations that occur in viable trout waters as a result of precipitation induced runoff. Currently, results of this study are being used to refine existing approaches to total iron/sediment TMDLs and to support WVDEP's pursuit of coldwater fisheries water quality criterion revision.

West Virginia TMDL Development Support for USEPA Region 3. (2000-2004). For USEPA Region 3, served as project manager for the development of over 1,000 pH and metals TMDLs in West Virginia including the Monongahela River, West Fork River, Tug Fork River, and Guyandotte watersheds. Provided lead role both technically and administratively in the evaluation of data and pollutant sources to assess and determine relationships between acid mine drainage and in-stream metals concentrations.

Source Water Protection Plan Support for WV DHHR. (2010-present). Currently managing two support contracts with WV DHHR's Source Water Protection Technical Help Program (SWPTHP) by implementing source water protection activities for 104 community public water supply (CPWS) systems in the Beckley, Philippi, and Kearneysville Districts. Source water protection activities include public meetings and facilitation with local stakeholders followed by a survey of potential contaminant sources. Site-specific reports for each CPWS system are being developed and will include a summary of the PCS survey, management plan, contingency plan, and identification of potential funding sources.

TMDL Development Support for USEPA. (2011-present). Providing management and technical oversight and client coordination for multiple TMDL development projects including Lake Champlain TMDL Redevelopment (USPA R1);, Wissahickon Creek, PA Nutrient TMDLs, , DC Toxics TMDLs Redevelopment (USEPA R3); and Ohio River Pathogen TMDL (USEPA R5).

Left Hand Creek Watershed TMDL and Remediation Alternatives Analysis. (2004-2008). In support of EPA Region 8, served as project manager to developed dissolved metals TMDLs for the Left Hand Creek watershed. Tasks included developing an in-stream chemical transport model to simulated water quality under critical flow conditions and assign loading to specific abandoned mine sources. The customized in-stream model includes 1-D transport model was used to dynamically simulate dissolved zinc, cadmium, copper, and lead in three reaches of the Left Hand Creek watershed.

Chesapeake Bay TMDL Implementation Support. (2010 – present). Through EPA Region 3, project manager supporting WVDEP with various Chesapeake Bay TMDL Watershed Implementation Plan (WIP) development activities, including detailed analyses of model output, development of a model output viewer tool, development of management scenarios to evaluate using the model, confirmation of nonpoint and point source representation in the CBPO model, and stakeholder meeting support.

Piney Creek Comprehensive Watershed & TMDL Implementation Plan. (2009-2011). Project manager supporting WVDEP Nonpoint Source Group in developing a comprehensive watershed and TMDL implementation plan for the Piney Creek watershed. Using a holistic watershed approach, the goal of this project was to integrate the regulated MS4 entities and the non-regulated nonpoint source community to identify specific water quality goals and objectives and formulate site-specific projects for TMDL implementation.

Green Infrastructure Stormwater Services, City of Beckley, WV. (2010-present). For the City of Beckley, WV, currently serving as project manager for evaluating Green Infrastructure Stormwater Improvements on Winger Avenue and Pine Hills Subdivision. Products included alternatives analyses, preliminary engineering design, full engineering design and specifications for the Pine Hills Subdivision.

Paint Branch Abandoned Mine Land Reclamation. (2010). Supporting West Virginia Department of Environmental Protection, served as project manager to develop a reclamation design of an abandoned underground mining site in Paint Branch, WV. The site consisted of three open mine portals and approximately 42 abandoned bridge piers. Topographic mapping of the site was prepared and used by Tetra Tech to develop a bat gate design including construction drawings, specifications, and a construction cost estimate.

Stormwater Support, City of Hurricane, WV. (2008-2011). Project manager for as-needed stormwater support services. Services included review of new construction and redevelopment plans to ensure compliance with City stormwater design specifications and with West Virginia's construction stormwater permit requirements, general stormwater program guidance, construction and post-construction program guidance, LID and green infrastructure guidance; ordinance development and review; and public outreach/education/involvement.

TETRA TECH

Yoichi Matsuzuru

Soils Specialist

EDUCATION

M.E.M., Water Resources, Duke University, 1999

Post-graduate studies in Water Quality, University of Hawaii at Manoa, 1996

B.S., Applied Chemistry, Okayama University of Sciences, Japan 1991

YEARS OF EXPERIENCE

Tetra Tech: 14

Total: 16

PROFESSIONAL AFFILIATIONS

American Chemical Society

International association of Geochemistry

AREAS OF EXPERIENCE

- Aqueous geochemical modeling
- Water quality modeling
- Watershed hydrology modeling
- Hydrodynamic modeling
- Water quality assessment
- Pollutant source assessment
- TMDL development

Mr. Matsuzuru is an environmental scientist with more than 15 years of experience in the development, application, and communication of hydrologic, hydraulic, and water quality models, including aqueous geochemical modeling. He has led technical efforts to support EPA, state, and local governments in a variety of TMDL, waste load allocation, watershed/water quality modeling, and model development projects. He has been a technical lead for developing and maintaining chemical reactive transport model codes including Mining Data Analysis System (MDAS) and acid deposition module. He is a proficient computer programmer using Visual Basic Application and FORTRAN and experienced in C++. He has used numerous hydrologic/water quality models to simulate metals, pH, nutrients, DO, algae, sediments and temperature for TMDL development.

Project Experience

Upper Kanawha Water Quality Modeling and Monongahela River Watershed Aluminum and pH TMDLs, EPA Region 3, West Virginia (2012-2013). Applied MDAS model to West Virginia's upper Kanawha watersheds for high dissolved inorganic chemicals, including metals and major cations and anions, and Monongahela tributary watersheds for pH and dissolved aluminum impairments resulting from mining activities. Conducted statistical water quality data analyses (principal component analysis, hierarchical & K-mean clustering and piper plots) to evaluate site conditions and source loadings. To support model inputs, also used Richard's equation to identify subsurface transient water movement in the presence of evapotranspiration.

MDAS Code Update for Ionic Stress TMDLs, West Virginia DEP (2012-2013). Updated EPA's Mining Data Analysis System (MDAS) model to integrate EPA's LSPC watershed loading model with an in-stream reactive transport model. The model was designed to address the linkage between watershed pollutant loading and chemical fate/transport in the receiving streams. The identified linkages were used to establish effective contaminants abatement scenarios.

Monongahela River Watershed TMDLs, West Virginia DEP (2004). Served as technical lead for development of metals TMDLs for the tributaries to the Monongahela River watershed. Constructed LSPC model to perform continuous hydrologic and water quality simulations for 42 impaired segments of the watershed. The model included 210 subwatersheds and considered direct inputs of numerous NPDES point sources discharges to the tributaries and their effects on water quality conditions. Also incorporated into the model loadings of numerous mine sources.

Montana Temperature TMDLs, Montana DEQ and EPA Region 8 (2012-2013). Conducted instream temperature simulation for streams affected by shading, groundwater inflows, irrigation outflows and point sources inflows. Applied, calibrated and validated EPA's QUAL2K model and simulated remediation scenarios to improve the instream temperature at the level of temperature criterion of the state of Montana.

Red lake/Anton pond Iron and Manganese Modeling to Support TMDLs in Red Lake/Anton Pond, AK, Alaska DEC (2012). Conducted modeling to evaluate lake impairments due to leachate from historical landfill located adjacent to the lakes and the interaction of the highly contaminated lake bottom sediments and the overlying water. Following water quality data analysis, simulated current water quality conditions of the sediment pore solution and lake water using USGS's

PHREEQC model and simulated remediation scenarios that could meet water quality criteria for total iron and manganese.

Lake Helena Metal TMDLs, Montana DEQ (2009). Technical lead for TMDL development for aluminum, antimony, arsenic, cadmium, copper, iron, lead, mercury, silver, and zinc. Calibrated and applied LSPC model for these metals to develop remediation scenarios at the watershed scale. Statistically analyzed and evaluated water quality data.

Gills Creek Watershed LSPC modeling for Nutrients and Bacteria TMDLs, South Carolina DHEC (2010-2011). Technical lead to develop TMDLs for Gills Creek watershed. Applied LSPC watershed model to simulate hydrology and water quality and evaluate pollutant loads causing dissolved oxygen/nutrients and fecal coliform bacteria impairments. Incorporated SSOs into the model as discrete time series inputs.

Little Wabash River, Saline River, Shoal Creek and Silver Creek pH TMDL Development, Illinois DEQ, EPA Region 5 (2008). Applied MINEQL speciation model to estimate current nonpoint and point source metals and hydrogen acidity loadings to several pH-impaired rivers and streams. Evaluated water quality data for acidity loading for both mining sources and agricultural land sources to simulate in-stream pH conditions. Subsequently, quantified alkalinity additions to raise pH based on the Total H concept..

Wabash River Bacteria and Nutrients TMDLs, Illinois DEQ and Indiana DEM (2006-2007). Technical lead for development of nutrient, temperature, and E. coli TMDLs for Wabash River. Evaluated measured loadings and estimated loading using regression curves and the characteristics of more than 150 subwatersheds (e.g., land uses, watershed slope, and soil type) to develop EPD-RIV-1 model (one dimensional hydrodynamic and water quality model). Calibrated hydrology and water quality parameters such as temperature, nutrients and fecal coliform bacteria and incorporated CSO loadings to address additional loading during storm events.

Chagrin River BMP Studies, Ohio EPA (2007). Developed and implemented BMP scenarios under stormwater influence of Chagrin River watershed. Tested several scenarios with LSPC and its BMP module by varying particular land use areas and implementing two BMPs (detention pond and infiltration detention pond) for subwatersheds in the watershed. Compared results with the current flow conditions and recommended to Ohio EPA as effective flow mitigation methods.

Atmospheric Deposition-Stream Acidification Model Development, EPA Region 3, Maryland Department of the Environment (2006-2007). Developed atmospheric deposition-stream acidification module for LSPC model. Developed model to consider acidity loading from atmospheric deposition and soil chemical reactions including gibbsite dissolution, cation exchange and ionic charge balance among major and minor ions within subsurface layers. Developed six subroutines to estimate in-stream pH within a basin scale setting, including subsurface chemical reaction, aqueous chemical reaction, sulfate/nitrogen subsurface and instream reaction routines. Incorporated mining sources such as abandoned mine lands and tailing piles in the model. Applied the model to the watersheds experiencing acidic deposition influences to identify acidity loading reductions.

California Gulch Remediation Modeling Study, Colorado DPHE (2009-2010). Co-developed reactive transport model for California Gulch, a stream affected by acid mine drainage to include sub-models of steady-state flow equation, suspended sediment transport, contaminants transport, and chemical equilibrium speciation and kinetic model. Also simulated the exchanges of contaminants between the water column and bottom sediments. Applied the model to evaluate remediation scenarios/planning. Recommended sampling locations and chemical parameters to support modeling.

Conceptual Model Development, South Florida Water Management District, Florida (2005). Drafted sixteen conceptual models for nutrients, including nitrogen and phosphorus, and trace metals in both oxic and anoxic conditions of the wetlands. The models were ranked from the highest data intensive conceptual model to the lowest data required conceptual model. The project identifies natural processes to be incorporated into an appropriate model for the environmental system in the Everglades wetlands.

Boulder Creek Watershed TMDLs, Arizona DEQ (2003). Technical lead for metals TMDL development for Boulder Creek. Used LSPC watershed model to simulate watershed hydrologic conditions. Coupled the chemical speciation model MINEQL with a plug flow model to simulate various chemical reactions to evaluate loading effects from tailing piles, adits and groundwater along the creek. Analyzed acidity loading and neutralizing capacity from tailing piles and adits. After the model was calibrated, identified source loading reductions to achieve water quality standards.

TETRA TECH

Allen Medine, PhD, PE

Soils Specialist

EDUCATION

Ph.D., Environmental Engineering, Utah State University, Logan (w/chemistry minor), 1980

M.S., Civil Engineering, University of California, Berkeley, 1973

B.S., Civil Engineering, University of Illinois, Urbana, 1972

YEARS OF EXPERIENCE

Tetra Tech: 2

Total: 36

LICENSES/REGISTRATIONS

Professional Civil Engineer, California (2011, [redacted]

Professional Engineer, Colorado (1994, No. 29856)

Board Certified Environmental Engineer (BCEE), American Academy of Environmental Engineers, Hazardous Waste Certification (1999, 98-20077)

PROFESSIONAL AFFILIATIONS

American Society of Civil Engineers

Water Environment Federation

American Chemical Society, Div. of Environmental Chemistry

AREAS OF EXPERIENCE

- Waste site investigations, characterization, environmental forensics
- Water quality, contaminant fate and geochemical modeling
- Natural resource restoration
- Contaminant loading analyses
- Remedial design and costs
- Industrial water chemistry
- Sediment investigations and remediation
- Bankruptcy environmental evaluations / cost estimating
- Litigation strategy, negotiations, testimony

Dr. Medine has 35 years of professional experience in civil/environmental engineering and environmental chemistry/geochemistry. Experience includes seven years of teaching and research in Civil and Environmental Engineering, and substantial, complex Project Management experience, Business Development experience, and Expert Technical Support experience. Business experience includes developing and managing programs for data quality, report production, client services, and litigation as a company founder/vice-president in several successful consulting companies. He has worked on a wide variety of multi-disciplinary civil/environmental engineering and environmental science projects at over 90 waste sites (in all EPA regions) and provided a wide range of technical support at over five-dozen Superfund sites.

Dr. Medine has been committed to technology transfer and research in surface water, sediment, and groundwater quality management for over 35 years, including the development, testing, and application of modeling to attain water quality goals. His expertise includes hazardous waste management, watershed management and restoration of damaged ecosystems, behavior of toxic substances in the environment, hydrologic and sediment transport modeling, geochemical modeling, water quality and contaminant transport modeling, river basin hydrology, geomorphology, and regulations and procedures pertaining to the Clean Water Act (CWA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Resource Conservation and Recovery Act (RCRA), and Natural Resource Damage Assessment (NRDA).

Project Experience

West Virginia TMDL Development Support for WVDEP and EPA. Served as a technical resource in the modifications and application of the loading simulation and geochemical models (LSPC-MDAS) to evaluate ionic composition and metals fate and transport in the Upper Kanawha River. Developed various technical data related to mining impacts (nonpoint and point sources) on metals loading and input data to evaluate impacts of iron, aluminum, cations/anions, and pH in support of water quality concerns.

Geochemical Modeling for Clearfield Creek, Pennsylvania, to Support Metals and pH Impairment. Served as a technical expert in the geochemical modeling effort to predict and evaluate the water quality conditions of Clearfield Creek and Sugar Run in response to the modified flow and pollutant loading from the mine discharges. The use of MINTEQA2 provided the ability to quantify the distribution of dissolved species, which can provide insight on the potential toxic conditions. The geochemical evaluation of the impact of the Cresson Acid Mine Drainage Project on the in-stream water quality of Clearfield Creek evaluated the existing and expected water quality conditions based on the mine drainage treatment alternatives, the model uncertainty, and underscored the impacts of mine water discharges on regulating the surface water quality of Clearfield Creek and Sugar Run. Recommendations included the development of an Integrated Reactive Transport Model (LSPC-MDAS) would permit an assessment of flow conditions, point and non-point loadings, geochemical interactions, precipitation and groundwater interactions throughout Clearfield Creek.

Green River Watershed and Lower Duwamish Waterway Water Quality Assessment Technical Approach (Washington). Served as a technical resource in the development of a technical approaches and modeling tools to assess the management activities that could be implemented in the Lower Duwamish

Waterway (LDW) and the larger Green River watershed to achieve measureable improvements in water, sediment, and tissue quality. The technical approach considered impairments in the system due to elevated metals, PCBs, PAHs, dioxins/furans (mainly 2,3,7,8,-TCDD) pesticides, phthalates, and pesticides, along with conventional parameters. Developed a Conceptual Site Model and evaluated modeling considerations for carcinogenic PAHs and both high and low molecular weight PAHs and how best to represent the variety of PCBs found in the watershed and LDW.

Expert Support to EPA at Upper and Middle Silver Creek, Richardson Flat Tailings Superfund Site, Utah. Expert engineer for site characterization, remedial investigation support, field data collection, laboratory QA, and implementation of characterization and evaluation of work conducted by others in the Silver Creek floodplain areas (OU2, OU3), and Prospector Gulch (OU4) and in adjacent areas under Utah's Voluntary Cleanup Program in the Park City, Utah area. The technical support focused on the evaluation of source, transport and fate of metals, including arsenic, cadmium, lead, and zinc, throughout the area in surface waters, sediments, and groundwater, including the development of advanced decision support tools for managing the remediation/restoration activities under CERCLA and as part of the NRDA..

East Helena ASARCO Smelter Superfund Site. Served as an Expert Witness in the ASARCO LLC v. Atlantic Richfield Company et al. case (Montana) and prepared a liability and damages report regarding ASARCO's wastes vs. wastes produced by American Chemet Corporation. Following analysis of information concerning types of chemical wastes that were generated by ASARCO and the other industries, how those wastes were disposed, the resulting releases of hazardous substances, and where those hazardous substances came to be located on the Site, it was determined that ASARCO generated the overwhelming majority of the wastes and disposed of wastes in the smelter site (soils, impoundments, surface water, groundwater) and that the contaminants released from the ASARCO smelter site are responsible for the contamination of downgradient soils, surface water, sediments and floodplain deposits. American Chemet played an insignificant role in the observed contamination of environmental media (Lawsuit withdrawn).

Expert Environmental Engineer for U.S. Department of Justice. Supported the U.S. Government on over 50 major Superfund/CERCLA sites throughout the U.S for the last 20 years in areas such as contaminant source, transport and fate; remedial design, technology and cost analysis; historical releases; sediment transport and dredging; environmental forensics; liability and apportionment; bankruptcy environmental liabilities; National Contingency Plan (NCP) compliance; and natural resource damages. Provided support on 15 NRDA projects including contaminant source, fate, transport, exposure assessment, and Restoration Analysis (directly on 5 projects, including the Blackbird Mine (ID) and four in Colorado). Projects involved substantial state-of-the-art research, interpretation of complex subjects, and application of advanced analyses to prepare opinions for the court. Developed and applied numerical contaminant transport modeling in conjunction with GIS systems to integrate large quantities of environmental data to evaluate waste treatment location / volumes, transport pathways, soil erosion, groundwater contaminant migration and fate, cost evaluations, sediment and floodplain dynamics, and historical natural contaminant loadings and maximum daily loadings to meet water quality needs.

Expert Environmental Engineer; Various Litigations for Private Law Firms. Supported private firms on the source, release, transport, and fate of a variety of toxic chemicals at the Upper Columbia River Basin, eastern Washington (2011, metals); Lakewood, Colorado Groundwater TCE site; Quality Metal Products (1999, TCE, degradation products); and at the Lowry Landfill Superfund Site, City of Lakewood v. Various Insurance Companies.

Project Manager and Senior Environmental Engineer; Potentially Responsible Party (PRP) Activities Under the Technical Enforcement Support (TES) IV and Aircraft Reporting and Compliance System (ARCS) Programs for USEPA. Project manager and senior environmental engineer for technical oversight; provided coordination of technical review of all RI/FS and RD/RA documents at 9 major Superfund sites including mining sites and organic chemical sites (technical review included review of feasibility studies, RD planning documents, site characterization plans, QA/QC plans, fate and transport studies, modeling, remedial designs, and technology demonstration plans).

Expert Environmental Engineer; Various Projects for City of Thornton. Supported the City of Thornton on drinking water infrastructure and sources through expert technical services on Regulation 31, Regulation 38, nitrate Total Maximum Daily Load (TMDL) assessment for the South Platte River, the Englewood Water Rights Case, the Denver Case, and other issues on an as-needed basis. The work involved data analysis, strategy meetings, document review, preparing testimony for the Water Quality Control Commission, and offering testimony before the Commission.

TETRA TECH

Christina Mellors

Senior Water Resource Engineer

EDUCATION

M.S., Environmental Science, Drexel University, 1998

B.S., Chemical Engineering, Carnegie Mellon University, 1994

YEARS OF EXPERIENCE

Tetra Tech: 12

Total: 18

AREAS OF EXPERIENCE

- TMDL development
- Water quality modeling
- Hydrodynamic modeling

Ms. Mellors provides technical support to federal and state clients in the areas of watershed modeling, water quality assessment and management, and Total Maximum Daily Load (TMDL) development. Her duties include research, data compilation and analysis, data analysis in GIS, and technical writing. She has experience with BASINS, LSPC and the Mining Data Analysis System (MDAS), a dynamic watershed tool that has been customized for watershed assessment and TMDL development efforts in West Virginia. In addition to her graduate and undergraduate studies, Ms. Mellors has extensive knowledge and experience dealing with environmental issues on the state government level as an employee of the Virginia Department of Environmental Quality. During that time she regularly dealt with EPA Region 3 in support of RCRA permitting and corrective action activities. Ms. Mellors also has professional experience as a consultant providing engineering services to the specialty chemical and pharmaceutical industries. She is currently serving as technical lead for the development of West Virginia's watershed implementation plan for the Chesapeake Bay TMDL for WVDEP.

Project Experience

Metals and Sediment TMDLs for the Tygart River Watershed, WV. Currently serving as technical lead for metals and sediment TMDL development for 81 impaired streams in West Virginia for WVDEP Division of Water and Waste Management.

Chesapeake Bay TMDL Implementation. Currently serving as technical lead for support of West Virginia's Chesapeake Bay TMDL efforts. Supported WVDEP in the development of West Virginia's Chesapeake Bay watershed implementation plans (WIP). Provide technical support to client for the analysis of model results, assessment of implementation activities, development of model input decks, and guiding potential allocation approaches for consistency with established WVDEP TMDLs.

PCB Watershed Restoration Plan. Developed and wrote a restoration plan for PCB-impacted watersheds in Prince George's County, MD, as required by the county's MS4 permit. Calculated load reductions for existing and proposed BMPs.

Metals and Sediment TMDLs for the Upper Kanawha, Upper Ohio North, South Branch Potomac, Monongahela and West Fork River Watersheds, WV. Served as technical lead for metals and sediment TMDL development for five watersheds in West Virginia for WVDEP Division of Water and Waste Management.

Chesapeake Bay TMDL Support. Created a database tool for Delaware Department of Natural Resources (DENREC) to extrapolate baseline loads from the Chesapeake Bay model for nine municipalities and three counties in Delaware.

Agricultural BMP Tracking and Reporting Database. Managed development of an Access database to track and report implementation of non-cost share BMPs for WV Department of Agriculture. Database streamlines WVDA's data management and ultimately reports BMP implementation for direct input to the Chesapeake Bay Model for nutrient and sediment reduction credit.

Metals and Sediment TMDLs for the Elk River, Middle Ohio South and Middle Ohio North Watersheds, WV. Served as technical lead for metals and sediment TMDL development for the Elk River watershed and Middle Ohio South and North watersheds, West Virginia for WVDEP Division of Water and Waste Management.

Metals and Fecal Coliform TMDLs for the Greenbrier River, James River, Little Kanawha River, Upper and Lower New River Watersheds, WV. Served as technical lead for metals TMDL development for the Little Kanawha River watershed and the Upper and Lower New River watersheds, West Virginia for WVDEP Division of Water and Waste Management. Provided technical oversight and guidance for the development of fecal coliform TMDLs for the Greenbrier River and James River watersheds, West Virginia.

Metals, Sediment and Fecal Coliform TMDLs for the Gauley River and Potomac Direct Drains Watersheds, WV. Served as technical lead for metals and sediment TMDL development for the Gauley watershed, West Virginia. Provided technical oversight and guidance for the development of fecal coliform TMDLs for the Gauley watershed, West Virginia and sediment and fecal coliform TMDLs for the Potomac Direct Drains watershed, West Virginia for WVDEP Division of Water and Waste Management. Developed an approach for modeling sediment and sediment related metals using MDAS.

Fecal Coliform TMDLs for the Coal River Watershed, WV. Served as technical lead for fecal coliform TMDL development for 83 streams in the Coal River watershed, West Virginia for WVDEP Division of Water and Waste Management. Documented the approaches and compiled findings in a final report.

Metals, Fecal Coliform and Sediment TMDLs for the Coal River, Lower Kanawha River, and North Branch of the Potomac River Watersheds, WV. Provided technical support for TMDL development for metals, fecal coliform and biological impairments for 175 streams in the Coal River, Lower Kanawha River, and North Branch of the Potomac River watersheds in West Virginia. Developed approaches and tools to quantify pollutant loadings from mining permits while working closely with WVDEP.

Fecal Coliform TMDLs for the Guyandotte River Watershed, WV. Served as technical lead for fecal coliform TMDL development for the Guyandotte River watershed, West Virginia, for USEPA Region 3. Documented the approaches and compiled findings in a final report and participated in public meetings.

Metals and Fecal Coliform TMDLs for the Upper Kanawha River and Upper Ohio River North Watersheds, WV. Served as technical lead in the development of fecal coliform TMDLs and provided technical support for the development of metals TMDLs for the Upper Kanawha and Upper Ohio North watersheds in West Virginia. Documented the approaches and compiled findings in a final report and participated in public meetings.

Source Water Protection Field Surveys, WV. For the West Virginia Department of Health and Human Resources, Source Water Assessment and Protection Program, developed a database to track and manage project data and generate system-specific source water protection plans for over 100 community water systems in West Virginia.

Chartiers Creek, PA and Cheat River, WV. Provided technical support for WVDEP TMDL projects as well as USEPA Region 3 TMDL projects in Chartiers Creek and the Cheat River.

Virginia Department of Environmental Quality. Wrote, reviewed and issued permits, closure plans and corrective action documents for hazardous waste management (treatment, storage and disposal) facilities throughout the state of Virginia in accordance with RCRA and Virginia State Hazardous Waste Regulations. Worked closely with the US Navy to develop a Research Demonstration and Development permit for an experimental plasma arc hazardous waste treatment unit at US Naval Station Norfolk. Performed extensive reviews and analyses of all sampling data submitted in support of solid and hazardous waste permitting activities and to demonstrate closure of hazardous waste management units. Worked with RCRA facilities throughout Virginia to develop groundwater and human exposure environmental indicators for RCRA corrective action. Regularly engaged in public participation activities related to permit approval and issuance for both solid and hazardous waste facilities. In addition to those activities required by law, met with various local interest groups and concerned citizens to educate them about the requirements of RCRA and state regulations and has facilitated meetings between facility owner/operators and the public to resolve issues related to facility operation.

TETRA TECH

Russell Myers

Watershed Analyst

EDUCATION

M.S., Natural Resource Management, North Carolina State University, 2012

B.S., Environmental Science, Shepherd University, 2008

YEARS OF EXPERIENCE

Tetra Tech: 1

Total: 4

AREAS OF EXPERIENCE

- Source water protection
- Water quality monitoring
- Stream ecology and hydrogeomorphology surveys
- Fisheries surveys
- First Aid/CPR/AED

Mr. Myers is an environmental scientist specializing in source water protection and water quality assessment. He has 4 years of professional experience, including master's thesis work investigating forest management in Latin America. Mr. Myers supports source water protection work in West Virginia and Virginia. His duties include technical writing, editing, field investigations, and public outreach support. Mr. Myers also has experience participating in stream ecology, hydrology, and fisheries studies.

Project Experience

Source Water Protection Guidance, WV. For the West Virginia Department of Health and Human Resources, Source Water Assessment and Protection Program, edited source water protection guidance document.

Previous Experience

Greenhouse/Lab Technician, NC. For Medicago, USA, collaborated with a team of greenhouse staff to manage research scale tobacco crops for use in pharmaceutical research and vaccinations. Maintained and sterilized lab and greenhouse facilities, harvested and processed tobacco crops, and conducted soil and water testing using pH and EC meters. Managed greenhouse irrigation and automation, as well as virus-like particle infiltration technology. Assisted in various upstream lab processes, including fermentation and clarification of raw vaccination materials.

Crew Leader/Field Technician, OR. For the United States Forest Service, managed four person crew to collect data on stream morphology and water quality for streams throughout the Northwest United States as a part of a multi-year effectiveness monitoring program. Studied effects of grazing and timber harvest on stream ecosystems and gathered data on habitat structure, water chemistry, riparian vegetation, bank structure, sinuosity, and stream gradient. The results of the study are used to determine acceptable grazing limits on federal land all over the country. Responsible for effective communication, crew safety, data management, and backcountry navigation.

Teacher's Assistant, NC. For North Carolina State University, provided logistical support for professors in multiple courses, including Renewable Resource Management and Policy, Adaptive Management and Governance, and Environmental Issues in Water Resources. Administered and graded tests, presentations, and research papers on a wide range of topics.

Research Assistant, NC. For North Carolina State University, developed spreadsheets representing optimal forest resource allocation and interaction with other land uses to be used by land owners and resource management professionals. Collected data and co-authored a research paper on agroforestry systems management, titled "Tree growth and timber returns for an agroforestry trial in Goldsboro, NC." The paper was presented at the North American Agroforestry Conference 2011 in Athens, GA. Developed growth and yield projections and economic analyses for various timber species in North Carolina.

Federal Fisheries Observer, AK. For Northwest Observers, Inc., lived aboard multiple commercial trawling vessels targeting Alaskan Pollock and Cod, and collected fishing data for the National Marine Fisheries Service (NMFS). Duties included performing regular safety inspections, monitoring target and by-catch species frequency, species identification, and fishing location. Reported daily to NMFS and the National Oceanic and Atmospheric Administration via satellite.

Biological Research Assistant, WV. For the U.S. Geological Survey-Leetown Science Center, Kearneysville, completed the final year of a 5-year study of freshwater mussel populations in the Allegheny River, PA aimed at detecting any population and biodiversity impacts of regional development and changes in water quality. Worked and coordinated with a small team of researchers to collect and organize population and species data for the study. Duties also included species identification, boat operation, and SCUBA research techniques.

TETRA TECH

John O'Donnell

Quality Assurance Manager

EDUCATION

B.S., Business Administration, Glendale University, 2009

YEARS OF EXPERIENCE

Tetra Tech: 12

Total: 31

AREAS OF EXPERIENCE

- Quality Assurance/Quality Control (QA/QC)
- Quality Assurance Project Plans (QAPP)
- Quality Management Plans (QMP)
- Standard Operating Procedures (SOP)
- Laboratory, field, and system audits

Mr. O'Donnell is an Environmental Quality Assurance Chemist with 30 years of experience providing technical and project management, and quality assurance support to federal, state, and municipal clients throughout the United States. Mr. O'Donnell currently serves as Quality Assurance Officer on a number of EPA contracts and on individual work assignments and task orders. He is responsible for the overall management of quality system for Tetra Tech's Fairfax center offices. He has developed, refined, and maintained Quality System components including the organizational Quality Management Plan (QMP), contract-specific Quality Control Plans (QCPs), Standard Operating Procedures (SOPs), procedural and technical training and documentation systems, and project and system audit protocols, as well as project specific Quality Assurance Project Plans (QAPPs). Mr. O'Donnell has been supporting EPA Headquarters, EPA Regions, and states with TMDL issues since 2003, including development of QAPPs in support of TMDL development. Mr. O'Donnell's areas of expertise include Quality System Development, including preparation of QMPs, QAPPs, SOPs, and other documents; conducting laboratory, field, and system audits; reviewing and validating environmental data; and performing data analysis and usability assessments. Mr. O'Donnell has experience and training in environmental data validation, analytical laboratory auditing, project management, quality assurance, health and safety, chemical hygiene, and personnel management and supervision gained through on-the-job training and technical courses, seminars, and conferences.

Project Experience

Regional and state TMDL Support. Mr. O'Donnell has provided technical and QA support in the development of quality system guidance for: Illinois EPA for TMDL projects on Little Vermilion River, and Salt Fork; for Indiana Department of Environmental Management on South Fork Wildcat Creek, and Busseron Creek watersheds; and for Minnesota Pollution Control Agency on Lower Vermillion River; for Ohio EPA. Routine QA support included development or oversight of the development of quality assurance guidance (QAPPs) for TMDL development, as well as QAPPs for any primary data collection conducted to address gaps in temporal or spatial characterizations.

Klamath River Basin Monitoring and Hydrodynamic and Water Quality Modeling Support (QA Chemist; Oregon and California, U.S.A.; 2004 - 2007). Oversaw the primary data collection efforts for Oregon, California, and USEPA in the 15,700 mi2 Klamath and Lost River Basins. Assisted in the design of a comprehensive monitoring plan to conduct a series of sampling events that included physical, chemical, and biological monitoring (including Sediment Oxygen Demand and periphyton surveys) at over 30 independent sites throughout the semi-arid, high desert region of the basin. Developed procurement documents and relevant technical specifications to address laboratory analysis of surface water samples collected in the basins, conducted negotiations with qualified respondents and developed detailed statements of work for award of the subsequent subcontract agreement. Assisted with the development of quality system documents to describe the requirements of the monitoring design and subsequent field data collection operations (sampling and analysis plan or SAP), and developed the detailed quality assurance project plan (QAPP) for review and approval.

Conducted field and laboratory procedural reviews concurrent with the first field mobilization to ensure complete understanding of field sampling protocols and laboratory requirements to optimize data quality for this important data collection,

and retained primary oversight for field and laboratory activities throughout the data collection, including providing technical direction for selection of corrective action in instances of non-conformance in measurement system performance. Primary laboratory measurements were conducted for nutrient and bacteriological impairments, as well as to characterize overall oxygen budget within the system. Continuing support to modeling staff in interpretation of analytical measurement data and reports for monitoring conducted within the basin by other stakeholders.

Brazos River Basin (Basin Group D) Dissolved Oxygen TMDL Study (QA Chemist; Texas, U.S.A.; 2001 - 2005). A water quality and biological monitoring plan was developed and formalized in a project Sampling and Analysis Plan (SAP) to provide the necessary data to assess the status of impaired streams for modeling studies, Use Attainability Analyses (UAA), and TMDL development. A Quality Assurance Project Plan (QAPP) was developed to govern monitoring studies (biological and habitat assessments), laboratory analyses, data management, and reporting. Physical, biological, and chemical monitoring were conducted in 2003 and 2004 in two of the three creeks suspected to be impaired for DO. Stream segments were regularly monitored over two years. In support of the QA function, the QAPP and SAP were revised and updated to reflect revised TCEQ program monitoring objectives and to reflect revised scope (elimination of one of the three segments proposed for detailed investigation). Detailed Statements of Work were developed to contractually direct quality requirements of the laboratory service subcontractors, and annual on-site (field) sampling procedural reviews and laboratory technical project audits were conducted to ensure attainment of project goals, compliance with program requirements, and to verify adequacy of procedures and documentation. Procedural review and audit reports were prepared detailing observed deficiencies (findings), required corrective actions, and recommendations (observations).

Water Quality Monitoring for USEPA Region 2 in the U.S. Virgin Islands (QA Chemist; St. Thomas and St. John, U.S. Virgin Islands; Spring 2007). Developed and implemented quality system documents to support the primary data collection for the dissolved oxygen and overall oxygen budget (including sediment oxygen demand, respiration, diffusion, and productivity) investigation within St. Thomas Harbor in St. Thomas and Coral Bay on St. John in the US Virgin Islands (the approved project QAPP). Conducted field procedural reviews for sample collection and in situ field measurements conducted within the study areas, and continued to support modeling staff in the interpretation and use of field and laboratory analytical results. Under this task order, Tetra Tech selected a field investigation team internationally recognized for their specialization in oxygen budget monitoring design and measurement.

TETRA TECH

Jennifer Olson, PG

Soils Specialist

EDUCATION

M.S., Water Resources Science, University of Minnesota, 2005

B.S., Hydrogeology and Environmental Geology, University of Minnesota ,1997

YEARS OF EXPERIENCE

Tetra Tech: 5

Total: 18

LICENSES/REGISTRATIONS

Licensed Professional Geologist (P.G.), Minnesota, [redacted]

TRAINING

Systematic Development of Informed Consent, Institute for Participatory Management and Planning, 2005

Better Site Design Techniques Workshop, Center for Watershed Protection, 2003

P8 Urban Catchment Model Training, Instructor John Panuska, WI DNR, 2002

AREAS OF EXPERIENCE

- Water quality planning and assessment
- Total Maximum Daily Load studies
- Watershed planning and restoration
- Stormwater and green infrastructure
- Surface and groundwater interactions

Ms. Olson is a water resource scientist with broad experience in watershed and water quality planning and management. She has extensive experience developing water quality and Total Maximum Daily Load (TMDL) studies and has worked closely with stakeholders and municipalities to develop successful implementation programs. She also has background in stormwater management and green infrastructure practices including best management practice optimization modeling to determine cost-effective solutions to water quality and flooding problems. Ms. Olson also has experience with surface and groundwater interactions, designing and implementing comprehensive monitoring programs, implementation of regulatory programs, private sector coordination, meeting facilitation, and public education and outreach.

Project Experience

Pecatonica River Watershed TMDLs, IL, Illinois Environmental Protection Agency (2013 – present). Managing development of TMDLs for a HUC8 watershed in northwestern Illinois, including evaluation of sources and causes of stream and lake impairments and development of loading capacities. EPA's STEPL model will simulate pollutant loadings from a primarily agricultural landscape. An implementation plan will also be developed that will meet EPA's Nine Key Elements.

Guidance on Implementing TMDLs to Address Stormwater-Related Impairments, USEPA Region 5 (2012 – 2013). Led development of guidance to address several key questions and perceived implementation impediments related to stormwater driven TMDLs. Specific guidance is included on translating flow duration curve hydrologic targets to BMP implementation, translating a TMDL wasteload allocation to stormwater standards, and identifying priority areas for implementation of stormwater infiltration practices.

Jordan Creek Mercury TMDLs, ID, USEPA Region 10 (2012 – present). Currently supporting USEPA Region 10 with development of mercury TMDLs for the highly contaminated Jordan Creek in Idaho. Developed allocation approach and TMDLs and assisted with response to comments. Legacy mining activities, deposition of mercury by the global pool, and presence of mercury deposits in natural sediments all lead to the highly controversial nature of this project as well as the potential impacts to gold and silver mine reclamation work in the watershed and concerns for downstream fish consumption in tribal areas.

Minnesota Statewide Nutrient Reduction Strategy, Minnesota Pollution Control Agency (2012 – 2014). Managed the development of a statewide nutrient reduction strategy in Minnesota that will help achieve nutrient reductions both at the local level and in downstream receiving waters, including the Great Lakes, Gulf of Mexico, and Lake Winnipeg. Led and facilitated many Interagency Coordination Team meetings of more than 40 participants and 10 state agencies. The Strategy includes quantification of baseline and existing nutrient loads, development of reduction goals and interim milestones, and evaluation of state programs. Priority watersheds and sectors are identified for focused implementation activities. Detailed strategies are provided for key sectors (wastewater, agricultural, and miscellaneous) through detailed BMP modeling at the HUC8 watershed scale. Provided support for public review of the Strategy including outreach and education, public meetings, and comment compilation and responses. The Strategy was completed in 2014.

Middle Illinois River TMDL Implementation Plan, IL, USEPA Region 5 (2012). Managed a pilot project in the Middle Illinois River basin that provides focused TMDL implementation recommendations for use by local stakeholders and municipalities. This implementation plan, the first of its kind in Illinois, is in part based on watershed and BMP modeling using the Long-Term Hydrologic Impact Analysis (L-THIA) model and Prince George's County's BMPDSS. These models are used to determine an effective suite of BMPs and activities which will result in attainment of the TMDL and load reduction strategies in two subwatersheds. The implementation plan includes a cross walk to EPA's Nine Key Elements, and the project was supported by a series of public input meetings.

Indiana Lake and Watershed Model Selection and Training, USEPA Region 5. For USEPA, provided support to Indiana Department of Environmental Management for selection of watershed models for use in nutrient and nutrient-related TMDL development and associated NPDES permitting. Coordinated training workshop on STEPL and BATHTUB to over 20 IDEM staff including working with Indiana to determine workshop objectives, developing workshop agenda and content, facilitating training workshop, and providing follow-up support as needed.

Judith Mountains Watershed TMDLs, MT, USEPA Region 8. Managed development of TMDLs for metals, nutrients, and sediment for several streams in central Montana. Developed high and low flow TMDLs for metals and nutrients based on available flow data. Developed sediment TMDLs based on surrogate measures for TMDL implementation.

Montana Temperature TMDL Development Support, USEPA Region 8. Managed development and application of SSTEMP and Qual2K models for development of temperature TMDLs for 13 impaired rivers and streams.

Lower Grand TMDL Study, OH, USEPA Region 5 (2010 – 2012). Deputy project manager for the first flow-based TMDL in USEPA Region 5, developed for the lower Grand River watershed in northeastern Ohio, which is impaired for biology and pathogens. The "Flow Regime TMDL" was approved in 2012 to address the impacts of stormwater and reduced base flow on biology in the watershed. The TMDL was based on attainment flow duration curves derived using a reference watershed approach. Led analysis using the SUSTAIN model to determine cost-effective BMPs for inclusion in the implementation plan.

Middle Illinois River Watershed TMDLs, IL, USEPA Region 5 (2011 – 2012). Managed TMDLs and supported load reduction strategies for the main stem of the Illinois River as well as tributaries and two impaired lakes in the Middle Illinois River watershed. TMDLs were developed for pathogens, chloride, manganese, total dissolved solids, phosphorus, and low dissolved oxygen levels. Load reduction strategies were developed for total suspended solids and nutrients. Also conducted two public meetings.

USEPA Compendium of Nutrient TMDLs, USEPA (2010 – 2011). Managed development of the draft USEPA Compendium of Nutrient TMDLs. Conducted interviews with USEPA Regional TMDL staff to gain insight into typical approaches and methods being used across the country to develop nutrient TMDLs. Participated in and managed review of more than 100 nutrient TMDLs to further evaluate the recent approaches being used. Summarized results along with the pros and cons on the various approaches, challenges being faced, and lessons learned from each of the Regions. Also worked with USEPA to organize and conduct a workshop on nutrient TMDLs in February 2011.

Silver Lake TMDL Study and Implementation Plan, MN. Prior to joining Tetra Tech, project manager and primary author of the Silver Lake TMDL (Ramsey County, MN), approved by USEPA in 2010. This TMDL utilized a linked StormNET hydrologic and hydraulic model and P8-UCM to simulate the urban conditions and effectiveness of existing BMPs in the Silver Lake watershed. A Bathtub model was then constructed to simulate the in-lake response which was calibrated with long term monitoring data.

Pope County TMDL Study and Implementation Plan, MN, Minnesota Pollution Control Agency. Prior to joining Tetra Tech, supported the MPCA on development of a multiple lake TMDL study in west central Minnesota. This primarily agricultural watershed included eight lakes impaired by excess nutrients. Ms. Olson was the primary author on the TMDL. This TMDL included several permitted point sources, a CAFO site that was out of compliance, and significant internal loading issues. Worked closely with NPDES permitting staff at the MPCA as well as with the permittees to develop reasonable strategies to reduce nutrient loadings.

Carnelian – Maine St. Croix Watershed District (CMSWD) Multi-Lake TMDL, MN. Prior to joining Tetra Tech, project manager on the first two phases of a multi-lake nutrient TMDL in Washington County, working closely with MPCA, local watershed organization, and soil and water conservation district. The TMDL included a comprehensive monitoring program including plankton and macrophytes, sediment, water column, flow and bathymetry. Land use-based GIS analysis and in-lake response modeling was used to evaluate existing conditions.

TETRA TECH

Andrew Parker

Deputy Program Manager

EDUCATION

M.E., Civil/Environmental Engineering, University of Virginia, 1996

B.S., Civil Engineering, University of Virginia, 1995

YEARS OF EXPERIENCE

Tetra Tech: 18

Total: 19

LICENSES/REGISTRATIONS

Engineer in Training, Commonwealth of Virginia, 1996

PROFESSIONAL AFFILIATIONS

American Society of Civil Engineers (EWRI TMDL Analysis and Modeling Subcommittee Member)

Journal of American Water Resources Association (Technical Manuscript Reviewer)

Water Environment Federation (Technical Manuscript Reviewer)

SPECIAL TRAINING

HSPF Training Workshop, 4 days, Annapolis, MD, 1996

Manhattan College Water Quality Modeling Summer Session, 5 days, Riverdale, NY, 2001

AREAS OF EXPERIENCE

- Watershed management
- Watershed modeling
- Receiving water hydrodynamic and water quality modeling
- Model development
- Water quality monitoring program design and implementation
- Climate change impacts evaluation
- Information management system development
- Training and technology transfer
- Project and contract management

Mr. Parker is a Vice President and Director of the Water Resources Group, a team of 120 engineers and scientists focusing on water resources planning and management, environmental model development and application, and green infrastructure engineering. Mr. Parker has managed more than 50 projects for federal, state, provincial, municipal, and private clients in over 25 states in all regions of the U.S.A., as well as Canada, China, Korea, and the Caribbean. He has extensive experience implementing a range of hydrologic, hydrodynamic, and water quality models for planning and regulatory purposes including TMDLs, Environmental Impact Statements, NPDES permitting, mixing zone analyses, criteria development, implementation plans, green infrastructure, and rule development. Mr. Parker has been part of the team developing and maintaining EPA environmental models and modeling systems, including BASINS, LSPC, and the TMDL Modeling Toolbox. He also has extensive experience training individuals in the use of models, having conducted more than 40 courses for over 1,000 environmental professionals around the world. Mr. Parker has managed a number of high profile projects including a Chesapeake Bay TMDL development and implementation planning support contract; a national scale climate change modeling project; a Gulf of Mexico modeling project; and basin-wide modeling projects for the Klamath (U.S.A.), Mobile (U.S.A.), North Saskatchewan (Canada), and Nakdong (Korea) Rivers and Lake Champlain (U.S.A./Canada). Mr. Parker has also been a primary author or contributing author on more than 30 publications for conferences or peer-reviewed journals.

Project Experience

Technical Support for Chesapeake Bay TMDL and Watershed Implementation Plan Development. EPA Region 3 and the Chesapeake Bay Program. 10/06-3/18. Program Manager for more than $10 million of support for Chesapeake Bay TMDL development and implementation. Provides managerial and technical support for TMDL and Watershed Implementation Plan (WIP) development efforts for the Chesapeake Bay Watershed. Work has included participation in steering committee and technical team meetings, TMDL and model documentation, development of white papers, logistical support for all public meetings, development of critical model datasets, support to each state and the District of Columbia for local and state-wide WIP development, and design and configuration of a Tracking and Accountability System to ensure compliance with implementation milestones.

Modeling, Monitoring, Training, and TMDL Support for EPA Region 3 and Mid-Atlantic States - DE, PA, VA, MD, WV, and DC. 1996-2012. Managed watershed and receiving water modeling and TMDL development projects in WV, VA, MD, PA, DE, and the District of Columbia. For West Virginia, played a lead role in development of the Mining Data Analysis System (MDAS) and its application to metals and pH modeling and TMDL development for more than 100 streams, lakes, and rivers impacted by mining in the Tygart, Cheat, Monongahela, and Elk River Basins, WV. Developed fecal coliform bacteria models and TMDLs for six rivers in the WV portion of the Potomac River Basin using BASINS-NPSM/HSPF. Developed siltation TMDLs for Mountwood Park Lake, Burches Run Lake, and Tomlinson Run Lake in WV using BASINS-NPSM/HSPF and EFDC. Led development of PCB TMDLs for the Flat Fork, WV using a spreadsheet model.

EPA's Modeling Toolbox Development. EPA Region 4. 2003-2006. Was a senior technical advisor and developer of EPA's Modeling Toolbox (Toolbox). The Toolbox is a collection of environmental models, modeling tools, and databases

(including EFDC, LSPC, SWMM, WASP, and EPD-RIV1) that have been utilized over the past decade for water quality analysis. The Toolbox takes these proven technologies and provides the capability to more readily apply the models, analyze the results, and integrate watershed and detailed hydrodynamic and water quality receiving water applications. It provides exchange of information between the models through common databases and has been applied to TMDL development throughout the country.

EPA's Loading Simulation Program in C++ (LSPC) Development. EPA Region 3. 2002-2004. Was a senior technical advisor and developer of EPA's LSPC, an advanced watershed and receiving water modeling and data storage system with a GIS interface. The system includes streamlined Hydrologic Simulation Program Fortran (HSPF) algorithms for simulating hydrology, sediment, and general water quality on land as well as a simplified stream transport model. A key data management feature of this system is that it uses a Microsoft Access database to manage model data and weather text files for driving the simulation. The system also contains a module to assist in TMDL calculation and source allocations. LSPC has no inherent limitations in terms of modeling size or model operations, unlike many existing environmental models. The Microsoft Visual C++ programming architecture allows for seamless integration with modern-day, widely available software such as Microsoft Access and Excel.

Modeling, Stormwater Management, and TMDL Support for EPA Region 1 and Northeastern States. Provided technical oversight and management support to EPA Region 1 and Vermont DHEC for stormwater modeling (using the P8 model). Provided management support for detailed flow evaluation and development of a BMP Decision Support System to support statewide stormwater permitting. Managed development of a hydrodynamic and water quality model of the Lower Charles River in Boston, MA, to address eutrophication concerns. The project involved monitoring recommendations, EFDC model development and calibration, participation in technical advisory committee meetings, and support to EPA in developing the TMDL report. Supported EPA Region 1 and Maine DEP in selecting monitoring stations and monitoring parameters for six waterbodies in both urban and rural settings, assessing flow and water quality monitoring data, selecting appropriate models to support TMDL development, setting-up and applying those models, and developing TMDLs. The technical approaches used serve as templates for nonpoint source TMDLs in the state.

Modeling, Monitoring, Training, and TMDL Support for EPA Region 3. Has managed all TMDL-related efforts in EPA Region 3 states (DE, PA, VA, MD, WV and DC) for more than 10 years. Projects have included watershed and receiving water modeling, TMDL development, expert model review, model training, monitoring design, development of nutrient targets, stakeholder coordination, and tool development. Projects have addressed a wide variety of sources, including agriculture, CSOs, SSOs, WWTPs, industrial facilities, and stormwater, and a range of pollutants and impairments, including biological impairments, temperature, dissolved oxygen, nutrients, toxics, bacteria, sediment and metals. Modeling approaches have included HSPF, GWLF, WASP, LSPC, MDAS, EFDC, GEMSS, BATHTUB, LAKE2K, and BASINS.

Modeling, Training, and TMDL Support for EPA Region 4. Support has included TMDL modeling and development, strategy and procedural development, modeling tools development, technical and modeling support and training. Conducted 5 training courses in Georgia, Alabama, South Carolina, and Tennessee focusing on modeling and TMDL development using BASINS, HSPF, and tools developed for U.S. EPA Region 4. The courses consisted primarily of hands-on exercises using local data and were followed by technical support. Managed watershed and receiving water modeling and TMDL development projects in GA, FL, and SC for dissolved oxygen and bacteria impairments.

Lake Champlain TMDL Redevelopment. EPA Region 1. 03/11-3/14. Contract Manager. Provides managerial and technical support to EPA Region 1 for redevelopment of the Lake Champlain phosphorus TMDL. The project involves evaluating monitoring data collected over the past decade for the lake and watershed, customization of a BATHTUB model for the lake, and development of a basin-wide modeling framework that represents all phosphorus sources and evaluates management scenarios for TMDL determination and implementation planning. The TMDL revision will pay special attention to climate change and reasonable assurance considerations.

Brazos River Basin and Sam Rayburn Reservoir Monitoring and TMDL Projects, TX. Texas Commission on Environmental Quality. 10/01-9/05. Project Manager. Managed monitoring and TMDL scoping efforts for two Texas Commission on Environmental Quality projects - the Brazos River Basin and Sam Rayburn Reservoir. Conducted a historical data review and analysis, developed a sampling and analysis plan, prepared a model selection document, and supported development of a QAPP for the Brazos project. The effort involved monthly monitoring (physical, chemical, and biological) over three years for 2 watersheds (Rocky and Salado Creeks) exhibiting DO impairments. The Sam Rayburn Reservoir project involved a comprehensive historical data review, preliminary monitoring recommendations, and development of a stakeholder group to address DO, pH, and aluminum impairments in the reservoir.

TETRA TECH

Teresa Rafi

Technical Writer

EDUCATION

M.A., Marine Affairs, University of Virginia, 1996

B.A., Environmental Science, University of Virginia, 1993

YEARS OF EXPERIENCE

Tetra Tech: 15

Total: 18

AREAS OF EXPERIENCE

- Clean Water Act support
- TMDL development
- Water quality and watershed modeling
- Water quality monitoring program design and implementation
- Guidance development
- Water quality assessment
- Pollutant source assessment
- Project and contract management
- Watershed management

Ms. Rafi has more than 16 years of professional experience in public sector environmental science and policy. Recent responsibilities include curriculum development for watershed modeling courses, database development in support of EPA programmatic initiatives and development of technical guidance and documentation for various EPA program initiatives including documentation for the Chesapeake Bay TMDL. She has managed and supported development of a variety of TMDLs for fecal coliform bacteria, nutrients, sediment, and metals-impaired waterbodies, using a range of models from simple to complex. Her technical and communications skills include watershed assessment and modeling using GIS-based tools and spatial data analysis techniques. She is experienced in development of outreach materials and presentation of technical information at public forums. Ms. Rafi has been a vital member of a team that is responsible for developing more than 3,000 TMDLs nationwide over the past 14 years for EPA, states, and territories. The majority of these TMDLs were developed in the mid-Atlantic region through support to EPA Region 3 and Region 3 states and have addressed almost every type of water body and pollutant.

Project Experience

Lake Champlain TMDL Development (USEPA Region 1). November 2011 to April 2015. Managing development of a linked modeling framework to update the Lake Champlain phosphorus TMDL and support implementation planning. Phase I of the project involved a significant modeling effort, including a recalibrated and refined BATHTUB model of Lake Champlain, a calibrated SWAT model of the basin, a related effort using the calibrated SWAT model to predict the effects of potential climate change on loading in the basin, and design of a BMP Scenario Evaluation Tool for predicting the effects of BMP implementation.

Sediment TMDL Development in West Virginia (West Virginia DEP). For the West Virginia Department of Environmental Protection, supported development of sediment TMDLs in the Upper Kanawha, Lower Kanawha, Upper Ohio, North Branch Potomac, and Coal River Basins. Project activities involved working with a team developing a large number of TMDLs for metals, fecal coliform bacteria, and sediment. Her duties required the coordination of two modeling efforts using GWLF and LSPC to generate allocations on the same spatial scale.

Metals and Bacteria TMDLs for Dunloup Creek, West Virginia (USEPA Region 3). Reviewed available data for the Dunloup Creek watershed in southern West Virginia and prepared a metals, fecal coliform bacteria, and biological impairment TMDL. Watershed loading was modeled with the Mining Data and Analysis System and a reference watershed approach was used for calibrating hydrology. Prior to modeling, activities included acquiring and analyzing available datasets; identifying missing information areas; and recommending additional data collection. TMDL development required representation of permitted point sources and nonpoint sources, as well as continuously flowing mine seeps and discharges

Mining TMDL Development (USEPA Region 3). For EPA Region 3, supported the development of mining TMDLs for the Cheat River and Tygart Valley River watersheds in West Virginia. Provided technical writing, editorial, and mapping support for the draft and final documents. Assisted project team in preparing materials for public meetings. Performed a data review and analysis for the Tug Fork River watershed in preparation of a metals and pH TMDL. Activities included acquiring and analyzing available datasets; identifying missing information areas; and recommending additional data collection.

LSPC Modeling to Support Chlorophyll *a* Criteria Re-evaluation in the James River (VA DEQ). Supporting watershed modeling for VA DEQ as part of a larger modeling and monitoring effort that will provide a scientific basis for re-evaluating existing chlorophyll a criteria for the James River, which is a major tributary to the Chesapeake Bay and is subject to the Chesapeake Bay TMDL. Managing and tracking project tasks and budget; identifying and engaging necessary staff for project subtasks; and working with project team to ensure that modeling methodologies are consistent with the Chesapeake Bay Watershed Model and overall project goals.

Mining TMDL Development for the Kiskiminetas-Conemaugh River Watershed (USEPA Region 3). Managed development of mining TMDLs in the Kiskiminetas-Conemaugh River watershed in southwestern Pennsylvania. Coordinated efforts of Tt team to compile information necessary for completing mining related TMDLs to satisfy Consent Decree deadlines for two eight digit HUC watersheds. Project involved extensive efforts to gather NPDES permit information for hundreds of municipal and industrial wastewater treatment facilities and mining facilities. GIS data related to abandoned mine lands were compiled and incorporated into a custom landuse coverage for use in setting up a Mining Data Analysis System model of the watershed. TMDLs for iron, aluminum, manganese, sediment and pH were developed for the impaired waterbody segments.

Analysis of Manure Transfer Activity in the Chesapeake Bay Watershed (USEPA Office of Wastewater Management). For rulemaking activities spanning 2011-2012, supported cost and benefit analysis to support rulemaking under the Concentrated Animal Feeding Operations regulation. Assisted project team to survey state contacts to understand current practices and levels of activity related to the transfer of manure among and between producers in the Chesapeake Bay watershed. Contacted state agency staff and relied on Chesapeake Bay watershed model output to develop written summary for Virginia.

Technical Documentation and Writing Support for the Chesapeake Bay TMDL (USEPA Region 3). For USEPA Region 3 and the Chesapeake Bay Program Office, coordinated development of the Chesapeake Bay Nutrients and Sediment TMDL Report, completed in December 2010. In charge of ensuring that the report clearly communicates the many technical concepts related to the TMDL, including the complex modeling framework and the unique allocation procedures developed for the TMDL. Responsible for developing original text as well as coordinating and compiling submissions by multiple contributors; organizing, prioritizing and incorporating comments from multiple reviewers within EPA and the state partners; and ensuring that all the required TMDL elements are included and adequately and clearly described.

Guidance Development for TMDL Daily Loads (USEPA Headquarters). For the USEPA Office of Water, supported development of draft national guidance to support states in developing appropriate daily load expressions in TMDLs. Entitled, Options for Expressing Daily Loads in TMDLs, the guidance development effort was a result of the 2006 ruling by the U.S. Court of Appeals for the DC Circuit in Friends of the Earth v. EPA in which the court ruled that TMDLs using non-daily loading allocations must also include daily load expressions. As part of the team supporting this guidance development effort, was involved with policy discussions with EPA Headquarters staff and developed guidance to convey both policy and technical information related to development and use of appropriate daily load expressions.

Guidance Development for Developing Watershed TMDLs (USEPA Headquarters). Provided critical support in developing the draft guidance document for EPA headquarters, Handbook for Developing Watershed TMDLs. The document provides information to state TMDL programs and developers in the development of watershed-based TMDLs that address multiple segments and/or multiple pollutants. This guidance is designed to compliment other recent guidance documents recently produced by EPA, including watershed planning and watershed permitting.

Bacteria TMDL Development using LSPC (USEPA Region 4). Provided support to U.S. Environmental Protection Agency, Region 4 and the State of South Carolina to develop a fecal coliform TMDL for the Rocky River watershed in the upstate region of South Carolina. Analyzed available data and developed a watershed loading model using the Loading Simulation Program (C++). The model simulated point and nonpoint sources of fecal coliform bacteria, including permitted sources, septic systems, and agricultural runoff.

Indian Creek Nutrients TMDL (USEPA Region 3). Managed the data gathering and technical approach development efforts for nutrient TMDLs for the Indian Creek watershed in southeastern Pennsylvania. Developed a stream water quality sampling plan to support water quality evaluation and model development. The watershed is dominated by two sewage treatment plant discharges and experiences significant nonpoint source runoff as well. Developed the technical report for the TMDL and assisted EPA in responses to comments related to the TMDL.

TETRA TECH

Mindy S. Ramsey

Project Manager

EDUCATION

M.S., Biological Sciences, Marshall University, 2002

B.S., Biology, University of Rio Grande 1996

YEARS OF EXPERIENCE

Tetra Tech: 4

Total: 13

AREAS OF EXPERIENCE

- Project Management for projects representing more than $600K annually.
- TMDL development
- Source water assessment and protection for public drinking water systems
- Conducting NEPA studies for threatened and endangered species, wetlands, and streams
- Report writing to document resources and assessed impacts
- Public meeting presentations and facilitation

Ms. Ramsey is a biologist, whose training and experience has prepared her to perform data collection and analysis, write technical and planning documents, coordinate with stakeholders, and communicate environmental topics to the public. She has extensive experience in developing Source Water Protection Plans for public drinking water systems throughout West Virginia and Virginia. In the role of Director for Tetra Tech's Charleston, WV, office, she has led the TMDL development in D2, E2, A3, B3, and C3 watershed groups for West Virginia DEP. Ms. Ramsey acts as the project manager for Charleston office projects for state and municipal clients.

Project Experience

TMDL Development, Group C3, Meadow River, Rocky Marsh Run, and Warm Spring Run Watersheds, WV. WV Department of Environmental Protection. November 2014-present. As project manager, oversees all aspects of TMDL development, communicates with technical leads and the WVDEP program manager and staff daily to insure progress and address any concerns that arise immediately. Coordinates with contract administrator to track progress and prepare financial reports to WVDEP.

TMDL Development, Group B3 Tygart Valley River Watersheds, WV. WV Department of Environmental Protection. January 2014-present. As project manager, oversees all aspects of TMDL development, communicates with technical leads and the WVDEP program manager and staff daily to insure progress and address any concerns that arise immediately. Coordinates with contract administrator to track progress and prepare financial reports to WVDEP. Participated in biological stressor identification.

TMDL Development, Group A3 Upper Ohio North, Upper Kanawha, South Branch Potomac, and Shenandoah Watersheds, WV. WV Department of Environmental Protection. January 2013-Present. As project manager, oversees all aspects of TMDL development, communicates with technical leads and the WVDEP program manager and staff daily to insure progress and address any concerns that arise immediately. Coordinates with contract administrator to track progress and prepare financial reports to WVDEP. Participated in biological stressor identification.

TMDL Development, Group E2 West Fork River Watershed, WV. WV Department of Environmental Protection. 2012-2014. As project lead for Group E2, works closely with WVDEP Project Manager and technical staff to identify areas of concern and opportunities to improve upon existing methodologies and protocols. Coordinates tasks and staffing to maintain project schedule. Provides progress and financial reporting. Participated in the EPA stressor identification (SI) process for biologically impaired streams TMDL development for the WVDEP, which included preparing data analyses of water chemistry, benthic macroinvertebrates, and physical habitat parameters. Also contributed to the stressor determination for the biologically impaired streams.

Biological TMDL Development, Group D2 Monongahela River Tributaries, WV. WV Department of Environmental Protection. 2011-2014. After taking on the role as office director, oversaw TMDL development, coordinated with technical leads and WVDEP staff to revise public and technical documents, performed QAQC on TMDL reports, allocations, supporting materials and comment responses. Participated in the EPA stressor identification (SI) process for biologically impaired streams for Group D2 TMDL development for the WVDEP,

included preparing data analyses of water chemistry, benthic macroinvertebrate, and physical habitat parameter; contributing to preliminary and final stressor determinations.

Ionic Stress TMDL Development, Upper Kanawha Pilot Study, WV. Participated in a pilot study in Upper Kanawha streams impaired by ionic loading in order to develop TMDLs. Was active in data management and analysis, took part in workgroups assigned to provide information on ionic stress parameters and treatment technology for the planning and development of the TMDL.

Biological TMDL Development, Group C2 Middle Ohio Tributaries, WV. WV Department of Environmental Protection. 2010-2013. Lead the revision of the TMDL Technical Report, and participated in finalizing the drafts of the public report to include updates to the technical methodology for assessing sediment sources and assigning allocations. Participated in the EPA SI process for biologically impaired streams for Group C2 TMDL development for the WVDEP, which included preparing data analyses of water chemistry, benthic macroinvertebrate, and physical habitat parameter; also contributed to preliminary and final stressor determinations.

Drinking Water State Revolving Fund (DWSRF) Program Support, West Virginia Department of Health and Human Resources (WVDHHR). US Environmental Protection Agency. 2009-Present. Through a contract with USEPA, supporting WVDHHR Infrastructure and Capacity Development Program to guide and monitor DWSRF funding recipients through state and federal regulations. Activities include contributing to the Asset Management guidance materials and webinars. Also have been responsible for conducting NEPA environmental reviews and writing assessments seeking concurrence with the WVDHHR Finding of No Significant Impact for select projects. Provide support to the WV Source Water Assessment and Protection Program creating tools to enable water systems to meet state requirements to develop or update source water protection plans. Work with individual water systems to guide the development process.

Community Water System Source Water Protection Plan Updates, Clarksburg and Fairmont, WV. Clarksburg Water Board and City of Fairmont. (March 2014-present). Project Manager and source water specialist for two separate contracts work with the communities of Clarksburg and Fairmont, WV to update their existing source water protection plans to meet all requirements of state code enacted after the 2014 water crisis in the Elk River, Charleston, WV. Conducted protection team meetings, drafted protection plans, communicate progress with client, prepare invoices, and oversee staff activity.

Asset Management Plan Development Wilderness Public Service District, WV. Wilderness PSD. February 2014-Present. Act as project manager for the development of an asset management plan for Wilderness PSD, a recipient of funds through the WVDWTRF. Recipients are expected to develop a plan that will account for existing and newly constructed assets. Tetra Tech is guiding the system through required monthly submissions and use of the CUPSS software. Oversees staff and project activity, communicate progress with client, prepare invoices, and provide quality assurance.

Virginia Source Water Protection and Implementation. Virginia Department of Health. April 2012-Present. Managing a project with Virginia Department of Health to develop Source Water Protection Plans for waterworks in the northern region of the state. Project will include providing implementation services. Responsible for identifying water works to participate, meeting with Local Advisory Committees, conducting surveys of protection areas, characterizing threats and proposing protective activities. As project manager responsible for project status and financial reporting, as well as overseeing activities of support staff.

SFBWQIF Grant Program Review, USEPA Region 9. December 2013-December 2014. Assessed the San Francisco Bay Water Quality Improvement Fund grant program to summarize the status of the program and funded projects and make recommendations for improvement. Prepared a draft assessment report with figures illustrating the funding allocations into different project types: wetland restoration, water quality restoration, and green development.

Source Water Protection Technical Help Program. WV Department of Health and Human Resources. (2009-2012). As a task manager of a contract with the West Virginia Department of Health and Human Resources, Source Water Assessment and Protection (WV SWAP) Program, developed Source Water Protection Plans for public drinking water systems throughout West Virginia. Plan identify protection areas and potential contaminant sources; prioritizes threats; develops management strategies to address threats; contains an implementation plan to be carried out by the water system; recommends education and outreach activities; and develops contingency plans for source water in case of a short or long term water outages.

TETRA TECH

Mark Sievers

Watershed Analyst

EDUCATION

M.S., Civil Engineering, University of Virginia, 1998

B.S., Environmental Geoscience, Indiana University of Pennsylvania, 1995

YEARS OF EXPERIENCE

Tetra Tech: 14

Total: 15

AREAS OF EXPERIENCE

- Water quality monitoring program design and implementation
- TMDL development
- Watershed modeling
- Water quality model development
- Environmental statistics
- Information management system development

Mr. Sievers has 15 years of experience as an environmental scientist and engineer. This experience has covered a wide range of environmental areas, including data management, data analysis, geographic information systems (GIS), hydrologic modeling, TMDL development, environmental monitoring, watershed planning, and remedial investigations. Mr. Sievers is Tetra Tech's TMDL development Program Manager for EPA Region 6, Louisiana, and Maryland. He has successfully managed the development of more than 200 TMDLs in 7 states and 4 EPA regions. Many of these TMDLs were performed under tight budget and time restriction. Mr. Sievers oversees work under Tetra Tech's on-call stormwater support contract with the Prince George's County Department of the Environment, managing several tasks orders and providing general oversight for contract reporting, project staffing, and tracking project budgets and schedules. Mr. Sievers has experience performing data management and analysis on various data types for the TMDL development process including stream flow, stream channel characteristics, water quality, point source and nonpoint information, and weather information. He is conversant with ArcView GIS, ArcMap, Microsoft Office (Word, Excel, Access, and PowerPoint), FlowLink, and Adobe Acrobat Professional. His modeling experience includes MDAS, LSPC, LA-QUAL, QUAL2Kw, and various MS Excel-based modeling approaches.

Project Experience

Local TMDL Restoration Plan Development (Prince George's County, MD; May 2014–April 2015). Managed development of local TMDL restoration plans to address USEPA-approved MS4 WLAs for fecal coliform bacteria, nutrients, sediment, biological oxygen demand, and PCBs in seven County watersheds and to meet NPDES regulatory requirements. Tasks included collection of watershed data, including land use, impervious area, permitted discharges, water quality, sanitary sewer overflows, BMPs, and potential sources of impairment; development of tracking and reporting strategies and tools; development of pollutant reduction strategies that include structural BMPs and outreach and other nonstructural activities; and development of the watershed-specific TMDL restoration plans.

TMDL Watershed Implementation Plan Support (Prince George's County, MD; 06/2011–present). Led the Phase II WIP development for Prince George's County to implement Chesapeake Bay TMDL allocations. Responsible for attending all project meetings and communicating with the client and other County agencies. Presented at County team meetings, attended public meetings, and facilitated internal Tetra Tech meetings. Investigated BMPs and current capacity of County agencies. Worked with others to develop loading analysis for stormwater and onsite wastewater systems in the County. Entered plan scenarios into the Maryland Assessment Scenario Tool (MAST) and used results in County meetings and presentations. Prepared draft Phase II WIP document.

Chesapeake Bay TMDL Watershed Implementation Plan State Support (USEPA CBPO and Region 3; 09/2009–present). Performed various tasks to support development of statewide WIPs for implementation of the Chesapeake Bay TMDL, including: 1) Worked with various Maryland state agencies and staff to support them in their WIP. This included attending Phase II pilot study meetings in Annapolis and Denton, talking with different jurisdictions about data needs, and determining baseline loads for Caroline County and Anne Arundel County. Developed guidance for Maryland for counties to use in developing their Phase II WIPs. 2) Organized and summarized public comments to Maryland's Phase I and Phase II WIPs. 3) Answered questions on the Maryland Assessment Scenario Tool

(MAST) online tool via helpline and email. 4) Managed comparison of the number of septics and amount of impervious area in the seven Maryland counties in the Patuxant River basin. Researched how the model calculated septic loads and how the model results would change if the base number of septics in a county was changed. Developed final memorandum detailing results. 5) Managed research of potential Phase II MS4 entities (federal, state, and municipal) in Maryland. 6) Helped develop Scenario Builder files for New York for model input. 7) Reviewed public comments to the Chesapeake Bay TMDL and categorized them into groups based on subject. 8) Task Order Leader for support to expert panels for the review of BMPs and other load reduction technologies for incorporation into the model for the Chesapeake Bay Program Office.

West Virginia Upper Kanawha and Upper Ohio Watershed Pollutant Source Reports (02/2003–06/2003). Supported development of pollutant source reports for metals, pH, and pathogen TMDLs. Performed data analysis with ArcView GIS and MS Excel and reviewed pollutant source data including logging activities, abandoned mines, roads, and sampling locations. Delineated the watersheds with ArcView GIS.

Metal TMDLs Upper North Branch of the Potomac River Watershed, Maryland (Maryland Department of the Environment; 01/2009–10/2009). Worked with the Maryland Department of the Environment to build on previous pH TMDL development in the watersheds to develop additional TMDLs for aluminum and iron. Managed the model development and completion of the draft TMDL report for aluminum and iron in the Upper North Branch of the Potomac River watershed. Aided in model calibration and load reduction determination. Developed load duration curve using MDAS model results. Wrote TMDL report.

Kiskiminetas and Conemaugh Rivers TMDLs (USEPA Region 3; 04/2008–01/2010). Supported development of metal (aluminum, iron, and manganese) TMDLs for acid mine drainage impacted streams in the Kiskiminetas and Conemaugh River watersheds in Western PA. Attended and presented at two public meetings in Johnstown, PA, as part of the public review of the TMDL. Researched and organized information on several hundred permits from various sources.

Grand Lake o' the Cherokees (USEPA Region 6 and Region 7; 01/2010–05/2013). Project manager for development of dissolved oxygen and turbidity TMDLs for impaired portions of Grand Lake o' the Cherokees watershed. Managed and lead writer on the development of comprehensive modeling report, which includes sensitivity analysis and extensive documentation of model set up, calibration, and assumptions. Lead writer for the TMDL report and model scenario report, which documents the results of different management scenarios on watershed loadings and lake water quality compliance.

Soos Creek TMDLs (USEPA Region 10; 11/2011–05/2013, 09/2013–12/2014). Project manager for the development of dissolved oxygen and temperature TMDLs for impaired portions of the Soos Creek watershed in Washington. Technical approach incorporates three models: Shade, HSPF, and QUAL2Kw. Oversaw and aided in the development of project QAPP and data summary report. Participated in site tour and site meetings in Auburn, WA. Ran QUAL2Kw to investigate scenarios for all forested, increased shade, and predicted future impervious growth conditions. Worked with client to incorporate the results of a bioassessment. Developed modeling and TMDL sections of the TMDL report for inclusions in a Washington Ecology Department TMDL report.

TMDL Support for EPA Region 6 – Louisiana TMDLs (US Environmental Protection Agency, Region 06; 06/2005–04/2012). Project Manager for development of TMDLs for impaired subsegments in Louisiana. Developed or oversaw the development of TMDLs for impaired subsegments in seven basins in Louisiana (Atchafalaya River, Lake Pontchartrain, Mississippi River, Pearl River, Red River, Sabine River, and Terrebonne Basin) for parameters including fecal coliform bacteria, sulfate, chlorides, mercury, total dissolved solids, dissolved oxygen, nutrients, turbidity, sediment, and total suspended solids (TSS). Most TMDLs, except for dissolved oxygen and nutrient TMDLs, were calculated using load duration curves or other Microsoft Excel techniques. Dissolved oxygen and nutrient TMDLs were developed using LA-QUAL or WASP.

Atkisson Reservoir TMDL Support (USEPA, Region 03: 09/2011–01/2013). Managed task order for the development of potential TMDLs addressing total phosphorus, sedimentation, and impacts to biological communities impairments in Atkisson Reservoir, owned by Aberdeen Proving Grounds, in Harford County, MD. Compiled data and reviewed technical documentation from Aberdeen Proving Grounds. Provided project summary report describing rationale for possible delisting of waterbody for sediment and documenting the delisting of phosphorus.

TETRA TECH

Jonathan T. Smith, PE

Deputy Project Manager

EDUCATION

B.S., Biological & Agricultural Engineering, North Carolina State University, 1995

Graduate Course Work: 21 units focused on hydrology and stormwater management, NCSU, 1998–2006

YEARS OF EXPERIENCE

Tetra Tech: 5

Total: 19

LICENSES/REGISTRATIONS

Professional Engineer: South Carolina ([redacted]; Virginia ([redacted]; North Carolina ([redacted]; West Virginia (#19285)

Certified Professional in Erosion and Sedimentation Control (CPESC), [redacted]

Certified Professional in Storm Water Quality (CPSWQ), [redacted]

LEED-Accredited Professional

PROFESSIONAL AFFILIATIONS

CPSWQ Inc. Council Chair (2008–2011); CPSWQ Approved Instructor

NC-APWA Water Resources Division Director (2008–2012) ; Chair (2011)

CPESC Regional Representative (2005–2009)

EnviroCert International Inc., Board of Directors Chair (2010–2011) Technical Vice-Chair (2008–2010)

AREAS OF EXPERIENCE

- Stormwater BMP design
- Hydrologic and hydraulic analysis
- Low impact development
- Ecosystem restoration
- Stormwater master planning
- Design analysis
- Environmental permitting
- BMP performance monitoring
- Watershed management

Mr. Smith is an expert in stormwater management and focuses on incorporating sustainable and LID practices. He has conducted assessments of more than 250 potential stormwater BMPs and 8,000 linear feet of impaired streams over the past 4 years. In addition he has served as the engineer of record for nearly 4,000 linear feet of stream restoration and multiple stormwater BMPs. Before becoming a consultant, Mr. Smith was an extension engineer at NCSU for more than 11 years, where he supervised numerous projects in a stormwater focused research group. Mr. Smith has completed design and construction of numerous stormwater BMPs, including stormwater wetlands, bioretention areas, green roofs, pervious pavement practices, innovative wet ponds and level spreaders.

Project Experience

Pine Hills Green Infrastructure Design, Beckley Sanitary District, WV 9/10-Present. Led design and construction administration for conveyance improvements and green infrastructure into a 6.6 acre residential subdivision watershed with a history of nuisance and structural flooding. Green infrastructure components include bioretention and bioswales. Drainage system improvements included 615 ft of culvert replacement on four parcels and under two roadways.

Stormwater Plan Review, City of Hurricane, WV. Provided engineering reviews to Hurricane City Manager of development plans submitted by private developers. Reviewed plans for compliance with local and state construction general permits (NPDES) and local stormwater ordinances. Provided detailed review summaries and recommendations for approval or denial of proposed development.

Non-point source Guidance under Chesapeake Bay Executive Order 502. Task Manager responsible for development of Hydromodification Section of a guidance document for Federal land management in the Chesapeake Bay watershed describing proven, cost-effective tools and practices that reduce water pollution and define the next generation of tools and actions to restore the bay's water quality. The implementation measures presented in the guidance promote the best, cost-effective and reasonable practices available to achieve reductions in sediment and nutrients from agriculture (row crops and animals), urban and suburban areas (including consideration of reducing vector attraction in practices with standing water), forestry, riparian areas, decentralized wastewater treatment and hydromodification (including streambank and shoreline erosion).

Comprehensive Load Reduction Plans (CLRPs), City of San Diego, CA. Assisting in development of CLRPs for five watersheds in the San Diego Region to comply with the approved Bacteria TMDL for beaches and creeks and address other 303(d) impairments in the watersheds. Led development of present value cost of potential structural and non-structural BMPs proposed by the CLRPs.

National Demonstration of Advanced Drainage Concepts Using Green Infrastructure for CSO Control. For USEPA ORD served as monitoring system reviewer for a project that combines local and regional efforts to collect performance data on green infrastructure practices and assess management performance at the watershed scale. The project focuses on an urban core neighborhood subwatershed drained by a combined sewer system retrofitted with integrated, green infrastructure-based solutions. Provided technical review of the project plan development to monitor the change in peak flow, total flow volume, and pollutant mass of storm-generated flows through the watershed. Analysis of

this data will ultimately contribute to determining the effects of larger-scale application of source control stormwater management in urban environments.

Third Fork Creek Watershed Planning and Design, Durham, NC. Task manager for watershed planning and design project in Durham, NC. Relevant tasks included stormwater retrofit planning and design, LID and Better Site Design, and BMP maintenance program review for Third Fork Creek. Led the screening, site analysis and prioritization of potential retrofit opportunities in a mixed urban setting. Identified 53 potential stream restoration reaches and 51 retrofit BMP opportunities that were ranked and prioritized for implementation. Developed conceptual designs for restoration of five degraded stream reaches within priority subwatersheds. Led the preparation of preliminary (30% Progress) plans for five stormwater retrofit BMPs.

Rich Fork Creek Stream Restoration, High Point, NC Leading restoration design and permitting of three relic sand mining areas along Rich Fork Creek in Davidson County North Carolina. The restoration design was completed as part of an application by the City of High Point to NC Division of Water Quality to increase assimilative capacity in Rich Fork Creek to support future expansion of the City's Westside WWTP discharge. Upon approval of the assimilative capacity increase the next project phase will include overseeing construction of channel restoration.

Concord Ecosystem Restoration, Concord, NC, U.S. Army Corps of Engineers, Wilmington District. Project Manager for USACE designing four retrofit stormwater management practices and restoring 819 linear feet of perennial stream in an urbanized watershed. Project deliverables include basis of design reports, various preliminary and final construction plans and specifications, cost estimates and Sediment and Erosion Control Plan applications for each site. Stormwater practices include stormwater wetlands, wet ponds, and temporary detention. Natural channel design techniques were utilized in the development of the restoration design for the stream reach.

Green Infrastructure/LID Consulting Services, City of Raleigh, NC 10/13-Present. Managing project to provide technical consulting services for implementing green infrastructure/LID into City programs. Specific services have included facilitation of a work group comprised of select city departments in developing a green infrastructure work plan, stakeholder outreach, development of LID performance standards in a nutrient sensitive water supply watershed, and recommendation of LID enhancements to planned public transportation projects. Currently implementing Green Infrastructure/LID work plan including code and ordinance reviews, BMP and development type factsheets, design template development and development of cost effectiveness tools among other tasks.

Stormwater BMP Identification, Selection, and Design for Statewide NPDES Compliance, Maryland State Highway Administration, 10/14-Present. In support of Maryland State Highways Administration efforts to comply with Maryland's Chesapeake Bay Watershed Implementation Plan, leading identification and evaluation of potential stormwater BMP sites and subsequent BMP concept designs in Montgomery and Carroll Counties. Focusing on areas that currently have minimal existing water quality treatment within SHA rights-of way and considering available right-of-way space, roadway slope, cross-slope, existing stormwater conveyance systems, and potential conflicts, such as existing BMP structures and SHA tree planting projects.

Anneewakee and Crooked Creek Ecosystem Restoration, USACE Mobile District, Atlanta and Douglassville, GA. Led screening and assessment of 30 potential retrofit stormwater BMPs and 15 stream restoration reaches for development of two feasibility studies under the Continuing Authorities Program Section 206 Aquatic Ecosystem Restoration to establish BMPs and stream restoration projects that would provide the greatest benefit to the aquatic ecosystem at the least cost. Project components included stream walks, biological monitoring, implementation of the Corps six-step planning process to formulate alternatives, and modeling of hydraulic and hydrologic conditions.

Modeling Conventional and Green Infrastructure Solutions to Resolve CSOs, USEPA Office of Wastewater Management, 4/14-Present. Through USEPA's Green Infrastructure Community Partners Project, led evaluation of green and grey infrastructure solutions to a resolve CSOs in a 45-acre watershed in the historic ship building community of Bath, ME. Potential solutions were identified during field investigations and then evaluated using a long-term simulation of a PC-SWMM model calibrated to a recent overflow event. The evaluation revealed that reducing CSO frequency would require both conventional stormwater techniques (such as stormwater diversion and centralized infiltration) and green (distributed bioretention) practices.

New Mexico Predevelopment Runoff Hydrology Analysis, USEPA Office of Wastewater Management, 10/14-4/15 Led an analysis of predevelopment runoff hydrology for seven regulated urbanized areas in New Mexico. Analysis was conducted using a SWAT model incorporating long-term precipitation soil type, evapotranspiration and predevelopment land cover. Modeling results supported the incorporation of stormwater retention standards into MS4 permits.

TETRA TECH

James Stribling, PhD

Biological Analyst

EDUCATION

Ph. D., Entomology, The Ohio State University, 1986

M.S., Entomology, The Ohio State University, 1982

B.S., The University of Mississippi, 1980, Zoology

YEARS OF EXPERIENCE

Tetra Tech: 23

Total: 29

TRAINING

Fluvial Geomorphology 1993, Pagosa Springs, Colorado

AREAS OF EXPERIENCE

- Ecological Monitoring and Assessment
- Identification and Prioritization of Retrofit and Restoration Opportunities
- Evaluation of BMP Effectiveness
- BMP Planning and Design
- Watershed management plan development
- Quality Assurance and Quality Control (QA/QC)
- Development of Ecological Indicators Management
- Quantifying Error Rates in Biological Taxonomy
- Statistical Design for Monitoring at Multiple Spatial Scales

Dr. Stribling is an environmental scientist with over 29 years of experience in applying ecological principles to natural resource management decision making. He has been instrumental in developing methods for the U. S. Environmental Protection Agency for the assessment of biological condition, physical habitat quality, and landscape integrity and the use of QA/QC for ensuring improved data quality. Dr. Stribling has been a national lead for developing techniques for biological method performance characteristics and comparability analyses, led analyses of taxonomic data quality for the USEPA National Wadeable Streams Assessment, is a co-author of USEPA Rapid Bioassessment Protocols (RBP), and provided primary technical support to the USEPA Office of Research and Development for development of Large River Bioassessment Protocols. He is involved in development of biological and nutrient loadings indicators and monitoring design for evaluating conditions in the Gulf of Mexico for the Gulf of Mexico Alliance (GOMA). In addition, he has extensive experience in applying these tools to County- and State-scale environmental management needs including monitoring designs, ecological assessments of streams and watersheds, NPDES permit requirements, stressor identification/restoration designs, stormwater management, and public outreach.

Project Experience

Comprehensive Stream Assessment for High Gradient, Perennial Streams in West Virginia. Directed staffing, field sheet and database development, and final product delivery. Project is focused on characterization of reference streams throughout West Virginia, with field crews gathering data on physical habitat, hydrology, field water chemistry, benthic macroinvertebrates, amphibians, riparian vegetation (density, stand health, and diversity). Habitat data gathered are being input to RiverMorph software for intermediate post-processing, and are sufficient for geomorphic characterization equivalent to Rosgen level 2. The totality of the dataset will be used as input to the hydrogeomorphic (HGM) approach.

Watershed-based, County-wide Biological Monitoring using Fish and Benthic Macroinvertebrates. Project manager and technical lead for a watershed-based biological monitoring and assessment program in Prince George's County, Maryland, that will sample approximately 250 stream sites over a three year period for benthic macroinvertebrates, fish, physical habitat quality, and field water chemistry. Results will be presented, with known confidence, as the proportion of stream miles that are biologically degraded, and will be used to help prioritize County efforts to reduce and eliminate stressor sources in its streams and rivers.

Technical Support for Biological Indicators Research and Development Activity, including Review of a Fish Index of Biotic Integrity for the Yazoo River Delta (Mississippi). Technical lead in providing support to USACE-ERDC to evaluate the foundation of their efforts in developing a fish indicator of biological integrity of waterbodies in Mississippi, in particular, the Yazoo River watershed, which occupies the Mississippi Delta. For this project, he is evaluating field fish sampling methods, data quality associated with the results coming from those efforts, including precision, accuracy, bias, representativeness, and completeness, in short, the capacity of the methods for accomplishing stated objectives.

Ecological Assessment Input to an Ecosystem Response Model (ERM) for the Indian-Sugar-Intrenchment-Snapfinger Watershed (Georgia). Lead aquatic ecologist in this multidisciplinary study of which the goal is conceptual design for watershed restoration alternatives. He designed the ecological assessment, which used fish and benthic macroinvertebrates as indicators of stream and watershed conditions, and led to defensible statements of problem areas and identification of the sources of pollutants. He managed the fieldwork and laboratory and data analysis, and coauthored the technical report. As part of the team, Dr. Stribling provided technical input and critique of the Ecosystem Response Model (ERM) output and the design alternatives.

Conduct Statistical Analysis and Quality Control Services the Wisconsin Macroinvertebrate Biotic Index. Project manager and technical lead in this project to work with Wisconsin DNR scientists to characterize stressor vs. non-stressor conditions (stream sites), quantify performance of field and laboratory methods, document stressor-response relationships to the extent possible, and develop a benthic index of biological integrity for the streams of Wisconsin. The dataset he is working with represents 678 samples (including macroinvertebrates, physical habitat, and field chemistry) from streams throughout the state.

Mississippi-Benthic Index of Stream Quality (Phases 1-10). Program and project manager for MDEQ in maintenance of their statewide biological monitoring and assessment program, including comprehensive quality assurance/quality control (QA/QC) oversight, data management, and statistical analysis of their indicators of stream quality. He led initial calibration of the Mississippi-Benthic Index of Stream Quality (M-BISQ) in 2001, and has directed its refinement and recalibration with additional sets of data collected from approximately 100 new streams each of 9 years. Assessment results are used for setting TMDL targets, listing-delisting stream impairment for CWA §303(d), and for the Mississippi 305(b) report on "state of the streams".

An Assessment of Storm Water Management Retrofit and Stream Restoration Opportunities in Bennett Creek Watershed. Project manager and technical lead supporting the Frederick County (MD) Department of Public Works in evaluating ecological data to identify and prioritize stressor sources for correction and elimination (retrofit assessment). He directed water resources engineers on the project team in developing 10% conceptual designs for five separate best management practice (BMP) projects in the watershed, including engineering designs and CADD drawings.

Taxonomic Data Quality Control Analysis for the National Aquatic Resource Surveys. Dr. Stribling developed a detailed approach for characterizing the quality of data associated with taxonomic identifications used in biological assessments as part of the USEPA National Wadeable Streams Assessment (WSA). He used the same approach for documenting taxonomic precision for the National Lakes Assessment (NLA), and evaluated 200 randomly – selected samples as approximately 10% of the project total sample lot, was able to show a 5% reduction in error rate to about 10% nationally. As a result of this work, Dr. Stribling is the national lead for QC oversight, in general, and taxonomic data quality, in particular, for all of the USEPA National Aquatic Resource Surveys (NARS), including streams, rivers, and lakes.

Watershed Assessment of the Lake Allatoona/Upper Etowah River Basin. Project manager and lead aquatic ecologist, and used statistical power analysis to develop a long-term, watershed-scale monitoring program with the capacity of detecting a 20% change in biological condition for a 1,120 mi^2 watershed in northern Georgia. He organized field teams and managed sampling of 50-60 stream sites per year over a six-year period resulting in a rigorous and defensible estimate of the percentage of stream miles that are biologically impaired. Those values are being used to establish ecological restoration goals for the watershed.

Evaluation of Effluent Toxicity as an Indicator of Aquatic Life Condition in Effluent-Dominated Streams: A Pilot Study. Co-project manager, Dr. Stribling led the analytical design for evaluating the comparability of biological assessments using instream collections of fish, benthic macroinvertebrate, and diatoms with those from whole effluent toxicity (WET) tests from wastewater treatment plants. He used a quantitative Data Quality Objective (DQO) process to develop very specific statement of the quantity and quality of data needed to address this question for WERF. Subsequent to standardized field data collection and acquisition of WET testing data from WWTPs, Dr. Stribling performed statistical analysis determined that there is a low rate of synchrony between failing WET tests and instream biological impairment.

TETRA TECH

Barry Tonning

Outreach Specialist

EDUCATION

M.A., Risk Communication, Morehead State University, 1994

B.A., Journalism, University of Georgia, 1977

YEARS OF EXPERIENCE

Tetra Tech: 15

Total: 32

LICENSES/REGISTRATIONS

Kentucky Division of Water Class I Wastewater Treatment Plant Operator

Erosion and Sediment Control (GA Soil & Water Conservation Commission, Louisville MSD)

PROFESSIONAL AFFILIATIONS

International Erosion Control Association

American Society of Agricultural Engineers

National Onsite Wastewater Recycling Association

Water Environment Federation

AREAS OF EXPERIENCE

- Stakeholder facilitation
- Watershed management
- Stormwater assessment and control
- Erosion and sediment control
- Training
- Antidegradation
- Public outreach
- Onsite wastewater treatment systems

Mr. Tonning is a senior level water resource management consultant specializing in stormwater management, erosion and sediment control, risk assessment and communication, public health, and technology transfer with extensive experience in training, policy development, and program design. Over the past 30 years he has directed and managed stormwater and erosion/sediment control training and compliance programs, environmental and natural resource policy research initiatives, solid waste planning and management programs, decentralized wastewater and nonpoint source pollution assessment and control projects, watershed planning and management activities, the publication of environmental management guidance documents, and the development, coordination, and facilitation of public meetings, conferences, and workshops on a wide variety of environmental, public health, and natural resource topics.

Project Experience

US EPA Stormwater and TMDLS Workshops. Currently developing training materials and schedules for a series of workshops for MS4s in US EPA Region 4 on the connection between stormwater programs and TMDLs. Workshop topics include review of water quality standards, assessment methodologies, how impairment decisions are made, BMP selection and siting, quantifying BMP load reductions, monitoring program development, and related topics. Workshops are set for Kentucky (January) and Florida (February); others TBD.

US EPA Low-Impact Development Training Modules. Developed training and other materials for US EPA training program on low-impact development during 2005 – 2006. Researched LID principles, field applications, performance data, and demonstration projects. Created slides and text for workshop presenters, and used the materials personally in presentations related to stormwater management, smart growth, and integrated water resource management.

USEPA Stormwater Phase II - National Training Program. Project leader and trainer for a series of US EPA workshops on the Stormwater Phase II program, delivered in Charleston (WV), Philadelphia, Atlanta, Kansas City, Boise, Lexington (KY), and other US EPA Regional Office locations and Phase I and II cities during 2004 – 2009. Developed and delivered training materials on construction site runoff controls, inspector training, education/ outreach, and public participation; led sessions at workshops; assisted in training program review.

Indiana Low-Impact Development and Watershed Management Workshops. Created training materials and conducted workshops in northern Indiana on "improving development by design" and watershed assessment, planning, and management during 2006 – 2007. Presented information on design principles and field application of LID practices, developed and delivered watershed assessment/planning/management workshop, sponsored by regional conservation foundation and local government.

Construction Site Stormwater Training, West Virginia. Conducted training workshops on construction site erosion, sediment, and stormwater permit compliance in Hurricane (2008), Beckley (2007), and Charleston (2007, as part of the US EPA stormwater workshop). Conducted all presentations and provided analysis for field trip site reviews, in cooperation with local workshop hosts.

Chesapeake Bay Executive Order Guidance for Federal Facilities, USEPA. Served as task order manager and conducted focused research on methods for addressing nutrient inputs into the Chesapeake Bay from individual and clustered

wastewater treatment systems; developed guidance for treatment system effluent quality for various spatial risk zones, based on current treatment technological capabilities and pollutant time/travel/removal research. Co-authored relevant chapter of USEPA guidance document in 2010.

Construction Site Stormwater Field Guide and Technical Manual, Kentucky. Conducted research on construction site erosion, sediment, and stormwater management approaches in various states and localities during 2004-2006; wrote and produced new statewide Field Guide on construction site stormwater runoff control in 2005, co-developed (with Richard Walker of Tetra Tech – Lexington KY) and produced the new Technical Specifications Manual for the Kentucky construction site stormwater management program in 2006.

Lake Maumelle Watershed Management Plan. Provided support for construction site erosion and sediment control ordinance development and wastewater treatment options for Central Arkansas Water, which manages Lake Maumelle near Little Rock AR as a major drinking water supply lake. Researched approaches for minimizing area of exposed soil and minimizing the time of exposure, developed language for incorporation into Stormwater Pollution Prevention Plan requirements, developed wastewater options for analytical studies.

Watershed Management Planning – Arkansas. Provided research, program development, and other support for the development of watershed management plans in the Fayetteville-Springdale-Rogers-Bentonville metro area of Northwest Arkansas. Conducted focused research on wastewater treatment facility performance, decentralized wastewater management, stormwater program development, and stakeholder interests.

Antidegradation Implementation - Arizona and West Virginia. Co-leader of work assignments to develop an antidegradation implementation guidance document for the West Virginia Department of Environmental Protection and Arizona Department of Environmental Quality. Conducted research on state and national Clean Water Act antidegradation issues and approaches, prepared issue summaries for state water agency staff, led consensus meetings with stakeholders, and co-wrote guidance document.

TMDL National Training Project. Work assignment leader for Total Maximum Daily Load (TMDL) overview workshop developed by USEPA and Tetra Tech. Assisted in curriculum development, produced and edited slide presentations, conducted presentations, led group exercise, and facilitated case study discussion.

Onsite Wastewater Treatment Systems - National Guidance. Work assignment leader for 2002revision of the USEPA Onsite Wastewater Treatment and Disposal System Design Manual, which was first issued in 1980. Wrote two chapters of the five-chapter document, conducted research on management approaches, implementation strategies, technological applications, and integration of onsite system management with broader watershed planning programs.

Decentralized Wastewater Management - National Guidance. Work assignment leader for the USEPA Office of Wastewater Management's program to improve the management of onsite wastewater systems. Assisted in development of the onsite systems management guidance manual, co-wrote management handbook, led USEPA OWM outreach efforts to promote voluntary management guidelines, facilitated meetings among stakeholders and interested parties in management guidelines development, and provided support for agency staff conducting workshops or briefings on septic system management topics.

Clean Water Act - National Training Program. Work assignment leader for Clean Water Act training programs sponsored by the USEPA Office of Water. Assisted in program development, conducted presentations on various sections of the Clean Water Act, facilitated group exercises, led discussion groups for workshops at USEPA Regional Offices in Denver, Chicago, Atlanta, Boston, New York, and other state/federal training sites.

Acid Mine Drainage Guide - USEPA. Co-wrote *A Citizen's Guide to Address Contaminated Coal Mine Drainage* for USEPA Region 3. The guide addresses identification of CMD problems, organization of watershed partnerships, watershed assessment, contaminated mine drainage treatment technologies and options, and fundraising.

USEPA Watershed Management and Stream Restoration Training. Project manager for developing and conducting *Working at a Watershed Level* and *Stream Corridor Restoration* training courses for USEPA, The Nature Conservancy, California State University, The Council of State Governments, University of New Hampshire, and other clients in MI, WV, GA, FL, and OH. Responsible for developing course content and materials, recruiting instructors, planning field trips, facilitating interactive group exercises, and conducting sessions on watershed planning, management, threat abatement strategies, monitoring, and outreach. Course attendees included representatives from federal, state, local, and nongovernmental organizations at each location.

TETRA TECH

Peter von Loewe

Senior Water Resource Engineer

EDUCATION

M.S., Environmental Studies, University of Charleston/Medical University of South Carolina, 2001

B.S., Anthropology, College of Charleston, 1992

YEARS OF EXPERIENCE

Tetra Tech: 13

Total: 15

AREAS OF EXPERIENCE

- Watershed modeling
- Receiving water modeling
- TMDL development
- Water quality monitoring program design and implementation
- Watershed characterization
- Watershed management
- Clean Water Act program support
- Technical writing
- Project and contract management

Mr. von Loewe has more than 15 years of professional experience in watershed modeling, receiving water modeling, and GIS applications. Mr. von Loewe is a water resources engineer providing technical and project management support to federal, state, and municipal clients in the areas of watershed and hydrodynamic modeling, watershed management, hydrologic and water quality studies, point and nonpoint source pollution characterization and assessment, TMDL development and implementation, and model interface development. He has provided technical and management support and guidance for TMDL efforts in Pennsylvania, Washington, Maryland, California, Puerto Rico, and the U.S. Virgin Islands for waterbodies impaired by metals, pH, bacteria, nutrients, turbidity, oil and grease, toxic contaminants, and low dissolved oxygen. His TMDL experience ranges from nutrient TMDLs in bay systems of the Virgin Islands and lakes/reservoirs in California to fecal coliform TMDLs in coastal lagoons of California and rivers in Pennsylvania, South Carolina and Virginia, to metals TMDLs for West Virginia rivers. Mr. von Loewe has also managed model interface design and development to assist with model management and implementation. He has designed several interfaces to the Environmental Fluid Dynamics Code (EFDC) hydrodynamic model, which provide a user-friendly GIS-based interface for model development.

Project Experience

Chesapeake Bay TMDL Support, USEPA Chesapeake Bay Program Office (CBPO). Provided support to CBPO staff during development of several key source loading datasets. Managed compilation of more than 5,000 permitted industrial facilities from various sources including PCS and ICIS databases, depending on the jurisdiction. For these facilities, loads were then estimated based on the PCS or ICIS databases and contributions from facilities without DMR or permitted limit information were estimated based on literature values developed by USEPA. Also managed development of a dataset to characterize contributions from CSOs from more than 50 municipalities in the Chesapeake Bay watershed. The resulting dataset incorporated a wide range of quality in terms of data that were provided.

Chesapeake Bay Watershed Implementation Plan (WIP) for Virginia DEQ. Provided support to Virginia Department of Environmental Quality (DEQ) with development of its WIP for the Chesapeake Bay nutrient and sediment TMDL. Tasks included obtaining permit information from the DEQ CEDS database and producing a revised list of permits in the Virginia portion of the CB 5.3 watershed model. In addition, revised wastewater and industrial stormwater contributions were estimated for these facilities. The new information was subsequently used in the Chesapeake Bay watershed model and the WIP that was delivered to USEPA.

Chesapeake Bay WIP for Virginia DCR. Provided support to Virginia Department of Conservation and Recreation (DCR) relating to the Chesapeake Bay nutrient and sediment TMDL. Tasks included delivery and installation of the Chesapeake Bay watershed model to DCR staff for the purposes of DCR running the model in-house in its native UNIX environment. This allowed DCR staff access to the model, and provided the opportunity to run their own scenarios and review model datasets. Mr. von Loewe assisted VADEQ with updating the permitted point source dataset being used in the Chesapeake Bay TMDL modeling.

Virginia Local Pilot WIP, Rivanna River Basin Commission, VA. Provided support to the Rivanna River Basin Commission (RRBC) for development of a WIP for the Chesapeake Bay nutrient and sediment TMDL. Tasks included estimation of nutrient and sediment loads for the Thomas Jefferson Planning

District Commission (TJPDC) counties based on the Chesapeake Bay 5.3 watershed model results. The counties were overlayed with the model output and the loads were extracted and compared to an approved local TMDL for sediment. The linkage between the model and the area of interest, as well as the comparison of loads, was documented and delivered with supporting GIS data.

Virginia Local Pilot WIP, Prince William County, VA. Provided support to Prince William County for development of WIP for the Chesapeake Bay nutrient and sediment TMDL. Tasks included the estimation of nutrient and sediment loads for the county based on the Chesapeake Bay 5.3 watershed model results and other sources of information. Land use and ownership data were obtained and used to assign loads to the various stakeholders in the county. Identified data gaps needing to be filled in order to finalize the load allocations. This work is ongoing.

Metals TMDLs for the Shenango River, PA. Managed development of metals TMDLs for the Shenango River and surrounding watershed in western Pennsylvania. Compiled monitoring and spatial data from a variety of sources for developing a linked LSPC watershed modeling system. Sources such as point source discharges, MS4s, nonpoint source loading of local metals-rich soils, and internal loading of lakebed sediment-associated metals were addressed in the TMDL. Additionally, a site-specific model postprocessor was developed for the Shenango River LSPC model to allow DEP or municipal staff to investigate alternative scenarios.

Nutrient TMDLs for Wissahickon Creek, PA. Managed development of nutrient TMDLs for Wissahickon Creek and the surrounding watershed in eastern Pennsylvania. Compiled monitoring and spatial data from a variety of sources and managed development and calibration of a linked LSPC (watershed) and EFDC (receiving water) modeling system. This work is a continuation of a previous TMDL effort where both sediment and nutrient TMDLs were established for this waterbody. Additional data have been collected to support revision of the previous work, including monitoring data for both ambient and permitted discharges, and stressor analyses performed on the Wissahickon Creek datasets.

Bacteria TMDLs for the Pine Creek Watershed, PA. Managed development of bacteria TMDLs for the Pine Creek system and surrounding watershed in western Pennsylvania, just outside of Pittsburgh. Compiled monitoring and spatial data from a variety of sources for developing an LSPC watershed modeling system. In this heavily-developed watershed, sources such as permitted and nonpermitted discharges, MS4s, CSO/SSO discharges, and nonpoint source loading were addressed in the TMDL. Monitoring data collected in preparation for this work requires a high level of detail regarding source characterization. Worked closely with local agencies and municipalities to obtain data required by the modeling system.

Dissolved Oxygen TMDL for Salt River Bay, St. Croix (USVI DEP, USEPA Region 2). Managed development of a dissolved oxygen TMDL for Salt River Bay and surrounding watershed in St. Croix, USVI. Compiled monitoring and spatial data from a variety of sources to develop a linked LSPC watershed and EFDC receiving water modeling system to assess sources and processes that have led to the impairment of Salt River Bay. The reduction of Biochemical Oxygen Demand (BOD) was used as the vehicle to attain water quality standards in this productive system, in lieu of limited nutrient monitoring data, illustrating the flexibility of the linked LSPC-EFDC modeling system.

Multiple TMDLs for St. Croix, St. Thomas, and St. John, USVI (USVI DEP, USEPA Region 2). Managed development of multiple TMDLs in the USVI. For each impairment, identified a modeling system that would address the source-impairment linkage and be used to calculate the TMDL. Based on the relatively small size of the watersheds and proximity to tidal waters, a linkage of watershed and receiving water modeling techniques allowed for the assessment of sources and influential processes that occur in these systems. This work resulted in approved TMDLs developed on St. Thomas, St. Croix, and St. John for dissolved oxygen, bacteria, and oil and grease.

Nutrient TMDL for Clear Lake, Lake County, California (USEPA Region 9). Managed nutrient TMDL development for Clear Lake watershed. Assessed and compiled monitoring and spatial data from a variety of sources for developing a linked LSPC watershed and EFDC receiving water modeling system. Developed various condition scenarios (e.g., pre-development land use distribution, incremental phosphorus reduction to represent site-specific BMP implementation) to represent a range of loading rates to insure that appropriate TMDL targets are set considering the unique nutrient budget. Applied the linked LSPC and EFDC to assess sources and processes that have led to the impairment of Clear Lake and identify a solution to attain water quality standards in this naturally productive system.

EFDCView Software Development, USEPA Region 4. Manages design, development, and maintenance of EFDCView; a graphical user interface to EFDC. The user interface enables the user to develop a complex series of input files required by EFDC within a familiar shapefile-oriented environment, and provides seamless access to extensive post-processing capabilities.

TETRA TECH

Julie Wandling

Watershed Analyst

EDUCATION

B.S., Biology, West Virginia State College, Institute, 1998

YEARS OF EXPERIENCE

Total: 15

With Tetra Tech: 5

TRAINING

ArcView Introduction to ArcGIS, 2001

ArcGIS Introduction to GIS, WVU/NRAC 2006

ArcGIS Advanced Topics, WVU/NRAC 2006

Dale Carnegie, WVDEP, 2005

EPA NPDES Permits Writers Course, VA 11/2001

Managing Wet Weather with Green Infrastructure, WVDEP/EPA 7/2009

Microsoft Excel and Access, 2009

Phase II Stormwater Management, WVDEP/EPA, 5/2007

Going Places with Spatial Analyst, ESRI 2014

QUAL2E Enhanced Stream Water Quality Model Training Seminar, PA 3/2002

AREAS OF EXPERIENCE

- TMDL development
- Watershed assessment
- Watershed data management
- ArcGIS analysis
- Data manipulation in GIS, MS Excel and MS Access
- Water quality modeling
- Wasteload allocation development
- NPDES permitting
- Low flow estimating statistics of unregulated streams
- Metals analysis
- Inorganic data package analysis

Mrs. Wandling is an environmental scientist specializing in water resource management and TMDL development. She currently provides data management, GIS analysis, and water quality modeling support in the development of TMDLs for the West Virginia Department of Environmental Protection (WVDEP), Division of Water and Waste Management. Mrs. Wandling works with West Virginia DEP staff as well as other state and federal agencies to develop the most recent and accurate watershed data necessary to build TMDL models for metals, sediment, acid deposition, and fecal coliform. She also has more than 8 years of experience in implementing and managing the Wasteload Allocation program for the WVDEP, Division of Water and Waste Management. She has a breadth of knowledge and experience in NPDES permitting, antidegradation implementation, and low flow estimating statistics.

Project Experience

TMDLs for Selected Tributaries of Tygart Valley River Watersheds, WV; WVDEP; 2014-present. Served as TMDL development team member. Organized chemical, biological and physical data for statistical analysis. Aided in the development of the OWR NPDES Permits Database which generated the NPDES permits data. Worked in unison with staff at the Division of Water and Waste Management to determine point and non-point source permits within the TMDL watersheds. Provided technical review and comments on the OWR NPDES and Mining NPDES Permits to WVDEP staff. Developed the Permits Summary and Pollutant Source Reports.

TMDLs for Selected Tributaries of Upper Kanawha River, Upper Ohio North River, and South Branch Potomac River Watersheds, WV; WVDEP; 2012-2014. Served as TMDL development team member. Organized chemical, biological and physical data for statistical analysis. Aided in the development of the OWR NPDES Permits Database which generated the NPDES permits data. Worked in unison with staff at the Division of Water and Waste Management to determine point and non-point source permits within the TMDL watersheds. Provided technical review and comments on the OWR NPDES and Mining NPDES Permits to WVDEP staff. Developed the Permits Summary and Pollutant Source Reports. Contributed to the model setup and development. Developed the Technical Report Appendices, report figures, and ArcGIS viewer project and shapefiles.

TMDLs for West Fork River Watershed, WV; WVDEP; 2012-2014. Served as TMDL development team member. Organized chemical, biological and physical data for statistical analysis. Aided in the development of the OWR NPDES Permits Database which generated the NPDES permits data. Worked in unison with staff at the Division of Water and Waste Management to determine point and non-point source permits within the TMDL watersheds. Provided technical review and comments on the OWR NPDES and Mining NPDES Permits to WVDEP staff. Developed the Permits Summary and Pollutant Source Reports. Contributed to model setup and development. Developed the Technical Report Appendices, report figures, and ArcGIS viewer project and shapefiles.

TMDLs for Tributaries of the Monongahela River Watershed, WV; WVDEP; 2011-2013. Served as TMDL development team member. Organized chemical, biological and physical data for statistical analysis. Aided in the development of the OWR NPDES Permits Database which generated the NPDES permits data. Worked in unison with staff at the Division of Water and Waste Management to determine point and non-point source permits within the TMDL watersheds. Provided technical review and comments on the OWR NPDES and Mining

NPDES Permits to WVDEP staff. Developed the Permits Summary and Pollutant Source Reports. Contributed to the model setup and development. Developed the Technical Report Appendices, report figures, and ArcGIS viewer project and shapefiles.

West Virginia Department of Health and Human Resources (WVDHHR), Drinking Water Treatment Revolving Fund (DWTRF) Support; 2009-present: Served as the lead contractor supporting WVDHHR-DWSRF. Provided technical, programmatic support, and asset management support to applicants whose project are being considered for WVDHHR-DWSRF funding. This includes evaluating systems for compliance with State and Federal requirements, bond conditions, DBE, ARRA, Davis Bacon, Buy American, and Asset Management. Designed the WVDWTRF Projects Tracking Database, which aids in tracking utility and prime contractors compliance with program requirements. Worked closely with program staff to effectively manage the workload and upcoming inspections. Key role in the development of the WVDWSRF Asset Management Guidance Tool which was spotlighted at USEPA collaboration meetings, WV Public Service Commission, and Rural Water Association Conferences.

Bear River Watershed Comprehensive Lake Management Plant, Lac du Flambeau Indian Tribe; 2014. Prepared 30 figures/maps using ArcGIS or inclusion in the Bear River watershed lake management plan which highlights the lakes, aquatic plants, habitats, and landuse for the area. Delineated the Lac du Flambeau Indian reservation boundary using original survey and legal description provided by client. Determined percent landuse for each subwatershed.

Prince George County, TMDL Implementation; 2014. Supported Prince George County in performing data analysis that organized and standardized various water quality datasets to present in a meaningful way to further support TMDL implementation efforts for various watersheds.

Ohio River Bacteria TMDL, OH; 2012- 2013. Gathered NDPES outfalls contributing fecal coliform to the Ohio River from 2005-2008. Reviewed and analyzed the data to select only the relevant outfalls. Assisted WVDEP to gather the DMR data for the appropriate outfalls. Supported model setup tasks for representation of the WV Combined Sewer Overflows discharges.

Agriculture Non Cost Share BMP Database for Chesapeake Bay TMDL; WVDA; 2011-2012. Supported West Virginia Department of Agriculture (WVDA) in developing a Non Cost Share BMP Database that will aid them in implementing the Chesapeake Bay requirements in the Eastern Panhandle. Worked closely with WVDA in gathering necessary data. Created and finalized the database tables and established the field relationships for incorporation into an Oracle database application.

Online TMDL Viewer Tool; WVDEP; 2011- 2012. Created the GIS Viewer Tool for UOS, A2 TMDL, B2 TMDL, and C2 TMDL. Worked closely with Tetra Tech IT programmers to develop the projects, shapefiles, geodatabases, and provided testing of the tool and reports.

TMDLs for Middle Ohio South and Middle Ohio North Watersheds, WV; WVDEP; 2009-2012. Served as TMDL development team member. Organized chemical, biological and physical data for statistical analysis. Aided in the development of the OWR NPDES Permits Database, which generated the NPDES permits data. Worked in unison with staff at the Division of Water and Waste Management to determine point and non-point source permits in the TMDL watersheds. Provided technical review and comments on the OWR NPDES and Mining NPDES Permits to WVDEP staff. Developed the Permits Summary and Pollutant Source Reports. Developed the Technical Report Appendices, report figures, and ArcGIS viewer project and shapefiles.

TMDLs for Elk, Lower Kanawha, and North Branch Potomac Watersheds, WV; WVDEP; 2009- 2012. Served as TMDL development team member. Prepared reduction alternative allocations for the Lower Kanawha and the North Branch Potomac using LSPC model. Developed the Technical Report Appendices, report figures, and ArcGIS viewer project and shapefiles.

TMDLs for Cheat Watershed, WV; WVDEP; 2009-2011. Served as TMDL development team member. Developed the Technical Report Appendices, report figures, and ArcGIS viewer project and shapefiles.

West Virginia Department of Environmental Protection, Division of Water and Waste Management; 2001-2009: As a former employee of the West Virginia Department of Environmental Protection, has extensive prior experience in the West Virginia NPDES Permit program and in environmental regulation. Prepared permits registrations for NPDES permit subtypes such as carwash, water treatment plants, HAU, Sewage 50,000 gpd or less, and individual industrial and municipal sewage wastewater discharges permits. Performed water quality modeling for the Division of Water and Waste Management. Lead environmental resource scientist for the wasteload allocation program.

TETRA TECH

John Zastrow, PMP

Model Development

EDUCATION

P.M.P, Project Management Professional, George Mason University, Fairfax, Virginia, Project Management Institute, 2006

Certificate, Urban GIS, University of Wisconsin, Milwaukee, Wisconsin, 2001

M.S., Biology, University of Wisconsin, Milwaukee, Wisconsin, 2001

B.A., Biology, University of Colorado, Boulder, Colorado, 1995

YEARS OF EXPERIENCE

Tetra Tech: 11

Total: 16

LICENSES/REGISTRATIONS

Project Management Professional, Project management Institute. PMP #: [redacted]

GIS Certification Institute – GIS Professional. GISP [redacted]

PROFESSIONAL AFFILIATIONS

Maine GIS User Group

Maine Project Management Institute

AREAS OF EXPERIENCE

- Information system design
- GIS design and implementation
- Geospatial data management
- Guidance development
- Water quality assessment
- Water withdrawal permitting
- Environmental statistics
- Watershed management

Mr. Zastrow has more than 16 years of experience in the application of GIS and information technology for environmental resource management. His experience includes the design, management and technical oversight of projects involving the delivery of GIS, database, and system products and services for a range of federal, state, local, and tribal government clients. As a PMP certified professional, he has served projects in various capacities including project manager, technical lead/architect, GIS/systems analyst, and subject matter expert. He has many years of supporting GIS and data management and analysis projects involving EPA, Navy and other data and content management systems. His experience also includes chemistry analysis, aquatic toxicology and ecology, and field data collection.

Project Experience

Project Manager, California State Water Resources Control Board (SWRCB), Water Rights Management System (eWRIMS). Sacramento, CA. (July 2012 – December 2013). Project manager and lead analyst for the update of the online, desktop and GPS-based systems and business processes supporting recording the place of use and points of diversion for water usage throughout California. Responsibilities included costing, task management, conceptual design of new features, subcontractor coordination, client training, and acting as point of contact with SWRCB IT management and the Division of Water Rights users.

Project Manager, Georgia Water Quality Monitoring and Assessment System. Georgia Environmental Protection Division (EPD), Atlanta, GA. (January 2013 – September 2014). Project manager and lead analyst for the design and development of an integrated online system to manage water quality (chemical, physical, biological, habitat) data along with EPA Integrated Assessment (303(d) & 305(b)) details for biennial reporting through the online system. Responsibilities included costing, task management, conceptual design of new features, subcontractor coordination, client training, and acting as point of contact with EPD IT management and the EPD users.

Project Manager. Environmental Permit Tracking System, Navy Mid-Atlantic Installations (MIDLANT), Norfolk, VA. (October 2012 – August 2014). Project manager and lead analyst for the design, construction, deployment and training of a central, searchable browser-based database system with geospatial capabilities to manage environmental permits (natural resources, cultural resources and National Environmental Planning Act) and mitigation requirements to provide a field engineering command-wide view of permitting requirements within the approximately 16 major installations of the NAVFAC MIDLANT region.

Lead Analyst, Georgia Water Withdrawal Permitting and Tracking System. Georgia Environmental Protection Division (EPD), Atlanta, GA. (July 2011 – September 2011) Lead analyst supporting the design and development of a Web-based, GIS-integrated system to manage agriculture, municipal, and industrial ground and surface water withdrawal permitting and consumption tracking for Georgia. Mr. Zastrow interviewed EPD, developed design materials, conducted database design, and lead the profiling and migration design of existing permitting and withdrawal records, led training sessions.

Project Manager. Utah Division of Wildlife Resources, Western Governors Association (WGA) (Arizona, California, Nevada, Utah), Southwest States Wildlife GIS Data Inventory. (September 2010 - August 2011) The project collected and characterized geospatial data and metadata pertaining to ecosystems

management throughout the four states and was a first phase leading to a West-wide decision support system to expedite decision making with regards to wildlife and ecosystem impacts from large development projects. Tetra Tech systematically identified, collected, tracked, and evaluated over 4000 geospatial data sets, and over 2000 non-geospatial data files to produce a 4-state library of the best available wildlife data for hundreds of species and several land conditions. Acquired data were evaluated for their quality and value in terms of documentation, specificity, pedigree and credibility of the data producers and sources, applicability to the goals of the project, spatial and temporal scales and extents, and comparability to other similar data sets.

Project and Data Manager. Marine Resource Assessment and Living Document System Naval Facilities Engineering Command Atlantic (NAVFAC), Norfolk, VA. (November 2008 – Present). Mr. Zastrow is currently serving as a technical project and GIS data manager for multiple projects and aspects of support for the US Navy (NAVFACLANT). His responsibilities include technical data management for numerous task orders, geospatial analysis and technical liaison between multiple parties, management of systems development, and staff supervisor. He is also a project manager for the implementation of a document management system to support collaborative development of large, technical documents by a dispersed team.

Project Manager, Forest Inventory Management System (FIMS). Marine Corps Base, Camp Lejeune North Carolina. Naval Facilities Engineering Command Atlantic (NAVFAC), Norfolk, VA. (September 2009 – December 2010). Project manager for the implementation of a web-based forest inventory management system (FIMS). The FIMS integrated the national forest volume estimator model (US Forest Service) into an online system that captured repeated forest cruise survey results to determine growth and value to support merchandizing of Camp Lejeune's valuable forests through automated calculations and reporting. The system met all applicable defense system security standards, including those imposed by the Navy Marine Corps Intranet and associated integrations. Responsibilities included costing, task management, conceptual design, subcontractor coordination, client training, and acting as point of contact with Navy NAVFACLANT and the Camp Lejeune client and systems managers.

Data Manager, Marine Environmental Resource Assessments, Naval Facilities Engineering Command Atlantic (NAVFACLANT), Norfolk, VA. (September 2008 – February 2010). Data manager for the Naval Facilities Engineering Command Atlantic (NAVFAC) Atlantic Global Area of Responsibility to develop an environmental data compilation as a comprehensive body of data on protected and commercial marine species, habitats, geologic and oceanographic and to assess and interpret that information in support of Navy environmental planning and regulatory compliance efforts. Tetra Tech identified and acquired new or existing geospatial data from many government, private, academic and NGO sources and then standardized and assimilated the data and metadata for inclusion in the data set.

Project Manager, Second Generation Environmental Data Analysis System (EDAS2), Fairfax, VA. (November 2006 – July 2009). Project manager and a lead designer of EDAS2, a free and open source enterprise system for the storage and analysis of biological data. Responsibilities include overseeing technical implementation of the system, conducting outreach and marketing, and controlling direction and scope of system development.

Project Manager, Fairfax County Virginia Comprehensive Watershed Planning and Stormwater Support. Stormwater Division, Fairfax, VA. (February 2007 – March 2009). Project manager and lead designer for data management and the development of a web and desktop-based information system to support watershed management in Fairfax County, VA. The system is used to develop and maintain watershed plans, analyze future stormwater management options, evaluate indicators of water quality, provide for long-term data management, and visualization of modeling results and countywide GIS data.

Project Manager, Website Redesign and Content Development, Department of Environmental Protection, Montgomery County, MD (May 2008 – July 2010). Project manager leading the redevelopment of the Montgomery County, Maryland Department of Environmental Protection (DEP) public website. The project involved producing information architecture designs that restructured the existed website to follow a newly developed template. Tetra Tech then coordinated with DEP staff to develop new content and integrate social networking features with the site. Tetra Tech completed all page redesigns and integrated with the county's servers.

Project Manager, EPA Environmental Data Adapter. EPA Office of Science and Technology, Washington, DC. (December 2007 – June 2008). Project manager and lead designer of novel software to transform Superfund Staged Electronic Data Deliverable (SEDD) analytical result files and FORMS II Lite field sampling files to produce valid electronic data deliverables for direct submission into EPA's Central Data Exchange (CDX) following the Water Quality Exchange (WQX) schema.

TETRA TECH

Hua Zhang, PhD

Soils Specialist

EDUCATION

Ph.D., Soil Science, Louisiana State University, 2006

M.S., Soil Science, Chinese Academy of Sciences,2002

B.S., Environmental Management, HuaZhong Agricultural University, 1999

YEARS OF EXPERIENCE

Tetra Tech: 8

Total: 13

PROFESSIONAL AFFILIATIONS

Soil Science Society of America

American Geophysics Union

AREAS OF EXPERIENCE

- Water Quality Modeling
- TMDL Development
- Reactive Transport Modeling
- Heavy Metal Biogeochemistry
- Agricultural and storm water BMPs
- Acid Mine Drainage

Dr. Zhang is an environmental engineer with extensive engineering and scientific experience specializing in hydrologic and water quality modeling, watershed management, point and nonpoint source pollution assessment, soil and groundwater remediation, agricultural system management, heavy metal contamination analysis, TMDL development and implementation. He has extensive scientific knowledge in soil and water sampling, characterization, and assessment. Dr. Zhang possesses extensive programming experience concentrated in the surface and groundwater quality modeling. He currently develops and applies reactive transport model for TMDL development and remedial investigation. Dr. Zhang published more than 10 peer reviewed articles on major journals in the area of environmental science. He has also served as peer reviewer for several international journals on environmental management.

Project Experience

West Virginia Metals TMDLs Development for Hydrologic Groups B2. For the West Virginia Department of Environmental Protection (WVDEP), gathered, compiled, and prepared relevant water quality data for characterization and modeling of the Elk and Lower Kanawha watersheds. Developed and calibrated models for total iron, pH, and dissolved aluminum impaired streams. Conducted stream bank erosion and sediment transport modeling. Prepared mining and non-mining NPDES permit relational databases. Prepared comprehensive TMDL scenario databases where all of the project information can be accessed and queried.

Support Activities for the Re-evaluation of the Cheat River Watershed TMDL in West Virginia. In support of EPA Region III, developed and calibrated mining data analysis system (MDAS) water quality models for pH, total iron, dissolved aluminum, and manganese. The model dynamically simulate stream acidity results from multiple sources including acid precipitation caused by sulfur and nitrogen emissions, as well as acid mine drainage (AMD) with very high concentrations of sulfate and dissolved metals (Fe and Al) from abandoned coal mining sites in the region.

West Virginia Troutwater Iron Modeling. In support of WVDEP, developed and calibrated hydrologic, sediment and water quality models for two trout streams (Elklick Run and Holcomb Run). Created dynamic landuse to simulate impacts of forest harvest on soil erosion and sediment generation in streams.

West Virginia Metals TMDLs Development for Hydrologic Groups C, D, and E. For West Virginia Department of Environmental Protection (WVDEP), gathered, compiled, and prepared relevant water quality data for characterization and modeling of the Gauley, Little Kanawha, New River, Youghiogheny, and Dunkard Creek watersheds. Developed and calibrated models for total iron, total manganese, pH, dissolved aluminum, and chloride impaired streams. Prepared mining and non-mining NPDES permit relational databases. Prepared comprehensive TMDL scenario databases where all of the project information can be accessed and queried.

Piney Creek Watershed Management Plan. In support of WVDEP, developed a MS Excel based BMP decision support tool to help plan and prioritize potential projects based on available funding sources, project cost, and measureable water quality benefits in Piney Creek watershed.

Dissolved Metals Transport Modeling for Left Hand Creek, James Creek, and Little James Creek, CO. In support of EPA region VIII, developed dissolved copper, zinc, lead, and cadmium TMDL in the Left Hand watershed using an in-stream chemical transport model developed by Tetra Tech. Analyzed hydrologic and water quality data collected under the critical high flow and low flow conditions. Evaluated remedial effectiveness scenarios of various mining reclamation activities in the Left Hand watershed.

Acid Mine Drainage TMDLs for the Kiskiminetas-Conemaugh River Watershed, Pennsylvania. In support of EPA Region III, analyzed water quality data and pollutant discharge permits of streams impacted by abandoned mine land (AML) in Kiskiminetas River watershed. Developed and calibrated water quality models for total iron, aluminum, and manganese using MDAS model.

Dissolved Cadmium and Zinc Transport Modeling for Silver Creek, Utah. In support of EPA Region VIII, had a lead technical role in the development of models for simulating dissolved Cd and Zn transport for Silver Creek near Park City, Utah. Evaluated water quality data and pollutant sources to determine the relationships between in-stream metal concentrations and discharge from mine tailing. Used steady state solute transport model equipped with sediment transport routines coupled with a dynamic chemical speciation model to simultaneously simulate multiple dissolved metals.

Non-Point Source Monitoring and BMP Development for TMDL Implementation in Bayou Wikoff Sub-Watershed. In support of Louisiana Department of Environmental Quality (LADEQ), technical lead for monitoring nonpoint pollutant source and developing BMPs for TMDL implementation in Bayou Wikoff watershed in southern Louisiana. Evaluated multiple BMPs for reducing sediment and nutrient (N and P) load from sugarcane and pasture field.

TETRA TECH

Jenny X. Zhen, PhD, PE

Senior Water Resource Engineer

EDUCATION

Ph.D., Environmental and Civil Engineering, University of Virginia, 2002

M.S., Environmental Engineering, Tsinghua University, China, 1998

B.S., Environmental Engineering, Tsinghua University, China, 1996

YEARS OF EXPERIENCE

Tetra Tech: 13

Total: 15

LICENSES/REGISTRATIONS

Professional Engineer, License [redacted], Commonwealth of Virginia, 2008

PROFESSIONAL AFFILIATIONS

American Society of Civil Engineers

Water Environment Federation

Journal of Water Resources Planning and Management (Technical Manuscript Reviewer)

Journal of Environmental Science and Health (Technical Manuscript Reviewer)

AREAS OF EXPERIENCE

- BMP evaluation and modeling
- Stormwater management model/tool/decision support system development and application
- Watershed hydrology and water quality modeling
- TMDL development
- Watershed management plan development

Dr. Zhen is a registered professional senior water resources engineer, specializes in urban stormwater management, watershed planning and management, and nonpoint source pollution control. Over the past fifteen years, Dr. Zhen has intensive experience in evaluation and design of best management practices (BMPs) with the assistance of numerical computer models, watershed hydrology and water quality modeling, watershed restoration implementation plan development, and applying optimization techniques for BMP implementation and watershed management. She developed System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) for US EPA Urban Watershed Management Branch (UWMB) as a technical lead. Since its debut in 2009, SUSTAIN has been applied in the United States and internationally for finding the cost-effective solutions to mitigate the adverse impact of stormwater. Dr. Zhen has conducted a dissertation research in applying simulation and optimization approach to develop cost effective BMPs placement strategies at the watershed scale.

Project Experience

Evaluation of Urban Implementation Options for Maryland's Chesapeake Bay TMDL Watershed Implementation Plan (2013). Technical lead to develop an approach for redefining and evaluating the load reduction with the Maryland E3 (Everyone, Everything, Everywhere) scenario in the Chesapeake Bay model. The scenario is a theoretical scenario that assumes that maximum levels of BMPs are applied and that loads from every available acre are being treated by BMPs, with few physical limitations and regardless of cost. The technical approach involved using USEPA's SUSTAIN Siting Tool to identify the maximum potential BMP opportunities and corresponding drainage areas, followed by quantifying the load reduction that can be achieved.

Development of Cost-effective Stormwater BMP Implementation Strategy to Meet Nutrients Reduction Goals for Sugartree Creek Watershed (2014-2015) in Nashville TN. Technical lead to develop BMP implementation strategies for meeting nutrient reduction target. The project involves identifying suitable BMP opportunities and options, estimating BMP costs, evaluating BMP performance, and recommending cost-effective stormwater BMP implementation strategies

Development of a Stream Routing and Sediment Transport Simulation Module Accommodating (6/2003–1/2004). West Virginia Department of Environmental Protection. As the principle technical investigator, developed a stream routing and sediment transport simulation module that can be used in combination with Generalized Watershed Loading Function (GWLF). The module has been used to development of TMDLs for watersheds in USEPA Region 3 (West Virginia and Pennsylvania), and Region 10 (Idaho).

Benthic TMDL Development for Streams in Virginia, USEPA Region 3. 6/2003–12/2004. Supported development of TMDLs for several watersheds in Virginia to address biological (benthic macroinvertebrate community) impairments caused by nonpoint source pollution. The methodology used in this project incorporates a reference watershed approach for the identification of benthic community stressors and appropriate TMDL endpoints. The reference watershed selection process was based upon a comparative analysis of key watershed attributes and the results of a Multimetric Bioassessment Index that was developed specifically for this project using metric discrimination analyses. The stressor identification process involved the review of water and sediment quality data, toxicity test results, and physical

processes (i.e. hydromodification, riparian buffer disturbance, etc.) to determine the primary causes of impairment. Impaired and reference watersheds are currently being modeled to determine the conditions necessary to support a healthy benthic community.

Sediment TMDL Development for Fighting Creek, Idaho, Region 10. 5/2002–8/2003. Provided technical support in nutrients and sediment TMDL development for Fighting Creek, using Generalized Watershed Loading Function (GWLF) to simulate watershed loadings. Reference watershed approach was applied to identify the sediment and nutrients TMDL target.

Reasonable Assurance Technical Assistance for Coquille River Bacteria TMDL (2012). Technical lead to develop an approach for identifying priority implementation areas and specific BMP scenarios to meet water quality standards and proposed load allocations identified in the bacteria TMDL for Coquille River (located in southwestern Oregon). Identified priority implementation areas where high concentrations of bacteria are entering the waterbody and where significant, quantifiable bacterial load reductions can be achieved and collected and analyzed information on BMP types and efficiencies to develop a list of BMPs considered to be beneficial and relevant to reduction of bacteria loading and the Coquille Subbasin. As a final product, developed a geodatabase with ArcGIS add-in query capabilities that implements the proposed approach to help the user identify agricultural, rural, and urban priority implementation areas and BMP treatment scenarios to meet the water quality criteria in a selected focus area in the watershed.

Development of Multi-Pollutant TMDL Implementation Plan for Ballona Creek and Los Angeles River Watersheds, County of Los Angeles, CA (05/2009–05/2010). Performed watershed and BMP simulation and optimization to identify cost-effective solutions for meeting TMDL targets in the Ballona Creek and Los Angeles River watersheds with a comprehensive, phased approach of BMP implementation. To develop this plan, BMPs to treat stormwater and dry weather flows to reduce metals, bacteria, and toxic pollutants were identified and selected. As part of this process, benefits of management activities were estimated in terms of pollutant load reductions or improvement in water quality to meet wasteload allocations (WLAs) defined by approved TMDLs. The process of BMP selection included considering cost-effectiveness to provide assurance that the plan is practical and implementable. The plan also includes integrated approaches that consider BMPs that can address multiple pollutants cost-effectively, while considering parallel water resources planning strategies for the watershed.

Application Case Studies of System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN), USEPA ORD, Edison, NJ (1/2010–2012). Applying SUSTAIN at three locations with varying wet weather characteristics across the United States—Kansas City, MO, Louisville, KY, and Albuquerque, NM—to quantify cost savings and water quality benefit of "green" stormwater management options that meet various stormwater management goals. Kansas City and Louisville applications focus on evaluating use of green and grey infrastructure for CSO control while Albuquerque study evaluates options for meeting TMDL and MS4 permit requirements.

Modeling of BMP Implementation Options in Support for TMDL Implementation and Strategic Watershed Planning, County of Los Angeles, CA (7/2008–2011). Provided technical support for development of a comprehensive watershed management decision support system to assist in strategic stormwater and water quality improvement planning. Configured management options in the context of the modeling framework and provided model development and application to support optimal BMP implementation planning.

Nutrients TMDL for Lake Ontelaunee, PA, Region 3 (1/2005–8/2005). Provided technical support in nutrients TMDL development for Lake Ontelaunee, using Generalized Watershed Loading Function (GWLF) to simulate watershed loadings and BATHTUB model to simulate lake water quality.

System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) Development. USEPA ORD, Edison, NJ (2003–present). Provided system design and development support for SUSTAIN. Identified needs, available models and modeling systems, conceptual design, and system prototype. This integrated decision-support system provides the needed link between management action, source loading, stressors, and water quality endpoints and provides tools to optimize watershed management activities and trade resources to meet identified water quality goals. The system supports comprehensive studies for TMDLs, stormwater/MS4 management and planning, and CSO mitigation.

Evaluation of Site-Scale Stormwater Management Options (6/2005–11/2005). For Prince George's County, MD, conducted a case study at a suburban residential site to examine integrated stormwater management at the site scale. Conducted a detailed water balance analysis, including assessment of potable water, wastewater, and stormwater, to identify opportunities for maximizing the reuse of stormwater to effectively minimize the use of potable water.

TETRA TECH

Lei Zheng, PhD

Biological Analyst

EDUCATION

Ph.D., Ecology, Evolutionary Biology, and Behavior (EEBB) Program and Department of Zoology, dual degree, Michigan State University, 2003

M.A., Botany, Xiamen University, China, 1991

B.S., Botany, Xiamen University, Xiamen, China, 1988

YEARS OF EXPERIENCE

Tetra Tech: 12

Total: 16

AREAS OF EXPERIENCE

- Statistical analysis
- TMDL support
- Stressor identification
- Biological assessment
- Indices of biological integrity
- Nutrient and conductivity water quality criteria developement
- Water resources management

Dr. Zheng is a senior aquatic ecologist in Tetra Tech Inc., Center for Ecological Sciences, located in Owings Mills, Maryland. He is a research scientist with broad experiences in aquatic environmental sciences especially in biological assessment of aquatic ecosystems. He is an algae and nutrient expert, specialized in algal ecology, taxonomy, and physiology; and his particular interest is to use biological indicators (algae, macroinvertebrates, fish, and plants) to assess ecosystem health. During his professional career, he has been involved in a range of multidisciplinary research in streams, lakes, wetlands, as well as marine systems. His strong background in experimental design and statistical analysis has helped to integrate complicated information into simple models and indices for environmental management. Dr. Zheng has worked with EPA and other state agencies to identify environmental stressors and human disturbance that cause the degradation of aquatic system. By using statistical modeling approaches, he has been able to identify the relative risk of environmental stressors to aquatic systems, therefore to develop scientific defensible water quality standards/criteria. His other technical abilities include, but are not limited to, wetlands ecology, stream ecology, and algae-nutrient interactions.

Project Experience

West Virginia Stressor Identification and TMDL Development. Dr. Zheng's research was part of a multiple-year project focused on identifying environmental stressors impairing biological condition (macroinvertebrates) in West Virgina streams to help the West Virginia Department of Environmental Protection (WVDEP) develop Total Maximum Daily Loads (TMDLs) for streams throughout the state. Research included: applied multivariate statistical approaches to develop empirical models; weighted averaging for tolerance development; and a dirty reference model (discriminant functional analysis) for stressor identification. Dr. Zheng developed nutrient targets for the Potomac Direct Drains Watershed based on responses of algae and macroinvertebrates. He developed pH, and Aluminum toxicity thresholds based on multiple approaches; and developed sulfate and chloride thresholds based on statistical approaches.

Development of Biological Indicators (IBI) Of Urban Disturbance In Wetlands. Principal investigator and data analyst for wetland IBI (indices of biological integrity) development in Ramsey-Washington Metro watershed district, MN. Dr. Zheng performed data analyses to identify an urban disturbance gradient using landscape disturbance intensity (LDI) index; He also applied multivariate statistical approaches to identify the main stressors that impact plant and macroinvertebrate communities in the urban wetlands. Based on the analyses, he developed both plant and macroinvertebrate IBIs to indicate the conditions of urban wetlands.

Using Field Data to Derive An Aquatic Life Benchmark For Conductivity. Contracted by National Center for Environmental Assessment (NCEA), USEPA to develop methodologies to derive conductivity criteria for mountain top mining (MTM) impacted regions in the U.S. Dr. Zheng explored numerous statistical methods, including weighted average, weighted/un-weighted cumulative distribution function(CDF), linear and quadratic logistic regression (Generalized Linear Models, GLM), and generalized addictive models, by using macroinvertebrate species compositional data and a number of environmental variables to derive numerous benchmark for conductivity. The final product is a report adapting the standard U.S. EPA methodology (species sensitive distribution) for deriving ambient water quality criteria. The method is applied to derive effect benchmarks for dissolved salts as measured by conductivity in Central Appalachian

streams using data from West Virginia and Kentucky. Upon request from USEPA region 3 and the states, Dr. Zheng has adapted this methodology to derive for water quality benchmarks for Tennessee and Ohio.

Florida Nutrient Criteria Development. As part of the EPA teams, Dr. Zheng is actively involved in an ongoing process of developing nutrient criteria for Florida's lakes and streams. Dr. Zheng reviewed and analyzed datasets for Florida's lakes and streams and provided valuable comments and suggestions to EPA for revising and finalizing Florida's criteria documents. He applied various statistical techniques (Regression analyses, change point analysis, hierarchical (mixed) models etc.) and scientific expertise to help EPA derive the final criteria.

Clermont County Watershed Management. Provided assistance on development of a community-led TMDL for Little Miami River watershed in Clermont County, Ohio. Dr. Zheng participated this multi-year project to develop and implement a comprehensive water resources management program for the county. He conducted statistical analysis to develop stressor end points (habitat, nutrients, and hydrological stressors) and provided recommendations for management.

Method Evaluation for Effluent Toxicity Test. A project sponsored by USEPA office of Wastewater Management to evaluate statistical methodologies of Effluent Toxicity Test using various techniques. Dr. Zheng evaluated statistical properties (Type I and Type II errors) of a number of testing methods (Ceriodaphnia, fish, sea urchin, etc reproduction and survival data) and determined a balance of different error rates based on risk assessment decisions. Numerous simulation models have been developed to test these methods using R.

N-STEP Support: Nutrient Endpoint Development for Various States. Dr. Zheng provided technique support through Tetra Tech's nutrient center (Office of Wastewater Management) to help states to develop scientificly defensible nutrient criteria for lakes and streams. Dr. Zheng has helped review nutrient criteria guidance for various states, including Maine, Ohio, and Minnesota. Dr. Zheng also applied statistical methodology to derive numeric nutrient endpoints for waterbodies in various regions of Kentucky, West Virginia, and Montana. In order to more effectively conduct statistical analysis for similar sets of data from different regions and states, Dr. Zheng developed a statistical package using R programming to perform the main approaches commonly used for nutrient criteria development: summary statistical analysis, scatter plots and LOWESS regression, conditional probability analysis, change point analysis, uncertainty analysis, propensity function for covariance, and hypothesis testing. Dr. Zheng has also directed usages of the application for develop nutrient endpoints for Illinois, Indiana, Delaware, and other states.

Nutrient Target for Northern Piedmont Ecoregion in PA. 2007. The goal of this project was to develop nutrient TMDL targets for six watersheds in Southeast Pennsylvania, a project sponsored by EPA region 3. Due to limited sample size and data availability, Dr. Zheng expanded his analysis to the Northern Piedmont Ecoregion by collecting data from PA, NJ and MD. Dr. Zheng and colleagues used a Weighted Evidence Approach from multiple sources to develop nutrient targets for this region, including reference approach, stressor-response approach, modeling approach, and literature reviews. He applied a number of statistical techniques, e.g., regression tree, linear regression. He used both algal and macroinvertebrate metrics to examine biological condition gradients for the analysis.

Nutrient Criteria Development for Wadeable and Non-Wadeable Streams In The State Of Mississippi. The goal of this project was to develop scientific defensible nutrient criteria for both wadeable and non-wadeable streams. Dr. Zheng took on the majority of the tasks of this project include: 1. Building a comprehensive database with existing nutrient and biological data (mostly macroinvertebrates); 2. Classifying streams and defining reference conditions for each class; he developed three stream classes (minimally disturbed, least disturbed, and biological attained reference conditions. 3. Using scientific approaches to analyze data to reach nutrient end points; He used a number of statistical approaches (change point analysis, LOWESS regression, and biological indicators to identify thresholds. 4. Making sure criteria are comparable across waterbodies.

Excel Statistical Tools for Wastewater Effluent Toxicity Test. A project sponsored by USEPA office of Wastewater Management to develop a statistical tool which performs various statistic tests for WET test. Dr. Zheng directed and implemented adapting these statistic techniques, including Shapiro-Wilkes normality test, Bartlett's Test of Homogeneity, Levy's multiple comparison of variance, Dunnett's multiple comparison and t-test with Bonferroni's adjustment, nonparametric Steel's many one multiple comparisons and Wilcoxon rank sum test, Fisher's exact test, and linear interpolation of IC25 into the spreadsheet tool. The tool would allow users select one WET test methods from a total of 20 WET test types, input WET test data, run through these statistical methods, and view statistical output and graphs automatically.

TETRA TECH

Rui Zou, PhD

Senior Water Resource Engineer

EDUCATION

Ph.D., Environmental Engineering, University of Virginia, 2002

M.S., Environmental Chemistry (Systems), Peking University, China, 1998

B.S., Ecology and Environmental Sciences, Yunnan University, China, 1990

YEARS OF EXPERIENCE

Tetra Tech: 11

Total: 16

PROFESSIONAL AFFILIATIONS

American Society of Limnology and Oceanography

American Geophysical Union

American Society of Civil Engineers (ASCE)

AREAS OF EXPERIENCE

- Hydrodynamic and Water Quality Modeling
- Environmental System Analysis
- Watershed Planning and Optimization
- Linear and Non-linear Programming
- Uncertainty Based Decision-Making
- Numerical Model Development
- Modeling Algorithm Development

Dr. Zou is a senior scientist in the areas of environmental sciences/engineering and water resources, specializing in integrated watershed management, hydrodynamic and water quality modeling, toxics and sediment transport modeling, large scale watershed simulation-optimization analysis, watershed hydrology and pollutant modeling, regional water resource development and pollution control, environmental system analysis, and uncertainty and risk assessment.

He has extensive experience with developing, enhancing and applying a wide range of sophisticated water quality modeling systems including USEPA's Environmental Fluids Dynamics Code (EFDC), Water Quality Simulation Program (WASP), Loading Simulation Program in C++ (LSPC) watershed modeling system, QUAL-2E, QUAL-2K, and U.S. Army Corp's CE-QUAL-W2, RMA-2, RMA-11. He has developed a large number of complicated computational modules in these modeling systems to enhance the capability of representing real world systems. Examples of these efforts include enhancement of EFDC with high complexity level eutrophication kinetics, nitrogen fixing and luxury phosphorus uptake algorithms, advanced sediment diagenesis-macrophyte-phytoplankton interaction modules, coupling sediment deposition-resuspension computation with sediment diagenesis modules, direct differential analysis module, and a general bacteria modeling system.

Project Experience

Integrated Hydrodynamic and Nutrient-Periphyton TMDL Modeling for Wissahickon, PA. Developed sophisticated hydrodynamic, nutrient fate and transport, phytoplankton and periphyton simulation modeling system for Wissahickon Creek. Enhanced EFDC with a comprehensive periphyton simulation module, which enables simultaneous simulation of the interactions of two periphyton species with temperature, nutrient, light, and phytoplankton. Conducting model calibration against observed data of DO, NH4, NO3, TKN, TN, BOD, PO4, TP, phytoplankton, and periphyton biomass. Conducting nutrient reduction scenario analysis for TMDL development.

Linked Hydrodynamic and TMDL Water Quality Modeling for the Appoquinimink River, DE. Provided technical support to USEPA Region 3 and DNREC for the TMDL development of Appoquinimink River. Developed an enhanced WASP/EUTRO code with predictive sediment diagenesis modules. Fixed errors in the model previously developed. Updated the hydrodynamic model for Appoquinimink River based on the DYNHYD framework. Developed a dynamic water quality model simulating mass transport, nutrient cycling, algae dynamics, and sediment diagenesis for the river. Implemented pollution control scenario analysis and TMDL development.

Nested Hydrodynamic and Bacteria Fate and Transport Modeling for San Diego Bay and Beaches, CA. Provided technical support to San Diego RWQCB and USEPA Region 9 to develop an integrated hydrodynamic and bacteria fate and transport model for San Diego Bay based on the EFDC modeling framework; developed a series of nested hydrodynamic models to represent the water circulation patterns in San Diego Bay as well as five beach areas in the Bay; developed five beach area hydrodynamic and bacteria fate and transport models to implement bacteria source-response analysis.

Optimal Bacteria TMDL for City of San Diego. Developed a large-scale simulation-optimization modeling system for the City's watersheds, incorporating the full scale hydrological, sediment and fecal coliform simulation model into a

NIMS-based high-performance optimization framework for developing optimal load allocation across the near 800 subwatersheds to achieve the compliance of water quality.

Simulating Nutrient-Algae-DO Dynamics and Evaluating Watershed Development and Management alternatives for Lake Maumelle, AR. Provided technical support to Central Arkansas Waters (CAW) for the effort of lake water quality protection and watershed management; developed a luxury uptake module for phytoplankton and periphyton/macrophyte and incorporated it into the source code to simulate spatially temporal variable algal phosphorus composition in response to water column phosphate concentration; developed an integrated hydrodynamic and eutrophication simulation model based on the CE-QUAL-W2 modeling framework for the lake; conducted watershed pollutant impact analysis in support of the development of management schemes for protecting the water quality in this primary drinking water source.

Three-Dimensional Hydrodynamic and Power Plant Thermal Discharge Impact Modeling and TMDL Development for Indian River Bay, DE. Provided technical support to USEPA Region 3 and the Delaware Department of Natural Resource and Environmental Control (DNREC) for the effort of developing thermal TMDL for the Indian River Bay; developed a three-dimensional modeling system for the Bay, and calculated a TMDL to ensure environmental compliance in terms of excessive temperature, which can have severe impact on the aquatic ecological system.

Integrated Hydrodynamic and Water Quality Modeling for Supporting TMDL Development of Wissahickon Creek Basin, PA. Provided technical support to USEPA Region 3 and the Pennsylvania Department of Environmental Protection (PADEP) to develop a hydrodynamic model for Wissahickon Creek basin, including enhanced WASP/EUTRO water quality model with real-time visualization, a full periphyton-DO interaction module, and DO diurnal simulation module. Enhanced the linking interface between EFDC and WASP to integrate the hydrodynamic model with the water quality model. Developed a water quality modeling system for the entire basin based on the enhanced WASP/EUTRO modeling framework. Developed an automatic TMDL tool for the linked hydrodynamic and water quality modeling system. Implemented pollution control scenario analysis and TMDL development.

Modeling Famosa Slough for Watershed Management and Lagoon Ecological Restoration Analysis. Developed an integrated hydrodynamic and water quality EFDC model for Famosa Slough, a shallow tidal-influenced coastal lagoon in San Diego, CA. Simulating the complex dynamics involving the interaction of fresh water and salt water, culvert, growth and metabolism of floating macroalgae, benthic macroalgae, and phytoplankton, as well fate and transport of nutrients. Developed the model with predictive capability that dynamically tracks deposition of particulate organic matters to bed sediment and the sediment diagenesis process in the bed that generates benthic nutrient flux and sediment oxygen demand (SOD). Developed the model for evaluating various management scenarios, including watershed load reduction, macroalgae harvesting, dredging, and change of culvert configuration, and the corresponding water quality responses in the lagoon.

Watershed-wide Optimal Planning for BMP Placement in Los Peñasquitos Watershed, San Diego, CA. Developed an interactive decision support modeling system, coupling watershed scale quadratic programming model and smaller scale SUSTAIN models to conduct optimal BMP placement planning for Los Pen watershed. The model considers the different cost-effectiveness of various non-structural and structural BMPs and the equity constraints between different jurisdictions and obtains the optimal implementation strategy through interactively solving the modeling systems to meet the pollutant loading target in the watershed.

Watershed-wide Optimal Planning for BMP Placement in Chollas Creek Watershed, San Diego, CA. Developed an interactive decision support modeling system, coupling watershed scale quadratic nonlinear programming model and smaller scale SUSTAIN models to conduct optimal BMP placement planning for Chollas Creek watershed. The model considers the different cost-effectiveness of various non-structural and structural BMPs and the nonlinear interactions between centralized and distributed BMPs, accounts for the equity constraints between different jurisdictions, and obtains the optimal implementation strategy through interactively solving the modeling systems to meet the pollutant loading target in the watershed.

Integrated Hydrodynamic and Water Quality Modeling for the Susitna River, Alaska. Developing an integrated hydrodynamic and water quality modeling system for the Susitna River. Developed fate and transport simulation modules within EFDC to simulate the fate and transport of multiple species of Hg and various processes, including adsorption/desorption with sediment, mythylation, demythylation, oxidation, reduction, and volatization. The model simulated flow, temperature, nutrients, algae, and toxics (including Hg) in a fully dynamic fashion used to evaluate the water quality consequences of a proposed power generation dam.