The following documentation is an electronically-submitted vendor response to an advertised solicitation from the *West Virginia Purchasing Bulletin* within the Vendor Self-Service portal at ***wvOASIS.gov***. As part of the State of West Virginia's procurement process, and to maintain the transparency of the bid-opening process, this documentation submitted online is publicly posted by the West Virginia Purchasing Division at ***WVPurchasing.gov*** with any other vendor responses to this solicitation submitted to the Purchasing Division in hard copy format.

Header 1

List View

General Information | Contact | Default Values | Discount | Document Information | Clarification Request

Procurement Folder: 1289039
Procurement Type: Central Purchase Order
Vendor ID: 000000232671
Legal Name: TETRA TECH INC
Alias/DBA:
Total Bid: $0.00
Response Date: 10/23/2023
Response Time: 13:32
Responded By User ID: jfwbeckman
First Name: John
Last Name: Beckman
Email: john.beckman@tetratech.cor
Phone: 681-313-4276

SO Doc Code: CEOI
SO Dept: 0313
SO Doc ID: DEP2400000009
Published Date: 9/27/23
Close Date: 10/24/23
Close Time: 13:30
Status: Closed
Solicitation Description: EOI - TMDL SEEPS
Total of Header Attachments: 1
Total of All Attachments: 1

Department of Administration
Purchasing Division
2019 Washington Street East
Post Office Box 50130
Charleston, WV 25305-0130

State of West Virginia
Solicitation Response

Proc Folder:	1289039
Solicitation Description:	EOI - TMDL SEEPS
Proc Type:	Central Purchase Order

Solicitation Closes	Solicitation Response	Version
2023-10-24 13:30	SR 0313 ESR10232300000001952	1

VENDOR

000000232671
TETRA TECH INC

Solicitation Number: CEOI 0313 DEP2400000009

Total Bid: 0 **Response Date:** 2023-10-23 **Response Time:** 13:32:30

Comments:

FOR INFORMATION CONTACT THE BUYER
Joseph E Hager III
(304) 558-2306
joseph.e.hageriii@wv.gov

Vendor
Signature X **FEIN#** **DATE**

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

Line	Comm Ln Desc	Qty	Unit Issue	Unit Price	Ln Total Or Contract Amount
1	Professional engineering services				

Comm Code	Manufacturer	Specification	Model #
81100000			

Commodity Line Comments: EOI response

Extended Description:

Provide Total Maximum Daily Loads (TMDLs) for Selected Elk River and Eastern Panhandle Streams (SEEPS)

Department of Administration
Purchasing Division
2019 Washington Street East
Post Office Box 50130
Charleston, WV 25305-0130

State of West Virginia
Centralized Expression of Interest
Architect/Engr

Proc Folder: 1289039 **Doc Description:** EOI - TMDL SEEPS **Proc Type:** Central Purchase Order			**Reason for Modification:**
Date Issued	**Solicitation Closes**	**Solicitation No**	**Version**
2023-09-27	2023-10-24 13:30	CEOI 0313 DEP2400000009	1

BID RECEIVING LOCATION

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

VENDOR

Vendor Customer Code: 000000232671

Vendor Name : Tetra Tech, Inc.

Address :

Street : 10306 Eaton Place, Suite 340

City : Fairfax

State : Virginia **Country :** USA **Zip :** 22030

Principal Contact : Jon Ludwig

Vendor Contact Phone: 703-385-1973 **Extension:**

FOR INFORMATION CONTACT THE BUYER
Joseph E Hager III
(304) 558-2306
joseph.e.hageriii@wv.gov

Vendor Signature X  **FEIN#** 954148514 **DATE** October 12, 2023

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

ADDITIONAL INFORMATION

The Acquisitions and Contract Administration Section of the Purchasing Division ("Purchasing Division") is soliciting Expression(s) of Interest for the West Virginia Department of Environmental Protection (WVDEP), from qualified firms to provide architectural/ engineering services to provide Total Maximum Daily Loads (TMDLs) for selected impaired streams in the Upper Elk River watershed and Eastern Panhandle area in West Virginia per the attached specifications and terms and conditions.

INVOICE TO	SHIP TO
ENVIRONMENTAL PROTECTION DIV OF WASTE AND WATER MGT 601 57TH ST SE CHARLESTON WV 25304 US	ENVIRONMENTAL PROTECTION DIVISION OF WATER AND WASTE MGT 601 57TH ST SE CHARLESTON WV 25304 US

Line	Comm Ln Desc	Qty	Unit Issue
1	Professional engineering services		

Comm Code	Manufacturer	Specification	Model #
81100000			

Extended Description:
Provide Total Maximum Daily Loads (TMDLs) for Selected Elk River and Eastern Panhandle Streams (SEEPS)

SCHEDULE OF EVENTS

Line	Event	Event Date

DESIGNATED CONTACT: Vendor appoints the individual identified in this Section as the Contract Administrator and the initial point of contact for matters relating to this Contract.

(Printed Name and Title) John Beckman, Project Manager

(Address) 1538 Kanawha Blvd E., Suite 110, Charleston, WV 25311

(Phone Number) / (Fax Number) Phone 681-313-4276 / Fax 703-385-6007

(email address) john.beckman@tetratech.com

CERTIFICATION AND SIGNATURE: By signing below, or submitting documentation through *wv*OASIS, I certify that: I have reviewed this Solicitation/Contract 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/Contract 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 this bid or offer was made without prior understanding, agreement, or connection with any entity submitting a bid or offer for the same material, supplies, equipment or services; that this bid or offer is in all respects fair and without collusion or fraud; that this Contract is accepted or entered into without any prior understanding, agreement, or connection to any other entity that could be considered a violation of law; 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.

By signing below, I further certify that I understand this Contract is subject to the provisions of West Virginia Code § 5A-3-62, which automatically voids certain contract clauses that violate State law; and that pursuant to W. Va. Code 5A-3-63, the entity entering into this contract is prohibited from engaging in a boycott against Israel.

Tetra Tech, Inc.

(Company)

(Signature of Authorized Representative)

Jon C. Ludwig, Director October 12, 2023

(Printed Name and Title of Authorized Representative) (Date)

Phone 703-385-1973 Fax 703-385-6007

(Phone Number) (Fax Number)

jon.ludwig@tetratech.com

(Email Address)

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

October 24, 2023
_____
Date

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

CERTIFICATE OF LIABILITY INSURANCE

DATE(MM/DD/YYYY)
10/06/2023

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 have ADDITIONAL INSURED provisions or 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:

INSURER(S) AFFORDING COVERAGE		NAIC #
INSURER A:	American International Group UK Ltd	AA1120187
INSURER B:	Allied World Surplus Lines Insurance Co	24319
INSURER C:	Zurich American Ins Co	16535
INSURER D:		
INSURER E:		
INSURER F:		

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

COVERAGES **CERTIFICATE NUMBER:** 570102137003 **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	
C	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:	Y	Y	GLO181740605	10/01/2023	10/01/2024	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 $2,000,000 $2,000,000
C	**AUTOMOBILE LIABILITY** X ANY AUTO OWNED AUTOS ONLY HIRED AUTOS ONLY SCHEDULED AUTOS NON-OWNED AUTOS ONLY	Y	Y	BAP 1857085 05	10/01/2023	10/01/2024	COMBINED SINGLE LIMIT (Ea accident) BODILY INJURY (Per person) BODILY INJURY (Per accident) PROPERTY DAMAGE (Per accident)	$2,000,000
A	X **UMBRELLA LIAB** X OCCUR **EXCESS LIAB** CLAIMS-MADE DED X RETENTION $100,000			62785232	10/01/2023	10/01/2024	EACH OCCURRENCE AGGREGATE	$2,000,000 $2,000,000
C C	**WORKERS COMPENSATION AND EMPLOYERS' LIABILITY** ANY PROPRIETOR / PARTNER / EXECUTIVE OFFICER/MEMBER EXCLUDED? Y / N: N **(Mandatory in NH)** If yes, describe under DESCRIPTION OF OPERATIONS below	N / A	Y AOS Y	WC254061605 WC185708705 WI	10/01/2023 10/01/2023	10/01/2024 10/01/2024	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
B	Environmental Contractors and Prof			03120276 Prof/Poll-Claims Made Cov SIR applies per policy terms & conditions	10/01/2023	10/01/2024	Each Claim Aggregate	$2,000,000 $2,000,000

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

West Virginia Department of Environmental Protection is included as Additional Insured in accordance with the policy provisions of the General Liability and Automobile Liability policies as required by written contract. A Waiver of Subrogation is granted in favor of West Virginia Department of Environmental Protection in accordance with the policy provisions of the General Liability, Automobile Liability and Workers' Compensation policies as required by written contract. Stop Gap Coverage for the following states: OH, ND, WA, WY.

CERTIFICATE HOLDER

West Virginia Department
of Environmental Protection
601 57th St.
Charleston WV 25304 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

DocuSigned by:
A98876D2EBAA46D...

Holder Identifier : 131
Certificate No : 570102137003

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

PROJECT NAME	DATE (DAY, MONTH, YEAR)	FEIN
TMDL Development for Selected Elk River watershed and Eastern Panhandle area Streams	24, October, 2023	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

1538 Kanawha Blvd E, Suite 110 / (681)313-4276 / John Beckman, Project Manager / 2 TMDL development personnel in office
Charleston, WV 25311

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

9. PERSONNEL BY DISCIPLINE

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

26 TOTAL PERSONNEL

Note: If needed, Tetra Tech has over 20 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.

The table below displays the total recoverable metals TMDLs developed by Tetra Tech and USEPA approved or under development through task orders for WVDEP.

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)	USEPA Approved	232
D3 (Hughes River Watershed)	USEPA Approved	26
E3 (Upper Guyandotte Watershed)	USEPA Approved	235
E4 (Big Sandy, Lower Ohio, Twelvepole Watershed)	USEPA Approved	319
C4 (Lower Guyandotte Watershed)	USEPA Approved	273
C5 (Tug Fork Watershed)	USEPA Approved	238
D4 (Little Kanawha Watershed)	USEPA Approved	357
TOTAL WEST VIRGINIA RECOVERABLE METALS TMDLS DEVELOPED FOR WVDEP (SINCE 2002)		**3211**

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 include:

- Total Maximum Daily Loads for the Tygart Valley River Watershed, West Virginia, available online at: https://apps.dep.wv.gov/dwwm/TygartFinal2016/USEPAApprovedTygartPublicReportJune%202016_modified.pdf
- Total Maximum Daily Loads for the West Fork River Watershed, West Virginia, available online at: https://dep.wv.gov/WWE/watershed/TMDL/grpe/Documents/West%20Fork%202%20-%202014%20docs/USEPA%20Approved_E2_Public_Report_2014.pdf

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 2** 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. 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)	USEPA Approved	83
C3 (Meadow River)	USEPA Approved	7
E4 (Big Sandy, Lower Ohio, Twelvepole Watershed)	USEPA Approved	3
C4 (Lower Guyandotte Watershed)	USEPA Approved	2
C5 (Tug Fork Watershed)	USEPA Approved	11
D4 (Little Kanawha Watershed)	USEPA Approved	3
TOTAL WEST VIRGINIA pH/DISSOLVED METALS TMDLS DEVELOPED FOR WVDEP (SINCE 2002)		**495**

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.

- Total Maximum Daily Loads for the Meadow River Watershed, West Virginia, available online at: https://apps.dep.wv.gov/dwwm/FinalMeadow/USEPA%20Approved_Meadow_River_Public_Report_Nov%202016.pdf
- Total Maximum Daily Loads for the Tygart Valley River Watershed, West Virginia, available online at: https://apps.dep.wv.gov/dwwm/TygartFinal2016/USEPAApprovedTygartPublicReportJune%202016_modified.pdf

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 2** 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.

The table below displays the fecal coliform TMDLs developed by Tetra Tech and USEPA 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)	USEPA Approved	117
C3 (Meadow River, Rocky Marsh Run, Warm Spring Run)	USEPA Approved	19
D3 (Hughes River Watershed and Monongahela River mainstem)	USEPA Approved	95
E3 (Upper Guyandotte Watershed)	USEPA Approved	103
E4 (Big Sandy, Lower Ohio, Twelvepole Watershed)	USEPA Approved	184
C4 (Lower Guyandotte Watershed)	USEPA Approved	183
C5 (Tug Fork Watershed)	USEPA Approved	214
D4 (Little Kanawha Watershed)	USEPA Approved	130
TOTAL WEST VIRGINIA FECAL COLIFORM TMDLS DEVELOPED FOR WVDEP (SINCE 2002)		**2132**

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.

- Total Maximum Daily Loads for the Hughes River Watershed, West Virginia, available online at: https://dep.wv.gov/WWE/watershed/TMDL/grpd/Documents/D3%20Little%20Kanawha%20Hughes%20River/USEPA_Approved_Hughes_Public_Report_2018_09_28.pdf
- Total Maximum Daily Loads for the Tygart Valley River Watershed, West Virginia, available online at: https://apps.dep.wv.gov/dwwm/TygartFinal2016/USEPAApprovedTygartPublicReportJune%202016_modified.pdf

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 2** 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). 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 continued to be performed under WVDEP supervision.

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
D3 (Hughes River Watershed)			45
E3 (Upper Guyandotte Watershed)			134
TOTAL WEST VIRGINIA TMDLS DEVELOPED FOR WVDEP (SINCE 2002)		**376**	**869**

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.

- Total Maximum Daily Loads for Selected Streams in the Elk River Watershed, West Virginia, available online at: https://dep.wv.gov/WWE/watershed/TMDL/grpb/Documents/Elk_TMDL_B2_2011/Elk_Approved_Docs_2012/FINAL_Approved_Elk_TMDL_Report_6_6_12.pdf

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 2** of the proposal that accompanies this questionnaire.

12. E. Is your firm experienced in development of TMDLs for nutrients?
YES

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

Waterbody/State	Impairment	Status	Nutrient TMDLs
Rainbow Lake, AZ	nutrients, DO, 1999	USEPA Approved	1
Luna Lake, AZ	nutrients, DO, 1999	USEPA Approved	1
Wissahickon Creek, PA	nutrients, DO, 2003, 2015	USEPA Approved 2003, Draft 2015	1
Pend Oreille Lake, ID	eutrophication, 2002	USEPA Approved	1
Kokomo Creek, IN	DO, CBOD, NH3-N, phosphorus, 1999	USEPA Approved	2
Rocky River, OH	nutrients, 1999	USEPA Approved	1
Green Lane Reservoir, PA	nutrients, DO, 2003	USEPA Approved	1
Lake Nockamixon, PA	nutrients	USEPA Approved	1
Conodoguinet Creek, PA	phosphorus, 2000	USEPA Approved	9
Chartiers Creek, PA	nutrients, organic enrichment/DO, habitat/flow alter, pH, 2002	USEPA Approved	1
East Canyon Creek, UT	phosphorus, 1999	USEPA Approved	1
Turkey Run Lake, WV	nutrients, siltation, Fe, Al, 6/1999	USEPA Approved	1
Castleman Lake, WV	nutrients, siltation, 6/1999	USEPA Approved	1
Bear Lake, WV	nutrients, siltation, DO, 6/1999	USEPA Approved	1
Burches Run Lake, WV	nutrients, siltation, 9/1998	USEPA Approved	1
Hurricane Lake, WV	Fe, nutrients, sediment, 1999	USEPA Approved	1
Ridenour Lake, WV	nutrients, siltation, Fe, Al, 6/1999	USEPA Approved	1
TOTAL NUTRIENT TMDLS DEVELOPED (SINCE 1998)			**26**

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

12.E.2 Provide an example of a USEPA approved TMDL for nutrients to address dissolved oxygen impairments (nitrogen or phosphorus based).

- Total Maximum Daily Load For Sediment and Nutrients Wissahickon Creek Watershed, Pennsylvania, 2003 USEPA approved TMDL available online at: https://boroughofambler.com/download/stormwater_management/related_documents/WissahickonTMDL_Report.pdf
- Total Phosphorus TMDL for the Wissahickon Creek Watershed, Pennsylvania, 2015 update remains in draft status, available online at: https://www.epa.gov/tmdl/proposed-wissahickon-creek-phosphorus-tmdl
- Total Maximum Daily Load of Nutrients for Green Lane Reservoir, Montgomery County, PA, 2003 USEPA approved TMDL available online at: https://www.dep.state.pa.us/dep/deputate/watermgt/wqp/wqstandards/tmdl/GreenlaneReservoir_TMDL.pdf

12.E.3 Provide a detailed description of the methodology to develop a nutrient TMDL as per the EOI.

A detailed description of the nutrient TMDL methodology is presented in **Section 2** of the proposal that accompanies this questionnaire.

12. F. Is your firm experienced in development of Adaptive Management Plans or Watershed-based plans or Implementation Plan?

YES

12.F.1 Provide Names and Number of Projects

Piney Creek Watershed Plan (1), Raleigh County, WV, 2012
Watershed Restoration and TMDL Implementation Planning (6), Prince George's County, MD, 2014-present
Western Hills Watershed Management Plan, Loudoun County (1), VA, 2019
Pennsylvania 319 Watershed Implementation Plan Updates (3), Lancaster County, Schuylkill and Allegheny Counties, PA, 2021

12.F.2 Provide an example of a USEPA or State approved implementation plan for any pollutant.

- Piney Creek Watershed Plan, revised 2012, available online at: https://dep.wv.gov/WWE/Programs/nonptsource/WBP/Documents/WP/PineyCreekWBP.pdf

12.F.3 Provide a detailed description of the methodology to develop an implementation plan.

A detailed description of the Watershed-based Plan methodology is presented in **Section 2.H** of the proposal that accompanies this questionnaire.

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

Working directly with WVDEP for 20 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:

- $9.5M over 15 task orders
- No budget overruns or requested change orders
- Constantly developing tools to improve efficiency and reduce costs

A detailed description of Tetra Tech's management capabilities and available resources to support this project is presented in **Section 1** of the proposal that accompanies this questionnaire.

12. H. 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 2** and five examples that demonstrate successful application of LSPC/MDAS include:

- Total Maximum Daily Loads for the Hughes River Watershed, West Virginia
- Total Maximum Daily Loads for the Meadow River Watershed, West Virginia
- Total Maximum Daily Loads for the Tygart Valley River Watershed, West Virginia
- Total Maximum Daily Loads for the West Fork River Watershed, West Virginia
- Total Maximum Daily Loads for Selected Streams in the Elk River Watershed, West Virginia

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	28	28	28

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 American Society of Civil Engineers

REGISTRATION (Type, Year, State) 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.	23	23	23

Brief Explanation of Responsibilities

Mr. Ludwig will support Mr. Beckman 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 Mr. Beckman 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 American Water Resource Association. Water Environment Federation.

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…
Beckman, John, F.	18	18	18

Brief Explanation of Responsibilities

Mr. Beckman will serve as the local day-to-day point of contact to WVDEP. He will staff projects and maintain communication between all parties. Mr. Beckman will continue to provide leadership for all tasks associated with bacteria TMDLs under this contract, coordinating technical tasks closely with the Program Manager. Mr. Beckman will also work with WVDEP TMDL staff to refine technical approaches for all WV TMDLs under development.

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…
Smith, Jonathan, P.E.	15	15	15

Brief Explanation of Responsibilities

Mr. Smith will support Mr. Ludwig and Mr. Beckman 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, Ph.D., P.E.	19	19	19

Brief Explanation of Responsibilities

Dr. Bai will provide support for tasks associated with nutrient and dissolved oxygen modeling, coordinating technical tasks closely with the Project Manager. He will also support Ms. Mellors to develop and refine sediment and total metals modeling approaches using MDAS.

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	In EPA-approved TMDL development
Mellors, Christina, E.	21	21	21

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, Tan Zi, and Sen Bai 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	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…
Zi, Tan, Ph.D., P.E.	9	9	9

Brief Explanation of Responsibilities

Dr. Zi will lead tasks associated with Dissolved Metals/pH TMDLs under this contract. Dr. Zi will also work closely with the project and program managers, as well as Ms. Mellors and Sen Bai to provide technical solutions for dissolved metals/acidity and total metals/sediment modeling issues.

EDUCATION (Degree, Year, Specialization)
Ph.D., 2016, Civil/Environmental Engineering
M.S., 2006, Meteorology
B.S., 2004, Applied Meteorology

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS None

REGISTRATION (Type, Year, State) Professional Engineer, 2018, Virginia #040259494

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…
Allen, Diane, M.E.M, M.D.	8	8	8

Brief Explanation of Responsibilities

Dr. Allen’s work will focus on identifying environmental stressors impairing biological condition of macroinvertebrates and fish in West Virginia streams to support the Stressor Identification process, or if necessary, help the WVDEP develop Total Maximum Daily Loads for biologically impaired streams.

EDUCATION (Degree, Year, Specialization)
M.E.M., 2014, Environmental Management
M.D., 1995, Medicine
B.S., 1991, Molecular Biology and Mathematics

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 7225i Printer/Copier	1

Database Software*

- Oracle 11g/12g
- Microsoft Office 2016/365
- Microsoft Project 2016/365
- MS Office One Note 2016
- MS SharePoint 2016

*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 10.8	5
ESRI ArcGIS Desktop Standard 10.8	5
ESRI ArcGIS Desktop Basic 10.8	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 E5 Watershed (Cacapon River Watershed)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304	Prime Contractor - TMDL Development Lead	$338,603.00	8%
West Virginia Ionic Toxicity TMDLs for the Lower Guyandotte Watershed	USEPA Region 3, Four Penn Center 1600 John F Kennedy Blvd Philadelphia, PA 19103-28523	Prime Contractor - TMDL Development Lead	$838,964.89	80%
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, Four Penn Center 1600 John F Kennedy Blvd Philadelphia, PA 19103-28524	Prime Contractor	$703,526.24	76%
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	$4,397,093.77	92%
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	$516,464.00	40%
Illinois EPA – TMDL development and related support in Illinois (e.g., TMDL development, TMDL implementation)	Illinois EPA, 1021 North Grand Avenue East, Springfield, IL 62794	Prime Contractor	$456,642.20	99%
Mississippi DEQ - Water Quality Program Support	MS DEQ, 700 North State Street, Jackson, MS 39202	Prime Contractor	$1,599,775.54	78%
District of Columbia - Hydrodynamic, Water Quality, Contaminated Sediment Transport Modeling for the Anacostia River	District of Columbia, Department of Energy and Environment, 1200 First St NE, Washington, DC 20002	Prime Contractor	$1,715,665.65	94%

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
Massachusetts DEP - Water Quality Program Support	MassDEP, 8 New Bond Street, Worchester, MA 01606	Prime Contractor	$478,636.00	88%
Thermal, Salinity and Sediment Plume Modeling in the Gulf of Mexico (New Orleans, LA and Brownsville, TX)	New Fortress Energy, 111 W 19TH Street 2nd Floor, New York, NY 10011	Prime Contractor	$975,535.00	31%
City-Wide Stormwater Loading Model and Bow River TLMP Updates, Calgary, AB	City of Calgary, Resource Analysis - Environment Climate & Environment, Water Centre, 625 - 25 Ave SE, Calgary, AB T2G 4K8	Prime Contractor	$492,517.90	56%
EFDC Modeling of Tidal Delaware River System	Philadelphia Water Department, 1101 Market St. 4th Floor, Philadelphia, PA 19107	Prime Contractor	$200,000.00	0%
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	$9,312,779.35	99%

TOTAL NUMBER OF PROJECTS: 13

TOTAL ESTIMATED PROJECT COSTS: $22,026,203

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 D4 Watershed (Little Kanawha Watershed)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	$379,899.00	2023	Yes
TMDL Development for WV Group C5 Watershed (Tug Fork Watershed)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	$692,453.00	2023	Yes
TMDL Development for WV Group C4 Watershed (Lower Guyandotte Watershed)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	$502,994	2022	Yes
TMDL Development for WV Group E4 Watershed (Big Sandy, Lower Ohio, and Twelve Pole watersheds)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	$513,207	2021	Yes
TMDL Development for WV Group E3 Watershed (Upper Guyandotte River Watershed)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	$618,444	2021	Yes
EPA Region 9 - TMDL tracking and related support; NPDES pretreatment support in California; NPDES permit coding support in Hawaii	USEPA Region 9, 75 Hawthorne Street, San Francisco, CA 94105	$684,286.00	2017-2021	Yes
Monongahela River hydrodynamic and sediment transport modeling for the Big John's Salvage Superfund Site, Fairmont, WV	U.S. Army Corps of Engineers Buffalo District 1776 Niagara Street Buffalo, NY 14207	$164,807	2019-2021	Yes
Saddle River, NJ Nutrient and Dissolved Oxygen Modeling	USEPA Region 2,Ted Weiss Federal Building, 290 Broadway, New York, NY 10007	$167,900	2019-2022	Yes
Updating Pennsylvania 319 Watershed Implementation Plans, Lancaster County, Schuylkill and Allegheny Counties, PA	USEPA Region 3, Four Penn Center 1600 John F Kennedy Blvd Philadelphia, PA 19103-28524	$145,716	2019-2021	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?
Rancocas Creek Nutrient and Dissolved Oxygen Modeling, NJ	USEPA Region 2,Ted Weiss Federal Building, 290 Broadway, New York, NY 10007	$203,339	2022-2023	Yes
Hydrodynamic, Water Quality, Contaminated Sediment Transport Modeling for Willamette River and Portland Harbor, OR	ExxonMobil Global Service Company E&PS Environmental 2800 Decker Drive Baytown, TX 77520	$533,890	2019-2022	Yes
Lower Alamosa River Contaminated Sediment and Metals Modeling, Summitville, CO	Colorado Department of Public Health and Environment 4300 Cherry Creek Drive South Denver, CO 80246	$172,173	2022-2023	Yes
Western Hills Watershed Management Plan, Loudoun County, VA	Loudoun County Government Department of Building & Development, Natural Resources Division 1 Harrison St, MC #60 Leesburg, VA 20175	$190,000	2018-2019	N/A
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, Four Penn Center 1600 John F Kennedy Blvd Philadelphia, PA 19103-28524	$5,460,652	2018-2023	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	$2,735,601	2018-2023	Yes

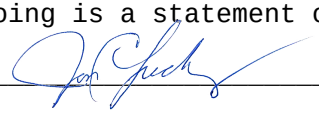
18. COMPLETED WORK WITHIN LAST 5 YEARS ON WHICH YOUR FIRM HAS BEEN A SUB-CONSULTANT TO OTHER FIRMS (INDICATE PHASE OF WORK FOR WHICH YOUR FIRM WAS RESPONSIBLE)

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 7,000 USEPA 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 5,600 of the TMDLs have been developed directly supporting WVDEP with 34 TMDLs currently under development.

20. The foregoing is a statement of facts.

Signature:  Title: Director

Date: October 12, 2023

Printed Name: Jon C. Ludwig

Expression of Interest to Provide Professional Engineering Services for Total Maximum Daily Loads in Selected Elk River Watershed and Eastern Panhandle Area Streams

CEOI 0313 DEP2400000009

Submitted by:

Tetra Tech, Inc.
1538 Kanawha Blvd E
Suite 110
Charleston, West Virginia 25311

Submitted to:

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

CONTENTS

I. 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.

I.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 450 offices with over 21,000 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, Tetra Tech was ranked 1st in the top U.S. water firms by *Engineering News-Record* for 20 consecutive years. Tetra Tech also was ranked #1 in Wind Power, Water Treatment and Desalination, and Environmental Management. In addition, *Engineering News-Record* ranked Tetra Tech #7 in their "The Top 200 Environmental Firms" and #4 overall in their "The Top 500 Design Firms" issues.

Key Environmental Services of Tetra Tech's Integrated Watershed Management group

- 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 Integrated Watershed Management (IWM) group 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 IWM has supported USEPA's watershed and water quality programs, through multiple contract re-competes. In addition to our national role in developing watershed and water quality management tools and practices, IWM 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, IWM has grown and located offices across the United States, all reporting to central management in IMW's headquarters in Fairfax, Virginia. Our success demonstrates our ability to adapt to our clients' needs. For example, IWM 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 $9.5 million worth of work directly for WVDEP, resulting in more than 5,600 approved TMDLs in addition to over 500 ongoing TMDLs.

Our Charleston, West Virginia office will be the primary office for this project and will be supported by more than 30 staff members in our Integrated Watershed Management group reporting to Fairfax, Virginia; as well as staff specialized in ecological studies from Owings Mills, Maryland as necessary. Resources and equipment available to support this project are described in the following section (I.B. Resources).

I.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 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. Teleconferencing and web conferencing can be arranged on demand using Microsoft® Teams.

Tetra Tech maintains state-of-the-art computing facilities, equipment, and software (Tables I-B-1 through I-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 I-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 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, 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 can produce 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 I-B-1. 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 offices, including the Charleston, WV location.

Software applications used by Tetra Tech for statistical, database and web development are listed in Table I-B-2, for computer programming are listed in Table I-B-3, for GIS development and data processing are listed in Table I-B-4 and for environmental modeling are listed in Table I-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 10.8, 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 Water Quality Portal (WQP) and U.S. Geological Survey's (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.

Table I-B-1. 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 Internet Server with FTP and Web Site Support	12
Linux Internet Server with FTP and Web Site Support	15
Hewlett-Packard DesignJet T1200 PostScript 42-inch plotter	1
Xerox ColorCube Printers / Copiers	2
Xerox WorkCenter Printer / Copiers	3

Table I-B-2. Statistical, Database, and Web Development Software Packages

Database Software	Statistical Software	Web Development Software
▪ Oracle 11g/12c ▪ MySQL ▪ Postgres ▪ MS SQL Server 2008 R2 or later (2012, 2014, 2016) ▪ Microsoft Office 2016/365 ▪ Microsoft Project 2016/365 ▪ Microsoft Visual Studio 2013/2015 ▪ MS Visual Studio Ultimate 2013/2015 ▪ MS Office One Note 2016/365 ▪ MS SharePoint 2016	▪ Statistica 6.1 ▪ Mathematica ▪ Crystal Ball ▪ Delta Graph ▪ IMPLAN ▪ MathCAD ▪ PC-ORD ▪ R ▪ @Risk ▪ SAS IBM or SAS PC ▪ Sigma Stat ▪ SYSTAT	▪ AdobeDreamweaver CC 2017 ▪ Macromedia Studio MX ▪ Adobe Fireworks CS6 ▪ Adobe Flash CS5/CS6 ▪ Adobe Photoshop CC 2017 ▪ Oracle Jdeveloper ▪ ASP, ASP.NET ▪ ColdFusion ▪ HTML/HTML5 ▪ JavaScript ▪ PHP ▪ JSP ▪ Python/Django ▪ JAWS

Table I-B-3. Programming Language Compilers

Compilers		
▪ Intel Visual Fortran Compiler ▪ Sun Java Studio	▪ Pascal 7.0, DOS and Windows ▪ Visual C++ 14.0 ▪ Visual Studio v6.0 ▪ Visual Studio 2010, 2012, 2013, 2015 ▪ Borland C++ 5.5 ▪ Visual Basic 6.0	▪ Visual Source Café ▪ SPARC Works C++ ▪ Visual KAP Parallel Computing ▪ Oracle JBuilder ▪ Python

Table I-B-4. GIS Development and Data Processing Hardware and Software

Equipment	Quantity
IBM-Compatible Workstations/Laptops	220
40TB Mass Storage	4
Overland Tape Drive LTO-4 20TB	1
CD/DVD Writers	20
ESRI ArcGIS Desktop Advanced 10.8	7
ESRI ArcGIS Desktop Standard 10.8	24
ESRI ArcGIS Desktop Basic 10.8	7
ESRI ArcGIS 3D Analyst	1
ESRI Spatial Analyst 10	16
ArcGIS for Server Enterprise 10	2

Table I-B-5. 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, FEQ
Hydrodynamics	EFDC, CAFE, TEA, CE-QUAL-W2, TABS-2, FESWMS-2DH, DYNHYD5, MIT-DNM, RMA, FLO-2D
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, EPD-RIV1, HEC-5Q
Toxic Fate	TOX15, SMPTOX, RIVRISK, AMMTOX, TOXCALC
Sediment Transport and Scour	TABS-2, STUDH, HEC-6, QUASED, HEC-RAS, EFDC, HEC-2SR
Ground Water	MODFLOW, MOC, PLASM, Random Walk, GLEAMS

I.C. PERSONNEL

Tetra Tech will administer the proposed contract from the Charleston, WV office of Tetra Tech's TMDL and Water Resources Center. Figure I-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, John Beckman, is located in the Charleston, WV office. Other management staff (Program and Deputy Program Manager) are in our Fairfax, VA, office. For almost 20 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. Over 25 staff have contributed to the innovative technical approaches and designs for more than 5,600 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.

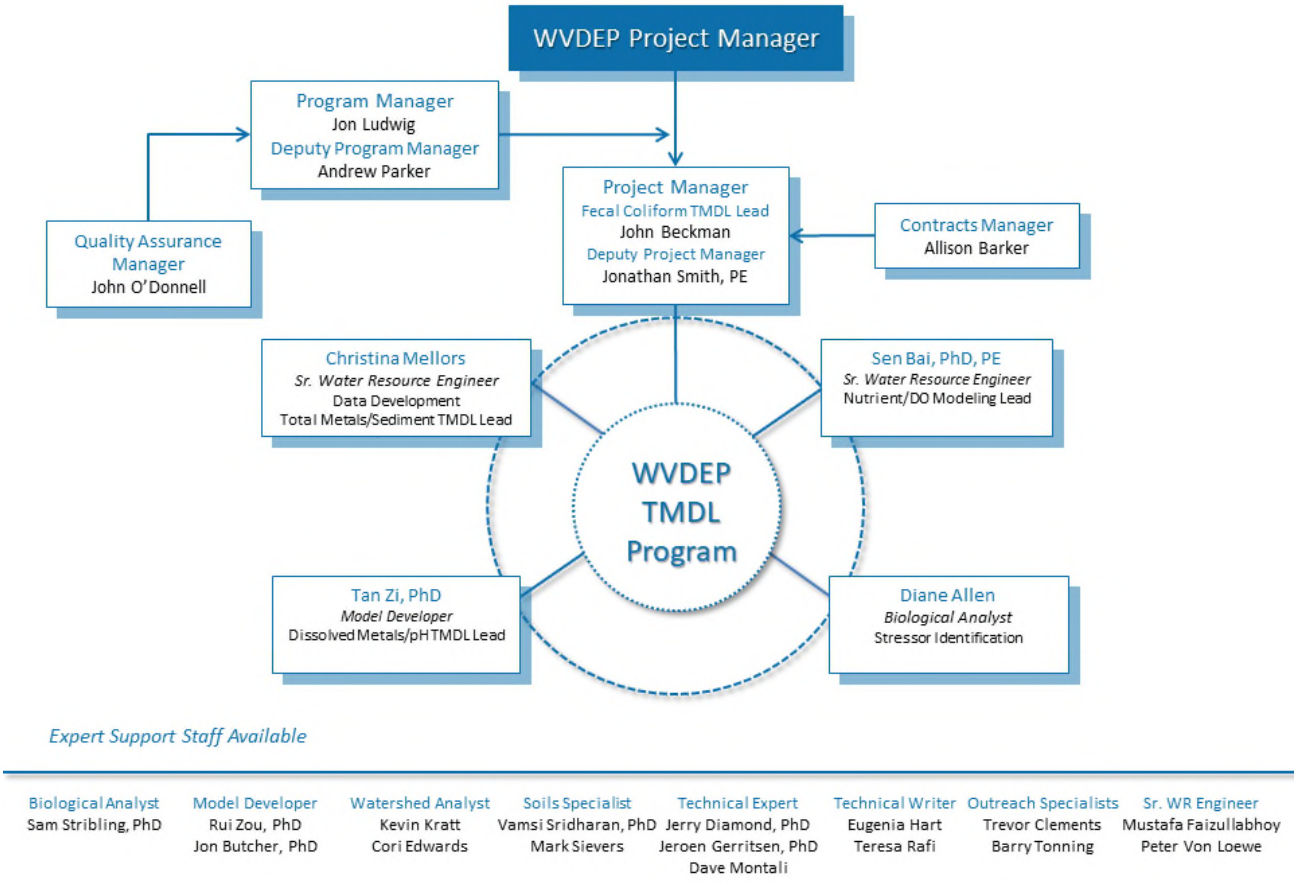


Figure I-C-1. Organization of the Proposed Tetra Tech Team

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 contained 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 4,100 USEPA approved TMDLs. Mr. Ludwig has over 20 years of experience providing technical expertise and management in all areas of TMDL development. Mr. Ludwig has collaborated with WVDEP's TMDL Program staff to develop practical solutions for complex programmatic issues. Mr.

Ludwig will provide leadership and technical guidance to ensure WVDEP's TMDL Program continues as the national leader in TMDL development.

John Beckman, Project Manager and Fecal Coliform Bacteria TMDL Lead

Mr. Beckman is responsible for day-to-day management of Tetra Tech's Charleston, WV office and will serve as the local point of contact to WVDEP. He will work closely with WVDEP to maintain clear, focused direction of the project. He is currently leading the watershed group C5 and D4 TMDL development efforts, and is responsible for staff planning, reporting progress, and invoicing. Mr. Beckman will also lead all tasks associated with bacteria TMDLs under this contract, coordinating technical tasks closely with Charleston and Fairfax staff. Mr. Beckman is a watershed analyst with over 20 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 15 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.

Allison Barker, Contracts Manager

Ms. Barker will be responsible for financial reports, contract administration, and cost control. She has served as the Contract Administrator for the previous and current WVDEP TMDL contracts (Purchase Order No. DEP12147, DEP13860, DEP15231 DEP15530, DEP15990, DEP16379, DEP16550, and DEP1600000072, DEP1700000011, DEP1800000018, DEP1900000013, DEP2000000018 and DEP2200000001) 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, Nutrient and Dissolved Oxygen Modeling Lead

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 nutrient and dissolved oxygen modeling as necessary.

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, Tan Zi, and Sen Bai to continue to evolve the technical representation of the total metals and sediment in MDAS model. Over the past 16 years, she has led or contributed to 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 Mr. Beckman 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, Mr. Beckman and the WVDEP Project Manager to ensure that projects are meeting all technical and scheduled objectives. Mr. Parker is a senior environmental engineer with more than 20 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.

Diane Allen, Stressor Identification Lead

Diane Allen's work will focus on identifying environmental stressors impairing biological condition of macroinvertebrates and fish in West Virginia streams to support the Stressor Identification process. Dr. Allen is a biostatistician with 9 years of experience in analysis of aquatic datasets and coding in the R statistical programming language. For the past two years she has been performing random forest statistical modeling on DEP's statewide fish species dataset.

Jonathan Smith, PE, Deputy Project Manager

Mr. Smith will support Mr. Ludwig and Mr. Beckman in assigning staff, monitoring individual task orders, and representing Tetra Tech in selected technical matters. He has 20 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 types of 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.

Tan Zi, PhD, PE, Aluminum and pH TMDL Lead

Dr. Zi will lead Aluminum and pH TMDL development efforts. He will also support the watershed modeling team by using his unique expertise to build data management applications and GIS tools to enhance TMDL development. He is an environmental engineering professional with 9 years of experience in water resources management and scientific research. He has in-depth expertise in hydrologic & hydraulic model development, data processing, analysis, and model output visualization, with hands-on experience in remote sensing and GIS. His work at Tetra Tech is mainly focused on hydrologic modeling, water quality modeling, sediment yield modeling, meteorological data processing, geospatial analysis, and climate change research.

Other Key Staff

Table I-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
- 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 (●). Many 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 provided in Appendix A of the proposal.

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

Staff	Proposed Role	Highest Degree	Total Years of Experience	TMDL Development					Watershed Assessment			Modeling & Data Management					Stressor Identification			Training & Outreach		Regulatory Guidance		
				Nutrients/DO TMDLS	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 Statistical Modeling	Biological Index/Metric Development	Training/Technology Transfer	Public Outreach	QAPP Development	Water Quality Standards/UAA	Permitting
Jon Ludwig	Program Manager	MS	24	☐	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
John Beckman	Project Manager	MEM	26		●	●	●	●	●	☐	☐	●	●	●		●		●		☐	●	☐		
Christina Mellors	Senior WR Engineer	MS	26		●	●	●	●				●	●	●	●	●	●			☐	●			☐
Andrew Parker	Deputy Program Manager	ME	28	☐	●	●	●	●	☐		☐	●	●	●	●			☐		●	●	●	●	☐
Jonathan Smith, PE	Deputy Project Manager	BS	27						☐		☐	☐	☐		☐		☐			☐	☐			☐
Sen Bai, PhD, PE	Senior WR Engineer	PhD	23	☐			☐	☐	☐		☐	☐	☐		☐		☐			☐				
Diane Allen	Biological Analyst	MEM	9	☐		●	☐			●		●					●	●	●	☐				
Allison Barker	Contracts Manager	JD	24		●	●	●	●																
Jonathan Butcher, PhD	Model Developer	PhD	37		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐
Trevor Clements	Outreach Specialist	MEM	40	☐			☐	☐	☐		☐		☐				☐			●	☐		☐	☐
Jerry Diamond, PhD	Technical Expert	PhD	43							●	●						☐	☐	☐			☐	☐	☐
Cori Edwards	Watershed Analyst	MGIS	12						●			●									●			
Mustafa Faizullabhoy, PE	Senior WR Engineer	MS	24	☐	☐	☐	☐	☐				●	●	●	☐		☐							

Staff	Proposed Role	Highest Degree	Total Years of Experience	TMDL Development					Watershed Assessment			Modeling & Data Management					Stressor Identification			Training & Outreach		Regulatory Guidance		
				Nutrients/DO TMDLS	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 Statistical Modeling	Biological Index/Metric Development	Training/Technology Transfer	Public Outreach	QAPP Development	Water Quality Standards/UAA	Permitting
Jeroen Gerritsen, PhD	Technical Expert	PhD	41							●		●					●	●	●	●		☐	☐	
Eugenia Hart	Technical Writer	MS	23	☐	●		●	☐				●	●							☐				
Kevin Kratt	Watershed Analyst	MEM	28	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐				☐			☐	☐		☐	☐
Dave Montali	Technical Expert	BS	42	●	●	●	●	●	●	●	●	●	●	●		●				●	●		●	●
John O'Donnell	Quality Assurance Manager	BS	40								●											●		
Teresa Rafi	Technical Writer	MA	27	☐	●		●	●			●	●	●							☐	☐			☐
Mark Sievers	Soils Specialist	MS	24	☐	☐	☐	☐	☐	●		☐	●	☐		☐					☐		☐		
Vamsi Sridharan, PhD	Soils Specialist	PhD	19			☐		☐	☐	☐	☐	☐	☐		☐		☐	☐		☐	☐			
James Stribling, PhD	Biological Analyst	PhD	35							☐	☐	☐					☐	☐	☐	☐	☐	☐		
Barry Tonning	Outreach Specialist	MA	35						☐	☐	☐									●	●	☐	●	●
Peter von Loewe	Senior WR Engineer	MS	23	☐	☐	☐	☐				☐	☐	☐	☐	☐					☐		☐		
Tan Zi, PhD, PE	Model Developer	PhD	14			●	☐	☐				☐	☐		☐		☐	☐		☐				
Rui Zou, PhD	Model Developer	PhD	23	☐		☐	☐	☐				☐	☐		☐							☐		

● Experience in West Virginia ☐ General experience

I.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 due to the exceptional performance of key technical staff and 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, Andrew Parker and Deputy Project Manager, Jonathan Smith, PE. John Beckman will serve as the Project Manager as with the two ongoing TMDL projects. He 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 are discussed in Section I.D.2

I.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)

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. Tetra Tech has direct experience managing multiple TMDL projects at the same time. It is not unusual for Tetra Tech staff to be working on two or more concurrent TMDL projects at various stages of development. Over the past 15 years, Tetra Tech has successfully demonstrated the ability to meet these challenges by maintaining overall schedules and budgets while simultaneously managing large West Virginia TMDL projects across multiple Hydrologic Groups. Tetra Tech has also held several other contracts similar in size and scope to this WVDEP solicitation (e.g., USEPA, Georgia Environmental Protection Division (EPD), and City of San Diego, CA). 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 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 I-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 I-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	▪ 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
Water Quality Modeling	▪ 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
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

Service Offered	Meeting the Objectives of WVDEP
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 has written 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 several 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 four-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. Tetra Tech has contributed toward the development of 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 with 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 has worked 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 supported numerous agencies 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 supported a landmark long-range watershed-based planning effort for the MMSD. One purpose of the planning effort was to identify improvements needed for MMSD wastewater treatment facilities to accommodate growth and protect water quality through the year 2020. Tetra Tech 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.

I.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 I.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 I.C and resumes for all staff are included in Appendix A. This section outlines our approach to project organization and management, including:

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

I.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 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.

I.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.

I.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.

I.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, John Beckman 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 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 I.C of this proposal. The information presented in Section I.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 program management team of Andrew Parker and Jon Ludwig 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. He 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 frequent meetings at WVDEP's offices for project updates, and transfer of materials.

II. APPROACH AND METHODOLOGY

Tetra Tech has played a continuous 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, DEP16550, DEP1600000072, DEP1700000011, DEP1800000018, DEP1900000013, DEP2000000018, and DEP2200000001 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 20 years, Tetra Tech has successfully met aggressive project schedules while maintaining project budgets. While working directly for WVDEP, Tetra Tech has completed over 5,600 USEPA approved TMDLs in West Virginia, with over 30 TMDLs currently under development. The success in meeting aggressive schedules and workloads is due to the exemplary efforts of Tetra Tech staff (shown in Section I.C) and our proven approach for effective project management (described in Section I.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.

II.A. DATA DEVELOPMENT

Tetra Tech has been working with WVDEP for over 20 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 account for all potential point and nonpoint pollutant sources. Tetra Tech modelers have developed Microsoft Access database and Microsoft Excel 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, ESRI-compatible GIS shapefiles, 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 outset of the TMDL development process, an exhaustive search will be made to solicit all available data from all watershed stakeholders. Table II.A-1 lists various TMDL stakeholders matched with a summarized overview of the type of data they contribute. Stakeholders who contribute their data become aware of the TMDL process, which can lead to increased understanding of the long-term goals and regulatory implications of TMDL implementation.

Table II.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 2021)	▪ 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	▪ Political Boundaries ▪ Cities/populated places ▪ TIGER Roads ▪ Population change ▪ Demographics and Economic Activity
USDA Forest Service	▪ Timber harvest data

Stakeholder	Data Type
U.S. Environmental Protection Agency	▪ STORET water quality database ▪ Water quality monitoring station locations ▪ Federal standards and regulations ▪ Clean Air Interstate Rule (atmospheric deposition)
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 20 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.

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.

The following sections describe the datasets in more detail and how they are used to inform model setup.

II.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 assessment units such that only one impaired stream segment is contained in an individual subwatershed unit. 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.

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 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, which will be further divided into smaller, hydrologically connected subwatersheds based on topographic hydrologic boundaries. The delineation will incorporate detail from 1:24,000 scale USGS topographic maps, stream connectivity, stream-specific TMDL assessment units, impairment status of modeled streams, and monitoring station locations.

Upon completion of the subwatershed delineation, the subwatershed units will then be labeled with identifying information including, but not limited to, stream name, stream code, TMDL assessment unit number, subwatershed area, and subwatershed identification number. 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. 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. It is necessary that the structure of the stream network is preserved in the delineation, that the connectivity is correct, and that subwatershed boundaries compliment TMDL assessment unit designations.

II.A.2. Watershed Physiographic Data

Tetra Tech builds MDAS models with information from 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. The inclusion of GIS 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 (Jin et al., 2013). NLCD 2021 is the most up to date landuse grid coverage available for the state of West Virginia.

II.A.3. 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.

II.A.4. Potential Point Sources

II.A.4.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 model. MS4 urban stormwater runoff is treated as a point source for TMDL development purposes. Urban areas under MS4 permit will have their boundaries delineated for inclusion in the model as a separate source of fecal coliform.

II.A.4.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.

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 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 will obtain the most up to date version of these coverages for inclusion in the model.

II.A.4.c. Nutrient Point Sources

The most significant nutrient point sources would be permitted discharges from sewage treatment plants and large food processing facilities. These permitted dischargers, regulated by NPDES permits, could include publicly and privately-owned treatment works, combined sewer overflows, home aeration units, sewage package plants, WVDOH municipal sewage plants, and food processors. Although West Virginia does not have state water quality standards for nitrogen or phosphorus nutrients, permitted outlets could have outlet discharge monitoring data and receiving stream water quality observations that could be used to characterize these outlets in the MDAS model. The Chesapeake Bay TMDL Program also has literature values for nutrient concentrations for sewage outlets without nutrient limits that could be used to estimate point source loads. WVDEP's non-mining NPDES GIS coverage shows the locations of NPDES permitted outlets. Tetra Tech will obtain the most up to date version of this coverage to use for model setup. MS4 urban stormwater runoff is treated as a point source for TMDL development purposes. If present in the watershed, urban areas under MS4 permit will have their boundaries delineated for inclusion in the model as a separate source of nutrients.

II.A.5. Potential Nonpoint Sources

II.A.5.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, with fecal coliform bacteria accumulating over time and washing off into the stream during rain events. 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 coliform bacteria 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 using the following information:

- Areas not served by public sewer.
- Areas within 100 meters of a stream that has been mapped at 1:24,000 resolution.
- Number of potential failing septic systems in each subwatershed.
- 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 model and transform the data where necessary to enhance spatial representation.

II.A.5.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 model and transform the data where necessary to enhance spatial representation. Table II.A-2 lists the shapefiles that describe nonpoint sources that may be included in model setup.

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.

II.A.5.c. Nutrient Nonpoint Sources

Nonpoint sources contribute nutrient loads that can be a driving factor for dissolved oxygen and algae impairments in a watershed. The nonpoint nutrient sources in a watershed are represented differently in the model depending on their type and behavior. Potential nonpoint sources of nitrogen and phosphorus include agricultural inorganic fertilizer application, livestock pasture, manure application, residential/urban runoff and failing septic systems. The Chesapeake Bay TMDL Program has detailed nutrient application and uptake rates per landuse per county in the Potomac River basin that could be used to characterize nonpoint nutrient loading rates in an MDAS model.

In the MDAS model, nonpoint sources are characterized by build-up and wash-off processes, with nutrients accumulating over time and washing off different landuse categories during rain events. Failing septic systems represent non-permitted (nonpoint) sources that can contribute nitrogen to receiving water bodies through surface or subsurface flow. Flows from failing septic systems will be quantified using the method described in the Fecal Coliform Nonpoint Source section above and will be added to the model as continuous flows with a constant concentration.

II.A.6. 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 II.A-2 lists the shapefiles that describe source tracking data that may be included in model setup.

II.A.7. Data Deliverables

There are critical points in the model development process where it is beneficial for both Tetra Tech and WVDEP to review and assess the accuracy of the data that has been gathered and processed before proceeding with the next step. Tetra Tech typically presents these data packages as draft deliverables, which are reviewed by both parties before WVDEP approves and the documents are finalized. The following sections describe the deliverables that will be submitted to WVDEP for final approval before proceeding with the next step of model development.

II.A.7.a. Subwatershed Delineation

The subwatershed delineation deliverable will be submitted through managed file transfer 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.

II.A.7.b. NPDES Permit Summary Report

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 NPDES GIS coverages (mining and non-mining outlets and permits shapefiles) against the subwatershed delineation, streams layer, and the aerial images. The NPDES GIS coverages are then joined to the subwatershed delineation to tag each outlet with the appropriate modeled subwatershed number to facilitate model setup. Permit details such as flows, areas, and permit limits are gathered for the outlets from WVDEP's ERIS database. Tetra Tech works with WVDEP staff to address any missing information or provide greater detail regarding how outlets function. 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 final Permit Summary Report Excel Spreadsheets list the relevant outlets for each model, by type. For example: Fecal OWR Outlets, Fecal Mining Outlets, Metals OWR Outlets, Metals Mining Outlets, and Metals Construction Stormwater Outlets. Each permit summary list will provide the permit number; facility name; responsible party; permit type; outlet ID; outlet location (latitude and longitude); the model status (model or do not model), and the parameters of interest for which limits are found, including flow, chemical concentrations, and pH. A supporting GIS shapefile will be included for each set. These summaries will be submitted through managed file transfer in a Microsoft Excel filterable spreadsheet format.

Tetra Tech is aware that new permits may be issued between the time that the data 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.

II.A.7.c. Pollutant Source Summary

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 Summary 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. Table II.A-2 lists the datasets typically included in the Pollutant Source Report, depending on the pollutants for which TMDLs are being developed. 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.

Once complete, Tetra Tech will coordinate a meeting with WVDEP representatives to thoroughly review the Pollutant Source Report data and approve the information as the final deliverable. The Pollutant

Source Report will be submitted through managed file transfer 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 data frame for each impairment type, such as metals, bacteria, or other impairment. Within each data frame, impairment-specific shapefiles will be presented that represent potential point and nonpoint pollutant sources, watershed physiographic data, and monitoring data required for modeling. An impaired streams shapefile will be provided in the project so that streams impaired for a particular pollutant can be easily identified. The shapefiles will be derived from 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 relevant details will be presented in the shapefile attribute table. A supporting Word document will also be submitted with the Pollutant Source Report that explains in detail the contents of each project, view, and shapefile.

Table II.A-2. Spatial Data Included in Pollutant Source Report

Data Category	Associated Shapefiles
Subwatershed Delineation	▪ Subwatershed Delineation ▪ Streams ▪ Impaired Streams ▪ Modeled Reach ▪ TMDL Watershed Boundary
Watershed Physiographic Data	▪ TIGER Roads ▪ Towns ▪ Soils ▪ Landuse – NLCD 2021 ▪ 911 Coverages (if available)
Point Source Data	▪ OWR Non-Mining NPDES Outlets ▪ CSO Outlets ▪ MS4 Areas ▪ Mining NPDES Outlets (HPU) ▪ Bond Forfeiture Sites ▪ Permitted Mining Areas ▪ Valley Fills
Non-Point Source Data	▪ AML Portals (WVDEP) ▪ AML Highwall ▪ AML Area ▪ Oil and Gas Wells ▪ Marcellus Shale Wells ▪ Harvested Forest ▪ Burned Forest
Monitoring Data	▪ WAB Stations ▪ WAB Samples ▪ Additional Monitoring ▪ Stations ▪ Additional Monitoring Samples ▪ Weather Stations
Source Tracking Data	▪ Septic Zones ▪ Sewered Areas ▪ Sewage Overflow Events ▪ Agricultural Source Tracking Sites ▪ AML Seeps Source Tracking ▪ MS4 Permits ▪ AML Disturbances Source Tracking

II.B. MODELING APPROACH

II.B.1. Watershed Modeling

II.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, the Loading Simulation Program in C++/Mining Data Analysis System (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. The model has been approved by the USEPA for use in TMDL development. 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. Tetra Tech can transfer all models, model codes, tools, and relevant data to WVDEP without restriction. 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 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.

The optional 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.

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. Another key advantage of MDAS is that it can be customized to fit West Virginia's individual TMDL development needs. Table II.B-1 lists the MDAS modeling and data management features useful for TMDL development. 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 II.B-1).

Table II.B-1. MDAS Modeling and Data Management Features

	Feature
1.	Simulates watershed hydrology using hourly local meteorological data
2.	Presents no inherent limitations regarding the size and number of subwatersheds and streams that can be modeled at any given time. Over 500 subwatersheds can be modeled simultaneously.
3.	Simulates all of the necessary pollutants on land and instream under a range of flow conditions. Can be calibrated for existing conditions and can be modified to allow for baseline and allocation scenarios.
4.	Because of the small time-step capability, it can be used to evaluate compliance with varying water quality criteria, including exposure duration and exceedance frequency components.
5.	Allows for representation of loading processes for both point and nonpoint sources as either precipitation-driven or constant discharge, as appropriate.
6.	Can represent loading from atmospheric deposition.
7.	Allows for representation of pollutant build-up/wash-off rates and/or representative event mean concentrations (EMCs) for various landuse categories.
8.	Model stream network connectivity allows for instream transfer of pollutants from upstream to downstream watersheds in a conservative manner.
9.	MDAS has an optional unique graphical interface that supports GIS functions.
10.	Allows for representation of in-stream dissolved metals. Dissolved metals sources and sinks such as atmospheric deposition, total metals land-based runoff, and watershed buffering capacity can be modeled. Modeling can be used to develop load allocation scenarios that differentiate between atmospheric and land-based sources and meet state dissolved metals water quality criteria.
11.	Provides post-processing and analytical tools designed specifically to support TMDL development and reporting requirements. These tools are used to develop point source WLAs and nonpoint source LAs.
12.	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.

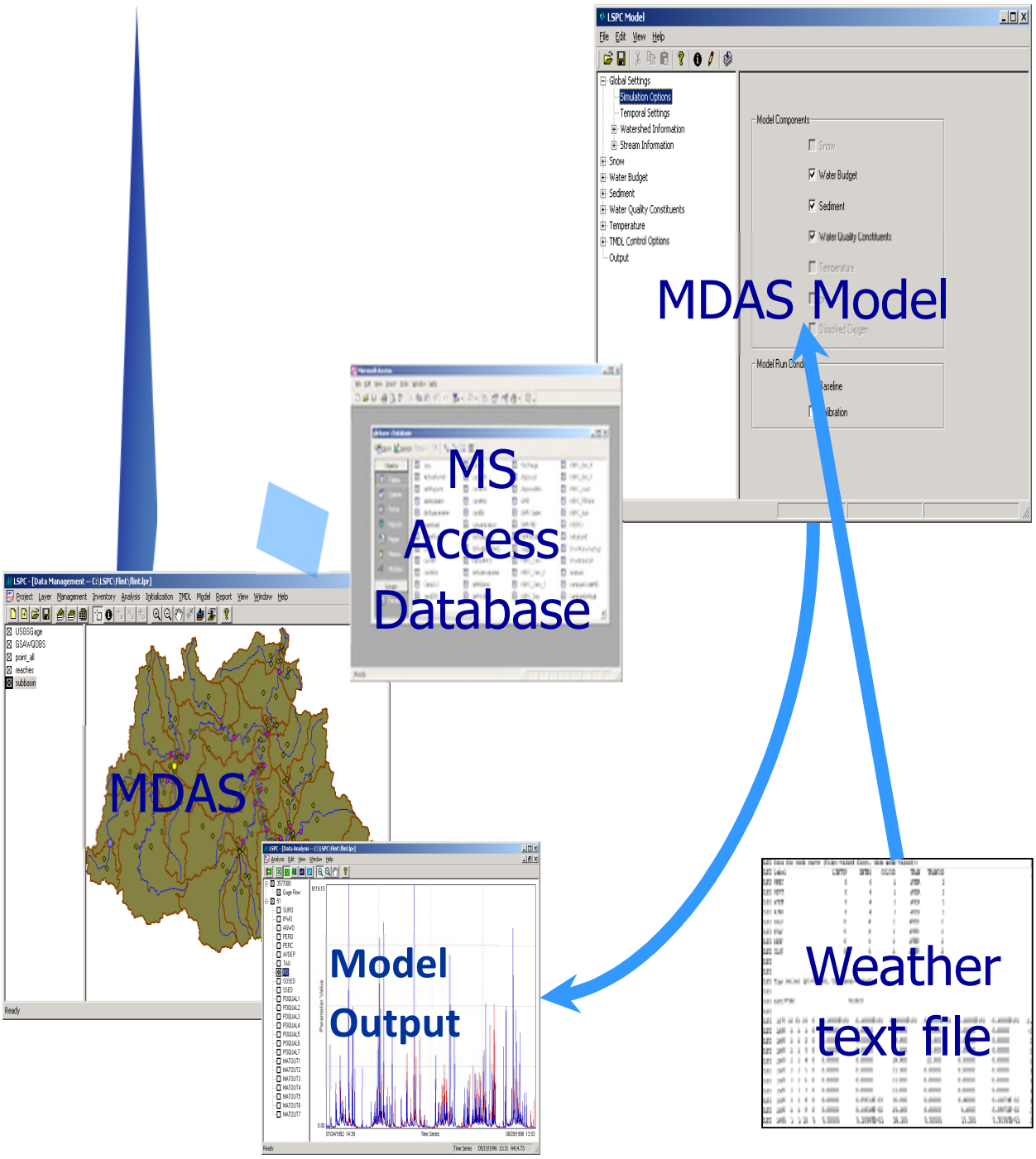


Figure II.B-1. MDAS Model Features

II.B.1.b. Modeling Quality Assurance Project Plan (QAPP)

Tetra Tech has broad experience developing and implementing quality systems and preparing documentation according to USEPA requirements and guidance, including contract-specific quality management plans (QMPs), project-specific data quality objectives, project-specific quality assurance project plans (QAPPs), sampling and analysis plans, and standard operating procedures (SOPs). Tetra Tech has prepared more than 630 QAPPs and Quality Statements, including TMDL modeling QAPPs across multiple USEPA regions. Tetra Tech will prepare a project QAPP that addresses watershed modeling and TMDL allocation development. Tetra Tech will ensure that the QAPP developed for this effort is consistent with USEPA Guidance on Quality Assurance Project Plans for Modeling (EPA/240/R-02/007, EPA QA/G-5M,) and Region 10's Guidance for Quality Assurance Project Plans for Water Quality Modeling Projects (EPA 910-R-16-007).

Tetra Tech will work with WVDEP to prepare a QAPP with appropriate elements to document how quality assurance and quality control (QA/QC) will be applied to the analysis of water quality data. Tetra Tech will write the QAPP in the active voice and will provide sufficient detail to clearly describe the objectives of the project, the types of data to be used, the quality objectives, and the QA/QC activities to be performed to ensure that any TMDL modeling results are documented and are of the type, quality, transparency, and reproducibility needed. Tetra Tech will not evaluate, analyze, or use water quality data prior to receiving notification of QAPP approval.

II.B.1.c. Watershed Model Configuration

II.B.1.c.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 2021. 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, 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.

II.B.1.c.2 Nutrient Model Setup

The nutrient model will be configured using the MDAS model to simulate modeled point and nonpoint pollutant sources, as well as general hydrologic characteristics of the modeled subwatersheds. The modeled landuse for nutrient modeling will be developed by starting with the fecal coliform MDAS model landuse and refining it to identify significant nutrient source landuses. Model parameters that influence water quality include the rates of accumulation and washoff of nutrients on the land surfaces, nutrient concentrations in interflow and baseflow groundwater, the transport of flows from one subwatershed to another, and the chemical reactions/kinetics in-stream. Nutrient and carbon variables important to modeling nutrients for the sake of Dissolved Oxygen (DO) include CBOD, ammonia, nitrate, organic nitrogen, orthophosphate, and organic phosphorus. Ambient environmental factors such as flow, temperature, solar radiation, shade, and DO inputs from land-based runoff will also be included in the model.

Loading of nutrients from point sources will be characterized as continuous flows with constant flows and concentrations. NPDES permitted outlets will be characterized with available information or literature values. MS4 landuses, while considered point sources, will be modeled as landuses with precipitation driven inputs. Non-point failing septic sources will configured in the model as continuous flows although they are not NPDES permitted outlets.

II.B.1.c.3 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 II.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 most recent 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.

II.B.1.c.4 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. Specifically, TMDL modeling capabilities will address water quality criteria 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.

We propose an updated version of the MDAS model for the development of dissolved metals and pH TMDLs. 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 II.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.

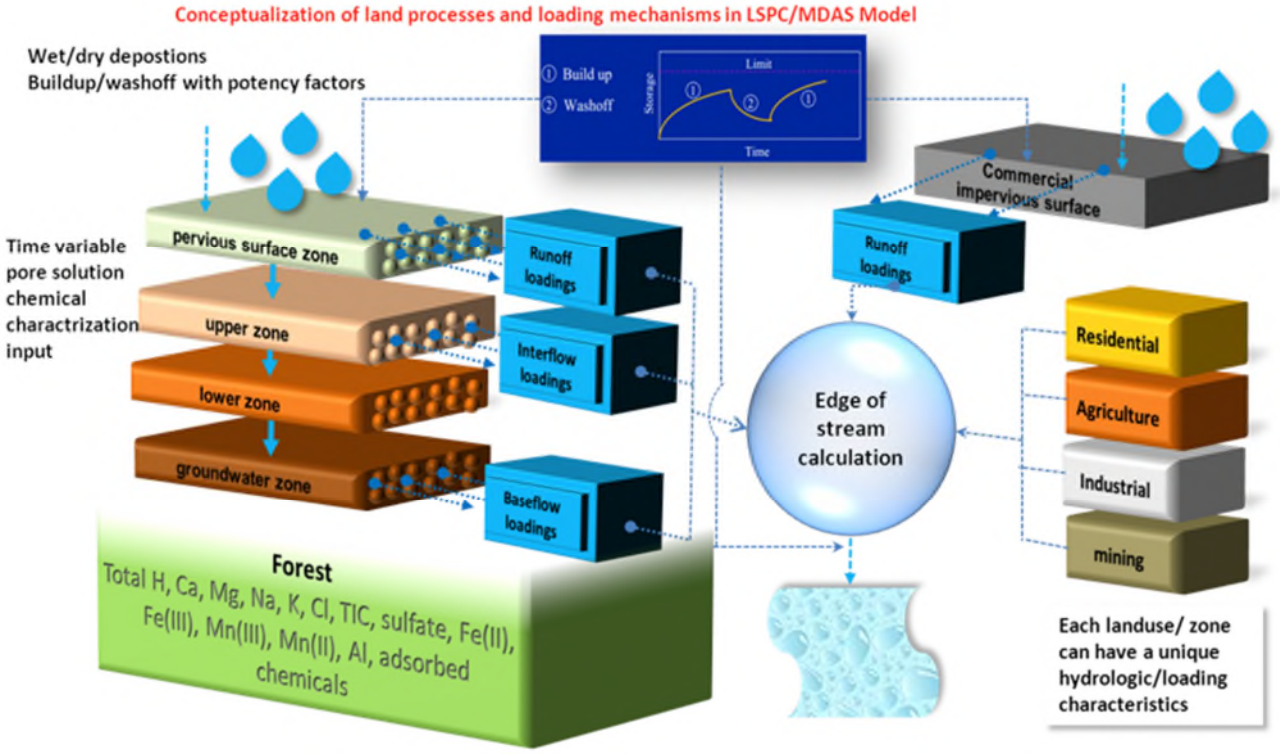


Figure II.B-2. Land components of LSPC-MDAS model

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 II.B-3.

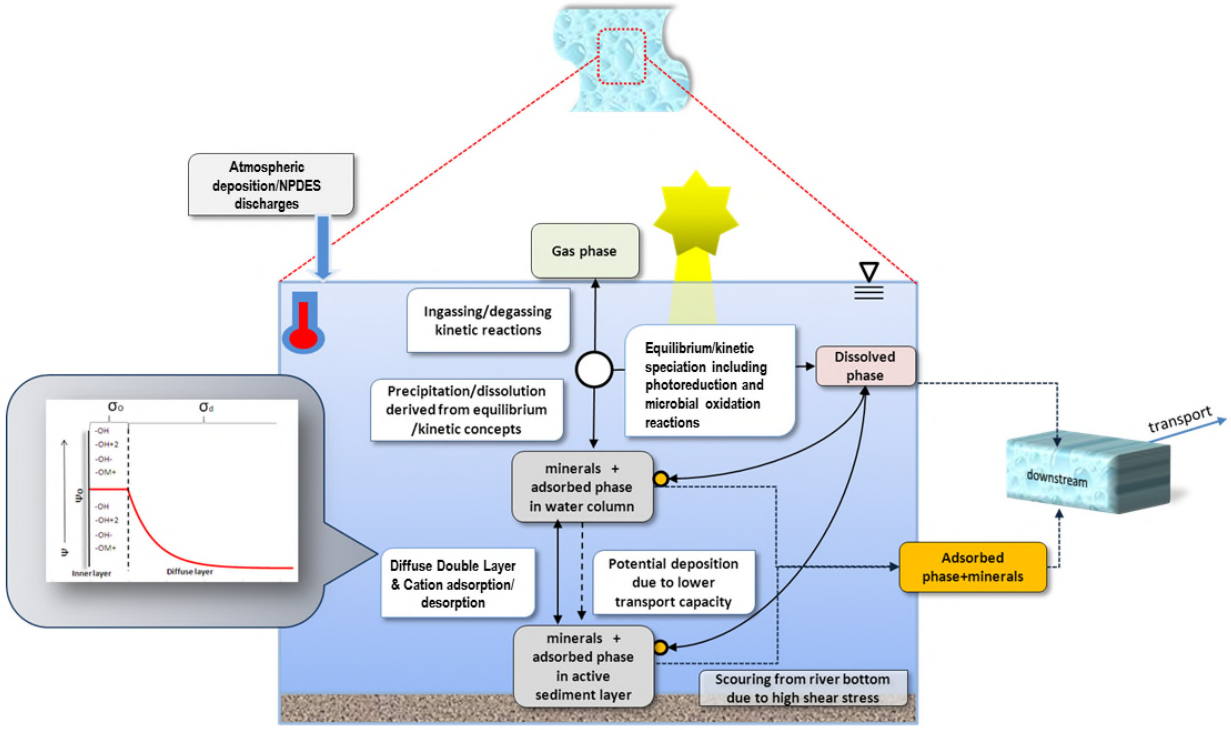


Figure II.B-3. Stream components in MDAS

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.

II.B.1.c.5 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 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 at the subwatershed scale during the water quality calibration phase of MDAS. An example result of the correlation analysis is shown in Figure II.B-4.

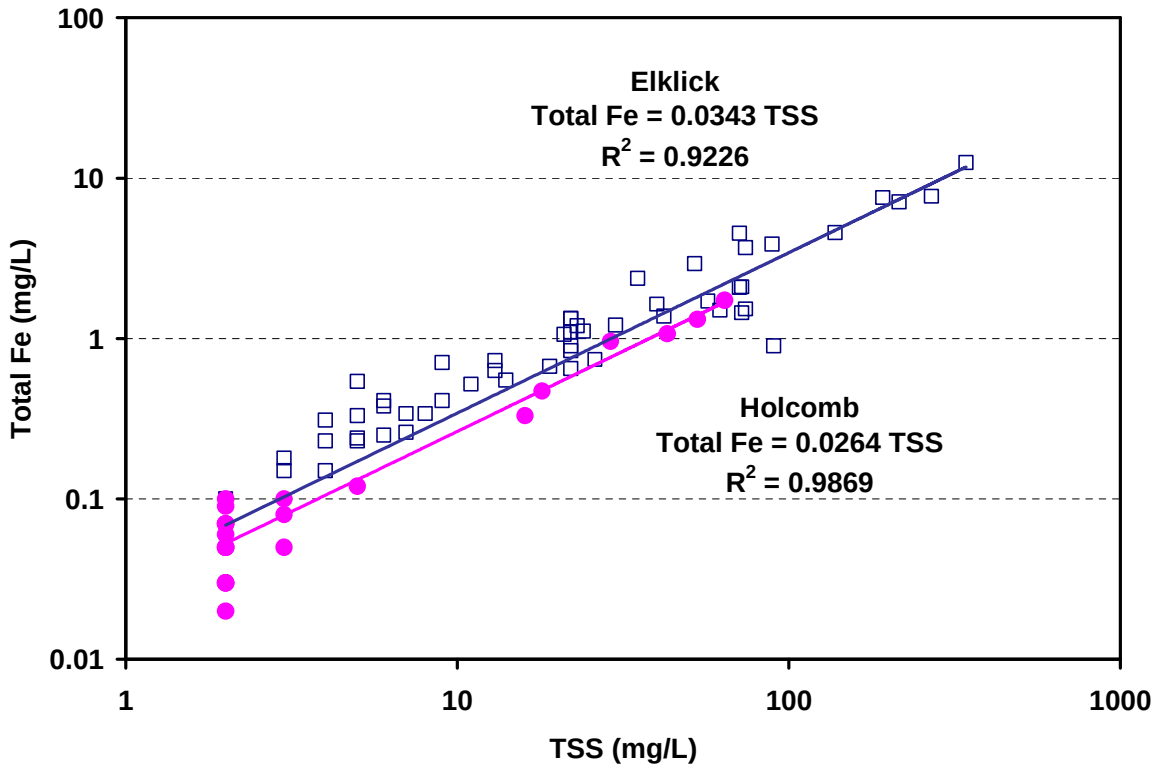


Figure II.B-4. Metals-sediment correlation

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.

II.B.1.c.6 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 II.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).

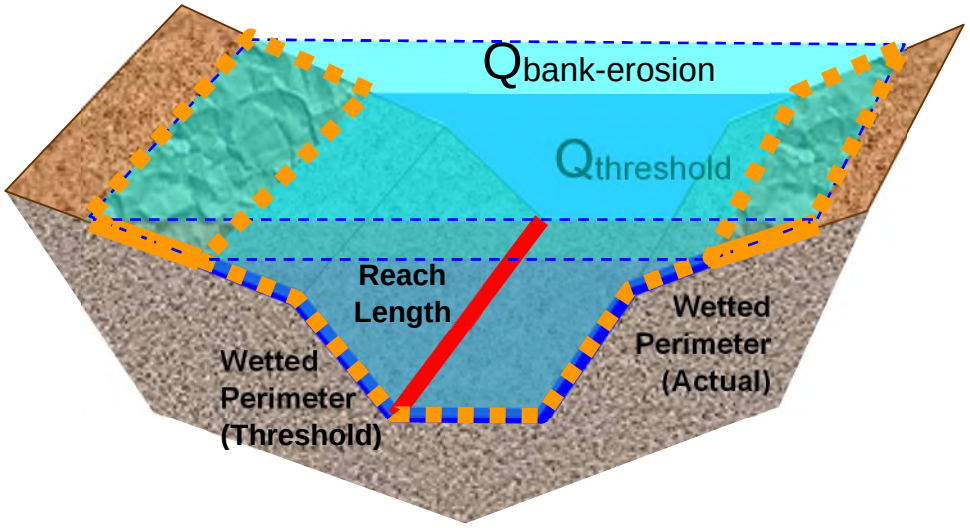


Figure II.B-5. Conceptual diagram of bank erosion model

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.

II.B.1.d. Watershed Model Calibration

II.B.1.d.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.

Tetra Tech will use the best available weather and land cover data as core model inputs. Tetra Tech will strive to use weather data with a complete period of record that corresponds to key model inputs. Variations in annual total precipitation will be considered by selecting a model time period that includes a range of high and low annual flows.

Two grid-based weather data products will be used to develop MDAS model weather input files for TMDL modeling. The Parameter-Elevation Regressions on Independent Slopes Model (PRISM) and the North American Land Data Assimilation System (NLDAS-2) are both publicly available weather datasets. PRISM data features daily weather on 4 km grid spatial scale, and NLDAS-2 data has hourly weather on a 12 km grid scale. Both datasets combine rain gauge data with radar observations to predict hourly weather parameters such as precipitation, solar radiation, wind, and humidity.

PRISM daily weather data and NLDAS-2 hourly precipitation data will be obtained and processed to create a time series for each PRISM grid cell that contained modeled TMDL watersheds. Using the precipitation and temperature time series, a model weather input file will be developed for each PRISM grid cell. To allow for faster model run times, one weather input file per each of the 12-digit HUCs will be developed by taking an area-weighted average of PRISM values within each 12-digit HUC. Model subwatersheds falling within each 12-digit HUC will be assigned the appropriate weather input file for hydrologic modeling purposes.

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. If 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. WVDEP pre-TMDL monitoring flow observations will also be used to validate the hydrologic calibration.

Hydrologic calibration will be achieved by adjusting model parameters so that model output matches observed in-stream stream flow data from USGS gage stations in the modeled watershed within an acceptable range of variability. Tetra Tech will calibrate the model with respect to annual water balance, variations in seasonal and monthly flow volumes, base flow conditions, and precipitation-driven storm peak flows.

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. Tetra Tech has developed calibration spreadsheet tools customized to interpret MDAS model output. Sample output from one of these tools is presented in Figure II.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 through managed file transfer in an electronic deliverable 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.

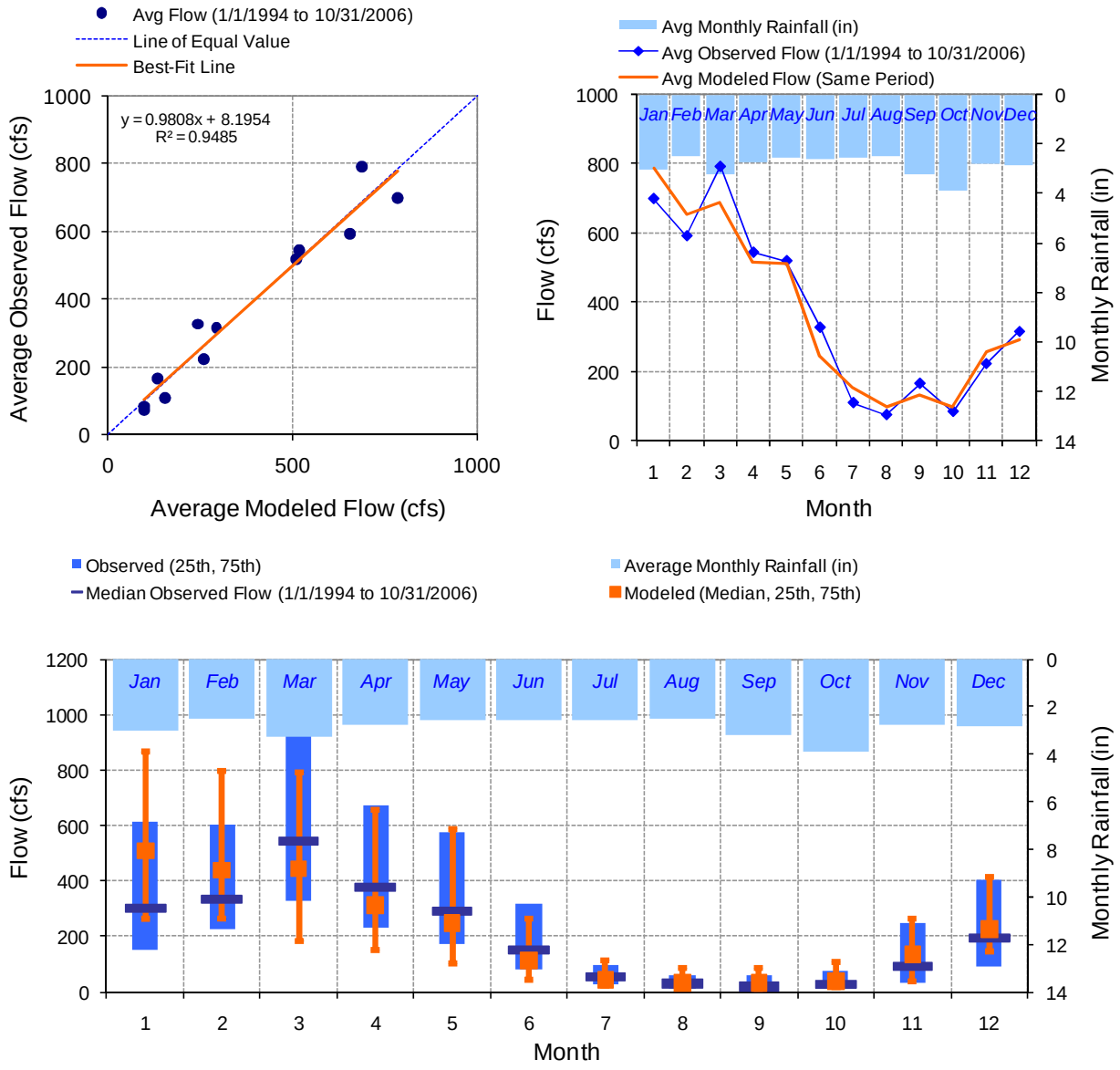


Figure II.B-6. Example Hydrology Calibration Spreadsheet Tools

II.B.1.d.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 submitted electronically through managed file transfer 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.

II.B.1.d.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 II.B-7.

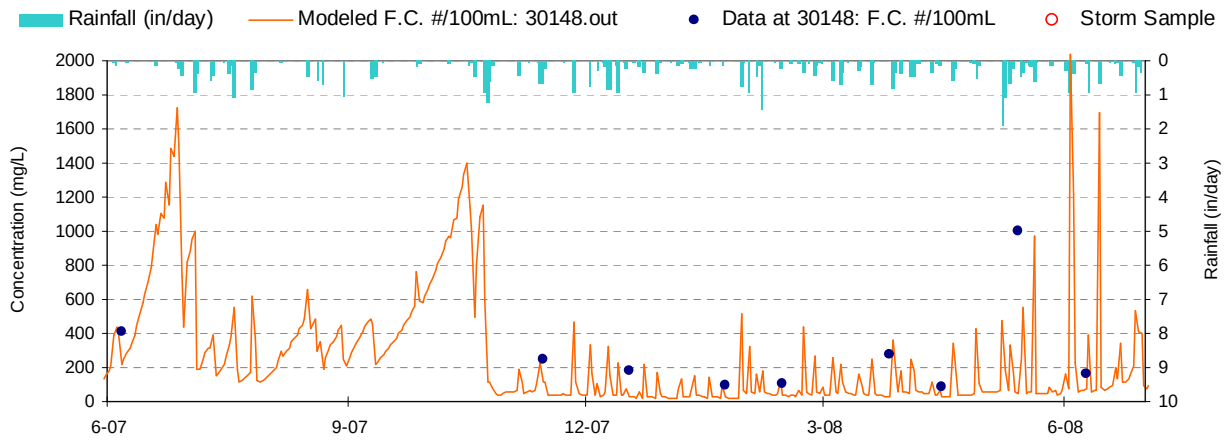


Figure II.B-7. Fecal coliform concentration: model output vs. observed data

II.B.1.d.4. Nutrient and Dissolved Oxygen Water Quality Calibration

Six water quality constituents - Carbonaceous Biochemical Oxygen Demand (CBODu), Organic Nitrogen (ORG-N), Ammonia-N (NH3-N) , Nitrate/Nitrite (NOX), Organic Phosphorous (ORG-P), and Soluble Reactive Phosphorous (SRP or PO4) will be represented in the MDAS model to simulate land-based processes. Calibration will be achieved by adjusting the landuse-specific modeled build-up and wash-off rates of these constituents. The build-up and wash-off rates can be adjusted either as constant or monthly variable rates for each modeled landuse. The build-up and wash-off processes together determine the nutrient loadings from the surface runoff. In addition to surface runoff, interflow and groundwater also can carry nutrients to receiving streams. These loading parameters can be adjusted to reflect nutrient loading under dry weather baseflow conditions. Modeled concentrations of land-based water quality constituents will be calibrated to match pre-TMDL water quality monitoring data.

Once nutrient loading from land-based sources has been calibrated, modelers will calibrate in-stream temperature and DO. Calibration of modeled heat transfer and transport processes that drive water temperature will be achieved first because water temperature controls the rates of the kinetics and saturation level of DO. Water temperature is impacted by weather conditions such as air temperature, dew point temperature, solar radiation, and wind. Shade from riparian vegetation often determines the amount of solar radiation that reaches the water surface in small, narrow streams. All of these factors will be included in the model through the weather data input file or adjustable model parameters.

DO in streams is largely governed by the algae growth. Once nutrients enter a stream, changes in nutrients and DO are related to the algae levels in the river. In addition, the nitrification process converts ammonia to nitrite/nitrate; the reaeration and sediment oxygen demand process impacts the DO level. Algae related rates and coefficients will be adjusted in water quality calibration. DO concentrations often reflect the biomass level of benthic algae. Photosynthesis and respiration processes of benthic algae are expected to cause significant diurnal fluctuation in DO. Model results for temperature and DO will be compared with both grab sample water quality data and any available continuous DO data using time series plots and scatter plots. Figure II.B-8 shows an example of a calibration plot of model output versus hourly DO observations exhibiting diurnal DO fluctuation over a 9-day period.

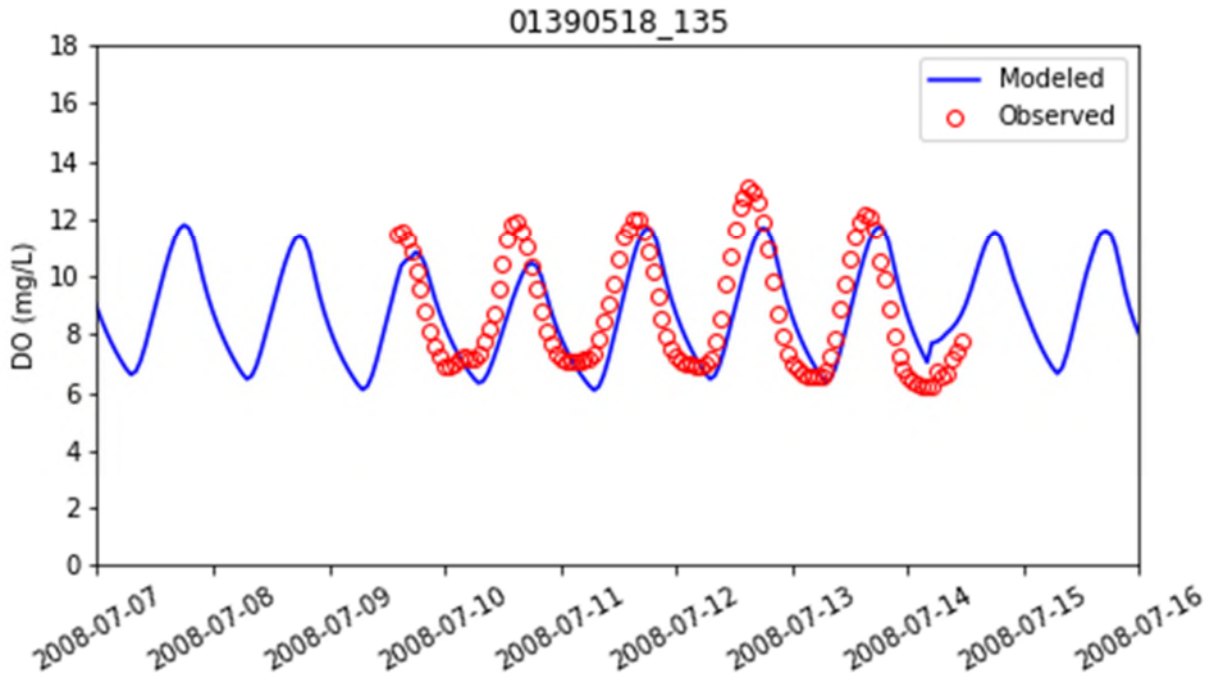


Figure II.B-8. Dissolved Oxygen concentration: model output vs. observed data

II.B.1.d.5. 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.

II.B.1.d.6. 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.

II.B.2. Biological Stressor Identification

Beginning with 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 A 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 II.B-2 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 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 I.C. Personnel, such as Michael Paul, have lead or contributed to biological indices, TMDL development, impairment and implementation studies that utilize multiple data sources including fish communities. Recent Tetra Tech SI work under the current TMDL development contract included O/E (observed over expected) analysis of statewide benthic invertebrate datasets to support O/E sensitive/opportunistic, Discriminant Analysis, Tolerance Value analysis, and Percent Model

Affinity SI approaches. This experience will enable Tetra Tech to build upon the existing SI framework to include the best available data in decision making and future TMDL development.

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 II.B-2. 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
D3	37
TOTAL	**665**

II.B.2.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.

II.B.2.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 II.B-8). 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.

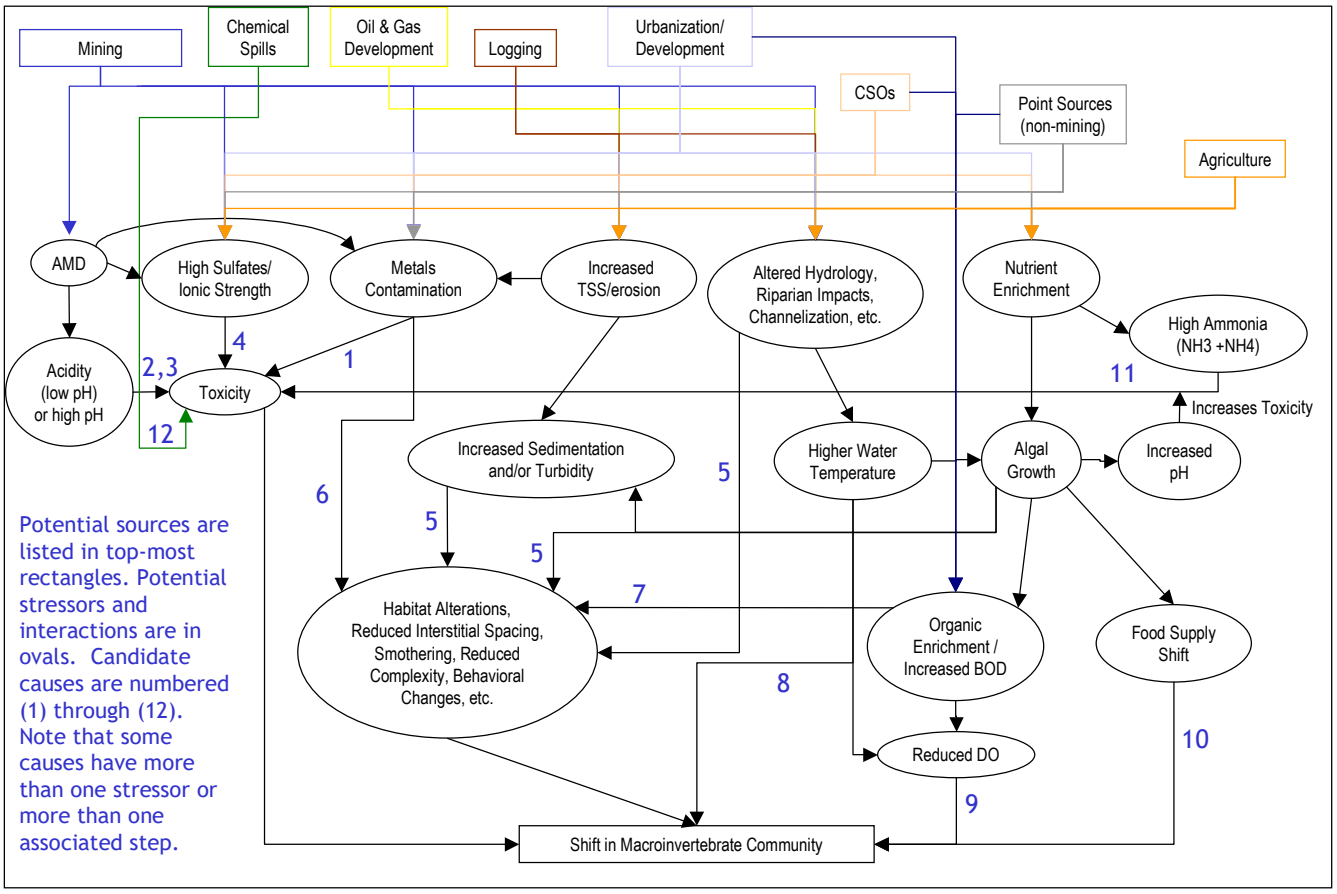


Figure II.B-8. Conceptual model of candidate causes used in Stressor Identification

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 watersheds.

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 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 WVDEP to further improve the decision-making process. The SI results will be incorporated into a stressor identification section for each TMDL report and the technical report.

II.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). Prescribed allocations will be provided in the TMDL report in electronic format as filterable Excel spreadsheets. Background loading from undisturbed landuses will be called out when appropriate in source-specific LAs. Seasonality will be considered in allocations if relevant to TMDL development. Future growth allocations for metals/sediment TMDLs will also be calculated.

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.

II.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 wastewater 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.

II.C.2 Dissolved Oxygen and Nutrient Allocations

The Dissolved Oxygen TMDL endpoint will be based on the acute and chronic water quality standards for warmwater fisheries and human health where DO shall not be less than 5 mg/l at any time; or in troutwaters where DO shall not be less than 6 mg/l at any time. Because West Virginia does not have state water quality criteria for nitrogen or phosphorus nutrients, TMDL development would not be for nutrients themselves, but instead nutrient loads would be used as TMDL endpoints that are understood to drive in-stream DO concentrations subject to state law Using the watershed approach (headwaters will be analyzed first, with pollutant loads transferred to downstream watersheds), Tetra Tech will reduce land-based nutrient sources following WVDEPs allocation strategy to meet TMDL endpoints. NPDES point sources will be given allocations consistent with their existing permit limits. If desired, nutrient loads from

point sources like POTWs could be configured to be consistent with nutrient loads already calculated for these outlets in the Chesapeake Bay TMDL nutrient model. Any modeled loads from CSOs will be reduced in a manner consistent with the wastewater 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.

II.C.3 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 II.B.1.b.4, 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 as filterable spreadsheets that identify pollutant-specific and subwatershed-specific baseline and TMDL loadings for individual point sources and categories of point sources.

II.C.4 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 be 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.

II.D. TMDL REPORT DEVELOPMENT

II.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 3 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 final report package will be presented in digital form either on a CD-ROM or through managed file transfer. 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.

Tetra Tech has produced TMDL reports for the WVDEP for more than 15 years. Prior to submission, Tetra Tech will subject draft reports to internal technical review to assure accuracy of content, grammatical correctness, and accuracy of spatial data displayed on maps or in GIS shapefiles. 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. All streams referenced in the TMDL report will be identified by both their NHD code and WV streams code. To help address WVDEP reporting requirements for the 303(d) list, Tetra Tech will also be prepared to present LAs, WLAs, and TMDLs by stream segment as identified by assessment unit code.

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

Tetra Tech will provide technical report appendices that allow stakeholders to understand modeled pollutant sources and locate information concerning impaired streams. Tetra Tech will work with WVDEP to format appendices so that they are useful to state agencies and programs tasked with TMDL implementation. Appendices will also help interpret TMDL allocations in terms of the actions necessary to restore streams to meet state water quality criteria. Operable point source effluent concentrations will be included in appendices and allocation sheets. Technical report appendices will include summaries of baseline conditions, source characterization assumptions, and identification of priority implementation areas to benefit the preparation of watershed-based plans. For the past several TMDL projects, Tetra Tech has provided a breakdown of failing septic system estimates by subwatershed to assist TMDL implementers. Similar tools will be developed to present fecal coliform TMDL allocations for different intensities of livestock pasture, for example.

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 in the TMDL report.

The spatial data featured in the ArcGIS project will be organized as in Table II.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 II.C-1. Example of Interactive GIS Project Shapefiles

Watershed Coverages	▪ Pre-TMDL Monitoring Sites ▪ MDAS modeled subwatersheds ▪ Impaired Streams ▪ Streams ▪ NLCD 2021 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

II.D.2. Preliminary Draft TMDL Report

Tetra Tech has worked closely with WVDEP TMDL staff for over 15 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 through managed file transfer. 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.

II.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.

II.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.

II.G. RESPONSE TO PUBLIC COMMENT

II.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.

II.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 through managed file transfer. Submittal date will be determined by the project timetable.

II.G.3. TMDL Records Retention

Tetra Tech will provide a complete administrative record for each TMDL watershed on DVD to WVDEP 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.

II.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 II.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 II.G-1). Although the TMDL process is primarily cumulative in nature, throughout the process there are multiple tasks that can be performed 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.

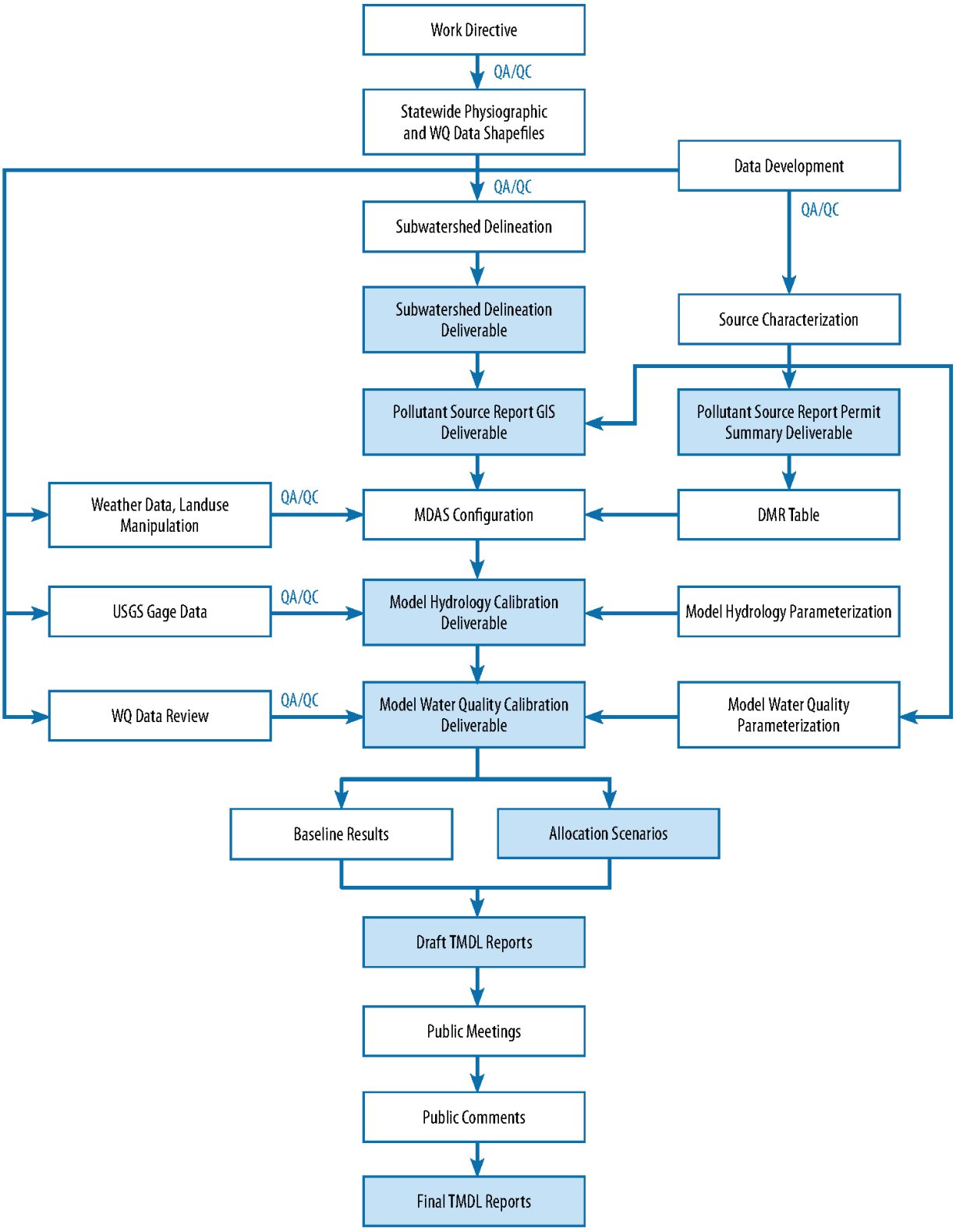


Figure II.G-1. TMDL Development Process Flowchart

II.H. WATERSHED PLAN DEVELOPMENT

The Charleston office of Tetra Tech, under contract to WVDEP, provided technical support for the development of the Piney Creek Watershed Plan from 2009 to 2012. Tetra Tech helped assemble stakeholders to establish a steering committee, planned regular meetings, and drafted key components of the watershed plan. Tetra Tech is currently developing implementation guidance for Advanced Restoration Plan development as a task under the Group E5 Cacapon TMDL project.

Watershed plans are developed for various reasons, including TMDL implementation, compliance with Section 319 funding requirements, cooperating with government initiatives like the Chesapeake Bay Program, or simply out of a desire to protect environmentally sensitive areas. Watershed plans follow a watershed approach to restore impaired waterbodies. The watershed approach addresses water quality problems in a holistic manner where stakeholders are engaged in all phases of watershed plan development. The watershed planning process is iterative, holistic, geographically defined, integrated and collaborative (USEPA 2008). A watershed plan should identify significant pollutant sources, identify management measures that will reduce those sources, and estimate the expected load reductions.

The watershed planning process includes multiple steps within a flexible framework that can be customized to achieve goals within a particular watershed. Methodology described here follows the USEPA Handbook for Developing Watershed Plans (USEPA 2008). The first step is to build partnerships between interested stakeholders and technical experts. A local watershed association can enlist the assistance of local, state, and federal government entities, environmental consultants, as well as local business interests to partner with during plan development. The establishment of a steering committee made up of interested stakeholders early in plan development is recommended. Public outreach throughout plan development can also foster success by explaining the plan goals and attracting additional volunteer support.

The second step is to define the geographic extent of the watershed, and characterize the hydrology, geology, landuse, land ownership, and other relevant information. The defined watershed should be sufficiently large to address all the major sources of impairment, but not so large that it reduces stakeholder engagement or makes technical analyses and monitoring too difficult. Water quality impairments and pollutant sources should be identified under this step. Data gaps should be identified and addressed. Background, point, and nonpoint source loading rates can be calculated with the help of a watershed model like LSPC or SWMM. If a TMDL has already been developed for the watershed, pollutant loads and percent reductions in the watershed plan should follow the baseline and allocated LAs and WLAs in the TMDL.

The third step in watershed planning is to set goals for water quality improvement and identify the management practices that could reduce pollutant sources. A goal could be to meet state water quality standards for a specific pollutant, or in the absence of a standard, a percent increase in a particular parameter such as forested buffers. Management practices could include a broad spectrum of nonstructural, regulatory, and structural measures taken to achieve source reductions. Nonstructural management practices include outreach measures that could reduce pollutant loading by changing existing behavior. For example, encouraging the cleaning up of pet waste could reduce bacterial loading; while farm nutrient management plans could reduce nitrogen and phosphorus loading. Regulatory measures carried out by state and local government agencies could incorporate increased enforcement of NPDES permit limits to reduce excessive bacteria or metals discharges. For example, enforcement of soil erosion BMPs on construction sites would be expected to reduce sediment loading to streams. Structural practices involving construction or revegetation could vary widely in terms of cost and complexity. These projects could include, but are not limited to, streambank restoration, green infrastructure to reduce impervious surface, livestock fencing, forested buffer planting, sewer line

extensions to capture failing septic systems, abandoned mine drainage treatment systems, and constructed wetlands. Determining the efficiency of pollutant removal and calculating expected load reductions will likely require the use of a model. Some appropriate models include SWAT, PLET (Pollutant Load Estimation Tool, formerly STEPL), and CAST (Chesapeake Assessment Scenario Tool).

Step 4 is to design an implementation program. This program should incorporate components that support the successful implementation of selected management practices. Public outreach in the form of an information/education component to encourage public participation and build support for management practices. The implementation program should also include a schedule for implementing management measures along with milestones for completion of specific management practices. Criteria for measuring success should also be incorporated into this part of the plan. Design of a monitoring program with sufficient predictive accuracy should be created prior to implementation to measure watershed or water quality improvements. Finally, estimates of financial and technical resources needed to implement management practices should also be included. Each proposed practice would be analyzed to compute the expected quantity of pollutant load reduced and the approximate cost to implement the project. Projects can be assigned a priority ranking based on estimated load reduction, total cost, and cost effectiveness. Because large-scale restoration project costs can easily cost hundreds of thousands of dollars or more, a watershed plan should contain information on potential funding sources. Some donations of land, labor, or equipment could be available from local stakeholders, however most sources of funding would likely come from established federal and state conservation programs. Examples of federal funding sources include Office of Surface Mining Watershed Cooperative Agreement Program and the USEPA Brownfields Program. West Virginia state funding sources include the West Virginia Conservation Agency, WVDEP Section 319 funds, and the WVDEP Stream Restoration Fund.

Implementing the watershed plan is the obvious fifth step in the process. Implementation could take years or decades, and success is not guaranteed. The sixth and final step is to measure progress toward goals using the monitoring program and make adjustments to the watershed plan as needed. Water quality and habitat monitoring is necessary to measure the effectiveness of restoration projects. A watershed plan would provide detailed instructions for recommended follow-up monitoring for up to 5 years after project implementation. Water quality monitoring could include monthly or quarterly water quality sampling for pollutants that implementation was designed to reduce. Monitoring during both high flow and low flow conditions can help measure restoration effectiveness during these critical periods. Monitoring benthic invertebrates or fish can integrate the overall long-term stream conditions that might be missed by only taking monthly or quarterly grab samples. Vegetation sampling may be useful to measure survival rates of planted species in constructed wetlands or revegetated streambanks. Ecological stream habitat measurement techniques such as Rosgen methods or rapid bioassessment protocols can help record year-to-year progress or degradation following implementation.

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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 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 I.C. We have proposed staff who have worked on the projects described, nearly 20 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. Tetra Tech 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 20 years, we have developed thousands 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 be able 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 despite 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 22 years, Tetra Tech has developed more than 7,000 TMDLs throughout West Virginia, initially supporting USEPA to meet strict consent decree deadlines (and subsequently assisting WVDEP with its own program). Over 5,600 of these TMDLs have been developed directly supporting WVDEP over the past 20 years, and there are 34 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	4	
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**	**16**	
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	5	6	52			29
B3	USEPA Approved	174	232	33	50	117			
C3	USEPA Approved	26			7	19			

Year or Hydrologic Group	Status	Number of Streams	Total Recoverable Metals	Dissolved Metals	Acidity/pH	Bacteria	Biological	Sediment	Chloride/ selenium*
D3	USEPA Approved	97	26			95			
E3	USEPA Approved	255	235			103			40
E4	USEPA Approved	335	319	1	2	184			4
C4	USEPA Approved	278	273	1	1	183			8
C5	USEPA Approved	#328	238	4	7	214			
D4	USEPA Approved	#364	357	1	2	130			
E5	Under Development	#34			1	33			
TOTAL		**3592**	**3211**	**240**	**256**	**2165**	**376**	**255**	**93**
TOTAL WEST VIRGINIA TMDLS		**4101**	**4277**	**322**	**517**	**2206**	**437**	**271**	**93**

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

Assessment Units, not streams. For Group C5 and after, WVDEP began using Assessment Unit stream segmentation for impairment listings and TMDL development.

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.

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 TMDL 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, A3, B3, C3, D3, E3, E4, C4, C5, and D4; and are currently under development for Hydrologic Group E5.

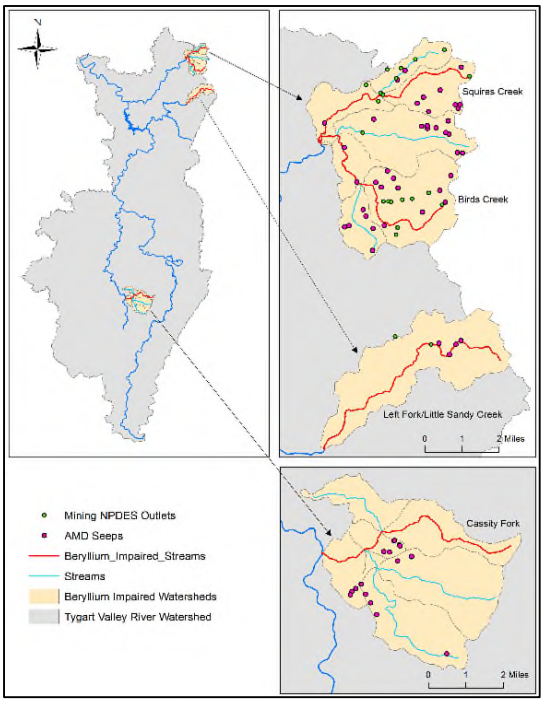
Descriptions of successfully completed TMDL development and watershed modeling projects are provided below. Also included are descriptions for two watershed planning projects.

Total Maximum Daily Loads for the Tygart Valley River Watershed, West Virginia

Client: West Virginia Department of Environmental Protection

In 2016, Tetra Tech developed USEPA-approved TMDLs for 251 impaired streams in the Tygart Valley River Watershed. Impairments addressed included total iron, dissolved aluminum, pH, beryllium, fecal coliform bacteria, and dissolved oxygen.

Metals impairments were attributable to both point and nonpoint sources. Nonpoint sources of metals included abandoned mine lands, roads, oil and gas operations, timbering, agriculture, urban/residential land disturbance and streambank erosion. Metals point sources included the permitted discharges from mining activities, bond forfeiture sites, and stormwater contributions from Municipal Separate Storm Sewer Systems (MS4s) and construction sites. pH impairments were attributed to both legacy mining and acidic atmospheric deposition.



Fecal coliform bacteria point and nonpoint sources were present in the watershed. Failing on-site septic systems, direct discharges of untreated sewage, and precipitation runoff from agricultural and residential areas were nonpoint sources of fecal coliform bacteria. Point sources of fecal coliform bacteria included the effluents of sewage treatment facilities, and stormwater discharges from MS4s.

To incorporate point and non-point sources in a watershed modeling framework, the Mining Data Analysis System (MDAS) was used to represent linkage between pollutant sources and instream responses for fecal coliform bacteria, iron, beryllium, pH, and aluminum. Impaired and unimpaired streams in the Tygart drainage were divided into 520 smaller subwatershed units for hydrologic modeling purposes. Hydrologic properties and landuse characteristics of the watershed were developed using Geographic Information System techniques and incorporated into MDAS. Permitted point sources and nonpoint source loadings were also characterized using WVDEP data. Weather inputs were developed from National Oceanic and Atmospheric Administration datasets. The MDAS model was calibrated for hydrology by comparing model output to seven U.S. Geological Survey stream gages in the watershed. Water quality calibration was achieved by comparing model output to pre-TMDL monitoring water quality samples collected monthly by WVDEP in advance of the modeling effort.

Using MDAS, Tetra Tech simulated instream flow and water quality conditions throughout the Tygart Valley River watershed for a 6-year period. Reductions to modeled point and nonpoint sources were applied under stepwise allocation scenarios to ensure the attainment of water quality criteria throughout the watershed, achieve equity among categories of sources, and target pollutant reductions from the most problematic sources. Load allocation (LA) nonpoint source reductions were not specified below natural (background) levels. Similarly, point source wasteload allocations (WLAs) were no more stringent than numeric water quality criteria. The MDAS model could also be used to analyze permit applications for new mining and construction activities that could impact the watershed in the future.

Tetra Tech developed 232 total iron, 33 dissolved aluminum, 50 pH, and 117 fecal coliform bacteria TMDLs. Beryllium impairments were addressed with a pH TMDL surrogate because beryllium exceedances were only detected in streams when pH was less than 5. Dissolved oxygen impairments

were addressed with a fecal coliform TMDL surrogate because sources of organic enrichment contributing to dissolved oxygen impairments were the same as those for fecal coliform. Tetra Tech developed a comprehensive TMDL report with information geared toward the general public as well as technical documentation of modeling techniques. TMDLs were presented in filterable spreadsheets with LAs and WLAs broken out by subwatershed, source, or permit ID. Supporting information such as pre-TMDL water quality monitoring data was provided in report appendices.

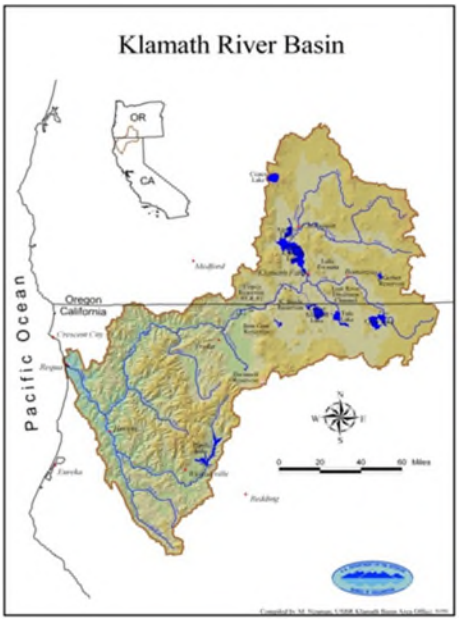
Although no biological TMDLs were developed under this effort, the Stressor Identification (SI) process was implemented to identify the significant stressors associated with identified impacts. WVDEP generated the water quality monitoring data, benthic sampling, and habitat assessments used in SI through its pre-TMDL monitoring program. The SI process entailed reviewing available information, analyzing possible stressor scenarios, and implicating causative stressors. The report identified streams for which biological stress to benthic macroinvertebrates would be resolved through the implementation of other pollutant-specific TMDLs for those streams.

The overall effort involved the application of innovative modeling techniques to address a variety of requirements related to water quality criteria, water use designations, pollution sources, and the intricate details of permitting. Tetra Tech also provided technical support for public meetings and response to comments on the draft TMDL report.

Nutrient Model Development for the Klamath and Lost Rivers in California and Oregon

Client: USEPA Regions 9 and 10, Oregon DEQ, and North Coast RWQCB (CA)

Tetra Tech (Tt) led hydrodynamic and water quality model development and physical, chemical, and biological monitoring efforts in the Klamath and Lost River Basins from 2003 to 2011 to support TMDL development. The Klamath and Lost Rivers have impairments related to low dissolved oxygen and elevated 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. The Lost River is a tributary to the Klamath River, and its watershed is approximately 2,996 square miles. 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.



Tetra Tech's 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, Tt proposed independent modelling approaches for the Lost and Klamath Rivers to meet TMDL requirements. Tt developed and calibrated a multiple-domain CE-QUAL-W2 model of the Lost River. 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). Tt also developed a dynamic modelling framework for the Klamath River composed of a series of one-

dimensional RMA models for riverine segments, two-dimensional CE-QUAL-W2 models for 4 impoundments, and a three-dimensional EFDC model for the estuary. Both modelling systems were peer-reviewed by modelling experts from federal agencies, academia, and private consulting firms.

To support calibration of both dynamic models, Tt also performed a series of physical, chemical, and biological sampling events at over 30 independent sites. Tt used the calibrated models 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. 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

Algae and Nutrient Assessment Studies

Client: USEPA Regions 3 and 8

Protocol for the USEPA Region 3 Stream Algal Aesthetics Survey. USEPA OST/HECD and Region 3. 6/21 to 3/22. As part of the national nutrient criteria center (NSTEPS) contract, supported USEPA OST/HECD and Region 3 with the development of a protocol for collecting benthic algal aesthetic data along with quantitative filamentous and non-filamentous algal and water quality samples to support the development of algal recreational use perception surveys in a subset of United States Environmental Protection Agency (US EPA) Region 3 wadeable streams. This protocol included methods for measuring visual periphyton composition and benthic chlorophyll a that could be integrated into standardized stream monitoring and included methods for site identification, photographing the stream, taking water quality measurements, a rapid filamentous algal and other periphyton sampling method based on the National Rivers and Streams Assessment methods to measure filamentous cover and algal biomass, and percent canopy estimation. The survey is being carried out and data will be analyzed in a follow-up project.

Development of a Source Water Harmful Algal Bloom/Cyanobacterial Source Water Index for Wyoming. USEPA OWOW and Region 8. 7/21 to 4/22. Supported Region 8 and Wyoming by developing a source water Harmful Algal Bloom risk index. The source water risk index was composed of a watershed metric that scored levels of fertilizer application, animal density and point source load to watershed, a reservoir metric that scored harmful algal bloom cell counts and toxin concentrations, nutrient concentrations and algal production in upstream reservoirs (weighted for distance to intake), and a stream metric that scored toxin producing harmful stream algae, nutrient concentrations, and algal biomass. The three metrics were combined into an overall source water score that ranked intake source waters from 0 (low risk) to 5 (high risk). Source water index scores were calculated for drinking water facilities across Wyoming.

Fish Creek Nutrient Assessment, USEPA/Region 8 (Wyoming). 8/20 to 8/21. Wyoming DEQ has neither numeric nutrient criteria nor an explicit assessment method for interpreting the relevant narrative criteria. The purpose of this project was to assist WDEQ with completing a use support determination for Fish Creek and to use Fish Creek and this exercise as a case study to assist WDEQ with developing an assessment method for nutrients in wadeable streams statewide in Wyoming, including evaluation of filamentous algae. Work included developing a summary of representative state nutrient criteria and consolidated assessment and listing methodologies (CALM), compiling all available data for Fish Creek into a database and constructing maps using GIS, identifying potential data gaps, developing a nutrient assessment methodology for Fish Creek, applying that methodology on Fish Creek, and recommending a statewide nutrient assessment methodology based on this experience. Tasks included literature review, database construction, statistical modeling of chemical and biological data, and report writing.

Harmful Algal Bloom and Cyanotoxin Evaluations in Utah Lake and Great Salt Lake. USEPA/Region 8. 2/16 to 12/19**.** Led the development of recommendations for microcystin levels,

chlorophyll a concentration, and cyanobacterial thresholds for protecting aquatic life and human health in Utah Lake, UT. Conducted literature reviews and statistical analysis of existing data to support the development of protective thresholds for these indicators associated with harmful algal blooms. In addition, conducted an expert peer review of a white paper criticizing the presumed eutrophic condition of Utah Lake. This consisted of in-depth review of technical reports and studies along with additional analysis as well as development of a detailed technical rebuttal of the major points of the white paper, including identification of several inaccuracies and illogical statements. The review led to support for listing of the lake as nutrient impaired. In Great Salt Lake, supporting an assessment of recreational use attainment in Farmington Bay associated with harmful algal blooms including Nodularia and the toxin nodularin. Conducting technical reviews of recreational use, existing literature, reanalysis of existing data, and comparison of toxin data to existing health advisories for comparable toxins. Will then draft an assessment to support Region 8 attainment decisions.

Technical Support for Water Quality Monitoring in Kentucky Tributaries to the Tug Fork River for Ionic Toxicity TMDL Development

Client: USEPA Region 3

U.S. EPA Region 3 contracted with Tetra Tech to conduct water quality monitoring in the Kentucky portion of the Tug Fork River watershed. Monitoring began in spring 2019 and lasted approximately one year through spring 2020. The data was used by the West Virginia Department of Environmental Protection to develop TMDLs for fecal coliform and iron. For the monitoring, Tetra Tech followed the WV DEP sampling QAPP and SOPs, including sample filtration, flow measurement, and the collect of quality assurance samples.

As a first step, Tetra Tech established sampling locations near the base of the seven EPA-identified tributaries. Tetra Tech collected monthly samples over a range of flow conditions. Samples were collected and sent to a laboratory and analyzed for iron and aluminum (total and dissolved), minerals (Mg, Ca, K, NA, Mn), alkalinity, acidity, chloride, TSS, TDS, and bacteria. Tetra Tech also collected field readings for temperature, DO, pH, and specific conductivity. Staff collected field notes using WV DEP field forms. All monitoring data and field forms were provided monthly to EPA. In addition, Tetra Tech developed a monthly quality assurance statement after reviewing the laboratory results, including the results of the field blanks and sample duplicates. At the end of the monitoring period, Tetra Tech developed a final quality assurance report.

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 an 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.

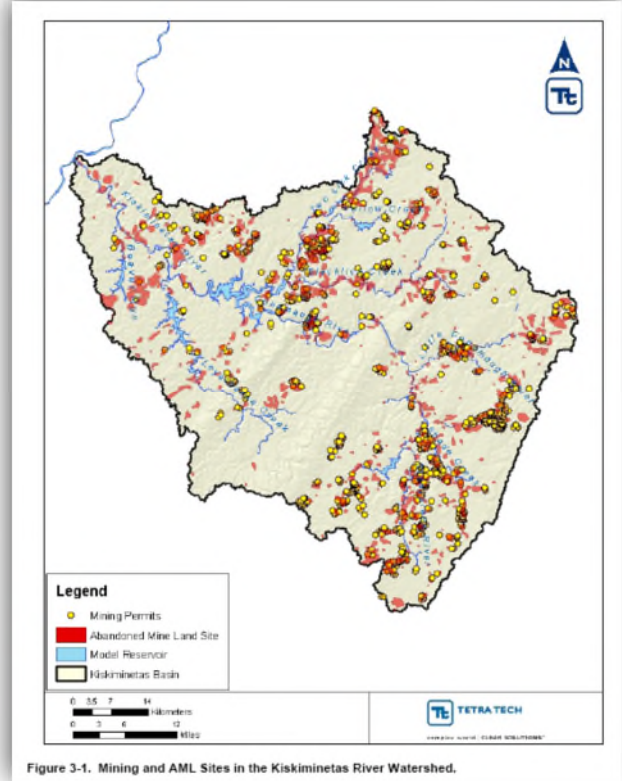


Figure 3-1. Mining and AML Sites in the Kiskiminetas River Watershed.

Minnesota Watershed Modeling

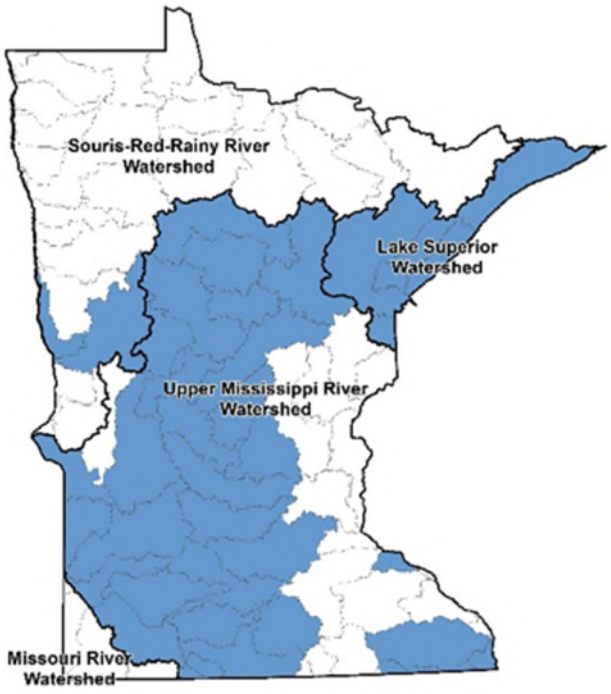
Client: Minnesota Pollution Control Agency (MPCA)

Tetra Tech has been supporting the Minnesota Pollution Control Agency (MPCA) with developing Hydrological Simulation Program—FORTRAN (HSPF) models throughout Minnesota for over 16 years. Tetra Tech's support in the Minnesota River basin has occurred over a 16-year period and began with development of a basin-wide HSPF model to support dissolved oxygen TMDL development in the Minnesota River in 2000. Tetra Tech then used the model to develop a set of scenarios for a Turbidity TMDL and was then contracted to update the hydrologic and sediment simulations in the basin in 2015.

These models provide information that supports total maximum daily load studies (TMDLs), watershed restoration and protection strategies (WRAPS), and comprehensive watershed planning under Minnesota's Watershed Approach. In addition to simulating hydrology, these models are designed to support biological stressor identification and analysis of pollution-related impairments such as elevated turbidity and the effects of elevated nutrient concentrations. The models also provide a tool for evaluating appropriate point source effluent limits for permitted facilities.

Tetra Tech has led the development of many HUC8-scale watershed models in the state and has provided additional support for calibration and validation in many others. The models simulate the complete sequence of flow, sediment, nutrients, dissolved oxygen, algae, and temperature and simulate continuous conditions over a multi-year time period.

Each watershed has posed unique circumstances that required a detailed knowledge of the watershed, data, and stakeholder needs. For example, in the Lake Superior Basin there have been significant hydrologic changes associated with iron and taconite mining operations. A GFLOW model was developed to simulate changes in groundwater to supplement the hydrology portion of the HSPF model in this case. Similarly, in the Root River watershed (southeastern MN), an approach was developed to model karst geology. The results of dye tracing studies and hydrologic work was incorporated into this model. The Otter Tail River watershed in northwestern Minnesota is extremely lake-rich. Over 100 lakes were explicitly modeled and an approach was developed to integrate the use of the Bathtub model to simulate lake response in key lakes. Tetra Tech's continued modeling support to the MPCA has also included the use of Soil Water Assessment Tool, CE-QUAL-W2, and Qual2K.



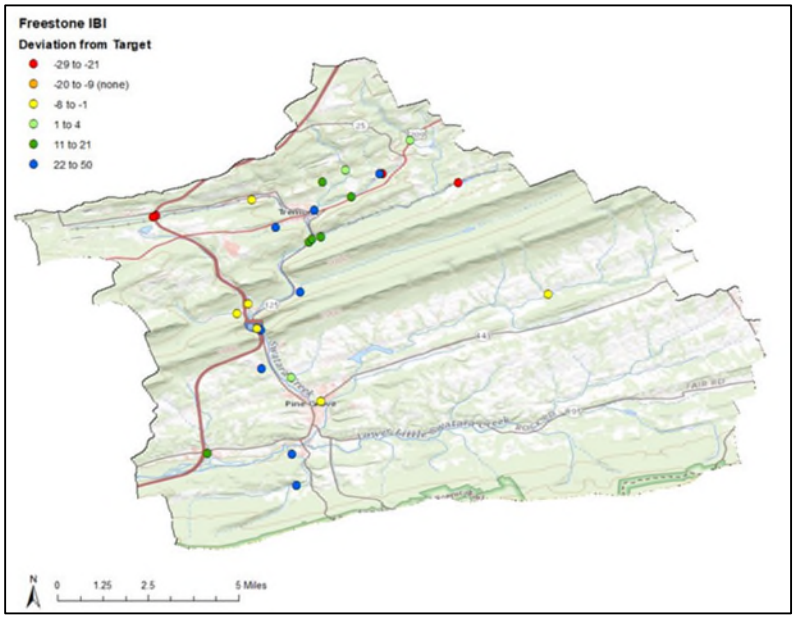
Tetra Tech has developed watershed plans to implement TMDLs, manage stormwater, meet WRAPS requirements in MN's Clean Water Legacy Act, meet EPA section 319 minimum elements, comply with MS4 permits, protect drinking water supply, and provide flood control. The skills and expertise of our staff allow us to provide comprehensive support throughout the entire planning process, from the development of goals and targets and characterization of the watershed and its problems, through identification, evaluation and prioritization of BMP and stream restoration opportunities, through design and construction of projects, with expert facilitation and stakeholder involvement throughout.

Updating Pennsylvania 319 Watershed Implementation Plans

Client: U.S. Environmental Protection Agency Region 3 in support of Pennsylvania DEP

Tetra Tech assisted EPA Region 3 with updates to three older Watershed Implementation Plans (WIPs) in Lancaster County, Schuylkill and Allegheny Counties, Pennsylvania. Although EPA was the primary client, Tetra Tech worked with the local watershed sponsors from 2019 to 2021 to develop the plan updates, with input and feedback from Pennsylvania Department of Environmental Protection. EPA's objective in funding plan updates was to bring the plans into compliance with the Nine Elements for Watershed Based Plans, making these watersheds and the projects identified in their plans eligible for EPA's Section 319 grant funds.

Developing the WIPs required close coordination with the local watershed sponsors to ensure that local feedback, knowledge and input were incorporated into each plan. Along with the local sponsors, each plan was developed with the involvement of the respective stakeholder group, which included the sponsor, the county Conservation District, universities, the U.S. Geological Survey, local stormwater utilities, consultants, watershed groups, and municipal elected officials. Tetra Tech coordinated four meetings with each watersheds' stakeholder group to present information on the WIP development process and obtain local data and information.



The WIPs were updated to account for watershed changes over the past 15 years and implementation already conducted, and to identify new project types and locations. A key new focus of the updated WIPs is the requirement to identify critical areas – small water quality-impaired subwatersheds that, with targeted implementation, can be restored to meet water quality standards and be removed from Pennsylvania's Impaired Waters list in 5-10 years. Tetra Tech analyzed the water quality impairment listings in each watershed, reviewed available water quality data and macroinvertebrate data to identify 3-4 critical areas within each watershed.

Tetra Tech presented the candidate critical areas to each watershed stakeholder group to obtain their approval and incorporate their local knowledge of the feasibility of working in each of these areas. In some cases, critical areas were revised to better account for landowner willingness, project feasibility, ongoing implementation projects, and other factors identified by the stakeholders. Implementation in critical areas will be prioritized for EPA Section 319 funding in future rounds of grant-making. Tetra Tech was also responsible for identifying water quality targets, watershed modeling to quantify the potential load reductions from implementation activities in the plans, and developing schedules and milestones to achieve the water quality targets and remove segments from the impaired waters list.

Western Hills Watershed Management Plan

Client: Loudoun County, Virginia

Tetra Tech supported Loudoun County, Virginia, Department of Building & Development, Natural Resources Division, in developing a watershed plan to help guide actions for the protection and restoration of the Western Hills Watershed Management Area: North Fork Goose Creek and South Fork Catoctin Creek watersheds. The plan, developed in 2018 to 2019, will assist the County in prioritizing actions to maintain water quality, reduce stream erosion, and reduce pollutant loads, particularly to address Chesapeake Bay Total Maximum Daily Load (TMDL) goals for nutrient and sediment reductions.

Tetra Tech conducted initial desktop analyses to characterize current watershed conditions and to target candidate sites for field surveys. GIS analyses included review of existing data sources and maps pertinent to watershed management and water quality including, for example, geology, soils, streams, forest cover, stormwater infrastructure, streamflow, water quality, stream habitat and benthic macroinvertebrates, and land use (zoning, planned use, build-out, population). Tetra Tech analyzed groundwater quality and water use data to screen for water quality concerns and to prepare a water budget, particularly in light of recent and planned future development, and conducted well sampling to characterize current groundwater quality.

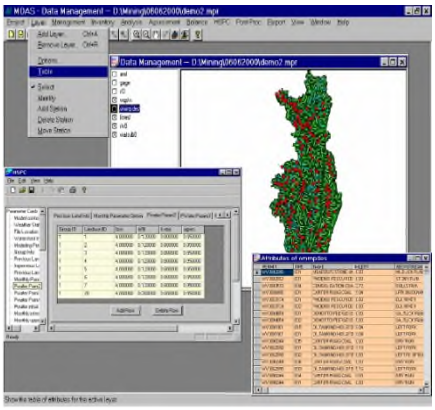
Tetra Tech conducted field investigations including stream assessments, hotspot investigations for pollutant discharges, evaluations of existing stormwater Best Management Practices (BMPs), and identification of opportunities for new BMPs. To facilitate work by multiple field teams, Tetra Tech designed a custom mobile data application. Commercial/industrial sites were inspected for potential pollution runoff and illicit discharge issues; recommendations were made on good housekeeping practices. Along 10 miles of stream, teams collected stream data including habitat assessments and documentation of fish barriers, erosion sites, and other channel features. We developed and ranked a suite of restoration recommendations, including stream restoration, fish passage, upland and riparian tree plantings, new and upgraded BMPs, pollution prevention, and landowner best management practices. Tetra Tech employed the Chesapeake Assessment Scenario Tool (CAST) to quantify pollutant loads and the expected load reductions from proposed strategies under current and future land use scenarios.

To involve the community and local watershed leaders in Plan development, Tetra Tech supported community outreach, including meeting with a Watershed Partnership Workgroup of diverse stakeholders (Soil and Water Conservation District, Virginia Department of Forestry, Virginia Department of Environmental Quality, Town of Purcellville staff, environmental groups, and local residents) and facilitating a community meeting to solicit public input. Tetra Tech presented interim results and the final watershed plan to the County's Water Resources Technical Advisory Committee (WRTAC).

Tetra Tech coordinated closely with Loudoun County staff throughout the project through regular communications, including in-person and virtual meetings at key decision points. By utilizing a team of experts with advanced scientific, engineering, and GIS skills, Tetra Tech provided high-quality deliverables that met or exceeded County expectations. The County's WRTAC expressed appreciation for the quality and quantity of information provided by Tetra Tech in presentations and reporting. Work was completed in June 2019: on time, within the ambitious one-year timeframe, and within the allotted project budget.

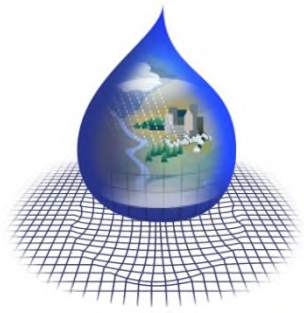
III.C. WATER QUALITY MODEL EXPERIENCE

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 comprehensive modeling systems, model interfaces and supporting analytical tools. We have built multiple 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

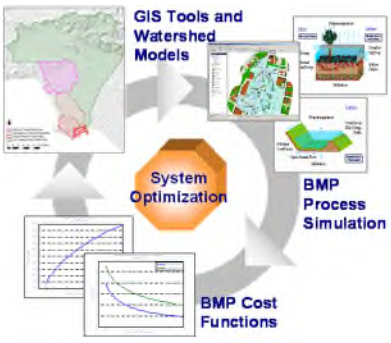


Figure III-1 illustrates the West Virginia basins where Tetra Tech has performed modeling to support TMDL development, resulting in watershed models that cover more than 92 percent of the state.

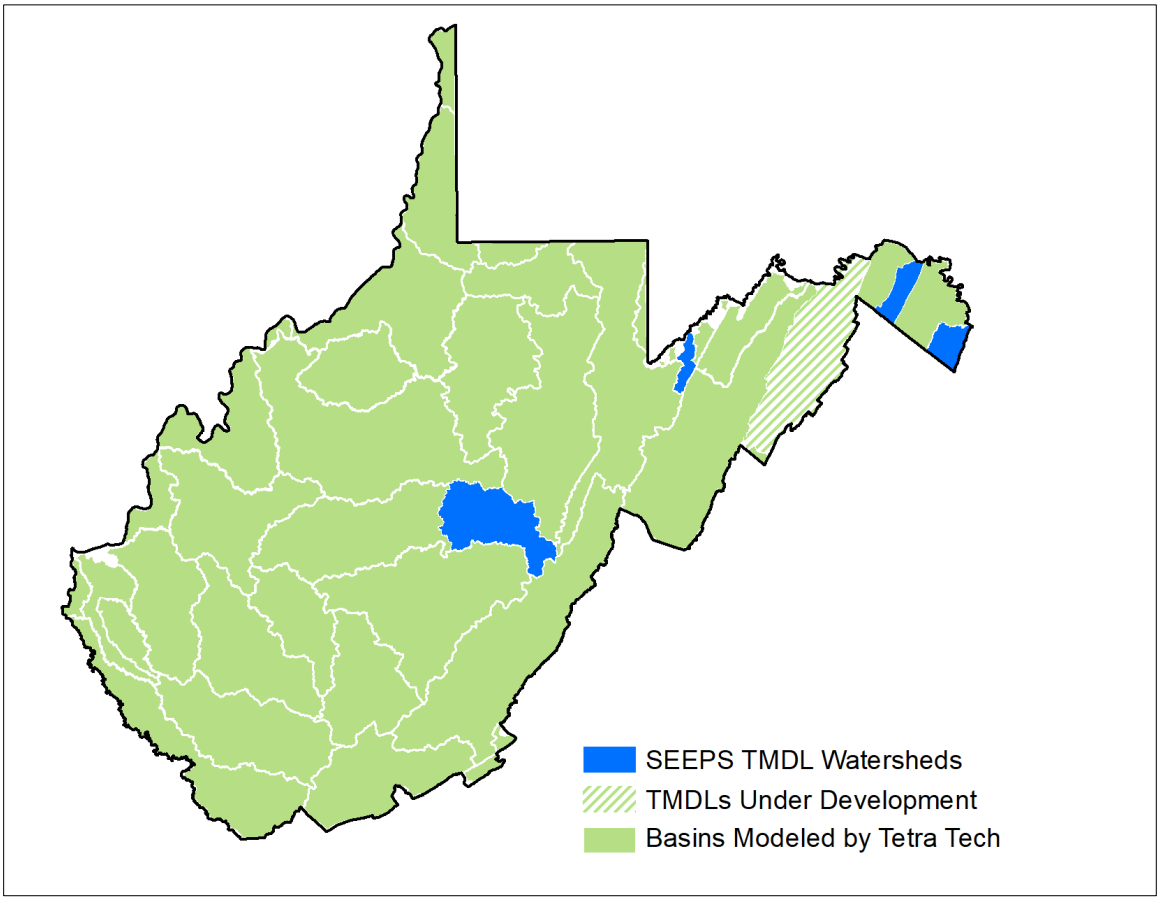


Figure III-1. West Virginia basins in which Tetra Tech has conducted watershed and water quality modeling

III.D. ENTITIES FOR WHICH TETRA TECH HAS DEVELOPED TMDLS

Mindy Neil
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1200 6th Ave, Suite 900
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USEPA Region 2
290 Broadway, 24th Fl.
New York, NY 10007
212-637-3823
OConnor.Rosella@epa.gov

Ruth Kolb
City of San Diego
Storm Water Department
9370 Chesapeake Drive, Suite 100
San Diego, CA 92123
858-541-4328

Appendix A

Resumes

TETRA TECH

Diane Allen, MEM, MD
Biological Analyst

EXPERIENCE SUMMARY

Diane Allen is an aquatic ecologist at Tetra Tech with over 8 years of experience in aquatic ecology, statistical analyses, GIS, ecosystem services, literature reviews, and data preparation and management. Her work has primarily focused on statistical model development and application for the analysis of water quality and biological response to stress. Her primary focus over the last 8 years has been on nutrient criteria and biological tool development. Dr. Allen is also experienced in the quantification and evaluation of ecosystem services and their application in landscape management to improve water quality. Dr. Allen has conducted work for local, state, and federal agency clients.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Staff Scientist/Freshwater Ecologist, 2015-Present

Duke University, Ecosystem Services Research Aide, Summer-Fall 2014

Environmental Defense Fund, Program Intern, Summer 2013

Duke University and Durham VA, Assistant Professor, 2002-2012

Duke University, Hand and Microsurgery Fellow, 2001-2002

Duke University, Orthopaedic Surgery Resident, 1997-2001

RELEVANT EXPERIENCE

West Virginia Fish Index of Biological Integrity. West Virginia Department of Environmental Protection. 2021 - present. Analyst. Used random forest modeling techniques to analyze richness and proportion of 115 different fish species with respect to approximately 240 different metrics across 502 unique stations including both stress and reference conditions.

West Virginia Stressor Identification Models. West Virginia Department of Environmental Protection. 2018 - 2021. Chief supporting analyst. Developed a general stressor PCA gradient, and single stressor gradients (acid, sediment, organic pollution, conductivity/ions, and metal) to generate tolerance values for benthic macroinvertebrate taxa. Developed an O/E bioassessment model.

Development of Ionic Toxicity Endpoints for TMDL Development. USEPA/Region 3. 1/2020 to present. Chief supporting analyst. Developed endpoint thresholds for conductivity to protect aquatic life in West Virginia Streams to support development of ionic toxicity TMDLs in the Lower Guyandotte River system. Compiled available landscape, water quality, and biological stream data. Conducted classification analyses using uni- and multivariate statistical models in the R programming platform. Developed linear and non-linear stressor-response models to identify conductivity and individual ion thresholds associated with meeting aquatic life use indicator targets. Deployed the stressor-response models in an R Shiny Application for collaborative review. Developed empirical models relating continuous conductivity data maximum 4-day concentrations to annual average values to predict maximum targets associated with average annual conductivity targets.

EDUCATION

Master of Environmental Management, Ecosystem Science and Conservation, Nicholas School of the Environment, 2014

M.D., Duke University School of Medicine, 1995

B.S., Molecular Biology and Mathematics, Vanderbilt University, 1991

AREAS OF EXPERTISE

Data analysis to support nutrient criteria and biologic indicator development

Freshwater ecology

Geospatial analyses

Ecosystem Services

LICENSES/REGISTRATIONS

Certificate of Geospatial Analysis

OFFICE LOCATION

Research Triangle Park, NC

YEARS OF EXPERIENCE

9

YEARS WITH FIRM

8

Development of a Biological Potential Model for North Carolina Urban Streams. North Carolina Water Resources Research Institute (NC WRRI)/Urban Consortium Stormwater Group. Raleigh, NC. 2014-2018. Lead analyst. Developed a biological potential model for urban streams in North Carolina. For the Phase 2 project, led the statistical analysis create a biological potential model based on Paul et al. (2009) research paper that develops realistic expectations for biological condition along urban gradients in cities using quantile regression, analyzed watershed and habitat factors associated with better and worse than expected potential using discriminant analysis, classification and regression trees and other multivariate statistics, and recommended policy strategies for advancing the management of biological conditions in urban NC streams based on this research. Co-authored the technical report and subsequent presentations to local government, state, and regional audiences.

National Nutrient Criteria Technical Support: NSTEPS. USEPA Office of Science and Technology/Health and Ecological Criteria Division (OST/HECD) Nationwide. 2015-present. Chief supporting analyst. Provided a wide range of technical services for OST including: compiling large state databases of water quality and biological data (including reconciling taxonomic inconsistencies); conducting statistical analyses (descriptive/exploratory as well as stressor-response relationship modeling including multivariate exploratory statistical analyses, parametric and non-parametric regression models, machine learning methods including classification and regression trees (CART), Random Forests, and model based recursive partitioning, and structural equation modeling) to establish thresholds of nutrient effects; developed observed/expected RIVPACS-type model for benthic macroinvertebrates; co-authored technical report development; supported literature reviews and syntheses on a variety of technical topics. Through N-STEPS, provided technical support to more than 10 state and tribal water quality agencies including leading analysis of North Carolina estuarine and lake data to support classification for purposes of numeric nutrient criteria development. Developed interactive web-based application (R Shiny) to assist Alabama in calculating their own O/E scores from their statewide model.

South Dakota Lakes Classification and Stressor-Response Modeling. USEPA Region 8 and USEPA OST/HECD. South Dakota. 2016-2018. Chief supporting analyst. Conducted analyses to develop classification and stressor-response relationship models to identify numeric targets for protecting water quality of lakes in South Dakota. Using a conceptual model of nutrient impacts to lakes in South Dakota, conducted a variety of statistical analyses to inform classification of South Dakota lakes including univariate and multivariate analyses of water quality and biological data. Following agreement on classification, conducted stressor-response based analyses to inform development of numeric nutrient thresholds using nutrient stressor and a variety of biological responses including dissolved oxygen depletion, algal biomass, and nuisance algal biomass and composition. Statistical modeling included classification and regression trees (CART), non-metric multidimensional scaling (NMS), model based recursive partitioning, and regression modeling.

Using Green Infrastructure to Enhance Biodiversity in the MMSD Planning Area. Milwaukee Metropolitan Sewerage District. Milwaukee, WI. 2016-2018. Supported development of a biodiversity plan for MMSD for use in informing decision-making with regards to green infrastructure implementation. Conducted a review of existing urban biodiversity plans. Evaluated GI planning efforts with landscape ecological principles to construct recommendations on how to apply GI to potentially improve regional biodiversity. Also conducted an analysis of the ecosystem goods and services associated with the current palette of GI practices used by MMSD including development of spatial models in GIS. Developed recommendations on a monitoring framework and education and citizen involvement opportunities associated with GI as well as part of the broad ecosystem goods and services valuation.

TETRA TECH

Sen Bai, Ph.D., P.E.
Senior Water Resource Engineer

EXPERIENCE SUMMARY

Dr. Sen Bai is a senior modeler providing technical and project management support to federal, state, and municipal clients in the areas of water quality/sediment transport modeling, watershed modeling, hydrodynamic modeling, watershed management, point and nonpoint source pollution characterization and assessment, TMDL development and implementation. Dr. Bai has extensive experience in eutrophication, enteric bacteria, and sediment transport areas, and has served as lead modeller for over 40 waterbodies and watersheds, including lakes, rivers, reservoirs, bays and coastal area in Alberta, the U.S., and in Europe (Slovenia) using CE-QUAL-W2, EFDC (including EFDC Explorer), WASP, HEC-RAS, RMA2 and RMA11, EPASWMM, XPSWMM, LSPC, and HSPF. He is knowledgeable in numerical methods, and he is a skillful programmer. Dr. Bai also developed post processors for models such as W2, EFDC, and LSPC with Matlab, Excel VBA, FORTRAN, Python, and Tecplot.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Environmental Engineer, January 2004–present

RELEVANT EXPERIENCE

Monongahela River Fecal Bacteria EFDC Model Development, WV. WVDEP, 2018, Led the development of a high resolution, two-dimensional hydrodynamic and fecal coliform bacteria fate and transport model for the Monongahela River using EFDC. The EFDC model was linked with an LSPC watershed model, which provided bacterial loading from upstream tributaries. The model also considered fecal coliform loading from WWTPs and CSOs and considered the first-order die off mechanism of fecal bacteria. Two-dimensional and three-dimensional animations were generated to demonstrate fecal coliform concentrations spatially over time. The model was applied to simulate load reduction scenarios that provided decision support for TMDL development.

Sandusky Bay Eutrophication Model Development, OH. EPA, 2017, Led the development of the hydrodynamic and eutrophication model of the Sandusky Bay using EFDC. The EFDC model was linked with a watershed model SWAT, and Lake Erie influences were incorporated via open boundary conditions. Sediment diagenesis module was activated to allow seamless representation of nutrient cycles in the bay. Internal phosphorus loadings were compared with external phosphorus loadings. It was found that the internal phosphorus loadings are significant especially in summer seasons.

Grand Lake Eutrophication Model Development, OK. EPA, 2012, Led the development of the hydrodynamic and eutrophication model of the lake using EFDC. The EFDC model was linked with a watershed model SWAT. Sediment diagenesis module was activated to allow seamless prediction of lake conditions corresponding to the management practices on land. TMDL was developed using the developed EFDC.

Famosa Slough Eutrophication Modeling and TMDL Support, City of San Diego, CA. City of San Diego, 2015. Served as a QA/QC officer to

EDUCATION

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

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

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

AREAS OF EXPERTISE

Watershed management

Watershed modeling

Stormwater modeling

TMDL Development

Hydrodynamic modeling

Water quality modeling

Sediment transport modeling

Reservoir management

Water quality monitoring program design and implementation

LICENSES/REGISTRATIONS

Professional Engineer, Virginia, License No. 0402 045241

PROFESSIONAL AFFILIATIONS

American Society of Civil Engineers

American Society of Limnology and Oceanography

American Geophysical Union

OFFICE LOCATION

Fairfax, VA

YEARS OF EXPERIENCE

23

YEARS WITH FIRM

18

review the model configurations and model report. Checked the input files, output files, comparisons of model and data to evaluate if model agrees well with data. Provided feedback to the model developer to improve the model performance.

Frank Lake Water Quality Model Development, Alberta, Canada. AEP, 2014. Prepared the technical approach in the proposal. Estimated the cost and hours. Developed a lake model with linked SWAT and EFDC framework. The model represented complete cycles of nitrogen, phosphorus, and carbon in the lake environment under the influence of both natural contributions and WWTP discharges. It simulated nutrients, phytoplankton, DO, sediment diagenesis, and rooted plant. The model is ready to simulate management scenarios.

South Saskatchewan River In-stream Water Quality Model Development, Alberta, Canada. AEP, 2015. Prepared the technical approach in the proposal. Estimated the cost and hours. Developed a hybrid one dimensional and two dimension model for simulating the SSR water quality using EFDC-Explorer. The model represented kinetics of nitrogen, phosphorus, and carbon in the river under the influence of Bow River and Oldman River, tributaries, irrigation return flows, and point sources including WWTP discharges. The EFDC model simulated nutrients, carbon, DO, phytoplankton, benthic algae, and macrophyte. The model is ready to simulate management scenarios.

Sheep River In-stream Water Quality Model Development, Alberta, Canada. AEP, 2014. Prepared the technical approach in the proposal. Estimated the cost and hours. Developed a two dimension model for simulating the Sheep River water quality using EFDC. The model represented kinetics of nitrogen, phosphorus, and carbon in the river under the influence of both non-point source contributions and WWTP discharges. A SWAT model provides the non-point sources and loadings. The EFDC model simulated nutrients, carbon, DO, phytoplankton and benthic algae. The model is ready to simulate management scenarios.

Green/Duwamish River Watershed PLA, Seattle, WA. EPA, 2015. Led the refinement of the technical approach to address the cleanup of contaminated sediment in the Lower Duwamish River. Reviewed the RI and FS reports. Prepared memos on data gaps and pollutant groupings. Led the review of two existing EFDC models for the Lower Duwamish River.

Stanislaus River Water Temperature Modeling, NOAA NMFS. NOAA, 2011. Served as the lead modeler. Developed three-dimensional hydrodynamics and water temperature models for three reservoirs and a one dimensional EFDC model to simulate the water temperature in the channel below the reservoirs. Guided the application of HEC5-Q to obtain water temperature changes corresponding to reservoir operations and used the results to evaluate the impacts of reservoir operations on the downstream water temperature.

Nutrient Criteria Development: Hydrodynamic and Water Quality Model Development for the Charlotte Harbor, Caloosahatchee Estuary, and Estero Bay, FL. EPA, 2012. Led the development of the hydrodynamic and water quality model of the Charlotte Harbor, Caloosahatchee Estuary, and Estero Bay. It is an integrated modeling system with LSPC for watershed, EFDC for hydrodynamics and WASP for water quality. The modeling system was applied to simulate various management scenarios to investigate the potential environmental benefit corresponding to management practices. The ultimate goal is to protect the sea grass habitat in the system.

North Saskatchewan River Integrated Water Quality Model Development and Application to Evaluate Basin Scenarios. AEP, 2013. Supported AENV in integrating the existing hydrodynamic and water quality models of the river with a basin-wide watershed model so that scenarios can be readily evaluated. Led development of 2 new EFDC hydrodynamic and water quality models for the Brazeau Reservoir and Abraham Lake.

Hydrodynamic and Water Quality Model Development for the Lower Athabasca River, Alberta. AEP, 2012. For AENV, developed an EFDC hydrodynamic and water quality model for the Lower Athabasca River. The model was developed to evaluate potential impacts of tributary and facility inputs on conditions in the oil sands region.

Mispillion River and Cedar Creek modeling, DE. DNREC, 2006. Served as the lead modeler to develop a linked watershed and receiving water model to support the nutrient and bacteria TMDL for the state of Delaware. 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.

TETRA TECH

John Beckman
Project Manager

EXPERIENCE SUMMARY

Mr. Beckman has over 20 years of professional experience performing scientific research, analysis, and field surveys. Mr. Beckman leads Tetra Tech's statewide TMDL development efforts for the West Virginia Department of Environmental Protection (WVDEP). His duties include project management, water quality modeling, data management, GIS analysis, technical writing, field investigations, and public outreach support. Mr. Beckman has also performed stream ecology, forestry, wildlife, and botanical studies in the eastern United States.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Environmental Scientist, 2000–present

West Virginia Division of Natural Resources/The Nature Conservancy, Wildlife Biologist, 1998–2000

RELEVANT EXPERIENCE

Total Maximum Daily Load (TMDL) Development for Little Kanawha River, West Virginia Department of Environmental Protection (WVDEP), Charleston, WV. 2021-2023. Serving as project manager for fecal coliform and metals TMDL development contract. Led modeling effort for fecal coliform. Built Loading Simulation Program in C++ (LSPC) model, performed hydrology and water quality calibration. Ran pollutant reduction scenarios and developed TMDL allocations.

Watershed Modeling for Rancocas Creek, Burlington County, New Jersey, USEPA Region 2. 2021-2023. Project manager for watershed modeling effort to simulate phosphorus, nitrate, and dissolved oxygen concentrations in a tidally influenced tributary of the Delaware River. Also leading watershed model setup and hydrology calibration.

TMDLs for Tug Fork River Watershed, WVDEP, Charleston, WV. 2020-2023. Serving as project manager for fecal coliform and metals TMDL development. Created subwatershed delineation using GIS, built LSPC model, and performed hydrology calibration. Led fecal coliform and selenium TMDL development, including water quality calibrations and TMDL allocations. Characterized Combined Sewer Overflow (CSO) inputs for two outlets.

Watershed Modeling for Saddle River, Bergen County, New Jersey, USEPA Region 2. 2020-2022. Developed model landuse using GIS, digitized subwatershed delineation, built and calibrated LSPC model hydrology.

TMDLs for Lower Guyandotte River Watershed, WVDEP, Charleston, WV. 2019-2022. Project manager for TMDL development contract. Created subwatershed delineation, built LSPC model, and performed hydrology calibration. Led fecal coliform and selenium modeling, including water quality calibrations and TMDL allocations.

TMDLs for Big Sandy, Lower Ohio, and Twevelpole Watersheds, WV. 2018-2021. For WVDEP, served as project manager for TMDL

EDUCATION

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

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

AREAS OF EXPERTISE

TMDL development

Watershed modeling

Project Management

Water quality field studies

Land use analysis and GIS

Watershed data management

Stream ecology and hydrogeomorphology surveys

Botanical surveys

LICENSES/REGISTRATIONS

None

TRAINING/CERTIFICATIONS

Rosgen Level I - Applied Fluvial Geomorphology, 2006

PROFESSIONAL AFFILIATIONS

Southern Appalachian Botanical Society

OFFICE LOCATION

Charleston, WV

YEARS OF EXPERIENCE

26

YEARS WITH FIRM

23

development for watershed group E4. Led fecal coliform and selenium TMDL development, including water quality calibrations and TMDL allocations. Created subwatershed delineation, built MDAS model, and performed hydrology calibration.

TMDLs for Upper Guyandotte River Watershed, WV. 2017-2020. For WVDEP, served as project manager for TMDL development for watershed group E3. Created subwatershed delineation, built MDAS model, and performed hydrology calibration. Led fecal coliform and selenium TMDL development, including water quality calibrations and TMDL allocations.

TMDLs for Hughes River and Monongahela River Watersheds, WV. 2016-2018. For WVDEP, led fecal coliform TMDL development for watershed group D3. Created subwatershed delineation and modeled reach for MDAS model setup. Developed EFDC model inputs to represent point and nonpoint sources of pollution.

TMDLs for Meadow River, Warm Spring Run, and Rocky Marsh Run Watersheds, WV. 2015-2017. For WVDEP, led fecal coliform TMDL development for watershed group C3. Developed and calibrated MDAS water quality models for fecal coliform. Developed model inputs for failing septic systems, MS4 areas, and agricultural sources. Supported pH model landuse setup. Calculated TMDL fecal coliform load allocations and wasteload allocations.

TMDLs for Tygart Valley River Watershed, WV. 2014-2015. 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. Provided technical support to WVDEP at public meetings.

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.

TETRA TECH

Jonathan Butcher, PhD, PH
Model Developer

EXPERIENCE SUMMARY

Dr. Butcher has over 35 years of experience in watershed planning; risk assessment; water quality management; and 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 include applications for TMDL development, source water protection, climate change analysis, and development of numeric water quality criteria.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Director, Senior Hydrologist, 2011–present

Tetra Tech, Inc., Associate Director/Principal Hydrologist, 1996–2011

The Cadmus Group, Inc., Hydrologist, 1993–1996

Gradient Corporation, Senior Associate, 1990–1993

Duke University, Department of Civil and Environmental Engineering, Research Assistant, 1985–1989

RELEVANT EXPERIENCE

Mercury TMDL Development for Willamette River Basin, 8/2017-present. USEPA Region 10 and Oregon Department of Environmental Quality. Leading project to support development of a revision to the Willamette River Basin mercury TMDL in accordance with a consent decree that requires a compressed schedule. The modeling framework consists of a probabilistic Food Web Model that establishes the relationship between fish tissue concentrations and methyl mercury (MeHg) exposure concentrations, a Mercury Translator, which describes observed relationships between MeHg and total mercury, and a Mass Balance Model, which relates mercury sources to instream concentrations. Required revisions include incorporation of new data and recalculation based on new fish tissue mercury standard. Tt converted the existing Food Web Model from a proprietary format to R code and enhanced the Mass Balance Modeling through incorporation of an existing Tt-developed HSPF watershed model of the basin.

Otter Tail Watershed Model, **Minnesota Pollution Control Agency (MPCA). 2016–2018.** Developed comprehensive HSPF watershed model of hydrology, sediment, and nutrients for the Otter Tail HUC8 watershed, which has hundreds of connected lakes. Devised approaches to represent lake stratification and ice cover effects within HSPF and calibrated model to lake level and discharge information.

Green Infrastructure Performance under Climate Change, EPA ORD. 12/13–present. Leading modeling evaluation of impacts of climate change

EDUCATION

PhD, Civil and Environmental Engineering (Water Resources), Duke University, 1989

MEM, Water Resources, Duke University School of Forestry and Environmental Studies, 1984

BA, Harvard College, 1973

AREAS OF EXPERTISE

Environmental statistics

Hydrodynamic modeling

Pollutant source assessment

TMDL development

Water quality modeling

Watershed management

REGISTRATIONS/ AFFILIATIONS

Professional Hydrologist (No. 1087, Registered by the American Institute of Hydrology, 1995)

American Geophysical Union

American Institute of Hydrology

American Society of Civil Engineers

American Water Resources Association

International Water Association

North American Lake Management Society

Society of Environmental Toxicology and Chemistry

Water Environment Federation

OFFICE

Research Triangle Park, NC

YEARS OF EXPERIENCE

37

YEARS WITHIN FIRM

27

on water quality performance and nitrogen and carbon cycling in green infrastructure components such as bioretention and green roofs. Simulations use the RHESSys biogeochemical model applied to unit-area archetypal urban land subunits.

Santa Margarita River Assimilative Capacity/TMDL, EPA Region 9 and San Diego County. 05/93–12/94, 09/12–present. Initially responsible for modeling and analysis of instream impacts from WWTP discharges and nonpoint agricultural sources. Developed plan for analysis of geomorphological response of the stream corridor to increased impervious area and flood control efforts in upstream communities using Rosgen methodology and concepts of dynamic stream equilibrium. In follow-on work, developing a detailed HSPF model of sediment and nutrient transport from the watershed to the estuary. Linking a MODFLOW groundwater model to the surface water model and building WASP and QUAL2K receiving water models to assess nutrient assimilative capacity in the river itself.

Lower Duwamish Toxics Model, EPA Region 10 and Washington State Ecology. 01/15–12/18. Task lead for development of watershed model components for an effort to develop comprehensive loading and response models for a variety of toxics, including PCBs, dioxins, phthalates, and metals, for the Lower Duwamish Waterway in King County, WA. The watershed modeling component is being developed in LSPC, building on hydrologic model calibrations previously developed in HSPF. This will link to an EFDC model of the receiving estuary and a food web model of accumulation in biota.

Big Elk Creek, EPA Region 10 and Oregon Department of Environmental Quality (DEQ). 2015–2016. Assisted Oregon DEQ in the creation of a modeling system to represent and calibrate bacterial loads in coastal watersheds as a function of domestic and wild animal densities, on-site wastewater systems, and agricultural operations. Modeling system includes HSPF linked to custom R code for source load generation and the PEST automated calibration tool.

Des Moines River Model, MPCA. 2015–2016. Developed comprehensive HSPF watershed model of hydrology, sediment, and nutrients for the Des Moines River multiple HUC8 watershed. Key issues of interest include nutrient loading to prairie lakes and export of nitrogen to downstream impaired reaches. Devised approach to represent interactions with the productive alluvial aquifer that controls hydrology in much of the watershed.

Upper Minnesota and Lac qui Parle River Watershed Models, MPCA. 2015–2016. Developed comprehensive HSPF watershed model of hydrology, sediment, and nutrients for two HUC8 watersheds in Minnesota and South Dakota.

Superior North and South Watershed Models, MPCA. 2014–2016. Developed comprehensive HSPF watershed model of hydrology, sediment, and nutrients for two HUC8 watersheds draining to Lake Superior. Characterized meteorology using gridded NLDAS-2 project. Devised methods to represent impacts of bluff sloughing on sediment balance in model.

South Fork Nooksack Temperature TMDL and Climate Change Analysis, EPA ORD. 07/13–12/16. 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 and used to produce broad-scale projections of hydrologic changes using the VIC model. The team localized this information to develop estimates of relative changes in forcing variables important to water temperature prediction, including air temperature, precipitation, relative humidity, summer baseflow, and expected temperature of headwater, tributary, and groundwater discharges through the 2080s.

Downstream Protection Values, EPA ORD. 01/14–09/16. Led project to analyze interpretation of monitoring in stream networks where a downstream criterion was established in a terminal lake or reservoir. Implementing spatial network kriging analysis using SSN/STARS toolboxes as a framework for Monte Carlo analysis of the implications of different variance structures and sampling schemes. Tested the approach on real networks in Wisconsin and Tennessee.

Global Change Hydrology Impacts, EPA ORD. 07/08–09/16. Technical and modeling lead for large-scale, multifirm 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 United States. Basins were simulated with HSPF and SWAT, with future impacts simulated in response to a variety of different scenarios.

TETRA TECH

J. Trevor Clements
Outreach Specialist

EXPERIENCE SUMMARY

Trevor Clements is the Mid-Atlantic Regional Manager for Tetra Tech's Integrated Water Management Unit operating out of the Research Triangle Park in North Carolina. He has a Masters of Environmental Management from Duke University and over 30 years of experience in water management. Mr. Clements is a company leader in comprehensive watershed management and integrated ("One Water") water planning, working with public and private clients to develop and implement sustainable and resilient practices including green infrastructure and low impact development. From leading implementation of a watershed approach for North Carolina in the 1980s, to leading consultant support for rollout of the USEPA Watershed Academy in the 1990s, to focusing on local community integrated water approaches in the 21st Century, Mr. Clements has forged a reputation as an innovator in his field. He has researched and developed triple-bottom line management approaches for communities to respond to change (water quantity and quality, climate, land use, population, social and economic), managed numerous watershed-based assessments and management planning projects, advised on innovative facility and infrastructure planning, and assisted many implementation programs. He has achieved national recognition for his skills in facilitating teams to build organizational capacity for implementing integrated water approaches to support more resilient communities. Mr. Clements has authored multiple technical publications and guidance documents, and is a guest lecturer on sustainable water management practices at the ETH Swiss Federal Institute of Technology in Zurich, Switzerland.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Water Resources Planner, 1996–present

The Cadmus Group, Inc., Associate, 1993–1996

NCDENR, Water Quality Section, Modeler, 1983–1993

RELEVANT EXPERIENCE

Flood Resilience Tool. Managed development of new Building Blocks Tool and Workshop for offer by the USEPA Office of Sustainable Communities. A self-assessment tool allows a community to identify gaps for making the community more resilient (capacity, ordinances, plans, building policies, etc.). The workshop then follows to help the community develop next steps for increasing flood resilience. Managed team working with 10 communities that were selected for technical assistance and for which workshops were conducted between 2015 and 2017.

Smart Growth Assistance for Communities Impacted by Hurricane Sandy. Supported Renaissance Planning Group and USEPA to help a community in Long Island, NY, review opportunities for revising local codes to encourage use of smart growth practices related to flood resilience. Led efforts to incorporate flood management, stormwater management, green infrastructure, and LID aspects in an assessment tool and supported pilot application of the tool in Long Island.

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

AREAS OF EXPERTISE

Integrated One Water program development and planning

Community resiliency planning

Watershed planning

Watershed assessment

Source water protection

Stakeholder facilitation and public outreach

Program development and implementation support

Sustainable practices research

Water quality modeling

NPDES permitting support

PROFESSIONAL AFFILIATIONS

U.S. Water Alliance

American Water Works Association

Water Environment Federation

North Carolina Water Resources Association

OFFICE LOCATION

Research Triangle Park, NC

YEARS OF EXPERIENCE

40

YEARS WITH FIRM

27

Land and Water Quality Tool. Supported team to refine and use the USEPA Land and Water Quality Building Blocks tool to support rural and economically-challenged local communities, including pilot application communities in New Mexico with support from Region 6.

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.

EPA Office of Science and Technology. Managed contract overseeing work on water quality standards training, contaminated sediment management strategy, TMDL guidance for episodic conditions, mercury in fish tissue, state antidegradation procedures, revision of mixing zone guidance, and ecological modeling.

Planning Tool for Economic Resilience. Led development of a new tool for the USEPA Office of Sustainable Communities aimed at increasing economic resilience and growth. The Tool provides a framework for organizing and assessing potential impacts, both negative and positive, of natural hazards and climate change on local economic activity. In addition to USEPA, the project was supported by a team from the State of Rhode Island, and the Tool was piloted in the coastal village of North Kingstown, Rhode Island.

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 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.

Nebraska Watershed Management Approach. Lead facilitator for design and implementation of statewide watershed planning in the State of Nebraska. Over 12-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 watershed management approach.

State Watershed Management Scoping Facilitation. Under work assignments to the USEPA Office of Wetlands, Oceans, and Watersheds provided assistance to the States of South Carolina, Washington, Delaware, Idaho, New Jersey, Florida, Oregon, Minnesota, Tennessee and West Virginia. Facilitated outreach and efforts to scope changes that needed to be made in resource agency operations to support watershed-based management.

NPDES Point Source Control Policies and Procedures Development. Participated in and led numerous task force committees for the State of North Carolina to address regulatory issues, procedures, policies, and program infrastructure. Issues included antidegradation, discharges to zero 7Q10 streams, toxic controls, nutrient controls, controlling colored wastewaters, assimilative capacity banking, disinfection requirements in high-dilution streams, and mixing zone requirements.

Jordan Watershed Modeling and Jurisdictional Load Allocations. Managed project 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.

Case Studies on New Water Paradigm. Principal Investigator for research 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.

TETRA TECH

Jerry Diamond, PhD
Technical Expert

EXPERIENCE SUMMARY

Dr. Jerry Diamond is Vice President and a Director of ecotoxicology at Tetra Tech with over 40 years of experience in environmental toxicology, water quality criteria and standards, risk assessments, aquatic ecology, and design and interpretation of ecological and water quality assessments. For over 15 years, he has been Director of Tetra Tech's nationally accredited Ecological Testing Facility in Baltimore, MD, specializing in toxicology/fate evaluations of chemicals, aquatic, soil, and sediment toxicity tests under the Toxic Substances Control Act (TSCA), OECD, REACH, and NPDES, and toxicity identification evaluations of treated wastewater effluents. He has developed and managed over 300 environmental assessments involving a variety of commercial applications including oil and gas, pharmaceuticals, mining, metal plating/finishing, electronics, food processing, textiles, and chemical manufacturing. Dr. Diamond has also served as an invited water quality specialist for several international projects including Thailand's Ministry of the Environment, Brazil's Ministry and Petrobras, Japan's Ministry of the Environment, and Environment Canada. He has been an invited peer reviewer of water quality criteria for EPA, Environment Canada, and several others and he has developed toxicological threshold response values for chemicals in different media. He is an Editor of Aquatic Toxicology for the international journal *Environmental Toxicology and Chemistry,* and he has served on many peer review committees for other journals, EPA's Office of Research and Development and the Health and Ecological Criteria Division, NSF, and other granting institutions.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Vice President, 2012–present

Tetra Tech, Inc., Director of Ecotoxicology, 1993–present

Biological Monitoring, Inc., Blacksburg, VA, Technical Director, 1984–1993

Oregon Department of Fish and Wildlife, Fisheries Biologist, 1974–1980

Case Western University, Research Assistant, 1973–1974

RELEVANT EXPERIENCE

Biological Assessment and Decision Support Tool, City of San Diego. 2011 - present. Led bioassessment support to the City and stakeholder groups working with the State Water Quality Control Board in the development of a state-wide Biological Integrity plan. Reviewed technical information prepared by the SWQCB and led several technical studies and authored several reports examining key components of a bioassessment framework including reference conditions, modified streams and attainable bio-objectives, non-perennial streams and biological expectations, and causal analyses involving total dissolved solids/conductivity and pyrethroids using the San Diego River watershed as a case study.

Diagnostic Tools to Evaluate Impacts of Trace Organic Compounds on Aquatic Biota, Water Environment Research Foundation. 2009 – present**.** Directed a 2-year project to develop a screening framework that can be used to assess whether impacts on aquatic populations or communities are caused by, or could be caused by, unregulated organic contaminants of emerging concern (CECs) such as synthetic and natural hormones, current use pesticides, personal care products, and flame retardants. Directed various approaches for prioritizing which CECs are of most concern from an ecological perspective.

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, Case Western Reserve University, 1973

AREAS OF EXPERTISE

- Environmental toxicology
- Risk assessment
- Water and sediment quality assessments
- Statistical analysis

PROFESSIONAL AFFILIATIONS

Water Environment Federation

Society of Environmental Toxicology and Chemistry

Society for Freshwater Science

Sigma Xi

OFFICE LOCATION

Owings Mills, MD

YEARS OF EXPERIENCE

43

YEARS WITH FIRM

30

Ecological Risk Assessments, Lockheed Martin (Baltimore, MD). 12/2006 – present. Project manager for ERAs at the Middle River Lockheed Martin facilities near Baltimore Harbor involving historic sources of contamination, primarily metals (e.g., lead, zinc), solvents (e.g., TCE), dioxins, and PAHs. Directed terrestrial, sediment, and aquatic baseline ERAs involving a variety of receptors and habitat uses. Helped identify "hot spots" based on groundwater and soil data collected using a statistical sampling design and a combination of spatial analyses of chemical concentrations and statistical tools such as ordination and cluster analysis. Evaluated tentative hot spots in subsequent sampling phases to determine areas in need of potential remediation.

Remedial Investigation and ERA of the Anacostia River, Washington, D.C., Washington District Dep't of the Environment. 1/2014 – 9/2016. Assisted in developing an RI and ERA for a long-term assessment of the Anacostia River for Washington D.C. Department of the Environment. Assisted in developing the sampling design, analytical methods, and detection limits for ecological indicators used in the ERA. Oversaw sediment toxicity testing and bioaccumulation analyses of sediments and assisting in interpreting biota and chemical data as part of the ERA.

Sanitary Sewer Overflow Sampling Program Assessment, Metro Vancouver, B.C. 6/2010 – 10/2016. Helped develop a risk-based framework for prioritizing SSO sites in the metro Vancouver area, which was used as one of the tools for developing recommendations for improving the SSO sampling program. Performed and recommended various statistical analyses of SSO water quality data collected by Metro Vancouver and others as well as other site information such as aquatic life and habitat indicators and public accessibility to a given site. Used indicators of SSO discharge characteristics, site characteristics, and exposure characteristics to help formulate a weight of evidence tool that could summarize the relative risk of exposure and effects to human health and aquatic life.

Wetland ERA of Wood Preservative Facility, Florida. 5/2010 – 9/2016. Supervised an ERA for Southern Wood Piedmont in Baldwin, FL regarding historic dioxin contamination in runoff from the site. Various media including sediment, surface water, and surface soil were sampled and analyzed. Dioxins were characterized using toxicity equivalence following the procedure outlined by the World Health Organization. Spatial analysis was applied to delineate the area of concern within the study area based on the exposure point concentration that indicated potential risk to the most sensitive receptor of concern.

Drinking Water Technical Support, EPA/OGWDW. 4/2014 – 9/2016. Directed several projects in support of methods and data quality evaluations in response to EPA's Unregulated Contaminant Monitoring Rule as well as their disinfection byproduct monitoring rule for the drinking water program. Compiled information on analytical methods and their performance relative to different types of organic chemicals in raw and finished drinking water matrices and assisted EPA's TSD under OGWDW facilitate discussions with other laboratory staff regarding the reliability, robustness, and sensitivity of various sampling and analytical methods. Facilitated workgroup meetings regarding sampling and analysis methods for *Giardia* and *Cryptosporidium* and helped develop recommendations regarding analytical detection limits and method performance characteristics for protozoan pathogens.

Health Effects and Health Advisory Documents for Cyanotoxins, EPA/OST. 5/2015 – 6/2015. Reviewed and technically edited several documents summarizing health effects information for cyanotoxins including microcystins, anatoxin-a, and cylidrospermopsin. Reviewed toxin fate and occurrence in water and other media, toxicokinetics, acute and chronic toxicity studies from animal studies using oral, dermal, and other routes of exposure evaluating neurotoxicity, reproductive toxicity, immunotoxicity, carcinogenicity, mutagenicity and genotoxicity, and tumor promotion. These documents identified key studies and endpoints which were used to derive RfDs as well as national health advisory values for children and adults, where sufficient information existed.

Development of Risk Targets and Benchmarks for Selected Pollutants, EPA Region 6/ EPA/ORD. 9/2011 – 2/2012. Developed and recommended options for interpreting risks of various chemicals to aquatic life and wildlife that could be used to help determine acceptable fish tissue concentrations based on data collected in U.S. EPA's National Coastal Condition Assessment (NCCA). Chemicals included mercury, PCBs, various PAHs, and several pesticides that were observed in water or sediment samples at various estuarine and marine sites across the U.S. Sources evaluated included CSOs and SSOs, industrial and municipal effluent discharges, and urban and agricultural runoff.

Clinch River, VA Watershed Ecological Risk Assessment, EPA/ORD. 9/1995 – 1/2012. Project Manager of a watershed ecological risk assessment for the Clinch River Basin, VA focused on native fish and unionid mussel species, many of which are threatened and endangered. 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.

TETRA TECH

Cori Edwards
Watershed Analyst

EXPERIENCE SUMMARY

Ms. Edwards is an environmental scientist with over 8 years' experience with West Virginia infrastructure project management and grant writing, including source water protection, and over 11 years' experience with ESRI ArcMap software. She has authored numerous source water protection and hazard mitigation plans in compliance with local, state, and federal authorities. Ms. Edwards is proficient in meeting and stakeholder facilitation and public education and outreach. Her expertise includes advanced experience with ArcGIS and Trimble Global Positioning System (GPS) technology for demographic and environmental analysis, project area mapping, and transit evaluation. Ms. Edwards has managed FEMA Hazard Mitigation Planning for 33 jurisdictions, Source water and emergency response planning, Federal Transit Administration (FTA) and Federal Highways Administration (FHWA) Title VI and Disadvantaged Business Enterprise (DBE) Programs, and National Environmental Policy Act (NEPA) Environmental Assessments for WV Housing & Urban Development (HUD) programs.

EMPLOYMENT HISTORY

Tetra Tech, Inc., GIS Analyst, 2017–present

Region I Planning & Development Council, Project Manager/GIS Specialist 2014-2017

Region I Planning & Development Council, GIS/Planner 2006-2010

RELEVANT EXPERIENCE

Total Maximum Daily Load (TMDL) support for West Virginia Watersheds. 2017-Present. For WVDEP, GIS support, technical writing, pollutant source report, and map figure creation for watershed groups D3, E3, E4, C4, and C5 representing these river watersheds: Hughes, Upper Guyandotte, Big Sandy, Twelvepole, Lower Ohio, Lower Guyandotte, and Tug Fork, respectively. Created elevation mosaics and performed QA/QC for subwatershed delineation. Calculated disturbed areas represented by oil and gas industry activity and unpaved roads not represented by existing TIGER datasets. Performed GIS analysis, creation, and modification and QA/QC for land use representation and metals modeling.

Eastern Lancaster County Nutrient Pollution Assessment Tool, PA. 2017-2018. For Eastern Lancaster County Source Water Collaborative, USEPA, and Pennsylvania DEP, developed a GIS desktop methodology and ModelBuilder component to provide a relative risk assessment of nutrient pollution to both surface and ground water based on Chesapeake Bay CAST nitrogen and phosphorus loading rates.

Source Water Protection Plan Updates and support, WV. 2017-Present. For Wilderness PSD, Buffalo Creek PSD, the city of Fairmont, the City of Summersville, the Town of Gilbert, and the Town of Athens, updated existing source water protection plans. Scope of services provided include conducting protection team meetings, mapping potential sources of contamination using field investigations and GIS, drafting standard protocol

EDUCATION

MGIS, Pennsylvania State University, 2018

B.A., Geography/Cartography & GIS, Concord University, 2006

AREAS OF EXPERTISE

HUD & RUS NEPA Environmental Review

SHPO Coordination

Source Water Protection

Hazard Mitigation Planning

ArcGIS Desktop & Online

TRIMBLE GPS

Grant & Technical Writing

LICENSES/REGISTRATIONS

None

TRAINING/CERTIFICATIONS

HUD ERR Training

ICS-100 Introduction to the National Incident Management System

WVAGP ESRI ArcGIS Online Governance

Deriving Rasters for Terrain Analysis Using ArcGIS

3D Analysis of Surfaces and Features Using ArcGIS

PROFESSIONAL AFFILIATIONS

WV Association of Geospatial Professionals

OFFICE LOCATION

Charleston, WV

YEARS OF EXPERIENCE

12

YEARS WITH FIRM

6

for water sampling, and coordinating with WVDHHR to provide updates within the online portal developed in 2019. Additionally, successful grant applications helped acquire mobile pumps for Wilderness PSD and the Town of Gilbert.

Operational Support for CB45, Prince George's County, MD. 2017–Present. Provides GIS support for implementation of Prince George's Clean Water Act Fee, County Bill (CB) 45. CB45 establishes a stormwater management fee based on tiered residential zoning and direct measurements of impervious area on commercial, industrial, and multifamily properties. Proceeds from fee are used for MS4 and TMDL stormwater compliance programs. Duties include account review and update using GIS data and Access database, QA/QC, and GIS parcel editing. Performance also includes developing SQL queries for future use in Access database updates and comparisons.

Source Water Protection Plan Development and Program Support, VA. 2017- Present. For Virginia Department of Health, assists with the annual survey response from 112 systems. Developed, updated, and implemented source water protection plans (SWPPs) for water supply systems including systems including Fauquier County Water and Sanitation Authority, the Towns of Luray, Bowling Green, and Hillsboro, Woodslodge Cottages, and New Kent Department of Public Utilities. In addition to creating plans that meet state requirements, successful grant applications have provided the Town of Luray with surveillance equipment.

Iowa Source Water Protection Plan Updates, IA. 2017. For Spirit Lake Waterworks in Dickinson County and Winterset Waterworks in Madison County, updated existing source water protection plans. Performed technical writing and mapping of potential sources of contamination using GIS. Coordinated with Robin McNeely, GIS Program Manager at the ISU GIS Facility, and duplicated Best Management Practice (BMP) mapping for areas of Minnesota used in the Agricultural Conservation Planning Framework tool.

Muskegon Water Filtration Plant Source Water Intake Protection Plan, MI. 2017. Drafted the first Source Water Intake Protection Plan (SWIPP) for the Muskegon Water Filtration Plant in Muskegon County approved by the Michigan Department of Environmental Quality (MDEQ). Conducted protection team meetings, investigated potential contamination sources, and executed technical writing to complete the 2017 SWIPP.

Region I Hazard Mitigation Plan Update, WV. 2015. For FEMA, formed the foundation for a community's long-term strategy to reduce disaster losses and break the cycle of disaster damage, reconstruction, and repeated damage in accordance with Title 44 Code of Federal Regulations (CFR) §201.6 and section 322 of the Stafford Act, 42 U.S.C 5165. Evaluated natural hazard risk to individual communities. Conducted extensive public outreach and stakeholder collaboration meetings. Served as technical lead updating the hazard mitigation plans for McDowell, Mercer, Monroe, Raleigh, Summers, and Wyoming Counties in West Virginia including the following municipalities therein: Town of Anawalt, Town of Athens, Town of Bradshaw, City of Bluefield, Town of Davy, Town of Bramwell, City of Gary, Town of Matoaka, Town of Iaeger, Town of Oakvale, City of Keystone, City of Princeton, Town of Kimball, Town of Northfork, Town of Peterstown, City of War,Town of Union, City of Welch, City of Hinton, City of Mullens, City of Beckley, Town of Oceana, Town of Lester, Town of Pineville, Town of Mabscott, Town of Rhodell, and Town of Sophia.

Environmental Review Record (ERR) Compilation, WV. 2008 - 2015. Prepared Environmental Review Records governed by NEPA for West Virginia Housing and Urban Development Funds, Appalachian Regional Commission Funds, Land and Water Conservation Funds, and USDA Rural Development Funds concerning the following projects: Town of Union and UTC Aerospace Systems water infrastructure project, McDowell County Coalwood Connector water infrastructure project, 2009 Raleigh County Housing Authority 5 Year Action Plan, 2009 Beckley Housing Authority 5 Year Action Plan, 2008 McDowell County Welch Woodmont 7C water infrastructure project, Town of Sophia Interpretive Park, and Town of Oceana Gilliland Park. Executed project mapping, site suitability evaluations based on the National Environmental Policy Act, and coordination with engineers, the West Virginia Development Office, and regulatory organizations including the State Historical Preservation Office (SHPO), Tribal Historical Preservation Agencies, Department of Natural Resources (DNR), U.S. Fish and Wildlife Service (USFWS), Natural Resource Conservation Center (NRCS), Environmental Protection Agency (EPA), and the Corps of Engineers. Managed ERR revisions corresponding to engineering amendments.

TETRA TECH

Mustafa S. Faizullabhoy, P.E.
Senior Water Resource Engineer

EXPERIENCE SUMMARY

Mr. Faizullabhoy is a water resources/environmental engineer with more than 20 years of professional experience in the areas of water quality modeling, hydrologic and hydraulic modeling, and storm water management planning and design. His comprehensive modeling projects have included application for evaluation of climate change and TMDL development. He specializes in the field of hydrodynamic modeling, surface water quality modeling, contaminant transport, data analysis and statistics 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, SWMM, HEC-RAS, HEC-5/Q, and GWLF. Mr. Faizullabhoy's experience also includes spreadsheet and database programming for managing, analyzing, summarizing, and visualizing 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, Python), and Geographic Information Systems (GIS).

EMPLOYMENT HISTORY

Tetra Tech, Inc., Sr. Environmental Engineer, September 2000–present

KCI Technologies, Design Engineer, October 1999–September 2000

RELEVANT EXPERIENCE

Development of a Hydrodynamic and Water Quality Model for the Milton Seaman Reservoir, CO. (10/2016 to 11/2019.) Lead Modeler for providing water quality modeling support to the City of Greeley and the U.S. Army Corps of Engineers for the Milton Seaman Reservoir. The reservoir is located in the Cache La Poudre watershed in Larimer County, about 11 miles northwest from Fort Collins. The water from the Milton Seaman Reservoir is an important source (component) of water supply for the City of Greely. Water quality concerns over the past years in the reservoir included organic enrichment and oxygen depletion.

STEPL Model User Group Support, EPA Office of Water. (1/2017 to 3/2018). As technical lead provided user support for STEPL, which employs simple algorithms to calculate nutrient and sediment loads from different land uses and load reductions that would result from implementing various BMPs. Responsible for conceptual and model specific reviews and model documentation. Fixed bug and made software upgrades. Conducted a nationwide STEPL webinar outlining the latest features in version 4.4. Served as webmaster for the STEPL website.

Famosa Slough Eutrophication Modeling and TMDL Support (2016-2017). For City of San Diego assisted in the 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 in urban San Diego

EDUCATION

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

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

AREAS OF EXPERTISE

Watershed management

Watershed modeling

Climate Change

TMDL Development

Hydrodynamic modeling

Water quality modeling

Water quality monitoring program design and implementation

Information management system development

Environmental statistics

LICENSES/REGISTRATIONS

Professional Engineer, Virginia, License No. 0402 039154

TRAINING/CERTIFICATIONS

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

OFFICE LOCATION

Fairfax, VA

YEARS OF EXPERIENCE

25

YEARS WITH FIRM

23

County, California. A watershed and receiving water models were developed 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. Assisted in the development of the EFDC model which was used to analyze multiple management scenarios focusing on different aspects of controlling processes: watershed load reduction, macroalgae harvesting, dredging, and the combination of different options.

Los Penasquitos Lagoon Restoration Modeling, San Diego, CA (2015-2017). The Los Peñasquitos watershed and lagoon are in central San Diego County. In order to support the development of the WQIP EFDC modeling was undertaken to restore Los Peñasquitos Lagoon to promote the restoration of saltmarsh areas, increase the lagoon's resiliency to various impacts, and provide overall improvements in estuarine and other beneficial uses. Assisted in the development of a high-resolution hydrodynamic and sediment transport for the simulation of Los Penasquitos Lagoon using EFDC. The model simulates the sediment deposition under the influence of tidal force and freshwater inflows covering the entire lagoon with wetting and drying features.

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.

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.

Stormwater BMP Site Searches and Concept Designs in Montgomery County (2014-2015). 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.

Benthic TMDL for Cedar, Hall/Byers and Hutton Creek, Virginia. For the USEPA Region 3 and VA Department of Environmental Quality developed a benthic TMDL for three creeks (Cedar Creek, Hall/Byers creek, and Hutton Creek) draining to the North Fork Holston river. The streams are in Washington County, VA and drain predominantly agricultural areas. The methodology used incorporates a reference watershed approach for identifying benthic community stressors and approximate TMDL endpoints. Impaired and reference watersheds were modeled to determine the conditions necessary to support a healthy benthic community. Project involved setup and calibration of the GWLF model, statistical data analysis, and GIS mapping/analysis.

Navarro River Basin Analysis of Historical Flow Trends (2014-2015). For North Coast RWQCB and USEPA Region 9 performed statistical analysis on flow and precipitation data to evaluate trends over time (daily, annual average, and monthly average). Used the Kendall trend test to evaluate temporal trends for the period of record for flow and precipitation data along with a double mass curve of cumulative streamflow against cumulative precipitation was also generated.

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.

TETRA TECH

Jeroen Gerritsen, PhD
Technical Expert

EXPERIENCE SUMMARY

Dr. Gerritsen has over 40 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.

RELEVANT 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.

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.

AREAS OF EXPERTISE

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

PROFESSIONAL AFFILIATIONS

North American Benthological Society

Ecological Society of America

Society for Environmental Toxicology and Chemistry

Estuarine Research Federation

North American Lake Management Society

OFFICE LOCATION

Owings Mills, MD

YEARS OF EXPERIENCE

41

YEARS WITH FIRM

29

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

EXPERIENCE SUMMARY

Ms. Hart is an environmental scientist with over 20 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.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Environmental Scientist, 2005–present

Water Environment Research Foundation (WERF), Environmental Scientist, 2003–2005

Tetra Tech, Inc., Environmental Scientist, 1999–2003

RELEVANT 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; review and modification of DNREC's Nutrient Budget Protocol for use as an offset tool in the watershed; review of local land use ordinances to identify potential barriers to implementation of the WIP in local municipalities and counties; developing template for formatting and submitting annual urban BMP data to the Bay Program for inclusion in the watershed model; supporting annual agricultural and urban BMP NEIEN submissions; developing training videos for the use of offset and stormwater loading tools; providing technical support for updating the state's local BASINS watershed models for waterbodies within the Chesapeake Bay watershed; supporting development of Delaware's BMP Verification Protocol; and providing guidance on the format and development of the Phase III WIP based on review of the Phase II WIP and Phase III WIP Expectations.

Development of BMP Database for submittal of NEIEN Data. DNREC. 9/2016-4/2018. Assisted with the transfer of a previously developed BMP database to DNREC's server. This included making updates to the database based on new requirements from CBP as well as leading a training session for DNREC staff on how to upload data and submit the data to NEIEN.

TMDL Development for Stampede Creek, AK. USEPA Region 10. 1/2018-3/2018. Assisted with development of TMDLs for antimony in Stampede Creek in the Denali National Park and Preserve. Stampede Creek exceeds the water quality criterion for antimony due to historic mining in the watershed.

TMDL Development for Crooked Creek, AK. USEPA Region 10. 6/2017-present. Assisted with developing TMDLs for sediment in four waterbodies in the Crooked Creek watershed – Boulder Creek, Deadwood Creek,

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

AREAS OF EXPERTISE

Clean Water Act support

TMDL development and implementation

Pollutant source assessment

Water quality assessment

Watershed management

Watershed modeling

Watershed characterization

Technical writing

OFFICE LOCATION

Fairfax, VA

YEARS OF EXPERIENCE

23

YEARS WITH FIRM

18

Ketchem Creek and Crooked Creek. The waterbodies exceed the sediment water quality criterion due to historic and current placer mining in the area. The TMDL approach involves load duration curves to identify sediment loads to the waterbodies. The TMDLs will be expressed as sediment loads for the months of May through September based on sediment targets determined in a nearby reference watershed. Support for this project includes calculating the TMDLs as well as writing the supporting technical documents and addressing stakeholder comments.

Development of a Point Source QAPP for DE. DNREC. 3/2017-5/2017. Assisted with development of a QAPP for reporting Delaware's Chesapeake Bay point source data to NEIEN. The QAPP included the steps employed to collect information from the four point sources in the Chesapeake Bay watershed (Laurel WWTP, Seaford WWTP, Invista, and Bridgeville WWTP). Worked with DNREC to identify the sources of data (monthly DMRs) and the methods used to convert the data into a usable format for NEIEN submission.

TMDL Development for Hawk Inlet, AK. USEPA Region 10. 1/2015-6/2017. Developed TMDLs for metals in the sediment of Hawk Inlet due to an historic ore spill at a loading dock in 1989. The TMDL approach involved extensive data analyses to identify potential sources to Hawk Inlet and to evaluate spatial or temporal trends. The TMDLs were expressed as concentrations, equivalent to the NOAA SQuiRT screening standard ERLs. Support for this project included calculating the TMDLs as well as writing the supporting technical documents and addressing stakeholder comments.

Chesapeake Bay Watershed TMDL Support. USEPA CBPO. 5/2014–present. Provided assistance to the USEPA'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 Bay Watershed Model.

TMDL Development for the Matanuska River, AK. USEPA Region 10. 8/2016–6/2017. Developed a residues (debris) TMDL for a portion of the Matanuska River in Palmer, Alaska that contains large quantities of junk railroad cars and other debris above the ordinary high water mark of the riverbank. The TMDL was based on a water quality criterion of "zero" debris allowed in or adjacent to the waterbody.

New York Statewide Chesapeake Bay Watershed Implementation Plan (WIP). USEPA Region 3. 5/2016–9/2016. Providing support to New York's Department of Environmental Conservation (NYSDEC) for their WIP for the Chesapeake Bay nutrient and sediment TMDLs by developing a template for formatting and submitting annual urban BMP data to the Bay Program for inclusion in the watershed model. Supported historical urban BMP NEIEN submissions for the year 2003 through 2013.

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.

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.

TETRA TECH

Kevin Kratt
Watershed Analyst

EXPERIENCE SUMMARY

Kevin Kratt has been with Tetra Tech for more than 25 years, working initially as a water resources scientist and steadily advancing to project management and oversight of multi-partner teams with successful completion of numerous complex and high-profile projects. He is the director of the Cleveland, Ohio, Water Resources office and provides technical and project management support for a wide variety of federal, state, and local government clients. Kevin has a strong interdisciplinary background, having supported and managed projects that range from hydrologic studies and water quality assessments to master planning and full design. His entire career has focused on water resource projects, including watershed planning, water quality modeling, feasibility studies, concept design, preliminary and final design, permitting, and post construction monitoring. He has managed numerous stormwater retrofit and green infrastructure planning and design projects, and several large ecosystem and stream restoration studies. He was a contributing author to EPA's national watershed planning guidance (Handbook for Developing Watershed Plans to Restore and Protect Our Waters) and is a national expert on the Clean Water Act total maximum daily load (TMDL) program.

He is also currently managing several projects addressing nutrient problems in the Great Lakes, especially in Lake Erie. He is very familiar with most of the public domain H&H and water quality models, including HSPF, LSPC, SWAT, SWMM, HEC-RAS, EFDC, and QUAL2, as well as several stream geomorphic assessment techniques (e.g., Channel Evolution Model, Natural Channel Design).

EMPLOYMENT HISTORY

Tetra Tech, Inc., Project Manager and Water Resources Scientist, 1995–present

RELEVANT EXPERIENCE

Sandusky Bay 3D Eutrophication Modeling (USEPA, 6/17 – 2/18). Project manager leading the development of a 3D EFDC model of Sandusky Bay to provide for a better understanding how nutrients and sediments are transported through the Sandusky Bay system and how they impact water quality conditions, especially the formation of harmful algal blooms (HABs). The model will help guide management decisions related to the bay, such as how to best control tributary loadings, how to assess the importance of internal loading, and how to select and design optimal living shoreline, wetland, and other types of restoration projects.

Methodology for Connecting Annex 4 Water Quality Targets with TMDLs in the Maumee River Basin (USEPA, 1/17 – 9/18). Project manager leading the development of a tiered, staged methodology to identify total phosphorus and soluble reactive phosphorus load and concentration targets that meet the criteria and goals of the Annex 4 Lake Erie targets lake targets for the St. Joseph River Watershed and the Tiffin River Watershed. The methodology is designed such that it can be replicated in other Maumee River and Lake Erie basin subwatersheds. The methodology consists of different protocols that vary based upon data availability (i.e., quantity, completeness), robustness (i.e., representativeness, reasonableness, quality), and resolution (i.e., scale).

EDUCATION

M.E.M., Water Resources, Duke University, 1995

B.S., Business Economics, Miami University, 1992

AREAS OF EXPERTISE

Clean Water Act

TMDL development

Hydrologic, hydraulic, and water quality modeling

Nutrient/eutrophication issues

Water quality assessment

Watershed management

Stormwater management/green infrastructure

Ecosystem and stream restoration

REGISTRATIONS/AFFLIATIONS

Ohio Stormwater Association

US Water Alliance

TRAINING/CERTIFICATIONS

None

OFFICE LOCATION

Cleveland, OH

YEARS OF EXPERIENCE

28

YEARS WITH FIRM

28

Development of Management Actions to De-List the Cuyahoga River Area of Concern (Ohio EPA, 11/15 – 2/16). Project manager to evaluate and rank projects that will remove beneficial use impairments in the Cuyahoga River watershed. Managed the compilation and assessment of fish, macroinvertebrate, and habitat data and used those data to evaluate a variety of habitat restoration projects, such as dam removals and stream and wetland restoration projects.

***Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (USEPA, 2006-2008).** Contributing author to this document which provides comprehensive guidance for meeting federal and state regulatory requirements related to Section 319 of the Clean Water Act, and provides insight into building capacity and engaging stakeholders to meet a variety of watershed planning objectives.

Critical Source Area Identification and BMP Selection: Supplement to Watershed Planning Handbook (USEPA, 2017-2018). Project manager and provided QA/QC review of this document which is intended to help watershed project teams define critical source areas where appropriate BMPs and BMP systems will be implemented to achieve water quality goals in the most efficient manner possible.

Feasibility Assessment for the Removal of the Gorge Dam (Ohio EPA, 2/15 – 8/15). Led the development of a feasibility study to evaluate the removal of the 57' tall by 420' long Gorge Dam on the Cuyahoga River. Managed the preparation of planning level cost estimates for the removal and disposal of more than 830,000 cubic yards of sediments upstream of the dam and for the removal and disposal of the dam itself. The estimation of planning level costs required the assessment of feasible methods of sediment removal and dewatering; identification of potential disposal sites; characterization of sediment for potential future restrictions with the use of dewatered dredge materials; development of probable construction sequencing for sediment removal, dewatering, and management; and the development of concept level drawings of the existing site.

Identifying Priority Green Infrastructure Opportunities to Improve Instream Biological Conditions (USEPA, 9/15 – 4/17). Principal overseeing a project to better connect stormwater retrofit/green infrastructure projects to improved water quality and biological conditions. Helped develop an approach that targets the level of implementation needed to reduce stormwater volumes and pollutant loads to meet water quality standards and protect beneficial uses in urban watersheds.

Nonpoint Source Implementation Strategies (NPS-IS) for Big Creek and West Creek (West Creek Conservancy, 12/16 – 5/17). As project manager, led the development of NPS-IS plans for the Big Creek and West Creek watersheds. Worked closely with the West Creek Conservancy and Big Creek Connects to identify critical areas and priority projects to develop nine-element watershed plan that meet Ohio EPA and USEPA requirements.

Nutrient and TSS TMDLs for Lower Sandusky River and Bay, Ohio, USEPA Region 5, 2012–2014. Managed development of TMDLs for nitrate + nitrite, total phosphorus, and total suspended solids. Technical review of SWAT modeling and linkage analyses between stream biology and agricultural and urban runoff with a focus on the effects of agricultural practices. Coordinated TMDL development project with several related implementation projects (e.g., identification of priority areas for tile drainage management and constructed wetlands).

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. Tetra Tech has won back-to-back Region 5 contracts through competitive bidding processes, and the two contracts have provided Region 5 with the ability to task important program efforts (35 task orders totaling $6.5M).

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. Tetra Tech has won back-to-back Region 8 contracts through competitive bidding processes, and the two contracts have provided Region 8 with the ability to task important program efforts (34 task orders totaling $5.8M).

TETRA TECH

Jon Ludwig
Program Manager

EXPERIENCE SUMMARY

Mr. Ludwig is a director of Tetra Tech's Water Resources Group offices 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 more than 20 years of experience in 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, multimillion-dollar contracts with federal and state clients and is currently overseeing multiple large water resource projects with U.S. Environmental Protection Agency (EPA) 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 United States and Canada. Working closely with West Virginia Department of Environmental Protection's (WVDEP's) TMDL program manager over 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. Mr. Ludwig has extensive experience in implementing various hydrologic and water quality models and has played an instrumental role in the technical development of the Mining Data Analysis System (MDAS), a dynamic watershed tool that has been customized for watershed assessment and TMDL development efforts in West Virginia. Additionally, he has reviewed National Pollutant Discharge Elimination System (NPDES) permits and assessed measures taken to model the effects of discharge to stream systems. He has also conducted a series of training courses to support EPA and various states (Arizona, Kentucky, Pennsylvania, and West Virginia) in modeling and TMDL development. Course have topics included bacteria, sediment, mining, and TMDL report writing.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Director/Senior Environmental Scientist, 2000–present

Summit Lake Paiute Tribe, 1998-2000

RELEVANT EXPERIENCE

Mt. Olivet Cemetery Stormwater Retention Credit BMP Design-Build Pilot Project, Washington, DC. Contract Manager for designing stormwater bioretention systems to generate 80,000 gallons of stormwater retention credits. Tetra Tech is partnered with EQR to design and construct BMPs to maximize treatment volume to generate Stormwater Retention Credits using innovative funding incentives driven by private investors.

NPDES Support, Prince George's County, MD. Deputy Program Manager providing oversight of work conducted under this multi-million dollar on-call stormwater program support contract to a nationally recognized leader in stormwater management and LID advancement. Tasks have included Chesapeake Bay TMDL Watershed Implementation Plan support; local TMDL restoration plan development; BMP design and permitting; BMP siting for rural impervious areas and roads; NPDES

EDUCATION

MS, Environmental Pollution Control, The Pennsylvania State University, 1997

BS, Environmental Science, Widener University, 1995.

AREAS OF EXPERTISE

Clean Water Act support

Ecological risk assessment

Environmental statistics

Guidance development

Hydrodynamic modeling

Mining-related water quality studies

Pollutant source assessment

Safe Drinking Water Act support

Source water protection

TMDL development

Water quality assessment

Water quality modeling

Watershed management

REGISTRATIONS/AFFLIATIONS

American Water Resources Association

Water Environment Federation

TRAINING/CERTIFICATIONS

None

OFFICE LOCATION

Fairfax, VA

YEARS OF EXPERIENCE

24

YEARS WITH FIRM

23

monitoring program support including monitoring services for LID retrofits, BMP effectiveness monitoring, physical, chemical, and biological monitoring of selected streams; development of web enabled GIS based flood warning system; and public outreach.

Sheep River and Frank Lake Water Quality Model Development, Alberta Environment and Sustainable Resource Development, Canada. 2013–present. Providing management and technical oversight for development of EFDC model for nutrients and sediment. Coordinating technical approach development of eutrophication modeling using Tetra Tech's newly released Windows-based Visual EFDC.

TMDL Development Support for EPA. 2011–present. Providing management and technical oversight and client coordination for multiple TMDL development projects, including Lake Champlain TMDL redevelopment (Region 1); Wissahickon Creek, PA nutrient TMDLs; DC Toxics TMDLs redevelopment (Region 3) ; and Ohio River pathogen TMDL (Region 5).

Geochemical Modeling for Cresson Mine Pool Project, Pennsylvania Department of Environmental Protection, Bureau of Abandoned Mines. 2011–present. Project manager for development of a geochemical water quality modeling approach to evaluate the in-stream effects of combining, pumping, and treating three underground mine pools in Cresson, PA. The modeling approach links the MINTEQA2 geochemical speciation model to load duration curve analysis. Multiple scenarios will be established to evaluate water quality impacts of a proposed treatment plant to Clearfield Creek.

Chesapeake Bay Program Support. Project Manager for support for Chesapeake Bay TMDL and implementation. Provides 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, detailed analyses of model output and development of model output viewer tools, stakeholder meeting support. Participated in planning discussions with stakeholders to determine stormwater retrofit strategies, development of white papers, 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.

Chesapeake Bay TMDL Implementation Support, West Virginia, EPA Region 3. 2010–present. Project manager supporting WVDEP in developing a Chesapeake Bay TMDL watershed implementation plan (WIP), including performing detailed analyses of model output, developing a model output viewer tool, developing management scenarios to evaluate using the model, confirming nonpoint and point source representation in the Chesapeake Bay Program Office model, and stakeholder meeting support. Participated in planning discussions with WVDEP to determine how stormwater retrofit and offset strategies can be applied to meet nutrient load reductions in the Chesapeake Bay TMDL. Current work includes developing data management tools to help WV Department of Agriculture and WVDEP verify and track agricultural and urban stormwater BMPs.

Statewide West Virginia TMDL Development Support. Project manager for more than 10 years, supporting West Virginia Department of Environmental Protection (WVDEP) and USEPA Region 3 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. Managed application of the approach by dozens of staff to result in more than 3,500 TMDLs 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).

West Virginia Biological TMDL Development, WVDEP Division of Water and Waste Management. 2003–present. Project manager for development of biological TMDLs throughout West Virginia using EPA's Stressor Identification guidance to identify and rank physical, chemical, and biological stressors that may have caused impairments to the aquatic community. Stressor Identification requires the integration of watershed-based conceptual models of impairment, field biological and chemical monitoring databases, empirical models of biological impairment, and ecotoxicological principles in a strength-of-evidence approach to infer causes of impairment.

Piney Creek Comprehensive Watershed and TMDL Implementation Plan, WVDEP Nonpoint Source Group. 2009–2011. Project manager to develop 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 regulated MS4 entities and the nonregulated nonpoint source community to identify specific water quality goals and objectives and formulate site-specific projects for TMDL implementation.

TETRA TECH

Christina Mellors
Senior Water Resource Engineer

EXPERIENCE SUMMARY

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 USEPA 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 metals TMDL development in support of the West Virginia Department of Environmental Protection (WVDEP).

EMPLOYMENT HISTORY

Tetra Tech, Inc., Environmental Engineer, 2003–present

Virginia Department of Environmental Quality, Environmental Engineer, 2000–2002

Chemical Engineering and Instrumentation Consultants, Process Engineer, 1997–2000

EDUCATION

M.S., Environmental Science, Drexel University, 1998

B.S., Chemical Engineering, Carnegie Mellon University, 1994

AREAS OF EXPERTISE

TMDL development and implementation

Water quality modeling

Hydrodynamic modeling

OFFICE LOCATION

Charleston, WV

YEARS OF EXPERIENCE

26

YEARS WITH FIRM

20

RELEVANT EXPERIENCE

Metals and Sediment TMDLs for the Little Kanawha River Watershed, WV. Technical lead for metals and sediment TMDL development using MDAS for impaired streams in West Virginia for WVDEP Division of Water and Waste Management.

Metals and Sediment TMDLs for the Tug Fork River Watershed, WV. Technical lead for metals and sediment TMDL development using MDAS for impaired streams in West Virginia for WVDEP Division of Water and Waste Management.

Metals and Sediment TMDLs for the Lower Guyandotte River Watershed, WV. Technical lead for metals and sediment TMDL development using MDAS for impaired streams in West Virginia for WVDEP Division of Water and Waste Management.

Abandoned Mine Drainage-Related TMDLs for the Casselman River Watershed, PA. Technical lead for metals (iron, aluminum, manganese) and pH TMDL development for impaired streams in Somerset County, PA, for PADEP.

Metals and Sediment TMDLs for the Big Sandy River, Lower Ohio River, and Twelve Pole Creek Watersheds, WV. Technical lead for iron TMDL development for 37 impaired streams in West Virginia for WVDEP Division of Water and Waste Management.

Metals and Sediment TMDLs for the Upper Guyandotte River Watershed, WV. Technical lead for iron TMDL development for 59 impaired streams in West Virginia for WVDEP Division of Water and Waste Management.

Metals and Sediment TMDLs for the Hughes River Watershed, WV. Technical lead for iron TMDL development for 26 impaired streams in West Virginia for WVDEP Division of Water and Waste Management.

Metals and Sediment TMDLs for the Tygart River Watershed, WV. 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. 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, Prince George's County, MD. Developed and wrote a restoration plan for PCB-impacted watersheds in Prince George's County 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. 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, WV. 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.

TETRA TECH

Dave Montali
Technical Expert

EXPERIENCE SUMMARY

Mr. Montali has over 40 years of professional experience in the water resource management areas of NPDES permitting, numeric and narrative Water Quality Standards, Watershed assessment, Pretreatment, Impaired Waters listing and reporting, and TMDL development. Over a long career with the West Virginia Department of Environmental Protection (WVDEP), he served as the Team Leader of the NPDES Permitting Team, the West Virginia Pretreatment Coordinator, and the West Virginia TMDL Program Manager. His experience with WVDEP and subsequently Tetra Tech includes 10 years of past and continuing experience with the activities of the Chesapeake Bay Program Partnership where he served as the West Virginia representative on numerous workgroups and committees, including the continued co-chairmanship of the Modeling Workgroup through the Midpoint Assessment where a new Phase 6 suite of models were developed and approved for use in recalculation of planning targets for Phase III Watershed Implementation Plans.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Environmental Scientist, December 2016–present

West Virginia Department of Environmental Protection December 1981-October 2016

RELEVANT EXPERIENCE

Chesapeake Bay Program

Served as West Virginia jurisdictional representative on workgroups and committees:

- Modeling Workgroup (Co-chair 2013-present)
- Water Quality Goal Implementation Team
- Wastewater Treatment Workgroup
- Agricultural Modeling Subcommittee
- Toxic Contaminants Workgroup

Frequent participant in the activities of, and technical assistance to West Virginia representatives of:

- Agricultural Workgroup
- Urban Stormwater Workgroup
- Watershed Technical Workgroup
- Land Use Workgroup

Participated in Watershed Implementation Plan Development:

- Active participant in West Virginia Phase I, II and III WIP development
- BMP planning with consideration of WVDEP and Partner Agency program capacity
- Wastewater source characterization
- Model BMP input deck development
- Technical writing of portions of WIP documents

Provided technical assistance to West Virginia decision makers with respect to policy considerations before the Management Board and Principle Steering Committee

EDUCATION

B.S., Environmental Engineering, The Pennsylvania State University, 1981

AREAS OF EXPERTISE

Chesapeake Bay Program

TMDL development

Watershed Quality Assessment and Reporting

Water Quality Standards

NPDES Permitting (municipal, industrial and mining)

Watershed modeling data development and output review

Technical writing/editing

OFFICE LOCATION

Charleston, WV

YEARS OF EXPERIENCE

42

YEARS WITH FIRM

6

Expert Panel Participation:

- Onsite Wastewater Treatment Systems Nitrogen Reduction Technology (Final Report February 2014)
- Onsite Wastewater Nutrient Attenuation (Final Report August 2016)

Member of Modeling Laboratory Action Team (2014)

Member of Steering Committee – Scientific and Technical Advisory Committee (STAC) Workshop *Development of Climate Projections for Use in Chesapeake Bay Program Assessments* (March 2016)

TMDL Development (2001-2016)

Planning, coordination and oversight of TMDL development projects for West Virginia Department of Environmental Protection

- TMDLs developed and approved for thousands of stream/impairment combinations
- Significant TMDL experience in coal mining settings with both active and legacy mining impacts
- TMDLs developed for total metals, pH and dissolved aluminum, fecal coliform, selenium, biological integrity
- TMDL development organized under Watershed Management Framework
- Projects planned as Watershed TMDLs where prescribed loads predict attainment in impaired tributaries as well as mainstems
- Projects included stressor identification with respect to biological integrity nonattainment
- Projects incorporated results of intensive stream monitoring and source tracking/characterization
- TMDL alternative for Phosphorus nuisance algae impacts to Greenbrier River
- Public Comment and EPA approval issue resolution
- Technical writing for reports

Water Quality Assessment and Reporting

West Virginia CWA Section 303(d) List and 305(b) Report development (2002-2014)

- Numeric Water Quality Criteria assessment
- Narrative Water Quality Criteria assessment (biological integrity, algae)
- Listing methodology development and documentation
- Decision documentation
- Public Comment and EPA approval issue resolution
- Technical writing for reports

NPDES Permitting and Pretreatment

NPDES Permit writer and Team Leader for industrial and municipal wastewater discharges (1981-2000)

- Technology-based requirements
- Water Quality Based Effluent Limitation development per EPA Technical Support Document
- CSO and SSO program policies and procedures

West Virginia Pretreatment Program Coordinator

- Technology-based requirements for industrial users of POTWs pursuant to Categorical Standards
- Indirect discharge limitation development to address 40 CFR 403 general and specific prohibitions
- Review and approval of POTW Program development and reporting
- POTW program auditing and Industrial User inspection

TETRA TECH

John O'Donnell
Quality Assurance Manager

EXPERIENCE SUMMARY

Mr. O'Donnell is a chemist by training with over 25 years of experience in the environmental laboratory industry and more than 35 years of environmental industry experience overall. He is currently the quality assurance (QA) manager for the Water Division's Integrated Water Management (IWM) Group and QA officer (QAO) for several contracts, including Tetra Tech's EPA contracts with the Office of Wetlands, Oceans and Watersheds, Assessment and Watershed Protection Division (OWOW/AWPD), Office of Wastewater Management (OWM), Office of Research and Development National Center for Environmental Assessment (ORD/NCEA), and multiple EPA regional and GSA support contracts. He is also QAO for Tetra Tech's Center for Ecological Sciences and Biological Research Facility, which provides biological monitoring and aquatic ecotoxicology services. Prior to joining Tetra Tech, Mr. O'Donnell had more than 20 years of environmental laboratory experience in capacities ranging from technician and analyst to project and operations manager. He is experienced in laboratory and data audits; laboratory data validation; data quality and usability assessments; preparation of quality assurance project plans (QAPPs), sampling and analysis plans (SAPs), health and safety plans (HSPs), and standard operating procedures (SOPs) and procedural descriptions; as well as QA implementation, training, and performance reviews. He has extensive experience in the operations of environmental laboratories and in process troubleshooting; developing contingency plans and quality and management systems, tools, and plans; and overall laboratory personnel health and safety, QA, and general operations training. Mr. O'Donnell is currently a member of Tetra Tech's Corporate QA Steering Group and has developed hundreds of QAPPs for Tetra Tech's existing contracts with the EPA's OWOW/AWPD, OWM, ORD/NCEA, and regional offices; and supported the Office of Science and Technology's Standards and Health Protection Division (OST/SHPD) in implementation and oversight of project-specific QA guidance. He has worked with internal clients and the Tetra Tech QA team in support of a variety of related national and regional scale environmental projects and programs, as well as providing technical and quality system development and management support for states and municipalities.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Environmental Quality Assurance Chemist, 2003–present.

Self-Employed Consultant, 2002.

Quanterra/Severn Trent Laboratories, Customer Service Manager, Laboratory Director, 1998-2001.

EA Laboratories, Group Leader Client Services, Section Chief, 1994–1997.

Versar Laboratories, Division Manager Applied Chromatography and Organic Extraction, Chemical Hygiene and Laboratory Safety Officer, 1992–1994.

Versar Laboratories, Chemist, 1982–1992.

RELEVANT EXPERIENCE

AREAS OF EXPERTISE

Corrective Action Investigation and Remedy

Data Management

Documentation Systems (Plans, Forms, Worksheets, Checklists)

Field and Laboratory Quality Assurance and Safety Audits

Hazard Assessment and Development of Project Health and Safety Plans and Task- and Activity-Specific Safe Work Practices

Quality Assurance Development, Implementation, and Management

Quality System and Health and Safety Program Orientation and Training

Sampling Design, Monitoring, Field Sampling, and Analytical Chemistry

REGISTRATIONS/AFFLIATIONS

American Society for Quality

TRAINING/CERTIFICATIONS

OSHA 40-Hour; Flood Clean-up Awareness

OFFICE LOCATION

Fairfax, VA

YEARS OF EXPERIENCE

40

YEARS WITH FIRM

20

On-Call Civil Engineering, Environmental Engineering and Construction Management Services, Prince Georges County Department of Environment (Prince George's County, Maryland). 01/03-present. As QAO for this contract, manages quality system development and oversight for DoE's long term stormwater monitoring conducted in support of their National Pollutant Discharge Elimination System (NPDES) municipal separate storm sewer system (MS4) permit MD0068284. QA oversight for the stormwater monitoring plan has included development of a project specific quality system including a programmatic QAPP (p-QAPP; a broad QAPP including multiple indicators and parameters which may be incorporated into smaller investigations county-wide). In addition to the pQAPP, project- and site-specific SOPs and documentation systems were developed for autosampler maintenance, calibration, and operation based on their locations and required operating parameters. The programmatic QAPP approach was selected to facilitate agility in responding to other surface or stormwater chemistry investigations within the county. The current autosampler deployments in the Bear Branch watershed are slated for relocation potentially in the fall of 2018, and the p-QAPP will be amended with the new locations and modified SOPs for the new locations, if appropriate.

Assisted in the development of the quality guidance for DoE's Biological Monitoring, Assessment, and Data Integration for Prince George's County Streams and Watersheds. This broad programmatic plan includes the basic elements of a QAPP as well as project-specific SOPs, and an integrated health and safety plan.

Technical Support for EPA Region 5 Watershed Program (TSWP), EPA Region 5, General Services Administration (GSA). 09/13–present. QAO for this contract, which requires full implementation of the organizational quality system, including project-specific QAPPs, as requested in individual orders. Advises program managers and deputies, assisting in defining quality requirements or verifying compliance with Agency Quality Policy, and recommending appropriate QA and QC support staff and documentation to fulfill the quality planning and oversight requirements. As project- or TO-specific QAO, works with EPA QAOs and QA coordinators to develop project-specific QA guidance appropriate for the scope of work. Works closely with project technical staff and quality control officers (QCOs) to define and implement comprehensive quality control (QC) protocols and documentation systems.

Technical Support for Assessment and Watershed Protection, EPA OWOW / AWPD. 2009–present. Tetra Tech's contract QAO for this contract since its award and assumed that functional responsibility in 2009 for the previous contract. Develops and maintains contract-specific quality system documentation, as required; and advises program managers and deputies, assisting in defining quality requirements or verifying compliance with Agency Quality Policy, and recommending appropriate QA and QC support staff and documentation to fulfill the quality planning and oversight requirements. As project- or TO-specific QAO, works with EPA QAOs and QA coordinators to develop project-specific QA guidance appropriate for the scope of work. Developed and documented the quality system description for Tetra Tech in the contract-specific QMP and continues to ensure that the organizational QMP is implemented for contracts or subcontracts without client-specific quality system descriptions or requirements.

Region 8 TMDL Support Services, EPA Region 8, GSA. 04/08–present. The Region 8 TMDL support contract was primarily procured to address outstanding TMDLs in Montana that were under a court-ordered schedule for completion by the end of 2014. Assisted the task order leaders (TOLs) in developing or reviewing and commenting on QA guidance, recommended QC protocols where applicable, and collaborated with the TO-specific QCOs and TOL on overall quality performance, impediments, and improvement opportunities. In response to client-inquiry and EPA project quality system review, conducted supplemental training with contract TOLs to reiterate the importance of planning, documentation, and inspection and acceptance in the management of subcontractors. The Region 8 GSA contract includes additional annual QA review and reporting requirements, as well as supplemental documentation requirements for project-specific plans, annual reviews, and overall tracking from statement of work through award.

Technical Support for NCEA Ecological Risk Assessment Programs, EPA ORD / NCEA. 10/07–04/18. As the contract QAO, advises program managers and deputies, assisting in defining quality requirements or verifying compliance with Agency Quality Policy, and recommending appropriate QA and QC support staff and documentation to fulfill the quality planning and technical quality requirements. As the project QAO on individual work assignments, works with EPA QAOs and QA coordinators to develop project-specific QA guidance appropriate for the scope of work..

TETRA TECH

Andrew Parker
Deputy Program Manager

EXPERIENCE SUMMARY

Mr. Parker is a vice president and operations manager for the Integrated Water Management unit, a team of 110 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 United States as well as in Canada, China, Korea, and the Caribbean. He has extensive experience in 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, SUSTAIN, and the TMDL Modeling Toolbox. He also has extensive experience in 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 basinwide modeling projects for the Klamath (U.S.), Mobile (U.S.), North Saskatchewan (Canada), and Nakdong (Korea) rivers and Lake Champlain (U.S./Canada). Mr. Parker has also been a primary author or contributing author on more than 30 publications for conferences and peer-reviewed journals.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Environmental Engineer / Director / Vice President / Operations Manager, 1996–Present

University of Virginia, Research and Teaching Assistant, 1995–1996

RELEVANT EXPERIENCE

NPDES Services Statewide for Maryland State Highway Administration (SHA). 12/14–present. Principal in charge for Maryland SHA contract focused on identifying stormwater BMP opportunities for state-owned roadways to comply with requirements of the Chesapeake Bay TMDL and SHA's MS4 permit. Established and managing a joint venture with RK&K. Coordinating with RK&K on strategic planning, costing and staffing task orders, and providing contract oversight. Oversaw task orders for Montgomery and Carroll counties. Support included desktop geospatial analysis of SHA rights-of-way to identify the most promising locations for BMP installation, field verification on a subset of the sites, and concept designs for more than 30 locations. The project required rapid and accurate execution of SHA protocols.

Watershed Professional Engineering Services, Fairfax Water, Fairfax, VA. 09/11–present. Deputy project manager. As a subcontractor to Hazen and Sawyer, leads modeling and source water protection support for Fairfax Water. Evaluated the potential for water supply-related impacts from uranium mining and associated activities if the uranium mining moratorium currently in place in the

EDUCATION

ME, Civil/Environmental Engineering, University of Virginia, 1996

BS, Civil Engineering, University of Virginia, 1995

AREAS OF EXPERTISE

Information management

Modeling and model development

Monitoring and field studies

Project and contract management

Training and technology transfer

Watershed management

REGISTRATIONS/ AFFILIATIONS

Engineer-in-Training, Virginia, (1996)

American Society of Civil Engineers (EWRI TMDL Analysis and Modeling Subcommittee)

Journal of American Water Resources Association (Technical Manuscript Reviewer)

Water Environment Federation (Technical Manuscript Reviewer)

TRAINING/CERTIFICATIONS

Water Quality Modeling Summer Session, Manhattan College, Riverdale, NY, 2001

OFFICE LOCATION

Fairfax, VA

YEARS OF EXPERIENCE

28

YEARS WITH FIRM

28

Commonwealth of Virginia is lifted. The evaluation included review of mining and drinking water regulations in the commonwealth, identifying potential mining areas, hydrologic analyses, and catastrophic and chronic risk assessments.

Technical Support for Chesapeake Bay TMDL and Watershed Implementation Plan Development, EPA Region 3 and the Chesapeake Bay Program. 10/06–present. 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 participating in steering committee and technical team meetings, TMDL and model documentation, developing white papers, logistical support for all public meetings, developing critical model data sets, support of each state and the District of Columbia for local and statewide WIP development, and design and configuration of a tracking and accountability system to ensure compliance with implementation milestones.

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, 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.

West Virginia TMDL Development Support. 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.

Hydrodynamic and Water Quality Modeling Support for the Philadelphia Water Department (PWD). 01/12–12/15. Program manager to provide technical support to PWD Office of Watersheds in developing and applying hydrodynamic and water quality models in support of their Green Cities, Clean Water approach to stormwater and CSO remediation, established through consent order and agreement (COA) with the state. Managed Tetra Tech's support to PWD for developing, testing, and application of EFDC and linkage of EFDC to WASP for the tidal Delaware and Schuylkill rivers and some tributaries to address requirements of the COA and demonstrate the effects of the green approach on bacteria and dissolved oxygen. Tasks included review, enhancing, and optimizing a model grid; assigning model inputs, parameters, and boundary conditions.

TETRA TECH

Teresa Rafi
Technical Writer

EXPERIENCE SUMMARY

Ms. Rafi has more than 25 years of professional experience in public sector environmental science and policy. She has been a member of the Water Resources Group at Tetra Tech, since October 2000, where her activities include curriculum development for watershed modeling courses, database development in support of numerous USEPA programmatic initiatives as well as development of technical guidance and documentation for various USEPA 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. She currently serves as a project manager and coordinator for modeling and TMDL related projects.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Environmental Scientist VI 2000–present

Florida Coastal Management Program, Outreach Coordinator, July 1996–October 2000

RELEVANT EXPERIENCE

Anacostia River Fate and Transport Model, Washington, D.C. District Department of the Environment. April 2016 – Ongoing. Serving as project manager on a linked watershed – receiving water model project to support development of remediation options for sediment in the Anacostia River. Project includes developing an LSPC watershed model to provide boundary conditions for a hydrology and water quality model of the Anacostia for the Northeast/Northwest Branch confluence to the Anacostia/Potomac confluence, including Kingman Lake and Washington Channel.

Casselman River Watershed Modeling, Pennsylvania. Pennsylvania Department of Environmental Protection. August 2015 – Present. Serving as project manager coordinating the development of an LSPC model to simulate metals in a mining impacted watershed in Western Pennsylvania. Developed work plan, track task budgets and coordinate all staff activities related to project tasks and deliverables. Supported development of pre-model calibration sampling plan. Additional activities will include technical writing for model documentation and other deliverables which are expected to include a TMDL or an acceptable TMDL alternative.

TMDL Methodology Development and Model Training. USEPA Headquarters and CT DEEP. February 2017 – February 2018. For the CT Department of Energy and Environmental Protection, reviewed existing data and assisted in development of multiple methodologies that the department could consider in establishing a statewide methodology to develop lake/watershed nutrient and eutrophication TMDLs. Prepared documentation outlining results of data inventory, available modeling methodologies and recommendations for an approach the state could adopt to develop its remaining lake TMDLs.

Water Quality Model Status Assessment. **USEPA Modeling Workgroup.** October 2017 – Present. Project manager and researcher coordinating the review of the current maintenance and support status for a variety of water quality modeling applications of interest to the Modeling Workgroup. Coordinated a team of modelers from

EDUCATION

M.A., Marine Affairs, University of Virginia, 1996

B.A., Environmental Science, University of Virginia, 1993

AREAS OF EXPERTISE

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

OFFICE LOCATION

Fairfax, VA

YEARS OF EXPERIENCE

27

YEARS WITH FIRM

23

within Tetra Tech to review and document information such as basic model capabilities, current support and funding status, programming language, underlying code availability and recent research papers and projects references using each model. In phase 2, coordinating the workgroup on implementation of interface enhancements to the WASP water quality model and provision of training on the model.

Water Quality Trading and Offsets Support, Chesapeake Bay Region. USEPA Region 3. April 2014 – March 2018. Provided support to EPA Region 3's coordination and oversight of jurisdictions' trading and offset programs related to implementing the Chesapeake Bay TMDL. Coordinate staff and subcontractor development of various technical memoranda related to trading and offset topics, such as credit and baseline calculation methodologies, stormwater credit trading, credit permanence, etc. Work with EPA to develop concepts and outlines, and draft the memoranda, which are shared with the jurisdictions for feedback and refinement.

Technical Documentation and Writing Support for the Chesapeake Bay TMDL USEPA Region 3. 2009 – March 2011. 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 communicated the many technical concepts related to the TMDL, including the complex modeling framework and the unique allocation procedures developed for the TMDL. Developed original text as well as coordinated and compiled submissions by multiple contributors; organized, prioritized and incorporated comments from multiple reviewers within USEPA and the state partners; and ensured that all the required TMDL elements were included and adequately and clearly described.

Mining TMDL Development for the Kiskiminetas-Conemaugh River Watershed, Pennsylvania. USEPA Region 3. February 2008 – January 2010. 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.

Sediment TMDL Development using LSPC, 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.

Bow River Model Update, Alberta, Canada. **Alberta Parks and Environment**. October 2016 – June 2017. Project manager for a project in which the HEC-RAS and WASP model of the Bow River in Alberta, Canada was updated to reflect major changes in its channel morphology, vegetation and sediment that occurred as a result of the 2013 flood in Southern Alberta. Assisted project staff to coordinate task and budget allocations and provided administrative reporting and technical documentation support.

TMDL Modeling Webinar Coordination, U.S. USEPA Region 8. December 2014 – Fall 2017. Provided support to USEPA Region 8 in coordinating development and delivery of a series of TMDL Modeling Webinars. The webinar series was developed in collaboration with the Water Quality Modeling Workgroup, a group composed of USEPA Regions and state agency representatives with an interest in modeling applications for TMDL development and other CWA purposes. Providing technical and communication support for the webinars and working with USEPA client to identify topics, develop webinar agendas, identify potential speakers (from Tetra Tech and elsewhere), and host each webinar.

Lake Champlain TMDL Development, Vermont, New York. USEPA Region 1. November 2011 - April 2015. Managed 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.

TETRA TECH

Mark Sievers
Soils Specialist

EXPERIENCE SUMMARY

Mr. Sievers has over 20 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 is the Deputy Program Manager for Tetra Tech's current on-call stormwater support contract with Prince George's County Department of the Environment, managing staff, subcontractors and tasks orders. He provides 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 ArcMap, Microsoft Office (Word, Excel, Access, and PowerPoint), and FlowLink. His modeling experience includes MDAS, LSPC, LA-QUAL, QUAL2Kw, and various Excel-based modeling approaches.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Environmental Engineer, 2001–present

KEMRON Environmental Services, Inc., Environmental Scientist, 1999–2001

RELEVANT EXPERIENCE

On-Call Contract for Civil Engineering, Environmental Engineering, Construction Management and Inspection Services. Prince George's County Department of the Environment. 07/2014–present. Deputy Program Manager for Tetra Tech's on-call stormwater support contract with the Prince George's County Department of the Environment. Acts as main contact for County program managers. Oversees progress report and invoice preparation. Main contract administrator for small business subcontractors. Prepares or reviews all task order proposals to County. Tracks task order budgets and status of small/minority and county-based business requirements. Manages task orders on range of topics including chemical, biological and physical monitoring and reporting to comply with the county's MS4 permit; Clean Water Act fee development and support; development of IT tools; development of the county's Phase II WIP for the Chesapeake Bay TMDL; identification of potential BMP opportunities on municipal-owned land; and development of local TMDL restoration plans to address EPA-approved MS4 WLAs for fecal coliform bacteria, nutrients, sediment, biological oxygen demand, and PCBs in five county watersheds.

Western Branch Watershed Restoration Plan, Prince George's County, MD. Prince George's County Department of the Environment. 01/2018–present. Project manager for the development of a watershed

EDUCATION

M.S., Civil Engineering, University of Virginia, 1998

B.S., Environmental Geoscience, Indiana University of Pennsylvania, 1995

AREAS OF EXPERTISE

Watershed planning

Restoration planning

Data management/analysis

Watershed modeling

Water quality model development

TMDL development

Information management system development

Water quality monitoring program design and implementation

Project and contract management

LICENSES/REGISTRATIONS

None

TRAINING/CERTIFICATIONS

None

PROFESSIONAL AFFILIATIONS

None

OFFICE LOCATION

Fairfax, VA

YEARS OF EXPERIENCE

24

YEARS WITH FIRM

22

restoration plan for the Western Branch watershed. Oversaw the data collection and reporting. Currently overseeing the development of the methodology to identify restoration strategies and opportunities.

Chesapeake Bay TMDL Watershed Implementation Plan Support, Prince George's County, MD. Prince George's County Department of the Environment. 06/2011–present. Led the Phase II WIP development for Prince George's County to implement Chesapeake Bay TMDL allocations. 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.

National Pollutant Discharge Elimination System (NPDES) Long-Term Monitoring Program, Prince George's County, MD. Prince George's County Department of the Environment. 08/2005–present. Project leader for chemical, biological and physical monitoring of Bear Branch Watershed in Laurel, MD and physical monitoring of Black Branch Watershed in Upper Marlboro, MD, as part of the County's MS4 permit compliance program. Responsible for producing MS4 monitoring annual reports and databases for Maryland Department of the Environment. Performs data management and analyses for the annual report, including analyses of stream level, precipitation, and water quality data to develop event mean concentrations and seasonal pollutant loadings.

Identification of Undocumented Municipal BMPs. Prince George's County Department of the Environment. 10/2016–11/2017. Managing the identification of undocumented BMPs in county municipalities. Once identified, these BMPs can be included in the county's BMP database, reducing restoration needs of the county. Developed written communication to the municipalities. Oversaw collection, processing, and analysis of data from municipalities, including desktop evaluation (e.g., GIS, BMP plan review) and field investigation. Reviewed data analysis methodology. Created final documentation with results of project.

Web-GIS Based Flood Warning System, Prince George's County, MD. Prince George's County Department of the Environment. 04/2015–present. Overseeing final updates to a web-GIS based flood warning system using ArcGIS runtime technology. The system covers the central part of the County and automatically calls County staff to alert them of a potential flood. Main contact for County. Reviewing and editing system documentation.

Quantification of BMP Impacts on Chesapeake Bay Program Management Strategies. Chesapeake Bay Trust. 05/2016–04/2017. Applied for and received a Chesapeake Bay Trust (CBT) grant to quantify the impacts of BMPs on the Chesapeake Bay Program's (CBP's) management strategies. Managing the execution of the grant by working with multiple staff and the CBP. Purpose of the grant was to score (i.e., -5 to 5) BMPs as to its effect selected management strategies and co-benefits. Worked with the CBP technical lead to identify the relevant management strategies for the project and definitions of the co-benefits.

Kiskiminetas and Conemaugh Rivers TMDLs, Pennsylvania. 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.

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 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.

pH TMDL for the Youghiogheny River, Maryland. USEPA Region 3. 06/2005–07/2007. For EPA Region 3 and the Maryland Department of the Environment, managed development of TMDLs for 25 impaired streams with allocations for iron, aluminum, sulfate, nitrate, and ammonium. Used an updated version of MDAS to model the hydrology and water quality of the watershed. Managed the updates the model, which included the ability to simulate atmospheric deposition, soil moisture transportation, and advance chemical reactions to better simulate pH in stream segments. Performed data management, created model weather files and performed watershed delineation. Reviewed and included mining permits and mining seeps into the MDAS model.

Jonathan Smith, PE, CPSWQ, CPESC
Deputy Project Manager

EXPERIENCE SUMMARY

Jonathan Smith has over 20 years of experience in assisting communities in adopting sustainable stormwater management solutions to address flooding and surface water quality issues in a manner that also meets community specific objectives such as ecosystem restoration, urban revitalization, and watershed scale improvements. He is an Engineering Manager for Stormwater Services for Tetra Tech and serves as a lead technical services provider to municipal, state, and federal clients. For the past several years Mr. Smith has worked extensively with municipalities across the country to advance the use of green infrastructure through code revisions, policy updates, technical support, design manuals, and outreach and education. He has served as project manager since 2013 for a City of Raleigh support contract to implement green infrastructure into city programs.

Mr. Smith is a professional engineer (NC, SC, VA and WV), a Certified Professional in Stormwater Quality (CPSWQ), a Certified Professional in Erosion and Sedimentation Control (CPESC) and is a LEED-Accredited Professional. He is an approved instructor for CPSWQ.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Engineering Manager- Stormwater Services, 2009–present

McKim & Creed PA., Project Manager, 2006–2009

North Carolina State University, Department of Biological and Agricultural Engineering, Extension Engineer, 2001–2006

North Carolina State University, Department of Biological and Agricultural Engineering, Extension Assistant, 1995–2001

SELECTED RELEVANT EXPERIENCE

Green Infrastructure/LID Consulting Services, Raleigh, NC. City of Raleigh Stormwater Services Department 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.

Making a Visible difference: Building Blocks for Sustainable Communities Program, Nationwide. U.S. EPA-Office of Sustainable Communities. 11/15-present**.** Serves as lead facilitator providing technical assistance to communities across the country for the purpose of integrating green streets into each communities' existing complete streets policy. Services included facilitation of a 1 ½ day workshop for local stakeholders and preparation of a "Next Steps"

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

AREAS OF EXPERTISE

Green Infrastructure

Hydrologic and Hydraulic Design

Low Impact Development

Ecosystem Restoration

Program Development and Support

LICENSES/REGISTRATIONS

Professional Engineer: South Carolina, # 26822; Virginia (#44925); North Carolina (#026523); West Virginia (#19285)

TRAINING/CERTIFICATIONS

Certified Professional in Erosion and Sedimentation Control (CPESC), #4111

Certified Professional in Storm Water Quality (CPSWQ), #0048

LEED-Accredited Professional

OFFICE LOCATION

Marion, NC

YEARS OF EXPERIENCE

27

YEARS WITH FIRM

13

memo which describes specific actions the community can take to advance the implementation of green streets to create more sustainable communities.

Stormwater BMP Identification, Selection, and Design for Statewide NPDES Compliance, Maryland. 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, **lead** 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.

Climate Change and Urban Stormwater Design Guide, Nationwide. USEPA Office of Research and Development. 2014-2015. Providing technical support in the development of a design guide for stormwater control that identifies regionally relevant factors affecting stormwater control efficiency that are impacted by climate change. Tasks include literature review, simulation modeling using SUSTAIN, and developing the guide.

Green Infrastructure Concept Designs, Various Locations Nationwide. USEPA, 2012-2015. As a part of USEPA's 2012, 2013, and 2014 Green Infrastructure Community Partners technical assistance program, led development of concept designs for communities in a variety of settings across the country, including Norfolk, VA, Bath, ME, Atlanta, GA, Boise, ID, Pueblo de Cochiti, NM and Fall River, MA. The concept designs include site layout, preliminary calculations, and construction cost estimates and have addressed such considerations as resilience to climate change and associated sea level rise, off-site mitigation to incentivize private redevelopment, design of a pilot tree filter project in conjunction with U.S. Forest Service reforestation efforts, adaptation of design elements to be consistent with Native American culture and arid environments, and comparison and integration of gray and green infrastructure for CSO reduction

Minnesota Stormwater Manual Updates. Minnesota. Minnesota Pollution Control Agency. 2015-present. Serving as lead technical reviewer for detailed revisions of six chapters of the state's construction site erosion prevention and sediment control manual. Revisions include development of a chapter on general principles of erosion prevention to serve as the foundation of a wise construction site management program.

Stormwater Policy Manual Support, Boise, ID. Ada County Highway District (ACHD), 2016. Managed project to provide support to Professional Advisory Group (PAG) convened to identify and recommend revisions to stormwater design standards. Developed discussion papers and presentations on a variety of technical topics and issues including ponds, subsurface practices, pretreatment and practices for areas of high groundwater. Conducted webinars for the PAG on each topic and participated in a facilitated discussion on potential updates to ACHD stormwater policy.

Integrated Wastewater and Stormwater Planning Technical Assistance, City of Burlington, VT. USEPA Office of Wastewater Management. 11/14-12/15. Supporting USEPA grant-funded project to develop a toolkit and prioritized list of project scenarios for making integrated wastewater/stormwater management decisions, considering a wide range of technical and non-technical factors. Support focused on identification of wastewater and stormwater scenarios, both capital and programmatic, that would lead to reduction of phosphorus loading to Lake Champlain.

Urban Tree Planting Workshop, Springfield, MA. Pioneer Valley Planning Commission 11/15. Developed and led a ½ day workshop on the use of trees in urban settings to mitigate impacts of stormwater runoff. The workshop explored topics such as benefits of trees, placement considerations, species selection, mitigating conflicts, and the use of tree filters in an urban street setting.

USEPA Region 4 Post-Construction Workshop, Kentucky, 11/15. Lead technical presenter at a one-day workshop focused on the use of green infrastructure and LID to manage post-construction stormwater runoff to maintain pre-development runoff conditions. The workshop explained site design procedures, presented examples and case studies, and discussed the costs of benefits of green infrastructure.

Montana and North Dakota Stormwater Criteria Manuals, USEPA Office of Wastewater Management, 10/14-6/15. Supporting development of a guidance manual on stormwater BMP practices that may meet post-construction retention standards required in Montana and North Dakota's NPDES MS4 permit.

Vamsi Krishna Sridharan, PhD, M.ASCE
Soils Specialist

EXPERIENCE SUMMARY

Dr. Vamsi Krishna Sridharan is a senior environmental scientist with 18 years of experience building computer models for scientific investigations of reservoirs and riverine systems, estuarine aquatic habitat, and water quality management. In California, for the National Marine Fisheries Service, Vamsi led an interdisciplinary team comprised of academics, federal and state agency experts, and private sector consultants in building the flagship juvenile salmonid migration model, which is being used in NOAA's biological assessment of water operations and restoration actions. He has engaged with numerous stakeholder groups in California in education and outreach efforts, software delivery and scientific communication, and has conducted several regional and national educational workshops.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Senior Environmental Scientist, 2022–present

National Marine Fisheries Service, Scientist, 2017-2022

RELEVANT EXPERIENCE

Portland Harbor 4,4'-DDx Fate and Transport Model Development, Confidential Client, Williamette River, Portland, OR. 2022-present. Prepared technical memorandum to client rebutting comment made by litigant third party critiquing Tetra Tech's watershed (HSPF) and river hydrodynamic and fate and transport (EFDC) modeling and questioning validity and reliability of results. Worked with senior modeler on Tetra Tech team who had developed original models to provide point-by-point technical rebuttal of claims that would have absolved litigant of all contaminated sediment clean-up responsibility by synthesizing modeling report results and original scientific literature and identifying logical fallacies in litigant's reasoning.

Deep Water Project, Confidential Client, Gulf of Mexico, LA. 2022-present. Prepared quantitative responses to urgent questions pertaining to NEPA by the Council of Environmental Quality about environmental impacts of sediment resuspension during subsurface dredging and construction activities based on EFDC modeling report prepared by the Tetra Tech's senior modeler. Produced quick calculations of shallow water sediment transport and mixing, deposition, and resuspension in Excel to produce quantitative estimates on time to return to ambient conditions after dredging operations, deposition depths, impacts to sea floor ecosystems and mixing zone disturbance, developed a rapid response advection-dispersion-deposition sediment transport evaluation tool in Excel based on draft modeling report. Designed suspended sediment loads to be used in sediment transport model for anchoring operations, offshore platform installation and pile driving using hydrodynamic and geotechnical principles.

District of Columbia Bacteria Data Compilation, Data Gap Assessment, and Monitoring, Washington D.C., Bacteria contamination data gap analysis. US EPA, District of Columbia. 2022-present**.** Leading revisions to the data gaps report by delegating statistical analysis and GIS tasks to modeling team. Liaising with the US EPA Region 3 and District of Columbia monitoring staff to collect monitoring data and additional sources of

EDUCATION

Ph.D. Civil and Environmental Engineering, Stanford University, 2015

M.Sc. Environmental Engineering and Science, Singapore Stanford Partnership Program, Nanyang Technological University, 2005

B.E. (Hons.) Civil Engineering, Birla Institute of Technology and Science, Pilani, India, 2004

AREAS OF EXPERTISE

- Surface Water Systems Modeling
- Water Operations Evaluation
- TMDL and Watershed Modeling
- Statistical and Stochastic Modeling
- Decision Support Systems
- Data Analysis and Visualization
- Remote Sensing Technology

PROFESSIONAL AFFILIATIONS

Member of the American Society of Civil Engineers

Watershed Management Technical Committee of the Environmental and Water Resources Institute (EWRI)

OFFICE LOCATION

Fairfax, VA

YEARS OF EXPERIENCE

19

YEARS WITH FIRM

1

information to help the Tetra Tech team update the data gap report. These activities will result in updating the recommendations section of the report. The updated report will lead to subsequent work including designing a monitoring plan, developing a modeling plan and eventually revising the TMDL for bacteria in the District of Columbia.

Technical Assistance to EPA Region III for Toxic Pollutant TMDL Revisions and Climate Change Analysis in the Anacostia River Watershed, US EPA, District of Columbia. 2022-present. Preparing detailed statement of work for climate change assessment task by coordinating with personnel of the project team, downloading, analyzing, and synthesizing source tide gauge and climate projections data, and planning subtasks. Worked with senior modelers at Tetra Tech and provided guidance to liaison with Chesapeake Bay Modeling Workgroup to strategize the use of a climate projection and select future time horizons and collect relevant meteorological and relative sea level rise data for the Anacostia River and its watershed that are consistent with the medium- to long-term policy planning windows for the Chesapeake Bay region.

Modeling and remote sensing for Total Maximum Daily Loads and Watershed Management, ASCE. 2019-2022. Collaborated with academic and industry partners from various backgrounds to develop guidance papers and Manual of Practice on the selection of reliable models for holistic water quality and watershed management in the United States. Facilitated participation of experienced, but incongruent authors on one research paper and three manual of practice chapters. Conducted a survey and workshop on educating participants on the role of remote sensing in water quality management and modeling and understanding barriers to adoption of remote sensing in the EWRI Congress 2022. Facilitated high level of participant engagement by pre- and post-workshop meet-and-greet outreach with participants, and operationalized world café-based workshop breakout sessions. Working with Virginia DEQ, Tetra Tech, UC Berkeley and Arizona State University collaborators to conduct periodic workshops on holistic watershed management practices and modeling technologies. Leadership in committees has already produced two original research papers and one open-source Google Earth Engine app to explore the potential of remote sensing for water quality management anywhere within the United States and minor territories.

Vulnerability assessment of market squid fisheries off the coast of California to climate change, University of California Santa Cruz, Santa Cruz, CA. 2021-2022. Developed a probabilistic graphical model using data from source literature and reports to develop a research paper on assessing the vulnerability of the ecological, social, and economic aspects of the market squid fishery in California. Collaborated with a group of faculty and graduate students. Showcased the potential of probabilistic graphical models to the research group by developing a qualitative Bayesian Belief Network model using published literature for red sea urchin fisheries under climate change. This led to the decision to develop a probabilistic graphical model of the market squid fishery in the state of California as one of the research outcomes. To date, this is the first study attempting to develop a semi-quantitative decision support tool to evaluate the impacts of climate change on the California market squid fishery.

Enhanced Particle Tracking Model Version 2, National Marine Fisheries Service, California Department of Fish and Wildlife, U.S. Bureau of Reclamation, Santa Cruz, CA. 2017-2021**.** Developed a stochastic particle tracking model with fish behaviors in Fortran and Java with custom calibration and validation, pre- and post-processing workflows in R, Python, Matlab and AWS and GitHub repo and Wiki pages. Led an interdisciplinary inter-entity team comprised of UCSC, NMFS, USGS, DWR and QEDA Consulting LLC staff in developing the model. Engaged with local, regional, federal and industry stakeholders including think tanks, not for profit organizations, state and federal regulatory agencies, trade groups and water supply districts in regular stakeholder calls and convened several knowledge elucidation sessions with technical experts while developing and applying the model.

The next generation salmon migration model. National Marine Fisheries Service, California Department of Fish and Wildlife, Santa Cruz, CA. 2017-2022. Guided a post doctoral scholar in collaboration with a research ecologist at NMFS in developing a computational fluid dynamics-based particle tracking model of fish movements in the San Joaquin River, in which fish behaviors were encoded using a neural network and OpenFOAM. Subsequently developing research papers on explaining salmon migration dynamics by innovatively combining localized and systemwide acoustic telemetry datasets of fish migration through the California Central Valley.

Bathymetry comparison project in the Sacramento River, NMFS, Santa Cruz, CA. 2017-2022**.** Evaluated the early adoption of remote-sensing for habitat characterization by the NMFS by collecting ADCP, thermistor, and LISST data, ground-truthed LiDAR, drone-based hyperspectral and WorldView 3 satellite-based multispectral bathymetry and drone based thermal imagery in a fluvial system in collaboration with NMFS and USGS research scientists and Headwall Photonics. Helped set up and calibrate a Deltf-3D model of the Sacramento River.

TETRA TECH

James Stribling, Ph.D.
Biological Analyst

EXPERIENCE SUMMARY

Dr. Stribling is an environmental scientist with over 30 years of experience in applying ecological principles to natural resource management decision-making. He has been a national lead for developing techniques for biological method performance characteristics and comparability analyses, and has been leading analyses of taxonomic data quality for most of the USEPA National Aquatic Resources Surveys. Dr. Stribling has been 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, storm water management, and public outreach. Dr. Stribling's current research interests include developing a new terminology for communicating success and effectiveness in ecological/environmental restoration, developing a biological indicators-driven decision framework for stressor management and ecological restoration, and in refining techniques for defining data quality and using QC indicators in routine comparability and uncertainty analyses. He is working on an objective system for quantifying uncertainty associated with taxonomic identifications of benthic macroinvertebrates, and will ultimately result in a comprehensive searchable database of taxa gathered from streams, rivers, lakes, reservoirs, and estuarine and near-coastal waters throughout the US. Dr. Stribling provides technical review support to 16 journals, and is author or coauthor of 21 peer-reviewed publications, 4 book chapters, and numerous reports and documents for Federal, State, and local agencies.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Senior Scientist, Director, 1991-present.

EA Engineering, Science and Technology, Inc., Environmental Scientist, 1990–1991.

Georgetown University, Department of Biology, Assistant Research Professor, 1988–1990.

Cambridge Scientific Abstracts, Freelance Editor, 1988–1990.

University of Wisconsin, Department of Entomology, Post-Doctoral Research Associate, 1988.

Smithsonian Institution, Departments of Entomology and Invertebrate Zoology, Museum Technician, 1987–1988.

Montgomery College, Department of Biology, Adjunct Professor and Lecturer, 1987.

The Ohio State University, Department of Entomology, Graduate Research/Teaching Associate, 1980–1986.

The University of Mississippi, Department of Zoology, Teaching Assistant, 1980.

EDUCATION

- Ph.D., Entomology, The Ohio State University, 1986
- M.S., Entomology, The Ohio State University, 1982
- B.S., Zoology, The University of Mississippi, 1980

AREAS OF EXPERTISE

- Program/project management
- Biological monitoring and assessment
- Evaluation of BMP effectiveness
- Watershed assessments
- Document development and editing
- Statistical analysis
- Quality assurance/quality control

TRAINING/CERTIFICATIONS

HAZWOPER 40-Hour Training, Hazardous Waste Operations and Emergency Response, 2014, Certificate #521179 (*expired*)

PROFESSIONAL AFFILIATIONS

American Association for the Advancement of Science

American Water Resources Association

Society for Ecological Restoration

Society for Freshwater Science (Taxonomic Certification Committee, founding member)

Maryland Geologic Mapping Advisory Committee (voting member)

OFFICE LOCATION

Owings Mills, MD

YEARS OF EXPERIENCE

35

YEARS WITH FIRM

32

RELEVANT EXPERIENCE

Countywide Watershed Assessment, Prince George's County, Maryland, Department of the Environment, Stormwater Management Division. 2017–2018. Lead biologist on a watershed assessment/restoration planning team, working with specialists in water quality standards/water resources modelling, stream channel restoration, and storm water management, analyzed existing monitoring data and results, land use and land cover, and water quality data to develop objective assessments. Developed a trash rating protocol where over 3,000 stream photographs were evaluated for presence and intensity of solid trash, and quantitative trash scores used to rank individual streams and the Maryland 8-digit watersheds.

Benthic Invertebrate, Water Quality, and Vegetation Sampling for Alley Creek (Long Island, New York). The City of New York, Department of Environmental Protection, Bureau of Environmental Planning and Analysis. New York, NY (under subcontract to Hazen and Sawyer, Inc.). 2016–2017. As technical lead and project ecologist, established baseline ecological conditions using benthic macroinvertebrates for tidally-influenced estuarine Alley Creek, and assessment of potential changes due to chlorination treatment of combined sewer overflows. Assembled and deployed a field team to take benthic invertebrate samples with a Petite PONAR dredge from a boat, measure field water chemistry with YSI multiprobes, and to take quadrat samples of emergent wetlands vegetation, primarily *Spartina*. Used taxonomic data of known quality, performed all data analysis, including metric and index calculations, specifically focusing on the multimetric index calibrated for the Virginian Province, with the metrics: Number of individuals, as Spionidae; Number of individuals, as Tubificidae; and Gleason's D salinity normalized.

Recalibration of the Mississippi Benthic Index of Stream Quality (M-BISQ). Mississippi Department of Environmental Quality, Office of Pollution Control, Jackson, MS. 2015–2016. Served as lead ecologist. Led analysis of 14 years of sampling data from throughout the state of Mississippi (exclusive of the northwestern Alluvial Plain), totaling 941 benthic macroinvertebrate samples associated with data on physical habitat quality, land use and land cover, and selected field metered water chemistry. Determined preliminary regional site classes; established numeric criteria for site reference status, as either least disturbed or most disturbed, or other; determined naturally occurring bioregional delineations; tested metric sensitivity; and combined metrics into an index. Site class-specific index formulations included 17 different metrics, seven of which are common to at least two bioregions. The final version of the index is divided into four bioregions: East, South Bluff, Southeast, and West, with discrimination efficiencies ranging from 82-91%.

Technical Support to the NRCS National Water Quality Initiative (NWQI). US EPA, Nonpoint Source Program, Washington, DC. 2013–2016. For one of several NWQI projects, provided primary technical support to a monitoring and assessment program for the Upper Salem River, New Jersey. Purpose of monitoring to demonstrate degree of effectiveness of nonpoint source control practices in decreasing stressor loads (nutrients and sediments) and enhancing positive biological responses. Provided recommendations on sampling design/site placement, data analysis, and interpretation to the New Jersey Department of Environmental Protection.

Baseline Conditions for Evaluating Biological Response to Restoration in the Anacostia River Watershed. Prince George's County, Department of the Environment (DoE), Storm water Management Division, Landover, MD. 2015. In collaboration with the USACE-Baltimore District, performed site selection, reach assessment, and reporting and managed field sampling and data analysis. Purpose of the assessments was to document conditions for 11 stream and river reaches in the lower Anacostia River watershed in anticipation of ecological restoration. Data and indicators used to document pre-restoration conditions included Maryland DNR fish and benthic Indexes of Biological Integrity (F-IBI and B-IBI), physical habitat quality (PHAB, PHI), relative bed stability (RBS), and substrate particle size distribution (modified Wolman 100 particle pebble count).

Calibration of the Gulf Benthic Index for Mississippi (GBI-MS). Mississippi Department of Environmental Quality, Office of Pollution Control, Jackson, Mississippi. 2013. Project manager, directed effort to develop a refined index based on samples collected strictly within the estuarine and near-coastal waters of Mississippi. Gulf Benthic Index for Mississippi (GBI-MS) is a multimetric index with individual metrics calibrated to the natural and stressor gradients detectable in the data set. Identified natural site classes by comparing taxonomic composition among samples with relatively minimal. Tested metric sensitivity between sites within four site classes. Samples from sites with relatively minimal disturbance were identified as a reference to which conditions in other sites were compared. Sites having evidence of stressors identified as highly disturbed.

TETRA TECH

Barry Tonning
Outreach Specialist

EXPERIENCE SUMMARY

Mr. Tonning is a senior level water quality planning and management consultant specializing in nonpoint source pollution control; industrial, construction site, and municipal stormwater management; environmental regulatory compliance; and risk assessment, communication, and management. Over the past 25 years he has directed and supported various water resource programs focused on stormwater management, watershed planning, nonpoint source pollution control, and decentralized wastewater management. Mr. Tonning is also an experienced facilitator, trainer, and communications expert, supporting US EPA's national nonpoint source pollution program, the federal interagency Gulf of Mexico / Mississippi River Hypoxia Task Force, tribal water resources training and watershed management programs, and construction site stormwater permit compliance. He has also supported water quality standards (uses, criteria, antidegradation) projects, technology transfer and technical writing/editing tasks, and activities related to State Revolving Fund projects, source water assessment and protection, and risk communication/management.

EMPLOYMENT HISTORY

Tetra Tech, Director, 1999 – present

The Council of State Governments, Environmental Director, 1996 – 1999

Gateway District Health Department, NPS Program Director, 1991 – 1999

Montgomery Times, News Editor, 1985 – 1991

Cave Run Contracting, Owner, 1983 – 1985

Winnebago Tribe of Nebraska, Planner, 1980 – 1983

American Indian Human Resource Center, Director, 1978 – 1980

VISTA Volunteer, 1977 – 1978

RELEVANT EXPERIENCE

Stormwater Inspector Training, San Francisco Public Utilities Commission. Lead trainer for the city of San Francisco Public Utilities Commission stormwater training program. Developed training program materials for orienting and training staff from SFPUC, Department of Public Works, and Health Department on compliance with State Water Resources Control Board requirements for areas with Municipal Separate Storm Sewer Systems (MS4s). Delivered training program in June 2015 to staff and planned for a larger training event in May 2016.

Commercial and Industrial Facilities Compliance Program, City of Lexington (KY). Staff consultant and trainer for the City of Lexington's commercial and industrial facilities stormwater compliance program, which was mandated by a federal Consent Decree related to various alleged violations of Clean Water Act programs. Developed and delivered training materials, conducted specialized workshops, and worked with staff involved in the stormwater and illicit discharge programs. Conducted inspections, developed a SWPPP template for construction contractors, conducted

EDUCATION

MA, Communication / Environmental and Public Health Risk, Morehead State University, 1994

BA, Journalism, University of Georgia, 1977

AREA OF EXPERTISE

Nonpoint Source Pollution Management

MS4, Construction, and Industrial Stormwater Management

Integrated Planning for Stormwater and Wastewater

Decentralized Wastewater Management

Clean Water Act Support

Education and Outreach

Facilitation and Training

Tribal NPS and Water Resources Management Training

REGISTRATIONS/ AFFILIATIONS

American Water Works Association

Water Environment Federation

TRAINING/CERTIFICATIONS

Certified Erosion, Sediment, and Stormwater Inspector

OFFICE

Fairfax, VA; Lexington, KY

YEARS OF EXPERIENCE

35

YEARS WITHIN FIRM

24

training programs for city staff and outside contractors, and provided consultation on various stormwater topics during 2008 – 2014.

US EPA 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 program review.

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.

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.

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.

Site Inspector Certification Program Development. Provided training materials, slide presentations, instructor services, and consultation for the development of the Kentucky Erosion Protection and Sediment Control inspector qualification program, sponsored by the Kentucky Transportation Cabinet and the University of Kentucky’s Technology Transfer Program. Served as one of the first training program instructors, and later developed a separate course covering how to develop a construction site Stormwater Pollution Prevention Plan and taught those classes during 2010 – 2013.

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.

Industrial Facilities Inspections and Audits, Kiewit Corporation. Project lead, inspector, Stormwater Pollution Prevention Plan (SWPPP) developer, and stormwater compliance consultant for a four-year program serving Kiewit Corporation, a major construction contractor based in Omaha. Inspected industrial facilities and construction sites for stormwater compliance, developed construction site and industrial facility Stormwater Pollution Prevention Plans (SWPPPs), conducted compliance audits, and provided consultation to the company on cost-effective approaches for improving stormwater permit compliance during 2010 – 2015.

Tribal Water Quality Standards Development (Michigan). Lead researcher and consultant for developing tribal water quality standards for two American Indian Tribes in Michigan, the Little Traverse Bay Bands of Odawa and the Saginaw-Chippewa Indian Tribe. Reviewed and analyzed tribal water quality data, tribal waterbody uses, local and state regulatory frameworks, tribal authorities under the Clean Water Act, and other relevant issues. During 2013 – 2017, developed tribal water quality standards (waterbody beneficial uses, narrative/numeric criteria, antidegradation policies and implementation methods) and related documents.

Source Water Protection Program, City of Mount Sterling (KY). Staff consultant for a Source Water Assessment and Protection Program developed to protect the main drinking water reservoir serving Montgomery County and portions of surrounding counties. Developed program approach, conducted watershed assessment, worked with public agencies to refine the project scope, and successfully secured funding for implementation of management practices to address nutrient sources in the watershed during 2015.

TETRA TECH

Peter von Loewe
Senior Water Resource Engineer

EXPERIENCE SUMMARY

Mr. von Loewe has more than 20 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.

Mr. von Loewe currently provides technical and management support and guidance for Remedial Investigations and Feasibility Studies on the Anacostia River in the District of Columbia. Specifically, he serves as both the technical and project management lead for the development of watershed and receiving water quality models to support multiple areas of concern in surface waters impacted by legacy and ongoing toxicant contamination including PCBs, organochlorine pesticides, PAHs, and metals.

Mr. von Loewe also provides general and technical support on projects for the USEPA's Assessment and Watershed Protection Division to implement the Total Maximum Daily Load (TMDL) Program under Clean Water Act section 303(d). These projects have included technical assistance in the development of TMDLs in EPA Regions 2, 3, 4, and 9, including nutrient TMDLs in non-tidal riverine systems in Pennsylvania, tidal bay systems of the Virgin Islands and lakes/reservoirs in California, fecal coliform TMDLs in coastal lagoons of California, rivers in South Carolina and Virginia, and metals TMDLs for West Virginia rivers.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Environmental Scientist, 2002–present

NOAA Coastal Services Center, 2000–2002

EDUCATION

M.S., Environmental Studies, University of Charleston/Medical University of South Carolina, 2001

B.S., Anthropology, College of Charleston, 1992.

AREAS OF EXPERTISE

Hydrodynamic and water quality model development

Watershed model development

Water quality monitoring program design and implementation

Source characterization

Watershed management

Clean Water Act program support

TMDL development

Technical writing

Project and contract management

OFFICE LOCATION

Fairfax, VA

YEARS OF EXPERIENCE

23

YEARS WITH FIRM

21

RELEVANT EXPERIENCE

Monongahela River Fecal Coliform Bacteria EFDC Model Development, WV. WVDEP, 2018. Performed hydrologic model development of a high resolution, two-dimensional hydrodynamic EFDC model for the Monongahela River mainstem in West Virginia. Compiled river bathymetry data and constructed a two-dimensional model grid using GIS. Grid cells varied in size to provide higher resolution where needed to model fecal coliform sources.

Toxicant Fate and Transport Model Development for the Anacostia River. Mr. von Loewe is currently managing the development of a toxicant modeling system for the tidal Anacostia River in the District of Columbia and Maryland. He is working with a number of municipal, federal and local stakeholders to obtain information regarding the study area to characterize this complex, heavily-urbanized system. Compiled a rich dataset from a variety of sources to develop a linked LSPC watershed and EFDC receiving water modeling system to support a Remedial Investigation and Feasibility Study for the Anacostia River. Mr. von Loewe is developing and conducting scenario runs of the modeling system to investigate a variety of remedial alternatives to address PRGs for the Anacostia River.

District of Columbia Toxic Monitoring for TMDL Development. Provided support to U.S. Environmental Protection Agency Region 3 for addressing toxic impairments in the District of Columbia, and revising previous TMDLs to address daily load requirements. Mr. von Loewe is working with EPA Region 3 to revise previously-approved TMDLs for 33 waterbodies in the DC jurisdiction to assess current impairments and collect data for potential re-evaluation. The re-evaluation may use watershed (LSPC) and receiving water modeling (EFDC) techniques, and the monitoring has been tailored to support modeling at that level of detail, and includes physical, chemical, and fish tissue analyses for toxic contaminants of concern. Mr. von Loewe lead the development of recommendations on the status of the impairments, and additional monitoring needs to support TMDL development as needed.

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.

EFDCView Software Development for USEPA Region 4. Mr. Von Loewe managed the design, development, and maintenance of EFDCView; a graphical user interface to the EFDC receiving water model. 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. Ongoing development will ultimately provide a linkage to other stand-alone watershed and water quality models. This streamlined interface represents an integral component of the USEPA Region 4 TMDL Toolbox; a compendium of tools designed to assist in TMDL development.

Visual Orthogonal Grid Generator (VOGG) Development. Mr. von Loewe managed the optimization and testing of VOGG to support TMDL development in USEPA Region 4 studies that require finite difference modeling grids. He has helped facilitate seamless communication between VOGG and the EFDC preprocessor; EFDCView, to further reduce the effort required to develop an EFDC simulation. He has applied VOGG to a variety of coastline features and projected datasets to ensure a programmatically sound product, and has developed a tutorial and other components of the User's Manual document.

Multiple TMDLs for St. Croix, St. Thomas, and St. John, USVI. Managed multiple USEPA contracts to develop and apply hydrodynamic and water quality models for waters of the Virgin Islands. Mr. von Loewe was involved with making water quality monitoring recommendations, developing and applying a linked watershed-receiving water modeling system, evaluating management scenarios, and recommending pollution mitigation strategies. Provided modeling and management plan development support for 10 embayments in St. Thomas, St. John, and St. Croix. Modeling involved development of a range of modeling techniques, from complex LSPC-EFDC configurations to spreadsheet-based watershed load estimation tools and linkage to tidal-prism models. This work resulted in approved TMDLs developed on St. Thomas, St. Croix, and St. John for dissolved oxygen, bacteria, and oil and grease.

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. Assisted VADEQ with updating the permitted point source dataset being used in the Chesapeake Bay TMDL modeling.

TETRA TECH

Tan Zi, Ph.D., P.E.
Model Developer

EXPERIENCE SUMMARY

Dr. Tan Zi is an environmental engineering professional with over 10 years of experience in water resources practices and scientific research. He has expertise in hydrologic and water quality model development and application, and specialized in data processing, analysis and visualization with strong hand-on skills on GIS and remote sensing. His work in Tetra Tech focused on using a range of hydrologic, hydrodynamic, and water quality models and tools to solve problems and provide sustainable solutions of varied projects including TMDL development, environmental and climate change impact analysis, watershed/stormwater management plan for federal, state, municipal, and private clients. He has a versatile background in water resources, green infrastructure, climate, meteorology, agriculture, and ecology. He serves as a member for IWM northeast regional group and helps with technical methodology development for proposals.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Environmental Engineer, July 2014–Present

Duke University, Department of Civil and Environmental Engineering, Research Assistant, 2009–2014

China Meteorological Administration, Senior Staff Member, 2006-2009

RELEVANT EXPERIENCE

TMDLs for Upper Guyandotte River Watershed, WV. 2017-2019. Principal modeler for dissolved aluminum & pH TMDL development; Refining model code, performing analyses associated with geotechnical and watershed modeling. Calibrated and verified watershed model and conducted allocation analysis. Developed Al, Mn, and pH TMDLs for Upper Guyandotte River Watershed.

TMDLs for Monongahela River Watersheds, WV. 2016-2018. Developed and software code to translate and interpret hydrodynamic and water quality model output to support fecal coliform TMDL development for the Monongahela River. Created data visualization tool for integrating LSPC and EFDC modeling time series.

Prince George's County ArcGIS based BMP module development, Prince George's County. 2016-2020. Developer for an enterprise desktop tool application designed to calculate pollutant load reduction resulting from Best Management Practices (BMPs). Designed and developed ArcGIS based BMP management extension using ArcObjects library. Prepared user guide for the tool. Conducted quality control on the County BMP geodatabase. The designed system combines functionalities of database management, ArcGIS spatial analysis, statistical analysis, data visualization, and documentation generation.

Prince George's County Web-GIS Based Flood Warning System, Prince George's County. 2016-2020. Developer for an enterprise desktop application designed to forecast potential flooding conditions and communicate with local emergency management authorities. Researched solutions when software program was discontinued before software finalized. Upgraded FWS underlaying software development package from ArcGIS Runtime SDK for WPF to ArcGIS Runtime SDK for .Net.

EDUCATION

Ph.D., Civil and Environmental Engineering, Duke University, 2016

M.S., Meteorology, China Agricultural University, 2006

B.S., Applied Meteorology, China Agricultural University, 2004

AREAS OF EXPERTISE

Hydrology

Hydrologic and hydraulic modeling

Stormwater BMP modeling

Water quality modeling

Geospatial analysis

Environmental statistics

TMDL development

Climate change

Project management

TRAINING/CERTIFICATIONS

P.E., Virginia (040259494)

OFFICE LOCATION

Fairfax, VA

YEARS OF EXPERIENCE

14

YEARS WITH FIRM

8

Passaic River Contaminated Sediment modeling. Glen Springs Holdings. 2018. Conducted review of an existing contaminant transport modeling system for the Passaic River, NJ. Developed processing tools to translate and interpret hydrodynamic and water quality model output. Assisted with the development of high resolution hydrodynamic/sediment transport model that will be used to support engineering design of contaminated sediment dredging efforts.

Sandusky Bay Eutrophication Model Development, USEPA Region 5. 2018. Technical Support. Processed EFDC model outputs and calculated the mass balance and fluxes at boundaries (between stream and stream bed, from tributaries to bay area) of Phosphorous at Sandusky Bay based on EFDC model results. Analyzed the sources and sinks of P at different regions of water body.

Nutrient Pollution Risk Assessment Tool, Eastern Lancaster County. 2018**.** Main developer for a GIS based risk assessment tool of nutrient pollution. Created an ArcGIS toolbox to process related data and apply assessment methodology for identifying and prioritizing areas for best management practice implementation for any user-defined region.

Establishing N Thresholds for LIS Watershed, EPA OEP. 2017-2018. Analyst. Calculated total N delivered to LIS by each state using the SPARROW model outputs. Conducted literature review and tool testing for the particle tracking method being used for this project.

Bow River Water Quality Model Upgrade, Alberta AEP. 2017. Programmer. Developed the Python-VBA combined post-process tool for Bow River WASP model to support the data process, analysis, and visualization of the model outputs. Tested and debugged the pre-processor tool for the four HEC-RAS/WASP linked models.

Total loading objective Assessment for the City of Calgary, City of Calgary. 2015-2017. Lead modeler for SWMM and SUSTAIN models to develop total loading objectives assessment (TLOA) for stormwater and wastewater to identify the allowed loads of total suspended solids (TSS), carbonaceous biochemical oxygen demand (CBOD), phosphorus and nitrogen that will support aquatic life and habitat in the Bow River. Cleaned precipitation data and prepared 7 rainfall time series for SWMM model. Prepared SUSTAIN model input files for the project. Prepared clean flow and water quality data for model calibration. Combined simulations of two models for the estimation of hydrology and water quality of the City's watersheds. Estimated pollutant loadings under future scenarios. Summarized and analyzed data, prepared final report. Conducted a detailed data compilation and QAQC to incorporate available flow and TSS, TP data. Completed optimization for the EMC analysis based on continuous sampling from different sites with varied land uses.

Chesapeake Bay Program TMDL Midpoint Assessment and Watershed Implementation Plan Support. EPA Chesapeake Bay Program Office. 2015-2017. Python programmer. Provided enhancement to an ArcPy geospatial model. Reduced the runtime significantly when conducting complex land use analysis for large raster datasets. Modelled sediment yield, canopy cover, and residue of crops for different crop and tillage systems of Chesapeake Bay. Summarized modelled data into monthly.

Environmental Safe Guards Unit – Screening Toolkit Enhancements. Inter-American Development Bank (IDB). 2016. Task Lead. Provided GIS data acquisition and analysis for a large-scale, multi-country project to analyze the heatwave risks for existing and potential future conditions. Conducted data analysis and visualization for the heat wave risks at Central and South America.

Pollutant Loading Assessment for Lower Duwamish Waterway Superfund Site, EPA Region 10 and Washington Ecology. 2015-2016. Modified groundwater routing portion of LSPC model to fit the project needs. Conducted a detailed data compilation and QAQC to incorporate available water quality data and information available from multiple studies. Conducted analysis of data availability and prepared data summarization for project report.

Prince George's County Rural Impervious Area Analysis, Prince George's County. 2016. Programmer. Conducted spatial analysis for identifying disconnected rural impervious area from millions of candidates of the whole county. Algorithms were designed to deal with two types of impervious area, rooftop and non-rooftop. ArcGIS raster and vector analysis, Python programming were used to automate the screening process for the disconnected impervious area based on various raster and vector layers (e.g., DEM, slope, land use, flow direction, flow accumulation, and etc.) and the criteria proposed by MDE.

TETRA TECH

Rui Zou, Ph.D.
Model Developer

EXPERIENCE SUMMARY

Dr. Zou is a senior scientist in the areas of environmental 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, as well as uncertainty and risk assessment. He has developed theoretical frameworks including Intelligent Watershed Management (IWM), and Object-Oriented Intelligent Design (OOID) that are significant and important in guiding the future research areas of watershed management and environmental engineering designs. Dr. Zou's recent research produced an important breakthrough in the area of large scale watershed simulation-optimization and waste load optimal allocation through development of a new algorithm that is capable of solving a complex watershed simulation-optimization model faster than traditional algorithms such like Genetic Algorithms (GA), therefore making it possible to solve large scale watershed management problems.

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 many complicated computational modules in these modeling systems to enhance the capability of representing real world systems.

EMPLOYMENT HISTORY

Tetra Tech, Inc., 2002-present

University of Virginia, Graduate Research Assistant, 1998-2002

Peking University, Graduate Research Assistant, 1995-1998

Dali Institute for Environmental Sciences, China, Engineer, 1990-1995

RELEVANT EXPERIENCE

Regional Stormwater Buildup-Washoff Parameter Estimation, USEPA Region 1. Developed an advanced modeling system to intelligently estimate regional parameters to approximate the buildup-washoff process for impervious areas in New England. Developed semi-analytic solutions to buildup-washoff model equivalent to the formulation in SWMM and developed Fortran code to solve the model. Coupled the buildup-washoff model with a Genetic Algorithm (GA) to form an automatic parameter estimation system, and implemented an uncertainty-based parameter estimation process. Developed a K-means clustering routine to identify robust parameter sets which are representative to the condition of the EMC data collected in the region, providing basis for further nutrient loading estimate for BMP performance curve generation.

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

AREAS OF EXPERTISE

Hydrodynamic and Water Quality Modeling

Environmental Systems Analysis

Watershed Planning and Optimization

Linear and Non-linear Programming

Uncertainty Based Decision-Making

Numerical Model Development

Modeling Algorithm Development

PROFESSIONAL AFFILIATIONS

American Society of Limnology and Oceanography

American Geophysical Union

American Society of Civil Engineers (ASCE)

OFFICE LOCATION

Fairfax, VA

YEARS OF EXPERIENCE

23

YEARS WITH FIRM

21

Bow River Water Quality Model Extension, Alberta, Canada. Provided technical support to update and extend the existing Bow River water quality models. Extended the original Bow River flow and water quality model simulation period of 1990 to 2007 to until 2014. Developed flow balance routines to facilitate coupling of HEC-RAS model to the WASP model; enhanced WASP source code to allow flexible capability in handling boundary conditions, and benthic macrophyte substrate availability. Calibrated the interactions between nutrient-phytoplankton-macrophyte-dissolved oxygen for supporting scenario analysis for load reductions.

Hydrodynamic modeling for Southern Saskatchewan River (SSR), Alberta. Developed a hydrodynamic model based on EFDC framework for SSR, including model configuration and model calibration for flow and temperature, serving as the basis for subsequent water quality model and scenario analysis.

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.

Application of HEC-5/5Q Hydrological/Reservoir Operation Model and Salsim Salmon Population Simulation Model to Evaluate Temperature Target and Fish Response in San Joaquin River and Delta. Applied an integrated hydrological and reservoir operation modeling system using HEC-5/5Q for the San Joaquin River (SJR) system to analyze the response of flow and water temperature to temperature targets at different tributaries of the SJR, including Stanislaus River, Tuluomne River, and Merced River. Evaluated the implication of setting seasonally variable temperature. Coupled the reservoir operation model to the salmon whole lifecycle simulation model Salsim to evaluate the response of fish productivity at the entire SJR and delta system to support EPA's attempt of setting a proper temperature targets in the rivers to reach more beneficial water operation in the SJR system.

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 Nutrient-Periphyton Modeling for Wissahickon TMDL, 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.

Integrated Hydrodynamic and Water Quality Modeling for the Susitna River, Alaska. Developing an integrated hydrodynamic and water quality modeling system for the Susitna River. Developing 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, methylation, demethylation, oxidation, reduction, and volatilization. The model will simulate flow, temperature, nutrients, algae, and toxics (including Hg).