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

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

Proc Folder: 600332
Doc Description: EOI TMDL Tug Fork River Watershed
Proc Type: Central Purchase Order

Date Issued	Solicitation Closes	Solicitation No	Version
2019-08-12	2019-09-05 13:30:00	CEOI 0313 DEP2000000001	1

BID RECEIVING LOCATION

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

VENDOR

Vendor Name, Address and Telephone Number:

Tetra Tech
803 Quarrier St. Suite 400
Charleston WV 25301
304-414-0054

RECEIVED
2019 AUG 30 AM 10:30
WV PURCHASING DIVISION

FOR INFORMATION CONTACT THE BUYER

Brittany E Ingraham
(304) 558-2157
brittany.e.ingraham@wv.gov

Signature X [signature] **FEIN #** 95-4148514 **DATE** 8/21/2019

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

ADDITIONAL INFORMATION:

Expression of Interest

TMDL Tug Fork River Watershed

The West Virginia Purchasing Division is soliciting Expression(s) of Interest for the Agency, the Department of Environmental Protection, from qualified firms to provide architectural/engineering services to provide necessary engineering, and other related professional services to design and specify for construction as well as provide construction administration, to provide TMDL for impaired streams in the Tug Fork River Watershed, per the bid requirements, specifications, terms, and conditions as attached hereto.

*Online submissions of Expressions of Interest are prohibited.

INVOICE TO	SHIP TO
ENVIRONMENTAL PROTECTION DIV OF WASTE AND WATER MGT 601 57TH ST SE CHARLESTON WV25304 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	Water Testing Services		

Comm Code	Manufacturer	Specification	Model #
81100000			

Extended Description :

** DATES OF SERVICE ESTIMATED FOR BIDDING PURPOSES **
TMDL development for impaired streams in the Tug Fork River Watershed

STATE OF WEST VIRGINIA
Purchasing Division

PURCHASING AFFIDAVIT

CONSTRUCTION CONTRACTS: Under W. Va. Code § 5-22-1(i), the contracting public entity shall not award a construction contract to any bidder that is known to be in default on any monetary obligation owed to the state or a political subdivision of the state, including, but not limited to, obligations related to payroll taxes, property taxes, sales and use taxes, fire service fees, or other fines or fees.

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

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

DEFINITIONS:

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

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

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

AFFIRMATION: By signing this form, the vendor's authorized signer affirms and acknowledges under penalty of law for false swearing (*W. Va. Code* §61-5-3) that: (1) for construction contracts, the vendor is not in default on any monetary obligation owed to the state or a political subdivision of the state, and (2) for all other contracts, that neither vendor nor any related party owe a debt as defined above and that neither vendor nor any related party are in employer default as defined above, unless the debt or employer default is permitted under the exception above.

WITNESS THE FOLLOWING SIGNATURE:

Vendor's Name: Tetra Tech, Inc.

Authorized Signature: _____ Date: August 21, 2019

State of VA

County of FAIRFAX, to-wit:

Taken, subscribed, and sworn to before me this 21 day of AUGUST, 2019.

My Commission expires 05/31, 2022.

AFFIX SEAL HERE

Wayne Chen
Notary Public
Commonwealth of Virginia
My Commission Expires 05/31/2022
Commission ID# 7070912

NOTARY PUBLIC _____

West Virginia Ethics Commission

Disclosure of Interested Parties to Contracts

Pursuant to *W. Va. Code* § 6D-1-2, a state agency may not enter into a contract, or a series of related contracts, that has/have an actual or estimated value of $1 million or more until the business entity submits to the contracting state agency a Disclosure of Interested Parties to the applicable contract. In addition, the business entity awarded a contract is obligated to submit a supplemental Disclosure of Interested Parties reflecting any new or differing interested parties to the contract within 30 days following the completion or termination of the applicable contract.

For purposes of complying with these requirements, the following definitions apply:

"Business entity" means any entity recognized by law through which business is conducted, including a sole proprietorship, partnership or corporation, but does not include publicly traded companies listed on a national or international stock exchange.

"Interested party" or *"Interested parties"* means:

(1) A business entity performing work or service pursuant to, or in furtherance of, the applicable contract, including specifically sub-contractors;
(2) the person(s) who have an ownership interest equal to or greater than 25% in the business entity performing work or service pursuant to, or in furtherance of, the applicable contract. (This subdivision does not apply to a publicly traded company); and
(3) the person or business entity, if any, that served as a compensated broker or intermediary to actively facilitate the applicable contract or negotiated the terms of the applicable contract with the state agency. (This subdivision does not apply to persons or business entities performing legal services related to the negotiation or drafting of the applicable contract.)

"State agency" means a board, commission, office, department or other agency in the executive, judicial or legislative branch of state government, including publicly funded institutions of higher education: Provided, that for purposes of W. Va. Code § 6D-1-2, the West Virginia Investment Management Board shall not be deemed a state agency nor subject to the requirements of that provision.

The contracting business entity must complete this form and submit it to the contracting state agency prior to contract award and to complete another form within 30 days of contract completion or termination.

This form was created by the State of West Virginia Ethics Commission, 210 Brooks Street, Suite 300, Charleston, WV 25301-1804. Telephone: (304)558-0664; fax: (304)558-2169; e-mail: ethics@wv.gov; website: www.ethics.wv.gov.

Revised June 8, 2018

West Virginia Ethics Commission

Disclosure of Interested Parties to Contracts

(Required by *W. Va. Code* § 6D-1-2)

Name of Contracting Business Entity: Tetra Tech, Inc. **Address:** 10306 Eaton Place, Suite 340, Fairfax, VA 22030

Name of Authorized Agent: Jon C. Ludwig **Address:** 10306 Eaton Place, Suite 340, Fairfax, VA 22030

Contract Number: CEOI 0313 DEP2000000001 **Contract Description:** TMDL Development for Tug Fork River

Governmental agency awarding contract: Department of Environmental Protection

☐ **Check here if this is a Supplemental Disclosure**

List the Names of Interested Parties to the contract which are known or reasonably anticipated by the contracting business entity for each category below *(attach additional pages if necessary)*:

1. **Subcontractors or other entities performing work or service under the Contract**
   ☐ Check here if none, otherwise list entity/individual names below.

2. **Any person or entity who owns 25% or more of contracting entity (not applicable to publicly traded entities)**
   ☐ Check here if none, otherwise list entity/individual names below.

3. **Any person or entity that facilitated, or negotiated the terms of, the applicable contract (excluding legal services related to the negotiation or drafting of the applicable contract)**
   ☐ Check here if none, otherwise list entity/individual names below.

Signature: _____ Date Signed: August 21, 2019

Notary Verification

State of VA, County of FAIRFAX:

I, JON C. LUDWIG, the authorized agent of the contracting business entity listed above, being duly sworn, acknowledge that the Disclosure herein is being made under oath and under the penalty of perjury.

Taken, sworn to and subscribed before me this 21 day of August, 2019

_____
Notary Public's Signature

Wayne Chen
Notary Public
Commonwealth of Virginia
My Commission Expires 05/31/2022
Commission ID# 7070912

To be completed by State Agency:

Date Received by State Agency: _____

Date submitted to Ethics Commission: _____

Governmental agency submitting Disclosure: _____

Revised June 8, 2018

CERTIFICATE OF LIABILITY INSURANCE

DATE(MM/DD/YYYY)
08/14/2019

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	CONTACT NAME:	
Aon Risk Insurance Services West, Inc. Los Angeles CA Office 707 Wilshire Boulevard Suite 2600 Los Angeles CA 90017-0460 USA	PHONE (A/C. No. Ext): (866) 283-7122	FAX (A/C. No.): (800) 363-0105
	E-MAIL ADDRESS:	

INSURED	INSURER(S) AFFORDING COVERAGE		NAIC #
Tetra Tech, Inc. 10306 Eaton Place, Suite 340 Fairfax VA 22030 USA	INSURER A:	Lexington Insurance Company	19437
	INSURER B:	Zurich American Ins Co	16535
	INSURER C:	American International Group UK Ltd	AA1120187
	INSURER D:		
	INSURER E:		
	INSURER F:		

COVERAGES **CERTIFICATE NUMBER:** 570077846576 **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	
B	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:			GL0181740600	10/01/2018	10/01/2019	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 $4,000,000 $4,000,000
B	AUTOMOBILE LIABILITY X ANY AUTO OWNED AUTOS ONLY HIRED AUTOS ONLY SCHEDULED AUTOS NON-OWNED AUTOS ONLY			BAP 1857085-00	10/01/2018	10/01/2019	COMBINED SINGLE LIMIT (Ea accident) BODILY INJURY (Per person) BODILY INJURY (Per accident) PROPERTY DAMAGE (Per accident)	$2,000,000
C	X UMBRELLA LIAB X OCCUR EXCESS LIAB CLAIMS-MADE DED X RETENTION $100,000			62785232	10/01/2018	10/01/2019	EACH OCCURRENCE AGGREGATE	$10,000,000 $10,000,000
B B	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		WC254061600 WC185708700	10/01/2018 10/01/2018	10/01/2019 10/01/2019	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
A	Env Contr Prof			028182375 Prof/Poll Liab SIR applies per policy terms & conditions	10/01/2017	10/01/2019	Each Clain Agggregate	$5,000,000 $5,000,000

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

Stop Gap Coverage for the following states: OH, ND, WA, WY.

CERTIFICATE HOLDER

Department of Administration
Purchasing Division
Attn: Brittany Ingraham
2019 Washington St., E.
Charleston WV 25305 USA

CANCELLATION

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

AUTHORIZED REPRESENTATIVE

Aon Risk Insurance Services West, Inc.

Holder Identifier :

Certificate No : 570077846576

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.

John Beckman, Project Manager

(Name, Title)

John Beckman, Project Manager

(Printed Name and Title)

803 Quarrier Street, Suite 400, Charleston WV 25301

(Address)

304-414-0054 x103 / 304-720-2334

(Phone Number) / (Fax Number)

john.beckman@tetratech. com

(email address)

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

Tetra Tech, Inc.

(Company)

(Authorized Signature) (Representative Name, Title)

Jon C. Ludwig, Director

(Printed Name and Title of Authorized Representative)

August 21, 2019

(Date)

703-385-1973 / 703-385-6007

(Phone Number) (Fax Number)

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

PROJECT NAME	DATE (DAY, MONTH, YEAR)	FEIN
TMDL Development for Select Streams in Hydrologic Group C Tug Fork River Watershed	30, August, 2019	954148514

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

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

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

803 Quarrier Street, Suite 400 / (304) 414-0054 / John Beckman, Project Manager / 3 TMDL development personnel in office
Charleston, WV 25301

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

9. PERSONNEL BY DISCIPLINE

1	CONTRACT ADMINISTRATOR(S)	4	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)	3	TECHNICAL WRITER(S)	—	_____
4	BIOLOGICAL ANALYST(S)	2	OUTREACH SPECIALIST(S)		
3	MODEL DEVELOPER(S)	4	SENIOR WATER RESOURCE ENGINEER(S)		

31 TOTAL PERSONNEL

Note: If needed, Tetra Tech has over 25 additional highly qualified staff to support this project.

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

11. OUTSIDE KEY CONSULTANTS/SUB-CONSULTANTS ANTICIPATED TO BE USED. Attach "TMDL Vendor Qualification Questionnaire".

NAME AND ADDRESS: **NOT APPLICABLE**	SPECIALTY: **NOT APPLICABLE**	WORKED WITH BEFORE _____ Yes **NOT APPLICABLE** _____ No
NAME AND ADDRESS:	SPECIALTY:	WORKED WITH BEFORE _____ Yes _____ No
NAME AND ADDRESS:	SPECIALTY:	WORKED WITH BEFORE _____ Yes _____ No
NAME AND ADDRESS:	SPECIALTY:	WORKED WITH BEFORE _____ Yes _____ No
NAME AND ADDRESS:	SPECIALTY:	WORKED WITH BEFORE _____ Yes _____ No
NAME AND ADDRESS:	SPECIALTY:	WORKED WITH BEFORE _____ Yes _____ No
NAME AND ADDRESS:	SPECIALTY:	WORKED WITH BEFORE _____ Yes _____ No
NAME AND ADDRESS:	SPECIALTY:	WORKED WITH BEFORE _____ Yes _____ No

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

YES

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

Tetra Tech began developing TMDLs in WV in 1998 initially supporting USEPA Region 3 and has directly worked with WVDEP since 2002 to develop various technical approaches for total recoverable metals TMDLs throughout WV. For EPA and WVDEP, Tetra Tech has developed **2,855** EPA approved total recoverable metals TMDLs in 30 WV projects (includes multiple watersheds for some task orders). The table below displays the total recoverable metals TMDLs approved or under development through task orders for WVDEP since 2002.

WV Hydrologic Group	Status	Total Recoverable Metals TMDLs
A (Upper Kanawha & Upper Ohio North Watersheds);	USEPA Approved	63
B (Coal River, Lower Kanawha & North Branch Potomac Watersheds);	USEPA Approved	139
C (Gauley River Watershed);	USEPA Approved	60
D (New River & Little Kanawha Watersheds);	USEPA Approved	17
E (Upper Ohio South, Dunkard Creek, Camp Creek & Youghiogheny Watersheds)	USEPA Approved	32
B2 (Elk River & Lower Kanawha Watersheds)	USEPA Approved	406
C2 (Middle Ohio North & Middle Ohio South Watersheds)	USEPA Approved	299
D2 (Monongahela Watershed)	USEPA Approved	140
E2 (West Fork Watershed)	USEPA Approved	300
A3 (Upper Kanawha, Upper Ohio North, South Branch Potomac, & Shenandoah)	USEPA Approved	75
B3 (Tygart Valley River Watershed)	USEPA Approved	232
D3 (Hughes River Watershed)	USEPA Approved	26
E3 (Upper Guyandotte Watershed)	Under Development	61
E4 (Big Sandy, Lower Ohio, Twelvepole Watershed)	Under Development	37
C4 (Lower Guyandotte Watershed)	Under Development	22
TOTAL WEST VIRGINIA TMDLS DEVELOPED FOR WVDEP (SINCE 2002)		**1909**

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

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

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

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

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

A detailed description of the total recoverable metals TMDL methodology is presented in **Section 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. For EPA and WVDEP, Tetra Tech has developed **819** EPA approved pH/dissolved aluminum TMDLs in over 25 WV projects (includes multiple watersheds for some task orders). 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
E3 (Upper Guyandotte Watershed)	Under Development	19
E4 (Big Sandy, Lower Ohio, Twelvepole Watershed)	Under Development	3
C4 (Lower Guyandotte Watershed)	Under Development	2
TOTAL WEST VIRGINIA TMDLS DEVELOPED FOR WVDEP (SINCE 2002)		**500**

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.

Three (3) USEPA approved total recoverable metals TMDL projects are provided as examples (on CD-ROM) in **Appendix A** of the proposal that accompanies this questionnaire. The two projects include:

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

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

A detailed description of the pH/dissolved metals TMDL methodology is presented in **Section 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.

Tetra Tech began developing TMDLs in WV in 1998 initially supporting USEPA Region 3 and has directly worked with WVDEP since 2002 to develop various technical approaches for fecal coliform TMDLs throughout WV. For EPA and WVDEP, Tetra Tech has developed **1,359** EPA approved fecal coliform TMDLs in 25 WV projects (includes multiple watersheds for some task orders). In addition, Tetra Tech has developed hundreds more in other states and EPA Regions. The table below displays the fecal coliform TMDLs approved or under development through task orders for WVDEP since 2002.

WV Hydrologic Group	Status	Fecal Coliform Bacteria TMDLs
A (Upper Kanawha & Upper Ohio North Watersheds)	USEPA Approved	54
B (Coal River, Lower Kanawha & North Branch Potomac Watersheds)	USEPA Approved	102
C (Gauley River & Potomac Direct Drains Watersheds)	USEPA Approved	54
D (New River, Greenbrier River, James River & Little Kanawha Watersheds)	USEPA Approved	128
E (Upper Ohio South, Dunkard Creek, Camp Creek & Youghiogheny Watersheds)	USEPA Approved	101
B2 (Elk River, Lower Kanawha & North Branch Potomac Watersheds)	USEPA Approved	192
C2 (Middle Ohio North & Middle Ohio South Watersheds)	USEPA Approved	164
D2 (Monongahela Watershed)	USEPA Approved	65
E2 (West Fork Watershed)	USEPA Approved	175
A3 (Upper Kanawha, Upper Ohio North, South Branch Potomac, & Shenandoah)	USEPA Approved	52
B3 (Tygart Valley River Watershed)	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)	Under Development	104
E4 (Big Sandy, Lower Ohio, Twelvepole Watershed)	Under Development	186
C4 (Lower Guyandotte Watershed)	Under Development	183
TOTAL WEST VIRGINIA TMDLS DEVELOPED FOR WVDEP (SINCE 2002)		**1791**

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

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

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

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

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

A detailed description of the fecal coliform bacteria TMDL methodology is presented in **Section 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 has 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
E4 (Big Sandy, Lower Ohio, Twelvepole Watershed)			Under Development
C4 (Lower Guyandotte Watershed)			Under Development
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.

One (1) USEPA approved biological TMDL and its associated stressor identification evaluation is provided as an example (on CD-ROM) in **Appendix A** of the proposal that accompanies this questionnaire. The project:

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

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

A detailed description of the biological stressor identification process and biological TMDL methodology is presented in **Section 2** of the proposal that accompanies this questionnaire.

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

Working directly with WVDEP for 16 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
- Deadlines met
- 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. F. Describe your firm's experience with the LSPC/MDAS or equivalent modeling system in TMDL development. Provide names and number of projects for which this type of modeling system was employed.

Tetra Tech developed the LSPC/MDAS model specifically for TMDL development in West Virginia. Tetra Tech has modeled 29 individual USGS 8 Digit Hydrologic Unit Codes in West Virginia using LSPC/MDAS, and over 70 projects using LSPC/MDAS in various states throughout the country. A detailed description of Tetra Tech's familiarity with LSPC/MDAS model can be found in **Section 2** and three examples that demonstrate successful application of LSPC/MDAS are provided in **Appendix A** of the proposal that accompanies this questionnaire. The three projects include:

- 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 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	24	24	24

Brief Explanation of Responsibilities

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

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

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

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

NAME & TITLE (Last, First, Middle Int.)	YEARS OF EXPERIENCE		
	In EPA-approved TMDL development	In TMDL-related projects	With modeling system(s), e.g., LSPC, MDAS, etc…
Ludwig, Jon, C.	19	19	19

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	REGISTRATION (Type, Year, State)
American Water Resource Association. Water Environment Federation.	None

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

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

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
Southern Appalachian Botanical Society

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…
Smith, Jonathan, P.E.	11	11	11

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
American Public Works Association, NC Chapter.

Envirocert International.

REGISTRATION (Type, Year, State)
Professional Engineer, 2011, West Virginia [redacted]
Certified Professional in Erosion and Sedimentation Control, 2005, North Carolina [redacted]
Certified Professional in Storm Water Quality, 2010, North Carolina [redacted]

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.	15	15	15

Brief Explanation of Responsibilities

Dr. Bai will provide support for tasks associated with water quality modeling in large rivers, 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
American Society of Limnology and Oceanography. American Geophysical Union.

REGISTRATION (Type, Year, State) Professional Engineer, 2009, Virginia [redacted]

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.	17	17	17

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 None

REGISTRATION (Type, Year, State) None

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

NAME & TITLE (Last, First, Middle Int.)	YEARS OF EXPERIENCE		
	In EPA-approved TMDL development	In TMDL-related projects	With modeling system(s), e.g., LSPC, MDAS, etc…
Zi, Tan, Ph.D., P.E.	5	5	5

Brief Explanation of Responsibilities

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

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 [redacted]

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…
Paul, Michael, Ph.D.	12	12	12

Brief Explanation of Responsibilities

Dr. Paul's work will focus on identifying environmental stressors impairing biological condition of macroinvertebrates 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)
Ph.D., 1999, Ecology
M.S., 1994, Zoology
B.A., 1991, Biology

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS
Society for Freshwater Science.
Ecological Society of America.
American Institute for Biological Sciences

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
- Microsoft Project 2016
- 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 10.3	5
ESRI ArcGIS Desktop Standard 10.3	5
ESRI ArcGIS Desktop Basic 10.3	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 C4 Watershed (Lower Guyandotte Watershed)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	Prime Contractor - TMDL Development Lead	$502,944.00	15%
TMDL Development for WV Group E4 Watershed (Big Sandy, Lower Ohio, and Twelve Pole watersheds)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	Prime Contractor - TMDL Development Lead	$513,207.00	60%
TMDL Development for WV Group E3 Watershed (Upper Guyandotte River Watershed)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	Prime Contractor - TMDL Development Lead	$618,444.00	90%
EPA Region 3 - TMDL development and related support in West Virginia, Pennsylvania, Delaware, Maryland and Virginia; Chesapeake Bay TMDL and WIP development support	USEPA Region 3, 1650 Arch Street, Philadelphia, PA 19103	Prime Contractor	$2,370,375.00	64%
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	$3,096,029.00	84%
EPA Region 10 - TMDL development and related support in Alaska, Washington, Oregon and Idaho (TMDL development, TMDL model peer review, TMDL review/revision)	USEPA Region 10, 1200 6th Ave, Suite 900, Seattle, WA 98101	Prime Contractor	$1,090,197.00	39%
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	Prime Contractor	$684,286.00	95%
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	$449,045.00	26%
District of Columbia - Hydrodynamic, Water Quality, Contaminated Sediment Transport Modeling for the Ancostia River	District of Coulmbia, Department of Energy and Environment, 1200 First St NE, Washington, DC 20002	Prime Contractor	$1,234,517.00	19%

15. CURRENT PROJECTS/ACTIVITIES IN WHICH YOUR FIRM IS PRESENTLY INVOLVED (Continued)				
PROJECT NAME, TYPE AND LOCATION	NAME AND ADDRESS OF OWNER	NATURE OF YOUR FIRM'S RESPONSIBILITY	ESTIMATED PROJECT COST	PERCENT COMPLETE
City of 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	$8,185,146.00	67%
TOTAL NUMBER OF PROJECTS: 10		TOTAL ESTIMATED PROJECT COSTS: $18,744,190		

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 D3 Watersheds (Monongahela River and Hughes River)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	$446,075	2018	Yes
TMDL Development for WV Group C3 Watershed (Meadow River, Rockymarsh Run and Warm Spring Run)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	$272,471	2017	Yes
TMDL Development for WV Group B3 Watershed (Tygart Valley River)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	$574,954	2016	Yes
TMDL Development for WV Group A3 Watershed (Upper Kanawha, Upper Ohio North, South Branch Potomac, and Shenandoah)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	$565,866	2015	Yes
TMDL Development for WV Group E2 Watershed (West Fork River)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	$574,954	2014	Yes
TMDL Development for WV Group D2 Watershed (Tributaries of the Monongahela River)	WVDEP DWWM, 601-57th Street, Charleston, WV 25304-2345	$536,524	2014	Yes
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	$2,015,070	2010-2016	Yes
EPA Region 3 - TMDL development and related support in West Virginia, Pennsylvania, Delaware, Maryland and Virginia; Chesapeake Bay TMDL and WIP development support	USEPA Region 3, 1650 Arch Street, Philadelphia, PA 19103	$6,850,149	2013-2018	Yes
EPA Region 4 - TMDL development in South Carolina, Florida, Kentucky, North Carolina and Alabama; TMDL model training; hydrodynamic and water quality modeling for TMDL development	USEPA Region 4, 61 Forsyth Street SW, Atlanta, GA 30303	$2,380,672	2008-2014	Yes
EPA Region 5 - TMDL development and related support in Illinois, Indiana, Michigan, Ohio, Minnesota, and Wisconsin (e.g., TMDL development, TMDL implementation plans, methodologies for permitting Great Lakes nutrient dischargers, Section 319 support)	USEPA Region 5, 77 West Jackson Blvd, Chicago, IL 60604	$1,833,538	2013-2018	Yes
EPA Region 8 - TMDL development and related support in Montana (e.g., TMDL development, monitoring, water quality modeling)	USEPA Region 8, Montana Office, Federal Building, 10 W. 15th Street, Suite 3200, Helena, MT 59626	$3,695,988	2013-2018	Yes

17. COMPLETED WORK WITHIN LAST 5 YEARS IN WHICH YOUR FIRM WAS THE DESIGNATED FIRM OF RECORD (Continued)				
PROJECT NAME, TYPE AND LOCATION	NAME AND ADDRESS OF OWNER	ESTIMATED PROJECT COST	YEAR	EPA APPROVED?
EPA Region 9 - TMDL development and related support in California, Arizona, and Hawaii; NPDES permit development (individual, general, and stormwater) in California and Arizona; and water quality standards support in California (natural conditions, use attainability, and whole effluent toxicity training)	USEPA Region 9, 75 Hawthorne Street, San Francisco, CA 94105	$11,926,421	2013-2018	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	$2,216,890	2013-2018	Yes
EPA Region 1 - TMDL development support for Lake Champlain	USEPA Region 1, 5 Post Office Square, Boston, MA 02109-3912	$920,106	2010-2014	Yes
City of Calgary - Bow River Total Loading Objectives Assessment & City-Wide Stormwater Targets	City of Calgary, Water Centre, 625 25 Ave SE, Calgary, AB T2G	$789,349	2015-2017	Yes
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	$17,307,563	2013-2018	Yes

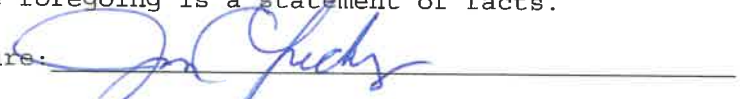
18. COMPLETED WORK WITHIN LAST 5 YEARS ON WHICH YOUR FIRM HAS BEEN A SUB-CONSULTANT TO OTHER FIRMS (INDICATE PHASE OF WORK FOR WHICH YOUR FIRM WAS RESPONSIBLE)

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

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

Since the late 1990's, Tetra Tech has developed more than 5,600 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 4,100 of the TMDLs have been developed directly supporting WVDEP with over 300 TMDLs currently under development.

20. The foregoing is a statement of facts.

Signature: 

Title: Director

Date: August 21, 2019

Printed Name: Jon C. Ludwig

Expression of Interest to Provide Professional Engineering Services for Total Maximum Daily Loads in the Tug Fork River Watershed

EOI NUMBER 0313 DEP2000000001

Submitted by:

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

Submitted to:

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

CONTENTS

I. 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 400 offices with over 16,000 employees worldwide. More important than our size, however, is that Tetra Tech is rated consistently by the industry as one of the most financially stable, top-quality environmental engineering firms. This year marked the ***sixteenth*** consecutive year in which Tetra Tech was ranked 1st in the top U.S. water firms by *Engineering News-Record.* Tetra Tech also was ranked #1 in Environmental Science, Consulting/Studies, Solid Waste, Wind Power, Water Supply, and Environmental Management. In addition, *Engineering News-Record* ranked Tetra Tech #4 in their "The Top 200 Environmental Firms" and #5 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 4,100 approved TMDLs in addition to over 300 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, 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 three contract administrators dedicated to tracking the financial status of contracts and ensuring Tetra Tech meets all contractual requirements. Activities of the contracts management staff include accessing and distributing weekly financial reports to the Tetra Tech Project Manager, issuing subcontractor agreements, tracking and administering subcontracts, and generating and submitting progress reports and invoices. We also have several administrative support staff who perform a variety of administrative duties, such as answering phones, arranging conference calls and package delivery, processing expense reports and invoices, and photocopying.

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

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

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 10.3, customized MapObjects applications, and dedicated systems. Tetra Tech also uses a variety of database platforms and software tools. Our broad information technology expertise includes proficiency in Oracle

and Microsoft SQLServer, MS Access databases; operating systems such as VMware, Linux and Windows; and programming languages C++, Visual Basic, Java, .NET, ArcView Avenue, and Arc/Info AML. Tetra Tech also utilizes virtual server operating systems and cloud computing using VMware Esx Server.

Other support functions include Tetra Tech's accounts with numerous online information services, including GIS data repositories, and personnel with familiarity and experience searching a wide variety of databases, including USEPA's STORET and U.S. Geological Survey'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 ▪ Microsoft Project 2016 ▪ Microsoft Visual Studio 2013/2015 ▪ MS Visual Studio Ultimate 2013/2015 ▪ MS Office One Note 2016 ▪ 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 10.3	7
ESRI ArcGIS Desktop Standard 10.3	24
ESRI ArcGIS Desktop Basic 10.3	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 more than 15 years, the Charleston office has worked on West Virginia TMDL projects, fostering close working relationships with key WVDEP personnel. As demonstrated during this time, we can draw upon our extensive technical expertise and resources from offices throughout the country (Cleveland, OH; Fairfax, VA; Owings Mills, MD; Atlanta, GA; Research Triangle Park, NC; and San Diego, CA) to support the WVDEP TMDL program seamlessly and in an efficient, cost-effective manner. Nearly 30 staff have contributed to the innovative technical approaches and designs for more than 4,100 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.

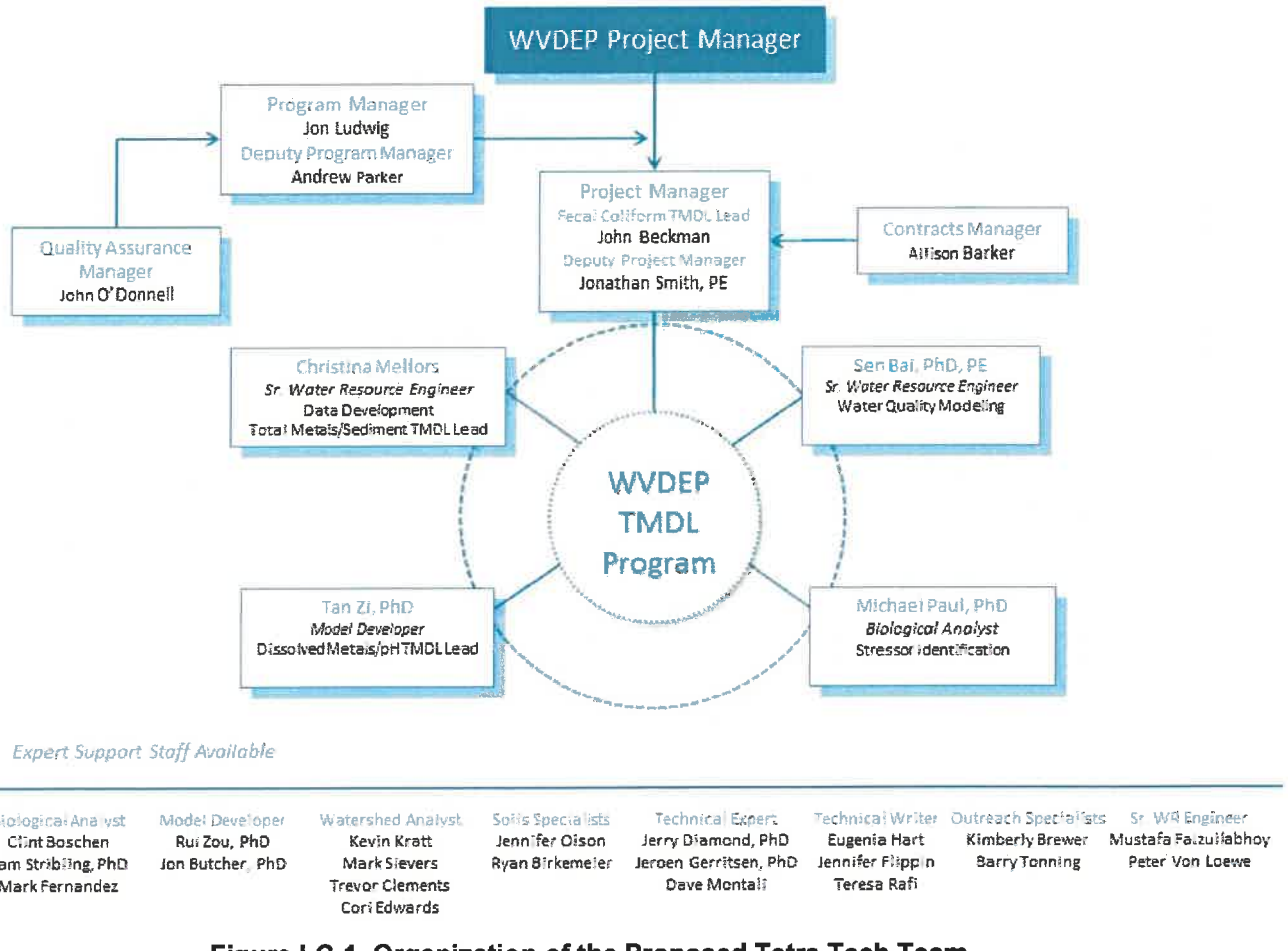


Figure I-C-1. Organization of the Proposed Tetra Tech Team

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 19 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 E3, E4, and C4 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 13 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, and DEP1900000013) 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, Water Quality Modeling

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 contribute to the fecal coliform and metals 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.

Michael Paul, PhD, Stressor Identification Lead

Dr. Paul's work will focus on identifying environmental stressors impairing biological condition of macroinvertebrates 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. Dr. Paul is an aquatic ecosystem ecologist/biogeochemist with over 20 years of experience in the research and management of aquatic ecosystems. His work, which has included teaching, research, and public policy, has focused on the ecology of freshwater ecosystems, including more than 12 years' experience in water quality standards development across the nation.

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
- Senior Water Resource Engineer

The Technical Experts who are identified provide specialized skills in toxicology, modeling, database management, or statistics. Direct experience with TMDL work in West Virginia is indicated in the table by a circle (•). 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 B of the proposal.

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

				TMDL Development				Watershed Assessment			Modeling & Data Management					Stressor Identification			Training & Outreach		Regulatory Guidance		
Staff	Proposed Role	Highest Degree	Total Years of Experience	Total Recoverable Metals TMDLs	Dissolved Metals/pH TMDLs	Bacteria TMDLs	Sediment TMDLs	Pollutant Source Tracking	Biological Assessment	Water Quality Sampling & Analysis	Data Development & GIS	Watershed/Water Quality Modeling	In-stream/Dissolved Metals Modeling	Model System Development	Sediment/Metals Relationship (Fe/TSS)	Conceptual Model Design	Biological Diagnostic/Statistical Modeling	Biological Index/Metric Development	Training/Technology Transfer	Public Outreach	QAPP Development	Water Quality Standards/UAA	Permitting
Jon Ludwig	Program Manager	MS	20	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
John Beckman	Project Manager	MEM	22	●	●	●	●	●	□	□	●	●	●		●		●		□	●	□		
Christina Mellors	Senior WR Engineer	MS	22	●		●	●				●	●	●	●	●	●			□	●			□
Andrew Parker	Deputy Program Manager	ME	24	●	●	●	●	□		□	●	●	●	●			□		●	●	●	●	□
Jonathan Smith, PE	Deputy Project Manager	BS	23					□		□	□	□		□		□			□	□			□
Sen Bai, PhD, PE	Senior WR Engineer	PhD	19			□	□	□		□	□	□		□		□			□				
Allison Barker	Contracts Manager	JD	20	●	●	●	●																
Ryan Birkemeier	Soils Specialist	M.S.	7				□	□		□	□	□							□	□			
Clint Boschen	Biological Analyst	MS	22		□	●	●	●	●	●	●	●		●		●	●	□	□	□	□	□	□
Kimberly Brewer	Outreach Specialist	MRP	34																	●		●	●
Jonathan Butcher, PhD	Model Developer	PhD	33	□	□	□	□	□	□	□	□	□	□	□		□	□	□	□	□	□	□	□
Trevor Clements	Watershed Analyst	MEM	36			□	□	□		□		□				□			●	□		□	□
Jerry Diamond, PhD	Technical Expert	PhD	39						●	●						□	□	□			□	□	□
Cori Edwards	Watershed Analyst	BA	8					●			●									●			
Mustafa Faizullabhoy, PE	Senior WR Engineer	MS	20	□	□	□	□				●	●	●	□		□							
Mark Fernandez	Biological Analyst	MS	8			□	□	□	□	□	□	□					□						□

Staff	Proposed Role	Highest Degree	Total Years of Experience	TMDL Development				Watershed Assessment			Modeling & Data Management					Stressor Identification			Training & Outreach		Regulatory Guidance		
				Total Recoverable Metals TMDLs	Dissolved Metals/pH TMDLs	Bacteria TMDLs	Sediment TMDLs	Pollutant Source Tracking	Biological Assessment	Water Quality Sampling & Analysis	Data Development & GIS	Watershed/Water Quality Modeling	In-stream/Dissolved Metals Modeling	Model System Development	Sediment/Metals Relationship (Fe/TSS)	Conceptual Model Design	Biological Diagnostic/Statistical Modeling	Biological Index/Metric Development	Training/Technology Transfer	Public Outreach	QAPP Development	Water Quality Standards/UAA	Permitting
Jennifer Flippin	Technical Writer	MS	15					□	□	□	□						□		□	□	□	□	
Jeroen Gerritsen, PhD	Technical Expert	PhD	37						●		●					●	●	●	●		□	□	
Eugenia Hart	Technical Writer	MS	19	●		●	□				●	●							□				
Kevin Kratt	Watershed Analyst	MEM	24	□	□	□	□	□	□	□	□	□				□			□	□		□	□
Dave Montali	Technical Expert	BS	38	●	●	●	●	●	●	●	●	●	●		●				●	●		●	●
John O'Donnell	Quality Assurance Manager	BS	36							●											●		
Jennifer Olson	Soils Specialist	MS	22			□	□	□	□	□	□	□							□	□			□
Michael Paul, PhD	Biological Analyst	PhD	24						●		□	□		□	□	□	●	●	□	□			
Teresa Rafi	Technical Writer	MA	23	●		●	●			●	●	●							□	□			□
Mark Sievers	Watershed Analyst	MS	20	□	□	□	□	●		□	●	□		□					□		□		
James Stribling, PhD	Biological Analyst	PhD	31						□	□	□					□	□	□	□	□	□		
Barry Tonning	Outreach Specialist	MA	31					□	□	□									●	●	□	●	●
Peter von Loewe	Senior WR Engineer	MS	19	□	□	□				□	□	□	□	□					□		□		
Tan Zi, PhD, PE	Model Developer	PhD	10			□	□				□	□		□		□	□		□				
Rui Zou, PhD	Model Developer	PhD	19		□	□	□				□	□		□							□		

● 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 B. 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

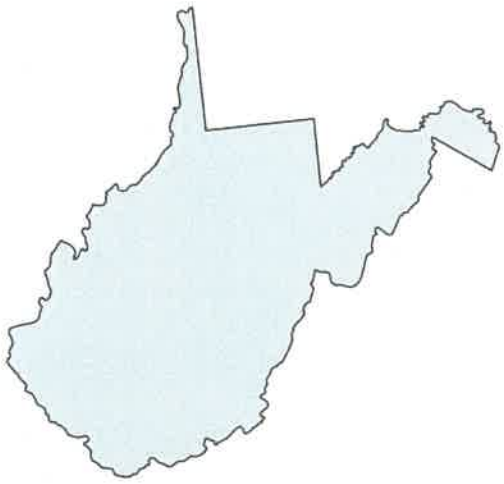
easily accommodate shifts in priority and facilitate assignment of the team's personnel to high-priority, complex assignments.

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 substantial role in Total Maximum Daily Load (TMDL) development in West Virginia, initially supporting U.S. Environmental Protection Agency (USEPA) to meet strict consent decree deadlines for more than 400 waters impaired by acid mine drainage (AMD) throughout the state. Since 2002, Tetra Tech has worked closely with West Virginia Department of Environmental Protection (WVDEP) through Purchase Order Nos. DEP12147, DEP13860, DEP15231, DEP15530, DEP15990, DEP16550, DEP1600000072, DEP1700000011, DEP1800000018, and DEP1900000013 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 16 years, Tetra Tech has successfully met aggressive project schedules while maintaining project budgets. Tetra Tech has completed over 4,100 USEPA approved TMDLs in West Virginia, in addition to over 300 TMDLs currently under development, while working directly for WVDEP. The success in meeting aggressive schedules and workloads is due to the exemplary efforts of Tetra Tech staff (shown in Section 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 16 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 2016)	▪ 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 15 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. An example subwatershed delineation is provided in Appendix A.

Before delineation is begun, the location, stream name, stream code and impairment status of all streams will be verified. Any stream whose impairment status is questionable will be considered 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 2016 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.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.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 in a CD directory with shapefiles compatible with the latest version of ArcGIS, representing the subwatershed delineation, TMDL watersheds, impaired streams, modeled reach, and NHD streams reach coverage. If necessary, a revised WAB monitoring station location shapefile will be included if discrepancies in monitoring station location data are discovered during the subwatershed delineation process. A separate document detailing any questionable or conflicting information encountered during the review of the stream reach and monitoring station shapefiles and impairment listings will be submitted along with the subwatershed delineation. An example subwatershed delineation is provided in Appendix A.

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 on a CD in a Microsoft Excel filterable spreadsheet format. An example Permit Summary Report is provided in Appendix A.

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 Report

Working closely with WVDEP and interested stakeholders, Tetra Tech will develop an accurate and detailed assessment of all possible pollutant sources in these watersheds. The results of this assessment will be presented in a Pollutant Source Report. The Pollutant Source Report is the starting point for MDAS model configuration. All of the datasets required for model setup are represented in the Pollutant Source Report: from the subwatershed delineation to the pollutant sources to the meteorological data that drives the model. 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. An example Pollutant Source Report is provided in Appendix A.

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 in a CD directory containing an ArcGIS project that spatially represents the potential sources of stream impairments in the watershed. A separate project will be created for each watershed and each project will contain a separate 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	▪ Roads ▪ Towns ▪ Soils ▪ Landuse – NLCD 2011 or 2016 ▪ 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.

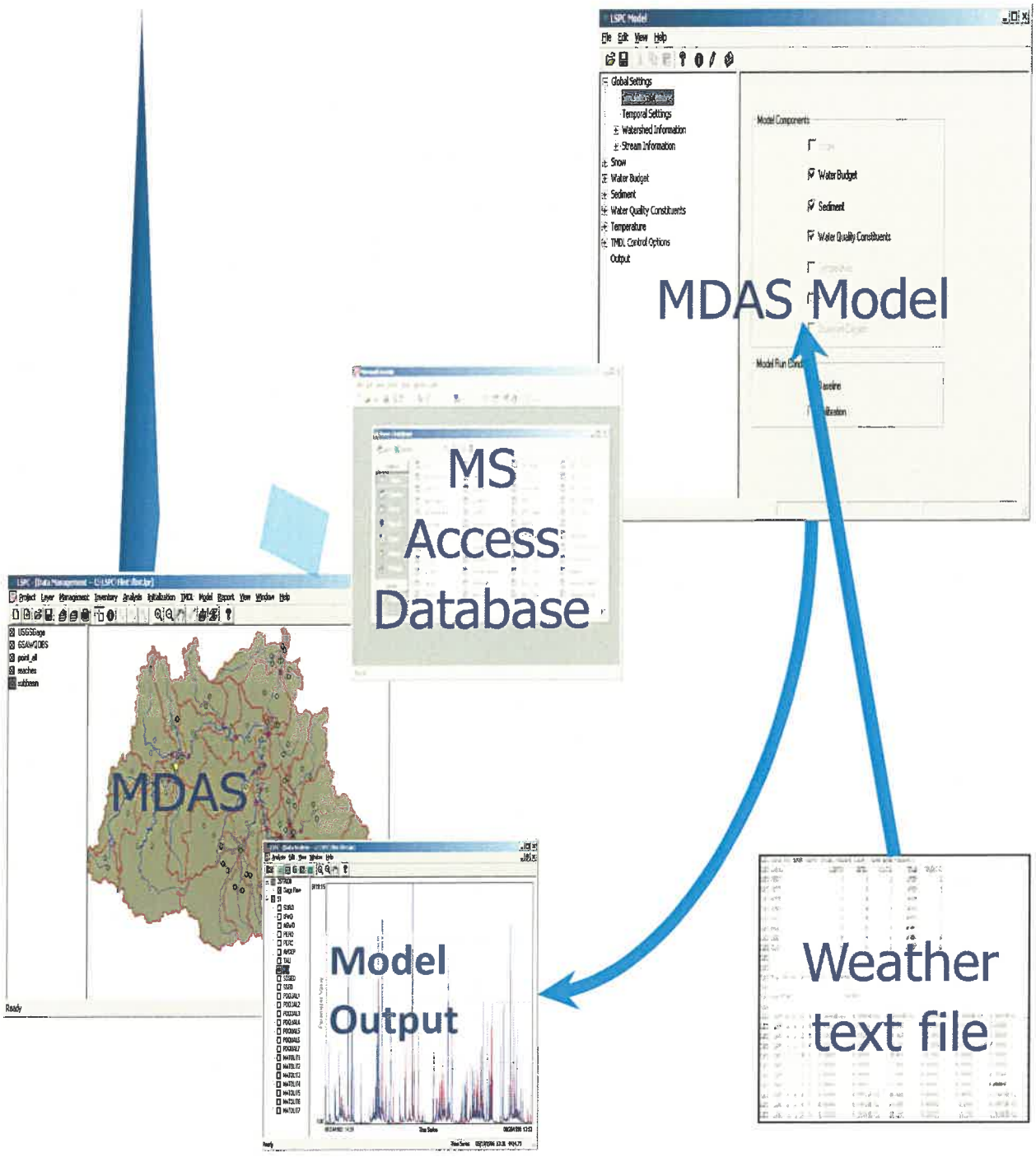


Figure II.B-1. MDAS Model Features

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 2016. This coverage will be modified to incorporate WVDEP source tracking information. For instance, areas of high concentrations of livestock (agricultural intensity) or fecal runoff potential; differences between grasslands versus pastures; new residential development; and other nonpoint pollutant sources not described on the original coverage will be taken into account. A roads analysis will also be performed using polylines from sources such as TIGER, WVRoads, and USGS topographic maps. Roads will be classified as either paved or unpaved. In addition, an analysis of the percent imperviousness of urban/residential areas will be performed. MS4 areas that occur in TMDL watersheds will be delineated using information obtained from WVDEP, WVDOH, and local city engineers.

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

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

II.B.1.c.2 Total Metals and Sediment Model Setup

To explicitly model nonpoint sources in the sediment and metals impaired watersheds, additional landuses need to be represented in the model beyond the modified fecal landuse described in 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.3 pH and Dissolved Metals Model Setup

As noted in previous work for WVDEP, the majority of water quality impairment relates to mine drainage and bacterial contamination. The development of TMDLs is needed to address the typical stressors and water quality impairment due to pH, metal toxicity, and sedimentation. 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.

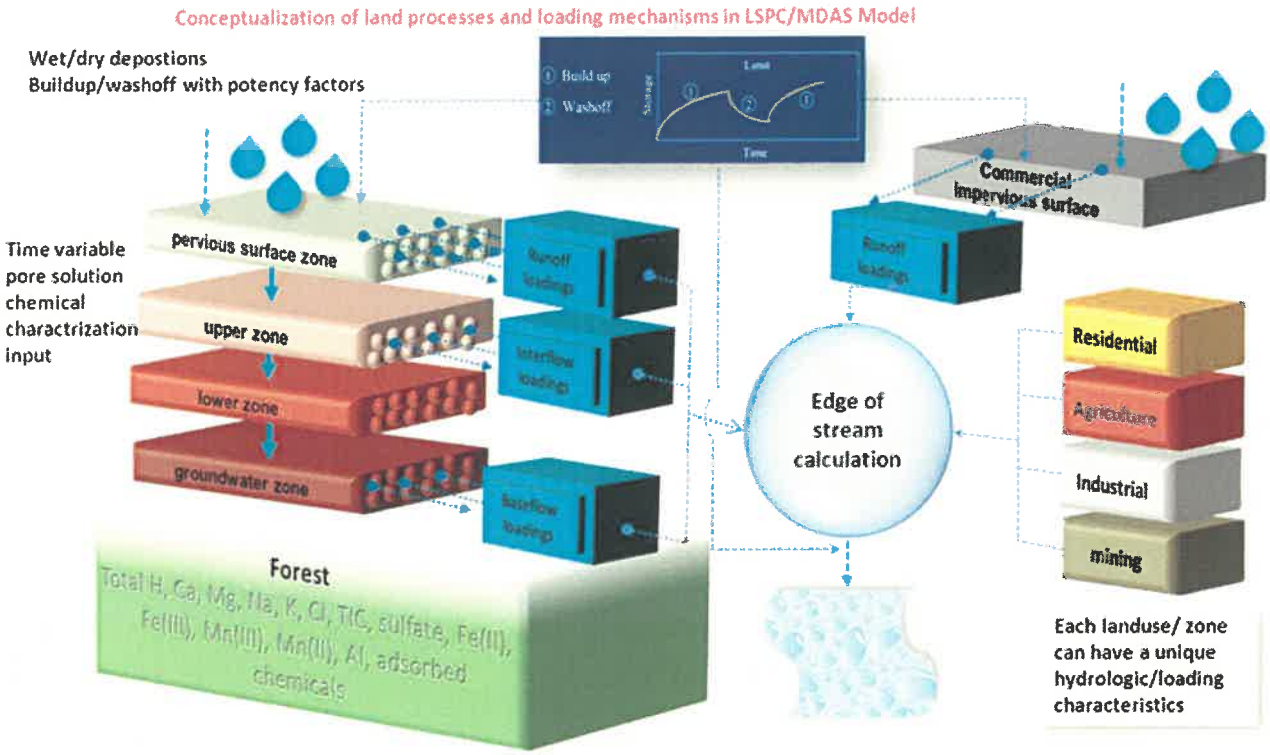


Figure II.B-2. Land components of LSPC-MDAS model

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.

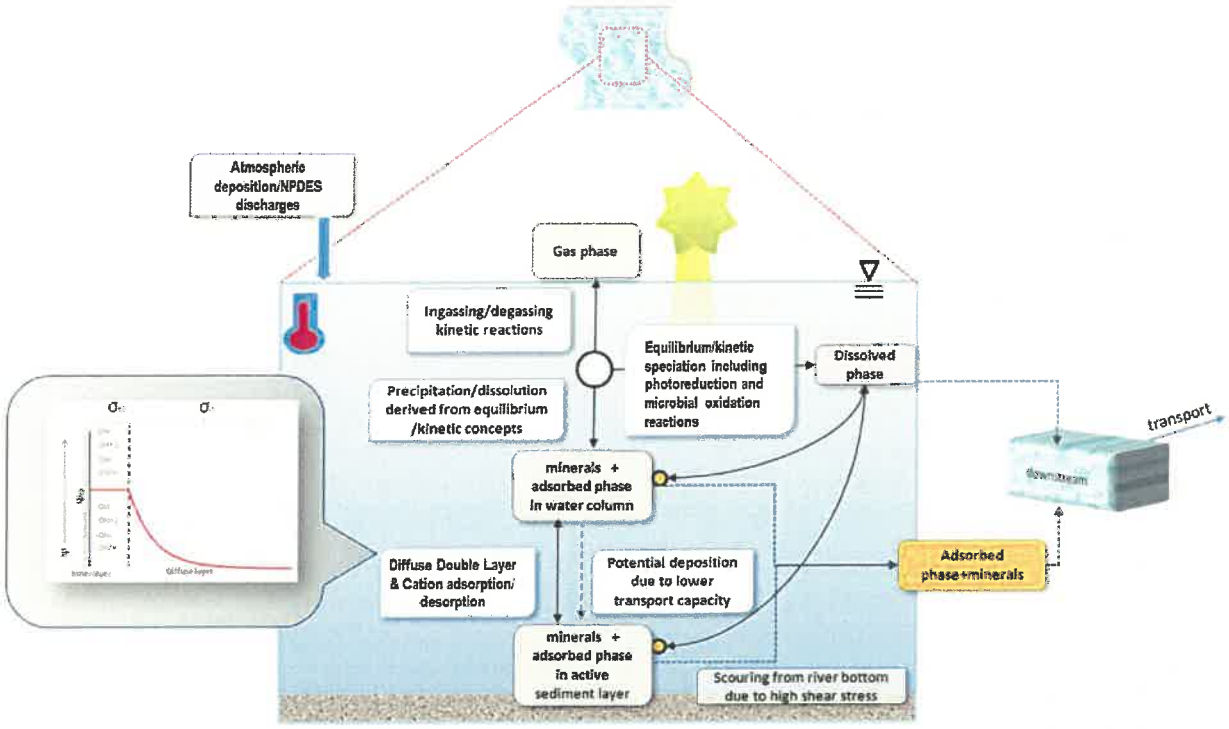


Figure II.B-3. Stream components in MDAS

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.4 Sediment-Metals Relationship

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

Iron loads are delivered to the tributaries with surface runoff, subsurface flows, and direct point sources. Sediment-producing landuses and bank erosion are also sources of iron because iron is associated with sediment. MDAS provides mechanisms for representing all 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.

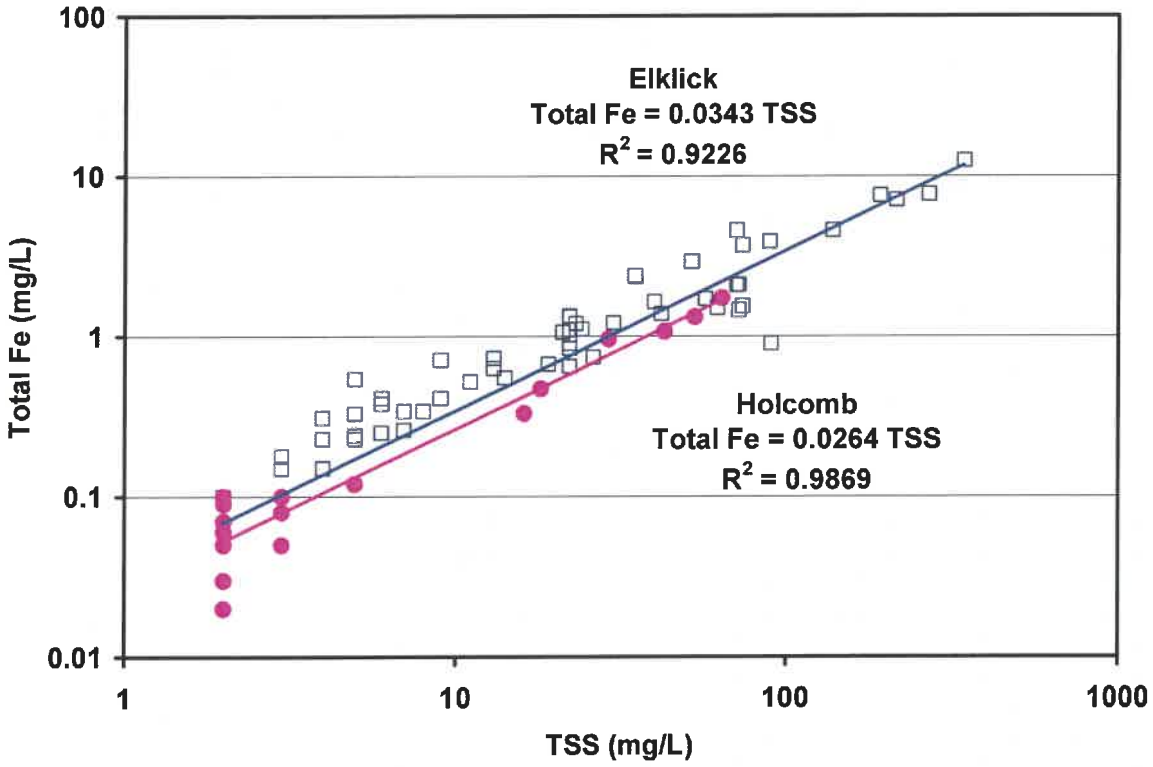


Figure II.B-4. Metals-sediment correlation

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.5 Streambank Erosion

The MDAS streambank erosion model is a function of stream flow and bank stability. The bank erosion algorithms of MDAS are based on the scour erosion algorithms of HSPF. The bank erosion rate per unit area is defined as a function of: bank flow volume above a specified threshold, the bank erodible area, the coefficient of scour for the bank soil, and an optional exponent for non-linearity. The streambank soil matrix is assumed to be unlimited, and bank scour is defined uniquely for each stream segment. Each stream segment will have a user-specified flow threshold above which streambank erosion may occur.

The bank scouring process is a power function dependent on high-flow events, defined as exceeding the flow threshold. The coefficient of scour for the bank soil can be determined by calibration, where modeled bank erosion sediment loads are compared with loads calculated from the pin study and kber values are adjusted iteratively. Streambank erosion is represented as a unique source independent of other upland-associated erosion sources.

The wetted perimeter and reach length represent ground area covered by water (Figure 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).

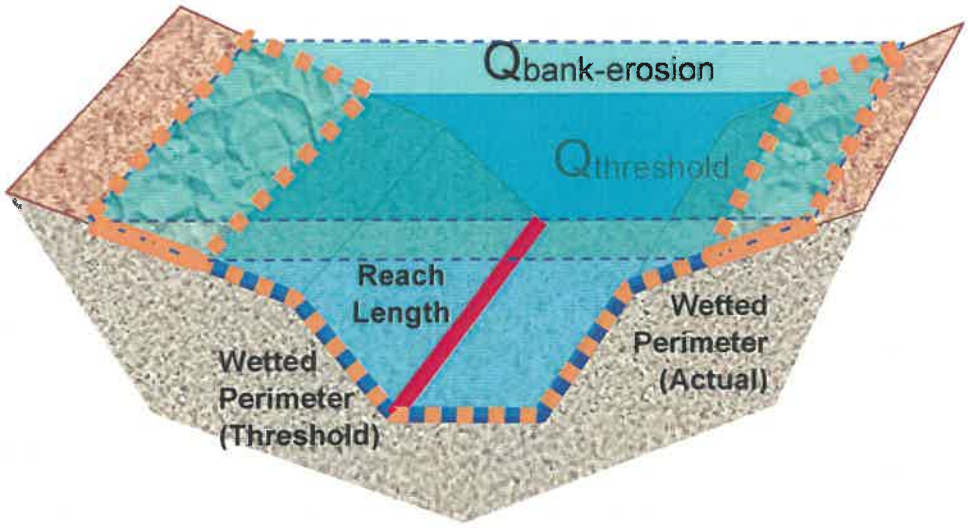


Figure II.B-5. Conceptual diagram of bank erosion model

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.

To begin the hydrology calibration process, 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. Gaps in weather data completeness will be addressed using statistical methods, including Meteorological Data Analysis and Preparation Tool (MetADAPT) software available from the USEPA Region 4 TMDL Toolbox. Tetra Tech will also obtain USGS gaging station data for streams in TMDL watersheds. Instantaneous flow measurements collected during pre-TMDL monitoring and WAB stream surveys will also be used when appropriate. In the event that USGS gaging stations are not present in the TMDL watershed, model hydrology will be calibrated to a nearby watershed with similar weather patterns and landuse characteristics. Model parameters will initially be set to the best available literature values within scientifically accepted ranges. 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 on a CD containing calibration tools described above and will contain worksheets that represent the observed data and modeled output, with graphs and tables designed to assess the goodness-of-fit of the calibration, and a statistical analysis of the calibration. Daily, monthly, and annual flow volumes will be considered. An example of the hydrology calibration deliverable from West Virginia Hydrologic Group C3 TMDL is presented in Appendix A.

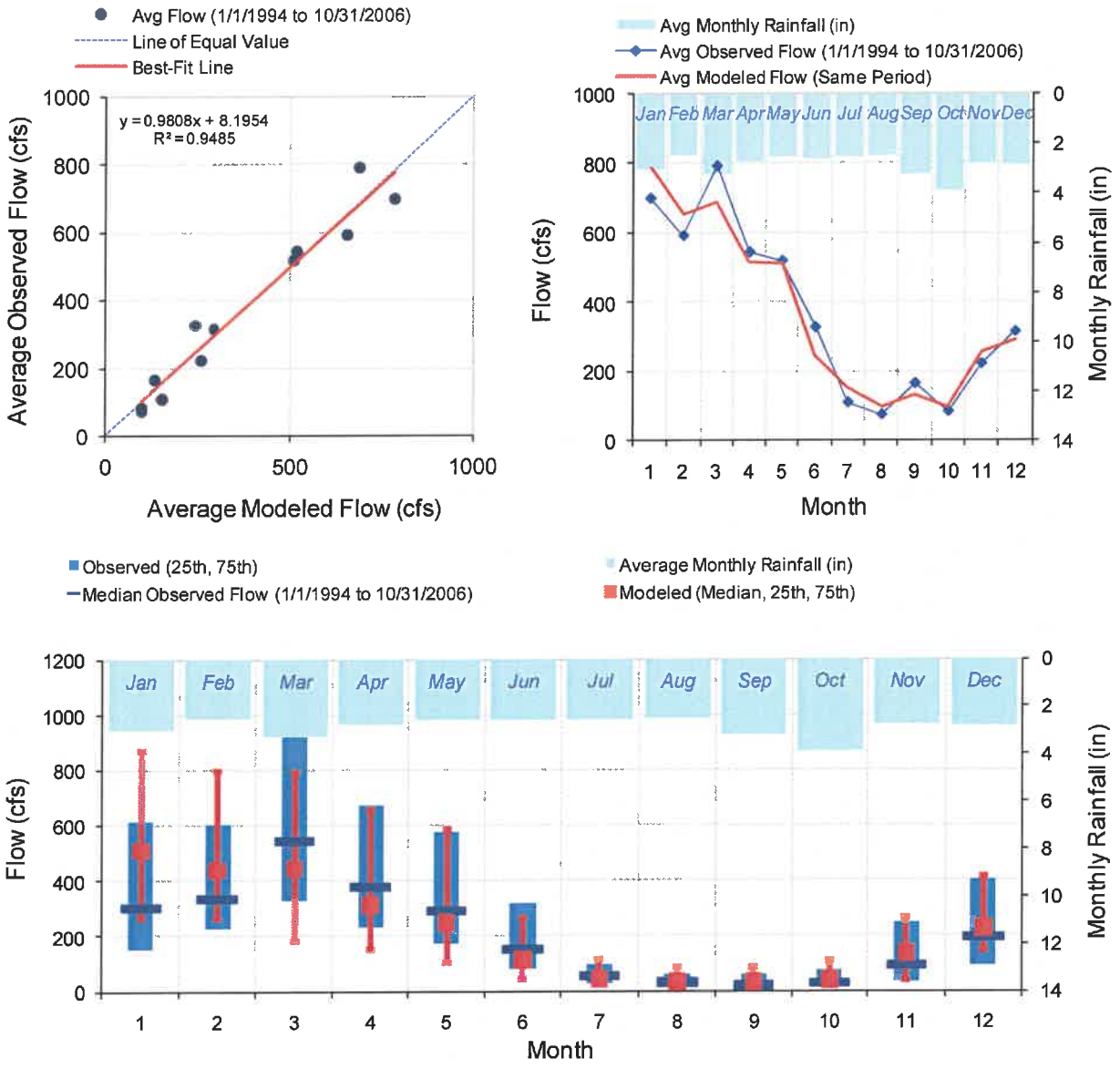


Figure II.B-6. Example Hydrology Calibration Spreadsheet Tools

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 presented on a CD and will contain worksheets that represent the observed data and modeled output, with graphs and tables designed to assess the goodness-of-fit of the calibration, and a statistical analysis of the calibration. Calibration will be performed on a significant number of watersheds to ensure the scientific validity of the process. An example of the water quality calibration deliverable from the West Virginia Hydrologic Group B3 TMDL project is presented in Appendix A.

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.

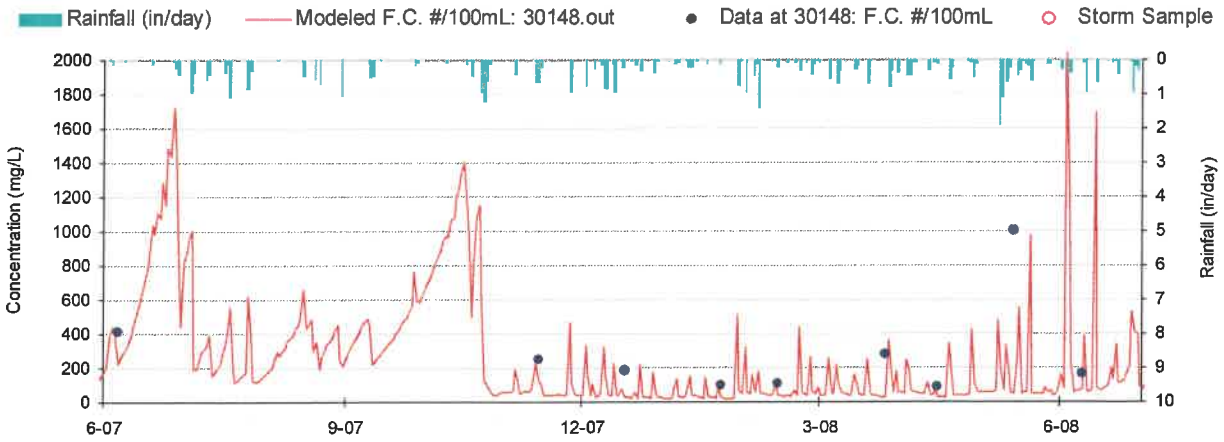


Figure II.B-7. Fecal coliform concentration: model output vs. observed data

II.B.1.d.4. 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.5. pH and Dissolved Metals Water Quality Calibration

Historical mining activities are an important consideration in the development of dissolved aluminum and pH TMDLs. AMD is drainage that flows from open or deep mines and coal refuse piles. The formation of AMD is a function of geology, hydrology, and mining technologies used at the site. It tends to be highly

acidic and to contain high concentrations of dissolved metals. These metals remain dissolved until the pH of the water increases to the level at which the metals precipitate out. AML seeps will be modeled as direct, continuous-flow sources in the model. AML and other land-based sources will be modeled using representative average concentrations for the surface, interflow and groundwater portions of the water budget.

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

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

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, 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.

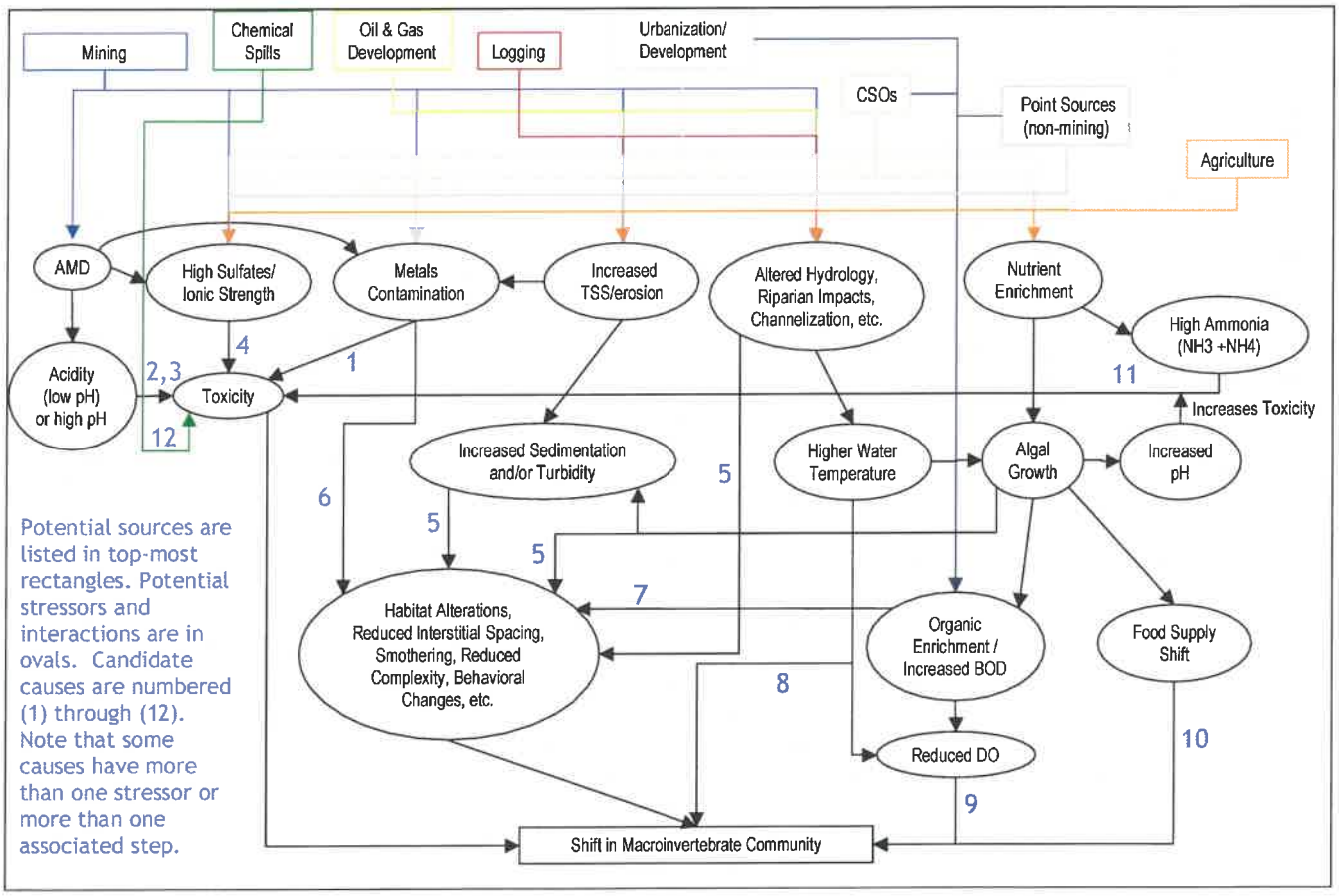


Figure II.B-8. Conceptual model of candidate causes used in Stressor Identification

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 biological section for each TMDL report and the technical report. An example of the SI summary database for Hydrologic Group B3 (Tygart Valley River Watershed) is included in Appendix A, SI Database folder.

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 CD deliverable 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 waste water treatment system's Long Term Control Plan. Loads from MS4 communities will be identified in allocation tables and summarized by municipal jurisdiction. Tetra Tech will provide WVDEP with a filterable spreadsheet with modeled unit area loading results by subwatershed and landuse.

II.C.2 Metals Allocations

The total iron TMDL endpoint for warm-water streams will be based on the chronic 4-day average of 1.5 mg/L minus an explicit margin of safety (MOS) (WVDEP typically assigns a 5% MOS). The endpoint for trout streams will be derived in the same manner, but using the chronic 4-day average of 1.0 mg/L.

If, under the most stringent and unachievable allocation scenarios, modeling output does not ensure troutwater criterion attainment, Tetra Tech will work closely with WVDEP to propose phased implementation of the TMDLs under which the source allocations necessary to universally achieve an interim iron water quality target. The approach to allocations for total recoverable metals sources will be guided by WVDEP's allocation order. Tetra Tech will make necessary reductions to meet metals

endpoints in the priority sequence that WVDEP establishes for each watershed. Using the watershed approach, Tetra Tech will reduce metals sources (including sediment-related metals sources) using WVDEP's allocation strategy to meet the TMDL endpoints. Given the established total iron/sediment relationship described in Section 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 on a CD as filterable spreadsheets that identify pollutant-specific and subwatershed-specific baseline and TMDL loadings for individual point sources and categories of point sources.

II.C.3 pH and Dissolved Metals Allocations

The allocation approach will focus on reducing metals concentrations and increasing pH by assigning buffering capacity (alkalinity) using the MDAS model to meet metals water quality criteria; and then verifying that the resultant pH under these conditions would be in compliance with pH criteria.

As general steps of the allocation process, substantive sources (e.g., seeps) of total iron will be reduced first. This step will be taken because, depending on the stream's buffering capacity, existing instream dissolved iron concentrations could significantly reduce pH. Once the model results indicate the achievement of the iron criterion, dissolved aluminum and pH model results will be evaluated under the reduced iron loadings condition. If model results predict non-attainment of the pH and dissolved aluminum criteria, alkalinity additions will 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 report package will be presented in digital form on a CD-ROM. This format allows for cost-effective distribution of the report to state agency personnel, stakeholders, and the concerned public. This format also allows for easy uploading to the WVDEP website. Example TMDL packages are provided in Appendix A.

Tetra Tech has produced TMDL reports for the WVDEP for more than 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 on the report CD-ROM.

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 2011 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 on CD-ROM, or via a restricted-access Internet ftp site. The preliminary draft report will consist of a complete report outline with supporting text and appendices, minus any report text of regulatory nature that is the responsibility of WVDEP.

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

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

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.

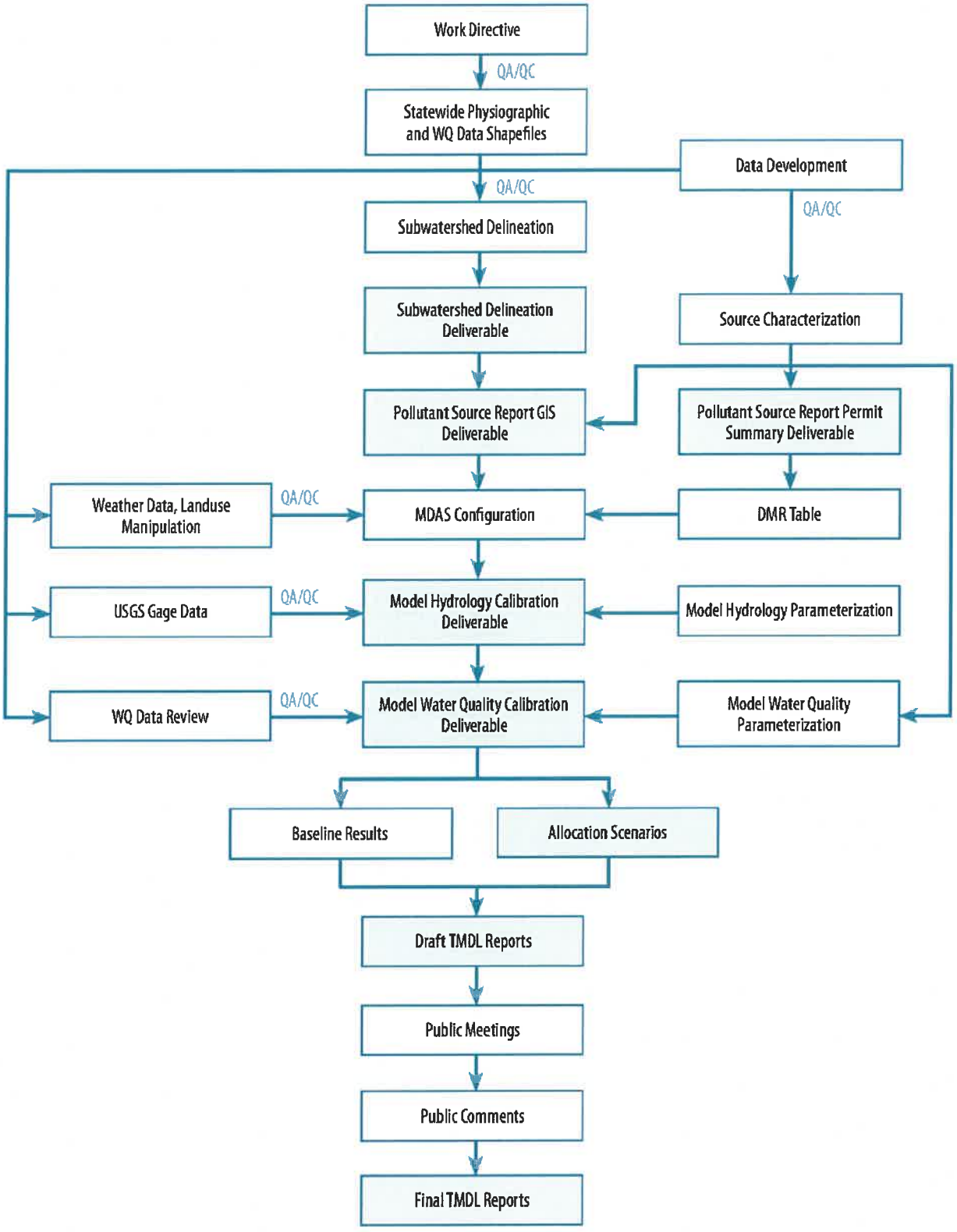


Figure II.G-1. TMDL Development Process Flowchart

REFERENCES

NLCD (National Land Cover Database). 2016. Multi-Resolution Land Characteristics (MRLC) Consortium. Electronic source: www.mrlc.gov, accessed June 27, 2019.

Jin, S., Yang, L., Danielson, P., Homer, C., Fry, J., and Xian, G. 2013. A comprehensive change detection method for updating the National Land Cover Database to circa 2011. Remote Sensing of Environment, 132: 159 – 175.

USEPA (U.S. Environmental Protection Agency). 2005c. *Technical Support Document for the Final Clean Air Interstate Rule – Air Quality Modeling.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. <http://www.epa.gov/cair/pdfs/finaltech02.pdf>. (Accessed in January 2006.)

USEPA. 2009. Loading Simulation Program in C++ (LSPC) Version 3.1, EPA Region 3 and 4 User's Manual.

Watts, K.C. Jr., M.E. Hinkle and W.R. Griffitts. 1994. *Isopleth Maps of Titanium, Aluminum and Associated Elements in Stream Sediments of West Virginia.* United States Department of the Interior, United States Geological Survey.

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 30 of whom have worked directly on West Virginia projects. The experience presented is particularly relevant to the West Virginia TMDL program because it demonstrates the continuity of support we offer to WVDEP. Key staff proposed for this project have long-standing working relationships with WVDEP. 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 20 years, Tetra Tech has developed more than 5,600 TMDLs throughout West Virginia, initially supporting USEPA to meet strict consent decree deadlines (and subsequently assisting WVDEP with its own program. Over 4,100 of these TMDLs have been developed directly supporting WVDEP over the past 16 years, and there are over 300 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

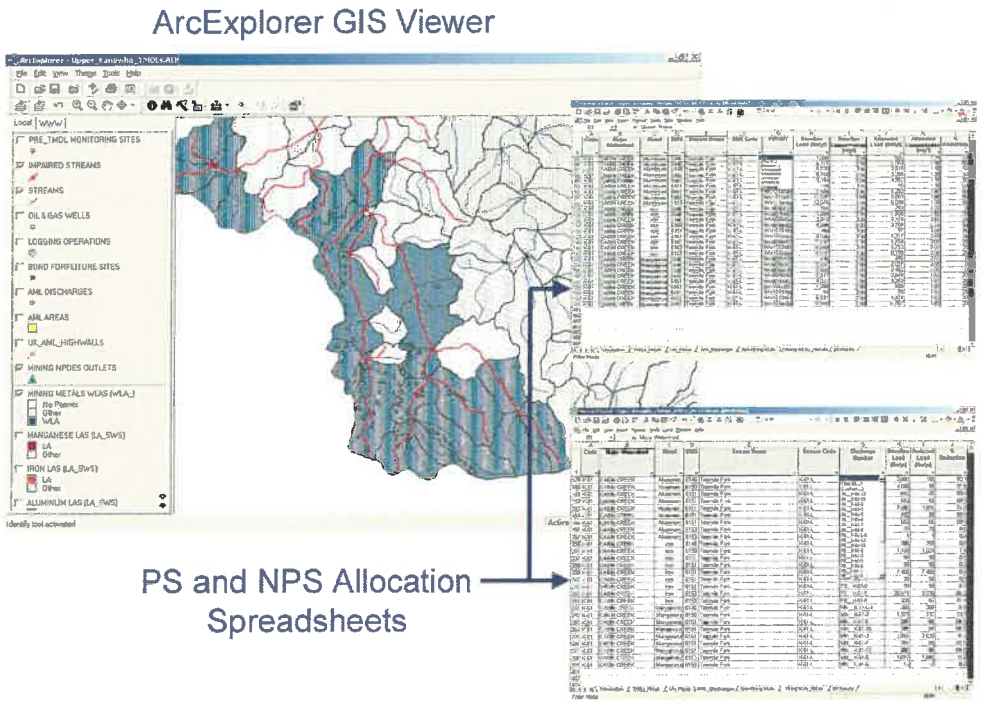
Year or Hydrologic Group	Status	Number of Streams	Total Recoverable Metals	Dissolved Metals	Acidity/pH	Bacteria	Biological	Sediment	Chloride/ selenium*
Developed for USEPA									
1998	USEPA Approved	9	3	0	0	5	0	4	
1999	USEPA Approved	6	4	4	0	0	0	4	
2000	USEPA Approved	7	12	0	0	0	0	1	
2001	USEPA Approved	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	Under Development	177	61	12	7	104			45
E4	Under Development	224	37	1	2	186			4
C4	Under Development	205	22	1	1	183			10
TOTAL		**2604**	**1909**	**247**	**253**	**1791**	**376**	**255**	**100**
TOTAL WEST VIRGINIA TMDLS		**3113**	**2975**	**329**	**514**	**1832**	**437**	**271**	**100**

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

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

Tetra Tech and WVDEP also have designed the "TMDL on CD" concept where all relevant TMDL information (TMDL reports and appendices, technical documentation, and supporting data) is included on a CD-ROM. To further improve the usability of the TMDLs, Tetra Tech and WVDEP developed a series of interactive tools to provide TMDL implementation guidance. These tools are designed to simplify and assist 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, and D3; and are currently under development for Hydrologic Groups E3, E4, and C4.



We have included the TMDL Project CDs for Elk River, Meadow River, and Tygart Valley River watersheds as examples in Appendix A.

Table III-2 summarizes the pollutant specific TMDLs for the each of these example projects.

Table III-2. West Virginia Pollutant-specific TMDLs for Example TMDLs Presented in Appendix A

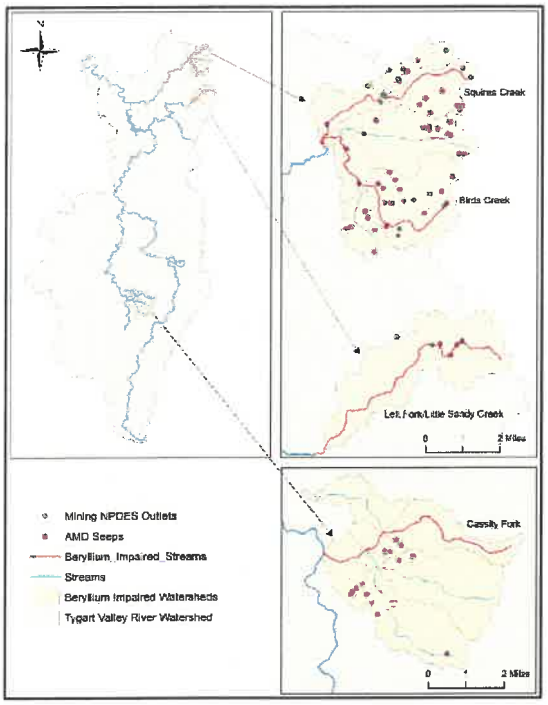
Watershed	Number of Streams	Dissolved Aluminum	Total Iron	pH	Biological	Bacteria	Sediment
Elk River Watershed	195	16	189	20	44	79	24
Meadow River Watershed	20	0	0	7	0	13	0
Tygart Valley River Watershed	174	33	232	50	0	117	0
TOTAL	**389**	**49**	**421**	**77**	**44**	**209**	**24**

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

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 will last approximately one year. The data will be used by the West Virginia Department of Environmental Protection to develop TMDLs for ionic toxicity, which contribute to the biological impairment. For the monitoring, Tetra Tech is following 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 identified sampling locations near the base of the seven EPA-identified tributaries. Tetra Tech is collecting monthly samples over a range of flow conditions. Samples are collected and sent to a laboratory for iron and aluminum (total and dissolved), minerals (Mg, Ca, K, NA, Mn), alkalinity, acidity, chloride, TSS, TDS, and bacteria. Tetra Tech is also collecting field readings for temperature, DO, pH, and specific conductivity. Staff are collecting field notes using WV DEP field forms. All monitoring data and field forms are provided monthly to EPA. In addition, Tetra Tech develops 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 will develop a final quality assurance report.

Ohio River Bacteria TMDL Development

Client: USEPA Region 5

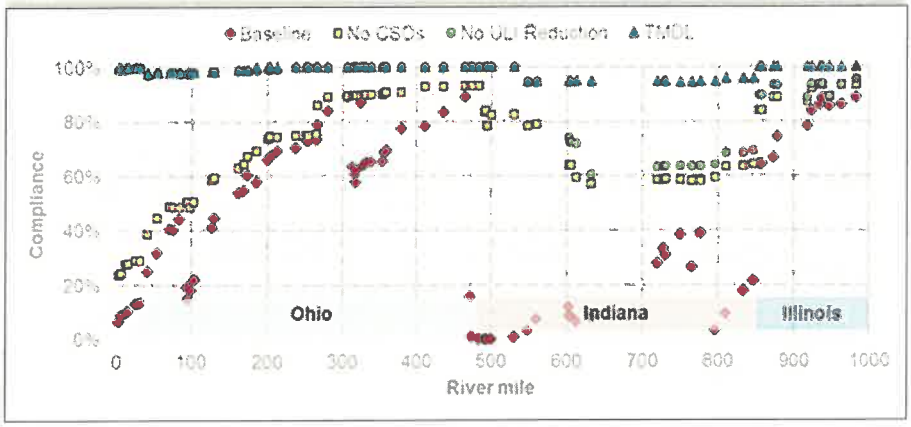
Tetra Tech is currently in the process of developing a bacteria TMDL for the Ohio River. The Ohio River Basin covers more than 200,000 square miles (5 percent of the contiguous United States) and the river itself spans more than 900 miles and traverses six states: Pennsylvania, West Virginia, Kentucky, Ohio, Indiana, and Illinois. Each of these states, as well as the Ohio River Valley Water Sanitation Commission (ORSANCO), has its own set of bacteria water quality standards and more than 600 miles of the river are impaired for contact recreation from high counts of bacteria. Sources of bacteria include runoff from urban and agricultural areas, discharges from more than 500 tributaries, and stormwater runoff and combined sewer overflows from 49 communities located along the river.

Tetra Tech initiated this complex and multi-jurisdictional project by working with EPA and each of the six states to develop a project Quality Assurance Project Plan (QAPP). The QAPP specifies a recommended modeling approach; a process for allocating to the different sources of bacteria; a means of translating between the E. coli and fecal coliform bacteria data; and the roles and responsibilities of the different entities involved in the project.

Tetra Tech has also compiled all of the available flow, bacteria, land use, and other types of data along the Ohio River. The water quality data have been assessed for key spatial, temporal, and flow trends. For example, load duration curves were created at each of the locations along the river where ORSANCO has historical bacteria data. Tetra Tech also created water and bacteria budgets for the entire river, identifying key sources between each of the river's 21 lock and dams. Through this analysis it became evident that additional bacteria data were needed for many Ohio River tributaries as most had fewer than 30 bacteria samples. Tetra Tech supported EPA and ORSANCO with the development of a sampling and analysis plan, and the additional data were collected during the 2011 and 2012 field seasons.

Tetra Tech has also worked closely with the states and local communities to collect information on the wastewater treatment plants, CSOs, SSOs, and stormwater systems that drain to the river. There are 49 combined sewer system communities in the watershed and Tetra Tech has retrieved data on these systems from Long Term Control Plans, historical monitoring data, and engineering studies. Estimates of CSO flow volumes and bacteria loads for all 49 communities for the period between 2005 and 2008 have been made as inputs to the model.

Tetra Tech compiled bacteria water quality data for the major tributaries and for many of the minor tributaries of the Ohio River from ORSANCO, USGS, and federal and state agencies. Approximately 130 of the major and minor tributaries to the Ohio River were sampled and statistically analyzed to fit a power regression relationship and to develop a time series input for bacteria. For monitored tributaries with insufficient sample sizes or a statistically insignificant regression, other statistical measures (e.g., medians) were calculated and used as inputs to the model.



Tetra Tech also used the Community Ohio River HEC-RAS Model to simulate bacteria conditions along the entire river. This model was developed by the National Oceanic and Atmospheric Administration (NOAA), the National Weather Service's Ohio River Forecast Center (OHRFC), and USACE LRD to facilitate hydrologic flood forecasting and stage management for navigation of the Ohio River by USACE. Tetra Tech worked closely with USACE-HEC to use the new water quality module of HEC-RAS. The model was calibrated and used to determine the tributary, CSO, and MS4 reductions that are needed to achieve water quality standards throughout the 900 miles of the river. A variety of scenarios have been run with the model, including a baseline scenario; a no CSOs scenario, and the TMDL scenario. Tetra Tech has processed the results of these scenarios in a variety of ways to provide insight into key sources and how compliance with water quality standards varies along the nearly 1000 miles of river. Model output is produced at 83 assessment locations on an hourly basis for the four year model run, thus providing nearly 3 million data points that need to be processed and distilled into charts and graphics that can be used to support decision making.

Work on this highly complex project has progressed in phases, with continuous communication among EPA, ORSANCO, the six main stem states, and Tetra Tech. Agencies involved in the effort include Illinois EPA; Indiana Department of Environmental Management; Kentucky Division of Water; NOAA; Ohio EPA; ORSANCO; Pennsylvania Department of Environmental Protection; USACE; USGS; West Virginia Department of Environmental Protection; EPA Regions 3, 4, and 5; and EPA's Office of Research and Development.

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.

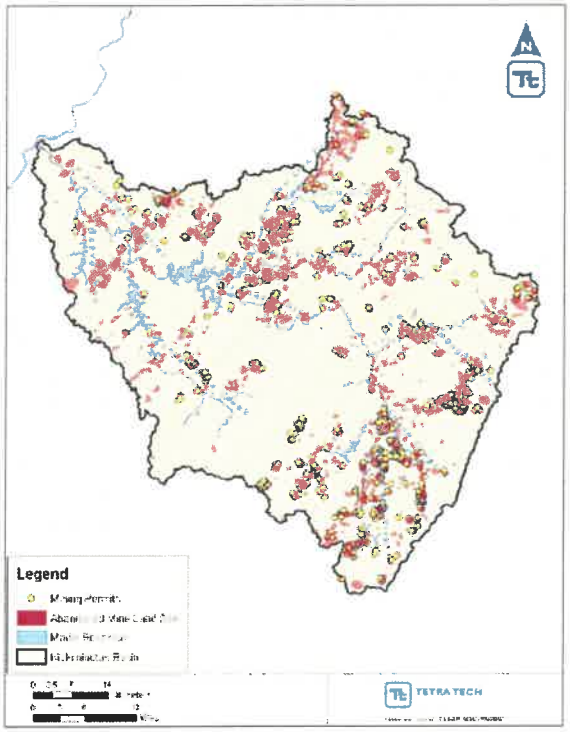


Figure 3-1. Mining and AML Sites in the Kiskiminetas River Watershed.

Minnesota Watershed Modeling

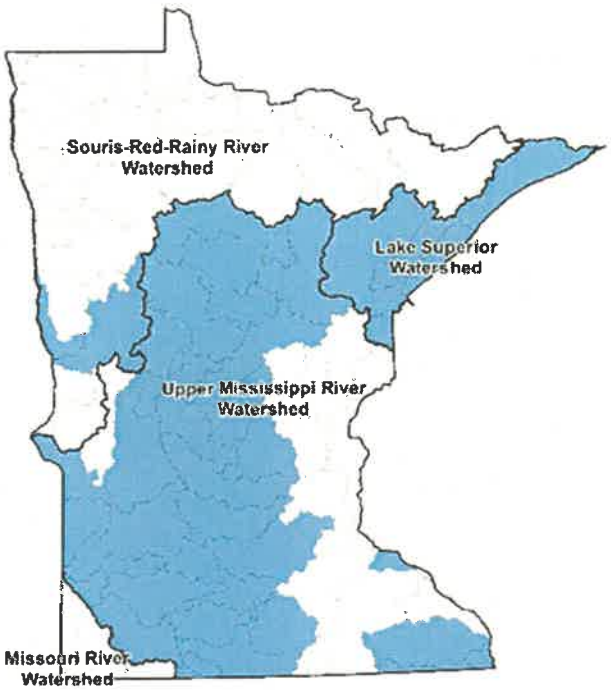
Client: Minnesota Pollution Control Agency (MPCA)

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.

Watershed Management in the Lake Tahoe Basin

Clients: University of California – Davis, Nevada Department of Environmental Protection, and California Lahontan Regional Water Quality Control Board

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

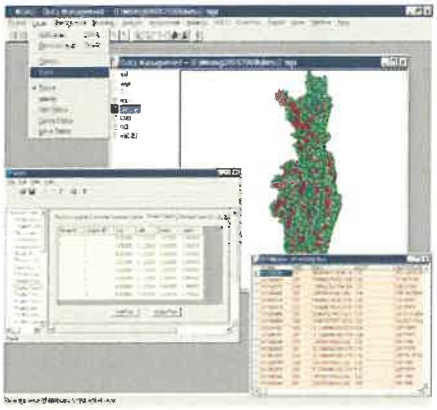
Tetra Tech used LSPC, a modeling framework developed by Tetra Tech for USEPA to support large, complex watershed modeling applications. Tetra Tech incorporated data from a number of concurrent research efforts, including a satellite-derived high-resolution impervious cover layer, site-specific stormwater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

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

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

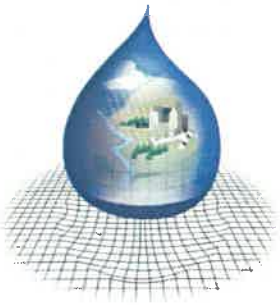
III.C. WATER QUALITY MODEL EXPERIENCE

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



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

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



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

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

Tetra Tech combines our practical modeling experience with our understanding of our clients' needs and growing trends to create innovative modeling tools and systems that are more user-friendly and accessible. In the mid-1990s Tetra Tech developed for USEPA the BASINS modeling system—a powerful GIS-based system integrating national environmental datasets, analytical tools, and USEPA-supported watershed and receiving water models. Since then, Tetra Tech has developed 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

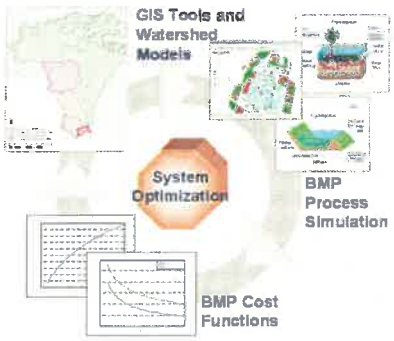


Figure III-1 illustrates the West Virginia basins where Tetra Tech has performed modeling to support TMDL development, resulting in watershed models that cover more than 92 percent of the state.

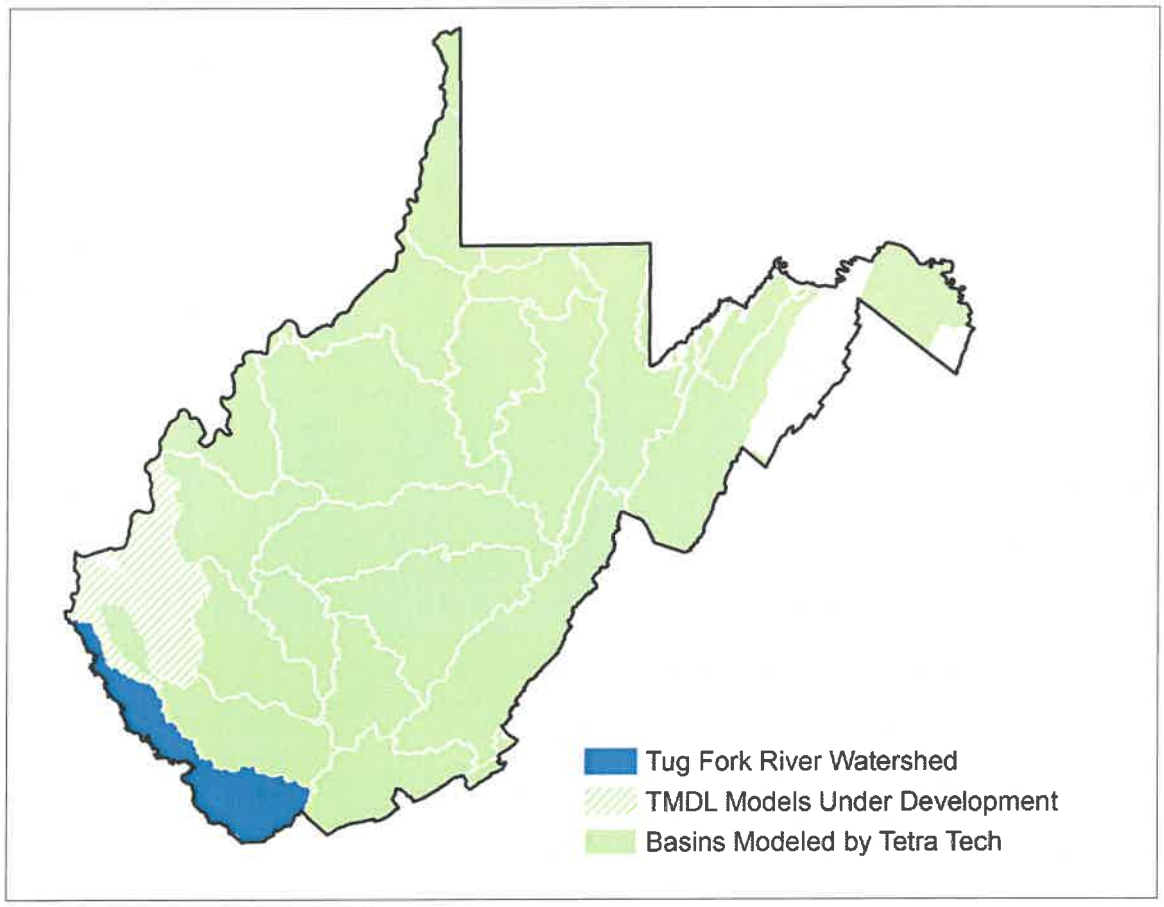


Figure III-1. West Virginia basins in which Tetra Tech has conducted watershed and water quality modeling

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

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

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. [redacted]

PROFESSIONAL AFFILIATIONS

American Society of Civil Engineers

American Society of Limnology and Oceanography

American Geophysical Union

OFFICE LOCATION

Fairfax, VA

YEARS OF EXPERIENCE

20

YEARS WITH FIRM

15.5

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

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

Planning Level Surveys for Flora, Fauna, and Noxious Weed Species, U.S. Army, Joint Systems Manufacturing Center – Lima, OH. 2016-2017. Compiled existing data and researched vegetative communities known from the ecoregion. Identified herb, shrub, and tree species in research plots across approximately 95 acres.

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.

Planning Level Surveys for Vegetation Classification, Bats, and Small Mammals, U.S. Army, Holston Ammunition Plant, TN. 2014-2015.

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

22

YEARS WITH FIRM

19

TETRA TECH

Ryan Birkemeier
Soils Specialist

EXPERIENCE SUMMARY

Mr. Birkemeier is an environmental scientist supporting water quality projects and geomorphic assessments. He has six years of experience that includes assessment of fluvial systems, water quality data analysis, geographic information systems, TMDL development, and disaster response.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Environmental Scientist, 2015-present

Applied Ecological Services, Ecological Restoration Crew Member, 2014-2015

RELEVANT EXPERIENCE

Cedar Lake Stream Assessment – Source Water Protection Planning, Iowa. U.S. Environmental Protection Agency. Spring 2018. Completed rapid stream assessment to identify areas of stream bank erosion and to locate stream features such as agricultural tile inlets and cattle access points. Summarized potential projects and problem areas for future source water improvement efforts by local municipalities.

Illinois TMDL development – multiple watersheds, Illinois. Illinois Environmental Protection Agency. 2018-present. Organizing and developing 319-compliant TMDL reports for eight watersheds. Assessing spatial and water quality data to identify impairments, watershed characteristics and pollutant sources.

Hurricane Irma FEMA Disaster Response, Florida. City of Tampa and Pinellas County, FL. 2017. Supervised and conducted office and field-based training of new employees for various tasks related to hurricane debris removal. Aided supervisors in management of several projects including new hire training, field supervision and contractor support.

Maryland National Capital Park and Planning Commission – WSSC Waterline Break Restoration, Maryland. Montgomery County, Maryland. 2017. Construction oversight for a stream restoration project designed to eliminate risk to a waterline utility. Summarized daily material quantities used onsite and provided a daily log of construction activities to the project supervisor.

Minnesota River Watershed TMDLs, Minnesota. Minnesota Pollution Control Agency. 2016-present. Processed spatial and water quality data in support of a large number of sediment and pathogen TMDLs in the main stem Minnesota River and tributaries. Responsible for map creation, data analysis, source assessment and technical writing.

Hurricane Matthew FEMA Disaster Response, Florida and South Carolina. Brevard County, FL and Beaufort County, SC. 2016. Aided in the initial training and coordination of new employees for various tasks related to hurricane debris removal. Supervised new employees at several debris drop-off locations and ensured correct use of debris collection software.

EDUCATION

M.S., Water Resources Science, Emphasis in Watershed Science and Management, University of Minnesota, 2015

B.S., Geological Sciences, Emphasis in Natural History, University of Minnesota Duluth, 2011

AREAS OF EXPERTISE

- Stream geomorphic assessment
- Assessment and restoration of fluvial systems
- Data processing and GIS analysis
- TMDL development and implementation planning
- FEMA Disaster Debris Removal Monitoring

TRAINING/CERTIFICATIONS

Minnesota Geologist In-Training (GIT), Cert. Number: [redacted]

Stream Restoration Certificate, University of Minnesota, Department of Civil Engineering, 2014

PROFESSIONAL AFFILIATIONS

Society for Ecological Restoration, Midwest-Great Lakes Chapter

Restoring Minnesota

Partnership for River Restoration and Science in the Upper Midwest

OFFICE LOCATION

St. Paul, MN

YEARS OF EXPERIENCE

7

YEARS WITH FIRM

4

TETRA TECH

Clint Boschen
Biological Analyst

EXPERIENCE SUMMARY

Mr. Boschen has more than 18 years of professional experience providing technical and program management support to federal, state, municipal, and local water resource agencies. He has extensive experience in the areas of stormwater management, water quality planning, stream and lake assessment, watershed/receiving water modeling studies, water quality and biological sampling, and wetland permitting. He is currently leading Tetra Tech's TMDL and watershed management support to the City of San Diego and other municipalities in the region. A key component of this work includes facilitating beneficial and effective relationships with other MS4 copermittees, USEPA, the San Diego Regional Board, Coastkeeper, and other water resource organizations. He is also currently supporting WQIP development for the Los Peñasquitos, San Dieguito, Mission Bay, and San Diego Bay watersheds. Recent efforts include the successful development of a third-party TMDL for Los Peñasquitos Lagoon, development of Comprehensive Load Reduction Plans (CLRPs) for several watersheds, leadership in the development of Bio-objectives for the State of California, San Diego Bay TMDL and bioaccumulation studies, and technical support leading to future adoption of site-specific objectives (SSOs) in the region. Mr. Boschen has experience with all aspects of the Clean Water Act, including wetland and stream protection programs (Sections 404 and 401), water quality standards, NPDES, and TMDLs. He has led or participated in complex TMDL and modeling projects to address biological impairments, metals, bacteria, toxic pollutants, sediment, dissolved oxygen, and nutrient enrichment. He also has extensive technical experience designing monitoring studies, developing and applying water quality and hydrologic models (LSPC, SWMM, GWLF, STEPL, etc.), performing water quality analyses, and providing technical training.

EMPLOYMENT HISTORY

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

Virginia Department of Environmental Quality, Environmental Engineer, 1997–2000

RELEVANT EXPERIENCE

Los Peñasquitos Lagoon Restoration Strategy, City of San Diego, CA. Managed the development of a long-term strategy for restoring the Los Peñasquitos Lagoon and update the WQIP. Conducted modeling analyses to help determine lagoon and watershed improvements that are needed to promote the restoration of saltmarsh areas and increase the lagoon's resiliency.

Sediment Load Reduction Quantification through Outfall Repair and Relocation for the Los Peñasquitos WMA, City of San Diego, CA. Managed the assessment of sediment load reduction benefits from various MS4 outfall repair and relocation options. Storm flows from existing outfalls within canyon areas have caused excessive erosion and sedimentation downstream. Conducted analysis using the USDA Bank Stability and Toe Erosion Model (BSTEM) to estimate scour potential and prioritize outfalls for management action.

EDUCATION

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

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

AREAS OF EXPERTISE

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

TRAINING/CERTIFICATIONS

None

PROFESSIONAL AFFILIATIONS

Water Environment Federation

OFFICE LOCATION

San Diego, CA

YEARS OF EXPERIENCE

22

YEARS WITH FIRM

19

TETRA TECH

Kimberly A. Brewer, A.I.C.P., Outreach Specialist

EXPERIENCE SUMMARY

Throughout her over 30 years of water resources planning and management experience, Ms. Brewer has coupled technical and policy analysis with stakeholder facilitation/mediation to develop innovative, cost-effective watershed management and green design strategies. She has pioneered approaches for low-impact design, reviewed more than 35 local governments' ordinances and codes to strengthen LID and green infrastructure, assisted in conducting numerous local watershed management studies and action plans, and co-designed the U.S. Environmental Protection Agency's Watershed Academy. She was a principal co-author of the *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (USEPA, 2008). Ms. Brewer was a co-investigator and co-author for the joint Electric Power Research Institute (EPRI)/WERF project on Case Studies for the New Water Infrastructure Management Paradigm to help communities develop sustainable approaches to water management. Prior to consulting, Ms. Brewer worked 11 years in local, state, and regional agencies, gaining extensive experience in water resource protection. Ms. Brewer has a track record of not only reaching consensus, but also of developing action plans that are implemented.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Associate Director/Principal Planner 1996–present

The Cadmus Group, Inc., Principal Planner, 1995–1996

Triangle J Council of Governments, Director of Resource Conservation, 1989–1995

Town of Chapel Hill Planning Department, Long-Range Planner, 1987–1989

North Carolina Division of Water Resources, 1985–1987

University of North Carolina Center for Urban and Regional Studies, Research Assistant, 1984–1985

Southeastern Office, The Nature Conservancy, Intern, 1982–1983

RELEVANT EXPERIENCE

Green Infrastructure Code Review for City of Alpharetta, GA. Conducted a detailed code, ordinance, stormwater design manual, Downtown Master Plan, and Comprehensive Plan review to identify barriers and recommend revisions to strengthen implementation of green infrastructure. Facilitated a City Staff Work Group and Community Stakeholder Group to develop a list of recommendations for revisions to City codes, policies, and practices, as well as recommended incentive programs. Also evaluating off-site stormwater mitigation options for the Downtown District undergoing redevelopment.

San Antonio LID and Natural Channel Design Permitting Track. For the San Antonio River Authority and the City of San Antonio, assisted in developing a voluntary, stand-alone LID/NCDP permitting track (LID/NCDP Use Pattern Ordinance) that includes incentives, LID performance standards, natural channel design performance standards, site design strategies, construction activity requirements, inspections and maintenance requirements, and multi-pronged incentives. Worked with a staff

EDUCATION

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

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

AREAS OF EXPERTISE

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

LICENSES/REGISTRATIONS

American Institute of Certified Planners

TRAINING/CERTIFICATIONS

American Institute of Certified Planners

PROFESSIONAL AFFILIATIONS

American Institute of Certified Planners

American Planning Association

OFFICE LOCATION

Research Triangle Park, NC

YEARS OF EXPERIENCE

34

YEARS WITH FIRM

23

TETRA TECH

Jonathan Butcher, PhD, PH
Model Developer

EXPERIENCE SUMMARY

Dr. Butcher has 32 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. [redacted] 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

33

YEARS WITHIN FIRM

22

TETRA TECH

J. Trevor Clements
Watershed Analyst

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

36

YEARS WITH FIRM

23

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 30 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

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

39

YEARS WITH FIRM

26

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.

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, and C4 representing these river watersheds: Upper Guyandotte, Lower Guyandotte, Hughes, Big Sandy, Twelvepole, and Lower Ohio. 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

8.5

YEARS WITH FIRM

2.5

TETRA TECH

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

EXPERIENCE SUMMARY

Mr. Faizullabhoy is a water resources/environmental engineer with more than 17 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 present.) 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. [redacted]

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

20

YEARS WITH FIRM

19

TETRA TECH

Mark Fernandez
Biological Analyst

EXPERIENCE SUMMARY

Mr. Fernandez is an environmental data scientist for Tetra Tech. He has seven years of experience in water resources and water quality data. He has worked on surface water hydrology, ecosystem field assessments; GIS land cover analysis; and water quality empirical models. He employs hierarchical, non-parametric, kriging, ordination, Bayesian, Monte Carlo, and machine learning methods to identify stressor–response relationships, support threshold development, and corroborate mechanistic water quality model results. He focuses on data visualization methods to summarize findings and convey those insights to all stakeholders. He has studied at some length the effects of urbanization on stream geomorphology and biota, and has co-authored two publications related to lotic systems.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Data Scientist, 2017–present

AECOM, Environmental Scientist, 2013–2016

RELEVANT EXPERIENCE

Nutrient Threshold Development for Long Island Sound, US EPA. 2017–2018. Developed a stressor–response hierarchical regression models for the Environmental Protection Agency and state partners to support the creation of nitrogen thresholds for individual embayments within the Long Island Sound in New England. Modeled the relationships between light attenuation and chlorophyll, dissolved oxygen and chlorophyll, and chlorophyll and nitrogen. Assessed model fit and variable selection. Performed spatial kriging analysis of nitrogen data.

Mercury TMDL Development for Willamette Basin (Oregon), ODEQ. 2017–present. Converted an existing food web Monte Carlo model from commercial software to R code for the Oregon Department of Environmental Quality. The food web model estimates mercury bioaccumulation in invertebrates and fish in support of an existing TMDL. Assisted in the update of the food web model. Compiled new data into a database. Updated the food web Monte Carlo model parameters based on new data. Will propose revised surface water mercury thresholds based on updated model results.

Previous Employment Experience

Technical Support for TMDL Permit Compliance, Georgia Department of Transportation. 2013–2016. Provided technical support to help achieve TMDL compliance. Compiled and organized data from multiple organizations; developed, populated, and maintained an Access database with custom queries; identified watersheds of concern via GIS analysis of outfalls within TMDL watersheds; exported watershed and district-scale maps; and prepared annual reports

Literature Review for Georgia Stormwater Management Manual. Atlanta Regional Commission. 2015. Provided technical support to develop the 2016 Georgia Stormwater Management Manual. Reviewed multiple state and metropolitan stormwater manuals across the country. Documented recurring themes, emerging trends, existing federal and state regulations, useful illustrations, audience focus, guidelines for local stormwater ordinances, and

EDUCATION

M.S., Statistics, North Carolina State University, 2017

M.S., Ecological Engineering, North Carolina State University, 2013

B.S., Civil Engineering, North Carolina State University, 2011

AREAS OF EXPERTISE

- Water quality analysis
- Empirical modeling
- Hierarchical modeling
- Bayesian analysis
- Machine learning
- Ordination analysis
- Data visualization
- TMDL compliance
- Technical writing
- Ecological field assessments
- Data management
- GIS analysis
- Surface water hydrology

TRAINING/CERTIFICATIONS

Surface Water Identification Training and Certification (NC)

PROFESSIONAL AFFILIATIONS

American Statistical Association

OFFICE LOCATION

Research Triangle Park, NC

YEARS OF EXPERIENCE

8

YEARS WITH FIRM

2

TETRA TECH

Jennifer Flippin
Technical Writer

EXPERIENCE SUMMARY

Ms. Flippin is a Senior Environmental Toxicologist for Tetra Tech. She has fourteen years of experience in toxicology, aquatic biology, and environmental science fields, and provides technical assistance and management for numerous, diverse projects on the local, state, and federal levels. She has extensive experience relating to water quality standards and criteria, ecological and human health toxicology, field work, and technical writing.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Senior Environmental Toxicologist, 2009–present

United States Environmental Protection Agency/ North Carolina State University, Graduate Research Assistant, Endocrine Disruption and Mixture Modeling Laboratory, US EPA, National Health and Environmental Effects Research Laboratories, Experimental Toxicology Division, Pharmacokinetics Branch, Research Triangle Park, NC, 2005-2007

RELEVANT EXPERIENCE

San Juan River Human Health Risk Assessment. Utah Department of Environmental Quality. 2018. Provided human health screening assessment of multiple contaminants in sediments, fish tissue, and water samples collected from the San Juan River following the mine discharge to the Animas River.

Technical Support Services. Agency for Toxic Substances and Disease Registry (ATSDR). 2012-Present. Currently comanaging a contract with ATSDR to provide ad-hoc scientific expertise on a variety of public health assessment issues, including chemical toxicity, public health, environmental risk assessment and education and outreach activities as needed. Projects to date have involved being a subject matter expert in public health assessments methodology, review of minimal risk levels and toxicity data used by ATSDR, and reviewing EPA databases (including TRI and IRIS) for potential uses in public health evaluation and outreach.

EDUCATION

M.S., Environmental and Molecular Toxicology, North Carolina State University, 2007

B.S., Biology, West Virginia University, 2005

AREAS OF EXPERTISE

- Environmental toxicology
- Human health toxicology
- Water quality criteria
- Aquatic biology

PROFESSIONAL AFFILIATIONS

Society of Environmental Toxicology and Chemistry, Chesapeake and Potomac Regional Chapter

Association of Mid Atlantic Aquatic Biologists

OFFICE LOCATION

Owings Mills, MD

YEARS OF EXPERIENCE

15

YEARS WITH FIRM

10

Farmington Bay Assessment Methodology to Evaluate Harmful Algal Blooms, US EPA, Region 8. 2017-2018. Currently developing 303(d) listing methodology for waters of the Great Salt Lake that experience harmful algal blooms, especially those dominated by *Nodularia.*

Health and Ecological Effects Support Document, US EPA, Region 8. 2016-2017. Served as project manager and primary technical support for a literature and data review of the cyanobacterial toxin nodularin to determine the feasibility of developing ambient water quality criteria based on currently available toxicity studies. Developed a health and ecological effects document to describe toxicity (humans, dogs, other mammals, birds, fish, and invertebrates), environmental fate/transport, and carcinogenicity. Provided an in-depth discussion of toxicokinetics, animal toxicity studies, neurotoxicity, developmental and reproductive toxicity, immunetoxicity, and hematotoxicity. Identified toxicological similarities and differences between nodularin and microcystins to evaluate whether microcystin standards can be reliably used if insufficient data are available describing nodularin toxicity.

Review and Compilation of ATSDR Risk Assessment Comparison Values, Agency for Toxic Substances and Disease Registry. 2012-2017. Reviewed and compiled Comparison Values (CVs) for over 520 chemicals routinely evaluated in risk assessments for soil, air, and drinking water. Gathered toxicity data from various sources including ATSDR ToxProfiles, EPA IRIS, IARC, and state guidance documents. Revised calculations and

TETRA TECH

Jeroen Gerritsen, PhD
Technical Expert

EXPERIENCE SUMMARY

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

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

37

YEARS WITH FIRM

25

TETRA TECH

Eugenia Hart
Technical Writer

EXPERIENCE SUMMARY

Ms. Hart is an environmental scientist with 19 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

19

YEARS WITH FIRM

16

TETRA TECH

Kevin Kratt
Watershed Analyst

EXPERIENCE SUMMARY

Kevin Kratt has been with Tetra Tech for more than 20 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 20-year 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

24

YEARS WITH FIRM

24

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 16 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 the past 11 years, he has provided leadership and energy to produce highly technical and innovative solutions that have helped WVDEP's TMDL Program become a national leader in TMDL development. 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

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

20

YEARS WITH FIRM

19

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

22

YEARS WITH FIRM

16

RELEVANT EXPERIENCE

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

TETRA TECH

Dave Montali
Technical Expert

EXPERIENCE SUMMARY

Mr. Montali has more than 35 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

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

38

YEARS WITH FIRM

3

TETRA TECH

John O'Donnell
Quality Assurance Manager

EXPERIENCE SUMMARY

Mr. O'Donnell is a chemist by training with more than 20 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.

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

36

YEARS WITH FIRM

16

TETRA TECH

Jennifer Olson, PG
Soils Specialist

EXPERIENCE SUMMARY

Ms. Olson is a project manager and water resource scientist with broad experience in watershed and water quality planning and management. She has extensive experience developing water quality and Total Maximum Daily Load (TMDL) studies and has authored numerous watershed-based plans that are in compliance with EPA's nine elements for 319 plans. She has also led many projects which focus on identifying targeted implementation activities and identifying opportunities for restoration activities or best management practice placement including use of the Agricultural Conservation Planning Framework tool. She also manages complex watershed and water quality modeling projects that use various tools including Hydrologic Simulation Program-FORTRAN, LSPC, SWMM, SUSTAIN, Soil and Water Assessment Tool, Qual2K, and Bathtub. She has additional experience stormwater management and green infrastructure practices, surface and groundwater interactions, designing and implementing comprehensive monitoring programs, private sector coordination, meeting and stakeholder facilitation, and public education and outreach.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Project Manager and Water Resource Scientist, 2010–present

Emmons & Olivier Resources, Inc., Hydrologist, 1997–2010

RELEVANT EXPERIENCE

Septic System Risk Assessment, Washington County (2018 – present). Developing a risk assessment model for over 17,000 septic systems that will inform management actions related to groundwater and surface water protection as well as regulatory and voluntary actions. The risk assessment makes use of numerous local spatial datasets, water quality monitoring data, and a detailed database describing exiting septic systems in the county. Responsibilities include client and project management, development of the technical approach, stakeholder meeting facilitation, and technical oversight.

Basin-Wide Nutrient Trading Program, DuPage River Salt Creek Workgroup (2017 – present). Supporting development of a nutrient trading program that integrates both point to point and point to non-point trading elements. Project entails evaluation of point source optimization opportunities, determining baseline and potential trading boundaries, evaluating habitat project eligibility, and development of trading program framework. Supporting project components related to watershed water quality, implementation options, and client management.

Minnesota Sediment Reduction Strategy, Minnesota Pollution Control Agency (2017 – present). Leading development of technical resources to support an update to the Sediment Reduction Strategy focused on the Minnesota River. Project entails a comprehensive review of past studies and available literature, facilitation of a Technical Advisory Team (TAT) that includes numerous experts and academia, and simulation of multiple best

EDUCATION

M.S., Water Resources Science, University of Minnesota, 2005

B.S., Hydrogeology and Environmental Geology, University of Minnesota,1997

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

Licensed Professional Geologist (P.G.), Minnesota, [redacted]

TRAINING/CERTIFICATIONS

Project Management Training, 2015

Systematic Development of Informed Consent. Institute for Participatory Management and Planning, 2005

Better Site Design Techniques Workshop, Center for Watershed Protection, 2003

P8 Urban Catchment Model Training, Instructor John Panuska, WI DNR, 2002

OFFICE LOCATION

St. Paul, MN

YEARS OF EXPERIENCE

22

YEARS WITH FIRM

9

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

24

YEARS WITH FIRM

23

TETRA TECH

Michael Paul, Ph.D.
Biological Analyst

EXPERIENCE SUMMARY

Dr. Paul is an aquatic ecosystem ecologist/biogeochemist with over 20 years of experience in the research and management of aquatic ecosystems. His work, which has included teaching, research, and public policy, has focused on the ecology of freshwater ecosystems, including more than 12 years' experience in water quality standards development across the nation. He has provided technical support in assessment and criteria development for more than 29 states, tribes, and federal government agencies, has developed instructional materials for and led instructional workshops on assessment, analysis, and criteria development across the nation, and has co-authored EPA guidance on the statistical analysis of bioassessment data, the design, sampling and analysis of bioassessment for large rivers, and the application of stressor-response analysis for nutrient criteria development. Dr. Paul has also been involved in several EPA Office of Research and Development ecological risk assessment projects involving causal analysis, multiple stressor analysis, and the effects of climate change on state water quality assessment and criteria programs. He currently co-manages the national nutrient criteria support center for EPA Office of Science and Technology and is Deputy Contract Manager of a 5-year, $60 million Ecological Risk Support contract in the Office of Research and Development. Dr. Paul has authored more than 15 peer reviewed scientific papers, proceedings, book chapters, and more than 31 technical reports.

EMPLOYMENT HISTORY

Tetra Tech, Inc., Director and Senior Scientist, 2001–present

Howard University, Assistant Professor, 2003–2005

University of Georgia, Post-doctoral Research Scientist, 1999–2001

RELEVANT EXPERIENCE

Hodges Reservoir Nutrient Loading Conceptual model. City of San Diego. 1/17 to present. Developed a conceptual model of the sources, pathways, and fates of nutrient loading to Hodges Reservoir in San Diego, CA. Led research into existing watershed geology, morphology, land use/land cover, and nutrient loading information. Conducted several presentations with a technical advisory group and made recommendations on nutrient pathways.

Application of Technical Approach for Establishing Nitrogen Thresholds and Allowable Loads for Three Long Island Sound Watershed Groupings: Embayments, Large Riverine Systems, and Western LIS Point Source Discharges to Open Water. USEPA, Office of Wetland, Oceans, and Watershed (OWOW) and Region 1. 9/16-present. Project manager and technical lead providing technical support to EPA Region 1 for development of nutrient thresholds to protect aquatic life uses in LIS. Provides management of multiple activities involving most areas of the PWS: assessment (e.g., nutrient and biological assessment), data management (e.g., development of water quality, nutrient loading, and biological response databases), literature review (e.g., to support endpoint development), and analysis and modeling.

EDUCATION

Ph.D. Ecology, University of Georgia, 1999

M.Sc. Zoology, University of Georgia, 1994

B.A., Biology, Colgate University, 1991

AREAS OF EXPERTISE

- Project/Contract Management
- Nutrient Pollution Assessment and Management
- Clean Water Act Support
- Water Quality Standards and Criteria Development
- Watershed Monitoring and Assessment
- Bioassessment and Indicator Development
- Study Design and Data Analysis
- Causal Analysis
- Aquatic Ecology/ Biogeochemistry

PROFESSIONAL AFFILIATIONS

Society for Freshwater Sciences

Ecological Society of America

American Institute for Biological Sciences

OFFICE LOCATION

Research Triangle Park, NC

YEARS OF EXPERIENCE

24

YEARS WITH FIRM

18

TETRA TECH

Teresa Rafi
Technical Writer

EXPERIENCE SUMMARY

Ms. Rafi has more than 20 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

23

YEARS WITH FIRM

19

TETRA TECH

Mark Sievers
Watershed Analyst

EXPERIENCE SUMMARY

Mr. Sievers has 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

20

YEARS WITH FIRM

18

TETRA TECH

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, [redacted] Virginia [redacted]; North Carolina [redacted] West Virginia [redacted]

TRAINING/CERTIFICATIONS

Certified Professional in Erosion and Sedimentation Control (CPESC) [redacted]

Certified Professional in Storm Water Quality (CPSWQ) [redacted]

LEED-Accredited Professional

OFFICE LOCATION

Marion, NC

YEARS OF EXPERIENCE

23

YEARS WITH FIRM

9

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 [redacted] (*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

31

YEARS WITH FIRM

28

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 – 2018

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

31

YEARS WITHIN FIRM

20

TETRA TECH

Peter von Loewe
Senior Water Resource Engineer

EXPERIENCE SUMMARY

Mr. von Loewe has more than 18 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

19

YEARS WITH FIRM

17

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.

TETRA TECH

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

EXPERIENCE SUMMARY

Dr. Tan Zi is an environmental engineering professional with 9 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-present. 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-present. 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-present. 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 [redacted]

OFFICE LOCATION

Fairfax, VA

YEARS OF EXPERIENCE

10

YEARS WITH FIRM

5

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

19

YEARS WITH FIRM

14