187526

City Agreement No._____

Pursuant to City Ordinance No._____

Multi Funded Research Agreement 04653
Titled,
"Use of Flushing as a Corrective Action Under the Revised Total Coliform Rule"

This Multi Funded Research Agreement (hereafter "MFRA") is entered into on _____, 20__, (the "Effective Date") by and among the Water Research Foundation ("WRF"), a Delaware non-profit corporation whose principal place of business is located at 6666 W. Quincy Ave., Denver, Colorado 80235, the organization(s) executing this MFRA and Portland Water Bureau, Seattle Public Utilities ("Co-funders"), and Confluence Engineering Group LLC ("Sub-recipient") whose principal place of business is located at 517 Northeast 92nd Street, Seattle, Washington 98115.

WRF and the Co-funders have selected said Sub-recipient to receive a research and development grant as more specifically detailed in this MFRA. The parties mutually agree as follows:

I. **DEFINITIONS.** The following defined terms shall apply in this MFRA:

A. "Co-funder Funds" is that portion of the Project Funds which each Co-funder has agreed to provide to fund the Project under this MFRA, as detailed in Exhibit C.

B. "Cost Share" the portion of allowable costs that the sub-recipient, subcontractor, or third-party participant funds toward completing the WRF project. Cost share includes any non-federal cash and non-cash project funding from the sub-recipient and subcontractors, and non-federal cash funding from participants. All Cost Share must meet Code of Federal Regulations (CFR) requirements in 2 CFR Part 200.306.

C. "Foundation Award" is that portion of the Project Funds which WRF has agreed to provide to fund the Project under this MFRA, as detailed in Exhibit C.

D. "IP" is all rights to copyrights, trademarks, service marks, patents, trade secrets, know how, and confidential information, including the right to enforce, divest, license, seek registration, prosecute infringers, and commercially or otherwise exploit such rights.

E. "PAC" is the Project Advisory Committee that consists of independent volunteers selected by WRF and Co-funders to provide technical review, assistance, and/or expertise related to the Project. The number of volunteers to serve on the PAC will be determined by WRF.

F. "Principal Investigator" is the Sub-recipient employee identified in Exhibit B, who is primarily responsible for ensuring that all terms and conditions of this MFRA are met and to whom WRF shall give all notices intended for the Sub-recipient.

G. "Project" is the work to be completed by the Sub-recipient, as described more specifically in the Project Proposal attached hereto as Exhibit A.

H. "Project Funds" is the aggregate maximum amount of cash award which WRF and the Co-funders have collectively agreed to provide to Sub-recipient to fund its performance of the Project pursuant to this MFRA.

I. "Project Proposal" is the final and written description of the project to be undertaken by Sub-recipient for which the Project Funds is granted and performance is monitored pursuant to this MFRA.

J. "Proposal Guidelines" is WRF's written guidelines, currently maintained at http://www.waterrf.org/funding/ProposalDocuments/TailoredCollaborationProposalGuidelines.pdf which the procedures, criteria and requirements for eligibility, proposal, performance, administration, reporting, and other matters governing the proposal of and performance of a Project are set forth. The Proposal Guidelines were provided to the Sub-recipient prior to its submission of a Project Proposal, and its terms and requirements are incorporated in this MFRA by this reference. The terms "Deliverable", "Periodic Report", "Draft Report", and "Final Report" appearing in this MFRA shall have the definitions, and be governed by the requirements applicable thereto, as set forth in the Proposal Guidelines.

K. "Reports" are the Periodic Reports, Draft Report, and/or Final Report, collectively.

L. "Subcontractor" is any individual or entity identified by Sub-recipient in the Project Proposal as assisting in the performance of the Project under this MFRA.

M. "Work Product" is copyrightable works of authorship created by or on behalf of the Sub-recipient or its Subcontractors in the course of performing under this MFRA or the Project, including, without limitation, the Scope of Work, all Deliverables, Periodic Reports, Draft Reports, the Final Report, all interim drafts of the foregoing, and any computer software and related documentation developed under the Project.

II. GENERAL OBLIGATIONS OF THE PARTIES

A. The Sub-recipient.

1. The Sub-recipient agrees to complete the research, prepare written Reports, deliver the Deliverables to WRF, and perform such other functions, all in accordance with the schedules and other requirements set forth in the Exhibits and this MFRA. The Sub-recipient shall itself, and shall require all of its Subcontractors to, perform the Project and all other activities related thereto in full compliance with all laws, regulations, ordinances, and other requirements governing them.

2. Sub-recipient may not use Project Funds received under this MFRA as a match or cost-sharing vehicle to secure U.S. Federal monies or money from any other sources, unless otherwise expressly stated and fully disclosed in the Project Proposal. The Sub-recipient may not use any portion of the Project Funds for any purpose other than as detailed in the Project Proposal, and as is necessary to perform the Project.

3. All disbursements of Project Funds will be paid directly to Sub-recipient. Sub-recipient shall remain solely responsible for payment of its Subcontractors, and for procurement of all equipment, materials, and other resources necessary for performance of the Project hereunder.

B. The Co-funders. The Co-funders agree to pay their respective Co-funder funds in accordance with the terms and timelines in this MFRA. The Co-funders shall deliver their full Co-funder funding; by company check made payable to WRF, by no later than the Effective Date.

C. WRF. Provided that WRF has received the full Co-funder funding from each of the Co-funders by no later than the Effective Date, WRF will disburse the Project Funds to the Sub-recipient as detailed in this MFRA

and Exhibit C. WRF's disbursement of the Project Funds shall be subject to WRF first having received full corresponding payment from all of the Co-funders, and may further be subject to WRF's receipt of its own funding from appropriate sources. In no event shall WRF be required to disburse the Co-funder funding if WRF itself has not received same from Co-funders.

III. DISBURSEMENT OF PROJECT FUNDS

A. Advance Payment. All payments of the Project Funds will be disbursed by WRF directly to the Sub-recipient. Each disbursement shall be deemed to be made by WRF and the Co-funders in proportion to their relative payment to the Project Funds. The amount of Project Funds was determined on the basis of the budget submitted by the Sub-recipient, and set forth in Exhibit C. The Project Funds is a "not to exceed" amount and no payments in excess of such amount are authorized or required. Subject to WRF's prior receipt of the full amount of the Co-funder funding, following the Effective Date WRF will advance to the Sub-recipient 10% of the Project Funds. All subsequent disbursements of the Project Funds shall be governed by the requirements described in Section III.B below and in Exhibit C.

B. Invoicing and Payments.

1. Beginning three (3) months after the Effective Date, and every three (3) months thereafter during the term of this MFRA, Sub-recipient shall submit to WRF a detailed invoice itemizing the expenses actually incurred in the three (3) months prior to the invoice date by the Sub-recipient in the performance of the Project, and identifying all Cost Share and third party in-kind contributions as well as the contributing parties. The invoice shall be sent to the Project Coordinator identified in Exhibit B.

2. Each invoice should be displayed according to the budget line items in Exhibit A. All invoices must be submitted using the form attached in Exhibit D, must be on the Sub-recipient's letterhead, and must be sent to WRF's Project Coordinator identified in Exhibit B. Only out of pocket costs and expenses actually incurred by the Sub-recipient may be invoiced under this MFRA.

3. WRF will disburse Project Funds conditioned upon the Sub-recipient timely submitting Reports. No portion of the Project Funds will be disbursed by WRF unless and until WRF receives and accepts each corresponding invoice and Report. If the invoices and Reports are accepted, the Sub-recipient will be paid as follows:

   (a) The ten percent (10%) advance payment must be shown on all invoices, including the final invoice, as an advance payment received. Subject to the hold back provision below, invoices will be paid to the extent actual costs incurred exceed the advance payment.

   (b) Regardless of the actual amounts invoiced, WRF will at all times during this MFRA hold back twenty percent (20%) of the Project Funds, and will only disburse same as follows: Ten percent (10%) of the Project Funds will be disbursed to the Sub-recipient when WRF receives and accepts the Draft Report. The remaining held back ten percent (10%) of the Project Funds will be disbursed to the Sub-recipient after the Sub-recipient has completely and adequately responded to editor queries on the Final Report, has made all revisions reasonably requested by WRF to finalize the Final Report, submitted a final invoice, and Exhibit E – Assignment of Copyright (if applicable).

   (c) No conditions, notations, acknowledgements, comments, or terms other than the items required to be included and itemized on the Sub-recipient's invoice shall be binding on WRF.

(d) WRF may deduct amounts or withhold payments invoiced by the Sub-recipient if the Sub-recipient fails to comply with any WRF standard and/or Federal Uniform Administrative Requirements of the Sub-recipient's cognitive agency.

IV. COMPLIANCE MONITORING

A. Financial Management System. The Sub-recipient shall maintain an accounting system and accurate and complete accounting records that, at a minimum but without limitation, allow for the identification, tracking, and verification of costs, expenses, Cost Share, in-kind contributions, invoiced items, and funding received, all in a manner that is segregated and allocable solely to performance of the Project. All costs incurred must be supported by original receipts and be made available to WRF upon request.

B. U.S. Federal Administrative, Cost and Audit Requirements. The Sub-recipient represents and warrants that the budget disclosures included in the Project Proposal and presented to WRF were prepared by Sub-recipient in full compliance with Water Research Foundation Guidelines and all relevant U.S. laws, regulations and agreement terms and conditions related to U.S. Federal Financial Assistance including, but not limited to, 2 CFR 200 [U.S. Code of Federal Regulations Title 2 (Grants and Agreements) Part 200: Uniform Administrative Requirements, Cost Principles and Audit Requirements for Federal Awards (a/k/a/ Uniform Grants Guidance or UGG). Cost Principles specifically applicable for awards to for-profit organizations are set forth in the Federal Acquisition Regulations System (FARS, at 48 CFR 31.2) to determine allowable costs under WRF project funding agreements.Sub-recipient shall throughout the Project, and in the preparation of every invoice, report, and maintenance of its accounting system, remain in compliance with the above regulations. It shall be Sub-recipient's obligation to determine and comply with its governing cost principles.

C. Indirect Costs and Allocation of Costs:

1. If the Sub-recipient proposes to invoice for indirect costs, substantiation of those charges must be in compliance with WRF's "Tailored Collaboration Proposal Guidelines," which include compliance with the applicable cost principles referenced in Section IV.B.

D. Record Retention. Sub-recipient shall retain all records pertinent to this MFRA and the Project for at least three (3) years from the termination of this MFRA.

E. Audit and Monitoring.

1. The Sub-recipient's use of the Project Funds under this MFRA are to be in compliance with 2 CFR 200, including Subpart F, Audit Requirements, and may be audited by WRF or its designee. Furthermore, WRF shall have the right to itself or through a designee visit the Sub-recipient premises to observe, review, and monitor the Sub-recipient's performance of the Project, as well as its application and use of the Project Funds. Accordingly, following a two (2) business day prior notice from WRF, the Sub-recipient shall provide WRF and its designee access to its premises, technical staff, supervisors, knowledgeable personnel, computer systems and databases, assistance, original documents, including those required to be maintained under this MFRA, and any information related to the Sub-recipient's use of the Project Funds and performance under this MFRA, to enable WRF's audit and monitoring. WRF's audit rights shall survive termination of this MFRA by three (3) years.

2. WRF will keep any of Sub-recipient's proprietary financial, technical and/or scientific proposal information reviewed under this Section in confidence provided that such material is appropriately marked as "Confidential," was not already generally known to the public, is not required to be disclosed as a result of a legal proceeding, or applicable legal requirement, and was not already known to WRF or others without a confidentiality obligation.

3. Any deficiencies or non-compliance in Sub-recipient's systems, procedures, record keeping, finances, and performance of other obligations under this MFRA discovered in the audit, review or monitoring process, or discovered otherwise, may, at WRF's option, require Sub-recipient to take corrective action that has been detailed by the Sub-recipient and approved by WRF for the Sub-recipient to remedy the deficiency or noncompliance, or may result in WRF exercising its termination rights under Section VII below.

4. If WRF approves of the Sub-recipient's proposed corrective action plan, in connection with such approval it may require the Sub-recipient to submit additional periodic written verification that the corrective action plan has been implemented and continues to correct the targeted deficiencies and noncompliance. If the approved corrective action fails to correct the deficiencies within the time set by WRF in its sole discretion, WRF may exercise its termination rights under Section VII.

5. Nothing herein obligates WRF to accept or approve a corrective action or to forbear from exercising its right to terminate this MFRA. WRF's right to termination shall be in addition to all other rights and remedies available to it at law or in equity.

V. PROCUREMENT STANDARDS

A. Procurement Standards. It is an express requirement under the Proposal Guidelines and this MFRA that the Sub-recipient remain in compliance with the U.S. Federal standards for procurement under 2 CFR 200 Subpart D, Procurement Standards. These standards govern procedures for procurement of supplies, equipment, and other services for which cost is incurred in whole or in part under this MFRA. These standards include but are not limited to the following:

1. Sub-recipient procurement policies must adhere to the minimum standards applicable to its organization type;

2. Sub-recipient shall maintain and enforce with its officers, employees, and agents (including Subcontractors) a code of conduct designed to enhance goodwill, ethics, and compliance with laws while performing under this MFRA; and

3. Sub-contractor shall conduct all procurement transactions in a manner that maximizes open and free competition.

VI. IP RIGHTS AND PUBLICATION

A. Work Product.

1. WRF shall own all worldwide copyrights in all the Work Product including the Scope of Work, All Periodic Reports, All Draft Reports, the Final Report, and all drafts of these works and reports. Sub-recipient shall and hereby does assign exclusively to WRF all right, title, and interest in and to the Work

Product and the copyrights embodied therein. And subject to provisions of 2 CFR 200 Subpart D, Property Standards, Intangible Property (200.315); and 37 CFR 401 which are made part of this PFA by reference except where superseded by this Section VI or the U.S. Federal Grant Agreement. The Sub-recipient may use without restrictions all data from the Work Product such as innovations, creations, processes, designs, methods, formulas, plans, technical data, and specifications.

2. WRF will provide the Sub-recipient with five (5) hardcopies of the Final Report and a PDF. If the Final Report is published in a PDF format only, the Sub-recipient will receive the Final Report in that format. The Work Product may not be copied, published, adapted, posted on an intranet or website, or disclosed in any manner by the Sub-recipient, any Subcontractor or other third party except with WRF's prior written approval. The Sub-recipient shall utilize WRF's *Material Use Permission Request Form* located at http://www.waterrf.org//funding/Pages/project-report-guidelines.aspx for securing the foregoing required permission for WRF.

3. WRF hereby grants the Sub-recipient and Co-funders a royalty free, perpetual, irrevocable, world-wide, nonexclusive license, without the requirement for any accounting, to utilize Foundation's Intellectual Property solely for Educational Purposes.

B. Inventions and Patents.

1. All proprietary or patentable ideas, devices, methods, formulations, designs, and other inventions developed or conceived by or on behalf of the Sub-recipient in the course of performing under the Project, including, but not limited to, the right to apply for patent protection thereon (collectively, "Inventions"), shall remain the property of the Sub-recipient.

2. If the Sub-recipient decides to abandon its rights to the Inventions, or not to seek patent protection on its Inventions, or to abandon any pending patent application or patent issued on the Inventions, Sub-recipient shall notify WRF of the same and promptly assign all rights in the abandoned Inventions to WRF at its request.

3. Sub-recipient shall not withhold any information on or descriptions of Inventions, whether or not patentable, from Work Products or any Report. The Sub-recipient's rights in Inventions shall not limit, delay, restrict, or in any other manner interfere with WRF's right to own, publish, and exercise all other copyrights in the Work Product. If information contained in the Work Product owned by WRF is considered to be and is treated by the Sub-recipient as confidential information and/or trade secrets, the Sub-recipient shall be solely responsible for marking confidential portions of the Work Product as such, and may request that WRF reasonably delay, but in no event by more than one month, publication of a Work Product in order to allow the Sub-recipient to apply for patent protection on Inventions described in the Work Product.

4. All IP rights that were owned and developed by the Sub-recipient or third parties prior to the Effective Date and outside the scope of the Project (collectively, "Preexisting IP"), and which the Sub-recipient will use in the performance of the Project, or incorporate in whole or in part into any Deliverables, has been fully disclosed and identified by the Sub-recipient in the Project Proposal. The Sub-recipient represents and warrants that all Preexisting IP is used with full authorization and permission from its respective owner, and copies of such permissions and licenses shall be provided to WRF by the

Effective Date. The Sub-recipient shall obtain all appropriate permissions on WRF's behalf to the extent necessary to enable WRF to exercise its ownership and publication rights in the Work Product, including the Final Report, such right shall be transferable, sublicenseable, and shall not be subject to any payment or other obligation on the part of WRF. Such agreements to procure rights for WRF shall be subject to WRF's prior approval, in its sole discretion.

5. The Sub-recipient hereby grants WRF a fully paid-up, royalty free, perpetual, irrevocable, world-wide, nonexclusive license, with the right to grant sublicenses, to utilize the Inventions and Preexisting IP for educational or other non-profit purposes.

C. Publication. As the owner of Work Product, all rights to publish, distribute, publicly perform, and publicly present the Reports belong solely to WRF. The Co-funders and Sub-recipient may publish or present based on the Work Product, in whole or in part, and only with the prior written permission of WRF, which may be withheld or conditioned at WRF's sole discretion. Any such request for permission from WRF must be made to WRF at least three (3) weeks prior to the requesting party's proposed date of publication or presentation based on any portion of the Work Product, and the request must be accompanied by copies of the proposed publication or presentation material. All copies of or presentations based on the Work Product authorized to be made by WRF shall furthermore conspicuously display the following notice:

Author, Title of Foundation Work
Copyright [year of publication]
Water Research Foundation Reproduced with permission

D. Acknowledgement. Any public presentation or publication by the Sub-recipient or Co-funders, including a student writing a thesis, dissertation, or report, based on the Inventions or any portion of the Work Product, if permitted by WRF, shall include a statement substantially as follows: *"Confluence Engineering Group LLC gratefully acknowledges that the Water Research Foundation, City of Portland Water Bureau, and Seattle Public Utilities are co-funders of certain technical information upon which this publication [manuscript] [presentation] is based. Confluence Engineering Group LLC thanks Water Research Foundation City of Portland Water Bureau, and Seattle Public Utilities for their financial, technical, and administrative assistance in funding the project through which this information was discovered."*

E. Return of IP. The Sub-recipient shall provide to WRF legible copies of all Work Product (including source and object code of any computer software program) and all Inventions abandoned by the Sub-recipient, and shall furthermore provide to WRF and Co-funders legible copies of all Preexisting IP, all within thirty (30) days of any party's delivery of a notice of termination hereunder, whether or not a cure period is provided. Further, at the same time, Sub-recipient shall provide copies and originals shall be delivered in whatever medium and format is reasonably designated by WRF. No further payments will be made unless the Sub-recipient fully complies with the foregoing requirements.

F. Originality. The Sub-recipient represents, warrants, and covenants that it, and its Subcontractors, are the sole creator(s) and originator(s) of all Work Product, Inventions, and Preexisting IP; none of those rights have been bargained, sold, encumbered, licensed or otherwise transferred to any other party in a manner that would limit or interfere with the requirements and covenants of the Sub-recipient under this MFRA. Further, the Sub-recipient shall ensure that no portion of this Project, including any portion completed by Subcontractors, infringes upon the IP rights of any other person or entity or violates the common law or statutory right, title, or interest of any person or entity. The Sub-recipient, shall execute and deliver to WRF, and shall cause its Subcontractors and agents to execute and deliver to WRF, all documents and instruments reasonably requested by WRF, including, without limitation, the Assignment of Copyright attached hereto as Exhibit E, to further evidence or memorialize the assignment of rights to WRF set forth in this MFRA.

VII. TERM AND TERMINATION

A. Term. This MFRA is effective as of the Effective Date, and shall continue for the duration of the Project, ending on WRF's delivery to the Sub-recipient of the final disbursement of the Project Funds in accordance with Section III.B above, and as further specified in Exhibit C. This MFRA may be terminated earlier for the following reasons:

1. WRF may terminate this MFRA by written notice to the other parties at any time in the event of a breach of this MFRA or any requirements of or timelines in the Project by the Sub-recipient or its agents following Sub-recipient's receipt of WRF's notice of breach.

2. WRF may terminate this MFRA effective immediately by written notice to the other parties in the event WRF after consultation with the Co-funders and the PAC reasonably determines that the Project is no longer feasible or its performance desired, or that if Sub-recipient is not likely to complete the requirements of the Project on time.

3. Co-funders may terminate this MFRA by a ninety (90) day prior written notice to the other parties if either the Sub-recipient or WRF materially breaches this MFRA.

4. Upon receipt of any written notice of termination, the Sub-recipient shall cease all work associated with this MFRA as of the date of receipt of the notice, but shall continue to prepare whatever reports, accounting statements, and invoices that are necessary to support receipt of any payments and deliver existing Work Product as required under the MFRA.

5. If the Sub-recipient, after reasonable consultation with WRF and sufficient exploration of other options and possible mutual agreements to amend this MFRA, determines that circumstances beyond its control prevent it from continuing the Project, the Sub-recipient may terminate this MFRA at any time by written notice to WRF.

6. Any change in legal requirements or entitlements which materially alter Sub-recipient's performance under this MFRA, or any change in the availability of funds to WRF, shall warrant good faith renegotiation of the provisions of this MFRA impacted by such change. If the parties cannot agree to an amendment to this MFRA, at WRF's option the Sub-recipient's performance of the Project may be suspended, or this MFRA may be terminated effective immediately by WRF's written notice.

7. If termination occurs under this Section, the Sub-recipient shall prepare and submit to WRF a final invoice and accounting of expended and non-cancellable funds as of the date of receipt of the notice of termination. Any portion of the Project Funds that was prepaid to the Sub-recipient but which remains unspent shall be returned to WRF with the final invoice. WRF shall pay any amount owed under the final invoice, if reasonably accepted by WRF, and shall return to the Co-funders any remaining and unspent funds in proportion to the Co-funder funding. The Sub-recipient shall be entitled to compensation for all satisfactory and authorized work completed as of the termination date, provided that all Work Product corresponding to the invoiced amounts have been delivered to WRF, and further provided that funds are available (i.e., a reduction in granted funds as stated above).

VIII. DISPUTE RESOLUTION

A. In the event of a dispute between WRF and the Co-funders with respect to the Sub-recipient's performance, or other acts or omissions in performing the Project or under this MFRA, WRF's final determination, following reasonable consultation with the PAC, shall govern.

B. All other disputes arising under this MFRA by or among the parties shall be resolved by binding arbitration conducted in accordance with the then effective rules of expedited commercial arbitration of the American Arbitration Association ("AAA") in Denver, Colorado U.S.A. There shall be one Arbitrator selected in accordance with such rules. The Arbitrator shall have subpoena powers. Any final binding determination issued by the Arbitrator shall be in writing within thirty (30) days of the final mediation session. Such written decision may be enforced in any court having proper jurisdiction.

IX. STANDARD TERMS AND CONDITIONS

A. Survival. All terms which by their nature and intent are required to be performed after termination of this MFRA shall survive to the extent necessary to enable their fulfillment.

B. Quality Assurance. The Sub-recipient shall use its best efforts to ensure that all data and test results developed during the course of this MFRA and included, or relied upon, in the Final Report are accurate to the best of its knowledge, information, and belief. In the event the Sub-recipient obtains any data, test results, information derived from such data or test results, or other information to be included in the Project from water utilities or any Subcontractor, the Sub-recipient will utilize reasonable and customary efforts to ensure the accuracy of the information obtained.

C. Co-funders Review. The Co-funders shall have the right and reasonable opportunity prior to submission of the Final Report, to review the data, results and conclusions derived from the Project, and to correct or comment upon any discrepancies in the reviewed materials. The Sub-recipient shall be responsible for providing letters for review and execution by each Co-funder confirming that they have reviewed the submitted materials. Such confirmation letters, signed by each Co-funder, shall be submitted to WRF with the Final Report. If the Sub-recipient has made reasonable efforts but is not able to obtain signed confirmation letters, the Principal Investigator may submit a signed letter stating this fact and further stating that the Co-funders were provided reasonable opportunity to review and comment upon the materials as required.

D. Standard of Performance. At all times, all obligations performed by the Sub-recipient or by any Subcontractors pursuant to this MFRA shall be performed in a manner consistent with or exceeding the professional standards governing such activities. Further, the Sub-recipient shall be responsible for, and shall hold harmless and indemnify WRF, Co-funders, and their officers, directors, affiliated organizations, employees, agents, volunteers, and publisher, if any, from any and all liability, obligation, damage, loss, cost, claim, lawsuit, cause of action, or demand whatsoever of any kind or nature, including, but not limited to, attorneys' fees and costs, arising from (i) any actions taken by, or omissions of, the Sub-recipient, its officers, directors, Subcontractors, employees independent contractors, agents, or other related entities or individuals, (ii) any use or misuse of IP claimed to be owned by another, or (iii) any material breach of this MFRA by the Sub-recipient.

E. Governmental Entities. If the Sub-recipient or any Subcontractor is a governmental or quasi-governmental entity that is by law prohibited from indemnifying others, Section XIV.D is modified to the extent that will impose the maximum available liability and responsibility on Sub-recipient. Sub-recipient shall require all

parties involved in the performance of this MFRA that are not prohibited from indemnifying others to so indemnify WRF and the Co-funders through a written agreement acceptable to WRF and the Co-funders.

F. Insurance. The Sub-recipient shall maintain a financially sound program of self-insurance or commercially purchased liability insurance covering unfair competition claims and all reckless, intentional, knowing, and negligent actions or omissions of any and all of Sub-recipient's officers, directors, employees, agents, and independent contractors and/or Subcontractors in the amount of one million dollars ($1,000,000.00). Proof of such insurance shall be presented to WRF pursuant to the schedule detailed by Exhibit B and to the Co-funders upon request. The proof of insurance document shall clearly specify the Project by number and title on the insurance certificate. *The City of Portland is self-insured.*

G. Worker's Compensation. The Sub-recipient and all Subcontractors shall maintain Worker's Compensation Insurance which complies with the applicable state laws. Proof of such insurance shall be presented to WRF pursuant to the schedule detailed by Exhibit B.

H. Authority. The individuals executing this MFRA on behalf of their respective parties hereby represent and warrant that they have the right, power, legal capacity, and appropriate authority to enter into this MFRA on behalf of the entity for which they sign below.

I. Modifications: No provision, requirement, or term of this MFRA may be modified, supplemented or amended, nor may it be waived or discharged, except in writing, signed by all parties. A written waiver of a breach of one provision in this MFRA shall not operate as a waiver of a subsequent breach of the same provision.

1. Examples of items requiring WRF's prior written approval include, but are not limited to, the following:

- Deviations from the Project plan.
- Change in scope or objective of the Project.
- Change in a key person specified in the application.
- The absence for more than three months or a 25% reduction in time by the principal investigator.
- Need for additional funding.
- Inclusion of costs that require prior approvals as outlined in the Uniform Grants Guidance and 48 CFR 31.2, as applicable.
- Any changes in budget line item(s) as described in Exhibit A of greater than ten percent (10%) of the total.

J. No Assignment. The Sub-recipient shall not assign this MFRA in whole or in part, including by operation of law, merger, reorganization, or change in ownership or control. Any unauthorized assignments shall be void.

K. Sub-Contracting: The Sub-recipient may only utilize Subcontractors under this MFRA that have been disclosed in the Project Plan and are pre-approved by WRF.

1. Sub-recipient shall require any and all Subcontractors to comply with all applicable and material terms of this MFRA prior to working on the Project in any manner. All obligations of the Sub-recipient apply equally to the Subcontractor(s). Sub-recipient shall at all times remain primarily responsible and liable to

WRF and the Co-funders for the acts and omissions and performance of this MFRA by its Subcontractors.

2. Payment for services of any and all Subcontractors shall be the Sub-recipient's sole obligation and responsibility. The Sub-recipient hereby indemnifies and holds WRF and Co-funders harmless for any liability concerning such payment. In furtherance of the foregoing, and to safeguard WRF if Sub-recipient or any Subcontractors is legally prohibited from indemnifying others, Sub-recipient shall in all its Subcontractor agreements specify that WRF and Co-funders shall have no liability or obligation to the Subcontractor, and that the Subcontractor agrees to look solely to the Sub-recipient for payment and enforcement of its rights under its agreement with the Sub-recipient.

3. Subcontractor shall conduct all procurement transactions in a manner that maximizes open and free completion.

4. WRF shall require for Sub-recipient to notify WRF, within two (2) months of the project start date pursuant to the schedule detailed in Exhibit B, that all Subcontractor agreements have been executed between the Sub-recipient and any Subcontractors set forth in the Project Proposal.

L. Integration. This MFRA, including all attachments hereto and the documents and requirements referenced herein, contains the entire understanding between the parties relating to this MFRA. This MFRA supersedes all prior and contemporaneous understandings, representations, negotiations, and agreements between the parties whether written or oral. In the event of a conflict between the terms of an Exhibit or other document referenced herein and this MFRA, the terms of this MFRA shall control.

M. Severability. The provisions of this MFRA shall be severable, and the invalidity, illegality or unenforceability of any provision of this MFRA shall not affect the validity or enforceability of any other provisions. If any provision of this MFRA is found to be invalid, illegal, or unenforceable, such provision shall be modified to the extent necessary to render it enforceable, and as modified, this MFRA shall remain in full force and effect.

N. WRF Right of Approval. WRF and Co-funders shall have the right, in their sole discretion, to refuse to permit any employee of the Sub-recipient, or employee of an approved agent, assignee, or subcontractor of the Sub-recipient, to be located at a WRF or Co-funders work location, or to provide services to WRF, Co-funders or their clientele pursuant to this MFRA.

O. Notices. Any notice, request, demand, or communication required or allowed under this MFRA shall be sent in writing to the addresses and contact information for the parties set forth in Exhibit B, and shall be deemed sufficiently given upon delivery, if delivered by hand (signed receipt obtained), or three (3) days after posting if properly addressed and sent certified mail return receipt requested, or upon receipt if sent via facsimile or email, if delivery can be confirmed by the sender. Notices shall become effective on the date of receipt or the date specified within the notice, whichever comes later.

P. Captions for Convenience. All captions, fonts, underlining, or footers used in this MFRA are for convenience only and shall have no meaning in the interpretation or effect of this MFRA.

Q. Construction. This MFRA, and any and all amendments to it, shall not be construed against the drafter.

R. Force Majeure. None of the parties hereto will be liable for damages for any delay or default in performance during the term hereof if such delay or default is caused by conditions beyond its control,

including, but not limited to, acts of God, Government restrictions, continuing domestic or international problems such as wars, threats of terrorism, or insurrections, strikes, fires, floods, work stoppages and embargoes; provided, however, that any party will have the right to terminate this MFRA upon thirty (30) days prior written notice if another party's delay or default due to any of the above-mentioned causes continues for a period of two (2) months.

S. Limitation of Liability. IN NO EVENT SHALL WRF OR ANY OF ITS OFFICERS, DIRECTORS, EMPLOYEES, AFFILIATES, AGENTS OR REPRESENTATIVES BE LIABLE TO ANY OTHER PARTY, OR ANY THIRD PARTY FOR ANY SPECIAL, INDIRECT, INCIDENTAL, EXEMPLARY OR CONSEQUENTIAL DAMAGES OR LOSS OF GOODWILL OR EXPECTED PROFITS OR REVENUES, IN ANY WAY RELATING TO THIS MFRA, INCLUDING, WITHOUT LIMITATION, THE FAILURE OF ESSENTIAL PURPOSE, EVEN IF IT HAS BEEN NOTIFIED OF THE POSSIBILITY OR LIKELIHOOD OF SUCH DAMAGES OCCURRING, AND WHETHER SUCH LIABILITY IS BASED ON CONTRACT, TORT, NEGLIGENCE, STRICT LIABILITY, STATUTE, PRODUCTS LIABILITY OR OTHERWISE. IN NO EVENT SHALL WRF'S OR THE CO-FUNDERS' LIABILITY HEREUNDER EXCEED THEIR RESPECTIVE FUNDING ALREADY MADE UNDER THIS MFRA.

T. Applicable Law/Venue. This MFRA is written and shall be construed in accordance with and governed by the laws of Colorado unless U.S. Federal law applies. However, if legal action is taken against Sub-recipient and U.S. Federal or state laws which exist that govern Sub-recipient (as a quasi-public or public entity) exclusively, this MFRA shall be construed and interpreted in accordance with such laws to the extent if such exclusivity. Any action under this MFRA must be brought in a Colorado State Court or U.S. Federal District Court located in Denver, Colorado.

U. Counterparts. This MFRA may be executed and delivered in counterparts, and by facsimile and email, and each shall be valid as if all parties had executed the same document.

V. Relationship. The parties are independent contractors, and no agency, employer-employee, partnership, or joint venture relationship is intended or created by this MFRA. No party shall have any right or authority to assume or create any obligation, commitment or responsibility for or on behalf of the others except as the other may expressly authorize in writing. No party shall be eligible to participate in another's benefit program. Sub-recipient shall be solely responsible for the performance and compensation of its employees, for withholding taxes and providing unemployment and other benefits.

Project 04653

IN WITNESS WHEREOF, the parties have caused this MFRA to be signed and dated as shown below.

Water Research Foundation

By: Robert C. Renner, P.E., BCEE
Title: Executive Director
Date: 10/20/2015

P Falor
pf

Confluence Engineering Group LLC

By: Melinda Friedman
Title: Founder & President
Date: _____

Water Research Foundation

By: Grace Jang, Ph.D
Title: Research Manager
Date: 10/19/2015

Above signed has read and understands the terms, conditions, and deliverables of this MFRA.

Confluence Engineering Group LLC

By: Melinda Friedman
Title: Principal Investigator
Date: _____

Above signed has read and understands the terms, conditions, and deliverables of this MFRA.

Signature Page Instructions

1. Review document and have a duly authorized representative and the Principal Investigator sign this page.
2. Only this signature page is required to be returned back to the Foundation.
3. Please **Email** a scanned PDF of the executed signature page to the following:
   a. Peggy Falor at pfalor@WaterRF.org and
   b. Corina Santos at csantos@WaterRF.org
4. Do not return the entire agreement, only the signature page.
5. Please return no later than **ten (10) calendar days** from receipt.
6. WRF will email a PDF of this fully executed agreement to you for your files. .

187526

Project 04653

Title: Use of Flushing as a Corrective Action Under the Revised Total Coliform Rule

Co-Funder
City of Portland Water Bureau

By: Michael Stuhr, P.E.
Title: Administrator Portland Water Bureau

Date: 11/30/15

APPROVED AS TO FORM

CITY ATTORNEY

Above signed has read and understands the terms, conditions, and deliverables of this MFRA.

City Agreement No. _____

City Ordinance No. _____

Signature Page Instructions

1. Review document and have a duly authorized representative sign this page.
2. Only this signature page is required to be returned back to the Foundation.
3. Please return the executed signature page using **one** of the choices below:
   a. **Email** a scanned PDF to pfalor@WaterRF.org or,
   b. **Fax** a copy back to Peggy Falor at (303) 730-0851 or,
   c. **Mail** a copy back to Peggy Falor at Water Research Foundation, 6666 W. Quincy Ave., Denver, CO 80235, phone: (303) 734-3424
4. Do not return the entire agreement, only this signature page.
5. Please return no later than **ten (10) business days** from receipt.
6. WRF will email a PDF of this fully executed agreement to you for your files.

Project 04653

Title: Use of Flushing as a Corrective Action Under the Revised Total Coliform Rule

Co-funder

Seattle Public Utilities

_____

By: Rick Scott
Title: Deputy Director, Water Line of Business

Date: _____

Above signed has read and understands the terms, conditions, and deliverables of this MFRA.

Signature Page Instructions

1. Review document and have a duly authorized representative sign this page.
2. Only this signature page is required to be returned back to the Foundation.
3. Please return the executed signature page using **one** of the choices below:
   a. **Email** a scanned PDF to pfalor@WaterRF.org or,
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4. Do not return the entire agreement, only this signature page.
5. Please return no later than **ten (10) business days** from receipt.
6. WRF will email a PDF of this fully executed agreement to you for your files.

Exhibit A
Project 04653

Title: Use of Flushing as a Corrective Action Under the Revised Total Coliform Rule

Project proposal, & all subsequent correspondence.

Exhibit A

TAILORED COLLABORATION PROPOSAL COVER WORKSHEET

Proposal Title: Use of Flushing as a Corrective Action under the Revised Total Coliform Rule

Sponsoring Utility (Foundation Subscriber submitting proposal): Portland Water Bureau

Contact at Sponsoring Utility:
Name: Yone Akagi
Address: 1900 N. Interstate Ave, Portland, OR 97227

Phone: 503.823.7648 Fax: NA email:Yone.Akagi@portlandoregon.gov

Co-Funding and In-kind Summary: (attach additional sheet if needed)

Organization Name	Cash Co-fund Amount	In-Kind Contribution Amount (sponsoring utility)
1.Portland Water Bureau	$50,000	
2.Seattle Public Utilities	$40,000	
3.Confluence Engineering Group		$10,000
4.WaterRF	$90,000	
	Total cash $180,000	**In-Kind** $10,000

Project Personnel
Principal Investigator (i.e., researcher responsible for conducting research)
Name: Melinda Friedman
Organization: Confluence Engineering Group LLC
Address: 517 Northeast 92nd Street, Seattle, Washington 98115

Phone: (206) 527-6832 Fax: 206-523-8560 e-mail: Melinda@confluence-engineering.com

Person responsible for finalizing *Funding Agreement* (i.e., research contract)
Name: Yone Akagi
Address: 1900 N. Interstate Ave, Portland, OR 97227

Phone: 503.823.7648 Fax: NA email:Yone.Akagi@portlandoregon.gov

Person responsible for accounting matters of contractor:
Name: Michael Hallett
Address: 517 Northeast 92nd Street, Seattle, Washington 98115

Phone: (206) 527-6832 Fax: NA e-mail: Michael@confluence-engineering.com

Foundation Funds Requested: $90,000

Amount of Funds eligible for Foundation match: $90,000

Amount of Funds not eligible for Foundation match: $0

Total Cash Budget (Foundation Funds + All Co-Funding Cash): $180,000

Total In-kind Contributions: $10,000

Total Project Budget (Cash + In-kind): $190,000

Proposals with an incomplete Proposal Cover Worksheet will not be accepted.

187526

Exhibit A

TC CO-FUNDING SUPPORT FORM

Note: Each co-funding organization (including the sponsoring utility) must complete a separate Co-Funding Support Form and include it in the proposal.

Co-Funding Organization: Portland Water Bureau

Type of Organization: _x_water utility ____consulting firm ____ manufacturer ____other (describe)

Is your organization eligible to participate in one of The Foundation's subscription programs? __x_ Yes ____ No

Is your organization requesting that The Foundation match its funds? _x__ Yes ____No

Is your organization eligible for The Foundation matching funds? __x_ Yes ____No

Cash co-funding amount being provided by your organization (in USD) $ 50,000

Person responsible for contract matters for your organization:
Name: Annette Dabashinsky

Address at which FedEx packages can be received: 1900 N Interstate Ave, Portland, OR 97227

Phone/Fax/e-mail: 503.823.7521; 503.823.4500; annette.dabashinsky@portlandoregon.gov

Person responsible for accounting matters for your organization:

Name: Mary Leung

Address at which FedEx packages can be received: 1120 SW 5th Avenue Room 600, Portland, OR 97204

Phone/Fax/e-mail: 503.823.7551; 503.823.7024; mary.leung@portlandoregon.gov

What approvals will be required in order for your funds to be released to the Foundation? (e.g., City Council, Board of Commissioners)
City Council

Have these approvals been obtained? ____ Yes x__ No

Can approvals be obtained and co-funding agreements be signed within 120 days of award? x___Yes _____No
(Note: 120 days after award notification the Foundation may cancel the award--see TC proposal guidelines for details.)

Are there any conditions of the Foundation Co-Funding Agreement that would prevent you from signing it as it is currently worded? _____Yes _x_No
If yes, please explain: (attach additional pages if required)

The person signing below acknowledges they are authorized to commit their organization to the proposed work.

Signature _____ Print Name Chris Wanner

Title Director of Operations Organization Portland Water Bureau

Date March 23, 2015 Phone 503.823.4050

Mailing Address 1900 N Interstate Ave, Portland, OR 97227

Version: 12/01/2013 (previous versions are obsolete and will not be accepted for review).

187526

Exhibit A

TC CO-FUNDING SUPPORT FORM

Note: Each co-funding organization (including the sponsoring utility) must complete a separate Co-Funding Support Form and include it in the proposal.

Co-Funding Organization: Seattle Public Utilities

Type of Organization: _X_water utility ____consulting firm ____ manufacturer ____other (describe)

Is your organization eligible to participate in one of The Foundation's subscription programs? _X_ Yes ____ No

Is your organization requesting that The Foundation match its funds? _X_ Yes ____No

Is your organization eligible for The Foundation matching funds? _X__ Yes ____No

Cash co-funding amount being provided by your organization (in USD) $ 10,000 in 2015, $30,000 in 2016

Person responsible for contract matters for your organization:
Name: Wylie Harper, Drinking Water Quality Manager

Address at which FedEx packages can be received: Seattle Public Utilities, 800 S. Stacy St., Seattle, WA 98134

Phone/Fax/e-mail: (ph) 206-684-7880, (fax) 206-684-4133, Wylie.Harper@seattle.gov

Person responsible for accounting matters for your organization:

Name: Sharon Gill, Accounts Payable Supervisor

Address at which FedEx packages can be received: Seattle Public Utilities, Accounts Payable, 700 5th Ave, Suite 4900, Seattle, WA 98124

Phone/Fax/e-mail: 206-233-7169

What approvals will be required in order for your funds to be released to the Foundation? (e.g., City Council, Board of Commissioners)
Deputy Director level approval

Have these approvals been obtained? _X_ Yes ____ No

Can approvals be obtained and co-funding agreements be signed within 120 days of award? __X__Yes _____No
(Note: 120 days after award notification the Foundation may cancel the award--see TC proposal guidelines for details.)

Are there any conditions of the Foundation Co-Funding Agreement that would prevent you from signing it as it is currently worded? _____Yes __X__No
If yes, please explain: (attach additional pages if required)

The person signing below acknowledges they are authorized to commit their organization to the proposed work.

Signature _____ Print Name Rick Scott

Title Deputy Director, Water Line of Business Organization Seattle Public Utilities

Date 3-25-15 Phone 206-233-2613

Mailing Address Seattle Public Utilities, 2700 Airport Way S., Seattle, WA 98134

Version: 12/01/2013 (previous versions are obsolete and will not be accepted for review).

187526

Exhibit A

3. PROJECT ABSTRACT

Research Objectives. Utilities and regulators need guidance to demonstrate that flushing is a corrective action under the Revised Total Coliform Rule (RTCR) by preventing coliform regrowth and biofilm formation, reducing disinfectant demand, and avoiding unintended consequences by "stirring stuff up". The objectives of this project include: 1) assess mobilization and removal of microorganisms, nutrients, and microbially-active sediments as a function of flushing technique and pipe type, 2) evaluate bulk water response to changes in pipe surface conditions due to flushing, 3) provide the basis for investing in preventative flushing for biofilm control, and 4) provide protocols and guidance to ensure that flushing is indeed a corrective action under the RTCR, and that scarce resources are used effectively to meet intended water quality objectives.

Technical Approach. We have developed a 4-Task approach that includes: 1) start the project in the right direction through development of case studies and holding a workshop; 2) development and implementation of field protocols to evaluate four different flushing techniques on two pipe materials (see box to the right); 3) evaluation of findings and development of industry guidance; and 4) Project Management including preparation of reports, PAC meeting, etc. Our approach is streamlined and efficient, yet will address each project objectives, will fill important research gaps, and will provide the industry with much needed guidance that can be applied on a system-specific basis.

Flushing Techniques to be Evaluated

- Conventional Spot Flushing
- Dead-End Flushing
- Quasi-Unidirectional Flushing (localized)
- Strict-Unidirectional Flushing (regional)

Anticipated Results. This project represents one of the first detailed comparison of flushing techniques that are routinely applied (or mis-applied) by utilities throughout North America and beyond. Anticipated deliverables will provide much needed guidance and will include flushing protocols and data collection SOPs and Decision Trees; and information on cost vs. measured benefit for each flushing technique so that utility managers can better allocate O&M resources to optimize their flushing practices to both prevent and respond to coliform events.

Submitting Organization. The Sponsoring Utility for this project is Portland Water Bureau (PWB), in Portland, OR. The co-Sponsoring Utility is Seattle Public Utilities (SPU) in Seattle, WA. The submitting organization is Confluence Engineering Group, LLC (Confluence), of Seattle, Washington.

Researchers. Melinda Friedman, P.E., President and founder of Confluence will serve as Principal Investigator. Andrew Hill, P.E. Project Manager with Confluence will serve as Co-Principal Investigator. Melinda will lead the overall team, and will be directly responsible for project outcomes. Andrew will oversee development and implementation of field sampling plans and will lead the effort to evaluate results. He will also be a key contributor to all project deliverables.

Budget. The total budget for the project is $190,000 of which $90,000 is requested in WaterRF funding. As the Sponsoring Utility, PWB has committed to contributing $50,000. SPU has committed to $40,000, with $10,000 available in 2015 and $30,000 available in 2016, as discussed in the Budget Narrative section. Confluence will contribute an additional $10,000 as an in-kind contribution over the duration of the project.

Requested WaterRF Funding:	$90,000
Sponsoring Utility Contribution:	$90,000
In-Kind Contributions:	$10,000
Total Project:	**$190,000**

4.0 PROJECT DESCRIPTION

4.1 Background

Utilities spend a considerable amount of time and resources flushing to maintain or improve distribution system (DS) water quality. System flushing is performed with the intent of cleaning distribution pipelines of sediment, impurities, and biofilm. Flushing can also be used to achieve other water quality objectives such as increasing turnover to increase residual chlorine levels and resolve discolored water complaints or taste and odor problems. Flushing programs may be preventative, responsive, or both, and there are a variety of flushing techniques that can be implemented as part of an overall program.

Over the last decade, more attention has been placed on demonstrating the effectiveness of flushing techniques for meeting specific performance objectives. *Establishing Site-Specific Flushing Velocities* (Friedman et al., 2003) was one of the first studies to put science behind particle lifting, entrainment, and removal and to identify the many variables that impact flushing effectiveness on loose vs. adhered deposits. As shown in Figure 1, the appropriate flushing velocity and frequency is impacted by numerous complex and interrelated variables, many of which are not fully considered or are unknown when utilities conduct flushing.

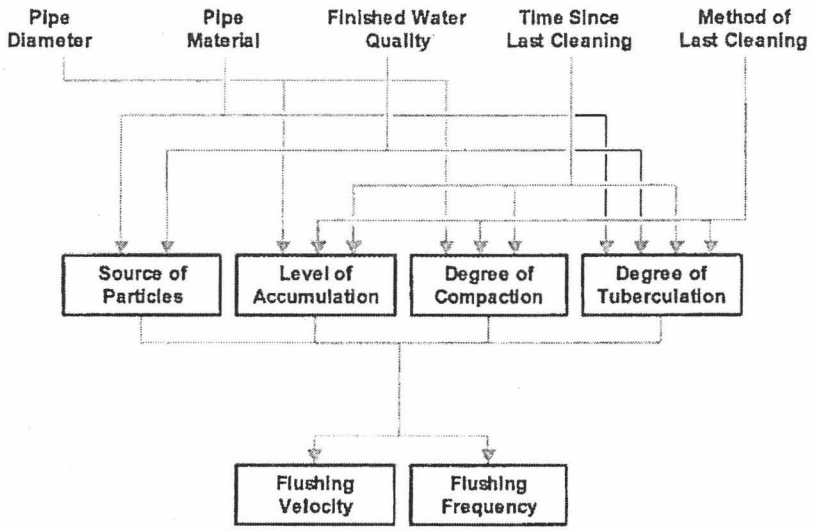

Figure 1. Variables Impacting Flushing Effectiveness
(Source: Friedman et al., 2003)

Recent research led by our project team has begun to demonstrate the effectiveness of flushing (or lack thereof) for removal of accumulated metals (Friedman et al, 2010; Friedman et al, 2015). Detailed protocols for setting up flushing loops, profiling discharge water quality over the duration of a flush, and determining the occurrence and inventory of inorganic contaminants removed in the process have been developed as part of these studies. However, very little is known

about the effectiveness and duration of benefits associated with various flushing approaches for enhancing microbial water quality conditions with regard to:

- Biofilm and nitrification control
- Removal of microbially-active scale and sediments
- Removal of nutrients and substrates
- Reducing disinfectant demand

This is a significant industry knowledge gap considering the reliance on flushing as a preventative tool and Best Available Technology under the Total Coliform Rule (TCR), and as a corrective action under the Revised Total Coliform Rule (RTCR). All Public Water Systems (PWSs), community or non-community, are required to comply with the Total Coliform Rule (TCR) which was promulgated in 1989, and the RTCR which will become effective in 2016.

A major premise of the RTCR construct is that the RTCR will offer *greater* public health protection by the addition of new requirements. The health goal and legal limits for the presence of total coliforms in drinking water have been replaced with a treatment technique that requires PWSs to conduct an assessment of their system if monitoring results indicate that they might be vulnerable to contamination, and to correct for any problems identified during the assessment (USEPA, 2014). The Revised Total Coliform Rule Assessments and Corrective Action Guidance Manual (USEPA, Interim Final, 2014) identified flushing as a corrective action and provides one page of guidance to utilities, primarily referring them to AWWA Standard G-200, which also provides less than one page of guidance on the importance of developing a flushing program. No specific guidance is offered with regard to: flushing technique, velocity, frequency, data collection, or data evaluation to ensure that the actions taken by the utility in response to a coliform event have actually corrected a problem. Thus, utilities do not know if they are still vulnerable to coliform occurrence, and regulators do not know if the utility has actually corrected a deficiency.

Flushing may not always be a corrective action in response to coliform occurrence. In instances where coliform occurrence is due to source water contamination, treatment breakthrough, direct contamination of the DS, or sampling/analytical error, flushing is not a corrective action since it does not correct the underlying cause of the coliform occurrence. If coliform occurrence is due to biofilm and disinfectant demand issues, then flushing, when performed properly, may help to correct the underlying problem and could be considered a corrective action under the RTCR since contaminants and disinfectant-demand causing materials are lifted and removed from the distribution system. When mis-applied or performed incorrectly, flushing may be a waste of resources, or may actually *increase* risks to public health by mobilizing and spreading microbial contaminants without achieving their removal.

Liu et al (2014) compared the bacterial community of bulk water, suspended solids, loose deposits, and biofilm in an unchlorinated distribution system. Results showed that the bulk water bacteria (including the contribution of suspended solids) contributed less than 2% of the total inventory of bacteria. The bacteria associated with loose deposits and pipe wall biofilm that accumulated in the DS accounted for over 98% of the total inventory of bacteria. The contributions of

bacteria from loose deposits versus pipe wall biofilm varied to some degree with the sampling site (Figure 2). Depending on the amount of loose deposits, its contribution was up to 7-fold higher than the pipe wall biofilm.

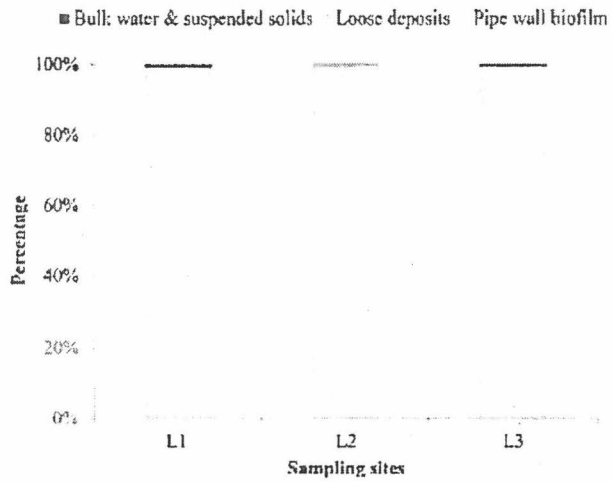

Figure 2. Comparison of bacterial abundance (comparison of biomass as inferred from ATP results) of different phases within a 1-m water main (PVC, 110 mm).
Source: Liu et al (2014)

This suggests that flushing activities in response to coliform occurrences, if conducted incorrectly, can stir up and spread microbial contaminants around the flushed area (thus increasing public health risk) rather than lifting and removing them from the DS in a controlled manner. This potential consequence, and more broadly-speaking, the application niches of different flushing approaches, are not widely recognized amongst water utilities as reflected by results obtained by Ellison et al (2003). Based on a survey of 500 U.S. utilities, while 98% of respondents reported using flushing, 76% reported the use of conventional flushing practices for the purpose of scouring and cleaning DS mains, versus just 22% of utilities that used the controlled practice of unidirectional flushing (UDF) for that purpose.

Therefore, a systematic methodology is needed to demonstrate the elements of a flushing program that truly constitute a corrective action based on the likely cause of the coliform occurrence.

4.2 Research Approach

Project Objectives

Utilities and regulators need specific guidance to demonstrate that flushing activities are preventing or addressing coliform regrowth, minimizing biofilm formation, and reducing disinfectant demand, while also avoiding unanticipated consequences. As there are a variety of different types of flushing (e.g., conventional, UDF, dead-end, etc.), guidance regarding the appropriate flushing technique(s) to apply, based on the most likely cause of coliform occurrence, is also

needed. This study will help utilities justify the expense and effort associated with development and implementation of preventative and reactive flushing programs, as well as modification and optimization of existing practices within their own systems and their purveyor systems. The specific objectives of this project are as follows:

1. Assess mobilization and removal of microorganisms, nutrients, and microbially-active sediments as a function of flushing technique, velocity, and pipe type.
2. Evaluate bulk water response to changes in pipe surface conditions due to flushing. Demonstrate impacts (magnitude, duration) of flushing practices on disinfectant demand and residual stability.
3. Use findings to provide the basis for investing in preventative flushing for biofilm control, and to provide guidance on the applicability, benefits, and potential risks of various types of reactive flushing in response to coliform events.
4. Provide protocols and guidance to ensure that flushing is indeed a corrective action under the RTCR, and that scarce resources are used effectively to meet intended water quality objectives.

Four tasks have been developed to meet the project objectives, as summarized in Figure 3 and described in more detail below.

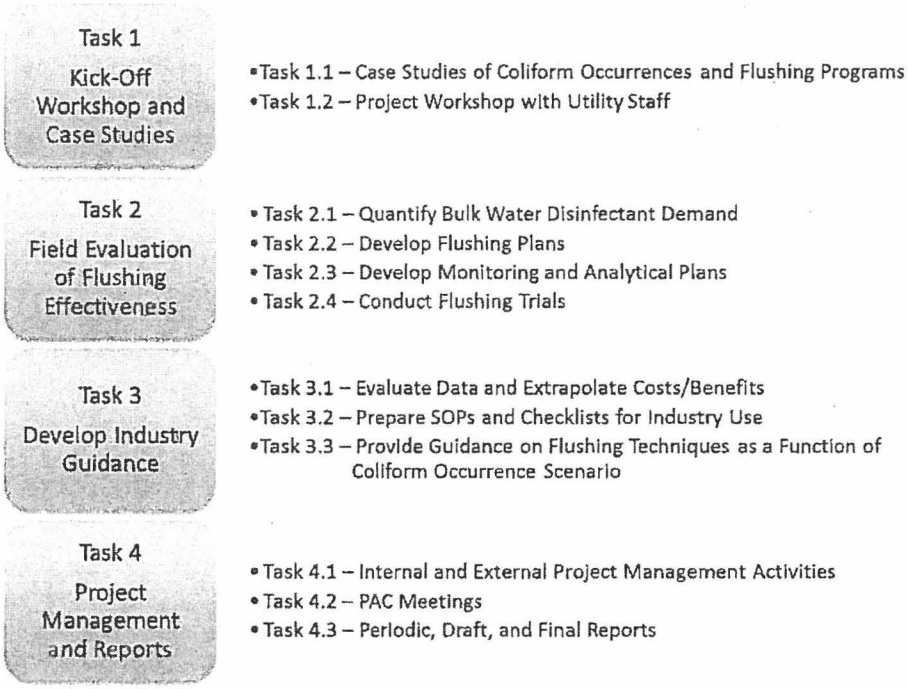

Figure 3. Project approach flow chart

4.3 Project Tasks

Task 1 – Kick-off Workshop and Case Studies

The first task will ensure that the project gets off to a good start by holding a workshop at PWB with the Project Team and utility stakeholders to review project objectives and discuss anticipated field approaches. The workshop will be held at Portland Water Bureau during the beginning of the project.

Case studies summarizing PWB and SPU experiences with coliform occurrence and the history of their flushing programs will also be prepared. Both Portland Water Bureau (PWB) and Seattle Public Utilities (SPU) have had recent issues with coliforms within their own and/or purveyor distribution systems. These large, Pacific Northwest utilities share some similarities in terms of age of system, pipe materials used, seasonal temperatures, and a history of unfiltered sources of supply while both serve large regional areas and many purveyors. These similarities provide an opportunity to compare conditions and the relative effectiveness of operational practices between the two systems. One key difference is that PWB is chloraminated and SPU uses free chlorine for secondary disinfection. This important difference provides the opportunity to compare flushing effectiveness and response in a distribution system that is susceptible to nitrification and one that is not, ensuring the usefulness of results to the drinking water industry at large.

Case studies summarizing recent coliform events within PWB's retail system and within SPU's retail and one wholesale system will be prepared. The perceived effectiveness of response activities (including UDF, spot flushing, booster disinfection, etc.) will be described. Members of our project team worked with both utilities during and after these events, and as a result will be able to cost-effectively leverage reports and materials that were prepared as part of "After Action" investigations of these coliform events. A brief summary of each utility's recent coliform experience is provided below.

Portland Water Bureau – 2013 Non-Acute TCR Violation

- PWB serves more than 950,000 retail and wholesale customers in a geographic area of approximately 225 square miles. The majority of the water supply is unfiltered, surface water with additional supply from groundwater wells during emergencies and to supplement during summer peak season demand. The utility relies on chlorine to provide primary disinfection and adds ammonia to produce chloramines for secondary disinfection.
- In mid-September 2013, the system experienced a non-acute TCR violation, with total coliform positive (TC+) samples exceeding 5% of the total monthly TCR samples. One initial positive TCR sample cascaded into more positive coliform samples as the system collected repeat samples nearby. No samples were positive for *E. coli* during this event.
- In response to the event, PWB temporarily removed tanks from service, implemented increased spot and unidirectional flushing, unidirectional flushing, and increased the chlorine target leaving the water treatment plant.

- PWB contracted with Confluence to assess the effectiveness of these strategies. It was concluded that in addition to deep cycling of reservoirs with poor water quality, initial spot flushing may have drawn contaminated water further into the system and/or may have disturbed biofilms containing coliform bacteria, perpetuating numerous positive samples in a specific pressure zone. Data collected during conventional spot flushing activities in the affected area (see Figure 4) also suggest that chlorine residual improvements were very short lived (less than 24 hours).
- PWB's current flushing program consists of limited conventional and unidirectional flushing. Conventional flushing is used by PWB with the overall goal of reducing water age and responding to customer complaints (dirty water issues and taste and odor complaints when appropriate). On the other hand, UDF is generally a proactive program with the overall goal of removing sediment deposits and biofilm from the system. Both types of flushing are important tools to the utility; however, development and implementation of an effective, holistic flushing program has been challenging for PWB. This is due, at least in part, to lack of knowledge and guidance on the subject, lack of tools to evaluate efficacy of the existing programs, training, and staffing levels. At PWB's current staffing level, it is estimated that it would take xx years to UDF the entire system; as a result, PWB's UDF program is limited to targeted areas with known water quality issues. In terms of the conventional flushing program, there are two staff members that spend a portion of their time spot flushing throughout the entire system.

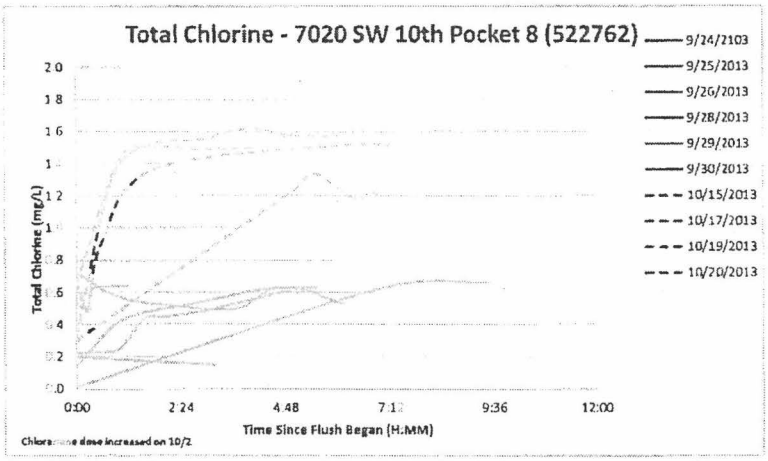

Figure 4. Chlorine profiles from sequential spot flushing efforts.

SPU – 2014 Coliform Positives and E. coli Event in Purveyor System (Mercer Island)

- SPU serves approximately 1.4 million retail and wholesale customers in the greater Seattle areas. SPU's transmission and distribution system consists of over 1,800 piles of pipe, over 40 percent of which is unlined cast iron, and over 25 finished water storage facilities ranging in

size from 0.9-60 MG. The supply comes from two protected watersheds in the Cascade Mountains. The Cedar River source is an unfiltered surface water supply that provides 60-70% of water demand. The South Fork Tolt Reservoir is a filtered surface water supply that provides the remainder of the demand. Both sources rely on free chlorine to provide secondary disinfection (Harper, WQTC, 2014).

- Similar to many water utilities, SPU is trying to determine an appropriate level of flushing for their system, balancing costs and benefits. Measuring the benefits has been a challenge. In the past, SPU experienced numbers of positive coliform samples near the regulatory limits. That led to several efforts to improve distribution water quality, including coordinated proactive water main flushing. Competition for resources over time lead to a reduction in the flushing program and the need to look more closely at the benefits and costs of flushing.
- Over the past 10 years, SPU has averaged approximately 10 TC+ samples per year. However, for the two-day period September 24-25, 2014, SPU reported a total of 7 TC+ samples from 3 separate systems served. Of these 7 detections, 5 different bacteria were identified in speciation.
- During this same time period, the City of Mercer Island (one of SPU's wholesale systems) experienced multiple *E. coli* detections (EC+) in various locations of its DS. The first EC+ result and following positive results two days later triggered a precautionary boil water notice implemented by Mercer Island with support from the Washington State Department of Health (DOH). DOH and Mercer Island jointly agreed to lift the boil water order after repeat samples were absent, only to re-impose the order when additional EC+ results were obtained a few days later. Figure 5 captures images from around Mercer Island during the Boil Water Advisory.

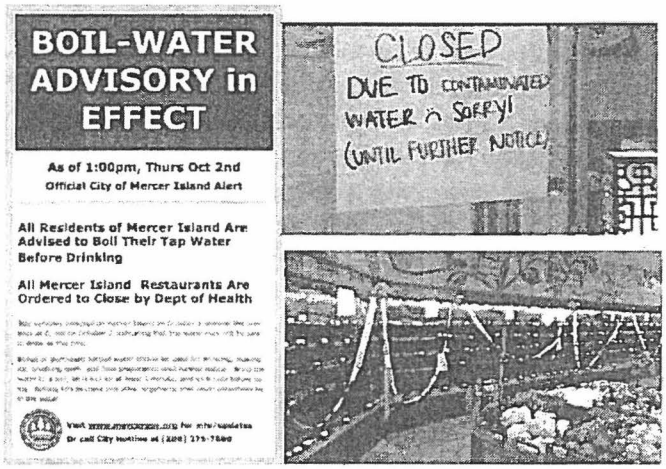

Figure 5. Affects of E. coli Event – Mercer Island

(Source: Muto, 2014. Operational Response to an E. coli Event and Lessons Learned – Sammamish Plateau Water and Sewer District Workshop)

- With guidance and oversight from DOH, Mercer Island implemented a response action plan that included increased monitoring, inspection activities, system-wide booster chlorination, and flushing activities. The goals were to try to identify potential causes, document existing conditions, and improve DS water quality to fully eradicate the problem.
- The City of Mercer Island contracted with Confluence to conduct an "After Action" evaluation of possible causes of the coliform event, the effectiveness of response strategies including flushing, and additional corrective actions needed. While no "silver bullet" with regard to a specific contamination source or point of entry could be identified, contamination risks such as numerous below grade air-vac vaults, high-hazard cross connections lacking test verifications, and lapses in cross connection control program enforcement were identified.

Task 2 – Field Evaluations of Flushing Effectiveness

There will be four major activities in Task 2:

1. Characterize bulk water chlorine demand to differentiate from demands associated with pipe walls and accumulated deposits (collectively referred to as pipe wall demands)
2. Develop flushing plans
3. Develop sampling, monitoring, and analytical plans
4. Conduct flushing field trials and assess effectiveness and duration of benefit as a function of flushing technique and pipe material

1. Characterize Bulk Water Disinfectant Demand

When flushing is used to prevent or respond to biofilm challenges, an implicit goal is to minimize long-term chlorine demand/decay (CDD) brought about by pipe wall effects in order to improve and stabilize disinfectant residual levels. Long-term disinfectant residual demand/decay reactions typically occur according to a rate expression of the form: $R = dC/dt = -KC^n$, where n is the reaction order and K is the overall rate coefficient. For the first-order reaction (n=1) typical of chlorine residual behavior, CDD is represented as $C_o(1-e^{-Kt})$. To assess the impact of flushing on disinfectant residual stability, it is necessary to separate the overall rate coefficient into its constituent terms: k_b and $k_w \cdot a_v$, representing bulk water and pipe wall effects, respectively. The pipe wall term, and specifically, any change in this term due to flushing, can be determined by characterizing overall CDD and the bulk water component and calculating the difference.

For each utility, the bulk water CDD component will be characterized through the use of bench-scale Simulated Distribution System (SDS) tests. SDS testing will be conducted on samples collected from the Point of Entry (POE) to each DS and at locations within each DS representative of the pipe material, water age, and water quality where flushing activities will be conducted. Flushing activities will be performed as soon as is feasible after the SDS tests are completed, so that the bench-scale results are as representative as possible. It is anticipated that five tests will be conducted at PWB (1 POE, 2 unlined cast iron, 2 cement-lined ductile iron), and four tests will be conducted at SPU (1 POE, 2 unlined cast iron, 1 cement-lined ductile iron).

2. Develop Flushing Plans

Four different flushing techniques representative of the most commonly-applied approaches in the industry will be evaluated at each system:

- Conventional spot flushing
- Dead-end conventional flushing
- Quasi-unidirectional flushing
- Strict unidirectional flushing

Brief descriptions of each technique in terms of hydrant set up and expected water quality response are provided in Table 1.

These techniques will be applied in a controlled manner in pre-selected areas of each DS. Site selection will be guided by the desire to capture different pipe types (likely unlined cast iron and cement-lined ductile iron), evaluate known problem areas with respect to disinfectant residual maintenance and/or biofilm growth, and considering logistical feasibility to implement and support the project objectives.

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Table 1. Summary of Flushing Technique and Expected Water Quality Response

Flushing Technique	Expected Water Quality Response
Conventional Spot Flushing -Select hydrants are opened at low rate. Flow originates from multiple directions and pipe segments.	• Bulk water turnover. Little-to-no pipe cleaning benefit. • Improvement in disinfectant residual, HPC, etc. attributable to water age reduction. • Water quality improvements expected to be: ***localized***; ***limited*** in magnitude (due to need to use low flow rate); and ***temporary*** (conditions gradually revert to pre-flush baseline, with exception of any bulk water contamination purged). • Higher flows can accelerate process but risk disturbing sediment and/or spreading contamination.
Dead-end Conventional Flushing -Similar to conventional spot flushing, but dead-end location results in a single flow path for the local pipe segment.	• Typically similar response as conventional spot flushing, although the unidirectional flow may provide local pipe cleaning and improve the post-flush response. • Higher flows can accelerate process but risk disturbing sediment upstream. • Presents an opportunity to evaluate water age versus pipe wall demand effects.
Quasi-Unidirectional Flushing -Hybrid of conventional and UDF. Specific mains (not part of a larger, complete sequence) are valved for high-rate unidirectional flow. Lacks a true upstream clean water source.	• Specific main segments are cleaned; pipe wall issues are addressed on a local basis but the water introduced from upstream is not "clean." After ~2 pipe volume (PV) turnover, additional improvements are primarily water age reduction. • Post-flush water quality response would likely be comparable to conventional flushing, with improved new baseline depending on the length of upstream main cleaned. • High flow rates used creates potential for upstream issues (disturbing sediment).
Strict Unidirectional Flushing -Organized sequential main cleaning from a clean starting point. Requires extensive planning.	• All local and upstream pipes are (at least partially) cleaned; also achieves > 100% bulk water turnover. • After flushing, age-related component of water quality degradation will return to prior condition. Overall water quality improvement depends on % of initial degradation attributable to water age vs pipe effects, and effectiveness of cleaning. • Use of high flow rate with controlled process results in least amount of water used and avoids risk of disturbing sediment without removal.

Flushing plans (including maps, hydrants, valves, discharge locations, etc.) will be developed to characterize the effectiveness of flushing techniques as a function of:

- Pipe material (cement-lined ductile iron and unlined cast iron) and initial condition
- Disinfectant residual and CDD response
- Microbial and nutrient removal profiles and
- Duration of improvement post-flushing.

For example, with regard to disinfectant residual response, we will characterize the following:

- Bulk water demand (measured prior to conducting flushing trials)
- Spatial/Pipe network demands
- Localized pipe wall demands

Figure 6 illustrates operational scenarios for each of the four flushing techniques targeted in this study and provides a conceptual comparison of the expected post-flush disinfectant residual response profiles for each, consistent with the expected response description in Table 1. The anticipated spatial and temporal variations will be used to guide the monitoring plan, as discussed in the following section.

3. Develop Monitoring and Analytical Plans

Distribution system water quality monitoring planned for this research falls into two categories: (1) investigative "routine flow" monitoring to assess baseline and flushing response conditions, and (2) sampling of flush discharge streams to assess the inventory of microbes, nutrients, etc. removed from the mains under varying techniques.

With regard to the former, the monitoring strategy is based on the premise that flushing produces a transient response in which bulk water quality (represented by disinfectant residual concentration) undergoes a shift from an initial pre-flush baseline to a new post-flush steady state condition. Figure 7 illustrates a conceptual profile of this response for an application involving strict UDF. The magnitude of the shift (with related implications for the pipe wall term) and the timeframe needed for re-equilibration are the primary data goals to be identified through the trials.

During the transient response period, the concentration profile will have both spatially- (x) and temporally-dependant (t) components as governed by the unsteady-state material balance: $\partial C/\partial t = -v\partial C/\partial x + R$, where v = flow velocity and R = reaction rate, as previously defined. Thus, in order to characterize system response to various flushing approaches, it will be important to monitor multiple DS locations over a period of time long enough to cover the transient period.

Regarding locations, pre- and post-flush water quality monitoring will be conducted at multiple fixed sites along the general flow path. These sites will include:

- The zone/area entry-point
- The most immediate upstream "clean water source" used for the flushing area
- The locations of the flush hydrant
- Nearby locations that may experience changes in flow direction or velocity

Sites represented by the first three bullets will be used to develop and compare pre-flush vs post-flush CDD profiles. Cleaning performance will be evaluated as:

$$\Delta CDD_{x1\rightarrow x2} = CDD_{x1\rightarrow x2,\,final} - CDD_{x1\rightarrow x2,initial}$$

where x1 and x2 are fixed locations. Sites represented by the fourth bullet will be used to assess the potential for sediment and biofilm to be stirred up and transported in nearby pipe segments. For non-UDF approaches, steady-state hydraulic modeling may be performed to identify potential at-risk pipe segments based on changes in routine flow direction and/or velocities.

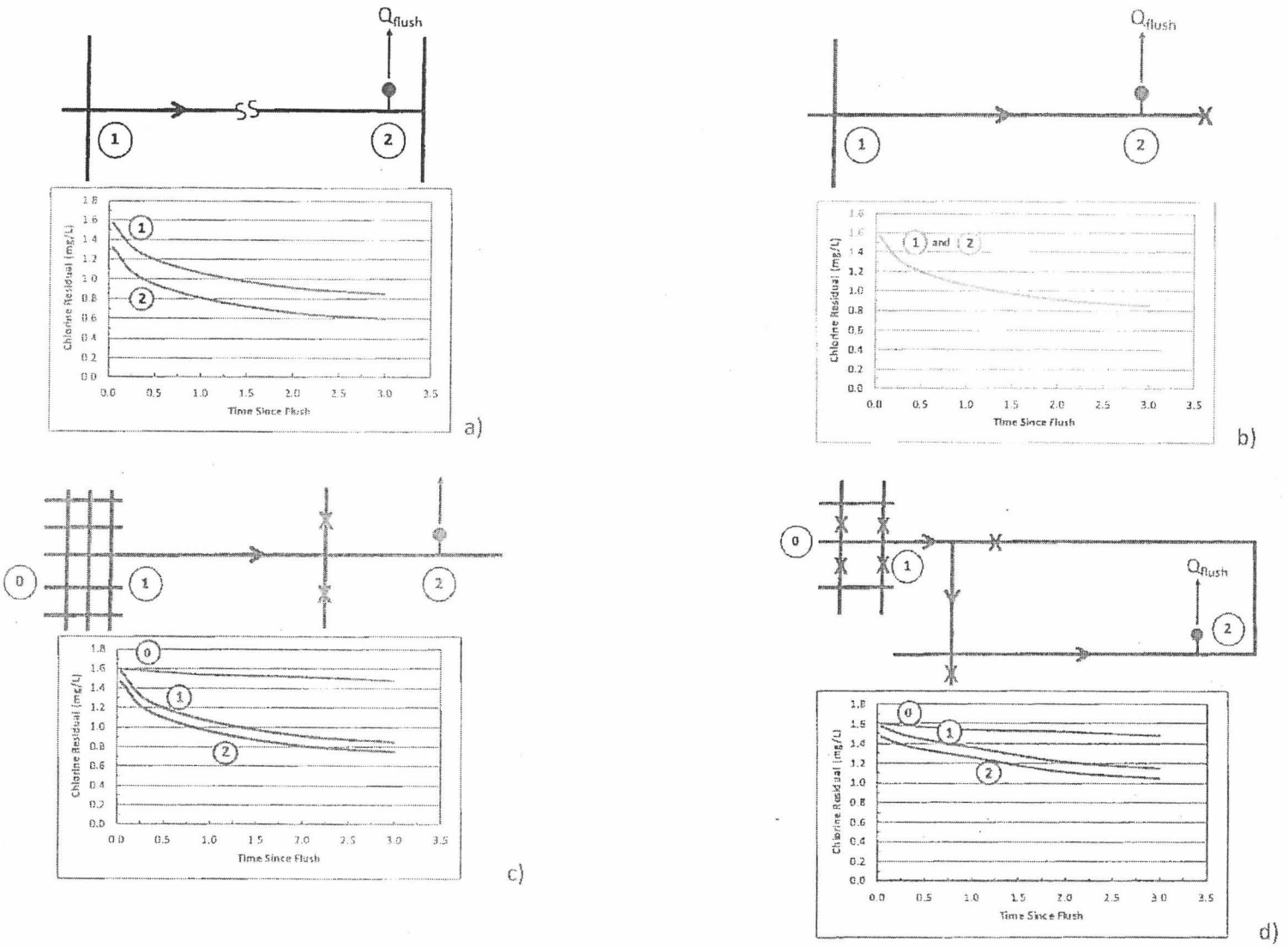

Figure 6. Hydrant configuration and conceptual chlorine residual profiles for: a) conventional flushing; b) dead-end flushing; c) quasi-UDF; and d) strict UDF. Numbers 0, 1, and 2 represent locations to be monitored spatially during the flush.

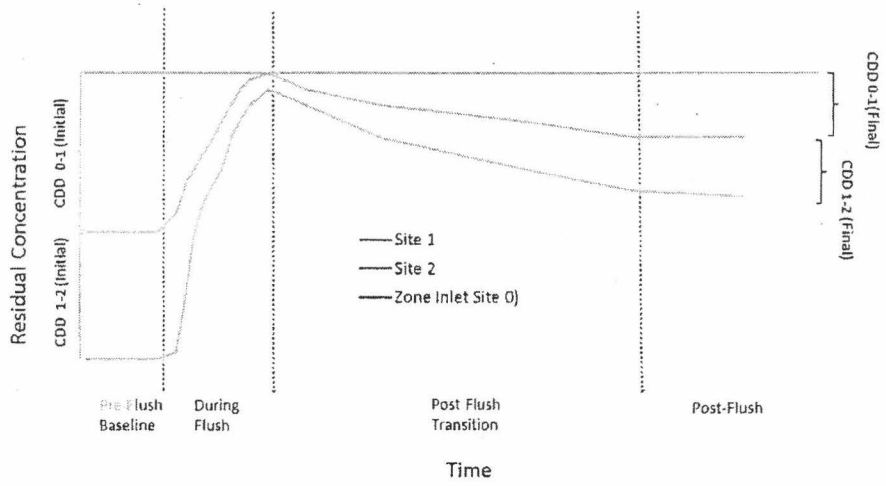

Figure 7. Hypothetical chlorine residual profile for strict UDF, illustrating change in baseline CDD conditions due to pipe cleaning.

Regarding timeframe, Figure 8 illustrates the anticipated sample timing scheme to be applied. The frequency and duration may be adjusted as the collected data are analyzed, and it is possible that flushing/sampling conducted in the Fall could be repeated in the Spring to assess longer term changes.

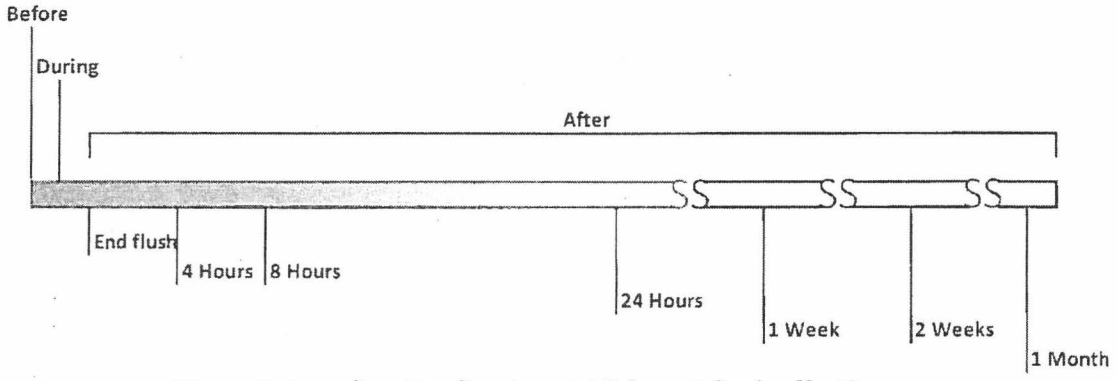

Figure 8. Sampling timeline to establish post-flush effectiveness.

Dead-end flushing will be studied on "stand-alone" dead-end segments and in conjunction with UDF leading up to the dead-end, to examine long-term water quality improvements and risks associated with each of these approaches. Because dead-end segments behave like batch reactors (i.e., primarily temporal variability with little spatial differences), these trials provide an opportunity to quantify the pipe wall coefficient before and after flushing and under different velocities.

Monitoring plans and analytical protocols will be developed to guide field activities. Analysis of samples collected during field trials will be performed by certified laboratories, including participating utilities and external laboratories. Protocols for sampling bulk water before, during, and after flushing will be developed for microbial, nutrient, organic, and inorganic constituents under consideration. Table 2 provides a preliminary analyte list. A range of parameters will be included to characterize microbial water quality. The microbial analyses will serve as surrogates for total coliforms when interpreting the data with regard to RTCR compliance, since we do not anticipate detecting total coliform during the field testing. Approximately $20,000 is being reserved for external laboratory work as described in the Budget Detail section of the proposal. This should allow for approximately 50 bacterial enumeration (flow cytometry) and microbial characterization (pyrosequencing and 16s) analyses, plus numerous other general chemistry and QA/QC checks on field and utility laboratory analyses. The research team has been communicating with Research and Testing Laboratory (Lubbock, TX) and Boston University with regard to performing the pyroseqequencing and flow cytometry analyses, respectively.

Table 2. Preliminary Analyte List

Parameter	Analysis Location				Method[1]
	Field	PWB	SPU	Commercial Lab	
General					
pH/Temperature	✓				SM 4500-H^+
ORP	✓				SM 2580
Conductivity	✓				SM 2510
Alkalinity		✓	✓		SM2320 B
Metals					
Fe (total/soluble)	✓				Hach 8008
Mn (total/soluble)	✓				Hach 8149
Solids					
Turbidity	✓				SM 2130B
Apparent Color	✓				Hach 8025
True Color	✓				Hach 8025
TSS		✓	✓		SM 2540
Disinfectant					
Cl2 Residual (free)	✓				Hach 8021
Cl2 Residual (total)	✓				Hach 8167
CDD		✓	✓		see notes[2]
Nutrients					
Total Ammonia	✓				Hach 10200
Free Ammonia	✓				Hach10200
Nitrite	✓				Hach 8507
Nitrate	✓				Hach 8192
Orthophosphate	✓				Hach 8048
Total Phosphorus	✓				Hach 8048[3]
TOC		✓	✓		SM 5310C
Microbes					
HPC		✓	✓		SM 9215B
Total Coliform		✓	✓		SM 9222B
ATP	✓				per vendor[4]
Biolog				✓	per vendor[5]
Flow Cytometry				✓	see notes[6]
Pyrosequencing				✓	see notes[7]
16s Analysis				✓	see notes[7]

Notes:

1. SM = Standard Methods.
2. Chlorine demand and decay (CDD) curves to be prepared, as described under "Task 2 – Field Evaluations of Flushing Effectiveness", above.
3. With digestion prior to analysis.
4. Using PhotonMaster™ luminometer from LUMINULTRA.
5. Using microbial identification testing protocol from Biolog.
6. Per Hammes et al., 2008.
7. Using similar methodology as described in Liu et al., 2014.

4. Conduct Flushing Trials

Flushing trials will be divided between the Fall of 2015 and Spring of 20136 based on allocation of project funds. It is anticipated that 10 trials will be conducted at PWB and 2 trials will be conducted at SPU during the Fall of 2015. An additional 6 trials (for a total of 8 at SPU) will be conducted at SPU during the Spring of 2016. As discussed above, four different flushing techniques will be demonstrated on unlined cast iron pipe and cement-lined ductile iron pipe.

Flushing trials will be used to evaluate mobilized microbial load, substrate constituents, and changes in the pipe wall component of disinfectant demand before and after various flushing approaches. The trials will help to identify unanticipated or unrecognized benefits and/or consequences of various flushing techniques. Just as the performance benefits of the various techniques can vary substantially, so too can the costs to implement them. To help utilities make cost-benefit decisions with regard to preferred mitigation strategies, it will be important to develop reliable cost estimates and note the key assumptions associated with such estimates. The participating utilities will track costs (labor, field equipment, etc.) associated with each technique so that the degree of benefit per unit cost can be assessed and included as part of Task 3 – Industry Guidance.

Our team has conducted flushing profiles at numerous other utilities, and hence we have developed peer-reviewed protocols and in-house spreadsheets and field-tested SOPs that are readily available. Figure 9 shows some examples of our team members in the field. We have used these protocols to track and evaluate mobilized constituents (primarily inorganics) compared to background levels, as a function of flushing technique, velocity, and duration (Friedman et al. 2003, 2010, 2015).

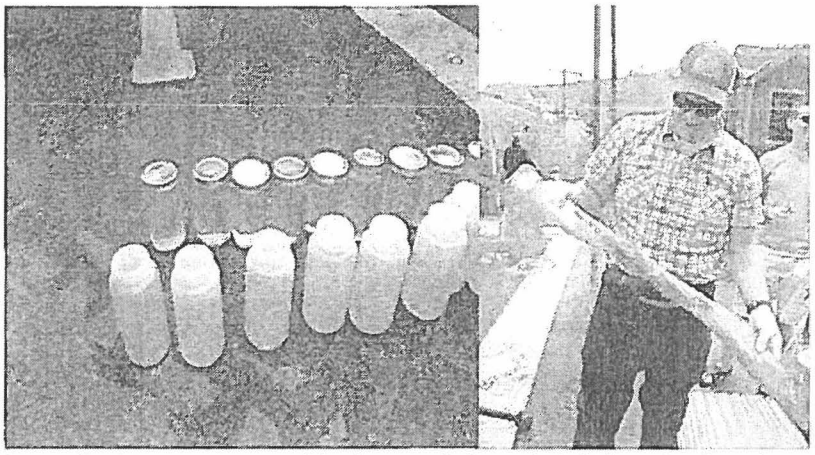

Figure 9. Hydrant flushing net assembly (upper left and right), paired grab samples of net passage water (lower left) and loaded net assembly (lower right) collected during a hydrant flushing tests.

For example, Figure 10 shows the solids removed during a flushing trial using two consecutive velocities at two sites from a utility in the Southwest. Table 3 summarizes the inventory of solids removed during flushing, normalized to pipe surface area. Table 4 summarizes Relative Cleaning Effectiveness (an operational definition of the normalized mass removed per a particular technique relative to the mass removed with the most aggressive technique, in this case two-pass swabbing) as a function of the various main cleaning techniques evaluated. A graphical representation of these Relative Cleaning Effectiveness data is presented in Figure 11. The data collection in the field and subsequent manipulation and analysis envisioned for this project is labor intensive and requires the development of detailed protocols, in order to be performed efficiently. Field testing approaches and data analysis for trace inorganics and substrate materials that our team has already developed have undergone peer-review as part of WaterRF project #4509. Those existing approaches can be efficiently adapted for this project.

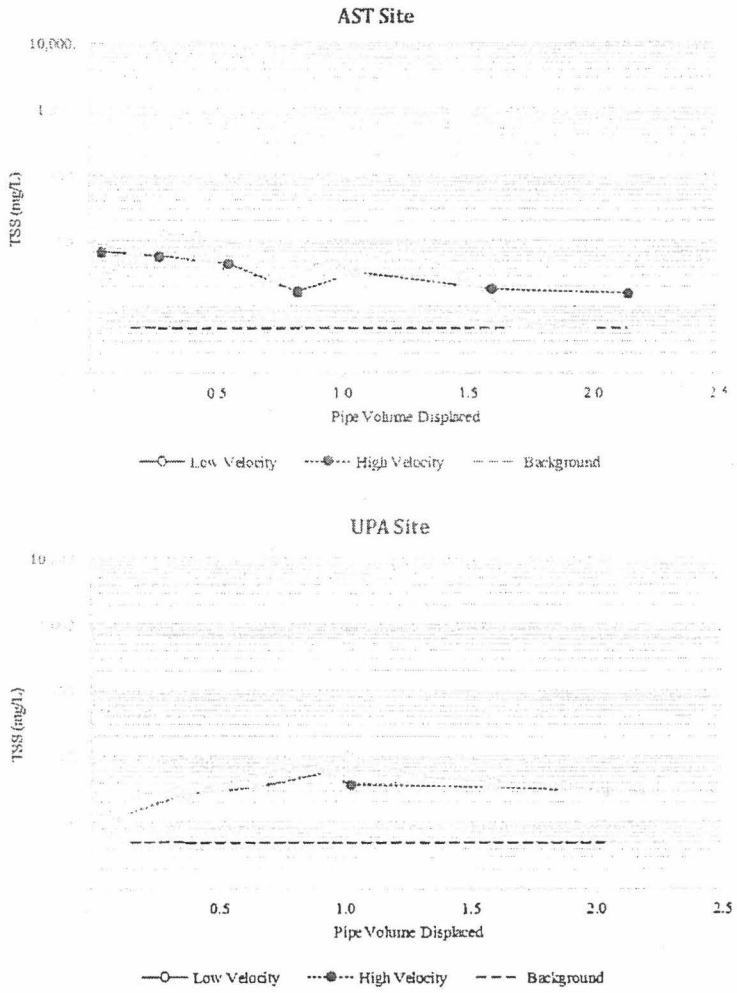

Figure 10. Total suspended solids discharge profiles for unidirectional flushing
(Source: WaterRF 4509- Friedman et al., 2015)

Table 3. Total solids mass removed for unidirectional flushing trials
(Source: WaterRF 4509- Friedman et al., 2015)

Condition	AST Site		UPA Site	
	grams	mg/ft²	grams	mg/ft²
Low Velocity	109	36.7	51	41.2
High Velocity Incremental	81	27.2	33	26.4
High Velocity – Cumulative	190	64.0	83	67.6
Low Velocity Contribution	57%		61%	

Table 4. Normalized total solids removed
(Source: WaterRF 4509- Friedman et al., 2015)

Technique	AST Site			UPA Site		
	lb/mile	mg/ft²	RCE[1]	lb/mile	mg/ft²	RCE
UDF – 3 fps	0.9	36.7	4%	1.0	41.2	7%
UDF – 6 fps[2]	1.6	64.0	7%	1.6	67.6	12%
Ice Pigging	11.7	479	56%	12.8	527	95%
Swab – 1 run	12.2	501	59%	11.9	488	88%
Swab – 2 runs[3]	20.8	854	100%	13.5	555	100%

[1]RCE = relative cleaning effectiveness
[2]Represents cumulative solids removed at 3 fps and 6 fps
[3]Represents cumulative solids removed from run 1 and run 2

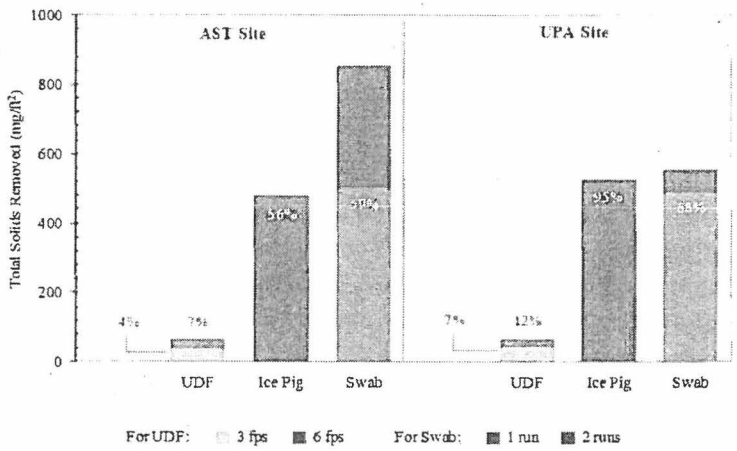

Figure 11. Normalized total solids removed (note: values shown as percentages reflect site-specific relative cleaning effectiveness, or RCE).
(Source: WaterRF 4509- Friedman et al., 2015)

Water quality analyses will be conducted as a function of flushing technique and pipe material for key parameters of interest including:

- Microbial load
- Nutrients
- Disinfectant demand
- Nitrification indicators

To our knowledge, this type of analysis related to flushing effectiveness and usefulness as a corrective action under the RTCR has not been conducted in the industry before.

Initial training on implementation of flushing and sampling/field analytical protocols will be provided by Confluence. Subsequent flushing rounds and follow up monitoring to demonstrate the

post-flush effectiveness will be implemented by the participating utilities. All data will be captured in data sheets prepared by Confluence and will be posted to a shared project drive for analysis by Confluence in subsequent tasks.

Task 3 – Develop Industry Guidance

In this task we will integrate the findings of the utility case studies and field evaluations into a packet of easy to use guidance materials.

Flushing Protocols and Data Collection SOPs

We will develop tables and matrices that summarize short-term and long-term performance of each flushing technique with regard to microbial and nutrient load removed, as well as impacts on each form of disinfectant demand evaluated (bulk water, upstream network, and pipe wall normalized to pipe length/diameter), and potential unanticipated consequences/risks of specific flushing applications. Example Standard Operating Procedures will be prepared that can be used by utilities and to serve as a checklist for regulators to ensure that proper flushing techniques are employed to address specific microbial occurrence pathways.

Decision Trees Based on Coliform Occurrence Pathway

Decision trees (DTs) or matrices will be prepared so that utilities and regulators can quickly consider the most appropriate flushing technique based on the likely coliform occurrence scenario. Risk factors that typically contribute to each occurrence pathway will also be summarized using materials available from the literature (USEPA Corrective Actions Guidance Manual, Friedman et al., 2009, Besner et al., 2011). The DTs are envisioned as a series of hard-copy tables and flow charts that will allow a utility to position themselves based on historical and existing water quality, treatment, and Operations and Maintenance (O&M) practices. This will allow for system-specific assessment of likely occurrence pathways and rapid implementation of the most effective flushing technique. An example of a summary matrix that was presented at WQTC in 2013 is shown in Figure 12.

Cause of Coliform +	Reactive Spot Flushing	Reactive UDF	Proactive UDF
Breakthrough	**Likely waste of water**	**Potentially Appropriate** •If coliform occurrence localized	**Potentially Appropriate** •Does not correct problem •May prevent build up in system
Direct Contamination	**Potentially Appropriate** •Can remove bulk water contamination •Does not correct cause of problem •Can spread problem if done incorrectly	**Most Appropriate** •Most likely to remove contamination without spreading	**Likely waste of water** •Does not correct problem •Can make problem worse if done incorrectly
Regrowth	**Likely waste of water** •May temporarily increase residual •Does not correct cause of problem	**Potentially Appropriate** •If regrowth localized	**Most Appropriate** • Can correct problem if done appropriately • Can be cause of problem if done incorrectly

Figure 12. Appropriateness of flushing as a corrective action under the RTCR
(Friedman, WQTC 2013)

Costs and Resources versus Measured Benefit

This effort will fill a critical industry data gap, and will allow utility managers to justify O&M expenses associated with various flushing techniques/programs. Absolute and unit cost estimates will be generated for each flushing technique by accounting for labor effort and direct costs. We propose to track, categorize, and summarize costs along key activity lines, such as: labor for planning (pre-inspection, loop development); labor for fieldwork (mobilization/demobilization, valve isolation, cleaning); consumables; etc. The following key conditions are known to impact site-specific costs and thus would be clearly defined and associated with the estimates:

- Staff and crew size needed, including third-party support
- Type and number of system retrofits needed
- Size of area to be cleaned (pipe-miles)
- Average length of cleaning loops (feet)
- Site-specific issues such as: water disposal, permitting, temporary water supply, etc.

Unit costs will be developed by normalizing absolute costs to the length of main cleaned and expressed as hours or dollars per pipe-mile. Tasks will also be characterized as either "one-time" or "repeat" to indicate future needs, as some planning tasks are a first-time-only need. For fieldwork, typical rate-of-cleaning estimates (pipe-miles per day) would also be developed. The advantages and disadvantages of each flushing strategy will be summarized so that a utility can tailor its response program according to its system-specific risk and its operational capabilities.

Task 4 – Project Management and Deliverables

The purpose of this task is to manage the overall project and prepare the project deliverables which will include periodic reports and the Draft and Final Reports to the WaterRF and the PAC. The importance of solid project management and communications cannot be overlooked for a complex research project to be successful. Therefore, a separate subtask has been created to ensure that proper time and resources are allocated to project management responsibilities including routine internal and external communications, QA/QC, and tracking of project deliverables, schedule, and budget.

Interim periodic reports will be prepared on an ongoing basis to provide a summary of the work completed, as required by the WaterRF. The Final Report will provide key findings and recommendations from each major project task including: recommendations for appropriate flushing techniques based on the likely cause of the coliform event; data collection and analyses protocols for bulk water and flushed samples, and associated costs; and what information is needed to demonstrate that flushing practices have indeed corrected a system deficiency that may have contributed to the cause or propagation of coliform positives within the distribution system.

4.4 Evaluation Criteria

Specific criteria that can be used to evaluate the development and success of each project objective are summarized below:

1) **Objective 1: Assess mobilization and removal of microorganisms, nutrients, and microbially-active sediments as a function of flushing technique.**
   a) Develop monitoring plans that can be implemented by utilities to conduct site-specific assessments.
   b) Sound lab procedures will be employed including microbial analysis methods cited in the RTCR as well as culture-independent methods to allow a broad assessment of microbial activity and removal effectiveness.
   c) Using input from participating utilities, appropriate and representative operating conditions for each flushing technique will be established prior to conducting field work.
2) **Objective 2: Evaluate bulk water response to change in pipe surface conditions due to flushing.**
   a) Develop the work-plan to establish post-flush disinfectant residual and characterization of residual demand and decay.
   b) Demonstrate impacts (magnitude, duration) of flushing practices on disinfectant demand and residual stability.
3) **Objective 3: Use findings to provide the basis for investing in preventative flushing for microbial water quality control in the distribution system**
   a) Summarize level of effort expended and microbial water quality benefits achieved as a function of flushing technique and pipe material.
   b) Where feasible, identify alternative water quality control strategies (booster disinfection, water age management, pipe replacement etc.) that may provide more widespread, longer-lasting, or more cost-effective water quality improvement compared to flushing.
4) **Objective 4: Provide protocols and guidance to ensure that flushing is indeed a corrective action under the RTCR, and that scarce resources are used effectively to meet intended water quality objectives.**
   a) Provide guidance on the applicability, benefits, and potential risks of various types of reactive flushing in response to coliform events.
   b) RTCR language and rule intent will be applied to assess appropriateness of flushing as a corrective action and identify potential risks in comparison to potential benefits.
   c) SOPs and checklists will be provided for utility use and to support the regulatory assessment process.

5.0 APPLICATIONS POTENTIAL

There is little information available in the literature on the effectiveness of flushing for enhancing microbial water quality. Specifically, there is a need for a better understanding of the following with respect to flushing:

- Biofilm and nitrification control
- Removal of microbially-active scale and sediments
- Removal of nutrients and substrates
- Reducing disinfectant demand

By providing greater insight into these aspects of flushing, this project will help utilities to improve compliance with the RTCR by providing specific guidance for more appropriate application of flushing as a corrective action under that rule. Utility managers, water quality specialists, distribution system operations managers, and flushing crews will be able to directly apply the findings from this research project to improve the cost-effectiveness of flushing operations.

Two utilities: PWB; and SPU will be directly involved in the design of the experiments, field trials, data collection, and analysis. Both of these utilities have had recent issues with coliform occurrence within their own and/or purveyor distribution systems. All field work will be performed directly on their actual distribution systems, will be representative of actual conditions, and hence relevant to the water industry. The usefulness of the results to the water industry will be maximized since both a chloraminated system (PWB) and a system using free chlorine (SPU) are being included in the study.

Specific deliverables include:

- **Two case studies** summarizing PWB and SPU experiences with coliform occurrence and the history of their flushing programs.
- **Direct comparison of the effectiveness of different flushing techniques** for enhancing microbial control. Flushing techniques evaluated will include conventional, dead-end, quasi-UDF and true UDF. This range of flushing practice will provide a comprehensive assessment and allow broad applicability of the results to the water industry.
- **Flushing protocols and data collection SOPs**. Tables and matrices that summarize short-term and long-term performance of each flushing technique with regard to microbial and nutrient removal, as well as impacts on each form of disinfectant demand evaluated will be provided. Example SOPs will be prepared that can be used by utilities and will serve as a checklist for regulators to ensure proper flushing techniques are employed to address specific microbial occurrence pathways.
- **Decision trees based on coliform occurrence pathway**. Decision trees will be prepared so that utilities and regulators can quickly select the most appropriate flushing technique based on the likely coliform occurrences scenario. Risk factors that typically contribute to each occurrence pathway will be summarized. The advantages and disadvantages of each flushing strategy will be summarized so that utilities can tailor their response according to its system specific risk and operational capabilities.
- A **cost/benefit analysis** will be included to help utility managers to justify O&M expenses associated with various flushing techniques and programs. Absolute and unit cost estimates will be generated for each flushing technique accounting for labor effort and direct costs.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

6.1 Introduction

This section addresses the quality assurance/quality control (QA/QC) requirements for data collection and analysis for this project. The major goal for QA/QC is to ensure that the Project Team, PWB, and SPU are collecting and analyzing data in a consistent manner, and that the laboratory analyses follow accepted QA/QC procedures.

The following sections address the QA/QC practices that will be implemented by the Project Team to ensure the validity of this project's findings. QA/QC will be implemented to cover the following aspects of the project:

- Site selection criteria and sampling procedures
- Field analyses
- Laboratory analyses
- Data storage and reporting

Since federal funding is not being provided, a Quality Assurance Project Plan (QAPP) as prescribed by the USEPA in EPA QA/R-5 is not required.

6.2 Site Selection Criteria and Sampling Procedures

Samples will be collected and analyzed for the purposes defined in the objectives, research plan, and other sections of this proposal. In general, all measurements will be made such that the results are measured to a target precision and accuracy, representative of conditions being assessed, and complete. Appropriate procedures will be utilized to ensure that all samples collected for analysis are statistically representative of the studied system. The data quality objectives for precision and accuracy for each measurement will be at least as stringent as those specified in *Standard Methods*, and more stringent, if needed, to meet the objectives of a particular experiment.

6.3 Field Analyses

Analyses performed in the field will be conducted as part of specific flushing evaluations. Analyses will be performed to be representative of bulk water conditions and in order to avoid degradation or other unwanted changes between sample collection and analysis. Confluence will develop standard procedures for conducting sampling in the field with input from utility staff. The procedures will be reviewed by all individuals conducting field work so that field sampling procedures are consistent. Utility and Confluence staff will participate in demonstration of established procedures.

The hypotheses to be tested and project objectives are listed in the body of the proposal. This QA/QC plan contains the basic components of accuracy, precision, completeness, representativeness, and comparability as described in Guidance for the Data Quality Objectives Process (U.S. Environmental Protection Agency 1994); EPA Guidance for Quality Assurance Project Plans (U.S. Environmental Protection Agency 2002), and Practical Methods for Data Analysis (U.S. Environmental Protection Agency 2000). The raw data, and precision and accuracy checks on the raw data for the microbiological studies and chemical analyses, will be organized in a form to permit defense of the data and the conclusions drawn.

To ensure the consistency of the data among laboratories and analysts: 1) all field analyses will done in accord with *Standard Methods*; 2) only experienced analysts that have already demonstrated competency (satisfactory precision and accuracy) will be permitted to conduct sampling and analyses; 3) when analyses are to be done in the field, the accuracy of the results will be confirmed in advance by analyzing external standards (to insure accuracy) and split samples (to verify that matrix effects and interferences are not biasing the results); and 4) uniform collection, handling, storage, preservation, and labeling procedures will be adopted for all project-related samples.

Methods for analysis of water samples will be conducted using accepted procedures (i.e. per Standard Methods for the Examination of Water and Wastewater). Water samples to be used in precision analyses will be collected, handled and preserved according to Standard Method 1060 and stored, when required, at 4°C. Metal-containing samples will be routinely acidified. Filtration will be carried out using pre-washed standard 0.20 or 0.45 µm filters, or filters with other nominal pore sizes, as needed.

Field Sampling and Instrumentation

Field instruments and equipment used for field analysis include Hach DR 2800 spectrophotometer, Hach DR 900 colorimeter, Hach 2100Q portable turbidimeter, Hach HQ 40 multimeter with probes for pH, temperature, DO, ORP, and conductivity, Oakton 110 pH/ORP meter, Hach digital titrator, and Hach 45600 COD block digester.

6.4 Laboratory Analyses

Analyses will be performed at the laboratories of PWB, SPU, and commercial labs. Standard QA/QC procedures will be followed for all analysis. Sufficient analysis time will be dedicated to quality control, including analyses of blanks and standards. Analytical precision will be determined by multiple analyses on a single sample. Approximately ten percent of the samples will be analyzed in duplicate. Accuracy will be calculated from internal standards, standard additions, or external standards. Quantification of internal and external standards will be held to accepted precision throughout the study. Analyses in which any measures of QC parameters fall out of control of the data quality objectives will be flagged, corrective action will be taken, and all analyses in that analytical batch will be repeated. Standard curves used in the determination of all parameters shall be prepared following standard methods. Calibration controls, using check samples, will be required for all analytical operations. Matrix spike duplicate samples will be spiked with standard material and percent recovery and relative error will be calculated to demonstrate whether the analysis is being performed with the required precision and accuracy to satisfy the QA/QC objectives. The reported selectivity, sensitivity, accuracy and precision for these procedures are adequate to meet the data quality objectives of the project. Holding times for the various analyses will not be exceeded.

To ensure that contamination from glassware or reagents is not interfering with sample analysis, a reagent blank will be analyzed. The laboratory control sample (LCS), a blank spiked with a known amount of analyte, provides information on the overall performance of the analysis without matrix effects. The need for corrective action may be identified by system or performance audits or by standard QC procedures. The essential steps in the corrective action system are: (1) Identification and definition of the problem; (2) Assignment of responsibility for investigating the problem; (3) Investigation and determination of the cause of the problem.

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Portland Water Bureau

The Portland Water Bureau Laboratory is accredited by the Oregon Environmental Laboratory Accreditation Program (ORELAP), which requires that laboratories meet the standards adopted by the national program NELAP. The essential standards outlined in the 2009 TNI Standards, the requirements of 40 CFR Part 141, the 2005 Certification Manual for Drinking Water Laboratories, and the appropriate editions of Standard Methods, are incorporated into the Quality Manual and in the Standard Operating Procedures for each analytical method. All quality control measures are assessed and evaluated on an on-going basis and quality control acceptance criteria are used to determine the validity of the data.

PWB is ORELAP accredited to perform the following analyses:

- pH
- Alkalinity (SM2320 B)
- Fe (EPA 200.8)
- Mn (EPA 200.8)
- Turbidity
- Free Cl2 Residual (SM 4500-Cl D)
- Nitrite (SM4500-NO3 F)
- Nitrate (SM4500-NO3 F)
- TOC
- HPC (standard media at 35°C)
- Total and fecal coliform
- E. coli

PWB also has the capability to perform the following analyses of relevance to this project:

- ORP
- Conductivity
- Apparent Color
- TSS
- Total Cl2 Residual
- Free Ammonia
- Total Ammonia
- Orthophosphate (SM 4500-P F)
- Total Phosphorus (SM 4500-P F)
- ATP

Seattle Public Utilities

SPU is accredited for a wide range of analyses under the Washington State Department of Ecology (WDOE) Environmental Laboratory Accreditation Program. QA/QC procedures are maintained for each analysis as part of the method and part of each respective standard operating procedure. Beyond the accredited methodology, QA/QC is incorporated into maintaining and operating analytical equipment, data integrity and validation, documentation, reagent and media preparation, and appropriate staffing. Each of these additional components is also reviewed by WDOE on an annual basis.

Selected analyses for which SPU is accredited include:

- Alkalinity
- Specific Conductance
- Color
- Turbidity
- Hardness
- Total dissolved solids
- Total suspended solids (non-potable)
- Chlorine (Residual), Free
- Chlorine (Residual), Total
- Total Organic Carbon
- HPC
- Total and fecal coliform
- E. Coli
- Numerous metals
- Regulated VOCs and SOCs

6.5 Data Storage and Reporting

Standardized data formats for collection, calculation and reporting of data will facilitate the generation of comparable data. All project data will be entered into notebooks and electronic data files for computerized data management and statistical analyses. The on-site analyst will be responsible for verifying sample identification codes and checking that proper data transmission has occurred.

The validation of data will be the responsibility of the Principal Investigators, and will be based on the following approaches:

- The Principal Investigators will prepare the guidance on sample collection, analysis methods, and QA/QC for utility collection and field water quality analysis.
- Lab managers at PWB an SPU will be responsible for verifying that appropriate QA/QC procedures are implemented and followed at each of their repsective labs.
- Any anomolies or data found to be outside acceptable ranges for QA/QC will be duly noted.

Experimental results will be summarized in tabular and/or graphical form and reviewed at least quarterly by the Principal Investigators to check for trends and inconsistencies. Once data collection is completed, the Research Team will carefully and critically review and summarize the information provided.

Back-up copies of all data will be maintained at Confluence. All data will be reviewed for accuracy and completeness and any error will be resolved by communication with the information source. This approach to data management, applied from the beginning of the project, will facilitate the subsequent review and interpretation of information provided by the participating utilities.

Statistical Analysis Methods

Data analysis will employ commercially available statistical programs. Principle procedures to be used will include regression analysis, descriptive statistics such as the mean, range, standard deviation, and

confidence intervals for the mean. Comparative and inferential data analysis will be done using analysis of procedures and/or multiple linear regression analyses. Exploratory procedures, such as principal component analyses, may also be used. The data reduction schemes for analytical measurements, including all equations used to calculate concentration or values of measured parameters and reporting units are contained in the standard methods.

6.6 Safety

Existing safety plans for laboratory work conducted at PWB and SPU are in place and will be followed during analysis of project-related samples at both of these facilities. These plans include information on chemical hygiene and proper handling and disposal of hazardous substances. All laboratory personnel are required to familiarize themselves with the plans.

Field sampling protocols will include safety considerations and will be consistent with existing safety plans of the PWB and SPU.

7.0 MANAGEMENT PLAN AND STATEMENT OF QUALIFICATIONS

Principal Investigators

Our **Principal Investigator (PI) and Project Manager** will be **Melinda Friedman, P.E.**, President of Confluence Engineering Group, LLC (CEG). Melinda has spent the past 20 years studying and providing consulting services related to maintenance of distribution system water quality. Melinda has served as the PI for seven completed WaterRF studies (4509, 4109, 3118, 3116, 2875, 2606, 2686), and has served as co-PI or Project Manager for five additional WaterRF studies. She has successfully demonstrated her abilities to lead diverse teams, work with PACs, and meet project objectives according to established budgets and schedules. Melinda will lead the overall team, and will be directly responsible for project outcomes. She will commit approximately 11% of her time to this project over the 21-month schedule.

Co-PI Andrew Hill, P.E., is a Project Manager at CEG. Andrew and Melinda have worked together for over 10 years and have collaborated successfully on four completed WaterRF studies (4509, 3118, 2606, 2686). Andrew served as the technical lead for WaterRF 3118 – *Assessment of Inorganics Accumulation in Drinking Water Systems Scales and Sediments*, and is currently serving as Co-PI along with Melinda Friedman for WaterRF 4314 - *Legacy of Manganese Accumulation in Water Systems: Assessment, Consequence, Remediation, and Prevention*, and 4509 – *Metal Accumulation and Release within Distribution Systems*. Andrew will oversee development of field sampling plans and will lead the effort to evaluate the effectiveness of flushing techniques. He will also be a key contributor to all project deliverables. Andrew will commit approximately 14% of his time to this project over the 21-month schedule.

Key Project Staff

Michael Hallett is the Business Manager and Field Scientist at CEG. For more than 25 years Michael has worked in a wide variety of positions within the field of physical sciences, with experience in the collection and analysis of air, water, and soil samples. He will assist with the administrative management of the project and budget and will lead the field work. Michael will commit approximately 5% of his time over the 21-month schedule of the project.

Stephen Booth, Ph.D., P.Eng., is a Sr. Project Manager with CEG. Stephen has 16 years of professional experience specializing in water treatment process evaluations and water quality studies. He has led studies to evaluate water quality, corrosion control, taste and odor, and emerging contaminants. Additionally Stephen has expertise in treatment process selection, pilot testing, and optimization of treatment processes. Stephen will commit approximately 4% of his time over the 21-month schedule of the project.

Key Co-Sponsoring Utility Staff

Yone Agaki is the Water Quality Compliance Manager for the Portland Water Bureau (PWB). She is currently the chair of the AWWA Organisms in Water committee. Yone worked on a previous Tailored Collaboration project 4348 - *Matrix Effects on Cryptosporidium Oocyst Recovery* and has or is currently serving as a Project Advisory Committee (PAC) member on three WaterRF projects. Yone will spend up to 5% of her time on this project over the 21-month schedule.

Kimberly Gupta is a Water Quality Engineer at PWB and has 13 years of experience in the drinking water industry. Her primary responsibilities include working on distribution system issues related to nitrification, DBP formation, corrosion control and emerging contaminants. Kim is an active member of the AWWA Inorganics and Distribution System Water Quality Committees. She will spend up to 10% of her time on this project over the 21-month schedule.

Jim Nilson, P.E. is a senior water quality engineer at Seattle Public Utilities (SPU) with over twenty years of experience. For the past 10 years at SPU, Jim has had a broad range of responsibilities overseeing water quality issues, including source water quality monitoring and protection, water treatment operations and

performance, management of distribution water quality, and regulatory compliance. Recently, Jim has served on the PAC for WaterRF Project 4222 and contributed to WaterRF Project 4307, he serves on the AWWA UV Disinfection Committee the Disinfection of Facilities Committee, and he worked with the AMWA Regulatory Committee during the development of the Agreement in Principle for the RTCR.

Wylie Harper, P.E. is the director of drinking water quality for SPU. Previous work experience includes serving on active duty as an Army Medical Service Corps officer and Sr. Environmental Engineer with the Army Center for Health Promotion and Preventive Medicine. He has been with SPU for 12 years as a Sr. Water Quality Engineer, Laboratory Manager, and currently is in charge of drinking water quality and treatment for SPU. Wylie will commit approximately 5% of his time over the 21-month schedule of the project.

Project Organization

Confluence Engineering Group, LLC will be the research contractor and will manage the project using established tracking and scheduling procedures to document work progress and expenditures. Melinda Friedman will lead all project administrative tasks, and will work closely with Andrew, Michael and Stephen to ensure quality control, oversee deliverable development, tracking internal and overall project budgets, and project schedule. Melinda will also communicate routinely with both Yone and Jim and the Foundation's Project Manager on both technical and project management-related matters. Melinda's experience conducting WaterRF projects and understanding of protocols will provide for efficient management and communication throughout the project. Specific technical responsibilities have been clearly defined and are shown in the project organizational chart, included as Figure 1.

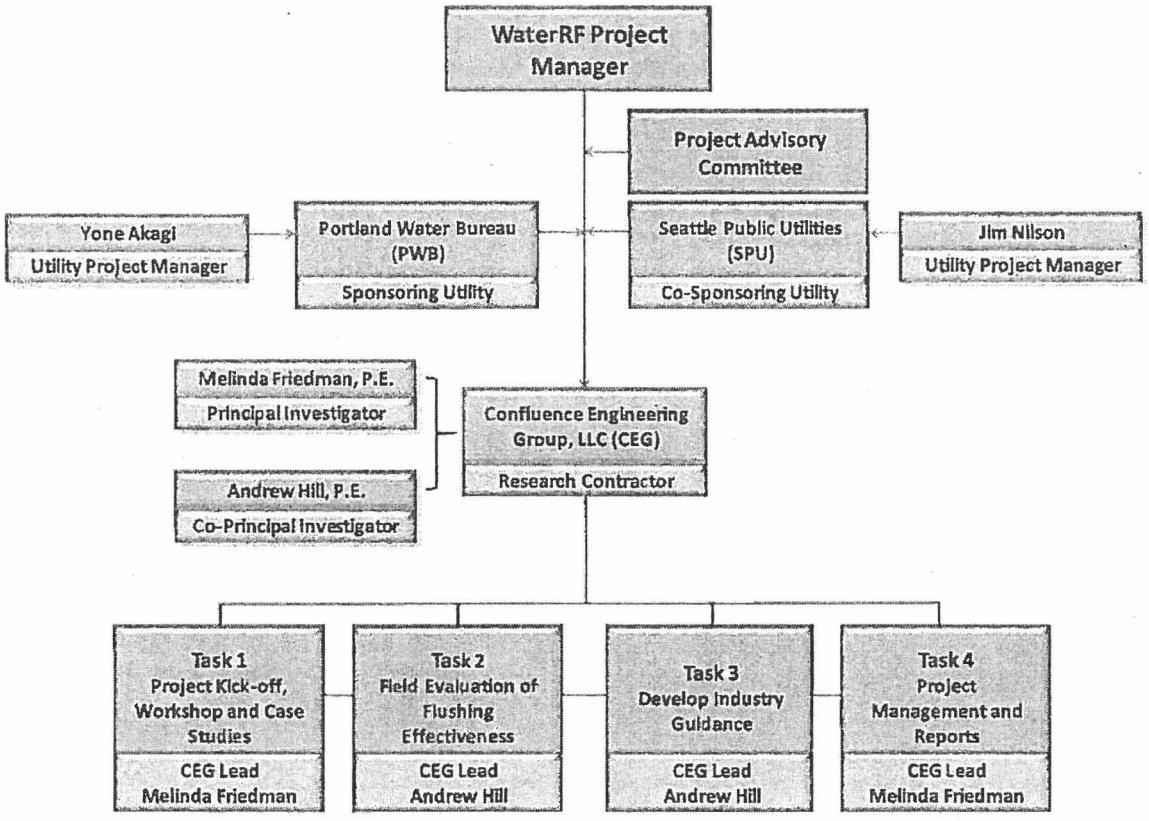

Figure 1. Project Organizational Chart

8. References

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USEPA, 2014. The Revised Total Coliform Rule Assessments and Corrective Action Guidance Manual (Interim Final).
http://water.epa.gov/lawsregs/rulesregs/sdwa/tcr/regulation_revisions.cfm#proactions

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10. SCHEDULE

As shown in the figure below, it is anticipated that this project will encompass 21 months from the Notice-to-Proceed to submission of the Final Report. We propose to hold a kick-off workshop with the participating utilities at PWB as part of Task 1, within the first two months to set the stage for subsequent project tasks. All 10 of PWB's Task 2 field trials, and two of SPU's field trials will be planned during the first quarter of the project. A conference call will be held with the PAC to discuss the progress of the planning, the monitoring plans, and key considerations for implementation. The PAC will have the opportunity to review and comment on these materials prior to implementation of the field protocols. We conduct the field trials during the late fall/early winter of 2015. When the remainder of SPU's funding is received by the Foundation in January, 2016, we will conduct an additional six trials at SPU, anticipated for spring 2016. When the field trials are complete and the Project Team has had time to evaluate results, we will hold a PAC meeting at SPU's office in Seattle. This is anticipated to occur in late summer of 2016. The draft report will be submitted in early winter 2016, with the final report submitted by May, 2017.

We would like to emphasize that SPU's additional funding is already approved and reserved, so we do not anticipate any issues with conducting a second set of field trials in 2016. However, if for some reason this funding falls through, we will still have all 10 trials from PWB and 2 trials from SPU to use as the basis for the project findings and industry recommendations. In this case, the entire schedule will move up by four months. The draft report would be submitted in July, 2016, with the final report by the end of 2016.

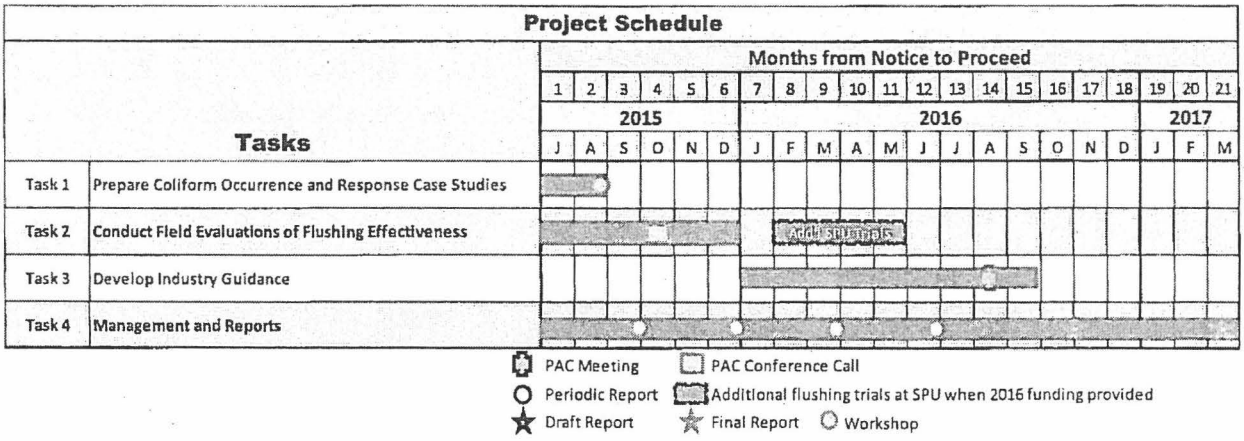

Exhibit A

187526

confluence
517 NE 92nd Street, Seattle, WA 98115 (206) 527-6832 confluence-engineering.com

March 27, 2015

Kim Linton
Water Research Foundation
6666 West Quincy Avenue
Denver, Colorado 80235-3098 USA

RE: Water Research Foundation (WaterRF) Tailored Collaboration (TC) Proposal – ***Use of Flushing as a Corrective Action under the Total Coliform Rule***

Dear Kim and Members of the TC Selection Committee:

Confluence Engineering Group, LLC is please to commit to providing an in-kind contribution of $10,000 to this TC project, should we be successful in our pursuit. In-kind services will be provided in the form of professional services, estimated to be approximately 50 hours of Melinda Friedman's time over the 21 month project schedule. We appreciate the opportunity to propose on this exciting project.

Sincerely,

Melinda Friedman, P.E.
President
Confluence Engineering Group, LLC

Water Research Foundation
Research Project Budget

Sub-recipient (organization name): Confluence Engineering Group, LLC
PI Name: Melinda Friedman
Project Title: Ensuring Flushing is a Corrective Action under the Revised Total Coliform Rule
Preparation/Revision Date: 3/27/2015
RFP # (if applicable): Tailored Collaboration

OK
OK

Note: All amounts below will be automatically populated from the following pages/worksheets.

		Total	Award	Cost Share
A	Key Personnel	101,799	91,799	10,000
B	Other Personnel	48,344	48,344	0
	Total Direct Labor and Fringe Benefits	*150,143*	*140,143*	*10,000*
C	Equipment Rental	0	0	0
	Special Equipment	0	0	0
D	Materials and Supplies	1,750	1,750	0
E	Travel	4,093	4,093	0
F	Subcontracts	0	0	0
G	Other Direct Costs	20,000	20,000	0
	Total Direct Costs	*175,986*	*165,986*	*10,000*
H	Indirect Costs	0	0	0
I	Fee	14,014	14,014	0
J	Surveys	0	0	0
	Total Direct and Indirect Costs	***190,000***	***180,000***	***10,000***
	Third-Party Non-Cash In Kind	0	n/a	n/a
	Total Project Value	190,000		

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Exhibit A

Water Research Foundation
Research Project Budget

Instructions for budgets are at http://www.waterrf.org/funding/pages/quicklinks.aspx

*** Required fields are highlighted in yellow.**

*** Required fields are highlighted in yellow.**

Sub-recipient (organization name): Confluence Engineering Group, LLC
PI Name: Melinda Friedman
Project Title: Ensuring Flushing is a Corrective Action under the Revised Total Coliform Rule
Preparation/Revision Date: 3/27/2015
RFP # (if applicable): Tailored Collaboration

Note: The information above will carry over to subsequent pages/worksheets.

Sources of Award, Cost Share, and Non-Cash In-Kind Contributions (Insert rows to list more third parties.)		Award			Cost Share		Third-Party Non-Cash In Kind
		Foundation Funds	*Sub-recipient*	*Third-Party Cash to Foundation*	*Sub-recipient*	*Third-Party Cash to Sub-recipient*	
Water Research Foundation		90,000	n/a	n/a	n/a	n/a	n/a
Sub-recipient (including subcontract contributions)		n/a		n/a	10,000	n/a	n/a
Third Parties	Portland Water Bureau	n/a	n/a	50,000	n/a		
	Seattle Public Utilities	n/a	n/a	40,000	n/a		
		n/a	n/a		n/a		
		n/a	n/a		n/a		
		n/a	n/a		n/a		
		n/a	n/a		n/a		
		n/a	n/a		n/a		
		n/a	n/a		n/a		
		n/a	n/a		n/a		
		n/a	n/a		n/a		
		n/a	n/a		n/a		
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		n/a	n/a		n/a		
		n/a	n/a		n/a		
		n/a	n/a		n/a		
		n/a	n/a		n/a		
		n/a	n/a		n/a		
		n/a	n/a		n/a		
	Subtotal	*90,000*	*0*	*90,000*	*10,000*	*0*	*0*
Total Award, Cost Share, and Third-Party Non-Cash In Kind		180,000			10,000		0
Total Project Value		190,000					

Exhibit A

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Water Research Foundation
Research Project Budget

* Required fields are highlighted in yellow.

Sub-recipient (organization name): Confluence Engineering Group, LLC
PI Name: Melinda Friedman
Project Title: Ensuring Flushing is a Corrective Action under the Revised Total Coliform Rule
Preparation/Revision Date: 3/27/2015
RFP # (if applicable): Tailored Collaboration

A. Key Personnel *(PI and Co-PIs. Sub-recipient's employees only. †)*

Name	Project Role	Number of Hours	Direct Hourly Rate	% Time Allocated to Project	Subtotal Direct Labor	Fringe Benefit % of Direct Labor	Subtotal Fringe Benefits	Total	Award	Cost Share
Melinda Friedman	PI	265.55	67.10	7.5%	17,818	168.30%	29,988	47,806	37,806	10,000
Andrew Hill	Co-PI	360.00	55.90	10.0%	20,124	168.30%	33,869	53,993	53,993	0
					0		0	0		0
					0		0	0		0
					0		0	0		0
				Total Key Personnel	37,942		63,857	101,799	91,799	10,000

B. Other Personnel *(Sub-recipient's employees only.)*

Name/Position	Project Role	Number of Hours	Direct Hourly Rate	% Time Allocated to Project	Subtotal Direct Labor	Fringe Benefit % of Direct Labor	Subtotal Fringe Benefits	Total	Award	Cost Share
Stephen Booth	Senior Project Eng.	114.00	60.00	3.0%	6,840	168.30%	11,512	18,352	18,352	0
Amie Hanson	Project Eng.	32.00	48.10	0.1%	1,539	168.30%	2,590	4,130	4,130	0
Michael Hallett	Field Scientist/Admin	254.00	37.95	7.0%	9,639	168.30%	16,223	25,862	25,862	0
					0		0	0		0
					0		0	0		0
					0		0	0		0
					0		0	0		0
					0		0	0		0
					0		0	0		0
					0		0	0		0
					0		0	0		0
					0		0	0		0
					0		0	0		0
				Total Other Personnel	18,019		30,325	48,344	48,344	0

† PI and co-PIs that are not Sub-recipient's employees must **NOT** be listed here. Describe their project roles and responsibilities in the Budget Narrative under ***Category F, Subcontracts***.

Water Research Foundation
Research Project Budget

Sub-recipient (organization name): Confluence Engineering Group, LLC
PI Name: Melinda Friedman
Project Title: Ensuring Flushing is a Corrective Action under the Revised Total Coliform Rule
Preparation/Revision Date: 3/27/2015
RFP # (if applicable): Tailored Collaboration

C. Equipment Rental and Special Equipment Purchase

Equipment Rental (*List items and dollar amount for each item exceeding $1,000*)	Total	Award	Cost Share
			0
			0
			0
			0
			0
Total Equipment Rental	0	0	0

Special Equipment Purchase (*List items and dollar amount for each item exceeding $5,000*)	Total	Award	Cost Share
			0
			0
			0
			0
			0
Total Special Equipment Purchase	0	0	0

Exhibit A

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Water Research Foundation
Research Project Budget

Sub-recipient (organization name): Confluence Engineering Group, LLC
PI Name: Melinda Friedman
Project Title: Ensuring Flushing is a Corrective Action under the Revised Total Coliform Rule
Preparation/Revision Date: 3/27/2015
RFP # (if applicable): Tailored Collaboration

D. Materials and Supplies	Total	Award	Cost Share
Field equipment reagents	1,750	1,750	0
			0
			0
			0
			0
			0
			0
			0
Total Materials and Supplies	**1,750**	**1,750**	**0**

E. Travel	Total	Award	Cost Share
Workshop at PWB	1,000	1,000	0
Field work at PWB	2,000	2,000	0
PAC Meeting at SPU	343	343	0
Field work at SPU	750	750	0
			0
			0
			0
			0
Total Travel	**4,093**	**4,093**	**0**

Water Research Foundation
Research Project Budget

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Preparation/Revision Date: 3/27/2015
RFP # (if applicable): Tailored Collaboration

F. Subcontracts	Total	Award	Cost Share
			0
			0
			0
			0
			0
			0
			0
			0
Total Subcontracts	**0**	**0**	**0**

G. Other Direct Costs	Total	Award	Cost Share
External Laboratories	20,000	20,000	0
			0
			0
			0
			0
			0
			0
			0
Total Other Direct Costs	**20,000**	**20,000**	**0**

Exhibit A

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Water Research Foundation
Research Project Budget

Sub-recipient (organization name): Confluence Engineering Group, LLC
PI Name: Melinda Friedman
Project Title: Ensuring Flushing is a Corrective Action under the Revised Total Coliform Rule
Preparation/Revision Date: 3/27/2015
RFP # (if applicable): Tailored Collaboration

H. Indirect Costs *(Attach copy of federally approved rates or detailed basis for rates)*					
Cost Category	**Rate %**	**Base $**	**Total**	**Award**	**Cost Share**
			0		0
			0		0
			0		0
			0		0
			0		0
Total Indirect Costs			**0**	**0**	**0**

I. Fee	**%**	**Base $**	**Total**	**Award**	**Cost Share**
	10.00%	140,143	14,014	14,014	0
Total Fee			**14,014**	**14,014**	**0**

J. Survey	**Total**	**Award**	**Cost Share**
			0
			0
			0
			0
			0
			0
Total Survey Costs	**0**	**0**	**0**

14. BUDGET NARRATIVE

Schedule of Ongoing Costs:

Confluence Engineering Group LLC (Confluence) is proposing to complete this project in 21 months. Assuming a Notice to Proceed by June 30th, 2015, it is estimated that approximately $60,000 of the Water Research Foundation (Foundation) share of the project will be spent in 2015. The remainder, approximately $30,000, will be used in in 2016 and 2017. This breakdown assumes that SPU's remaining funds ($30,000) are successfully appropriated to the project in January, 2016. If for some reason these funds cannot be made available by SPU, the Project Team will not use the $30,000 Foundation match described above for 2016/2017, and it will be returned to the Foundation. The project has been designed to be successful with or without these additional funds. With the funds, we will conduct 10 trials at PWB and 8 trials at SPU. Without the additional funds we will conduct only 2 trials at SPU. The project schedule will shorten by approximately 4 months, and the costs associated with planning, implementing, and evaluating results of the 6 additional SPU field trials will be allocated toward development of the draft and final reports. SPU has received approval to disperse the 2016 funds, and they have been reserved, so we have every reason to believe that full funding will occur. A breakdown of utility, Foundation, and in-kind contributions with and without SPU funding is shown in the tables below.

Budget Allocation With Full SPU/WRF Funds		
Available Budget	2015	2016
PWB	$50,000	
SPU	$10,000	$30,000
WRF PWB	$50,000	
WRF SPU	$10,000	$30,000
Total	$120,000	$60,000
Combined Total	$180,000	
Inkind- Confluence		$10,000
Project Total	$190,000	

Budget Allocation Without Full SPU/WRF Funds		
Available Budget	2015	2016
PWB	$35,000	$15,000
SPU	$7,000	$3,000
WRF PWB	$35,000	$15,000
WRF SPU	$7,000	$3,000
Total	$84,000	$36,000
Combined Total	$120,000	
Inkind- Confluence		$10,000
Project Total	$130,000	

PRIMARY CONTRACTOR BUDGET JUSTIFICATION:

Wages and Salaries

The salary rates for employees: Melinda J. Friedman, Andrew S. Hill, Stephen D. Booth, and Michael R. Hallett are established in conjunction with their employer, Confluence. Overhead costs of 126.3% and fringe benefit costs of 42% are added to these rates on Tab A/B of the budget form (sum of 168.3%). On Tab J-H a fee of 10% is add to these rates to produce the fully loaded rates which appear on the budget summary tab. These rates will not change over the course of the research project. Melinda J. Friedman, PI, will devote approximately 11% of her time providing project management and research direction, as well as budget over-site and the preparation of detailed project reports for submission to the Foundation. Andrew S. Hill, Co-PI, will devote 14% of his time over the course of the project helping with project management, the development and implementation of research objectives, and field work, and report preparation. Stephen D. Booth will devote 4% of his time assisting with back-ground reviews, data analysis and cost development. Michael R. Hallett will devote 5% of his time over the course of the project assisting with project administration, data analysis, and field data collection.

Fringe Benefits

Fringe benefits for Confluence employees are estimated to be 42% of direct labor costs. Fringe benefit costs are accounted for on tab A/B by combining with overhead costs, as described above in Wages and Salaries.

Equipment Rental

The project team does not have plans to rent equipment. All equipment needed to conduct flushing (trucks, hoses, etc.) are owned by the utilities. All field analyses will be conducted using analytical equipment owned by the utilities and Confluence.

Materials and Supplies

We estimate that a total of $1,750 in supplies related reagents and consumables for field analyses will be needed. Costs associated with analytical work conducted by the utilities will be estimate and provided as an additional in-kind contribution to the project.

Travel

Total travel costs are estimated at $4,093. Travel costs and meals will be needed for the kick-off workshop at PWB, to support one week of on-site field work at PWB, as well as for up to 4 days of field work at SPU. Since the Project Team is local to the Seattle area, only lunch expenses are anticipated for the PAC meeting at SPU.

SUBCONTRACT

No subcontractors are needed for this project.

Other Direct Costs

We have reserved up to $20,000 for use of external certified laboratories where more complex microbial enumeration and characterization techniques will be performed. We anticipate using $15,000 in 2015 and $5,000 in 2016.

Indirect Costs

The contract mechanisms to be used by Confluence for this project have no indirect costs associated with them, so no indirect costs are included for the Confluence direct costs on tab H/J. As noted earlier Confluence applies a combined indirect rate of 168% (126% overhead plus 42% fringe) to the base labor rate of its employees. This loaded rate is then subject to a 10% fee on tab H/J, which is standard within Confluence's business practices.

15. COMMUNICATIONS PLAN

The target audiences for the findings of this project include the full suite of Foundation subscribers. Water utilities, universities, manufacturers, regulators, and consultants will all find elements of this research pertinent to their work. The project team will make every effort to disseminate interim and final results of the project through a variety of means to reach the wide variety of anticipated audience members. At a minimum, we are committed toward sharing results through the following outlets:

1) **Standard WaterRF Final Report** – as described in the proposal, the Final Report will contain two case studies summarizing PWB and SPU experiences with coliform occurrence and the history of their flushing programs, direct comparison of the effectiveness of different flushing techniques for enhancing microbial control, flushing protocols and data collection SOPs, and decision trees based on the likely coliform occurrence pathway. The advantages and disadvantages of each flushing strategy will be summarized so that utilities can tailor their response according to its system specific risk and operational capabilities. The Report will be prepared according to the Foundation's *Format-Style Guide*. The costs for preparation of the Final Report are included in the project budget.

2) **Journal Articles** – The Project Team plans to submit a minimum of two articles to selected industry Journals (Journal AWWA, Water Research, etc.). Publication is not planned before submittal of the Final Report, and therefore the costs of preparation of Journal articles are not included in the project budget.

3) **Trade Magazines** – We plan to prepare one article for publication in Opflow that focuses on demonstrated effectiveness of flushing techniques and appropriate applications. The project will not be charged for time associated with article preparation.

4) **Webcasts** – The Project Team will prepare a webcast to present project findings and recommendations before a live audience. We have participated in numerous Foundation and AWWA webcasts over the past several years, and readily understand how to deliver a successful presentation. We will conduct polls and take questions as part of the webcast, and will follow up with written responses to all questions that could not be answered live. Project Team costs for participation in the webcasts will be donated, regardless of whether the webcast is scheduled prior to or after delivery of the Final Report.

5) **Conference Presentations** – Members of the Project Team plan to give a minimum of two presentations at national conferences and up to two presentations at the local PNWS AWWA subsection. The costs for presentation preparation and conference attendance will not be charged to project and are not included in the project budget.

6) **PowerPoint Presentations** – The Project Team will make PowerPoint presentations prepared for the Webcasts and Conference Presentations available to the Foundation for use and distribution as appropriate to Foundation subscribers.

7) **Workshop** – As part of Task 1, a workshop is planned for the participating utilities' water quality, engineering, O&M, and communications staff as well as the project team. Presentation materials from the workshop will be made available to the Foundation.

Confluence, PWB, and SPU have the technology, equipment, time, and staff resources to meet the obligations described above.

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Exhibit B
Project 04653

Title: Use of Flushing as a Corrective Action Under the Revised Total Coliform Rule

TASK	DUE DATE
Begin Project	January 15, 2016
Scope of Work	February 15, 2016
Participant presents Proof of Insurance(s) or Certificate of Self Insurance & Worker's Compensation Insurance	February 15, 2016
Periodic 1 Report & Invoice	April 15, 2016
Periodic 2 Report (incl. Technical Summary & Web Update) & Invoice	July 15, 2016
Periodic 3 Report & Invoice	October 15, 2016
Periodic 4 Report (incl. Technical Summary & Web Update) & Invoice	January 15, 2017
Draft Report & Invoice	May 15, 2017
Final Report	October 15, 2017
Letters of Confirmation from participating utilities	October 15, 2017
Complete & Submit Exhibit E – Assignment of Copyright	October 15, 2017
Final Invoice & Final Compensation	October 15, 2017
Project End & Foundation Publication Date	May 15, 2018

Note: **Please submit one electronic copy of each Periodic Report. And submit one electronic copy for Draft & Final Report and hardcopy in *MSWord format.* For each report an invoice must be submitted for payment using Exhibit D – printed on your company letterhead.**

Exhibit B
Project 04653
Continued

WRF Key Contacts:

Project Management

- Grace Jang, Research Manager, Water Research Foundation, 6666 W. Quincy Ave., Denver, CO 80235, Phone: 303-347-6112, and Email: hjang@WaterRF.org.

Contract Administration

- Peggy Falor, Manager Contracts and Project Administration, Water Research Foundation, 6666 W. Quincy Ave., Denver, CO 80235, Phone: 303-734-3424, and Email: pfalor@WaterRF.org.
- Drew Ivers, Project Coordinator, Water Research Foundation, 6666 W. Quincy Ave., Denver, CO 80235, Phone: 303-347-6211, and Email: divers@WaterRF.org.

Sub-recipient Key Contacts:

Principal Investigator/Authorized Representative

- Melinda Friedman, Founder & President, Confluence Engineering Group LLC, 517 Northeast 92nd Street, Seattle, WA 98115, Phone: 206-527-6832, and Email: Melinda@confluence-engineering.com

Accounting Contact (Project Funds disbursements will be mailed to the care of this contact)

- Michael Hallett, Business Manager and Field Scientist, Confluence Engineering Group LLC, 517 Northeast 92nd Street, Seattle, WA 98115, Phone: 206-527-6832, and Email: Michael@confluence-engineering.com.

Co-Principal Investigator:

- Andrew Hill, Project Manager, Confluence Engineering Group LLC, 517 Northeast 92nd Street, Seattle, WA 98115, Phone: 206-527-6832, and Email: Andrew@confluence-engineering.com.

Co-funder(s) Contact:

- Chris J. Wanner, Director of Operations, City of Portland Water Bureau, 1900 N. Interstate Ave., Portland, OR 97227, Phone: 503-823-4050, and Email: chris.wanner@portlandoregon.gov.
- Yone Akagi, Water Quality Compliance Manager, City of Portland Water Bureau, 1900 N. Interstate Ave., Portland, OR 97227, Phone: 503-823-7648, and Email: yone.akagi@portlandoregon.gov.
- Rick Scott, Deputy Director, Water Line of Business, Seattle Public Utilities, 800 S. Stacy Street, Seattle, WA 98134, Phone: 206-233-2613.
- Wylie Harper, Drinking Water Quality Manager, Seattle Public Utilities, 800 S. Stacy Street, Seattle, WA 98134, Phone: 206-684-7880, and Email: Wylie.Harper@seattle.gov.

Each party shall provide written notice of changes in contact persons, addresses, telephone, fax, and email addresses. The Principal Investigator, Co-Principal Investigator, or any Subcontractor may only be changed with the prior written approval of the Foundation.

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BUDGET SUMMARY

Exhibit C
04653

Sub-recipient: Confluence Engineering Group LLC
517 Northeast 92nd Street
Seattle, Washington 98115

Title: Use of Flushing as a Corrective Action Under the Revised Total Coliform Rule

This MFRA shall be effective from **January 15, 2016** and shall end on **May 15, 2018** detailed in Exhibit B. Neither WRF nor the Co-funders shall have any obligation for payment of invoices for costs incurred by the Sub-recipient after the foregoing end date.

WRF and the Co-funders agree to provide aggregate Project Funds to the Sub-recipient in an amount not to exceed One Hundred Eighty Thousand US dollars ($180,000.00) for the completion of this MFRA. WRF funding and the Co-funders funding are as detailed below. The Sub-recipient agrees to provide Ten Thousand US dollars ($10,000.00) in Cost Share and Zero US dollars ($0.00) in in-kind contributions as detailed below. The total budget for the Project is One Hundred Ninety Thousand US dollars ($190,000.00).

Payments to the Sub-recipient will be issued to the Sub-recipient organization and mailed to the address shown in the first paragraph and shown above of this funding agreement unless otherwise noted below:

- Michael Hallett, Business Manager and Field Scientist, Confluence Engineering Group LLC, 517 Northeast 92nd Street, Seattle, WA 98115, Phone: 206-527-6832, and Email: Michael@confluence-engineering.com.

ORGANIZATION	Award Amount	Cost Share	In-Kind Amount
Sponsor / Co-funder			
City of Portland Water Bureau	$50,000.00	$0.00	$0.00
Co-funders			
Seattle Public Utilities	$40,000.00	$0.00	$0.00
Sub-recipient			
Confluence Engineering Group LLC	$0.00	$10,000.00	$0.00
Water Research Foundation	$90,000.00	$0.00	$0.00
TOTALS	**$180,000.00**	**$10,000.00**	**$0.00**
Total Project Budget $190,000.00			

Project Award Funds: not to exceed $180,000.00
10% of Project Funds advanced on or following Effective Date: $18,000.00
(Ref. III.B.3.a)
Amount due upon the WRF's acceptance of Draft Report: $18,000.00
(Ref. III.B.3.b)
Amount due upon WRF's acceptance of the Final Report and final invoice: $18,000.00
(Ref (III.B.3.b)

Exhibit D
Project 04653

Title: Use of Flushing as a Corrective Action Under the Revised Total Coliform Rule

Exhibit D – Invoice Form

For access to the Water Research Foundation website please see:
http://www.waterrf.org

To download Exhibit D – Invoice Form please see WRF's website:
http://www.waterrf.org/funding/ContractMaterials/Invoice_ExhibitD.pdf

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Exhibit E
Project 04653

Title: Use of Flushing as a Corrective Action Under the Revised Total Coliform Rule

Assignment of Interest in Copyrighted Works

Whereas, _____ whose address is _____ ["Assignor"] makes this assignment having full ownership and authority to make such assignment [or being authorized to make such assignment by _____ _____].

Whereas, Assignor has created and authored the original, tangible expressions of ideas described as follows: _____ _____ (hereafter the "Works"); and

Whereas, the Assignor warrants and represents to own all right, title and interest in and to the Works, including the copyright; and

Whereas, the Water Research Foundation (Foundation) whose principal place of business is located at 6666 W. Quincy Avenue, Denver, Colorado 80235 U.S.A. ["Assignee"] is desirous of obtaining all rights in and to the Works, including the copyright.

NOW, THEREFORE, in return for grants provided to Assignor by Assignee for research, said Assignor does hereby assign unto the said Assignee all world-wide right, title and interest in and to the said Works, including the right to transfer any registration of copyright, or file application for copyright registration for such Works as Owner.

By: Date	Approved and authorized individual by Date
Title For	Title for Legal Department For
Assignor Name/Entity	Assignor Name/Entity

State of _____ }
} ss
County of _____ }

On this _____ day of _____, 201_, _____ [Assignor or authorized agent] appeared before me, the person who signed this instrument, and of his/her own free will executed this document [on behalf of the identified corporation or other entity with authority to do so].

_____
Notary Public Comm'n. Exp.