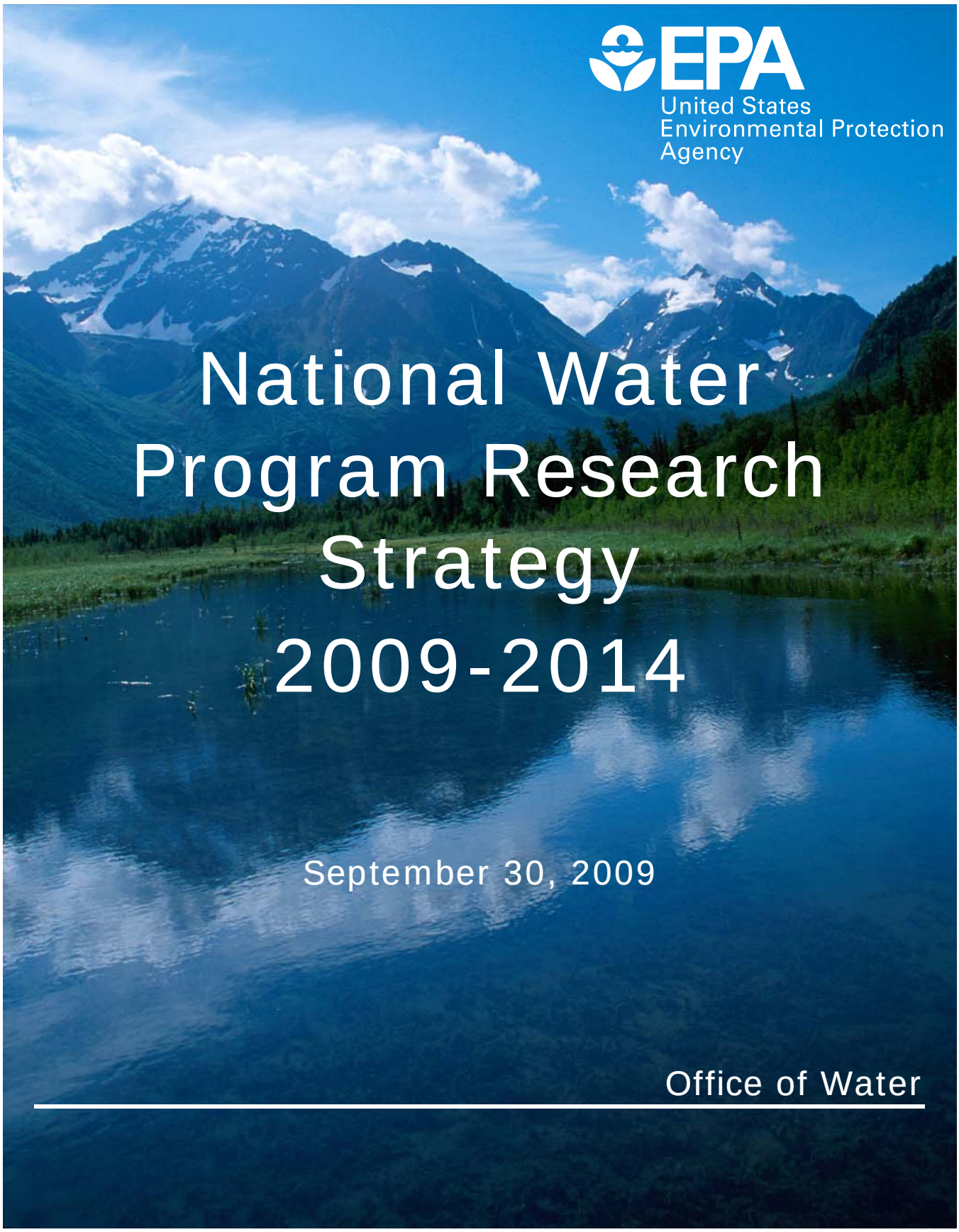

United States Environmental Protection Agency

National Water Program Research Strategy 2009-2014

September 30, 2009

Office of Water

The *Strategy* is available online at:
www.epa.gov/waterscience/strategy

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Disclaimer

This *National Water Program Research Strategy (Water Research Strategy)* presents the hierarchy of research needed for EPA's National Water Program to successfully achieve its statutory and regulatory obligations, and its strategic targets and goals. To the extent the document mentions or discusses statutory or regulatory authority, it does so for information purposes only. The document does not substitute for those statutes or regulations, and readers should consult the statutes or regulations themselves to learn what they require. Neither this document, nor any part of it, is itself a rule or a regulation. Thus, it cannot change or impose legally binding requirements on EPA, States, the public, or the regulated community. The use of words such as "should," "could," "would," "will," "intend," "may," "might," "encourage," "expect," and "can," in this document means solely that something is intended, suggested or recommended, and not that it is legally required. Any expressed intention, suggestion or recommendation does not impose legally binding requirements on EPA, States, the public, or the regulated community. Agency decision makers remain free to exercise their discretion in choosing to implement the actions described in this Strategy.

Foreword

Results and Accountability – Innovation and Collaboration – Best Available Science

I am very pleased to release the National Water Program's first Research Strategy. The goal of the *National Water Program Research Strategy (Water Research Strategy)* is threefold: (1) to ensure the National Water Program's research, science, and technology needs are identified and documented in a comprehensive plan that supports our commitment to collaborative corporate planning, prioritization, and research management to meet the environmental goals of the National Water Program, (2) to expand partnerships and collaborations across EPA and the federal research family, and (3) to engage the broader research community in the investigation of water research needs.

The *Water Research Strategy* presents a hierarchy of research needed for EPA's National Water Program to successfully achieve its statutory and regulatory obligations as well as its strategic target and goals. The *Water Research Strategy* is one of three products designed to compile, organize, and communicate water research needs. The second is a compendium of the National Water Program's research needs, the drivers behind them, and the environmental challenges they are intended to address. The third component, expected to be available to the public in 2010, is the Research Management Status Tool (RMST)*;* an electronic appendix to the *Water Research Strategy* that will provide queriable access to the research needed by the National Water Program.

Our objective through all of these products is to bring a broader diversity of relevant and appropriately vetted science to the National Water Program's regulatory and non-regulatory tools and water management decisions. By expanding the science base we will increase program credibility, expedite the production of the needed tools, and water quality environmental outcomes will be achieved faster and quantified better.

I invite those researchers that are conducting, or considering conducting investigations in the areas identified in the *Water Research Strategy* to let us know about their work so we can improve our communications.

Michael H. Shapiro
Deputy Assistant Administrator
Office of Water

Acknowledgements

This *National Water Program Research Strategy (Water Research Strategy)*, the Compendium, and the Research Management Status Tool were made possible through the collaboration and commitment of the Office of Water-Research Coordination Team (OW RCT), Water Division Directors, and the Water Executive Committee for Research. The team provided content, reviewed contributions, and obtained consensus across the Water Program to ensure the document was both comprehensive and reflective of National Water Program objectives. The *Water Research Strategy* is organized around the National Water Program's priority themes as identified by the Water Executive Committee for Research. The three tier hierarchy was designed by the Water Division Directors.

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Table of Contents

List of Exhibits

Introduction

Why the Strategy Was Developed

The *National Water Program Research Strategy* (hereafter referred to as the *Water Research Strategy*) was developed to more completely define the Water Program's research needs, organize them around EPA's Strategic Goals and Sub-objectives (see Exhibit 1), and communicate them to potential research partners. The development, goals, and organization of this document are described in more detail in later sections.

> "A course of action marked by the creation and maintenance of a coordinated, comprehensive, and balanced national water resources research agenda, combined with a regular assessment of the water resources research activities … … represents the nation's best chance for dealing effectively with the many water crises sure to mark the 21st century."
>
> *Confronting the Nation's Water Problems – The Role of Research*
>
> The National Academies - National Research Council, 2004

EPA received recommendations from the National Academy of Sciences, EPA Science Advisory Board (SAB), and the Board of Scientific Counselors (BOSC) regarding the need for a documented and transparent water research portfolio linked to environmental outcomes. In 2001 and 2005, the SAB suggested that the Office of Research and Development (ORD) and the Water Program should strengthen their collaborations with external parties and work together to define the strategic links among long-term goals, desired outcomes, and research. These efforts would help both the Water Program and its stakeholders meet regulatory obligations and link ORD's multi-year plans to Water Program needs.

The BOSC (2005 and 2006) added to these recommendations and emphasized the need for transparency when prioritizing research, a system to evaluate and report progress, and a definition of "anticipatory" research to address future/emerging needs.

The *Water Research Strategy* heeds the recommendations of the National Academy, the SAB, and the BOSC, and provides EPA's ORD and other potential collaborators with information to prepare highly program-relevant research plans. The *Water Research Strategy* also enables the National Water Program to address its research needs more comprehensively.

Exhibit 1: National Water Program Goals

EPA's Office of Water (OW) and Regional Water Divisions (Regions) are responsible for the Agency's water quality and water resource protection activities including development of national programs, technical policies, and regulations relating to drinking water, water quality, ground water, pollution source standards, and the protection of wetlands, marine, and estuarine areas.

The National Water Program has three goals under the Agency Strategic Plan:

1. Ensure clean and safe water and drinking water to protect human health.

2. Protect and restore aquatic ecosystems and human health through watershed and Place-Based Programs.

3. Protect and restore water quality to ensure the health of aquatic life and aquatic dependent wildlife.

Four principal programs within OW and the Regions are charged with achieving the National Water Program Goals:

Drinking water, ground water, source water and water security protection programs provide comprehensive protection of drinking water sources, health-based drinking water treatment standards, and prepare drinking water systems for large-scale contamination events, natural disasters, terrorist attacks, and other intentional acts.

Wastewater management for water quality protection programs characterize and manage sources of water quality degradation and provide information on the latest wastewater and residuals treatment and reuse technologies and management practices. They also manage potential sources of pollution, such as decentralized wastewater systems and stormwater runoff.

Wetland, ocean, watershed, and place-based protection and restoration programs provide decision makers with the data and tools to select the most appropriate water bodies, restoration methods, and monitoring schemes to protect and restore the ecological, economic, and cultural services provided by aquatic ecosystems.

Aquatic life and human health protection programs ensure that: 1) State-adopted criteria for pathogens and indicator organisms are current and sound; 2) the science underpinning core water programs is current and appropriately vetted for use in State and Tribal water quality standards, total maximum daily loads (TMDLs), permits, assessments, and drinking water regulations; 3) health effects and human health risk assessment science is available and used to support human health protection programs; and 4) the National Water Program is able to address emerging water quality concerns.

How Themes and Tiers Were Selected

The Water Executive Committee for Research discussed a variety of approaches to organize, prioritize, and present research needs to potential collaborators. The approaches (including the selected themes and tiers approach, budget percentages, immediacy, etc.) were all examined for how well each would communicate to the target audiences. The group also discussed the common research priority themes found in the Administrator's recent budget testimony, the EPA Science Advisor's research priorities, the 2009-2014 Draft Agency Strategic Plan, and the OW's process of categorizing research activities into defined bins. The agreed to priority Themes are (in no priority order):

Theme A: Healthy Watersheds and Coastal Waters Research Needs

Theme B: Safe Drinking Water Research Needs

Theme C: Sustainable Water Infrastructure Research Needs

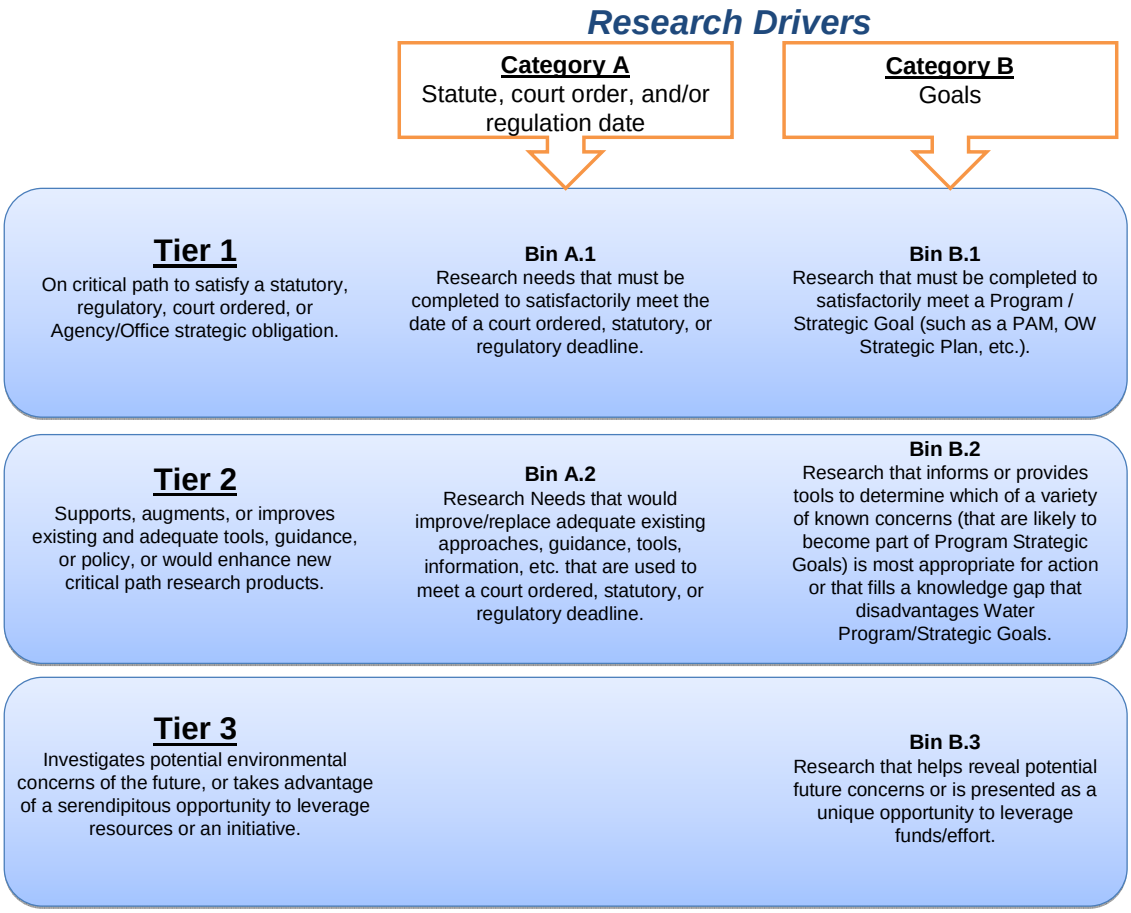
Theme D: Water Security Research Needs

To organize the research needs within each theme and communicate them more clearly to collaborators, the specific research needs identified in the 2008 Compendium were grouped within one of five technical tool areas:

- aquatic life health effects;
- human health effects;
- method development;
- occurrence and exposure; and,
- treatment technologies and effectiveness.

Finally, the research needs within each technical tool area were sorted into three tiers to communicate the relevant driver and urgency, as summarized in Exhibit 2. Senior water managers designed a process to prioritize water research needs dividing the needs into two categories containing a total of five bins. The categories were defined based on the type of driver necessitating the research: Category A: statute/court order/regulation date driven, and Category B: goal driven. The bins within the categories defined whether the research was: critical path to meet program obligations -- Bins A.1 and B.1; or non-critical path to meet program obligations -- Bins A.2, B.2, and B.3 (see Exhibit 2). For more detail see Appendix 3.

Exhibit 2: Tier Definitions Specific to the Driver and Urgency of OW Research Needs



How the Strategy Will Be Used

This *Water Research Strategy* documents the hierarchy of research needed for successful implementation of EPA's National Water Program and, along with the Research Management Status Tool (RMST), will be used to achieve the following goals of the National Water Program:

- Ensure that the Office of Water's (OW, inclusive of the Regional Water Management Divisions) water research, science, and technology needs are identified and documented in a comprehensive plan that supports our commitment to collaborative corporate planning, prioritization, and research management to meet the environmental goals of the National Water Program;
- Expand partnerships and collaborations across EPA and the federal research family; and
- Engage the broader research community in water research.

The *Water Research Strategy* and RMST will also help to stimulate the evaluation and communication of research results to decision makers and users in a form that leads to environmental outcomes.

Consistent with the *EPA Strategic Plan* and the *National Water Program Guidance*, this research strategy emphasizes:

> **Results and Accountability:** We have designed the *Water Research Strategy* to address the long-term goal of providing "Clean and Safe Water" set out in the *EPA Strategic Plan.* We will report annually on our progress on the research portfolio and adjust it appropriately to meet changes in objectives and priorities.
>
> **Innovation and Collaboration:** Our progress toward water and public health protection goals depends on both our ability and continued commitment to identify and use innovative tools, approaches, and solutions to address environmental problems and engage extensively with our partners, stakeholders, and the public.
>
> **Best Available Science:** EPA needs the best scientific information available to anticipate potential environmental threats, evaluate risks, identify solutions, and develop protective standards. Sound science helps us ask the right questions, assess information, and characterize problems clearly for Agency decision makers.

It has been demonstrated time and again that environmental protection research is best conceived and most appropriately vetted when it has been identified through purposeful evaluation of the current, near-future, and potential far-future environmental protection and restoration needs. The process used by the National Water Program to draft the *Water Research Strategy* provided the avenue for purposeful evaluation of program research needs.

How the Portfolio Will Be Managed

The research portfolio for Water Programs will be managed through the Water Executive Committee for Research and its staff (described below) using the *Water Research Strategy* and the Research Management Status Tool (RMST).

The RMST is a tool that will be used to continuously manage and improve the research portfolio to ensure it meets its objectives. The RMST serves as both an electronic appendix to this Strategy and as a tool to support Water Program managers. Specific research needs and products for the Water Program will be captured in the RMST. The management functions and status reports that will be available within the RMST will enable Water Program senior managers to evaluate the relevance and timeliness of research intended to help them achieve strategic goals and specific deadlines. The RMST will also make it possible to assess which specific needs are not being met, evaluate proposed and ongoing research against programmatic needs, and find opportunities for collaboration.

The cross-office research planning infrastructure designed by OW and the Regional Water Divisions to achieve the goals of the *Water Research Strategy* includes two principal organizational units: an OW Executive Committee for Research staffed by an OW-Research Coordination Team (OW RCT). The Executive Committee (the Deputy Assistant Administrator, the four Office Directors, and the Water Division Director from the lead Region for Water) is responsible for promoting coordinated and collaborative research activities and planning within the National Water Program and between the Program and its research partners. The Executive Committee is also responsible for evaluating:

- The progress of research activities against Program research needs;
- Emerging issues for research;
- The relevance of proposed research to Program objectives;
- Adjustments to research portfolios because of changes in budget or priorities; and,
- The need for new research management tools or the effectiveness of existing ones.

How the Strategy Is Organized

The remainder of this *Water Research Strategy* is organized into the following chapters with each providing the Theme, Tool, and Tier hierarchy, as well as brief background.

Chapter 1 – Healthy Watersheds and Coastal Waters Research Needs

Chapter 2 – Safe Drinking Water Research Needs

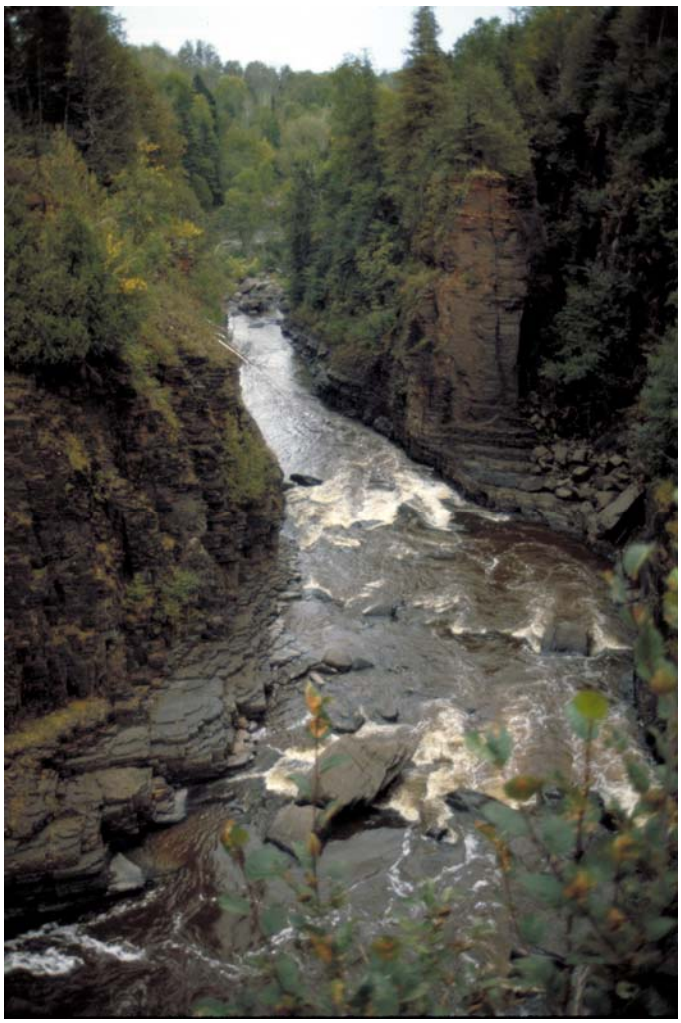
Chapter 3 – Sustainable Water Infrastructure Research Needs

Chapter 4 – Water Security Research Needs

Within each of the Theme-based chapters, technical "Tool" subsections provide discussion of the practical implementation areas of the National Water Program. The Tool subsections include: aquatic life health effects; human health effects; method development; occurrence and exposure; and, treatment technologies and effectiveness. Finally, within each Tool subsection is a summary of relevant research needs. These summaries are organized under one of three Tiers to reflect the relevant drivers and urgency of research needs (see Exhibit 2 for Tiering definitions).

Appendix 3 – the Research Needs Matrix – provides detailed information on the research needs that are summarized in the Chapters. The Matrix is organized in the same Theme, Tool, Tier hierarchy as the document so it can be easily referenced for a full listing of the research needs summarized in the Tiers. Note that research needs and activities do not necessarily fit under just one Theme/Tool/Tier category. Because research can have a variety of drivers and objectives, the same or similar research needs and activities are sometimes listed under more than one Theme or Tool in the Matrix.

1 ● Healthy Watersheds and Coastal Waters Research Needs



EPA's Water Program promotes water quality protection through a variety of Clean Water Act (CWA) programs designed to manage, protect, and restore the Nation's fresh and marine water resources and associate aquatic ecosystems. These efforts are coordinated among the Office of Wetlands, Oceans, and Watersheds (OWOW), the Office of Science and Technology (OST), the Office of Ground Water and Drinking Water (OGWDW), the Office of Wastewater Management (OWM), and the Regional Water Divisions (Regions) to implement EPA's Water Program.

The objective of the Clean Water Act is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C. Sec. 1251(a), CWA Sec 101(a)). Since enacted in 1972, federal water quality regulations have led to significant reductions in pollutant levels in many impaired lakes, rivers, and streams. Further, significant efforts have been undertaken to restore aquatic ecosystems in the Nation's impaired watersheds.

Despite these efforts, aquatic ecosystems are declining nationwide. The rate at which new waters are being listed for water quality impairments exceeds the pace at which restored waters are removed from the list. Challenges such as loss of habitat, stream connectivity, hydrologic alteration, invasive species, pollution, and climate change continue to exist. It is clear that EPA's Water Program is compelled to develop this strategy to achieve the objective of the Clean Water Act as envisioned by Congress.

In addition to the core programs, the National Water Program runs a variety of Place-Based Programs for protection and restoration of large aquatic ecosystems that have been identified as having significant water pollution problems. Place-Based Programs include: Chesapeake Bay; Great Lakes; Gulf of Mexico; Long Island Sound; South Florida; Lake Champlain; Puget Sound - Georgia Basin; Columbia River; San Francisco Bay Delta; and Pacific Islands. The water quality concerns in these water bodies include legacy toxic chemicals, hypoxia, nutrient enrichment, habitat alteration, pharmaceuticals, pesticides, microbials and other contaminants of emerging concern.

Aquatic Life Health Effects

The biological integrity of our nation's coastal, estuarine, and freshwater environments has been, and continues to be, substantially impacted by a suite of biological, chemical, and physical stressors. Specific stressors include habitat alteration, nutrient loading, suspended and bedded sediments (SABS), pathogens, toxic chemicals, over harvesting of fish and shellfish populations, and introduction of invasive species, all of which have changed the biological communities. There is a need to understand the parameters that contribute to a healthy aquatic habitat: nutrient criteria that protect waters from nutrient over-enrichment; biological criteria designed to describe and maintain the biological condition of aquatic communities; criteria to define the chemical concentrations below which aquatic life is protected; clean sediment criteria that protect aquatic life from excessive or insufficient sedimentation; climate change and anthropogenic stressors; invasive species; and non-point sources.

Research needs and activities related to aquatic life health effects as a tool for understanding and attaining healthy watersheds and coastal waters include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Assess emerging water quality concerns and the impact of emerging contaminants on aquatic life health and ecosystem function; establish water quality criteria to protect them. Determine the impact of global change on aquatic ecosystems, watersheds and ocean processes. Identify indicators of aquatic health and develop new models of aquatic ecosystems. Project the effects and mitigation of stormwater runoff from future land development to support stormwater regulations and respond to the NRC Report. Connect effects of nutrients to aquatic system health to support numeric nutrient criteria development by States.

Tier 2

Understand the individual and combined impact of isolated wetlands, headwaters, habitat, and nutrient load-responses on ecosystem integrity and biological conditions. Establish the science to address concerns regarding Place-Based Programs and unique habitats such as wetlands and coral reefs. Establish sufficiently sensitive detection and quantification methods for traditional pollutants. Maintain the scientific foundation of existing criteria.

Tier 3

Develop the science to project the consequences of future land development and other anthropogenic factors to minimize negative impacts on aquatic life health and habitats.

Human Health Effects

Under the authorities of CWA, the Safe Drinking Water Act (SDWA), and other acts and executive orders, the Human Health Protection Program helps produce regulations, guidelines, methods, models, standards, science-based criteria, and studies that are critical components of national programs that protect human health and the aquatic environment. The Water Program endeavors to

improve water quality to protect and restore waters to their designated uses, thereby protecting the health of humans, aquatic life, and wildlife. Actions taken to improve water quality will also increase the number of water bodies that can be enjoyed for recreational purposes and from which fish and shellfish can be safely consumed.

Research needs and activities related to human health effects as a tool for understanding and attaining healthy watersheds and coastal waters include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Understand the interacting effects of global change, land use, and economic development on human demand for water, water quality and human pathogens. Conduct research on and determine measures to reduce emerging contaminants and develop criteria to protect human health.

Tier 2

Conduct research on indicators of potential illnesses in salt water environments.

Tier 3

None yet identified.

Method Development

EPA decision makers need information and tools to make proactive policy and management decisions that ensure ecological and human well-being; these may include: simulation tools, predictive models, remote sensing technologies, ambient monitoring methods, classification methods, mapping techniques, rapid assessment field methods, and criteria derivation methods.

Research needs and activities related to method development as a tool for understanding and attaining healthy watersheds and coastal waters include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Develop methods to: establish statistically-based national assessments; evaluate watershed recovery potential and decisions; establish biocriteria and condition gradients; value ecosystem services; provide rapid and timely detection of pathogens and indicators; prioritize chemicals of emerging concern and derive criteria; manage water programs for climate change; and incorporate decentralized systems in TMDLs.

Tier 2

Develop methods to: support trading programs; predict effects of multiple stressors on watershed degradation; target watersheds for restoration and obtain improvement; classify and assess headwater streams and wetlands; monitor and respond to invasive species; assess sediments in estuaries; understand climate change on ecosystem protection and restoration; and motivate change in public behavior.

Tier 3

Select appropriate pathogens and indicators to assess sewage sludge quality.

Occurrence and Exposure

Policy makers and watershed managers need reliable chemical, physical, and biological information that will allow them to understand the status and functioning of aquatic ecosystems and to evaluate the success of watershed protection and restoration measures over time. Methods to gather this information must be developed and deployed. Information on the status of a waterbody or watershed enables its condition to be determined and demonstrates whether the services it provides (ecological, economic, and cultural) have been diminished. Monitoring can indicate coastal and watershed recovery and whether a system is able to once again provide the desired services. Occurrence monitoring is also necessary to understand where and how non-indigenous plants and aquatic organisms have become established in coastal and watershed environments.

Research needs and activities related to occurrence and exposure as a tool for understanding healthy watersheds and coastal waters include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Evaluate trends in water quality and aquatic systems; determine the occurrence and exposure of emerging contaminants in water; determine the appropriate geographic scale for nutrient, wetland, and services trading; establish causal links between climate and other stressors to surface water impairments.

Tier 2

Account for pollutant's multiple routes of exposure to aquatic life; identify the pathways of invasive species introduction; determine the occurrence of pollutants in runoff to large aquatic ecosystems.

Tier 3

None yet identified.

Treatment Technologies and Effectiveness

To protect and restore the health and diversity of water resources and aquatic ecosystems, research into treatment technologies and effectiveness is needed, including: best management practices, control of invasive species, decentralized wastewater system technology, and cost effective technologies. To decide what watershed management strategies to implement, managers need to be able to compare costs and benefits of various practices and approaches through models that predict the watershed-wide impacts of one or multiple management measures.

Research needs and activities related to treatment technologies and effectiveness as tools for understanding healthy watersheds and coastal waters include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Identify or develop technologies to: improve resilience to global change stressors; determine the effectiveness and performance costs of management measures and optimal placement in watersheds; reduce nutrient, hypoxia, and sediment ecosystem impacts; control the introduction of invasive species; and evaluate treatment system efficiencies. Provide guidance/technical assistance for using the information and technologies in program decisions and implementation.

Tier 2

Identify wetland nutrient removal rates for use in trading credits; evaluate treatment alternatives for onsite/decentralized systems; evaluate best management practices (BMPs) for nonpoint source control at multiple scales.

Tier 3

Develop tools and knowledge to control invasive species impact on aquatic ecosystems.

2 ● Safe Drinking Water Research Needs

Guided by the Safe Drinking Water Act (SDWA), the Ground Water and Drinking Water Protection Program strives to provide safe drinking water and to protect sources of drinking water. The SDWA requires EPA to set national drinking water standards to ensure the safety of water consumed by the millions of people in the US who receive their water from public water systems (PWSs). Under the SDWA, EPA is charged with evaluating unregulated contaminants and developing and revising drinking water standards. The Office of Ground Water and Drinking Water and the Office of Science and Technology are responsible for these programs.

The SDWA mandated several processes by which EPA identifies contaminants that may need new or revised standards: the Contaminant Candidate List (CCL), Regulatory Determination process, the Six-Year Review process, and a monitoring plan for unregulated contaminants. The CCL is the first step in the process and identifies any significant information gaps that in turn generate the need for specific research. The results of this research help decide if a contaminant should be included on the List and what priority it is given. The Regulatory Determination process examines the highest priority contaminants from the List and may generate research needs of its own before a decision can be made to regulate or not to regulate a given contaminant. Under Six-Year Review, EPA examines existing National Primary Drinking Water Regulations (NPDWRs) at least every six years to determine if revisions to the existing rules are needed. This effort may entail new research of its own. Research is also needed in the area of unregulated contaminants, about which relatively little may be known. Under the Unregulated Contaminant Monitoring Rule (UCMR), contaminant occurrence data are collected and analyzed. The results of this process often generate additional research needs, such as the need for information on the toxicity or health effects of a particular contaminant.

Preventing identified contaminants from reaching drinking water sources is the foundation for source water protection. Underground injection activities must be re-evaluated periodically to assess human health risks and determine appropriate practices to prevent the endangerment of underground sources of drinking water as new uses for injection and new data on current uses arises. Climate change strategies increasingly include underground injection in greenhouse gas mitigation and management of water resources. State-delineated source water protection and

wellhead protection areas, which were required by SDWA, provide guidance in planning land and water use in proximity to drinking water sources. Community outreach and education initiatives provide the knowledge to protect drinking water and reinforce individual responsibility in maintaining high quality water resources. These are supplemented by the designated uses implemented under the CWA Water Quality Standards Program which specifies waters for protection as designated drinking water sources.

Human Health Effects

The SDWA requires EPA to evaluate human exposure and risks of adverse health effects in the general population and sensitive subpopulations (*e.g.*, infants and young children, the elderly, the immunocompromised) when setting drinking water standards. Risk assessment is essential when determining whether regulatory action is warranted, what actions should be implemented, and whether such actions are effective. When developing and revising drinking water standards, EPA evaluates threats to public health from microbial and chemical contaminants. Through the CCL, Regulatory Determination, and Six-Year Review processes, EPA may determine that additional health effects data are needed (*e.g.,* reproductive studies) for specific drinking water contaminants to determine if a new or revised drinking water regulation is warranted.

Research needs and activities related to human health effects as a tool for achieving safe drinking water include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Understand the human health effects of known and emerging pathogens, chemicals, and suites of contaminants; improve the risk assessment process for these contaminants; determine the impact of co-contaminants injected with CO_2 on drinking water sources; reduce uncertainty in extrapolation from animals to humans and from high to low doses.

Tier 2

Determine the effects of short term lead exposure on developmental processes; evaluate the potential impact of shallow class V-well injected brines and residuals on underground sources of drinking water; assess impacts of UIC Class V mine backfill wells accepting coal fly ash on USDWs.

Tier 3

Determine impacts on drinking water sources from injection activities and waste management associated with oil and gas production.

Method Development

EPA decision makers need information and tools to make proactive policy and management decisions that ensure safe drinking water; these may include methodologies for: laboratory analysis, sampling and monitoring, measurement, classification, valuation, prediction, and indicator selection, frameworks, and models.

Central to EPA's determination of whether to regulate a contaminant or revise an existing regulation is the ability to detect and quantify the contaminant and to determine its occurrence in drinking water. These evaluations cannot be made, nor standards set, without adequate analytical methods to support national occurrence data collection and monitoring for regulatory compliance.

Research needs and activities related to method development as a tool for achieving safe drinking water include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Develop methods to: evaluate the appropriateness and improve the timeliness of analytical techniques; capture the risk of exposure to contaminants in support of CCL and UCMR; identify tools for longitudinal research with children; determine impacts of climate change on integrated water resource management; determine the risks of underground CO_2 injection and manage alternatives to protect drinking water sources; determine management and treatment practices appropriate for aquifer storage and recovery injection activities that prevent endangerment of USDWs.

Tier 2

Develop methods to: evaluate human health risks from chemical mixtures; assess the vulnerabilities of drinking water sources to contamination; develop and improve methods to detect and quantify regulated and unregulated contaminants; evaluate the ability of culture and molecular methods to address the viability and infectivity of pathogens.

Tier 3

None yet identified.

Occurrence and Exposure

Occurrence monitoring provides vital information on the national occurrence of contaminants and helps to estimate public exposure to contaminants. Specifically, such information can indicate how the public is exposed to contaminants, how often they are exposed, and the duration of exposure. Occurrence data are needed not only for regulated contaminants, but also for unregulated contaminants. The occurrence data collected through the UCMR support EPA's determination of whether or not to regulate certain contaminants. Furthermore, the timing of the CCL and UCMR cycles means that monitoring under the UCMR can provide needed data not just for current CCL contaminants and emerging contaminants, but also for future CCL selection efforts.

Research needs and activities related to occurrence and exposure as a tool for achieving safe drinking water include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Determine the national occurrence of contaminants in source water and drinking water and the routes, frequency, and duration of the public's exposure.

Tier 2

None yet identified.

Tier 3

None yet identified.

Treatment Technologies and Effectiveness

Effective treatment technologies are essential to the provision of safe drinking water and the protection of drinking water sources. To effectively regulate a contaminant, there must be an available removal or inactivation method. Thus, an understanding of available treatment methods and the development of new methods must go hand in hand with efforts to develop and evaluate drinking water standards. In particular, research is needed to improve EPA's understanding of simultaneous compliance with multiple contaminant treatment/removal requirements, drinking water treatment residuals (the material removed from source water), impacts of treatment changes on lead and copper corrosion, and control of microbes and disinfection by-products (DBPs). Research related to the Enhanced Surface Water Treatment Rule, the Interim Enhanced Surface Water Treatment Rule, the Long Term 1 Enhanced Surface Water Treatment Rule, Stage 2 Disinfection By-Products Rule, and the Long Term 2 Enhanced Surface Water Treatment Rule and other regulated contaminants such as fluoride, TCE and PCE is needed.

Research needs and activities related to treatment technologies and effectiveness as tools for achieving safe drinking water include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Evaluate BMPs for source water quality improvement; identify treatment technologies and techniques to remediate emerging contaminants.

Tier 2

Optimize corrosion control treatment approaches while improving drinking water quality; assess water resources for vulnerability to contamination; control pollution at the watershed scale.

Tier 3

None yet identified.

3 ● Sustainable Water Infrastructure Research Needs

The National Water Program has made a commitment to promoting sustainable water infrastructure across all of its programs including wastewater and storm water management, and drinking water treatment and supply. EPA's four pillars of sustainable water infrastructure are: 1) better management of water and wastewater utilities; 2) rates that reflect the full cost pricing of services; 3) efficient water use; and 4) watershed approaches to protection. One of the Agency's major programs for addressing aging water and wastewater infrastructure and incorporating Green Infrastructure as a management practice is the Sustainable Water Infrastructure Initiative. This initiative aims to change how the nation views, values, manages, and invests in its water infrastructure. It is led by the Office of Water and supported by many other Program Offices. Through the initiative, the Agency is actively promoting sustainable infrastructure, including the provision of research, tools, techniques, and incentives, where appropriate.

The lead offices in the area of Sustainable Water Infrastructure are the Office of Wastewater Management, the Office of Wetlands, Oceans, and Watersheds, and the Office of Ground Water and Drinking Water. Wastewater, drinking water, and watershed management play key roles in protecting water resources. The programs promote water conservation, efficient water use and reuse, support effective decentralized wastewater treatment , evaluate point source abatement and control programs, encourage the protection and restoration of watersheds and wetlands, advance green infrastructure programs, and design methods to assess and cost effectively renovate existing water collection, supply, and treatment systems.

Aquatic Life Health Effects

Urban nonpoint sources represent permanent changes in the landscape and are large nitrogen and phosphorous sources. Hypoxia and other eutrophication-related impacts on water quality are centered on major population centers or closely associated with developed watersheds that export large quantities of nutrients and organic matter. Agricultural practices, such as those associated with biofuels and energy independence, as well as climate change-induced alterations in weather patterns (especially precipitation), will also likely alter the sources, transport, and fate of nutrients. The use of manure as a more complete resource (*e.g.,* nutrients and biofuel) may help to reduce the amount of phosphorous pollution from agricultural runoff. In addition to alternative energy production, carbon sequestration may affect aquatic life by impacting water quality through the influx of injected carbon impacted ground water to surface waters.

Research needs and activities related to aquatic life health effects as a tool for achieving sustainable water infrastructure include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Understand the full effects and consequences of alternative energy production (*e.g.,* biofuels) and carbon sequestration on water quality and quantity.

Tier 2

Understand the effectiveness of green infrastructure approaches for wet weather management and municipal permit selection to met specific TMDL needs in a targeted watershed.

Tier 3

None yet identified.

Human Health Effects

In 2002, the National Research Council (NRC) published a report titled "Biosolids Applied to Land: Advancing Standards and Practices". The NRC noted that there is "persistent uncertainty on possible adverse health effects" from sewage sludge. There is a need to understand if contaminants in biosolids applied to land pose a public health risk. For example, studies are needed to better understand the sudden spike of fecal coliforms that occurs following high-speed centrifugation of anaerobic biosolids at some facilities. With water reuse as one of the Sustainable Infrastructure 4 Pillars, it is important to understand the potential for cross-system connections and gray water storage and disinfection impacts on human health, if any.

Research needs and activities related to human health effects as a tool for achieving sustainable water infrastructure include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Understand the potential impacts of water reuse (gray water) on human health from cross connections, improper disinfection/storage, etc.

Tier 2

Conduct field studies to determine whether contaminants in biosolids pose a public health risk when applied in compliance with current regulations.

Tier 3

None yet identified.

Method Development

Water infrastructure (*e.g.,* drinking water treatment and decentralized wastewater systems) is expensive, as are the monetary and social costs incurred when infrastructure fails. If a system is well maintained, it can operate safely over a long time period. Research is needed to provide utilities with tools that will allow them to better manage the nation's aging drinking water and wastewater infrastructures. Helpful research may also include methodologies for classification, valuation, prediction, indicator selection, frameworks, and models.

Research needs and activities related to method development as a tool for achieving sustainable water infrastructure include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Develop methods to: determine the effectiveness of decentralized wastewater systems; evaluate effectiveness of residuals (both biosolids and drinking water residuals) treatment and management; assess decentralized system failures and their impacts; examine the economic costs and benefits of green infrastructure.

Tier 2

Develop methods to: account for decentralized systems in TMDL models on a watershed scale; detect, identify, track, disinfect, and stabilize pathogens in wastewater, biosolids, and animal wastes; integrate water and wastewater management approaches to improve cost effectiveness; educate the public about water conservation; conduct cost studies of similar systems using different capital replacement and repair strategies.

Tier 3

None yet identified.

Occurrence and Exposure

Global change can affect water resources and infrastructure engineering and management by changing hydrologic regimes. Such changes might impact the effectiveness of our water treatment infrastructure, potentially changing the public's exposure to contaminants. Exploration of such potential effects is needed. Managing impacts will require strategies for decreasing the vulnerability of existing infrastructure, assessing future needs, and developing and adopting new engineering and management methods to ensure compliance with CWA, SDWA and its amendments, and other related congressional mandates.

Emerging contaminants (e*.g.,* endocrine disrupting compounds, PPCPs, nanoparticles, and prions) are another area of concern. They have come under increasing scrutiny over the last decade, and there are growing concerns over the fate of these emerging contaminants in land-applied biosolids, septage, and manure.

Research needs and activities related to occurrence and exposure as a tool for achieving sustainable water infrastructure include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Define the impact of global change stressors on the design, operation, and performance of water infrastructure and built environment; identify and quantify the pollutants in wet weather flows.

Tier 2

Assess the occurrence of nanochemicals and particles in products produced from land-applied biosolids; develop tools that increase capacity to respond to future global change. Determine effects of nanomaterials and other emerging contaminants on publicly owned treatment works (POTWs). Understand the fate of pharmaceuticals in land applied biosolids.

Tier 3

None yet identified.

Treatment Technologies and Effectiveness

Conventional wastewater and drinking water treatment processes have provided a relatively solid barrier between humans, the environment, and the many contaminants in domestic and industrial wastewaters and in source waters. However, new innovative technologies still need to be identified and evaluated. Additionally, information will be needed on the abilities (*e.g.,* efficiencies, performance capabilities/effectiveness, reliability) of conventional and innovative (*e.g.,* green infrastructure) treatment technologies to remove emerging and currently regulated contaminants.

A number of management methods (best management plans and collection system management) currently exist to control wet weather flow from municipal separate stormwater sewers, municipal wastewater overflows (combined sewer overflows (CSOs)/sanitary sewer overflows (SSOs)), concentrated animal feeding operations (CAFOs), industrial facilities, and construction sites. Further action needs to be taken to characterize, treat, and manage (*e.g.,* Nutrient Management Plans (NMPs)) current and emerging contaminants (*e.g.*, prions and nanomaterials) in wet weather flows, runoff, and wastewater.

Research needs and activities related to treatment technologies and effectiveness as tools for achieving sustainable water infrastructure include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Identify and develop technologies to: reduce and control pollutants in wet weather flows; improve effectiveness of animal livestock nutrient management plans; evaluate green infrastructure effectiveness and integration with water reuse and reclamation at the watershed scale; identify and evaluate secondary benefits of green infrastructure.

Tier 2

Develop sewer and treatment system design concepts for centralized and decentralized systems for contaminants, energy efficiency, and energy production; evaluate current residuals disinfection and stabilization technologies; understand how antimicrobial resistance and nanoparticles may impact treatment processes.

Tier 3

None yet identified.

4 ● Water Security Research Needs

As the water sector-specific federal lead for protecting the nation's drinking water and wastewater infrastructure, EPA plays a critical role in homeland security. The Office of Ground Water and Drinking Water's (OGWDW's) Water Security Division (WSD) takes the lead in working with EPA's National Homeland Security Research Center (NHSRC) to identify and conduct research on ways to better secure the nation's drinking water and wastewater systems against threats and attacks. These initiatives focus on the nation's drinking water and wastewater supply, infrastructure, treatment, and distribution systems.

The Water Security Program has supported drinking water and wastewater utilities by preparing vulnerability assessments and emergency response tools and training, providing technical and financial assistance, and developing information exchange mechanisms. The Water Security Program is also charged with supporting best security practices, providing security enhancement guidance, and incorporating security into the day-to-day operations of drinking water and wastewater utilities.

The NHSRC's Water Infrastructure Protection Division (WIPD) conducts research and develops tools to increase our understanding of public health and environmental impacts from various kinds of water infrastructure attacks. This understanding, when integrated into water security practices, leads to improved awareness, preparedness, prevention, response, and recovery from intentional acts against water and wastewater systems. WIPD is producing analytical tools and procedures, technology evaluations, models and methodologies, decontamination techniques, technical resource guides and protocols, and risk assessment methods (http://www.epa.gov/nhsrc/pubs.html). All of these products are for use by EPA's key water infrastructure customers – water utility operators, public health officials, and emergency and follow-up responders.

Aquatic Life Health Effects

No Tier level research needs have yet been identified.

Human Health Effects

No Tier level research needs have yet been identified.

Method Development

To safeguard our drinking water supplies, treatment processes, and distribution systems from natural disasters and physical attacks, methods to detect and identify chemical, biological, and radiological (CBR) contaminants in drinking water are critical. EPA is responsible for developing methods to protect drinking water and wastewater systems from physical and cyber attacks (Bioterrorism Act 2002, Homeland Security Presidential Directives (HSPD) 7 and 9). The development of the Water Laboratory Alliance will provide the drinking water sector with an integrated nationwide network of laboratories with the analytical capabilities and capacity to support monitoring and surveillance, response, and remediation in the event of CBR contamination. EPA's detection research program focuses on developing detectors, analytical methods, sample preparation techniques, and models and tools to detect, in real-time when possible, contaminants introduced into the water and the wastewater. EPA's Water Security Initiative (WSI) program addresses the risk of intentional contamination of drinking water distribution systems (identification and consequences of an attack, and counter-measures for prevention and mitigation). Under the Water Security Program's Threat Ensemble Vulnerability Assessment (TEVA) Program, event detection systems consisting of data analysis tools have been developed to analyze water quality data streams. This will permit the rapid and accurate identification of anomalous conditions in distribution systems that require further investigation. As part of this effort, the Water Security Program collaborated with Sandia National Laboratory to develop a tool called CANARY, which reads data in real time and returns a normal or alarm signal to a utility computer system.

Research needs and activities related to method development as a tool for achieving water security include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Develop methods to: identify, evaluate, and protect utilities and systems from threats; optimize choices between water supply management and water demand management; address gaps in Water Security priority chemical and biological (including biological toxins) contaminants detection.

Tier 2

Improve the accuracy of CANARY (tool that analyzes water quality data streams and identifies anomalous conditions in distribution systems that require further investigation); Upgrade and expand the Water Contaminant Information Tool (WCIT), the National Environmental Methods Index for Chemical, Biological, and Radiochemical Methods (NEMI-CBR), and the laboratory compendium.

Tier 3

None yet identified.

Occurrence and Exposure

No Tier level research needs have yet been identified.

Treatment Technologies and Effectiveness

To ensure water security, tools are needed to respond to and remediate contamination events. Understanding the persistence of microbial contaminants in distribution systems is important in planning for decontamination approaches. Furthermore, as persistence and deactivitation of microbial contaminants is better understood, work will begin on studying the association of radiological contaminants with various pipe surfaces and methods of removing adhered agents. Understanding persistence and decontamination of radiological agents is necessary due to the general dearth of information on this topic in the technical literature. The Water Security Program is working on research to develop technology to appropriately handle the large volumes of water that may be generated when responding to an incident.

Research needs and activities related to treatment technologies and effectiveness as tools for achieving water security include (see Exhibit 2, page 4 for Tiering definitions, and Appendix 3 for details on research needs within each Tier):

Tier 1

Determine the fate and transport properties of contaminants in drinking water; develop a surrogate/simulant database to provide a resource/reference for contaminant modeling.

Tier 2

Identify and develop technologies to respond to and decontaminate systems in the event of intentional or accidental contamination.

Tier 3

None yet identified.

Appendices

Appendix 1 - List of Acronyms and Abbreviations

Bioterrorism Act	Public Health Security and Bioterrorism Preparedness and Response Act
BMPs	Best Management Practices
BOSC	Board of Scientific Counselors
CAFOs	Concentrated Animal Feeding Operations
CBR	Chemical, Biological, and Radiological
CCL	Contaminant Candidate List
CO_2	Carbon Dioxide
CSOs	Combined Sewer Overflows
CWA	Clean Water Act
DBPs	Disinfection by-product
EPA	Environmental Protection Agency
HSPD	Homeland Security Presidential Directive
NEMI-CBR	National Environmental Methods Index for Chemical, Biological, and Radiochemical Methods
NHSRC	National Homeland Security Research Center
NMPs	Nutrient Management Plans
NPDWRs	National Primary Drinking Water Regulations
NRC	National Research Council
OGWDW	Office of Ground Water and Drinking Water
ORD	Office of Research and Development
OST	Office of Science and Technology
OW	Office of Water
OWM	Office of Wastewater Management
OWOW	Office of Wetlands, Oceans, and Watersheds
OW RCT	Office of Water-Research Coordination Team
POTW	Publicly Owned Treatment Works
PWS	Public Water System
Regions	Regional Water Divisions
RMST	Research Management Status Tool
SAB	Science Advisory Board
SABS	Suspended and Bedded Sediments
SDWA	Safe Drinking Water Act
SSOs	Sanitary Sewer Overflows
TEVA	Threat Ensemble Vulnerability Assessment
TMDL	Total Maximum Daily Load

UCMR	Unregulated Contaminant Monitoring Regulation
UIC	Underground Injection Control
USDW	Underground Sources of Drinking Water
USEPA	United State Environmental Protection Agency
Water Research Strategy	National Water Program Research Strategy
WCIT	Water Contaminant Information Tool
WIPD	Water Infrastructure Protection Division
WSD	Water Security Division
WSI	Water Security Initiative

Appendix 2 - List of Contributors

The development of the *National Water Program Research Needs and Management Strategy (Water Research Strategy)* was made possible through the collaboration and commitment of the Office of Water Research Coordination Team. The team provided content, review, and obtained expertise and consensus across the Water Program that ensured the document is both comprehensive and integrated. Their names and affiliations are captured below, as are those of other major contributors.

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Appendix 3 - Research Needs Matrix

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Identify appropriate indicators of aquatic health and determine suitability of new analytical methods.			✓		✓	Nutrient criteria	47
Quantify the effects of exposures at, below, and above the criteria; tissue-based criteria to assess the risks posed by compounds that bioaccumulate through diet.			✓	✓			97
Toxicity data, particularly two-generation tests with multiple relevant endpoints. A derivation methods for use when available data set does not meet minimum Guidelines requirements.			✓	✓	✓		98
Understand the relationship between harmful algal blooms and nutrient dynamics (also useful for human health related to cyanotoxins and drinking water).	✓	✓		✓	✓	Nutrient criteria; Gulf of Mexico Hypoxia and HABs; CCL cyanotoxin decision	101
Community and population-level assessment models to replace current organism based criteria. Ecosystem models to integrate risk across an assemblage of species.			✓	✓		Guidelines and PAMs	105.1
BAFs for methylmercury in fish tissue relative to methylmercury in the water column across different water body types or ecological conditions to develop water column translations of the January 2001 fish tissue-based criterion.		✓	✓	✓			106
Conceptual and empirical approaches to predict, diagnose, prevent, and manage the combined effects of multiple stressors in aquatic systems. Methods to assess change in aquatic ecosystems that reflect responses to multiple and variable stressors.			✓	✓	✓		119 and 120
Assess emerging water quality concerns; both biological (pathogens, invasive species) and chemical (*e.g.,* pharmaceuticals) and which constituents to regulate.	✓	✓	✓			CCL	122
What is the impact of contaminants on ecosystem function?			✓	✓		Healthy Watersheds Initiative	124
How will/are aquatic ecosystems affected by climate changes?			✓				127

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Impact of climate and other global change stressors on the watershed and ocean processes that influence the structure, functioning, and services of freshwater and coastal ecosystems.			✓	✓		Climate change; Acidification of oceans	193
Conduct "Nutrient sources, fate, transport and effects" studies within Gulf of Mexico ecosystems.			✓			Gulf of Mexico hypoxia; Nutrients	208
Assess the contribution of isolated wetlands to the integrity of navigable downstream water bodies.				✓	✓	Nutrient criteria	45
Examine how the degradation, loss, or restoration of headwater streams and isolated wetlands affects the quality and integrity of navigable waters.				✓		Nutrient criteria	46
Estimate the environmental and economic impacts of invasive species affecting the aquatic environment.				✓	✓	Biocriteria	49
Characterize the effects of global change and anthropogenic stressors on conditions of coral and coral reefs.				✓	✓	Could in future as result of CBD pH petition re: ocean acidification to protect coral; Nutrient criteria, Biosolids	50
Characterize the interactive roles of ultraviolet radiation (UVR), temperature, and water quality on coral bleaching.				✓	✓	Biocriteria	51
Characterize the responses of coral symbionts (*Symbiodinium* spp.) to elevated UVR, elevated temperature and changes in water quality.				✓			52
Provide the scientific basis and load-response relationships needed to develop and implement numeric nutrient criteria, with an emphasis on the health of estuaries and coastal wetlands.				✓	✓	Nutrient criteria	99
Evaluate the relationship between nutrient criteria and flow conditions.				✓	✓	Nutrient criteria; Watershed Approach	100
Computational toxicology to help set priorities for data requirements and chemical risk assessments.		✓				CCL, Six-Year, UCMR, etc.	105.3
Tools to measure and predict the contributions of aquatic habitat protection and restoration to the maintenance and improvement of biological integrity.		✓		✓		Nutrient criteria, Biocriteria - Florida Petition	107

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Integrative methods and approaches to incorporate habitat into BCGs for application to tiered aquatic life use (TALU) frameworks.		✓		✓		Nutrient criteria, Biocriteria	108
Incorporate nutrient stressor-response relationships into BCG and TALU approaches.		✓		✓		Nutrient criteria, Biocriteria, Florida Petition	110
Classify ecosystems, landscapes, and watersheds for efficient and scientifically sound development and application of biocriteria		✓		✓		Biocriteria	121
Why is the *Diporeia* population in the Great Lakes declining				✓			123
What is the relative importance (risk) of emerging contaminants in Puget Sound?				✓			125
How does sedimentation affect coral reefs?				✓	✓		126
Effectively account for the combined and cumulative effects of point and nonpoint sources of pollution, habitat alteration, and other sources of impairment.		✓			✓	Nutrient criteria; Program Implementation; TMDL decisions	146
Determine the significance of ballast water introduction and transfer or native and invasive HABs species in the Gulf of Mexico.				✓		Balast Water; Gulf of Mexico HABs	205
Identify and develop environmental and biological indicators of nutrient impacts.				✓	✓	Nutrients	209
Characterize the connectivity and contribution of adjacent, freshwater systems to Gulf of Mexico watersheds using a regionally consistent methodology.				✓			211
Provide projections of the consequences of future development and other anthropogenic changes (such as climate change) and develop strategies to minimize negative impacts on important ecosystems.					✓	Nutrient criteria	48

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Theme: Healthy Watersheds and Coastal Waters							
For those emerging contaminants (or classes) that are candidates for regulation, conduct the necessary supporting research.	✓		✓			SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and UCMR (UCMR 3 - 2010; every 5 years)	86
Understand which human illnesses are caused by swimming in waters contaminated with human fecal matter from different sources, with non-human fecal matter, the levels of fecal matter (human and non-human) that cause human illness, the relationship between different levels of fecal matter (human and non-human) in waters and human illness rates, and differences in risk to children versus adults swimming in these waters.	✓	✓		✓		Settlement Agreement/BEACHES (Dec 15, 2010)	88
Extrapolation of research results for developing new or revised criteria. Are indicators, methods, and models suitable for use in different types of waters and for different CWA programs.	✓	✓		✓	✓	Settlement Agreement; Could impact some water quality and drinking water treatment needs (Dec 15, 2010)	95
Determine effective measures for reducing pathogens and emerging contaminants from sludge in environmental media.	✓			✓			96
Whether or not qPCR for *Enterococci* is applicable to other settings or appropriate for use across the range of CWA programs.	✓	✓				Settlement Agreement BEACHES (Dec 15, 2010)	169
Interaction of climate change with land use/land cover change and other global change stressors to exacerbate or ameliorate impacts on water quality and aquatic ecosystems; and the types and levels of human pathogens that can enter, be sustained, and thrive in waters of the U.S.			✓			Climate change (2013)	192
The influence of the interacting effects of changes in climate, land use, and economic development on human demand for water.			✓	✓		Climate change; Four pillars	195
Improve the understanding of specific pathogens in Gulf of Mexico waters that constitute risks to human health.	✓		✓			Gulf of Mexico; BEACHES	202
Understand the fate of pharmaceuticals in land applied sewage sludge.	✓		✓			503 Regulations	213

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Theme: Healthy Watersheds and Coastal Waters							
Study on alternative indicators of potential illnesses in salt water environments (e.g. Bacteroides).		✓		✓		Recreational Water	226
Develop new and improved methods to identify the coastal waters and beaches that are impaired by pathogens and to track the sources of these disease causing organisms.							201
Monitoring strategies to measure the effectiveness of watershed management programs.			✓	✓	✓	CWA §305(b); CWA §106; Healthy Watersheds Initiative	58
Methods to determine factors that motivate change in public behavior toward the protection or restoration of water quality.			✓	✓		2007 memo focus to increase outreach and education/toolbox (e.g., Weather Channel)	59
Develop technology transfer mechanisms that provide watershed managers with resources needed to make technically-sound watershed management decisions.			✓	✓			60
Better model the hypoxic zone to understand its dynamics and predict the impacts of restoration scenarios.			✓			Nutrient criteria, TMDLs	65
Determine how the assessment of ecological conditions, the modeling of ecological and human development futures, and the development of restoration and protection strategies can be done effectively at differing geographic and temporal scales. Incorporate and complement best professional judgment.			✓		✓	Nutrient criteria, Biocriteria; ASWIPCA	66
Provide national frameworks for statistical assessments.			✓			National Aquatic Resource Survey; CWA §305(b)	69
Methods (including predictive models) that provide more rapid and timely detections of pathogens or indicators of the presence of pathogens that are harmful to human health in recreational waters and drinking waters.	✓	✓		✓		Settlement Agreement/BEACHES; CCL (CCL4 - 2013; every 5 years) and Six-Year Review (Six-Year 3 - 2015; every 6 years), plus (B2) water security	87

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Establish a framework for prioritizing high-risk emerging contaminants for exposure and hazard assessment and criteria development.	✓		✓			SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and UCMR (UCMR 3 - 2010; every 5 years)	92
Indicators and methods of how well culture and molecular methods for various indicators (singly or in combination) correlate with swimming-related illnesses.	✓	✓			✓	Settlement Agreement; Indicators of co-occurrence (Dec 15, 2010)	93
Sampling and analytical methods or models to predict the recovery potential of different water body types.			✓	✓	✓	Nutrient criteria, Biocriteria	103
Methods for measuring biocriteria in arid systems, large and great rivers, wetlands, estuarine areas, and marine systems (including coral reefs).		✓	✓			Biocriteria	104
New concepts for defining and classifying ecosystem services and bundles of those services.			✓		✓	Healthy Watersheds Initiative	114
Improved approaches and information for describing the production of services.			✓		✓	Healthy Watersheds Initiative	115
Methods to quantify the values of ecosystem services and innovative ways of using this knowledge in proactive environmental management decisions.			✓		✓	Healthy Watersheds Initiative	116
Methods for valuation of services provided by wetlands and by coral reefs.			✓		✓	Healthy Watersheds Initiative	117
How do we manage ecosystems for climate change?			✓	✓		Carbon sequestration	130
Providing tools for effective ecosystem monitoring, identifying appropriate indicators of aquatic health and determining suitability of new analytical methods.			✓		✓	TALUs; Nutrient criteria, Biocriteria; National Aquatic Resource Surveys; CWA §305(b); CWA §106	148
Develop and improve integrative watershed modeling frameworks for describing the impacts of changing surface water quantity on water quality.			✓	✓		Water Climate Change Action Plan; CWA §106	149
Develop strategies to optimize the selection and location/placement of management measures in a watershed.			✓			Healthy Watersheds Initiative	151
Identify an approach for estimating the risks, costs, and benefits associated with wetland trading.			✓	✓		Tied to specific OWM strategy goals/permit issuance	155

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Determine how to manage and monitor wetlands used in water quality trading.			✓	✓	✓	Tied to specific OWM strategy goals/permit issuance; Nutrient criteria, Biocriteria	156
Accurately account for decentralized wastewater systems (both properly and poorly designed, operated, and maintained systems) in watershed models and TMDL calculations.		✓	✓				157
Select appropriate pathogens and indicators to properly assess sewage sludge quality.	✓	✓			✓	Biosolids; 503 regulations	167
Understand how well the various indicators and methods perform in other settings (e.g., marine versus fresh water; human versus non-human sources of fecal contamination), and how they relate to one another.	✓	✓		✓		Settlement Agreement; CCL (CCL4 - 2013; every 5 years) and Six-Year Review (Six-Year 3 - 2015; every 6 years)	178
The influence of climate change on EPA water quality and ecosystem protection and restoration programs.			✓	✓		Climate change	194
Develop methods for any new water quality criteria that HECD develops.			✓			304(a) of CWA	224
Methods to project the relative and combined risks from multiple stressors to aquatic and aquatic-dependent wildlife populations				✓			118
Determine how to avoid unintended negative consequences from wetland trading.				✓	✓	Nutrient criteria; Healthy Watersheds Initiative	147
Methods to evaluate and describe condition, thresholds of impairment, and attribute value to watershed goods and services.		✓			✓	Biocriteria; TMDLs; CWA §305(b); CWA §106	55
Methods, tools, and models to determine which (and how) stressors are causing degradation, or likely to cause degradation to enable targeted action for protection and restoration of watersheds.		✓			✓	Nutrient criteria, Biocriteria; diagnostics for TMDLs; CWA §305(b); CWA §106	56
Tools and knowledge to target watersheds for management and offer the greatest opportunity for achieving positive and intended environmental results.		✓				CWA §106	57
Determine how to avoid unintended negative consequences associated with wetlands managed for nutrient removal.				✓	✓	Nutrient criteria, Biocriteria	61

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Identify an acceptable approach for estimating risk and uncertainty in wetlands used in water quality trading.				✓	✓	Nutrient criteria, Biocriteria	62
Classification methods, simple models, mapping techniques, and rapid assessment field methods for headwaters, adjacent wetlands, and isolated wetlands that incorporate and complement best professional judgment.				✓	✓	Nutrient criteria, Biocriteria	64
Develop an improved scientific basis for the establishment and maintenance of rapid response and monitoring programs for non-indigenous species.				✓			67
Create education and outreach opportunities to assist groups and individuals affected by invasive species.				✓			68
Develop improved analytical techniques for pathogens and priority toxic contaminants in or released from biosolids.		✓				503 Regulations; Six-Year	89
Methods to establish Biological Condition Gradient (BCG) and Generalized Stressor Gradient models.		✓		✓		Nutrient criteria, Biocriteria	102
Tools for measuring and predicting the economic and societal benefits of aquatic habitat protection and restoration at local, regional, and national scales.				✓	✓	Healthy Watersheds Initiative	109
Tools (monitoring methods, models, guidance) to implement environmentally sound nutrient trading approaches				✓	✓	Nutrient criteria	111
Improve technical methods used in EPA's Framework for Developing SABS Water Quality Criteria		✓			✓	TMDLS	112
Verify methods and support implementation of the SABS Framework		✓			✓	TMDLS	113
What is the relationship between sediment deposition and anthropogenic (land use) and natural (climate change) impacts on a system.				✓		Healthy Watersheds Initiative	128
What is the origin, transport, and residence time of sediments in estuaries?				✓	✓	Healthy Watersheds Initiative	129
Assess the costs associated with various management measures to allow for the development of effective watershed strategies.				✓		Healthy Watersheds Initiative	150

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Determine the factors that most motivate changes in public behavior with respect to the protection or restoration of water quality.				✓			153
Effective technology transfer mechanisms are needed to provide watershed managers with resources needed to make technically-sound watershed management decisions.				✓			154
Up-to-date technology transfer methods regarding innovations and costs of treatment technologies.				✓			158
Develop and evaluate methods that help prevent, control and mitigate HABs and their impacts.				✓		Gulf of Mexico HABs	206
Water quality methods for under-represented organisms in our aquatic life criteria so that we can improve our Endangered Species Act consultations by having data on organisms that U.S. Fish and Wildlife Service and others believe are more sensitive				✓		Water quality criteria; Method improvement	217
Develop sound nutrient criteria for different waterbody types. Case studies on high priority watersheds (e.g., Illinois River, Gulf of Mexico, Bosque River) and more refined methodologies would be highly desirable for developing numeric values.				✓		Nutrients	218
Forecasting based on tidal movements from the day before.		✓				BEACHES; Recreational Water	223
Risk assessment modeling to determine if microbial indicators are from birds or an actual sewage spill.		✓				BEACHES; Recreational Water	240
Monitoring protocols for MEP and MS4 permits (Where are the appropriate locations for sample stations, e.g., outfalls junction manholes, in-stream? When should sampling occur, e.g., dry weather, wet weather, prior to implementing structural BMPs, after implementing structural BMPs? What would constitute a statistically sound number or percentage of stations to target as an MEP in a MS4 general permit? And, what number of samples would be sound for each station?)		✓		✓		Wet weather/OWM Strategy	225
Identify trends in water quality and aquatic systems.	✓				✓		70
How often, where, and at what concentrations do emerging contaminants occur?		✓	✓		✓	TMDLs; CCL	133

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Chemical, physical, and biological information that will allow them to understand the status and functioning of aquatic ecosystems and to evaluate the success of watershed protection and restoration measures over time.			✓				159
Determine the geographic scale on which trading might occur.		✓	✓				160
Information about the pollutants in various types of wet weather flows, including pathogens and emerging contaminants.			✓			Tied to specific OWM strategy goals and Hanlon's Performance Standards	185
Identify impaired surface waters and establish causal links between climate and other stressors and endpoints of concern.			✓	✓		Climate change	197
Develop scientific knowledge of potential pathways of introduction of nonindigenous and invasive species and tools to ensure their prevention.				✓		Ballast water	71
Dose-based toxicity models to account for multiple routes of exposure, including diet. Bioaccumulation, tissue concentrations, and fate and transport models.		✓				Relative Source Contributions for CCL chemicals, RegDet	105.2
How have non-native species become established?				✓		Ballast water	131
What is the distribution of pollutants in runoff, including metals and polycyclic aromatic hydrocarbons in Puget Sound?		✓				TMDLs	132
Improve Gulf of Mexico-wide harmful algal blooms (HABs) monitoring networks.				✓		Hypoxia	204
Quantify and model the major sources of mercury (for instance, atmospheric or river input), fate and transport of mercury in the Gulf of Mexico.		✓		✓	✓	Fish survey	207
Limiting use of fertilizers within 5 feet of pavement, 25 feet of a storm drain, or 50 feet of a waterbody.				✓		Healthy Watersheds Initiative	215
Identify and characterize the watershed structures, features, and processes that influence the likelihood for successful management interventions.			✓				72

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Determine the performance and costs of individual management measurements to support the development of watershed management strategies.			✓				73
Optimize the selection and location/placement of management measures in a watershed.			✓				74
Determine the effectiveness of best management practices (BMPs).			✓		✓	Nutrient criteria	75
Effective management strategies to reduce nutrient and sediment ecosystem impacts in the Mississippi Basin and in the Gulf of Mexico.			✓	✓	✓	Nutrient criteria; Hypoxia Task Force goal	78
Management measures to control hypoxia			✓	✓		Nutrient criteria; TMDLs	134
Methods to control the introduction of invasive species in ballast water to native waters.		✓	✓			Ballast water general permit issuance every 5 years	136
Evaluate treatment system efficiencies for currently regulated pollutants (pathogens and nutrients) and emerging pollutants of concern.		✓	✓		✓	Nutrient criteria; Six-Year Review	163
How to increase the resilience of watersheds, water infrastructure, and aquatic ecosystems to global change stressors (hurricanes, tsunami, and other natural disasters.			✓	✓	✓	Healthy Watersheds Initiative	200
Identify existing data regarding wetland nutrient removal rates to be used for modeling and assigning trading credits.				✓	✓	Nutrient criteria	76
Feasibility of offsetting stream segment degradation with improvements.				✓			77
What is the effectiveness of BMPs for sediment reduction?				✓	✓	Wet Weather; Healthy Watersheds Initiative	135
How do we best manage sources of toxics as a part of remediation?				✓		303(d)	137
Identify existing data regarding wetland nutrient removal rates for modeling and assigning trading credits.		✓		✓	✓	Nutrient criteria; permitting	161
Evaluate treatments that will improve system performance such as the abilities of the various soil types to provide treatment.				✓		decentralized systems	162

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Evaluate performance capabilities and reliability of many currently available onsite/ decentralized treatment technologies.		✓					164
Develop science-based tools that better control nonpoint source and otherwise unregulated point source pollution at the water resource scale (i.e., watershed and aquifer).		✓		✓			166
How antimicrobial resistance in wastewater streams may impact the treatment process.				✓		Healthy Watersheds Initiative	187
Develop tools and scientific knowledge to control invasive species that affect aquatic ecosystems.					✓		79
How does underground injection of large volumes of CO2 impact ground water chemistry and microbiology?	✓					Geologic Sequestration Rulemaking (2013)	7.1
What are the actual or potential human health effects of known and emerging pathogens, chemicals, and suites of contaminants and how can the risk assessment process be improved to best assess these effects? (This includes CCL 3 chemicals: 74 FR 51850)	✓	✓	✓	✓		CCL Regulatory Determination; SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years)	1
What is the cumulative risk associated with combinations of contaminants that are likely to co-occur and affect similar target organs or modes of action?		✓	✓	✓		SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years) Statute does not require, but requested by NAS	2
What is the impact of CO2 co-contaminants on drinking water sources?	✓					Geologic Sequestration Rulemaking (2013)	7.2

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Use of mechanistic data in risk assessment. Understanding key events associated with exposure and the ultimate manifestation of an adverse health effect (i.e., the toxicity pathway or mode or mechanism of action) would help reduce the uncertainty associated with data extrapolation from animals to humans and from high to low doses.	✓	✓		✓		SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years)	80
Sensitive subpopulations. Is there differential life-stage responsiveness or exposure to environmental agents (chemical and pathogen)?	✓	✓	✓			SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years)	82
Contaminant-specific health studies. Sufficient occurrence, health effects, reproductive effects, etc. data on specific chemicals to determine if regulation is warranted under the Safe Drinking Water Act and/or criteria recommendations under the Clean Water Act (CWA).	✓	✓	✓			SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years)	83
Determine whether contaminants in biosolids pose a public health risk when applied in compliance with current regulations.	✓	✓				Ground Water Rule/DBPs; 503 Regulations	84
Develop approaches to identify/categorize which emerging contaminants (or classes) are risks to the environment or human health.	✓	✓		✓		SDWA CCL (CCL4 - 2013; every 5 years), and RegDet (2011; every 5 years)	90
Define appropriate toxicological data and health endpoints to evaluate emerging contaminants, such as pharmaceuticals.	✓	✓	✓			Tied to specific OWM strategy goals; (CCL4 - 2013; every 5 years); TMDLs; Criteria development	180
Improved understanding of Vibrio bacteria ecology, health risks and research needs.	✓					CCL; Six-Year Review	203
What are the critical developmental adverse health effects following short term lead exposure?		✓				Six-Year Review (Six-Year 3 - 2015; every 6 years)	1.1
What is the potential for brines and residuals from drinking water treatment facilities to impact underground sources of drinking water when injected in shallow class V wells?				✓		Climate change, need for developing guidance (2013)	5.2
Assess impacts of UIC Class V mine backfill wells accepting coal fly ash on USDWs		✓					227

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Theme: Safe Drinking Water							
Determine impacts on drinking water sources from injection activities and waste management associated with oil & gas production					✓		228
Which methods and models are appropriate for longitudinal research with children? How should genetic differences among populations that influence their susceptibility to illness or disease from a hazardous substance be considered in risk assessments?	✓	✓	✓			SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years)	82.1
Do analytical methods exist with enough sensitivity, specificity, accuracy and precision to: (i) detect and quantify the contaminant, and (ii) verify remediation or removal? For pathogens, can the methods address viability? (This includes CCL 3 chemicals: 74 FR 51850)	✓	✓	✓			CCL Regulatory Determination; Detection and quantification of pollutants in the environment is necessary to calculate RSCs; SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), Six-Year Review (Six-Year 3 - 2015; every 6 years), and UCMR (UCMR 3 - 2010; every 5 years)	3
Are the methods robust enough to support national occurrence data collection and/or can they be widely applied to support monitoring for regulatory compliance? (This includes CCL 3 chemicals: 74 FR 51850)	✓	✓	✓			CCL Regulatory Determination; SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), Six-Year Review (Six-Year 3 - 2015; every 6 years), and UCMR (UCMR 3 - 2010; every 5 years); must promulgate methods associated with drinking water regulations; need methods for occurrence information	4

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
How do we account for and address climate change impacts on water resources? (tools to support integrated water resource planning and management at multiple water resource scales, assessment and multi-decadal projection of water quantity and quality, and the optimization of choices among water supply management and water demand management alternatives)?			✓		✓	Climate change	6
What is the capability of existing models to evaluate hydrologic and geologic factors in the area of review for CO2 injection?	✓					Geologic Sequestration Rulemaking (2013)	8.1
What monitoring methods are best at detecting soil gases and ground water movement related to CO2 injection?	✓					Geologic Sequestration Rulemaking (2013)	8.2
What models should be used to predict potential leakage in area of review for CO2 injection?	✓					Geologic Sequestration Rulemaking (2013)	9.1
What methods are best to test mechanical integrity of wells accepting large volumes of supercritical CO2 for deep underground injection?	✓					Geologic Sequestration Rulemaking (2013)	10.1
What materials are most reliable for the construction and plugging of UIC wells for long-term storage of CO2 and plugging abandoned wells in area of concern?	✓					Geologic Sequestration Rulemaking (2013)	10.2
What technical tools and decision models should be used or built to support aquifer storage and recovery for non-potable reuse?			✓	✓		Climate change (2013)	11
What methods are best at determining the geochemical and hydrological conditions for storing water underground for future use?			✓			Climate change (2013)	11.1
What data collection practices best capture the risk for both acute (where applicable) and chronic exposure?	✓	✓	✓	✓		CCL Regulatory Determination; SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years); Relative source contributions	18
How do we determine aggregate exposures to the same chemical from multiple media (*e.g.,* water, air, food)?	✓	✓	✓	✓		Relevant to RSC calculations; SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years); Relative source contributions	19

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Methods (including predictive models) that provide more rapid and timely detections of pathogens or indicators of the presence of pathogens that are harmful to human health in recreational waters and drinking waters.	✓	✓				Settlement Agreement; SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years)	91
Develop improved analytical techniques for pathogens and priority contaminants in residuals/biosolids.		✓	✓			Tied to specific OWM strategy goals	170
Methods to assess emerging pathogens (from viruses to prions, for example).	✓	✓				SDWA CCL (CCL4 - 2013; every 5 years), and UCMR (UCMR 3 - 2010; every 5 years); CCL	171
Analytical methods to gather occurrence data for unregulated and emerging contaminants for future UCMR data collection efforts and the CCL Regulatory Determination process.	✓	✓	✓			CCL Regulatory Determination; This will be important for RSC calculations as well; SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), A-2 for Six-Year Review (Six-Year 3 - 2015; every 6 years), and UCMR (UCMR 3 - 2010; every 5 years)	172
More robust methods for measuring pathogens and emerging DBPs and DBP mixtures in drinking water and distribution systems.	✓	✓				Total Coliform Rule; SDWA CCL (CCL4 - 2013; every 5 years), Six-Year Review (Six-Year 3 - 2015; every 6 years), and UCMR (UCMR 3 - 2010; every 5 years)	174
Evaluate whether or not the existing toxicological methods can adequately account for and address emerging contaminants, such as pharmaceuticals.	✓	✓	✓			SDWA CCL (CCL4 - 2013; every 5 years)	179
Testing procedures or models for evaluating emerging contaminants fate and effects.	✓		✓			Tied to specific OWM strategy goals; SDWA CCL (CCL4 - 2013; every 5 years); Goals	181
Assess the quality and utility of data, tools, and methods used for risk assessments for new and unique contaminants, such as prions and nanomaterials.	✓	✓	✓	✓		Tied to specific OWM strategy goals; SDWA CCL (CCL4 - 2013; every 5 years), and UCMR (UCMR 3 - 2010; every 5 years)	182

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
New or improved analytical methods are needed to gather occurrence data on emerging contaminants.	✓	✓	✓	✓		SDWA CCL (CCL4 - 2013; every 5 years)	183
Determine management and treatment practices appropriate for aquifer storage & recovery injection activities that prevent endangerment of USDWs.	✓						229
Cumulative risk. Risk assessment methods to evaluate human health risks from exposure to chemical mixtures.		✓		✓		SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years)	81.1
How do we assess drinking water resources and their vulnerability to contamination?		✓				SDWA six-year - LT2 (vulnerability assessments for guidance), GWR; 303(d) (2015; every 6 years)	5
Assess how well culture and molecular methods for pathogens (singly or in combination) may perform (new molecular methods must consider the specificity and sensitivity of the methods and how they can address viability and infectivity of the pathogens.		✓		✓		SDWA CCL (CCL4 - 2013; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years)	168
New methods or refine existing analytical methods for the detection and quantification of regulated contaminants to improve existing drinking water standards.		✓				SDWA Six-Year Review (Six-Year 3 - 2015; every 6 years)	173
Best approach to obtain water samples for in lab testing. In particular, what is the best method for sample preparation and concentration for those pathogens present is such small numbers that it takes filtering up to 100 + liters of water to obtain a workable concentrate for analysis?		✓				CCL; Six-Year Review	220
What is the national occurrence of contaminants and the resultant exposures to the public?	✓	✓	✓			CCL Regulatory Determination; SDWA CCL, RegDet, UCMR, and Six-Year Review	16

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
How is the public exposed to these contaminants (*i.e.,* inhalation, ingestion, dermal), how often, and for what duration?	✓	✓	✓	✓		CCL Regulatory Determination; SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years); Relative source contributions	17
Cumulative risk. Exposure assessment information to evaluate human health risks from exposure to chemical mixtures.		✓		✓		SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years)	81
National baseline of what the current background levels of Contaminant Candidate List (CCL) pathogens or waterborne pathogens are in US distribution systems and in the US population.					✓	Interest in support for CCL	221
Provide data and information on BMPs to improve source water quality.			✓			Nutrients (2010)	5.1
What treatment technologies or techniques exist to remediate the contaminant or are new technologies needed?	✓	✓			✓	SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years)	20
How can public water systems minimize the impacts of treatment changes upon lead and copper corrosion?		✓				SDWA Six-Year Review (Six-Year 3 - 2015; every 6 years)	20.1
Which are optimal corrosion control treatment approaches?		✓				SDWA Six-Year Review (Six-Year 3 - 2015; every 6 years)	20.2

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Control of pollution at the water resource scale (*i.e.,* watershed and aquifer).		✓		✓	✓	Implementation of SDWA; (to credit watershed management as a treatment technique); 303(d)	21
Develop science-based tools that better enable the assessment of drinking water resources and their vulnerability to contamination.		✓					165
The full effects and consequences of alternative energy production (*e.g.,* biofuels) and carbon sequestration for water quality.			✓	✓	✓	Biosolids, Nutrient criteria; Geologic sequestration rulemaking (2013), climate change	191
Analyze the effectiveness of green infrastructure approaches for wet weather management and MP selection to meet specific TMDL needs in a targeted watershed.				✓	✓		212
Investigate water-reuse options. Research is needed for topics such as human health effects from possible gray water exposure resulting from in home cross-connections, impacts of the improper disinfection or storage of gray water, and maintenance and upkeep of in home systems to prevent adverse health effects.			✓				219
Field studies to determine if contaminants in biosolids pose a public health risk where biosolids are applied to land.		✓				Biosolids; Part 503 biennial reviews	24
Determine decentralized wastewater system and residuals treatment effectiveness and management, including fate of emerging contaminants.			✓	✓			25

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Assess system failures and their impacts (including cause and effect studies); leach field/soil treatment and water acceptance capacity; comprehensive system management; and fate/transport of pathogens and emerging pollutants.			✓	✓	✓	Biosolids	26
Examine economic costs and benefits of green infrastructure (GI) and develop methods and protocols for economic parameters.			✓	✓	✓	Tied to specific OWM strategy goals	30
Develop standard protocols for assessing multiple benefits from GI (*e.g.,* energy savings, carbon sequestration, urban heat island reduction, biodiversity, water conservation).			✓		✓	Biosolids; Wet Weather Goals	31
Methods to compare the benefits of GI with those of grey infrastructure approaches.			✓	✓	✓	Biosolids; Tied to specific date driven OWM strategy goals	32
Additional data are needed to help utilities evaluate and estimate the costs of treatment and delivery of drinking water and wastewater.	✓			✓		SDWA CCL (CCL4 - 2013; every 5 years), RegDet (2011; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years)	140
Better define the effectiveness, costs, and benefits of water conservation and water efficiency practices and programs.			✓	✓	✓	Tied to specific OWM strategy goals; Indirectly impacts rule costs (lower flows)	142
What are the best methods for improving monitoring protocols to evaluate optimal corrosion control treatments?		✓				Six-Year Review	15.3
How can we best characterize the aggressiveness of drinking water nationally?		✓				Six-Year Review	15.4
Accurately account for decentralized systems in TMDL models: evaluate the risk associated with decentralized systems on a watershed scale; compare and prioritize at-risk watersheds; the impact of both properly and poorly designed, operated, and maintained systems; new or refined source tracking and remote sensing methods to accomplish reliable watershed-scale assessments.				✓	✓	Decentralized systems	27
Methods for the detection and identification of pathogens in wastewater, biosolids, and animal wastes to ensure proper disinfection and stabilization.		✓		✓		TMDLs; support rule but no dateline	28

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Refine methods for microbial source identification and tracking.				✓		BEACHES	29
New and innovative condition assessment and rehabilitation methods and technologies for sewerage systems.				✓		Biosolids	33
Information on new and innovative condition assessment and rehabilitation and replacement methods and technologies.				✓			138
Comprehensive, integrated management approaches to improve the ability of water and wastewater utilities to cost-effectively assess, maintain, operate, rehabilitate, and replace their collection and treatment systems.		✓		✓	✓	Biosolids, SDWA CCL (CCL4 - 2013; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years)	139
Social marketing approaches need to be explored to determine how to best educate the public regarding the benefits and costs of providing high-quality public services.				✓	✓	Rule costs	141
Social marketing approaches to provide effective education and outreach campaigns on water conservation.				✓	✓		143
Provide cost studies of similar systems that managed capital replacements and repairs using an asset management program versus a system that fixed things as they break.				✓		Four pillars	214
The regional differences in vulnerability of water quantity, water quality, ecosystems, water infrastructure, and human health to global change.			✓	✓		Climate change	198
Impact of climate and other global change stressors on the design, operation, and performance of water infrastructure (e.g., drinking water treatment, wastewater treatment, urban drainage) and the built environment.			✓	✓		Climate change; Four pillars	199
Appearance of nanochemicals/particles in products produced from land-applied biosolids.		✓				Biosolids	184
Information, capabilities, and tools to increase their capacity for assessing and responding to global change given uncertainty about the type and magnitude of future change.				✓			196

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Theme: Sustainable Water Infrastructure							
Approaches to reduce and control nutrients and difficult to treat chemicals and pathogens.			✓	✓		Nutrient criteria; Tied to specific OWM strategy goals	35
Management and treatment of municipal, industrial and construction wet weather flows "outside the fence line" of the POTW.			✓	✓	✓	Nutrient criteria	38
Studies to determine the effectiveness of Nutrient Management Plans for animal livestock operations and other land applications of residuals.	✓	✓	✓			Nutrient criteria, Biosolids; Tied to implementation of CAFO rule	43
Characterize GI practices and their effectiveness at the watershed scale, taking into consideration upstream and downstream conditions, some of which can be done through case studies.			✓	✓			43.1
Better understand and integrate Green Infrastructure approaches into a comprehensive approach, as well as water reuse and reclamation approaches.			✓			Wet Weather Goals; Healthy Watersheds Initiative	145
Effectiveness of both conventional and innovative treatment technologies for minimizing the risk from emerging contaminants.	✓	✓		✓		SDWA CCL (CCL4 - 2013; every 5 years), and Six-Year Review (Six-Year 3 - 2015; every 6 years)	186
Identify appropriate new or existing treatment techniques and BMPs for removing or inactivating emerging contaminants in runoff from various sources, activities and materials.		✓	✓		✓	Biosolids; Tied to specific OWM strategy goals; TMDLs	189
Effects of nanomaterials on POTWs, the abilities of nanomaterials to survive the treatment process.			✓	✓	✓	Biosolids	190
Control emerging contaminants, through additional treatment, source reduction, and product substitution.		✓		✓		503 regulations	36
Improve energy efficiency and decentralized power production.				✓			37
Reduce the volume of wastewater treatment residuals.				✓	✓	Nutrient criteria	39

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Ability of various soil types to provide treatment; treatment system efficiencies for currently regulated pollutants (pathogens and nutrients), as well as emerging pollutants of concern (endocrine disruptors, PPCPs, and difficult to treat pathogens); performance capabilities and reliability of many currently available decentralized treatment technologies.				✓	✓	Nutrient criteria, Biosolids; Decentralized systems, accounting for lead testing	40
Documentation of the effectiveness of current residuals disinfection and stabilization methods.		✓					41
New sewer and treatment system design concepts.				✓			44
Determine performance capabilities and reliability of many currently available decentralized/on-site treatment technologies for emerging pollutants of concern.		✓					188
What methods and tools are needed to protect water and wastewater utilities from physical and cyber threats (i.e., water security, emergency response)?			✓	✓		Decontamination emergency response planning (2011) and WSI (2013)	12
How do we evaluate potential utility and system threats and their impacts (i.e., water security, emergency response)?			✓	✓		Decontamination emergency response planning (2011) and WSI (2013)	13
Are there methods and tools to evaluate and address system vulnerabilities (i.e., water security, emergency response)?			✓			Water security	14
What are the optimal methods for detection of contaminants and means to quantify, determine and reduce the impact of such events (i.e., water security, emergency response)?			✓			Water security	15.1
What methods exist for optimization of choices among water supply management and water demand management alternatives (i.e., water security, emergency response)?			✓			Water security	15.2
Developing detectors, analytical methods, sample preparation techniques, and models and tools to detect, in real-time when possible, contaminants introduced into the water and wastewater systems (i.e., water security, emergency response).		✓	✓	✓		SDWA Six-Year Review (Six-Year 3 - 2015; every 6 years), Water security	175

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Expansion of select agent and toxin capabilities beyond the current CDC supported methods.	✓						230
Development and validation of methods for toxins including but not limited to aflatoxins, alpha-amanitin, colchicines, digoxin, and picrotoxins.	✓						231
For many non-select agents there are methods available that can be leveraged and subjected to laboratory optimization and validation (e.g., E. coli O157:H7, Vibrio cholerae, enteric viruses).	✓						232
Efforts to standardize sample collection procedures are necessary in order to provide laboratories with representative samples that maintain sample and contaminant integrity.	✓						233
Development of training programs targeting the laboratory community are necessary to ensure that as new methods and technology become available laboratories would be provided training in the use of these methods which would result in expansion of capability and capacity.			✓				235
Efforts to develop, improve, and evaluate online sensors and capabilities to detect chemical and biological agents and to test the validity of assumptions relating to threshold levels of target contaminants required to trigger sensor(s) remain a priority.	✓	✓					236
Improve the accuracy of CANARY, a tool that analyzes water quality data streams and identifies anomalous conditions in distribution systems that require further investigation.		✓				Water security	176
Continual upgrade and expansion of the Water Contaminant Information Tool (WCIT), National Environmental Methods Index for Chemical, Biological, and Radiochemical Methods (NEMI-CBR) and the laboratory compendium.		✓					237
Evaluation of innovative, cutting-edge technologies to support water security related activities is a priority.					✓		234

Research Activity*	Bins					Driver and Dates	Matrix Reference Number
	A.1	A.2	B.1	B.2	B.3		
Theme: Water Security							
Determining the fate and transport properties of contaminants in drinking water is a priority.	✓						238
Development of a surrogate/simulant database would provide a resource/reference for contaminant modeling.	✓						239
Are methods available to respond to system contamination events (including emergency response)?		✓			✓	Six-Year Review (Six-Year 3 - 2015; every 6 years) (distribution system security)	22
Are approaches available to decontaminate systems in the event of intentional or accidental contamination (including emergency response)?		✓		✓	✓	Six-Year Review (Six-Year 3 - 2015; every 6 years) (distribution system security)	23

* The Matrix is organized in the same Theme, Tool, Tier hierarchy as the document so it can be easily referenced for a full listing of research needs that are summarized in the document. Note that research needs and activities do not necessarily fit under just one Theme/Tool/Tier category. Because research can have a variety of drivers and objectives, the same or similar research needs and activities are sometimes listed under more than one Theme or Tool in the Matrix.

Themes and corresponding document chapters include:

Chapter 1: Healthy Watersheds and Coastal Waters Research Needs
Chapter 2: Safe Drinking Water Research Needs
Chapter 3: Sustainable Water Infrastructure Research Needs
Chapter 4: Water Security Research Needs

Tools are the practical implementation areas of the National Water Program and include:

Aquatic Life Health Effects
Human Health Effects
Method Development
Occurrence and Exposure
Treatment Technologies and Effectiveness

Bins and Tiers:

Senior water managers designed a process to prioritize water research needs dividing the needs into two categories containing a total of five bins. The categories were defined based on the type of driver necessitating the research: Category A: statute/court order/regulation date driven, and Category B: goal driven. The bins within the categories defined whether the research was critical path to meeting program obligations: Bins A.1 and B.1, or non-critical path to meeting a program obligation: Bins A.2, B.2, and B.3.

Tier 1: On critical path to satisfy a statutory, regulatory, court ordered, or Agency/Office strategic obligation. (Bins A.1 and B.1)
Tier 2: Supports, augments, or improves existing and adequate tools, guidance, or policy, or would enhance new critical path research products. (Bins A.2 and B.2)
Tier 3: Investigates potential environmental concerns of the future, or takes advantage of a serendipitous opportunity to leverage resources or an initiative. (Bin B.3)