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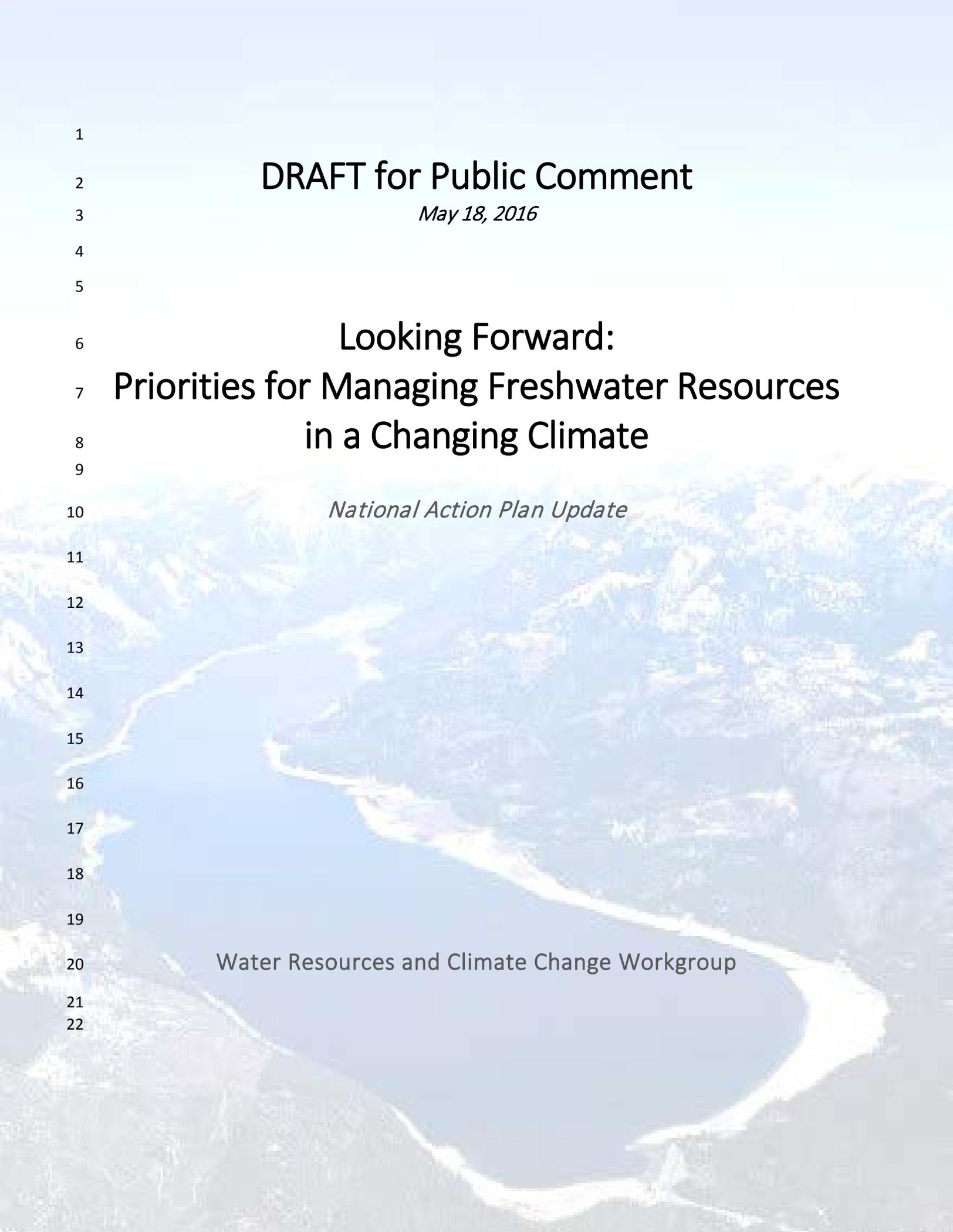
DRAFT for Public Comment

May 18, 2016

**Looking Forward:
Priorities for Managing Freshwater Resources
in a Changing Climate**

National Action Plan Update

Water Resources and Climate Change Workgroup



DRAFT

Cover Photo: Naches River Basin, Washington. Climate change projections indicate a steady increase in temperature progressing through the 21st century, generally resulting in snowpack reductions, changes to the timing of snowmelt, altered stream flows, and reductions in soil moisture, all of which could affect water management, agriculture, recreation, hazard mitigation, and ecosystems across the nation. Despite some widespread similarities in climate change trends, climate change will affect specific water basins in the U.S. differently, based on the particular hydrologic and geologic conditions in that area.

Photo Credit: U.S. Geological Survey.

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89 EXECUTIVE SUMMARY

90 The *National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate*
91 (*NAP*)¹ was published in 2011 as the product of the Federal interagency Water Resources and
92 Climate Change Workgroup (Workgroup). Since then, member agencies have worked together
93 to make notable progress in advancing understanding of climate change impacts on water
94 resources and developing information and new approaches to adapt to these changes.
95 Meanwhile, the Nation has witnessed the effects of more intense storms, drought, and
96 unseasonable weather that is causing significant damage to property and loss of life.
97 Consequently, interest in building greater resilience to extreme weather phenomena and other
98 impacts of a changing climate has grown among state, tribal and local communities.

99 In presenting this draft *Looking Forward* report updating the 2011 NAP, the participating Federal
100 agencies are reaffirming the importance of continuing to improve the Nation's ability to respond
101 to the impacts of climate change on water resources. This draft report takes into consideration
102 the recommendations of the State, Tribal and Local Leaders Task Force², the Climate and Natural
103 Resources Workgroup³, the Advisory Committee on Water Information,⁴ and public input in
104 other forums. This draft document is not an inventory of the wide range of activity underway
105 among water resources agencies throughout the Federal government; rather, it focuses on
106 addressing the highest priority actions that the Workgroup member agencies are planning to
107 address in the next several years. General recommendations and specific actions are identified
108 in three thematic areas.

109 Data and Research

110 Many different water resource managers and others throughout society rely largely on the Federal
111 government's data systems to collect and analyze information on hydro-meteorological conditions.
112 Maintaining observational networks remains a challenging task and there is a recognized need to better
113 understand how to both detect emerging trends attributable to climate change as well as how to
114 incorporate the concept of nonstationarity into projections of future conditions. Meanwhile, the
115 competing demands for use of water resources suggests that research into improving water use
116 efficiencies could benefit not only water supply managers but also users such as the energy and

¹ *National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate*, 2011, available at http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_national_action_plan.pdf.

² State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience, Recommendations, November, 2014. <https://www.whitehouse.gov/administration/eop/ceq/initiatives/resilience/taskforce>.

³ *Priority Agenda*, 2014. Climate and Natural Resources Working Group. https://www.whitehouse.gov/sites/default/files/docs/enhancing_climate_resilience_of_americas_natural_resources.pdf.

⁴ *Next Steps for Managing Freshwater Resources in a Changing Climate*, April 10, 2014.

http://acwi.gov/climate_wkq/climate_water_recommendations_report_4_21_14_final_draft.pdf.

117 agricultural sectors that rely on availability of supplies for production. The Workgroup suggests strategic
118 actions addressing four key recommendations:

- 119 1. Sustain and expand existing monitoring networks and data collection on hydrologic and
120 meteorological conditions and water demand;
- 121 2. Modernize statistical analyses of observational data sets so that climate changes that
122 have already occurred are recognized in water resources decision-making;
- 123 3. Improve reliability and accessibility of water-related projections of future conditions;
- 124 4. Enhance water supply and reduce water use through investment in energy-water
125 technologies and improved agricultural practices.

126 Please see **Appendix C: Summary of Strategic Actions and Lead Agencies** for a tabulation of all
127 Strategic Actions and lead Agencies.

128 **Planning and Decision Support**

129 It has long been recognized that climate change impacts are unique to every locality and sector
130 and that solutions are also necessarily unique. Managing the development of new information
131 and tools and applying them to localized decisions necessitates close cooperation among
132 researchers and practitioners. Many activities are underway to ‘downscale’ production, delivery,
133 and application of information to more regional and local levels. Improving collaboration
134 between agencies and regional and local decision makers and improving guidance on use of
135 climate information is the focus on the following two recommendations and the associated
136 strategic actions:

- 137 1. Advance regional coordination among Federal water resource management agencies to
138 support climate change adaptation and resilience efforts.
- 139 2. Develop guidance and provide assistance to communities and water resource managers
140 on use of climate change information and tools for assessing vulnerability and facility
141 resilience.

142 **Training and Outreach**

143 In response to the demand for access to information about projected impacts of climate change,
144 there has been an information explosion as Federal agencies, local planners, nonprofit
145 organizations, and the private sector have developed many different websites, models,
146 guidebooks, and training resources, on ways to evaluate climate change vulnerability and to
147 inform water resource decisions. Now, water resource decision-makers are expressing
148 frustration at the overwhelming amount of information. Decision-makers need to know how to
149 readily find applicable information and how to decide which tools best support a specific
150 decision. The Workgroup, therefore, intends to undertake actions in support of the following
151 recommendations:

- 152 1. Increase involvement in the U.S. Climate Resilience Toolkit Water Theme.
- 153 2. Sustain and build upon the existing Professional Development Series for Water Resource
154 Professionals on Climate Change Principles and Practices.

155 3. Encourage stakeholder partnerships to improve delivery of tools and training and to
156 identify gaps.

157 **Workgroup Management and Coordination**

158 Finally, there are more than a dozen Federal agencies involved in some aspect of water
159 resources management, all of which are undertaking various efforts to incorporate climate
160 change considerations into their programmatic missions. Given the inter-related nature of
161 agencies' respective programs, it is important that agencies continue to work together to
162 leverage resources, find synergies, and develop consistency. To ensure ongoing coordination,
163 the Workgroup intends to:

164 1. Ensure effective support for the Workgroup to maintain continuity of interagency
165 collaboration and leadership on climate change adaptation among Federal water
166 resource agencies.

167 The recommendations and strategic actions in this *Looking Forward* document are recognized as
168 high priorities that need to be pursued in the coming years. As this work proceeds, however,
169 new priorities are likely to emerge and the Workgroup will work to recognize new challenges and
170 refocus efforts as needed.

171 *Today, there's no greater threat to our planet than climate change.*

172 -- President Barak Obama, Weekly Address, April 18, 2015

173

174 INTRODUCTION: PROGRESS AND CHALLENGES

175 Background and Goal of *National Action Plan*

176 The *National Action Plan: Priorities for Managing Freshwater Resources*
177 *in a Changing Climate (NAP)*⁵ was published in 2011 as the product of
178 the interagency Water Resources and Climate Change Workgroup (the
179 Workgroup). The *NAP* reflected Federal agencies' commitment to
180 develop a coordinated effort to tackle the challenges posed by climate
181 change for water resources management. The 2011 report outlined six
182 priority areas with 24 specific "Supporting Actions" that Federal agencies
183 engaged in water resources management would undertake to
184 understand and address climate change challenges. The six priority areas
185 were:

The Water Resources and Climate Change Workgroup was established in 2009 by the Interagency Climate Change Adaptation Task Force, and continues to operate under the auspices of the 2013 President's Climate Action Plan and Executive Order 13653.

- 186 1) Establish a Planning Process;
- 187 2) Improve Information for Decision Making;
- 188 3) Strengthen Vulnerability Assessments;
- 189 4) Expand Water Use Efficiency;
- 190 5) Support Integrated Water Resources Management; and
- 191 6) Support Training and Outreach.

192 Working together, Federal agencies have made notable progress in each of these six priority
193 areas, as reflected in annual reports⁶ of the Workgroup. For example, some notable advances
194 are:

- 195 • Creating a 40 member stakeholder advisory group on climate change and water
196 resources as part of the Advisory Committee on Water Information (ACWI);
- 197 • Recognizing climate change in water planning Principles⁷ and Requirements;
- 198 • Expanding and upgrading reporting requirements for waterborne disease outbreaks
199 expected to increase as water and air temperatures warm;
- 200 • Developing vulnerability assessment tools for water managers including tools for
201 understanding climate vulnerability of water utilities, watersheds, and national forests;

⁵ *National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate*, 2011, available at http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_national_action_plan.pdf.

⁶ 2014 Highlights of Progress and 2015 Implementation Plan, http://acwi.gov/climate_wkg/nap-fy1415-version9_hwclean_final508c.pdf. And 2013 Highlights of Progress and 2014 Implementation Plan, http://acwi.gov/climate_wkg/NAP_2014_implementation_plan&2013_highlights_final3-24-14a.pdf. Highlights of Progress: 2012, https://www.whitehouse.gov/sites/default/files/2012_progress_report.pdf

⁷ Updated Principles, Requirements and Guidelines for Water and Land Related Resources Implementation Studies, December 2014. <https://www.whitehouse.gov/administration/eop/ceq/initiatives/PandG>.

- 202
- Supporting water use efficiency through expansion of the WaterSense program, the
- 203 Department of Interior WaterSmart program, and related efforts;
- Advancing pilot projects to demonstrate how integrated water resources management
- 204 can address climate change impacts and challenges; and
- Developing training programs addressing climate change and water resources
- 206 management challenges for Federal government employees and others.
- 207

208 Implementing the NAP over the past several years has been coordinated with related efforts

209 including the National Ocean Policy, the National Fish, Wildlife and Plants Climate Adaptation

210 Strategy and the National Drought Resilience Partnership^{8,9}.

211 Another collaboration among Federal agencies is the Federal Climate Change and Water

212 Working Group¹⁰ (CCAWWG), a technical forum to share expertise across Federal science and

213 water resource management agencies. Furthermore, Federal agencies all have been

214 implementing their own adaptation plans^{11,12} working with stakeholders to focus on mission-

215 related water issues.

216 Meanwhile, as risks inherent in a changing climate were better understood, and as the Nation

217 continued to witness impacts of a changing climate, the Federal government developed new

218 initiatives and activities to tackle the complex challenges posed by climate change. For example,

219 under Executive Order 13653¹³, the President established the Climate and Natural Resources

220 Working Group as well as the State, Local and Tribal Leaders Task Force, each of which identified

221 recommendations and priorities that provide context for this NAP update.

222 **Process to “Refresh” the *National Action Plan***

223 Addressing issues and needs related to water resources and a changing climate in the U.S. has

224 evolved significantly since the NAP was issued in 2011 and it is appropriate to step back and

225 consider next steps.

226 During discussions of new directions convened in Spring 2015, two key ideas emerged. First,

227 there is a need for a forum to promote interagency dialogue and to lend continuity to Federal

228 work to adapt water resources management to a changing climate. Second, there are additional

⁸ Note: Climate change and water issues for aquatic habitat as well as for terrestrial habitat are more fully addressed in the *Fish, Wildlife & Plants Climate Adaptation Strategy*.

⁹ For comprehensive information about the President’s climate change initiatives, see:

<https://www.whitehouse.gov/administration/eop/ceq/initiatives/resilience>

¹⁰ Climate Change and Water Working Group website: <http://www.ccawwg.us/>.

¹¹ Federal Agency Adaptation Plans are available here:

<http://www.performance.gov/node/3406/view?view=public#supporting-info>

¹² In addition, the U.S. Army Corps of Engineers produced a crosswalk of water-related information contained in the 2014 adaptation plans, available at:

http://www.corpsclimate.us/docs/Comparison_of_2014_Adaptation_Plans_JUNE_2015.pdf

¹³ Executive Order 13653, available at: <https://www.whitehouse.gov/the-press-office/2013/11/01/executive-order-preparing-united-states-impacts-climate-change>

229 opportunities for Federal agencies to strengthen water resources management to better
230 respond to climate change.

231 It is in this spirit that the Workgroup has chosen to “refresh” its approach – first by reaffirming its
232 role as a community-of-practice convener and second by articulating particular focus areas for
233 advancement. To address these two goals, the Workgroup decided to “refresh” the 2011 NAP
234 and develop this “Looking Forward” document.

235 At the outset, the Workgroup convened a listening session webinar to solicit public comments.
236 The Workgroup asked for input on several questions, including:

- 237 • What are the most important issues you are dealing with due to current or anticipated
238 effects of climate change?
- 239 • In what way can Federal agencies facilitate your ability to manage water resources in the
240 face of climate change?
- 241 • What are your greatest training and outreach needs?
- 242 • What are the most important decision support tools that could be provided by Federal
243 agencies?
- 244 • What are the most important data gaps or research topics that Federal agencies should
245 be addressing?

246 Comments submitted during and after the webinar were incorporated into deliberations. The
247 Workgroup also reviewed several recent documents that identified particular needs for building
248 resilience in the water resource management sector. These documents included an April 2014
249 report by the Advisory Committee on Water Information, titled *Next Steps for Managing*
250 *Freshwater Resources in a Changing Climate*¹⁴; the November 2014 *Recommendations* of the
251 State, Local, and Tribal Leaders Task Force On Climate Preparedness and Resilience¹⁵; and the
252 *Priority Agenda* of the Climate and Natural Resources Workgroup published in October 2014¹⁶.

253 Considering progress made to date, input received in the listening session, and review of recent
254 reports and recommendations, the Workgroup decided to re-focus on three substantive themes:

- 255 • Data and Research
- 256 • Planning and Decision Support
- 257 • Training and Outreach

¹⁴ *Next Steps for Managing Freshwater Resources in a Changing Climate*, April 10, 2014.

http://acwi.gov/climate_wkg/climate_water_recommendations_report_4_21_14_final_draft.pdf.

¹⁵ State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience, Recommendations, November, 2014. <https://www.whitehouse.gov/administration/eop/ceq/initiatives/resilience/taskforce>.

¹⁶ *Priority Agenda*, 2014. Climate and Natural Resources Working Group.

https://www.whitehouse.gov/sites/default/files/docs/enhancing_climate_resilience_of_americas_natural_resources.pdf.

258 Interagency teams of Federal staff drawn from the Workgroup were formed into four teams to
259 address these three themes plus ongoing Workgroup management. These themes form the
260 organizational structure for this document represented as chapters of this report.

261 Further, each team was directed to focus attention in three areas - primarily related to needs
262 identified by the State, Local and Tribal Leaders Task Force:

- 263 • Evaluate long-term risks of climate change on water resources availability;
- 264 • Provide guidance on assessments of vulnerability of water infrastructure; and
- 265 • Promote integrated watershed management and planning to protect water quality and
266 quantity.

267 In addition, the Workgroup intends to continue to actively engage in the Water Theme of the
268 Climate Data and Tools Initiative, which includes both *Climate Data.gov* and the *Climate*
269 *Resilience Toolkit*¹⁷ and will continue to inform and advise the Climate and Natural Resources
270 Workgroup under the President's Climate Action Plan.

271 Federal agencies are implementing many other activities to address climate change in addition
272 to the strategic actions articulated in the 2011 NAP and related reports. This document does not
273 attempt to comprehensively inventory, track, or document all the efforts underway that are
274 addressing the impacts of climate change on water resources. Rather, the actions identified in
275 this report were selected either to address important gaps as possible with existing resources, or
276 to lend support for particularly important activities that, in the Workgroup's view, merit further
277 consideration.

278

¹⁷ <https://www.data.gov/climate/> and <https://toolkit.climate.gov/>.

279 1 DATA AND RESEARCH

280 Various users of environmental and water information have expressed concerns related to the
281 state of water data collection -- how well observation networks are being sustained now and into
282 the future to provide adequate and consistent data collection for evaluation of long-term trends
283 in hydrological and meteorological conditions, how this information is transferred between
284 agencies and to the public, how to best use information to address climate change issues, and
285 how to develop partnerships supporting these efforts.

286 For example, the Advisory Committee on Water Information (ACWI), made the following
287 recommendations related to water information and climate change:

- 288 • *Ensure continuity and viability of long-term hydro-climate observations and data*
289 *management systems*
- 290 • *Enhance data access and interoperability of data systems.... This includes the*
291 *development of an integrative tool to assist in the access to data and information from*
292 *multiple sources.*
- 293 • *Bolster critical data sets, including those related to groundwater, stream and river flow,*
294 *waterborne disease, water use, and paleoclimate reconstruction.*

295 Further, of the three State, Local Tribal Leaders Task Force recommendations that the
296 Workgroup is tackling, one focuses specifically on water information:

297 *Promote risk assessment information and risk analyses to identify “hot spots” across the*
298 *country where water demand is high and water availability is low, [including through] the*
299 *national water census, [highlighting] water resource availability issues, further collaborating*
300 *with state and tribes, and developing potential frameworks in collaboration with partners.*

301 The Data and Research Team concurs with these recommendations. Federal agencies have long
302 played a significant role in supporting data collection, data analysis, and modeling, providing
303 essential information for many types of decisions. Water supply managers, flood control
304 engineers, land use planners, and many others have long relied on federal data systems to
305 inform planning and design – and need to understand and prepare for the added complications
306 posed by climate change.

307 Federal agencies are working to maintain and improve the availability and accessibility of water
308 data and information, including information to inform decision-making in light of climate change.
309 For example:

- 310 • The Open Water Data Initiative (OWDI)¹⁸ of the Advisory Committee on Water
311 Information (ACWI) was started to “integrate currently fragmented water information

¹⁸ Open Water Data Initiative. <http://acwi.gov/spatial/index.html>,

312 into a connected, national water data framework and leverage existing systems,
313 infrastructure and tools to underpin innovation, modeling, data sharing, and solution
314 development.”

- 315 • The National Groundwater Network¹⁹ that includes multiple agencies is working to
316 improve the accessibility of groundwater information.
- 317 • Coastal communities are collaborating to add LIDAR data for improved mapping of
318 coastal flood risk²⁰.
- 319 • The U.S. Forest Service and partners have developed the National Stream Internet, a
320 statistical and geospatial framework for organizing physical, chemical, and biological data
321 about streams.

322 While efforts are underway to make existing datasets more accessible, the underlying data
323 collection networks must also be strengthened. Further, while some monitoring networks
324 provide good spatial and temporal coverage others do not. It is important to sustain these
325 networks and fill gaps. Appendix A: Inventory of Major Hydro-climatic Data Collection Systems in the
326 U.S.. highlights some of the critical networks that are of particular concern for informing decision
327 making to build resilience to climate change.

328 While managing water depends on the use of energy, producing energy depends on access to
329 water supplies. Research into innovative technologies offer hope for reducing demand on limited
330 water supplies while ensuring a reliable energy grid.

331 More work remains to support well-informed decisions and to manage current and future risk. In
332 particular, the Workgroup recommends focused attention to four key areas.

- 333 1. Sustain and expand existing monitoring networks and data collection on hydrologic and
334 meteorological conditions and water demand;
- 335 2. Modernize statistical analyses of observational data sets so that climate changes that
336 have already occurred are recognized in water resources decision-making;
- 337 3. Improve reliability and accessibility of water-related projections of future conditions; and
- 338 4. Enhance water supply through innovative technologies.

339 These issues are elaborated in the following recommendations and strategic actions that the
340 Workgroup believes should be prioritized.

¹⁹ National Groundwater Network. <http://acwi.gov/sogw/index.html>.

²⁰ Digital Coast. <https://coast.noaa.gov/digitalcoast/tools/slr>.

341 **1.1 RECOMMENDATION: SUSTAIN AND EXPAND EXISTING MONITORING NETWORKS AND DATA**
342 **COLLECTION ON HYDROLOGIC AND METEOROLOGICAL CONDITIONS AND WATER DEMAND**

343 Federal agencies managing freshwater data systems work with States and other partners to
344 provide the most complete and reliable data possible. The nation has many monitoring systems and
345 data networks important to protecting public health and aquatic resources including those for
346 streamflow, water quality, groundwater, meteorology, snow and ice, and soil moisture.
347 However, monitoring systems and data networks need ongoing support to maintain and expand
348 their value. In fact, even robust networks have gaps in terms of spatial coverage or monitoring
349 capabilities.

350 Given the diverse range of Federal agencies that support these systems, strong communication
351 among agencies helps to focus resources on critical priorities and avoid duplication of effort.

352 Some steps that Federal agencies should take to build on this progress and strengthen
353 cooperation and communication on water data issues, and thus strengthen the capacity to
354 support informed climate adaptation decisions, are described below.

355 **1.1.1 Strategic Action - Continue to identify and address data gaps and needs for water resource**
356 **management**

357 The Federal agency managers of the multiple data systems related to water resources would
358 benefit from a forum for sharing information about operations of the systems, planned changes,
359 and options for addressing emerging challenges such as climate change. These activities should
360 be a regular agenda item for this Workgroup or a subgroup under this Workgroup that is formed
361 specifically on this topic.
362

363 This team should consider convening a national water data forum on this issue as well as
364 conducting a more comprehensive survey of monitoring systems with a special focus on data
365 needed by climate change adaptation decision-makers. Appendix A represents a basic inventory
366 of federal data capabilities and needs that should be enhanced.
367

368 Goals for this team's activities would include identifying opportunities for federal agencies to
369 collaboratively fill gaps in water data, expand spatial coverage of existing data collection systems,
370 or make other improvements that would strengthen data collection and management to support
371 water resource management in a changing climate. Some of these improvements may involve
372 little or no cost and can be adopted using existing resources or by modifying existing processes.
373 Other priority improvements may require supplemental funding in the budgets of individual
374 agencies.
375

376 **1.1.2 Strategic Action - Expand adoption of reference monitoring networks to establish baseline**
377 **conditions for evaluating impacts due to climate change**

378 The Workgroup realizes that it is challenging to discern changes in water resources variables that
379 are due to the impacts of climate change versus land use change or other stressors. "Reference

380 sites” offer an opportunity to try to understand such causation. Citing the Advisory Committee
381 on Water Information (ACWI)²¹:

382 A significant challenge faced by water-resource scientists in the public and private sectors
383 is the need for reliable long-term data and information from watersheds minimally
384 disturbed by human activities. Monitoring in areas with minimal human disturbance
385 helps to provide (1) an understanding of natural patterns of variability that can be used
386 to differentiate changes due to land and water use from changes associated with natural
387 climatic cycles and (2) reference information that can be used to establish water-quality
388 criteria or appropriate expectations for watershed restoration....These synoptic
389 measurements provide important information for understanding natural spatial patterns
390 and variability. Unfortunately, there are relatively few sites among networks with long-
391 term records for streamflow, water chemistry, and stream ecology necessary to
392 distinguish changes associated with natural climatic cycles.

393 Highlighting the availability of data at reference monitoring sites as well as expanding data
394 collection from reference monitoring sites can yield information that broadens decision makers
395 understanding of what to expect in the future and how to target protective activities. Therefore
396 the Workgroup intends to work with Agencies and the Advisory Committee on Water
397 Information (ACWI) to further inventory such networks and make this information more readily
398 available.

399 **1.2 RECOMMENDATION: MODERNIZE STATISTICAL ANALYSES OF OBSERVATIONAL DATA SETS TO** 400 **IMPROVE UNDERSTANDING OF EMERGING TRENDS ASSOCIATED WITH CLIMATE CHANGE**

401 Various federal agencies have historically compiled statistical analyses based on observational
402 data that are used in many ways throughout society. For example, NOAA Atlas 14 is based on
403 precipitation gages throughout the U.S. and provides Intensity, Duration, and Frequency
404 estimates used in engineering designs for applications such as stormwater infrastructure. USGS
405 analyzes streamflow gages to compile stream flow statistics used, for example, in water quality
406 evaluations and infrastructure design for floods, and the Bulletin 17B standard provides guidance
407 on estimation procedures for flood frequency.

408 Such statistical methods are foundational for engineers and water managers. Concerns have
409 been raised on two aspects of these methods. First, some of the statistics have not been
410 updated in many years; for example, some have not included analyses of more recent data,
411 while others may not be based on more advanced methods, thus raising concerns about the
412 accuracy of the statistics. Second, statistical methods developed in the past did not necessarily

²¹ Advisory Committee on Water Information, National Water Quality Monitoring Council. National Network of Reference Watersheds, at: <https://my.usgs.gov/nnrw/main/home>.

413 take into account a nonstationary climate, and therefore designing systems based on the past
414 may not be protective under future climate regimes without some further consideration.

415 Given the importance of these heavily used statistics, new analysis of historic data is needed to
416 understand how water-specific variables are changing, whether changes are consistent with
417 climate model projections, and how to understand climate trends along with other drivers such
418 as water diversion or land use change. To this end, the federal government should work with
419 stakeholders such as the Advisory Committee on Water Information and standards setting
420 bodies to re-evaluate, update and modernize statistical analyses of observational data as
421 appropriate and to evaluate options for evaluating nonstationary trends that could inform
422 decision making under future climates. In particular, the Workgroup recommends the following
423 priorities.

424 **1.2.1 National Oceanic and Atmospheric Administration Precipitation Frequency Datasets**

425 These datasets are used to help estimate the severity of real events and to inform infrastructure
426 design. The current approach to develop the data is based on a stationary climate. NOAA has
427 done some work to consider how to address non-stationarity in NOAA Atlas 14 statistical
428 estimates intensity, duration and frequency of precipitation. Furthermore, statistics for several
429 parts of the country have not been updated in recent decades. The Workgroup strongly
430 recommends that Agencies work with NOAA to ensure that this work is undertaken in the near
431 future.

432 **1.2.2 Flood Frequency Guidelines**

433 Flood Frequency Guidelines, known as Bulletin 17B, support planning and engineering design to reduce
434 flood risks. Bulletin 17B was published in 198, and is currently being updated as Bulletin 17C by
435 the Subcommittee on Hydrology of the Advisory Committee on Water Information²². The
436 proposed Bulletin 17C guidelines, while an improvement from the older Bulletin 17B methods,
437 do not provide guidance on methods for considering potential climate change. The Workgroup
438 recommends that follow-on work be done to develop best practices for considering non-
439 stationarity in flood frequency analyses.

440 **1.2.3 Streamflow Statistics.**

441 Many different users at the federal, state, and local level use instream flow statistics to design
442 and manage water infrastructure and water quality. Streamflow data are collected by USGS,
443 USACE, as well as states. Similarly, USGS and other compute statistical estimates. USGS and
444 USEPA are working to update statistical methods and to explore ways to evaluate potential
445 future impacts of climate change. However, more work is needed to ensure access to updated
446 flow statistics.

²² Advisory Committee on Water Information, Subcommittee on Hydrology, Hydrologic Frequency Analysis Work Group - Bulletin 17C, <http://acwi.gov/hydrology/Frequency/b17c/>.

447 **1.3 RECOMMENDATION: IMPROVE RELIABILITY AND ACCESSIBILITY OF WATER-RELATED PROJECTIONS**
448 **OF FUTURE CONDITIONS**

449 A substantial amount of work is underway in the community of researchers who produce and
450 use projections of future climate risks and impacts. This community includes parts of many
451 Federal agencies as well as state, local, tribal, and private-sector organizations. Despite this
452 growing body of work, some water resource managers still find it difficult to understand and
453 appropriately use these projections. In an effort to improve accessibility and utility of
454 projections, activities are underway to catalogue describe, and provide guidance for different
455 users.

456 **1.3.1 Strategic Action: Evaluate the feasibility of developing the capability to project water**
457 **temperature under future climates.**

458 Climate models commonly generate projections in terms of changes in air temperatures,
459 precipitation, extreme weather, and rain/snow shifts but do not project changes in water
460 temperatures. There is growing evidence, however, that water temperatures are increasing in
461 water bodies at rates that are different than the increases in ambient air temperatures. In
462 addition, even small increases in water temperature have the potential to degrade water quality
463 and, more specifically, promote harmful algal blooms or threaten cold-water fisheries. The
464 Workgroup will work with Federal agency research programs and the academic community to
465 conduct a preliminary feasibility evaluation of developing methods that project changes in water
466 temperatures for various types of water bodies in different regions of the country.

467 **1.3.2 Strategic Action: Evaluate the feasibility of integrating climate-impacted hydrology**
468 **projections with projections of population and land use.**

469 Climate models project changes in precipitation and other hydrologic variables of interest. These
470 projections can be used to estimate long-term changes in stream flows that are critical for long-
471 term water resources planning and engineering design. These long-term changes in streamflow
472 are central to many climate change vulnerability assessments and response plans. Streamflow,
473 however, is also influenced by the condition of the watershed and variables such as such as soil
474 moisture and groundwater recharge. Land use, water demand, and water system operational
475 decisions also affect streamflow; land use in particular is closely correlated with changes in
476 population and resulting changes in impervious surfaces that affect watershed conditions.

477 Some long-term models are available that project changes in population and land use on time-
478 scales comparable to those of climate change models. Examples include USEPA's Integrated

479 Climate and Land-Use Scenarios (ICLUS)²³ database, USGS’s FORE-SCE mode²⁴, and the Forestry
480 and Agricultural Sector Optimization Model (FASOM)²⁵. Previous studies²⁶ that integrate land
481 use changes with climate model projections suggest such integration can have significant effects
482 on projections of future streamflow in specific watersheds and at specific spatial scales. The
483 Workgroup will work with the Federal agency research programs and the academic community
484 to identify and expand (where feasible) research efforts on integrating these projections to
485 generate more reliable projections of streamflow and other impacts.”

486 1.4 RECOMMENDATION: ENHANCE WATER SUPPLY THROUGH INNOVATIVE TECHNOLOGIES

487 Federal agencies have conducted research in evaluating the safe and productive use of
488 nontraditional water sources (e.g., saline, brackish, impaired groundwater, etc.) for major water
489 use sectors, such as agriculture and energy production. Increased water use efficiency as well as
490 the use of nontraditional water by major water users has the potential to mitigate shortages of
491 freshwater by displacing or augmenting its use.

492 1.4.1 Strategic Action: Enhance water supply through investment in energy-water technologies

493 Energy and water are interdependent, and the availability and predictability of water resources
494 can directly affect energy systems and energy security. Changes in hydrology in major regions of
495 the country will not only strain water resources, but also will likely pose significant problems for
496 the domestic energy sector that relies heavily on secure and reliable water availability. For
497 example, thermoelectric power generation withdraws large quantities of fresh water for cooling.
498 Expanded use of nontraditional waters, such as brackish and saline waters, for energy can
499 protect and increase the Nation's water supply.

500
501 While technologies such as desalination have been practiced at commercial scales for decades,
502 the production of water of acceptable quality requires energy, and efforts are needed to reduce

²³ Integrated Climate and Land-Use Scenario, USEPA, <http://www.epa.gov/iclus>.

²⁴ The FORE-SCE model: a practical approach for projecting land cover change using scenario-based modeling. Terry L. Sohl , Kristi L. Sayler , Mark A. Drummond , Thomas R. Loveland. *Journal of Land Use Science* Vol. 2, Iss. 2, 2007

²⁵ Drs. Bruce McCarl (Texas A&M University) and Darius Adams (Oregon State University) developed the Forestry and Agricultural Sector Optimization Model (FASOM) initially. A research consortium that includes members from USEPA, USDA, USDA Forest Service, Duke University, RTI International, Oregon State University and the Electric Power Research currently maintains it. A variant of the FASOM model with Greenhouse Gases (FASOM-GHG) has been used in several EPA analyses and USDA’s Resources Planning Assessment. The EPA peer review of the FASOM model by EPA can be found here:

http://www3.epa.gov/climatechange/Downloads/EPAactivities/peerreview_FASOM.pdf.

²⁶ See, for example, *Investigating the Sensitivity of U.S. Streamflow and Water Quality to Climate Change: U.S. EPA Global Change Research Program’s 20 Watersheds Project*, T. E. Johnson¹; J. B. Butcher, M.ASCE²; A. Parker, M.ASCE³; and C. P. Weaver. *Journal of Water Resources Planning and Management*, Volume 138, Issue 5, September 2012. At: [http://ascelibrary.org/doi/abs/10.1061/\(ASCE\)WR.1943-5452.0000175](http://ascelibrary.org/doi/abs/10.1061/(ASCE)WR.1943-5452.0000175).

503 the cost, energy input, and associated greenhouse gas emission levels. The Department of
504 Energy will launch a new Energy-Water Desalination Hub focused on researching and developing
505 technologies to reduce the cost, energy input, and carbon emission levels of desalination. DOE
506 will also invest in complementary research on desalination technologies relevant to fossil,
507 concentrated solar power, and geothermal applications. The Department will also invest in
508 research, development and demonstration of efficient heat exchanger and other technologies to
509 reduce water requirements at thermoelectric power plants.

510 **1.4.2 Strategic Action: Improve water use efficiency in agriculture**

511 Agricultural irrigation relies on access to significant quantities of water and, under pressure from
512 climatic challenges such as wide-spread regional drought, increasingly having to compete for
513 limited supplies with municipal users, the energy sector, and ecological needs. Agriculture is also
514 facing increased pressure from climatic challenges such as the drought in western states. While
515 this sector has significantly increased its water use efficiency over the past decades, greater
516 efficiencies are needed to ensure a reliable food supply. USDA will continue to work to find ways
517 to improve agricultural technologies that conserve water and increase efficiencies.

DRAFT

518 2 PLANNING AND DECISION SUPPORT

519 This chapter highlights recommendations and strategic actions that support planners, policy
520 makers, and decision makers to manage freshwater resources in a changing climate. Existing
521 tools as well as those that are in development are considered in order to identify particular areas
522 that remain challenging. For example, some of the challenges expressed by stakeholders are that
523 decision makers may not know how to find, select, or use existing tools. This could be addressed
524 by developing various scenarios that could be considered prior to making a decision. For
525 example, the Office of Science and Technology Policy, through existing interagency work groups
526 or committees, could provide a consistent range of national, regional, and local scenarios based
527 on downscaled climate information with which to evaluate options. Another challenging area is
528 helping decision makers understand how to embrace uncertainty in decision processes.

529 This section reframes and combines aspects of three of the priority areas from the 2011 NAP,
530 i.e., strengthen vulnerability assessments, expand water use efficiency, and support integrated
531 water resources management. The Advisory Committee on Water Information (ACWI) also made
532 recommendations in these areas, including²⁷:

- 533 • Develop guidance and build capacity for assessing vulnerability.
- 534 • Collaborate with non-Federal water partners to improve future tool development.
- 535 • Prioritize agriculture for development of "nationally consistent metrics for water use
536 efficiency".
- 537 • Update Federal efficiency standards for showerheads, faucets, toilets, and urinals.
- 538 • Promote water efficiency and reuse/reclamation.
- 539 • Create regional Federal Agency Support Teams modeled after the Western States Federal
540 Agency Support Team (WestFAST).
- 541 • Create incentives for State, interstate, local and tribal governments to plan on a
542 watershed basis for preparedness and resilience.
- 543 • Create incentives to incorporate ecosystem services (i.e., natural capital).

544 In addition, the State, Local Tribal Leaders Task Force recommended the following focus areas
545 related to policy, planning, and decision support²⁸:

- 546 • Identify "hot spots" where water demand is high and water availability is low.

²⁷ *Next Steps for Managing Freshwater Resources in a Changing Climate*, Water Resources Adaptation to Climate Change Workgroup to the Advisory Committee on Water Information, April 10, 2014.

http://acwi.gov/climate_wkg/climate_water_recommendations_report_4_21_14_final_draft.pdf

²⁸ *Recommendations to the President*, President's State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience, November, 2014.

https://www.whitehouse.gov/sites/default/files/docs/task_force_report_0.pdf

- 547
- Bridge the communication gap between science and management to address
- 548 downscaling, decision support, vulnerability assessment, and practical guidance.
- Establish regional interagency water security partnerships with state, local, and tribal
- 549
- partners.
- 550

551 There are several activities underway throughout the federal government that are not included
552 in the current set of recommendations. Their importance should not be diminished, however, as
553 they are critical activities that need federal agencies to follow through. Examples include
554 incentivizing use and protection of ecosystem services, i.e., natural capital;²⁹ and adopting and
555 promoting green infrastructure to manage stormwater, reduce urban heat island effects, and
556 provide other benefits.³⁰

557 Considering past recommendations, ongoing activities, and recent developments, the team
558 recommends the following:

- 559 1. Advance regional coordination among federal water resource management agencies to
560 support climate change adaptation and resilience efforts
- 561 2. Develop guidance and provide assistance to communities and water resource managers
562 on use of climate change information and tools for assessing vulnerability and facility
563 resilience.

564 **2.1 RECOMMENDATION: ADVANCE REGIONAL COORDINATION AMONG FEDERAL WATER RESOURCE**
565 **MANAGEMENT AGENCIES TO SUPPORT CLIMATE CHANGE ADAPTATION AND RESILIENCE EFFORTS**

566 Many federal agency climate change adaptation and resilience activities are underway across the
567 country, and coordination has advanced. Partnerships and activities underway include the
568 Department of Interior Climate Science Centers and Landscape Conservation Cooperatives,
569 NOAA’s Regional Integrated Science and Assessments, the Army Corps of Engineers Silver Jackets
570 teams, and the U.S. Department of Agriculture Climate Hubs, as well as other federal activities

²⁹ For information about Ecosystem Services, see: *Incorporating Ecosystem Services into Federal Decision Making*, October 7, 2015. <https://www.whitehouse.gov/sites/default/files/omb/memoranda/2016/m-16-01.pdf>

³⁰ For information about Green Infrastructure, see also: Federal Agency Support for the Green Infrastructure Collaborative, http://www.epa.gov/sites/production/files/2015-10/documents/federal-support-for-green-infrastructure-collaborative_508.pdf

USEPA Green Infrastructure Program, <http://www.epa.gov/green-infrastructure>.

National Park Service INSTEP for Design and Construction Transportation Projects, <http://www.nps.gov/articles/transinstep.htm>

National Association of Regional Councils, *A Roadmap to Green Infrastructure in the Federal Agencies*, <http://narc.org/environment/green-infrastructure-and-landcare/roadmap/>.

571 (see Appendix B: Regional Collaborations for more description). Despite these many activities,
572 there are still opportunities to improve coordination to assist state, tribal and local partners.

573 **2.1.1 Strategic Action - Develop new regional Federal Agency Support Teams (X-FAST) for Water**
574 **Resources Management**

575 As suggested in the Climate and Natural Resources Working Group Priority Agenda, Federal
576 agencies will use the Western States Water Council’s Federal Agency Support Team (WestFAST)
577 as a template and model to facilitate collaboration between other states and the Federal
578 government regarding water resources management generally, and water-related climate issues
579 more specifically. The success of WestFAST is a model for addressing cross-boundary and multi-
580 institutional stakeholder-driven issues, including those that are affected by federal activities or
581 that could benefit from federal engagement. The Federal X-FAST team will work to develop
582 potential new regional opportunities to work with stakeholders, identify regional issues, and
583 recommend focus areas that would benefit from involvement by an X-FAST or other regional
584 interagency team.

585 **2.1.2 Strategic Action - Expand engagement of Federal water resource agencies in regional**
586 **cooperative efforts on climate science and decision-making**

587 Federal agencies have deployed substantial resources to develop climate science at the regional
588 level and support State and local climate resilience efforts. USDA has established Climate Hubs,
589 NOAA has established Regional Integrated Science and Assessments (RISAs), and DOI has
590 established Climate Science Centers and worked with partners to stand up Landscape
591 Conservation Cooperatives (LCCs) across the country. There has been some engagement of
592 water resource management agencies in these efforts, for instance BOR is co-lead for two LCCs,
593 and EPA and USACE participate on many LCC Steering Committees. Federal agency support for
594 State and local climate resilience would be strengthened by expanded participation of Federal
595 water resource management agencies in the regional climate science and services effort. A key
596 step in this direction is for Federal water resources management agencies to more consistently
597 participate in the existing regional programs (e.g., Hubs, RISAs, CSCs, and LCCs). In addition,
598 these components of Federal agencies work together to coordinate investments and stakeholder
599 engagement. For example, under section 10 of the President’s Sustainability Executive Order,
600 EO 13693³¹, agencies are working together to assure that climate services at the regional level
601 are well coordinated. The water resources management agencies should support this work to
602 strengthen cooperation among Federal agencies providing climate resilience services at the
603 regional level.

³¹ Executive Order 13693, *Planning for Federal Sustainability in the Next Decade*, available at:
<https://www.whitehouse.gov/the-press-office/2015/03/19/executive-order-planning-federal-sustainability-next-decade>

604 **2.1.3 Strategic Action – Encourage agencies to consider the effects of climate change on water**
605 **resources and the implications for federal agency supply chains**

606 While the direct effects of climate change may disrupt the functioning of federal, state, and
607 local governments and communities, indirect effects may be as significant because of climate
608 change effects on suppliers to these organization and communities. Changes in sea level and
609 changes in the frequency, intensity, and duration of storms have the potential to prevent,
610 disrupt, or delay the production and delivery of goods and provision of services that are critical.
611 Drought can parallel these effects regionally, e.g., insufficient water for operation. The large
612 number and geographical dispersion of suppliers across the U.S. and around the world makes it
613 likely that a subset of all suppliers will likely be affected at some point in the future by climate
614 change. Agencies are already directed in Executive Order 13693 to consider the need to improve
615 climate adaptation and resilience with respect to agency suppliers and supply chains. The
616 Workgroup will initiate conversations with the Office of Federal Sustainability and collaborate to
617 provide information on the effects of climate change on water resources and its implications for
618 federal agency supply chains in order to inform their overall climate change adaptation and
619 sustainability planning.

620 **2.1.4 Strategic Action - Develop case studies to inform restoration of wetlands to build resilience**

621 Wetlands provide a range of services for society; they buffer the impact of storms, filter
622 pollutants, and sequester carbon. Federal, state and tribal governments are working to
623 understand impacts of climate change on these services and how to leverage wetland protection
624 and restoration that effectively increase community resilience. Building on the wetland mapping
625 work referenced in the 2011 NAP, the Workgroup now recommends that agencies increase
626 collaboration to conduct pilot studies to inform restoration of key wetlands, such as in the
627 Chesapeake Bay watershed, to both protect wetlands from the impacts of climate change where
628 feasible as well as to help build community resilience.

629 **2.2 RECOMMENDATION: DEVELOP GUIDANCE AND PROVIDE ASSISTANCE TO COMMUNITIES AND**
630 **WATER RESOURCE MANAGERS ON USE OF CLIMATE CHANGE INFORMATION AND TOOLS FOR**
631 **ASSESSING VULNERABILITY AND BUILDING RESILIENCE**

632 There is a plethora of new tools, data and trainings being produced which, while responsive to
633 demand, can, in turn, contribute to confusion and duplication of effort. This recommendation
634 asks that we take a step back and help users better understand the resources that are available
635 and how to begin to use them in decision-making.

636 **2.2.1 Strategic Action - Develop an online dashboard to help water resource managers and**
637 **urban planners prepare for and respond to extreme events**

638 In response to stakeholders' request, NOAA will lead an effort to develop a dashboard for
639 centralized access to a variety of information sources that can be quickly accessed and

640 customized for local use. Such a dashboard of existing sources would enable users to access
641 datasets related to forecasts and outlooks, e.g., precipitation totals and outlooks, observations,
642 daily summaries from weather stations, current drought, etc.; and, people and assets, e.g., land
643 cover and watersheds. Using hyperlinks, the water managers and planners would be able to go
644 directly to the data sources for more information or to directly download data sets, if desired.

645 **2.2.2 Strategic Action - Streamline access to climate adaptation information for the water theme** 646 **of the Climate Resilience Toolkit**

647 A wealth of climate adaptation information has come online in recent years, so much so that
648 stakeholders express frustration at the prospect of wading through it all to find what is relevant
649 to the decisions they are seeking to inform. NOAA will collaborate with partners to refine the
650 user interface to the toolkit that will connect people to specific tools and resources that fit their
651 particular needs and interests. Reducing the time it takes to find useful tools for a wide variety of
652 applications and information relevant to water resource decision makers will increase the uptake
653 of these products that were developed to help build the nation's resilience to climate change and other
654 stressors.

655 **2.2.3 Strategic Action Adopt a system for coordinating vulnerability assessments and advancing** 656 **peer-to-peer learning**

657 More and more communities and institutions have been evaluating the vulnerability of many
658 different aspects of the natural and built systems at different scales, using various methods and
659 for diverse issues. Stakeholders have expressed interest in a means of facilitating geographic
660 coordination as well as peer-to-peer learning. There is value in making a publicly available
661 consolidated repository of completed vulnerability assessments, and therefore the Workgroup
662 should evaluate options for more fully filling this need. One option to consider adopting and
663 promoting is the Climate Registry on the Assessment of Vulnerability (CRAVe)³² that was
664 developed by USGS and the non-profit EcoAdapt to better understand impacts of climate change
665 on wildlife, ecosystems, and other resources. The registry enables users to enter information or
666 metadata on climate change vulnerability assessment projects completed or underway across
667 the country, pooling examples from federal, state, local, and tribal governments.

668 **2.2.4 Strategic Action – Continue to develop, distribute, and provide guidance on the use of** 669 **projected future climate information for water resources management**

670 Many Federal agencies, including members of the Water Workgroup, have self-organized into
671 groups to produce or use projections of future climate based on their needs, and application.
672 Some of those groups are also creating guidance on appropriate uses for different types of
673 future projections. These efforts to provide guidance and information on future projections,

³² USGS and EcoAdapt, Climate Registry for the Assessment of Vulnerability, <https://nccwsc.usgs.gov/crave/>.

674 including downscaled model results, are being collected and indexed to aid users with specific
675 needs in finding the information they need.

676 For example, the U.S. Climate Resilience Toolkit (Toolkit)³³ is a central repository within the U.S.
677 government for projections of future climate made by multiple different approaches. The
678 Toolkit is designed to be a continuing work-in-progress and does not include all possible future
679 projections, but is more comprehensive and easier to use than other sites serving future climate
680 projections that attempts to serve up information for different types of users. In addition, the
681 U.S. Global Change Research Program³⁴ is developing the Global Change Information System
682 where examples of appropriate uses of future climate projections will be collected along with
683 links to the projections and example uses.

684 The Workgroup will continue to explore ways to improve accessibility, utility, and user-friendly
685 methods for using climate projections in various kinds of water-related decision processes for
686 different types of users.

687 **2.2.5 Strategic Action - Evaluate credit provided within the FEMA Community Rating System for**
688 **the development of watershed scale plans for managing flooding that consider projected**
689 **climate changes**

690 The National Flood Insurance Program's (NFIP) Community Rating System (CRS) provides
691 incentives for local communities to adopt flood protection standards and practices that exceed
692 the minimum standards of the NFIP and that will reduce flood damage and cost. Communities
693 that adopt specific practices are provided CRS credits that reduce flood insurance policy
694 premiums. We recommend the CRS program examine current credits and evaluate potential
695 options for providing credits for the adoption of climate resilience plans by water infrastructure
696 facilities within the community or region and for the adoption of watershed scale plans for
697 managing flooding that consider projected climate changes.

³³ Climate Resilience Toolkit, <http://toolkit.climate.gov>.

³⁴ U.S. Global Change Research Program, <http://data.globalchange.gov>.

699 As previously discussed, Federal and non-Federal decision makers have expressed a need for
 700 better understanding of how to use climate and hydrological data, information, and tools as they
 701 develop climate change vulnerability assessments and response plans and make a range of other
 702 climate adaptation decisions. As a result, a variety of organizations such as federal agencies,
 703 local governments, land-grant universities, and
 704 NGOs have been working to address this need.
 705 Their collective efforts have resulted in numerous
 706 training sites, recorded webinars, and written
 707 materials for water resources decision-makers.

708 These training materials are of varying quality, are
 709 found in various websites and other locations, and
 710 have been created for different audiences with a
 711 wide variety of backgrounds. Given increased
 712 interest in using these products, often by those
 713 who have limited scientific background, there is a
 714 need to streamline access to some of these
 715 resources to make them more readily findable,
 716 provide appropriate guidance on best practices
 717 for using information, and provide a service to the
 718 community by making them easier to use.

719 This opportunity is broad in nature and must be
 720 planned to meet the needs of people with varying
 721 specialties, skill levels, and project focus. For
 722 example, an overview of principles and issues
 723 associated with climate adaptation could prove
 724 helpful for a policy maker or manager unfamiliar
 725 with climate change. On the other hand, an
 726 engineer who is concerned with water system operations and design might require an
 727 introduction to global change models and climate risk assessment prior to very specific analytical
 728 methods.

729 The need for a more considered focus on meeting training needs has been recognized on a
 730 number of fronts. For example, in 2014, the Water Resources Adaptation to Climate Change
 731 Workgroup to the Advisory Committee on Water Information made the following
 732 recommendations for training and capacity building, briefly summarized:

- 733 • Develop mechanisms to facilitate sharing of research and capacity building for climate
 734 change adaptation.
- 735 • Expand workforce training, college traineeships, training of technical service providers,
 736 and training for laypersons.

Climate Literacy

Climate literacy is an understanding of your influence on climate and climate's influence on you and society. A climate-literate person:

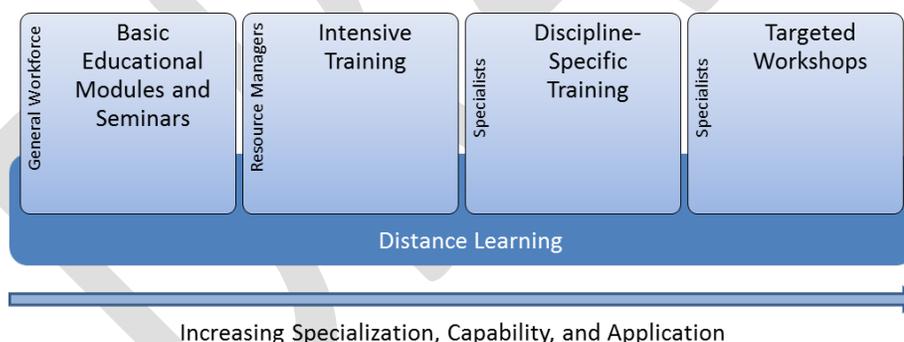
- Understands the essential principles of Earth's climate system;
- Knows how to assess scientifically credible information about climate;
- Communicates about climate and climate change in a meaningful way; and
- Is able to make informed and responsible decisions with regard to actions that may affect climate.

-- *Climate Literacy: The Essential Principles of Climate Science*, U.S. Global Change Research Program, at:
https://downloads.globalchange.gov/Literacy/climate_literacy_highres_english.pdf.

737 In addition, the President’s *Priority Agenda for Enhancing the Climate Resilience of America’s*
738 *Natural Resources* called for the development of a framework for education and training to
739 ensure climate literacy in the federal workforce. Subsequently, the *Federal Framework for*
740 *Building Climate Literacy and Capabilities* was published December 15, 2015. The Framework
741 describes the importance of a workforce that is able to:

- 742 • Understand the diverse range of impacts that a changing climate has on natural, cultural
743 and historic resources and infrastructure, including the underlying scientific principles,
744 historic trends in natural resource conditions, modeled projections of future changes,
745 and uncertainties associated with such projections;
- 746 • Critically assess the adequacy of existing institutional planning and decision-making
747 processes within the context of climate risks;
- 748 • Routinely assess and communicate the climate risks associated with continuing or
749 departing from business-as-usual operations, including the vulnerability of managed
750 systems; and
- 751 • Communicate meaningfully with the public to invite participation in climate
752 preparedness, resilience, and adaptation.

753 To achieve these objectives, several types of training are needed to meet the needs of different
754 types of users. Training for the general workforce can be basic while resource managers and
755 decision makers may need more advanced training. Additionally, different missions involve a
756 variety of disciplines and information needs, therefore special attention must be paid to
757 developing training that is directly applicable and that equips personnel with specialized
758 functions.



Conceptual diagram of educational, training, and developmental efforts leading to increased climate preparedness. -- *Federal Framework for Building Climate Literacy and Capabilities*, December 15, 2015

759 The activities described in this chapter address these recommendations. Furthermore, the
760 proposed work builds on a number of efforts that Federal agencies have made in the last several
761 years. Some examples include:
762

- 763 • The Bureau of Reclamation, Army Corps of Engineers, the University Corporation for
764 Atmospheric Research’s COMET MetEd program, along with other partners, have
765 developed training for water resource professionals incorporating climate science into

- 766 hydrologic assessment studies ([http://www.ccawwg.us/index.php/education/recent-](http://www.ccawwg.us/index.php/education/recent-training)
767 [training](http://www.ccawwg.us/index.php/education/recent-training)).
- 768 • USEPA and its partners present Climate Ready Water Utilities webinars for water utility
769 managers (<http://www2.epa.gov/crwu>).
 - 770 • NOAA and its partners have been hosting monthly webinars on “Climate Information for
771 Managing Risks in Water Resources”.
772 ([http://cpo.noaa.gov/ClimatePrograms/ClimateandSocietalInteractions/SARPPProgram/W](http://cpo.noaa.gov/ClimatePrograms/ClimateandSocietalInteractions/SARPPProgram/WebinarsandWorkshops.aspx)
773 [ebinarsandWorkshops.aspx](http://cpo.noaa.gov/ClimatePrograms/ClimateandSocietalInteractions/SARPPProgram/WebinarsandWorkshops.aspx)).
 - 774 • The Fish and Wildlife Service has developed climate training for conservation
775 professionals (<http://training.fws.gov/courses/programs/climate-change/>).
 - 776 • The U.S. Forest Service conducts annual training for land managers with decision–making
777 authority for National Forests that includes anticipated impacts of climate change on
778 aquatic resources and options for adaptation.
 - 779 • USDA and its partners have convened a ThinkWater Education Summit to increase the
780 impact of existing water education curriculum (<http://www.h2osummit.org/>).

781 Given the continuing need for training and outreach, and considering the work already underway
782 by a number of agencies and collaboratives, the Workgroup will focus attention in two key areas:

- 783 1. Increase involvement in the U.S. Climate Resilience Toolkit Water Theme.
- 784 2. Support and enhance the Climate Change and Water Working Group Professional
785 Development Series.

786 3.1 RECOMMENDATION: INCREASE INVOLVEMENT IN THE U.S. CLIMATE RESILIENCE TOOLKIT WATER 787 THEME

788 In response to the President’s Climate Action Plan, U.S. Federal government agencies have been
789 working together to build a centralized website that can better convey data, information and
790 tools to the public so they can better understand their risks and vulnerabilities to a changing
791 climate and improve their resilience to extreme events. The Climate Resilience Toolkit (Toolkit)³⁵
792 is a key component of this plan and federal agencies, under NOAA’s leadership, are working
793 towards answering users’ calls for a one-stop shop for climate adaptation information. The
794 Toolkit provides scientific tools, information, and expertise to help those interested in managing
795 their climate-related risks and opportunities. Within the Toolkit are resources available by
796 various topics, including water resource management.

797 The Workgroup is uniquely positioned to add content and increase the capabilities of the
798 Toolkit’s Water Resource Management Theme to provide purposeful climate and hydrological
799 information, tools, and training for decision and policy makers. The Workgroup should ensure
800 that the Water Theme is populated with information and training that meets the needs of a
801 wider variety of water resource professionals grappling with climate-related risks and

³⁵ Climate Resilience Toolkit, <https://toolkit.climate.gov/>.

802 opportunities. In addition, the Workgroup should ensure that the site is kept up to date as new
803 tools become available.

804 **3.1.1 Strategic Action – Develop learning progressions to improve the utility and accessibility of** 805 **the Climate Resilience Toolkit Water Theme**

806 While the Toolkit provides a variety of resources and educational opportunities for its users,
807 training resources are listed without sorting for skill levels and types of training. As a result,
808 navigating the toolkit for those with limited climate-related experience may be daunting while
809 those with more knowledge may find it cumbersome. This issue can be addressed by developing
810 a “learning progression” – that is, a system to rate and organize the existing and available
811 training according to a knowledge progression. Under the guidance of the Toolkit organizers,
812 Workgroup members will work with their respective user communities to inventory readily
813 available trainings, recommend sequences for acquiring knowledge and for water resource
814 managers, including those with both little and substantial understanding of climate processes,
815 and ultimately to use these progressions to identify information gaps.

816 These are just two examples of ways to improve delivery of appropriate and useful training for
817 the Toolkit’s Water Theme users.

818 **3.1.2 Strategic Action - Ensure new water-related training opportunities are accessible through** 819 **the Climate Resilience Toolkit**

820 Federal agencies continue to develop information and training targeted to their constituents that
821 are useful to a variety of users. Further, there is potential for Federal agencies to duplicate
822 efforts by, for example, creating similar training such as Climate 101-type lessons. To ensure
823 comprehensive access to available information and to avoid duplication of effort, the Workgroup
824 should ensure that new offerings are routinely linked to the Toolkit.

825 Further, while the Toolkit has many different offerings, some users need instruction on how to
826 apply them, especially with regards to more complex scientific information such as models
827 employing downscaled climate models that are difficult for many to understand and apply to
828 their local situations. To fill this need, the Workgroup should collaborate with the NOAA
829 outreach team to conduct live and recorded webinars demonstrating use of the tools for
830 beginners, intermediate and advanced users, all of which can then be posted online.

831 **3.1.3 Strategic Action - Help build a network of technical expertise on water and climate change,** 832 **available on request**

833 Currently users of the Toolkit can access experts through the “Expertise” section, which consist
834 primarily of state climatologists and federal staff involved with the USDA Climate Hubs, NOAA’s
835 Regional Integrated Science and Assessment centers, and USGS’ Climate Science Centers and
836 Landscape Conservations Cooperatives. The expertise section of the Toolkit should be expanded
837 to include other Federal agency expertise across the country relevant to water resource
838 managers, including regional, local, tribal, and academic experts as well as universities’
839 Cooperative Extension Services and Water Resources Research institutes.

840 **3.1.4 Strategic Action - Form stakeholder partnerships to improve delivery of training on use of**
841 **existing tools and to identify new training needs**

842 The Workgroup should form a stakeholder partnership to evaluate existing water-related tools
843 and identify gaps to be filled. At a minimum, these partnerships should address basic climate
844 literacy; intensive and discipline-specific training and targeted workshops; and climate leadership
845 development. Several private sector and nonprofit organizations have developed their own
846 delivery mechanisms, such as the Climate Adaptation Knowledge Exchange (CAKE), Association
847 of Climate Change Officers (ACCO), Climate Central, and others. These voices add innovative and
848 creative perspectives that should be considered for inclusion in the Climate Resilience Toolkit to
849 fill out the one-stop shop concept.

850 Further, the President's Council of Advisors for Science and Technology (PCAST)³⁶ recommends
851 that the federal government improve development and dissemination of information relevant to
852 the private sector through public-private partnerships. The Water Workgroup will specifically
853 reach out to private sector decision makers in the water sector to improve relevant offerings in
854 the Climate Resilience Toolkit and to improve outreach.

855 **3.1.5 Strategic Action - Develop a focused communication and outreach effort to expand**
856 **awareness of the Toolkit offerings**

857 The focus of Toolkit activity among Federal agencies has been primarily to build and populate it.
858 In order to increase awareness of how Toolkit content could help communities, the Workgroup
859 recommends redoubling outreach efforts. Furthermore, messaging and content of outreach is
860 best targeted to particular communities of practice. The Workgroup will work with NOAA to
861 develop water-related outreach, including considering convening a workshop with water-related
862 intermediary organizations. This could help with outreach as well as understanding unmet user
863 needs. Such engagement has the potential to provide use cases for additional case studies to
864 expand the Toolkit content as well.

865 **3.2 RECOMMENDATION: SUPPORT AND ENHANCE THE CLIMATE CHANGE AND WATER WORKING**
866 **GROUP PROFESSIONAL DEVELOPMENT SERIES**

867 The Federal Climate Change and Water Working Group (CCAWWG) was formed in 2007 to
868 provide engineering and scientific collaborations in support of water management under a
869 changing climate. It is an effective working-level forum among federal agencies that fosters
870 communication, as well as operational, and research partnerships to meet user needs across the
871 water resources and science communities of practice. Since 2012, CCAWWG agencies have
872 been working with the University Corporation for Atmospheric Research COMET MetEd

³⁶ President's Council of Advisors on Science and Technology,
<https://www.whitehouse.gov/administration/eop/ostp/pcast>.

873 Program³⁷ and NOAA RISAs to develop climate change training resources³⁸. Development of
874 these resources was motivated, in part, by the 2011 NAP Recommendation 6 (Support Training
875 and Outreach to Educate Water Resource Managers and Build Capacity), and Action 21 (Establish
876 a core training program on climate change science). Several online and classroom courses have
877 already been developed and delivered through COMET MetEd. The knowledge, capabilities and
878 insights developed through this activity provide a guide for future efforts.

879 Two COMET MetEd Professional Development Series are being developed and piloted:

- 880 • (2015-present) General Water Resource Audiences: *Integrating Climate Change*
881 *Adaptation into Water, Environmental, and Land Resources Management*
- 882 • (2012-present) Water Resource Technical Professionals: *Assessing Natural Systems*
883 *Impacts under Climate Change*

884 The series feature a mix of instructor-led and online, self-paced courses, with the latter served
885 through COMET's MetEd website.

886 3.2.1 Strategic Action - Continue to add new content to the Climate Change and Water Working 887 Group Professional Development series

888 Climate training collaborators continue to develop, pilot and deliver courses in both series.
889 Planned offerings in 2016 include the following instructor-led courses unless otherwise noted:

- 890 • General Water Resource Audiences: (Winter 2016) General Principles of Climate Change
891 Integration into Water Management (*online*); (Spring 2016) Integrating Climate Change
892 into Long-term Planning and Environmental Compliance.
- 893 • Water Resource Technical Professionals: (Spring 2016) Sedimentation Impacts Under
894 Climate Change; (Summer 2016) Coastal Impacts and Vulnerability under Sea Level
895 Change; (Fall 2016) Hydrologic Impacts under Climate Change.

896 After 2016, the development partners should continue to add course subjects with both online
897 and instructor-led format, where initial instructor-led offerings are residence-based followed by
898 future offerings converted to virtual format that allows greater remote participation at lower
899 cost.

900 3.2.2 Strategic Action - Workgroup agencies should work with the Climate Change and Water 901 Working Group to identify gaps and develop courses to broaden offerings

³⁷ The COMET® MetEd Program was established in 1989 by UCAR and NOAA's National Weather Service to promote a better understanding of meteorology among weather forecasters. The COMET MetEd mission has expanded, and today COMET MetEd uses innovative methods to disseminate and enhance scientific knowledge in the environmental sciences. See: http://www.comet.ucar.edu/who_about_us.php

³⁸ <http://www.ccawwg.us/index.php/education/recent-training>

902 The Climate Change and Water Working Group (CCAWWG) offers a successful model for inter-
903 agency collaboration for developing professional coursework. While coursework has, to date,
904 been developed largely for personnel in operational agencies such as the Bureau of Reclamation
905 and the Corps of Engineers, students from state and local agencies and several non-profit
906 organizations have been recruited and have successfully taken these courses as well.
907 Furthermore, the physical hydrology training created to date is common to many other impacts
908 assessments and is useful as primary input to a range of potential users, as evidenced by the
909 wide range of students already benefiting from this training series. It is intended that other
910 federal agencies will continue to add professional development course work building on this
911 foundation.

912 The Workgroup agencies will work (as is applicable) with CCAWWG and COMET MetEd to
913 identify the most needed course topics and develop additional coursework that will serve
914 policymaking and operational demands relevant to their agencies and their constituencies.

915 **3.2.3 Strategic Action - Identify ways to sustain the Climate Change and Water Working Group**
916 **Professional Development Series and expand the student base**

917 The CCAWWG professional development series is intended to serve the demand for technical
918 and managerial training while becoming a financially sustainable activity fueled and funded by
919 broader demand from private and public sector users. The Workgroup will collaborate with
920 CCAWWG to identify ways to sustain the platform, ensure that agency personnel are taking
921 advantage of the training opportunities, and expand the non-federal student base. Such an effort
922 would require exploring marketing and pricing methods and ways to offer competitive incentives
923 for seeking professional continuing education courses, working with federal human resources
924 offices to develop methods for incentivizing uptake, and engaging senior managers in adopting
925 policies for taking these trainings.

926 4 WORKGROUP MANAGEMENT AND COORDINATION

927 Since its inception in 2009, the Workgroup has been co-chaired by three agencies – CEQ, USGS,
928 and USEPA -- and has had active participation of six to eight other agencies concerned with the
929 management of water resources in a changing climate. The Workgroup serves three key
930 functions:

- 931 • to facilitate interagency coordination, collaboration, and dialogue on climate change and
932 water matters;
- 933 • to ensure long-term continuity and representation about water-related climate change
934 issues; and
- 935 • to identify and address evolving priorities for effective management of water resources
936 as the climate changes.

937 Over the past five years Federal activity on climate change adaptation has increased as Federal,
938 state, and tribal governments, local communities and other stakeholders seek guidance on
939 addressing climate change. The need for the kind of role performed by this Workgroup is
940 expected to continue for the foreseeable future given the importance of managing water
941 resources in a changing climate and the ongoing challenges.

942 Recognizing resource constraints in light of the wide range of activities underway, it remains a
943 priority to ensure continuity of this Workgroup to help address the nation’s response to climate
944 change in the water sector.

945 4.1 RECOMMENDATION: ENSURE EFFECTIVE SUPPORT FOR THE WORKGROUP TO MAINTAIN 946 CONTINUITY OF INTERAGENCY COLLABORATION AND LEADERSHIP AMONG FEDERAL WATER 947 RESOURCE AGENCIES

948 To date, three agencies have served as workgroup co-chairs: USGS (a research agency), USEPA (a
949 policy agency), and CEQ (the Administration). Initially, CEQ provided lead staff support with the
950 assistance of USEPA and USGS. Since 2012, the lead staff support role has been assumed by
951 USEPA. In addition, CEQ’s leadership has been – and continues to be - essential for ensuring
952 communication between the Workgroup and the various other activities initiated by the
953 Administration over the years.

954 4.1.1 Strategic Action – Rotate workgroup leadership among member agencies to provide fresh 955 perspectives in leadership

956 The Workgroup recommends that the leadership structure be reevaluated to share
957 responsibilities and to adapt to changing needs. One recommended option would be to have
958 the science agency and policy agency leadership role rotate every other year. In other words,
959 each year one of the two agency co-chairs will rotate out and a new co-chair from a member
960 agency will rotate in as agreed to by Workgroup members. Thus, each agency will serve in a
961 leadership role for two years. CEQ would remain a co-chair throughout. This structure serves

962 three purposes: it provides continuity of structure, it shares the role of responsibility, and it
963 brings in fresh perspective on the leadership of the Workgroup.

964 4.1.2 Strategic Action – Strengthen staffing to support the Workgroup

965 An effective coordination mechanism depends upon the ability to maintain ‘the big picture,’ to
966 serve as a central coordinator, and to engage with activities that are not directly and
967 immediately related to the activities that Workgroup members are implementing. As the nation’s
968 concerns with climate change ramp up, coordination becomes more essential. The Workgroup
969 has had an effective coordination function to date, but alternative staffing arrangements that
970 could provide more robust support need to be evaluated. The co-chairs will seek to identify a
971 means to improve availability of staff support to ensure the robust functioning of the
972 Workgroup, including support for:

- 973 • Workgroup operations including convening monthly meetings, producing annual reports
974 and workplans;
- 975 • Implementing key climate adaptation actions and consulting with member agencies
976 implementing actions;
- 977 • Coordinating with other Federal climate change adaptation activities such as the
978 National Ocean Policy implementation team, the Fish, Wildlife and Plants Strategy Joint
979 Implementation Working Group (JIWG), the Climate and Natural Resources Working
980 Group, the Climate Data and Tools Initiative, the National Drought Partnership, the U.S.
981 Global Change Research Program, and others;
- 982 • Engaging and supporting the Climate Workgroup of the Advisory Committee on Water
983 Information (ACWI)³⁹ and finding opportunities to engage stakeholders in other forums;
984 and
- 985 • Identifying opportunities to integrate Workgroup activities with regional federal
986 initiatives.

There is one issue that will define the contours of this century more dramatically than any other and that is the urgent and growing threat of a changing climate.

- President Barack Obama, September 2014, addressing the United Nations

987

³⁹ ACWI is an existing public advisory body chartered under the Federal Advisory Committee Act (FACA) to advise the Federal government on water issues. The committee is managed by the Department of the Interior and advises a range of Federal agencies on water matters. In 2012, in response to a recommendation in the 2011 NAP, ACWI established the Subcommittee on Water Resources Adaptation to Climate Change. The 40-member committee has been a valuable source of input and feedback, and the Workgroup intends to continue to support and engage with it.

988

989 **5 APPENDICES**

990 Appendix A: Inventory of Major Hydro-climatic Data Collection Systems in the U.S.

991

992 Appendix B: Regional Collaborations

993

994 Appendix C: Summary of Strategic Actions

995

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996 APPENDIX A: INVENTORY OF MAJOR HYDRO-CLIMATIC DATA COLLECTION SYSTEMS IN THE U.S.

997 *Note: this is not a comprehensive list but is provided as an initial inventory*

Variable (control-click for description)	Network or Database	Agency	Mission	Status	Gaps
Streamflow	National Water Information System (NWIS) http://waterdata.usgs.gov/nwis	U.S. Geological Survey	Provide streamflow information for multiple purposes including water management, engineering design, emergency planning, recreation, and scientific study.	Funding for 8100+ real time gages comes from a mix of federal, state, and local sources.	There are clear differences in the density of the streamflow network in different parts of the country. Additional analysis is needed to optimize addition of new gages for the purposes of climate monitoring.
Water Temperature and other water quality variables	National Water Information System (NWIS) http://waterdata.usgs.gov/nwis	USGS	Provide current and historical information on water quality for the U.S.		The availability of historical records varies greatly by constituent and location in the U.S.

Variable (control-click for description)	Network or Database	Agency	Mission	Status	Gaps
Physical, Chemical and Biological Data on Streams	National Stream Internet http://www.fs.fed.us/rm/boise/AWAE/projects/NationalStreamInternet.html	US Forest Service	Statistical and geospatial framework to support robust inferences about stream network conditions		
Water Temperature	NorWeSt http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html	U.S. Forest Service	Based on the National Stream Internet, for current and future conditions under various climate change scenarios		
Meteorological Variables	Quality Controlled Local Climatological Data (QCLCD) https://www.ncdc.gov	NOAA- NCEI	National and global datasets on meteorology and climate-	Many different datasets are available including data from land-based	

Variable (control-click for description)	Network or Database	Agency	Mission	Status	Gaps
	<p>noaa.gov/data-access/land-based-station-data/land-based-datasets/quality-controlled-local-climatological-data-qclcd</p> <p>Global Historical Climatology Network-Daily (GHCN-D)</p> <p>https://www.ncdc.noaa.gov/oa/climate/ghcn-daily/</p> <p>and other data sets</p>		related vars.	observations, radar observations, and satellite observations.	
Soil Moisture	<p>Soil Climate Analysis Network (SCAN)</p> <p>http://www.wcc.nrcs.usda.gov/scan/</p>	USDA Natural Resources Conservation Service	To implement a nationwide soil-climate network that increases the ability to make sound resource	Presently 221 stations in 40 states and U.S. territories. Not a designated program with annual funding	Number of stations does not provide adequate spatial coverage for tracking and mapping soil moisture/soil temperature values across the US.

Variable (control-click for description)	Network or Database	Agency	Mission	Status	Gaps
			and watershed management decisions	levels. Funded through initiatives and cooperative agreements with unstable funding.	
Snow	Snow Survey and Water Supply Forecasting Program http://www.wcc.nrcs.usda.gov/partnerships/links_wsfs.html	USDA Natural Resources Conservation Service	To provide critical high elevation climate information from the major water yield areas of the mountainous west and play a key role in providing near real-time precipitation, air temperature and snowpack	Over 1,100 manual snow courses and 885 automated SNOTEL sites across the western US. Expansion in the number of automated is needed.	Limited stations/data points for many basins in the west. No stations located in the Midwest or eastern parts of the US.

Variable (control-click for description)	Network or Database	Agency	Mission	Status	Gaps
			information to forecast streamflow volumes		
Groundwater Networks	National GW Monitoring Network http://cida.usgs.gov/ngwmn/	Federal Advisory Committee on Water Information (ACWI) and USGS	Integrate groundwater measurements from different networks into one nationally accessible framework.	Integration of networks is just beginning.	Includes the Climate Response Network (USGS), which is designed to monitor wells sensitive to climate conditions, but is incomplete in spatial coverage. Gaps also in monitoring groundwater quality
Water use and availability	NWISWeb interface <i>Water Data for the Nation</i> http://water.usgs.gov/watuse/data/	USGS		Data compiled from state and local sources on a 5-year cycle.	Limited site-specific data and information on consumptive use.
Evapotranspiration	FLUXNET http://fluxnet.ornl.gov/	NASA	Coordinate regional and global analysis of observations		Limited in-situ monitoring data for calibration and validation of models of spatially distributed ET.

Variable (control-click for description)	Network or Database	Agency	Mission	Status	Gaps
			from micrometeorol ogical towers.		
Public Health Data	The Waterborne Disease and Outbreak Surveillance System http://www.cdc.gov/mmwr/	Center for Disease Control	WBD OSS collects data on waterborne disease and outbreaks associated with recreational and drinking water, environmental, and undetermined water exposures.	Data collected have been published in CDC reports from 1971 to 1984 and in the Morbidity and Mortality Weekly Report (MMWR) from 1985 to the present.	This system is dependent on states and territories to provide, therefore, funding for to public health departments is essential. Expanding state waterborne disease surveillance capacity in Great Lakes basin states
Aquatic Animal Health Data	National Wild Fish Health Survey Database https://www.fws.gov/wildfishsurvey/	US Fish and Wildlife Service	To assess health status of aquatic animal health in the wild	Data from 2009- 2015 available to the public	Limited to opportunistic data collection by partners and contains geographic limitations.

999 Description of Needs for improvements of Data Networks

1000 For some of the data types included in the table above, some specific actions that could be
1001 considered are described below.

1002 Soil Moisture

1003 Numerous soil moisture networks exist across parts of the US and managed by different federal,
1004 state and university groups. A coordinated effort to incorporate these networks into a National
1005 Soil Moisture Network, combining in situ measurements with remote sensing data collection and
1006 modeling, would provide a single product. The different networks would need a common set of
1007 standards and specifications for sensors, data format and other parameters. Additional in situ
1008 stations would be needed in areas of sparse coverage to allow for adequate spatial distribution
1009 of data collection.

1010 Snow

1011 The Cooperative Snow Survey in the western US provides strong coverage of mountain
1012 snowpack utilizing the SNOTEL network and manual snow courses. There are some networks in
1013 the eastern US, including data collection for water supplies for New York City and in Maine, but
1014 otherwise in situ snowpack measurements for much of the country does not exist. Increased
1015 snowpack data collection using automated stations and potentially volunteer observers, similar
1016 to CoCoRaHS, combined with remote sensing, such as NOAA's NOHRSC, could improve
1017 assessment of annual snowpack.

1018 Groundwater Networks

1019 Groundwater can be an integrator of short and long-term climate signals, thus long-term
1020 groundwater data can be valuable for monitoring climate effects. Water level or spring discharge
1021 monitoring should primarily reflect climatic variability and not human influences. A Climate
1022 Response Network of wells or springs (hereafter "sites") is ideal for this research, where
1023 uninterrupted, long-term water level or spring discharge records are collected. These data also
1024 can be supplemented with long-term data that do not meet such strict criteria. Many Federal
1025 and State agencies collect these data. An expansion of the Climate Response Network is
1026 underway by the USGS in support of research on climate effects. Additionally, the
1027 Subcommittee on Ground Water is building a National Groundwater Monitoring Network
1028 composed of data from willing State and Federal agencies. Implementation of these two
1029 networks is in the early stages. Support for their continued development is needed to assure
1030 that these critical data will be available for future climate effects research.

1031 Water use and availability

1032 The USGS has helped to lay a foundation of water use data through its Water Use in the United
1033 States Surveys, carried out every five years since 1950. The USDA, DOE, and EPA also have
1034 programs that consider water use. These efforts should be continued and expanded where
1035 feasible, with particular emphasis on the programs below.

1036 (a) Continue to support efforts being carried out under the National Water Census managed by
1037 the USGS as part of the WaterSmart initiative. The program is helping to develop new sources of
1038 data and platforms to integrate data needed to develop water budgets for individual
1039 watersheds. The information will help water managers to assess water availability and use.
1040 WaterSMART should also continue to carry out associated projects to develop a site-specific
1041 water use database for public water systems and efforts to better assess consumptive use of
1042 irrigation by better estimating evapotranspiration.

1043 (b) Monitor federal and non-federal efforts to survey water use in the municipal, energy and
1044 agricultural sectors, as well as development of metrics and indicators to assess water use.
1045 Grants to allow states to support water use data collection efforts as part of the WaterSMART
1046 Water Use Data and Research grant program should be continued. To the extent possible,
1047 efforts between the federal agencies should be coordinated and data shared with federal and
1048 non-federal data users.

1049 (c) Expand efforts to support basin and geographic focus area studies that evaluate supply and
1050 demand with an eye towards helping decision makers identify appropriate management
1051 strategies. This includes programs carried out by the Bureau of Reclamation and the USGS under
1052 the auspices of the WaterSMART program.

1053 **Public Health Data**

1054 Data on waterborne diseases in the U.S. are documented and reported by state and local health
1055 departments to the Centers for Disease Control and Prevention (CDC). Obtaining accurate,
1056 consistent and representative epidemiologic data from U.S. States and jurisdictions is essential to
1057 understand and track current and emerging diseases that are relevant to climate change and to
1058 develop predictive models and control strategies that protect public health. Existing monitoring
1059 systems for waterborne diseases and outbreaks should be maintained and expanded to provide
1060 baseline data on which to assess future changes in disease occurrence, seasonality or geographic
1061 range that may be related to climate change. Specific initiatives that should be supported
1062 include:

1063 a) Providing funding to states through the Epidemiologic and Laboratory Capacity grant to
1064 support waterborne disease surveillance and detection, laboratory testing, and emergency
1065 response capacity;

1066 b) Expanding state waterborne disease surveillance capacity in Great Lakes basin states to
1067 improve disease surveillance systems, develop waterborne disease surveillance and response
1068 networks, and improve public health capacity for ambient water quality issues, such as harmful
1069 algal bloom events and illnesses.

1070 **Aquatic Animal Health Data**

1071 The nation's fisheries face many challenges in relation to climate change. There is sufficient
1072 evidence that the earth's atmosphere and oceans are warming. Rising summer water
1073 temperatures, drought, severity in rain or snow events and winter-spring flooding are likely to

1074 potentially negatively impact aquatic animal health or wild fish stocks. The USFWS conducts
1075 opportunistic sampling of aquatic animals to assess their health status and maintains a Wild Fish
1076 Health Survey Database to house this data. The database includes a mapper that can be used to
1077 cross reference climate and water level data with health status. A direct outcome of the
1078 database is to model potential climate change with disease status in wild aquatic animal
1079 populations throughout the United States. This is the only database of its kind and is widely used
1080 both nationally and internationally to make management decisions or such things as interstate
1081 and international animal movements and to justify species conservation efforts.

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1082 **APPENDIX B: REGIONAL COLLABORATIONS**

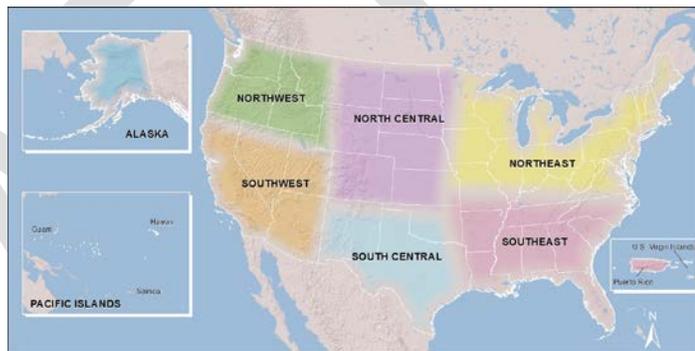
1083 **DOI Climate Science Centers**

1084 <https://www.doi.gov/csc>

1085 The regional Department of the Interior Climate Science Centers (CSCs) partner with natural & cultural
1086 resource managers to provide science that helps fish, wildlife, ecosystems & the communities they
1087 support adapt to climate change. The Climate Science Centers conduct cutting-edge research projects at
1088 local, regional and national scales; and produce products that include climate, water and ecosystem
1089 modeling, and geospatial, habitat, and species-level data. The CSCs are built upon federal-university
1090 partnerships; provide educational opportunities for students and early career scientists through
1091 fellowships, workshops, and training; and work with tribes and indigenous communities to better
1092 understand their specific vulnerabilities to climate change and to help them adapt to these impacts. The
1093 CSCs are dependent upon engagement with a community of stakeholders to define research priorities
1094 and initiatives.

1095 There are eight DOI CSCs:

- 1096 • Alaska CSC
- 1097 • Pacific Islands CSC
- 1098 • North Central CSC
- 1099 • South Central CSC
- 1100 • Southeast CSC
- 1101 • Northeast CSC
- 1102 • Southwest CSC
- 1103 • Northwest CSC



1104 **DOI Landscape Conservation Cooperatives (LCCs)**

1105 <https://lccnetwork.org/>

1106 Managing the landscapes that provide our natural and cultural resources has become increasingly
1107 challenging. The Department of the Interior launched the Landscape Conservation Cooperatives (LCCs)
1108 to better integrate science and management to address climate change and other landscape scale
1109 issues. By building a network that is holistic, collaborative, adaptive, and grounded in science, LCCs are
1110 working to ensure the sustainability of our economy, land, water, wildlife, and cultural resources.

1111 The 22 LCCs collectively form a network of resource managers and scientists who share a common need
1112 for scientific information and interest in conservation. Each LCC brings together federal, state, and local
1113 governments along with Tribes and First Nations, non-governmental organizations, universities, and
1114 interested public and private organizations. Our partners work collaboratively to identify best practices,
1115 connect efforts, identify science gaps, and avoid duplication through conservation planning and design.

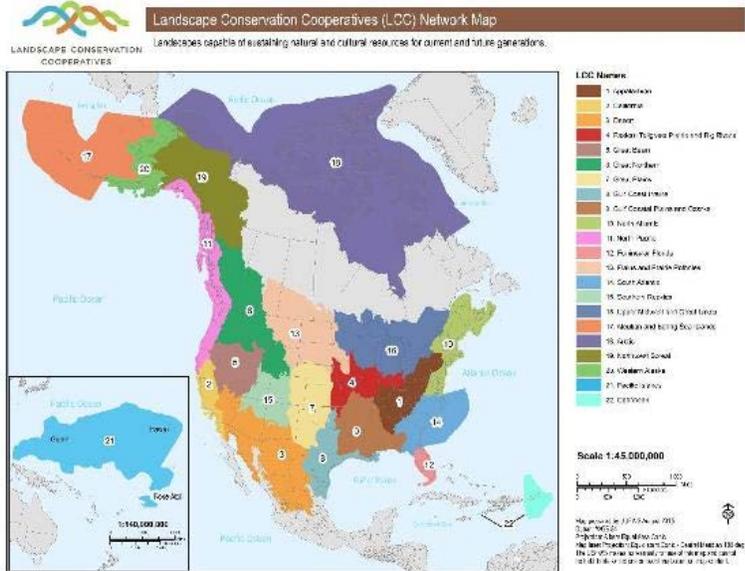
1116 The 22 DOI LCCs are:

- | | |
|--|---|
| 1117 • Aleutian and Bering Sea Islands | 1121 • Caribbean |
| 1118 • Appalachian | 1122 • Desert |
| 1119 • Arctic | 1123 • Eastern Tallgrass Prairie and Big Rivers |
| 1120 • California | 1124 • Great Basin |

- 1125 • Great Northern
- 1126 • Great Plains
- 1127 • Gulf Coast Prairie
- 1128 • Gulf Coastal Plains and Ozarks
- 1129 • North Atlantic
- 1130 • North Pacific
- 1131 • Northwest Boreal

- 1132 • Pacific Islands
- 1133 • Peninsular Florida
- 1134 • Plains and Prairie Potholes
- 1135 • South Atlantic
- 1136 • Southern Rockies
- 1137 • Upper Midwest and Great Lakes
- 1138 • Western Alaska

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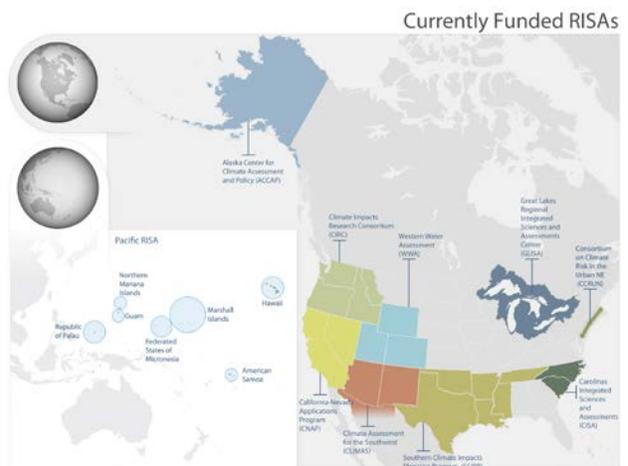
NOAA Regional Integrated Science and Assessments (RISAs)

<http://cpo.noaa.gov/ClimatePrograms/ClimateandSocietalInteractions/RISAProgram/AboutRISA.aspx>

NOAA’s Regional Integrated Sciences and Assessments (RISA) program supports research teams that help expand and build the nation's capacity to prepare for and adapt to climate variability and change. Central to the RISA approach are commitments to process, partnership, and trust building. RISA teams work with public and private user communities to advance understanding of context and risk; support knowledge to action networks; innovate services, products and tools to enhance the use of science in decision making; and advance science policy.

There are nine currently funded NOAA RISAs:

- Alaska Center for Climate Assessment and Policy (AACAP)
- California-Nevada Applications Program (CNAP)
- Climate Impacts Research Consortium (CIRC)
- Western Water Assessment (WWA)
- Climate Assessment for the Southwest (CLIMAS)



1204 The ten regional USDA Climate Hubs are:

- 1205 • Northeast
- 1206 • Southeast
- 1207 • Caribbean
- 1208 • Midwest
- 1209 • Northern Forest
- 1210 • Northern Plains
- 1211 • Southern Plains
- 1212 • Northwest
- 1213 • Southwest
- 1214 • California



[View National Land Cover Dataset Legend](#)

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APPENDIX C: SUMMARY OF STRATEGIC ACTIONS AND LEAD AGENCIES

Team 1: Data and Research (Team Lead: USGS)		
Recommendations	Strategic Actions	Lead(s)
1.1: Sustain and expand existing monitoring networks and data collection on hydrologic and meteorological conditions and water demand.	1.1.1 - Continue to identify and address data gaps and needs for water resource management.	USGS
	1.1.2 - Expand adoption of reference monitoring networks to establish baseline conditions for evaluating impacts due to climate change.	EPA
1.2: Modernize statistical analyses of observational data sets to improve understanding of emerging trends associated with climate change.	1.2.1 - Precipitation Frequency Datasets	NOAA
	1.2.2 - Flood Frequency Guidelines.	USGS
	1.2.3 - Streamflow Statistics.	EPA
1.3: Improve reliability and accessibility of water-related projections of future conditions.	1.3.1 - Evaluate the feasibility of developing the capability to project water temperature under future climates.	EPA
	1.3.2 - Evaluate the feasibility of integrating climate-impacted hydrology projections with projections of population and land use.	EPA
1.4: Enhance water supply through innovative technologies	1.4.1 - Enhance water supply through investment in energy-water technologies	DOE
	1.4.2 - Improve Water Use Efficiency in Agriculture	USDA

Team 2: Planning and Decision Support (Team Lead: USACE)		
Recommendations	Strategic Actions	Lead(s)
2.1: Advance regional coordination among federal water resource management agencies to support climate change adaptation and resilience efforts	2.1.1 - Develop new regional Federal Agency Support Teams (X-FAST) for water resources management.	USACE
	2.1.2 - Expand engagement of Federal water resource agencies in regional cooperative efforts on climate science and decision-making.	DOI, NOAA, USDA
	2.1.3 - Provide support to agencies to incorporate supply chain issues and water use vulnerability into adaptation plans.	DOD

	2.1.4 - Develop case studies to inform restoration of wetlands to build resilience.	EPA, USACE
2.2: Develop guidance and provide assistance to communities and water resource managers on use of climate change information and tools for assessing vulnerability and building resilience	2.2.1 - Develop an online dashboard to help water resource managers and urban planners prepare for and respond to extreme events.	NOAA
	2.2.2 - Streamline access to climate adaptation information for the water theme of the Climate Resilience Toolkit.	NOAA
	2.2.3 - Continue to develop, distribute, and provide guidance on the use of projected future climate information for water resources management.	NOAA
	2.2.4 - Adopt a system for coordinating vulnerability assessments and advancing peer-to-peer learning.	USGS
	2.2.5 - Evaluate policies to provide points within the FEMA Community Rating System for the development of watershed scale plans for managing flooding that consider projected climate changes.	FEMA

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Team 3: Training & Outreach (Lead: NOAA)		
Recommendations	Strategic Actions	Lead(s)
3.1: U.S. Climate Resilience Toolkit Water Theme	3.1.1 - Develop learning progressions to improve the utility and accessibility of the Climate Resilience Toolkit Water Theme.	NOAA, EPA
	3.1.2 - Ensure new water-related training opportunities are accessible through the Climate Resilience Toolkit.	NOAA, EPA
	3.1.3 - Help build a network of technical expertise on water and climate change, available on request.	NOAA
	3.1.4 - Form stakeholder partnerships to improve delivery of training on use of existing tools and to identify new training needs.	NOAA, EPA
	3.1.5 - Develop a focused communication and outreach effort to expand awareness of the Toolkit offerings.	NOAA

3.2: Sustain and build upon the Climate Change and Water Working Group Professional Development Series	3.2.1 - Continue to add new content to the Climate Change and Water Working Group Professional Development series.	BuRec
	3.2.2 - Workgroup agencies should work with the Climate Change and Water Working Group to identify gaps and develop courses to broaden offerings.	BuRec
	3.2.3 - Identify ways to sustain the Climate Change and Water Working Group Professional Development Series and expand the student base.	BuRec

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Team 4: Management and Coordination (Co-Leads: USEPA, USGS, CEQ)

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Recommendations	Strategic Actions	Lead(s)
4.1: Ensure effective support for the Workgroup to maintain continuity of interagency collaboration and leadership among Federal water resource agencies	4.1.1 - Rotate workgroup leadership among member agencies to provide fresh perspectives in leadership.	CEQ, USGS, EPA
	4.1.2 – Strengthen staffing to support the Workgroup.	CEQ, USGS, EPA

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Co-chairs

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Council on Environmental Quality - Charles Kovatch

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Environmental Protection Agency - Michael Shapiro

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U.S. Geological Survey - Jerad Bales

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Members

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1231 **Army Corps of Engineers**1261 **Department of the Interior**

1232 Rachel Grandpre

1262 *Bureau of Reclamation*

1233 Kathleen White

1263 Levi Brekke

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1264 Kenneth Nowak

1235 **Centers for Disease Control and
Prevention**

1265 Dave Raff

1237 Joan Brunkard

1266 *U.S. Geological Survey*

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1239 **Department of Agriculture**1269 **Environmental Protection Agency**1240 *Forest Service*

1270 Veronica Blette

1241 Christopher Carlson

1271 Karen Metchis

1242 David Levinson

1272 Jeff Peterson

1243 *Natural Resources Conservation*

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1244 *Service*1274 **FEMA**

1245 Noel Gollehon

1275 Mark Crowell

1246 Michael Strobel

1276 William Lesser

1247 *Office of the Chief Economist*

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1248 Carolyn Olson

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1251 *Office of the Secretary of Defense*

1281 Jared Entin

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1285 Nancy Beller-Simms

1256 **Department of Energy**

1286 Michael Brewer

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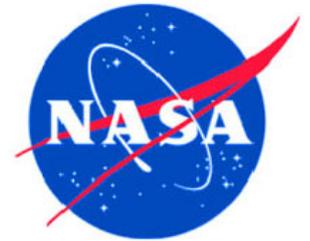
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