Water Priorities Delphi Survey: Phase 1

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Introduction

Purdue University and the University of Connecticut are conducting a synthesis evaluation of the U.S. Department of Agriculture National Institute of Food and Agriculture (USDA NIFA) 2001 – 2013 Water Portfolio (called NIFA Water Portfolio from this point forward). The NIFA Water Portfolio has funded a variety of research, education, and extension efforts focusing on water resource issues in the United States and abroad. Through this synthesis, we seek to identify critical findings and lessons learned, and to evaluate the effectiveness of projects in promoting solutions to water problems in agricultural, rural, and urbanizing watersheds.

One component of the NIFA Water Portfolio Synthesis (called Synthesis from this point forward) is an analysis of water priorities that lead to water funding priority recommendations. In this document, we report on the first phase (Phase 1) of a survey process in which we are gathering information about what water experts in federal agencies believe to be pressing water-related issues that NIFA should consider funding in the future. These water experts were asked to rate 40 water-related issues (water priority areas) that they believe NIFA should prioritize for future funding. A second survey will be distributed to the respondents of the Phase 1 survey in order to further refine recommended water priorities.

Methods

Data Collection and Analysis

The Phase 1 survey was distributed online through Qualtrics software in February 2016. It was sent to federal agency staff identified as water experts by the NIFA Water Program National Program Leader (James Dobrowolski), the Synthesis Program Directors (Mike O'Neill and Linda Prokopy) and advisory group, and through recommendations received through Phase 1 survey respondents.

The survey was initially sent to 80 federal agency employees that participated in focus groups conducted in October 2015 as part of the Synthesis project evaluation. The purpose of the focus group was to identify an initial list of water priority areas as perceived by federal water experts. As part of the Phase 1 survey, we asked respondents to suggest other water experts that should be included as survey participants. Subsequently, a second group of nine water experts were also invited to participate in the Phase 1 survey.

A total of 89 participants were sent survey invitations through Qualtrics; 35 surveys were completed, for a 39.3% response rate.

Nine federal agencies were represented through survey respondents. Agencies were identified through respondents' place of work, utilizing email addresses and information located on agency websites. The U.S. Environmental Protection Agency (EPA) (28.6%) and U.S. Department of Agriculture (USDA) (25.7%), together, represent over half (54.3%) of survey responses. Table 1 lists each federal agency and their corresponding survey completion numbers.

Table 1 Survey responses by federal agency

Federal Agency Name	Federal Agency Abbreviation	Completed Surveys (n)	Percent of Total Reponses
U.S. Environmental Protection Agency	**EPA**	**10**	**28.6**
U.S. Department of Agriculture	**USDA**	**9**	**25.7**
USDA Natural Resources Conservation Service	*USDA-NRCS*	*4*	*11.4*
USDA National Institute of Food and Agriculture	*USDA-NIFA*	*3*	*8.6*
USDA Economic Research Service	*USDA-ERS*	*2*	*5.7*
National Aeronautics and Space Administration	**NASA**	**4**	**11.4**
U.S. Department of Energy	**DOE**	**3**	**8.6**
National Oceanic and Atmospheric Administration	**NOAA**	**3**	**8.6**
Bureau of Reclamation	**BOR**	**2**	**5.7**
U.S. Geologic Society	**USGS**	**2**	**5.7**
National Science Foundation	**NSF**	**1**	**2.9**
U.S. Army Corps of Engineers	**ACE**	**1**	**2.9**
Total		**35**	

Survey data were analyzed using SPSS software. Water priority areas were ranked first according to overall response mean (1 = “Strongly Disagree” through 5 = “Strongly Agree”) and then by “Strongly Agree” responses for the statement: **“NIFA should prioritize future water funding within the following…broad topic areas**”. This ranking strategy shows respondents’ overall support for each water priority area by ranking by the mean of all responses, yet more weight has been placed upon water priority areas that respondents’ *strongly agreed* should be prioritized by NIFA. Open-ended questions were analyzed by one researcher who coded responses into broad themes which are noted on page 10. These open-ended questions informed the development of the Phase 2 survey.

Water Priority Development

Water priority areas included in the Phase 1 survey were developed through three data sources:

1. Priorities reported by Project Directors funded through the NIFA Water Portfolio through a Synthesis survey distributed between April and June of 2015; in response to the question “In your opinion, what water related science questions should NIFA funding be focused upon in the future?”.
2. A focus group conducted with water experts from different federal agencies in October 2015, in which water funding priorities were discussed.
3. Input from the Synthesis advisory group.

Water priority areas were identified by coding focus group information and survey responses into broad water resource issue themes. First, one researcher coded focus group recordings and meeting notes taken by two Synthesis researchers into 18 initial water priority areas. This researcher then coded approximately one-third of open-ended responses to the Project Director survey question, “In your opinion, what water related science questions should NIFA funding be focused upon in the future?” While many of the responses fit into the initial water priority area codes, 19 additional water priority areas were identified. This list of 37 water priority areas were distributed to the Synthesis advisory group and the Synthesis Project Directors, who agreed that the list was relevant and asked for three additional priorities to be added. The final list included in the Phase 1 survey was comprised of 40 water priority areas (see Table 6).

Results

Respondents' Water-Related Experience

Survey respondents were asked to provide information on their water-related work experience including longevity working in a water-related field, current water-related work responsibilities, and time with their current agency (Tables 2 through 5). Respondents spent an average of 25.8 years working in a water-related field (Table 2) and 17.7 years in their current agency (Table 3). Although almost a third (28.6%) of all respondents spent less than 10% of their working time on water-related tasks, over half (51.5%) spent over 50% of their work time on water-related tasks, with the overall response average at 51.4% of working time (Table 4). The majority of all respondents (77.1%) had a role in water-related funding decisions (Table 5).

Table 2 Years worked in a water-related field

Number of years	N	Percent of total respondents (n=35)
Less than 5	0	0.0
5 to 9	2	5.7
10 to 19	10	28.6
20 to 39	14	40.0
40 and above	6	17.1
Total responses	**32**	
Minimum	5	
Maximum	49	
Mean	25.8	

Table 3 Years worked in current agency

Number of years	N	Percent of total respondents (n=35)
Less than 5	3	
5 to 9	8	22.9
10 to 19	8	22.9
20 to 39	11	31.4
40 and above	2	5.7
Total responses	**32**	
Minimum	3	
Maximum	42	
Mean	17.7	

Table 4 Approximate percentage of time spent on water-related work

Percent of Time	N	Percent of total respondents (n=35)
Less than 10	10	28.6
10 to 24	2	5.7
25 to 49	2	5.7
50 to 99	8	22.9
100	10	28.6
Total responses	**32**	
Minimum	0	
Maximum	100	
Mean	51.4	

Table 5 Role in water-related funding decisions?

	N	Percent of total respondents (n=35)
Yes	27	77.1%
No	5	14.3%
Total responses	**32**	

Water Priorities and Ranking

Table 6 shows water priorities ranked in order from the highest to lowest means of all responses (1 = “Strongly Disagree” through 5 = “Strongly Agree”) and then by “Strongly Agree” responses. The rows shaded in green highlight water priorities with means ≥ 4.00 (n=12). Two other columns show the percentage of respondents who selected 1) “Agree” or “Strongly Agree” and 2) “Strongly Agree” that **“NIFA should prioritize future water funding within the following…broad topic areas**”. Over 90% of respondents selected “Agree” or “Strongly Agree” (see “%Agree/Strongly Agree” column) for the top three water priority areas, “Climate change and water quality and quantity”, “Climate change and adaptation and mitigation strategies”, and “Water quality and conservation practices”, thus showing overall strong overall support for these water priority areas.

Table 6 Water Priorities: Ranked by mean and then % "Strongly Agree"

Water Priority Areas	N	Mean	% Agree/Strongly Agree	% Strongly Agree
1) Climate change and water quality and quantity	34	4.41	91.2%	54.3%
2) Climate change and adaptation and mitigation strategies	33	4.39	90.9%	48.6%
3) Water quality and conservation practices	32	4.22	90.6%	31.4%
4) Water data (includes water monitoring, water usage, tool development, etc.)	33	4.21	75.8%	42.9%
5) Water quality and nutrients	33	4.21	87.9%	34.3%
6) Water quality and drought	33	4.18	84.8%	37.1%
7) Watershed management	34	4.18	85.3%	31.4%
8) Water reuse	33	4.15	78.8%	37.1%
49) Benchmarks, indicators, and models to study/monitor water quality and quantity	33	4.12	81.8%	31.4%
10) Climate change and economics	31	4.06	80.6%	22.9%
11) Irrigation efficiency and management	32	4.03	78.1%	31.4%
12) Tile drainage systems	33	4.00	69.7%	31.4%
13) Water quantity: Impact on water quality	32	3.94	75.0%	28.6%
14) Water quality and livestock	32	3.91	71.9%	25.7%
15) Water quantity and efficiency (includes technology and structures)	32	3.91	68.8%	22.9%
16) Stakeholder involvement/collaboration in water projects	33	3.88	63.6%	25.7%
17) Soil science and water	33	3.88	69.7%	22.9%
18) Groundwater recharge	32	3.88	65.6%	22.9%
19) Water quality and microbiological/organic material	33	3.88	72.7%	20.0%
20) Water protection and conservation behavior	33	3.88	69.7%	20.0%
21) Policy analysis: Water quality and quantity	32	3.84	68.8%	20.0%
22) Water quality and agrochemicals	32	3.84	75.0%	14.3%
23) Water quality and sedimentation	32	3.81	62.5%	20.0%
24) Water management tools	32	3.78	65.6%	17.1%
25) Water quantity and crop production	32	3.75	65.6%	20.0%
26) Water quality and salinity	32	3.75	62.5%	17.1%
27) Education strategies/programs for water resource educators	32	3.75	65.6%	11.4%
28) End-user use of water research and tools	31	3.74	64.5%	14.3%
29) Water vulnerability assessments	33	3.73	63.6%	20.0%
30) Drinking water and health (includes communities impacted by natural disaster)	32	3.72	56.3%	20.0%
31) Water quantity and allocation of water resources between different uses/users	32	3.72	65.6%	14.3%
32) Water and land use	33	3.70	66.7%	11.4%
33) Water quality and pharmaceuticals	32	3.69	65.6%	14.3%

Water Priority Areas	N	Mean	% Agree/Strongly Agree	% Strongly Agree
34) Food safety	31	3.65	58.1%	14.3%
35) Water quality and fracking	33	3.58	72.7%	8.6%
36) Waste water management (including storm water)	32	3.50	46.9%	17.1%
37) International food security	32	3.44	50.0%	17.1%
38) Water lifecycle analysis, water footprint	32	3.44	46.9%	17.1%
39) Water and invasives	32	3.41	46.9%	5.7%
40) Private wells and /or septic systems	32	2.97	28.1%	5.7%
Minimum		2.97	28.1%	5.7%
Maximum		4.41	91.2%	54.3%

Table 7 shows the percentage, by federal agency, of respondents who selected “Agree” or “Strongly Agree” (%A/SA) for each water priority area. There was broad support across agencies for the top three water priority areas, ranging from 50% to 100% of respondents selecting “Agree” or “Strongly Agree”. It should be noted that some water priority areas had varying levels of federal agency support; for example some water priority areas range from 0% to 100% of respondents selecting “Agree” or “Strongly Agree”. The top 12 water priority areas are highlighted in green.

Table 7 Federal Agency “Agree” and “Strongly Agree” responses to water priority areas (% of each agency)

Water Priority Areas	N	Mean	BOR (n=2) % A/SA	DOE (n=3) % A/SA	EPA (n=9) % A/SA	NASA (n=4) % A/SA	NOAA (n=3) % A/SA	NSF (n=1) % A/SA	USACE (n=1) % A/SA	USDA (n=9) % A/SA	USGS (n=2) % A/SA
1) Climate change and water quality and quantity	34	4.41	100.0%	66.7%	88.9%	75.0%	100.0%	100.0%	100.0%	88.9%	100.0%
2) Climate change and adaptation and mitigation strategies	33	4.39	50.0%	66.7%	66.7%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
3) Water quality and conservation practices	32	4.22	50.0%	66.7%	88.9%	75.0%	100.0%	100.0%	100.0%	77.8%	50.0%
4) Water data (includes water monitoring, water usage, tool development, etc.)	33	4.21	0.0%	0.0%	55.6%	75.0%	66.7%	0.0%	0.0%	44.4%	50.0%
5) Water quality and nutrients	33	4.21	50.0%	33.3%	66.7%	50.0%	66.7%	0.0%	100.0%	44.4%	100.0%
6) Water quality and drought	33	4.18	100.0%	33.3%	66.7%	50.0%	100.0%	100.0%	100.0%	66.7%	50.0%
7) Watershed management	34	4.18	100.0%	0.0%	66.7%	50.0%	66.7%	100.0%	100.0%	55.6%	50.0%
8) Water reuse	33	4.15	100.0%	33.3%	55.6%	100.0%	66.7%	100.0%	100.0%	55.6%	100.0%
9) Benchmarks, indicators, and models to study/monitor water quality and quantity	33	4.12	50.0%	33.3%	88.9%	75.0%	100.0%	100.0%	100.0%	66.7%	100.0%
10) Climate change and economics	31	4.06	100.0%	33.3%	55.6%	75.0%	100.0%	100.0%	0.0%	88.9%	100.0%
11) Irrigation efficiency and management	32	4.03	100.0%	33.3%	44.4%	75.0%	100.0%	100.0%	100.0%	88.9%	100.0%
12) Tile drainage systems	33	4.00	0.0%	0.0%	44.4%	50.0%	66.7%	100.0%	100.0%	44.4%	50.0%

Water Priorities	N	Mean	BOR (n=2) % A/SA	DOE (n=3) % A/SA	EPA (n=9) % A/SA	NASA (n=4) % A/SA	NOAA (n=3) % A/SA	NSF (n=1) % A/SA	USACE (n=1) % A/SA	USDA (n=9) % A/SA	USGS (n=2) % A/SA
13) Water quantity: Impact on water quality	32	3.94	0.0%	66.7%	100.0%	100.0%	100.0%	100.0%	100.0%	77.8%	50.0%
14) Water quality and livestock	32	3.91	50.0%	33.3%	100.0%	75.0%	66.7%	100.0%	100.0%	88.9%	100.0%
15) Water quantity and efficiency (includes technology and structures)	32	3.91	100.0%	33.0%	67.0%	50.0%	66.7%	100.0%	100.0%	67.0%	50.0%
16) Stakeholder involvement/collaboration in water projects	33	3.88	50.0%	0.0%	55.6%	75.0%	66.7%	100.0%	100.0%	77.8%	100.0%
17) Soil science and water	33	3.88	0.0%	33.3%	66.7%	50.0%	100.0%	100.0%	100.0%	55.6%	50.0%
18) Groundwater recharge	32	3.88	0.0%	66.7%	44.4%	75.0%	100.0%	100.0%	100.0%	66.7%	50.0%
19) Water quality and microbiological/organic material	33	3.88	50.0%	33.3%	44.4%	75.0%	33.3%	100.0%	100.0%	66.7%	100.0%
20) Water protection and conservation behavior	33	3.88	50.0%	33.3%	66.7%	75.0%	33.3%	100.0%	100.0%	100.0%	100.0%
21) Policy analysis: Water quality and quantity	32	3.84	50.0%	0.0%	66.7%	25.0%	66.7%	100.0%	100.0%	77.8%	100.0%
22) Water quality and agrochemicals	32	3.84	100.0%	33.3%	77.8%	100.0%	66.7%	100.0%	100.0%	88.9%	100.0%
23) Water quality and sedimentation	32	3.81	100.0%	0.0%	88.9%	50.0%	66.7%	100.0%	100.0%	66.7%	50.0%
24) Water management tools	32	3.78	50.0%	0.0%	77.8%	100.0%	66.7%	100.0%	100.0%	66.7%	50.0%
25) Water quality and salinity	32	3.75	50.0%	33.3%	44.4%	75.0%	66.7%	100.0%	100.0%	66.7%	100.0%
26) Education strategies/programs for water resource educators	32	3.75	100.0%	33.3%	33.3%	75.0%	100.0%	100.0%	100.0%	55.6%	100.0%

Water Priorities	N	Mean	BOR (n=2) % A/SA	DOE (n=3) % A/SA	EPA (n=9) % A/SA	NASA (n=4) % A/SA	NOAA (n=3) % A/SA	NSF (n=1) % A/SA	USACE (n=1) % A/SA	USDA (n=9) % A/SA	USGS (n=2) % A/SA
27) End-user use of water research and tools	31	3.74	50.0%	33.3%	44.4%	75.0%	100.0%	100.0%	100.0%	44.4%	100.0%
28) Water vulnerability assessments	33	3.73	50.0%	33.3%	66.7%	75.0%	66.7%	100.0%	100.0%	55.6%	100.0%
29) Water quantity and crop production	32	3.75	0.0%	33.3%	66.7%	100.0%	100.0%	100.0%	100.0%	33.3%	50.0%
30) Drinking water and health (includes communities impacted by natural disaster)	32	3.72	50.0%	0.0%	66.7%	75.0%	66.7%	100.0%	100.0%	11.1%	100.0%
31) Water quantity and allocation of water resources between different uses/users	32	3.72	100.0%	33.3%	66.7%	50.0%	66.7%	100.0%	100.0%	66.7%	50.0%
32) Water and land use	33	3.70	50.0%	66.7%	77.8%	100.0%	66.7%	100.0%	100.0%	55.6%	50.0%
33) Water quality and pharmaceuticals	32	3.69	0.0%	33.3%	55.6%	75.0%	100.0%	100.0%	100.0%	55.6%	100.0%
34) Food safety	31	3.65	50.0%	33.3%	33.3%	75.0%	33.3%	100.0%	100.0%	55.6%	100.0%
35) Water quality and fracking	33	3.58	50.0%	66.7%	66.7%	75.0%	66.7%	100.0%	100.0%	55.6%	100.0%
36) Waste water management (including stormwater)	32	3.50	100.0%	0.0%	33.3%	75.0%	66.7%	100.0%	0.0%	22.2%	100.0%
37) International food security	32	3.44	0.0%	33.3%	33.3%	75.0%	66.7%	0.0%	100.0%	33.3%	100.0%
38) Water lifecycle analysis, water footprint	32	3.44	50.0%	0.0%	55.6%	100.0%	66.7%	100.0%	100.0%	55.6%	50.0%
39) Water and invasives	32	3.41	50.0%	66.7%	44.4%	75.0%	100.0%	100.0%	0.0%	55.6%	100.0%
40) Private wells and /or septic systems	32	2.97	50.0%	66.7%	66.7%	75.0%	66.7%	100.0%	0.0%	66.7%	100.0%

Water priorities: Open-ended responses

Respondents were asked to provide optional additional information on water priorities for which they selected "Strongly Agree". The following section includes open-ended answers respondents entered when prompted: **"In the space provided, please feel free to write additional information about the topic…"**

Open-Ended Response Themes

Through coding the open-ended questions into broad categories, several themes were consistently expressed across water priority areas. We will ask questions specific to these themes in the Phase 2 survey. These themes included:

- Understand and predict effects of climate change across geographic and temporal scales.
- Connect climate change science knowledge across federal agencies.
- Incorporate interdisciplinary teams into projects.
- Include education, extension, and outreach into projects.
- Understand and communicate various tipping points/thresholds related to climate change impacts on water resources.
- Research various aspects of water reuse.
- Develop/generate data, tools, and technology related to various water resource issues.
- Ensure open-access data and data sharing.

Open-Ended Responses

The following text was taken verbatim from survey responses. Not all respondents entered information when prompted.

1) Climate change and water quality and quantity

1. This topic will be increasingly important as we understand the ramifications of a changing climate. Not only do we need to understand the obvious -- such as urban/suburban runoff and increasing temperatures.
2. Climate change will have unique impacts for different locations. Understanding and predicting these impacts will facilitate the planning of preventive and mitigation. This requires information at the regional and local scales.
3. adaptation options for regional water supply wipe outs by drought e.g., California began 2016 likely one winter away from that smoking gun connecting increased water temperature to increase in harmful algal blooms - correlation is not causation
4. Research and outreach needed.
5. Need to determine what type of agricultural systems protect water quality in a changing climate.
6. Reducing uncertainty about climate change impacts on water is critical to being able to do any sort of adaptation in this area. Another approach is to evaluate how robust alternative policies are to alternative hydrologic outcomes.
7. Water quality and quantity will be affected by climate change. For example, warmer water temperatures (increased frequency, duration and intensity of heat waves) or less available

water (drought) due to climate change will impact the ability to generate electricity and produce biofuels.

8. A key issue for producers...due to litigation worries and water demand.
9. Water quality evaluation needs more attention. Land use change, agriculture, and climate change interactions that affect water quality as well as watershed function.
10. Addressing extreme events and how climate change is impacting water availability, especially in light of competition for resources for ecosystem services, municipal uses, and energy (bioenergy, hydroelectric, etc.).

2) Climate change and adaptation and mitigation strategies

1. Because of the potential long-term impact to climate change, adaptation strategies are critical. It is best to start now while there is time to develop and deliver new technologies and methods. Besides, such strategies could be useful immediately to manage current risks.
2. Interdisciplinary teams (e.g., physical, social scientists with decision makers) to explore potential local impact. Once determined studies at various scales (e.g., local, river basin, county, state, tribal nation) discussions of approaches to the future. This would be followed by education and extension opportunities (at early stages - identification of most efficient and impactful
3. Research and outreach are needed.
4. Soil Science, Agronomy and Hydrology to address change in rainfall intensities, and resulting runoff.
5. I would include climate variability (i.e. year to year variability). How to deal with this, in particular working with and providing connectivity between other agencies, including USDA ARS, NOAA, NASA, NSF, DOE on the science of climate change and how it relates to NIFA areas of concern and those that study those areas (be they in research, education, extension, etc.).
6. Climate change will alter precipitation, drought, floods, etc. and the impact on various water dependent sectors such as the energy sector should be examined to assess the vulnerabilities and identify cost effective resilience solutions.
7. Focus on agriculture and food production.
8. As part of the Presidents Climate Change initiative all agencies need to consider how changing climate affects program delivery and conduct research and develop tools to help stakeholders address changing regimes in water availability, growing seasons and the like.
9. For agriculture: Adaptation: assessing vulnerability of crops to water availability and temperature on multi-year and decade scales.
10. Climate change and the uncertainty in the future regarding climate change is the largest unknown affecting water in all cases.
11. Addressing extreme events and how climate change is impacting water availability, especially in light of competition for resources for ecosystem services, municipal uses, and energy (bioenergy, hydroelectric, etc.).

3) Water quality and conservation practices

1. Often the linkages between the two are overlooked. A greater understanding and communication of the linkages will go a long way to modify behaviors to have a positive impact on water quality.

2. A conservation practice is the method that improved management is applied to the field. This topic is a key element of maintaining production agriculture and improving water quality. We need to know what to do where and how to do it if we wish to improve water quality and feed the world.
3. We must quantify the pollution reductions that systems of conservation practices provide so we can understand how we meet a variety of goals including both restoration and protection.
4. Producers need to learn best practices...and new practices need to be determined.
5. See above -- NIFA can serve a key role here in finding the most economical and effective water quality practices and then work with the producers to implement these practices in strategic ways.

4) Water data (includes water monitoring, water usage, tool development, etc.)

1. Need a national game plan for installing and maintaining a network of real time remote water sensors and 'big data' infrastructure to track flow, temperature, total nitrogen, total phosphorus and other pollutants at each the pour point along each of every state line.
2. Better, cheaper sensor and control systems are needed, as well as models and software that will enable their application.
3. There is strong shared need within the greater water management community to increase open access to water data, enhance how data are shared between the various data systems housed by Federal and non-Federal organizations, and improve decision-support through the development of tools that operate on open water data (which have attributes of being machine-readable, stored in modern formats, etc.). Development could focus on modernizing data sets, developing mechanisms for system-to-system data-sharing, and developing tools/visualizations to help the greater water management community better understand resource conditions.
4. Many types of water data remain very decentralized or difficult for researchers to use.
5. Simply put, you cannot manage what you cannot measure. We so not know the consumptive use of most crops in most locations. How can we manage this key element of the water cycle (and driver of agricultural productivity and profitability) if we cannot measure it?
6. Can't monitor, conduct research or mitigate without basic data.
7. Expand Reference Monitoring Networks for key variables to detect impacts attributable to climate change. Better modeling of water temperature under future climates.
8. It is ever more important to find new ways of managing data and collecting more monitoring data using sensors, satellites and other new technologies,

5) Water quality and nutrients

1. What is the relationship between this kind of pollution and water quality - we know about correlation, what about causation?
2. Development of BMPs that are economically viable in Midwest agriculture
3. Ag and nutrients--says it all.
4. Nutrient pollution is a significant threat to water quality and productivity in this country, and treatment is expensive. This is a key area for improved understanding, public awareness and technology improvement.
5. Continuing the theme of looking at how agriculture practices add nutrients into watersheds, and how we can economically and effectively use management practices to stem the flow of

nutrients and at same time increase productivity of working lands -- NIFA is uniquely situated to conduct this research.

6. Nutrient pollution has been a significant source of water quality impairment in the past 25 years, and that pollution has continued to increase over that time. We need more science to make better links between nutrient pollution and impacts on human health, for example, algal blooms that produce toxins, nitrate in drinking water and increases in THMs associated with OC.
7. Over-enrichment of waterbodies by nutrients is one of the nation's most pervasive water quality problems. What can be done to reduce agricultural contributions to this problem?

6) Water quality and drought

1. Drought is often accompanied with forest fires that change runoff patterns and the movement of contaminates. It is imperative to understand these changes and introduce practices that minimize these impacts.
2. What do state governors offices need to know about remaining water supply for each community and when do they need to know it e.g., number of days of supply left if there's no more precipitation?
3. Drought is a fundamental disruptive variable that helps and hurts depending on where you are concerned. Good for the Gulf bad upstream due to concentrations.
4. This is a key issue affecting the agricultural community as well as the country at large. As drought continues we are seeing impacts on Water quality, some of them from agriculture that become magnified when there is less water in streams. Research on water conservation in agriculture is relevant here.

7) Watershed management

1. The most effective way to understand many of the topics above is to address them at the watershed level.
2. What policies have failed (most) and what policies are needed to be effective?
3. USDA, and specifically NRCS, must move into the present and manage billions of dollars of Farm Bill subsidies, including conservation spending, from a watershed perspective. NRCS's sister agency can drive that change by delivering them information that they don't trust from any outside-of-USDA source.
4. All of the above areas are part of watershed management. It is important to look holistically at how individual actions affect overall watersheds in terms of water availability, water quality, soil health and the like.
5. How can USDA best collaborate with states and other partners and stakeholders to influence watershed scale adoption of conservation systems to maximize water quality improvements for the conservation investment?

8) Water reuse

1. In areas facing declining water quantity and quality water reuse is often becoming the last remaining choice for meeting the water needs of agriculture uses.
2. See 10) International food security

3. Use of grey water is likely to increase in areas where urban and agricultural water use are competing for scarce water resources. Research on the extent of such water reuse is needed, as is research on the drivers of the costs of such reuse.
4. Challenges and opportunities for water reuse and use of nontraditional water should be explored for the major water users including energy production and agriculture.
5. Having done work in water reuse since the 1970's - this may hold out hope for better managing our water resources and in particular where farms could use treated sewage and storm water for their benefit. This will require education, possibly policy changes - but should be a priority.
6. Populations increase and climate change (drought) has already put significant pressures on water supplies. We need to understand how to manage wastewater quantity and quality to address these pressures.
7. There are many questions needed to address the safety and other related issues (salinity) to address the ability to reuse water for agricultural purposes. Research, integrated, and extension (we need to address adoption)

9) Benchmarks, indicators, and models to study/monitor water quality and quantity

1. The use of market-mechanisms for the efficient allocation of policy resources requires better tools that can be used to estimate the delivery of ecosystem services from cropland, especially tools that can be applied at the field level.
2. What are the benchmarks we should use for dangerously low water supplies that would still provide enough time for action to be fully implemented if it never rained again?
3. This is a basic science issue. If NIFA does not fund the disciplinary and, more importantly, inter-disciplinary basic science on water models related to agriculture, who will? Agricultural scientists should have a say in these models, not just hydrologists.
4. Water quality and quantity issues often are presented from the perspective of the presenter. Quantifiable metrics, beyond WQ standards are needed.
5. In order to prioritize where we need to work on water quality and quantity and quality issues, and to judge our progress, we need good benchmarks and measures to see where we have been and where we are going. Models of course figure into this as well as we cannot physically monitor all the changes around the country. I view this as a critical need and appropriate area for NIFA to focus on.
6. We need more benchmarks for viruses, emerging contaminants and the impact of mixtures on human and aquatic ecosystem health.
7. Need practical tools/better models to ID loads from nutrient and sediment runoff and nutrient leaching and the likely effects of employing conservation systems.

10) Climate change and economics

1. A better understanding of the economics of climate change would help in the allocation of resources to those areas (regions, crops, etc.) that are the most important to address, from a social value standpoint.
2. We do not know what climate change will cost us (or currently costs us) nor do we understand the cost of inaction.
3. Infrastructure value at risk of inaction e.g., GDP, Federal Budget / Deficit.
4. Economic impacts to the nation of scenarios of climate change by decade over the 21st century. And benefits of avoiding climate change.

5. There needs to be better inclusion of socioeconomic modeling with climate, hydrological, and crop modeling to understand the human aspects of the.

11) Irrigation efficiency and management

1. Agricultural water use needs to be "smarter," that is, precise in time and space. We need to understand better irrigation technology adoption by producers.
2. Potential for significant water-use reduction
3. Most irrigation efficiency improvements end up using the 'extra' water for production on the farm proper. Or, the 'conserved water' goes to the next user for increased production. There is a public expectation that 'conserved water' should provide a public benefit such as habitat, or cleaner water. Is there a balance to be struck, or is it the nature of our water management laws?
4. Irrigation efficiency and management specifically need to be highly prioritized in western states where water availability is limited. Also, need to focus on shifting/moving to efficient irrigation method such as drip irrigation system especially during drought years.
5. important research area as we deal with climate change effects and also water quality issues

12) Tile drainage systems

1. Tile drainage is a major source of water pollution from cropland, and is resistant to common conservation practices. Many water quality problems, such as hypoxia in the Gulf of Mexico cannot be addressed until practices can be developed for mitigating pollution loss from tiles that farmers are willing to adopt.
2. A substantial increase in tile drained acreage over the past decade could have lasting impacts on water quality and cropland productivity, but those potential impacts are not widely studied.
3. Tile drains are the greatest water quality issue in agriculture. They represent the hub of the nutrient application and water quality policy issue. Improving the management of tile drains may represent the least cost manner that agriculture can avoid point source designation for nutrient pollution.
4. A major investment that likely is adversely affecting quantity and quality.
5. Subsurface drains are remarkably ubiquitous and contribute to or generate many of the water quality problem in the upper Midwest. No effective treatment, solution or regulation has shown any success at moderating this impact.
6. There is clearly a need to find practical, cost effective solutions that allow farming with tile drains to be economical while also protecting water quality. The negative effectives of tile drainage on water quality are all over the news throughout the Country, from Des Moines to Western Lake Erie. NIFA can help with research on end of drain systems that keep nutrients out of receiving streams as well as promote the acceptance of such practices with stakeholders.
7. We had Lake Erie cleaned up and then tile drainage came along, not regulated as a point source discharge, and it has set us back further than the gains we made. I have done three research cruises on Lake Erie - it was rebounding very well - now with the current regulatory atmosphere we may have lost our progress. I think the recalcitrance of farmers also I adversely affecting the Chesapeake - this will put USDA at odds with EPA - or already has - but farmers have to take responsibility for their share of 'clean up.' Tile drains may not be directly the problem in the Bay - but it appears that farmers and farming practice is?
8. The single largest contributor to degraded water quality across large areas of the landscape; how can impacts be reduced?

13) Water quantity: Impact on water quality

1. What's the rate of increase in pollutant concentrations based on flow conditions?
2. Quantity/quality issues are coming to the forefront as we experience effects of climate change. It becomes difficult to meet water quality standards for our rivers and streams as flow changes. Models need to factor in these changing flow regimes and how they impact our best practices.
3. Monitoring and controlling pollutants in light of the impacts of: Increasing air temperature and water temperature, reduced stream flow, timing of stream flow, less snow more rain effects on water temperature and flow, etc.

14) Water quality and livestock

1. How much buffer is needed under varying topographic landscape conditions to prevent pollution of waters of the US?
2. Identification and quantification of livestock practices to ensure protection of surface and ground water resources.
3. Livestock production remains a significant source of water pollution despite billions of dollars invested waste management. Research on barriers to improvements is greatly needed by all parties involved in this area.
4. Technologies must be affordable for implementation - onsite manure treatment tech is imperative to meeting water quality goals.
5. Livestock effluent is a major water issue...especially during major rainfall events. Steps need to be taken and better understood how to prevent runoff from livestock.
6. Issues of how livestock affect watersheds and how water quality and quantity affect livestock production are important as we address climate change and move to improve watershed quality.
7. This is a complex one, it relates to the next two questions, as well. As a nation, we use as much or more pharmaceuticals for livestock as we do people. This is to control infections (particularly in CAFOs) but also growth hormones. This may be one of the most important issues - the discharge of pharmaceutically contaminated waters to surface water - that we face in the 21st century. One adverse impact is microbial resistance to antibiotics - very, very scary!

15) Water quantity and efficiency (includes technology and structures)

1. Better technologies are needed to help us use water wisely.
2. Climate change and persistent drought conditions underscore our need to increase water management flexibility by enhancing our conservation tool box and our understanding of how conservation measures can create new water supplies for a range of water resource management objectives.

16) Stakeholder involvement/collaboration in water projects

1. Stakeholders should be active participants in decisions that involve their health. As scientist we often underestimate their contributions. The discussions with stakeholders should also include discussions on the amount of risk that is acceptable to them.
2. Can't expect success unless they are included from the beginning
3. NIFA is uniquely situated to bring science and stakeholders together to effect change and improve water quality. We at EPA are increasingly relying on USDA, and in particular NIFA

through the SERA program, to assist with how to reach out to the agriculture community to implement best practices to improve water quality, including social science research.

4. We need to integrate the public in the discussions BUT it is not essential to feel we have to satisfy everybody - there will be winners and losers - that is what we face with uncontrolled population growth.
5. Document and communicate how effective stakeholder involvement/collaboration can lead to successful water projects in terms of restoring water quality/meeting state water quality standards. How can such approaches be built into USDA SOPs?

17) Soil science and water

1. Soil health has been a key focus for USDA and is very important in watershed management and improving water quality
2. Soil science is under researched across the entire NIFA portfolio.

18) Groundwater recharge

1. This is especially important in coastal areas where there are significant drawdowns of the groundwater supplies.
2. Groundwater has been crucial to reducing the impacts of recent droughts, but long-term overdraft of major aquifers may mean that without substantial recharge efforts those aquifers won't provide a similar buffer in future droughts. Research is needed to identify the best available recharge options in different settings and to drive innovation and cost reduction in recharge technology.
3. Groundwater is emerging as a critical resource for drought relief and to offset the timing of water cycle associated with a changing climate. We so not know enough about the conditions where water recharge can be an effective adaptation strategy. We must find a way to capture flood flows into groundwater storage to build a buffer for late season agricultural use.
4. Most aquifers are being over drafted, and most are drafted well higher than any recharge rate. Even if we quit pumping tomorrow, refilling these 'safety-valve reservoirs'. Any long range solution probably involves a change in land use component.
5. Identify nation-wide geographic areas that are aquifer outcrop for recharge. These areas should be well advertised so their associated land use can be appropriately zoned to maximize ground water recharge.
6. Surface water-groundwater interaction. Projected impacts on recharge due to various scenarios of climate change, land use, and competing demand for supply.
7. Groundwater has long be thought to be the way out of water shortages. Again, with vast over pumping of this resource it is danger of being over use and underappreciated. Education!

19) Water quality and microbiological/organic material

1. What is the relationship between this kind of pollution and water quality - we know about correlation, what about causation?
2. Same as above ("Livestock effluent is a major water issue...especially during major rainfall events. Steps need to be taken and better understood how to prevent runoff from livestock")...and related.
3. Microbial contamination and organic material (I normally differentiate between what we call natural organic matter (NOM), or effluent organic matter, or any number of other identifiers of

largely uncharacterized organic matter, and that associated with other characterized compounds). Recent research has shown that NOM in sunlight may be an effective way of destroying many organic compounds and using constructed wetlands may be a way to sustainably deal with the minor compounds found in all of our natural waters.

20) Water protection and conservation behavior

1. Per other answers NIFA can help with both developing best management practices for water protection and help incorporate such conservation practices into use.
2. Need to document and communicate economic and other benefits of the adoption of conservation systems?
3. Through research (especially social science), integrated, and extension activities.

21) Policy analysis: Water quality and quantity

1. What policies need to be added or amended at the federal and state levels to enable executive agencies, local governments and their subdivisions (e.g., land use planning departments, public health departments, departments of environmental quality, departments of water supply management) to fully address climate change effects?
2. The current water intuitions and policy are limiting the agricultural sector's ability to respond to extreme conditions. Policy makers must be aware of this cost because when the cost is too high institutions and policy will change. Knowledge of the cost of current policies, requires research in the current and alternative policies.
3. Federal policy is disjointed, but unlikely to change.

22) Water quality and agrochemicals

1. Given the evolving attributes of agrochemicals used to support crop production and control weeds/pests, it seems important to stay well-informed on the fate, transport and effects of these agrochemicals in natural and managed water resource environments.
2. Again a litigious issue and potentially harmful long term damaging issue

23) Water quality and sedimentation

1. Sedimentation is a key issue as climate changes and lands become developed and more impervious. We need to better understand sediment delivery from streams themselves.
2. Sedimentation effects on water quality and how to keep soils in place is related to much of the above

24) Water management tools

1. Decision support tools and combined research, integrated, and extension programming

25) Water quantity and crop production

1. Decreasing water availability impacts our ability to provide water for irrigated agriculture as well as enough water for dryland agriculture.

26) Water quality and salinity

1. The issue of salinity is grossly understated in the current research system. Once land is affected by salinity it is difficult to recover and make productive again. This is an issue that can remove

large areas from production and collapse rural economies. The interplay between climate change, drought and salinity needs to be explored. Where is the threshold at which land is not recoverable and how do we keep irrigated land in the West from crossing that threshold?

2. Salinity from water reuse and soil accumulation is an increasing problem that needs to be addressed.

27) Education strategies/programs for water resource educators

1. Hugely important. Few people understand the value of our water - because we do not charge or guard our resources. An ad during the Super Bowl regarding how much water is lost by someone brushing their teeth - compared to how much water people use daily in lesser developed countries was a good first step.
2. Education of the public to the importance of water is essential if we are going to make any substantive headway in better managing our water resources. Once, it might have been considered a 'right' with the increasing population; however, we as a planet can no longer accept that ideal. We have to continue vigorous education of the public that water is essential and we have to pay for it as such.

28) End-user use of water research and tools

1. These need to be coordinated - this is the newest vogue - but there are so many - it is difficult to determine which ones to use - for the novice user.

29) Water vulnerability assessments

1. develop a model that lets users assess flow scenarios based on natural surface water flows and ground water infiltration
2. More effort is needed to quantify and prioritize water vulnerabilities at the national, regional and local level taking into account population growth, increased demand for agriculture and energy production, and climate change.
3. key step to communities, states, tribes and private interests in development meaningful mitigation

30) Drinking water and health (includes communities impacted by natural disaster)

1. Drinking water includes water provided by public and private systems. Private systems, i.e. individual well systems are often overlooked because of lack of regulatory oversight.
2. Source water protection guidelines for small drinking water communities and rural wells. Research on reducing impact of manure application on groundwater.
3. Flint.

31) Water quantity and allocation of water resources between different uses/users

1. What are the metrics for the most efficient technologies for different categories of users and water use and how can they be best applied through public policy requirements?

32) Water and land use

1. Climate change, watershed dynamics and land use interactions. Effects on watershed function, ecosystem services, and the economy.

33) Water quality and pharmaceuticals

1. The effectiveness of waste and water treatment system to remove pharmaceuticals is poorly understood. In addition the impact of the pharmaceutical metabolites in our body are just being studied.
2. As I stated above this is likely to be one of the top issues adversely affecting our natural water bodies as the population continues to grow and the demand increases.

34) Food safety

1. Development of screening or sampling procedures to i.d. potentially contaminated fruits and vegetables.
2. The importance of this topic keeps it as a high priority, even though it is already widely studies.
3. Water reuse and food safety

35) Water quality and fracking

1. Can we really protect fresh water aquifers? If so, how?
2. Understanding the opportunities to reduce the water footprint of fracking, and to ensure water reuse needs to be explored.

36) Waste water management (including storm water)

1. Storm water runoff represents a significant alternative water source to offset the lack of snowpack runoff for irrigated production. We must learn how to clean, capture and store this resource.
2. We are using 19th century technology for wastewater treatment in the US and there have been no real breakthroughs. Systems are manages to control bacteria but not viruses. Biosolids and struvite are seen as byproducts that are recycled onto fields to capture nutrients, but the impact isn't seriously analyzed (see example of PFC contamination of groundwater in Decatur GA).

37) International food security

1. Development of "home grown" food industry, incorporating animal production, aquaculture and fresh vegetable production to ensure high quality products that are locally grown.
2. Outside of the U.S., food security is very closely linked to water availability and water supply reliability.
3. National security issues associated with climate change and disruption of food supply over the 21st century, 2030, 2050, 2070, 2090.
4. Water issues greatly impact our ability to produce food and extreme event can greatly impact transportation.

38) Water lifecycle analysis, water footprint

1. Energy--ag-water interactions on both carbon and water footprint.

39) Water and invasives

1. Aquatic ecosystems - how changing water temperature and precip change the habitat; one species' resilience (e.g., migration) is another species' invasive (e.g., new predators inhabiting an ecosystem)

40) Private wells and /or septic systems

1. Private systems, i.e. individual well systems are often overlooked because of lack of regulatory oversight.

Additional Water-Related Issues NIFA Should Consider Funding

Respondents were asked to provide additional suggestions for water priority areas that were not covered in the survey by responding to the statement: **"Please indicate any other water-related issues that, in your opinion, NIFA should consider as funding priorities in the future"**. Nine respondents recommended the following water-funding priority areas. Text is taken verbatim from survey responses.

1. Training of new irrigation engineers will be important, if new water management tools and technologies are to be successfully applied.
2. Relocation of centers of agriculture from more arid regions to less arid...can we raise corn and soybeans in the SE instead of the Midwest...how do we adjust production to changing temperature and rainfall patterns.
3. Large scale basin improvement and modeling opportunities to drive change.
4. There was nothing about using satellite remote sensing information. That and other emerging areas of new tech should be looked at carefully to see if the risks of advanced implementation can outweigh the potential costs of not having additional information and/or tools.
5. 1) Irrigation efficiency; 2) Groundwater recharge; and 3) Climate change mitigation and adaptation strategy.
6. Coastal retreat - pathways for wetlands to migrate; encouraging development away from coasts; relocating infrastructure.
7. I think I have above…
8. Climate change and seawater intrusion.
9. Interconnection between food, energy, ecosystems, humans, and water systems.

Additional comments

Respondents were asked to provide general comments about NIFA and the survey by responding to the statement: **"Please use the space below for any additional comments about this survey or NIFA projects and funding."** Two respondents provided the comments listed below. Text is taken verbatim from survey responses.

1. USDA is advocate for agricultural industry. It will be difficult to fund projects out of NIFA that are not supportive of agriculture. It is good to see NIFA engaged with INFEWS. Similar partnerships are needed.
2. In order to make the information usable and have a strong impact, the decision makers must be included. Organizational feedback needs to merge with the science development. Thus including stakeholders and decision makers provides a relevant perspective and builds a strong framework for the research development.