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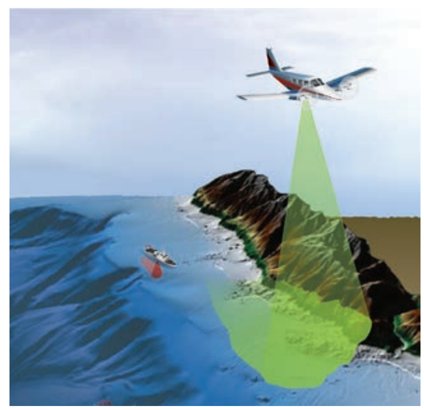

National Hydrography Requirements and Benefits Study

Preliminary Results

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Acronyms and Abbreviations

ARS	Agricultural Research Service
APHIS	Animal and Plant Health Inspection Service
ASFPM	Association of State Floodplain Managers
BLM	Bureau of Land Management
BMP	Best Management Practice
BOEM	Bureau of Ocean Energy Management
BU	Business Use
CLU	Common Land Unit
CONUS	Conterminous U.S.
DEM	Digital Elevation Model
DNR	Department of Natural Resources
DOE	Department of Energy
DOT	Department of Transportation
DU	Ducks Unlimited, Inc.
EPA	Environmental Protection Agency
ER	Entity Relationship
Esri	Environmental Systems Research Institute
FAQ	Frequently Asked Question
FSA	Farm Service Agency
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FTP	File Transfer Protocol
FIRM	Flood Insurance Rate Map
GeoJSON	Geospatial JavaScript Object Notation
GeoTIFF	Geospatial Tagged Image File Format
GIS	Geographic Information System
GNIS	Geographic Names Information System
H&H	Hydrology and Hydraulic
HRBS	National Hydrography Requirements and Benefits Study
HU	Hydrologic Unit
HUC	Hydrologic Unit Code
IJC	International Joint Commission
MCA	Mission Critical Activity
MOU	Memorandum of Understanding
NAWQA	National Water Quality Assessment
NED	National Elevation Dataset
NetCDF	Network Common Data Form
NASS	National Agricultural Statistics Service
NFIP	National Flood Insurance Program
NGP	National Geospatial Program

NHD	National Hydrography Dataset
NID	National Inventory of Dams
NITF	National Imagery Transmission Format
NLCD	National Land Cover Dataset
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Point Discharge Elimination System
NPS	National Park Service
NRC	Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
NWIS	National Water Information System
OGC	Open Geospatial Consortium
OMB	Office of Management and Budget
OSMRE	Office of Surface Mining Reclamation and Enforcement
POC	Point of Contact
SLR	Sea Level Rise
STORET	Storage and Retrieval
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TU	Trout Unlimited
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
WAPA	Western Area Power Administration
WaterML	Water Markup Language
WBD	Watershed Boundary Dataset

Executive Summary

U.S. Geological Survey (USGS) is considering an enhanced program to significantly improve the utility of hydrographic data for the U.S. and its territories. In order to determine the cost effectiveness of various enhanced program options, USGS is seeking to assess the requirements of users of hydrography data and the benefits to those users of improved hydrography data. The goal of this assessment, the National Hydrography Requirements and Benefits Study (HRBS), is to establish a set of national Business Uses (BUs) and requirements associated with hydrographic data. This information will then be used to evaluate the benefits of successfully supporting those requirements within the context of a national program.

This study is sponsored by USGS and the U.S. Department of Agriculture's (USDA's) Natural Resources Conservation Service (NRCS). It was conducted by Dewberry

In order to establish the set of national Business Uses and requirements associated with hydrographic data, user requirements and benefits were collected through an online questionnaire (Office of Management and Budget [OMB] Control Number 1028-0112). Mission Critical Activities (MCAs) and their associated requirements and benefits were identified by select Federal agencies, states, and other organizations. The MCA results were grouped into high-level Business Uses for each selected Federal agency and for each of the 50 states and other selected organizations. A list of the 25 Business Uses can be found in Appendix A. A geodatabase was developed to capture, store, and analyze the original questionnaire data. After a quality-control process including interviews with the states and responding agencies, a second geodatabase was developed to store summaries, refined versions, and aggregated content of the original data.

This report documents the preliminary findings of the HRBS. Further analysis of the data presented herein by USGS is anticipated, with the final outcome to be recommendations on enhanced program options and implementation recommendations.

Study Participation

Detailed responses to this study, in the form of 420 MCAs, were provided by 21 Federal agencies, all 50 states plus American Samoa and Washington D.C., 53 local and regional government organizations, eight Tribal governments, 14 private companies, four associations, and 20 other Not for Profit entities.

Table 1 below shows a breakdown of the study participation by organization type. Further breakdown of the Federal, state, Tribal, and association participation can be found in Section 4.1. Full details of all participating entities can be found in the summary reports for the Federal agencies, states, and associations found in Appendixes B, C, and D.

Table 1. Breakdown of study participation by organization type

Organization Type	Number of Agencies/ Entities	Number of MCAs	Percent of MCAs per Organization Type
Federal Agencies and Commissions	21	54	13%
Not for Profit	24	25	6%
Private or Commercial	14	16	4%

Organization Type	Number of Agencies/ Entities	Number of MCAs	Percent of MCAs per Organization Type
Regional, County, City or Other Local Government	53	80	19%
State Government	183	237	56%
Tribal Government	8	8	2%
Total	303	420	100%

Current Use of National Datasets

For each of the 420 reported MCAs, study participants were asked to indicate what national hydrography datasets are currently being used to address the water information needs of the MCA. Specifically, users were asked about their use of the National Hydrography Dataset (NHD), Watershed Boundary Dataset (WBD), and NHDPlus.

Figure 1 below provides a summary of the current use of the NHD, WBD, and NHDPlus datasets. Study respondents reported using NHD, WBD, and/or NHDPlus data for 88 percent of MCAs; another dataset in addition to the NHD, WBD, and/or NHDPlus data for 34 percent of the MCAs; and another dataset instead of the NHD, WBD, and/or NHDPlus data for 8 percent of the MCAs. Study respondents reported using no hydrography data for only 4 percent of the MCAs.

When another water-related dataset is used, 60 percent of the time it is state or locally developed and/or maintained hydrography data. These locally maintained data are either of higher resolution than the national datasets, having been collected or improved to fit recently collected lidar, orthoimagery, or parcel data, and/or have locally improved or added attributes that were customized to serve the MCA's business needs.

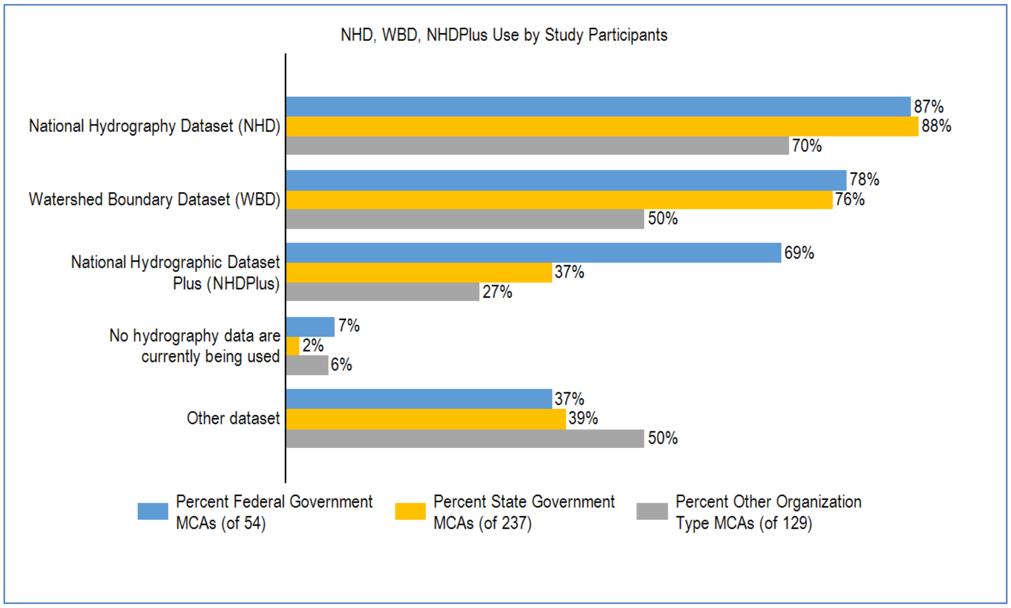

Figure 1. Summary of current use of the NHD, WBD, and NHDPlus datasets

Mission Critical Activities

For each of the 420 MCAs, study participants were asked to describe the MCA in their own words. Study respondents were also asked to identify the geographic area requirements for each MCA. Maps depicting the area of interest for each MCA are included in Appendixes B, C, and D. Figure 2 shows the distribution of the spatial extents of all 420 MCAs aggregated by HUC8 areas.

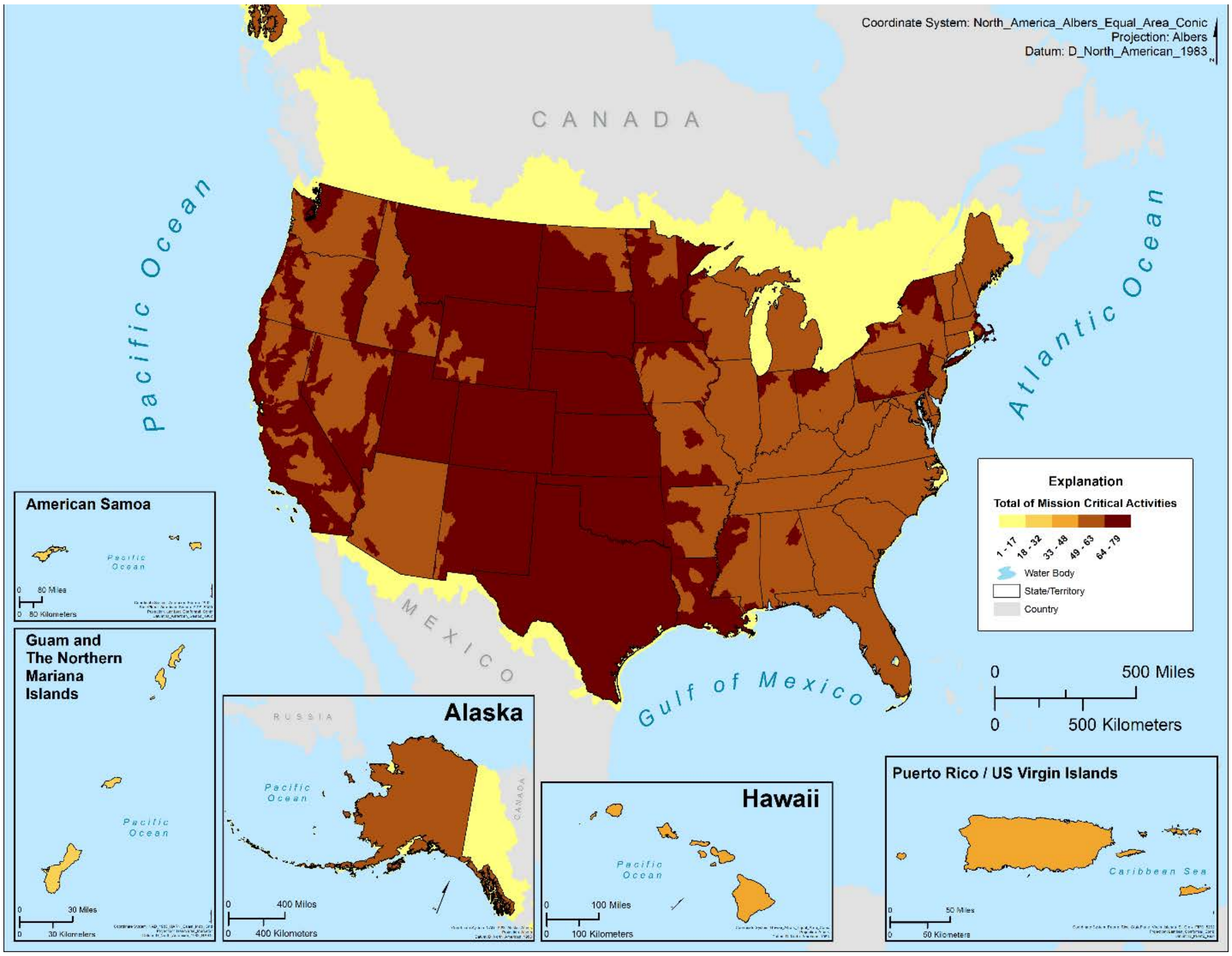

Figure 2. Distribution of spatial extents for all 420 MCAs aggregated by HUC8 areas

Business Uses

Study participants were requested to assign one (or more) of 25 pre-defined Business Uses to each MCA, in addition to providing an MCA title and description. The Business Uses are described in Section 4.3 and in detail in Appendix E. Because study participants were asked to describe their MCA in their own words and to assign a Business Use to each, there was a fairly wide variety among how the Business Uses were assigned to the MCAs. Some Business Uses seemed to be interpreted broadly and multiple types of activities were associated with them. Others seemed to be more narrowly interpreted. BU #4 Water Quality and BU #15 Flood Risk Management were among the more consistently applied Business Uses. BU #1 River and Stream Flow Management, BU #2 Natural Resources Conservation, BU #3 Water Resource Planning and Management, and BU #5 River and Stream Ecosystem Management had the widest variety of MCA descriptions ascribed to them.

Table 2 below shows the 25 Business Uses ranked by the total number of MCAs per Business Use. The top six Business Uses by overall number of MCAs, Water Quality, Water Resource Planning and Management, Flood Risk Management, River and Stream Flow Management, Natural Resources Conservation, and River and Stream Ecosystem Management account for approximately 75 percent of the MCAs.

Table 2. Business Uses ranked by total number of MCAs per Business Use

BU	No. of MCAs	Business Use	BU	No. of MCAs	Business Use
4	79	Water Quality	7	5	Forest Resources Management
3	69	Water Resource Planning and Management	22	4	Health and Human Services
15	54	Flood Risk Management	11	3	Geologic Resource Assessment and Hazard Mitigation
1	44	River and Stream Flow Management	13	3	Renewable Energy Resources
2	34	Natural Resources Conservation	14	3	Oil and Gas Resources
5	34	River and Stream Ecosystem Management	19	3	Marine and Riverine Navigation Safety
20	18	Infrastructure and Construction Management	25	3	Recreation
21	17	Urban and Regional Planning	12	2	Resource Mining
10	9	Agriculture and Precision Farming	16	2	Sea Level Rise and Subsidence
24	9	Education K-12 and Beyond	8	1	Rangeland Management
6	8	Coastal Zone Management	17	1	Wildfire Management, Planning, and Response
9	8	Wildlife and Habitat Management	23	0	Real Estate, Banking, Mortgage, and Insurance
18	7	Homeland Security, Law Enforcement, and Disaster Response		420	Total

Requirements

For each of the 420 MCAs, study participants were asked to provide detailed information about the data required to accomplish the mission. Users were asked to provide information regarding the required positional accuracy, stream density, smallest contributing watershed, smallest mapped waterbody, update frequency, post-event updates, and level of detail for each MCA. Users were also asked what characteristics or features and analytical functions are required and about the level of integration required between hydrography data and other datasets for the hydrography data to satisfy MCA requirements.

Additionally, non-MCA specific requirements were collected for hydrography data access methods including required data types or formats, geographic extents, data or service access methods, required elevation-hydrography data integration, required raster elevation-hydrography data integration, and the impact of hydrography data errors.

Section 4.5 provides details about the MCA specific and non-MCA specific requirements by organization type (Federal agencies, State government, and other entities). Section 5.5 provides information about the spatial distribution of selected MCA requirements.

Figure 3 below shows the distribution of the positional accuracy responses. The most frequently requested positional accuracy by Federal agencies was +/- 40 feet while the overall most frequently requested positional accuracy was +/- 3 feet. However, providing data with positional accuracy of +/- 40 feet would only meet 35 percent of Federal agency positional accuracy requirements and 23 percent of overall positional accuracy requirements. Providing data with positional accuracy of +/- 7 feet would meet 76 percent of Federal agency requirements, 73 percent of state government requirements, and 65 percent of the overall reported user requirements, but only 44 percent of other organization type requirements.

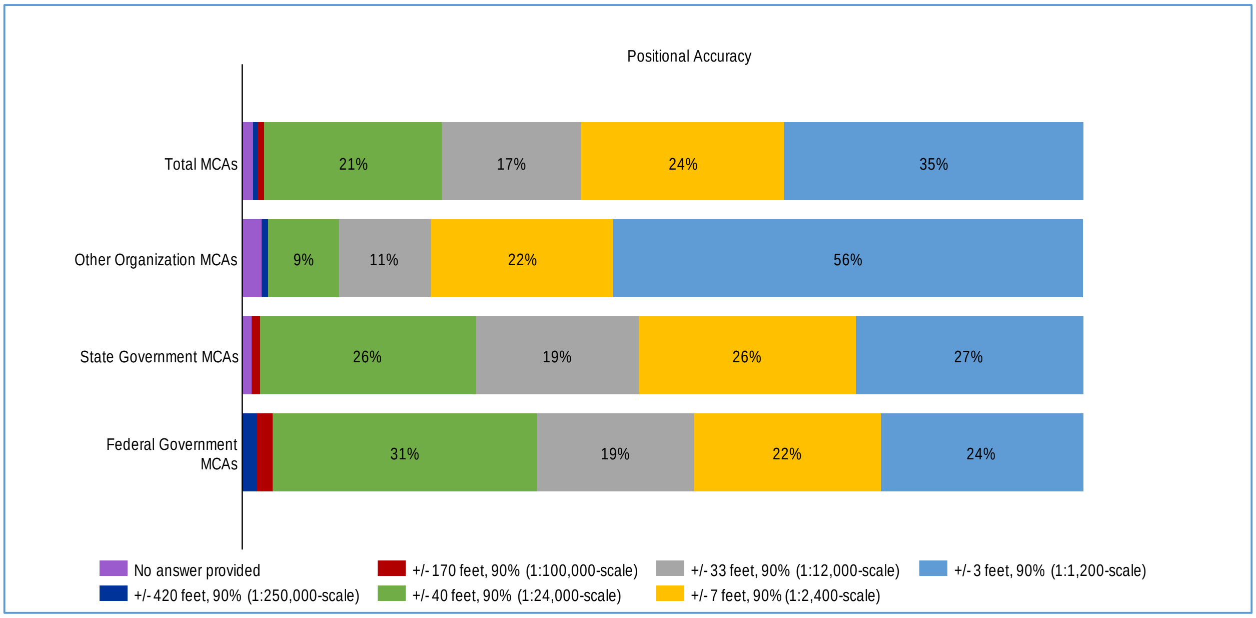

Figure 3. Distribution of positional accuracy responses

Figure 4 below shows the distribution of the stream density responses. The most frequently requested stream density by Federal agencies was 2.5 miles of channel per square mile while the overall most frequently requested stream density was 5.0 miles of channel per square mile. Providing data with stream density of 2.5 miles of channel per square mile would meet 69 percent of Federal agency requirements, 61 percent of state government requirements, and 61 percent of the overall reported user requirements.

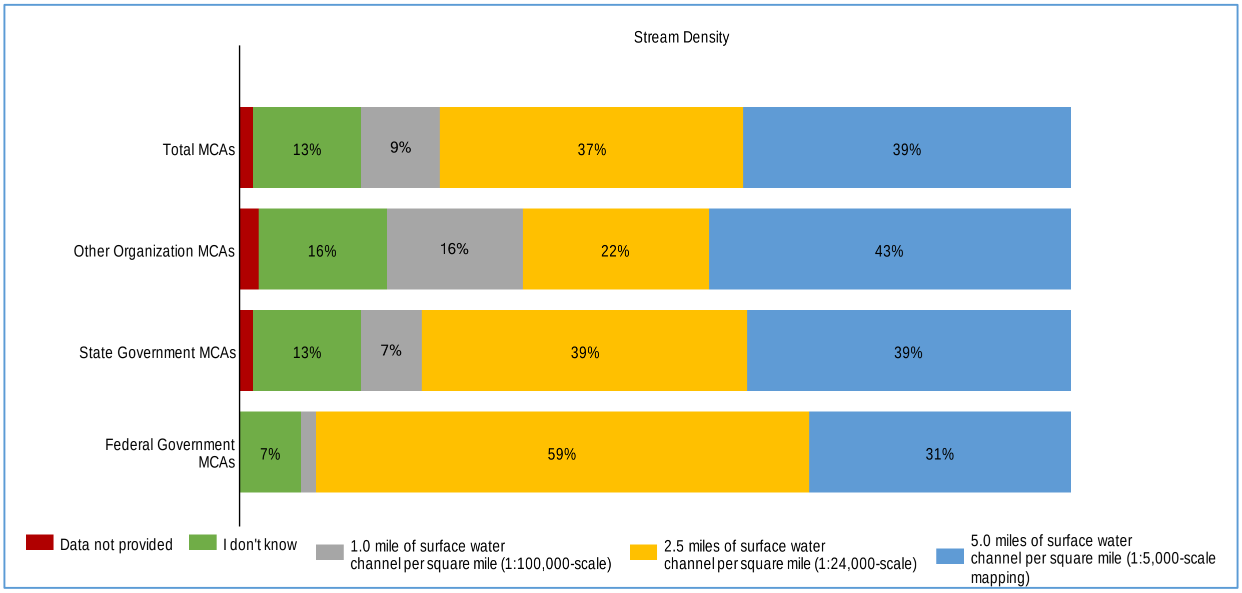

Figure 4. Distribution of stream density responses

Figure 5 on the following page shows the distribution of the smallest contributing watershed responses. The most frequently requested smallest contributing watershed by Federal agencies was 60 acres while the overall most frequently requested smallest contributing watershed was 6 acres. Providing data with a smallest contributing watershed of 60 acres would meet 80 percent of Federal agency requirements, 71 percent of state government requirements, and 71 percent of overall user requirements. Providing data with smallest contributing watershed of 6 acres would meet 99.5 percent of the reported user requirements.

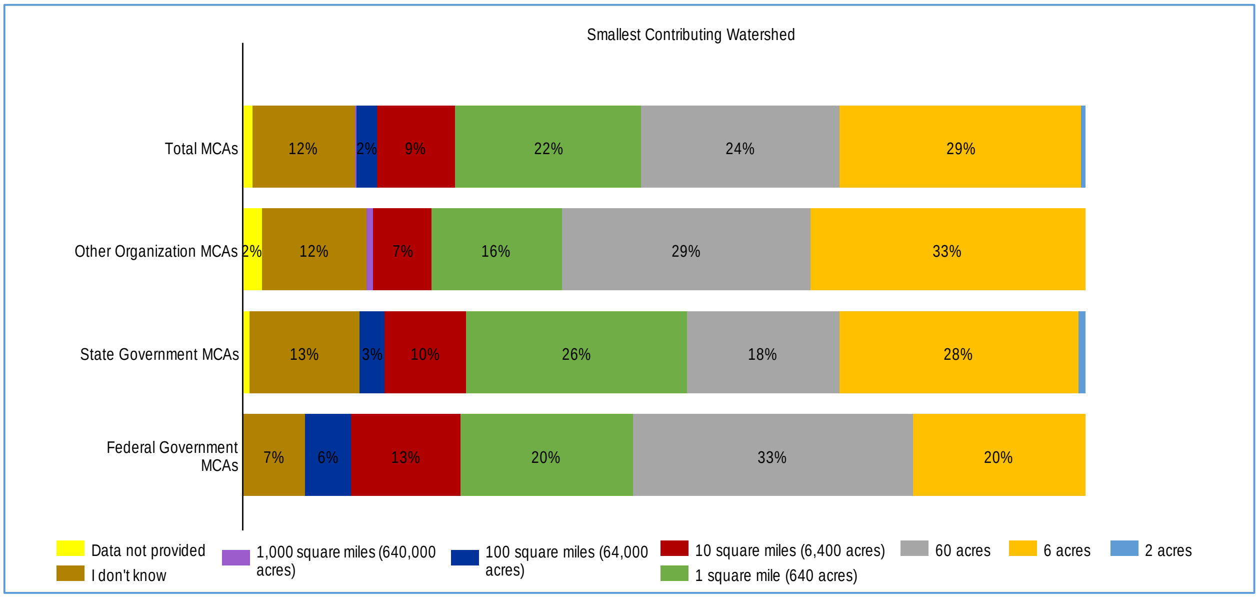

Figure 5. Distribution of smallest contributing watershed responses

Figure 6 below shows the distribution of the smallest mapped waterbody responses. The most frequently requested smallest mapped waterbody by Federal agencies was tied at less than an acre and one acre while the overall most frequently requested smallest mapped waterbody was less than an acre. Providing data with a smallest mapped waterbody of one acre would meet 74 percent of Federal agency requirements, 68 percent of state government requirements, and 66 percent of the overall reported user requirements.

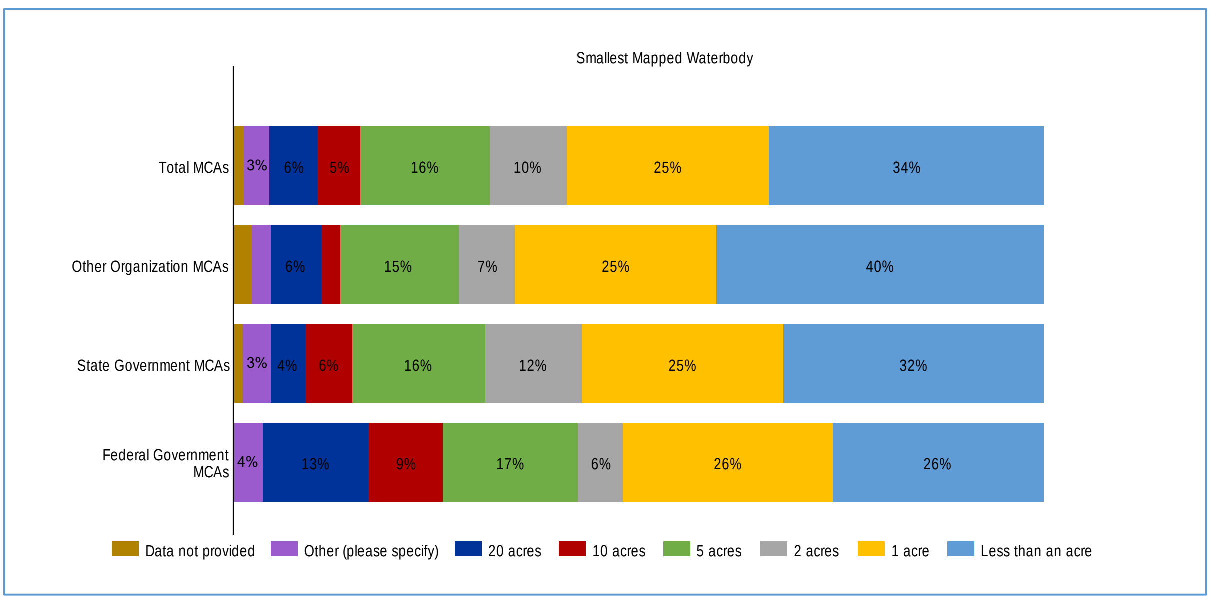

Figure 6. Distribution of the smallest mapped waterbody responses

Figure 7 below shows the distribution of the update frequency responses. The most requested update frequency was annually. However, providing updates every 2-3 years would meet 65 percent of Federal agency requirements, 65 percent of state government requirements, and 68 percent of the reported overall user requirements.

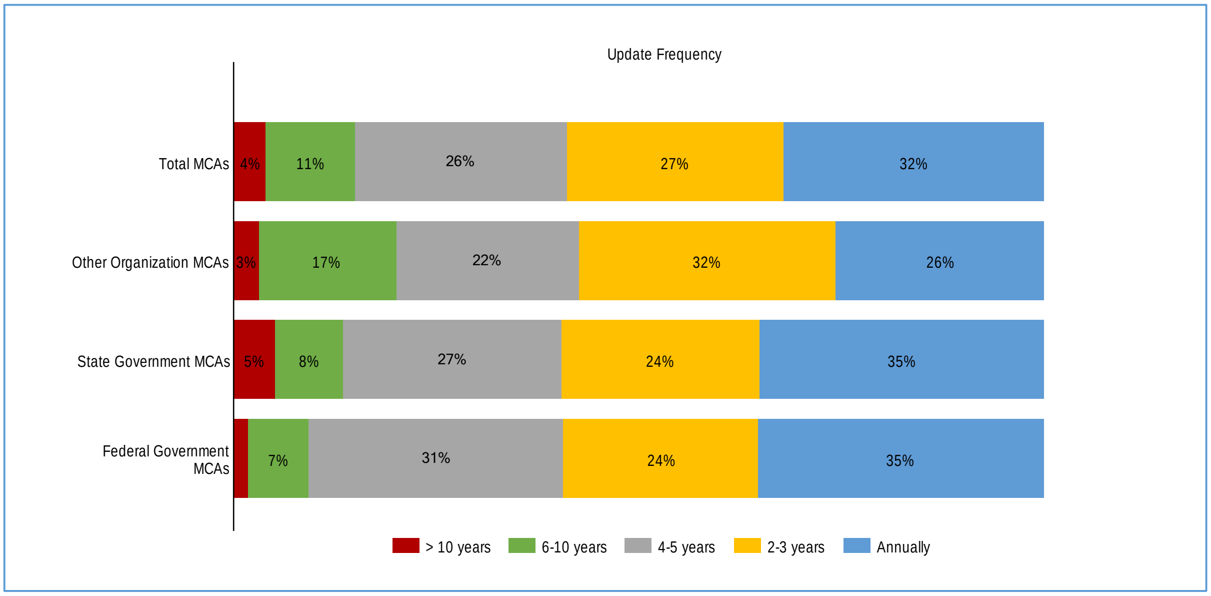

Figure 7. Distribution of the update frequency responses

Figure 8 below shows the distribution of the post-event update responses. The most frequently reported response by Federal agencies was "highly desirable," while the most frequently requested state government response and the overall most frequently requested response was that post-event updates would be "nice to have."

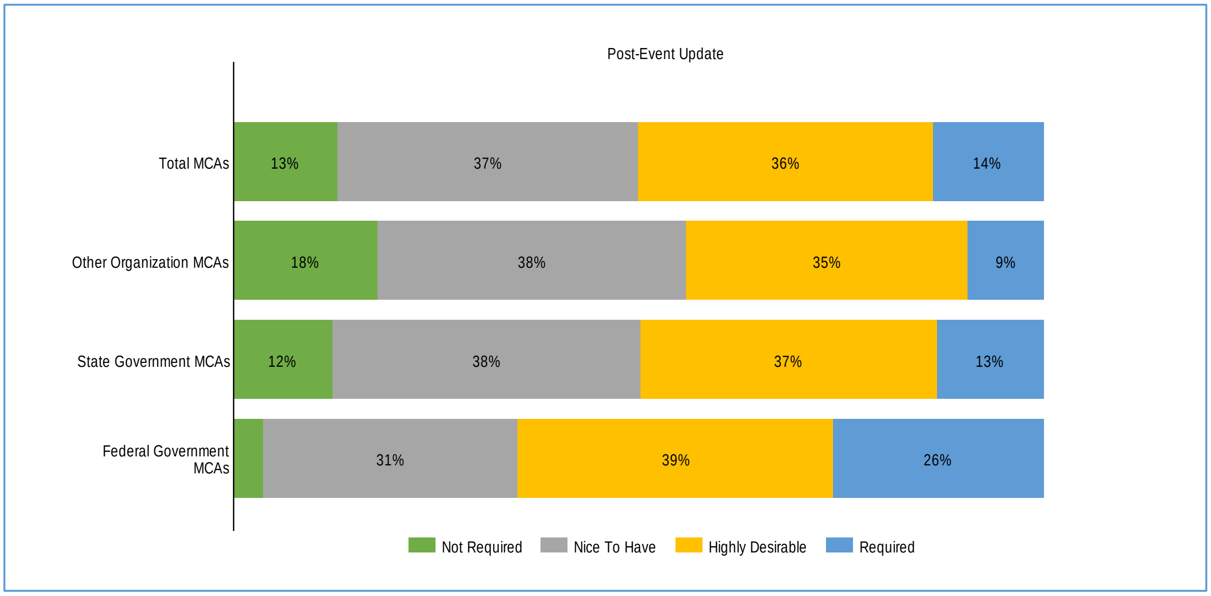

Figure 8. Distribution of the post-event update responses

Figure 9 below shows the distribution of the level of detail responses. A total of 70 percent of Federal agencies and 67 percent of overall study participants reported a requirement for best available data. These results appear to refute a commonly held belief that Federal agencies need consistent data as opposed to best available. Study respondents did note that disparities in level of detail cause modeling problems and also noted a desire for tools that would allow best available data to be selected or generalized such that a consistent level of detail could be achieved for modeling purposes from best available data.

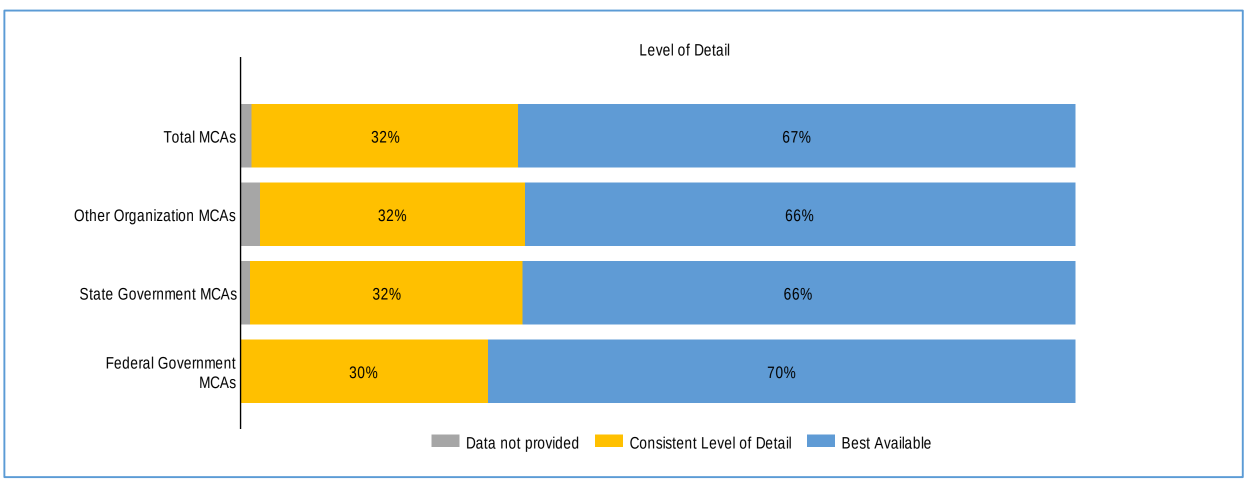

Figure 9. Distribution of the level of detail responses

Table 3 below shows the distribution of the top five (of 35 included in the study) required characteristics and analytical functions ranked by the number of MCAs for which Federal agencies reported the requirement. Wetlands data are the most frequently required characteristic by Federal agencies. Calculate drainage area is the most frequently required analytical function by States and overall (it is ranked second for Federal agencies).

Table 3. Top five required characteristics and analytical functions ranked by number of MCAs

Required Characteristics/Analytical Functions	Number of Federal Gov't. MCAs (of 54)	Percent of Federal Gov't. MCAs	Number of State Gov't. MCAs (of 237)	Percent of State Gov't. MCAs	Number of Other Organization Type MCAs (of 129)	Percent of Other Organization Type MCAs	Total Number of MCAs (of 420)	Percent of Total MCAs
Wetlands	47	87%	145	61%	77	60%	269	64%
Calculate drainage area	44	81%	183	77%	102	79%	329	78%
Flow periodicity	43	80%	149	63%	75	58%	267	64%
Linkages to stream gage observations	43	80%	156	66%	83	64%	282	67%
Delineate catchment	42	78%	146	62%	85	66%	273	65%

Table 4 on the following page shows the top five (of 20 included in the study) datasets ranked by the number of MCAs for which Federal agencies indicated that integration with that data type was "Required." The options provided for answering this question in the online questionnaire were "Required," "Highly Desirable," "Nice to Have," and "Not Required." Integration of hydrography data with elevation data was the most frequently required, followed by stream flow, wetlands, soils, and land cover data. The top five were the same for all study participants, although in differing order. Additionally, when the dataset was "Required," it was most frequently needed to "Perform Geospatial Analysis."

Table 4. Top five datasets ranked by number of MCAs

Data Type	Number of Federal Gov't. MCAs for which Data Integration is Required (of 54)	Percent of Federal Gov't. MCAs for which Data Integration is Required	Number of State Gov't. MCAs for which Data Integration is Required (of 237)	Percent of State Gov't. MCAs for which Data Integration is Required	Number of Other Organization Type MCAs for which Data Integration is Required(of 129)	Percent of Other Organization Type MCAs for which Data Integration is Required	Total Number of MCAs for which Data Integration is Required (of 420)	Percent of Total MCAs for which Data Integration is Required
Elevation	40	74%	149	63%	85	66%	274	65%
Stream Flow	37	69%	130	55%	64	50%	231	55%
Wetlands	35	65%	103	43%	31	24%	169	40%
Soils	33	61%	75	32%	48	37%	156	37%
Land Cover	30	56%	109	46%	58	45%	197	47%

In addition to the MCA-specific requirements discussed above, study respondents were asked to provide information about their program-wide (all identified MCAs) hydrography data requirements. These questions were not intended to apply to specific MCAs but to broader agency or general program hydrography data needs.

The following is a summary of the non-MCA specific requirements most frequently reported by study respondents.

- Data types or formats: For vector format data, Environmental Systems Research Institute (Esri) Shapefiles and file geodatabases are the most frequently required. For raster format data, Geospatial Tagged Image File Format (GeoTIFF), and Esri Grid format data are the most frequently required. However, all options receive considerable use.
- Geographic extent: Data tiled by HUC12 and HUC8 are the most frequently required. However, all options appear to be widely used.
- Data or service access methods: 95 percent of users require the ability to download data. Online services appear popular as well.
- Elevation-hydrography data integration: The most frequently reported requirement is for hydrography data to align with elevation data at 1:12,000-scale or larger.
- Raster elevation-hydrography data integration: The most frequently reported requirement is to determine new flow paths across the land surface into existing channels.
- Hydrography data errors with the greatest impact: The error with the greatest impact reported by study respondents is tributaries that are not connected to the main river, followed by stream flow reversal.
- Elevation-derived catchments need to be within 5 percent of the actual area.
- Error resolution needs to be within 2-30 days.
- 82 percent of study respondents would definitely or probably use a web-based tool to report errors.

Benefits

Study respondents were asked to provide information for each reported MCA about their estimated annual program budgets that are supported by hydrography data. They were also asked to estimate what their current annual benefits are, and what future annual benefits they are likely to receive from enhanced hydrography data. The future benefits would be those likely to be received if all of their reported requirements were met. Sections 4.6 and 5.6 provide additional details about the reported benefits.

For the 420 MCAs, study respondents reported a total estimated annual program budget of $18.5 to $22.5 billion for programs supported by hydrography data. It is clear that stakeholders are already receiving significant benefits from the currently available hydrography data; For the 420 MCAs, study respondents reported $538.5 to $544 million in estimated annual benefits from the currently available hydrography data. And if all of the reported hydrography data requirements could be met by enhanced datasets, the estimated future annual benefits from these enhanced hydrography data would be an additional $602.5 to $605 million over and above the current estimated annual benefits.

Study respondents were unable to provide estimated current annual dollar benefits for 192 (46 percent) of the MCAs. And study respondents were unable to provide estimated future annual dollar benefits for 145 (35 percent) of the MCAs. This means that the estimated annual dollar benefits, both current and future, are likely to be underestimated. However, as a high level State manager who was not able to quantify future benefits noted, the benefits to having high quality data to support environmental decisions that will affect generations is "immeasurable. It is worth millions of dollars."

Table 5 below provides a summary by organization type of the estimated annual program budgets supported by hydrography data, estimated annual dollar benefits provided by the currently available hydrography data, and estimated future annual benefits from enhanced hydrography data.

Table 5. Summary by organization type of the estimated annual program budgets

Organization Type	Total Number of MCAs	Estimated Annual Program Budget (in millions)	Estimated Current Annual Benefits (in millions)	Estimated Future Annual Benefits (in millions)
Federal Agencies and Commissions	54	$11,584.65	$212.35	$308.48
Not for Profit	25	$73.68	$3.02	$27.23
Private or Commercial	16	$7.47	$1.28	$2.13
Regional, County, City or Other Local Government	80	$282.70	$137.03	$19.74
State Government	237	$6,523.41	$184.62	$244.73
Tribal Government	8	$1.11	$0.21	$0.24
Total	420	$18,473.01	$538.50	$602.55

Table 6 on the following page shows the Business Uses ranked by those with the greatest estimated average annual future dollar benefits from enhanced hydrography data. This table also includes estimated annual program budgets supported by hydrography data and estimated annual dollar benefits provided by the currently available hydrography data. The overall average estimated future benefit per MCA is $1.4 million.

As a way to account for benefits that could not be quantified in terms of dollars, users were asked about potential qualitative future benefits. Table 6 also includes a weighted value for the future qualitative benefits for education or public safety, environmental or ecosystems, and human lives saved. Each was quantified as Major, Moderate, or Minor. The weighting was done as follows: Major = 5, Moderate = 3, Minor = 1, Don’t Know, Not Applicable, No response = 0. Note that no dollar values were estimated for these categories of qualitative benefits.

Table 6. Business Uses ranked by estimated average annual future dollar benefits

BU Number	Business Use	Total Number of MCAs	Estimated Annual Program Budget (in millions)	Estimated Current Annual Benefits (in millions)	Estimated Future Annual Benefits (in millions)	Average Estimated Future Annual Benefits /MCA (in millions)	Education or Public Safety Benefits Weighted Value	Environmental Benefits Weighted Value	Human Lives Saved Weighted Value
BU 1	River and Stream Flow Management	44	$763.58	$220.07	$154.73	$3.52	97	107	39
BU 5	River and Stream Ecosystem Management	34	$1,000.72	$13.96	$67.00	$1.97	78	119	17
BU 3	Water Resource Planning and Management	69	$988.88	$98.11	$115.88	$1.68	155	168	70
BU 4	Water Quality	79	$1,672.41	$115.46	$121.48	$1.54	189	254	68
BU 15	Flood Risk Management	54	$636.11	$56.12	$75.86	$1.40	168	124	133
BU 9	Wildlife and Habitat Management	8	$1,041.45	$0.18	$10.08	$1.26	26	27	5
BU 7	Forest Resources Management	5	$254.39	$1.76	$6.01	$1.20	19	19	7
BU 18	Homeland Security, Law Enforcement, & Disaster Response	7	$1.75	$0.10	$5.50	$0.79	18	13	12
BU 6	Coastal Zone Management	8	$63.30	$10.71	$5.55	$0.69	29	27	21
BU 24	Education K-12 and Beyond	9	$1.56	$0.53	$5.36	$0.60	28	26	3
BU 12	Resource Mining	2	$500.10	$1.03	$1.10	$0.55	10	10	6
BU 2	Natural Resources Conservation	34	$6,956.80	$10.17	$17.76	$0.52	84	111	19
BU 20	Infrastructure and Construction Management	18	$1,088.72	$1.65	$8.73	$0.49	53	60	26
BU 10	Agriculture and Precision Farming	9	$21.75	$1.25	$2.15	$0.24	21	34	7
BU 21	Urban and Regional Planning	17	$1,763.51	$2.17	$3.42	$0.20	36	46	18
BU 13	Renewable Energy Resources	3	$1,547.85	$2.80	$0.58	$0.19	1	5	0
BU 16	Sea Level Rise and Subsidence	2	$1.00	$0.35	$0.35	$0.18	6	6	6
BU 22	Health and Human Services	4	$58.45	$0.50	$0.50	$0.13	11	16	1
BU 8	Rangeland Management	1	$20.43	$0.00	$0.10	$0.10	3	5	0
BU 25	Recreation	3	$2.90	$1.41	$0.17	$0.06	11	11	7
BU 14	Oil and Gas Resources	3	$24.00	$0.10	$0.10	$0.03	9	11	7
BU 19	Marine and Riverine Navigation Safety	3	$43.00	$0.03	$0.10	$0.03	5	7	3
BU 11	Geologic Resource Assessment and Hazard Mitigation	3	$0.35	$0.04	$0.05	$0.02	5	1	3
BU 17	Wildfire Management, Planning, and Response	1	$20.00	$0.01	$0.01	$0.01	5	5	5
	Total	420	$18,473.01	$538.50	$602.55	$1.43	1067	1212	483

Figure 10 below shows the spatial distribution of the estimated future annual dollar benefits of all 420 MCAs aggregated by HUC8 areas per square mile. Areas with darker colors have greater numbers of areas of interest. Similar maps showing the estimated future annual dollar benefits for each individual Business Use aggregated by HUC8s are provided in Appendix E.

It is likely that most states and many county or local entities have additional MCAs and Business Uses that were not reported for this study. Since the representation of state and local agencies varied across states and the Business Uses were self-selected, it is likely that additional areas across the U.S. would have an interest in and potentially receive benefits for one or more of the Business Uses than what is currently described or reflected in the study data. Figure 10 shows concentrations of estimated future annual benefits in a few areas due to state agencies that reported rather significant benefits. However, it is likely that other states with similar activities may realize future benefits from enhanced hydrography data that were unable to be estimated, which would increase the estimated future annual benefits in other areas.

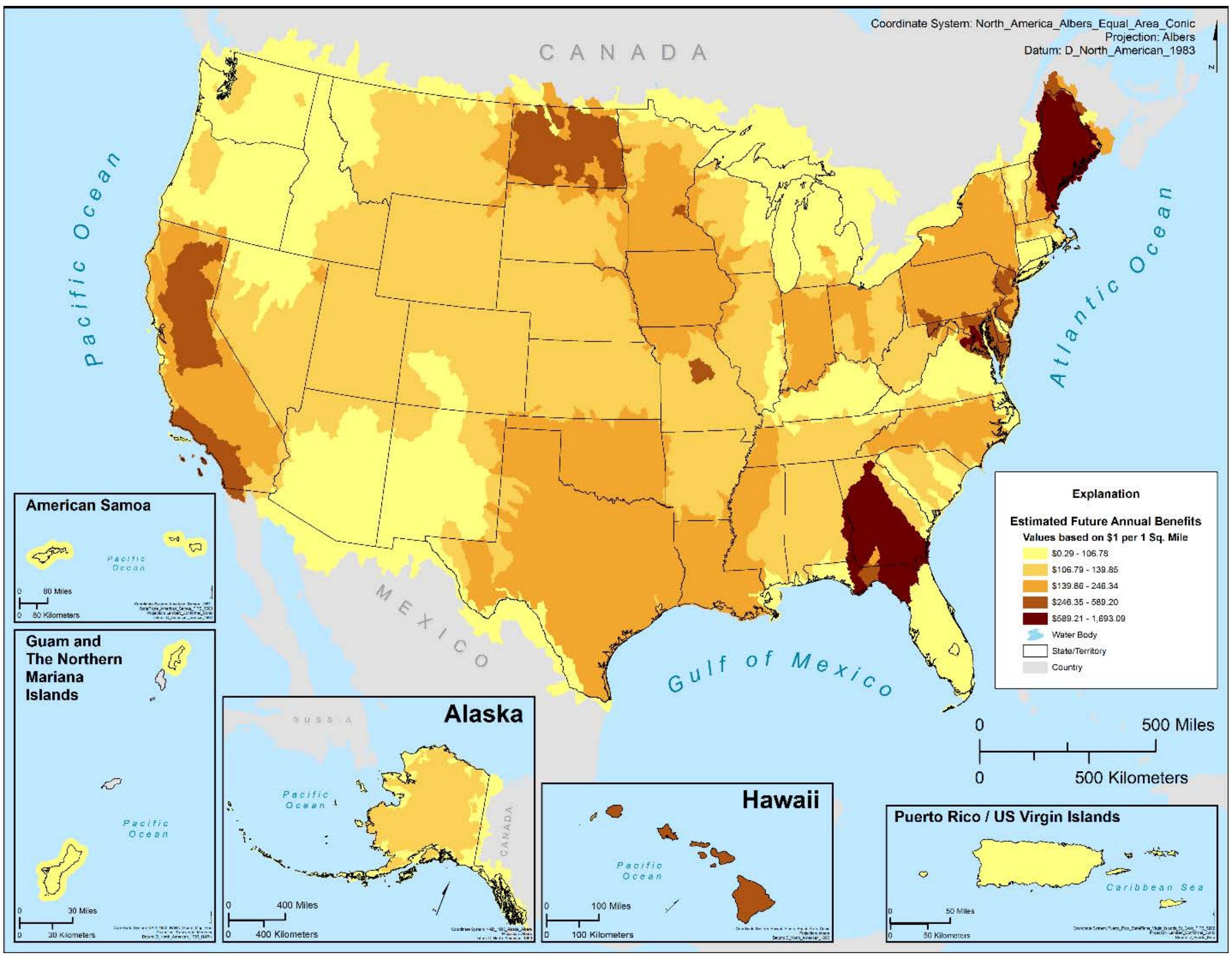

Figure 10. Spatial distribution of the estimated future annual dollar benefits of all 420 MCAs aggregated by HUC8 areas

Conclusions and Recommendations

The following observations and conclusions are provided based on the data collected for the HRBS and contained in the study geodatabase. Further analysis of the study data will be needed to associate benefits with fulfilling individual requirements and to plan program implementation scenarios. A few recommendations for future analysis considerations are also provided.

- Per the OMB restrictions, only 350 responses from the public (including state and local government employees) could be gathered. Study participants were selected by state POCs and may not represent all relevant agencies in all states. In fact, it is likely that most states and many local entities are likely to have additional MCAs and Business Uses with unreported requirements and would likely receive future benefits from enhanced hydrography data. A methodology for identifying and filling perceived gaps may need to be considered when further analyzing the data and developing implementation scenarios. For instance, data were provided by only 13 state Departments of Transportation (DOTs), but all states are likely to have a DOT that has hydrography requirements and benefits.
- The vast majority (90 percent) of the MCAs were provided by government agencies (Federal, state, regional, county, city, local, and Tribal). A total of 25 MCAs (6 percent) were provided by Not for Profit entities. A total of 16 (4 percent) MCAs were provided by private or commercial entities. However, the private or commercial entities were primarily contractors to government agencies. There was little or no representation of large-scale private entities such as the oil and gas industry, major utilities, or agribusiness. It should be noted that these unrepresented private entities are likely to also make use of national hydrography datasets, have requirements for hydrography data enhancements, and are likely to receive potentially significant but undocumented annual benefits from future enhanced hydrography datasets. Future analyses may not be able to quantify the requirements from or benefits to these unrepresented private entities, but their additional benefits may be able to be acknowledged.
- The MCAs reported by the Federal agencies (54) typically reflect nationwide interests with nationwide or nearly nationwide areas of interest. The remainder of the MCAs (237 from state government and 129 from other organizations) typically represent smaller areas of interest. Simply counting the number of MCAs for which requirements or benefits apply would be misleading. For this reason, in this report the MCA totals were broken down and reported by Federal agencies, state government agencies, and other entities along with the overall totals. This allows the responses that cover generally larger geographic areas represented by a smaller number of Federal agencies and the requirements that generally cover smaller but more numerous state and local geographic areas to be reported separately. Future analyses will need to take the geographic distribution of the requirements and benefits into account (not just numbers) using the MCA areas of interest contained in the study geodatabase.
- There was considerable variation in how the MCAs were defined and described by study participants. Some MCAs appear to have been described in terms of the respondent's agency's organization, some in terms of their daily activities. Some MCAs were very broad and encompassed multiple Business Uses and some were quite narrowly defined. This is further indication that further analyses using only the numbers of MCAs may not be useful.
- Study participants ascribed five or fewer MCAs to eleven of the 25 pre-defined Business Uses. For example, two MCAs were ascribed to BU #16, Sea Level Rise and Subsidence, and one MCA was ascribed to BU #17 Wildfire Management, Planning, and Response. Agencies or entities with

multiple responsibilities likely chose the Business Use that makes up the majority of their portfolio of business. However, it is likely that more than two agencies include planning for sea level rise in their mission and that most western states have a concern for wildfire management. When further analyzing requirements and benefits by Business Use, consideration should be given to imputing requirements for and benefits from hydrography data from the available information where it appears that there are significant gaps in the reported data.

- The top five requirements for integration with other datasets were elevation, stream flow, wetlands, soils, and land cover, with integration with elevation data being the top requirement. When developing program implementation scenarios for analysis, consideration should be given to evaluating whether future hydrography data models may be able to accommodate some or all of these data integration requirements.
- The HRBS results appear to refute a commonly held belief that Federal agencies need consistent data as opposed to best available. A total of 70 percent of Federal agencies and 67 percent of overall study participants reported a requirement for best available data. Study respondents did note that disparities in level of detail cause modeling problems and also noted a desire for tools that would allow best available data to be selected or generalized such that a consistent level of detail could be achieved for modeling purposes from best available data.
- The reported estimated future annual benefits are most likely underestimated. Study respondents were unable to provide dollar estimates for future annual benefits for 35 percent of the MCAs.
- Per OMB, no dollar benefits were allowed to be collected for the societal benefits (education or public safety, environmental, and human lives saved). However, study respondents noted moderate or major benefits for education or public safety for 62 percent of MCAs and moderate or major environmental benefits for 67 percent of the MCAs. While these benefits cannot be quantified, they should not be discounted.
- When the estimated future annual benefits are mapped by MCA area of interest, several concentrations of benefits are revealed. These reflect several state agencies with rather significant benefits. It should be noted that other states may have unreported but similar benefits.
- The estimated future annual benefits are associated with fulfilling all stated requirements for each MCA. When further analyzing the data and developing implementation scenarios, a methodology will be needed for degrading the benefits if not all requirements can be fulfilled by a given scenario. Having so many different requirements to consider will make this a challenge.
- While the requirements and benefits assigned to specific MCAs would not be duplicated or biased due to the way they were aggregated into Business Uses, the reader is cautioned to understand the inherent flaws associated with any consolidation of this information. Likewise, specific user requirements may require more detailed analysis of the study database to understand the full need or value of fully meeting a particular need.

1.0 Introduction

Hydrography data are integral to a myriad of mission critical activities undertaken and/or managed by government entities at all levels (Federal, State, regional, county, local, Tribal) as well as nonprofit organizations and private companies. Hydrography data make it possible for these groups to:

- Manage water flow including stream flow and stormwater;
- Monitor, manage, and report water quality both for drinking water and habitats;
- Assess water availability and water rights for agriculture and livestock as well as hydro power purposes;
- Model and map flood risk for floodplain management, emergency response, dam safety, and roadway design;
- Preserve terrestrial and aquatic habitats;
- Manage fisheries, rangeland, timberlands, and agricultural lands for optimum health and production;
- Assess coastal hazards to include natural events (storm, tsunami) and future sea level rise;
- Plan for future land development activities;
- Manage riverine and coastal navigation and safety; and
- Provide recreational opportunities for citizens.

The U.S. Geological Survey (USGS), the Environmental Protection Agency (EPA), other Federal agencies, and stewardship partners have worked to develop, maintain, and disseminate national hydrography datasets that can serve these and many more needs. As user requirements have expanded, so too have the data. And as the data improve, users find more and new uses for the data. However, there are still many unmet needs for hydrography data to include increased spatial accuracy; better integration with other related datasets, especially lidar data; improved consistency in level of detail; improved attribution – both additional attributes and enhanced consistency and accuracy; and improved documentation including more detailed metadata. Quantifying these requirements, determining the benefits of meeting the most significant requirements, and designing a program to fulfill the needs of its users is a challenge. This study is a building block toward doing just that. This study is sponsored by USGS and the U.S. Department of Agriculture's (USDA's) Natural Resources Conservation Service (NRCS). It was conducted by Dewberry.

1.1 Study Goals

USGS is considering an enhanced program to significantly improve the utility of hydrographic data for the U.S. and its territories. In order to determine the cost effectiveness of various enhanced program options, USGS is seeking to assess the requirements of users of hydrography data and the benefits to those users of improved hydrography data. The goal of this assessment, the National Hydrography Requirements and Benefits Study (HRBS), is to establish a set of national Business Uses (BUs) and requirements associated with hydrographic data. This information will then be used to evaluate the benefits of successfully supporting those requirements within the context of a national program.

This report documents the preliminary findings of the HRBS. Further analysis of the data presented herein by USGS is anticipated, with the final outcome to be recommendations on enhanced program options and implementation recommendations.

1.2 Project Scope

Under the Geospatial Products and Services Contract No. 2, USGS tasked Dewberry to conduct a study to collect and refine user requirements and to identify associated benefits for an expanded national hydrography data program that meets Federal, State and other national Business Uses and needs. The study's findings are expected to establish a baseline understanding of national Business Uses, needs, and associated benefits for national hydrography data, and to inform the design of an enhanced future program that balances requirements, benefits, and costs at a national scale.

This project includes three sub-tasks: (1) development of a project management plan; (2) collection and aggregation of user requirements and associated benefits; and (3) development of tools that USGS can use to analyze study results and evaluate program implementation scenarios. This report documents Tasks 1 and 2. Task 3 is a future task that will make use of the data collected under Task 2.

The collection of user requirements and benefits was accomplished through an online questionnaire (Office of Management and Budget [OMB] Control Number 1028-0112) about the use of hydrography information. Mission Critical Activities (MCAs) and their associated requirements and benefits were identified by select Federal agencies, states, and other organizations. The MCA results were grouped into high-level Business Uses for each selected Federal agency and for each of the 50 states and other selected organizations. A geodatabase was developed to capture, store, and analyze the original questionnaire data. After a quality-control process including interviews with the states and responding agencies, a second geodatabase was developed to store summaries, refined versions, and aggregated content of the original data. The study results are summarized in this report.

1.3 Project Approach

The project management plan presented the overall approach to the study and how it would be executed. The project management plan was refined slightly as the study progressed and subsequent tasks were performed.

The methodology for collecting MCAs was developed based on Business Uses and questionnaire input provided by USGS in the Statement of Work. The methodology was also informed by the need to design tools for analyzing the study results. The methodology included the design of a geodatabase to store the responses to the questionnaire and a second separate but consistent geodatabase to store consolidated and refined user information.

An online questionnaire was developed and administered to solicit input from Federal, state, and other hydrography users regarding their requirements and benefits. User requirements for hydrography data were defined for five aspects of data use: functionality, content, positional accuracy, level of detail, and currency. Users were also asked to describe their MCAs and identify the best matching Business Use to which the MCA applies. A Business Use is a higher level category used for aggregation of related MCAs. For example, MCAs for monitoring river flows, streamflow simulation, and stormwater management would all be grouped under the Business Use “River and Stream Flow Management.” A list of 25 pre-defined Business Uses was provided for users to choose from. The list of 25 Business Uses is provided in Appendix A. Respondents provided the geographic area of interest for each MCA, the data requirements and associated benefits. Questions were also designed to determine expected benefits to be realized from enhanced hydrography data for each MCA.

Federal agency Points-of-Contact (POCs) were selected by the participating agencies. For each state, one or more leaders in the water resources community were identified as POCs by USGS National Map Liaisons working with their local and state Geographic Information System (GIS) coordination contacts. These state leaders were primarily GIS managers, leaders, and coordinators within state government.

Presentation materials were developed for two workshops. One workshop was held to inform Federal POCs about the study. The second workshop was held to train USGS National Map Liaisons on use of the online questionnaire and the study geodatabase so they could administer the online questionnaire to state and other hydrography users.

Once online questionnaire responses were received from the 501 Federal, state, and other hydrography data users who responded, the results were aggregated within the study geodatabase by MCA and organization. Based on initial questionnaire responses, results from the Federal agencies with the most significant hydrography data requirements were identified for further review. USGS originally planned to select 12 Federal agencies to interview in person. However, upon review of the online questionnaire results, USGS determined that 21 of the 23 Federal agencies that responded to the online questionnaire should be interviewed. The Western Area Power Administration (WAPA) was selected to represent the four U.S. power administrations, consolidating responses received from three of the four power administrations.

In preparation for the interviews, summary reports of the Federal questionnaire responses were prepared and provided to USGS and the Federal POCs. Similar summary reports were also developed and provided to the USGS National Map Liaisons for the state and other agencies identified for follow up interviews.

Interviews were conducted with key managers and hydrography data users from the Federal agencies. In parallel, USGS National Map Liaisons conducted similar interviews with state and other hydrography users. The goal of the interviews was to: (1) document key Federal budget authorizations associated with the MCAs; (2) consolidate any redundant organization requirements; (3) summarize organization requirements; (4) fill in gaps in questionnaire responses; and (5) validate tangible and intangible benefits of enhanced hydrography data.

Once the interviews were complete, Federal agency POCs and USGS National Map liaisons were requested to validate the documented results of the interviews. The validated interview results were then aggregated within the study geodatabase by MCA and organization. The study results are described in this report.

1.4 Report Overview

Section one of this report provides an overview of hydrography data, presents the goals of this study, outlines the project scope, and provides a summary of the project approach.

Section two provides background information on relevant USGS geospatial programs; describes The National Map; provides an overview and description of their use by study participants of the National Hydrography Dataset (NHD), the Watershed Boundary Dataset (WBD), and the NHDPlus dataset; provides an overview of the current NHD and WBD stewardship process; and presents some feedback provided by study participants on the status quo national hydrography datasets.

Section 3 describes the study process including (1) the project management plan, (2) questionnaire development, (3) outreach and training, (4) online questionnaire administration, (5) development of the raw study geodatabase, (6) identification of the Federal agencies with the most significant requirements, (7) preparation of draft summary reports for participating agencies and states, (8) interviews/workshops, (9) preparation of summary reports for participating Federal agencies, states, and associations (which are included in Appendixes B, C, and D), (10) confirmation of study data by study participants, (11) key Federal authorizations, (12) development of the final study geodatabase, and (13) preparation of this study report.

Section 4 provides the study results including information about study participation, MCAs, Business Uses, data use by study participants, requirements for enhanced hydrography data, and estimated benefits of current hydrography data and future enhanced hydrography data. Full details of the MCAs, Business Uses, requirements, and benefits can be found in the summary reports in Appendixes B, C, and D.

Section 5 provides a summary of the study results including study participation, current use of the national hydrography datasets, MCAs, Business Uses, requirements for enhanced hydrography data, and estimated future benefits from enhanced hydrography data.

Section 6 provides study conclusions and recommendations.

2.0 Background

The following sections provide an overview of The National Map as well as an overview of several hydrography datasets in common use (NHD, WBD, and NHDPlus) along with an overview of the NHD and WBD stewardship process. Also included is information about use of the NHD, WBD, and NHDPlus datasets by study participants, a discussion of some of the other hydrography and hydrography-related datasets in use by the study participants, and finally a discussion of some of the issues with the status quo national hydrography datasets as noted by study participants.

2.1 The National Map

The National Map is a collaborative effort of USGS and other Federal, state, and local agencies to improve and deliver topographic and other information for the U.S. The purpose of the effort is to provide "…a seamless, continuously maintained set of public domain geographic base information that will serve as a foundation for integrating, sharing, and using other data easily and consistently."

The National Map is part of the USGS National Geospatial Program (NGP). The geographic information available in The National Map includes orthoimagery (aerial photographs), elevation, geographic names, hydrography, governmental unit boundaries, transportation, selected structures, and land cover. The National Map is accessible via the Web, as products and services, and as downloadable data. Its uses range from recreation to scientific analysis to emergency response.

The National Map serves the geospatial community by providing high quality, integrated geospatial data and products and services including new generation digital topographic maps. The NHD and WBD comprise the hydrography components of The National Map.

2.2 National Hydrography Dataset (NHD)

The NHD represents the drainage network of the U.S. with features such as rivers, streams, canals, lakes, ponds, coastline, dams, and stream gages. The NHD provides a routed network that supports the analysis of any type of movement (for example, navigation, sediment transport, and effluent dispersion) by surface waters. In addition to providing water information for mapping, the NHD may also be used for scientific analysis and hydrologic modeling.

The NHD includes datasets covering all streams and lakes at scales of 1:24,000 and 1:100,000. NHD data are available for Puerto Rico at 1:20,000-scale, and at 1:63,360-scale in Alaska. In some areas, the NHD is being supplemented through partnerships with local agencies with data larger than 1:24,000-scale. These data are combined into a single, best-resolution database, which has led to some areas having greater than 1:24,000-scale data, for example – Vermont has data scaled at 1:5,000 for the entire state.

The NHD is a digital vector dataset used by GISs. These data are designed to be used in general mapping and in the analysis of surface water systems. In mapping, the NHD is used with other data themes such as elevation, boundaries, and transportation to produce general reference maps. The NHD is also used by scientists to generate specialized information. These analyses are possible because the NHD contains a flow direction network that traces the water downstream or upstream. The NHD also uses an addressing system that allows specific information about the water such as discharge rates, water quality, and fish population to be linked to the hydrography features. Using the basic NHD attributes, flow network, linked information, and other characteristics, it is possible to study cause and effect relationships such as how a source of poor water quality upstream might affect a fish population downstream.

The features in the NHD are organized into polygons, lines, and points. The polygons most commonly portray waterbodies such as lakes, while lines commonly portray streams. Points represent confluences and landmark features. The stream lines are broken into shorter segments stretching from confluence-to-confluence. The segments are then linked together to trace the flow of water across the landscape. Flowlines attributed as artificial paths are added inside water bodies to maintain the flow network.

Figure 11 shows an example of the NHD depicting areal features and point features along flowlines.

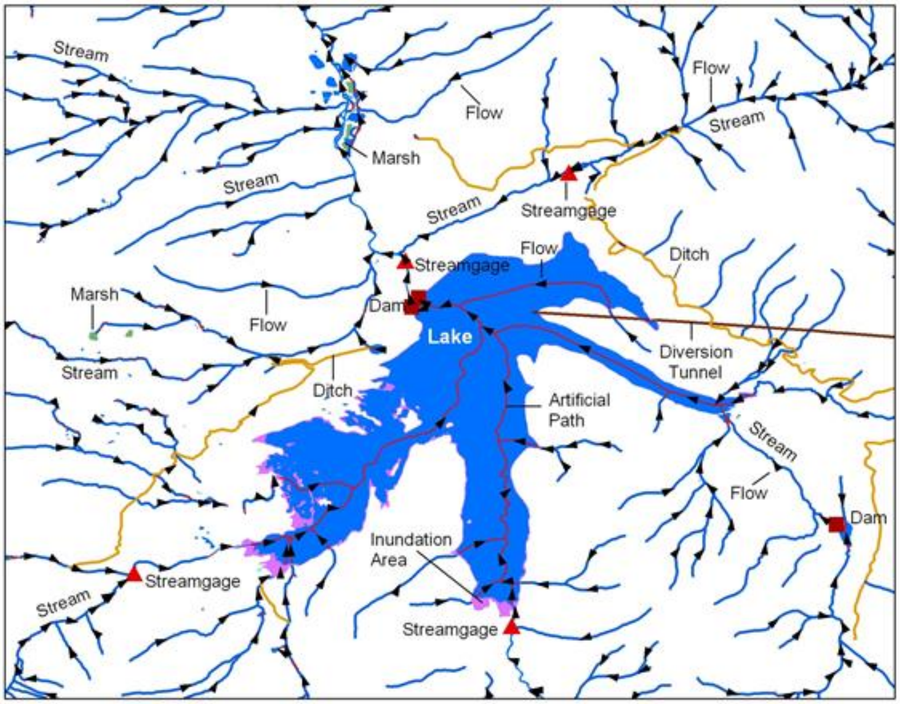

Figure 11. NHD features

The primary features making up the Nation's surface water are labeled with nationally unique and permanent identifiers known as reach codes. These unique identifiers give features an identity for inventory and analysis. Water chemistry, for example, can be linked to a stream or a lake using reach codes. Many features also are labeled with the name of the feature, such as the Ohio River. The feature names must be approved by the Board of Geographic Names to qualify for inclusion in the NHD.

The network of lines contains linear measurements, making it possible to locate the position of a stream gage, dam, or other event attached to a flow line. Measures, known as M-Values in the NHD, are used for linear referencing and are similar to the address of a house on a street. By recording the measurements upstream on a reach code it is possible to uniquely identify any position along a waterway. Linear referencing makes it easier to perform calculations in a GIS such as identifying dams upstream from a stream gage, and then determining the distance to those stream gages. The system of linear referencing also makes it easy for any agency to link data to the NHD without having to customize the NHD. In some cases, real-time access to readings or online documentation is provided via hyperlinks at specific locations, such as gage stations.

2.3 Watershed Boundary Dataset (WBD)

The WBD is a companion dataset to the NHD. It is a nationally consistent, seamless, and hierarchical dataset that delineates Hydrologic Units (HUs). An HU is a drainage area defined by terrain and other characteristics. It has a single flow outlet except in coastal or lakefront areas. The WBD is complete for the lower 48 states, Alaska, Hawai’i, Puerto Rico and the Virgin Islands. The WBD was developed through partnerships of Federal agencies, state agencies, local organizations, universities, and Tribes in all 50 states and U.S. territories.

The WBD defines the areal extent of surface water drainage to a point, accounting for all land and surface areas upstream of that point. Watershed boundaries are determined solely upon science-based hydrologic principles, not favoring any administrative boundaries or special projects, nor a particular program or agency. The intent of defining HUs for the WBD is to establish a base-line drainage boundary framework. At a minimum, the WBD is being delineated and geo-referenced to the USGS 1:24,000-scale topographic base maps, except for Alaska at 1:63,360-scale, and 1:25,000-scale in the Caribbean, to meet National Map Accuracy Standards.

Most HUs have one outflow point where water exits and flows into a neighboring unit, or, in coastal areas, into the ocean. HUs are subdivided into progressively smaller units and each unit of measurement has a Hydrologic Unit Code (HUC) which describes the level of subdivision and the geographic location of the HU. HUs are nested within one another; for example HU-4's are nested with HU-2's. Figure 12 below illustrates the nested nature of the HUs in the WBD.

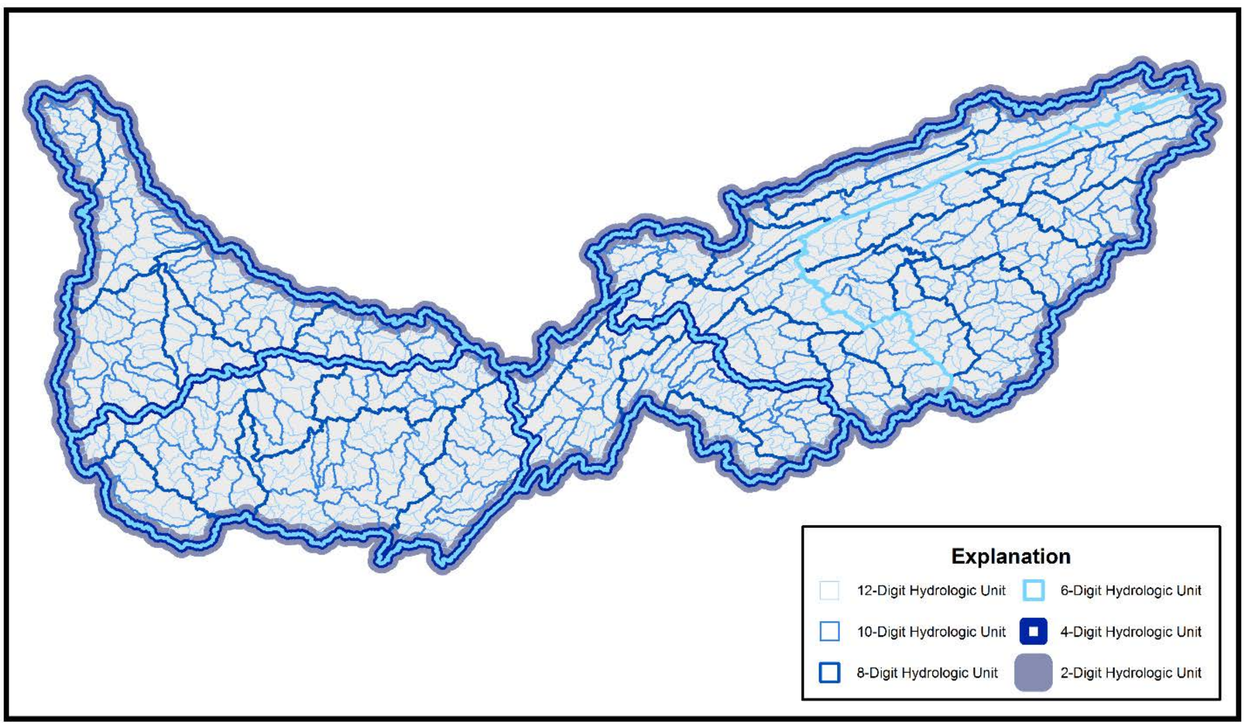

Figure 12. Nested HUs in the WBD

2.4 NHDPlus

NHDPlus is a suite of geospatial products that build upon and extend the capabilities of the NHD, the National Elevation Dataset (NED), and the WBD. Interest in estimating stream flow volume and velocity to support pollutant dilution (fate-and-transport) modeling was the driver behind the joint U.S. EPA and USGS effort to develop NHDPlus.

NHDPlus is produced from static snapshots of the NHD, NED, and WBD and it includes the features and capabilities of these ingredient datasets. NHDPlus integrates the vector NHD stream network and WBD HU boundaries with the NED gridded land surface. This hydrologically-conditioned surface enables the delineation of a catchment (local drainage areas) for each NHD stream segment. The catchments are used to associate precipitation, temperature, and runoff data with each stream segment for estimating NHDPlus stream flow. Figure 13 below illustrates the major rivers in the U.S. symbolized by their flow rate in NHDPlus. Image courtesy of USGS.

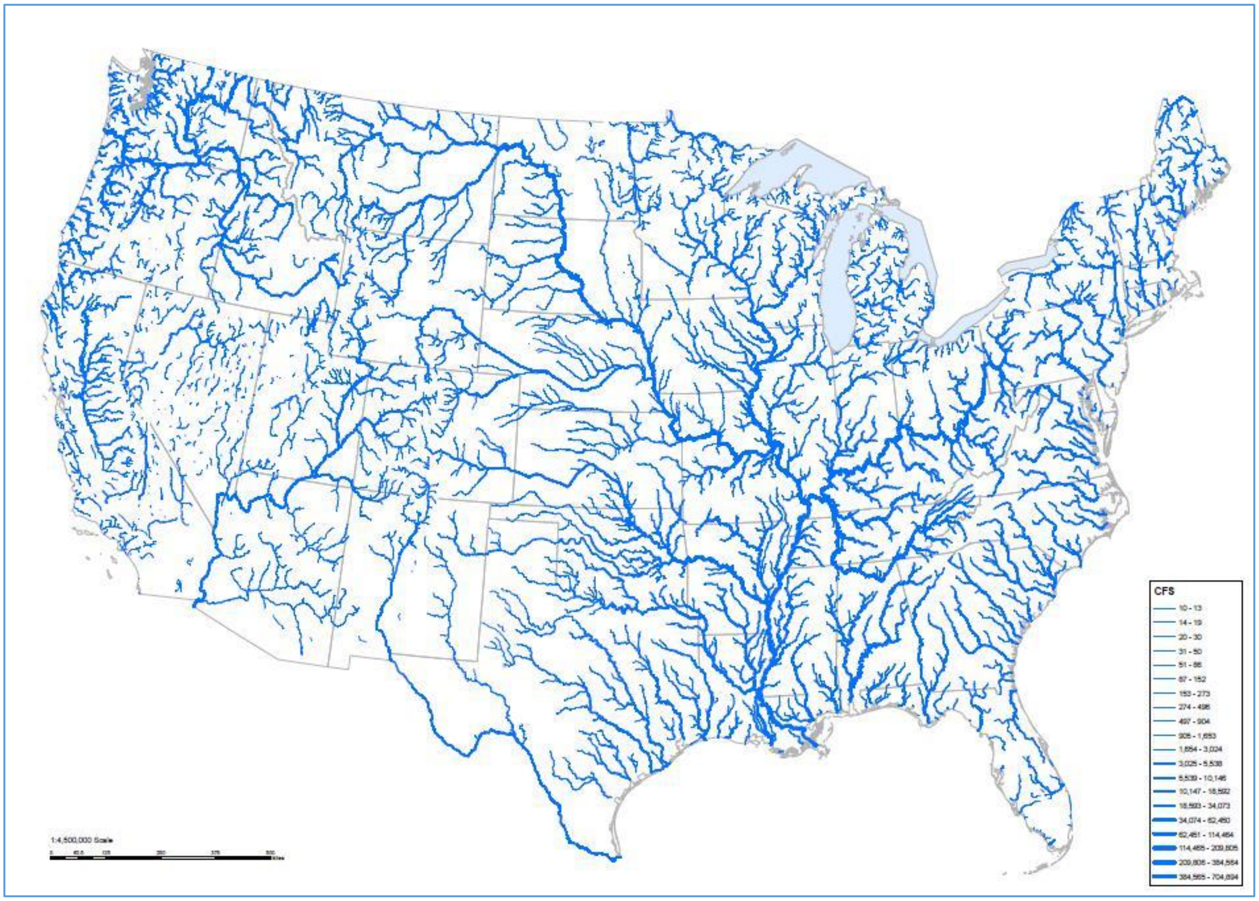

Figure 13. Major rivers in the U.S. symbolized by flow rate in NHDPlus

Elevations along each stream are used to compute stream slope for estimating NHDPlus velocities used in time of travel analyses. In addition to stream flow and velocity, NHDPlus provides attributes which greatly improve the capabilities for upstream and downstream navigation, analysis, and modeling.

Examples of these enhanced capabilities include the ability to use structured queries for rapid retrieval of all NHD Flowline features and catchments upstream of a selected NHD Flowline feature; the ability to select a subset of a stream level path (sorted in hydrologic order) for stream profile mapping, analysis, and plotting; and the ability to use hydrologic sequence routing attributes to calculate cumulative catchment attributes. Additionally, routing techniques were used to produce additional NHDPlus attributes such as cumulative drainage areas, temperature, and precipitation distributions. These cumulative attributes are used to estimate NHDPlus mean annual and mean monthly flow estimates and velocities. These capabilities enable a diverse collection of water-related applications implemented by a large and growing user community.

2.5 NHD and WBD Stewardship

The stewardship program of the NHD/WBD provides an opportunity for users who are knowledgeable about the hydrography to update the data. Generally, a Memorandum of Understanding (MOU) is established between USGS as the national data coordinator, and a principal steward for a region, which in many cases is a state government agency with a leadership role in water issues. There may be one or more sub stewards that provide hydrography updates under the principal steward. Each member of the stewardship process has specific duties and responsibilities as outlined in the MOU. Approximately 75 percent of states and territories have draft or signed stewardship MOUs and another 7 percent appear to have state stewards even though they have not yet entered into a formal MOU.

The principal steward is the primary POC between USGS and the state's NHD/WBD maintenance efforts. The steward adjudicates decisions on the data provided by sub stewards to provide the most accurate assessment of hydrography in the state. The steward also is responsible for promoting the NHD/WBD and for making the data publically available in the state. USGS is responsible for standards, data management, quality assurance, and distribution. USGS provides partner support with a POC assigned to the state. Further, USGS also is responsible for providing the training and resources needed to manage the editing process.

USGS provides NHD and WBD Update tools that guide the steward through each step of the editing workflow. The NHD Update tool ensures that a steward enforces the rules of the NHD/WBD database and provides a complete quality control process to ensure data integrity. As technology and the NHD/WBD evolve, the tool is updated to maintain its effectiveness.

Many study participants provided comments and recommendations on the current stewardship process. While not queried as part of this study, a total of 25 states indicated that they currently participate in the stewardship program or would be willing to contribute to the maintenance of the NHD, WBD, and/or NHDPlus datasets. A total of 24 states reported that they add value to the currently available NHD, WBD, and/or NHDPlus datasets and/or maintain similar information on local resolution data. Ten of those 24 states reported a desire for the national datasets to reflect the value they add locally. However, it was noted that a better strategy for making it easy for local stewards to incorporate their data into the national structure is needed. It was also noted that better tools (i.e. quick, easy, and online) for identifying errors and submitting changes to the national datasets would increase stewardship. Open source and crowd-sourced data editing were also suggested as possible solutions. When asked, 82 percent of the participating agencies said they would probably or definitely use a web-based tool to report errors in the national dataset.

Additionally, three states suggested that USGS expertise provided to assist local agencies to collect, maintain, and process hydrography data could improve stewardship. Increased coordination with local stewards regarding data model updates, applications, maintenance, tools, and support was also recommended by five states. And it was noted by eight states that additional USGS grants or funding for stewardship and tool development would also increase stewardship participation.

2.6 NHD, WBD, and NHDPlus Use by Study Participants

For each of the 420 reported MCAs, study participants were asked to indicate what hydrography datasets are currently being used to address the water information needs of the MCA. Note that questions about further requirements for integration of external datasets were asked in another section of the online questionnaire and are reported in Section 4.5 (Requirements) of this report.

Study respondents reported using NHD, WBD, and/or NHDPlus data for 88 percent of MCAs. Only 4 percent reported that no hydrography data are currently being used. Study respondents reported using another dataset in addition to the NHD, WBD, and/or NHDPlus data for 34 percent of the MCAs and using another dataset instead of the NHD, WBD, and/or NHDPlus data for 8 percent of the MCAs.

When another water-related dataset is used, 60 percent of the time it is state or locally developed and/or maintained hydrography data. These locally maintained data are either of higher resolution than the national datasets, having been collected or improved to fit recently collected lidar, orthoimagery, or parcel data, and/or have locally improved or added attributes that were customized to serve the MCA's business needs.

Usage of NHD, WBD, and NHDPlus data is shown in Table 7 below and Figure 14 on the following page.

Table 7. Usage of NHD, WBD, and NHDPlus data

Data Type Used	Number of Federal Gov't. MCAs (of 54)	Percent of Federal Govt. MCAs	Number of State Gov't. MCAs (of 237)	Percent of State Gov't. MCAs	Number of Other Organization Type MCAs (of 129)	Percent of Other Organization Type MCAs	Total Number of MCAs (of 420)	Percent of MCAs
National Hydrography Dataset (NHD)	47	87%	209	88%	90	70%	346	82%
Watershed Boundary Dataset (WBD)	42	78%	181	76%	65	50%	288	69%
National Hydrographic Dataset Plus (NHDPlus)	37	69%	87	37%	35	27%	159	38%
No hydrography data are currently being used	4	7%	4	2%	8	6%	16	4%
Other dataset	20	37%	93	39%	65	50%	178	42%

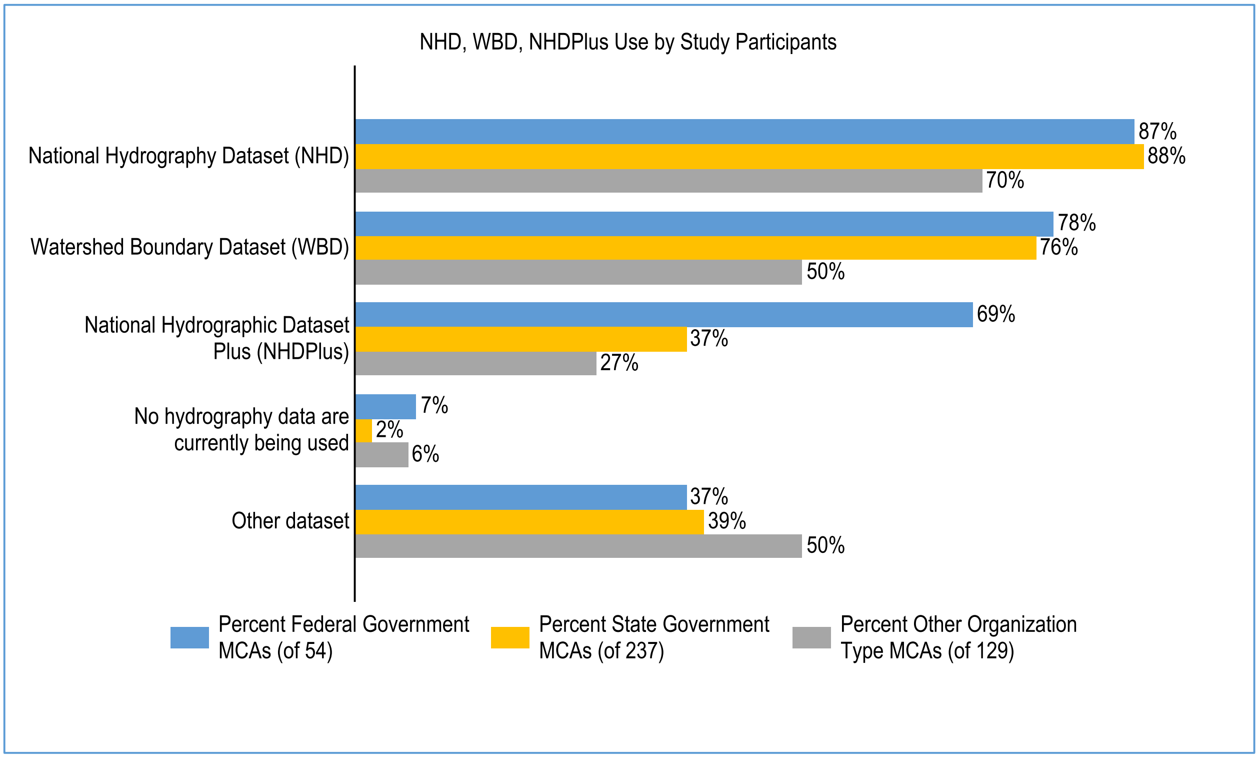

Figure 14. Usage of NHD, WBD, and NHDPlus data

2.7 Study Participant Feedback on the Status Quo

A total of 88 percent of study participants reported using the currently available NHD, WBD, and/or NHDPlus datasets for their MCA. However, all study respondents reported receiving benefits, either quantified as dollar values or qualitative benefits from available hydrography datasets. One State user noted "The efforts of the USGS to keep these core datasets of the highest quality possible is appreciated and not overlooked." Another state user noted that "There is tremendous value in the NHD and supporting materials." And EPA reported $2 million in annual savings from not having to maintain their own hydrography datasets. As described in the International Joint Commission (IJC) summary report in Appendix B:

> Hydrography data harmonization activities completed across the U.S.-Canada border to date have changed the behavior and expectations across the two nations. Both countries are benefiting from the use of the harmonized data across the landscape. The data harmonization could not have been accomplished without the NHD and WBD datasets as the starting point, and the harmonized data could not be maintained without the data framework and delivery mechanisms that are currently in place. Seamless data are now the expected norm across the border and having seamless data is providing large benefits to both nations.

Feedback on the available data for Alaska noted that these data are not meeting user requirements. As described in the State of Alaska summary in Appendix C:

> While consistently mapped at 1:24,000-scale or better in the contiguous U.S., the NHD in Alaska was taken from 1950s-era USGS Topographic Maps at a broad scale of 1:63,360. These historic

> data need extensive updates and improvements to meet modern mapping standards and user needs. Over the past five years, efforts by several organizations have updated the NHD to modern mapping standards for approximately 10 percent of the state. Significant work remains to complete updates across the state. Slow progress on updating the NHD to national high-resolution standards is due in part to the quality of the existing topographic data. Given the current hydrography situation in Alaska, there is a pressing need to correct these issues and improve the NHD to meet state and Federal agency needs.

A total of 88 percent of study respondents also indicated that integration of hydrography data with elevation data is either “required” or “highly desirable” to the accomplishment of their MCA. Users from three states and one association wanted to know more about the future plans to integrate the NHD and WBD datasets with other layers, and in particular how the 3DEP program would integrate with NHD and WBD updates.

Users from three states commented on the complexity of the currently available datasets as a barrier to their use by casual users. Two states reported that they also find the data complexity to be a deterrent to editing the NHD and submitting those edits for inclusion in the national dataset. Improved and/or simplified NHD editing tools were requested by users from twelve states and one Federal agency. A total of 15 comments were received about the need for additional documentation in the form of standards, data dictionary, metadata (including attribute definitions), improved clarity and/or consistency in attribute definition, or guidance on how to derive NHD data from lidar data and how to submit those data to the NHD dataset.

Study participants from ten Federal agencies and 31 states noted that a national dataset that meets their needs would save them time they currently spend on maintaining a local dataset. Participants from four Federal Agencies and nine states reported that having all of the data they need in one dataset would save them time they currently spend searching for and obtaining data. And the potential confusion caused by having to find and use multiple datasets was noted. When local data are maintained separately from the national datasets, if information is needed from the national datasets, users must develop a strategy for managing or merging the two datasets. As described in the State of Minnesota summary in Appendix C:

> Minnesota currently uses two distinct spatial datasets representing the state’s surface water hydrography. One is the MN Department of Natural Resources (DNR) Enterprise Hydrography Dataset maintained by the Minnesota DNR; the other is the National Hydrography Dataset (NHD). Each dataset has unique characteristics that were developed to meet differing business needs. Some agencies have a business requirement to use one dataset over the other. Other agencies have a historical familiarity with one dataset, while still others find that neither dataset contains the features necessary to fully satisfy their requirements. Users are often confused as to why there are multiple datasets, why the features and attributes differ, and how to choose the dataset to best meet their business needs. Agencies may maintain local datasets separately and need to cross-reference their data to different systems, resulting in challenges for data sharing and a duplication of efforts.

Another topic that was mentioned by a number of study respondents was the need for authoritative data. Idaho, Oregon, Washington, and at least one agency in Missouri reported that they have adopted the NHD as the state standard for the digital representation of surface water features. This requires state agencies to adjust their business processes to use this data source and to migrate any state-maintained data to this theme. In other states, users with statewide business needs may use the NHD as their surface water layer while entities that work at a local scale (e.g., local governments or site-specific applications) may not find the NHD as useful. Further, the EPA uses a 1:100,000-scale national dataset as the standard for submitting impaired waters, so users end up modifying a copy of the 1:100,000-scale data and improving its geometry and attributes for local use. A preference for a national hydrography dataset that can be adopted statewide and meets both statewide and local user requirements was reported by twelve states.

Users also noted that in order for states to adopt the NHD and/or WBD for regulatory use, a well-documented change and update process with feature level metadata is required. Additionally, state edits to the national dataset need to be reflected quickly. And state users require a way to be informed if edits within their state are made by others so they can know of possible changes that affect their regulations. A user in Ohio also requested information on how the use of high-resolution NHD for Clean Water Act and Waters of the U.S. might affect property owners. Further, it was noted that some regulations are built on flow periodicity, therefore consistent data density and attribution is very important.

This study indicates that there are significant benefits to be realized through the provision of nationwide enhanced hydrography datasets. As noted above, study participants from ten Federal agencies and 31 States noted that they would derive significant time or cost savings from not having to maintain their own datasets if the national datasets met their needs for positional accuracy, currency, consistency, completeness, and attribution. Additional improvements could be realized through improved online tools such as visualization and editing tools, and through streamlined stewardship approaches.

3.0 Study Process

This section provides a summary of the HRBS process, to include (1) development of a project management plan, (2) development of the study questionnaire, (3) outreach and training activities related to the study, (4) administration of the online questionnaire, (5) development of a geodatabase to store the raw study data, (6) identification of the Federal agencies with the most significant requirements, (7) preparation of draft summary reports for each state and Federal agency to be interviewed, (8) conducting the interviews/workshops, (9) preparation of summary reports for each state and Federal agency interviewed, (10) confirmation of the study data by the study participants, (11) extraction of the key Federal funding authorizations from the study data, (12) finalization of the study geodatabase, and (13) preparation of this report.

Figure 15 on the following page provides a flow chart illustrating this process.

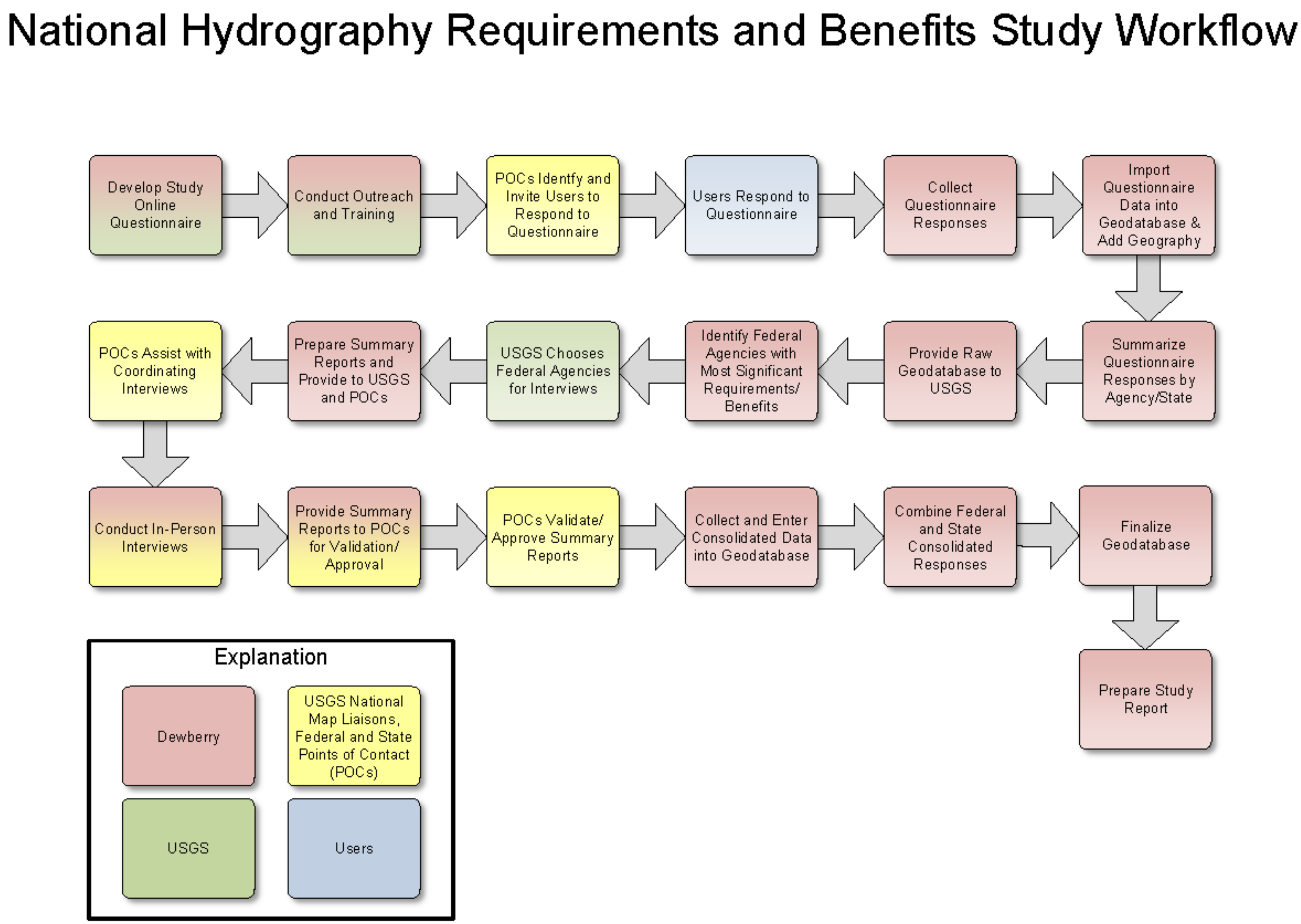

Figure 15. Flowchart of the National Hydrography Requirements and Benefits Study

3.1 Project Management Plan

Dewberry developed a detailed project management plan for the study that outlined procedures to be followed in developing the MCA collection methodology; designing the project geodatabases; designing the online questionnaire; developing the workshops; gaining responses to the online questionnaire and managing those responses; populating the geodatabase with the questionnaire responses; preparing for and conducting the follow-on interviews; populating the geodatabase with the interview results from Federal, State, and other respondents; and other information needed to execute the full Scope of Work for this task order. This plan provided Dewberry's strategy to design the collection efforts with the end uses of the information in mind.

The draft project management plan was used for an initial design meeting at USGS on August 26, 2014, to review Dewberry's overall approach and to clarify questions and resolve issues for revision of the project management plan and questionnaire. The project management plan was modified based on the feedback received at the design meeting.

3.2 Questionnaire Development

The online questionnaire was developed for this study using SurveyMonkey®. The initial questions were provided by USGS and subsequently refined as the online questionnaire was programmed. Before deployment of the questionnaire, USGS invited reviewers from NRCS; USGS' Office of Water Information; the Consortium of Universities for the Advancement of Hydrologic Science, Inc.; and representatives from the NHD Management Team to include USFS, EPA, BLM, USGS, and several states (Arkansas and Minnesota) to comment on the questionnaire. The complete online questionnaire is provided in Appendix F.

When users initiated the online questionnaire, they were first asked to provide contact information and information about the organization they represent. Contact information was requested in case clarification was needed on individual responses. The users' organizational information was used to aggregate responses.

Users were next asked to describe the MCA for which they were providing responses in their own words. They were also asked to choose the Business Use that most closely matches their MCA. A list of 25 pre-defined Business Uses was provided for users to choose from. The list of 25 Business Uses is provided in Appendix A. Users could provide information for up to five unique MCAs.

Users were asked to identify the geographic area requirements for their MCA. The online questionnaire included pick lists of common geographies (i.e., nationwide, state, county, HUC) and also provided a File Transfer Protocol (FTP) site where respondents could submit user-defined geospatial areas of interest for their MCAs such that the footprints of those areas could be stored in the study geodatabase.

Users were then asked to provide information about the hydrography requirements of each MCA including analytical, content, positional accuracy, level of detail, currency, access methods, integration with other data, and relationships to elevation data.

Users were also asked to provide the annual program budget supported by the MCA as well as both current and estimated future MCA operational and customer service benefits quantified as dollar values to the extent possible. Additionally, users were asked to provide alternative qualitative benefits such as those to agency operational time or cost savings, mission compliance, customer service improvements to products or services, customer service improvements to response or timeliness, customer experience improvements, education or public safety benefits, environmental or ecosystems benefits, and human lives saved, each quantified as Major, Moderate, or Minor. Note that only qualitative benefits were collected for the societal benefits categories of education or public safety, environmental, and human lives saved. No dollar values were estimated for these categories.

Finally, users were asked to provide some information about their access requirements for hydrography information. This section of the questionnaire was not MCA specific but rather was intended to capture information for a user's entire program.

The questionnaire was accompanied by a list of Frequently Asked Questions (FAQs) pertaining to some of the hydrography terms used throughout the questionnaire. Also within the questionnaire, hyperlinks were provided to the FAQs that defined some of the hydrographic and GIS concepts as well as national hydrography related datasets that were included as response options in the questionnaire. The FAQs are provided in Appendix G. A second tutorial also accompanied the questionnaire with examples of some of the types of benefits users might receive from improved hydrography information. It included methods for estimating financial benefits, which users were asked to estimate for each MCA. The Benefits Examples are provided in Appendix H.

Because the online questionnaire was administered to State and other respondents, OMB approval was required. The questionnaire was posted on the Federal Register on December 23, 2014. Minor changes to the questionnaire were made in response to OMB review comments. Final OMB approval (OMB Control Number 1028-0112) for the questionnaire was received on February 13, 2015. The online questionnaire was opened to users on February 17, 2015.

3.3 Outreach and Training

POCs at Federal agencies and each state were identified prior to launching the online questionnaire. Federal agency POCs were selected by the participating agencies. Letters of invitation were sent by Kevin Gallagher and William Werkheiser, USGS Associate Directors of Core Science Systems and Water Mission Area, respectively. Each letter briefly outlined the purpose of the study, expected roles for the POC, and invited the POC to a project kick-off meeting in December 2014.

For each state, one or more leaders in the water resources community were identified by USGS National Map Liaisons working with their local and state GIS coordination contacts. These state leaders were primarily GIS managers, leaders, and coordinators within state government. These individuals received a letter from the acting NGP director in January 2015 which briefly outlined the purpose of the study, expected roles for the POC, and invited the POC to a project kick-off meeting. The number of persons acting as POCs actually exceeded the number of states in that 13 states identified two or more people (RI and VT identified three each) to act as POCs.

Of the 67 state POCs representing 50 states plus the District of Columbia and territory of American Samoa, 58 came from state agencies, four from state geological surveys (ME, NH, NV, and SD), four from universities, and one from the private sector. Out of the 58 POCs from state agencies, about 30 percent came from Departments of Environmental Quality, 26 percent from Departments of Natural Resources, 17 percent from Departments of Water Resources, and the remainder split between GIS coordination groups (e.g. libraries) and miscellaneous agencies (such as economic, transportation).

Before launching the online questionnaire outreach and training was conducted to inform study POCs about the study and what to expect. In concert with USGS, Dewberry developed presentation materials for and conducted outreach workshops for the POCs and USGS National Map liaisons.

One workshop for Federal POCs was held in-person on December 11, 2014, at the Department of the Interior in Washington D.C. and online as needed. The workshop served to inform the POCs of the goals of the study, the process for collecting data from their agency responders, and expectations of the role they would play in the study. A second follow-up online workshop was held on January 13, 2015, for Federal POCs who were unable to attend the first workshop. Attendees at the Federal workshops are listed in Appendix I.

The Federal POC training included the following:

1. A summary of the goals and objectives of the project.

2. An overview of the responsibilities of the Federal POCs and how they were expected to coordinate with stakeholders and team members. The process for identifying respondents who did not or could not complete the questionnaire and providing alternate respondents was also covered. The Federal POCs were expected to fulfill the following roles:

    a. Provide an email list of Federal employees with hydrography data experience and needs to take the online questionnaire.
    b. Coordinate with any field staff to ensure their availability to participate in the online questionnaire.
    c. Follow up with identified respondents who did not complete the online questionnaire within two weeks.
    d. Provide alternate respondents if the original respondents were unable to participate in the online questionnaire.
    e. Review the summary reports of the online questionnaire results.
    f. Identify key managers and others to participate in the interviews.
    g. Assist with scheduling the interviews.
    h. Ensure key participants were prepared and available for the interviews.
    i. Assist with filling any remaining gaps in MCA data collection.
    j. Facilitate consensus among agency participants regarding consolidated MCAs.
    k. Review and approve the consolidated MCAs.

3. A review of the online questionnaire logistics including the questionnaire schedule and content. The questions were reviewed in detail along with examples of qualitative and quantitative benefits.

4. An overview of the interview logistics including a review of the pre-interview materials to be provided to the POCs and an explanation of any preparation required of the interviewees. The anticipated schedule for the interviews was also covered along with the format and questions likely to be asked during the interviews. Recommendations for determining the individuals that should be present for the interviews were also presented.

5. An overview of the post-interview approval process. The process used for consolidating the interview results and providing those results to the Federal POCs for review and approval that the results are accurately documented was described.

6. A review of the overall study schedule.

A separate state workshop was developed for the USGS National Map Liaisons to prepare them to orient the state and other agencies about the goals of the study and the process for collecting data from their respondents. The USGS National Map Liaison workshop was held December 4, 2014 by WebEx and conference call. The USGS National Map Liaison training included the following:

1. A summary of the goals and objectives of the project.

2. An overview of the types of state, regional, or local agency, or other hydrography users anticipated to participate in the study.

3. A review of the online questionnaire logistics including the questionnaire schedule and content. The questions were reviewed in detail along with examples of qualitative and quantitative benefits.

4. An overview of the interview/workshop logistics. Best practices for determining the individuals that should be present within the interviews were presented as well as suggestions for the format of the interviews or workshops, suggested interview tactics that could be used to gather benefits information during the interviews, and methods for building consensus.

5. An overview of the responsibilities of the USGS National Map Liaisons and how they were expected to coordinate with state POCs and team members. The process for identifying respondents who did not or could not complete the questionnaire and providing alternate respondents was also covered. The USGS National Map Liaisons and POCs were expected to fulfill the following roles:

    a. Provide an email list of state and other employees with hydrography data experience and needs to take the online questionnaire.
    b. Coordinate with any field staff to ensure their availability to participate in the online questionnaire.
    c. Follow up with identified study participants who did not complete the online questionnaire within two weeks.
    d. Provide alternate study participants if original participants were unable to complete the

online questionnaire.

e. Review summary reports of the online questionnaire responses.
f. Prioritize agencies for interview participation.
g. Identify key managers and others to participate in the interviews.
h. Schedule the interviews.
i. Conduct the interviews.
j. Ensure key participants were prepared and available for the interviews.
k. Work to fill any remaining gaps in MCA data collection.
l. Facilitate consensus among participants regarding consolidated MCAs.
m. Develop state narratives that describe the consolidated MCAs.
n. Review and approve the consolidated MCAs.
o. Provide the consolidated MCAs to USGS to be forwarded to Dewberry.

6. A review of the overall study schedule.

3.4 Online Questionnaire Administration

Dewberry administered the online questionnaire for the designated Federal, state, and other agencies using SurveyMonkey®. An email list of Federal POCs and state and other employees with hydrography data experience and needs was obtained from the Federal POCs and the USGS National Map Liaisons. Invitations were initially sent to 330 state participants and 37 Federal POCs.

The Federal POCs invited subject matter experts within their respective agencies to complete the online questionnaire. The state participants were each provided a user-specific link to the questionnaire. The questionnaire responses were tracked to identify any agencies with insufficient participation so that alternate questionnaire respondents could be sought from the Federal POCs or the USGS National Map Liaisons as appropriate. As state participants dropped out or were replaced, new links to the questionnaire were sent out. A total of 376 state participants were ultimately invited to participate in the online questionnaire process.

A total of 577 MCAs were originally reported by 501 initial respondents. Of these, 228 MCAs were submitted by 202 individuals in 23 Federal agencies and 349 MCAs were submitted by 299 individuals in 50 states plus American Samoa and the District of Columbia.

Along with the questionnaire responses, when the pre-defined areas of interest (i.e., states, Federal lands, HUC2s, and HUC4s) did not apply, respondents had the option of defining and submitting their own geospatial area of interest via FTP. Eleven user-provided Shapefiles were submitted. User-defined areas of interest that were submitted via FTP were downloaded and inserted into the study database and associated with the corresponding questionnaire response.

3.5 Raw Study Geodatabase

Dewberry designed and developed a schema for a file geodatabase to store the raw questionnaire responses as well as consolidated MCA hydrography requirements. The geodatabase schema was designed in conjunction with the questionnaire and keeping in mind the need to support aggregation of responses in multiple ways (e.g., by geography, agency, requirements, Business Use, etc.), analysis of the most significant requirements, production of summary reports, and development of future analysis tools. A data dictionary and Entity Relationship (ER) diagram for the raw study geodatabase is included in Appendix J.

All questionnaire responses are included in the geodatabase schema. Each response is linked to its spatial footprint. Standard polygons for spatial features such as states, counties, and selected Federal lands were derived from USGS small scale datasets, and HUCs were derived from the WBD. Non-standard user defined polygons are also supported. Domains have been established for all responses for which check boxes or drop downs were employed in the questionnaire. Non-spatial relational tables are included in the schema as necessary to support many-to-one relationships (i.e. where more than one response is allowed in the questionnaire). Database linkages to relational tables are enforced. The geodatabase includes metadata for each feature class and table.

Using the schema and domains defined for the geodatabase, the online questionnaire data were populated into the geodatabase. Each questionnaire response was tied to the spatial area of interest for that MCA. Where areas of interest were defined using drop down lists (e.g., nationwide, state, county, HUC) the questionnaire response was tied to a polygon for that feature derived from the USGS small scale datasets and/or the WBD. If a non-standard user-defined polygon was chosen and submitted, that polygon was imported into the geodatabase and the questionnaire response was associated with it. Additional user-defined areas of interest were also delineated as necessary using area descriptions provided by questionnaire respondents (e.g., specific counties or all HUC8s that intersect a state).

3.6 Identify Federal Agencies with Most Significant Requirements

Based on the initial questionnaire responses, the Federal agencies with the most significant hydrography data requirements and benefits were identified for further review. USGS originally planned to select 12 Federal agencies to interview in person. However, upon review of the online questionnaire results, USGS determined that 21 of the 23 Federal agencies that responded to the online questionnaire should be interviewed. The WAPA was selected to represent the four U.S. power administrations, consolidating responses received from three of the four power administrations.

3.7 Draft Summary Reports

Using the raw study geodatabase, Dewberry prepared summary reports of the online questionnaire results for each of the Federal agencies, states, and associations. These summary reports were provided to the Federal agency POCs and to the USGS National Map Liaisons in preparation for conducting the follow up in-person interviews/workshops.

The draft summary reports were prepared as MicroSoft® Excel workbooks, with a series of tabs as follows.

1. A summary of all of the MCAs submitted for that agency or state with the key requirements and the current and future benefits for each MCA.
2. A summary of the required MCA characteristics, giving a tabulation of the number of MCAs that reported each requirement.

3. A summary of the non-MCA specific requirements with a tabulation of the number of respondents who reported each requirement.
4. A tab for each MCA, with a map showing the area of interest for the MCA and all of the details of the requirements and benefits for that MCA.

Macros were embedded in the draft summary report workbooks such that when the reports were used during the interview/workshop process, any updates that were made would be highlighted so that the changes could be imported into the study geodatabase. Additionally, the summary tabs and the MCA tabs were linked such that when updates were made in one tab they propagated to the linked tab(s).

3.8 Interviews/Workshops

Dewberry scheduled and conducted in-person or online interviews with key managers and hydrography data users from each of the 21 selected Federal agencies. A listing of the Federal agencies and their interview dates is included in Appendix K. In parallel, USGS National Map Liaisons and State POCs conducted similar interviews or workshops with state and other hydrography users.

The interviews served to do the following:

- Validate the questionnaire responses;
- Fill any questionnaire gaps;
- Consolidate duplicate or similar MCAs within an agency or organization;
- Summarize Federal agency or state hydrography data requirements;
- Validate and quantify the benefits of current and enhanced hydrography data; and
- Document Federal budget authorizations associated with the MCAs.

The interviews with the Federal agencies were auto-recorded. The interviews resulted in a consolidated set of MCAs, each with clear requirements and benefits, for each Federal agency, state, and association.

3.9 Summary Reports

At the conclusion of the interview process, Dewberry prepared a summary report for each of the Federal agencies, states, and associations. These summary reports were provided to the Federal agency POCs and to the USGS National Map Liaisons for review and confirmation that the information contained therein was accurately documented.

The Federal summary reports, which can be found in Appendix B, include the following sections.

- A narrative describing the agency's mission, its use of hydrography data, a summary of the agency's hydrography data requirements and benefits, and a listing of the agency's MCAs.
- A consolidated agency-wide summary of the non-MCA specific hydrography data access requirements.
- A detailed description of each MCA including a map showing the area of interest for the MCA and all of the details of the reported requirements and benefits for that MCA.

The State and association summary reports, which can be found in Appendix C (states) and Appendix D (associations), include the following sections.

- A narrative summarizing the use of hydrography data by the entities represented by the state or association respondents, along with a summary of their hydrography data requirements and benefits.
- A consolidated state-wide or association summary of the non-MCA specific hydrography data access requirements.
- A detailed description of each MCA including a map showing the area of interest for the MCA and all of the details of the reported requirements and benefits for that MCA.

3.10 Confirmation of Study Data

Each Federal agency POC and state POC was requested to validate the documented results of the questionnaire and interview process as documented in the summary reports. Confirmation was provided in emails and captured in a study project file that was delivered to USGS.

3.11 Key Federal Authorizations

Based on the information provided by the 21 Federal agencies included in this study, at least $11.6 billion in Federal annual funding is associated with programs that rely heavily on hydrography data. A summary of the key Federal authorizations associated with each MCA is provided in Appendix L.

3.12 Final Study Geodatabase

Consolidated and validated MCAs were recorded in the final study geodatabase such that there is only one record per MCA containing the validated and approved information about that MCA from the submitting entity. Each MCA is tied to its spatial area of interest and the geodatabase includes tabular information about the requirements and benefits for each MCA. The geodatabase is compatible with Esri ArcGIS version 10.2 and is accompanied by FGDC-compliant metadata.

The schema for the final study geodatabase is similar to that of the raw study geodatabase. However, an additional table was added to contain the consolidated agency- or state-wide hydrography access information. And the database schema was simplified slightly for future ease of use. A data dictionary and ER diagram for the final study geodatabase is included in Appendix M.

3.13 Study Report

This report documents the results of the HRBS. Information presented in the maps and tables included in this report was derived from the final study geodatabase. These data were collected in the online study questionnaire and refined during the interviews/workshops conducted with study participants.

All of the information presented in this report was derived from the study geodatabases (raw and final) along with information provided in the Federal, state, and association summary reports. Additional state comments that were collected during the interview/workshop process were provided by the USGS National Map Liaisons and these comments provided additional insights into study participants' hydrography data requirements and benefits.

In tables that report number of MCAs, totals broken down by Federal agencies, state government agencies, and other entities are reported along with the overall totals. This allows the responses that cover generally larger geographic areas represented by a smaller number of Federal agencies and the requirements that generally cover smaller but more numerous state and local geographic areas to be reported separately.

Six Federal agencies provided overall program budgets for programs supported by hydrography data but were unable to allocate portions of the overall budget to their individual MCAs. Where this was the case, the overall program budget was divided evenly between the applicable MCAs. This allowed program budgets to be summed by MCA, by agency, or by Business Use. However, it also means that because these program budgets were arbitrarily subdivided, they may over- or under-estimate the actual program budget supported by the individual MCA.

Similarly, one state government agency and four local agencies provided overall program budgets and/or benefits that applied to several MCAs. Again, where this was the case the program budget and/or benefits were divided evenly between the applicable MCAs.

For the maps that are included in this report, the classification of the data shown on the maps was established as follows. For the maps that show the numbers of MCAs per area of interest or HUC8 area, the five map classes were set using an equal interval. The interval values were set based on dividing the maximum number of MCAs that spatially overlap for each map scenario into equal intervals. For the maps that show the future annual estimated dollar benefits per square mile, the five map classes were set using natural breaks. For the series of maps that show future annual estimated dollar benefits by Business Use, the complete dataset containing all Business Uses was used to establish the classes so that for all maps in the series, the same color would represent the same dollar value range.

In several sections of this report, weighted averages were used to rank study results. The weights (shown in Table 8 below) were applied as follows.

Table 8. Weighted values used for ranking study results

Qualitative Benefit	Requirement	Importance	Weight
Major	Required	Critically Impactful	5
Moderate	Highly Desirable	Highly Impactful	3
Minor	Nice to Have	Somewhat Impactful	1
Don’t Know / Not Applicable / No response	Not Required / Don’t Know / No response	Little or No Impact / No response	0

4.0 Study Results

This section provides a summary of some of the key findings of the Hydrography Requirements and Benefits Study. Details of the study data can be found in the summary reports provided in Appendixes B, C, and D and in the final study geodatabase.

4.1 Study Participation

Study participants were selected by the Federal POCs, state POCs, and the USGS National Map Liaisons. The POCs were asked to select individuals who use hydrography data to address business needs. Once the online questionnaires were completed, the POCs were asked to ensure that key managers were available to participate in the interviews/workshops in order to validate budget and benefits estimates. Additionally, the POCs were invited to include additional participation to fill any gaps in responses during the interviews/workshops.

A total of 577 MCAs (Table 9 below) were originally reported by 501 initial respondents to the online questionnaire.

Table 9. Breakdown of organizational types for initial respondents to the online questionnaire

Organization Type	Number of MCAs	Percent of MCAs
Federal Agencies and Commissions	228	40%
Not for Profit	25	4%
Private or Commercial	15	3%
Regional, County, City or Other Local Government	65	11%
State Government	234	41%
Tribal Government	10	2%
Total	577	100%

After consolidation, detailed responses in the form of 420 MCAs were provided from 21 Federal agencies, all 50 states plus American Samoa and Washington D.C., 53 local and regional government organizations, eight Tribal governments, 14 private companies, four nation-wide associations with national scope, and 20 other Not for Profit entities.

The vast majority (90 percent) of the MCAs were provided by government agencies (Federal, state, regional, county, city, local, and Tribal). A total of 25 MCAs (6 percent) were provided by Not for Profit entities. A total of 16 (4 percent) MCAs were provided by private or commercial entities. However, the private or commercial entities were primarily contractors to state government agencies. There was little or no representation of large-scale private entities such as the oil and gas industry, major utilities, or agribusiness. It should be noted that these unrepresented private entities are likely to also make use of national hydrography datasets, have requirements for hydrography data enhancements, and are likely to receive potentially significant but undocumented annual benefits from future enhanced hydrography datasets.

Table 10 on the next page shows a breakdown of the study participation by organization type. Tables 11 – 14 that follow list the participating Federal agencies, states and territories, Tribes, and associations. Full details of all participating entities can be found in the summary reports for the Federal agencies, states, and associations found in Appendixes B, C, and D.

Table 10. Breakdown of study participation by organization type

Organization Type	Number of Agencies/ Entities	Number of MCAs	Percent of MCAs per Organization Type
Federal Agencies and Commissions	21	54	13%
Not for Profit	24	25	6%
Private or Commercial	14	16	4%
Regional, County, City or Other Local Government	53	80	19%
State Government	183	237	56%
Tribal Government	8	8	2%
Total	303	420	100%

Table 11 below shows the breakdown of the 54 Federal agency MCAs submitted by the 21 participating Federal agencies.

Table 11. Breakdown of the 54 MCAs submitted by the Federal agencies

Agency Name	Number of MCAs
Agricultural Research Service (ARS)	3
Animal and Plant Health Inspection Service (APHIS)	5
Bureau of Land Management (BLM)	1
Bureau of Ocean Energy Management (BOEM)	1
Bureau of Reclamation (USBR)	4
Environmental Protection Agency (EPA)	5
Farm Service Agency (FSA)	1
Federal Emergency Management Agency (FEMA)	1
Federal Energy Regulatory Commission (FERC)	2
International Joint Commission (IJC)	1
National Oceanic and Atmospheric Administration (NOAA)	3
National Park Service (NPS)	1
Natural Resources Conservation Service (NRCS)	3
Nuclear Regulatory Commission (NRC)	1
Office of Surface Mining Reclamation and Enforcement (OSMRE)	1
U.S. Army Corps of Engineers (USACE)	3
U.S. Census Bureau (USCB)	1
U.S. Fish and Wildlife Service (USFWS)	4
U.S. Forest Service (USFS)	2
U.S. Geological Survey (USGS)	9
Western Area Power Administration (WAPA)	2
Total	54

Table 12 on the next page shows a summary of the MCAs submitted by state government; regional, county, city, or other local government; private or commercial; and not for profit entities by state. Note that the eight Tribal governments and four associations are listed separately.

Table 12. Summary of MCAs by state

State	Number of State Gov't. MCAs	Number of Regional, County, City, or Other Local Gov't. MCAs	Number of Private or Commercial MCAs	Number of Not for Profit MCAs (Minus Associations)	Total Number of MCAs per State
Alabama	5	2	0	2	9
Alaska	7	0	0	2	9
American Samoa	0	1	0	0	1
Arizona	2	1	0	0	3
Arkansas	6	0	2	0	8
California	3	5	0	2	10
Colorado	5	0	0	0	5
Connecticut	7	0	0	0	7
Delaware	3	0	0	0	3
Florida	3	3	0	1	7
Georgia	4	2	1	0	7
Hawai'i	1	1	0	1	3
Idaho	2	1	1	0	4
Illinois	3	1	2	0	6
Indiana	6	0	0	0	6
Iowa	2	1	1	1	5
Kansas	7	0	0	0	7
Kentucky	2	0	0	0	2
Louisiana	5	0	0	2	7
Maine	7	1	0	0	8
Maryland	3	0	0	0	3
Massachusetts	4	1	0	0	5
Michigan	4	2	0	0	6
Minnesota	8	3	0	0	11
Mississippi	5	2	1	0	8
Missouri	5	4	0	0	9
Montana	4	2	0	0	6
Nebraska	2	1	0	0	3
Nevada	3	1	1	0	5
New Hampshire	5	1	0	1	7
New Jersey	8	0	0	0	8
New Mexico	6	0	2	2	10
New York	7	2	3	0	12
North Carolina	7	5	0	0	12
North Dakota	2	0	0	0	2
Ohio	7	15	0	0	22
Oklahoma	10	0	1	0	11
Oregon	5	1	0	0	6

State	Number of State Gov't. MCAs	Number of Regional, County, City, or Other Local Gov't. MCAs	Number of Private or Commercial MCAs	Number of Not for Profit MCAs (Minus Associations)	Total Number of MCAs per State
Pennsylvania	6	4	0	3	13
Rhode Island	5	0	0	0	5
South Carolina	3	2	0	0	5
South Dakota	6	4	0	0	10
Tennessee	2	7	0	0	9
Texas	8	0	0	0	8
Utah	6	0	0	1	7
Vermont	3	0	0	1	4
Virginia	5	0	0	0	5
Washington	5	1	0	0	6
Washington D.C.	1	2	0	0	3
West Virginia	4	0	0	1	5
Wisconsin	3	1	0	1	5
Wyoming	5	0	1	0	6
Total	237	80	16	21	354

Table 13 below shows the eight Tribal governments that submitted MCAs:

Table 13. Summary of the Tribal governments that submitted MCAs

Tribe Name	State	Number of MCAs per Tribe
Bishop Paiute Tribe	CA	1
Fallon Paiute-Shoshone Tribe	NV	1
Fort Peck Assiniboine & Sioux Tribes	MT	1
Lac Courte Oreilles	WI	1
Lac du Flambeau Band of Lake Superior Indians	WI	1
Oglala Sioux	SD	1
Penobscot Nation	ME	1
The Seminole Tribe of Florida	FL	1
Total		8

Table 14 below shows the four associations that submitted MCAs:

Table 14. Summary of the associations that submitted MCAs.

Association Name	Number of MCAs per Association
Association of State Floodplain Managers (ASFPM)	1
Ducks Unlimited, Inc. (DU)	1
The Nature Conservancy (TNC)	1
Trout Unlimited (TU)	1
Total	4

4.2 Mission Critical Activities (MCAs)

Study participants were asked to describe in their own words their MCAs. Because the MCAs were self-described and titled, there was a wide variety among the MCAs. Some MCAs were described in terms of the respondent's agency's organization, some in terms of their daily activities. Some MCAs were very broad and encompassed multiple Business Uses and some were quite narrowly defined.

As noted above, after consolidation of the data during the follow on interviews/workshops and validation process, 420 MCAs were described. In general, the Federal agencies were found to have had multiple questionnaire respondents who described the same or very similar MCAs, in many cases coming from varying regional perspectives. During the consolidation process, these MCAs were combined such that the MCAs for each agency were unique. On the other hand, during the state interview/workshop process, 26 new MCAs were identified that had not been originally captured by the respondents to the questionnaire. These new MCAs were added to fill gaps in information provided by the states. Nine state MCAs that were initially reported in the online questionnaire were dropped because there was not enough information provided or there was duplication of information.

As noted previously, study respondents were asked to identify the geographic area requirements for each MCA. Maps depicting the area of interest for each MCA are included in Appendixes B, C, and D. Figure 16 below shows the distribution of the spatial extents of all 420 MCAs aggregated by HUC8 areas. Areas with darker colors have greater numbers of areas of interest.

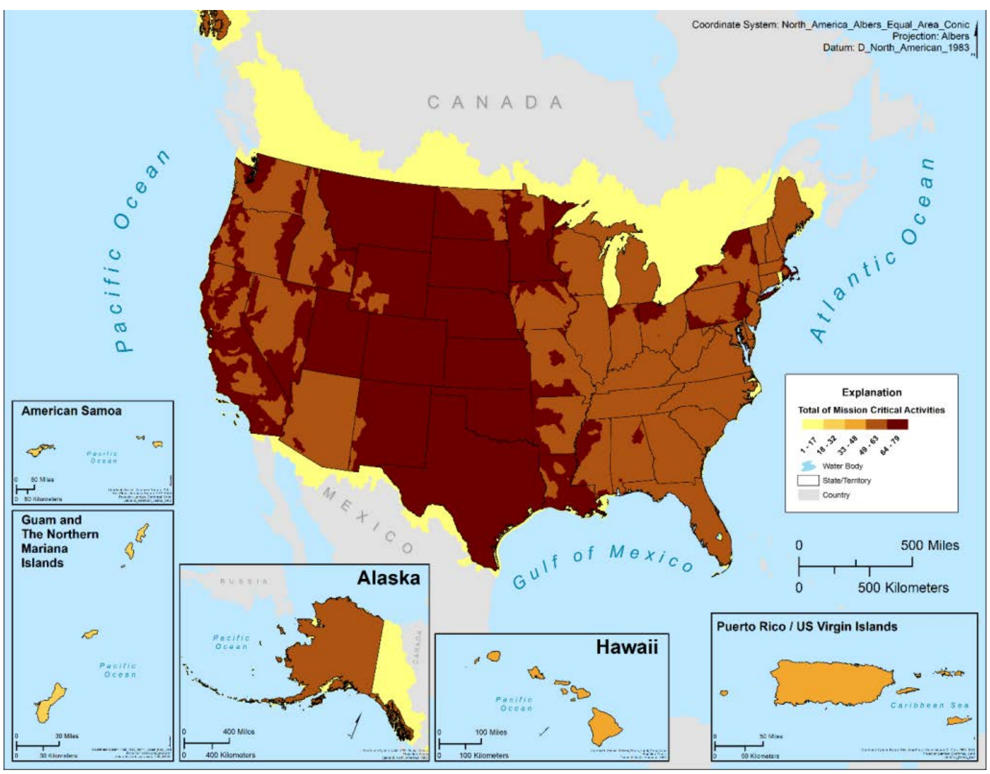

Figure 16. Distribution of spatial extents of all 420 MCAs aggregated by HUC8 areas

Study participants were requested to assign one (or more) of 25 pre-defined Business Uses to each MCA, in addition to providing an MCA title and description. The Business Uses are described in Section 4.3 and in Appendix E.

4.3 Business Uses

This section provides a summary of the 25 Business Uses included in this study. Complete details of the Business Uses can be found in Appendix E. Appendixes B, C, and D include full details of the MCAs including how respondents categorized the Business Use of each MCA.

Table 15 below shows the breakdown of the 420 MCAs by Business Use. The table is ranked by the total number of MCAs per Business Use as highlighted in light gray. The top six Business Uses by overall number of MCAs, Water Quality, Water Resource Planning and Management, Flood Risk Management, River and Stream Flow Management, Natural Resources Conservation, and River and Stream Ecosystem Management account for approximately 75 percent of the MCAs.

Table 15. Breakdown of MCAs by Business Use ranked by number of MCAs

BU Number	Business Use	Number of Federal Gov't. MCAs (of 54)	Percent of Federal Gov't. MCAs	Number of State Gov't. MCAs (of 237)	Percent of State Gov't. MCAs	Number of Other Organization Type MCAs (of 129)	Percent of Other Organization Type MCAs	Total Number of MCAs (of 420)	Percent of MCAs
4	Water Quality	6	11%	52	22%	21	16%	79	19%
3	Water Resource Planning and Management	4	7%	46	19%	19	15%	69	16%
15	Flood Risk Management	6	11%	22	9%	26	20%	54	13%
1	River and Stream Flow Management	7	13%	20	8%	17	13%	44	10%
2	Natural Resources Conservation	8	15%	16	7%	10	8%	34	8%
5	River and Stream Ecosystem Management	5	9%	24	10%	5	4%	34	8%
20	Infrastructure and Construction Management	0	0%	12	5%	6	5%	18	4%
21	Urban and Regional Planning	1	2%	5	2%	11	9%	17	4%
10	Agriculture and Precision Farming	2	4%	3	1%	4	3%	9	2%
24	Education K-12 and Beyond	0	0%	6	3%	3	2%	9	2%
6	Coastal Zone Management	0	0%	5	2%	3	2%	8	2%
9	Wildlife and Habitat Management	2	4%	5	2%	1	1%	8	2%

BU Number	Business Use	Number of Federal Gov't. MCAs (of 54)	Percent of Federal Gov't. MCAs	Number of State Gov't. MCAs (of 237)	Percent of State Gov't. MCAs	Number of Other Organization Type MCAs (of 129)	Percent of Other Organization Type MCAs	Total Number of MCAs (of 420)	Percent of MCAs
18	Homeland Security, Law Enforcement, and Disaster Response	1	2%	5	2%	1	1%	7	2%
7	Forest Resources Management	1	2%	4	2%	0	0%	5	1%
22	Health and Human Services	3	6%	1	0%	0	0%	4	1%
11	Geologic Resource Assessment and Hazard Mitigation	0	0%	3	1%	0	0%	3	1%
13	Renewable Energy Resources	3	6%	0	0%	0	0%	3	1%
14	Oil and Gas Resources	1	2%	2	1%	0	0%	3	1%
19	Marine and Riverine Navigation Safety	2	4%	1	0%	0	0%	3	1%
25	Recreation	0	0%	2	1%	1	1%	3	1%
12	Resource Mining	1	2%	0	0%	1	1%	2	0%
16	Sea Level Rise and Subsidence	0	0%	2	1%	0	0%	2	0%
8	Rangeland Management	1	2%	0	0%	0	0%	1	0%
17	Wildfire Management, Planning, and Response	0	0%	1	0%	0	0%	1	0%
23	Real Estate, Banking, Mortgage, and Insurance	0	0%	0	0%	0	0%	0	0%
		54	100%	237	100%	129	100%	420	100%

Since study participants were asked to describe their MCA in their own words and to assign a Business Use to each, there was a wide variety among how the Business Uses were assigned to the MCAs. Some Business Uses were interpreted broadly and multiple types of activities were associated with them. Others were more narrowly interpreted. Water Quality and Flood Risk Management were among the more consistently applied Business Uses. Of the 79 MCAs assigned to BU #4 Water Quality, most of the MCA descriptions included some aspect of water quality or clean water. However, BU #4 Water Quality also included MCA descriptions such as Environmental Protection, Flooding, Watershed Analysis, Habitat Conservation, Public Health, Stormwater Management, Transportation Planning, and Watershed Management. Of the 54 MCAs assigned to BU #15 Flood Risk Management, again, most MCA descriptions included an aspect of flood hazard, flood risk, or flood management; several more involved dam safety or H&H modeling. However, BU #15 Flood Risk Management also included MCA descriptions such as Stormwater Management, Water Supply Protection, Emergency Management, Water Supply Protection, and Watershed Protection. BU #1 River and Stream Flow Management, BU #2 Natural Resources

Conservation, BU #3 Water Resource Planning and Management, and BU #5 River and Stream Ecosystem Management had the widest variety of MCA descriptions ascribed to them.

While the requirements and the benefits assigned to specific MCAs would not be duplicated or biased due to the way they were aggregated into Business Uses, the reader is cautioned to understand the inherent flaws associated with any consolidation of this information. Likewise, specific user requirements may require more detailed analysis of the study geodatabase to understand the full need or value of fully meeting a particular need.

The geographic distribution of the Business Uses is portrayed in maps for each Business Use included in Appendix E. Note that it is likely that most states and many county or local entities have additional MCAs and Business Uses that were not reported for this study. Since the representation of state and local agencies varied across states and the Business Uses were self-selected, it is likely that additional areas across the U.S. would have an interest in one or more of the Business Uses than what is currently described or reflected in the study data.

Business Use benefits are summarized in Table 35 in Section 4.6 and Table 39 in Section 5.6.

4.4 Data Use

This section summarizes how hydrography data are being used by study participants to support the 25 Business Uses. The information contained in this section came primarily from study respondents, either in the form of comments provided in the study geodatabase, the narratives provided for each Federal agency and state, and supplemental comments compiled by the USGS National Map liaisons. Some additional information came from Federal agency websites.

4.4.1 BU #1 River and Stream Flow Management

River and stream flow management includes management of stormwater runoff. Stormwater runoff is the result of rain or snowmelt flowing over the surface of the land. Impervious surfaces prevent runoff from soaking into the ground. As stormwater runoff is carried to streams, lakes, wetlands, and rivers it can cause flooding and erosion, and wash away critical habitat areas. Stormwater runoff also carries with it pollutants found on the surfaces it crosses, including sediment, nitrogen, phosphorus, bacteria, oil and grease, trash, pesticides, and metals. In response to the Clean Water Act, many communities have adopted stormwater management regulations and best management practices. Hydrography data are used to model runoff, identify impaired waterbodies, monitor stormwater management practices, and assess the results of said practices.

Local resolution hydrography data are used to model runoff from pervious and impervious surfaces including rooftops which collect a lot of stormwater. Stormwater monitoring needs also involve proper siting of Best Management Practices (BMPs) such as rooftop gardens, bioretention, and other green infrastructure practices including riparian buffers to mitigate the runoff. BMPs support the goals of improving impaired waterbodies (such as the Chesapeake Bay) by improving the water clarity and overall health of the waterbody, as well as goals for improving local water quality in the contributing watersheds.

4.4.2 BU #2 Natural Resources Conservation

Natural resources conservation includes preserving the health of soil and vegetation, minimizing soil erosion and runoff into streams, and preserving wetlands. Many Federal and state agencies and nongovernmental organizations are responsible for natural resources conservation.

Hydrography datasets are used in conjunction with other data including orthoimagery, Common Land Unit (CLU) boundaries (farm and field boundaries), soils data, wetlands, flood zones, NOAA weather services, and impaired waters datasets to identify conservation priority areas. These priority areas may be identified by Federal, state, or local agencies. They include riparian areas that contribute to wetland restoration, stormwater management, erosion reduction, stream rehabilitation, and reduced nitrogen loading; specific targeted or endangered species areas (e.g., sage grouse, nesting ducks, etc.); areas that recharge underground aquifers; and areas that would increase wildlife and recreational activities.

The management of the U.S. Coastal Barrier Resources System requires the use of hydrography data to help manage the identification and mapping of coastal areas in which Federal expenditures and incentives (including flood insurance) are restricted in order to encourage conservation of these coastal barriers.

An estimated 46 percent of endangered or threatened species are associated with wetlands. The National Wetlands Inventory (NWI) was established by the USFWS to conduct a nationwide inventory of U.S. wetlands to provide biologists and others with information on the distribution and type of wetlands to aid in conservation efforts. Hydrography data are one of three primary parameters used to identify and map wetland habitats for the NWI. And wetlands data were reported as the third most frequently requested data type for integration with hydrography data and one of the most frequently required characteristic of enhanced hydrography data.

4.4.3 BU #3 Water Resource Planning and Management

Water resource planning and management includes ensuring the availability of water where and when required and ensuring that drinking water is safe. Many Federal and state agencies and nongovernmental organizations are responsible for water resource planning and management.

Hydrography data are used to develop water availability assessments that describe components of the water budget including consumptive use from irrigated agricultural lands, diversion-point locations, and their impact throughout the network including river depletion. These information products are then delivered to those with a need for information to inform a decision related to water availability and use.

Groundwater is another important component to studying water availability. Groundwater and coupled groundwater/surface-water modeling studies are used to assess and manage groundwater and surface water. Groundwater pumpage impacts on surface water, and losing stream contributions to groundwater are two critical considerations when using a water budget approach to estimate water availability. Information that facilitates the connection between surface water and groundwater information and models is critical to understanding these interactions. Understanding how surface water can inform critical groundwater recharge and management is of critical importance during prolonged drought.

In spring 2015, a 5-year drought in Oklahoma ended abruptly when the state experienced historic levels of rainfall. Together, the drought and the significant flooding that followed illustrate two of the major uses for water-related data: management of water supply to protect against future droughts, and to better predict areas of potential flooding. In addition, states need to ensure adequate water quality as well as quantity for growing populations to include the planning of rural water supply systems

4.4.4 BU #4 Water Quality

Recent EPA guidance requires states to prioritize watersheds for multiple Safe Drinking Water Act and Clean Water Act programs. Hydrography data coupled with water quality data are used to characterize waters, identify trends over time, identify emerging problems, determine whether pollution control programs are working, help direct pollution control efforts to where they are most needed, and respond to emergencies such as floods and spills. Watershed level data used for prioritization are based on hydrology and landscape condition. Indicators of ecological condition, stressors, and social aspects are compiled and aggregated by WBD HUC12s. Indicators are derived from hydrology, land cover, transportation, and use other related NHDPlus products.

Hydrography data are also used to support other water quality activities such as effluent permitting, drinking water protection, underground injection control, watershed protection, wetlands protection and mitigation, and enforcement and inspections authorized by the Clean Water Act and its implementing regulations. Without the current NHD these activities would not be possible. River reach addresses are used as the central index key for water quality and pollutant source locations. USGS, EPA, and USDA all share water quality monitoring data, and the NHD is the common modeling backbone used by these agencies (and others) to share data and see results.

State and local agencies use hydrography data to perform their regulatory activities including enacting water quality standards, generating required EPA reports, remediation, understanding environmental quality for species of concern, and understanding the quality of drinking water and wetland environments. Modeling point source and nonpoint source pollution of water and designing appropriate pollution control and environmental cleanup strategies (e.g. Total Maximum Daily Load [TMDL] program) require robust hydrography and related datasets.

Hydrography data are used throughout the lifecycle of a nuclear facility for licensing, regulation during operations, license amendments, and facility decommissioning. Because of the potential hazard of nuclear materials, extensive analysis of nuclear facility sites is performed to include use of hydrography and other data for flood risk analysis; riverine and coastal flooding such as tsunami, storm surge and wave run-up modeling; erosion modeling; radionuclide transport pathway analysis; rainfall-runoff modelling; and ground-water assessments. Hydrography data are used in conjunction with high-water marks, nearshore and offshore bathymetry, water intake locations, wetlands, gage locations, soil and water chemistry, and precipitation data for these and other analyses.

4.4.5 BU #5 River and Stream Ecosystem Management

River and stream ecosystem management focuses on aquatic habitat management, to include fisheries. Federal agencies, associations, and state and local government all have responsibilities for aquatic habitat management. Aquatic habitat relies on properly functioning stream channels that facilitate channel and flow stability and good water quality.

Hydrography data are a key component of aquatic habitat conservation planning, science, and restoration. Hydrography datasets are used to make high-resolution stream maps describing freshwater resources and fish habitat distribution; to quantify the pattern of those resources within jurisdictions including counties, states, national forest boundaries, and other public lands; to identify important conservation and restoration opportunities based on key stream attributes such as periodicity (perennial vs. intermittent), stream flow, stream order, and slope; for conducting hydrological and stream connectivity modelling; and for performing scientific research related to the habitat requirements and distributional patterns of fish species such as trout and salmon.

Hydrography data are also used for inventorying fish passage barriers; planning, designing and installing fish passage to restore anadromous fisheries; for various activities aimed at improving stream connectivity and protection and restoration of riparian buffers in order to support fish and wildlife management; and for tracking of aquatic invasive species in freshwater lakes, ponds, rivers and streams.

4.4.6 BU #6 Coastal Zone Management

Coastal zone management ensures that America's coastal zones sustain economic, recreational and subsistence activities and their other beneficial functions. NOAA works in partnership with multiple Federal agencies (USACE, USGS, and U.S. Navy) to solve common coastal mapping needs. Shoreline mapping activities typically require local scale hydrography data for detailed coastal zone management activities.

Coastal protection and restoration involves the modeling of coastal and inland hydrologic processes to understand the impacts of human activities and natural occurrences in order to develop alternative restoration scenarios and further coastal sustainability. These programs use hydrography data along with gage data (including real-time), bathymetry data, and water quality data for coastal modeling and analysis.

4.4.7 BU #7 Forest Resources Management

Forest land management programs involve conducting forest inventories, management of forest resources, watershed protection, flood calculation, bridge design, maintenance of aquatic passage, water diversion upgrades, stream and wetland restoration, riparian management, stream and habitat surveys, watershed condition classification, water quality monitoring, protection of drinking water sources, grazing management, and recreational facility/management, among other activities. Hydrography data including accurate locations of watersheds, streams, lakes, wetlands, seeps, springs and other water resources features are needed for all of these activities.

4.4.8 BU #8 Rangeland Management

Rangeland management entails ensuring that America's rangelands are managed and sustained for their beneficial functions. BLM and NRCS serve as champions for this Business Use on Federal and private lands respectively. BLM provides permits that allow ranchers to graze their livestock on public lands. BLM uses some of the money obtained from selling permits for rangeland improvements. BLM may also require permit holders to make improvements and/or to counter the impacts from grazing. Impacts can include erosion, which can impact streams and other water bodies and water pollution from runoff, which can include animal waste. Hydrography data and analyses performed using them directly inform how Federal rangelands are managed.

NRCS works with private landowners through conservation planning and assistance to protect and improve the water quality and quantity, wildlife and fish habitat, recreational opportunities, aesthetic character, agricultural operations, and sustainable agricultural practices on their lands. NRCS provides technical and financial assistance to producers who implement conservation practices and management strategies, including the restoration and protection of wetlands that benefit water quality and improve water management. Hydrography data are used in concert with numerous other datasets to include lidar data, high resolution imagery, farm field boundaries, land use, and soils inventories to support modeling and analysis as well as the preparation of cartographic products. Hydrography data are also invaluable for post-disaster operations to clear debris from waterways before it causes flooding.

4.4.9 BU #9 Wildlife and Habitat Management

Unlike BU #5 which focuses on aquatic habitat management, BU # 9 focuses on sustaining the economic, recreational, and subsistence activities of land-based wildlife habitats, including migratory birds. Federal agencies, associations, and state and local government all have responsibilities for wildlife and habitat management.

The National Wildlife Refuge System includes Refuges as well as small wetlands and other special management areas. Hydrography data are used in conjunction with property boundaries and ownership lines to map Refuges and to assess water supply and quantity within the Refuges.

In some parts of the U.S., over 90 percent of the original wetlands were drained. This was done though changing the hydrology of the landscape (mostly through installation of drain tiles or agricultural ditches). Understanding the hydrology at the regional, watershed, and site specific scales is extremely important for planning wetland conservation and restoration activities. At the watershed scale, hydrography data are used to estimate flow, accumulation, and benefits for restoration activities. At the site specific scale, local resolution hydrography data are needed to plan the restoration activities (where to place ditch plugs, berms, etc.).

Other wildlife and habitat management activities that rely on accurate hydrography and water quality data include identification and prioritization of endangered species' habitats as well as protection and restoration of riparian buffers in order to support fish and wildlife and reduce flood impacts.

4.4.10 BU # 10 Agriculture and Precision Farming

USDA, through several agencies including NRCS, FSA, ARS, and APHIS promotes technologies that reduce agricultural costs, increase agricultural productivity and efficiency, and/or reduce environmental impacts.

Seventy percent of the land in the U.S. is privately owned, making stewardship by private landowners absolutely critical to the health of our nation's environment. Working at the local level, in field offices at over 3,000 USDA Service Centers in nearly every county in the nation, NRCS works with landowners through conservation planning and assistance to benefit the soil, water, air, plants, and animals for productive lands and healthy ecosystems. NRCS is continually developing new tools to, among other things, improve current conservation practice technology; improve models to track nutrients; improve snowmelt prediction capabilities; and improve irrigation efficiency so that agricultural producers can more efficiently use water, increase water storage, and protect water quality by minimizing the potential loss of sediment and nutrients from their operations by applying science based conservation practices. Hydrography data are used in concert with numerous other datasets to include lidar data, high resolution imagery, farm field boundaries, land use, and soils inventories to help agricultural landowners manage their lands more efficiently and decrease negative impacts of farming practices on the environment.

Hydrography data are also used in risk assessment and disaster recovery programs to identify major crops within flood hazard areas, identify post-flood areas for debris removal, restore fences, and help restore land to production after an event. Stream channels are also used for future disaster estimates and mitigation plans.

Farming systems that use new technology to allow a closer, more site-specific management of the factors affecting crop production and farm run-off are known as Precision Agriculture (Precision Ag). Although the USDA promotes new agricultural technologies, the implementation of Precision Ag is largely left to the private sector. Note that private sector Precision Ag companies were not included in this study.

Precision Ag farming methods require detailed knowledge of site-specific application of seed, fertilizer, lime, pesticides, and resulting farm yields. This also includes knowledge of soil type, soil wetness, drainage and topographic variations within farm fields that can affect crop yield. Without such site-specific methods, the uniform treatment of fields is wasteful and uses an excess of costly resources in the form of fertilizers, pesticides, and herbicides, with potentially excessive farm run-off. An important effect of Precision Ag is the high environmental benefit from using chemical treatments only where and when they are necessary. The promotion of environmental stewardship is a key component of the new attitudes in Precision Ag. Local scale hydrography and other datasets are needed for Precison Ag practices, including environmental stewardship, to be implemented effectively.

4.4.11 BU #11 Geologic Resource Assessment and Hazard Mitigation

Hydrography data are used to analyze geologic hazards such as faults and landslides. Stream network patterns can help identify geologic structures such as faults that would be hidden on the surface by vegetation or sediment/soil and stream drainage patterns can also help identify historic landslides, landslide development, and susceptibility of slope failure. Streams, ponds, and coastlines help identify ancient flood plains which can indicate areas that may magnify shaking intensities during an earthquake. Hydrography data are also essential in interpreting the geologic history in the coastal plain; stream incising and meandering can help explain uplift and ancient shoreline delineation for paleogeographic studies.

Hydrography data are also used for karst research and mapping. Mapping relationships between surface water and groundwater can help identify where surface contamination may impact cave systems and water wells. Hydrography data also can help identify spring, sinkhole, and cave pattern development as well as depression marsh density.

4.4.12 BU #12 Resource Mining

Resource mining includes activities that ensure that surface mines are operated in a manner that protects citizens and the environment during mining, and assures that the land is restored to beneficial use following mining. OSMRE, within the Department of the Interior, is responsible for establishing a nationwide program to protect society and the environment from the adverse effects of surface coal mining operations, under which OSMRE is charged with balancing the nation's need for continued domestic coal production with protection of the environment. In its beginning, OSMRE directly enforced mining laws and arranged cleanup of abandoned mine lands. Today, most coal states have developed their own programs to do those jobs themselves, as Congress envisioned. OSMRE focuses on overseeing the state programs and developing new tools to help the states and tribes get the job done.

OSMRE oversees reclamation of land and waters damaged by coal mining prior to 1977 and regulates coal mines to ensure that coal mining operations are conducted in an environmentally responsible manner and that the land is adequately reclaimed during and following the mining process.

Hydrography data are used during permit reviews for new mining operations, as a part of monitoring during mining operations, and during reclamation. As a part of the permit review process, hydrography data are used as a baseline prior to mining to determine what needs to be protected outside the permit area and what condition the permit area needs to be returned to once mining operations are completed. During mining operations, monthly inspections are performed and changes resulting from mining activities are assessed to ensure that the mining plan is being followed. Once mining operations are finished, reclamation of the permit area is monitored for five or more years. Reclamation efforts typically may include re-vegetation, among other activities, to return the land to its pre-mine conditions. Additionally, surface waters in and near abandoned mine lands are monitored for the effects of acid mine drainage.

4.4.13 BU #13 Renewable Energy Resources

Surface water is used in a non-consumptive application for hydroelectric power generation in many states. FERC licenses all private, municipal, and state hydropower projects. All new and renewal hydropower project licenses and exemptions consider the extent to which a project is consistent with Federal or state comprehensive plans for improving, developing, or conserving a waterway or waterways affected by the project. Hydrologic and hydraulic (H&H) studies performed by dam owners are reviewed to ensure that minimum flow requirements and water surface elevations are maintained and that environmental protection measures, including protection of fish passage are enforced. Additionally, headwater benefits realized by downstream hydropower projects from any regulation of river flows by upstream storage reservoirs are calculated and charges are assessed to the downstream beneficiaries.

WAPA is one of four power marketing administrations within the U.S. Department of Energy (DOE) whose role is to market and transmit wholesale electricity from multi-use water projects including hydropower plants operated by USBR, USACE, and the International Boundary and Water Commission. Local-scale hydrography data are needed for long term planning and reservoir operations to include reservoir inflow forecasts, streamflow, snow melt, regression modelling, hydrologic forecasting, and weather and climate forecasting.

4.4.14 BU #14 Oil and Gas Resources

DOE performs research and development of future fossil energy technologies. FERC regulates the interstate transmission of natural gas and oil via development of safe, reliable and efficient energy infrastructure that serves the public interest. FERC also reviews proposals to build liquefied natural gas terminals and interstate natural gas pipelines. And BOEM models and monitors offshore oil spills. However, the publicly-responsible acquisition and safe delivery of oil and gas to generate electricity, heat our homes, and power our transportation systems, is largely left to the private sector. Note that private sector oil and gas companies were not included in this study.

Hydrography data are used in the reviews of gas pipeline and electric transmission line siting studies that include analysis of stream crossings. Ocean circulation models used for oil spill modeling have a riverine input component in addition to wind and tidal inputs. Additionally, the length of coastal shoreline within a jurisdiction determines certain oil royalties. Thus any shoreline movement from whatever cause (e.g. climate change, hurricanes, tropical storms, or riverine impacts) is of interest to Federal and local entities.

4.4.15 BU #15 Flood Risk Management

The National Flood Insurance Program (NFIP) was established to reduce future flood damage through hazard identification and mapping, effective community floodplain management, and insurance protection for property owners. FEMA's Risk Mapping, Assessment, and Planning (Risk MAP) approach integrates risk assessment, mitigation planning, risk communication, and actionable mitigation. It emphasizes updating the flood hazard data and maps of the nation's coastal areas; a reevaluation of the level of protection provided by levees; and watershed-based updates to reflect changes since current Flood Insurance Rate Maps (FIRMs) were produced. FEMA FIRMs are utilized 20-30 million times a year by communities issuing permits for building in high risk flood zones and mitigation planning; lenders in their enforcement of the insurance purchase requirement; Federal agencies under EO 11988 (Floodplain Management); developers who build in and near the high risk areas; emergency responders and those making decisions on where and how to recover and rebuild after disasters; and individuals who rely on insurance offered by the NFIP as a financial backstop to their most valuable investment, their homes. It is estimated that the NFIP's flood risk identification and floodplain management land use and building standards save the country more than $1 billion in prevented damages each year.

Flood risk studies rely on up-to-date lidar data; hydrologic modeling; and hydraulic modeling which relies on local resolution hydrography data that match the lidar. Also needed for accurate flood risk modeling are stream gage and stream flow data; accurate placement of levees and levee-like structures; location of bridges, culverts, and dams; and high water marks. In coastal areas, additional data are used for modeling including accurate coastlines, bathymetry, and tide gage and storm surge data. These data are needed to support hydrologic and hydraulic modeling, flood mapping, and flood hazard data visualization and dissemination.

Dam safety programs also rely on similar flood hazard modeling studies to ensure that dams are safe. Maintaining dam safety involves review and approval of designs, plans, specifications, and construction of new dams as well as inspections of ongoing operations. Dam inspection frequency is dictated by the hazard potential classification of the dam which is based on downstream populations potentially at risk of inundation by dam failure. Comprehensive inspections and engineering evaluations of high and significant hazard potential dams must be conducted every five years.

4.4.16 BU # 16 Sea Level Rise and Subsidence

Coastal areas and facilities, including ports and naval facilities must plan for the potential impacts of future Sea Level Rise (SLR). Additionally, many non-coastal areas are subject to subsidence, both of which require modeling and/or mitigation in order to adapt to the loss of land.

Because of the warming climate, SLR rates are increasing worldwide above the norm for prior centuries. Projected SLR rates vary for the U.S., especially when combined with subsidence. Regardless of the rate, SLR has caused major concerns for coastal states and communities planning for an unstoppable sea threat; Federal and state agencies are working closely together to mitigate this threat, and lidar and accurate shoreline data are both needed for this effort.

Subsidence may involve the sudden collapse of the land, as when a mine or sinkhole falls, or a more gradual process typically caused by extraction of subsurface water (especially in California's Central Valley), or oil or gas (especially in Louisiana and Texas) where extracted fluids previously helped to hold the ground up.

Mine subsidence can be defined as the movement of the ground surface as a result of readjustments of the overburden due to collapse or failure of underground mine workings. Surface subsidence often takes the form of sinkholes or troughs. Some sinkholes or troughs are caused by leaking sewer pipes or water mains. Florida has thousands of natural limestone sinkholes caused by water erosion that provides a route for surface water to disappear underground. These limestone sinkholes provide a primary pathway for rainwater to replenish subsurface groundwater; they are an important part of the aquifer system that supplies 95 percent of Florida's drinking water; and if left unprotected, polluted surface water can drain into sinkholes and easily contaminate the aquifers. Hydrography data used in conjunction with lidar, soils, geology, and other datasets can help identify potential surface water pathways to groundwater sources and help protect drinking water supplies.

4.4.17 BU #17 Wildfire Management, Planning, and Response

Working with the National Interagency Fire Center, BLM is supported by state and other Federal agencies managing wildfires on lands in their areas of responsibility. Hydrography data are used in wildfire management for identification of suitable water sources for fire-fighting as well as post-fire assessment of flood and landslide risk. Stream buffers are also used to mark areas of avoidance for aerial fire retardant application.

4.4.18 BU #18 Homeland Security, Law Enforcement, and Disaster Response

Enforcing environmental laws is a central part of EPA's strategic plan to protect human health and the environment. EPA works to ensure compliance with environmental requirements. When warranted, EPA will take civil or criminal enforcement action against violators of environmental laws. When this is necessary, hydrography data and point discharge data are components of the evidence collection, forensics, and scientific analyses used for criminal and civil enforcement.

FEMA, NRCS, USGS, and USACE need updated hydrography as soon as possible after a flood or hurricane event for collecting high water marks and other survey purposes, to identify changes to watercourse locations, and for operations to clear debris from waterways before it causes flooding. Disaster response activities also make use of hydrography datasets.

Additionally, hydrography data would be used for incident response if a problem were to occur at a nuclear facility or during transport of nuclear materials. Publicly available data such as the USGS NHD data are used in conjunction with data provided by licensees.

4.4.19 BU #19 Marine and Riverine Navigation and Safety

Navigation, navigation charting, and nautical charting are significant activities for the USACE and NOAA. However, neither agency currently uses USGS hydrography data products for these activities. Rather they rely on local-scale shoreline data and bathymetry. However, one USACE program manager noted that a navigable waterways dataset that could be used to support these activities would be “awesome.” States such as Louisiana and Illinois, where navigable waters and navigation routes are important economic drivers, would also benefit from having access to navigable waterways in the national hydrography dataset for monitoring goods and commodity flows, streamflow flow maintenance, and dredging operations.

4.4.20 BU # 20 Infrastructure and Construction Management

State DOTs are responsible for transportation planning and design to include design of bridges and stormwater BMPs, topographic mapping, emergency response, and flood control. Many of these activities typically rely on local-scale hydrography and lidar datasets. Hydrography data used for bridge design are similar to those used for hydrologic and hydraulic modeling performed for flood risk studies: lidar data; local resolution hydrography data that match the lidar; stream gage and stream flow data; high water marks; accurate placement of levees and levee-like structures; and location of other bridges, culverts, and dams.

The USACE evaluates permit applications and requests for jurisdictional determinations for essentially all construction activities that occur in the Nation's waters, including wetlands. Under Section 10 of the Rivers and Harbors Act of 1899 (RHA) a permit is required for work or structures in, over or under navigable waters of the U.S. Under Section 404 of the Clean Water Act (CWA), a permit is required for the discharge of dredged or fill material into Waters of the U.S. Many waterbodies and wetlands in the nation are Waters of the U.S. and are subject to the Corps' regulatory authority. Hydrography data requirements for these activities include a consistent definition of hydrographic features and an authoritative map of the Waters of the U.S. Additionally, permitting requires local resolution hydrography data and accurate flow line attributes.

4.4.21 BU #21 Urban and Regional Planning

Elevation and hydrography data are critical in urban and regional planning, often because of the need to address potential drainage issues when considering sites for future development. Many states have adopted buffer zones or otherwise regulate construction near perennial streams, the coastline, waterways, wetlands, and habitats designated for preservation. Local resolution hydrography data that can be linked to lidar, parcels, land use, and wetlands as well as other planning related datasets such as historic designated areas, hub zones, and Census data are needed for effective and sensitive urban and regional planning.

4.4.22 BU #22 Health and Human Services

EPA is responsible for the regulation of pesticide distribution, sale, and use. All pesticides distributed or sold in the U.S. must be registered (licensed) by EPA. Before EPA may register a pesticide, the applicant must show, among other things, that using the pesticide according to specifications "will not generally cause unreasonable adverse effects on the environment.'' As part of the pesticide registration process, hydrography data are used to determine the effect of pesticides on drinking water supplies and on the health of aquatic species, especially endangered species. Hydrography data are needed for fate transport modeling activities to analyze pesticide concentrations in all waterways and to help understand the causes of pesticide detections on water supplies.

To address its responsibilities for monitoring, notification, and remediation of water quality at beaches, EPA maintains data on beach locations and monitoring stations for those beaches, issues public advisories when necessary, locates the sources of pollution, and identifies remediation measures that can be taken to clean up the beaches. Locally provided shoreline data, topobathy data, tidal stage data, wetlands locations, as well as information about shellfish and predicted sea level rise are used for these beach monitoring activities.

Hydrography data are also critical for fish advisories, which are provided on state websites and by the EPA in an online interactive spatial tool by location to identify waterbodies where consumption of fish or other water-dependent species caught in those waters is not advised.

4.4.23 BU #23 Real Estate, Banking, Mortgage, and Insurance

In order for the real estate, banking, mortgage and insurance industries to properly serve American homeowners, it is important for all to recognize risks from natural disasters, and many of those risks depend on the geographic location, topography of the terrain on which homes are built, and proximity to flooding sources. Local building officials and permitting departments need detailed lidar and hydrography data along with floodplain information for issuing permits for building structures. Also key is linking hydrography data down to the parcel level so that local application of regulations can be engaged effectively.

4.4.24 BU #24 Education K-12 and Beyond

Hydrography data are used for university research involving among other things climate and climate change impacts on streamflow; paleo (using tree rings) reconstructions of historic streamflow; and forecasting streamflow, flood preparation/response, and drought frequency.

4.4.25 BU #25 Recreation

NPS manages over 400 parks nationwide, including units in the U.S. territories of Puerto Rico, U.S. Virgin Islands, Guam, and American Samoa. Over 292 million people visited a unit of the National Park System in 2014. Hydrography data are used for park GIS activities, for varied applications including inventory and monitoring, rivers and trails mapping and maintenance, water resources management, and geologic and biologic assessments. Hydrography data are critical to management of threatened and endangered species, flood hazard mitigation, monitoring aquatic ecosystem health, watershed protection, water quality monitoring, fisheries science and research, habitat assessment, park planning, and maintenance of cultural resources for park visitors.

Lands managed by the BLM also offer a variety of diverse recreational opportunities, and many of those activities involve water resources, such as fishing, boating, swimming, and whitewater rafting. Countless other activities can be impacted by the water resources on public lands including camping, hunting, hiking, all types of winter sports, and visiting natural and cultural heritage sites, just to name a few. To ensure water resources are not negatively impacted by recreational activities, thresholds are established for numbers, types, and duration of visitor use, and when those thresholds are reached, facilities are redeveloped to reduce those impacts and/or possibly limit or relocate use.

4.5 Requirements

Study participants provided information about their hydrography data requirements in a number of ways. Initial data were collected in the online study questionnaire and placed into the study geodatabase. Some of the requirements were specific to the MCA that was described and some were broader program level requirements that were not MCA-specific. During the interviews/workshops, additional requirements may have been articulated, and if so they were documented in the summary reports and in the geodatabase for each agency or state.

4.5.1 MCA-Specific Requirements

For each MCA, study participants were asked to provide information about the hydrography data required to accomplish the mission. This section provides the responses to this series of questions regarding required positional accuracy, stream density, smallest contributing watershed, smallest mapped waterbody, update frequency, post-event updates, and level of detail.

4.5.1.1 Positional Accuracy

Users were asked what positional accuracy is required for geographic features in the hydrography data to satisfy MCA requirements. Table 16 and Figure 17 on the following page show the distribution of the positional accuracy responses. The most frequently requested positional accuracy by Federal agencies was +/- 40 feet while the overall most frequently requested positional accuracy was +/- 3 feet. However, providing data with positional accuracy of +/- 40 feet would only meet 35 percent of Federal agency positional accuracy requirements and 23 percent of overall positional accuracy requirements. Providing data with positional accuracy of +/- 7 feet would meet 76 percent of Federal agency requirements, 73 percent of State government requirements, and 65 percent of the overall reported user requirements, but only 44 percent of other organization type requirements.

Table 16. Distribution of positional accuracy responses

Positional Accuracy	Number of Federal Gov't. MCAs (of 54)	Percent of Federal Gov't. MCAs	Number of State Gov't. MCAs (of 237)	Percent of State Gov't. MCAs	Number of Other Organization Type MCAs (of 129)	Percent of Other Organization Type MCAs	Total Number of MCAs (of 420)	Percent of Total MCAs
+/- 3 feet, 90% (1:1,200-scale)	13	24%	64	27%	72	56%	149	35%
+/- 7 feet, 90% (1:2,400-scale)	12	22%	61	26%	28	22%	101	24%
+/- 33 feet, 90% (1:12,000-scale)	10	19%	46	19%	14	11%	70	17%
+/- 40 feet, 90% (1:24,000-scale)	17	31%	61	26%	11	9%	89	21%
+/- 170 feet, 90% (1:100,000-scale)	1	2%	2	1%	0	0%	3	1%
+/- 420 feet, 90% (1:250,000-scale)	1	2%	0	0%	1	1%	2	0%
No answer provided	0	0%	3	1%	3	2%	6	1%
Total	54	100%	237	100%	129	100%	420	100%

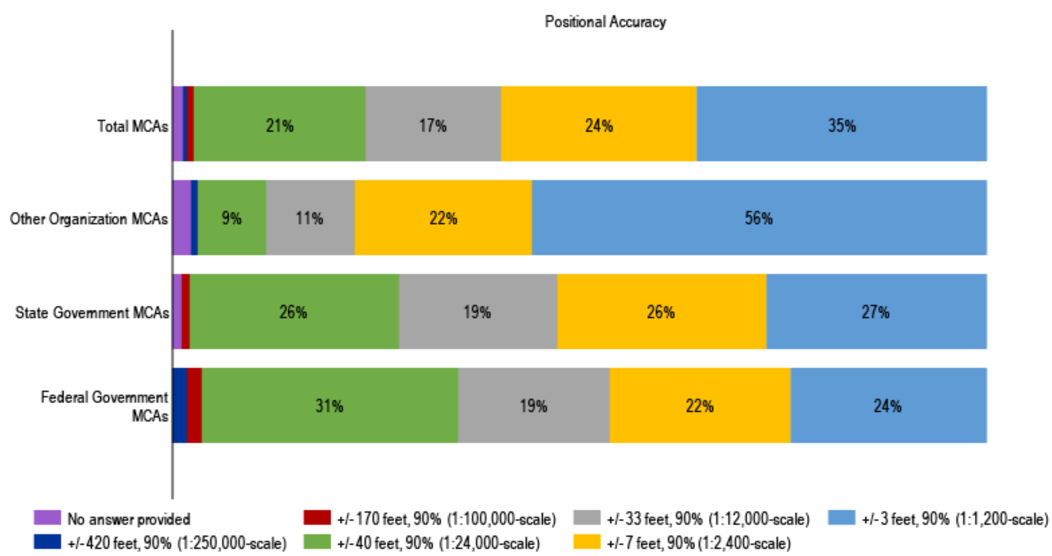

Figure 17. Distribution of positional accuracy responses

4.5.1.2 Stream Density

Users were asked what level of detail or stream density is required for the hydrography data to satisfy MCA requirements. This question was essentially asking about how many blue drainage lines would be needed in a mapped area. Table 17 and Figure 18 on the following page show the distribution of the stream density responses. The most frequently requested stream density by Federal agencies was 2.5 miles of channel per square mile while the overall most frequently requested stream density was 5.0 miles of channel per square mile. Providing data with stream density of 2.5 miles of channel per square mile would meet 69 percent of Federal agency requirements, 61 percent of State government requirements, and 61 percent of the overall reported user requirements.

Table 17. Distribution of stream density responses

Stream Density	Number of Federal Gov't. MCAs (of 54)	Percent of Federal Gov't. MCAs	Number of State Gov't. MCAs (of 237)	Percent of State Gov't. MCAs	Number of Other Organization Type MCAs (of 129)	Percent of Other Organization Type MCAs	Total Number of MCAs (of 420)	Percent of Total MCAs
5.0 miles of surface water channel per square mile (1:5,000-scale)	17	31%	92	39%	56	43%	165	39%
2.5 miles of surface water channel per square mile (1:24,000-scale)	32	59%	93	39%	29	22%	154	37%
1.0 mile of surface water channel per square mile (1:100,000-scale)	1	2%	17	7%	21	16%	39	9%
I don't know	4	7%	31	13%	20	16%	55	13%
Data not provided	0	0%	4	2%	3	2%	7	2%
Total	54	100%	237	100%	129	100%	420	100%

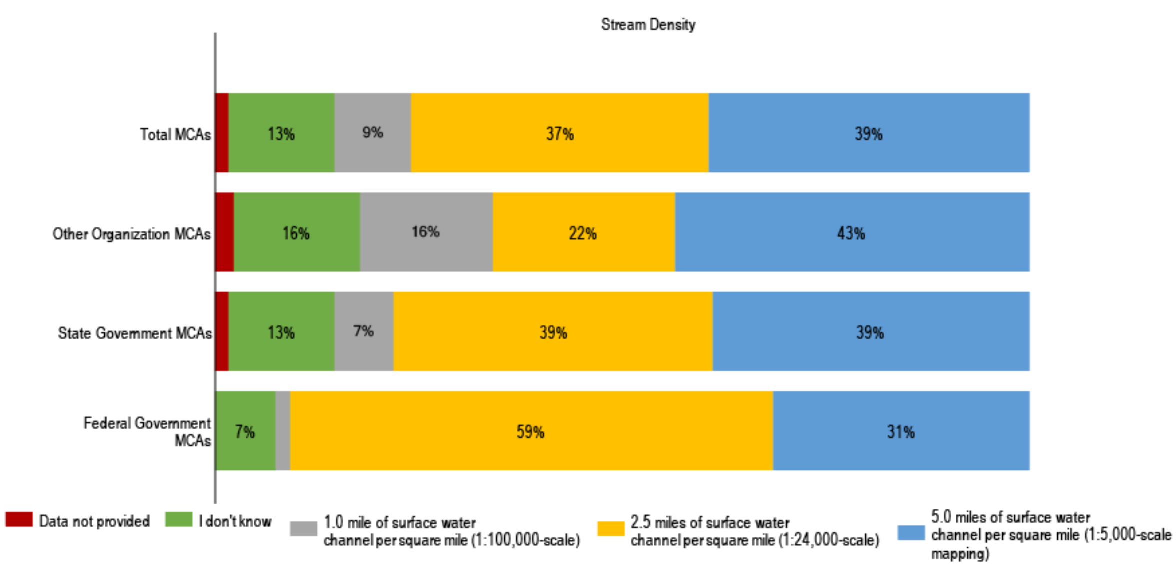

Figure 18.Distribution of stream density responses

4.5.1.3 Smallest Contributing Watershed

Users were asked what the smallest contributing area or watershed is for which a watercourse needs to be delineated for the hydrography data to satisfy MCA requirements. Table 18 below and Figure 19 on the following page show the distribution of the smallest contributing watershed responses. The most frequently requested smallest contributing watershed by Federal agencies was 60 acres while the overall most frequently requested smallest contributing watershed was six acres. Providing data with a smallest contributing watershed of 60 acres would meet 80 percent of Federal agency requirements, 71 percent of State government requirements, and 71 percent of overall user requirements. Providing data with smallest contributing watershed of 6 acres would meet 99.5 percent of the reported user requirements.

Table 18. Distribution of smallest contributing watershed responses

Smallest Contributing Watershed	Number of Federal Gov't. MCAs (of 54)	Percent of Federal Gov't. MCAs	Number of State Gov't. MCAs (of 237)	Percent of State Gov't. MCAs	Number of Other Organization Type MCAs (of 129)	Percent of Other Organization Type MCAs	Total Number of MCAs (of 420)	Percent of Total MCAs
2 acres	0	0%	2	1%	0	0%	2	0%
6 acres	11	20%	67	28%	42	33%	120	29%
60 acres	18	33%	43	18%	38	29%	99	24%
1 square mile (640 acres)	11	20%	62	26%	20	16%	93	22%
10 square miles (6,400 acres)	7	13%	23	10%	9	7%	39	9%
100 square miles (64,000 acres)	3	6%	7	3%	0	0%	10	2%
1,000 square miles (640,000 acres)	0	0%	0	0%	1	1%	1	0%
I don't know	4	7%	31	13%	16	12%	51	12%
Data not provided	0	0%	2	1%	3	2%	5	1%
Total	54	100%	237	100%	129	100%	420	100%

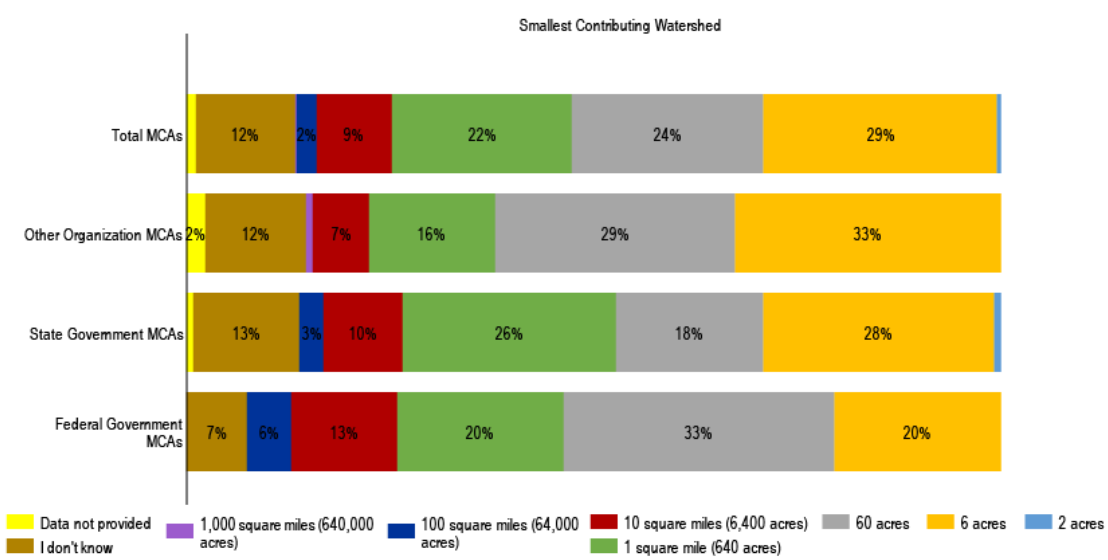

Figure 19. Distribution of smallest contributing watershed responses

4.5.1.4 Smallest Mapped Waterbody

Users were asked what the smallest mapped waterbody is for the hydrography data to satisfy MCA requirements. Table 19 below and Figure 20 on the following page show the distribution of the smallest mapped waterbody responses. The most frequently requested smallest mapped waterbody by Federal agencies was tied at less than an acre and 1 acre while the overall most frequently requested smallest mapped waterbody was less than an acre. Providing data with a smallest mapped waterbody of 1 acre would meet 74 percent of Federal agency requirements, 68 percent of State government requirements, and 66 percent of the overall reported user requirements.

Table 19. Distribution smallest mapped waterbody responses

Smallest Mapped Waterbody	Number of Federal Gov't. MCAs (of 54)	Percent of Federal Gov't. MCAs	Number of State Gov't. MCAs (of 237)	Percent of State Gov't. MCAs	Number of Other Organization Type MCAs (of 129)	Percent of Other Organization Type MCAs	Total Number of MCAs (of 420)	Percent of Total MCAs
Less than an acre	14	26%	76	32%	52	40%	142	34%
1 acre	14	26%	59	25%	32	25%	105	25%
2 acres	3	6%	28	12%	9	7%	40	10%
5 acres	9	17%	39	16%	19	15%	67	16%
10 acres	5	9%	14	6%	3	2%	22	5%
20 acres	7	13%	10	4%	8	6%	25	6%
Other (please specify)	2	4%	8	3%	3	2%	13	3%
Data not provided	0	0%	3	1%	3	2%	6	1%
Total	54	100%	237	100%	129	100%	420	100%

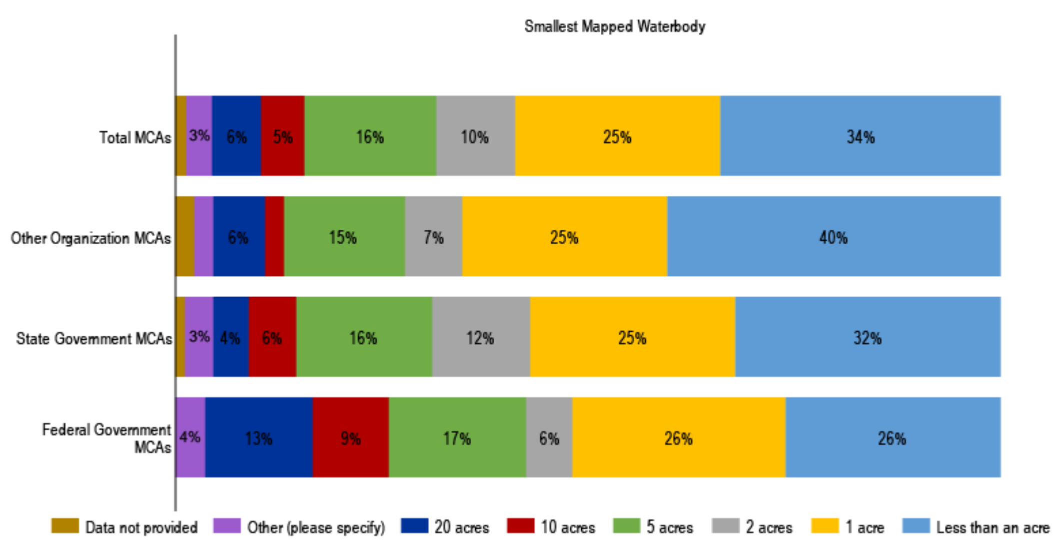

Figure 20. Distribution of smallest mapped waterbody responses

4.5.1.5 Update Frequency

Users were asked how frequently the hydrographic information needs to be updated to satisfy MCA requirements. Table 20 below and Figure 21 on the following page show the distribution of the update frequency responses. The most requested update frequency was annually. However, providing updates every 2-3 years would meet 65 percent of Federal agency requirements, 65 percent of State government requirements, and 68 percent of the reported overall user requirements.

Table 20. Distribution of update frequency responses

Update Frequency	Number of Federal Gov't. MCAs (of 54)	Percent of Federal Gov't. MCAs	Number of State Gov't. MCAs (of 237)	Percent of State Gov't. MCAs	Number of Other Organization Type MCAs (of 129)	Percent of Other Organization Type MCAs	Total Number of MCAs (of 420)	Percent of Total MCAs
Annually	19	35%	83	35%	33	26%	135	32%
2-3 years	13	24%	58	24%	41	32%	112	27%
4-5 years	17	31%	64	27%	29	22%	110	26%
6-10 years	4	7%	20	8%	22	17%	46	11%
>10 years	1	2%	12	5%	4	3%	17	4%
Total	54	100%	237	100%	129	100%	420	100%

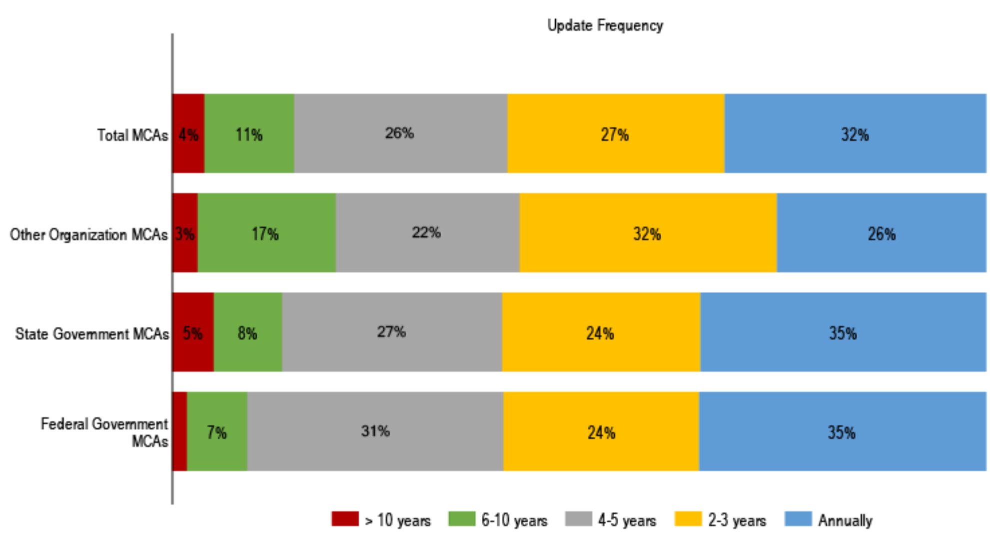

Figure 21. Distribution of update frequency responses

4.5.1.6 Post-Event Update

Users were asked how important it is for hydrographic data to be updated immediately after a major event such as a hurricane of flood for the hydrography data to satisfy MCA requirements. Table 21 below and Figure 22 on the following page show the distribution of the post-event update responses. The most frequently reported response by Federal agencies was “highly desirable,” while the most frequently requested State government response and the overall most frequently requested response was that post-event updates would be “nice to have.”

Table 21. Distribution of post-event update responses

Post-Event Update	Number of Federal Gov't. MCAs (of 54)	Percent of Federal Gov't. MCAs	Number of State Gov't. MCAs (of 237)	Percent of State Gov't. MCAs	Number of Other Organization Type MCAs (of 129)	Percent of Other Organization Type MCAs	Total Number of MCAs (of 420)	Percent of Total MCAs
Required	14	26%	31	13%	12	9%	57	14%
Highly Desirable	21	39%	87	37%	45	35%	153	36%
Nice To Have	17	31%	90	38%	49	38%	156	37%
Not Required	2	4%	29	12%	23	18%	54	13%
Total	54	100%	237	100%	129	100%	420	100%

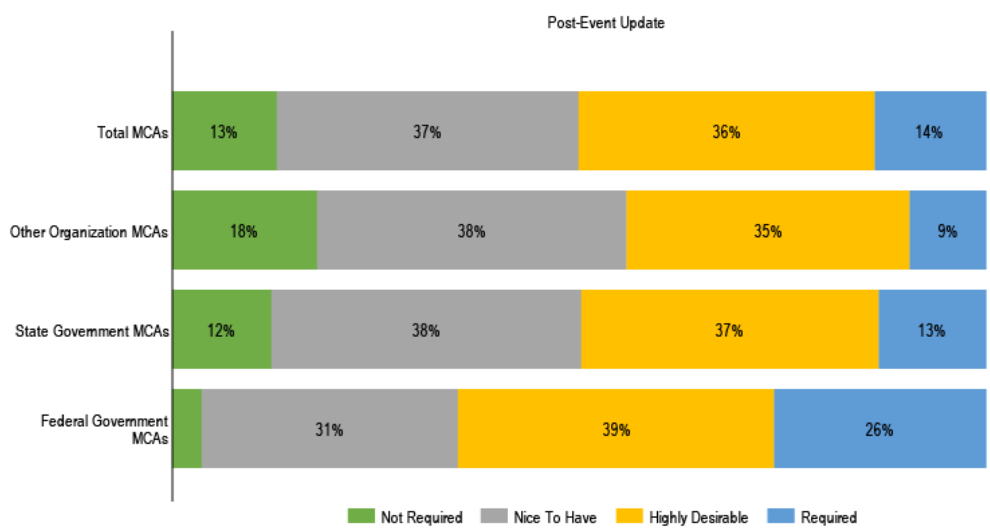

Figure 22. Distribution of post-event update responses

4.5.1.7 Level of Detail

Users were asked whether it is more important for hydrographic data to have the “best available” level of detail or whether it is more important to have a consistent level of detail for the hydrography data to satisfy MCA requirements. Table 22 below and Figure 23 on the following page show the distribution of the level of detail responses. The most frequently reported response was that best available data would best meet user requirements.

It should be noted that users from three Federal agencies and three states requested scalable data and/or some way to generalize more detailed data so that higher resolution and/or more detailed data could be included in the national dataset while allowing nationwide or regional mapping and analyses. This would allow best available data to meet the most user requirements.

Table 22. Distribution of level of detail responses

Level of Detail	Number of Federal Gov't. MCAs (of 54)	Percent of Federal Gov't. MCAs	Number of State Gov't. MCAs (of 237)	Percent of State Gov't. MCAs	Number of Other Organization Type MCAs (of 129)	Percent of Other Organization Type MCAs	Total Number of MCAs (of 420)	Percent of Total MCAs
Best Available	38	70%	157	66%	85	66%	280	67%
Consistent Level of Detail	16	30%	77	32%	41	32%	134	32%
Data not provided	0	0%	3	1%	3	2%	6	1%
Total	54	100%	237	100%	129	100%	420	100%

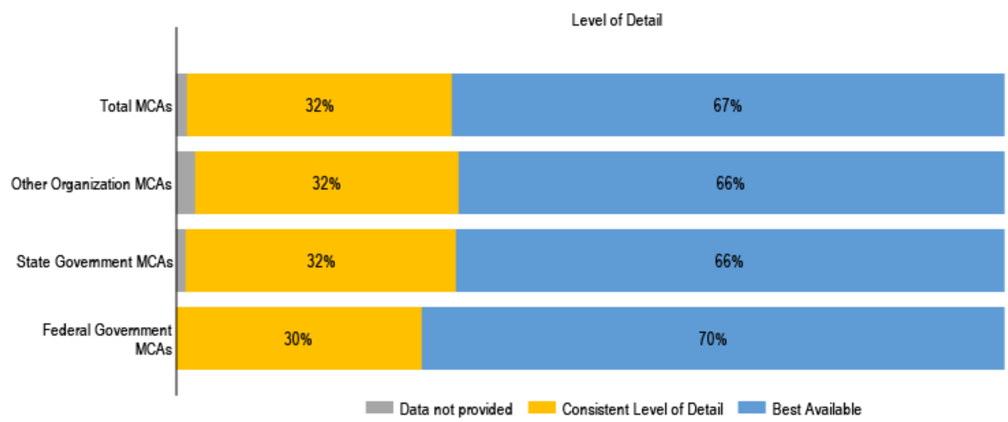

Figure 23. Distribution of level of detail responses

4.5.1.8 Characteristics and Analytical Functions

Users were asked what characteristics or features and analytical functions are required for the hydrography data to satisfy MCA requirements. In this section of the online questionnaire, users could check off any or all of the available characteristics or analytical functions needed to meet MCA requirements. Also within the questionnaire, hyperlinks were provided to the Frequently Asked Questions document (included as Appendix G) that defined some of the hydrographic and GIS concepts as well as national hydrography related datasets that were included as options in this section of the questionnaire.

Table 23 below shows the distribution of the required characteristics and analytical functions ranked by the number of MCAs for which Federal agencies reported the requirement. Note that the "Other" characteristics that were specified by users are discussed in Section 4.5.1.10.

Table 23. Distribution of required characteristics and analytical functions ranked by the number of MCAs for which Federal agencies reported the requirement

Required Characteristics/ Analytical Functions	Number of Federal Gov't. MCAs (of 54)	Percent of Federal Gov't. MCAs	Number of State Gov't. MCAs (of 237)	Percent of State Gov't. MCAs	Number of Other Organization Type MCAs (of 129)	Percent of Other Organization Type MCAs	Total Number of MCAs (of 420)	Percent of Total MCAs
Wetlands	47	87%	145	61%	77	60%	269	64%
Calculate drainage area	44	81%	183	77%	102	79%	329	78%
Flow periodicity	43	80%	149	63%	75	58%	267	64%
Linkages to stream gage observations	43	80%	156	66%	83	64%	282	67%
Delineate catchment	42	78%	146	62%	85	66%	273	65%
Find upstream or downstream feature within watershed	42	78%	157	66%	85	66%	284	68%
Left right bank delineation	41	76%	105	44%	54	42%	200	48%
Floodplain boundary	40	74%	125	53%	93	72%	258	61%
Velocity or time of travel	40	74%	100	42%	60	47%	200	48%
Calculate stream distance to points	39	72%	146	62%	63	49%	248	59%
Linkages to cross section geometry	39	72%	112	47%	56	43%	207	49%
Accumulate upstream or downstream features	38	70%	117	49%	0	0%	214	51%
Diversion lines	38	70%	117	49%	58	45%	213	51%
Flood stage	38	70%	109	46%	68	53%	215	51%
Bridges, culverts	37	69%	115	49%	77	60%	229	55%
Calculate distance on network	37	69%	111	47%	50	39%	198	47%
Diversion points	37	69%	92	39%	46	36%	175	42%
Navigate up or downstream on network	37	69%	162	68%	77	60%	276	66%
Determine downstream flood area	36	67%	106	45%	68	53%	210	50%

Required Characteristics/ Analytical Functions	Number of Federal Gov't. MCAs (of 54)	Percent of Federal Gov't. MCAs	Number of State Gov't. MCAs (of 237)	Percent of State Gov't. MCAs	Number of Other Organization Type MCAs (of 129)	Percent of Other Organization Type MCAs	Total Number of MCAs (of 420)	Percent of Total MCAs
Estuaries	36	67%	79	33%	28	22%	143	34%
Riverine bathymetry	36	67%	112	47%	53	41%	201	48%
Coastlines	35	65%	91	38%	34	26%	160	38%
Find upstream or downstream points	35	65%	103	43%	50	39%	188	45%
User defined symbolization	35	65%	104	44%	46	36%	185	44%
Mash-ups	34	63%	106	45%	50	39%	190	45%
Calculate time of travel to points	33	61%	95	40%	54	42%	182	43%
Find events or features on network	33	61%	93	39%	47	36%	173	41%
Preset symbolization	33	61%	100	42%	51	40%	184	44%
Leakage at points	32	59%	62	26%	24	19%	118	28%
Deltas	31	57%	35	15%	17	13%	83	20%
Leakage along lines	31	57%	54	23%	24	19%	109	26%
Coastal bathymetry	26	48%	58	24%	20	16%	104	25%
Animation of time-series	23	43%	52	22%	29	22%	104	25%
Other (please specify)	15	28%	47	20%	21	16%	83	20%
Badlands	14	26%	14	6%	7	5%	35	8%

4.5.1.9 Level of Integration between Hydrography and Other Datasets

Users were also asked about the level of integration required between hydrography data and other datasets for the hydrography data to satisfy MCA requirements. Users were asked to rate the importance of the level of integration of the data type with hydrography data. The options provided for answering this question in the online questionnaire were “Required,” “Highly Desirable,” “Nice to Have,” and “Not Required.”

Table 24 and Figure 24 on the following page show the datasets ranked by the number of MCAs for which Federal agencies indicated that integration with that data type was “Required.”

In order to take into account responses other than “Required,” the last column in Table 24 shows a weighted average of the responses to each question. The weighting was done as follows: Required = 5, Highly Desirable = 3, Nice to Have = 1, Don’t Know, Not Applicable, No response = 0.

Integration of hydrography data with elevation data was the most frequently required, followed by stream flow, wetlands, soils, and land cover data. Using the weighted average score would change the order of the top five responses slightly, but would not change the list of the top five.

Table 24. Datasets ranked by the number of MCAs for which Federal agencies indicated integration with data type was "required"

Data Type	Number of Federal Gov't. MCAs for which Data Integration is Required (of 54)	Percent of Federal Gov't. MCAs for which Data Integration is Required	Number of State Gov't. MCAs for which Data Integration is Required (of 237)	Percent of State Gov't. MCAs for which Data Integration is Required	Number of Other Organization Type MCAs for which Data Integration is Required (of 129)	Percent of Other Organization Type MCAs for which Data Integration is Required	Total Number of MCAs for which Data Integration is Required (of 420)	Percent of Total MCAs for which Data Integration is Required	Weighted Average of Level of Integration
Elevation	40	74%	149	63%	85	66%	274	65%	134
Stream Flow	37	69%	130	55%	64	50%	231	55%	125
Wetlands	35	65%	103	43%	31	24%	169	40%	107
Soils	33	61%	75	32%	48	37%	156	37%	99
Land Cover	30	56%	109	46%	58	45%	197	47%	114
NWIS	30	56%	72	30%	22	17%	124	30%	87
NWI	27	50%	61	26%	29	22%	117	28%	88
Water Use: Diversions	24	44%	70	30%	32	25%	126	30%	90
Climate	24	44%	34	14%	21	16%	79	19%	62
Point Discharges	23	43%	76	32%	40	31%	139	33%	93
NID	23	43%	59	25%	25	19%	107	25%	84
NAWQA	22	41%	22	9%	18	14%	62	15%	64
Geology	20	37%	51	22%	21	16%	92	22%	73
Aquifers	16	30%	52	22%	21	16%	89	21%	70
Bathymetry	16	30%	50	21%	17	13%	83	20%	70
Contaminants	12	22%	50	21%	17	13%	79	19%	68
NASS	12	22%	19	8%	8	6%	39	9%	51
NPDES	11	20%	60	25%	28	22%	99	24%	72
STORET	9	17%	32	14%	14	11%	55	13%	58
Census	4	7%	28	12%	18	14%	50	12%	51

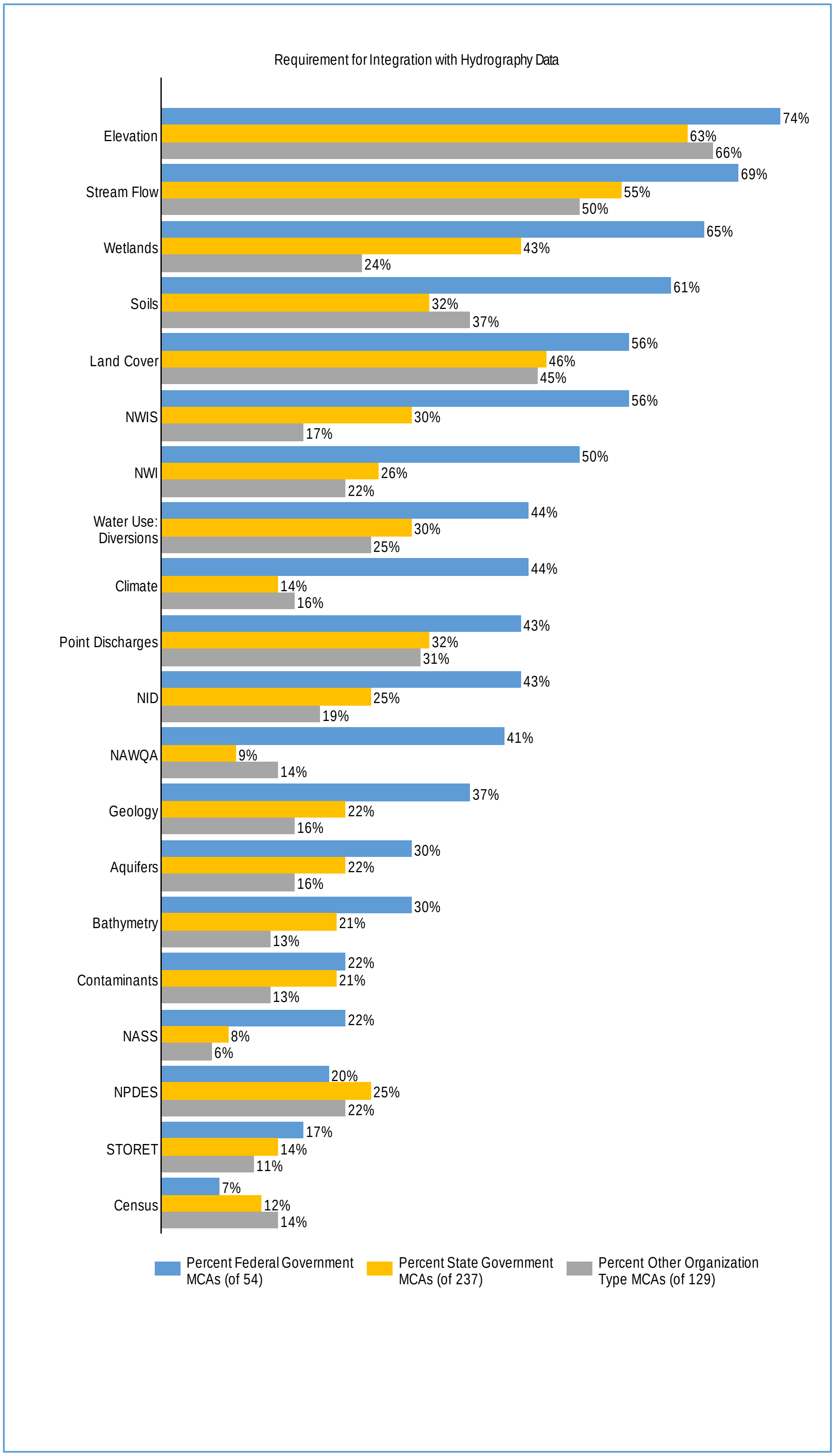

Figure 24. Datasets ranked by the number of MCAs for which Federal agencies indicated integration with data type was "required"

For the same list of datasets presented in Table 24, users were also asked what the highest level of analysis was required between those data and hydrography data to satisfy MCA requirements. The options provided for answering this series of questions in the online questionnaire were “Perform geospatial analysis (overlay, area calculation, buffers, etc.),” “Associate selected data type to hydrographic features with unique code(s),” “Visual inspection or graphic display,” and “None.”

Table 25 below and Figure 25 on the following page show the datasets ranked by the number of MCAs for which Federal agencies indicated that “Perform geospatial analysis” was required. The same five datasets that ranked highest in importance of integration with hydrography data were at the top of the list for requiring the highest level of analysis as well. And across the board, when integration of a dataset was “Required,” it was most frequently needed in order to “Perform geospatial analysis.” Full details of the required level of importance and level of analysis required for each of the datasets are provided in Appendix N.

Table 25. Datasets ranked by number of MCAs for which Federal agencies indicated “Perform geospatial analysis” was required

Data Type	Number of Federal Gov't. MCAs for which Geospatial Analysis is Required (of 54)	Percent of Federal Gov't. MCAs for which Geospatial Analysis is Required	Number of State Gov't. MCAs for which Geospatial Analysis is Required (of 237)	Percent of State Gov't. MCAs for which Geospatial Analysis is Required	Number of Other Organization Type MCAs for which Geospatial Analysis is Required (of 129)	Percent of Other Organization Type MCAs for which Geospatial Analysis is Required	Total Number of MCAs for which Geospatial Analysis is Required (of 420)	Percent of Total MCAs for which Geospatial Analysis is Required
Land Cover	44	81%	164	69%	92	71%	300	71%
Wetlands	42	78%	127	54%	56	43%	225	54%
NWI	42	78%	108	46%	51	40%	201	48%
Elevation	40	74%	181	76%	97	75%	318	76%
Stream Flow	39	72%	151	64%	77	60%	267	64%
Soils	37	69%	122	51%	84	65%	243	58%
Climate	34	63%	73	31%	41	32%	148	35%
NWIS	33	61%	86	36%	41	32%	160	38%
Contaminants	32	59%	84	35%	49	38%	165	39%
Point Discharges	32	59%	97	41%	54	42%	183	44%
Geology	30	56%	100	42%	42	33%	172	41%
Census	30	56%	73	31%	45	35%	148	35%
NID	30	56%	79	33%	43	33%	152	36%

Data Type	Number of Federal Gov't. MCAs for which Geospatial Analysis is Required (of 54)	Percent of Federal Gov't. MCAs for which Geospatial Analysis is Required	Number of State Gov't. MCAs for which Geospatial Analysis is Required (of 237)	Percent of State Gov't. MCAs for which Geospatial Analysis is Required	Number of Other Organization Type MCAs for which Geospatial Analysis is Required (of 129)	Percent of Other Organization Type MCAs for which Geospatial Analysis is Required	Total Number of MCAs for which Geospatial Analysis is Required (of 420)	Percent of Total MCAs for which Geospatial Analysis is Required
Water Use: Diversions	29	54%	102	43%	49	38%	180	43%
NAWQA	29	54%	55	23%	37	29%	121	29%
Bathymetry	28	52%	104	44%	51	40%	183	44%
NPDES	28	52%	77	32%	50	39%	155	37%
Aquifers	26	48%	79	33%	46	36%	151	36%
NASS	23	43%	58	24%	25	19%	106	25%
STORET	22	41%	56	24%	38	29%	116	28%

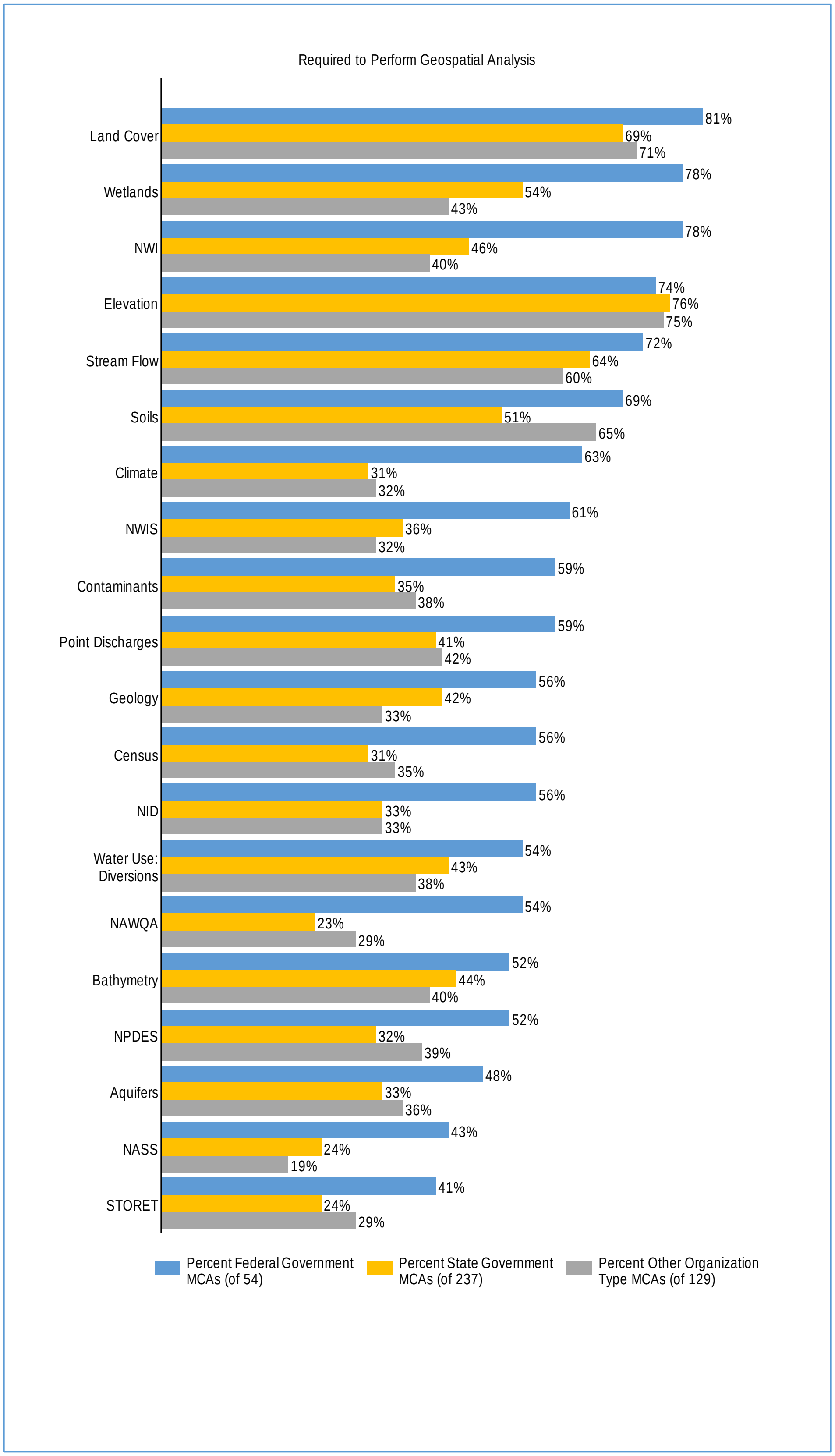

Figure 25. Datasets ranked by number of MCAs for which Federal agencies indicated "Perform geospatial analysis" was required

4.5.1.10 Other Required Characteristics and Data Integration

In the two online questionnaire sections discussed above, where users were asked about the required characteristics of the hydrography data and the level of integration required with other datasets, users had the option of specifying "Other." Table 26 below lists the ten most frequently reported hydrography or related "other" characteristics, analytical functions, or integration with other datasets required by study participants. This table is ranked by the total number of MCAs for which the data type was requested.

Table 26. The 10 most frequently reported other datasets required by study participants

Other Data Type Used	Number of Federal Gov't. MCAs	Number of State Gov't. MCAs	Number of Other Organization Type MCAs	Total Number of MCAs
Riparian zones	0	12	1	13
Flow/flow lines	3	4	1	8
Bathymetry	2	5	0	7
Control structures	2	3	2	7
Manmade structures/attributes (canal lining, constructed ponds, built channels)	2	2	2	6
Parcels/ownership/Common Land Unit	2	3	1	6
Karst/Sinkholes	0	3	3	6
NWS flow/meteorology/forecasts	1	1	3	5
Tide gages/tidal information	2	3	0	5
Water quality observations	4	0	1	5

4.5.2 Non-MCA-Specific Requirements

In addition to the MCA-specific requirements discussed above, study respondents were asked to provide information about their program-wide (all identified MCAs) hydrography data requirements. These questions were not intended to apply to specific MCAs but to broader agency or general program hydrography data needs. These questions were asked of all respondents to the online questionnaire. During the interview/workshop process, the responses to this series of questions were consolidated such that one final response was provided per Federal agency, state, and association. The pool of final responses was 76 entities after removing one which did not respond to this series of questions. The consolidated responses are shown in the tables below.

4.5.2.1 Data Types or Formats

Users were asked what data types or formats are required for the hydrography data to satisfy their program requirements. Users could select any or all of the data types or formats that are required.

Table 27 and Figure 26 on the following pages show the distribution of the data type responses ranked by the number of Federal agencies that indicated that data type was "Required." Percentages were calculated based on the number of consolidated responses to these questions (76), not the number of MCAs (420).

Among the vector dataset options, Esri Shapefiles and Esri file geodatabases were the most frequently required data types. Among the raster dataset options, GeoTIFF and Esri Grid were the most frequently required data types.

Table 27. Required data type/format responses

Data Type	Number of Federal Agencies that Require Data Type (of 21)	Percent of Federal Agencies that Require Data Type	Number of States that Require Data Type (of 51)	Percent of States that Require Data Type	Number of Associations that Require Data Type (of 4)	Percent of Associations that Require Data Type	Total Number of Entities that Require Data Type (of 76)	Percent of Total Entities that Require Data Type
Point, line, polygon – Esri shapefiles	20	95%	49	96%	2	50%	71	93%
Point, line, polygon – Esri file geodatabase	20	95%	51	100%	4	100%	75	99%
Raster – GeoTIFF	18	86%	46	90%	3	75%	67	88%
Raster – Esri Grid	16	76%	48	94%	1	25%	65	86%
Point, line, polygon – OGC conformant (for example, WaterML, GeoJSON)	14	67%	39	76%	1	25%	54	71%
Raster – NetCDF	13	62%	16	31%	1	25%	30	39%
Raster – NITF	8	38%	12	24%	0	0%	20	26%
Other format (please specify)	5	24%	13	25%	0	0%	18	24%

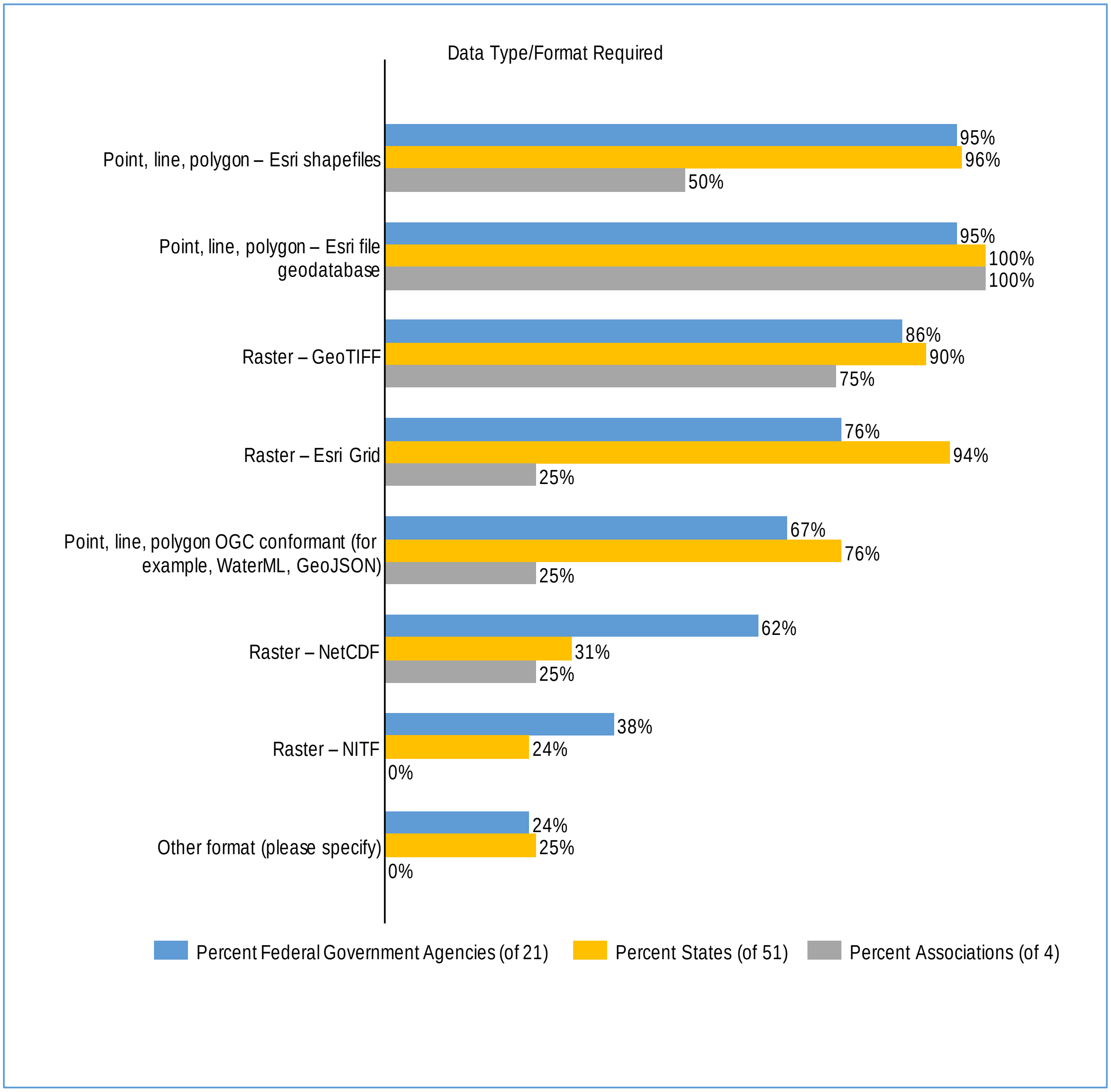

Figure 26. Required data type/format responses

4.5.2.2 Geographic Extents

Users were asked what geographic extents are needed to satisfy their program's hydrography data access requirements. Users could select any or all of the geographic extents that are required. Table 28 below and Figure 27 on the following page show the distribution of the geographic extent responses ranked by the number of Federal agencies that indicated that geographic extent was "Required."

Table 28. Geographic extents need to satisfy program requirements

Geographic Extent	Number of Federal Agencies that Require Extent (of 21)	Percent of Federal Agencies that Require Extent	Number of States that Require Extent (of 51)	Percent of States that Require Extent	Number of Associations that Require Extent (of 4)	Percent of Associations that Require Extent	Total Number of Entities that Require Extent (of 76)	Percent of Total Entities that Require Extent
12-digit Hydrologic Units	19	90%	51	100%	2	50%	72	95%
8-digit Hydrologic Units	18	86%	50	98%	2	50%	70	92%
State or Territory	18	86%	48	94%	2	50%	68	89%
User defined map ext ent	18	86%	26	51%	1	25%	45	59%
6-digit Hydrologic Units	16	76%	42	82%	2	50%	60	79%
NHDPlus Catchments	16	76%	46	90%	3	75%	65	86%
User defined irregular area (polygon)	16	76%	25	49%	2	50%	43	57%
Nationwide including Alaska and Hawai'i	15	71%	10	20%	3	75%	28	37%
4-digit Hydrologic Units	13	62%	39	76%	0	0%	52	68%
2-digit Hydrologic Units	10	48%	36	71%	0	0%	46	61%
Conterminous U.S.	10	48%	18	35%	2	50%	30	39%
Other (please specify)	7	33%	3	6%	0	0%	10	13%
I don't know	0	0%	0	0%	0	0%	0	0%

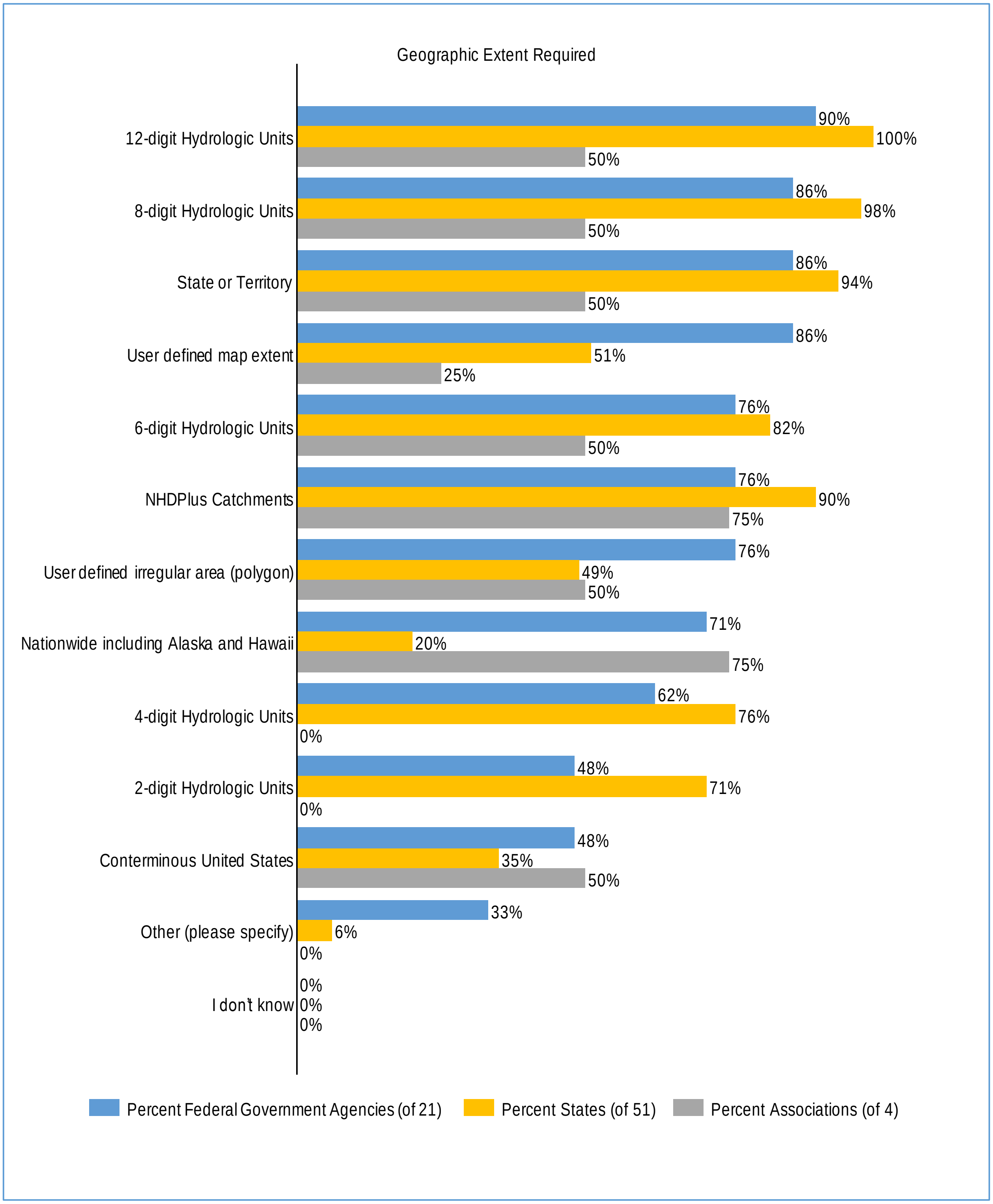

Figure 27. Geographic extents required

4.5.2.3 Data or Service Access Methods

Users were asked to rate the importance of each data or service access method for accessing hydrography data. The options provided for answering this question in the online questionnaire were "Required," "Highly Desirable," "Nice to Have," and "Not Required."

Table 29 below and Figure 28 on the following page show the distribution of the data or service access method responses ranked by the number of Federal agencies that indicated that data or service method was "Required." The most frequently required service was one to download standard data products, required by 95 percent of all study respondents.

Table 29. Importance of data service access method for accessing hydrography data

Data or Service Access Method	Number of Federal Agencies that Require Access Method (of 21)	Percent of Federal Agencies that Require Access Method	Number of States that Require Access Method (of 51)	Percent of States that Require Access Method	Number of Associations that Require Access Method (of 4)	Percent of Associations that Require Access Method	Total Number of Entities that Require Access Method (of 76)	Percent of Total Entities that Require Access Method
Services to download standard data products	20	95%	48	94%	4	100%	72	95%
Services to discover standard data products	14	67%	38	75%	2	50%	54	71%
Services to dynamically use data with client-based software (like a browser, GIS, or to feed other services)	10	48%	34	67%	2	50%	46	61%
Services to create and download customized data products	9	43%	25	49%	1	25%	35	46%
Services to support online analysis of hydrography information (such as StreamStats)	8	38%	25	49%	2	50%	35	46%
Services to create generalized versions of hydrography (different scales and level of detail)	4	19%	20	39%	1	25%	25	33%
Services to visualize cartographically rendered and symbolized hydrography data	3	14%	24	47%	1	25%	28	37%
Services that allow combination of visualizations with other visualization services (mashups)	3	14%	15	29%	1	25%	19	25%

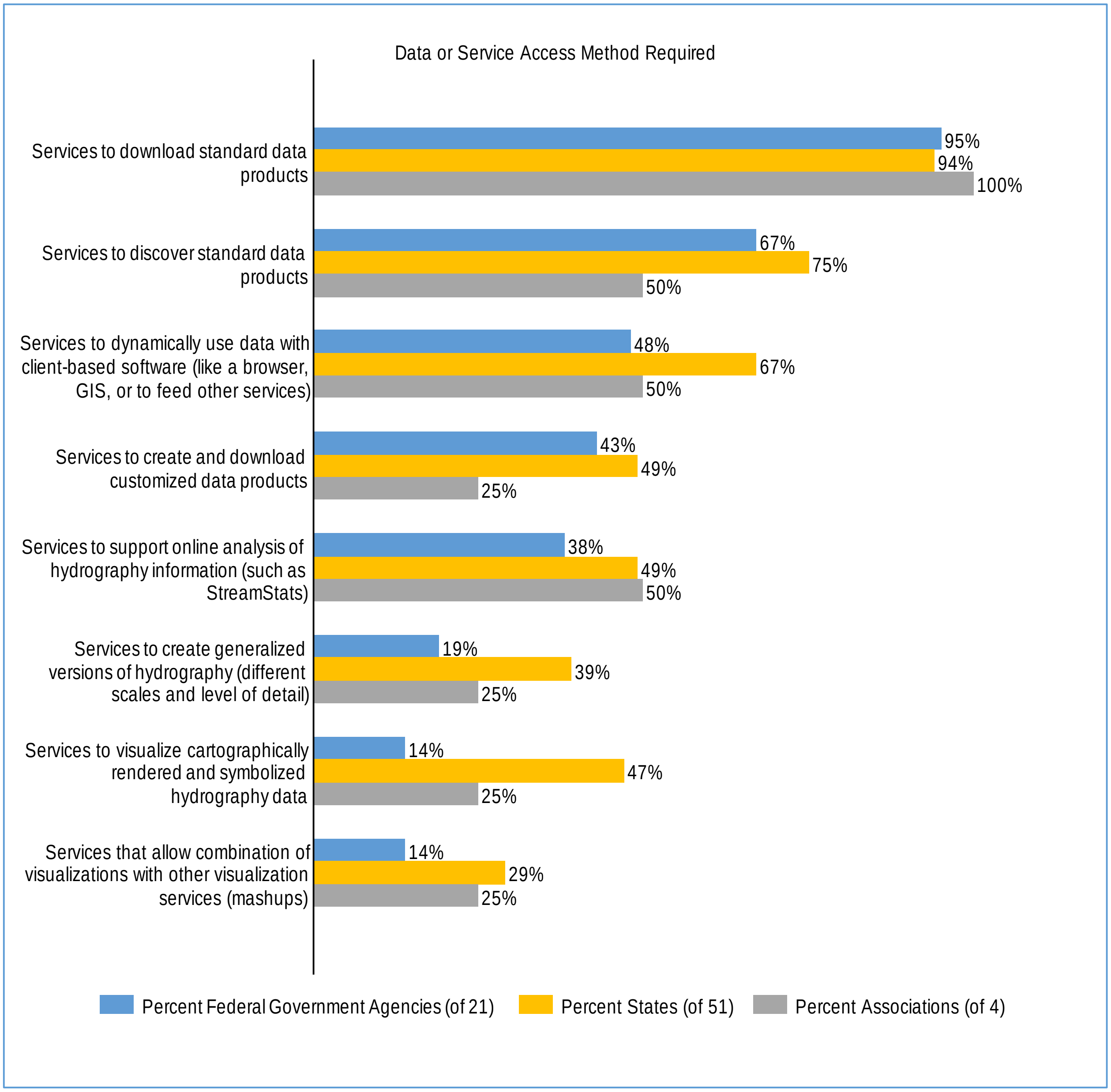

Figure 28. Importance of data service access method in accessing hydrography data

4.5.2.4 Elevation-Hydrography Data Integration

Acknowledging that integration between hydrography data and elevation data may be very important, users were asked to rate the importance of each type of elevation-hydrography data integration as it relates to their program requirements. The options provided for answering this question in the online questionnaire were "Required," "Highly Desirable," "Nice to Have," and "Not Required."

Table 30 below and Figure 29 on the following page show the distribution of the elevation-hydrography data integration responses ranked by the number of Federal agencies that indicated that level of integration between elevation and hydrography data was "Required." The most frequently reported requirement is for hydrography data to align to elevation data at 1:12,000-scale or larger.

Table 30. Level of elevation-hydrography data integration required

Level of Elevation-Hydrography Data Integration	Number of Federal Agencies that Require Integration Type (of 21)	Percent of Federal Agencies that Require Integration Type	Number of States that Require Integration Type (of 51)	Percent of States that Require Integration Type	Number of Associations that Require Integration Type (of 4)	Percent of Associations that Require Integration Type	Total Number of Entities that Require Integration Type (of 76)	Percent of Total Entities that Require Integration Type
Rivers and streams in the hydrography dataset align with channels as defined from the elevation data at 1:12,000-scale or larger (3 meter DEM)	12	57%	34	67%	1	25%	47	62%
Ensure that hydrography and elevation data represent a similar point in time	9	43%	22	43%	1	25%	32	42%
Manage hydrography and elevation data as a unified activity always keeping both datasets synchronized with one another	8	38%	19	37%	1	25%	28	37%
Objects defined by elevation, such as a levees, are linked to a particular river in the hydrography dataset	7	33%	24	47%	2	50%	33	43%
Hydrography and elevation data are packaged in a single product such as a TIN or a 3D dataset	6	29%	15	29%	1	25%	22	29%
Hydrography data (streams, stream gages, dams, hydrologic units) along with elevation data (elevations, catchments, levees, floodplains) coexist within a common data model	6	29%	29	57%	4	100%	39	51%

Level of Elevation-Hydrography Data Integration	Number of Federal Agencies that Require Integration Type (of 21)	Percent of Federal Agencies that Require Integration Type	Number of States that Require Integration Type (of 51)	Percent of States that Require Integration Type	Number of Associations that Require Integration Type (of 4)	Percent of Associations that Require Integration Type	Total Number of Entities that Require Integration Type (of 76)	Percent of Total Entities that Require Integration Type
Both hydrography and elevation data are delivered in unison rather than two separate operations	6	29%	14	27%	0	0%	20	26%
Perform synthesis such that streamflow can be estimated from elevation-based drainage area and other factors	5	24%	20	39%	2	50%	27	36%
Produce data derivatives such that gradient can be calculated on a stream using elevation data	4	19%	17	33%	1	25%	22	29%

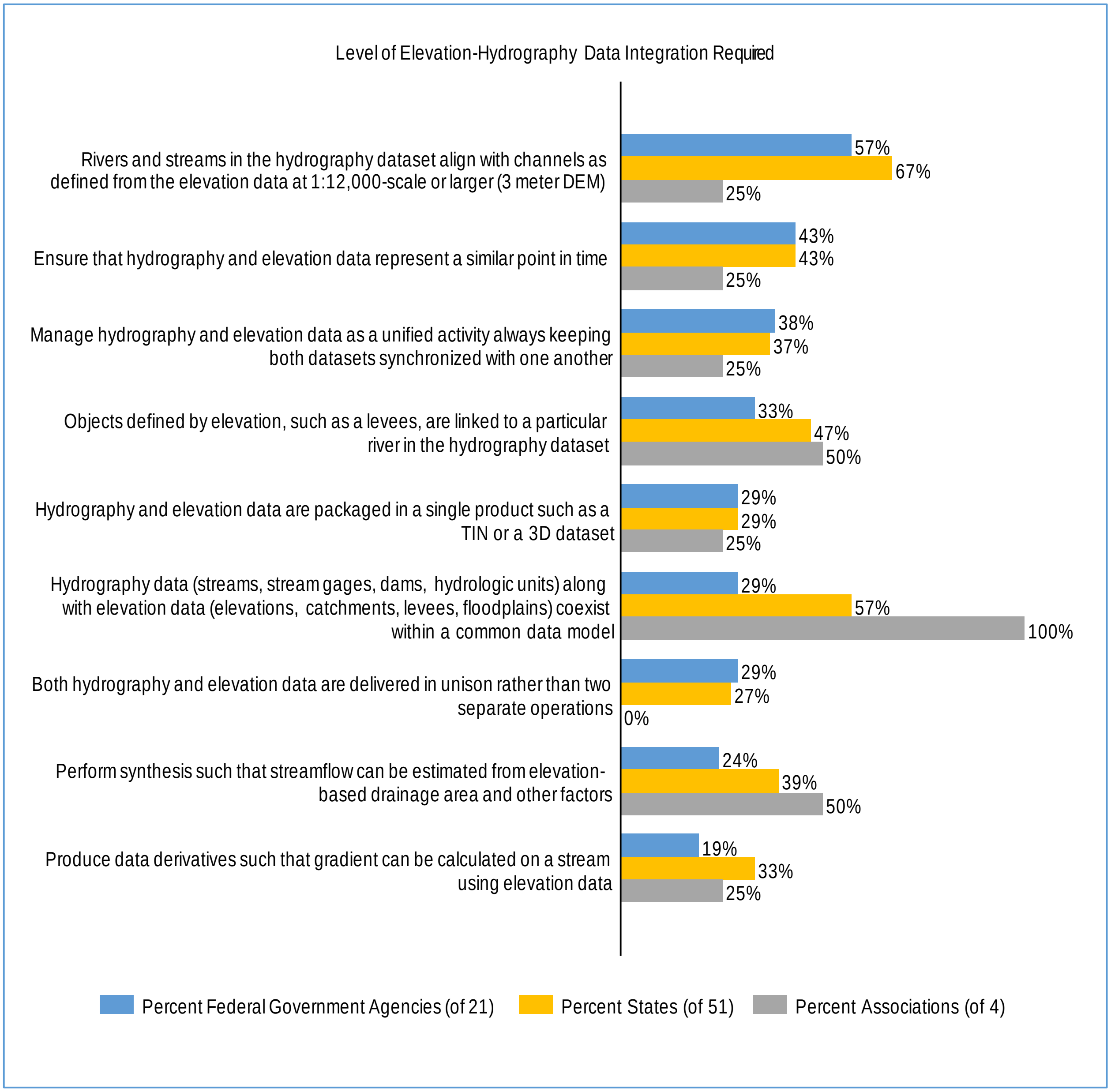

Figure 29.Level of elevation-hydrography integration required

4.5.2.5 Raster Elevation-Hydrography Data Integration

Users were asked a similar set of questions about the need for integration between hydrography data and raster elevation data as it relates to their program requirements. The options provided for answering this question in the online questionnaire were “Required,” “Highly Desirable,” “Nice to Have,” and “Not Required.”

Table 31 below and Figure 30 on the following page show the distribution of the raster elevation-hydrography data integration responses ranked by the number of Federal agencies that indicated that level of integration between raster elevation and hydrography data was “Required.”

Table 31. Level of raster elevation-hydrography data integration required

Level of Raster Elevation-Hydrography Data Integration	Number of Federal Agencies that Require Integration Type (of 21)	Percent of Federal Agencies that Require Integration Type	Number of States that Require Integration Type (of 51)	Percent of States that Require Integration Type	Number of Associations that Require Integration Type (of 4)	Percent of Associations that Require Integration Type	Total Number of Entities that Require Integration Type (of 76)	Percent of Total Entities that Require Integration Type
Determine new flow paths across the land surface into existing stream channels	8	38%	26	51%	3	75%	37	49%
Determine the actual point location (within a DEM cell) on the hydrographic network to which a point is connected	8	38%	19	37%	2	50%	29	38%
Determine feature on the hydrographic network to which a point (with elevation value) is connected	6	29%	23	45%	2	50%	31	41%

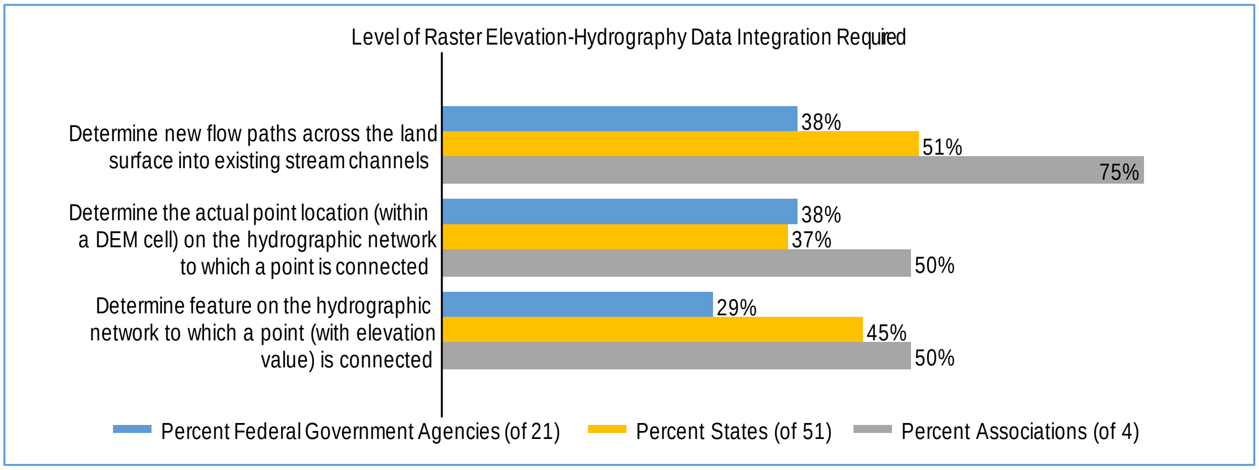

Figure 30. Level of raster elevation-hydrography data integration required

4.5.2.6 Impact of Hydrography Data Errors

Users were asked to rate the impact to their organization or program of a few commonly found errors in hydrography datasets. In the online questionnaire, users were provided with graphical illustrations of the types of errors being described. The options provided for answering this series of questions in the online questionnaire were "Critically Impactful," "Highly Impactful," "Somewhat Impactful," and "Little or No Impact."

Table 32 below and Figure 31 on the following page show the distribution of the impact of hydrography data error responses ranked by the number of Federal agencies that indicated that type of error in hydrographic data was "Critically Impactful." The most frequently reported error with critical impacts is disconnected flowlines, followed by reversed flow direction on third, second, and first order streams.

Table 32. Hydrographic dataset errors with critical impact

Hydrographic Dataset Errors	**Number of Federal Agencies Critically Impacted by Error (of 21)**	**Percent of Federal Agencies Critically Impacted by Error**	**Number of States Critically Impacted by Error (of 51)**	**Percent of States Critically Impacted by Error**	**Number of Associations Critically Impacted by Error (of 4)**	**Percent of Associations Critically Impacted by Error**	**Total Number of Entities Critically Impacted by Error (of 76)**	**Percent of Total Entities Critically Impacted by Error**
In a series of tributary streams, several streams do not connect with the main river	11	52%	36	71%	1	25%	48	63%
A third order stream flow direction is reversed	8	38%	33	65%	2	50%	43	57%
A second order stream flow direction is reversed	8	38%	30	59%	1	25%	39	51%

Hydrographic Dataset Errors	Number of Federal Agencies Critically Impacted by Error (of 21)	Percent of Federal Agencies Critically Impacted by Error	Number of States Critically Impacted by Error (of 51)	Percent of States Critically Impacted by Error	Number of Associations Critically Impacted by Error (of 4)	Percent of Associations Critically Impacted by Error	Total Number of Entities Critically Impacted by Error (of 76)	Percent of Total Entities Critically Impacted by Error
A first order stream flow direction is reversed	8	38%	29	57%	1	25%	38	50%
A large reservoir is misnamed	8	38%	22	43%	0	0%	30	39%
A perennial stream is misnamed	7	33%	22	43%	0	0%	29	38%
In a series of lakes formed at gravel pits, all lakes are missing from the NHD	6	29%	26	51%	1	25%	33	43%
Two first order streams coded as perennial should be intermittent	5	24%	18	35%	1	25%	24	32%
A meandering river represented in the NHD is overlaid over a contemporary image of the river. The position of the meanders has deviated over time with a mean error of 100 feet and a maximum error of 200 feet.	5	24%	25	49%	1	25%	31	41%
A ridge line in the WBD is portrayed along with contours and shaded terrain. The ridge line appears to be misaligned with the terrain by a mean of 70 feet.	5	24%	15	29%	0	0%	20	26%
In a series of lakes formed at gravel pits, one lake is missing from the NHD	4	19%	19	37%	0	0%	23	30%
An intermittent stream represented in the NHD is portrayed along with contours and shaded terrain. The stream appears to be misaligned with the terrain by a mean of 175 feet.	4	19%	18	35%	0	0%	22	29%
An intermittent stream represented in the NHD is portrayed along with contours and shaded terrain. The stream appears to be misaligned with the terrain by a mean of 75 feet.	3	14%	15	29%	0	0%	18	24%

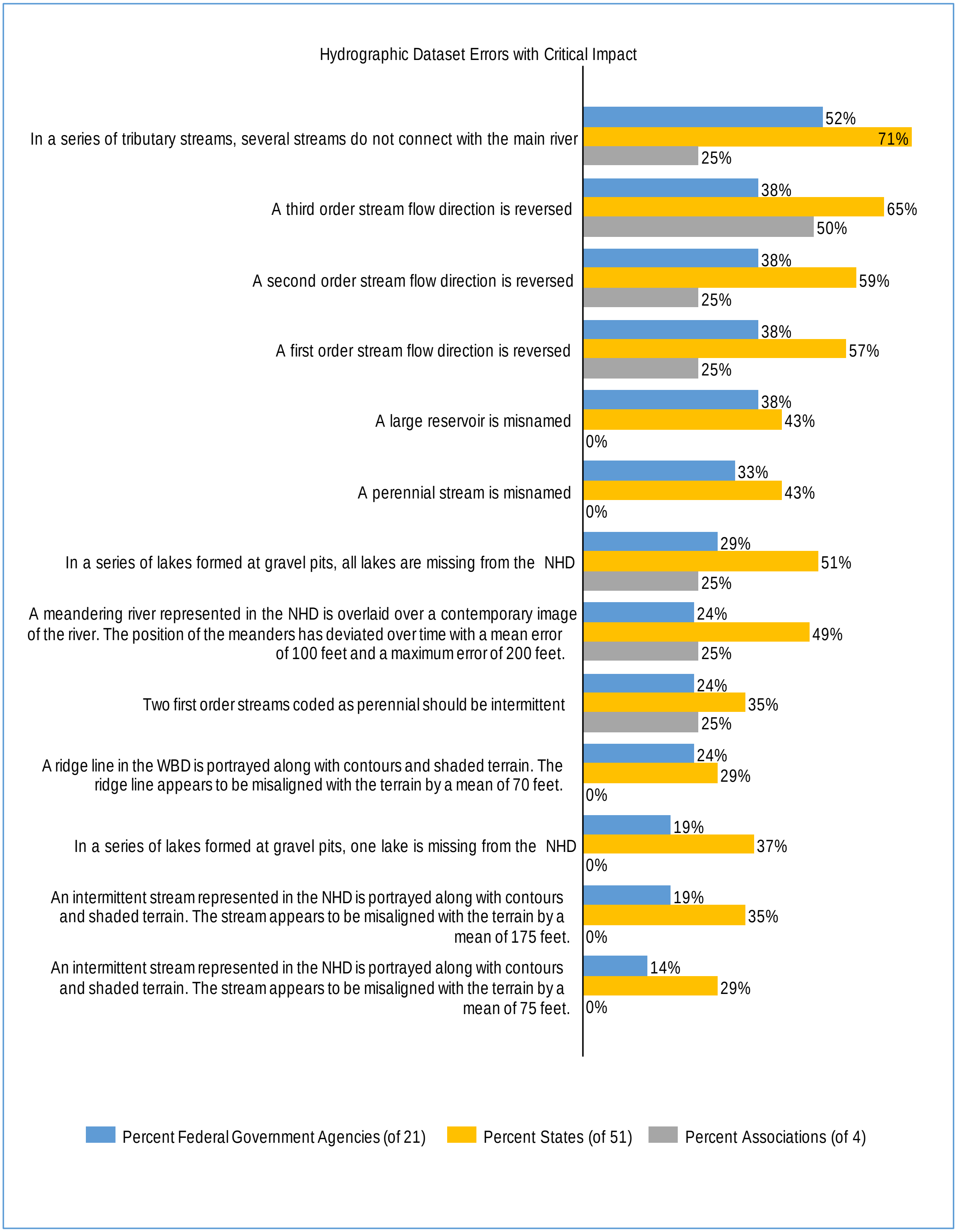

Figure 31.Hydrographic dataset errors with critical impact

4.5.2.7 Other Non-MCA Specific Requirements

Users were asked a few final questions about their hydrographic data requirements. Table 33 below shows the distribution of these responses.

Table 33. Additional hydrographic data requirements of users

Additional Requirements	Most Frequently Reported Federal Agency Response	Most Frequently Reported State Response	Most Frequently Reported Association Response	Most Frequently Reported Response (Total)
How accurate does the area of elevation-derived catchments need to be, relative to their true ground position (reality)?	Within 5% of actual area	Within 5% of actual area	Within 5% of actual area	Within 5% of actual area
If your program reported an error in the hydrographic data, how quickly would that error need to be resolved?	Within 2-30 days	Within 1-2 months	Within 2-30 days/ Within 1 year	Within 2-30 days
Differences in the way the WBD Hydrologic Units and NHDPlus catchments are defined lead to the situation that one cannot simply aggregate whole NHDPlus catchments to create replicas of the Hydrologic Units. How much of a problem does this situation pose to your program (all specified Mission Critical Activities)?	Major problem - data cannot be used for MCA	I don't know	Minor problem, requires some intervention	I don't know
Would your program use a simple web map tool to highlight and report errors in the spatial hydrographic data?	Probably	Yes	No	Yes

In addition to all of the information collected in tabular format from the online questionnaire, the study participants had several ways to submit free-form requirements. One was in a comments field in the questionnaire that was included in the study geodatabase. Another was in the Federal and state summary reports (which are included as Appendixes B, C, and D). Additionally, comments compiled by the USGS National Map Liaisons during the interview/workshop process were collected. A few items not specifically asked in the questionnaire were mentioned by a number of study participants as follows.

- Incorporation of unofficial or local (non-Geographic Names Information System [GNIS]) names into the NHD as alias names was requested by users from two Federal agencies and 13 states. Users noted that getting approval of names through the GNIS is a lengthy process.
- Improved attribution for perennial, intermittent, and ephemeral streams was requested by users from three Federal agencies and 11 states.
- Improved attribution of feature type (stream, canal, etc.) and flow was requested by users from three Federal agencies and five states.

- Transboundary requirements for data extending into Canada and Mexico were described by three Federal agencies, one state, and one association.

4.6 Benefits

Study respondents were asked to provide information for each reported MCA about their estimated annual program budgets that are supported by hydrography data. They were also asked to estimate what their current annual benefits are, and what future annual benefits they are likely to receive from enhanced hydrography data. The future benefits would be those likely to be received from enhanced hydrographic information if all of their reported requirements were met.

For the 420 MCAs, study respondents reported a total estimated annual program budget of $18.5 to $22.5 billion for programs supported by hydrography data. It is clear that stakeholders are already receiving significant benefits from the currently available hydrography data; For the 420 MCAs, study respondents reported $538.5 to $544 million in estimated annual benefits from the currently available hydrography data. And if all of the reported hydrography data requirements could be met by enhanced datasets, the estimated future annual benefits from these enhanced hydrography data would be an additional $602.5 to $605 million over and above the current estimated annual benefits.

Study respondents were unable to provide estimated current annual dollar benefits for 192 (46 percent) of the MCAs (27 from Federal agencies, 99 from state government agencies, and 66 from other entities). And study respondents were unable to provide estimated future annual dollar benefits for 145 (35 percent) of the MCAs (22 from Federal agencies, 82 from state government agencies, and 41 from other entities). This means that the estimated annual dollar benefits, both current and future, are likely to be underestimated. However, as a high level state manager who was not able to quantify future benefits noted, the benefits to having high quality data to support environmental decisions that will affect generations is "immeasurable. It is worth millions of dollars."

Some (but not all) organizations provided a range of values for their annual program budget and/or estimated annual benefits. Five organizations (one Federal, four states) provided a range of values for their estimated annual program budget. Six organizations (one Federal, five states) provided a range of values for their estimated current annual benefits. And six organizations (two Federal, four states) provided a range of values for their estimated future annual benefits. For simplification in this section of the report, only the low values are provided in the tables below for each category. However, the full details are provided for each MCA in Appendixes B, C, and D.

4.6.1 Benefits by Organization Type

Table 34 on the following page provides a summary by organization type of the estimated annual program budgets supported by hydrography data, estimated annual dollar benefits provided by the currently available hydrography data, and estimated future annual benefits from enhanced hydrography data.

Table 34. Estimated program budgets by organizational type

Organization Type	Total Number of MCAs	Estimated Annual Program Budget (in millions)	Estimated Current Annual Benefits (in millions)	Estimated Future Annual Benefits (in millions)
Federal Agencies and Commissions	54	$11,584.65	$212.35	$308.48
Not for Profit	25	$73.68	$3.02	$27.23
Private or Commercial	16	$7.47	$1.28	$2.13
Regional, County, City or Other Local Government	80	$282.70	$137.03	$19.74
State Government	237	$6,523.41	$184.62	$244.73
Tribal Government	8	$1.11	$0.21	$0.24
	420	$18,473.01	$538.50	$602.55

4.6.2 Benefits by Business Use

Table 35 below provides a summary by Business Use of the estimated annual program budgets supported by hydrography data, estimated annual dollar benefits provided by the currently available hydrography data, and estimated future annual benefits from enhanced hydrography data. This table is ranked by the estimated future annual benefits as highlighted in light gray.

Table 35. Benefits of enhanced hydrography data by Business Use

BU	Business Use	Estimated Annual Program Budget (in millions)	Estimated Current Annual Benefits (in millions)	Estimated Future Annual Benefits (in millions)
BU 1	River and Stream Flow Management	$763.58	$220.07	$154.73
BU 4	Water Quality	$1,672.41	$115.46	$121.48
BU 3	Water Resource Planning and Management	$988.88	$98.11	$115.88
BU 15	Flood Risk Management	$636.11	$56.12	$75.86
BU 5	River and Stream Ecosystem Management	$1,000.72	$13.96	$67.00
BU 2	Natural Resources Conservation	$6,956.80	$10.17	$17.76
BU 9	Wildlife and Habitat Management	$1,041.45	$0.18	$10.08
BU 20	Infrastructure and Construction Management	$1,088.72	$1.65	$8.73
BU 7	Forest Resources Management	$254.39	$1.76	$6.01
BU 6	Coastal Zone Management	$63.30	$10.71	$5.55
BU 18	Homeland Security, Law Enforcement, and Disaster Response	$1.75	$0.10	$5.50
BU 24	Education K-12 and Beyond	$1.56	$0.53	$5.36

BU	Business Use	Estimated Annual Program Budget (in millions)	Estimated Current Annual Benefits (in millions)	Estimated Future Annual Benefits (in millions)
BU 21	Urban and Regional Planning	$1,763.51	$2.17	$3.42
BU 10	Agriculture and Precision Farming	$21.75	$1.25	$2.15
BU 12	Resource Mining	$500.10	$1.03	$1.10
BU 13	Renewable Energy Resources	$1,547.85	$2.80	$0.58
BU 22	Health and Human Services	$58.45	$0.50	$0.50
BU 16	Sea Level Rise and Subsidence	$1.00	$0.35	$0.35
BU 25	Recreation	$2.90	$1.41	$0.17
BU 8	Rangeland Management	$20.43	$0.00	$0.10
BU 14	Oil and Gas Resources	$24.00	$0.10	$0.10
BU 19	Marine and Riverine Navigation Safety	$43.00	$0.03	$0.10
BU 11	Geologic Resource Assessment and Hazard Mitigation	$0.35	$0.04	$0.05
BU 17	Wildfire Management, Planning, and Response	$20.00	$0.01	$0.01
	Total	$18,473.01	$538.50	$602.55

4.6.3 Qualitative Benefits

In addition to the dollar benefits reported above, current and future qualitative benefits were reported for each MCA. The options provided for answering this series of questions in the online questionnaire were “Major,” “Moderate,” “Minor,” ”Don’t Know,” and “Not Applicable.” The following categories of qualitative benefits were included in the questionnaire:

- Operational Benefits: Time or Cost Savings – These benefits could come from reduced time spent acquiring data, reduced time spent needed for field work, more efficient modeling or analysis, or reduced overall labor costs.
- Operational Benefits: Mission Compliance – These benefits could come from more reliable analysis results, reduced possibility of errors resulting from the use of disparate datasets, improved customer responsiveness, or more effectively satisfying compliance requirements.
- Customer Service Benefits: Products or Services – These benefits could come from customers having access to improved data or analyses, being able to more effectively perform their mission critical tasks, or improving the outcomes of their water-related programs (e.g. reduced infrastructure or crop losses).
- Customer Service Benefits: Response or Timeliness – These benefits could come from customers getting more up-to-date products or analyses.

- Societal Benefits: Education or Public Safety – These benefits could come from using enhanced data for improved decision making (e.g. to avoid natural or man-made disasters) or safer communities due to better informed siting of drinking water or waste water infrastructure.
- Societal Benefits: Environmental – These benefits could come from restoration of watersheds, stream banks, wetlands, forests, grasslands, etc.
- Societal Benefits: Human Lives Saved – These benefits could come from reduction in loss of life due to flooding or other natural hazards.

Note that only qualitative benefits were collected for the societal benefits categories of education or public safety, environmental, and human lives saved. No dollar values were estimated for these categories.

4.6.3.1 Education or Public Safety

Table 36 below shows the number of MCAs for which study respondents rated the societal benefits for education or public safety as Major, Moderate, or Minor by Business Use. Additionally, a total weighted average of the societal benefits for education or public safety was calculated for each Business Use. The weighting was done as follows: Major = 5, Moderate = 3, Minor = 1, Don't Know, Not Applicable, No response = 0. The table is ranked by the weighted value as highlighted in light gray.

Table 36. Ranking of education or public safety benefits by Business Use

BU #	Business Use	Total Number of MCAs	Major Education or Public Safety Benefits (number of MCAs)	Moderate Education or Public Safety Benefits (number of MCAs)	Minor Education or Public Safety Benefits (number of MCAs)	Don't Know/Not Applicable/No Data Provided (number of MCAs)	Education or Public Safety Benefits Weighted Value
BU 4	Water Quality	79	13	36	16	14	189
BU 15	Flood Risk Management	54	22	16	10	6	168
BU 3	Water Resource Planning and Management	69	11	27	19	12	155
BU 1	River and Stream Flow Management	44	9	14	10	11	97
BU 2	Natural Resources Conservation	34	10	9	7	8	84
BU 5	River and Stream Ecosystem Management	34	7	13	4	10	78
BU 20	Infrastructure and Construction Management	18	6	6	5	1	53
BU 21	Urban and Regional Planning	17	1	10	1	5	36
BU 6	Coastal Zone Management	8	4	3	0	1	29

BU #	Business Use	Total Number of MCAs	Major Education or Public Safety Benefits (number of MCAs)	Moderate Education or Public Safety Benefits (number of MCAs)	Minor Education or Public Safety Benefits (number of MCAs)	Don't Know/Not Applicable/No Data Provided (number of MCAs)	Education or Public Safety Benefits Weighted Value
BU 24	Education K-12 and Beyond	9	5	0	3	1	28
BU 9	Wildlife and Habitat Management	8	2	5	1	0	26
BU 10	Agriculture and Precision Farming	9	2	3	2	2	21
BU 7	Forest Resources Management	5	2	3	0	0	19
BU 18	Homeland Security, Law Enforcement, and Disaster Response	7	1	4	1	1	18
BU 22	Health and Human Services	4	1	2	0	1	11
BU 25	Recreation	3	2	0	1	0	11
BU 12	Resource Mining	2	2	0	0	0	10
BU 14	Oil and Gas Resources	3	1	1	1	0	9
BU 16	Sea Level Rise and Subsidence	2	0	2	0	0	6
BU 11	Geologic Resource Assessment and Hazard Mitigation	3	1	0	0	2	5
BU 17	Wildfire Management, Planning, and Response	1	1	0	0	0	5
BU 19	Marine and Riverine Navigation Safety	3	0	1	2	0	5
BU 8	Rangeland Management	1	0	1	0	0	3
BU 13	Renewable Energy Resources	3	0	0	1	2	1

4.6.3.2 Environmental

Table 37 on the following page shows the number of MCAs for which study respondents rated the societal benefits for the environment as Major, Moderate, or Minor by Business Use. Additionally, a total weighted average of the environmental societal benefits was calculated for each Business Use. The weighting was done as follows: Major = 5, Moderate = 3, Minor = 1, Don’t Know, Not Applicable, No response = 0. The table is ranked by the weighted value as highlighted in light gray.

Table 37. Ranking of the societal benefits for the environment by Business Use

BU	Business Use	Total Number of MCAs	Major Environmental Benefits (number of MCAs)	Moderate Environental Benefits (number of MCAs)	Minor Environmental Benefits (number of MCAs)	Don't Know/Not Applicable/No Data Provided (number of MCAs)	Environmental Benefits Weighted Value
BU 4	Water Quality	79	29	33	10	7	254
BU 3	Water Resource Planning and Management	69	15	25	18	11	168
BU 15	Flood Risk Management	54	12	16	16	10	124
BU 5	River and Stream Ecosystem Management	34	19	7	3	5	119
BU 2	Natural Resources Conservation	34	16	9	4	5	111
BU 1	River and Stream Flow Management	44	12	12	11	9	107
BU 20	Infrastructure and Construction Management	18	7	7	4	0	60
BU 21	Urban and Regional Planning	17	6	5	1	5	46
BU 10	Agriculture and Precision Farming	9	6	1	1	1	34
BU 6	Coastal Zone Management	8	4	2	1	1	27
BU 9	Wildlife and Habitat Management	8	4	2	1	1	27
BU 24	Education K-12 and Beyond	9	3	3	2	1	26
BU 7	Forest Resources Management	5	2	3	0	0	19
BU 22	Health and Human Services	4	2	2	0	0	16
BU 18	Homeland Security, Law Enforcement, and Disaster Response	7	1	2	2	2	13
BU 14	Oil and Gas Resources	3	1	2	0	0	11
BU 25	Recreation	3	2	0	1	0	11
BU 12	Resource Mining	2	2	0	0	0	10
BU 19	Marine and Riverine Navigation Safety	3	0	2	1	0	7
BU 16	Sea Level Rise and Subsidence	2	0	2	0	0	6
BU 8	Rangeland Management	1	1	0	0	0	5
BU 13	Renewable Energy Resources	3	0	1	2	0	5
BU 17	Wildfire Management, Planning, and Response	1	1	0	0	0	5
BU 11	Geologic Resource Assessment and Hazard Mitigation	3	0	0	1	2	1

4.6.3.3 Human Lives Saved

Table 38 on the following page shows the number of MCAs for which study respondents rated the societal benefits for human lives saved as Major, Moderate, or Minor by Business Use. Additionally, a total weighted average of the societal benefits for human lives saved was calculated for each Business Use. The weighting was done as follows: Major = 5, Moderate = 3, Minor = 1, Don’t Know, Not Applicable, No response = 0. The table is ranked by the weighted value as highlighted in light gray.

Table 38. Ranking of the societal benefits for human lives saved by Business Use

BU	Business Use	Total Number of MCAs	Major Human Lives Saved Benefits (number of MCAs)	Moderate Human Lives Saved Benefits (number of MCAs)	Minor Human Lives Saved Benefits (number of MCAs)	Don't Know/Not Applicable/No Data Provided (number of MCAs)	Human Lives Saved Benefits Weighted Value
BU 15	Flood Risk Management	54	18	10	13	13	133
BU 3	Water Resource Planning and Management	69	6	9	13	41	70
BU 4	Water Quality	79	5	11	10	53	68
BU 1	River and Stream Flow Management	44	2	7	8	27	39
BU 20	Infrastructure and Construction Management	18	2	3	7	6	26
BU 6	Coastal Zone Management	8	2	3	2	1	21
BU 2	Natural Resources Conservation	34	2	2	3	27	19
BU 21	Urban and Regional Planning	17	1	3	4	9	18
BU 5	River and Stream Ecosystem Management	34	2	1	4	27	17
BU 18	Homeland Security, Law Enforcement, and Disaster Response	7	1	2	1	3	12
BU 7	Forest Resources Management	5	0	1	4	0	7
BU 10	Agriculture and Precision Farming	9	0	2	1	6	7
BU 14	Oil and Gas Resources	3	0	2	1	0	7
BU 25	Recreation	3	1	0	2	0	7
BU 12	Resource Mining	2	0	2	0	0	6
BU 16	Sea Level Rise and Subsidence	2	0	2	0	0	6
BU 9	Wildlife and Habitat Management	8	0	1	2	5	5
BU 17	Wildfire Management, Planning, and Response	1	1	0	0	0	5
BU 11	Geologic Resource Assessment and Hazard Mitigation	3	0	1	0	2	3
BU 19	Marine and Riverine Navigation Safety	3	0	1	0	2	3
BU 24	Education K-12 and Beyond	9	0	0	3	6	3
BU 22	Health and Human Services	4	0	0	1	3	1
BU 8	Rangeland Management	1	0	0	0	1	0
BU 13	Renewable Energy Resources	3	0	0	0	3	0

5.0 Summary of Study Results

This section provides a summary of the information collected for the HRBS. It provides information about study participation; a summary of the usage by study participants of the currently available NHD, WBD, and NHDPlus datasets and the benefits currently derived from their use; an overview of the MCAs; a summary of some of the major requirements for hydrography data enhancements; and a summary of the benefits to study participants if their requirements for hydrography enhancements were met.

5.1 Study Participation

Detailed responses to this study, in the form of 420 MCAs, were provided by 21 Federal agencies, all 50 states plus American Samoa and Washington D.C., 53 local and regional government organizations, eight Tribal governments, 14 private companies, four associations, and 20 other Not for Profit entities.

As documented in the preceding sections, 90 percent of the MCAs (379 of 420 MCAs) were provided by government agencies (Federal, state, regional, county, city, local, and Tribal). Six percent of the MCAs (25 of 420) were provided by Not for Profit entities. Four percent of the MCAs (16 of 420 MCAs) were provided by private or commercial entities. However, the private or commercial entities were primarily contractors to state government agencies. There was little or no representation of large-scale private entities such as the oil and gas industry, major utilities, or agribusiness. It should be noted that these unrepresented private entities are likely to also make use of national hydrography datasets, have requirements for hydrography data enhancements, and are likely to receive potentially significant but undocumented annual benefits from future enhanced hydrography datasets.

5.2 Current Use of National Datasets

For each of the 420 reported MCAs, study participants were asked to indicate what national hydrography datasets are currently being used to address the water information needs of the MCA. Study respondents reported using NHD, WBD, and/or NHDPlus data for 88 percent of MCAs. Study respondents reported using no hydrography data for only 4 percent of the MCAs. Study respondents reported using another dataset in addition to the NHD, WBD, and/or NHDPlus data for 34 percent of the MCAs and using another dataset instead of the NHD, WBD, and/or NHDPlus data for 8 percent of the MCAs.

When another water-related dataset is used, 60 percent of the time it is state or locally developed and/or maintained hydrography data. These locally maintained data are either of higher resolution than the national datasets, having been collected or improved to fit recently collected lidar, orthoimagery, or parcel data, and/or have locally improved or added attributes that were customized to serve the MCA's business needs.

A total of 24 states reported that they add value to the currently available NHD, WBD, and/or NHDPlus datasets and/or maintain similar information on local resolution data. Ten of those 24 states reported a desire for the national datasets to reflect the value they add locally. However, it was noted that a better strategy for making it easy for local stewards to incorporate their data into the national structure is needed. It was also noted that better tools (i.e. quick, easy, and online) for identifying errors and submitting changes to the national datasets would increase stewardship. When asked, 82 percent of the participating agencies said they would probably or definitely use a web-based tool to report errors in the national dataset.

However, all study respondents reported receiving benefits, either quantified as dollar values or qualitative benefits from the currently available hydrography datasets. One state user noted “The efforts of the USGS to keep these core datasets of the highest quality possible is appreciated and not overlooked.” Another state user noted that “There is tremendous value in the NHD and supporting materials.” And the IJC noted that hydrography data harmonization activities completed across the U.S.-Canada border to date have changed the behavior and expectations across the two nations. Both countries are benefiting from the use of the harmonized data across the landscape and the data harmonization could not have been accomplished without the NHD and WBD datasets.

Feedback on the available data for Alaska noted that these data are not meeting user requirements. While consistently mapped at 1:24,000-scale or better in the contiguous U.S., the NHD in Alaska do not meet modern mapping standards and user needs. Over the past five years, efforts by several organizations have updated the NHD to modern mapping standards for approximately 10 percent of the state, but significant work remains to complete updates across the state. Slow progress on updating the NHD to national high-resolution standards is due in part to the quality of the existing topographic data. Given the current hydrography situation in Alaska, there is a pressing need to correct these issues and improve the NHD to meet state and Federal agency needs.

This study indicates that there are significant benefits to be realized through the provision of nationwide enhanced hydrography datasets. Study participants from ten Federal agencies and 31 states noted that they would derive significant future time or cost savings from not having to maintain their own datasets if the national datasets met their needs for positional accuracy, currency, consistency, completeness, and attribution. The benefits from not having to maintain their own datasets contribute to an estimated $59 million in future annual benefits.

Participants from four Federal agencies and nine states reported that having all of the data they need in one dataset would save them time they currently spend searching for and obtaining data. Additional improvements could be realized through improved online tools such as visualization and editing tools, and through streamlined stewardship approaches.

5.3 MCAs

Study participants were asked to describe in their own words their MCAs. Because the MCAs were self-described and titled, there was a fairly wide variety among the MCAs. Some MCAs were described in terms of the respondent’s agency’s organization, some in terms of their daily activities. Some MCAs were very broad and encompassed multiple Business Uses and some were quite narrowly defined.

After consolidation of the data during the follow on interviews/workshops and validation process, 420 MCAs were described. During this consolidation, the Federal agency MCAs were reduced from 228 to 54. On the other hand, during the state interview/workshop process, 26 new MCAs were identified that had not been originally captured by the respondents to the questionnaire. These new MCAs were added to fill gaps in information provided by the states. Nine state MCAs that were initially reported in the online questionnaire were dropped because there was not enough information provided or there was duplication of information.

In tables that report number of MCAs, totals broken down by Federal agencies, state government agencies, and other entities are reported along with the overall totals. This allows the responses that cover generally larger geographic areas represented by a smaller number of Federal agencies and the requirements that generally cover smaller but more numerous state and local geographic areas to be reported separately.

Study respondents were asked to identify the geographic area requirements for each MCA. Maps depicting the area of interest for each MCA are included in Appendixes B, C, and D. Figure 16 in Section 4.2 above also shows the distribution of the spatial extents of all 420 MCAs aggregated by HUC8 areas.

5.4 Business Uses

Study participants were requested to assign one (or more) of 25 pre-defined Business Uses to each MCA, in addition to providing an MCA title and description. The Business Uses are described in Section 4.3 above and in detail in Appendix E. Because study participants were asked to describe their MCA in their own words and to assign a Business Use to each, there was a fairly wide variety among how the Business Uses were assigned to the MCAs. Some Business Uses seemed to be interpreted broadly and multiple types of activities were associated with them. Others seemed to be more narrowly interpreted. BU #4 Water Quality and BU #15 Flood Risk Management were among the more consistently applied Business Uses. BU #1 River and Stream Flow Management, BU #2 Natural Resources Conservation, BU #3 Water Resource Planning and Management, and BU #5 River and Stream Ecosystem Management had the widest variety of MCA descriptions ascribed to them.

5.5 Requirements

Study participants were asked to provide detailed information about their hydrography requirements. Section 4.5 above provides details about the MCA specific and non-MCA specific requirements by organization type (Federal agencies, State government, and other entities). Maps showing the spatial distribution of requirements are provided in this section. Maps depicting the MCA-specific requirements for the categories of positional accuracy (Figures 32-37), stream density (Figures 38-40), smallest contributing watershed (Figures 41-46), smallest mapped waterbody (Figures 47-52), update frequency (Figures 53-57), post-event updates (Figures 58-61), and level of detail (Figures 62-63).

5.5.1 Positional Accuracy

Users were asked what positional accuracy is required for geographic features in the hydrography data to satisfy MCA requirements. Figures 32-37 below show the spatial distribution of the positional accuracy responses. Each map shows the number of MCAs with one of the following positional accuracy requirement options: +/- 3 feet, 90% (1:1,200-scale), +/- 7 feet, 90% (1:2,400-scale), +/- 33 feet, 90% (1:12,000-scale), +/- 40 feet, 90% (1:24,000-scale), +/- 170 feet, 90% (1:100,000-scale), and +/- 420 feet, 90% (1:250,000-scale). Areas with darker colors have greater numbers of areas of interest.

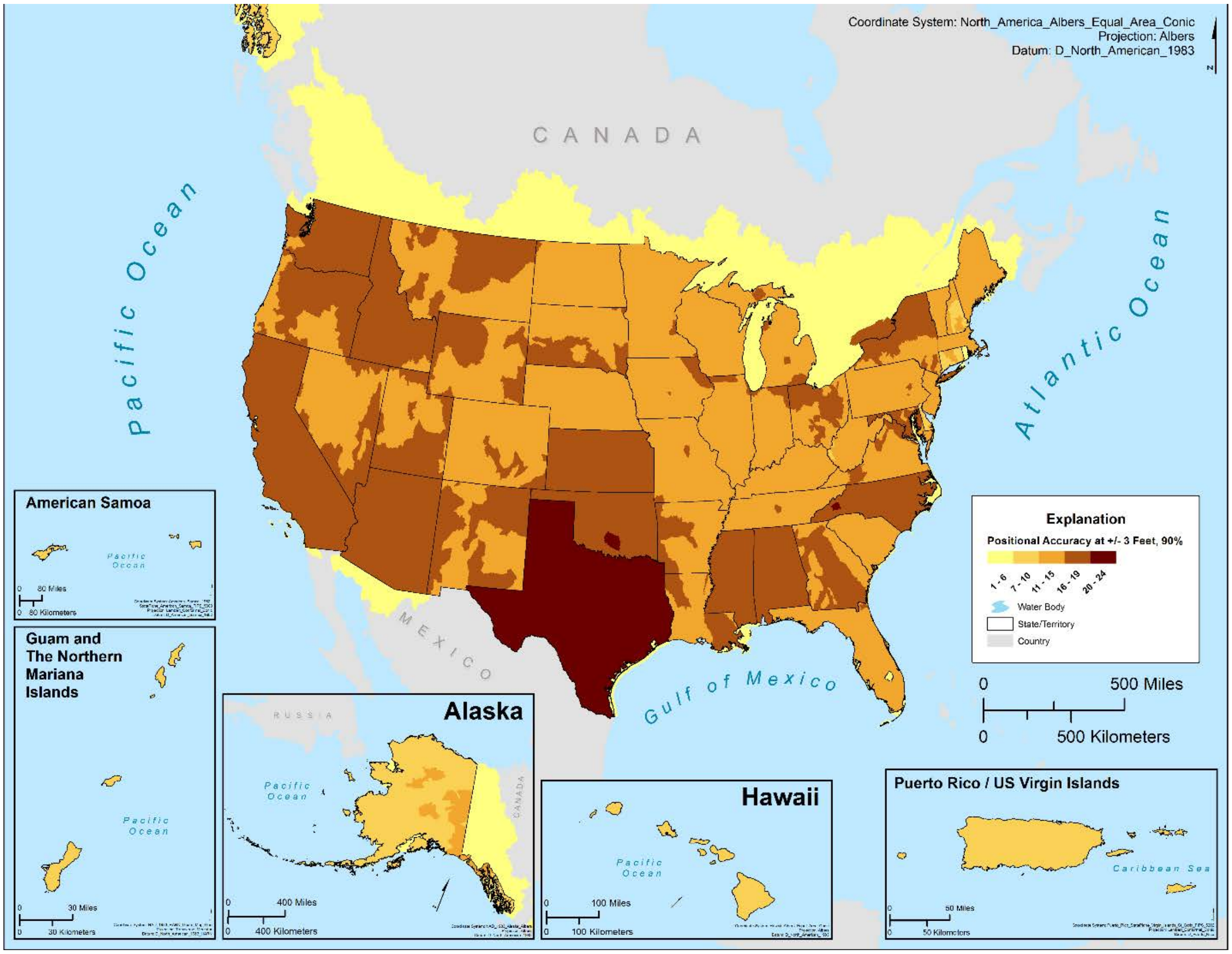

Figure 32. Number of MCAs for which positional accuracy is required at +/- 3 feet, 90%

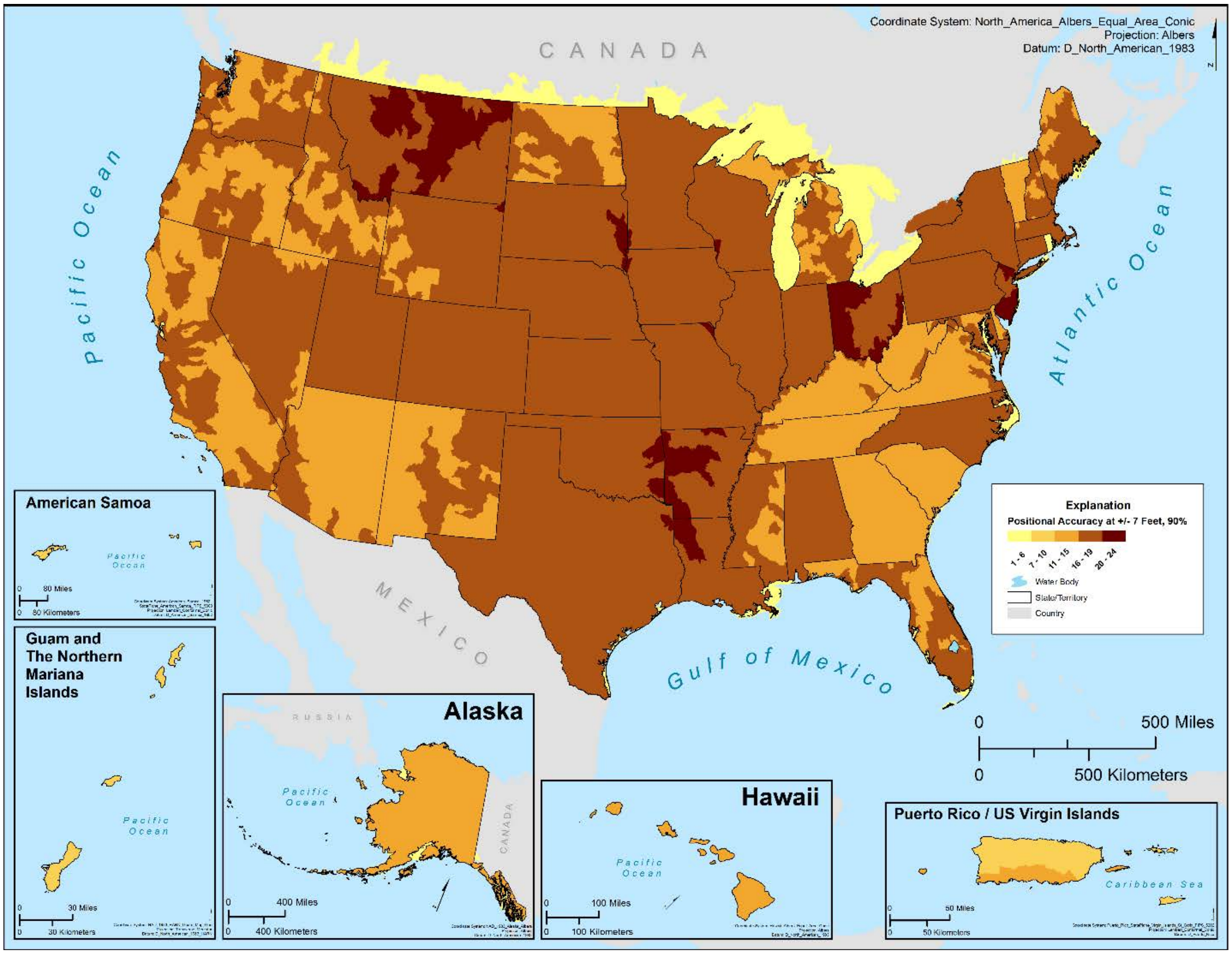

Figure 33. Number of MCAs for which positional accuracy is required at +/- 7 feet, 90%

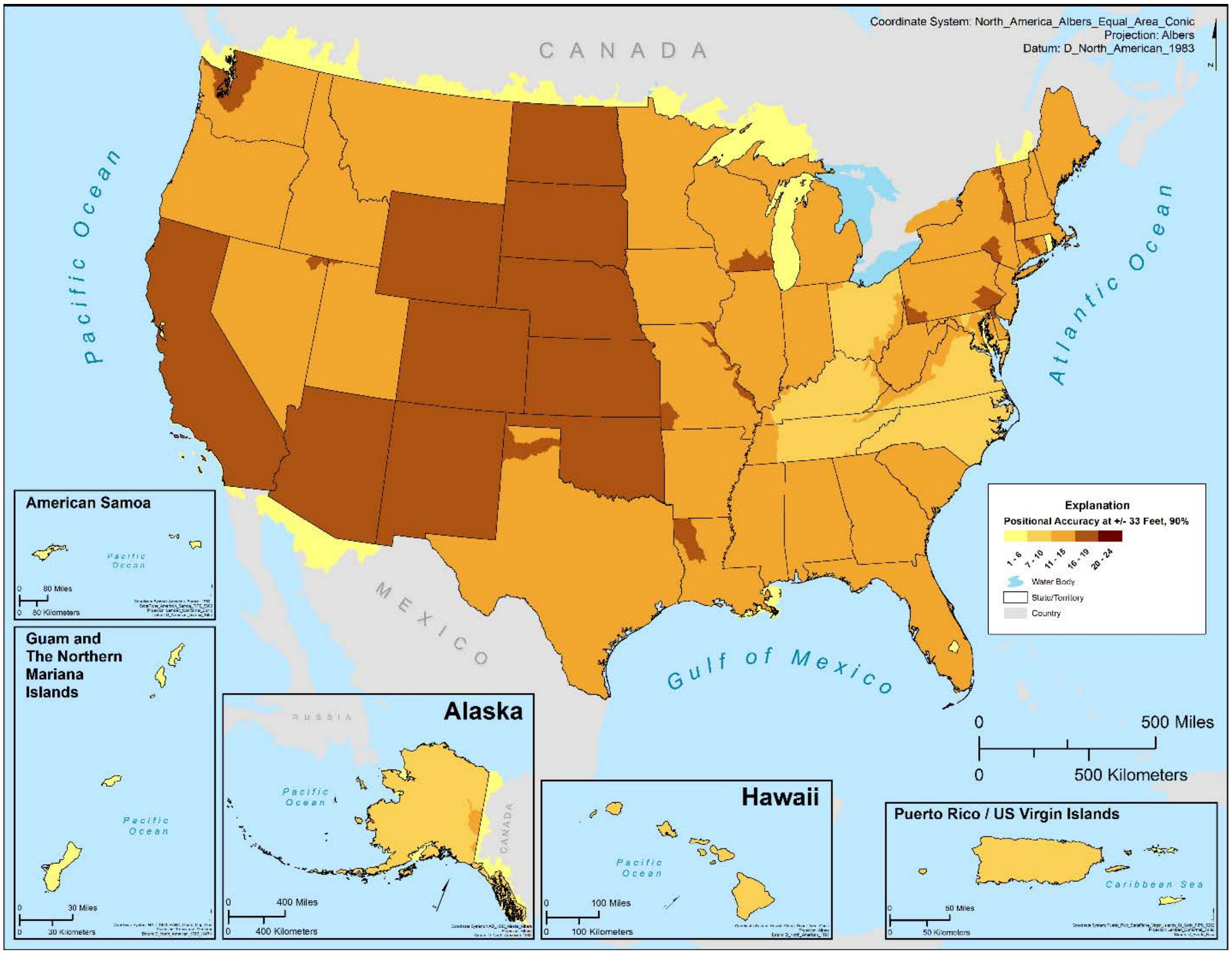

Figure 34. Number of MCAs for which positional accuracy is required at +/- 33 feet, 90%

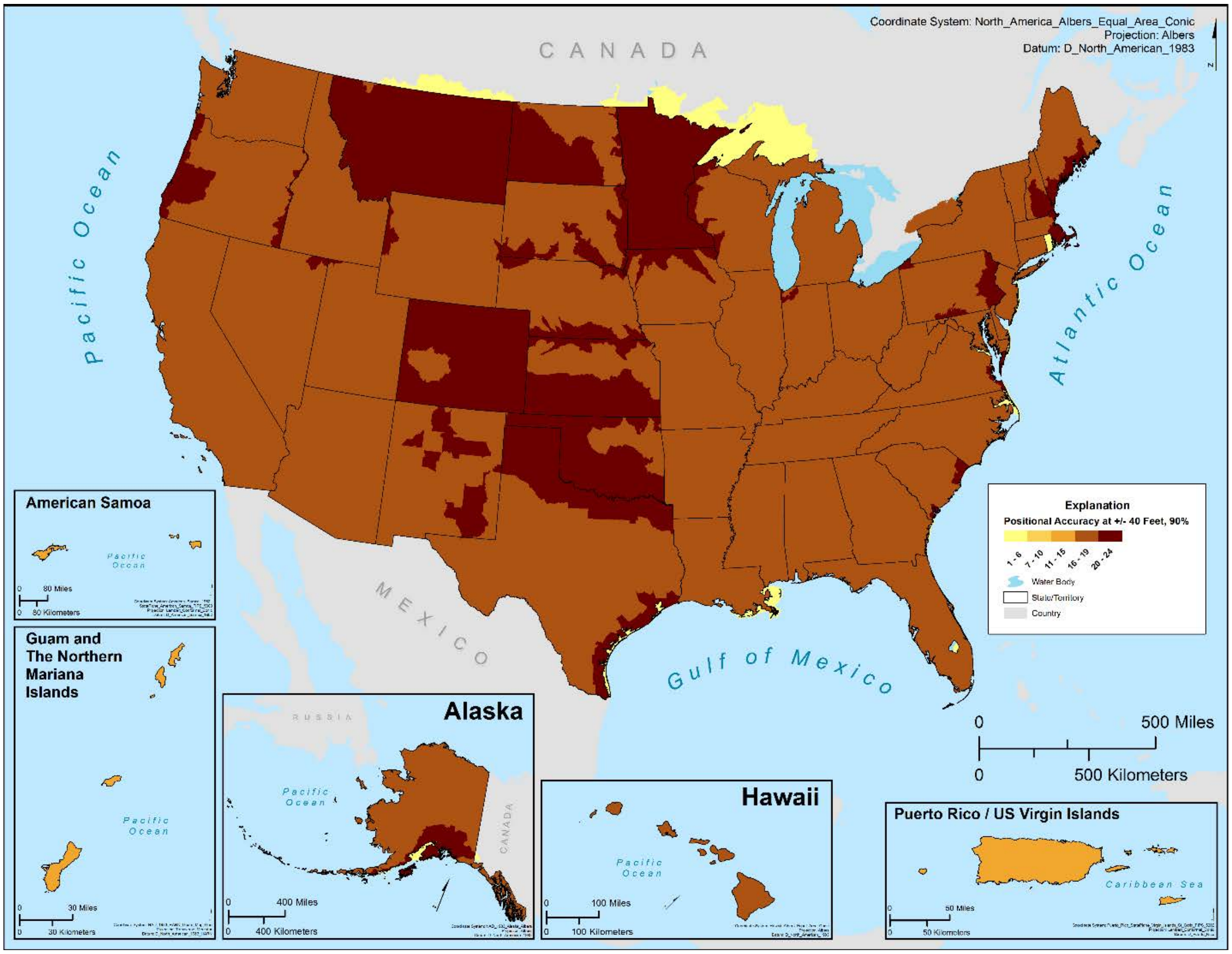

Figure 35. Number of MCAs for which positional accuracy is required at +/- 40 feet, 90%

Figure 36. Number of MCAs for which positional accuracy is required at +/- 170 feet, 90%

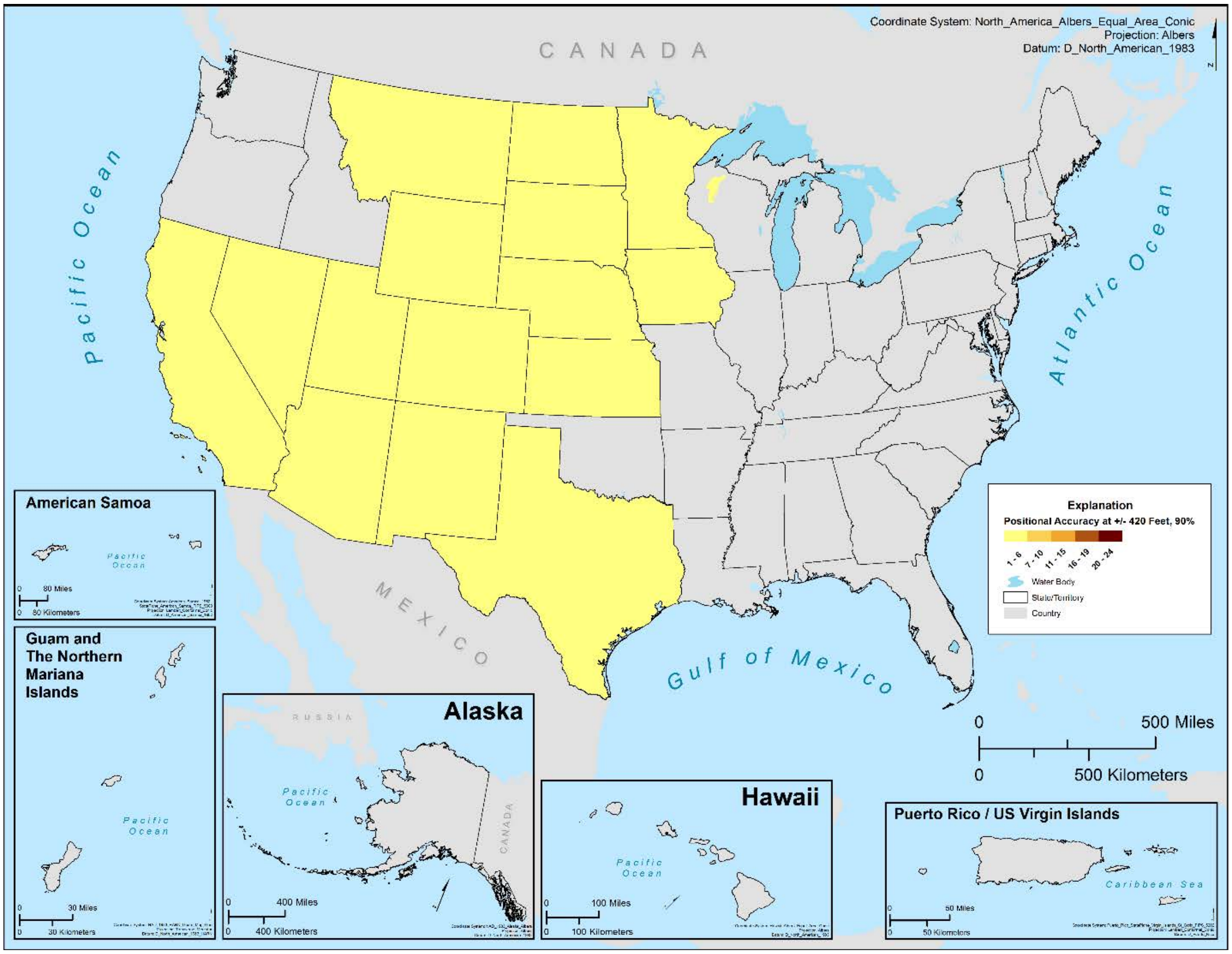

Figure 37. Number of MCAs for which positional accuracy is required at +/- 420 feet, 90%

5.5.2 Stream Density

Users were asked what level of detail or stream density is required for the hydrography data to satisfy MCA requirements. Figures 38-40 below show the spatial distribution of the stream density responses. Each map shows the number of MCAs with one of the following stream density requirement options: 5.0 miles of surface water channel per square mile (1:5,000-scale), 2.5 miles of surface water channel per square mile (1:24,000-scale), and 1.0 mile of surface water channel per square mile (1:100,000-scale). Areas with darker colors have greater numbers of areas of interest.

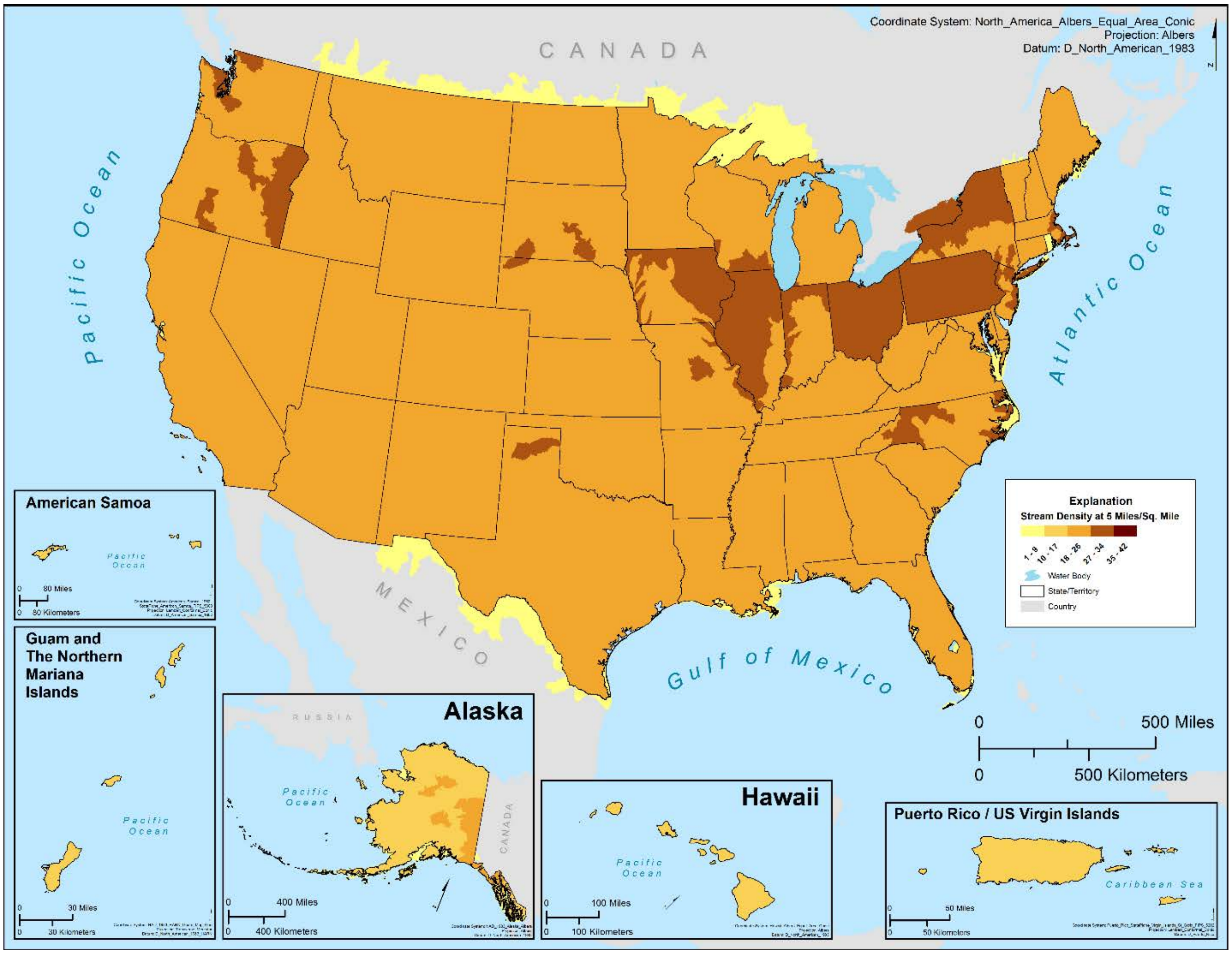

Figure 38. Number of MCAs for which stream density is required at five miles of surface water channel per square mile

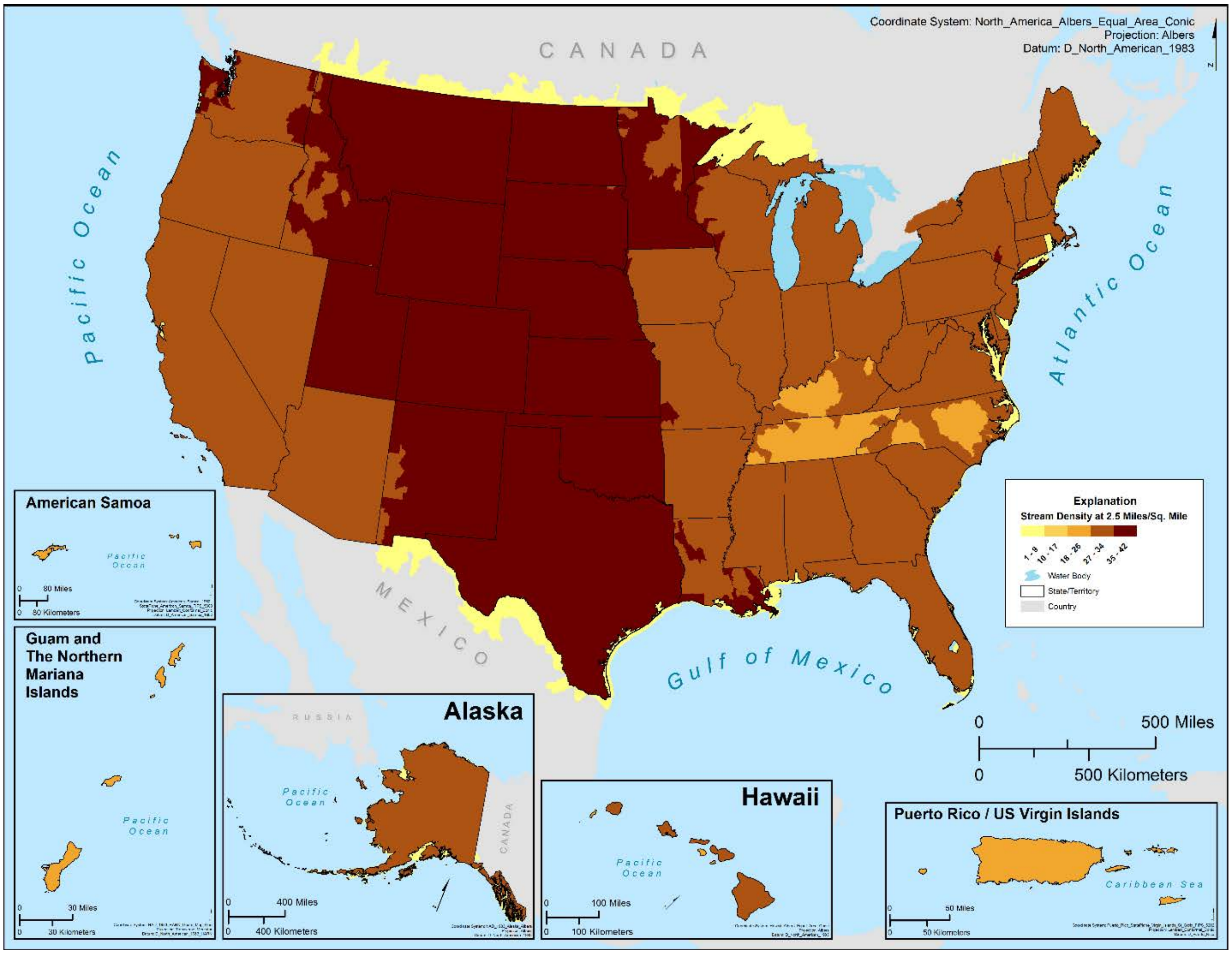

Figure 39. Number of MCAs for which stream density is required at 2.5 miles of surface water channel per square mile

Figure 40. Number of MCAs for which stream density is required at one mile of surface water channel per square mile

5.5.3 Smallest Contributing Watershed

Users were asked what the smallest contributing area or watershed is for which a watercourse needs to be delineated for the hydrography data to satisfy MCA requirements. Figures 41-46 below show the spatial distribution of the smallest contributing watershed responses. Each map shows the number of MCAs with one of the following smallest contributing watershed requirement options: 6 acres, 60 acres, 1 square mile (640 acres), 10 square miles (6,400 acres), 100 square miles (64,000 acres), and 1,000 square miles (640,000 acres). Areas with darker colors have greater numbers of areas of interest.

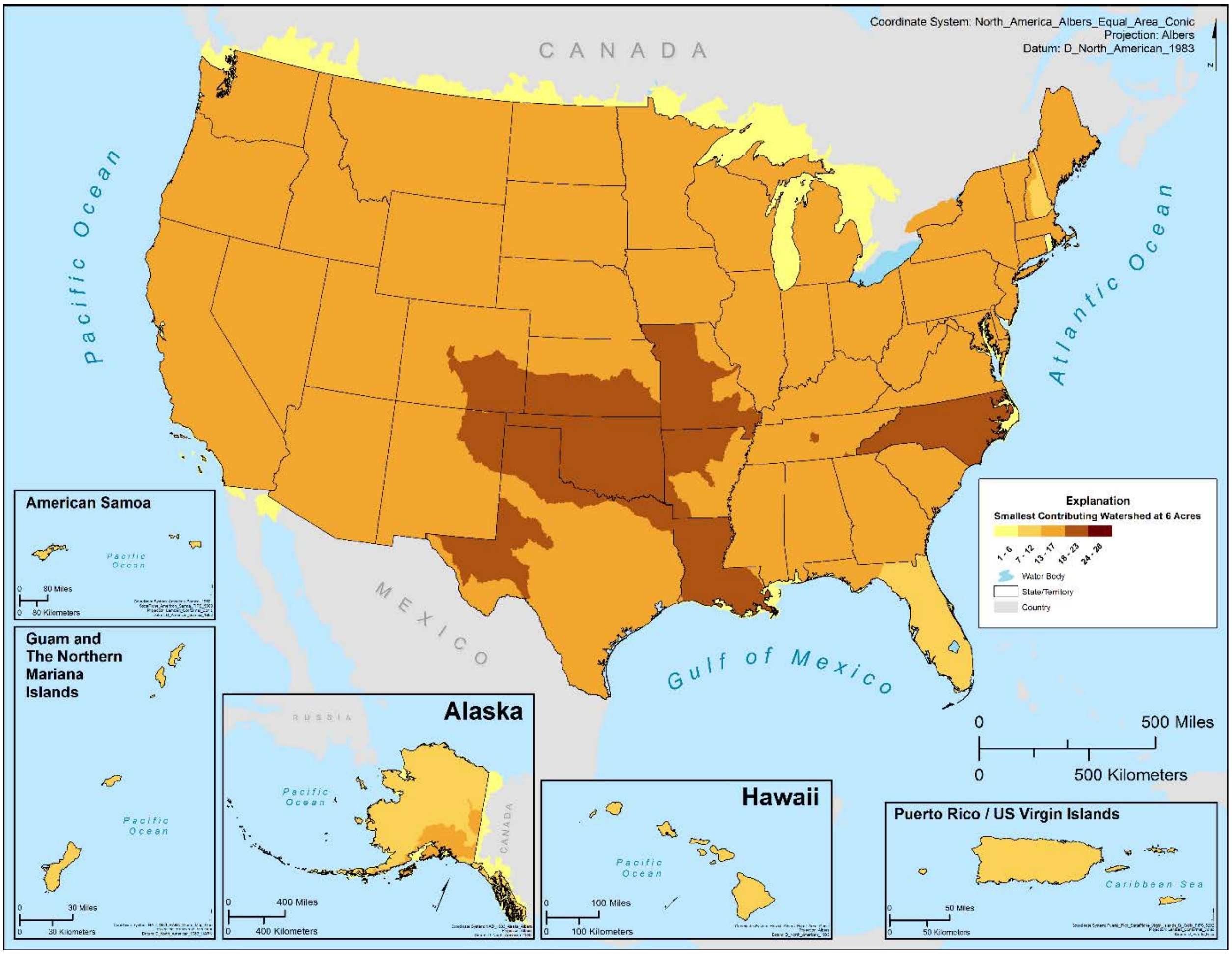

Figure 41. Number of MCAs for which smallest contributing watershed requirement is six acres

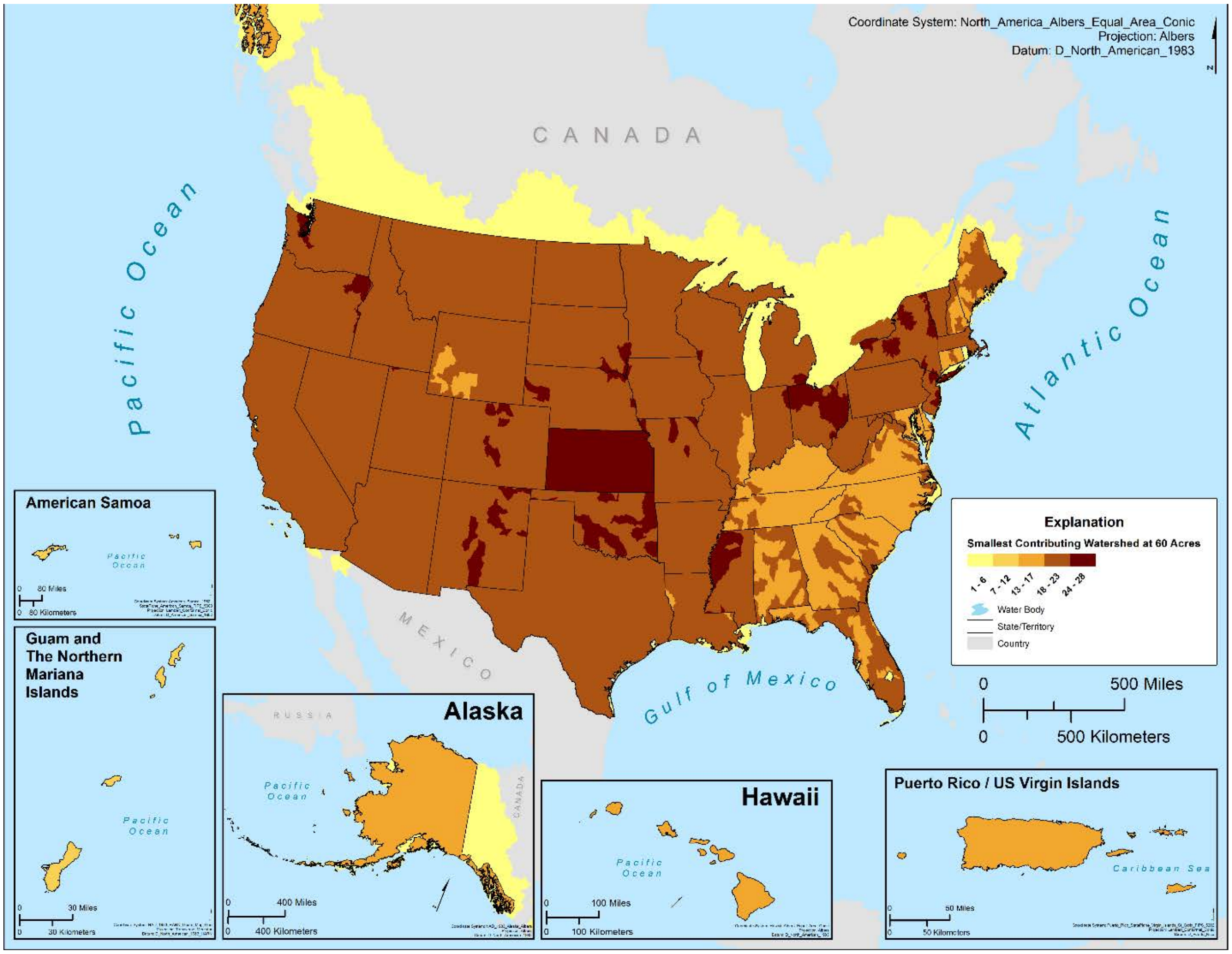

Figure 42. Number of MCAs for which smallest contributing watershed requirement is 60 acres

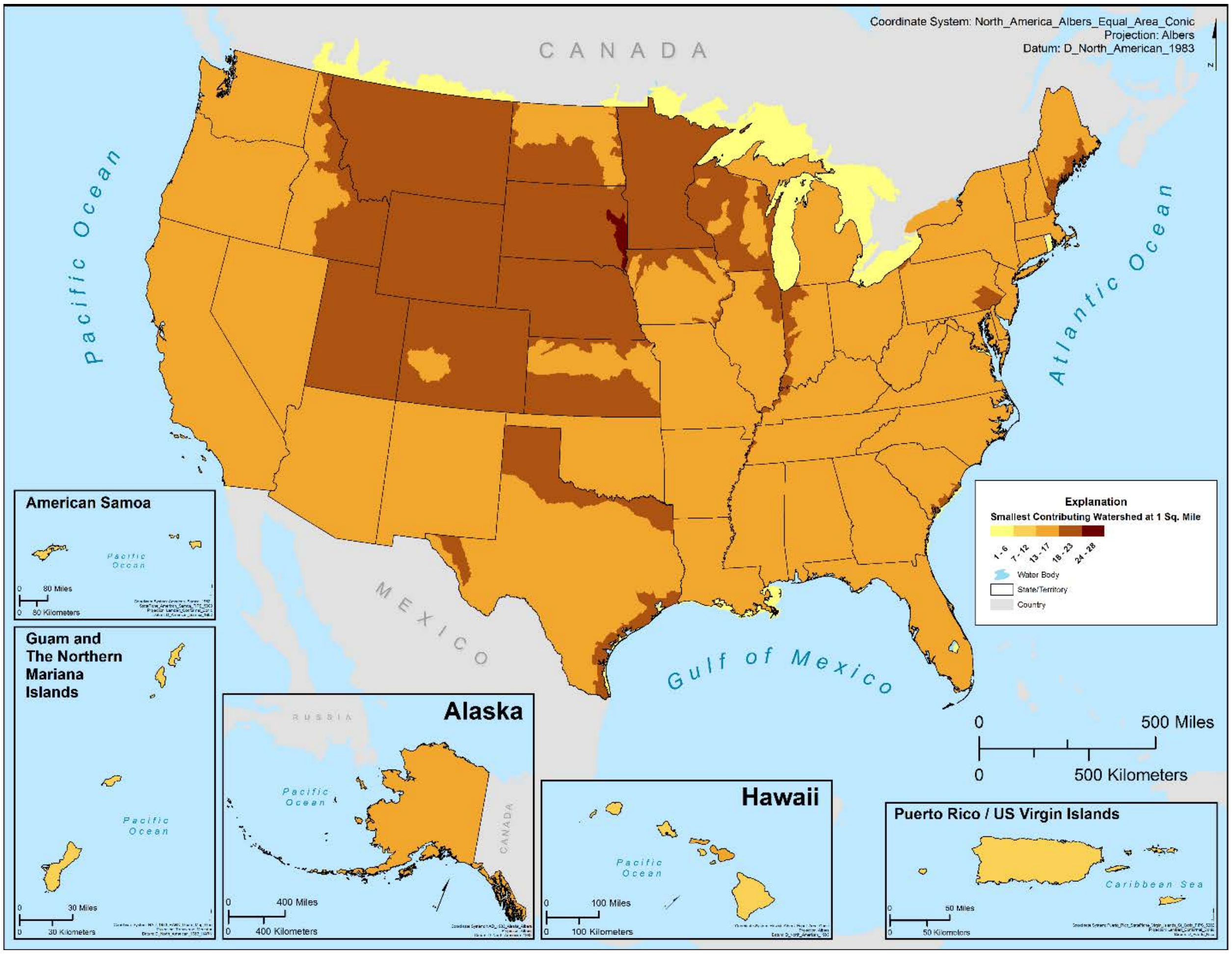

Figure 43. Number of MCAs for which smallest contributing watershed requirement is one square mile (640 acres)

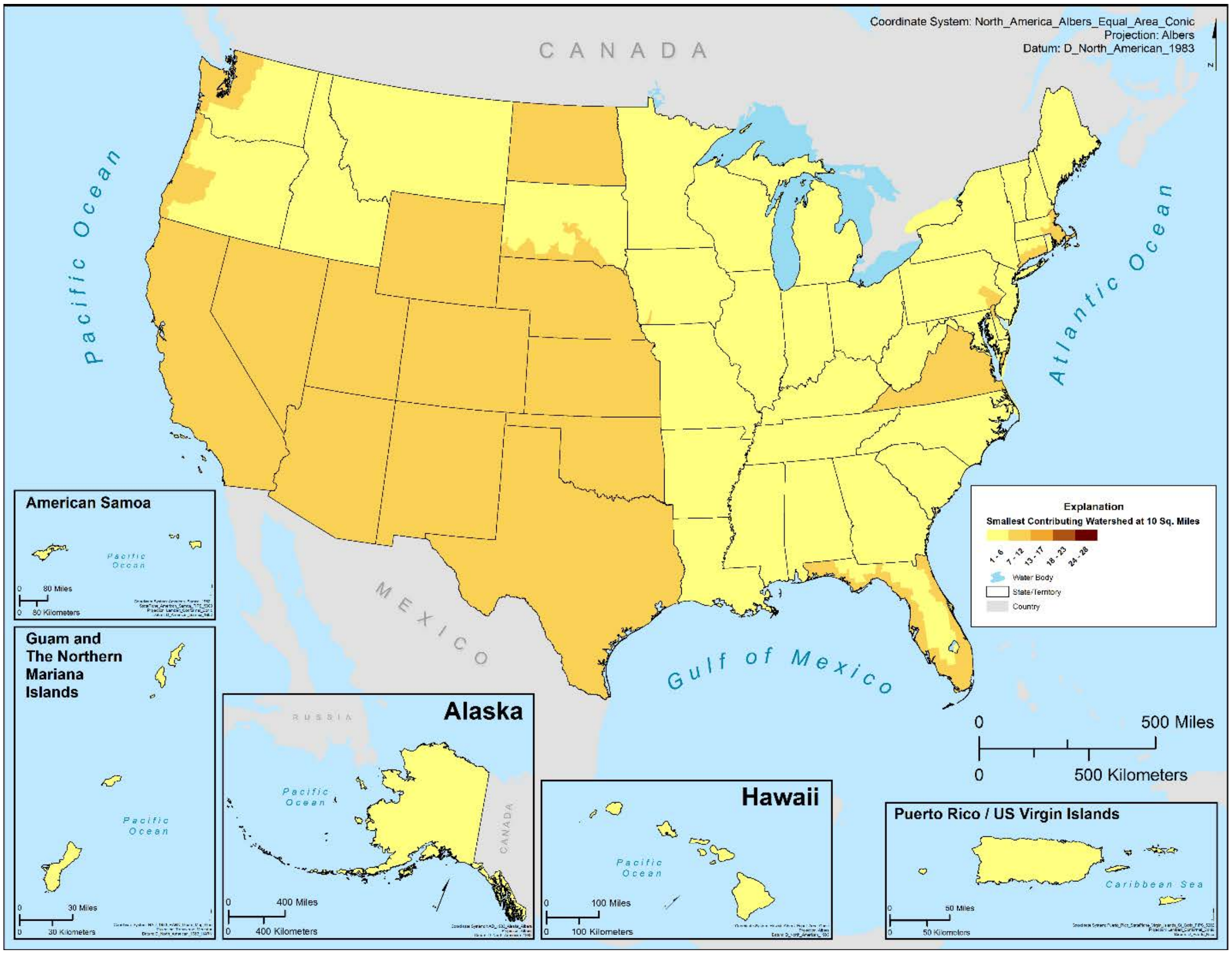

Figure 44. Number of MCAs for which smallest contributing watershed requirement is 10 square miles (6,400 acres)

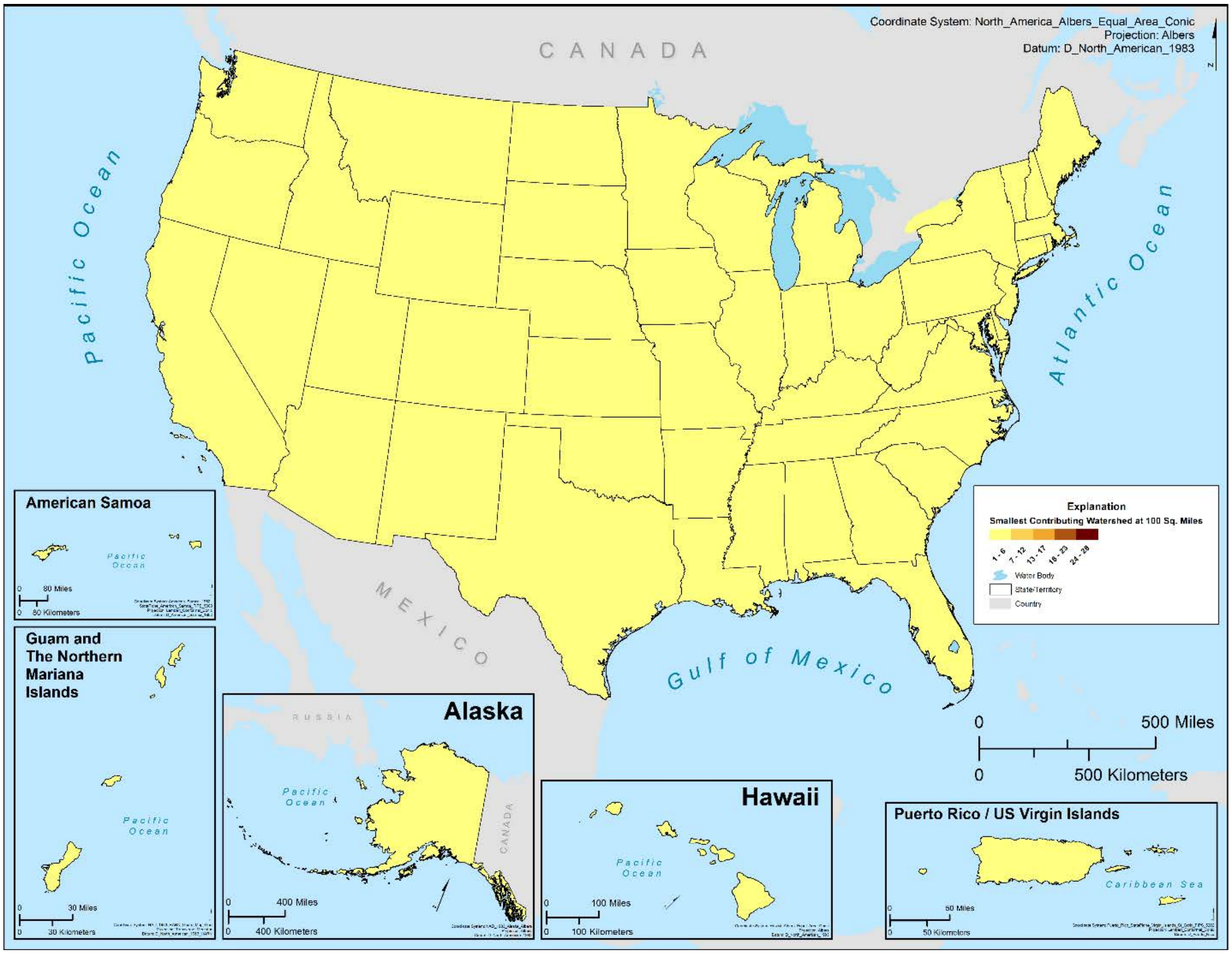

Figure 45. Number of MCAs for which smallest contributing watershed requirement is 100 square miles (64,000 acres)

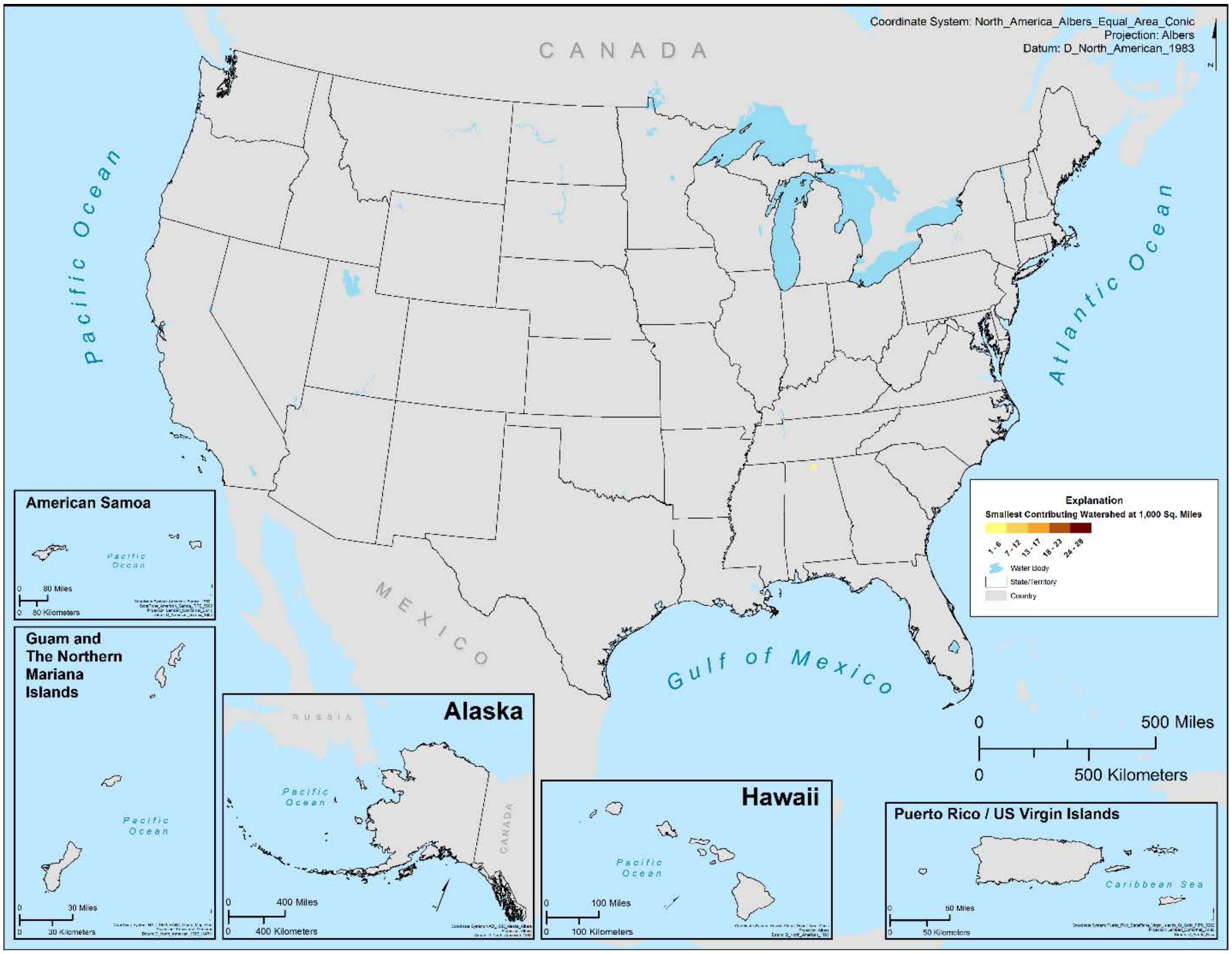

Figure 46. Number of MCAs for which smallest contributing watershed requirement is 1,000 square miles (640,000 acres)

5.5.4 Smallest Mapped Waterbody

Users were asked what the smallest mapped waterbody is for the hydrography data to satisfy MCA requirements. Figures 47-52 below show the spatial distribution of the smallest mapped waterbody responses. Each map shows the number of MCAs with one of the following smallest mapped waterbody requirement options: less than 1 acre, 1 acre, 2 acres, 5 acres, 10 acres, and 20 acres. Areas with darker colors have greater numbers of areas of interest.

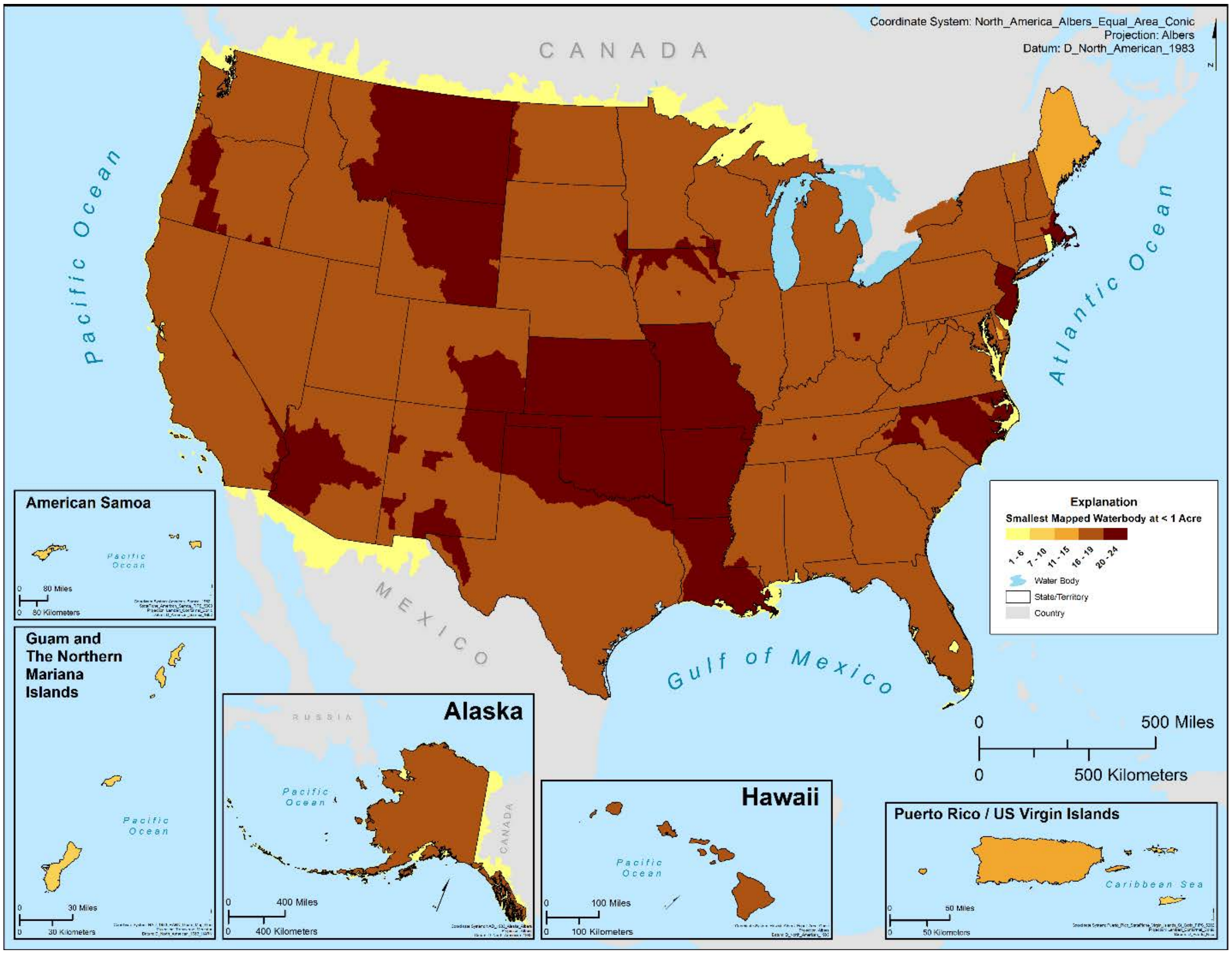

Figure 47. Number of MCAs for which smallest mapped waterbody requirement is less than one acre

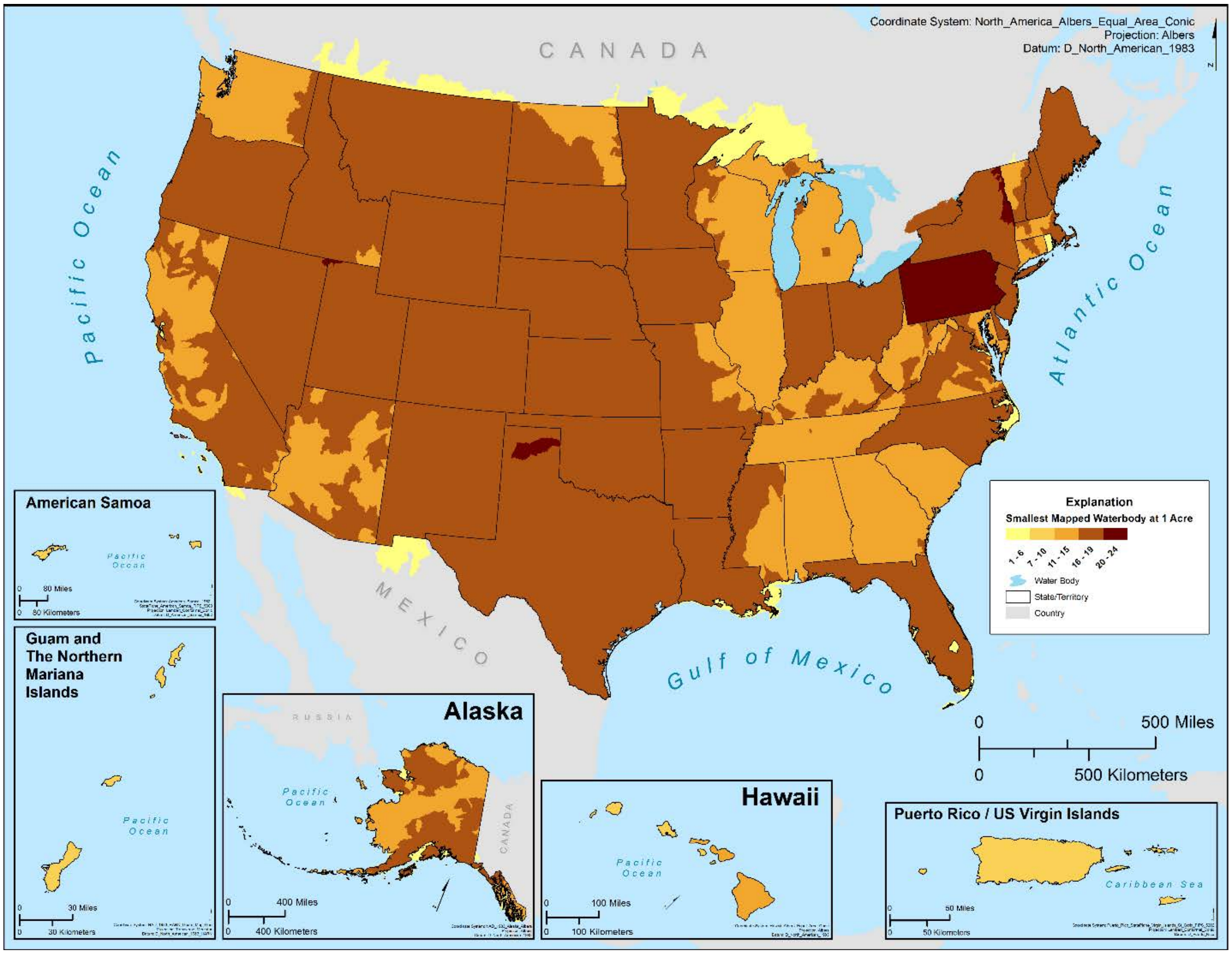

Figure 48. Number of MCAs for which smallest mapped waterbody requirement is one acre

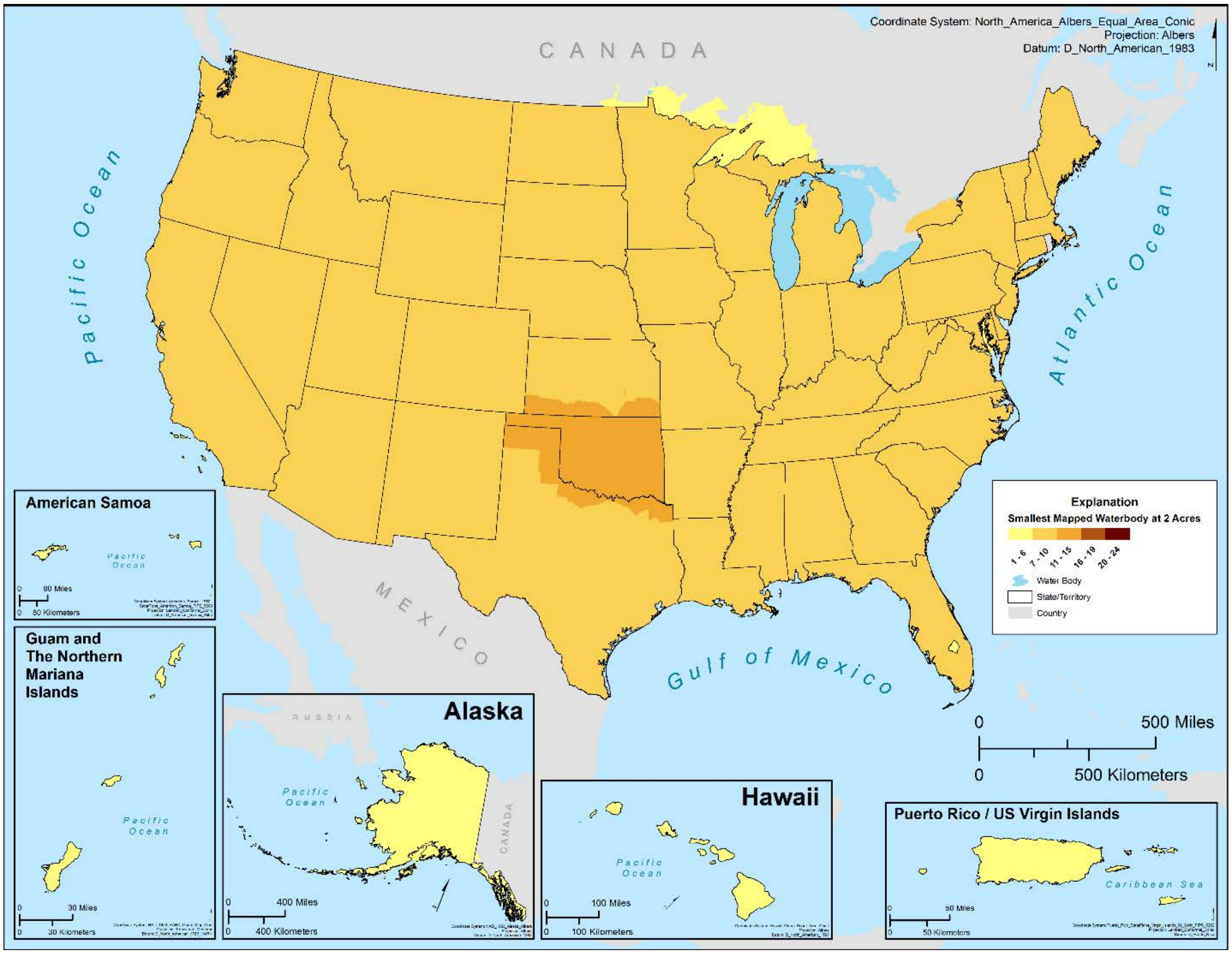

Figure 49. Number of MCAs for which smallest mapped waterbody requirement is two acres

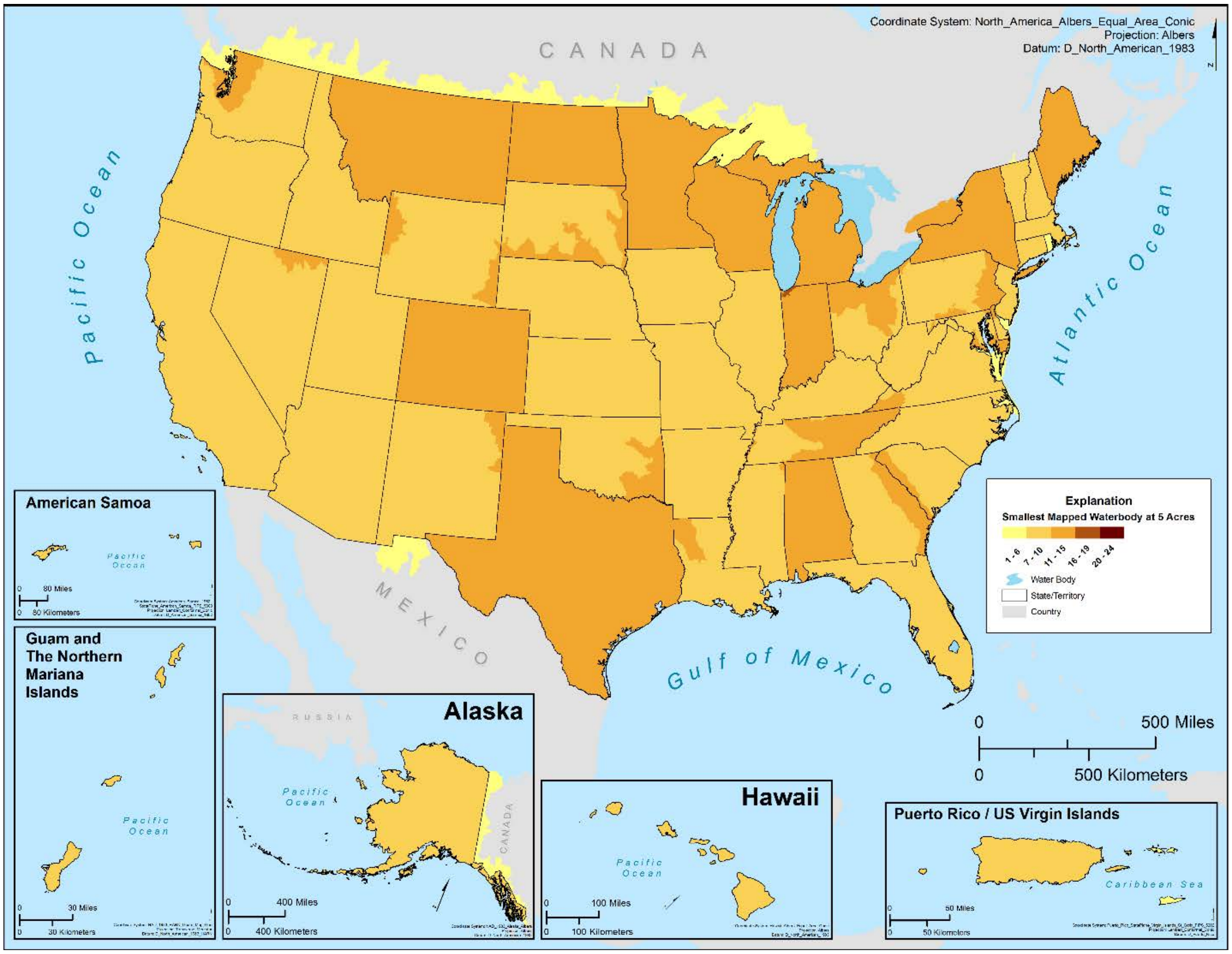

Figure 50. Number of MCAs for which smallest mapped waterbody requirement is five acres

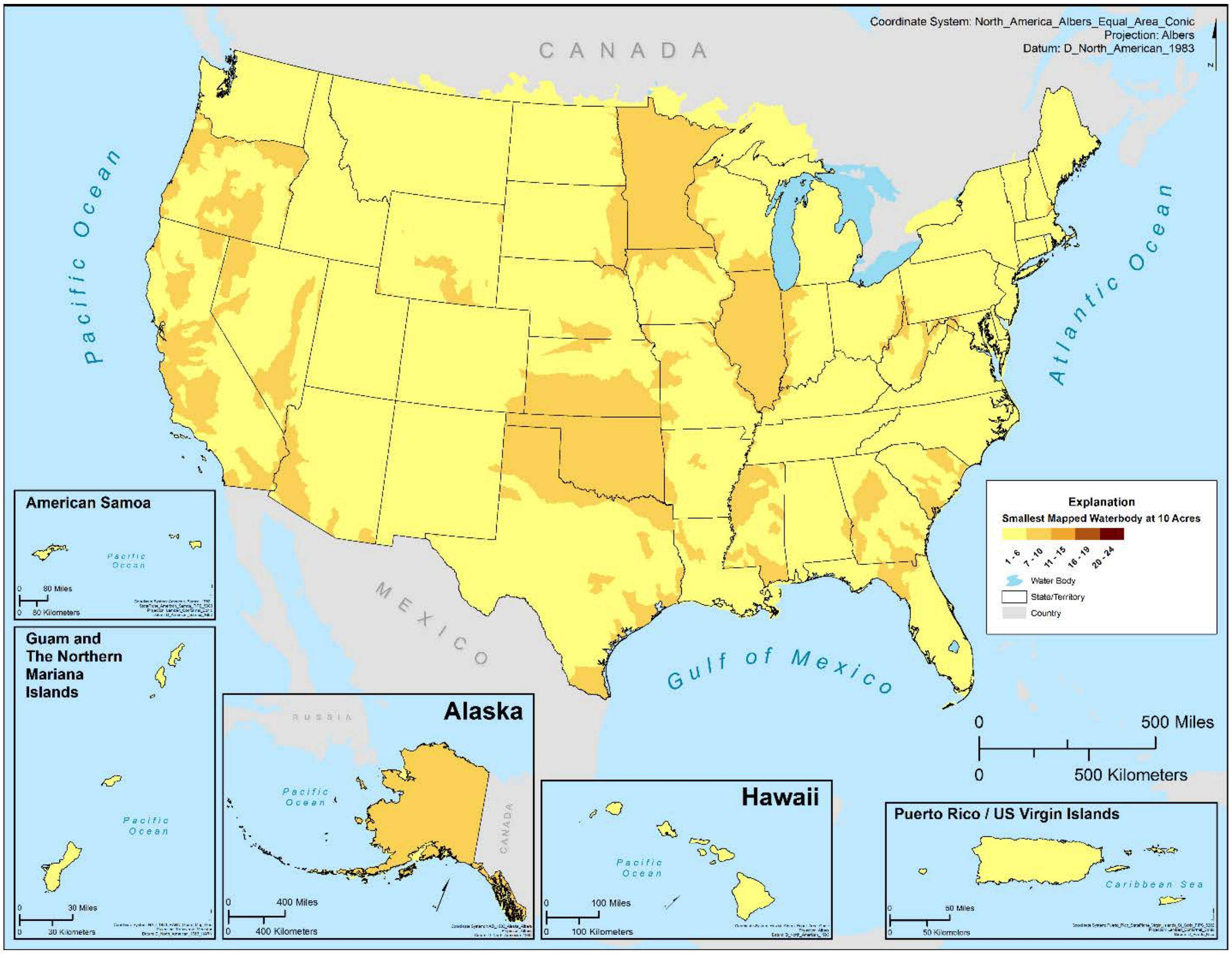

Figure 51. Number of MCAs for which smallest mapped waterbody requirement is 10 acres

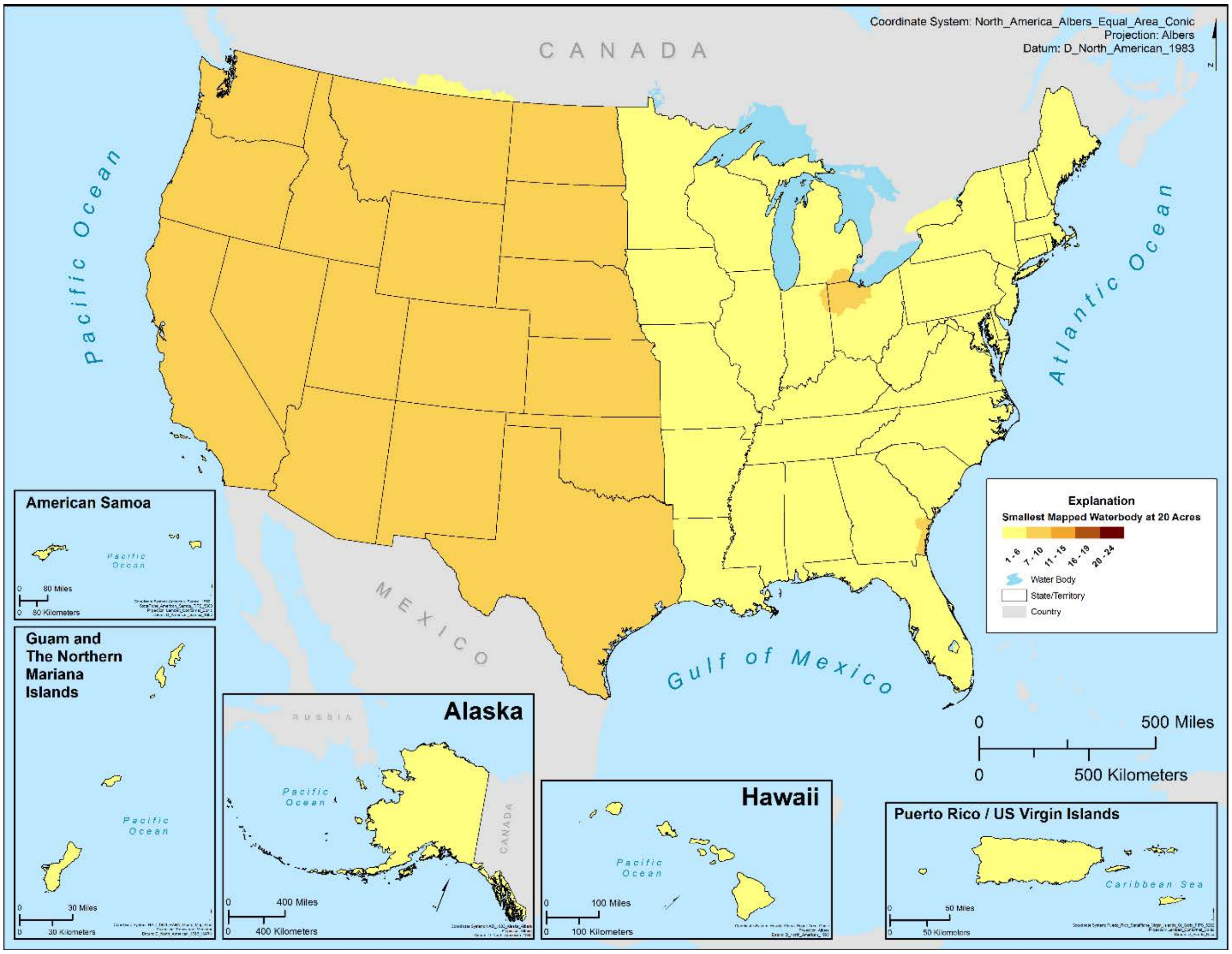

Figure 52. Number of MCAs for which smallest mapped waterbody requirement is 20 acres

5.5.5 Update Frequency

Users were asked how frequently the hydrographic information needs to be updated to satisfy MCA requirements. Figures 53-57 below show the spatial distribution of the update frequency responses. Each map shows the number of MCAs with one of the following update frequency requirement options: annually, 2-3 years, 4-5 years, 6-10 years, and >10 years. Areas with darker colors have greater numbers of areas of interest.

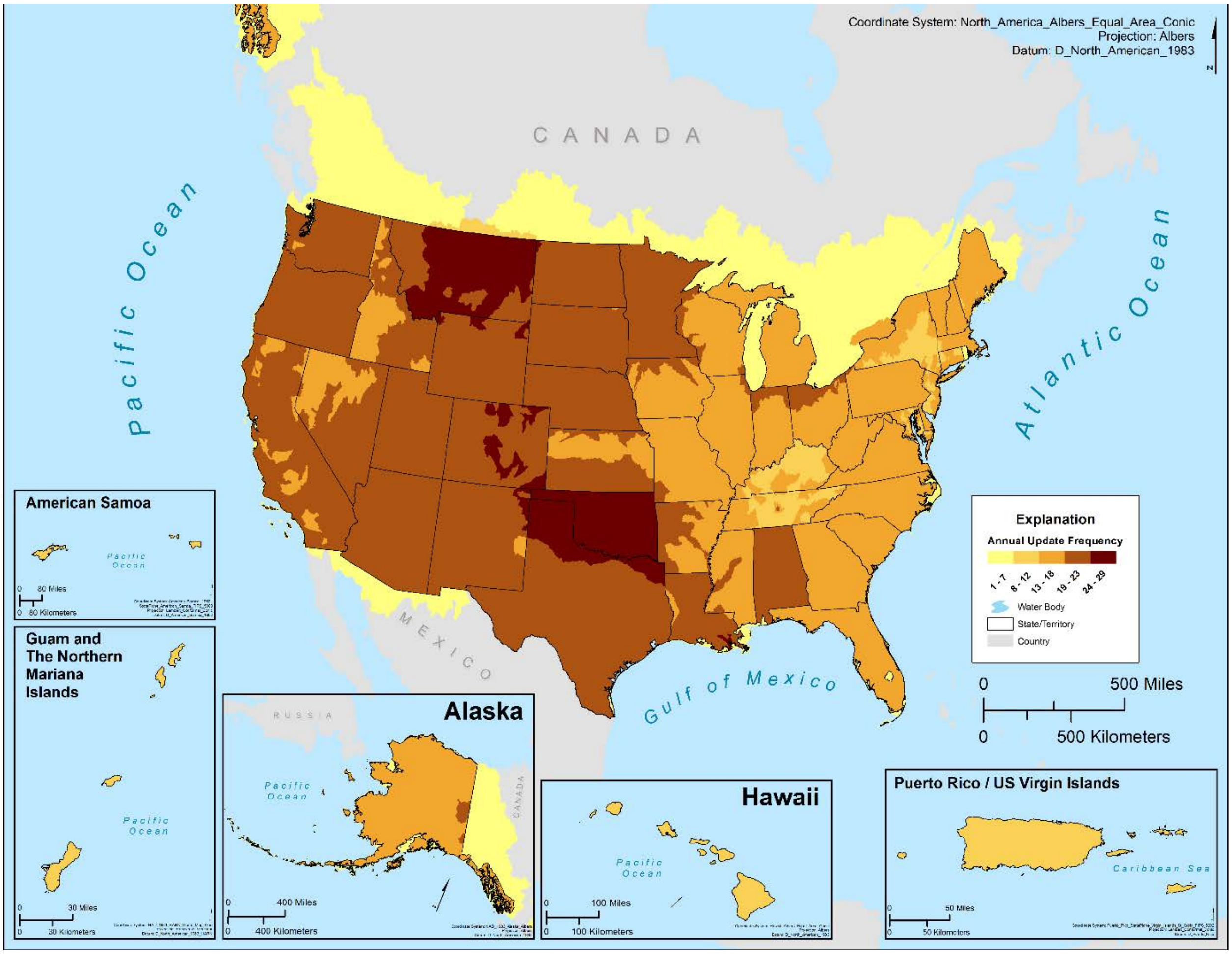

Figure 53. Number of MCAs for which annual updates are required

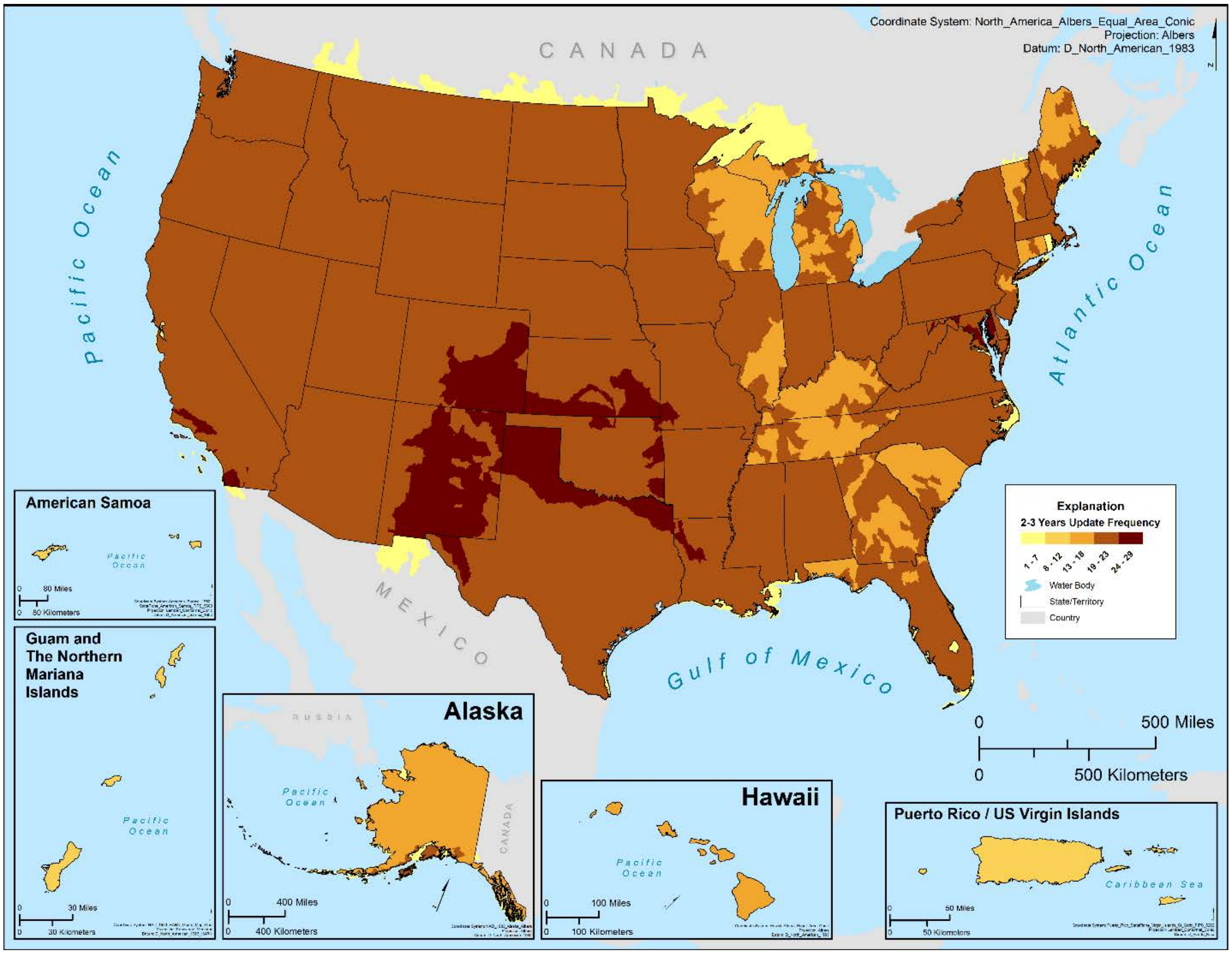

Figure 54. Number of MCAs for which 2-3 year updates are required

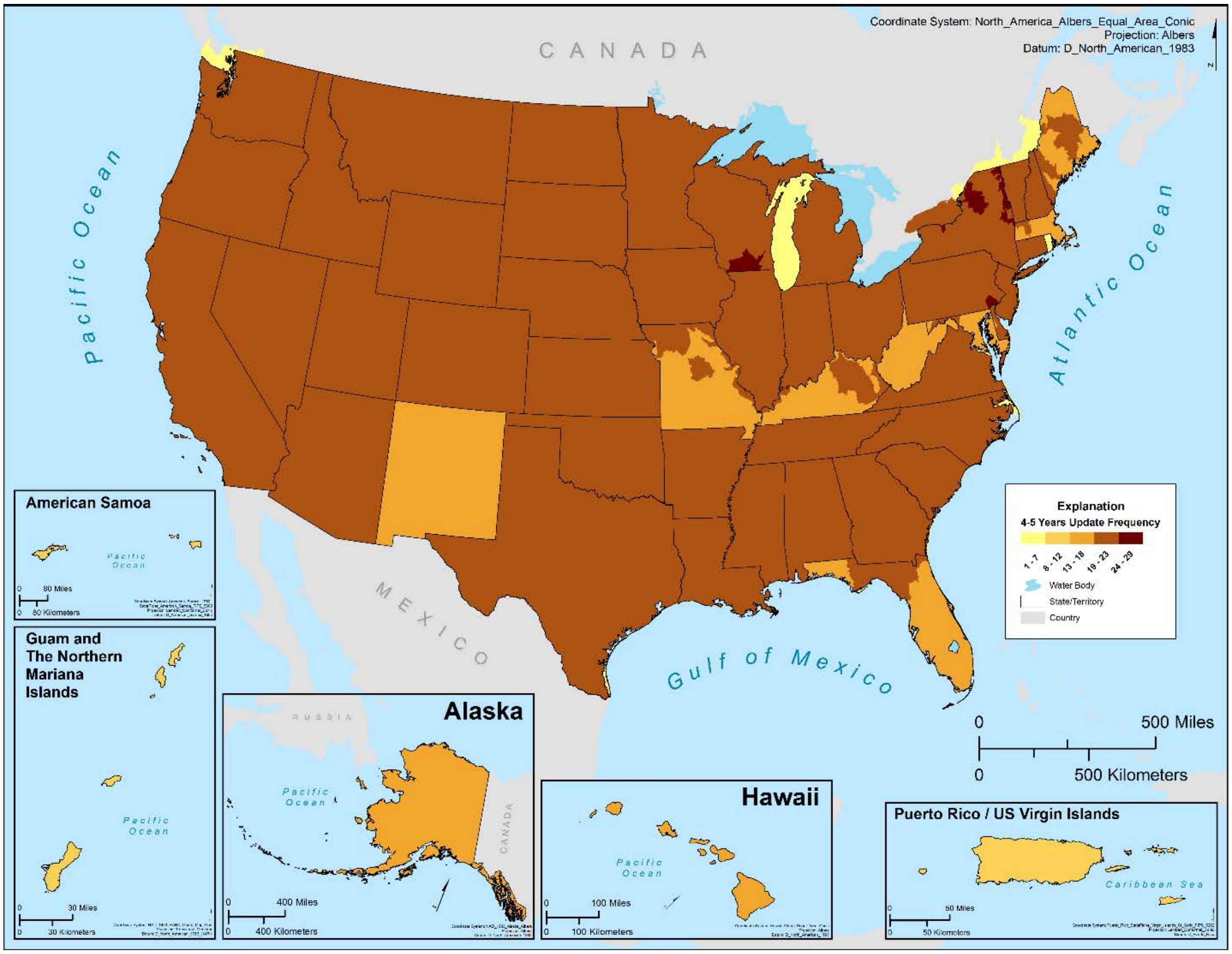

Figure 55. Number of MCAs for which 4-5 year updates are required

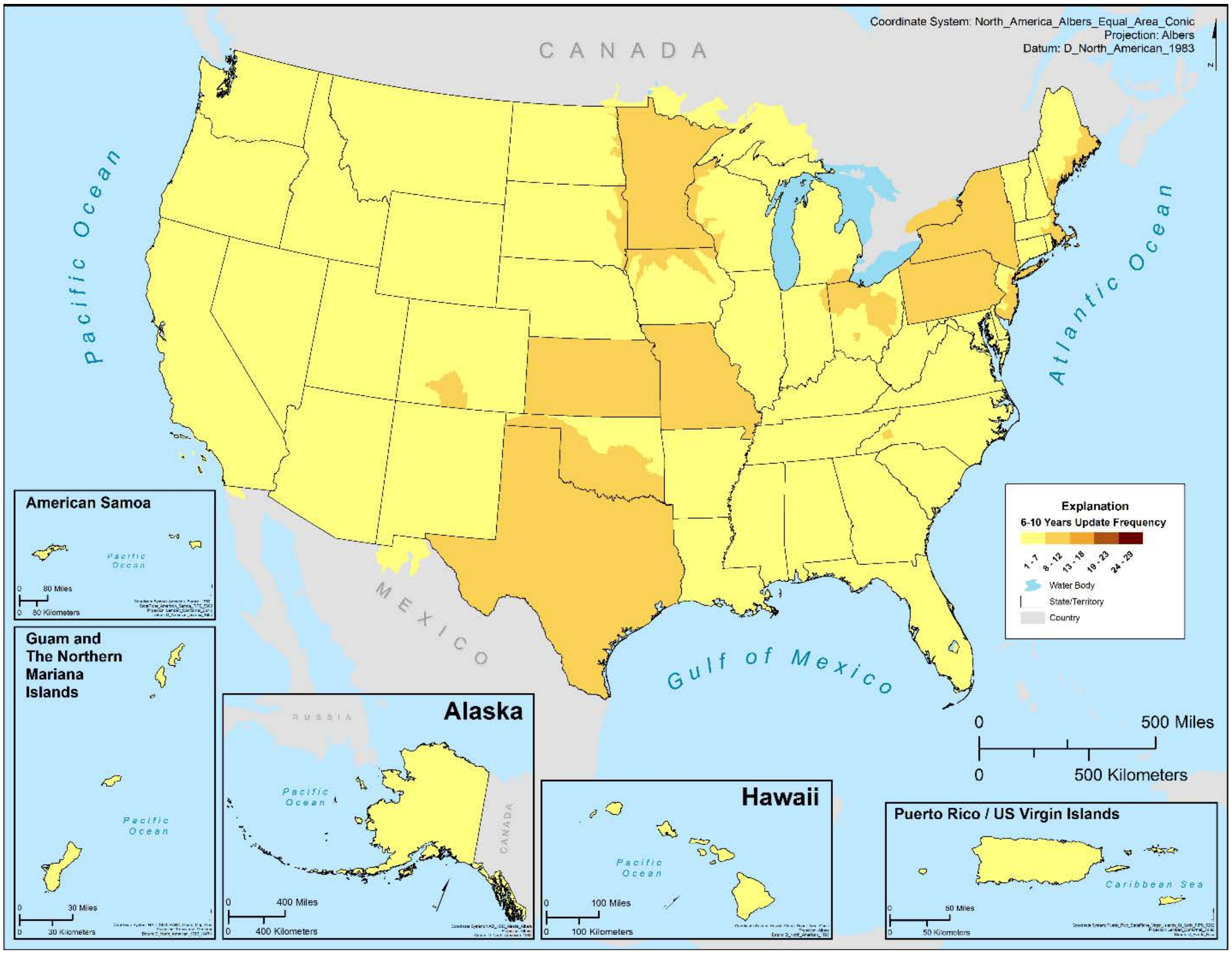

Figure 56. Number of MCAs for which 6-10 year updates are required

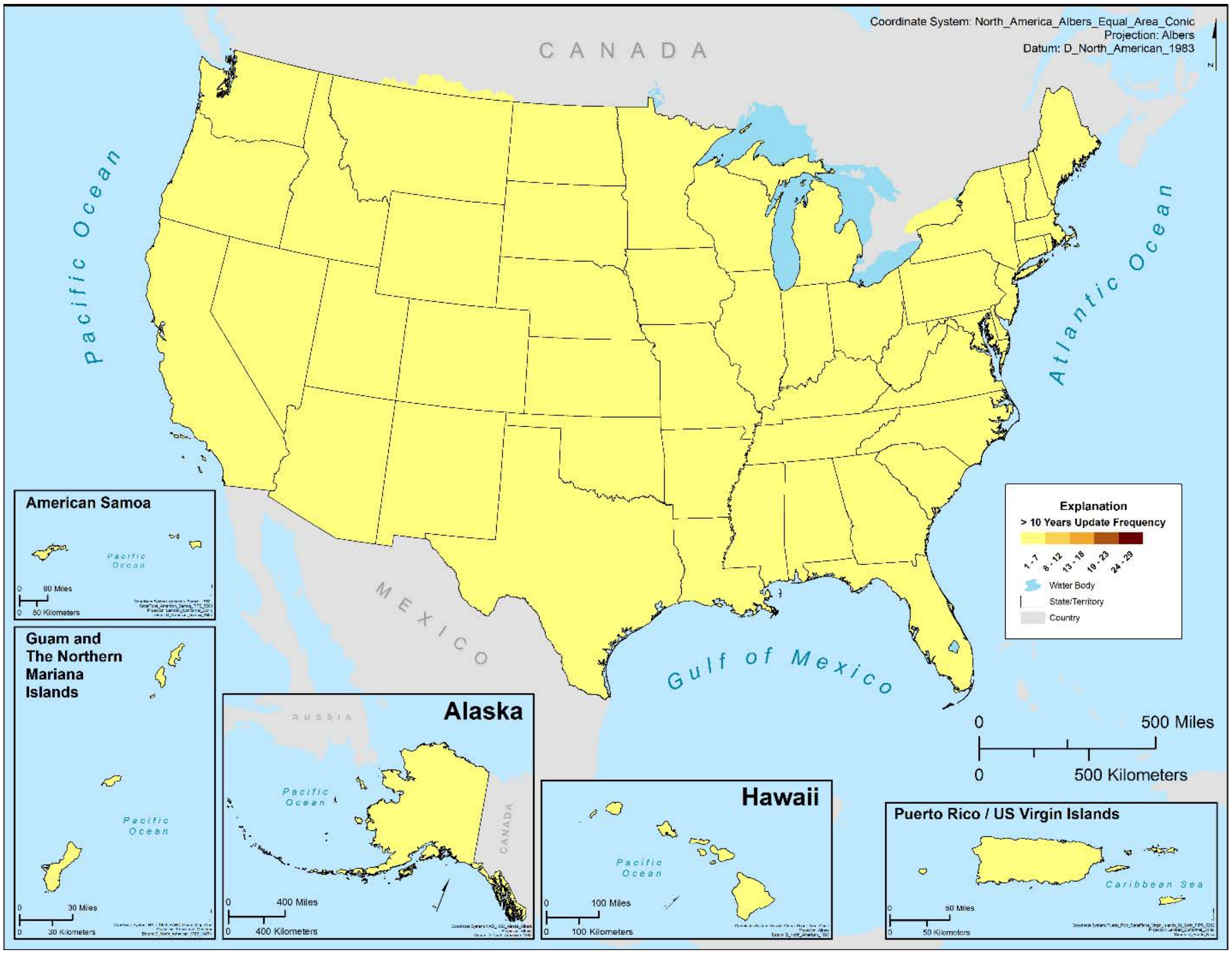

Figure 57. Number of MCAs for which greater than 10 year updates are required

5.5.6 Post-Event Updates

Users were asked how important it is for hydrographic data to be updated immediately after a major event such as a hurricane of flood for the hydrography data to satisfy MCA requirements. Figures 58-61 below show the spatial distribution of the post-event update responses. Each map shows the number of MCAs with one of the following post-event update requirement options: required, highly desirable, nice to have, and not required. Areas with darker colors have greater numbers of areas of interest.

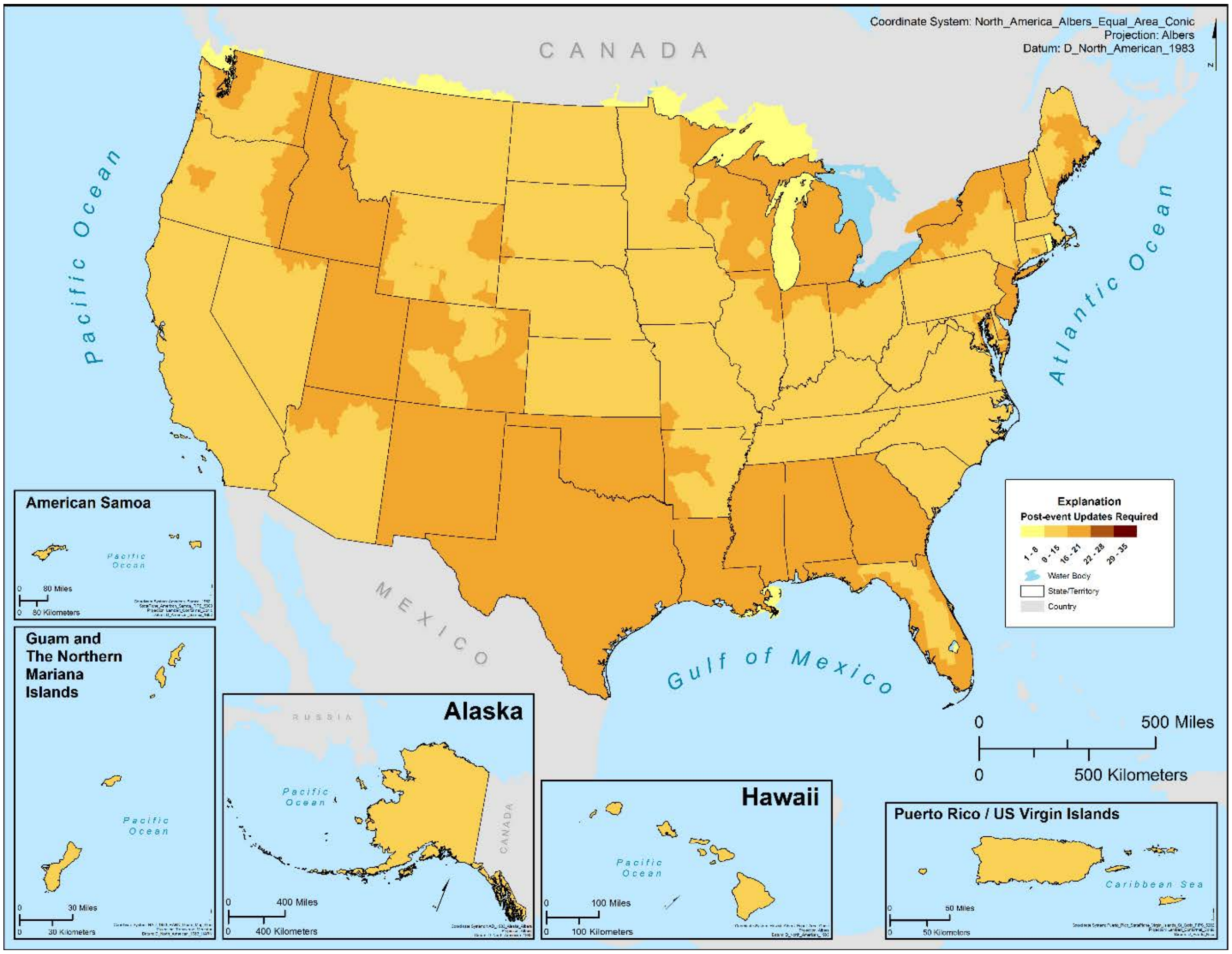

Figure 58. Number of MCAs for which post-event updates are required

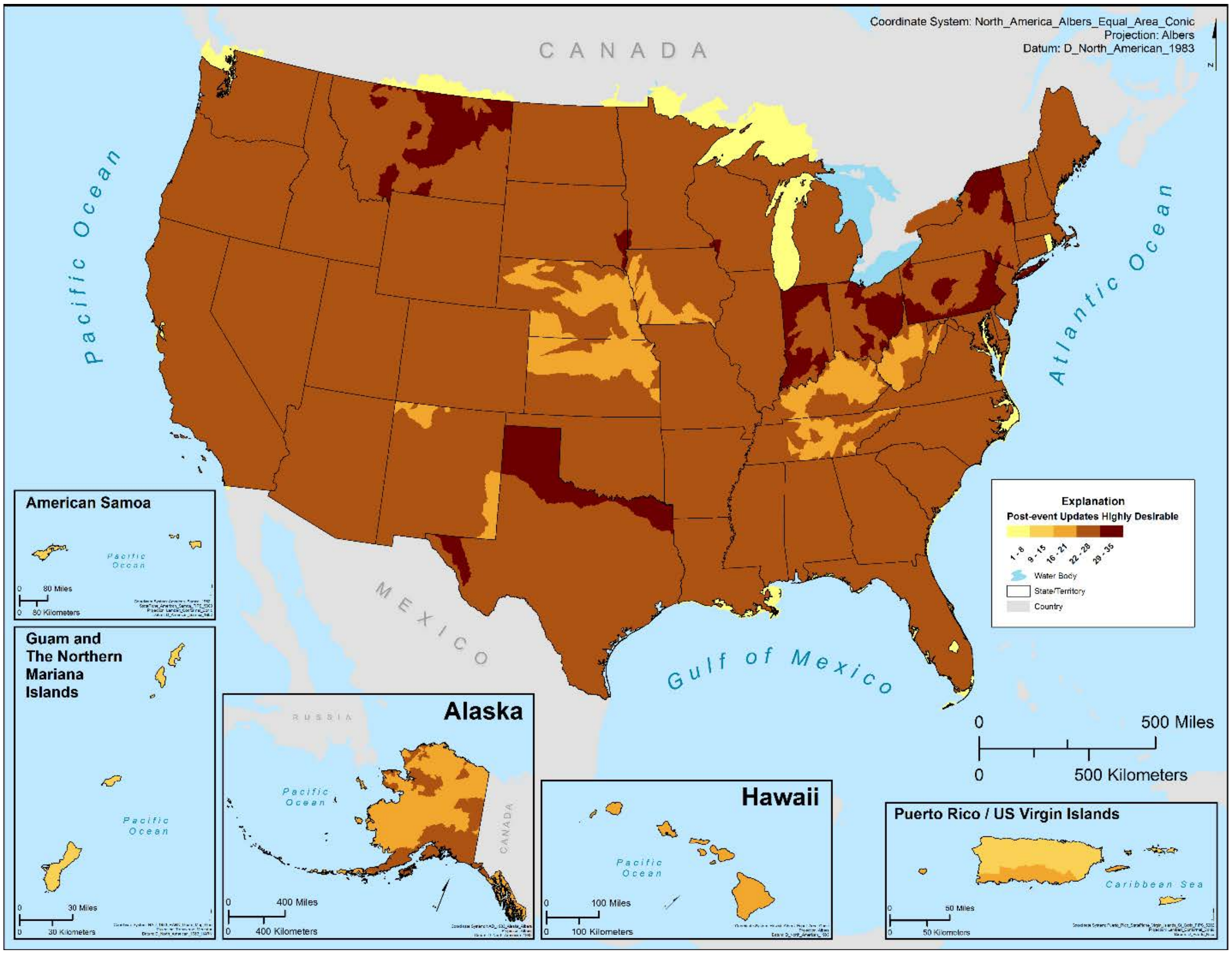

Figure 59. Number of MCAs for which post-event updates are highly desirable

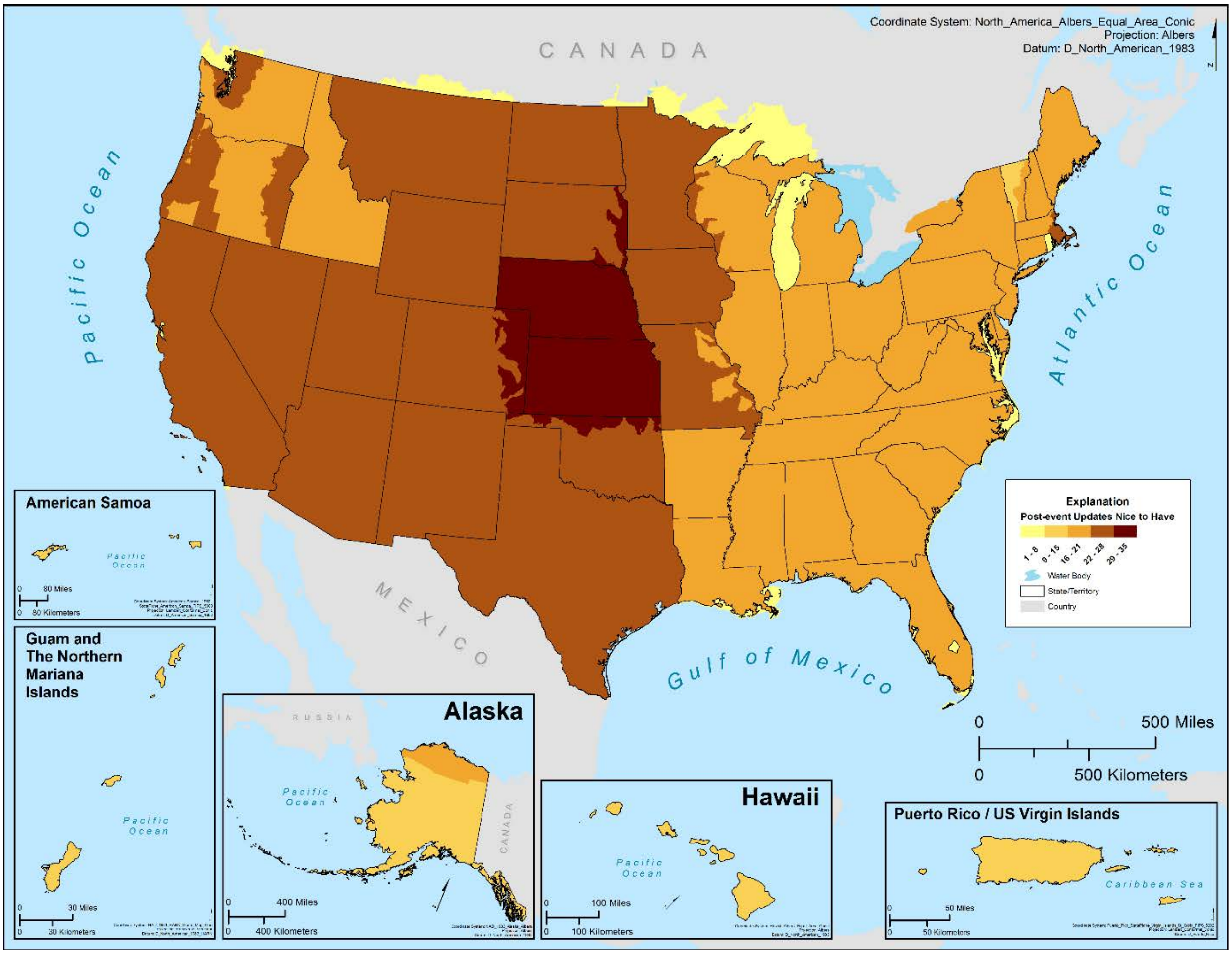

Figure 60. Number of MCAs for which post-event updates are nice to have

Figure 61. Number of MCAs for which post-event updates are not required.

5.5.7 Level of Detail

Users were asked whether it is more important for hydrographic data to have the "best available" level of detail or whether it is more important to have a consistent level of detail for the hydrography data to satisfy MCA requirements. Figures 62-63 below show the spatial distribution of the level of detail responses. Each map shows the number of MCAs with one of the following level of detail requirement options: best available data and consistent level of detail. Areas with darker colors have greater numbers of areas of interest.

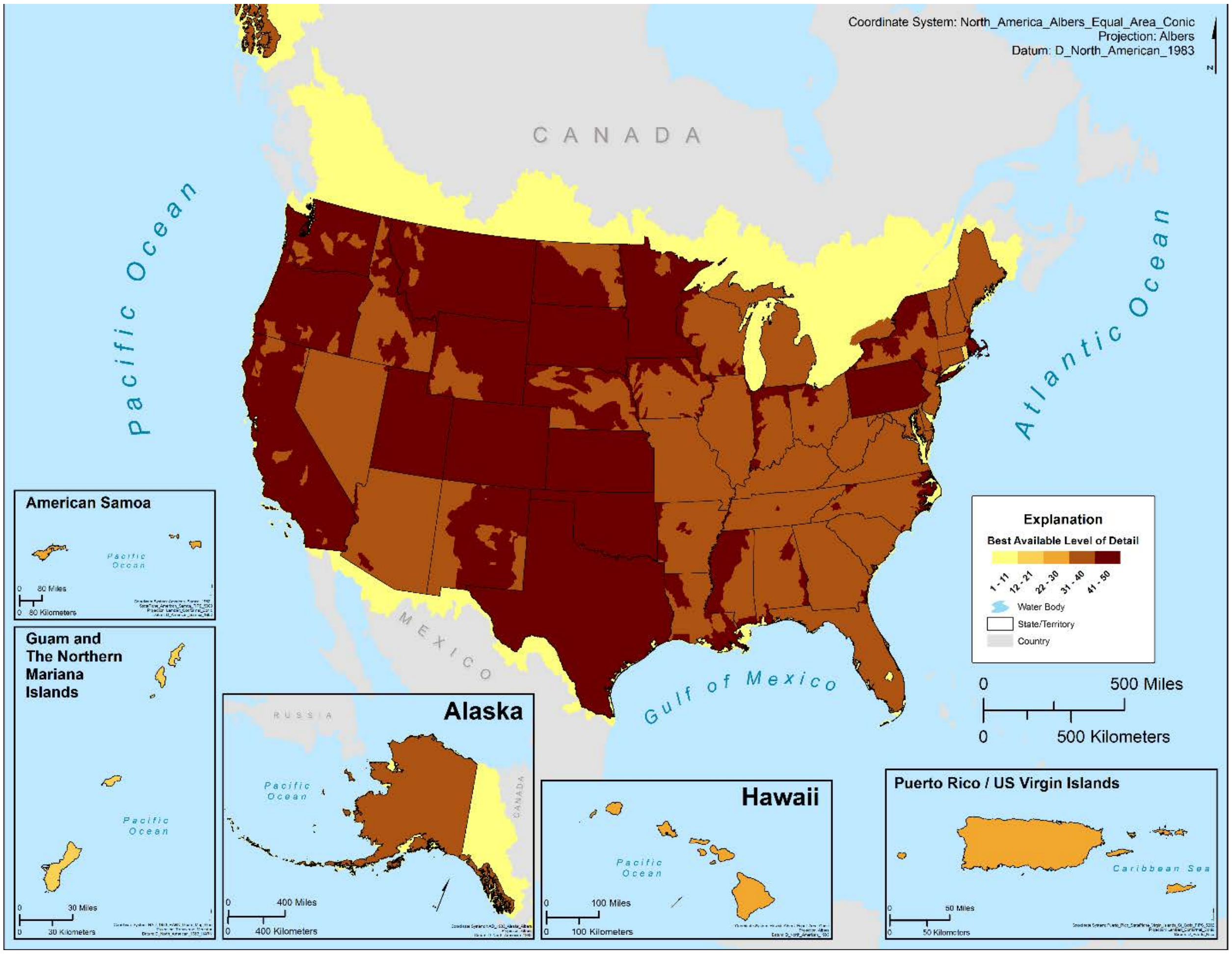

Figure 62. Number of MCAs for which best available level of detail for hydrography information is most important

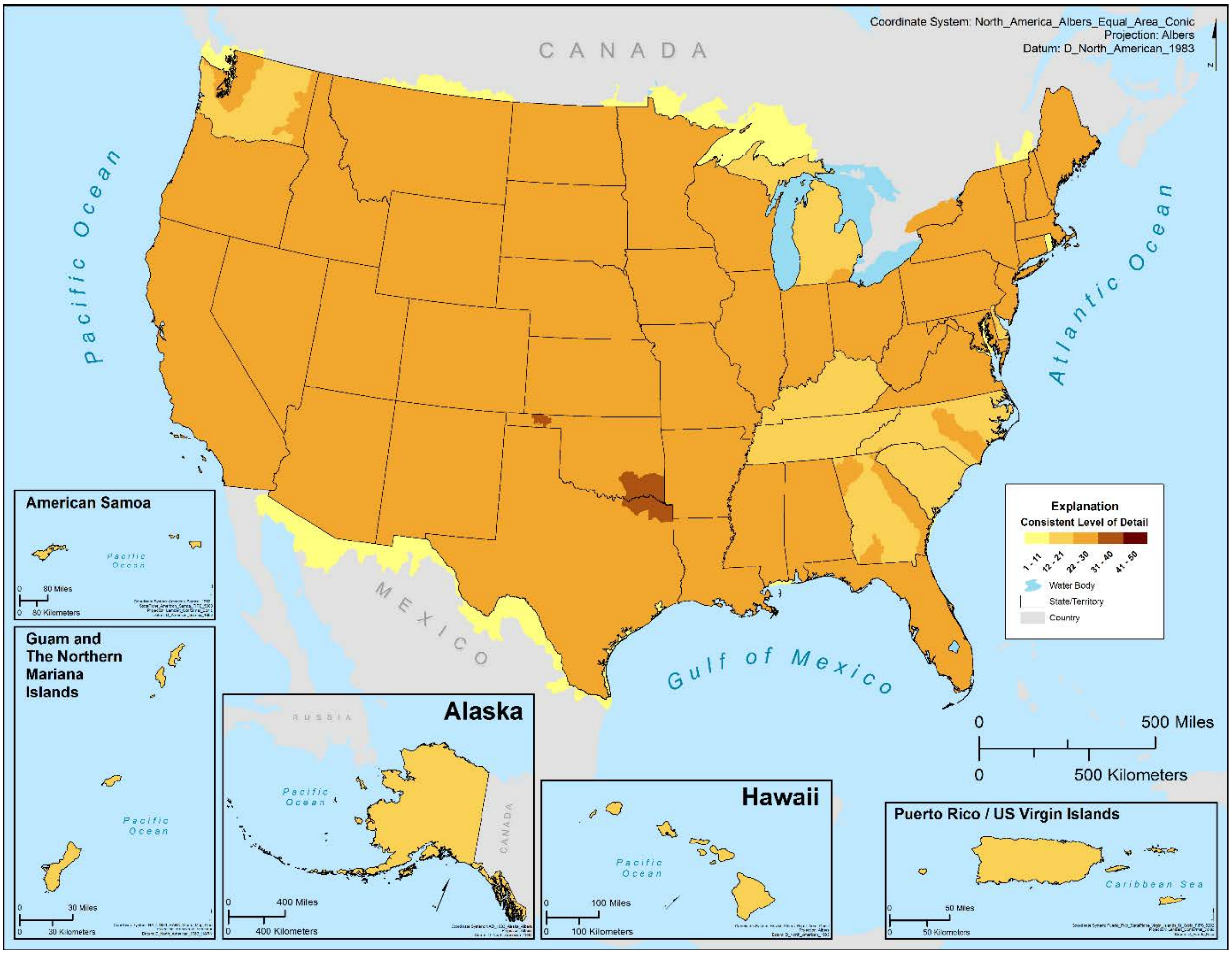

Figure 63. Number of MCAs for which consistent level of hydrography information is most important

5.6 Benefits

Table 39 on page 135-136 shows the Business Uses ranked by those with the greatest estimated average annual future dollar benefits from enhanced hydrography data. The table also includes estimated annual program budgets supported by hydrography data and estimated annual dollar benefits provided by the currently available hydrography data.

For the 420 MCAs, study respondents reported a total estimated annual program budget of $18.5 to $22.5 billion for programs supported by hydrography data. Stakeholders are receiving significant benefits from the currently available hydrography data; over half a billion dollars ($538.5 to $544 million) in estimated current annual benefits were reported. And if all of the reported hydrography data requirements could be met by enhanced datasets, the estimated future annual benefits would be another $602.5 to $605 million over and above the estimated current annual benefits.

Study respondents were unable to provide estimated current annual dollar benefits for 192 of the 420 MCAs (46 percent). Study respondents were unable to provide estimated future annual dollar benefits for 145 of the 420 MCAs (35 percent). This means that the estimated annual dollar benefits, both current and future, are likely to be significantly underestimated.

The overall average estimated future benefit per MCA is $1.4 million. Several MCAs with significant estimated future annual benefits account for major portions of six of the Business Uses ranked highest by estimated future annual benefits as noted below. These 15 MCAs account for approximately half of the total estimated future annual benefits.

- The River and Stream Flow Management Business Use includes four MCAs that account for 90 percent of the $154.73 million in estimated future annual benefits.
- The Water Quality Business Use includes four MCAs that account for 84 percent of the $121.48 million in estimated future annual benefits.
- The Water Resource Planning and Management Business Use includes three MCAs that account for 69 percent of the $115.88 million in estimated future annual benefits.
- The Flood Risk Management Business Use includes two MCAs that account for 78 percent of the $75.86 million in estimated future annual benefits.
- The River and Stream Ecosystem Management Business Use includes one MCA that accounts for 75 percent of the $67 million in estimated future annual benefits.
- The Wildlife and Habitat Management Business Use includes one MCA that accounts for 99 percent of the $10.08 million in estimated future annual benefits.

Table 39. Business Uses ranked by future dollars benefit of enhanced hydrography data.

BU Number	Business Use	Total Number of MCAs	Estimated Annual Program Budget (in millions)	Estimated Current Annual Benefits (in millions)	Estimated Future Annual Benefits (in millions)	Average Estimated Future Annual Benefits/MCA (in millions)	Education or Public Safety Benefits Weighted Value	Environmental Benefits Weighted Value	Human Lives Saved Weighted Value
BU 1	River and Stream Flow Management	44	$763.58	$220.07	$154.73	$3.52	97	107	39
BU 5	River and Stream Ecosystem Management	34	$1,000.72	$13.96	$67.00	$1.97	78	119	17
BU 3	Water Resource Planning and Management	69	$988.88	$98.11	$115.88	$1.68	155	168	70
BU 4	Water Quality	79	$1,672.41	$115.46	$121.48	$1.54	189	254	68
BU 15	Flood Risk Management	54	$636.11	$56.12	$75.86	$1.40	168	124	133
BU 9	Wildlife and Habitat Management	8	$1,041.45	$0.18	$10.08	$1.26	26	27	5
BU 7	Forest Resources Management	5	$254.39	$1.76	$6.01	$1.20	19	19	7
BU 18	Homeland Security, Law Enforcement, & Disaster Response	7	$1.75	$0.10	$5.50	$0.79	18	13	12
BU 6	Coastal Zone Management	8	$63.30	$10.71	$5.55	$0.69	29	27	21
BU 24	Education K-12 and Beyond	9	$1.56	$0.53	$5.36	$0.60	28	26	3
BU 12	Resource Mining	2	$500.10	$1.03	$1.10	$0.55	10	10	6
BU 2	Natural Resources Conservation	34	$6,956.80	$10.17	$17.76	$0.52	84	111	19
BU 20	Infrastructure and Construction Management	18	$1,088.72	$1.65	$8.73	$0.49	53	60	26
BU 10	Agriculture and Precision Farming	9	$21.75	$1.25	$2.15	$0.24	21	34	7
BU 21	Urban and Regional Planning	17	$1,763.51	$2.17	$3.42	$0.20	36	46	18
BU 13	Renewable Energy Resources	3	$1,547.85	$2.80	$0.58	$0.19	1	5	0
BU 16	Sea Level Rise and Subsidence	2	$1.00	$0.35	$0.35	$0.18	6	6	6
BU 22	Health and Human Services	4	$58.45	$0.50	$0.50	$0.13	11	16	1
BU 8	Rangeland Management	1	$20.43	$0.00	$0.10	$0.10	3	5	0
BU 25	Recreation	3	$2.90	$1.41	$0.17	$0.06	11	11	7

BU Number	Business Use	Total Number of MCAs	Estimated Annual Program Budget (in millions)	Estimated Current Annual Benefits (in millions)	Estimated Future Annual Benefits (in millions)	Average Estimated Future Annual Benefits/MCA (in millions)	Education or Public Safety Benefits Weighted Value	Environmental Benefits Weighted Value	Human Lives Saved Weighted Value
BU 14	Oil and Gas Resources	3	$24.00	$0.10	$0.10	$0.03	9	11	7
BU 19	Marine and Riverine Navigation Safety	3	$43.00	$0.03	$0.10	$0.03	5	7	3
BU 11	Geologic Resource Assessment and Hazard Mitigation	3	$0.35	$0.04	$0.05	$0.02	5	1	3
BU 17	Wildfire Management, Planning, and Response	1	$20.00	$0.01	$0.01	$0.01	5	5	5
	Total	420	$18,473.01	$538.50	$602.55	$1.43	1067	1212	483

As a way to account for benefits that could not be quantified in terms of dollars, users were asked about potential qualitative future benefits. The categories provided were operational time or cost savings, mission compliance, customer service improvements to products or services, customer service improvements to response or timeliness, customer experience improvements, education or public safety benefits, environmental or ecosystems benefits, and human lives saved. Each was quantified as Major, Moderate, or Minor. Note that only qualitative benefits were collected for the societal benefits categories of education or public safety, environmental, and human lives saved. No dollar values were estimated for these categories.

Table 40 below provides a summary of the future qualitative benefits reported for all 420 MCAs. While the qualitative operational and customer service benefits may also be accounted for in the estimated annual dollar benefits that were able to be quantified, the societal benefits are not quantified in this way. However, it seems clear that additional societal benefits would be provided if the enhanced hydrography requirements could be met. Approximately 35 percent of the MCAs would receive Major environmental benefits from enhanced hydrography data.

Table 40. Summary of future qualitative benefits reported by MCAs.

	Operational: Time or Cost Savings	**Operational: Mission Compliance**	**Customer Service: Products or Services**	**Customer Service: Response or Timeliness**	**Customer Service: Experience**	**Societal: Education or Public Safety**	**Societal: Environmental**	**Societal: Human Lives Saved**
Major	191	179	168	123	105	103	145	43
Moderate	134	146	147	166	161	159	136	63
Minor	55	54	55	77	81	81	79	79
Don’t Know/Not Applicable/No Answer Provided	40	41	50	54	73	77	60	235
Total	420	420	420	420	420	420	420	420

Figure 64 on the following page shows the spatial distribution of the estimated future annual dollar benefits of all 420 MCAs aggregated by HUC8 areas. Areas with darker colors have greater numbers of areas of interest. Similar maps showing the estimated future annual dollar benefits for each Business Use aggregated by HUC8s are provided in Appendix E.

As noted earlier, it is likely that most states and many county or local entities have additional MCAs and Business Uses that were not reported for this study. Since the representation of state and local agencies varied across states and the Business Uses were self-selected, it is likely that additional areas across the U.S. would have an interest in and potentially receive benefits for one or more of the Business Uses than what is currently described or reflected in the study data. Figure 64 shows concentrations of estimated future annual benefits in a few areas due to state agencies that reported rather significant benefits. However, it is likely that other states with similar activities may realize future benefits from enhanced hydrography data that were unable to be estimated, which would increase the estimated future annual benefits in other areas.

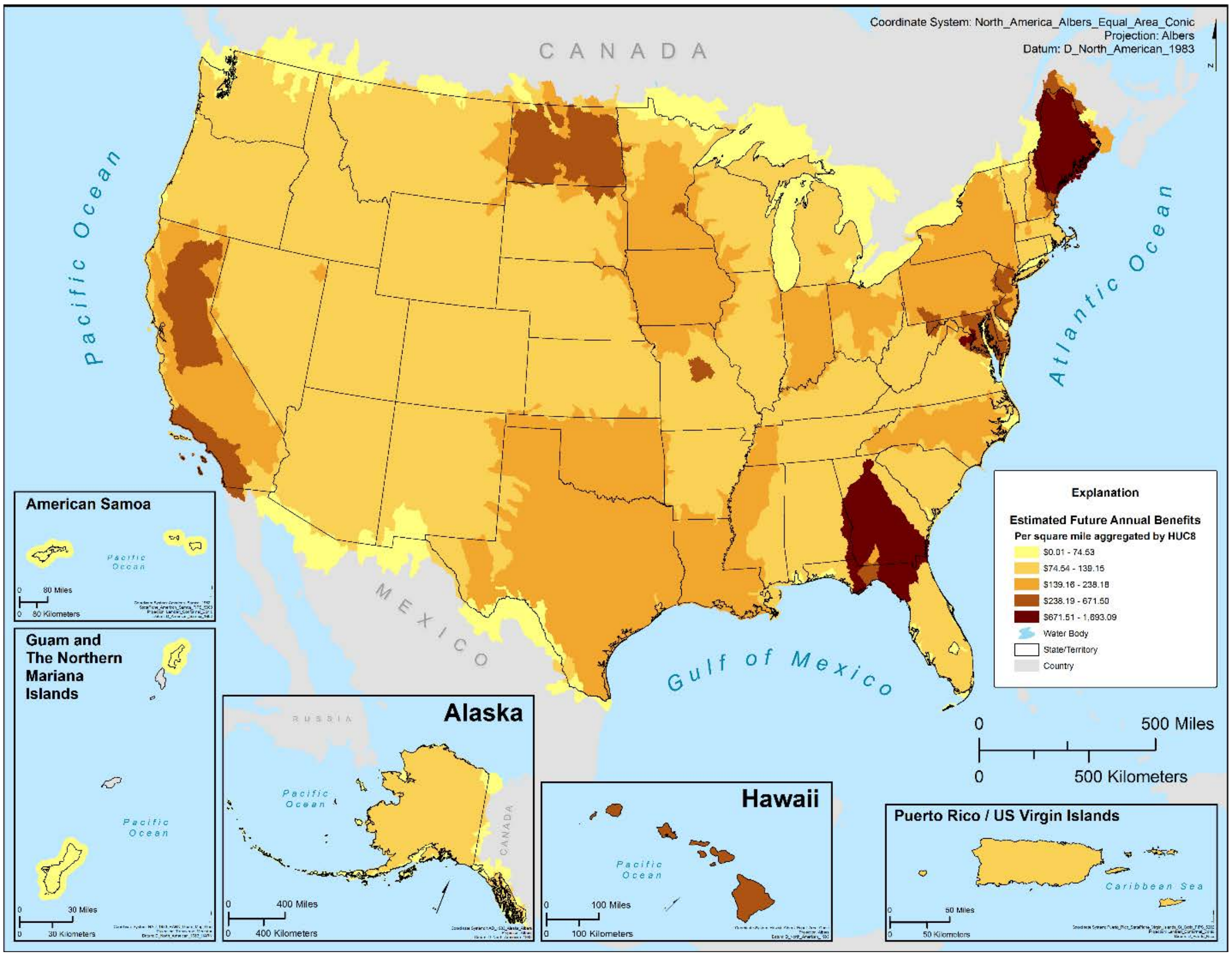

Figure 64. Estimated future dollar benefits for all 420 MCAs aggregated by HUC8 areas

6.0 Conclusions and Recommendations

The following observations and conclusions are provided based on the data collected for the HRBS and contained in the study geodatabase. Further analysis of the study data will be needed to associate benefits with fulfilling individual requirements and to plan program implementation scenarios. A few recommendations for future analysis considerations are also provided.

- Per the OMB restrictions, only 350 responses from the public (including state and local government employees) could be gathered. Study participants were selected by state POCs and may not represent all relevant agencies in all states. In fact, it is likely that most states and many local entities are likely to have additional MCAs and Business Uses with unreported requirements and would likely receive future benefits from enhanced hydrography data. A methodology for identifying and filling perceived gaps may need to be considered when further analyzing the data and developing implementation scenarios. For instance, data were provided by only 13 state DOTs, but all states are likely to have a DOT that has hydrography requirements and benefits.

- The vast majority (90 percent) of the MCAs were provided by government agencies (Federal, state, regional, county, city, local, and Tribal). A total of 25 MCAs (6 percent) were provided by Not for Profit entities. A total of 16 (4 percent) MCAs were provided by private or commercial entities. However, the private or commercial entities were primarily contractors to state government agencies. There was little or no representation of large-scale private entities such as the oil and gas industry, major utilities, or agribusiness. It should be noted that these unrepresented private entities are likely to also make use of national hydrography datasets, have requirements for hydrography data enhancements, and are likely to receive potentially significant but undocumented annual benefits from future enhanced hydrography datasets. Future analyses may not be able to quantify the requirements from or benefits to these unrepresented private entities, but their additional benefits may be able to be acknowledged.

- The MCAs reported by the Federal agencies (54) typically reflect nationwide interests with nationwide or nearly nationwide areas of interest. The remainder of the MCAs (237 from state government and 129 from other organizations) typically represent smaller areas of interest. Simply counting the number of MCAs for which requirements or benefits apply would be misleading. For this reason, in this report the MCA totals were broken down and reported by Federal agencies, state government agencies, and other entities along with the overall totals. This allows the responses that cover generally larger geographic areas represented by a smaller number of Federal agencies and the requirements that generally cover smaller but more numerous state and local geographic areas to be reported separately. Future analyses will need to take the geographic distribution of the requirements and benefits into account (not just numbers) using the MCA areas of interest contained in the study geodatabase.

- There was considerable variation in how the MCAs were defined and described by study participants. Some MCAs appear to have been described in terms of the respondent's agency's organization, some in terms of their daily activities. Some MCAs were very broad and encompassed multiple Business Uses and some were quite narrowly defined. This is further indication that further analyses using only the numbers of MCAs may not be useful.

- Study participants ascribed five or fewer MCAs to eleven of the 25 pre-defined Business Uses. For example, two MCAs were ascribed to BU #16, Sea Level Rise and Subsidence, and one MCA was ascribed to BU #17 Wildfire Management, Planning, and Response. Agencies or entities with multiple responsibilities likely chose the Business Use that makes up the majority of their portfolio of business. However, it is likely that more than two agencies include planning for sea level rise in their mission and that most western states have a concern for wildfire management. When further analyzing requirements and benefits by Business Use, consideration should be given to imputing requirements for and benefits from hydrography data from the available information where it appears that there are significant gaps in the reported data.

- The top five requirements for integration with other datasets were elevation, stream flow, wetlands, soils, and land cover, with integration with elevation data being the top requirement. When developing program implementation scenarios for analysis, consideration should be given to evaluating whether future hydrography data models may be able to accommodate some or all of these data integration requirements.

- The HRBS results appear to refute a commonly held belief that Federal agencies need consistent data as opposed to best available. A total of 70 percent of Federal agencies and 67 percent of overall study participants reported a requirement for best available data. Study respondents did note that disparities in level of detail cause modeling problems and also noted a desire for tools that would allow best available data to be selected or generalized such that a consistent level of detail could be achieved for modeling purposes from best available data.

- The reported estimated future annual benefits are most likely underestimated. Study respondents were unable to provide dollar estimates for future annual benefits for 35 percent of the MCAs.

- Per OMB, no dollar benefits were allowed to be collected for the societal benefits (education or public safety, environmental, and human lives saved). However, study respondents noted moderate or major benefits for education or public safety for 62 percent of MCAs and moderate or major environmental benefits for 67 percent of the MCAs. While these benefits cannot be quantified, they should not be discounted.

- When the estimated future annual benefits are mapped by MCA area of interest, several concentrations of benefits are revealed. These reflect several state agencies with rather significant benefits. It should be noted that other states may have unreported but similar benefits.

- The estimated future annual benefits are associated with fulfilling all stated requirements for each MCA. When further analyzing the data and developing implementation scenarios, a methodology will be needed for degrading the benefits if not all requirements can be fulfilled by a given scenario. Having so many different requirements to consider will make this a challenge.

- While the requirements and benefits assigned to specific MCAs would not be duplicated or biased due to the way they were aggregated into Business Uses, the reader is cautioned to understand the inherent flaws associated with any consolidation of this information. Likewise, specific user requirements may require more detailed analysis of the study database to understand the full need or value of fully meeting a particular need.