Exhibit A

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DEVELOPMENT OF A WATERSHED MODEL OF THE UPPER SCIOTO RIVER BASIN FOR ASSESSING POTENTIAL CLIMATE-CHANGE EFFECTS IN THE CENTRAL OHIO REGION

Proposal to

MID-OHIO REGIONAL PLANNING COMMISSION

Prepared by

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BACKGROUND AND NEED

The Mid-Ohio Regional Planning Commission (2008) estimates that nearly 2 million people live in the central Ohio region. The supply of fresh water plays a vital role in the health and economic well being of the area's residents. The Ohio Department of Development (2003) projects the central Ohio region, defined as Franklin County and the 6 counties adjacent to Franklin, to grow by 450,000 people between 2005 and 2030. If this growth occurs as expected, the demand for water will increase. Water managers and planners within the region must prepare to ensure that the existing water-supply systems, and components planned for future development, will be adequate to meet the region's future demand for water.

Along with the increased demand for water due to population growth, the potential influence of climate change on surface-water supplies in the central Ohio region must be considered. Climate change may alter water demand and operational performance of the region's water-supply systems, forcing planners to reassess design and operational assumptions. The constraints due to climatic effects on the supply and variability of water resources in the region may require that alternative management strategies be assessed and evaluated to ensure a sustainable water supply.

New tools are needed to help planners and water managers assess and adapt to potential water-supply challenges resulting from climate change. The City of Columbus, the region's largest water utility, supplies about 85% of its daily usage from surface water withdrawn from the Scioto River and Big Walnut Creek (City of Columbus, Department of Public Utilities, 2007). Del-Co Water Co., Inc., another major water utility located in the northern part of the region, also relies primarily on surface water. For calendar year 2010, Del-Co Water Co., Inc., estimates that 86% of its water supply was obtained from surface water, primarily from the Olentangy River and Alum Creek (written communication: S.F. Clark, Del-Co Water Co. Inc., 2011).

The strong dependence on surface-water-based supplies in the central Ohio region is evident, and the effects of climate change could potentially alter this resource base. To help assess potential effects on the water supply due to climate change, the U.S. Geological Survey (USGS) Ohio Water Science Center will develop a watershed rainfall-runoff model capable of incorporating climate-change scenarios for the region. Results from this model will be instrumental for evaluating future alternative water-management practices.

STUDY AREA

The study area encompasses the Scioto River basin (watershed) upstream of the streamgage on the Scioto River at Circleville, Ohio (USGS station 03230700). The drainage area at this site is 3,217 square miles, which represents nearly half of the Scioto's drainage area of 6,517 square miles at its confluence with the Ohio River. The headwaters of the Scioto River generally lie to the north of the central Ohio region. The major stream basins that drain into the Scioto in this region include Alum Creek, Big Darby Creek, Big Walnut Creek, and the Olentangy River These basins generally lie in a north to south alignment and drain towards the south (figure 1).

STUDY OBJECTIVES

1. Develop, calibrate, and validate a rainfall-runoff model for selected streams within the Upper Scioto River Basin based on current and historical data.

2. Estimate streamflow conditions for the region that may result from selected climate-change and build-out scenarios by acquiring spatially downscaled regional climate-projection data (specifically, precipitation and temperature data) and using those data in the calibrated rainfall-runoff model to estimate streamflow conditions for the region that may result from selected climate-change and build-out scenarios.

3. Document the study scope, approach, methodology, and results in a USGS Scientific Investigations Report.

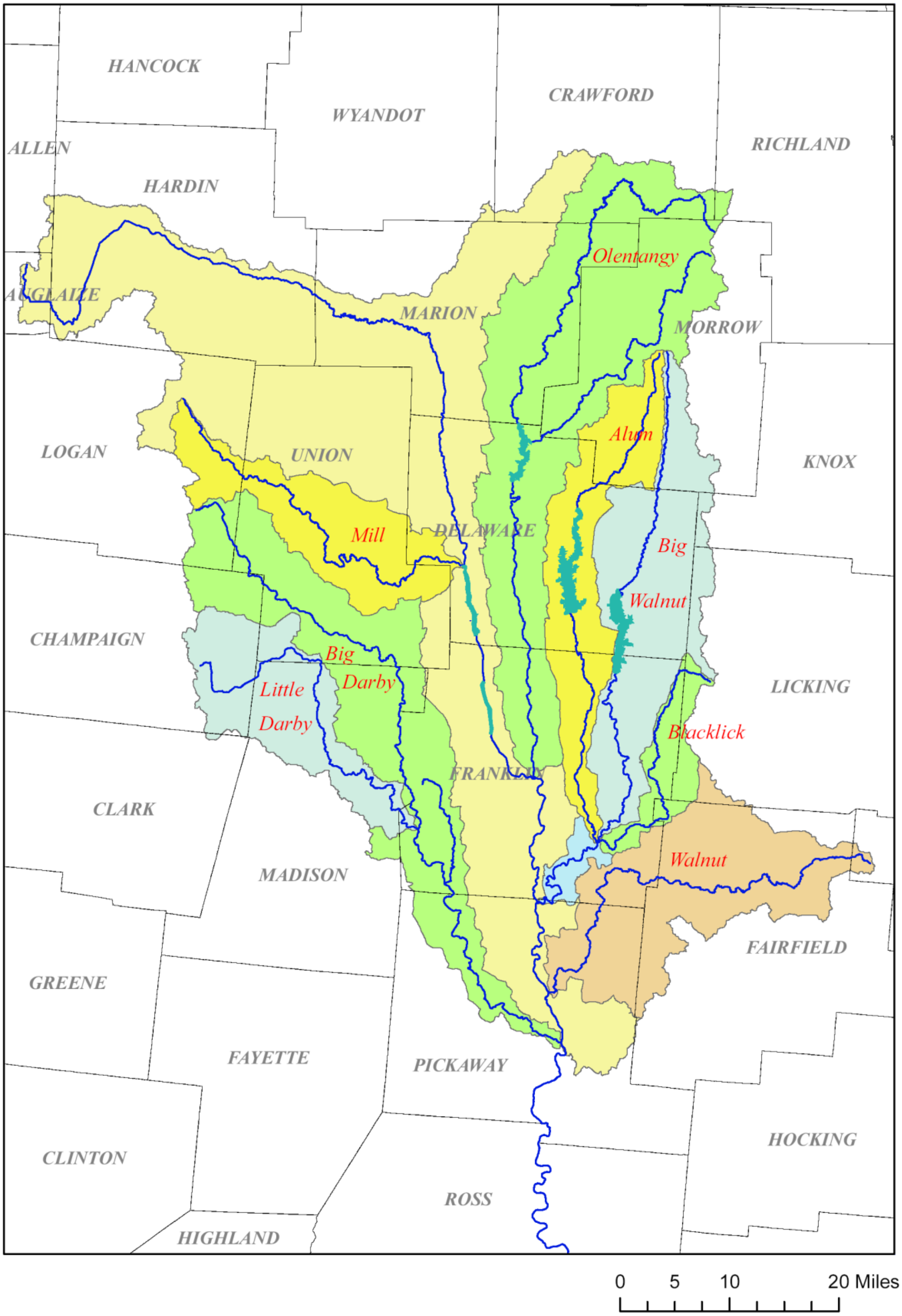

Figure 1. Overview of the Upper Scioto River Basin and its major tributary basins.

RELEVANCE AND BENEFITS

This study will help further the understanding of potential effects of climate change on future water resources of the central Ohio region. Water managers will be provided a framework for evaluating potential alternatives and developing strategies to meet future water-supply demands for the region. The watershed model for the region, developed as part of this study, will be a tool that can be reused in the future to model more refined climate-change data as climate-change forecasting improves.

By providing information to assist central Ohio water planners to evaluate and develop adaptive water-management strategies as necessary, this study supports the mission of the Mid-Ohio Regional Planning Commission: *MORPC will be the regional voice and a catalyst for sustainability and economic prosperity in order to secure a competitive advantage for central Ohio*.

This cooperative study with the Mid-Ohio Regional Planning Commission also supports two current USGS strategic directions (USGS, 2007):

- A Water Census of the United States: Quantifying, Forecasting, and Securing Freshwater for America's Future

  A primary focus point of this strategic direction includes producing forecasts of likely outcomes of variations in freshwater availability due to changing climate conditions.

- Climate Variability and Change: Clarifying the Record and Assessing the Consequences

  As a part of this direction, the USGS will use scientifically sound state-of-the-science information on climate change and its effects to provide predictive and adaptive tools and strategies for managers to use to reduce the risk of hazards, as well as increase the potential for hydrologic and ecological systems to be self-sustaining and resilient to climate change and related disturbances.

Although the development of the watershed model for this study is targeted for assessment of potential climate-change effects on runoff, there are other potential uses of such a model. For example, the model could be utilized in future study efforts for water-quality analyses, such as Total Maximum Daily Load or nonpoint-source assessments.

APPROACH

***Compile historical hydrologic, climatic, and water use information* —** Climatic data required for the model (including precipitation, air temperature, solar radiation, dewpoint, and wind speed) will be compiled for the period 1960 to present and will help to establish and evaluate baseline conditions. Data required to calibrate and validate the rainfall-runoff model of the Upper Scioto River Basin will be compiled for a selected historic timespan (typically 5–10 years) pertinent for the intended use of model. Daily withdrawal and wastewater discharge amounts will be obtained from local sources to the extent possible. The remaining withdrawal and wastewater discharge data will be obtained from State-provided monthly reports and then disaggregated into daily values by use of techniques most appropriate for those data.

***Model construction and calibration* —** The Hydrological Simulation Program-FORTRAN (HSPF) rainfall-runoff model will be used to simulate the hydrology of the basin. This model incorporates data on surficial geology, water storage, land use, and water use (withdrawals, discharges, and interbasin transfers) and is driven by meteorological data. Climatic, streamflow, and water-use data will be entered into a Watershed Data Management System database. This database format provides a direct interface to the HSPF model. The model will be calibrated to historical streamflow data at selected USGS streamgages within the Upper Scioto River Basin. Figure 2 shows the location of the 21 USGS streamgages within the basin, and table 1 lists the USGS streamgage station name and the map reference number as depicted in figure 2, along with data for each site. The streamgage on the Scioto River at Circleville, Ohio (USGS station 03230700), will serve as the most downstream point for the model developed for the Upper Scioto River Basin in this study.

***Climate Data Projections* —** Regionalized climate projections will be used to develop future temperature and precipitation scenarios for use in the HSPF model. Climate-change projections are based on global climate modeling, so regionalized climate projections will require the use of spatial downscaling techniques. The Intergovernmental Panel on Climate Change (IPCC, 2007a) was instrumental in developing a method to obtain regionalized climate projections of future temperature and precipitation datasets. Care must be exercised with this approach to compensate for a climate model's simulation bias (a tendency to simulate climates that are too wet or dry and/or too warm or cool). As of this writing, the use of regionalized climate projections is the recommended technique to estimate future climate conditions for small areas (USGS, 2009). However, climate science, and in particular approaches on how to incorporate climate-change data for long-range decision making and planning, are rapidly evolving. The USGS will reevaluate the best available regionalized climate data once calibration of the watershed model is completed. If improved climate-projection data become available for the central Ohio region, the USGS will coordinate with MORPC on the use of those data for simulation purposes.

Model Scenarios — Once the HSPF model is developed and calibrated on the basis of current and historical data, a select number of climate-change and land-use scenarios will be simulated. The effects of the following stressors on basin water resources will be assessed:

- Selected climate-change scenarios as derived from the climate projection data.
- Changes in land use/land cover (for example, various extents of build-out to reflect projected increases in urbanization).

The effects of these scenarios on streamflow will be evaluated from the simulation results by analyzing changes in the duration and frequency of high and low streamflows at selected points in the basin.

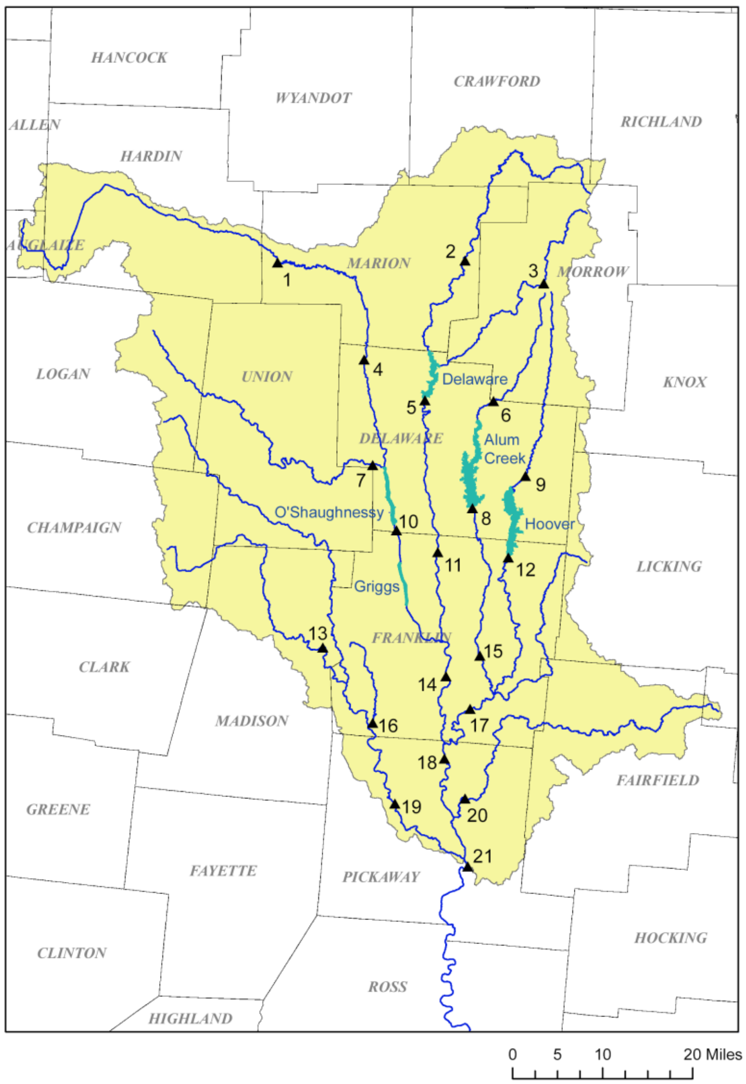

Figure 2. Overview of the Upper Scioto River Basin with pertinent USGS streamgages identified.

Table 1. USGS streamgages and site description data in the Upper Scioto River Basin (the listing number refers to figure 2).

No.	Station no.	Streamgage station name	Site equipped for:			Drainage area (sq. mi.)	Period of record (years)
			Q	S	P		
1	03217500	Scioto River at La Rue OH	x	x		257	42
2	03223000	Olentangy River at Claridon OH		x	x	157	53
3	03223425	Whetstone Creek at Mount Gilead OH	x	x		37.9	12
4	03219500	Scioto River near Prospect OH	x	x	x	567	77
5	03225500	Olentangy River near Delaware OH	x	x		393	86
6	03228750	Alum Creek near Kilbourne OH	x	x		64.9	17
7	03220000	Mill Creek near Bellepoint OH	x	x		178	66
8	03228805	Alum Creek at Africa OH	x	x	x	122	45
9	03228300	Big Walnut Creek at Sunbury OH	x	x		101	20
10	03221000	Scioto River below O'Shaughnessy Dam near Dublin OH	x	x		980	87
11	03226800	Olentangy River near Worthington OH	x	x		497	42
12	03228500	Big Walnut Creek at Central College OH	x	x	x	190	70
13	03230310	Little Darby Creek at West Jefferson OH	x	x	x	162	16
14	03227500	Scioto River at Columbus OH	x	x	x	1,629	88
15	03229000	Alum Creek at Columbus OH		x		189	87
16	03230450	Hellbranch Run near Harrisburg OH	x	x		35.8	16
17	03229500	Big Walnut Creek at Rees OH	x	x		544	85
18	03229610	Scioto River at Commercial Point OH	x	x		2,272	2
19	03230500	Big Darby Creek at Darbyville OH	x	x	x	534	85
20	03229796	Walnut Creek at Ashville OH	x	x		274	5
21	03230700	Scioto River at Circleville OH		x	x	3,217	15

Q: Discharge data are collected at this station.
S: Stage data are collected at this station.
P: Precipitation data are collected at this station.

REPORT

A USGS Scientific Investigations Report will be published to present the study methods and the results of the investigation. Before publication, the draft text of the final report will be reviewed by peers and editorial staff to ensure accuracy, logical organization, and readability. This report will be published in hardcopy and also will be be available in a portable document format (PDF) from the USGS Web site at *http://pubs.er.usgs.gov/*.

BUDGET AND TIMETABLE

The total cost for the study is $750,000. The study will begin April 1, 2011, and the final report will be delivered to the Mid-Ohio Regional Planning Commission by March 31, 2014.
The principal investigator (PI) will be a hydrologist. The PI will be supported by other USGS hydrologists and technicians, Ohio Water Science Center discipline specialists, and other support

personnel. The major tasks and their associated costs required to conduct the study are presented in sequential order in table 2. The funding required to conduct the study along with quarterly and annual breakdowns for the duration of the study are presented in table 3. A timeline of the estimated time (in months) required to complete each of the various tasks (1 – 12 as defined and explained in table 2) is presented in table 4.

Table 2. Study tasks and their associated cost.
(Note: HY12 refers to Hydrologist GS-12, etc.)

Task #	Task description	USGS personnel	Estimated hours	Estimated net cost
1	**Obtain and preprocess geospatial data for Upper Scioto River Basin**			
	1.1 Review available geospatial data for the Upper Scioto River Basin and assess for modeling suitability	HY12/HY11	197	$7,460
	1.2 Obtain all necessary geospatial data layers, process into seamless coverages, and conduct hydrologic conditioning on complete dataset	HY12/HY11/HY12	453	$18,121
		Subtotal	650	$25,581
2	**Obtain, process, and analyze downscaled predicted climate data**			
	2.1 Coordinate and obtain downscaled (or if available, most recent appropriate grid-size regional climate model) climate data (precipitation and temperature)	HY12/HY11/ HY12/HY13	182	$8,467
	2.2 Review for suitability and process climate data for input into hydrologic model	HY13/HY12	137	$6,749
	2.3 Assess climate data for temporal trends, and evaluate minimum, mean, and maximum for selected time periods and seasons	HY12/HY11/ HY13	331	$14,267
		Subtotal	650	$29,483
3	**Review and preparation of USGS streamgage data**			
	3.1 Review USGS streamgage records and assess for potential use in model	HY12/HY11/ HY13	302	$12,869
	3.2 Prepare and process streamgage data for input into hydrologic model	HY12/HY11	128	$5,180
		Subtotal	430	$18,048
4	**Develop and analyze model subbasin delineation**			
	4.1 Review characteristics of entire basin to develop reasonable subdivision strategy	HY12/HY11/ HY13	210	$8,560

	4.2 Evaluate future land use build-out development strategies and modify basin subdivisions accordingly	HY12/HY11/ HY13	298	$12,399
	4.3 Create model basin subdivisions	HY12/HY11/ HY12	220	$8,783
	4.4 Parameterize subbasins with current land-cover and soil hydrologic group characteristics	HY12/HY11	298	$11,856
	4.5 Review and finalize model framework	HY12/HY11/ HY13	255	$10,724
		Subtotal	1,280	$52,323
5	**Collect reservoir operation data, assign initial routing parameters, and collect historical meteorological data**			
	5.1 Obtain all reservoir operational data and parameters; assess and prepare data for modeling of various scenarios	HY12/HY11/ HY12	286	$12,746
	5.2 Collect or estimate historical evapotranspiration, air temperature, wind speed, dewpoint, and solar radiation data as needed	HY12/HY11/ HY12	286	$12,746
	5.3 Develop routing tables to assess existing storage and detention volumes for subbasins	HY12/HY11/ HY12	354	$15,673
	5.4 Conduct initial hydrologic model simulations and assess preliminary routing results for accuracy	HY12/HY11/ HY12	354	$15,673
		Subtotal	1,280	$56,838
6	**Hydrologic model calibration**			
	6.1 Conduct preliminary model verifications using observed flow values from USGS streamgage data	HY12/HY11/ HY12	400	$16,366
	6.2 Assess reported reservoir operational rules against measured historical streamflow data.	HY12/HY11/ HY12	394	$16,107
	6.3 Assess model results and make adjustments to calibrate model response. Conduct iterative process until model results are reasonable	HY12/HY11/ HY12	485	$19,548
		Subtotal	1,280	$52,021
7	**Sensitivity analysis and scenario modeling**			
	7.1 Conduct sensitivity analysis on model parameters to assess basin response	HY12/HY11	162	$6,320
	7.2 Assess and refine modeling scenarios as needed	HY12/HY11	168	$6,528
	7.3 Conduct climate-change scenarios	HY12/HY11	168	$6,528

	7.4 Conduct land-use-change scenarios	HY12/HY11	162	$6,320
		Sub Total	660	$25,695
8	**Finalize modeling and scenario results**			
	8.1 Conduct final sets of model-run scenarios	HY12/HY12	156	$6,292
	8.2 Interpret and refine modeling results	HY12/HY12	132	$6,292
	8.3 Prepare results for presentation in final report	HY12/HY12	132	$6,292
		Subtotal	420	$18,875
9	**Prepare USGS report manuscript**			
	9.1 Prepare draft copy of USGS report text	HY12/HY11/ HY12	200	$7,460
	9.2 Prepare tables, graphs, illustrations, and maps as necessary for report	HY12/HY11/ HY12	100	$3,918
	9.3 Compile draft text and graphics for review and assemble review teams	HY12/HY11/ HY12	100	$3,918
		Subtotal	400	$15,297
10	**Technical reviews and revisions**			
	10.1 Conduct periodic and final in-house reviews	GS12/GS12	40	$1,678
	10.2 Address final in-house review comments and prepare for USGS colleague and cooperator reviews	HY12/HY11	160	$6,816
		Subtotal	200	$8,494
11	**Report reviews and editorial revisions**			
	11.1 Compile and address colleague and cooperator review comments	HY12/HY11	100	$3,832
	11.2 Revise and prepare final manuscript	HY12/HY11	100	$3,832
		Subtotal	200	$7,664
12	**Report publication**			
	12.1 Final editorial review and formatting for publication	PUB STAFF	40	$2,200
		Subtotal	$40	$2,200
	Total Net Salary Cost		**7,490**	**312,518**
	Report Printing Cost (Net)			$1,270
	Science Support			$52,399
	Facilities			$44,128
	Overhead			$339,685
	Total Funding			**$750,000**

Table 3. Quarterly and annual breakdown of study costs.

Calendar year	**2011**			**2012**				**2013**				**2014**	**Totals**
Federal fiscal year	*2011*	*2011*	*2012*	*2012*	2012	2012	2013	2013	2013	2013	2014	2014	
Quarterly periods	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	**12 Quarters (36 Months)**
USGS funding	$7,250	$7,250	$7,250	$9,500	$9,500	$9,500	$9,500	$8,500	$8,500	$8,500	$10,050	$4,700	**$100,000**
MORPC funding	$54,249	$63,611	$36,170	$55,646	$121,485	$58,702	$37,317	$63,747	$49,138	$90,470	$14,765	$4,700	**$650,000**
USGS and MORPC funding	$61,499	$70,861	$43,420	$65,146	$130,985	$68,202	$46,817	$72,247	$57,638	$98,970	$24,815	$9,400	**$750,000**
Total funding			**$175,780**				**$311,150**				**$253,670**	**$9,400**	**$750,000**

Table 4. Study timeline depicted by the time required to complete each study task (in months), as described in table 2.

Task 1	■	■	■																																	
Task 2				■	■	■																														
Task 3							■	■	■																											
Task 4										■	■	■	■	■	■																					
Task 5													■	■	■	■	■	■																		
Task 6																			■	■	■	■	■	■	■	■										
Task 7																						■	■	■	■	■	■	■								
Task 8																												■	■	■						
Task 9																												■	■	■						
Task 10																													■	■	■	■	■			
Task 11																															■	■	■	■	■	
Task 12																																		■	■	■
Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36

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