Arkansas Water Resources Center

BEAVER LAKE WATER QUALITY MONITORING PLAN

DEPARTMENT OF THE ARMY
LITTLE ROCK DISTRICT, CORPS OF ENGINEERS
Post Office Box 867
Little Rock, Arkansas 72203-0867

Kenneth W. Carter, Chief
Planning Division

Project Manager: George Losak

Co-Principal Investigators: Dr. Kenneth Steele, Arkansas Water Resources Center, Dr. Joel Cahoon, Dr. Dwayne Edwards, Biological and Agricultural Engineering, Dr. Tommy C. Daniel, Agronomy, Dr. Richard Meyer, Department of Botany & Microbiology, Dr. Dee Mitchell, Civil Engineering, University of Arkansas, Fayetteville, Arkansas 72701

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Arkansas Water Resources Center
Ozark Hall 113
University of Arkansas
Fayetteville, Arkansas 72701

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Prepared by

ARKANSAS WATER RESOURCES RESEARCH CENTER
113 Ozark Hall
University of Arkansas
Fayetteville, Arkansas 72701

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Acknowledgments

We gratefully acknowledge the review of this Plan by the U.S. Army Little Rock Corps of Engineers (COE), the U.S. Environmental Protection Agency (EPA), District VI, the Arkansas Department of Pollution Control and Ecology (ADPC&E), the Arkansas Soil and Water Conservation Commission (ASWCC), the U.S.D.A. Soil Conservation Service (SCS), Arkansas, and the U.S.D.O.I. Geological Survey, Little Rock.

INTRODUCTION

The Beaver Lake basin is located in Northwest Arkansas, and includes portions of Washington, Madison, Benton, Carroll and Franklin counties. The White River is the major tributary to Beaver lake, with minor tributaries including the Middle and West Forks of the White River, Richland Creek and War Eagle Creek. The basin encompassing 1,186 square miles of drainage area provides a usable storage capacity of 1.22 million acre-feet, 300,000 of which are designated as flood control, the remainder is utilized for power generation and water supply. Beaver Lake is the water source for both the Beaver and Carroll County Water Districts. Ten recreational facilities have been developed around the lake by the U.S. Army Corps of Engineers (COE).

The most significant water quality problems are in the upper reaches of Beaver Lake. Identified problems include low dissolved oxygen, and high concentrations of fecal coliform, iron, manganese, turbidity, and algae. These water quality problems are associated with the addition of nitrogen, phosphorous and carbon from municipal point and non-point sources, and from rural nonpoint sources, which are exacerbated by the high concentrations of confined animals in the basin. Complicating these problems is the fact that 85 percent of the drainage area enters the lake upstream of Highway 12 bridge, whereas less than 20 percent of the volume is stored in this zone. Pollutants, not well diluted in the upper reaches of the lake, result in water quality problems.

A study of the present status of the streams and lake requires analyses of parameters affecting water quality in the reservoir. Data not presently available include the importance and influence of storm events on reservoir loading and the reaction of the primary biota to these perturbations. These analyses can be achieved by monitoring several source streams as well as investigating the interaction of parameters within the reservoir.

In order to ascertain the importance and influence of natural events and anthropogenic activities a standardized, approximately 5 year monitoring plan will be established. The information derived from this monitoring program will serve as a reference to evaluate natural trends, short term impacts, and best management practices (BMP's). Data derived from COE, SCS, Arkansas Water Resources Research Center (AWRRC) and and other documents were used to determine sampling sites, sampling protocol, and parameter selection.

OBJECTIVES

The overall goals of the plan are to perform point and nonpoint source nutrient load accounting for Beaver Lake Basin and to provide guidance in establishing the effectiveness of implementing BMP's within the Beaver Lake Basin. The project will be limited to the basin drainage area south of the bridge crossing the lake at Highway 12. The nutrient loading values from the various sources will be determined. In addition, the water quality in the upper reaches of the lake will be established and correlated with various land use management practices as they are implemented.

To accomplish the overall goal the following primary objectives will be met:

1 Twelve stream sites on the major lake basin watersheds will be established and monitored for flow and water quality. The location of each of these sites and the parameters to be analyzed are given in Section 1. Base flow samples will be collected on each of these sites on a six week schedule. Storm water samples will be collected at each site following four separate storm events annually. One additional site will be designated annually by the COE and sponsor.

2) Five sites for sampling the water parameters of the lake will be established and monitored for water quality. The locations of the lake sampling sites and the parameters to be analyzed are described in Section 2. Samples will be collected routinely at each site on a six week basis. Samples corresponding to the same four storm events as those sampled in the streams will also be collected.

3) Consultation will be maintained with the COE, sponsor and SCS concerning sample collection strategies and parameter analyses of water samples from three established land treatment test plots.

4) Data analysis and report preparation will be maintained throughout the course of the project to document all field and parameter analysis activities.

SECTION 1. STREAM SAMPLING AND ANALYSIS

Site Locations

Proper site selection is necessary to provide meaningful long-term flow and contaminant or pollutant loading data for evaluation of management practices and land use decisions. Several sites have been selected as sampling/monitoring locations for the Beaver Lake Water Quality Monitoring Plan. The actual locations may change slightly due to stream-bed characteristics.

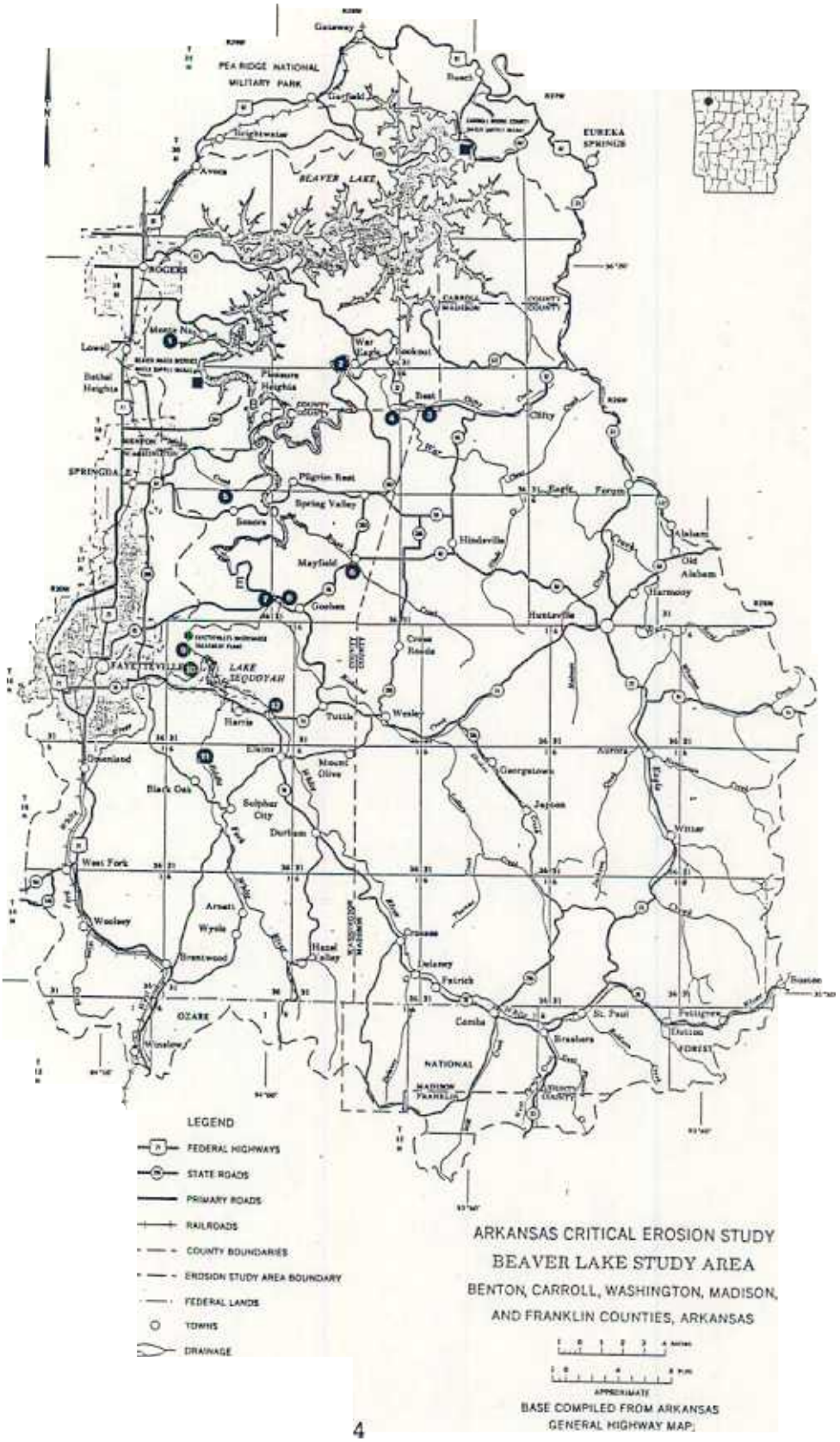
A name has been assigned to each monitoring site, as shown in Table 1. Approximate locations of the sites are identified in Figure 1. The sampling/monitoring sites include six sites specifically identified by the Arkansas Department of Pollution Control and Ecology (ADPC&E) as being necessary to determine nutrient loading rates from selected watersheds. An additional six sites are necessary to delineate the nutrient input to the lake. The U.S. Geological Survey (USGS) 7 1/2' Topographic Map in which the site lies, as well as the legal description of the site is given. One additional site may be designated annually by the COE and sponsor for special studies.

Table 1. Stream sampling/monitoring site locations and descriptions.

Site	Name	7 1/2' Map	Legal Description
1	Monte Cr. near Monte Ne *	Rogers	SW1/4, SE1/4, Sec 29, T19N, R29W
2	War Eagle Cr. at War Eagle *	War Eagle	SE1/4, SE1/4, Sec 34, T19N, R28W
3	Clifty Cr. near Best	Spring Valley	SW1/4, SE1/4, Sec 8, T18N, R27W
4	War Eagle Cr. near Best	Spring Valley	SE1/4, SW1/4, Sec 12, T18N, R28W
5	Friendship Cr. N. of Sonora *	Sonora	SW1/4, SW1/4, Sec 35, T18N, R29W
6	Brush Cr. near Mayfield *	Spring Valley	NW1/4, NE1/4, Sec 22, T17N, R28W
7	White River at Twin Bridges *	Elkins	NW1/4, NW1/4, Sec 31, T17N, R28W
8	Richland Cr. at Twin Bridges *	Elkins	NW1/4, NE1/4, Sec 31, T17N, R28W
9	White River at Wyman Bridge	Elkins	NE1/4, SW1/4, Sec 8, T16N, R29W
10	White R., Iron Bridge @ Mally Wagnon	Elkins	NW1/4, NW1/4, Sec 20, T16N, R29W
11	Middle Fork White River, L. Sequoyah	Sulphur City	NE1/4, NE1/4, Sec 8, T15N, R29W
12	East Fork White River near Elkins	Elkins	NE1/4, SE1/4, Sec 26, T16N, R29W

* ADPC&E recommended sites

Figure 1. Approximate locations of stream and lake sampling/monitoring sites. Numbers indicate stream sites, letters indicate lake sites.



Flow Measurement

Continuous flow monitoring at each stream sampling/monitoring site is necessary to establish nutrient loading rates within the basin. Each site will be instrumented to gage discharge on a continuous basis. Stream gaging information is provided in Appendix A.

Sampling Protocol

A. Base Flow

Each stream site will be sampled, using a grab sample technique on a time schedule basis to estimate nutrient loading attributable to base flow. The base flow sample should be taken on six week intervals at each site. This time table will govern the sampling frequency regardless of storm flow. This procedure would require a maximum of 9 samples per site annually. The actual number of base samples may be less, because of the intermittent nature of certain streams.

B. Storm Events

Each stream site will be instrumented to automatically sample for water quality analysis during storm events. The sampling unit will be designed to activate when the stage-discharge relationship indicates discharge of ten percent above seasonal base flow. Upon activation, the unit will sample according to a time schedule until the flow returns to less than 110% of seasonal base flow. Samples from four storms per year will be collected for laboratory analysis. Factors determining the selection of which storm events are analyzed must be submitted to the COE and sponsor annually for approval prior to sample collection. Storm event sampling will be scheduled such that two samples will closely follow the application of poultry litter in the Spring, one is scheduled during the growing season, and one is scheduled during the winter following leaf drop. The automated sampling units should be capable of collecting time dependent samples upon actuation, although the initial plan calls for integrated samples for each storm.

C. Field Measurements

In situ measurements are necessary for those parameters that may be affected by sampling and storage procedures. Water temperature, conductivity, and dissolved oxygen will be measured in situ at the time of collection of each stream base flow sample using the methods cited under parameter analysis.

Parameter Analysis

All analytical procedures used must be referenced in Guidelines for Establishing Test Procedures for the Analysis of Pollutants under the Clean Water Act; Technical Amendments and Notice of Availability of Information; 40 CFR, Part 136, June 30, 1986.

Each sample will be analyzed for the following standard parameters:

Phosphorous: Ortho Phosphate, Total P
Nitrogen: Ammonia, Nitrate, Total N
Misc.: Total Organic Carbon (TOC), Total Suspended Solids (TSS), Chlorophyll -a,-b,-c, Turbidity, Algae Qualitative Evaluation, pH

The samples collected at the additional COE designated site will be analyzed for the parameters listed above, as well as:

Metals: Iron, Manganese, Sodium, Potassium, Calcium, Magnesium
Anions: Chloride, Sulfate
Misc.: Chemical Oxygen Demand (COD), Alkalinity, Five-Day Biological Oxygen Demand (BOD), Fecal Bacteria

SECTION 2. LAKE SAMPLING AND ANALYSIS

Site Locations

Lake samples will be collected at five thalwag sites below and including the Highway 12 bridge. The locations of these sites are given in Table 2.

Sampling Protocol

Lake samples will be taken at the same time as the stream base flow samples. The lake sampling protocol will be based on stratification conditions present at the time of sampling. For unstratified conditions, samples will be taken at the subsurface, mid-depth, and at the suprabottom. Stratified conditions will be determined based on temperature, dissolved oxygen and conductivity profiles. When stratified conditions are present, sampling will be done at the subsurface, the metalimnion, and the suprabottom. Samples will be collected using the methods referenced in Parameter Analysis in Section 1. Light penetration will also be determined using a Secchi disk or a submarine photometer.

Weekly lake samples will be taken in association with each sampled storm event until the storm event front diffuses with the hypolimnion or extends north of lake sampling site C. Samples will be collected at the three sites indicated by the asterisk in Table 2.

Table 2. Lake sampling sites.

Site	Name	7 1/2' Map	Legal Description
A	Highway 12 Bridge	Rogers	SW1/4, NE1/4, Sec 12, T19N, R29W
B	Hickory Creek	Sonora	SW1/4, SW1/4, Sec 12, T18N, R29W
C	War Eagle/White Intersect *	Spring Valley	SE1/4, SE1/4, Sec 7, T18N, R28W
D	Highway 68 Bridge *	Sonora	SE1/4, SE1/4, Sec 1, T17N, R29W
E	Habberton *	Elkins	NE1/4, SE1/4, Sec 26, T17N, R29W

* Locations sampled after each sampled storm event.

Parameter Analyses

The recommended laboratory analysis for lake samples is identical to that used for base stream flow. In situ measurements for lake sampling are the same as those used for base stream flow. These will be taken at 1 meter depth intervals to provide temperature, dissolved oxygen and conductivity profiles for determining sampling depths.

SECTION 3. SMALL WATERSHED SAMPLING AND ANALYSIS

Three small (approximately 5 acres) grassed watersheds are currently instrumented and monitored by the SCS for the purpose of establishing the quality of runoff from land treated with poultry waste. Each of the three watersheds is equipped with a 90 degree triangular weir, a stage recorder, an automated sampler, and a Universal Recording Rain Gage. Runoff samples should be collected and analyzed for ammonium nitrogen, nitrate nitrogen, soluble phosphorus, potassium, total suspended solids, fecal bacteria, and those heavy metals specifically associated with applied wastes. Samples are collected for one storm prior to application of poultry waste and for one to three storms after application of poultry waste, depending on application date and weather.

In association with the water quality monitoring element of this work, soil samples are collected and analyzed both before

and after application of the waste. Also, the waste loading rates are determined and samples of the waste analyzed. This approach enables the estimation of the pollutant transport under conditions existing at these watersheds, which are representative of areas typically treated with poultry waste in the Beaver Lake watershed.

Active consultation with the SCS will be maintained to ensure that the small watershed monitoring and parameter analysis is compatible with the activities identified in Sections 1 and 2.

SECTION 4. BUDGETARY CONSIDERATIONS

Budgetary estimates are provided to indicate the magnitude of the project in terms of monetary issues. The budgetary concerns may be divided into two classifications; initial costs and annual expenses. The initial cost estimates are given in Table 3, and the annual expenses are shown in Table 4. Table 5 provides itemized cost estimates for laboratory parameter analysis.

The annual operating costs, less the report preparation and publication costs, represent a per-sample cost of $605.22. This per-sample cost will change if the sampling protocol, the number of sampling sites, or the parameters to be analyzed is altered. Attempts to alter the budget by altering any of the above would warrant recalculating the per-sample cost. The expected annual cost is $227,735.00 with an additional initial cost of $162,550.00 for the first year. This places the five year budget at $1,301,225.00. The breakdown of these budget estimates is documented in Tables 4 and 5.

Table 3. Initial cost estimates

Item Description	Unit Cost	Total Cost
Stream Gaging Installation		
1 USGS modified site	{3,500}	{3,500}
4 USGS large sites *	9,000	36,000
5 USGS small sites *	5,000	25,000
2 weir sites (incl. stage recorders)	5,000	10,000
Automated Samplers **		
17 sampling units	1,650	28,050
17 sets additional hardware	1,000	17,000
6 additional booster pumps	500	3,000
Miscellaneous		
1 operations vehicle ***	20,000	20,000
Miscellaneous equipment		20,000
Total		$162,550

* Costs based on information supplied by USGS (Appendix A).
** Approximate cost of ISCO equipment.
*** Vehicle with modifications to maintain and service samplers, transport water samples, etc.
{ } Estimated

Table 4. Annual cost estimates.

Item Description	Unit Cost	Total Cost
Stream Gaging *		
10 sites	$ 6,800	$68,000
Contingency (10%)		6,800
Lab Analysis **		
Stream Base Flow		
104 samples	184	19,125
Stream Storm Flow		
48 samples	184	8,827
Lake Time Interval Samples		
130 samples	184	23,907
Lake Storm Samples		
96 samples	184	17,654
COE Designated Sites		
52 samples	319	16,572
Contingency (10%)		8,609
Collection		
Technicians		
2 - Salary	25,000	50,000
2 - Fringe Benefits	4,330	8,660
Travel & Vehicle Maint.		4,000
Sample Transport		3,500
Equipment Maint.		2,500
Boat Operation (30 trips)	100	3,000
Contingency (20%)		14,330
Data File Prep. and Final Report		2,000
Total		$227,735

* Costs partially based on information supplied by USGS as shown in Appendix A.
** Unit cost estimates are derived from the information in Table 5.

Table 5. Laboratory parameter analysis costs

Parameter	Per Sample Cost ($) Lab 1	Lab 2	Lab 3	Lab 4
Phosphorous				
Ortho P	{18.00}	{18.00}	{18.00}	18.00
Total P	18.75	20.00	20.00	18.00
Nitrogen				
Ammonia	11.25	22.00	12.00	18.00
Nitrate	11.25	22.00	18.00	18.00
Total	{27.00}	{27.00}	{27.00}	27.00
Metals				
Iron	9.00	12.00	7.00	9.00
Manganese	9.00	12.00	7.00	9.00
Sodium	9.00	14.00	7.00	9.00
Potassium	9.00	14.00	7.00	9.00
Calcium	9.00	12.00	7.00	{9.00}
Magnesium	9.00	12.00	7.00	{9.00}
Anions				
Chloride	7.50	20.00	9.00	18.00
Sulfate	11.25	12.00	15.00	12.75
Misc.				
Total Organic Carbon	{22.50}	{22.50}	{22.50}	22.50
Chem. Oxygen Demand	{15.00}	{15.00}	{15.00}	{15.00}
Alkalinity	7.50	12.00	7.00	{8.83}
Bio. Oxygen Demand	{15.00}	{15.00}	15.00	{15.00}
TSS	7.50	6.00	8.00	13.50
Chlorophyll a,b,c	{20.00}	{20.00}	{20.00}	{20.00}
pH	7.50	6.00	2.00	{5.17}
Turbidity	7.50	15.00	8.00	{10.17}
Algae	{20.00}	{20.00}	{20.00}	{20.00}
Fecal Coliform	11.25	16.00	12.00	{13.08}
Cost estimate (full (Avg. = 318.69)	**292.75**	**364.50**	290.50	327.00

{ } Estimated, cost not quoted.
Lab 1: National Environmental Testing Inc. (11/88)
Lab 2: American Interplex Corporation Laboratories (11/88)
Lab 3: Daily Analytical Laboratories (11/88)
Lab 4: National Analytical Laboratories (1/90)

SECTION 5. CONSULTATION WITH AGENCIES

The plan will be reviewed annually with the COE and local sponsor for possible changes in sampling and analysis protocol. This review will take place at the time of submission of the annual report. The contractor for the Beaver Lake Water Quality Monitoring Plan will maintain a liaison with other groups and agencies conducting projects in the Beaver Lake Drainage Basin that affect water quality. For example, the contractor will consult with the SCS as mentioned previously, the contractor of the Clean Lakes Project for Beaver Lake, and other appropriate agencies/groups designated by COE and sponsor.

SECTION 6. FINAL REPORT

The data associated with the final report will be recorded in ASCII data format on 1/4" cassette tape.

APPENDIX A

Stream Gaging Information

For gaging purposes, each stream sampling/monitoring site is assigned one of five designations; weir, USGS modified, USGS active, USGS small and USGS large. These assignments are shown in Table 4.

Table 4. Stream gaging designations.

Site	Name	Gaging Designation
1	Monte Cr. near Monte Ne	Weir
2	War Eagle Cr. at War Eagle	USGS Large
3	Clifty Cr. near Best	USGS Small
4	War Eagle Cr. near Best	USGS Small
5	Friendship Cr. N. of Sonora	USGS Small
6	Brush Cr. near Mayfield	USGS Small
7	White River at Twin Bridges	USGS Large
8	Richland Cr. at Twin Bridges	USGS Large
9	White River at Wyman Bridge	USGS Active
10	White R. at Mally Wagnon	USGS Modify
11	Middle Fork White River, L. Sequoyah	USGS Small
12	East Fork White River near Elkins	USGS Large

A. Weir Sites (Site 1)

Site 1 is appropriate for installation of a small broad-crested weir. A stage recorder should be installed to provide continuous discharge estimates. It is anticipated that similar situations will exist at the COE designated sites.

B. USGS Active Site (Site 9)

The site on the White River at the Wyman Bridge is currently an active continuous discharge site maintained by the USGS.

D. USGS Modify Sites (Site 10)

Site 10 is currently monitored by the USGS to record instantaneous discharge. Modifications will be necessary to record continuous discharge.

C. USGS Small and Large Sites (Remaining Sites)

The sites designated USGS small and large are those at which a more significant effort will be required to accurately monitor

continuous discharge. This will include accurate surveys of the streambed profile, and installation and maintenance of stage recording equipment. The cost estimate is $5,000 for start-up of the small sites, $9,000 for start-up of the large sites, and $6,800 per site per water year for operation and maintenance.