THE MISSISSIPPI DELTA MANAGEMENT SYSTEMS EVALUATION AREAS PROJECT – CURRENT STATUS AND PRELIMINARY FINDINGS

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INTRODUCTION

One of the most intensive agricultural areas of the United States is the Mississippi River Alluvial Plain in northwest Mississippi, a 7,000-square-mile area locally referred to as "the Delta." Agricultural activities in the Delta differ significantly from those in other regions of the United States. The mild winters, humid sub-tropical climate, and an average of more than 50 inches of rain a year in the Delta dictate a different array of crops and cultural practices than those used in other areas of the Nation. Cotton is one of the primary crops produced in the Mississippi Delta. Cotton has a long growing season and is very susceptible to damage from weeds and insects; thus, multiple pesticide applications are needed. Additionally, little ground cover remains after cotton harvest in the late fall, and the soil may be left unprotected during the rainy season of the early winter months, thus increasing runoff potential. These factors, in combination with high regional rainfall, increase the potential for chemical movement and soil erosion in the Delta.

The Mississippi Delta Management Systems Evaluation Areas (MDMSEA) project began in 1994 to determine how agricultural activities affect water quality in the Mississippi Delta and to increase the knowledge needed to design and evaluate best management practices (BMPs) as components of Delta farming systems (Rebich et al. 1995). Although cotton production was selected as the primary crop-of-interest for this project, other crops such as soybeans and corn have been evaluated as well because such crops are integrated with cotton production in typical Delta farming operations. The MDMSEA project focuses on oxbow lake watersheds. An oxbow lake is an old river channel meander that has been cut-off over time. Oxbow lake watersheds were chosen because they are considered closed systems in that all of the runoff from the watershed drains into the oxbow lakes; therefore, these lakes act as biological endpoints that are affected by watershed management.

A Technical Steering Committee (TSC) composed of local, State, and Federal agencies, as well as local universities and organizations, cooperatively administer the MDMSEA project by guiding its development and overall direction. The TSC includes the following agencies: U.S. Geological Survey (USGS); U.S. Department of Agriculture (USDA)-Agricultural Research Service (ARS); Mississippi State University (MSU); Mississippi Department of Environmental Quality (MDEQ); USDA-Natural Resources Conservation Service (NRCS); USDA-Farm Service Agency (FSA); Mississippi Agricultural and Forestry Experiment Stations (MAFES); Yazoo-Mississippi Delta Joint Water Management District (YMD); Mississippi Soil and Water Conservation Commission (MSWCC); Delta Council; and the Mississippi Farm Bureau Federation. Other agencies that have contributed funding, technical expertise, or other services to the MDMSEA project include, but are not limited to: USDA-Wildlife Services; Mississippi Cooperative Extension Service; Delta Wildlife Federation; U.S. Environmental Protection Agency; U.S. Fish and Wildlife Service; Mississippi Department of Wildlife, Fisheries, and Parks; John Deere Corporation; and the Pyrethroid Working Group.

The data base generated from this project will be useful to landowners and management agencies in making sound decisions regarding agricultural nonpoint source pollution and implementation of BMPs. The BMPs are evaluated for their economic and environmental value at the farm and watershed scales. In addition, educational and public awareness programs associated with the project help to communicate the research findings and BMP information which will ultimately help improve water quality in the Delta region. The purpose of this paper is to present the current status and preliminary findings of the research activities of the MDMSEA project.

STUDY AREA

Three oxbow lake watersheds located in Sunflower and Leflore Counties, Mississippi, were selected for the MDMSEA project (Figure 1). These watersheds were selected by a sub-committee of the TSC whose selection criteria included the following: the oxbow lakes should be about 20 acres in size in order to be adequately managed; the predominant crop in the watersheds should be cotton; accessibility must be adequate during storms to service sampling equipment; the watersheds should be near each other to minimize travel time; the watersheds should be relatively isolated to minimize vandalism and fishing-access problems; and the land owners and operators must be willing to cooperate with the scientists and commit to the MSEA project for a minimum of 5 years. The MDMSEA oxbow lake watersheds are:

A. Thighman Lake watershed (Sunflower County) - The total drainage area of this watershed is about 3,900 acres with a lake surface area of about 22 acres. Soils in the watershed vary from a loam to a very heavy clay. The crops grown in this watershed are cotton, soybeans, corn, rice, and catfish.

B. Beasley Lake watershed (Sunflower County) - The total drainage area of this watershed is about 1,900 acres, and the surface area of the lake is about 62 acres. Soils are generally a loam, and primary crops are cotton, soybeans, corn, and rice. The watershed has a large riparian zone area on the eastern side of the lake.

C. Deep Hollow Lake watershed (Leflore County) - The total drainage area of this watershed is about 400 acres with a lake surface area of about 20 acres. Most of the watershed has loam soils that support cotton production (about two-thirds of the watershed), but heavier, clay soils are also present where soybeans are produced. The western side of the watershed is defined by the east levee of the Yazoo River, and a large riparian area lies between this levee and the lake.

BMPs implemented in the MDMSEA project can be characterized as structural or agronomic and were based on watershed farm plans developed by District and Area NRCS offices. Farm plans are the typical process that producers use to implement BMPs on their land. Structural improvements include slotted-board riser drainage pipes, slotted inlet pipes, and berms. Agronomic components include different tillage practices, vegetative buffer strips, cover crops, soil amendments, transgenic crops, and precision application of chemicals.

The BMPs were distributed among the three watersheds using a hierarchical approach. The Thighman Lake watershed was intended to be the control watershed where no BMPs sponsored by the project would be installed; however, producers in the Thighman Lake watershed have begun to use BMPs such as conservation tillage and crop rotation to improve production. The Beasley Lake watershed was selected to have a minimal BMP treatment that includes filter strips and structural practices such as slotted-board risers and slotted-inlet pipes. A comparison study has also been included at the Beasley Lake watershed to investigate transgenic cotton that is designed to be resistant to some insects. The Deep Hollow Lake watershed was selected to have the same structural BMPs as the Beasley Lake watershed, but would also include cultural BMP's such as conservation tillage, winter cover crops, and precision farming.

The NRCS offices designed and supervised the construction of all BMPs used throughout the MDMSEA study area. The Delta Wildlife Federation and the U.S. Fish and Wildlife Service donated pipes for slotted-board risers and culvert replacement. The cost-share programs of the USDA-Farm Service Agency and the Model Farm Project of the Mississippi Soil and Water Conservation Commission provided funding for the construction of the BMPs (Rebich et al. 1996).

CURRENT STATUS AND PRELIMINARY FINDINGS

The data collection and research activities associated with the MDMSEA project are comprehensive and detailed in design. The leading research organizations for the MDMSEA project are the USGS, ARS, and MSU. Team efforts among these agencies are coordinated to ensure a comprehensive assessment of management effects on key environmental quality parameters. For example, runoff is tracked from different cropping practices through existing riparian zones and drainage pathways to oxbow lakes; runoff, shallow ground water, and lake water are sampled and analyzed for a wide range of physical and chemical constituents; and different in-field and edge-of-field BMPs are monitored both for their environmental and agronomic effectiveness. In addition, the effects of BMPs on spatial variability are assessed in relation to soil quality factors, weed populations, and precision application of chemicals. The following paragraphs summarize the current status and preliminary findings of the lead research organizations.

U.S. Geological Survey

The USGS began operating a streamflow and water-quality sampling network in fall 1995 as part of a cooperative agreement with the MDEQ, Office of Pollution Control. The network includes six streamflow and sampling sites in the three MDMSEA watersheds (Rebich 1997). An additional three sampling sites are located in the riparian area at the Beasley watershed and were installed in collaboration with ARS (streamflow is not measured). Data from the various sites of the network will help to characterize the runoff in each of the three watersheds and to evaluate as many BMPs and BMP combinations as possible. About 1,350 sediment, 460 pesticide, and 500 nutrient samples have been collected. Only a slight difference exists in the discrete suspended-sediment concentration data collected to date between the Beasley sites and the Thighman sites; however, a much greater difference exists when comparing the Deep Hollow sites to the other two watersheds (Figure 2). Preliminary analyses of the nutrient and herbicide data indicate similar results. At all three locations, the highest levels of sediment, pesticides, and nutrients occur in runoff from the first few storms of each growing season. Changes in water quality have recently been observed due to a large amount of corn planted in the 1998 growing season. The changes include increased corn herbicide and nutrient concentrations at the Thighman and Beasley watersheds.

USDA Agricultural Research Service

The National Sedimentation Laboratory at Oxford, Mississippi, began their research effort in 1994 focusing on the quality of shallow ground water, the assessment of the ecological health of the lakes, and vertical crack development in heavy clay Delta soils in the three watersheds. In the area of shallow ground water research, the ARS has installed and sampled nearly one hundred wells throughout the MDMSEA watersheds. The wells are typically installed in sets of three and are screened at depths of 5, 10 and 15 feet. To date, about 700 samples have been collected from the wells. In all of these samples, only a few have had detections of pesticides (primarily herbicides), and these few detections were seasonal and at very low levels at or near the detection limits (J.D. Schreiber, USDA-ARS National Sedimentation Laboratory, written commun. 1998). Phosphorus concentrations are relatively high reflecting the naturally high phosphorus levels in Delta soils. The relatively low nitrate concentrations are likely the result of high rates of denitrification during the winter months when the soil profile is saturated (low oxygen levels). Further evidence for this scenario is offered by the existence of dissolved organic carbon, a necessary requirement for denitrification. Nitrate levels in ground water are lowest in the Beasley watershed riparian areas.

The lake ecology research has indicated that all three lakes were initially stressed due to high concentrations of suspended sediment (Knight et al. 1998). Beasley Lake had the highest concentrations of suspended sediment followed by Thighman and Deep Hollow (Table 1). Shortly after BMPs were installed in the Beasley and Deep Hollow watersheds, all three lakes were renovated by removing the resident fish species, and then restocked with sport species to observe survival, growth rates, and spawning ability. Preliminary indications show that survival and growth rates of sport fish populations are best in Deep Hollow Lake followed by populations in Thighman Lake. Fish populations at Beasley Lake have not shown signs of any significant improvement over the original stressed conditions; in fact, very few of the re-stocked sport fish survived at Beasley Lake. In terms of lake water quality, nutrient concentrations were fairly consistent among the three lakes but concentrations were about one order of magnitude lower than observed at the USGS edge-of-field sites.

Research by the Southern Weed Science Laboratory at Stoneville, Mississippi, focuses on soil and weed characteristics related to chemical application, the influence of BMP's on soil quality and pesticide fate in soil, and the effect of BMP's on microbial populations in the lakes. Soils in the Beasley and Deep Hollow watersheds have been sampled and mapped by using GPS technology for the purpose of using spatially varied herbicide application as a potential BMP. The soils are sampled with respect to cotton herbicide binding capacity and weed populations. The spatial variability of both herbicide binding and weed populations correlate well with organic carbon and clay and sand content (Locke et al. 1998). Preliminary results show that poorer weed control occurred in heavier texture soils. Such information will be useful should a producer choose to map the soils and weeds in a field to target herbicide applications. Thus, better weed control can be achieved while lowering herbicide costs and reducing the potential for off-site movement. Research in the area of microbial activity in the three lakes has identified certain beneficial algae that contribute to pesticide degradation (Zablotowicz et al. 1997). Riparian zones support the greatest microbial activity indicating their importance as a filter for nonpoint pollution.

Significant success in precision technology has been shown by the Application Production Technology Unit at Stoneville. Researchers have teamed with counterparts in industry to develop a hooded herbicide sprayer with weed sensing technology. A weed sensor is mounted in a hood to sense chlorophyll causing the sprayer unit to operate only when passing over weed vegetation in between crop rows. In the Deep Hollow watershed, the device has effectively controlled weeds using 57 to 82 percent less contact herbicide in cotton and 43 to 79 percent less herbicide in soybeans (Hanks and Bryson 1997). In other testing at a non-MDMSEA location, a side-by-side comparison has been made between conventional and sensor-controlled spraying using an 8-row hooded sprayer on a soybean field. Results shown in Table 2 indicate a range of savings from 50 to 82 percent using the sensor sprayer (Hanks and Beck 1998). Researchers using GPS technology have also identified and mapped about 70 different varieties of weeds at the Deep Hollow watershed so that any shifts in weed populations and weed control can be observed over time (Bryson and Hanks 1997). In 1998, yield mapping technology was added for cotton and soybean harvests at the Deep Hollow Lake watershed in cooperation with the USDA-ARS-National Sedimentation Laboratory. This technology will provide another layer of information to correlate with soil and weed variability and will be used for expanded economic evaluation of farming systems research at more locations in the future.

Research by the Soil and Water Research Unit at Baton Rouge, Louisiana, is concerned with the effect of BMPs on insecticide loading to surface runoff (in cooperation with the USGS) and the use of weather forecasts to optimize timing of pesticide applications. With respect to insecticide loading to surface runoff, samples were collected at all USGS surface water sampling locations and were analyzed for insecticides such as methyl parathion and some pyrethroids. No significant detections of insecticides in the runoff water have been observed thus far.

Mississippi State University

Research activities by MSU that are currently funded cross a wide range of disciplines. MSU scientists have been assessing the role of filter strips and riparian zones in enhancing herbicide dissipation. Numerous soil samples have been analyzed to measure herbicide sorption to soils in filter strips, soils adjacent to filter strips, and to soils in riparian areas. Preliminary findings indicate that herbicide sorption and degradation correlate well with organic content, clay content, and cation exchange capacity (Shankle et al. 1998). Therefore, herbicides are more likely to sorb to soils in filter strips and riparian areas than to soils in adjacent fields and turn rows (Table 3).

Another activity is in the area of sociological research in which a survey was mailed to several hundred residents throughout the entire Delta region to understand their attitudes concerning water quality and the adoption of BMPs in the Delta. Results of the survey indicate that individuals located near or individuals that operate farms near oxbow lakes or other water bodies are more concerned with water-quality issues and BMPs than those not located near water bodies. Also, those who use the water-bodies for sports activities such as hunting and fishing are much more concerned about water quality and BMPs than those who do not use the water bodies for sports activities. A follow-up survey is planned to determine if attitudes have changed during the MDMSEA project.

Scientists at MSU are also involved in economics research. The purpose of the research is to determine the costs of BMP implementation and maintenance to the farmers. Preliminary budgets for the farming operations located in the three watersheds are nearly complete.

Extension-related activities designed to introduce research methodology to Delta middle school teachers and students and to work side-by-side with MDMSEA scientists on existing projects have recently been added to the program. Professors at MSU have recently received a grant to fund STRIDE, which stands for Student Teacher Research Institute – the Delta Experience. More than 32 teachers and students and 50 researchers of 14 agencies participated in the program. Students traveled to each MDMSEA watershed and worked with the researchers in collecting samples and recording data. The students also traveled to each of the research agencies to observe areas of research other than MDMSEA. The experience exposed students to the daily activities of field researchers, thus promoting the science fields for future career choices. The ongoing collaborative effort is also helping the students with science-related projects during the school year.

SUMMARY

The Mississippi Delta Management Systems Evaluation Areas project began in 1994 with a purpose of determining how agricultural activities affect water quality in the Mississippi Delta and to increase the knowledge needed to design and evaluate best management practices as components of Delta farming systems. Primary research agencies involved in the MDMSEA project include the U.S. Geological Survey, the USDA-Agricultural Research Service, and Mississippi State University. Oxbow lake watersheds were chosen as specific study areas because they are closed systems where lake water quality and productivity are not affected by influences outside the watershed. Varying degrees of BMPs were applied to each of three watersheds.

BMPs implemented in the MDMSEA project can be characterized as structural or agronomic. Structural improvements include slotted-board riser drainage pipes, slotted inlet pipes, and berms. Agronomic components include varying tillage practices, vegetative buffer strips, cover crops, soil amendments, transgenic crops, and precision application of chemicals. Team efforts are coordinated to ensure a comprehensive assessment of management effects on key environmental-quality parameters. For example, runoff is tracked from different cropping practices through existing riparian zones and drainage pathways to oxbow lakes; runoff, shallow ground water, and lake water are sampled and analyzed for a wide range of physical and chemical constituents; and different in-field and edge-of-field BMPs are monitored both for their environmental and agronomic effectiveness. In addition, the effects of management on spatial variability are assessed in relation to soil quality factors, weed populations, and precision application of chemicals.

The MDMSEA project is currently in the fourth year of the first phase, and highlights of research findings from this phase include:

Pesticide and nutrient concentrations are high at edge-of-field locations but attenuate rapidly upon entering the lakes.

Shallow ground-water analysis has shown that most agrichemicals are processed at or near the surface and do not present a human or aquatic threat.

Survival and growth rates of re-stocked sports fish were highest at Deep Hollow Lake where upstream agronomic practices include a combination of structural and cultural practices.

Soil sorption and degradation characteristics associated with conservation tillage, filter strips, and riparian zones help to reduce pesticide and nutrient concentrations.

Certain algae and bacteria were identified that are capable of herbicide biodegradation.

Herbicide applicators using weed-sensing technology provided weed control using significantly less amounts of herbicides.

The project has socio-economic, extension, and teaching-related components.

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Table 1. Physical data from MSEA lakes before implementation of best management practices in September 1996 (modified from Knight and others, 1998)

[C, degrees Celsius; uS/cm, microsiemens per centimeter; mg/L, milligrams per liter; cm, centimeter]

Lake	Specific conductance uS/cm	Dissolved oxygen mg/L	pH	Secci visibility cm	Total solids mg/L	Dissolved solids mg/L	Suspended sediment mg/L
Thighman	0.309	5.06	7.2	11.5	487	119	381
Beasley	0.072	6.38	7	16.6	458	59	402
Deep Hollow	67.9	4.04	6.7	13.2	334	55	269

Table 2. Spray volume applied and savings achieved with eight-row hooded sprayed equipped with conventional and sensor-controlled spray systems (modified from Hanks and Beck, 1998)

[L, liters; %, percent]

	Spray volume applied		
Tank Number	Conventional L	Sensor L	Savings %
1	343	170	50
2	322	57	82
3	298	132	56
Mean	321	120	63

Table 3. Predicted fluometuron adsorption rates to soil from a cropped field, established filter strip, and riparian forested areas at the Beasley Lake watershed (modified from Shankle and others, 1998)

Location	Adsorption rate micrograms per gram
Cropped area	48.89
1-meter established filter strip	68.06
Riparian forest, sampled between 0 and 25 meters downstream of entrance	84.88
Riparian forest, sampled between 50 and 200 meters downstream of entrance	110.16
Riparian forest, sampled between 400 and 800 meters downstream of entrance	146.74

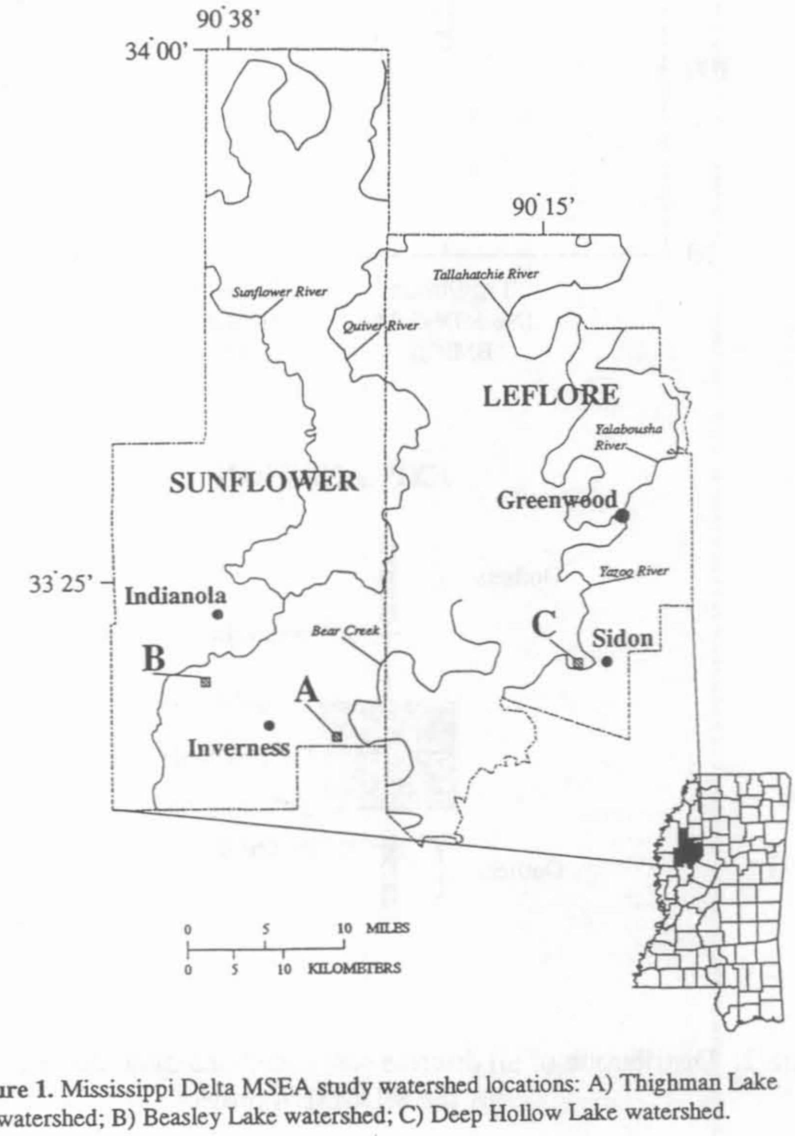

Figure 1. Mississippi Delta MSEA study watershed locations: A) Thighman Lake watershed; B) Beasley Lake watershed; C) Deep Hollow Lake watershed.

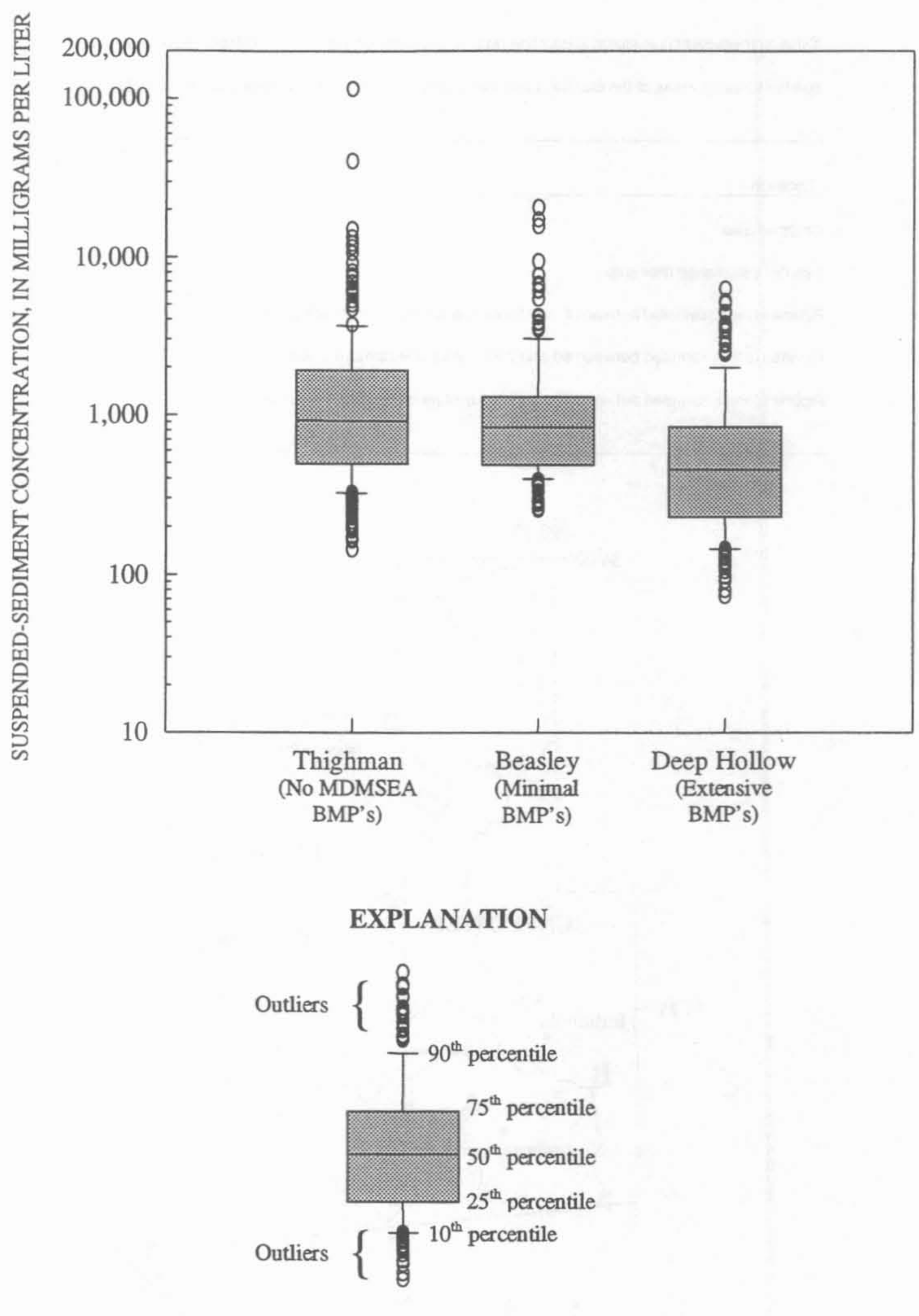

Figure 2. Distribution of all discrete suspended-sediment concentration samples for the MDMSEA project.