Appendix B
Economic Analysis

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B.1. Introduction

This appendix contains a summary of economic impacts of the alternative plans on each of the following seven economic elements addressed in the Feasibility Report and Environmental Impact Statement (EIS) text. A description of methodologies employed by the economic analysis team, where appropriate, and supporting documentation are included in this appendix. The economic elements include:

- Commercial Navigation
- Tourism and Recreation
- Hydropower
- Non-Agricultural Properties
- Agricultural Properties
- Real Estate
- Operations and Maintenance

B.1.1. General Study Purpose

The study was a combined effort of Little Rock and Tulsa Districts and generally followed the Corps of Engineers 6-step iterative planning process: identify the problems and opportunities, develop an inventory and forecast of critical resources (physical, demographic, economic, social, etc.), formulate alternatives, evaluate alternatives, compare alternatives, and select a recommended plan. Since this project was part of the inland waterway system, the feasibility study was conducted at full federal expense. Changes to the MKARNS are needed to make the system more reliable for navigation by modifying the flow management plan. Increasing channel depth is needed to make shipping on the system more competitive with the other deeper draft navigation systems such as the Lower Mississippi River.

The following three elements associated with the maintenance and improvement of the McClellan Kerr Arkansas River Navigation System (MKARNS) were investigated in this study:

a. Phase I - Flow Management: The purpose of Phase 1 was to develop and evaluate components to solve the problems resulting from sustained high flows on the MKARNS. High flows have resulted in decreased navigation traffic, flooding, loss of recreation use, and other adverse conditions. Proposed improvements could impact (positively or negatively) navigation, flood damages, hydropower, recreation, agriculture, and fish and wildlife.

b. Phase II- Channel Depth and Width: The purpose of Phase II was to investigate deepening the channel and to investigate widening the Verdigris River portion of the system to allow tows to pass at almost any location on the Verdigris River.

c. Channel Depth Maintenance Dredging and Disposal: As part of the ongoing operation and maintenance of the designated 9′ navigation channel on the MKARNS, periodic dredging is required in some locations within the river. The removal or excavation, transport, and placement of dredged sediments are the primary components of the “dredging process”. After the sediment

is excavated, it is transported from the dredging site to the designated disposal area. This transport operation is accomplished by the dredge itself or by using additional equipment such as barges or pipelines with booster pumps. The collected and transported dredged material is placed in either open-water, islands or upland locations. Since the completion of the MKARNS in 1971, some authorized maintenance dredge material disposal sites in Oklahoma have reached capacity and new disposal sites are required to continue channel maintenance activities.

B.1.2. Description of Existing Federal Project

The MKARNS provides 445 miles of channel improvements on the Arkansas River from the Mississippi River to the Port of Catoosa, 15 miles east of Tulsa, Oklahoma. It includes a series of 18 locks and dams. Flows on the main stem of the Arkansas River are modified primarily by 11 reservoir projects that provide about 7.7 million acre-feet of flood control storage. That storage represents in excess of 70% of the total flood control storage in the basin. The 11 projects are listed in Table 1-1. A map of the MKARNS is shown in Figure 1-1.

Table 1-1. Principal Upstream Flood Control Lakes, Arkansas River Basin, Oklahoma

Lake	River	Flood Control Storage (acre-feet)
Hulah	Caney	257,900
Copan	Little Caney	184,300
Kaw	Arkansas	919,400
Keystone	Arkansas	1,180,000
Oologah	Verdigris	965,600
Pensacola (Grand)	Grand (Neosho)	525,000
Hudson	Grand (Neosho)	244,200
Fort Gibson	Grand (Neosho)	919,200
Tenkiller	Illinois	576,700
Eufaula	Canadian	1,510,800
Wister	Poteau	386,800
Total		**7,669,900**

The primary purpose of the system water control plan is to achieve a reasonable balance of the purposes for which the projects are operated. The operating plans attempt to optimize flood damage reduction and navigation benefits as well as hydropower and recreation, and to minimize adverse impacts to the environment and fish and wildlife.

There are five public port facilities on the MKARNS, along with more than 70 companies with private port facilities. In 2002, 11.9 million tons of commodities moved on the system, including coal, petroleum products, fertilizers, grain, sand and gravel, and iron and steel products.

The reservoirs assist with the control of water releases through spillways and power generating units. The releases from each reservoir depend on many factors including available water storage, power requirements, navigation water requirements, inflow rates, river flow rates downstream and weather conditions. The Fort Smith/Van Buren, Arkansas, area near the Oklahoma-Arkansas state line is the primary control point for the lower Arkansas River navigation system (Van Buren to mouth). The reservoirs are operated to maintain flow targets at the Van Buren gage, and all reservoir releases flow past this point. About 7,500 square miles of uncontrolled drainage area lie below the regulating control point at Van Buren, Arkansas.

McClellan - Kerr
Arkansas River
Navigation System
MISSISSIPPI RIVER
NORRELL L&D
LOCK 2
WILBUR D. MILLS DAM
JOE HARDIN L&D
EMMETT SANDERS L&D
PINE BLUFF
L&D 5
DAVID D.TERRY L&D
LITTLE ROCK
MURRAY L&D
TOAD SUCK FERRY L&D
ARTHUR V. ORMOND L&D
DARDANELLE L&D
NIMROD
BLUE MOUNTAIN
ARKANSAS RIVER
OZARK-JETA TAYLOR L&D
JAMES W. TRIMBLE L&D
Van Buren
FORT SMITH
W.D. MAYO L&D
Sallisaw
ROBERT S. KERR L&D
WISTER
EUFAULA
WEBBERS FALLS L&D
TENKILLER FERRY
MUSKOGEE
CHOUTEAU L&D
NEWT GRAHAM L&D
FORT GIBSON
HUDSON
PENSACOLA
VERDIGRIS RIVER
OOLOGAH
HEAD OF NAVIGATION
TULSA
KEYSTONE LAKE
HEYBURN
MISSOURI
ARKANSAS
OKLAHOMA
N
LEGEND
NAVIGATION ROUTE
L&D with Federal Hydroelectric Power Facitily
LOCK & DAM
Dam with Federal Hydroelectric Power Facitily
DAM

Figure 1-1

B.1.3. Project Data

The MKARNS provides a year-round navigation channel with a minimum depth of nine feet (9´). Navigation locks in the system provide a total lift of 420´. Two tributary channels, Lake Langhofer and Sans Bois Creek, are included in the navigation system with each less than ten miles in length.

The channel begins at the confluence of the White and Mississippi rivers in Desha County in southeastern Arkansas. From that point, the first ten miles upstream are navigated via the White River to the Arkansas Post Canal, which conveys river traffic to the Arkansas River. Continuing upstream, the navigable waterway crosses Arkansas as it proceeds northward into Oklahoma. The system changes from the Arkansas River into the Verdigris River at Muskogee and terminates 50 miles upstream on the Verdigris at Catoosa.

The Corps maintains a minimum 9´ channel depth throughout the system. Passage through MKARNS lock chambers is configured for eight barges, but can accommodate up to 15 barge tows using double lockage. Each of the 17 locks measures 110´ wide and 600´ long. Individual locks have lifts ranging from 14´ to as much as 54´. There are 13 "low lift" lock and dam structures, which raise or lower river traffic from 14´ to 30´. The four other structures are "high lift" locks, which can raise or lower traffic from 30´ to 54´. In addition to the minimum 9´ depth, the Corps maintains a channel width varying from 300´ in the White River, Lake Langhofer, and the Arkansas Post Canal, to 250´ on the Arkansas River. A 225´ width is provided on Sans Bois Creek, and the Verdigris River segment has a 150´ width.

The lock and dam structures are constructed along the waterway in a stair step pattern that gradually follows the natural elevation changes of the topography and maintain a navigation pool.

B.1.4. History of Operating Plans

There are two primary issues with respect to water management: the authority of the Corps of Engineers to operate the 11 principal reservoirs in the Arkansas River Basin for the benefit of navigation, and the Corp´s authority to draw down into the conservation storage to augment low flows. The Department of the Army's position is that the Corps of Engineers is authorized to operate any of the reservoirs in the system to benefit navigation, and that the operating plan changes made to date have been within its discretionary authority. Also, during a navigation emergency, the Corps has the authority to draw down into the conservation storage of five reservoirs – Kaw, Keystone, Eufaula, Oologah, and Tenkiller – to augment low flows on the navigation system if the drawdown does not impact contracted water supply storage.

The operating plan that is presently in place is the culmination of a process of balancing the authorized purposes of the several reservoirs within the authorized purposes of the specific navigation uses set forth in the McClellan-Kerr Arkansas River Navigation System. This balancing is in response to the Congressional policy of authorizing Corps projects as part of a generally comprehensive plan for river basin development to serve multiple purposes, and not authorizing the projects in isolation to each other. Collectively within the Corps of Engineers

Southwestern Division, the Tulsa and Little Rock Districts have the mission of operating the complex system to satisfy each project purpose.

B.1.4.1. Taper Operation

Since the completion of the MKARNS in 1971, the Corps of Engineers has modified the system operating plans several times to improve the flow regime and to enhance benefits to users of the system. Shortly after the completion of the system it was noted that following a flood event, shoaling would occur in the river channel and restrict navigation until maintenance dredging could be performed. To maintain navigation depths during dredging activities, a "taper" operation was implemented to gradually reduce flows following such floods events. This navigation taper operation required an increase in the time water was held in the lower few feet of the flood control pools in the Oklahoma lakes. The taper operation does not increase the level in the flood control pools but it does delay the timing for complete evacuation of the flood pool. The first such navigation taper plan was utilized from 1979 to 1986.

B.1.4.2. Bench Operation

The bench is the flow rate at Van Buren, Arkansas. The current operating plan provides for a transition of floodwater releases to normal power generation releases by including a 75,000 cfs flow "bench" at Van Buren. This "bench" varies from about three to five days in duration. The purpose of this "bench" is to increase the number of days of flow below 80,000 cfs for the benefit of navigation and low-lying farms along the river. In order to accomplish this flow "bench", a delay in the evacuation of the lower portion (18% or less) of the flood control storage is required. The degree of delay varies depending on the basin hydrologic conditions, season of the year, and the distribution of the flood control storage in use among the projects.

B.1.4.3. Existing Operating Plan (1986 Fine Tuning Plan)

In 1985, the volume of water flowing down the Arkansas River past Van Buren was the second largest of record (at that time) and was the fourth year in succession of above normal flows. Because of the high flows, navigation interests experienced increased costs and delays; and, farmers, who had been accustomed to farming land near the river, found it impossible to produce crops during this period.

To address these problems, the Corps of Engineers restudied the operating plan and in June 1986, following a public comment period, implemented a new operating plan. The objective of the new plan (Fine Tuning Plan) was to increase the number of days of flow below 80,000 cfs for the benefit of the navigation system and low-lying farmland, while causing minimal impacts on hydropower, recreation and flood damages in Arkansas and Oklahoma.

The 'Fine Tuning Plan' has been used since June 1986 and is the current or existing operating plan. Key features of this plan are:

- A taper operation of 40,000 cfs to 20,000 cfs. When the flood storage remaining in the 11 controlling reservoirs reaches from 3% in the spring to 11% in the summer, the target

flow at Van Buren is gradually reduced from 40,000 cfs to 20,000 cfs. This allows navigation to continue until dredging operation can remove the sediment deposited in the channel during high flow.

- A 75,000 cfs bench (a range, 10%-18%, where the flow is held at or below 75,000 cfs). Storage is also adjusted seasonally to maximize benefits to farming and minimize flood impacts during that portion of the year that are more susceptible to floods.

B.1.5. Problems and Opportunities in Navigation

B.1.5.1. Phase I - Flow Management Feature

Navigation is impacted by the days of high flows when towboats cannot safely or economically operation on the system. Navigation traffic is severely restricted when river flows reach 100,000 cfs at Van Buren, Arkansas. For shippers and vessel operators, three specific problems exist. First, the closure of the river to navigation during and after storm events reduces reliability of shipping on the system. Second, the extended higher flow conditions require vessel operators to utilize higher horsepower towboats and smaller tow size, which increase shipping costs. Third, shipping charges during high flows, such as barge demurrage and "hot water" charges for special services, make the land mode of transport the least cost mode. Specific details of these three problems are as follows:

- The limitations on commercial navigation during and after storm events that cause high flow rates reduces reliability of shipping on the MKARNS. Shippers and vessel operators are in the position of absorbing costs associated with the unreliability of the navigation system. For shippers these costs include the risk of plant shut down due to inventory depletion or, conversely, high inventory cost of carrying excess inventories to avoid the stock out condition. For vessel operators, the costs associated with "parking" tows and towboats during high flows are not offset by revenues. Prices for towing services are established weeks before vessel departure; vessel "parking" is not included.
- Extended higher flow conditions require vessel operators to utilize higher horsepower towboats and smaller tow size. In anticipation of probable storm events, vessel operators on the MKARNS utilize above average horsepower towboats and smaller than average tow sizes for similar tributary river situations. With these higher operating costs tow operators have high towing rates, requiring barge operators to aggressively market the Arkansas River to effect the most efficient two-way loaded hauling and avoid empty barge movement.
- Shipping charges during high flows, such as barge demurrage and "hot water" charges for special services, are assessed to the shipper. For shippers and terminal operators on the MKARNS, the high flow storm events place uncertainty on shipping charges and costs. Specifically, when barges are "parked" and free time expires, demurrage charges are incurred. In addition, upon arrival barges become bunched at the terminals, exposing either the terminal or shipper to demurrage charges. Special charges, commonly referred to as "hot water" charges, can be incurred by shippers if they elect to have their barges moved to destinations in a one or two barge tow service.

B.1.5.2. Phase II- Channel Depth and Width Feature

B.1.5.2.1. Channel Deepening Components

Commercial navigation is not at optimum productivity within the MKARNS since its 9′ draft navigation channel limits towboat loads compared to the Lower Mississippi River's authorized 12′ draft channel. Changing the authorized channel depth to 12′ would allow tow drafts on the MKARNS to match those that are possible most of the time on the lower Mississippi River system. The lower Mississippi provides a 12′ channel depth approximately 96% of the time, but can fall to near 91% during the August to October season. The disparity between the navigation channel depths results in less efficient barge operations than could be achieved with a consistent 12′ navigation channel throughout the MKARNS and Lower Mississippi River commercial navigation systems.

Another problem addressed during this phase was disposal of the dredged material from construction and maintenance of the deepened channel. Dredged material can be placed in existing or newly built disposal areas, unconfined directly on the bank, and in-stream. This study addressed opportunities for beneficial uses of the dredged material such as least tern islands to improve tern habitat.

B.1.5.2.2. Channel Widening

Currently, the 150-foot wide Verdigris portion of the waterway can only accommodate one-way barge traffic with the exception of areas designed with passing lanes. The study briefly evaluated widening the Verdigris portion of the system to a 300′ wide channel to handle two-way traffic. Increasing the width of the Verdigris River to 300′ would ease congestion by allowing tows to pass at almost any location on that portion of the system.

B.1.5.3. Navigation Channel Depth Maintenance Feature

As noted, the current commercial navigation operation on the MKARNS requires the maintenance of a minimum 9′ navigation channel throughout the system from the Port of Catoosa to the Mississippi River. Periodic dredging is required and some authorized maintenance dredged material disposal sites in Oklahoma have reached capacity and new disposal sites are required to accommodate continued navigation channel maintenance activities. There are a number of components to address disposal needs for the next twenty years. Any of the alternatives implemented will be reevaluated over time to accommodate changes in the system due to river dynamics.

B.2. Existing Conditions

B.2.1. Real Estate

On the MKARNS, the USACE, Tulsa District (SWT) acquired land required for flooding and flowage from the confluence of the Arkansas, Canadian, and Verdigris Rivers downstream to the dam at the Robert S. Kerr Lock and Dam and Reservoir Project (RSK). Below RSK, the District relied entirely on navigation servitude to provide land for the project, except for the footprint of locks and other structural improvements. Other than that deemed navigation servitude, no land was acquired for flooding or flowage for the MKARNS between RSK and the civil works boundary within USACE, Little Rock District (SWL).

The reliance on navigation servitude, a right reserved in the Commerce Clause of the U.S. Constitution, is significant as it forms the legal basis for the Federal Government's use of the Arkansas River channel for navigation purposes. The lateral extent of this right is the ordinary high water mark (OHWM) elevation of a non-tidal river. Current application of the original navigation servitude determination is problematic as no record is available regarding either the location or elevation of the OHWM below RSK within SWT. Consequently, the location of the OHWM is a critical prerequisite to initiating a real estate determination. It should be noted that there is a significant difference between the OHWM elevation used by the Tulsa and Little Rock Districts. This anomaly has resulted in the acquisition by SWL of land on the MKARNS approximately two river miles west of the District boundary; an area SWT did not acquire as it considered it subject to navigation servitude.

The location of the OHWM was administratively determined at an Arkansas River Navigation Study Issue Resolution Conference (IRC), held in the Southwest Division office on 22 January 2003. The administrative finding of that IRC was that the OHWM of the Arkansas River from Robert S. Kerr Project to the civil works boundary within SWL is the one-year flood frequency high water mark based upon the currently existing operation of the system with all upstream flood control and navigation improvements in place. This elevation establishes the beginning point for the determination of real estate requirements for the Arkansas River Navigation Study alternatives, but does not resolve the OHWM elevation differences between the two Districts. At this time, there is no plan to resolve this issue. Study results are not dependent upon resolution of the OHWM differences.

B.2.2. Operations and Maintenance

The Corps maintains a minimum 9′ channel depth on the MKARNS. Most of the current levees along the MKARNS were built in the late 1940s and early 1950s, replacing the original levees, which were built in the early 1900s and destroyed by the flood of 1927. The focus of the levee system is protection of agricultural lands from periodic flooding by the Arkansas River and its major tributaries. The levees along the MKARNS (Table 2-1), consequently, control the area of influence of the MKARNS to those lands within the levees.

Table 2-1. Levees within the Arkansas River Navigation Study Area	
MKARNS POOL	**LEVEE**
White River	Levee Mile 7, 8.5, and 9.2
Pool 1	Levee Mile 11
Pool 2	Pendleton Levee
Pool 2	South Bend Levee
Pool 2	Farelly Lake Levee District
Pool 2	North Bank Levee Below Plum Bayou
Pool 2	Jefferson County Levee District No. 3
Pool 2	Southeast Arkansas Levee District
Pool 3	Jefferson County Levee District No. 3
Pool 3	Southeast Arkansas Levee District
Pool 3	North Bank Levee Below Plum Bayou
Pool 3	New Gascony Levee District
Pool 3	Linwood - Auburn Levee District
Pool 4	Linwood - Auburn Levee District
Pool 4	Non-Overflow Structure (USACE)
Pool 4	Tucker Lake Levee & Drainage District
Pool 4	Plum Bayou Levee District
Pool 5	T. A. Gibson Private Levee
Pool 5	Plum Bayou Levee District
Pool 5	Old River Drainage District
Pool 5	Woodson Levee District
Pool 5	Fourche Island Drainage District No. 2
D. D. Terry Lake	Fourche Island Drainage District No. 2
D. D. Terry Lake	Little Rock – Pulaski Drainage District No. 2
D. D. Terry Lake	North Little Rock Levee & Floodwall
D. D. Terry Lake	W. D. Cammack Private Levee
Pool 7	Roland Drainage District Levee
Pool 7	Faulkner County Levee District No. 2
Pool 7	Perry County Levee No. 1
Pool 7	Faulkner County Levee District No. 1
Pool 8	Conway County Levee District Nos. 1, 6, 8 and 10
Winthrop Rockefeller Lake	Conway County Levee District No. 1, 3 and 7
Winthrop Rockefeller Lake	Pope County Levee & Drainage District No. 2
Winthrop Rockefeller Lake	Galla Creek Levee
Winthrop Rockefeller Lake	Carden Bottoms Drainage District No. 2
Winthrop Rockefeller Lake	Holla Bend Levee District No. 1
Winthrop Rockefeller Lake	Point Bar Levee
Winthrop Rockefeller Lake	Flagg Lake Levee
Winthrop Rockefeller Lake	Dardanelle Drainage District Levee
Lake Dardanelle	Lower Hartman Bottom Levee
Lake Dardanelle	McLean Bottom Levee District No. 3
Ozark Lake	Crawford County Levee District
Pool 13	Crawford County Levee District
Pool 13	Van Buren Levee District No. 1
Pool 13	Southern Enterprises Private Levee
Pool 13	Fort Smith Levee Improvement District No. 1

Table 2-1. Levees within the Arkansas River Navigation Study Area	
MKARNS POOL	**LEVEE**
Chouteau Lake	Highway 51
Chouteau Lake	Oxbow Island Park
Newt Graham	Rogers Point Park
Source: MKARNS Navigation Charts, 1997	

Other in-stream structures created for stream stability include wing dikes and revetments. Wing dikes force the water flow away from the bank from which they are built. Typically, revetments, which strengthen and hold unstable banks from erosion forces, must be placed on opposite shores of wing dams to be effective.

In Arkansas, channel maintenance is performed using a contract maintenance dredge or Corps owned floating plant. The dredge works between Navigation Mile (NM) 0 and 444.8 on the MKARNS; between NM 10 and 255 on the White River; and in harbors at Rosedale and Greenville, Mississippi, on the Mississippi River. The work is done by station, which is equivalent to 100´ of advance by the dredge in a cut that averages 150´ in width at the base of the cut and averages 3´ of depth. Corps owned floating plants are located at marine terminals in Pine Bluff and Russellville, Arkansas and Sallisaw, Oklahoma. Barge mounted cranes rigged with clamshell buckets periodically clam sediment areas in downstream lock approaches that are too small for the dredge.

Dredge material is placed in designated disposal areas along the Arkansas portion of the MKARNS. Approximately 40 overboard disposal areas and 2 upland disposal areas are used. Overboard disposal areas are used by dredges with floating pipeline only or by mechanical dredges with dump barges. These areas are usually dike fields or other areas along the shoreline. In Arkansas, there are 138 pre-approved dredge material disposal sites encompassing 12,709 acres. All of these sites fall within existing dike fields.

Upland disposal areas require dredges with floating and shore pipelines to pump material over land into the disposal area. Containment dikes are initially built to hold the pumped material until the sediment settles out and the water is returned to the river through a flume box.

The Oklahoma portion of MKARNS includes approximately 150 navigation miles of channel. Tulsa District maintains five locks and dams and 6 navigation pools. These are: Pool 13 from the Arkansas/Oklahoma border to W. D. Mayo L&D 14, W. D. Mayo L&D 14, Pool 14, Robert S. Kerr L&D 15, Pool 15, Webbers Falls L&D 16, Pool 16, Chouteau L&D 17, Pool 17, Newt Graham L&D 18 and Pool 18 to the Port of Catoosa.

The Oklahoma dredge disposal plan has 21 existing maintenance dredge disposal sites.

B.2.3. Commercial Navigation

Inland waterways such as the MKARNS offer an environmental and fiscally responsible mode of transportation for goods. Navigation on the MKARNS is controlled by a series of 18 locks and dams (13 in Arkansas and five in Oklahoma). There are 5 public ports and over 70 companies

which use private port facilities along the MKARNS on which both foreign and domestic trade is conducted. The public ports of Little Rock, Fort Smith, Pine Bluff, Muskogee and Catoosa handle the majority of the in-bound and out-bound tonnage of goods shipped. The Ports of Little Rock, Catoosa and Muskogee are also designated as Foreign Trade Zones. The Tulsa Port of Catoosa is the largest port on the MKARNS with over 2,000 acres of contiguous land area. In 1996, 1,111 barges carrying 1,961,197 tons moved through the Port of Catoosa. The MKARNS was utilized for the shipment (upbound and downbound) of 11,206,000 tons of goods in 2001 and 11,903,000 tons in 2002. Commodities reported shipped in 2002 included 4,641,000 tons of aggregate; 1,392,000 tons of wheat; 1,871,000 tons of chemical fertilizer; 888,000 tons of iron and steel; 552,000 tons of soybeans; 865,000 tons of other farm products; and 523,000 tons of petroleum products.

The public ports of the MKARNS alone support over 90 industries and 5,200 employees. The Oklahoma Department of Transportation reports that there are over 65 industries in the Oklahoma portion of the MKARNS including direct employment of 4,000 people ($85 million in payroll) and approximately 6,000 in indirect employment ($90 million payroll) between Catoosa and Muskogee. There are almost 50 industries in the Tulsa port of Catoosa with over 1,100 employees. Direct employment is provided for over 2,300 employees at the 39 industries in the Little Rock Port Industrial Park, while the Port of Pine Bluff's Harbor Industrial District employs more than 800 workers in the riverfront industrial park. There are over 8,000 direct waterway-related jobs within those counties contiguous to the MKARNS in Arkansas.

A recently completed study (*Continuing Development of the McClellan-Kerr Arkansas River Navigation System,* Gulf Engineers and Consultants, August, 2000) using the IMPLAN (Impacts Analysis for Planning) regional economic model estimated the direct, indirect and induced economic impacts of the MKARNS on the State of Oklahoma. It was estimated that in 1997 waterway-related business activity of the MKARNS generated a total (direct, indirect and induced) of $2.06 billion in annual business volume (sales), $492.9 million in personal income (wages), 15,634 man-years of employment, and $66.8 million in indirect business taxes in Oklahoma. The 15,634 man-years of employment include approximately 6,375 direct jobs, 4,356 indirect jobs, and 4,903 induced jobs. Approximately one-third of the above total business volume, one-half of the personal income, and 40 percent of the employment was created at the Port of Catoosa.

B.2.4. Tourism and Recreation

There are over 100 recreational areas associated with the MKARNS main channel including USACE-operated recreational facilities and commercial concessions under leasehold with the USACE. These facilities include campgrounds, marinas, boat ramps, picnic areas, swimming and fishing areas, and trails. For example, there are 20 marinas associated with the MKARNS in the Arkansas portion of the study area and over 27 in Oklahoma. Recreation associated with these facilities has substantial economic impacts by generating employment, income, and business for the local and regional economies.

The recreational areas associated with the MKARNS and its associated upstream reservoirs provide recreational and aesthetic opportunities to millions of visitors annually. Table 2-2

portrays the trends in annual visits to the lakes and reservoirs associated with the McClellan-Kerr Navigation System. Total annual visits at the twenty-six recreational lakes and reservoirs in 2002 approximated 18.5 million, with the lakes and reservoirs in Oklahoma accounting for 60% of the visitors. Fort Gibson Lake and Eufaula Lake in Oklahoma and Dardanelle Lake in Arkansas each had two million or more visitors in 2002.

Table 2-2. Trends in Annual Visits[1], MKARNS and Related Lakes

Lake	2002	1999	1996
Arkansas			
Dardanelle Lake	2,908,987	1,995,185	2,136,266
David D. Terry L & D No. 6	964,958	1,307,063	1,354,007
Emmett Sanders L & D No. 4	458,992	541,565	698,337
Hammerschmidt Lake (J.W. Trimble L & D No.13)	563,819	864,721	1,135,563
Joe Hardin L & D No.3	92,028	78,749	95,784
Lock & Dam 5	133,985	176,802	185,017
Murray L & D No. 7	747,327	745,971	1,124,289
Norrell L & D No. 1	19,493	39,669	34,992
Ozark Lake	431,784	463,231	502,802
Rockefeller Lake (Arthur Ormond L & D No. 9)	241,830	203,280	346,290
Toad Suck Ferry L & D No. 8	452,319	447,968	614,254
Wilbur Mills Dam	257,025	274,672	357,292
Total	**7,272,547**	**7,138,876**	**8,584,893**
Oklahoma			
Chouteau L & D No. 17	164,882	184,948	124,482
Copan Lake	65,564	66,557	165,239
Eufaula Lake	2,064,190	2,127,130	2,446,503
Fort Gibson Lake	2,197,936	2,416,651	3,041,944
Hulah Lake	57,196	93,590	94,232
Kaw Lake	475,738	158,406	681,533
Keystone Lake	908,208	1,265,920	1,377,386
Newt Graham L & D No. 18	229,945	189,824	240,492
Oologah Lake	992,998	1,258,023	1,423,222
Robert S. Kerr L & D No. 15	1,022,396	923,622	770,960
Tenkiller Ferry Lake	2,080,299	1,149,237	1,224,694
W. D. Mayo L & D No. 14	112,729	109,767	114,921
Webbers Falls L & D No. 16	514,341	512,054	509,412
Wister Lake	361,420	415,962	317,764
Total	**11,247,842**	**10,871,691**	**12,532,784**
TOTAL	**18,520,389**	**18,010,567**	**21,117,677**

[1] Visit is defined as the entry of one person into a recreation area or site to engage in one or more recreation activities. A visit is a "head count" and does not indicate duration of use or length of stay.
Sources: U.S. Army Corps of Engineers, Little Rock District and Tulsa District.

Many of the recreational users include pleasure boaters along the MKARNS. Table 2-3 portrays the trend in the number of recreational boats that locked through the 12 Arkansas and five Oklahoma locks from 1991-2002.

Table 2-3. Trends in Recreational Lockages of the MKARNS, 1991 to 2002		
Year	**Arkansas**	**Oklahoma**
1991	13,595	3,012
1992	12,111	3,155
1993	9,978	2,629
1994	10,426	2,688
1995	9,895	2,066
1996	15,470*	2,941
1997	12,248	2,319
1998	9,750	2,577
1999	9,018	1,978
2000	6,849	2,325
2001	7,420	1,846
2002	6,243	2,341

* - Increase coincides with the MKARNS 25th Anniversary Celebration.
Source: Oklahoma Department of Transportation, USACE Little Rock District

B.2.5. Hydropower

The generation of hydroelectric power is one of the several authorized functions of the dams and reservoirs associated with the MKARNS. Fifteen of the MKARNS dam structures have hydroelectric power generation capabilities. Eight of the power plants are owned and operated by the Corps of Engineers with the electricity marketed by the Southwestern Power Administration (SWPA). SWPA is an agency of the Department of Energy whose mission was established by Section 5 of the Flood Control Act of 1944. The remaining seven power plants are operated through licenses issued by the Federal Energy Regulatory Commission. Table 2-4 provides pertinent information for the hydroelectric power facilities in the Arkansas River projects.

Table 2-4. Arkansas River Hydroelectric Power Projects Pertinent Data

Dam / Reservoir	Number of Units	Type of Units	Installed Capacity, kW	Full Power Discharge, cfs	Year Last Unit On-line	Average Annual Energy, kWh	Marketing Agency
Kaw Dam*	1	Kaplan	25,600	5,000	1989	-	OMPA
Keystone Dam	2	Kaplan	70,000	12,000	1968	282,032,000	SWPA
Pensacola Dam (Grand Lake)*	6	Francis	96,000	11,200	1940	340,600,000	GRDA
Robert S. Kerr Dam (Lake Hudson)*	4	-	100,000	28,000	1964	190,000,000	GRDA
Fort Gibson Dam	4	Francis	45,000	9,800	1953	208,482,000	SWPA
Webbers Falls Lock & Dam (No. 16)	3	Slant-Axis	60,000	30,000	1973	228,007,000	SWPA
Tenkiller Ferry Dam	2	Francis	39,100	3,500	1953	114,000,000	SWPA
Eufaula Dam	3	Francis	90,000	13,100	1964	275,149,000	SWPA
Robert S. Kerr Lock & Dam (No. 15)	4	Kaplan	110,000	40,000	1971	600,740,000	SWPA
James W. Trimble Lock & Dam (No. 13)*	3	Pit	32,400	31,350	1988	127,000,000	AECC
Ozark-Jeta Taylor Lock & Dam (No. 12)	5	Slant-Axis	100,000	70,000	1974	314,224,000	SWPA
Dardanelle Lock & Dam (No. 10)	4	Kaplan	148,000	45,000	1966	629,503,000	SWPA
Arthur V. Ormond Dam (No. 9)*	3	Pit	32,400	31,350	1993	134,000,000	AECC
Murray Lock & Dam (No. 7)*	2	-	39,000	-	-	-	NLR
Wilbur D. Mills Dam (No. 2)*	3	Bulb	108,000	51,000	1999	351,000,000	AECC

* Denotes Federal Energy Regulatory Commission (FERC) licensed projects.
OMPA – Oklahoma Municipal Power Authority
SWPA – Southwestern Power Administration
GRDA – Grand River Dam Authority
AECC – Arkansas Electric Cooperative Corporation
NLR – City of North Little Rock, Arkansas

B.2.6. Non-Agricultural Properties

The high-density population areas in the study area are primarily limited to the cities of Pine Bluff, Little Rock, Fort Smith, Muskogee, and Tulsa. Each of these urban areas was founded and grew due to the economic benefits afforded by the Arkansas River. Table 2-5 shows the U.S. Census Bureau population estimates for 2000 for each of these cities.

Table 2-5. Population Estimates (2000 Census)

City, State	Population
Fort Smith, Arkansas	80,268
Little Rock, Arkansas	183,133
Muskogee, Oklahoma	38,310
Pine Bluff, Arkansas	55,085
Tulsa, Oklahoma	393,049

Flood damages, particularly crop damages, result from above-normal flows. Within the Arkansas River Basin in Oklahoma, about 410,000 acres experience periodic flooding. Present residual flood damages, agricultural and non-agricultural, amount to about $16 million annually. The Arkansas River Basin and tributaries in the Oklahoma study area from Three Forks to the Arkansas-Oklahoma state line have had recurrent flooding. Major floods in 1986 and in 1990 caused significant damages throughout the basin. In 1986, total flood damages in the Arkansas River Basin in Oklahoma were about $160 million. It was estimated that in Oklahoma and Arkansas about $725 million in flood damages were prevented by projects in Oklahoma and Kansas, including levees. About $27 million in actual damages occurred along the main stem of the Arkansas River from Bixby, Oklahoma, to the state line.

In the spring of 1990, an unusual amount of rain produced record or near-record flooding during April and May in northeastern Texas, southeastern Oklahoma, western Arkansas, and along the Red River in Louisiana. In Oklahoma, the statewide average precipitation for the first four months of 1990 was the largest total reported since record keeping began in 1892. The late April rains, which fell on saturated soils, produced widespread flooding, and near record flow occurred in early May 1990. Most of the upstream reservoirs were at or near capacity. Floods the magnitude of 100-year or greater recurrence interval occurred on many streams. Discharges of 359,000 cfs occurred at Robert S. Kerr on May 4, and the peak discharge was 400,000 cfs at Van Buren, Arkansas, on May 5. For the four-state area, 17 deaths and millions of dollars in damage to public and private property occurred because of these floods. In Arkansas and Oklahoma, the homes of more than 2,000 families were damaged. Agricultural losses were extensive.

Table 2-6 provides a summary of the final number of structures by type and county within the Oklahoma study area floodplain. Almost 7,500 structures lie within the affected floodplain, and they have an estimated replacement cost less depreciation exceeding $446 million. *This is an underestimate given the numerous exempt properties in the data that have no assigned value*.

Table 2-6. Summary of Structure Count and Value in the Oklahoma Study Area.						
County	**Residential**	**Commercial**	**Exempt.**	**Misc & Ag.**	**Total Count**	**Value (FY02$)**
Haskell	4			2	6	92,481
LeFlore	8			6	14	593,364
Muskogee	55	4	1	17	77	4,307,747
Rogers	202	13		44	259	22,250,671
Sequoyah	86	19	10	29	144	5,595,025
Tulsa	4,615	667	716	85	6,083	373,059,545
Wagoner	54			9	63	3,524,258
Washington	649	48	18	50	765	36,318,647
Study Total	**5,673**	**751**	**745**	**242**	**7,411**	**445,741,738**

B.2.7. Agricultural Properties

Roughly, one-half of Arkansas' land is devoted to agriculture. Crop production is concentrated in the eastern one-third of the state and in the Arkansas and Red River Valleys. Agriculture is the states largest industry, with more than $5 billion in farm income generated annually. When combined with the value of agricultural and food processing and related service industries, the agricultural community accounts for more than 25 percent of Arkansas' economy. In the 1997 crop year, Arkansas was ranked first in the nation in rice production, and was in the top ten for cotton (5th among all states), sorghum for grain (8th), hay (8th), grapes (8th), soybeans for beans (9th), blueberries (9th), and freestone peaches (10th).

Similar to Arkansas, the climate and topography of Oklahoma makes it well suited for the production of a broad spectrum of commodities. Much of the fertile land in the Arkansas River Valley is devoted to agriculture. Based on the 1997 crop year, the State of Oklahoma ranks among the national leaders in several commodities, including winter wheat (2nd among all states), rye (2nd), all wheat (4th), hay (4th), pecans (4th), sorghum for grain (5th), peanuts (6th), and sorghum for silage (7th).

Crop acreage for each of the counties in the study area is shown in Table 2-7. Other major commodities are produced in these counties as well, however complete information is not available for all crops and counties. The counties along the downstream terminus of MKARNS, such as Arkansas, Desha, Jefferson, and Lincoln Counties, have the most total cropland of any Arkansas county in the study area and are major producers of rice, soybeans and cotton. The leading soybean, wheat, and sorghum producing counties in the Oklahoma portion of the study area (primarily Wagoner, Kay, and Noble Counties) are located along the northwest end of the MKARNS.

Table 2-7. Major Crop Acreage by County in the Study Area for 2002							
County	**Total Cropland (acres)[1]**	**Sorghum (acres)**	**Wheat (acres)**	**Rice (acres)**	**Cotton (acres)**	**Soybeans (acres)**	**Hay-alfalfa, (acres)[2]**
ARKANSAS							
Arkansas, AR	339,099	2,466	65,031	118,452	2,080	185,504	2,274
Conway, AR	102,364	1,708	9,883	(a)	0	20,771	40,977
Crawford, AR	81,906	2,047	4,230	125	0	9,056	28,330
Desha, AR	250,076	8,798	19,208	50,539	74,764	85,818	593
Faulkner, AR	119,921	301	3,118	2,444	0	7,587	47,408
Franklin, AR	84,872	0	(a)	0	0	930	44,227
Grant, AR	17,394	0	0	0	0	0	9,747
Jefferson, AR	247,639	5,418	38,579	55,120	37,798	115,065	3,336
Johnson, AR	62,416	0	1,213	0	0	3,756	27,228
Lincoln, AR	161,246	3,279	12,960	32,423	34,650	61,155	4,545
Logan, AR	99,576	(a)	2,601	0	0	5,558	47,752
Lonoke, AR	289,562	7,260	29,614	70,693	21,416	123,993	21,131
Perry, AR	40,737	121	750	1,700	0	3,129	16,866
Pope, AR	82,823	432	3,840	555	0	7,834	38,284
Pulaski, AR	77,480	1,247	11,436	5,117	1,726	28,525	12,895
Saline, AR	24,915	0	0	0	0	0	13,192
Sebastian, AR	54,003	233	635	0	0	3,007	24,792
Yell, AR	89,641	(a)	2,516	1,039	0	8,417	41,412
OKLAHOMA							
Adair, OK	91,087	(a)	1,642	NA	0	0	38,312
Cherokee, OK	91,972	0	(a)	NA	0	0	38,450
Creek, OK	131,077	359	1,484	NA	0	389	50,353
Delaware, OK	124,053	642	2,868	NA	0	1,790	59,484
Haskell, OK	108,427	0	1,002	NA	0	(a)	46,020
Kay, OK	323,705	18,975	186,482	NA	5,135	18,944	33,648
Le Flore, OK	184,664	(a)	4,935	NA	0	12,334	72,959
Mayes, OK	151,357	3,516	9,999	NA	0	7,115	72,975
McIntosh, OK	106,146	510	1,331	NA	0	1,110	45,391
Muskogee, OK	171,223	1,028	5,655	NA	0	18,285	71,500
Noble, OK	206,008	5,643	105,638	NA	(a)	7,932	34,979
Nowata, OK	95,324	509	3,931	NA	0	1,553	43,226
Okmulgee, OK	113,701	0	2,951	NA	0	2,067	49,595
Osage, OK	169,923	649	20,668	NA	0	8,068	42,846
Ottawa, OK	124,952	3,694	23,032	NA	0	21,786	48,840
Pawnee, OK	80,574	875	10,434	NA	0	4,496	24,639
Pittsburg, OK	159,989	837	288	NA	0	868	47,402
Rogers, OK	132,366	949	7,087	NA	0	3,324	55,489
Sequoyah, OK	102,946	288	3,802	NA	0	10,157	36,924
Tulsa, OK	86,063	0	2,458	NA	0	4,162	29,392
Wagoner, OK	131,599	1,164	12,316	NA	0	34,842	40,303
Washington, OK	75,371	1,043	9,638	NA	0	9,609	25,659

1 Note: columns do not sum to equal total cropland. Additional crops exist in each county for which total acreage is minor or data are not available.
2 Includes other small grain, wild grass
(a) Data withheld to avoid disclosing data for individual farms. NA=Not available.
Source: Census of Agriculture, 2002.

B.3. Project Features Evaluated

The proposed action for achieving the study objectives consists of multiple elements. The proposed action is to maintain and improve the navigation channel in order to enhance commercial navigation on the MKARNS, while maintaining the other MKARNS project purposes of flood damage reduction, recreation, hydropower, water supply, and fish and wildlife. The proposed action involves implementing actions associated with three features that influence navigation on the MKARNS. These three features are:

- River Flow Management
- Navigation Channel Deepening
- Navigation Channel Depth Maintenance.

The formulation of alternatives began by identifying components that met the planning objective of providing a safe, reliable, efficient, and sustainable MKARNS navigation channel. Components were then subjected to a screening process that resulted in the selection of the viable components for detailed analysis. The following sections provide a description of this process for each of the features.

B.3.1. River Flow Management Feature

The component screening process included the evaluation of a range of river flow management components to determine the most viable alternatives to be considered for implementation. The evaluation process considered 23 river flow management components that were compared using the USACE SUPER (Southwestern Division Modeling System for the Simulation of the Regulation of a Multipurpose Reservoir System) Model. The SUPER Model program was run for each of the initial components. Key information derived by the model to screen each non-structural component included:

- River flow and duration,
- Reservoir stages and duration, and
- Estimated operational damages within the system.

Based upon the component review process detailed in the EIS, four components were selected for detailed analysis. The components include the No Action component as well as three viable implementation components.

- Flow Management: No Action Component (FM-NA)
- Flow Management: 175,000 cfs Component (Step 2 # 18 – A02 x 12);(FM-175)
- Flow Management: 200,000 cfs Component (Step 2 # 22 – A02 x 11);(FM-200)
- Flow Management: Operations Only Component (Step 2 # 7 – A02 x 10); (FM-OPS)

B.3.1.1. No Action Component (FM-NA)

The No Action Component consists of maintaining the current MKARNS Operation System. No changes in existing river or reservoir operations would be made. A detailed description of the existing operations plan including general operations as well as a description of taper and bench operations are presented in the Feasibility Report. Key features of the current operations plan are:

- A taper operation of 40,000 cfs to 20,000 cfs. When the flood storage remaining in the 11 controlling reservoirs reaches from 3% in the spring to 11% in the summer, the target flow at Van Buren is gradually reduced from 40,000 cfs to 20,000 cfs. This allows navigation to continue until dredging operation can remove the sediment deposited in the navigation channel during high flow.
- A 75,000 cfs bench (a range where the flow is held at or below 75,000 cfs). This feature is also adjusted seasonally to maximize benefit to farming and minimize flood impacts during that portion of the year more susceptible to floods.

B.3.1.2. 175,000 cfs Component (FM-175)

The 175,000 cfs Component is described as: Van Buren at 175,000 cfs and Sallisaw at 175,000 cfs with a 60,000 cfs bench replacing the 75,000 cfs bench lowered 3% except from June 15 – October 1.

The SUPER Model analysis of this component indicates that there would be a decrease in the number of days above 60,000 cfs by nine days per year compared to the existing operation plan. The analysis also indicates a decrease in the number of days above 100,000 cfs by 16 days and a decrease in flows above 137,000 cfs by four days.

B.3.1.3. 200,000 cfs Component (FM-200)

The 200,000 cfs Component is described as: Van Buren at 200,000 cfs and Sallisaw at 200,000 cfs with a 60,000 cfs bench replacing the 75,000 cfs bench lowered 3% except from June 15 – October 1.

The results of the SUPER Model analysis indicate that there would be a decrease in the number of days above 60,000 cfs by nine days per year. It also decreases the number of days above 100,000 cfs by 17 days and it decreases the flow above 137,000 cfs by five days.

B.3.1.4. Operations Only Component (FM-OPS)

The Operations Only Component is defined as the existing plan with a modified 60,000 cfs bench in place of the 75,000 cfs bench beginning at 3% lower system storage except during June 15 through October 1.

SUPER Model analysis indicates that there would be a decrease in the number of days above 60,000 cfs at Van Buren by 14 days. The analysis also produced a 2-day increase in flows above 100,000 cfs at Van Buren compared to the existing operation plan. It also showed essentially no change at 137,000 cfs (channel capacity).

There were three primary differences between the No Action Component and the Operations Only Component (based upon the SUPER Model analysis). These three differences (beneficial for commercial navigation) are: 1) the reduction of 14 days below 60,000 cfs (a key level for farming interest in Arkansas), 2) an increase in days between 40,000 cfs and 60,000 cfs (key to scouring flows in the navigation system) and 3) accelerated evacuation of the storage projects when the system percent full exceeds 75%.

B.3.2. Navigation Channel Deepening Feature

Navigation channel depth limits the efficiency and volume of commercial navigation operations on the MKARNS. The proposed navigation channel deepening action is to deepen the navigation channel in the MKARNS to allow deeper draft tows to operate on the system. This incorporates the potential for establishing a consistent navigation channel depth throughout the entire MKARNS. In addition, other authorized MKARNS project purposes, including flood damage reduction, recreation; hydropower; water supply; and fish and wildlife will be maintained.

The component screening process included the evaluation of a range of components to determine the viable components to be considered for implementation. The component evaluation process considered the following:

- Navigation Channel Deepening via Dredging,
- Navigation Channel Deepening via Pool Raising,
- Navigation Channel Deepening via a combination of Dredging and Pool Raising, and
- Verdigris River Navigation Channel Widening.

Based upon the component review process detailed in the EIS, the No Action Component as well as a variety of navigation channel dredging components, which incorporate multiple navigation channel depths and river segments, were selected for detailed analysis. Table 3-1 shows a matrix of the navigation channel deepening components that were evaluated.

Table 3-1. Navigation Channel Deepening Components							
Navigation Depth		**River Segment**					
Change	**NAV DEPTH**	**Mouth to Pine Bluff**	**Mouth to Little Rock**	**Mouth to Dardanelle**	**Mouth to Fort Smith**	**Mouth to Muskogee**	**Mouth to Catoosa**
		N.M. 0.0 To N.M. 75.2	N.M. 0.0 To N.M. 119.5	N.M. 0.0 To N.M. 220.3	N.M. 0.0 To N.M. 308.7	N.M. 0.0 To N.M. 394.0	N.M. 0.0 To N.M. 444.8
		75.2 Miles	119.5 Miles	220.3 Miles	308.7Miles	394.0 Miles	442.8Miles
No Action (No Change in Depth)	**9´**	Evaluate	Evaluate	Evaluate	Evaluate	Evaluate	Evaluate
10´ Channel (1´ change)	**10´**	Evaluate	Evaluate	Evaluate	Evaluate	Evaluate	Evaluate
11 Ft Channel (2´ change)	**11´**	Evaluate	Evaluate	Evaluate	Evaluate	Evaluate	Evaluate
12´ Channel (3´ change)	**12´**	Evaluate	Evaluate	Evaluate	Evaluate	Evaluate	Evaluate

This component set explored the options of deepening the navigation channel to 10´, 11´ or 12´ at up to six separate segments of the MKARNS. To better assess the navigation channel deepening components, the MKARNS was divided into six river segments, from the mouth of the MKARNS near the Mississippi River to the Port of Catoosa in Oklahoma. This made analysis of the action comprehensive and flexible by providing the decision maker with the option of deepening the navigation channel only up to a certain segment on the system or the entire river, as appropriate.. Deepening the navigation channel to 10´, 11´, and 12´, was analyzed in addition to the No Action Component (9´ navigation channel).

The two elements of the navigation channel deepening components included:

- Navigation channel deepening via dredging and the disposal of dredged materials, and
- Construction of additional river training structures to facilitate the maintenance of the deeper navigation channel.

The three action components for navigation channel deepening (10´, 11´, and 12´) were similar in nature in that all three would include deepening the navigation channel. The three components vary only in the amount of material to be dredged and disposed, as well as the length of any necessary new or modified river training structures.

Based upon calculations (USACE Little Rock District, 2004) the following quantities of materials listed in Table 3-2 would need to be dredged from the navigation channel for each navigation channel depth and segment. Required new disposal sites are presented in Table 3-3.

Table 3-2. Dredge Volumes (cubic yards) by River Segment and Navigation Depth. *						
	River Segment					
	Mouth to Pine Bluff	Pine Bluff to Little Rock	Little Rock to Dardanelle	Dardanelle to Fort Smith	Ft Smith to Muskogee	Muskogee to Catoosa
Navigation Depth	N.M. 0.0 To N.M. 75.2	N.M. 75.2 To N.M. 119.5	N.M. 119.5 To N.M. 220.3	N.M. 220.3 To N.M. 308.7	N.M. 308.7 To N.M. 394.0	N.M. 394.0 To N.M. 444.8
No Action (9 Ft Channel)	0	0	0	0	0	0
10 Ft Channel	790,615	98,929	196,478	378,400	1,319,910	1,241,554
11 Ft Channel	1,299,276	225,517	387,227	643,500	2,255,323	2,026,333
12 Ft Channel	2,066,867	445,995	925,439	1,226,500	3,256,749	3,063,790
* In addition to maintenance dredging volumes						

Table 3-3. Additional Dredge Disposal Sites Required for Navigation Maintenance and Deepening Components on the MKARNS.				
Reach	Number Existing Disposal Sites	Number New 9 ft Maintenance Disposal Sites	Number of New 12 ft Maintenance and Deepening Disposal Sites	Number of New 12 ft Deepening Sites
Mouth To Pine Bluff	51	0	0	2
Pine Bluff to Little Rock	6	0	0	2
Little Rock to Dardanelle	45	0	0	2
Dardanelle to Fort Smith	35	0	0	0
Fort Smith to Muskogee	12	4	2	22
Muskogee to Catoosa	5	0	1	14
Source: USACE, 2004.				

B.3.2.1. Navigation Channel Deepening - No Action Component (NCD-NA)

Under this component, the current 9′ navigation channel would be maintained along the entire MKARNS. No sections of the navigation system would be deepened though dredging and new river training structures would not be required.

B.3.2.2. Navigation Channel Deepening - 10-foot Channel Component (NCD-10)

Under this component, parts of the MKARNS would be dredged and river training structures would be constructed to achieve a navigable depth of 10′ for some or all segments of the MKARNS. Additional dredge disposal sites would be required to accommodate the increase in dredge material.

Under this component, dredging to a depth of 10´ would require the removal and relocation of the following approximate volumes of sediment:

- Mouth to Pine Bluff 790,615 Cubic Yards
- Pine Bluff to Little Rock 98,929 Cubic Yards
- Little Rock to Dardanelle 196,478 Cubic Yards
- Dardanelle to Fort Smith 378,400 Cubic Yards
- Ft Smith to Muskogee 1,319,910 Cubic Yards
- Muskogee to Catoosa 1,241,554 Cubic Yards

- Total MKARNS (10´) 4,025,886 Cubic Yards

B.3.2.3. Navigation Channel Deepening - 11-foot Channel Component (NCD-11)

Under this component, parts of the MKARNS would be dredged and river training structures would be constructed to achieve a navigable depth of 11´ for some or all segments of the MKARNS. Additional dredge disposal sites would be required to accommodate the increase in dredge material.

Under this Component, dredging to a depth of 11´ would require the removal and relocation of the following approximate volumes of sediment:

- Mouth to Pine Bluff 1,299,276 Cubic Yards
- Pine Bluff to Little Rock 225,517 Cubic Yards
- Little Rock to Dardanelle 387,227 Cubic Yards
- Dardanelle to Fort Smith 643,500 Cubic Yards
- Ft Smith to Muskogee 2,255,323 Cubic Yards
- Muskogee to Catoosa 2,026,333 Cubic Yards

- Total MKARNS (11´) 6,837,176 Cubic Yards

B.3.2.4. Navigation Channel Deepening - 12-foot Channel Component (NCD-12)

Under this component, parts of the MKARNS would be dredged and river training structures would be constructed to achieve a navigable depth of 12´ for some or all segments of the MKARNS. Additional dredge disposal sites would be required to accommodate the increase in dredge material.

Under this Component, dredging to a depth of 12′ would require the removal and relocation of the following approximate volumes of sediment:

• Mouth to Pine Bluff	2,066,867 Cubic Yards
• Pine Bluff to Little Rock	445,995 Cubic Yards
• Little Rock to Dardanelle	925,439 Cubic Yards
• Dardanelle to Fort Smith	1,226,500 Cubic Yards
• Ft Smith to Muskogee	3,256,749 Cubic Yards
• Muskogee to Catoosa	3,063,790 Cubic Yards
• Total MKARNS (12′)	10,985,440 Cubic Yards

B.3.2.5. Verdigris River Widening Component

The Verdigris River portion of the MKARNS lies in Oklahoma and includes a portion of Pool 16 and all of Pools 17 and 18 including the Chouteau and Newt Graham Locks and Dams. This portion of the MKARNS is approximately 50 miles long. This portion of the MKARNS provides a 150-foot wide navigation channel rather than the wider navigation channel existing throughout the rest of the MKARNS. With this width, tows cannot pass in the navigation channel. Passing zones were included along the navigation channel so that down-river tows and up-river tows could pass. This narrower navigation channel causes time of travel delays for the tows.

As part of this study, a preliminary evaluation of the possibility of widening the navigation channel to eliminate these delays was conducted. A preliminary analysis was completed utilizing the following factors:

a. Excavation. One side of the navigation channel would be widened 100′ and the excavated material placed along the bank for the entire length of the navigation channel. Approximately 30 million cubic yards of material would be moved.

b. Lands. Along the navigation channel, additional easement would be required for widening and material disposal totaling 1,200 acres.

c. Mitigating. Assuming one-quarter of the total acres needed for construction are prime habitat (i.e. trees) and assuming a four-to-one habitat ratio, an additional 1,200 acres of farm land will be required for planting trees for habitat replacement. About 240,000 trees would be planted.

d. Pre-Construction, Engineering and Design (PED) costs and Supervision and Administration (S&A) costs were estimated at 15% of the construction cost.

The preliminary cost estimate for the widening of the Verdigris was $100 million based on the above factors. This preliminary cost estimate did not include contingencies or full compensation for landowners.

The estimated benefit of widening the Verdigris was based on both current and future delay times. In addition, a wider navigation channel offers a reduced risk of accidents on the

waterway, resulting from tows meeting on the navigation channel. From interviews with towboat operators, Tulsa District operations personnel indicate that delays on the Verdigris due to two-way congestion are fewer than two a week. The tows are in constant communication with one another and safety issues associated with two-traffic on the waterway has been minimal. A given delay due to two-way traffic is never more than five hours in length, amounting to less than a half-day a month. The preliminary examination of the current and projected traffic on the waterway indicated that the existing passing lanes could fully accommodate two-way traffic with minimum delays. Expected benefits of widening the Verdigris River and were calculated by multiplying an expected reduction in cost per ton of $0.10 by the number of tons on the Verdigris. The expected benefit per ton for widening is a rough estimate by TVA rate analysts and was used as a first-cut estimate to determine the likelihood of economic feasibility. In consideration of the economic and environmental costs, the widening of the Verdigris portion of the system did not generate enough tangible and intangible benefits to merit further evaluation for further development. Widening was not further evaluated as part of this study.

B.3.3. Navigation Channel Depth Maintenance Feature

As noted, the current commercial navigation operation on the MKARNS requires the maintenance of a minimum 9´ navigation channel throughout the system from the Port of Catoosa to the Mississippi River. Periodic dredging is required. Some authorized maintenance dredged material disposal sites in Oklahoma have reached capacity and new disposal sites are required to accommodate continued navigation channel maintenance activities. There are a number of components to address disposal needs for the next twenty years.

B.3.3.1. No Action Component (NCDM-NA)

Existing dredging and disposal to maintain a 9´ navigation channel would continue under this component. Dredged material would continue to be disposed of at existing sites until they reach their holding capacity. The Corps would utilize existing approved disposal sites, and no new dredge disposal sites would be developed.

B.3.3.2. Maintenance Dredge Material Disposal Via Approved sites In Original 1974 O&M Plan (NCDM-1)

Existing dredging and disposal to maintain a 9´ navigation channel would continue under this component. After currently utilized disposal sites reach their holding capacity, dredged material would be disposed of at unused sections within areas approved in the 1974 O&M Plan and EIS, regardless of the quality or type of habitat present.

B.3.3.3. Maintenance Dredge material Disposal Via New Disposal Sites (NCDM-2)

Existing dredging and disposal to maintain a 9´ navigation channel would continue under this component. After currently utilized dredge disposal sites reach their holding capacity, dredged material would be disposed of in new disposal sites designated in the 2003 long-term Dredge Material Management Plan. Under this component, areas with high quality habitat such as forest, wetlands, and high quality grassland would be avoided wherever practical.

B.4. Real Estate

Real estate costs associated with implementation of some of the components include the acquisition of land and easements, and all related costs such as surveys, mapping, title search, appraisals, negotiations and closings, and a built-in contingency factor. The determination of real estate requirements was based upon what the USACE currently owns, and what additional land would be required to implement each component.

For flow management components, the requirement for additional land was based on induced flooding resulting from changes in the frequency discharges that would occur under implementation of each of the components. Table 4-1 shows the total and annual real estate costs associated with the implementation of each of the flow management components. As indicated in Table 4-1, there were no additional real estate costs associated with the implementation of FM-NA or FM-OPS. The greatest total costs and, consequently, annual costs were associated with FM-200 with estimated annual costs of $933,000. Annual costs associated with the implementation of FM-175 were approximately $702,000.

All of the real estate costs under both FM-175 and FM-200 would occur in the Oklahoma portion of the study area. Implementation of FM-175 would require acquisition of almost 10,000 acres of private land (including 6,500 acres of cropland , 1,135 acres of pasture, and 2,250 acres of timberland) and residences; implementation of FM-200 would require acquisition of almost 15,000 acres of private land (including 9,600 acres of cropland, 1,900 acres of pasture, and 3,300 acres of timberland) and residences. In the Arkansas portion of the study area, implementation of any of the flow management components would not require additional flowage easements.

Table 4-1. Real Estate Costs ($1,000)[1] for Flow Management Components

	FM-NA No Action		FM-175 175,000 cfs		FM-200 200,000 cfs		FM-OPS Operations Only	
	Total Costs	**Annual Costs**	**Total Costs**	**Annual Costs**	**Total Costs**	**Annual Costs**	**Total Costs**	**Annual Costs**
Oklahoma	-	-	$11,455	$664	$15,230	$883	$0	$0
Arkansas	-	-	$0	$0	$0	$0	$0	$0
Total (FY01$)	-	-	$11,455	**$664**	$15,230	**$883**	$0	**$0**
Total (July04$)[2]	-	-	$12,105	**$702**	$16,094	**$933**	$0	**$0**

[1] Based on 5.375% interest amortized over a 50-year period of analysis.

[2]University of Missouri-Columbia Extension Farm Land Value Index, http://muextension.missouri.edu/explorepdf/agguides/agecon/G00404.pdf

Source: USACE, Tulsa and Little Rock Districts.

For navigation channel deepening components, the requirement for additional land was based on the need for land to be used for disposal of dredge material and land to be used for environmental mitigation. Table 4-2 shows the total and annual real estate costs associated with the implementation of each of the navigation channel deepening components.

Table 4-2. Real Estate Costs (July 2004 $1,000) for Navigation Channel Deepening Components								
	NCD-NA No Action Plan		NCD-10 10´ Channel		NCD-11 11´ Channel		NCD-12 12´ Channel	
	Total Costs	Annual Costs[1]	Total Costs	Annual Costs[1]	Total Costs	Annual Costs[1]	Total Costs	Annual Costs[1]
OK	-	-	$3,214	$ 185.6	$3,214	$ 185.6	$3,214	$ 185.6
AR-Total	-	-	$1,107	$ 63.9	$1,107	$ 63.9	$1,107	$ 63.9
Total	-	-	$4,321	$249.5	$4,321	$249.5	$4,321	$249.5
[1] Based on 5.375% interest amortized over a 50-year period of analysis.								
Source: USACE, Draft Real Estate Planning Reports, Tulsa and Little Rock Districts								

B.4.1. Real Estate - Arkansas

B.4.1.1. Real Estate for Flow Management Feature

The Arkansas real estate cost estimate for each of the three flow management components (FM-175, FM-200, FM-OPS) proposed under the Arkansas River Navigation Study is $0. Hydrology and hydraulic studies indicate that implementation of any of these three components is expected to result in little or no additional inundation depth as compared to the baseline condition (FM-NA). For all pools, including Ozark and Dardanelle, real estate personnel compared additional inundation depth to existing flowage easements or proposed flowage easements to be purchased under the Arkansas River Additional Land Acquisition (ARALA) project. Results of this comparison show that, for the purpose of this study, no additional flowage easements need to be acquired in Arkansas for any of the three flow management components.

It should be noted that completion of the ARALA project is not scheduled until FY14 and at this point only 42% of the proposed flowage easements have been purchased. If Ozark and Dardanelle pools are eventually added to the ARALA project, this will delay completion of ARALA even further.

B.4.1.2. Real Estate for Navigation Channel Deepening Feature

The real estate cost estimate for the navigation channel deepening components (NCD-10, NCD-11, and NCD-12) proposed under the Arkansas River Navigation Study is $1.1 million. This estimate includes the acquisition of the approximately 418.0 acres of land from three landowners to be used as disposal sites for dredge material taken from the Arkansas River.

The estimate does not include land acquired for mitigation in Arkansas. There is no need for terrestrial mitigation; all aquatic mitigation will be in-stream.

Table 4-3. Real Estate Cost Estimate Navigation Channel Deepening Components - Arkansas			
	NUMBER	ACRES	VALUE (July 2004 $)
LAND – DISPOSAL		418	$900,720
OWNERSHIPS – DISPOSAL	3		
LAND – MITIGATION		0	$0
OWNERSHIPS - MITIGATION	0		
RELOCATION ASSISTANCE			$5,000
ADMINISTRATIVE COSTS			$308,280
CONTINGENCY (20%)			$33,520
TOTAL ESTIMATED COST			**$1,107,000**
Note: Estimate above comes from Draft Real Estate Planning Report, Little Rock District, Appendix D.			

B.4.2. Real Estate – Oklahoma

B.4.2.1. Real Estate for Flow Management Feature

Real Estate Division's responsibility for the Arkansas River Navigation Study (ARNS) was to determine the real estate requirements, estimated cost, and acquisition schedule for each proposed operating plan component: FM-175, FM-200, and FM-OPS. This required a determination of the real estate requirements to implement the proposed components based upon two elements: what we currently "own", and what additional lands should be acquired to implement either of the prospective flow management operating plans. These two elements are discussed in detail below.

On the MKARNS, the Tulsa District acquired land required for flooding and flowage from the confluence of the Arkansas, Canadian, and Verdigris Rivers downstream to the dam at the Robert S. Kerr Lock and Dam and Reservoir Project (RSK). Below RSK, the District relied entirely on navigation servitude to provide land for the project, except for the footprint of locks and other structural improvements. Other than that deemed navigation servitude, no land was acquired for flooding or flowage for the McClellan-Kerr Arkansas River Navigation System (MKARNS) between RSK and the civil works boundary with Little Rock District. The reliance on navigation servitude, a right reserved in the Commerce Clause of the U.S. Constitution, is significant as it forms the legal basis for the Federal Government's use of the Arkansas River channel for navigation purposes. The lateral extent of this right is the ordinary high water mark (OHWM) elevation of a non-tidal river. Current application of the original navigation servitude determination is problematic as no record is available regarding either the location or elevation of the OHWM below RSK within the Tulsa District. Consequently, the location of the OHWM is a critical prerequisite to initiating a real estate determination. It should be noted that there is a significant difference between the OHWM elevation used by the Tulsa and Little Rock Districts. This anomaly has resulted in the acquisition by the Little Rock District of land on the MKARNS approximately two river miles west of the District boundary; an area Tulsa District did not acquire as it considered it subject to navigation servitude.

The location of the OHWM was administratively determined at an Arkansas River Navigation Study Issue Resolution Conference (IRC), held in the Southwest Division office on 22 January

2003. The administrative finding of that IRC was that the OHWM of the Arkansas River from Robert S. Kerr Project to the civil works boundary with SWL is the one-year flood frequency high water mark based upon the currently existing operation of the system with all upstream flood control and navigation improvements in place. This elevation establishes the beginning point for the determination of real estate requirements for the ARNS components, but did not resolve the OHWM elevation differences between the two Districts.

A second and equally significant issue to our real estate determination was whether additional land would be required to implement any of the ARNS flow management components (FM-175, FM-200, FM-OPS). Additional land would be required if implementation of a proposed component would induce or increase flooding to a duration or frequency that would constitute a taking of non-Federal land pursuant to the 5th Amendment to the U.S. Constitution. The common law standard developed over a long history of cases is a deceptively simple one, whether the Government has subjected the land to frequent, inevitably recurring floods.
In response to this issue, the following information was provided by Hydrology & Hydraulics Branch of the Little Rock District regarding induced flooding resulting from the implementation of either of the FM-175 and FM-200 components:

> "Induced flooding is that flooding that occurs when the different planning alternatives cause an increase in water elevations, due to increases in peak frequency or duration discharges, over some base condition. The base condition used was the existing Arkansas River Basin system regulation plan, which for this study was considered the "No Action Plan". The alternatives investigated consisted of changes in the system regulation plan and are referred to as the "175,000 cfs Plan", "200,000 cfs Plan", and "Operations Only Plan". The Operations Only Plan consisted of changing the 75,000 cfs bench to a 60,000 cfs bench. The frequency and duration discharges remained the same for the Operations Only Plan compared to the No Action Plan or base condition. The induced flooding which will occur with the 175,000 cfs Plan and the 200,000 cfs Plan result from changes in the frequency discharges rather than the duration discharges. This seems reasonable since the No Action Plan is the existing operating plan, which includes all of the 48 reservoirs. The peak frequency discharges were the same for all plans from the 10-year frequency through the 1000-year frequency.
>
> Graphs of the frequency curves for the No Action Plan and the 175,000 cfs Plan were plotted together. The point where the two curves merged was considered the upper limit of the induced flooding. For the 175,000 cfs Plan the upper limit of induced flooding at the Van Buren, Arkansas control point occurred at a 19 percent exceedance frequency or just over a 5-year flood. This frequency corresponded to a discharge of 200,000 cfs. This procedure was also used to compare the No Action Plan and the 200,000 cfs Plan. The point where the two curves merged was at a 12 percent exceedance frequency or just over an 8-year flood. This frequency corresponded to a discharge of 240,000 cfs.
>
> In order to determine the extent of induced flooding, for the 175,000 cfs Plan, a profile for the 200,000 cfs frequency discharge was computed from the backwater model. This profile was compared to the profile for the OHWM and the elevation and area differences were determined. For the 200,000 cfs Plan, a profile was computed using the frequency

discharge of 240,000 cfs. This profile was also compared to the profile for the OHWM and the elevation and area differences were determined. These area differences for each plan represent the real estate that would be affected by induced flooding from each of the proposed plans."

For real estate purposes, this induced flooding information provided the basis for the conclusion that each proposal, at some specific flows, would increase the frequency of flooding above that existing under the current operating plan. Additionally, the information provided a flow which, when translated to an elevation, provided a basis for an administrative determination of the guide taking line for each proposal. The maximum induced flooding from the FM-175 component would peak at just over the 5-year frequency. The maximum induced flooding from the FM-200 component would peak at the 8-year flood frequency. The corresponding elevations for these flood frequencies were considered for purposes of this study to constitute the guide taking line for each proposal. Based upon the frequency of induced flooding resulting from the two proposed components, the minimum estate required to implement either of these proposals would be a flowage easement.

Implementation of FM-175 would require the acquisition of approximately 9,900 acres from 267 owners and the relocation of two homes and six farm operations with a total estimated cost of $12,105,000 (July 2004 $). Implementation of FM-200 would require the acquisition of approximately 14,800 acres from 285 owners and the relocation of two homes and ten farm operations with a total estimated cost of $16,094,000 (July 2004 $). Either option would be a major undertaking, with significant political consequences, taking many years to accomplish, and requiring manpower resources far in excess of our current capability. Tables 4-4 and 4-5 detail the real estate acquisition costs for FM-175 and FM-200, respectively.

Table 4-4. Real Estate Cost Estimate FM-175 - Oklahoma			
	NUMBER	**ACRES**	**VALUE (FY03$)**
LAND		10,200	
GOVERNMENT OWNED		300	
PRIVATE LAND REQUIRED		9,900	
OWNERSHIPS	267		
CROPLAND		6,500	$4,290,000
PASTURE		1,135	$221,300
TIMBER		2,250	$78,700
HOME/FARM SITE		15	$24,000
SEVERANCE DAMAGE			$923,000
IMPROVEMENTS			$223,000
RELOCATION ASSISTANCE			
RESIDENCES			$50,000
FARMS			$150,000
ADMINISTRATIVE COSTS			$3,204,000
CONTINGENCY	25%		$2,291,000
TOTAL ESTIMATED COST (2003 $)			$11,455,000
TOTAL ESTIMATED COST (July 2004 $)			**$12,105,000**
Source: USACE, Tulsa District.			

Table 4-5. Real Estate Cost Estimate FM-200 - Oklahoma			
	NUMBER	**ACRES**	**VALUE (FY01$)**
LAND		15,300	
GOVERNMENT OWNED		500	
PRIVATE LAND REQUIRED		14,800	
OWNERSHIPS	285		
CROPLAND		9,600	$6,336,000
PASTURE		1,900	$370,500
TIMBER		3,280	$114,800
HOME/FARM SITE		20	$32,000
SEVERANCE DAMAGE			$1,370,700
IMPROVEMENTS			$240,000
RELOCATION ASSISTANCE			
RESIDENCES			$50,000
FARMS			$250,000
ADMINISTRATIVE COSTS			$3,420,000
CONTINGENCY	25%		$3,046,000
TOTAL ESTIMATED COST (2003$)			$15,230,000
TOTAL ESTIMATED COST (July 2004 $)			**$16,094,000**
Source: USACE, Tulsa District.			

B.4.2.2. Real Estate for Navigation Channel Deepening Feature

Most dredged material disposal sites previously constructed on the MKARNS are nearing capacity and additional sites are currently required to maintain the existing 9′ channel. Implementation of the proposed 12′ channel will only add to the requirement for additional dredge material disposal sites throughout the MKARNS. For the purposes of this analysis, 3′ of advance maintenance dredging is assumed over the entire length of the system. Based upon this assumption, 54 new or expanded dredged material disposal sites will be required within the Tulsa District to accommodate the 9′, 10′, 11′, and 12′ channel dredging requirements.

Proposed dredge material disposal sites have been located, where possible, to avoid adversely impacting biologically important riparian forest bottomland habitat areas. Unavoidable habitat impacts will be mitigated through the acquisition of additional lands to offset the loss. The size and location of the mitigation lands will be determined through coordination associated with compliance with the requirements of the National Environmental Policy Act (NEPA).

The total amount of private lands required for this proposed project for dredged material disposal areas and right-of-way access from public roads is estimated to total approximately 285 acres. Approximately 37 private landowners and an unknown number of tenants own this acreage. An additional 87 acres of privately owned land would be required for rights-of-way access to the dredged material disposal sites from public roads for construction, operation, and maintenance purposes. Approximately 376 acres of privately owned land have been identified for acquisition for environmental mitigation.

Land values are based upon the dredge material disposal area alignments and access rights-of-way determined as of June 28, 2004. Subsequent modifications to locations and sizes will impact the final land and damages values as used in this report. Table 4-6 details the real estate acquisition costs for navigation channel deepening components.

Table 4-6. Real Estate Cost Estimate Navigation Channel Deepening Components - Oklahoma

	NUMBER	ACRES	VALUE (July 2004 $)
LAND – DISPOSAL		372	$694,800
OWNERSHIPS – DISPOSAL	37		
LAND – MITIGATION		376	$732,400
OWNERSHIPS - MITIGATION	3		
RELOCATION ASSISTANCE			$100,000
LEASE MODIFICATIONS			$29,750
ADMINISTRATIVE COSTS			$1,245,000
CONTINGENCY			$412,425
TOTAL ESTIMATED COST			**$3,214,375**

Note: Estimate above comes from Draft Real Estate Planning Report, Tulsa District, Appendix D.

B.5. Operations and Maintenance

The estimated increase in Operations and Maintenance costs for all flow management components is $0 for both the Arkansas and Oklahoma portions of the project area. In addition, the USACE does not believe that any of the flow management components would result in the requirement of additional bank stabilization, revetments, or dike work.

The estimated increase in Operations and Maintenance costs for the navigation channel deepening components are listed in Table 5-1. Increases in O&M are due to additional dredging locations and quantities, bank stabilization structures repairs and maintenance of tow haulage equipment.

The existing tow haulage equipment on the Little Rock District locks was not designed for the proposed barge sizes for the navigation channel deepening components. Information from the project office for the upper locks (7 through 13) provided estimates of current O&M expenditures, average life of tow haulage components, material costs, and labor costs. Assuming the upper locks are representative of the lower locks, three O&M cost scenarios were developed for the Little Rock District: low, mid, and high. Factors in the analysis included current O&M expenditures on tow haulage equipment, number of locks with tow haulage equipment, current age of tow haulage equipment, increase in tow haulage O&M costs due to increased age, increase in tow haulage O&M costs due to increased strain on equipment. Costs were projected for 20 years, and were held constant for the remaining 30 years of the project life. The incremental costs were annualized, and a contingency of 20% was applied. Table 5-2 shows the estimated annual tow haulage O&M costs for the navigation channel deepening components. In Section B.12, a sensitivity test of the high cost scenario is performed on the NCD-12 component.

Table 5-1. Incremental Operations and Maintenance Costs (July 2004 $)

	NCD-NA	NCD-10	NCD-11	NCD-12
Arkansas	$0	$844,700	$1,273,500	$1,783,400
Oklahoma	$0	$729,100	$ 865,800	$ 945,700
Total	**$0**	**$1,573,800**	**$2,139,300**	**$2,729,100**

Table 5-2. Annual Tow Haulage Operations and Maintenance Costs (July 2004 $)				
Low Cost Scenario	**NCD-NA**	**NCD-10**	**NCD-11**	**NCD-12**
Reach 1	$128,894	$144,362	$159,829	$174,007
Reach 2	$22,087	$24,737	$27,387	$29,817
Reach 3	$88,346	$98,948	$109,549	$119,267
Reach 4	$44,173	$49,474	$54,775	$59,634
Reaches 1-4	**$283,500**	**$317,520**	**$351,540**	**$382,725**
Mid Cost Scenario	**NCD-NA**	**NCD-10**	**NCD-11**	**NCD-12**
Reach 1	$154,673	$173,234	$191,795	$208,900
Reach 2	$26,504	$29,684	$32,865	$35,799
Reach 3	$106,015	$118,737	$131,459	$143,194
Reach 4	$53,008	$59,369	$65,730	$71,597
Reaches 1-4	**$340,200**	**$381,024**	**$421,848**	**$459,490**
High Cost Scenario	**NCD-NA**	**NCD-10**	**NCD-11**	**NCD-12**
Reach 1	$257,076	$288,162	$319,249	$350,335
Reach 2	$44,050	$49,377	$54,704	$60,030
Reach 3	$176,201	$197,508	$218,814	$240,121
Reach 4	$88,100	$98,754	$109,407	$120,060
Reaches 1-4	**$565,428**	**$633,801**	**$702,173**	**$770,546**
Incremental Annual Tow Haulage Operations and Maintenance Costs (July 2004 $)				
Low Cost Scenario		**NCD-10**	**NCD-11**	**NCD-12**
Reach 1		$15,467	$30,935	$45,113
Reach 2		$2,650	$5,301	$7,730
Reach 3		$10,602	$21,203	$30,921
Reach 4		$5,301	$10,602	$15,461
Reaches 1-4		**$34,020**	**$68,040**	**$99,225**
Mid Cost Scenario		**NCD-10**	**NCD-11**	**NCD-12**
Reach 1		$18,561	$37,122	$54,227
Reach 2		$3,180	$6,361	$9,295
Reach 3		$12,722	$25,444	$37,179
Reach 4		$6,361	$12,722	$18,589
Reaches 1-4		**$40,824**	**$81,648**	**$119,290**
High Cost Scenario		**NCD-10**	**NCD-11**	**NCD-12**
Reach 1		$31,086	$62,172	$93,259
Reach 2		$5,327	$10,653	$15,980
Reach 3		$21,307	$42,613	$63,920
Reach 4		$10,653	$21,307	$31,960
Reaches 1-4		**$68,373**	**$136,746**	**$205,118**

B.6. Commercial Navigation

B.6.1. Project Description

The McClellan Kerr Arkansas River Navigation System (MKARNS) channel begins at the confluence of the White and Mississippi rivers in Desha County in southeastern Arkansas. From that point, the first ten miles upstream are navigated via the White River to the Arkansas Post Canal, which conveys river traffic to the Arkansas River. Continuing upstream, the navigable waterway crosses Arkansas as it proceeds northward into Oklahoma. The system changes from the Arkansas River into the Verdigris River at Muskogee and terminates 50 miles upstream on the Verdigris at Catoosa.

As shown in Table 6-1, the system includes eighteen lock and dam projects. The upper five projects are in Oklahoma and the lower thirteen are in Arkansas. The two uppermost projects are on the Verdigris River, thirteen projects are on the Arkansas River, two are on the Arkansas Post Canal, and one is on the White River.

The Corps maintains a minimum 9′ channel depth on the system. Passage through MKARNS lock chambers was configured for eight barges, but can accommodate up to 15 barge tows using double lockage. Each of the eighteen locks measures 110′ wide and 600′ long. Individual locks have lifts ranging from 14′ to as much as 54′. There are 13 “low lift” lock and dam structures, which raise or lower river traffic from 14′ to 30′. The four other structures are “high lift” locks, which can raise or lower traffic from 30′ to 54′. The lock and dam structures are constructed along the waterway in a stair step pattern that gradually follows the natural elevation changes of the topography and maintain a navigation pool.

In addition to the minimum 9′ depth, the Corps maintains a channel width varying from 300′ in the White River, Lake Langhofer, and the Arkansas Post Canal, to 250′ on the Arkansas River. A 225′ width is provided on Sans Bois Creek, and the Verdigris River segment has a 150′ width.

The Arkansas River Basin comprises about 138,000 square miles of contributing drainage area; about 128,000 square miles are above Van Buren, Arkansas. The Arkansas River system currently consists of 48 federally constructed and two state (Oklahoma) constructed projects operated for flood damage reduction, hydropower, water supply, water quality, sediment control, navigation, recreation, and fish and wildlife. These projects were constructed from the 1940’s into the 1980’s. These projects have many varied users and their interests, often differ, sometimes radically.

Table 6-1. Arkansas River Lock and Dam Projects

Project	River Mile	Chamber LxW	Depth Over Sill - Lower	Depth Over Sill - Upper	Lift	Tow Haulage	Type of Dam
Montgomery Point	0.5	600'x110'			38	Y	Gated
Norrell	10.3	600'x110'		16	30	Y	Fixed
L&D 2	13.3	600'x110'	14	18	20	Y	Tainter
Joe Hardin	50.2	600'x110'	14	18	20	Y	Tainter
Emmett Sanders	66.0	600'x110'	14	18	14	Y	Tainter
L&D 5	86.3	600'x110'	14	18	17	Y	Tainter
David D. Terry	108.1	600'x110'	14	18	18	Y	Tainter
Murray	125.4	600'x110'	14	18	18	Y	Tainter
Toad Suck Ferry	155.9	600'x110'	14	18	16	Y	Tainter
Arthur V. Ormond	176.9	600'x110'	14	18	19	Y	Tainter
Dardanelle	205.5	600'x110'	14	15	55	Y	Tainter
Ozark-Jeta Taylor	256.8	600'x110'	15	16	34	Y	Tainter
James W. Trimble	292.8	600'x110'	14	17	20	Y	Tainter
W.D. Mayo	319.6	600'x110'	14	15	21	N	Tainter
Robert S. Kerr	336.2	600'x110'	14	16	48	N	Tainter
Webbers Falls	366.6	600'x110'	14	16	30	N	Tainter
Chateau	401.4	600'x110'	14	15	21	N	Tainter
Newt Graham	421.6	600'x110'	14	15	21	N	Tainter

Flows on the main stem of the Arkansas River are modified primarily by 11 reservoirs in Oklahoma that provide about 7.7 million acre-feet of flood control storage. This is more than 70 percent of the total flood storage in the basin. These reservoirs are Keystone, Oologah, Pensacola, Hudson, Fort Gibson, Tenkiller Ferry, Eufaula, Kaw, Hulah, Copan, and Wister. The Fort Smith/Van Buren, Arkansas, area near the Oklahoma-Arkansas state line is the primary control point for the lower Arkansas River Navigation System (Van Buren to mouth). The reservoirs are operated to maintain flow targets at the Van Buren gage, and all reservoir releases flow past this point. There is about 7,500 square miles of uncontrolled drainage area below these projects and the regulating control point at Van Buren, Arkansas.

There are two primary issues with respect to water management: The authority of the Corps of Engineers to operate the 11 principal reservoirs in the Arkansas River Basin for the benefit of navigation, and the Corp's authority to draw down into the conservation storage to augment low flows. The Department of the Army's position is that the Corps of Engineers is authorized to operate any of the reservoirs in the system to benefit navigation, and that the operating plan changes made to date have been within its discretionary authority. Also, that during a navigation emergency, the Corps has the authority to draw down into the conservation storage of five reservoirs – Kaw, Keystone, Eufaula, Oologah, and Tenkiller – to augment low flows on the navigation system if the drawdown does not impact contracted water supply storage.

The operating plan that is presently in place is the culmination of a process of balancing the authorized purposes of the several reservoirs within the authorized purposes of the specific navigation uses set forth in the McClellan-Kerr Arkansas River Navigation System. This balancing is in response to the Congressional policy of authorizing Corps projects as part of a generally comprehensive plan for river basin development to serve multiple purposes, and not authorizing the projects in isolation to each other. Collectively within the Corps of Engineers Southwestern Division, the Tulsa and Little Rock Districts have the mission of operating the complex system to satisfy each project purpose.

The purpose of the navigation analysis is to compute the potential benefits of the alternative measures and to compare the benefits with the implementation, operation, and maintenance costs. The benefit and economic evaluations were performed in conformance with ER 1105-2-100, Appendix E, Section E-9. "NED Benefit Evaluation Procedures: Transportation Inland Navigation". The procedure requires a description and analysis of the existing condition, the most probable "without" project condition, and one or more "with" project conditions. The basic benefit for improvements is a reduction in the value of resources required to transport commodities. The procedure is described as a 10-step process with special emphasis on existing and projected future traffic, and on shipping costs given the current condition and alternative future conditions.

B.6.2. Study Area

The study area is fully described in Sections B.1.2 and B.1.3. Figure 6-1 shows the reaches used in the calculation of navigation benefits.

Figure 6-1

B.6.3. Commodity Traffic

The system was constructed for the purpose of commercial navigation. The amounts of traffic, types of commodities, and general patterns of movement of past and present traffic on the system are displayed and discussed in this section. Ranges of possible future traffic levels are also provided.

B.6.3.1. Historic Traffic

Historic traffic is discussed in terms of the volume, types, and patterns of commercial traffic. More detailed information is provided in Addendum E1.

Traffic on the river in the twenty years before the construction of MKARNS generally ranged from 500,000 tons to 1 million tons a year. Construction of the MKARNS was completed in 1970 and traffic increased rapidly through 1978 up to nearly 10 million tons a year. Traffic declined and then stabilized during the 1980s at a level of about 8 million tons. Traffic again increased in the 1990s to its current estimated level of 11.9 million tons. The volume of historic traffic is depicted in Figure 6-2. Historic traffic is shown in the Table 6-2.

Figure 6-2

Table 6-2. MKARNS Tonnage

Year	Tons	Year	Tons
1971	4,294,048	1988	6,678,244
1972	5,337,370	1989	7,926,783
1973	4,955,789	1990	8,785,000
1974	6,000,443	1991	9,014,000
1975	5,156,562	1992	8,526,000
1976	6,536,434	1993	9,382,000
1977	9,145,956	1994	10,706,000
1978	9,851,932	1995	10,348,000
1979	8,411,173	1996	10,551,000
1980	8,461,411	1997	11,154,000
1981	7,674,431	1998	12,036,000
1982	7,823,228	1999	11,716,000
1983	7,567,986	2000	10,733,000
1984	8,521,310	2001	11,206,000
1985	7,725,486	2002	11,903,000
1986	8,395,856	2003	12,988,000
1987	7,915,037	2004*	12,896,887

*Preliminary estimate of tonnage provided by Little Rock District Operations personnel.

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Total traffic is actually the sum of a multitude of individual commodities that can be grouped based on similarities in their characteristics and in the markets they serve. Historic traffic levels for the ten commodity groups used in this study are listed in the table below. The largest groups in terms of tonnage are also among the groups that experienced the fastest rates of growth – non-metallic minerals, farm products and agricultural chemicals (fertilizers). The overall annual rate of growth for all traffic between 1975 and 2002 was 3.1%, as shown in the following table.

Table 6-3. Historic Growth Rates in Commodity Group Traffic

Commodity Group	Annual Growth Rates 1975-2002
Farm Products	5.0%
Metals	2.9%
Coal	2.3%
Crude Petroleum	-
Nonmetallic Minerals	2.7%
Forest Products	-2.2%
Industrial Chemicals	1.6%
Agricultural Chemicals	7.1%
Petroleum Products	0.6%
Other	-5.2%
Overall	3.1%

B.6.3.1.1. Types of Commodities

The specific commodities that moved on the waterway in 2001 and their parent grouping are listed in Table 6-4. Four commodities were shipped in quantities of more than one million tons: 1) sand and gravel; 2) waterway improvement material; 3) wheat; and 4) nitrogenous fertilizer. Together, these commodities account for 63% of all tonnage shipped on the river system.

B.6.3.1.2. Directional Flows of Traffic

The directional flow of traffic for each commodity group is listed in the table below under the headings inbound, outbound, through, and intra. Through traffic is minimal and represents traffic with an origin or destination upstream of the defined navigation system on the White River. Internal traffic is traffic that moves between points on the MKARNS. Inbound and outbound is traffic that travels onto or off the MKARNS.

Outbound shipments account for 41% of tonnage, inbound shipments for 33% of tonnage, internal for 23% of tonnage, and the small remainder is classified as through traffic. The major outbound shipments are farm products and non-metallic minerals (sand and gravel), the major inbound shipments are agricultural chemicals (fertilizers) and the major internal movements are shipments of non-metallic minerals.

Table 6-4. Types of Commodities and Tonnage – 2001 (thousands of tons)

Farm Products	**2,582**	**Agricultural Chemicals**	**1,838**
Wheat	1,328	Ammonia	193
Rice	227	Double Salts	1
Maize	132	Ammonium Sulfate	6
Oats	28	Urea Fertilizer	800
Grain	254	Mineral/Chem Fertilizer	275
Buckwheat	1	Basic Slag Fertilizer	1
Meal & Flour	1	Superphosphate	15
Molasses	44	Mineral-Phosphate	77
Bran	34	Mineral-Posta.	101
Oil-Cake	38	Diammonium	213
Flour	9	Monoammonium	36
Food Wastes	2	Fertilizer-Tablet	2
Soya Beans	479	Fertilizer-NEC	118
Flour	6	**Nonmetallic Minerals**	**4,787**
Metals	**960**	Limes	34
Ferrous Wastes	108	Gypsum	5
Aluminum Ores	49	Sands	2,232
Manganese Ore	3	Pebbles	94
Ores - Others	1	Material-Waterway*	2,172
Pig Iron	26	Clays	7
Other Ferrous Alloys	5	Sodium	19
Ingots	3	Slag, Dross	8
Flat-rolled Prod.	352	Slag Ash	39
Iron & Steel Bars	159	Vermiculite	10
Wire	123	Portland Aluminous	165
Tubes	110	Glass	1
Aluminum	14	Glassware	0
Zinc	6	**Petroleum and Products**	**508**
Coal	**149**	Other Light Oils	127
Coal	36	Fuel	52
Coke	113	Lubricating Oils	3
Forest Products	**130**	Pitch	94
Wood Particles	111	Petro Coke	187
Pulp	2	Petro - NEC	45
Rubber	0	**Crude Petroleum**	**0**
Kraft	1	**Other**	**67**
Paper	16	Manufactured Goods	56
Industrial Chemicals	**184**	Machinery	10
Manganese Oxides	30	Pumps	1
Ammonium Nitrate	98	Electrical Equipment	0
Sodium Chloride	3		
Calcium Chloride	4		
Sodium Sulfide	49	**Total****	**11,206**

* 1.4 of the 2.2 million tons was subsequently reclassified as "Sands" and gravel.
** Totals differ due to rounding.

Source: Waterborne Commerce files

Table 6-5. Directional Flows of Traffic – 2001 (thousands of tons)							
	Inbound	Outbound	Through		Internal		Grand
Commodity Type	Up	Down	Up	Down	Up	Down	Total
Farm Products	561	2,018	0	0	3	0	2,582
Metals	833	121	0	0	6	0	960
Coal	143	6	0	0	0	0	149
Crude Petroleum	0	0	0	0	0	0	0
Nonmetallic Minerals	219	1,785	0	245	1,107	1,431	4,787
Forest Products	24	106	0	0	0	0	130
Industrial Chemicals	155	30	0	0	0	0	185
Agricultural Chemicals	1,460	359	0	0	8	12	1,838
Petroleum and Petroleum Products	278	212	0	0	1	17	508
Other	55	12	0	0	0	0	67
Total, all commodities	**3,726**	**4,649**	**0**	**245**	**1,126**	**1,460**	**11,206**
Source: Waterborne Commerce data.							

B.6.3.1.3. Regional Flows of Traffic

The single most important flow of traffic is from the MKARNS to the Lower Miss with 3.8 million tons and 34% of all tonnage, as shown in the following table. Two other flows are significant: 1) internal movements on the Arkansas River; and 2) shipments from the Lower Miss to the Arkansas River. Each of the latter two flows is approximately 2.5 million tons and 22% of total tonnage. Combined, the shipments between the Arkansas and Lower Miss amount to 6.3 million tons and 56% of all tonnage shipments.

Table 6-6. Regional Flows of Traffic – 2001		
Origin	**Destination**	**Tons**
Arkansas River	Arkansas River	2,585,941
Arkansas River	GIWW East	23,884
Arkansas River	GIWW West	183,561
Arkansas River	Lower Miss	3,786,393
Arkansas River	Ohio	166,556
Arkansas River	Tennessee	150,601
Arkansas River	Tenn-Tom	53,510
Arkansas River	Upper Miss	242,354
Arkansas River	White River	41,808
GIWW East	Arkansas River	128,366
GIWW West	Arkansas River	100,625
Lower Miss	Arkansas River	2,459,060
Lower Miss	White River	8,351
Ohio	Arkansas River	401,342
Tennessee	Arkansas River	20,993
Tenn-Tom	Arkansas River	30,103
Upper Miss	Arkansas River	308,422
Upper Miss	White River	245,315
White River	Lower Miss	269,028
Total		**11,206,393**

Data on regional flows and similar information for each of the ten commodity groups are provided in Addendum E1.

B.6.3.2. Base Year Traffic

Base year traffic is traffic that is used as a basis for projecting future commodity shipments. As such, base year traffic should be representative of the typical historic shipments in terms of absolute and relative volumes in each shipment and commodity type. Because of the importance of the base year shipment list, efforts were made to ensure that the base year traffic used in the study reflected past shipments and the expected pattern of future shipments.

The development of base year traffic began with the acquisition of two alternative sources of traffic data: waterborne commerce statistics (WCS) and lock performance monitoring system (LPMS) statistics. Waterborne commerce data are reported annually by the shippers to the Corps' Navigation Data Center and contain origin, destination, commodity type, and annual tonnage data. The data are typically available about six to twelve months after the end of the calendar year with the lag due to the time required for submitting, compiling and processing the data. The LPMS data are collected at each project for each vessel as it transits the lock and includes descriptive information of the tow, the commodity types in the tow and the estimated tonnage of each commodity. The collection is real time and the data are typically available with a lag of about two months. The important difference to note between waterborne commerce and LPMS data is that the waterborne commerce data include origin and destination information, whereas the LPMS does not. The difference is important because the forecasts are made for individual commodity shipments with specific origins, destinations, and commodity types. Therefore, the LPMS data can be used to identify the likelihood of recent changes in shipping patterns, but are of limited use in identifying the actual change. This must be done using the waterborne commerce data.

The starting point for the development of base year traffic in this study was the 2001 waterborne commerce data. The year 2001 data were the starting point because they were the most recent available when the Phase 1 analysis was performed and, as a result, all transportation rates were developed for shipments, as they existed in 2001. Some relatively minor changes in shipping patterns and volumes have occurred since then, but not enough to warrant a new transportation rate study. Instead, the year 2001 tonnage data were adjusted to reflect recent changes indicated by the 2002 waterborne commerce data and the 2002 and 2003 LPMS lock data. This allowed the continued use of the 2001 based transportation rates while reflecting recent changes in traffic. The procedure to develop base year traffic is described in Addendum E1 while the results are summarized below.

The "base" year for this study is 2003 and the base year tonnage is 11.9 million tons, which is 5.8 percent higher than the 11.2 million tons recorded in 2001. The percent difference in tonnage in each year and for each commodity group is shown in Table 6-7.

Table 6-7. Estimated Base Year (2003) Tonnage (thousands of tons)				
Commodity Type	**2001**	**2002**	**2003***	**Percent Change 2001-2003**
Farm Products	2,582	2,809	2,809	8.8%
Metals	960	1,162	1,242	29.4%
Coal	149	199	273	82.8%
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	4,787	4,728	4,728	-1.2%
Forest Products	130	91	91	-30.2%
Industrial Chemicals	185	243	243	31.6%
Agricultural Chemicals	1,838	1,871	1,871	1.8%
Petroleum Products	508	523	523	2.8%
Others	67	77	77	14.8%
All Commodities	**11,206**	**11,702**	**11,856**	**5.8%**
Note: added 74k to coal and 80k to metals tonnages in 2002 to estimate 2003. * 2003 is an approximation; 2001 and 2002 are actual waterborne tonnages.				

The percent change factors were applied to the tonnage of each shipment in the 2001 shipment list to obtain a first approximation of a 2003 shipment list. When the "approximated" list was traced through the locks and compared to actual 2003 lock tonnage data it was noted that the amount of tonnage was understated at the upper river projects and overstated at the lower river. Therefore, a secondary adjustment was made by increasing the tonnage for selected shipments with origins or destinations on the upper river and decreasing tonnage for selected movements with origins or destinations on the lower river. The results of this further adjustment in terms of tonnage through each of the locks are shown in the following table. The percent differences between actual LPMS lock tonnages and the tonnages using the 2001 WCS shipment list adjusted upward to 2003 are all less than 6 percent with some above and some below the actual 2003 tonnage levels. The adjustments are not perfect, but they were considered better than using older data and ignoring recent trends entirely. Given normal variations in traffic levels as well as differences due to possible errors in the data, the approximated 2003 traffic was considered acceptable for use as "base" year traffic. The additional advantage of this approach was that it allowed the continued use of the transportation rate data developed by Tennessee Valley Authority (TVA).

Table 6-8. Actual and Modeled Lock Traffic (thousands of tons)					
				Modeled	% Difference
Project	2001	2002	2003	2003	2003
GRAHAM	3,480	3,732	3,914	3,803	-2.8%
CHOUTEAU	3,633	3,828	4,066	3,997	-1.7%
WEBER	4,184	4,416	4,759	4,556	-4.3%
KERR	4,340	4,675	5,024	4,736	-5.7%
MAYO	4,325	4,698	4,979	4,736	-4.9%
TRIMBLE	4,611	5,031	5,322	5,018	-5.7%
OZARK	4,600	5,073	5,300	5,019	-5.3%
DARDANELLE	6,751	7,173	7,106	6,935	-2.4%
ORMOND	6,503	7,116	7,137	7,024	-1.6%
TOAD SUCK	6,527	7,007	7,111	7,095	-0.2%
MURRAY	6,744	7,149	7,108	7,146	0.5%
TERRY	7,493	7,999	8,102	8,035	-0.8%
L&D 5	7,548	8,088	8,158	8,041	-1.4%
SANDERS	8,100	8,214	8,358	8,712	4.2%
HARDIN	8,086	8,172	8,380	8,836	5.4%
L&D 2	8,691	8,853	9,126	9,317	2.1%
NORRELL	8,696	8,851	9,139	9,317	2.0%

B.6.3.3. Future Year Traffic

B.6.3.3.1. Forecast Procedures

Traffic was forecasted using the same general procedures as used in the on-going comprehensive studies of the Upper Miss and Ohio River navigation systems. Moreover, the economic sectors that were logically linked to different commodities and that could be used as a basis for forecasting waterborne traffic were frequently adopted from these two studies since they had devoted considerable time and effort to the task, and the procedures have been reviewed and found to be generally acceptable. A complete discussion of the procedure used to develop the traffic forecasts for MKARNS is provided in Addendum E1.

B.6.3.3.2. Regional Areas

Regional areas are geographic areas that include a riverside dock that either shipped or received commodities on the waterway system. Regional areas are important because they define the supply area for shipments and the demand area for receipts. Regional areas are typically defined as counties, groups of counties, states, or groups of states. This study defined regional areas in terms of groups of states since most traffic on the river system is destined for multi-state supply and demand markets. An additional consideration in defining the regions was the depth of the navigation system in the proposed regional area; i.e. the Lower Miss can normally accommodate 12′ draft barges whereas the Upper Miss can normally only accommodate 9′ draft barges. The regional areas and the states within each region are listed below. In a few cases, the same state is

included in two different regions since it lies within more than one river basin and could ship or receive goods on more than one river. If a state was only marginally within a basin area, it was excluded from the region.

Table 6-9. Regional Areas used in Analysis		
Region Number	**Region**	**States**
1	Arkansas River	Arkansas, Oklahoma
2	GIWW East	Florida, Alabama, Georgia, Mississippi
3	GIWW West	Texas
4	Lower Miss	Louisiana, Mississippi
5	Ohio River	Indiana, Kentucky, Ohio, Pennsylvania, West Virginia
6	Tennessee River	Tennessee
7	Tenn-Tom Waterway	Tennessee, Alabama
8	Upper Miss	Illinois, Missouri, Wisconsin, Minnesota, Indiana, Iowa
9	White River	Arkansas, Oklahoma

B.6.3.3.3. Indicators of Traffic Demands

The factors that were identified in Addendum E1 as reasonable proxy indicators of future changes in traffic demands are listed in the table below. Given the great importance of farm product exports, the most current USDA forecasts were used to develop a growth rate for short-term traffic thru 2010. After 2010, farm product exports were assumed to converge to the growth rate developed by the Sparks Co. for the Upper Mississippi River study team. Again, details are provided in Addendum E1.

Table 6-10. Indicators of Future Traffic Demands			
Commodity Type	**Prime Driver**	**Secondary Adjustment**	**Geographic Area**
Farm Products Foreign exports Domestic	 USDA/Upper Miss Population	 None None	 Foreign National
Metals	Gross Domestic Product	50% of GDP rate	National
Coal	Manufacturing earnings	None	Receipt Region
Crude Petroleum	Population	None	Receipt Region
Nonmetallic Minerals	Construction employment Construction earnings	Average of two	Receipt Region
Forest Products	Population	None	Receipt Region
Industrial Chemicals	Manufacturing earnings	None	Receipt Region
Agricultural Chemicals	Farm Product Shipments	None	Receipt Region
Petroleum and Petroleum Products	Population	None	Receipt Region
Other	Construction employment	None	Receipt Region
Source: USDA: "USDA Agricultural Baseline Projections to 2012", USDA Staff Report WAOB-2003-1; Feb 2003. Upper Miss: Upper Mississippi River and Illinois Waterway Navigation Study, 1 May 2002, Sparks Report on Future Traffic Demands, Table 22. Ohio River: Ohio River Mainstem Study, In-Progress Review Package, December 2003.			

B.6.3.3.4. Projected Traffic Demands

Traffic demand projections were developed for existing traffic shipments and for shipments that could potentially shift transportation modes (be 'induced' onto the waterway) as a result of navigation improvements. The traffic demand projections for existing shipments were developed in accordance with the general procedures described above and as provided in detail in Addendum E1. The identification and development of "induced" traffic were based on surveys and on assumptions regarding the price elasticity of demand.

(1) Existing Shipments

Existing shipments are shipments that currently move on the waterway system in terms of the commodity type, origin and destination. Forecasts generally refer to projected changes in the tonnage amount of each shipment from the base-year tonnage. Three sets of traffic forecasts were developed for existing shipments: low, middle and high growth. The middle forecasts are listed in the following table. The overall growth rate through 2060 is 1.1%. Growth rates for individual commodity groups range from 0.6% for forest products and "others" to 1.9% for coal.

Table 6-11. Mid-Level Forecasts by Commodity Group (thousands of tons)

	Base 03	2010	2020	2030	2040	2050	2060	Ann. %
Farm Products	2,835	3,260	3,593	3,888	4,132	4,391	4,667	0.9%
Metals	1,242	1,430	1,563	1,682	1,802	1,931	2,069	0.9%
Coal	273	339	400	483	571	676	800	1.9%
Crude Pet	0	0	0	0	0	0	0	-
Non-met.	4,730	6,065	6,869	7,464	8,084	8,755	9,482	1.2%
Forest Products	91	97	103	109	114	121	127	0.6%
Ind. Chemicals	243	296	346	415	488	574	676	1.8%
Ag Chemicals	1,871	2,220	2,403	2,551	2,707	2,873	3,049	0.9%
Petro Products	523	574	621	665	707	752	799	0.7%
Others	77	92	99	101	103	105	107	0.6%
Total	**11,884**	**14,372**	**15,997**	**17,356**	**18,708**	**20,177**	**21,775**	**1.1%**

Low and high forecasts were developed using the same procedure but keyed to low and high economic and demographic forecasts by NPA Data Services and others. The results of this effort were low forecasts that were near "no growth" and high forecasts that were only marginally higher than the middle forecasts. Given this, it was decided to simplify matters by using "no growth" as the low forecasts. For high growth, it was decided to allow traffic to grow to about 40 million tons. The rationale for the 40 million ton target was: 1) the MKARNS area is similar in a number of ways to the areas along the Illinois and Tennessee Rivers, both of which transport about 40 million tons; 2) in 50 years, the MKARNS will be the same age as the Illinois and Tennessee navigation systems are at the current time so it is not implausible to project a comparable tonnage at a comparable age; and 3) this is the tonnage cited as an expected traffic level by some shippers in the MKARNS area. The "high" target was met by doubling the growth of the middle forecast scenario. The low and
high forecasts developed using the procedure described in Addendum E1 ('classical') and the low and high used to actually bound the expected level of future traffic are listed in Table 6-12.

Table 6-12. High, Middle and Low Traffic Projections – Without Induced Traffic (thousands of tons)								
	Base 03	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**Ann. %**
Classical								
High	11,884	14,652	16,916	18,990	20,773	22,833	25,212	1.3%
Middle	11,884	14,372	15,997	17,356	18,708	20,177	21,775	1.1%
Low	11,884	12,221	12,033	11,436	10,528	9,854	9,344	-0.4%
Used								
High	11,884	21,558	31,994	34,712	37,415	40,353	43,551	2.3%
Middle	11,884	14,372	15,997	17,356	18,708	20,177	21,775	1.1%
Low	11,884	11,884	11,884	11,884	11,884	11,884	11,884	0.0%

Finally, the middle set of projections at the lock level is listed in Table 6-13. The growth rates for the individual projects are within a narrow range of 0.9% to 1.0% a year.

(2) Induced Traffic

The determination of how much, if any, traffic would be induced onto the waterway system due to lower waterway transportation costs is subject to a high degree of uncertainty. A survey conducted by TVA obtained responses that indicated a potential volume of 3.0 million tons of induced traffic, but it is impossible to determine how much is due to lower transportation costs and how much is due to other factors that are considered in the decision making process. Nonetheless, the consensus was that lower transportation costs would increase the competitiveness of waterway transportation. Given the uncertainty over the extent of the impact, a range of tonnage for induced traffic was developed based on different assumptions regarding the price elasticity of demand. Deepening would lower the overall water-routing costs by 3.2% to 5.6% depending on the depth. Assuming unitary elasticity between water-routing costs and traffic volumes, the reductions would result in the "inducement" of 358,000 to 627,000 tons based on the volume of traffic in the year 2001. Assuming perfect inelasticity, the lower costs would not have any effect on traffic volumes (zero induced tonnage). The percentages were likewise applied to future traffic levels to obtain future volumes of induced traffic for each deepening component.

Table 6-13. Mid-Set Traffic Projections by Lock and Dam Project (thousands of tons)								
Project	**Base 03**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**Ann. %**
GRAHAM	3,803	4,445	4,881	5,276	5,657	6,071	6,522	1.0%
CHOUTEAU	3,997	4,668	5,126	5,541	5,939	6,371	6,840	0.9%
WEBER	4,556	5,316	5,842	6,326	6,793	7,303	7,859	1.0%
KERR	4,736	5,527	6,072	6,572	7,055	7,580	8,154	1.0%
MAYO	4,736	5,527	6,072	6,572	7,055	7,580	8,154	1.0%
TRIMBLE	5,018	5,852	6,428	6,956	7,466	8,021	8,626	1.0%
OZARK	5,019	5,853	6,430	6,958	7,468	8,023	8,628	1.0%
DARDANELLE	6,935	8,304	9,205	9,967	10,728	11,555	12,454	1.0%
L&D 9	7,024	8,413	9,327	10,099	10,869	11,706	12,616	1.0%
TOAD SUCK	7,095	8,492	9,412	10,190	10,965	11,808	12,724	1.0%
MURRAY	7,146	8,558	9,487	10,271	11,054	11,904	12,828	1.0%
TERRY	8,035	9,611	10,647	11,521	12,393	13,341	14,370	1.0%
L&D 5	8,041	9,619	10,656	11,530	12,404	13,352	14,382	1.0%
SANDERS	8,712	10,399	11,518	12,471	13,420	14,452	15,575	1.0%
HARDIN	8,836	10,549	11,690	12,669	13,646	14,709	15,868	1.0%
L&D 2	9,317	11,115	12,319	13,356	14,385	15,506	16,728	1.0%
NORRELL	9,317	11,115	12,319	13,356	14,385	15,506	16,728	1.0%
LOWER WHITE	3,803	4,445	4,881	5,276	5,657	6,071	6,522	1.0%
WHITE RIVER	3,997	4,668	5,126	5,541	5,939	6,371	6,840	0.9%
WITHIN POOL	4,556	5,316	5,842	6,326	6,793	7,303	7,859	1.0%

Table 6-14. Transportation Cost Reductions and Induced Traffic ($Oct 03)			
	Waterway Costs ($1,000)	**Percent Reduction**	**Induced Traffic (thousands tons)**
Existing	148,021		
10´	143,241	3.2%	358
11´	140,669	4.9%	549
12´	139,744	5.6%	627

The specific commodities, volumes, and origins and destinations of the induced traffic could be based on the survey responses but these are highly uncertain, even in the estimation of the responders. If the list of potential induced traffic was developed from this list and the shipments did not develop exactly as currently expected, then it could distort the incremental analysis by overestimating the benefits of improving some sections of the river system and underestimating others. Given the high degree of uncertainty regarding how new shipments may develop, the risk of distorting the economic analysis by using specific "induced" shipments appeared high.

An alternative was to recognize the uncertainty in determining the specific commodity type, origin and destination of "induced" shipments, and allowing all existing shipments to share some portion of the induced traffic. This approach minimizes the severity of errors associated with using a few specific shipments that may never materialize. A listing of the maximum induced tonnage, by commodity group and channel depth based on year 2001 tonnage levels, is provided in Table 6-15.

Table 6-15. Induced Traffic by Depth and Commodity Group (thousands of tons)				
	2001	**Deepening Components**		
Commodity Type	**9-ft**	**10´**	**11´**	**12´**
Farm Products	2,582	82	126	144
Metals	960	32	50	57
Coal	149	5	7	8
Crude Petroleum	0	0	0	0
Nonmetallic Minerals	4,787	148	227	259
Forest Products	130	4	6	7
Industrial Chem	185	6	9	10
Agricultural Chem	1,838	59	90	103
Petroleum Products	508	16	25	28
Other	67	6	9	10
Total	**11,206**	**358**	**549**	**627**

Typically, "induced" traffic grows as more and more shippers take advantage of reduced transportation costs. It was assumed in this study that 50% of the "induced" traffic would shift by the year 2010 and 100 percent by 2020. A listing of total induced tonnage by decade is provided in Table 6-16.

Table 6-16. Induced Traffic by Year (thousands of tons)							
	Base 03	2010	2020	2030	2040	2050	2060
Middle							
10′	0.0	230.0	511.9	555.4	598.6	645.7	696.8
11′	0.0	352.1	783.8	850.4	916.7	988.7	1,067.0
12′	0.0	402.4	895.8	971.9	1,047.6	1,129.9	1,219.4
Low							
10′	0.0	190.1	190.1	190.1	190.1	190.1	190.1
11′	0.0	291.2	291.2	291.2	291.2	291.2	291.2
12′	0.0	332.8	332.8	332.8	332.8	332.8	332.8
High							
10′	0.0	344.9	1,023.8	1,110.8	1,197.3	1,291.3	1,393.6
11′	0.0	528.2	1,567.7	1,700.9	1,833.3	1,977.3	2,134.0
12′	0.0	603.6	1,791.6	1,943.9	2,095.2	2,259.8	2,438.8

B.6.4. Vessel Fleet

The vessel fleet is the equipment actually used to transport cargo on the navigation system. An understanding of the fleet is important since proposed modifications of the navigation system affect the configuration of tows and therefore the costs of transportation. The existing fleet and the fleet that is expected to utilize the MKARNS under the "with" project components are described below.

B.6.4.1. Existing Fleet

The vessel fleet consists of the barges and towboats that are used to transport commodities on the river system. Commodities are loaded into the barges, which are generally linked together by cables to form a larger unit. A towboat is connected by cables to the rear set of barges and powers the unit to different points on the transportation system. The flotilla of barges and a towboat are referred to as a "tow".

B.6.4.1.1. Towboats

A total of 87 different towboats moved on MKARNS in the year 2002. The average horsepower was 2,278. The maximum horsepower was 5,200. The minimum horsepower was 300 in the year 2002. The arithmetic average horsepower is the total horsepower of all towboats divided by the number of towboats. The trip-weighted average is computed by: 1) multiplying the horsepower of each towboat multiplied by its number of trips; 2) summing the weighted horsepower by the number of towboats; and 3) dividing by the total number of trips. There is significant dredging activity on the MKARNS that involves shuttling small sand flats to shore when filled. These are one-barge movements over a distance of 10 to 100 feet, which involve very small horsepower towboats. Because of the frequency of the trips and the small horsepower towboats involved, the inclusion of these in computing the weighted average results in a horsepower value that is half that of the arithmetic average.

Table 6-17. Towboat Horsepower					
Year	Towboats	Arithmetic Ave. H.P.	Min H.P.	Max H.P.	Trip Weighted Ave. H.P.
2001	77	2,248	230	4,400	1,423
2002	87	2,278	300	5,200	1,070
Source: provided by the Huntington District Navigation Planning Center					

B.6.4.1.2. Barges

A total of 2,850 different barges moved on MKARNS in the year 2002. The barges ranged in size from 60′ in length by 30′ in width and 6′ in maximum draft to 312′ in length by 54′ in width and 15′ in maximum draft.

There are three principle types of barges used on MKARNS: 1) sand flats; 2) jumbo barges; and 3) tankers. Each type is suited to a particular trade.

Sand flats are typically used to transport sand and gravel dredged from the river to land-side processing plants. The distances are short and each barge is generally moved as it is loaded. In sum, these are typically small tows moving short distances. The typical sand flat measures 60′ to 140′ in length by 30′ in width and 6′ to 9′ in draft.

As illustrated in Figure 2, jumbo barges are the workhorses of the fleet and are used to ship nearly all "dry" commodities, including farm products and coal. In the case of wheat and other perishables, the barges may be covered to protect the commodity en-route. Jumbo barges are used for both short and long distance trips and in both small and large tows. A jumbo barge measures 195′ in length by 35′ in width and 12′ in maximum draft.

Tanker barges are used to transport liquid commodities, such as petroleum products and chemicals. Because of the real and/or potentially hazardous nature of the products, the number of loaded tanker barges in a tow is generally kept to a small number, even though the distances are often long. A typical tanker barge used on MKARNS measures 150′ to 312′ in length by 54′ in width and 9′ to 15′ in maximum draft.

A listing of the number and characteristics of the major types of barges moved on the MKARNS in the years 2001 and 2002 are listed below. Jumbo barges represent the dominant type barge used on the waterway. Jumbo barges can be loaded to 12′ draft.

Barges are used efficiently on the MKARNS, as illustrated by the data in Table 6-19. Sixty-nine percent are loaded, which implies that 38 percent are loaded on both legs of the round trip. Given that many trips are short sand and gravel movements and that others are tanker shipments, the percentage is high. The data also indicate a high average load per loaded barge at between 1,400 and 1,550 tons. For reference, a typical 195′ x 35′ barge loaded to 9′ would haul 1,500 tons. Surprisingly the highest loads are at the upper river projects. The explanation is that most of these shipments traverse the entire waterway en-route to New Orleans, and therefore they are loaded to the maximum extent possible

Table 6-18. Barge Characteristics					
	Class	**Unique Barges**	**Length**	**Width**	**Draft**
2001	1 – sand flats	185	60'-140'	30'	6'-9'
	2 – tanker	31	150'-180'	54'	9'-15'
	3 – jumbo	2,327	195'-200'	35'	12'
	4 – tanker	104	220'-312'	54'	9'-15'
Average			192'	36'	n.a.
2002	1 – sand flats	260	60'-140'	30'	6'-9'
	2 – tanker	22	150'-180'	54'	9'-15'
	3 – jumbo	2,456	195'-200'	35'	12'
	4 – tanker	112	220'-312'	54'	9'-15'
Average			189'	35'	n.a.
Source: Huntington District Navigation Planning Center					

Table 6-19. Barge Loadings – 2001					
Project	**Tons**	**Barges**	**Loaded Barges**	**% Loaded**	**Tons/Loaded Barge**
Montgomery Point	n.a.	n.a.	n.a.	n.a.	n.a.
Norrell	8,697,000	9,016	6,051	0.67	1,437
L&D 2	8,691,000	9,008	6,033	0.67	1,441
Joe Hardin	8,086,000	8,401	5,623	0.67	1,438
Emmett Sanders	8,100,000	8,458	5,630	0.67	1,439
L&D 5	7,547,000	7,794	5,207	0.67	1,449
David D. Terry	7,493,000	7,764	5,198	0.67	1,442
Murray	6,744,000	7,063	4,669	0.66	1,444
Toad Suck Ferry	6,527,000	7,137	4,689	0.66	1,392
Arthur V. Ormond	6,503,000	7,076	4,625	0.65	1,406
Dardanelle	6,751,000	7,103	4,654	0.66	1,451
Ozark-Jeta Taylor	4,600,000	3,998	3,085	0.77	1,491
James W. Trimble	4,611,000	4,048	3,098	0.77	1,488
W.D. Mayo	4,324,000	3,617	2,804	0.78	1,542
Robert S. Kerr	4,340,000	3,641	2,819	0.77	1,540
Webbers Falls	4,184,000	3,480	2,700	0.78	1,550
Chateau	3,633,000	3,169	2,394	0.76	1,518
Newt Graham	3,479,000	3,068	2,285	0.74	1,523
Total	104,310,000	103,841	71,564		
Average	6,135,882	6,108	4,210		1,470
Overall % Loaded Barges				0.69	
Overall Average Tons per Loaded Barge					1,458
Source: LPMS Summary by Division/District					

B.6.4.1.3. Tows

The average MKARNS tow has 6.9 barges and the average number of tons per tow is nearly 7,000. The number of barges per tow ranges from between five and six at the upper five projects to between six and eight at the lower projects. The lower numbers at the upper projects is partly due to the narrow width of the Verdigris River, which restricts the size of tows that can navigate the river. Related to this, the upper projects also do not have tow haulage units. Tow characteristics by project are given in Table 6-20.

A more detailed breakdown of the size of tows moving on the river is given in Table 6-21. Seventy-four percent of the tows have eight or fewer barges, which is significant in that the maximum number of typically sized barges that can lock through the projects in a one-cut lockage operation is eight. The percent of tows with nine or more barges approximates the percent of tows that would require two-cut lockage operations. The data indicate that 24% or about one in four of the tows may require two-cut lockage operations. (Note: Average for "eight or fewer" equals 76%; therefore, 24% are nine or more).

Table 6-20. Tow Characteristics – 2001

Project	Barges	Tows	Tons	Barges/ Tow	Tons/ Tow
Montgomery Point	n.a.	n.a.	n.a.	n.a.	n.a.
Norrell	9,016	1,347	8,697,000	6.7	6,457
L&D 2	9,008	1,341	8,691,000	6.7	6,481
Joe Hardin	8,401	1,111	8,086,000	7.6	7,278
Emmett Sanders	8,458	1,159	8,100,000	7.3	6,989
L&D 5	7,794	1,023	7,547,000	7.6	7,377
David D. Terry	7,764	1,013	7,493,000	7.7	7,397
Murray	7,063	912	6,744,000	7.7	7,395
Toad Suck Ferry	7,137	910	6,527,000	7.8	7,173
Arthur V. Ormond	7,076	905	6,503,000	7.8	7,186
Dardanelle	7,103	976	6,751,000	7.3	6,917
Ozark-Jeta Taylor	3,998	617	4,600,000	6.5	7,455
James W. Trimble	4,048	662	4,611,000	6.1	6,965
W.D. Mayo	3,617	602	4,324,000	6	7,183
Robert S. Kerr	3,641	606	4,340,000	6	7,162
Webbers Falls	3,480	608	4,184,000	5.7	6,882
Chateau	3,169	596	3,633,000	5.3	6,096
Newt Graham	3,068	582	3,479,000	5.3	5,978
Total	103,841	14,970	104,310,000		
Total Barges Per Tow				6.9	
Total Tons Per Tow					6,968

Source: LPMS Summary by Division/District

Table 6-21. Barges per Tow – 2001						
Project	**3 or fewer**	**6 or fewer**	**8 or fewer**	**15 or fewer**	**20 or fewer**	**Total Tows**
Montgomery Point	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Norrell	29%	51%	69%	99%	100%	1,352
L & D 2	29%	50%	69%	99%	100%	1,347
Hardin	21%	41%	62%	99%	100%	1,116
Sanders	24%	43%	63%	99%	100%	1,165
L & D 5	18%	41%	63%	99%	100%	1,028
Terry	18%	41%	63%	99%	100%	1,016
Murray	16%	38%	65%	99%	100%	915
Toad Suck Ferry	15%	38%	65%	99%	100%	914
Ormond	30%	61%	89%	99%	99%	908
Dardanelle	35%	64%	89%	99%	99%	979
Ozark	19%	51%	80%	100%	100%	621
Trimble	25%	54%	82%	100%	100%	666
Mayo	20%	56%	87%	100%	100%	603
Kerr	20%	56%	87%	100%	100%	607
Webber Falls	22%	61%	89%	100%	100%	610
Chouteau	28%	70%	93%	99%	99%	596
Graham	25%	69%	91%	100%	100%	582
Total	**24%**	**50%**	**74%**	**99%**	**100%**	**15,025**

A review of tows by length yields similar results. If all tows greater than 730´ in length require a two-cut lockage and all tows less than 730´ in length require a one-cut lockage, then the percent of tows requiring a two-cut lockage is 24%, as shown in the table below. The comparable number based on the assumption that tows with nine or more barges would require a two-cut lockage was 26%. The 730´ length was based on a tow configured with eight barges pushed by a 130´ towboat. At the lock, the towboat would "set over" into empty slot where there would normally be a ninth barge and lock through the project as a single unit. Again, the data provide approximate values since there is variation in the length and number of the barges and the length of the towboat. In fact, some portion of the tows in the 600´ to 730´ length category actually required two-cut lockages based on an examination of the individual LPMS lockage records. To reflect the uncertainty in the percent of tow requiring one and two-cut lockages, the lock simulation model which is described later on used a range of probabilities for one and two-cut lockages rather than point estimates, such as 24%. The numbers of one and two-cut lockages are important when evaluating the effects of increased traffic on delays at the locks since a two-cut operation typically takes more than twice the time of a one-cut operation.

Table 6-22. Length of Tows – 2001				
Project	**Less than 600´**	**>600´ and <730´**	**Greater than 730´**	**Total**
Montgomery Point	n.a.	n.a.	n.a.	n.a.
Norrell	39%	36%	25%	1,352
L & D 2	39%	35%	25%	1,347
Hardin	32%	36%	32%	1,116
Sanders	35%	34%	31%	1,165
L & D 5	31%	37%	32%	1,028
Terry	31%	37%	32%	1,016
Murray	30%	40%	30%	915
Toad Suck Ferry	30%	40%	31%	914
Ormond	36%	41%	23%	908
Dardanelle	40%	39%	21%	979
Ozark	32%	51%	17%	621
Trimble	37%	47%	15%	666
Mayo	34%	51%	15%	603
Kerr	34%	51%	15%	607
Webber Falls	36%	52%	12%	610
Chouteau	45%	47%	8%	596
Graham	45%	47%	8%	582
Total	**35%**	**41%**	**24%**	**15,025**

B.6.4.2. Future Fleet

The future "without" project fleet is expected to be the same as the existing fleet but with one major change and one minor change in the "averages". The major change is due to the planned changes in the reservoir operations, which are expected to increase the average number of barges per tow from 6.9 to 7.9. The minor change is due to different growth rates projected for the different commodities. Since the commodity shipments typically move in different size tows, differences in commodity growth rates will result in a change in the average size tow. The future "with" project fleet will also change in terms of the average "tons per tow" as barges are more heavily laden to take advantage of deeper channel depths.

B.6.4.3. Other River Segments

The existing and future fleets are limited in terms of barge loadings by the depth of the river, which restricts barges to about 9´ in draft, depending on river conditions. The lower Mississippi River, which is the principle route of traffic moving onto or off MKARNS, is authorized at 12´. The same is true of the Gulf Intracoastal Waterway (GIWW) while most of the remainder of the inland navigation system is designed to allow barges loaded to 9´ in draft. Lesser or greater depths may be available at times depending on weather, dredging frequencies and natural conditions. Most barges are designed to load up to 12´ in draft, but there are exceptions. In many cases sand and gravel barges are designed for a maximum of 6´ in draft, some tanker barges are limited to 9´ draft, and some commodities such as steel are loaded to 9´ or less to

avoid shifting of loads within the barge. Given these qualifications, the following table lists the percentages of barges of greater than or equal to 10′ in draft and less than or equal to 9′ in draft that moved on different waterways in the year 2001. The highest percent of barges loaded to 10′ draft or more is on the GIWW at 7.7% followed by MKARNS at 5.7%. The more distant from the Gulf, the lower the percentage of heavily loaded barges.

Table 6-23. Percent of Barges by Draft on Other Rivers

Waterway	>=10′	<=9′	Barges
MKARNS	5.7%	94.3%	26,668
GIWW	7.7%	92.3%	225,205
Illinois	1.6%	98.4%	47,521
Ohio	3.2%	96.8%	396,591
Tennessee	3.0%	97.0%	75,445
Tombigbee-Black	4.2%	95.8%	26,865
Upper Miss (St. Louis)	3.0%	97.0%	64,467

Source: WCSC, Part 2, 2001.

Another source for barge data is LPMS, and this source indicates more severe restrictions on loadings on MKARNS than do the waterborne commerce data. The loadings at selected locks on the different major waterway segments are significantly higher than the loading at Norrell, which would indicate restrictions on MKARNS. The key locks were selected on the basis that they are located near the segment's mouth, just as Norrell is the furthest project downstream on MKARNS. The implications are that a wide range of shipments off MKARNS could benefit from a deeper channel and not only the traffic moving to/from the Gulf Coast area.

Table 6-24. Barge Loading on Other Rivers

River System	Site for Data	Tons/barge
Arkansas	Norrell	1,477.4
Lower Miss/GIWW	Harvey	1,668.1
Ohio	Smithland	1,653.0
Ohio	Greenup	1,649.0
Tennessee	Kentucky	1,622.2
Upper Miss	Melvin Price	1,617.9
Upper Miss	L&D 15	1,556.3
Illinois	O'Brien	1,525.1

The pathways for tows drafting more than 9′ are shown in the following table. The tables are based on tonnage and shipments moving internally on the MKARNS, or between MKARNS and other portions of the inland navigation system. Farm products and agricultural chemicals are the major beneficiaries of channel deepening. Non-metallic minerals rank first in terms of total MKARNS tonnage but third in terms of tonnage that could move in deeper draft barges.

Table 6-25: Percent of Total Tons that Move in Deeper Draft Barges by River Basin Of Origin/Destination						
				As a Percent of Total That Benefits		
	Tons (1000's)	% of Total Tonnage	% of Tons that Benefit	10-feet	11-feet	12-feet
Reach						
Mouth to Pine Bluff	1,134	10%	61%	12%	12%	12%
Pine Bluff to Little Rock	1,767	15%	28%	9%	9%	9%
Little Rock to Ozark	2,489	21%	33%	15%	15%	15%
Ozark to Fort Smith	1,288	11%	7%	2%	2%	2%
Fort Smith to Muskogee	631	5%	50%	6%	6%	6%
Muskogee to Catoosa	4,274	36%	73%	56%	56%	56%
White River	301	3%	0%	0%	0%	0%
Total	11,884	100%	47%	100%	100%	100%
Region						
Arkansas River (Internal)	2,558	22%	1%	0%	0%	0%
GIWW East	168	1%	93%	3%	3%	3%
GIWW West	310	3%	40%	2%	2%	2%
Lower Miss	7,035	59%	69%	88%	88%	90%
Ohio	696	6%	23%	3%	3%	1%
Tennessee	186	2%	89%	3%	3%	3%
Tenn-Tom	80	1%	0%	0%	0%	0%
Upper Miss	809	7%	7%	1%	1%	0%
White River	41	0%	0%	0%	0%	0%
Total	11,884	100%	47%	100%	100%	100%
Commodity						
Farm Products	2,835	24%	84%	43%	43%	44%
Metals	1,242	10%	35%	8%	8%	8%
Coal	273	2%	96%	5%	5%	4%
Crude Petroleum	-	0%	-	0%	0%	0%
Non-Metallic Minerals	4,730	40%	20%	17%	17%	18%
Forest Products	91	1%	0%	0%	0%	0%
Industrial Chemicals	243	2%	2%	0%	0%	0%
Agricultural Chemicals	1,871	16%	76%	26%	26%	26%
Petroleum Products	523	4%	15%	1%	1%	1%
Others	77	1%	0%	0%	0%	0%
Total	11,884	100%	47%	100%	100%	100%

Table 6-26: Percent of Shipments that Move in Deeper Draft Barges by River Basin Of Origin/Destination						
				As a Percent of Total That Benefits		
	Shipments	% of Total Shipments	% of Shipments that Benefit	10-feet	11-feet	12-feet
Reach						
Mouth to Pine Bluff	201	16%	70%	16%	16%	16%
Pine Bluff to Little Rock	196	15%	66%	15%	15%	15%
Little Rock to Ozark	117	4%	29%	4%	4%	4%
Ozark to Fort Smith	70	4%	50%	4%	4%	4%
Fort Smith to Muskogee	102	9%	75%	9%	9%	9%
Muskogee to Catoosa	624	52%	71%	52%	52%	51%
White River	37	0%	0%	0%	0%	0%
Total	1,347	100%	64%	100%	100%	100%
Region						
Arkansas River (Internal)	70	5%	1%	1%	1%	1%
GIWW East	43	3%	3%	5%	5%	5%
GIWW West	56	4%	2%	3%	3%	3%
Lower Miss	972	72%	52%	82%	82%	86%
Ohio	82	6%	3%	4%	4%	1%
Tennessee	27	2%	2%	3%	3%	2%
Tenn-Tom	5	0%	0%	0%	0%	0%
Upper Miss	87	6%	2%	2%	2%	1%
White River	5	0%	0%	0%	0%	0%
Total	1,347	100%	64%	100%	100%	100%
Commodity						
Farm Products	388	29%	83%	37%	37%	38%
Metals	196	15%	44%	10%	10%	10%
Coal	31	2%	87%	3%	3%	2%
Crude Petroleum	0	0%	-	0%	0%	0%
Non-Metallic Minerals	178	13%	32%	7%	7%	6%
Forest Products	22	2%	0%	0%	0%	0%
Industrial Chemicals	35	3%	6%	0%	0%	0%
Agricultural Chemicals	414	31%	84%	41%	41%	42%
Petroleum Products	57	4%	26%	2%	2%	1%
Others	26	2%	0%	0%	0%	0%
Total	1,347	100%	64%	100%	100%	100%

B.6.5. Transportation Cost Analysis

B.6.5.1. Rate Study – Flow Management Components

The 2001 Rate Study for Flow Management Components was conducted by the Tennessee Valley Authority (TVA) under contract with the Little Rock District of the U.S. Army Corps of Engineers (Corps) in order to facilitate the calculations of the National Economic Development (NED) benefits attributable to variations in flow rates on the Arkansas River. The study provides a full range of transportation rates and supplemental costs for a sampling of one hundred five

(105) 1998 waterborne commodity movements, which, in total or in part, were routed on the MKARNS.

Freight rates for each sample movement are calculated based on the actual water-inclusive routing, as well as for a competing all-land alternative. In addition, up to thirteen alternative tow size and horsepower configurations were included to compare the economic change in the adjustment of the flow rates when compared to the normal or current release practice. Currently, the average towboat horsepower is 2170, and the average tow configuration is 7. Thirteen configurations of average towboat horsepower and average tow configuration are in Table 6-27. Rate alternatives 1 through 12 are combinations of increased/decreased average towboat horsepower and increased/decreased average tow configurations. Rate alternative 13 increases tow configuration and has no change in towboat horsepower. For example, compared to current operations, rate alternative 1 is a decrease in horsepower with no change in tow configuration.

All computations reflect those rates and fees, which were in effect on March 1, 2001. Results are documented on a movement-by-movement basis, including a separate worksheet for each observation. These disaggregated data are also integrated into individual spreadsheets for each of six commodity groupings. A full description of the study's scope and guidelines, TVA's methods of rate research and construction, and supporting assumptions are provided in following paragraphs.

Table 6-27. Rate Alternative Tow Size and Horsepower Configurations

Rate Alternative	Towboat Horsepower	Tow Configuration
1	1800	7
2	1400	7
3	3000	7
4	1800	8
5	1400	8
6	3000	8
7	1800	9
8	1400	9
9	3000	9
10	1800	6
11	1400	6
12	3000	6
13	2170	8

B.6.5.1.1. Rate Study Parameters

A sample of 105 movements was identified for inclusion in this analysis. Dock-to-dock tonnage over included origin destination pairs ranges between 10,000 tons and 302,751 tons annually, representing 30 individual commodities. Reported rates for both the water movement and the all-land alternative are based on the actual location of shipment origins and destinations.

1. **Water Routings.** Because many of the sample movements have off-river origins and/or destinations, a full accounting of all transportation costs for waterborne movements also requires the calculation of railroad and/or motor carrier rates for movement to or from the nearest appropriate port facility. Additionally, all calculations reflect the loading and

unloading costs at origin and destination; all transfer costs to or from barge; and any probable storage costs. Finally, though it was rarely a concern, all waterborne routings were constrained to include at least partial use of the MKARNS.

2. **Land Routes.** With the exception of over-sized shipments and intra-pool sand dredging, rail or truck rates are calculated for all movements. As in the case of the barge-inclusive routings, many all-land routes require the use of more than one transport mode. Therefore, when appropriate, calculations include all requisite transfer charges and/or storage charges.

3. **Seasonality and Market Anomalies.** To accurately reflect NED benefits, it is necessary to develop rates, which portray the normal market conditions, which are anticipated over the project life. For this reason, every attempt was made to purge the data of anomalous or transitory influences. As a part of all shipper surveys and interviews, respondents were directed to ignore temporary market disruptions and provide information reflective of "normal" operating conditions. Because of the commodity mix represented within the sample, we detected no need to adjust for seasonal fluctuations.

In the Arkansas River High Flow Study, three notable situations have emerged in respect to long-term cost efficiencies for the rail mode of transportation. First, prior rail mergers in 1996 through 1999 time periods have been completed. The result of these mergers is a decrease in the variable cost of the surviving carrier and a decrease in absolute rates to reflect the surviving carriers historic rate levels. Second, the Class 1 railroads continue to deploy larger rail cars and install heavier rail track capacity. Lading weights in excess of 115 tons for coal and grains frequently occur, reducing unit costs by 5% to 7% compared to the traditional 100-ton capacity rail cars. Third, the decline in volume in the export coal market has forced rail carriers to reduce coal pricing to selected export locations to maintain the viability of railroad owned transfer docks and terminals.

B.6.5.1.2. Judgments and Assumptions

Based on information collected from shippers, receivers, carriers, river terminal operators, stevedores, federal agencies, and private trade associations, TVA was able to identify probable origins and destinations for the majority of those movements that originated or terminated at off-river locations. In the absence of specific shipper/receiver information, it is assumed that the river origin and destination are the respective originating and terminating points for both river and alternative modes of transportation. In every case, an attempt was made to gather information from all shipping ports. However, in some instances, 2001 logistical data are not available from these ports. In other cases, port representatives declined to provide the requested information.

Specific commodity groups are discussed in more detail later in this section. However, for those movements that originate or terminate at a river port location, it is assumed that the shipper or receiver could also utilize rail service if that port is rail served. Exceptions to this assumption are noted on individual worksheets. When the shipper or receiver is served by truck only, a railroad team track or transfer facility at the station nearest the off-river shipper or receiver is used for the

land alternative. Only those shippers who ship more than 100,000 tons annually and who are adjacent to rail tracks would be assumed to undertake the significant capital expenditures necessary to acquire direct rail service. No consideration is given to private car leasing costs and mileage allowances made by carriers to shippers for the use of private equipment are also ignored.

In all cases, it is assumed that the alternative modes of transportation would have the physical capacity to accommodate the additional tonnage represented by each commodity movement. Commodity specific judgments and assumptions include:

1. **Coal.** A number of assumptions are made for land haul rates on the movements of coal to utility destinations that are not rail served. Volumes to these destinations are, in many cases, substantial, so that long-haul truck transportation cannot be considered a viable option. In the absence of water transportation, receiving utilities would have to carefully evaluate those available options, which might insure their ability to continue to receive large volumes of coal. These considerations might include the replacement cost of new or improved highway access, the economies of buying or leasing rail equipment, and the possibility of shifting origins to assure adequate coal supply. We may assume that rail carriers would be willing to construct additional track capacity if volumes are sufficient. However, these construction costs would most likely be passed on to the shipper via higher rates.

   To accommodate those instances in which sample barge movements are to non-rail served utilities, we have incorporated the following judgments and assumptions. If the receiving utility is not rail served, rates are applied to the nearest railhead and trucking costs from the railhead to the destination are applied. If the shipping point is not rail served, a motor carrier charge is applied from the mine origin to the nearest railhead. It is assumed that transfer facilities would be available at both origin and destination for transfer between rail and truck.

   If the receiving utility is rail served for supplies only, but not coal, the rail car unloading cost of the utility is inflated to accommodate an on-site truck shuttle to the coal stockpile. In some instances, movements involve a truck haul from multiple origins to a concentration or preparation point for loading to rail. In these instances, where shipments originate at several mines within the same general area, a representative rail origin is selected as the transfer location.

2. **Aggregates.** Land haul rates on limestone reflect the modes necessary to transport the shipments from actual origins to actual destination. If origins or destinations are not rail served, a trucking charge is applied from the nearest rail station. For those movements where both rail and truck transportation are an option, truck hauls are limited to a distance of 100 miles. This, on occasion results in slightly higher rates. However it was deemed impractical, in the absence of water transportation, to transport large volumes of these commodities for long distances by truck transport include lower cargo carrying capacity, the inability to round-trip more than two times per day, and the absence of loaded back-haul opportunities.

With regard to waterway improvement materials, we assume that land movements would require a truck haul at the destination for delivery to riverbank work locations. These truck movements would likely average ten miles each. It should be noted that a significant amount of channel improvement and bank stabilization work is conducted off shore or at locations without highway access, making land transportation impractical. For this study the measurement of the land transportation cost for dredged sand and gravel was not computed.

3. **Grain.** The computation of rates for grain is based upon the survey responses of the shippers and receivers. Specifically, if a country elevator gathers grain then ships it to the river terminal, we assume a 20-mile track haul from the farmer's field to the country elevator. For domestic and export shipments, the computation of rail rates is based on the track capacity of the country elevator or domestic receiver. We assume that the grain shipper would maximize the use of his facilities and utilize gathering rates to reach the track capacity of the receiver.
   Notable within the computational method is our use of both rail costing models and tariff rates. When applicable tariff rates are published, the tariff rate is used in the land rate computation and the modeled rate is shown in a footnote.[1] Since the rail tariff rates generally use the short line miles, the actual tariff miles were computed for both the cost model and grain tariff rates. No consideration is given to the Burlington Northern Santa Fe Certificate of Transportation (COT) program, the Union Pacific Railroad Gain Car Allocation System, OT-5 authority decision by rail carriers or the C6-X covered hopper car rate structure on grain.[2]

B.6.5.1.3. Methods and Procedures

As a result of the flexibility created by surface transportation deregulation, it is sometimes difficult to determine the exact rate charged by a carrier on shipments moving under contract. However, rates are a matter of negotiation between shipper and barge line operator, and these rates are not published in tariff form. Each carrier's rates are based on individual costs and specific market conditions, so that these rates will vary considerably between regions, across time, and from one barge line to another.

Contract rates are also common in pipeline, rail and motor carrier transportation, and like barge rates, may be maintained in complete confidentiality. In other cases (particularly grain), tariff rates are still applied. However, there is rarely any dependable means for determining whether a contract rate or a tariff rate should be used to price a particular movement. A further complication is the use of rebates and allowances as an incentive by carriers to shippers to induce higher traffic volumes.

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[1]Use of contract rates for the movement of grains appears to have peaked in 1986 when approximates 40% of all grain moved under contract. Since that time, a number of Class I carriers have returned to the use of traditional tariffs as the basis for rate calculations.

[2] C6-X cars are the over-sized covered hoppers, holding 110 tons of grain each. They were introduced by some carriers beginning in 1994.

For the purposes of this study, actual rates, as provided by shippers, receivers, or river port operators, are used whenever possible. Sources for these rates are identified by footnotes within the worksheets for the individual movements. All other rates were obtained from published sources or, when this was not possible, estimated by TVA based on the mode of transportation, the tonnage, and other shipment characteristics. All rates, whether actual or estimated, are based on those that were in effect March 1, 2001. However, when necessary, reported rates have been refined to eliminate seasonal impacts or the effects of abnormal market conditions. The methodologies employed in the estimation of unobservable rates were developed through extensive contacts with shippers, railroads, motor carriers, and the barge industry. This information was often integrated with confidential federal data and/or the output of computerized simulation and costing models. This process was both guided and augmented by in-house TVA rating and costing expertise developed through decades of experience as a major shipper of coal and other bulk commodities and through the implementation of navigation-based economic development programs throughout the Tennessee River Basin.

1. **Barge Rates.** Barge rates are calculated through the application of a computerized barge-costing model developed by TVA. The TVA model has been refined to include 1999 fixed and variable cost information obtained directly from the towing industry and from 1999 data published within the Corps' annual Estimated Towboat and Barge Line-Haul Cost of Operating on the Mississippi River System.

   The TVA model contains three costing modules: a one-way general towing service module, a round-trip dedicated towing service module, and a round-trip general towing service module. The one-way module calculates rates by simulating the use of general towing conditions between origin and destination, including the potential for a loaded return. The dedicated towing service module calculates costs based on a loaded outbound movement and the return movement of empty barges to the origin dock. The round-trip general towing service module is similar to the one-way, except that it provides for the return of empty barges to the point of origin. This module does not calculate costs for towboat standby time during the terminal process but does include barge ownership costs for both the terminal and fleeting functions. It does not require that the empty barges be returned with the use of the same towboat. Depending on the module in use inputs may include towboat class, barge type shipment tonnage, the interchange of barges between two or more carriers, switching or fleeting costs at interchange points or river junctions, and barge ownership costs accruing at origin and destination terminals, fuel taxes, barge investment costs, time contingency factors, return on investment and applicable interest rates.

   Barge rates on dry commodities are calculated with the use of general towing service round-trip costing module. Inputs, based on information from carriers and the Corps' Lock Performance Monitoring System (LPMS) database were programmed into the module to simulate average towboat size (horsepower) and corresponding tow size (barges) for each segment of the Inland Waterway System. Other inputs include barge types, waterway speeds, horsepower ratios and empty return ratios.

An example of a typical shipment cost in this analysis would be a dry bulk commodity (sea shells) originating on the Mobile River at Mobile, Alabama and terminating on the Ohio River at Cincinnati, Ohio. Based on the modeling process, this shipment would be assumed to move in a four-barge tow from Mobile to the Mississippi River at New Orleans, a twenty four-barge tow from New Orleans to Cairo, and a fifteen-barge tow from Cairo to Cincinnati. At each interchange point, appropriate fleeting charges would be calculated. Empty return (back haul) factors would also be included for each segment of the movement.

Barge rates for asphalt, heavy fuel oils, nitrogen fertilizer solution and light petroleum products are calculated using the dedicated service round-trip costing module. Twenty-four hours standby time is allocated at origin and destination for towboat terminal functions. Finally, rates for sodium hydroxide, lubricating oils, liquid chemicals, and molasses are calculated using the general service round-trip costing module. Because of comparable barge sizes, these commodities normally move in the same tow with dry commodities.

Barge rates calculated by the use of the TVA model reflect charges that would be assessed in a period of traditional demand for waterway service. It should be noted that the model does not explicitly consider market factors such as intra or inter-modal competitive influences, favorable back haul conditions created by the traffic patterns of specific shippers, or the supply and demand factors which affect the availability of barge equipment. These and other factors can influence rate levels negotiated by waterway users. The model does, however, calculate rates based on the overall industry's fully allocated fixed and variable cost factors, including a reasonable rate of return on assets. It is TVA's judgment that the rates are representative of the industry and provide a reasonable basis for the calculation of NED benefits.

2. **Railroad Rates.** As in the case of barge, reported rail rates are used in every case for which they are available. However, in the face of incomplete information, most movements require the calculation of probable railroad rates. For grain and feed ingredients, two methods are used. First, the appropriate tariff rate is identified. Next, the Rebee Rail Costing Model (RCAM) is used to generate an estimate of rail movement cost. This cost was then inflated to reflect rail carrier market power in order to produce a final estimate of the most likely rail rate.

   Rates for all other commodities are calculated based on the Rebee cost estimates plus an appropriate mark-up. Market-up factors and shipment characteristics were determined through a variety of means, with shipper information being the preferred source. However, in the absence of a superior source information from the Interstate Commerce Commission's annual Carload Waybill Sample was used.[3]

[3] In addition to shipper information and the Carload Waybill Sample, shipment characteristics were also identified from Association of American Railroads publications.

3. **Motor Carrier Rates.** Actual truck rates for off-river movements are used whenever possible. All other rates are estimated based on published motor carrier tariffs or regional rate quotations from truck brokers and contract motor carriers.

4. **Handling Charges.** Handling charges between modes of transportation are estimated based on information obtained from shippers, receivers, stevedores, and terminal operators. Handling charges for transfer of commodities from or to ocean-going vessels are based on information obtained from ocean ports or stevedoring companies. For import or export movements that involved mid-stream transfer operations, handling costs to or from land modes at a competing port with rail access are applied.

   Except as noted within individual worksheets, it is assumed that movements of bulk products (for example, grain or fertilizer) would be handled through elevators or storage facilities. It was also assumed that liquid commodities transferred between modes would require tank storage. Additional costs are incurred at both river and inland locations if shipments remain in storage past the free-time period allocated by the facilities involved. Storage charges are usually assessed on a monthly basis.

5. **Loading and Unloading Costs.** Because shippers and receivers do not usually document loading and unloading costs, they are particularly difficult to obtain.[4] Moreover, these costs can vary considerably across firms. In an attempt to provide the best possible estimates of these costs, we use available shipper and receiver information in combination with data from Corps studies performed by other researchers, as well as previous TVA studies. These data are revised to reflect 2001 conditions then averaged as required. In those cases where varying sources produced disparate estimates, we relied most heavily on shipper and receiver estimates.

B.6.5.1.4. Methodological Standards

Two points should be noted regarding the methodological standards applied within this study. First, the standards described above reflect essentially the same processes TVA has applied (or will apply) in developing transportation rates for other recent (or ongoing) Corps studies. Specifically, the outlined methodology was used in the 1996 Ohio River Study and the Upper Mississippi Navigation Feasibility Study and is being applied in the Missouri River Master Manual Review process and Port Allen Cutoff assessment. Thus, inter-project comparisons are facilitated by this uniform approach. More importantly, recent methodological improvements enable TVA to produce transportation rate/cost materials which are, simultaneously, more complete and more reliable than the transportation data TVA (or any other agency) has produced for similar studies in the past. Each rate study for each District of the Corps is integrated into a series of databases for quick accessibility and data manipulation.

[4] Loading and unloading costs are often considered a part of throughput or production costs.

B.6.5.1.5. Benefits to Users

Savings from the various alternative towsize and vessel horsepower configuration for each of the five general towing commodity groupings and for each of the three dedicated towing commodity groupings are summarized in Table 6-28. Using the summary data, the NED transportation savings with changes in tow size and/or horsepower can be computed.

As an example, if a new operating plan for the Arkansas River would reduce the peak or average flow rates, then general towing operators could increase tow size from the current average of seven barges to an average of eight barges per tow and reduce horsepower from 2170 hp to 1800 hp. In this situation, the savings from rate alternative 4 would apply with grain shipping adding $0.64 per ton with increased operator savings. Likewise, if flow rates increase and operators reduce tow size from seven to six barges and increase horsepower from 2170 hp to 3000 hp, then rate alternative 12 would apply for a reduction in NED benefits of $1.00 per ton for grain. It should be observed that if dedicated towing operators of chemicals are required to increase horsepower from 2170 hp to 3000 hp but maintain tow size, then dedicated towing chemical shippers would modal shift to the land alternative.

Table 6-28. Shipper Savings by Commodity Grouping (Oct 2001 $)

Rate Alternatives	Grain & Grain Products	Chemicals	Iron & Steel	Manufactured Products	Aggregates	Petroleum Products	Liquid Fertilizer	Dredged Sand & Gravel
1	$0.38	$0.48	$0.41	$0.42	$0.44	$0.79	$2.41	$0.04
2	$0.70	$0.86	$0.74	$0.78	$0.82	$0.79	$2.41	($0.18)
3	($0.50)	($0.19)	($0.49)	($0.56)	($0.59)	($1.14)	($3.20)	($0.03)
4	$0.64	$0.79	$0.68	$0.71	$0.75	$1.29	$3.95	$0.06
5	$0.92	$1.13	$1.01	$1.02	$1.08	$1.29	$3.95	$0.06
6	($0.13)	($0.02)	($0.04)	($0.13)	($0.15)	($1.14)	($3.20)	($0.03)
7	$1.61	$1.04	$1.04	$0.94	$0.99	$0.79	$2.41	$0.04
8	$1.09	$1.32	$1.16	$1.22	$1.29	$1.29	$3.95	$0.08
9	$0.16	$0.22	$0.19	$0.18	$0.19	$0.50	$1.54	$0.03
10	$0.02	$0.05	$0.06	$0.03	$0.03	($1.39)	($4.29)	($0.08)
11	$0.40	$0.51	$0.44	$0.44	$0.47	($0.39)	($1.22)	($0.18)
12	($1.00)	($1.19)	($0.99)	($1.11)	($1.18)	($4.14)	($12.68)	($0.25)
13	$0.26	$0.39	$0.31	$0.29	$0.30	$1.29	$3.95	$0.06

B.6.5.2. Rate Study – Navigation Channel Deepening Components

The Tennessee Valley Authority (TVA) under contract with the Little Rock District of the U.S. Army Corps of Engineers (Corps) conducted the 2003 Rate Study for Navigation Channel Deepening Components in order to facilitate the calculations of the National Economic Development (NED) benefits attributable to variations in channel depth on the MKARNS. The study provides a full range of transportation rates and supplemental costs for 1,341 waterborne commodity movements, which, in total or in part, were routed on the MKARNS. Storage and the construction of warehousing were excluded in the development of the transportation rates.

Freight rates for each movement are calculated based on the actual water-inclusive routing, as well as for a competing all-land alternative. In addition, rates for deeper channel depths were calculated to compare the economic change in the adjustment to deeper drafts when compared to the current drafts.

The rates are expressed in US dollars per net ton with a base time period of the third quarter 2003. Results are calculated on a movement-by-movement basis, including a separate worksheet for each observation. A full description of the study's scope and guidelines, TVA's methods of rate research and construction, and supporting assumptions are provided in following paragraphs.

B.6.5.2.1. Rate Study Parameters

The rate study consists of 1,341 sample movements in ten commodity groups: grain and grain products; manufactured products; coal; crude petroleum; aggregates, cement, salt, gypsum, and barites; forest products; chemicals; fertilizers; petroleum products; and slag, shells, waste products, and miscellaneous manufactured equipment. The rates are based upon the actual off waterway location of the origin and destination of the commodities identified.

1. **Water Routings.** The starting or ending point for the water routing was the off-river production or distribution point. Another point was the deep water vessel import or export dock for the commodity. The water route includes handling charges at each modal interchange or interface. Because most commodities require a rail or truck haul from/to the river, the appropriate rail or truck rate is included in the rate calculations.

   Each of the water routings and the subsequent depth alternatives have incorporated the proposed river operating changes that were developed in the Flow Management section of this study. In addition, it is assumed that the dock owners and operators would either dredge or construct the necessary access to the main channel after the deeper draft improvements were made in order to gain the increased shipper benefits. Last, the benefits of widening the Verdigris River were not computed.

2. **Land Routing.** For each movement, a land alternative was examined and, where appropriate, a truck segment was added to gain access to rail shippers or receivers. The rail and truck option was evaluated for each movement, and the lesser of the two cost options was selected. When the trucking option was selected, the shortest highway mileage utilizing the Household Goods Carrier's Bureau was shown. At each modal interface, handling charges of the transfer of the commodity were calculated.

3. **Alternative Vessel Routing.** As an aid to the evaluation of the NED benefits, alternative sets of rates, where appropriate, have been developed for each movement. In these alternatives, barge rates with ten, eleven, and twelve-foot depth capability were developed. It should be noted that the following metrics were employed to constrain the economics of deeper draft barge equipment.

   Equipment: Tank barge and flat deck barges were constrained to a nine-foot draft.

Commodities: Annual shipments of less than 1300 tons, low-density commodities such as wood chips, and linear constrained commodities such as coil steel were constrained to nine-foot draft.

Waterway: The draft capacity of each individual waterway project was applied (Illinois, Red, Tenn-Tom nine-foot draft, Ohio River above Smithland Lock, Cumberland, Upper Miss above St Louis ten-foot draft; and Tennessee eleven-foot draft).

One further limit on the economics computation was the towing industry practice of limiting depth to an average of 11´6" when available maximum depth is 12´. The problem is that the towing industry allows up to six inches "out of level" for a dry cargo hopper barge. The maximum 12´ depth was limited to 11´6" depth for rate computations.

4. **Seasonality and Market Anomalies.** To accurately reflect NED benefits, it is necessary to develop rates, which portray the normal market conditions, which are anticipated over the project life. For this reason, every attempt was made to purge the data of anomalous or transitory influences. As a part of all shipper surveys and interviews, respondents were directed to ignore temporary market disruptions and provide information reflective of "normal" operating conditions. As a result of the commodity mix represented within the sample, we detected no need to adjust for seasonal fluctuations.

B.6.5.2.2. Judgments and Assumptions

Based on information collected from shippers, receivers, carriers, river terminal operators, stevedores, federal agencies, and private trade associations, TVA was able to identify probable origins and destinations for the off-river shipments. In the absence of specific shipper/receiver information, it is assumed that the river origin and destination are the terminating points for both the barge and alternative modes of transportation. In every case, an attempt was made to gather information from shipping ports. However, in some instances port representatives declined to provide requested information.

For those movements that originate or terminate at a river port location, it is assumed that the shipper or receiver could utilize rail service if that port is rail served. When the shipper or receiver is served by truck only, a railroad team track or transfer facility at the station nearest the off-river shipper or receiver is used for the rail alternative. No consideration is given to private car leasing costs and mileage allowances made by carriers to shippers for the use of private equipment.

In all cases, it is assumed that each mode of transportation and each shipper would have the physical capacity to accommodate the additional tonnage represented by each commodity movement. Specifically, carriers would commit the required equipment, and shippers would provide the track capacity to load the commodities.

B.6.5.2.3. Methods and Procedures

As a result of the flexibility created by surface transportation deregulation, it is sometimes difficult to determine the exact rate charged by a carrier on shipments moving under contract. Barge rates are a matter of negotiation between shipper and barge line operator, and these rates are not published in tariff form. Each carrier's rates are based on individual costs and specific market conditions, so that these rates will vary considerably between regions, across time, and from one barge line to another.

Contract rates are also common in pipeline, rail and motor carrier transportation and, like barge rates, may be maintained in complete confidentiality. In other cases (particularly grain), tariff rates are still applied. However, there is rarely any dependable means for determining whether a contract rate or a tariff rate should be used to price a particular movement.

For the purposes of this study, actual rates, as provided by shippers, receivers, or river port operators, are used whenever possible. Sources for these rates are identified by footnotes within the worksheets for the individual movements. All other rates were obtained from published sources or, when this was not possible, estimated by TVA based on the mode of transportation, the tonnage, and other shipment characteristics. All rates, whether actual or estimated, are based on those that were in effect during the third quarter of 2003. However, when necessary, reported rates have been refined to eliminate seasonal impacts or the effects of abnormal market conditions. The methodologies employed in the estimation of unobservable rates were developed through extensive contacts with shippers, railroads, motor carriers, and the barge industry. This information was often integrated with confidential federal data and/or the output of computerized simulation and costing models. This process was both guided and augmented by in-house TVA rating and costing expertise developed through decades of experience as a major shipper of coal and other bulk commodities and through the implementation of navigation-based economic development programs throughout the Tennessee River Basin.

1. **Barge Rates**. With the exception of grain and feed ingredients, unobservable barge rates are calculated through the application of a computerized barge-costing model developed by the Tennessee Valley Authority. The TVA model has been refined to include 2002 fixed and variable cost information obtained directly from the towing industry and from FY 2000 data published within the Corps' annual *Estimated Towboat and Barge Line-Haul Cost of Operating on the Mississippi River System*.

   The TVA model contains three costing modules – a one-way, general towing service module, a round-trip dedicated towing service module, and a round-trip general towing service module. The one-way module calculates rates by simulating the use of general towing conditions between origin and destination, including the potential for a loaded return. The dedicated towing service module calculates costs based on a loaded outbound movement and the return movement of empty barges to the origin dock. The round-trip general towing service module is similar to the one-way, except that it provides for the return of empty barges to the point of origin. This module does not calculate costs for towboat standby time during the terminal process but does include barge ownership costs for both the terminal and fleeting functions. It does not require that the empty barges be

returned with the use of the same towboat. Depending on the module in use, inputs may include towboat class, barge type shipment tonnage, the interchange of barges between two or more carriers, switching or fleeting costs at interchange points or river junctions, and barge ownership costs accruing at origin and destination terminals, fuel taxes, barge investment costs, time contingency factors, return on investment, and applicable interest rates.

The computation of barge costs through the use of the TVA Barge Costing Model (BCM) utilized the actual route for each sample movement. Most sample movements employed circuitous routes when compared to the least mileage route.

Barge rates on dry commodities are calculated with the use of the general towing service round-trip costing module. Inputs, based on information from carriers and the Corps' Lock Performance Monitoring System (LPMS) database were programmed into the module to simulate average towboat size (horsepower) and corresponding tow size (barges) for each segment of the Inland Waterway System. Other inputs include barge types, waterway speeds, horsepower ratios and empty return ratios.

An example of a typical shipment cost in this analysis would be a dry bulk commodity (cement clinker) originating on the Mobile River at Mobile, Alabama and terminating on the Arkansas River at Muskogee, OK. Based on the modeling process, this shipment would be assumed to move in a four-barge tow from Mobile to the Mississippi River at New Orleans, a twenty-barge tow from New Orleans to Rosedale, and an eight-barge tow from Rosedale to Muskogee. At each interchange point, appropriate fleeting charges would be calculated. Empty return (back haul) factors would also be included for each segment of the movement.

Barge rates calculated by the use of the TVA model reflect charges that would be assessed in a period of traditional demand for waterway service. It should be noted that the model does not explicitly consider market factors such as intra or inter modal competitive influences, favorable back haul conditions created by the traffic patterns of specific shippers, or the supply and demand factors which affect the availability of barge equipment. These and other factors can influence rate levels negotiated by waterway users. The model does, however, calculate rates based on the overall industry's fully allocated fixed and variable cost factors, including a reasonable rate of return on assets. It is TVA's judgment that the rates are representative of the industry and provide a reasonable basis for the calculation of shipper savings.

2. **Railroad Rates**. As in the case of barge, reported rail rates are used when they are available. However, in the face of incomplete information, most movements require the calculation of probable railroad rates. For grain and feed ingredients, tariff rates are used when published. Next, the Reebie Rail Costing Model is used to generate an estimate of rail movement cost. This cost was then inflated to reflect rail carrier market power in order to produce a final estimate of the most likely rail rate. Estimated full and variable

railroad costs based on the Uniform Rail Costing System are included for each movement.[5]

Rates for all other commodities are calculated based on the Reebie cost estimates plus an appropriate mark-up. Mark-up factors and shipment characteristics were determined through a variety of means, with shipper information being the preferred source. However, in the absence of a superior source of information, shipping data from the Surface Transportation Board's 2001 Carload Waybill Sample was used.[6]

3. **Motor Carrier Rates**. Actual Truck rates for off-river movements are used whenever possible. All other rates are estimated based on published motor carrier tariffs or regional rate quotations from truck brokers and contract motor carriers.

4. **Handling Charges**. Handling charges between modes of transportation are estimated based on information obtained from shippers, receivers, stevedores, and terminal operators. Handling charges for transfer of commodities from or to ocean-going vessels are based on information obtained from ocean ports or stevedoring companies. For import or export movements that involved mid-stream transfer operations, handling costs to or from land modes at a competing port with rail access are applied.

   Except as noted within individual worksheets, it is assumed that movements of bulk products (for example, grain or fertilizer) would be handled through elevators or storage facilities. Additional costs are incurred at both river and inland locations if shipments remain in storage past the free-time period allocated by the facilities involved. Storage charges are usually assessed on a monthly basis.

5. **Loading and Unloading Costs**. Because shippers and receivers do not usually document loading and unloading costs, they are particularly difficult to obtain.[7] Moreover, these costs can vary considerably across firms. In an attempt to provide the best possible estimates of these costs we use available shipper and receiver information in combination with data from Corps studies performed by other researchers as well as previous TVA studies. These data are revised to reflect 2003 conditions, then averaged as required. In those cases where varying sources produced disparate estimates, TVA relied most heavily on shipper and receiver estimates.

B.6.5.2.4. Methodological Standards

Two points should be noted regarding the methodological standards applied within this study. First, the standards described above reflect essentially the same processes TVA has applied (or will apply) in developing transportation rates for other recent (or ongoing) Corps studies. Specifically, the outlined methodology was used in the Upper Mississippi Navigation Feasibility Study, Missouri River Master Manual Review process, Ohio River Basin Study, the New

[5] Reebie is an URCS based model.

[6] In addition to shipper information and the Carload Waybill Sample, shipment characteristics were also identified from Association of American Railroads publications.

[7] Loading and unloading costs are often considered a part of through-put or production cost.

Orleans Port Allen Morgan City Cut-off study, Tennessee Reservoir Operations Study, and the Soo Locks Study. Thus, inter-project comparisons are made more possible by this uniform approach. More importantly, recent methodological improvements enable TVA to produce transportation rate/cost materials that enhance the transportation data TVA (or any other agency) has produced for similar studies in the past.

B.6.5.2.5. Benefits to Users

To calculate benefits to users, third quarter 2003 cost levels and the 1,341 movement survey of vessel shippers were a starting point. In initially calculating benefits, inconsistencies were found in the data, and some adjustments were made. Table 6-29 shows the adjustments.

Table 6-29: Annual Tonnage and Origin to Destination Movements

	Movements	Thousands of Tons
Grand Total	1,347	11,884
1. Overland cheaper	34	186
2. Water routing cheaper	1,313	11,698
Removal of Inconsistent Rates	12	62
1. Cost greater at 10' than 9'	5	23
1. Cost greater at 11' than 10'	1	14
1. Cost greater at 12' than 11'	6	25
Total w/o Overland & Inconsistencies	1,301	11,636
1. Benefit from deeper channel	859	5,529
2. Do not benefit from deeper channel	442	6,108

Table 6-30 shows the percentage of tonnage by reach and type that can take advantage of each one-foot increment in channel depth, and the transportation savings per ton for the deeper depths. Table 6-31 shows the percentage of s by reach and type that can take advantage of each one-foot increment in channel depth, and the transportation savings per ton for the deeper depths.

Table 6-30: Tonnage by Reach and Commodity Group that Benefits from a Deeper Channel				
		Percentage that Benefits at Each Depth		
	Total Tons (1,000s)	10'	11'	12'
Mouth to Pine Bluff				
Farm Products	635	86%	86%	81%
Metals	107	28%	28%	28%
Coal	34	100%	100%	90%
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	18	16%	16%	16%
Forest Products	24	0%	0%	0%
Industrial Chemicals	126	0%	0%	0%
Agricultural Chemicals	78	94%	94%	84%
Petroleum Products	111	0%	0%	0%
Others	1	0%	0%	0%
Total	1,134	61%	61%	57%
Pine Bluff to Little Rock				
Farm Products	96	98%	98%	98%
Metals	335	45%	45%	45%
Coal	-	-	-	-
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	1,075	7%	7%	7%
Forest Products	17	0%	0%	0%
Industrial Chemicals	20	0%	0%	0%
Agricultural Chemicals	209	84%	84%	80%
Petroleum Products	6	0%	0%	0%
Others	8	0%	0%	0%
Total	1,767	28%	28%	28%
Little Rock to Ozark				
Farm Products	47	97%	97%	97%
Metals	-	-	-	-
Coal	-	-	-	-
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	2,378	32%	32%	32%
Forest Products	43	0%	0%	0%
Industrial Chemicals	-	-	-	-
Agricultural Chemicals	21	85%	85%	85%
Petroleum Products	-	-	-	-
Others	-	-	-	-
Total	2,489	33%	33%	33%

Table 6-30 Continued				
Ozark to Fort Smith				
Farm Products	60	87%	87%	84%
Metals	62	24%	24%	21%
Coal	-	-	-	-
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	1,147	1%	1%	1%
Forest Products	6	0%	0%	0%
Industrial Chemicals	4	100%	100%	100%
Agricultural Chemicals	8	100%	100%	100%
Petroleum Products	-	-	-	-
Others	-	-	-	-
Total	1,288	7%	7%	7%
Fort Smith to Muskogee				
Farm Products	93	77%	77%	77%
Metals	213	59%	59%	59%
Coal	13	100%	100%	100%
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	1	100%	100%	100%
Forest Products	0	0%	0%	0%
Industrial Chemicals	-	-	-	-
Agricultural Chemicals	125	80%	80%	79%
Petroleum Products	183	2%	2%	2%
Others	3	0%	0%	0%
Total	631	50%	50%	50%
Muskogee to Catoosa				
Farm Products	1,611	97%	97%	96%
Metals	525	21%	21%	19%
Coal	226	95%	95%	70%
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	110	93%	93%	85%
Forest Products	-	-	-	-
Industrial Chemicals	92	0%	0%	0%
Agricultural Chemicals	1,421	73%	73%	73%
Petroleum Products	223	33%	33%	25%
Others	65	0%	0%	0%
Total	4,274	73%	73%	70%
White River				
Farm Products	293	0%	0%	0%
Metals	-	-	-	-
Coal	-	-	-	-
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	-	-	-	-
Forest Products	-	-	-	-
Industrial Chemicals	-	-	-	-
Agricultural Chemicals	9	0%	0%	0%
Petroleum Products	-	-	-	-
Others	-	-	-	-
Total	301	0%	0%	0%

Table 6-30 Continued				
Total				
Farm Products	2,835	84%	84%	82%
Metals	1,242	35%	35%	34%
Coal	273	96%	96%	74%
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	4,730	20%	20%	20%
Forest Products	91	0%	0%	0%
Industrial Chemicals	243	2%	2%	2%
Agricultural Chemicals	1,871	76%	76%	75%
Petroleum Products	523	15%	15%	11%
Others	77	0%	0%	0%
Total	11,884	47%	47%	45%

Table 6-31: Shipments by Reach and Commodity Group that Benefits from a Deeper Channel				
		Percentage that Benefits at Each Depth		
	Total Shipments	10’	11’	12’
Mouth to Pine Bluff				
Farm Products	104	93%	93%	88%
Metals	32	19%	19%	19%
Coal	6	100%	100%	83%
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	5	20%	20%	20%
Forest Products	8	0%	0%	0%
Industrial Chemicals	9	0%	0%	0%
Agricultural Chemicals	32	94%	94%	88%
Petroleum Products	4	0%	0%	0%
Others	1	0%	0%	0%
Total	201	70%	70%	65%
Pine Bluff to Little Rock				
Farm Products	28	93%	93%	93%
Metals	46	43%	43%	43%
Coal	0	-	-	-
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	41	49%	49%	46%
Forest Products	1	0%	0%	0%
Industrial Chemicals	5	0%	0%	0%
Agricultural Chemicals	69	93%	93%	87%
Petroleum Products	2	0%	0%	0%
Others	4	0%	0%	0%
Total	196	66%	66%	64%

Table 6-31 Continued				
Little Rock to Ozark				
Farm Products	17	94%	94%	94%
Metals	0	-	-	-
Coal	0	-	-	-
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	79	10%	10%	10%
Forest Products	9	0%	0%	0%
Industrial Chemicals	0	-	-	-
Agricultural Chemicals	12	83%	83%	83%
Petroleum Products	0	-	-	-
Others	0	-	-	-
Total	117	29%	29%	29%
Ozark to Fort Smith				
Farm Products	20	80%	80%	75%
Metals	15	40%	40%	33%
Coal	0	-	-	-
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	25	24%	24%	24%
Forest Products	3	0%	0%	0%
Industrial Chemicals	2	100%	100%	100%
Agricultural Chemicals	5	100%	100%	100%
Petroleum Products	0	-	-	-
Others	0	-	-	-
Total	70	50%	50%	47%
Fort Smith to Muskogee				
Farm Products	21	90%	90%	90%
Metals	26	77%	77%	77%
Coal	1	100%	100%	100%
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	1	100%	100%	100%
Forest Products	1	0%	0%	0%
Industrial Chemicals	0	-	-	-
Agricultural Chemicals	36	97%	97%	94%
Petroleum Products	15	7%	7%	7%
Others	1	0%	0%	0%
Total	102	75%	75%	75%
Muskogee to Catoosa				
Farm Products	163	91%	91%	87%
Metals	77	45%	45%	40%
Coal	24	83%	83%	54%
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	27	78%	78%	59%
Forest Products	0	-	-	-
Industrial Chemicals	19	0%	0%	0%
Agricultural Chemicals	258	79%	79%	79%
Petroleum Products	36	39%	39%	22%
Others	20	0%	0%	0%
Total	624	71%	71%	66%

Table 6-31 Continued				
White River				
Farm Products	35	0%	0%	0%
Metals	0	-	-	-
Coal	0	-	-	-
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	0	-	-	-
Forest Products	0	-	-	-
Industrial Chemicals	0	-	-	-
Agricultural Chemicals	2	0%	0%	0%
Petroleum Products	0	-	-	-
Others	0	-	-	-
Total	37	0%	0%	0%
Total				
Farm Products	388	83%	83%	80%
Metals	196	44%	44%	42%
Coal	31	87%	87%	61%
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	178	32%	32%	29%
Forest Products	22	0%	0%	0%
Industrial Chemicals	35	6%	6%	6%
Agricultural Chemicals	414	84%	84%	82%
Petroleum Products	57	26%	26%	16%
Others	26	0%	0%	0%
Total	1,347	64%	64%	60%

Table 6-32 shows the percentage of tonnage which can benefit by directional flow.
Table 6-33 shows the percentage of shipments which can benefit by directional flow.

Table 6-32: Tons to Each River Basin that Benefit from a Deeper Channel				
		Percent that Benefits at Each Depth		
	Total Tons (1000's)	**10'**	**11'**	**12'**
Arkansas River (Internal)				
Commodity Group				
Farm Products	3	56%	56%	56%
Metals	8	100%	100%	100%
Coal	-	-	-	-
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	2,508	0%	0%	0%
Forest Products	-	-	-	-
Industrial Chemicals	-	-	-	-
Agricultural Chemicals	20	54%	54%	54%
Petroleum Products	19	0%	0%	0%
Others	-	-	-	-
Total	2,558	1%	1%	1%

Table 6-32 Continued				
GIWW East				
Commodity Group				
Farm Products	5	100%	100%	100%
Metals	60	100%	100%	100%
Coal	-	-	-	-
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	13	76%	76%	76%
Forest Products	-	-	-	-
Industrial Chemicals	-	-	-	-
Agricultural Chemicals	83	100%	100%	100%
Petroleum Products	6	0%	0%	0%
Others	2	0%	0%	0%
Total	168	93%	93%	93%
GIWW West				
Commodity Group				
Farm Products	57	79%	79%	79%
Metals	15	48%	48%	48%
Coal	3	100%	100%	100%
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	84	22%	22%	22%
Forest Products	-	-	-	-
Industrial Chemicals	65	0%	0%	0%
Agricultural Chemicals	44	28%	28%	28%
Petroleum Products	40	100%	100%	100%
Others	3	0%	0%	0%
Total	310	40%	40%	40%
Lower Miss				
Commodity Group				
Farm Products	2,459	85%	85%	85%
Metals	643	53%	53%	53%
Coal	203	100%	100%	98%
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	1,723	52%	52%	52%
Forest Products	13	0%	0%	0%
Industrial Chemicals	152	3%	3%	3%
Agricultural Chemicals	1,472	87%	87%	87%
Petroleum Products	317	6%	6%	6%
Others	52	0%	0%	0%
Total	7,035	69%	69%	69%
Ohio				
Commodity Group				
Farm Products	63	84%	84%	62%
Metals	365	3%	3%	1%
Coal	68	85%	85%	0%
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	14	100%	100%	34%
Forest Products	1	0%	0%	0%
Industrial Chemicals	26	0%	0%	0%
Agricultural Chemicals	125	7%	7%	1%
Petroleum Products	30	64%	64%	0%
Others	6	0%	0%	0%
Total	696	23%	23%	7%

Table 6-32 Continued				
Tennessee				
Commodity Group				
Farm Products	152	99%	99%	99%
Metals	4	100%	100%	0%
Coal	-	-	-	-
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	11	100%	100%	100%
Forest Products	-	-	-	-
Industrial Chemicals	-	-	-	-
Agricultural Chemicals	6	0%	0%	0%
Petroleum Products	1	0%	0%	0%
Others	13	0%	0%	0%
Total	186	89%	89%	87%
Tenn-Tom				
Commodity Group				
Farm Products	-	-	-	-
Metals	12	0%	0%	0%
Coal	-	-	-	-
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	-	-	-	-
Forest Products	17	0%	0%	0%
Industrial Chemicals	-	-	-	-
Agricultural Chemicals	-	-	-	-
Petroleum Products	52	0%	0%	0%
Others	-	-	-	-
Total	80	0%	0%	0%
Upper Miss				
Commodity Group				
Farm Products	96	34%	34%	3%
Metals	136	0%	0%	0%
Coal	-	-	-	-
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	342	3%	3%	3%
Forest Products	60	0%	0%	0%
Industrial Chemicals	-	-	-	-
Agricultural Chemicals	115	12%	12%	0%
Petroleum Products	59	0%	0%	0%
Others	2	0%	0%	0%
Total	809	7%	7%	2%
White River				
Commodity Group				
Farm Products	-	-	-	-
Metals	-	-	-	-
Coal	-	-	-	-
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	36	0%	0%	0%
Forest Products	-	-	-	-
Industrial Chemicals	-	-	-	-
Agricultural Chemicals	6	0%	0%	0%
Petroleum Products	-	-	-	-
Others	-	-	-	-
Total	41	0%	0%	0%

Table 6-32 Continued				
Total		**-**	**-**	**-**
Commodity Group		-	-	-
Farm Products	2,835	84%	84%	82%
Metals	1,242	35%	35%	34%
Coal	273	96%	96%	74%
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	4,730	20%	20%	20%
Forest Products	91	0%	0%	0%
Industrial Chemicals	243	2%	2%	2%
Agricultural Chemicals	1,871	76%	76%	75%
Petroleum Products	523	15%	15%	11%
Others	77	0%	0%	0%
Total	11,884	47%	47%	45%

Table 6-33: Shipments to Each River Basin that Benefit from a Deeper Channel				
		Percent that Benefits at Each Depth		
	Total Shipments	**10'**	**11'**	**12'**
Arkansas River				
Commodity Group				
Farm Products	2	50%	50%	50%
Metals	4	100%	100%	100%
Coal	0	-	-	-
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	52	0%	0%	0%
Forest Products	0	-	-	-
Industrial Chemicals	0	-	-	-
Agricultural Chemicals	8	63%	63%	63%
Petroleum Products	4	0%	0%	0%
Others	0	-	-	-
Total	70	14%	14%	14%
GIWW East				
Commodity Group				
Farm Products	1	100%	100%	100%
Metals	5	100%	100%	100%
Coal	0	-	-	-
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	4	50%	50%	50%
Forest Products	0	-	-	-
Industrial Chemicals	0	-	-	-
Agricultural Chemicals	31	100%	100%	100%
Petroleum Products	1	0%	0%	0%
Others	1	0%	0%	0%
Total	43	91%	91%	91%

Table 6-33 Continued				
GIWW West				
Commodity Group				
Farm Products	13	77%	77%	77%
Metals	6	33%	33%	33%
Coal	1	100%	100%	100%
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	9	67%	67%	67%
Forest Products	0	-	-	-
Industrial Chemicals	9	0%	0%	0%
Agricultural Chemicals	12	42%	42%	42%
Petroleum Products	2	100%	100%	100%
Others	4	0%	0%	0%
Total	56	46%	46%	46%
Lower Miss				
Commodity Group				
Farm Products	330	83%	83%	83%
Metals	139	50%	50%	50%
Coal	19	100%	100%	95%
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	81	42%	42%	41%
Forest Products	6	0%	0%	0%
Industrial Chemicals	23	9%	9%	9%
Agricultural Chemicals	324	92%	92%	92%
Petroleum Products	33	21%	21%	21%
Others	17	0%	0%	0%
Total	972	72%	72%	72%
Ohio				
Commodity Group				
Farm Products	13	92%	92%	46%
Metals	22	18%	18%	5%
Coal	11	64%	64%	0%
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	6	100%	100%	17%
Forest Products	1	0%	0%	0%
Industrial Chemicals	3	0%	0%	0%
Agricultural Chemicals	17	18%	18%	6%
Petroleum Products	8	75%	75%	0%
Others	1	0%	0%	0%
Total	82	46%	46%	11%

Table 6-33 Continued				
Tennessee				
Commodity Group				
Farm Products	17	94%	94%	94%
Metals	2	100%	100%	0%
Coal	0	-	-	-
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	4	100%	100%	100%
Forest Products	0	-	-	-
Industrial Chemicals	0	-	-	-
Agricultural Chemicals	1	0%	0%	0%
Petroleum Products	1	0%	0%	0%
Others	2	0%	0%	0%
Total	27	81%	81%	74%
Tenn-Tom				
Commodity Group				
Farm Products	0	-	-	-
Metals	3	0%	0%	0%
Coal	0	-	-	-
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	0	-	-	-
Forest Products	1	0%	0%	0%
Industrial Chemicals	0	-	-	-
Agricultural Chemicals	0	-	-	-
Petroleum Products	1	0%	0%	0%
Others	0	-	-	-
Total	5	0%	0%	0%
Upper Miss				
Commodity Group				
Farm Products	12	75%	75%	17%
Metals	15	0%	0%	0%
Coal	0	-	-	-
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	18	28%	28%	28%
Forest Products	14	0%	0%	0%
Industrial Chemicals	0	-	-	-
Agricultural Chemicals	20	35%	35%	0%
Petroleum Products	7	0%	0%	0%
Others	1	0%	0%	0%
Total	87	24%	24%	8%

Table 6-33 Continued				
White River				
Commodity Group				
Farm Products	0	-	-	-
Metals	0	-	-	-
Coal	0	-	-	-
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	4	0%	0%	0%
Forest Products	0	-	-	-
Industrial Chemicals	0	-	-	-
Agricultural Chemicals	1	0%	0%	0%
Petroleum Products	0	-	-	-
Others	0	-	-	-
Total	5	0%	0%	0%
Total				
Commodity Group				
Farm Products	388	83%	83%	80%
Metals	196	44%	44%	42%
Coal	31	87%	87%	61%
Crude Petroleum	0	-	-	-
Non-Metallic Minerals	178	32%	32%	29%
Forest Products	22	0%	0%	0%
Industrial Chemicals	35	6%	6%	6%
Agricultural Chemicals	414	84%	84%	82%
Petroleum Products	57	26%	26%	16%
Others	26	0%	0%	0%
Total	1,347	64%	64%	60%

Table 6-34: Savings per ton by Reach, Commodity, and Depths for Traffic that Benefits from a Deeper Channel ($/ton)								
		Transportation Savings				Incremental Savings over 9' Channel		
	Tons with Savings	Land-Water (9')	Land-NCDA-10	Land-NCDA-11	Land-NCDA-12	10'	11'	12'
Mouth to Pine Bluff								
Farm Products	545,951	10.31	10.76	11.40	11.73	0.45	1.09	1.42
Metals	30,115	16.83	17.28	17.98	18.42	0.45	1.15	1.59
Coal	34,476	14.93	15.23	15.65	15.88	0.30	0.72	0.95
Crude Petroleum	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-Metallic Minerals	2,917	9.15	9.47	9.96	10.27	0.32	0.81	1.12
Forest Products	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial Chemicals	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agricultural Chemicals	73,210	12.74	13.05	13.52	13.78	0.31	0.78	1.04
Petroleum Products	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Others	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	686,669	11.08	11.51	12.12	12.44	0.43	1.04	1.36
Pine Bluff to Little Rock								
Farm Products	93,903	13.68	14.04	14.58	14.92	0.36	0.90	1.24
Metals	150,482	13.27	13.42	13.70	14.04	0.15	0.43	0.77
Coal	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crude Petroleum	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-Metallic Minerals	78,608	7.72	8.06	8.57	8.90	0.34	0.85	1.18
Forest Products	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial Chemicals	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agricultural Chemicals	175,751	13.86	14.25	14.83	15.18	0.39	0.97	1.32
Petroleum Products	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Others	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	498,744	12.68	12.99	13.46	13.80	0.31	0.78	1.12

Little Rock to Ozark								
Farm Products	45,707	14.95	15.35	15.97	16.36	0.40	1.02	1.41
Metals	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crude Petroleum	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-Metallic Minerals	760,691	3.76	4.17	4.71	4.93	0.41	0.95	1.17
Forest Products	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial Chemicals	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agricultural Chemicals	17,948	12.70	13.13	13.78	14.20	0.43	1.08	1.50
Petroleum Products	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Others	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	824,346	4.57	4.99	5.54	5.76	0.42	0.97	1.19
Ozark to Fort Smith								
Farm Products	52,295	16.76	17.26	18.02	18.48	0.50	1.26	1.72
Metals	14,789	21.06	21.69	22.59	23.11	0.63	1.53	2.05
Coal	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crude Petroleum	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-Metallic Minerals	13,348	14.69	15.22	16.01	16.50	0.53	1.32	1.81
Forest Products	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial Chemicals	4,213	26.09	26.56	27.28	27.74	0.47	1.19	1.65
Agricultural Chemicals	7,885	19.90	20.38	21.11	21.57	0.48	1.21	1.67
Petroleum Products	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Others	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	92,530	17.84	18.36	19.14	19.62	0.52	1.30	1.78
Fort Smith to Muskogee								
Farm Products	71,591	14.37	14.93	15.79	16.32	0.56	1.42	1.95
Metals	125,073	18.17	18.76	19.66	20.23	0.59	1.49	2.06
Coal	13,167	21.10	21.66	22.52	23.05	0.56	1.42	1.95
Crude Petroleum	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-Metallic Minerals	1,406	16.05	16.63	17.52	17.82	0.58	1.47	1.77
Forest Products	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial Chemicals	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agricultural Chemicals	100,158	18.78	19.38	20.28	20.90	0.60	1.50	2.12
Petroleum Products	3,028	16.84	17.42	18.30	18.85	0.58	1.46	2.01
Others	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	314,422	17.60	18.19	19.08	19.65	0.59	1.48	2.05

Muskogee to Catoosa								
Farm Products	1,567,164	11.22	11.87	12.84	13.41	0.65	1.62	2.19
Metals	111,309	20.64	21.25	22.14	22.64	0.61	1.50	2.00
Coal	215,443	15.96	16.64	17.55	17.95	0.68	1.59	1.99
Crude Petroleum	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-Metallic Minerals	102,742	13.81	14.51	15.51	15.96	0.70	1.70	2.15
Forest Products	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial Chemicals	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agricultural Chemicals	1,041,391	18.77	19.36	20.26	20.84	0.59	1.49	2.07
Petroleum Products	74,209	10.85	11.82	13.15	13.80	0.97	2.30	2.95
Others	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	3,112,258	14.49	15.13	16.08	16.63	0.64	1.59	2.14
White River								
Total	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total								
Farm Products	2,376,609	11.40	11.98	12.84	13.34	0.58	1.44	1.94
Metals	431,768	17.11	17.54	18.21	18.66	0.43	1.10	1.55
Coal	263,086	16.08	16.71	17.55	17.94	0.63	1.47	1.86
Crude Petroleum	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-Metallic Minerals	959,711	5.34	5.78	6.38	6.63	0.44	1.04	1.29
Forest Products	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial Chemicals	4,213	26.09	26.56	27.28	27.74	0.47	1.19	1.65
Agricultural Chemicals	1,416,343	17.78	18.33	19.16	19.70	0.55	1.38	1.92
Petroleum Products	77,237	11.08	12.04	13.35	14.00	0.96	2.27	2.92
Others	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	5,528,968	12.66	13.20	14.00	14.46	0.54	1.34	1.80

B.6.6. Without-Project Condition

The existing condition refers to the current and expected future condition that exists in the absence of any pro-active measures to address problems and needs. The “without” project condition is the existing condition but with the likely implementation of pro-active measures to address problems, but which measures do not require authorization by Congress. The existing and “without” conditions for inland navigation studies are typically considered with respect to the volume and type of traffic, the fleet used for transportation, the condition of the projects, and operational measures employed by towing companies and the Corps. Because of their importance to the analysis, many of these items were discussed in detail in previous sections. Specifically, future traffic levels and the future fleet in the absence of any major structural or non-structural changes to the system have already been developed and described. This section ties the parts together into the “without” project condition and presents the transportation costs for this condition. The transportation costs of the “without” project condition will be used as the base for the computation in the reduction in transportation costs attributable to the implementation of flow management and navigation channel deepening components.

Changes to the system that require and have received Congressional authorization are included as part of the “without” project condition. Thus the completion of Montgomery Point Lock and Dam is part of the “without” project condition. The "without" project condition assumes continued dredging and disposal to maintain a 9′ channel.

Other measures that were considered as possible features of the “without” project condition were non-structural and small capital measures such as the use of tow-haulage units, implementation of self-help programs, and changes in the order of tow lockages during periods of high congestion. Based on the current and simulated future levels of delays, lock congestion did not surface as a problem under the mid-level growth traffic forecasts and so the addition of mooring cells, the use of helper boats and changes in the order of tow lockages were not evaluated. Also, the scoping process did not identify the need to double trip through the upper five projects as a significant problem, and therefore the installation of tow-haulage systems at these projects was not evaluated.

Increases in lock downtime due to the effects of age and usage on lock equipment were also not evaluated, since any major problems were expected to lie beyond the mid-term planning horizon of 20 years. Increased lock downtime would decrease the annual capacity of the projects to process traffic. The effects are expected to be neutral, i.e. the same in the “without” project condition and the “with” project condition.

B.6.6.1. Tonnage and Transportation Costs of Existing Shipments

Existing shipments are port-dock-to-port-dock shipments of a particular commodity that moved on the waterway in 2001. The tonnages in these shipments were adjusted to match 2003 traffic levels but the origins, destinations, and commodity types were not changed. TVA rate analysts obtained and/or developed transportation costs for all 1,347 existing shipments in 2001 via the water-routed and least cost all-overland modes. The water-routed transportation costs reflect the changes in the configuration of tows that are expected due to changes in reservoir release schedules. The all-overland shipping costs are not affected by the recommended Phase 1 changes. The transportation costs were updated to October 2003 price levels by TVA in December of 2003. The transportation costs for the water-routed and the least cost all-overland modes are listed in Table 6-35. The current benefits of the MKARNS system are about $116 million, or $9.75 per ton.

Table 6-35. Without Project Condition – Middle Forecasts
Tonnage and Transportation Costs (Oct 2003; $1,000 except for savings per ton)

	2003	2010	2020	2030	2040	2050	2060
Tons-thousands	11,884	14,372	15,997	17,356	18,708	20,177	21,775
Water-Route Cost	150,344.6	177,979.5	196,781.4	213,242.4	229,292.3	246,738.0	265,728.8
Overland – Route Cost	266,230.2	277,660.1	315,212.6	348,329.8	377,392.3	405,865.8	436,843.6
Savings	115,885.6	137,233.1	151,548.4	164,149.9	176,573.5	190,105.6	204,871.6
Savings/ton	9.75	9.55	9.47	9.46	9.44	9.42	9.41

B.6.6.2. Induced Tonnage and Transportation Costs

No traffic is expected to be induced onto the waterway system in the absence of significant improvements, such as deepening the river. Nonetheless, potential "induced" traffic currently moves in the study area via overland modes. The overland transportation cost currently paid by the traffic that could potentially be induced onto an improved waterway system is listed in Table 6-36. It is important to note that the costs increase with depth since more tonnage is "induced" at deeper depths. In terms of unit costs, the cost per ton to ship via the overland mode is approximately $23.0 per ton.

Table 6-36. Without Project Condition – Middle Forecasts Tonnage and Transportation Costs for Potential "Induced" Traffic							
	2001	2010	2020	2030	2040	2050	2060
Potential "Induced" Tons - thousands							
10´ - tons	0.0	230.0	511.9	555.4	598.6	645.7	696.8
11´ - tons	0.0	352.1	783.8	850.4	916.7	988.7	1,067.0
12´ - tons	0.0	402.4	895.8	971.9	1,047.6	1,129.9	1,219.4
All-Overland Transportation Costs for Potential "Induced" Tonnage – Oct 2003 $1,000							
10´ - cost	n.a.	5,043.4	11,146.6	12,076.6	12,987.7	13,979.0	15,059.2
11´ - cost	n.a.	7,722.7	17,068.2	18,492.2	19,887.4	21,405.4	23,059.4
12´ - cost	n.a.	9,270.8	20,513.9	22,224.8	23,909.8	25,742.6	27,739.0
Transportation Cost per Ton for All-Overland Transportation Mode for Potential "Induced" Tonnage - Oct 2003 $							
10´		21.93	21.77	21.74	21.70	21.65	21.61
11´		21.93	21.78	21.75	21.69	21.65	21.61
12´		23.04	22.90	22.87	22.82	22.78	22.75

B.6.6.3. Lock Processing Times and Costs of Existing Traffic

The costs of water-routed shipments generally increase over time due to increased congestion at the locks and increased lock outages. While traffic is projected to grow over time, it is not expected to reach the critical thresh-hold where serious delay situations develop. Nonetheless the chance of multiple arrivals of tows at a lock will increase as traffic increases, and therefore delays are expected to increase. The increase in shipping costs due to increased delays was estimated using a simulation model developed for the MKARNS system.

The simulation model includes site-specific data for each of the eighteen MKARNS locks. The data include lockage times for one and two-cut lockages, the number of recreational lockages, and the percent of tows that required one-cut and two-cut lockages. The model also randomly generated short unscheduled outages of two days or less that occur due to weather and equipment malfunctions. The model was calibrated to a target of delays at each project and for the system as a whole as recorded in the year 2001. Simulated delays for all of the locks amounted to 473.1 days; actual delays amounted to 423.2 days, or 11.8% lower. The overall cost attributable for processing through the projects (delay plus lockage times) amounted to $197,000 for the system in 2001, as simulated. A more detailed description of the model is provided in Addendum E6. The values used in the calibration process and the actual 2001 values are listed in Table 6-37.

Table 6-37. Calibration of Lock Simulation Model			
	2001	Model	% Difference
Tows	14,970	14,970	0.0%
Recreational lockages	3,361	3,361	0.0%
Delay time per tow – hours	0.5	0.5	0.0%
Lockage time per tow - hours	0.8	0.8	0.0%
Delay time – days	423.2	473.1	11.8%
Lockage time – days	575.5	578.9	0.0%
Total processing time – days	998.7	1,052.0	5.3%
Delays costs	n.a.	$85,200	n.a.
Lockage costs	n.a.	$111,800	n.a.
Total processing costs	n.a.	$197,000	n.a.
Note: Lockage time in model lists at 613.9 but this includes 3,361 recreational lockages at 15 minutes each. 3,361 x (15/60) / 24 = 35 days. 613.9 – 35 = 578.9.			

The "without" project condition is expected to differ from the existing condition due to implementation of changes in reservoir operations. Therefore, it was necessary to adjust the number of tows in the calibration year of 2001 to reflect the larger and fewer tows that would have transited the system if the adjustments had been in effect in 2001. The adjustment process is described in Addendum E8 – Towboat Traffic. The number of tows that would have been required to transport tonnage in the year 2001 with the revised release schedule was estimated at 13,144, compared to 14,970 with the current release schedule, a difference of 12%. The results indicate processing costs (delays plus lockage) of $154,200, or about 22% lower than the comparable costs with the existing fleet, which is what would be expected given fewer tows requiring lockage.

Lock processing times in the "without" project condition are listed in Table 6-38. The year 2003 processing times and costs are higher than in 2001 costs because of higher traffic levels, the inclusion of lockage times and delays at Montgomery Point, and adjustments to processing times for two-cut lockage times (reference Addendum E6 for details). The average delay per tow remains relatively low and the average lockage time (average of one-cut and two-cut lockages) is nearly constant at an average of 1.2 hours per tow (80 minutes).

Table 6-38. Without Project Condition – Middle Forecasts Lock Processing Times (Hours) and Costs (Oct 2003 $)							
	2003	2010	2020	2030	2040	2050	2060
Tow lockages	15,321	16,002	18,201	20,124	21,790	23,439	25,233
Delay/tow	1.06	1.09	1.07	1.01	1.28	1.51	1.95
Lockage/tow	1.17	1.19	1.20	1.21	1.21	1.21	1.21
Delay ($)	173.7	204.4	223.0	239.3	253.4	271.5	294.8
Lockage ($)	151.9	185.8	202.3	197.4	269.7	338.3	464.8
Total Processing ($)	325.6	390.1	425.2	436.7	523.1	609.7	759.6
Note: Delay and lockage time are hours per tow. Costs are thousands of $Oct 03							

B.6.6.4. Total Tonnage and Transportation Costs

The projected growth in existing traffic, the savings per ton for waterway routings, the number of tow lockages on the system, and the average delay per tow for 2003 and future decadal years are

listed in the table below. In sum, traffic is projected to nearly double, the savings per tons remains nearly constant, and delays remain relatively low.

Table 6-39. Without Project Condition – Middle Forecasts
Summary Data

	2003	2010	2020	2030	2040	2050	2060
Tons– thousands	11,884	14,372	15,997	17,356	18,708	20,177	21,775
Savings/ton	9.75	9.55	9.47	9.46	9.44	9.42	9.41
Tow lockages	15,321	16,002	18,201	20,124	21,790	23,439	25,233
Delay/tow	1.06	1.09	1.07	1.01	1.28	1.51	1.95

Transportation cost data for the "without" project condition are listed below. The costs are subcategorized as: 1) the water-routing costs for existing traffic; 2) lockage costs for existing traffic; and 3) the all overland costs of potentially induced traffic. The increases in costs are generally proportional to the increases in traffic with the exception of the costs of processing tows through the projects, which nearly triple. However, these costs remain relatively low.

Table 6-40. Without Project Condition – Middle Forecasts
Transportation Costs (Oct 2003; $1,000)

	2003	2010	2020	2030	2040	2050	2060
Transportation Costs of Existing Water-Routed Shipments except for Processing Costs							
9′	150,344.6	177,979.5	196,781.4	213,242.4	229,292.3	246,738.0	265,728.8
Processing Costs of Existing Water-Routed Shipments							
9′	325.6	390.1	425.2	436.7	523.1	609.7	759.6
All-Overland Transportation Costs of Potentially "Induced" Traffic							
10′	n.a.	5,043.4	11,146.6	12,076.6	12,987.7	13,979.0	15,059.2
11′	n.a.	7,722.7	17,068.2	18,492.2	19,887.4	21,405.4	23,059.4
12′	n.a.	9,270.8	20,513.9	22,224.8	23,909.8	25,742.6	27,739.0

B.6.7. "With" Project Condition

"With" project condition considers implementation of components designed to address residual problems after all reasonable and allowable measures are assumed to have been put into operation. As in the "without" project condition, "with" project condition can be include structural components, non-structural components, or some combination of the two. The imposition of congestion fees at locks is a required non-structural "with" project component. Consideration was given to congestion fees, but they do not address the navigation problems on MKARNS and were not therefore the subject of detailed analysis. The non-structural "with" project components considered for flow management were FM-175, FM-200, and FM-OPS. For the navigation channel deepening feature, three depths greater than the currently authorized 9′ channel were evaluated: 10′, 11′, and 12′. Deepening was evaluated for six incremental reaches of the river beginning at the mouth and extending upriver to the head of navigation near Tulsa. The navigation channel deepening components that were evaluated are listed in Table 6-41.

Table 6-41. List of Navigation Channel Deepening Components					
	Reach	River Mile	Deepen Channel Depth to		
			10′	11′	12′
1	Mouth to Pine Bluff	0.0 – 75.2	x	x	x
2	Mouth to Little Rock	0.0 – 119.5	x	x	x
3	Mouth to Ozark	0.0 – 220.3	x	x	x
4	Mouth to Fort Smith	0.0 – 308.7	x	x	x
5	Mouth to Muskogee	0.0 – 394.0	x	x	x
6	Mouth to Catoosa	0.0 – 444.8	x	x	x

B.6.7.1. Transportation Costs of Existing Traffic

Deepening the waterway would allow a significant portion of barges to be more fully loaded than is currently possible on the 9′ existing channel. The identification of shipments that could take advantage of a deeper channel given their commodity type, origin and destination was made by the group at TVA that developed the rates for both the flow management phase (Phase I) and the channel deepening phase (Phase II) of this Feasibility Study. Following identification of these shipments, new waterway transportation costs were developed for each shipment assuming barges would be loaded to 9.5′ for the 10′ channel component, 10.5′ for the 11′ component, and 11.5′ for the 12′ component.

The shipping costs for existing traffic given alternative depths are listed in Table 6-42. At the year 2003 base-level traffic, the costs range from $140.2 million for the 12′ depth waterway to $147.3 million for the 10′ depth waterway. Included in the table are the savings per ton for the "without" project condition and each "with" project condition as compared to the all-overland transportation costs. The increment of savings is from 9′ to 10′ is about $0.25 per ton, from 10′ to 11′ is about $0.38 per ton, and from 11′ to 12′ is about $0.21 per ton.

Table 6-42. "With" Project Conditions – Middle Forecasts Tonnage and Transportation Costs (Oct 2003; $1,000 except for savings per ton)							
	2003	2010	2020	2030	2040	2050	2060
Tons-thousands	11,884.3	14,372.0	15,997.0	17,356.0	18,708.0	20,177.0	21,775.0
Water-Routed Transportation Costs for Forecasted Shipments (Excluding Induced Shipments)							
9′	150,344.6	177,979.5	196,781.4	213,242.4	229,292.3	246,738.0	265,728.8
10′	147,297.1	174,377.2	192,798.7	208,922.2	224,647.2	241,739.9	260,345.9
11′	142,798.0	169,065.2	186,930.2	202,562.0	217,814.9	234,394.8	252,443.0
12′	140,224.9	166,032.8	183,585.7	198,942.2	213,933.8	230,231.0	247,972.8
Savings per Tons for Forecasted Shipments over All-Overland Transportation (Excluding Induced Shipments)							
9′	9.75	9.55	9.47	9.46	9.44	9.42	9.41
10′	10.01	9.80	9.72	9.71	9.69	9.67	9.66
11′	10.39	10.17	10.09	10.07	10.05	10.03	10.02
12′	10.60	10.38	10.30	10.28	10.26	10.24	10.22

B.6.7.2. Induced Traffic

The amount of "induced" traffic that may shift onto an improved waterway system was calculated based on the percentage reduction in water-routing shipping costs attributable to a deeper channel. It was expected that there would be a time lag between the completion of the deepening work and the shift of tonnage onto the waterway system. Based on an expected completion date of 2006, it was assumed that 50% of the maximum induced traffic would shift by the year 2010 and 100% by 2020.

The overland transportation cost for each potentially "induced" shipment is lower than the waterway costs, otherwise these shipments would presumably be moving on the river at the current time. Because "induced" shipments are not existing shipments, transportation costs were not developed as part of the TVA rate study. Therefore, it was necessary to estimate these costs. First, it was assumed that the overland transportation cost of potentially "induced" traffic was identical to the overland transportation costs of existing traffic. Second, it was assumed that the water-routing cost for potentially "induced" traffic was equal to or more expensive than the overland cost. Third, the average water routing costs of "induced" traffic would be equal to the overland cost minus one-half of the savings attributable to deepening. For example, if the overland cost for a shipment is $15 per ton, then the current water-routing costs for potentially "induced" traffic is equal to or greater than $15 per ton. If deepening the channel reduces water-routing costs by $2 per ton, then the waterway costs for the induced shipment is $14 per ton ($15 –(0.5*$2.0)). The average savings per ton for potentially induced traffic ranges from about $0.12 with a 10′ channel to $0.37 for a 12′ channel. A listing of induced tonnage and transportation costs and savings is provided in Table 6-43.

Table 6-43. With Project Conditions - Middle Forecasts
Induced Tonnage and Transportation Costs

	2001	2010	2020	2030	2040	2050	2060
Tons - thousands							
10′ - tons	0.0	230.0	511.9	555.4	598.6	645.7	696.8
11′ - tons	0.0	352.1	783.8	850.4	916.7	988.7	1,067.0
12′ - tons	0.0	402.4	895.8	971.9	1,047.6	1,129.9	1,219.4
Transportation Savings per Ton for Induced Traffic - $Oct 03							
10′ - cost	n.a.	0.13	0.12	0.12	0.12	0.12	0.12
11′ - cost	n.a.	0.31	0.31	0.31	0.31	0.31	0.31
12′ - cost	n.a.	0.38	0.37	0.37	0.37	0.37	0.37

B.6.7.3. Lock Processing Times and Costs

Increases in barge loadings reduce the number of barges and tows required for transport. Fewer tows result in decreases in processing and delay times. The inter-related effects of increased loadings, decreased tows, and decreased processing times were estimated in the following manner. First, the numbers of tows assuming no changes in reservoir release schedules or the depth of the channel were calculated based on existing tow sizes (barges per tow) and loadings. Second, the number of tows, assuming the reservoir release schedules are changed, was estimated based on an increase of one in the number of barges per tow. Third, the numbers of

tows were estimated for the deepening components based on consideration of reduced barge line-haul costs for each component both "without" and "with" changes in reservoir release schedules. The procedure is described in detail in Addendum E8 – Towboat Traffic.

The average lockage time per tow is not expected to change due to changes in the reservoir release schedules. However, lockage times are expected to increase if the channel is deepened because of longer entry/exit times at the chambers. Lockage times are also expected to increase if the existing tow-haulage systems are shown to be insufficiently powered to extract barges loaded to more than 9´. Increased times for safety reasons were estimated at 20 minutes for one-cut sized tows and 36 minutes for two-cut sized tows.

The existing tow haulage systems at the locks were not be designed to extract barges loaded to more than 9´. The alternative to the installation of more powerful tow-haulage systems is double tripping. Double tripping requires the tow to tie off at the guide wall, disconnect a set of barges from the tow, push these barges through the chamber, have the towboat relock to retrieve the "tied-off" barges, push these barges through the lock, and reconnect the barges into a single tow. The additional time for this operation was estimated at 54 minutes based on historic data. Benefits were estimated for both scenarios, i.e. operational tow-haulage and the double tripping. Unless noted otherwise, the number of tows and processing times shown in the following tables were based on the assumption of operable tow haulage equipment.

Finally, the number of tows that would increase their loadings to more than 9´ was estimated at 75% based on the percent of total river tonnage that passes through at least one lock and the percent of tonnage that would move in more heavily loaded barges. A detailed description of the procedure is provided in Addendum E8 – Towboat Traffic.

The processing costs for each of the "with" component conditions is listed in the table below. It is expected that the costs would be lower for deeper channels than shallower channels. This is generally the case but there are deviations from the expected values due to the randomness built into the simulation and the relatively low level of delays. This was considered important but not critical to the analysis since the processing costs in the year 2050 represent only one-tenth of one percent of the line-haul costs listed in section above.

Table 6-44. Without Project Condition Middle Forecasts Lock Processing Times and Costs, Without Induced Traffic							
	2003	2010	2020	2030	2040	2050	2060
Tow Locked through MKARNS Projects							
10′	n.a.	20,743	22,581	24,177	25,749	27,464	29,324
11′	n.a.	19,553	21,262	22,742	24,211	25,811	27,544
12′	n.a.	18,867	20,509	21,929	23,332	24,861	26,523
Delay per Tow – average in hours							
10′	n.a.	1.52	1.62	1.49	1.86	2.08	2.46
11′	n.a.	1.69	1.41	1.31	1.54	2.78	2.13
12′	n.a.	1.24	1.55	1.38	1.48	1.69	1.95
Processing Costs – sum of delay and lockage times – $Oct 03; thousands							
10′	n.a.	499.0	565.1	579.4	693.5	792.7	935.4
11′	n.a.	490.9	492.0	516.4	595.9	884.6	811.8
12′	n.a.	416.7	496.1	505.7	558.3	632.6	732.5

Tow processing costs with induced traffic added to existing traffic is summarized in Table 6-45. As expected, the costs of processing tows through the projects increases due to the greater number of tows requiring lockages and increased delays. Again, average delays remain relatively low.

Table 6-45. With Project Conditions– Middle Forecasts with Induced Traffic Lock Processing Times and Costs							
	2003	2010	2020	2030	2040	2050	2060
Tow Lockages							
10′	n.a.	21,302	23,198	24,841	26,468	28,237	30,157
11′	n.a.	20,346	22,138	23,695	25,235	26,912	28,729
12′	n.a.	19,737	21,467	22,968	24,452	26,067	27,821
Delay per Tow – average in hours							
10′	n.a.	1.22	1.72	1.83	1.93	2.50	1.96
11′	n.a.	1.33	1.51	1.38	1.98	2.11	2.21
12′	n.a.	1.23	1.57	1.73	1.80	2.00	1.74
Processing Costs – sum of delay and lockage times – $Oct 03; thousands							
10′	n.a.	464.7	595.0	654.6	727.5	910.0	848.4
11′	n.a.	454.5	531.3	547.1	702.8	774.4	857.3
12′	n.a.	429.1	519.4	586.2	644.3	731.2	736.9

B.6.7.4. Total Tonnage and Transportation Costs

Total tonnage and transportation costs for the "with-project" conditions are listed in the following table.

Table 6-46. With Project Conditions – Middle Forecasts
Tonnage and Transportation Costs (Tons and Dollars in Thousands, Oct 2003 $)

	2003	2010	2020	2030	2040	2050	2060
Existing Tonnage							
9′	11,884.3	14,372.0	15,997.0	17,356.0	18,708.0	20,177.0	21,775.0
Induced Tonnage							
10′	0.0	230.0	511.9	555.4	598.6	645.7	696.8
11′	0.0	352.1	783.8	850.4	916.7	988.7	1,067.0
12′	0.0	402.4	895.8	971.9	1,047.6	1,129.9	1,219.4
Total Tonnage							
9′	11,884.3	14,372.0	15,997.0	17,356.0	18,708.0	20,177.0	21,775.0
10′	11,884.3	14,602.0	16,508.9	17,911.4	19,306.6	20,822.7	22,471.8
11′	11,884.3	14,724.1	16,780.8	18,206.4	19,624.7	21,165.7	22,842.0
12′	11,884.3	14,774.4	16,892.8	18,327.9	19,755.6	21,306.9	22,994.4
Water-Routing Transportation Costs of Existing Traffic except Processing Costs							
9′	150,344.6	177,979.5	196,781.4	213,242.4	229,292.3	246,738.0	265,728.8
10′	n.a.	174,377.2	192,798.7	208,922.2	224,647.2	241,739.9	260,345.9
11′	n.a.	169,065.2	186,930.2	202,562.0	217,814.9	234,394.8	252,443.0
12′	n.a.	166,032.8	183,585.7	198,942.2	213,933.8	230,231.0	247,972.8
All-Overland Transportation Costs of Induced Traffic except Processing Costs							
10′	n.a.	5,043.4	11,146.6	12,076.6	12,987.7	13,979.0	15,059.2
11′	n.a.	7,722.7	17,068.2	18,492.2	19,887.4	21,405.4	23,059.4
12′	n.a.	9,270.8	20,513.9	22,224.8	23,909.8	25,742.6	27,739.0
Water-Routing Transportation Costs of Induced Traffic except Processing Costs							
10′	n.a.	5,014.6	11,082.8	12,007.4	12,913.4	13,899.0	14,973.1
11′	n.a.	7,613.5	16,826.8	18,230.5	19,606.2	21,103.0	22,733.9
12′	n.a.	9,119.5	20,180.4	21,863.4	23,522.0	25,326.1	27,291.4
Lock Processing Costs of Existing Traffic							
9′	325.6	390.1	425.2	436.7	523.1	609.7	759.6
10′	n.a.	499.0	565.1	579.4	693.5	792.7	935.4
11′	n.a.	490.9	492.0	516.4	595.9	884.6	811.8
12′	n.a.	416.7	496.1	505.7	558.3	632.6	732.5
Lock Processing Costs including Induced Traffic							
10′	n.a.	464.7	595.0	654.6	727.5	910.0	848.4
11′	n.a.	454.5	531.3	547.1	702.8	774.4	857.3
12′	n.a.	429.1	519.4	586.2	644.3	731.2	736.9

B.6.7.5. Local Facility Modifications

According to the Principles and Guidelines, resources required to achieve project purposes by project installation represent a National Economic Development Cost and should be evaluated as part of the project costs. This includes construction costs of non-Federal entities. In order for ports on waterway to realize the benefits associated with a deeper channel, the operators may have to modify their facilities. The costs associated with the modifications are part of the project costs. In order to estimate what those costs might be, a survey of port operators on the navigation system was conducted in the summer of 2004. The Tulsa District mailed the questionnaire to all port operators on the MKARNS. The survey collected basic information regarding ports as well as the ports response to deeper channel depths. The survey was conducted using an Office of Management and Budget approved questionnaire (OMB Control #0710-0001). The data was necessary to develop benefits and costs as prescribed by Corps regulation.

The Oklahoma/Arkansas Port Operators Association provided a list of operators. The survey was provided by mail to operators. As a result, sampling was 100% of this population. Corps staff made pre-mailing and follow-up phone calls. Data collected from this survey was tabulated for use for estimating costs

In some instances, port operators were not able to provide an estimate for what their cost would be to accommodate deeper draft barges. The depth of port facilities and dredging costs were unknown. To provide an estimate, the linear dimensions of the port and the depth of the channel at the nearest point of the facility were used to calculate the volume of material that might have to be removed. The estimated cost of the modification for each of these facilities was then based on the unit dredging and disposal costs associated at other locations on the system as applied to the estimated volume of dredge material at the facility.

Although not a Federal cost, local facility modification costs are a cost which must be incurred for navigation savings to be realized, and were therefore included as an associated non-Federal requirement in net benefit calculations.

B.6.7.5. Barge Impacts

Increasing the draft of barges will adversely affect the maneuverability of the tow as it traverses upstream. The change to an 11.5′ draft could alter the out draft and draw of the ports in the upper guard walls, and thus, increase the chance that entering barges could strike the upper guard wall. Exiting tows could get pinned against the guard wall due to these forces. The increase in draft to 11.5′ will increase the barge mass by about 35% and this translates to higher impact forces to the semi-gravity approach walls.

ERDC conducted an evaluation of all the upstream lock approaches. This evaluation was based on guidance in EM 1110-2-1611 and the results of recently completed Lock Approach Guidance research, ERDC/CHL TR-04-4. Based on this review, ERDC recommends that the projects having the greatest potential for approach problems be evaluated with the use of a physical

model. This evaluation may require only a single model study, but possibly as many as four model studies may be needed to answer the effects of the deeper draft vessels on navigation conditions in the upper lock approaches. Further study of the effects will be conducted in the PED phase of the study. At this time, two measures have been taken to roughly represent the barge impact issue. First, included in the cost estimate are costs for pinning guide walls at specific locks. Second, the navigation model includes additional lockage time for entry and exit from each lock (20 minutes for a single lockage, 36 minutes for a double lockage). Until more information is available for a risk and uncertainty analysis, these measures are the best representation of incremental costs due to barge impacts.

B.6.8. Benefits

B.6.8.1. Benefits for Flow Management Components

B.6.8.1.1. Shipper Savings, Type 1: Efficiency Gain

The first measure of shipper savings is the gain in efficiency resulting from a larger annual average tow size. The shipper savings benefit for navigation is computed for thirteen different towboat horsepower and tow size scenarios, representing the possible responses by the towing operators.

Interviews of the largest towing operators were conducted to determine if they would modify their towing operations under the FM-175, FM-200, or FM-OPS components. The two largest operators represent more than 50% of the towing traffic on MKARNS. Phone interviews were conducted with Jan Tran of Rosedale, MS and Pine Bluff Sand & Gravel Company of Pine Bluff, AR. Both firms stated that their tow configurations were sensitive to flows in the 60,000 – 80,000 cfs range. Jan Tran stated that when flows are below 60,000 cfs the company could increase tow sizes by a third.[8] Pine Bluff Sand & Gravel stated that boats with an 8-tow configuration could increase to a 12-tow configuration below 75,000 cfs.[9] By reducing flows, towing operators have more stable water to depend upon, and thus can operate more efficiently. According to historic H&H data, the MKARNS provides efficient flows for 297 days per year.

Currently the average tow configuration for traffic on the MKARNS is 6.9. Average towsize for Jan Tran and Pine Bluff Sand & Gravel equals 9.3 and 9.4, respectively. Given that these tow operators increase tow configuration during efficient flow periods, and that these tow operators represent more than 50% of the towing traffic on MKARNS, and a conservative estimate that no other tow operators modify tow configurations, the following table shows that the annual average tow size will increase.

[8] Memorandum for Record of the interview with Jan Tran is included in Addendum F1.

[9] Memorandum for Record of the interview with Pine Bluff Sand & Gravel is included in Addendum F2.

Table 6-47. Calculating an Increase in Annual Average Tow Size		
Towsize Increase by JanTran and PBSG (tows)		3
Percent of MKARNS Tows	x	58%
MKARNS Towsize Increase During Efficient Flow		1.74
Percentage of Year with Efficient Flow	x	81%
Increase in Yearly Average Towsize for MKARNS		1.42
Current Yearly Average Towsize for MKARNS	+	6.9
New Yearly Average Towsize for MKARNS		8.32

The survey also asked operators if they would modify their towboat horsepower under the FM-175, FM-200, or FM-OPS components. No towboat operators reported an expectation of shifting to higher or lower horsepower boats in response to the three flow management components.

After TVA computed the efficiency shipper savings per ton per commodity, the savings were multiplied by commodity forecasts to calculate annual shipper savings for each rate alternative. Currently, the average towboat horsepower is 2170, and the average tow configuration is 7. Rate alternatives 1 through 12 are combinations of increased/decreased average towboat horsepower and increased/decreased average tow configurations. Rate alternative 13 increases tow configuration and has no change in towboat horsepower. For example, compared to current operations, rate alternative 1 is a decrease in horsepower with no change in tow configuration. The rate alternative that corresponds to the tow operators' responses, a moderate increase in average tow configuration and a constant average towboat horsepower, is rate alternative 13.[10] Although several rate alternatives produce greater efficiency shipper savings, towboat operators do not expect to shift to lower horsepower towboats due to a change in flow management.

Savings were calculated by multiplying the average transportation savings per ton that was estimated in the 2001 Flow Management Rate Study by TVA by the updated traffic forecasts. The average savings per ton for 2001 traffic was $0.49. This savings per ton was multiplied by projected tonnage to compute the benefits of revised release schedules. This is an approximation since the $0.49 average could actually change over time as the traffic for different commodities grows at different rates. Any errors from using the average "total" savings per ton are thought to be small.

Benefits were estimated using the fiscal year 2005 discount rate of 5.375%, a base year for completion of construction of 2006 with benefits being first realized in 2007, and a 50 year economic life. The benefits attributable to the proposed revisions in the release schedules and using the updated mid-level traffic forecasts are listed in Table 6-48. In order to update these estimates to reflect July 2004 prices, the Consumer Price Index - transportation index, developed by the Bureau of Labor Statistics, was used (October 2001=152.3, July 2004=164.0, index=1.077).

[10] A spreadsheet calculating efficiency shipper savings for rate alternative 13 is located in the Navigation Addenda.

Table 6-48. Shipper Savings from Efficiency Gain for FMA-175, FMA-200, and FMA-OPS (Oct 2001 $1,000; 5.375%; 50 yr)			
Year	**Tons**	**Benefits - $**	**Present Value - $**
2003	11,884.2	5,823.3	
2005	12,435.9	6,093.6	6,093.6
2010	14,372.1	7,042.3	5,711.7
2020	15,996.8	7,838.4	3,766.2
2030	17,355.9	8,504.4	2,420.7
2040	18,707.5	9,166.7	1,545.7
2050	20,176.7	9,886.6	987.6
2060	21,775.4	10,669.9	631.4
Cumulative			$135,524.0
Average Annual Equivalent			**$7,857.77**
Shipper Savings from Efficiency Gain (July 2004 $1,000; 5.375%; 50 yr)			
Year	**Tons**	**Benefits - $**	**Present Value - $**
2003	11,884.2	6,270.66	
2005	12,435.9	6,561.72	6,561.72
2010	14,372.1	7,583.30	6,150.47
2020	15,996.8	8,440.56	4,055.51
2030	17,355.9	9,157.73	2,606.67
2040	18,707.5	9,870.90	1,664.48
2050	20,176.7	10,646.11	1,063.50
2060	21,775.4	11,489.58	679.95
Cumulative			$145,935.25
Average Annual Equivalent			**$8,461.42**

B.6.8.1.2. Shipper Savings, Type 2: Change in Operating Days

The second method for measuring the cost reductions from changes in the operating plan for the MKARNS would be to measure the average number of navigation days gained by a new operating plan. At the present time, the MKARNS is closed between 20 and 40 days per year due to excessively high flow rates that stop navigation. A reduction in cost method was employed to estimate the towboat operator savings based upon a daily operator cost for tying up (lay-up) of the vessel and tow.

The Flow Management No Action (FM-NA) component is operating the system with a flow of 150,000 cfs at Van Buren. This plan is the existing condition or without-project condition. This means that releases from upstream projects will be made such that the combined flow at Van Buren will be as near 150,000 cfs as is reasonably possible when the system is 40% - 50% full or higher. When the system is at a lower percent full, it would be operated at 105,000 cfs. When the system falls below 6% full, there would be a transition back to normal conservation operations. There is no change in the number of operating days for this component.

The Flow Management 175,000 cfs (FM-175) component refers to operating the system with a flow at Van Buren and Sallisaw gages of 175,000 cfs as is reasonably possible. In addition, this component would replace the 75,000 cfs bench with a 60,000 cfs bench operation. This component increases operating days (number of days below 100,000 cfs) by 16 days.

The Flow Management 200,000 cfs (FM-200) component refers to operating the system with a flow at Van Buren and Sallisaw gages of 200,000 cfs as is reasonably possible. In addition, this component would replace the 75,000 cfs bench with a 60,000 cfs bench operation. This component increases operating days (number of days below 100,000 cfs) by 17 days.

The Flow Management Operations Only (FM-OPS) component refers to operating Sallisaw and Van Buren at 150,000 cfs, or a 22-foot stage at Van Buren. A 60,000 cfs bench would replace the 75,000 cfs bench. Van Buren and Sallisaw would also be operated for 150,000 cfs to 250,000 cfs at 75% system storage. The regulating discharge would depend upon the highest flow achieved from local runoff at Van Buren that would be greater than 150,000 cfs and less than or equal to 250,000 cfs. After this component was developed and evaluated, another component with only a 60,000 cfs bench was evaluated. This component is the same as the existing operations plan except that the 75,000 cfs bench is being replaced with a 60,000 bench. In addition, this component contains 3% lower system storage. There is no change from the existing condition plan in regards to discharge frequency, pool elevation frequency, and duration. This component decreases operating days (number of days below 100,000 cfs) by two days.

To calculate this cost reduction for each component, the number of navigation days gained was multiplied by the daily towboat cost for the average size horsepower towboat and the average tow size and number of barges (8).[11] The result was multiplied by the average number of boats on the waterway (8). The total annual savings calculated represents the increased or decreased cost for "parked" tows.

<u>Cost Reduction for FM-175</u>

Gained Days	X	(Daily Towboat + Barge Expense)	X	Number Boats	= Annual Benefit
16	X	[$4315.15 + (8 x $105.70)]	X	8	= $660,600

For FMA175, the average annual cost reduction from an additional 16 days of operation is $660,600. For each component, gains or losses in operating days were obtained from SUPER Model output.[12] Using this procedure, the cost reductions from changes in operating days are calculated. In order to update these estimates to reflect July 2004 prices, the Consumer Price Index - transportation index, developed by the Bureau of Labor Statistics, was used (FY 2000=151.6, July 2004=164.0, index=1.08).

[11] Daily towboat and barge expense comes from the shallow draft guidance: FY 2000 Planning Guidance Shallow Draft Vessel Costs. Daily towboat is for 2200-2400 horsepower linehaul. Barge expense is total daily costs for 195' x 35' x 12' covered hopper barges.

[12] Gain in days below 100,000 cfs taken from SUPER Model results. Days rounded to whole numbers.

Table 6-49. Incremental Cost Reductions from Change in Operating Days (FY 2000 $)		
Components	**Change in Operating Days**	**Average Annual Cost Reduction**
No Action Component	0	$0
175,000 cfs Component	16	$701,900
200,000 cfs Component	17	$660,600
Operations Only Component	-2	($82,600)
Incremental Cost Reductions from Change in Operating Days (July 2004 $)		
No Action Component	0	$0
175,000 cfs Component	16	$759,311
200,000 cfs Component	17	$714,633
Operations Only Component	-2	($89,356)

B.6.8.1.3. Navigation Benefit for Flow Management Components

To calculate the total economic impact to navigation from flow management, add the cost reduction from efficiency gain and the cost reduction from a change in operating days. Table 6-50 shows the results. The greatest navigation cost reduction would occur under FM-175 with an estimated annual incremental benefit of over $9.2 million compared to the No Action component. Annual incremental benefits under FM-200 would be almost $9.2 million, while under FM-OPS annual incremental benefits would be almost $8.4 million. There would be no annual incremental benefits under the No Action component.

Table 6-50. Incremental Navigation Benefits for Flow Management Components (July 2004 $1,000)				
Type of Cost Reduction	**FM- NA**	**FM-175**	**FM-200**	**FM-OPS**
Shipper Savings from Change in Operation Days	$0	$759.31	$714.63	($89.36)
Shipper Savings from Navigation Efficiency	$0	$8,461.42	$8,461.42	$8,461.42
Total	**$0**	**$9,220.73**	**$9,176.05**	**$8,372.06**

B.6.8.2. Benefits for Navigation Channel Deepening Components

Benefits were estimated using the fiscal year 2005 discount rate of 5.375%, a base year for completion of construction of 2006 with benefits being first realized in 2007, and a 50 year economic life. Benefits are expressed in October 2003 dollars. In order to update these estimates to reflect July 2004 prices, the Consumer Price Index - transportation index, developed by the Bureau of Labor Statistics, was used (October 2003=157.1, July 2004=164.0, index=1.044).

Benefits were initially calculated assuming that 12′ of depth is available on the Lower Mississippi River 100% of the time. Gage readings indicate that 12% is actually available only about 96% of the time. During the low flow periods, the components that provide greater depth on MKARNS would not provide benefits to shippers since the depth of the Lower Mississippi would be a constraint to barge loadings. To reflect the occasional depth restrictions, the benefits attributed to each component were reduced. Since 9′ is available on the Lower Miss nearly 100% of the time, the percents of time that 10′ and 11′ would not be available were interpolated between the 9′ and 12′ percentages. The resulting percentages were 98.7% for 10′ , 97.3% for

11′ , and 96.0% for the 12′ depth component. In sum, the originally estimated benefits for the 12% channel were reduced by 4.0%, the 11′ by 2.7% and the 10′ by 1.3%. Depth-limited benefits are provided in this section. The unadjusted benefits are provided in Addendum E9.

Benefits were also estimated for two additional scenarios: 1) tow-haulage systems are operable; and 2) tow-haulage systems are not operable.

B.6.8.2.1. Benefits with Operable Tow-haulage Systems

Operable tow haulage systems would reduce the processing time for tows that require two-cut lockages. Faster lockage times means reduced processing and delay times. The following tables list the estimated benefits of this scenario.

Total Benefits of Navigation Channel Deepening with Operable Tow-Haulage Systems

The basic economic benefit of navigation improvement plans is a reduction in transportation costs. The reduction is due to the more efficient use of existing equipment, reductions in transit time, and in the use of water transportation rather than alternative overland modes. The benefits are expressed as average annual equivalent values in Table 6-51. Over 95% of the benefits are cost reduction benefits, which is consistent with the expected effects of providing a deeper channel. The only other category is “shift of mode”, which is relatively small due to the relatively small amount of “induced” traffic and the marginal savings realized by these shipments.

Table 6-51. Summary of Annualized NED Benefits for Components Middle Forecasts (Oct 2003 $1,000; 5.375%; 50 yr)			
Benefits With Induced Traffic			
	10´	11´	12´
Cost reduction	$3,798.10	$9,540.50	$12,655.30
Existing	$3,952.60	$9,643.10	$12,738.20
Processing	($154.50)	($102.60)	($82.90)
Shift of mode	$54.90	$205.00	$259.90
Shift in O/D	$0.00	$0.00	$0.00
New Movement	$0.00	$0.00	$0.00
Total	**$3,853.00**	**$9,745.50**	**$12,915.30**
Benefits Without Induced Traffic			
	10´	11´	12´
Cost reduction	$3,816.20	$9,592.60	$12,695.10
Existing	$3,952.60	$9,643.10	$12,738.20
Processing	($136.40)	($50.50)	($43.10)
Shift of mode	$0.00	$0.00	$0.00
Shift in O/D	$0.00	$0.00	$0.00
New Movement	$0.00	$0.00	$0.00
Total	**$3,816.20**	**$9,592.60**	**$12,695.10**
Summary of Annualized NED Benefits for Components Middle Forecasts (July 2004; $1,000; 5.375%; 50 yr)			
Benefits With Induced Traffic			
	10´	11´	12´
Cost reduction	$3,964.92	$9,959.53	$13,211.13
Existing	$4,126.20	$10,066.64	$13,297.68
Processing	($161.29)	($107.11)	($86.54)
Shift of mode	$57.31	$214.00	$271.32
Shift in O/D	$0.00	$0.00	$0.00
New Movement	$0.00	$0.00	$0.00
Total	**$4,022.23**	**$10,173.53**	**$13,482.55**
Benefits Without Induced Traffic			
	10´	11´	12´
Cost reduction	$3,983.81	$10,013.92	$13,252.68
Existing	$4,126.20	$10,066.64	$13,297.68
Processing	($142.39)	($52.72)	($44.99)
Shift of mode	$0.00	$0.00	$0.00
Shift in O/D	$0.00	$0.00	$0.00
New Movement	$0.00	$0.00	$0.00
Total	**$3,983.81**	**$10,013.92**	**$13,252.68**

Incremental Benefits by Reach

Benefits were categorized by reach in order to assess the incremental benefits of deepening the navigation system. There are alternative procedures for performing the computations, but all will yield the same answer if correctly applied. The procedure used in this study was to start at the upper reach near Tulsa and compute the transportation costs for traffic with an origin and/or destination in this reach "without" and "with" channel deepening. The difference in transportation costs are the benefits for deepening the final increment of the river given that other reaches were also deepened. The next step was to repeat the process for the next downstream reach with the added increment of benefits reflecting the traffic that had an origin or destination in that reach plus any upstream traffic moving into or through this second reach. The process was continued for all six reaches down to mouth of the river. The incremental benefits were then computed by subtracting the benefits of the upstream reach from the cumulative benefits of the adjacent downstream reach. For example, if the benefits for the upper most reach (Reach 6) were $100 and the cumulative benefits for the second most upper reach (Reach 5) were $150, then the incremental benefit of deepening Reach 6 given that the other reaches were deepened was $100 and the comparable benefit for Reach 5 was $50. An alternative, but computationally more complicated procedure, would have been to start the analysis at the mouth (Reach 1) and proceed upstream. The results would be identical if the analysis proceeded from the mouth upstream to Tulsa, but the computations would be more complicated since Reach 1 (mouth) traffic could either stay within the reach, move upstream or move downstream, whereas Reach 6 (Tulsa) traffic could only stay within the Reach or move downstream. The results of the computations are listed in Table 6-52. The largest increment of benefits is realized with the extension of the project through Reach 6. The table also shows that the benefits are sensitive to channel depth, with the benefits of an 11′ channel exceeding the benefits of a 10′ channel by nearly 168% and the benefits of the 12′ channel exceeding those of the 11′ channel by 35%.

Benefits for Alternative Traffic Forecasts

Benefits given alternative future traffic levels are listed in Table 6-53. The 10′ component with high traffic scenario results in negative benefits, assuming no diversion of traffic, because of high demands and limited capacity. Lockage demands are higher for the 10′ component than for the 11′ and 12′ components because of lighter barge loadings, and therefore higher numbers of barges and tows.

Table 6-52. Incremental Benefits by Depth and Reach - Middle Forecasts and Induced Traffic (Oct 2003; $1,000; 5.375%; 50 yr)						
	10´		11´		12´	
Reach	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental
1	324.9	324.9	893.9	893.9	1,197.60	1,197.60
2	168.0	492.9	537.1	1,431.0	769.60	1,967.20
3	468.4	961.3	1,117.6	2,548.6	1,374.30	3,341.50
4	63.0	1,024.3	164.1	2,712.7	216.70	3,558.20
5	224.5	1,248.8	581.4	3,294.1	803.00	4,361.20
6	2,604.2	3,853.1	6,451.4	9,745.4	8,554.10	12,915.30
Total	**3,853.1**		**9,745.4**		**12,915.30**	

Incremental Benefits by Depth and Reach - Middle Forecasts and Induced Traffic (July 2004; $1,000; 5.375%; 50 yr)						
	10´		11´		12´	
Reach	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental
1	339.17	339.17	933.16	933.16	1,250.20	1,250.20
2	175.38	514.55	560.69	1,493.85	803.40	2,053.60
3	488.97	1,003.52	1,166.69	2,660.54	1,434.66	3,488.26
4	65.77	1,069.29	171.31	2,831.84	226.22	3,714.48
5	234.36	1,303.65	606.94	3,438.78	838.27	4,552.75
6	2,718.58	4,022.23	6,734.75	10,173.53	8,929.81	13,482.55
Total	**4,022.23**		**10,173.53**		**13,482.55**	

Table 6-53. Average Annual Equivalent Benefits for Three Traffic Scenarios (Oct 2003; $1,000; 5.375%; 50 yr)			
		Without Induced	**With Induced**
Low Forecasts			
	10′	2,927.90	2,937.70
	11′	7,317.00	7,428.80
	12′	9,689.30	9,887.10
Middle Forecasts			
	10′	3,816.30	3,853.00
	11′	9,592.60	9,745.50
	12′	12,695.10	12,915.30
High Forecasts	(Assuming No Traffic Diverted Off Waterway)		
	10′	(3,566.10)	(8,188.70)
	11′	15,982.30	7,814.90
	12′	21,429.10	20,148.20
Average Annual Equivalent Benefits for Three Traffic Scenarios (July 2004; $1,000; 5.375%; 50 yr)			
		Without Induced	**With Induced**
Low Forecasts			
	10′	3,056.50	3,066.73
	11′	7,638.37	7,755.08
	12′	10,114.86	10,321.35
Middle Forecasts			
	10′	3,983.92	4,022.23
	11′	10,013.92	10,173.53
	12′	13,252.68	13,482.55
High Forecasts	(Assuming No Traffic Diverted Off Waterway)		
	10′	(3,722.73)	(8,548.36)
	11′	16,684.26	8,158.14
	12′	22,370.29	21,033.13

B.6.8.2.2. Benefits with No Operable Tow-Haulage Systems

There is uncertainty if the existing tow-haulage equipment is powerful enough to extract more heavily laden barges. Although the with-project condition assumes operable tow-haulage equipment, it is important to examine the effect of non-operable equipment. Without operable tow-haulage equipment, lock processing times lengthen for tows requiring two-cut lockage operations. Longer lockage times mean higher costs for processing tows and delays.

Total Benefits with No Operable Tow-Haulage Systems

Benefits without operable tow-haulage systems are in the range of $150,000 to $250,000 lower when measured on an average annual equivalent basis than the benefits "with" operable tow-haulage systems. The benefits without tow-haulage for each alternative depth and with/without induced traffic are listed in Table 6-54. In order to update these estimates to reflect July 2004 prices, the Consumer Price Index - transportation index, developed by the Bureau of Labor Statistics, was used (October 2003=157.1, July 2004=164.0, index=1.044).

Table 6-54. Summary of Annualized NED Benefits for Components Middle Forecasts No Tow Haulage (Oct 2003 $1,000; 5.375%; 50 yr)			
Benefits With Shift of Mode			
	10′	11′	12′
Cost reduction	3,559.70	9,353.60	12,488.80
Existing	3,952.60	9,643.10	12,738.20
Processing	(373.80)	(289.40)	(249.40)
Shift of mode	54.90	205.00	259.90
Shift in O/D	0.00	0.00	0.00
New Movement	0.00	0.00	0.00
Total	**3,614.60**	**9,558.60**	**12,748.70**
Benefits Without Shift of Mode			
	10′	11′	12′
Cost reduction	3,578.80	9,441.30	12,559.30
Existing	3,952.60	9,643.10	12,738.20
Processing	(373.80)	(201.80)	(178.90)
Shift of mode	0.00	0.00	0.00
Shift in O/D	0.00	0.00	0.00
New Movement	0.00	0.00	0.00
Total	**3,578.80**	**9,441.30**	**12,559.30**
Summary of Annualized NED Benefits for Components Middle Forecasts No Tow Haulage (July 2004; $1,000; 5.375%; 50 yr)			
Benefits With Shift of Mode			
	10′	11′	12′
Cost reduction	3,735.98	9,764.52	13,037.32
Existing	4,126.20	10,066.64	13,297.68
Processing	(390.22)	(302.11)	(260.35)
Shift of mode	57.31	214.00	271.32
Shift in O/D	0.00	0.00	0.00
New Movement	0.00	0.00	0.00
Total	**3,793.30**	**9,978.53**	**13,308.64**
Benefits Without Shift of Mode			
	10′	11′	12′
Cost reduction	3,735.98	9,855.97	13,110.92
Existing	4,126.20	10,066.64	13,297.68
Processing	(390.22)	(210.66)	(186.76)
Shift of mode	0.00	0.00	0.00
Shift in O/D	0.00	0.00	0.00
New Movement	0.00	0.00	0.00
Total	**3,735.98**	**9,855.97**	**13,110.92**

Incremental Benefits by Reach with No Operable Tow-Haulage Systems

The incremental benefits by reach are listed in Table 6-55. Least affected is Reach 6, where the uppermost projects do not currently have tow-haulage systems.

Table 6-55. Incremental Benefits by Depth and Reach - Middle Forecasts and Induced Traffic No Tow Haulage (Oct 2003; $1,000; 5.375%; 50 yr)						
	10´		11´		12´	
Reach	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental
1	207.1	207.1	801.8	801.8	1,118.3	1,118.3
2	91.4	298.5	486.5	1,288.3	719.8	1,838.2
3	436.7	735.2	1,084.3	2,372.7	1,347.3	3,185.5
4	58.7	794.0	160.1	2,532.8	212.9	3,398.3
5	218.4	1,012.4	576.1	3,108.9	798.1	4,196.4
6	2,602.2	3,614.6	6,449.6	9,558.6	8,552.3	12,748.7
Total	**3,614.6**		**9,558.6**		**12,748.7**	
Incremental Benefits by Depth and Reach - Middle Forecasts and Induced Traffic (July 2004; $1,000; 5.375%; 50 yr)						
	10´		11´		12´	
Reach	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental
1	216.20	216.20	837.02	837.02	1,167.42	1,167.42
2	95.41	311.61	507.87	1,344.88	751.41	1,918.94
3	455.88	767.49	1,131.92	2,476.91	1,406.47	3,325.41
4	61.28	828.87	167.13	2,644.04	222.25	3,547.56
5	227.99	1,056.87	601.40	3,245.45	833.15	4,380.71
6	2,716.49	3,773.36	6,732.87	9,978.42	8,927.93	13,308.64
Total	**3,773.25**		**9,978.22**		**13,308.64**	

Benefits for Alternative Traffic Forecasts with No Operable Tow-Haulage Systems

The benefits for "no tow-haulage" under each of the three traffic scenarios and with/ without induced traffic are listed in Table 6-56. The lack of operable tow-haulage equipment becomes especially critical under the high traffic growth scenario because lockage demands approach lock capacity, resulting in high delays. The benefits are shown to be negative, although this would only be the case in the unlikely event that no traffic diverted off the waterway because of high delays.

Table 6-56. Average Annual Equivalent Benefits for Three Traffic Scenarios No Tow Haulage (Oct 2003; $1,000; 5.375%; 50 yr)			
		Without Induced	With Induced
Low Forecasts			
	10′	2,839.1	2,842.4
	11′	7,246.5	7,347.5
	12′	9,621.9	9,813.8
Middle Forecasts			
	10′	3,578.8	3,614.6
	11′	9,441.3	9,558.6
	12′	12,559.3	12,748.7
High Forecasts	(assuming no traffic diverted off waterway)		
	10′	(11,836.2)	(36,330.8)
	11′	(3,980.6)	(19,166.6)
	12′	6,150.7	(5,158.4)
Average Annual Equivalent Benefits for Three Traffic Scenarios No Tow Haulage (July 2004; $1,000; 5.375%; 50 yr)			
		Without Induced	With Induced
Low Forecasts			
	10′	2,963.80	2,967.24
	11′	7,564.77	7,670.21
	12′	10,044.50	10,244.83
Middle Forecasts			
	10′	3,735.98	3,773.36
	11′	9,855.97	9,978.42
	12′	13,110.92	13,308.64
High Forecasts	(assuming no traffic diverted off waterway)		
	10′	(12,356.06)	(37,926.49)
	11′	(4,155.43)	(20,008.42)
	12′	6,420.85	(5,384.96)

B.7. Tourism and Recreation

B.7.1. Overview

The Environmental Laboratory, U.S. Army Engineer Research and Development Center (ERDC) was asked to assist the Districts in evaluation of changes in recreation use and National Economic Development (NED) benefits that would occur at Corps projects as a result of implementing flow management components on the Arkansas River. Building on experience with the Regional Recreation Demand Model (Ward, F.A., Roach, B.A., Ready, R.C. and Henderson, J.E. 1996. "Regional Recreation Demand Models for Large Reservoirs: Database Development, Model Estimation, and Management Applications," Technical Report R-96-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.), some work was performed by Mr. Jim Henderson, ERDC, and Dr. Brian Roach, Tufts University, under contract to ERDC.

B.7.2. Approach to Recreation Benefits

The approach to NED evaluation recommended to the Districts follows the process set out in Principles and Guidelines (U.S. Water Resources Council 1983) and the Planning Guidance Notebook (PGN) (US Army Engineers 2000, Engineer Regulation 1105-2-100, Appendix E). The guidance on evaluation of recreation benefits (PGN, Part E-50) recommends the use of Travel Cost Models (TCM) or Contingent Valuation Models (CVM) to estimate NED recreation benefits. Unit Day Values (UDV) are not appropriate for the Arkansas River Navigation Study because visitation and annual Federal project recreation costs exceed the limits under which UDV may be used (PGN, Part E-50). NED benefits for day-use and camping trips were estimated using information on visitor origins (i.e. zip codes) obtained from recreation surveys, demographic data, and project facility data. Visitation models were estimated to predict the impact of water level changes on visitation, and consequently, NED benefits. These models used historical visitation data, weather data, hydrologic information from the Districts, and other information to predict visitation.

The Arkansas River Navigation Study involves 18 locks and dams in Arkansas and Oklahoma and 11 reservoirs in Oklahoma. Early in the modeling effort in FY2001, we attempted to focus the analysis by asking whether projects could be identified that would not be impacted by the operation alternatives. Such projects could then be deleted from the analysis. However, the answer we received was that the projects in the system are operated together and that specific projects could not be excluded from the analysis. The modeling approach taken here was to develop visitation and travel cost models based on all projects in the system. Ultimately, model development covered 11 navigation projects in Arkansas,[13] and five navigation projects and nine reservoirs in Oklahoma.[14] When the Hydrologic Engineering Center (HEC) hydrologic runs were completed in late February 2003, only eight of the reservoirs in Oklahoma showed changes in water levels (Table 7.2, SUPER Model Report). Thus, the results presented here pertain to a larger number of projects than actually affected in the operation alternatives.

[13] There were no historic hydrologic data for Norrell L&D.

[14] Hudson and Pensacola reservoirs, being non-Corps projects, did not have historic visitation data in the Natural Resources Management System.

Another relevant issue that was not identified until after the hydrologic runs were completed was the need to evaluate scenarios of water levels above the recreation pool. The assumption used in the Arkansas River visitation models is that the design recreation pool elevation produces the optimal recreation conditions and, hence, the maximum recreation visitation. We also assumed that visitation would remain at this peak level for water levels above the recreation pool. In other words, water levels above the recreation pool would have no negative effect on visitation. This assumption has served well in previous studies (Ward et al 1996; Roach, Henderson, and Ward (draft)) because water levels above the recreation pool were quite infrequent and, when this did occur, only slightly above the recreation pool. Also, the impact of water levels above the recreation pool had not been studied previously because insufficient data were available to model this effect.

Planning in the early stages of the research did not indicate that water levels above the recreation pool would be a relevant issue, partly because formulation of alternatives were not available. Review by the Tulsa District of the initial visitation and benefit estimates indicated that the results did not reflect a loss of visitation and benefits for the projects affected by changes in water levels above the recreation pool. Discussion of this issue led us to examination whether the modeling strategy could be revised to estimate recreation changes for water levels above the design recreation pool level.

To accommodate the need to begin comparison of alternatives, without visitation model revision, the travel cost benefit models were used here to provide baseline NED benefits (FY2001 price levels, base year conditions in 2005). Changes in visitation were developed from "Change in the Number of Days Reservoirs are Expected to Be Above Conservation Pool Compared to Existing Conditions (No Action Component)," Table 7.2, SUPER Model Report.

B.7.3. Changes in Recreation Benefit

The changes in recreation use and benefits at the eight affected reservoir projects are summarized in Table 7-1, with detailed project-by-project calculations shown in Tables 7-2. For FM-NA, annual project benefits are $23.1 million for 2.51million annual visits (Table 7-2). Water management conditions under FM-175 produce annual benefits of $21.7 million for 2.37 million annual visits. FM-200 produces annual benefits of $22.3 million for 2.43 million annual visits. The annual incremental recreation loss is $1,381,350 for FM-175 and $759,700 for FM-200. In order to update these estimates to reflect July 2004 prices the Consumer Price Index - Recreation index, developed by the Bureau of Labor Statistics was used (FY 2001=104.5, July 2004=108.7, index=1.04). In July 2004 prices, the annual incremental recreation loss is $1,443,516 for FM-175 and $793,868 for FM-200.

According to the Hydrology and Hydraulics Report: Appendix A, Section 4.3, "The results of the backwater modeling indicate that there are negligible impacts to the 2-year and 100-year water surface elevations." Therefore, no additional recreation benefits occur under navigation channel deepening components.

Table 7-1. Average Annual Incremental Recreation Benefits (FY01$)						
	FM-175			FM-200		
Project	**Camping**	**Day-Use**	**Total**	**Camping**	**Day-Use**	**Total**
Copan	$97	$1,323	$1,420	$49	$662	$710
Eufaula	$6,197	$19,657	$25,854	$1,549	$4,914	$6,464
Fort Gibson	$85,373	$287,925	$373,297	$45,970	$155,036	$201,006
Hulah	$0	$0	$0	$1,008	$5,991	$7,000
Keystone	$33,102	$379,175	$412,277	$26,764	$306,567	$333,331
Oologah	$39,469	$101,358	$140,827	$31,830	$81,740	$113,570
Tenkiller Ferry	$89,968	$311,286	$401,253	$21,884	$75,718	$97,602
Wister	$3,462	$22,964	$26,426	$0	$0	$0
Total	$257,668	$1,123,687	**$1,381,355**	$129,054	$630,629	**$759,682**
Total (July04$)[1]			**$1,436,874**			**$790,215**

[1]Consumer Price Index, All Urban Consumers, Recreation, FY01=104.5, July 2004=108.7, Index= 1.04

Table 7-2. Visitation and Benefits						
	Per-Visit Benefits (FY01$)		FM-NA Annual Visits		FM-NA Annual Benefits (FY01$)	
Project	**Camping**	**Day-Use**	**Camping**	**Day-Use**	**Camping**	**Day-Use**
Copan	$13.17	$9.93	1,347	24,315	$17,743	$241,460
Eufaula	$12.43	$8.75	22,752	102,527	$282,750	$896,850
Fort Gibson	$11.48	$7.59	208,810	1,065,330	$2,396,999	$8,084,036
Hulah	$12.81	$9.58	4,787	38,030	$61,327	$364,478
Keystone	$12.87	$10.11	19,978	291,269	$257,071	$2,944,659
Oologah	$13.32	$8.03	34,891	148,610	$464,720	$1,193,404
Tenkiller Ferry	$13.62	$11.20	65,144	274,246	$887,518	$3,070,791
Wister	$12.33	$9.11	20,504	184,096	$252,730	$1,676,369
TOTAL			378,213	2,128,423	**$4,620,858**	**$18,472,047**

	FM-175		FM-175 Annual Visits		FM-175 Annual Benefits (FY01$)	
Project	**Days above Rec. Pool**	**% of Days above Rec. Pool**	**Camping**	**Day-Use**	**Camping**	**Day-Use**
Copan	2	0.005	1,340	24,182	$17,646	$240,137
Eufaula	8	0.022	22,253	100,280	$276,553	$877,193
Fort Gibson	13	0.036	201,373	1,027,387	$2,311,626	$7,796,111
Hulah	0	0.000	4,787	38,030	$61,327	$364,478
Keystone	47	0.129	17,405	253,763	$223,968	$2,565,484
Oologah	31	0.085	31,928	135,988	$425,250	$1,092,047
Tenkiller Ferry	37	0.101	58,540	246,446	$797,551	$2,759,505
Wister	5	0.014	20,223	181,574	$249,268	$1,653,405
TOTAL			357,850	2,007,650	**$4,363,190**	**$17,348,360**

Table 7-2 (cont.)						
	FMA-200		FM-200 Annual Visits		FM-200 Annual Benefits (FY01$)	
Project	**Days above Rec. Pool**	**% of Days above Rec. Pool**	**Camping**	**Day-Use**	**Camping**	**Day-Use**
Copan	1	0.003	1,343	24,248	$17,695	$240,799
Eufaula	2	0.005	22,627	101,965	$281,201	$891,935
Fort Gibson	7	0.019	204,805	1,044,899	$2,351,029	$7,929,000
Hulah	6	0.016	4,708	37,405	$60,319	$358,486
Keystone	38	0.104	17,898	260,945	$230,307	$2,638,092
Oologah	25	0.068	32,501	138,431	$432,890	$1,111,664
Tenkiller Ferry	9	0.025	63,538	267,484	$865,634	$2,995,073
Wister	0	0.000	20,504	184,096	$252,730	$1,676,369
TOTAL			367,925	2,059,474	**$4,491,805**	**$17,841,418**

B.7.4. Assumptions of Analysis

1. Baseline visitation obtained from the visitation model using the 5-year probability input data.
2. The reduction in visitation from baseline is assumed proportional to the number of days in which the water level is above the recreation pool. Historic hydrological data indicate that high pools are most likely in the late spring and early fall, times of high recreation use.
3. No differentiation is made between different magnitudes of water levels above the recreational pool.
4. The above two assumptions imply that visitation is zero on any day where the water level is above the recreation pool.
5. The distribution of days in which the water level is above the recreation pool is assumed to be randomly and evenly distributed throughout the year.
6. The analysis assumes no reduction in visitation for water levels below the recreation pool except for those incorporated into the baseline visitation.
7. The estimates should be considered an upper-bound estimate of the impact of water levels above the recreation pool unless the distribution of days above the recreation pool is skewed towards the recreation season (April-Oct.).

B.7.5. Potential Flood Impacts on Recreational Facilities

Various operational changes on the Arkansas River have been considered to determine if modifications could improve the number of navigation days along the waterway. Because changes in the operation of various upstream reservoirs in the Arkansas River basin were required to affect these downstream flows, impacts to other project purposes such as recreation, flood damage reduction and hydropower were evaluated to assess the overall feasibility of the existing operational plan. This section deals with the evaluation of impacts to recreational facilities on upstream reservoirs.

The “SUPER Model” hydrologic water control model was used to evaluate proposed flow management components to the existing flow regulation regime. Impacts to the recreation facilities were evaluated for three flow management components to measure, which would add benefits or provide the least harmful impacts to recreation.

A summary of average annual equivalent damages by component for the recreational facility sites in both Oklahoma and Arkansas is provided in Tables 7-3 and 7-4. The first part of the table identifies the estimated damages that would occur from FM-NA and the estimated damages that would occur from the other alternatives under consideration. A summary of estimated damages is shown at the bottom of each table that reflects the incremental net difference of each component less the without project component. Data presented in the tables is based on a 1988 inventory of recreational facilities, a general depth damage relationship and estimate pool changes based on historical based H&H model, all of which are contained within the SUPER Model. Typically, such damages are not accounted for as such, but rather part of the operations and maintenance of the projects. Damages were indexed to July 2004 price levels using the Civil Works Construction Cost Index System (CWCCIS) Recreation Facilities feature (FY1988=369.45, 3Q04=575.13, Index=1.557).

Table 7-3. Oklahoma Recreation Facilities, Average Annual Equivalent Damages ($1,000)				
Oklahoma Pool	**FM-NA**	**FM-175**	**FM-200**	**FM-OPS**
Inola	-	-	-	-
Muskogee	-	-	-	-
Sallisaw	-	-	-	-
Oologah	78.2	80.6	79.8	79.1
Hulah	25.7	25.4	25.5	25.5
Copan	18.0	18.0	18.1	17.9
Pensacola	72.8	67.3	66.3	68.1
Markham Ferry	-	-	-	-
Ft. Gibson	329.3	346.0	339.3	327.6
Kaw	122.1	123.5	122.5	122.1
Keystone	397.4	404.4	395.6	395.0
Tenkiller	282.8	303.5	297.5	290.9
Eufaula	337.3	342.3	336.3	339.1
Wister	59.0	60.4	60.4	60.8
Total (FY 1988 $1,000)	**1,722.6**	**1,771.4**	**1,741.3**	**1,726.1**
Total (July 2004 $1,000)	**2,698.8**	**2,775.3**	**2,728.1**	**2,704.3**
Summary of Average Annual Equivalent Benefits by Plan				
Oklahoma		**FM-175**	**FM-200**	**FM-OPS**
Incremental Recreation Facility Average Annual Equivalent Benefits* (July 2004 $1,000)		**76.5**	**29.3**	**5.5**
* Incremental net benefits are total less FM-NA				

Table 7-4. Arkansas Recreation Facilities, Average Annual Equivalent Damages ($1,000)				
Arkansas Pool	**FM-NA**	**FM-175**	**FM-200**	**FM-OPS**
Van Buren	5.1	6.1	7.1	5.2
Ozark	7.3	10.7	14.9	7.7
Dardanelle	3.4	3.5	3.4	3.4
Morrilton	37.8	40.6	42.2	35.7
Little Rock	17.0	17.3	17.8	16.7
Plum Bayou	3.1	3.2	3.6	3.1
Pine Bluff	30.7	31.8	34.6	30.0
Total (FY 1988$)	**104.4**	**113.2**	**123.6**	**101.8**
Total (July 2004 $1,000)	**163.6**	**177.4**	**193.6**	**159.5**
Summary of Average Annual Equivalent Benefits by Plan				
Arkansas		**FMA-175**	**FMA-200**	**FMA-OPS**
Incremental Recreation Facility Average Annual Equivalent Benefits* (July 2004 $1,000)		**(13.8)**	**(30.0)**	**4.1**
* Incremental net benefits are total less FMA-NA				

The results of the recreation analysis indicate that FM-OPS, the operations only component, contributes the least overall negative incremental net impacts to recreational facilities of any component that changes the existing river flow operation. As indicated by Tables 7-3 and 7-4, a slight improvement in recreation impacts along the facilities in Arkansas is matched with relatively low negative incremental net impacts in the Oklahoma area facilities.

In an effort to validate the relative accuracy of the impact measurements provided by the "SUPER" model used for the Arkansas River navigation system, recreational areas at three reservoirs in Oklahoma were evaluated. Three reservoirs were selected that contributed the greatest recreational impacts, in monetary terms, from various flow management components. Because of limited resources available for validation of all reservoirs, three were selected based on the large size of recreational losses (annually) and the availability of data used in the evaluation. These reservoirs were, Fort Gibson Lake, Tenkiller Lake, and Eufaula Lake.

The process of evaluation for these recreation facilities was to collect the number of recreational facilities, such as campsites and restroom facilities, and identify the number of facilities flooded at various flood elevations to determine how many sites would require cleanup or restoration. The number of facilities at various elevations was tabulated at each park location for each lake and the total facilities were summed and this number multiplied by per-unit costs for cleanup. Campsite cleanup costs were estimated based on the costs of debris removal, restoration of electrical service, safety checks, and roadway cleanup. Toilet facility costs were estimated on sewage removal operation and restoration of sanitary conditions at the facilities. A summary of data collected for these three lakes and the analysis is given in Tables 7-5, 7-6, and 7-7.

Table 7-5. Summary of Recreation Incremental Net Damage by Elevation Tenkiller Lake, OK; Jan-03$									
Tenkiller Campsites	**Elev**	**# Rec Areas**	**# Days Above CC FM-175**	**# Sites Above CC FM-175**	**Rec Site Damage****	**# Rec Areas**	**# Days Above CC FM-200**	**# Sites Above CC FM-200**	**Rec Site Damage****
	632	0	4	0		0	4	0	
	634	40	9	360		40	8	320	
	636	80	13	1040		80	8	640	
	638	120	11	1320		120	3	360	
	640	150	7	1050		150	-1	-150	
	642	190	0	0+		190	0	0+	
	644	240	0	0+		240	0	0+	
	Total Campsite Cleanup			**3770**	**($18,850)**			**1170**	**($5,850)**
Tenkiller Toilet Fac	**Elev**	**# Toilet Areas**	**# Days Above CC FM-175**	**# Sites Above CC FM-175**	**Toilet Damage*****	**# Toilet Areas**	**# Days Above CC FM-200**	**# Sites Above CC FM-200**	**Toilet Damage*****
	632	0	4	0		0	4	0	
	634	0	9	0		0	6	0	
	636	0	13	0		1	-1	-1	
	638	1	11	11		1	-1	-1	
	640	1	7	7		2	-1	-2	
	642	2	0	0+		2	0	0+	
	644	3	0	0+		3	0	0+	
	Total Toilet Site Cleanup			**18**	**($900)**			**-4**	**($200)**
Total All Facilities					**($19,750)**				**($5,650)**
+	Values not used due to unavailable or incomplete data								
*	State Park facilities were not counted in the assessment, only Corps recreation facilities.								
**	Rec Site Damages est based on $5.00 labor for each site per each flood event								
***	Toilet Cleanup cost est based on $50.00 per flood event (contract cost)								

Table 7-6. Summary of Recreation Incremental Net Damage by Elevation Fort Gibson Lake, OK; Jan-03$									
Fort Gibson Campsites	**Elev**	**# Rec Areas**	**# Days Above CC FM-175**	**# Days Above CC FM-175**	**Rec Site Damage****	**# Rec Areas**	**# Sites Above CC FM-200**	**# Sites Above CC FM-200**	**Rec Site Damage****
	554	0	1	0		0	1	0	
	556	30	2	60		30	2	60	
	558	60	6	360		60	5	300	
	560	100	6	600		100	4	400	
	562	140	3	420		130	1	130	
	564	160	0	0+		160	0	0+	
	566	180	0	0+		180	0	0+	
	Total Campsite Cleanup			**1,440**	**($7,200)**			**890**	**($4,450)**
Fort Gibson Toilet Fac	**Elev**	**# Toilet Areas**	**# Days Above CC FM-175**	**# Days Above CC FM-175**	**Toilet Damage*****	**# Toilet Areas**	**# Sites Above CC FM-200**	**# Sites Above CC FM-200**	**Toilet Damage*****
	554	0	1	0		0	1	0	
	556	4	2	8		4	2	8	
	558	6	6	36		6	5	30	
	560	8	6	48		8	4	32	
	562	10	3	30		10	1	10	
	564	11	0	0+		11	0	0+	
	566	12	0	0+		12	0	0+	
	Total Toilet Site Cleanup			**122**	**($6,100)**			**80**	**($4,000)**
Total All Facilities*					**($13,300)**				**($8,450)**
	+Values not used due to unavailable data								
*	State Park facilities were not counted in the assessment, only Corps recreation facilities.								
**	Rec Site Damages est based on $5.00 labor for each site per each flood event								
***	Toilet Cleanup cost est based on $50.00 per flood event (contract cost)								

Table 7-7. Summary of Recreation Incremental Net Damage by Elevation Lake Eufaula, OK; Jan-03$									
Lake Eufaula Campsites	**Elev**	**# Rec Sites***	**# Days Above CC FM-175**	**# Days Above CC FM-175**	**Rec Site Damages****	**# Rec Sites***	**# Sites Above CC FM-200**	**# Sites Above CC FM-200**	**Rec Site Damage ** **
	585	0	4	0		0	4	0	
	587	13	9	117		13	6	78	
	589	22	0	0		22	-1	-22	
	591	31	0	0		31	-1	-31	
	593	38	-1	-38		38	-1	-38	
	595	44	0	0+		44	0	0+	
	597	48	0	0+		48	0	0+	
	Total Campsite Cleanup			**79**	**($395)**			**-13**	**$65**
Lake Eufaula Toilet Fac	**Elev**	**# Toilet Sites***	**# Days Above CC FM-175**	**# Days Above CC FM-175**	**Toilet Damage*****	**# Toilet Sites***	**# Sites Above CC FM-200**	**# Sites Above CC FM-200**	**Toilet Damage*****
	585	0	4	0		0	4	0	
	587	0	9	0		0	6	0	
	589	1	0	0		1	-1	-1	
	591	2	0	0		2	-1	-2	
	593	2	-1	-2		2	-1	-2	
	595	2	0	0+		2	0	0+	
	597	3	0	0+		3	0	0+	
	Total Toilet Site Cleanup			**-2**	**$100**			**-5**	**$250**
Total All Facilities*					**($295)**				**$315**
	+Values not used due to unavailable data.								
*	State Park facilities not counted in the assessment only Corps recreation facilities.								
**	Rec Site Damages est based on $5.00 labor for each site per each flood event								
***	Toilet Cleanup cost est based on $50.00 per flood event (contract cost)								

Table 7-8. Summary of Estimated Recreation Incremental Net Damages SUPER Model vs. Calculated Totals; Jan-03$			
lAKE		**FMA-175**	**FMA-200**
Lake Tenkiller			
	SUPER Model Estimate*	($20,700)	($14,700)
	Calculated Estimate**	($19,700)	($5,650)
Fort Gibson Lake			
	SUPER Model Estimate*	($16,700)	($10,000)
	Calculated Estimate**	($13,300)	($8,450)
Lake Eufaula			
	SUPER Model Estimate*	($5,000)	$1,000
	Calculated Estimate**	($295)	$315
*	Calculated difference between existing damages and alternative damage estimate using the SUPER Model Ark River Nav Model..		
**	Calculated by tabulating rec structures by elev and mult by est cost of damage per # of events on an annual basis		
(Values)	Parenthesis represents negative benefits and therefore additional damage		

The purpose of the evaluation is to provide documentation and validation of the recreation damage estimates that have been calculated from the SUPER Model hydrologic model used in regulation of the Arkansas River Navigation System. Three reservoirs identified in the tables above were evaluated to locate the number of recreation sites at various elevations above the conservation pool and determine how often, on the average, they would be subjected to increased flood events. Both campsites and toilet and lavatory sites were tabulated for each elevation. Two primary components (FM-175, FM-200) were evaluated to determine the relative changes in recreation impacts in an overall evaluation of their feasibility.

Not all recreation facilities were tabulated in this assessment at each reservoir because of the lack of available data for non-federal recreation sites at the lakes considered. The predominant recreation facilities at Tenkiller and Fort Gibson lakes were, however, Corps of Engineers facilities and provided a good analysis of depth-damage relationships. The evaluation of Eufaula Lake, while more limited data was available for the overall number of recreation sites, did provide a good relative relationship of recreation sites flooded for the analysis.

It should be emphasized that the calculated estimates did not include all recreation facilities and this is indicated in the consistent, although slight, underestimate in the calculated values. The trends of the calculated estimate clearly follow the estimate provided for the SUPER Model estimate. As noted elsewhere in this analysis, historic hydrological data indicate that high pools are most likely in the late spring and early fall, times of high recreation use. While resources could have been devoted to estimating frequencies of pool levels and recreation use, the assumption also for a simple estimate of the impacts on recreation was used to assess the relative changes in the recreation losses. The high pools and recreation season generally coincide.

Impacts to recreation will be evaluated along with impacts to other project purposes such as flood damage reduction, hydropower and navigation benefits to determine the best overall plan of improvement to the existing operation. The findings of this evaluation indicate that the estimates of damages or impacts to recreation facilities provided by the SUPER Model are valid for use in the overall feasibility assessment of the components to be considered.
For flow management components, the impact to recreation is provided in Table 7-9.

Table 7-9. Recreation-Related Average Annual Equivalent Incremental Benefit (July 2004 $1,000)

Category	FM-NA	FM-175	FM-200	FM-OPS
Arkansas Rec Benefits		0	0	0
Arkansas Damages		(13.8)	(30.0)	4.1
Arkansas Subtotal		**(13.8)**	**(30.0)**	**4.1**
Oklahoma Rec Benefits		(1,443.5)	(793.9)	0
Oklahoma Damages		(76.5)	(29.3)	(5.5)
Oklahoma Subtotal		**(1,520.0)**	**(823.2)**	**(5.5)**
* Incremental benefits are total less FM-NA				

B.8. Hydropower

Information related to hydropower benefits is based on the following document entitled "Hydropower Benefit Calculations: Arkansas River Navigation Study" by the Hydropower Analysis Center, Northwestern Division, USACE.

The greatest incremental net economic benefit to hydropower would occur under FM-175 with an estimated $1,203,000 in additional annual benefits compared to FM-NA (baseline conditions). Approximately $928,000 in annual incremental net benefits would occur under FM-200 compared to FM-NA (baseline conditions), with $409,000 additional annual benefits under FM-OPS. No additional annual benefits would occur under the No Action component (baseline conditions).

According to the Hydrology and Hydraulics Report: Appendix A, Section 4.3, "The results of the backwater modeling indicate that there are negligible impacts to the 2-year and 100-year water surface elevations." Therefore, no additional hydropower benefits occur under navigation channel deepening components.

B.8.1. Introduction

B.8.1.1. Purpose and Scope

This section was prepared to assist in evaluating the feasibility of altering flows on the Arkansas River to benefit navigation and other project purposes. More specifically, the hydropower economic evaluation quantifies the economic effects resulting from the hydropower plants current operating conditions and evaluates the alternative components identified in the plan formulation process. This section describes the calculation of the energy and dependable capacity realized from each of the components as well as the corresponding hydropower benefits.

B.8.1.2. Project Description

There are fifteen hydropower plants located within the McClellan-Kerr Arkansas River Navigation Study area (MKARNS) that could potentially be affected by changes in flows for navigation. Six of these projects are operated by the Tulsa District Corps of Engineers and two of these projects are operated by the Little Rock District Corps of Engineers. The Southwestern Power Administration markets the power from these eight Corps projects. The remaining seven hydropower plants are operated by other public entities.

Seven of the fifteen hydropower plants are storage projects with the capability to store water for flood damage reduction and other project purposes. The other eight projects are run-of-river projects with no capability to store water. The total generating capability of all of these hydropower plants is over 1,000 MW. Most of these projects are peaking plants as such generation is scheduled for the peak demand hours when generation is needed most.

Table 8-1. Arkansas River Hydroelectric Power Projects Pertinent Data							
Dam / Reservoir	**Number of Units**	**Storage or Run-of-River**	**Installed Capacity, kW**	**Full Power Discharge, cfs**	**Year Last Unit On-line**	**Average Annual Energy, kWh**	**Marketing Agency**
Kaw Dam*	1	Storage	25,600	5,000	1989	92,000,000	OMPA
Keystone Dam (Tulsa District COE)	2	Storage	70,000	12,000	1968	235,000,000	SWPA
Pensacola Dam (Grand Lake)*	6	Storage	96,000	11,200	1940	382,000,000	GRDA
Robert S. Kerr Dam (Lake Hudson)*	4	Storage	100,000	28,000	1964	229,000,000	GRDA
Fort Gibson Dam (Tulsa District COE)	4	Storage	45,000	9,800	1953	196,000,000	SWPA
Webbers Falls Lock & Dam (No. 16) (Tulsa District COE)	3	Run-of-River	60,000	30,000	1973	243,000,000	SWPA
Tenkiller Ferry Dam (Tulsa District COE)	2	Storage	39,100	3,500	1953	110,000,000	SWPA
Eufaula Dam (Tulsa District COE)	3	Storage	90,000	13,100	1964	259,000,000	SWPA
Robert S. Kerr Lock & Dam (No. 15)	4	Run-of-River	110,000	40,000	1971	543,000,000	SWPA
James W. Trimble Lock & Dam (No. 13)*	3	Run-of-River	32,400	31,350	1988	128,000,000	AECC
Ozark-Jeta Taylor Lock & Dam (No. 12) (Little Rock District COE)	5	Run-of-River	100,000	70,000	1974	360,000,000	SWPA
Dardanelle Lock & Dam (No. 10) (Little Rock District COE)	4	Run-of-River	148,000	45,000	1966	692,000,000	SWPA
Arthur V. Ormond Dam (No. 9)*	3	Run-of-River	32,400	31,350	1993	137,000,000	AECC
Murray Lock & Dam (No. 7)*	2	Run-of-River	39,000	-	1988	208,000,000	NLR
Wilbur D. Mills Dam (No. 2)*	3	Run-of-River	108,000	51,000	1999	375,000,000	AECC

* Denotes Federal Energy Regulatory Commission (FERC) licensed projects.
OMPA – Oklahoma Municipal Power Authority
SWPA – Southwestern Power Administration
GRDA – Grand River Dam Authority
AECC – Arkansas Electric Cooperative Corporation
NLR – City of North Little Rock, Arkansas

B.8.1.3. Components Examined

Three primary components were analyzed in this study, along with the existing condition or base condition. The base condition is used as a baseline against which the remaining components are compared. The remaining components change flows on the Arkansas River in an effort to improve navigation.

B.8.1.3.1. Flow Management – No Action Component

The No Action component consists of maintaining the current MKARNS Operation System. No changes in existing river or reservoir operations would be made. A detailed description of the existing operations plan including general operations as well as a description of taper and bench operations is presented in Section 3 of this document. Key features of the current operations plan are:

- A taper operation of 40,000 cfs to 20,000 cfs. When the flood storage remaining in the 11 controlling reservoirs reaches from 3% in the spring to 11% in the summer, the target flow at Van Buren is gradually reduced from 40,000 cfs to 20,000 cfs. This allows navigation to continue until dredging operation can remove the sediment deposited in the channel during high flow.
- A 75,000 cfs bench (a range where the flow is held at or below 75,000 cfs). This feature is also adjusted seasonally to maximize benefit to farming and minimize flood impacts during that portion of the year more susceptible to floods.

B.8.1.3.2. Flow Management – 175,000 cfs Component

Under this component, the target flow at Van Buren and Sallisaw is 175,000 cfs. The "bench" release would be reduced to 60,000 cfs, lowered 3% except during the period of June 15 through October 1. This would be done to evacuate floodwaters quickly and reduce the number of days where agricultural lands are flooded along the river and make the river unavailable for navigation.

B.8.1.3.3. Flow Management – 200,000 cfs Component

Under this component, flood releases would be increased to a maximum of 200,000 cfs at Van Buren and Sallisaw. The "bench" release would be reduced to 60,000 cfs, lowered 3% except during the period of June 15 through October 1. This would be done to evacuate floodwaters even more quickly and reduce further the number of days where agricultural lands are flooded along the river and make the river unavailable for navigation.

B.8.1.3.4. Flow Management – Operations Only Component

Under this component, the existing plan would be changed to a 60,000 cfs "bench", lowered 3% except during the period of June 15 through October 1. This would be combined with filling in behind the flood hydrograph when the flow reaches 150,000 - 250,000 cfs when system storage exceeds 75%. Flows above the 100,000 cfs that impede navigation increased less than a day annually. There was a decrease in the number of days in the upper limits of the flood control

pools and there was an increase in the number of days in the lower 2 to 6 feet of the flood control pool, prolonging the tapering flows.

B.8.1.4. Procedure

The development of power benefits for the Arkansas River Navigation study included the following steps:

For Energy Benefits:

(1) Obtain period-of-record daily head, total discharge, and generation for hydropower projects modeled in SUPER Model. For projects where generation was not estimated in SUPER Model, daily total discharge for the period-of-record was obtained. These data represent project operation under current operating assumptions
(2) Obtain plant performance data (output and efficiency as a function of head) for each plant not modeled in SUPER Model.
(3) Make a period-of-record daily determination of project generation and peaking capability for each component.
(4) Utilizing the previous results, estimate the project average annual generation for each component.
(5) Determine the levelized energy value using energy value output from the PROSYM production cost model
(6) Using the average annual generation and levelized energy value determine life-cycle energy benefits for each component.

For Capacity Benefits:

(1) Obtain period-of-record daily head, total discharge, and generation for hydropower projects modeled in SUPER Model. For projects where generation was not estimated in SUPER Model, daily total discharge period-of-record was obtained. These data represent project operation under current operating assumptions.
(2) Obtain plant performance data (output and unit efficiency as a function of head) for each plant not modeled in SUPER Model.
(3) Make a period-of-record daily determination of project generation and peaking capability for each component.
(4) Utilizing the previous results and the average availability method, estimate the project dependable capacity for each component.
(5) Establish values for thermal plant availability and operational flexibility.
(6) Utilize MKARNS projects historical hourly generation data to develop annual generation-duration curves.
(7) Utilize Federal Energy Regulatory Commission (FERC) procedures to develop the capacity value for each thermal alternative.
(8) Perform a screening curve analysis to determine the unit capacity value for the most likely, least-cost thermal alternative.
(9) Using dependable capacity and the capacity value, determine life-cycle capacity benefits for each component.

B.8.1.5. Input Assumptions

B.8.1.5.1. Period of Analysis

The period of analysis begins in the year 2005. It extends from that point through the 50-year period of analysis.

B.8.1.5.2. Discount Rate

The interest rate used in this study is the FY 2004 Federal interest rate of 5.375%.

B.8.1.5.3. Price Levels

The unit capacity values and the fuel prices used in determining the unit energy values are based on 2000 price levels indexed to 2004. Real fuel cost escalation was not utilized in developing levelized energy values, and the indexed 2004 level fuel prices were assumed to apply over the entire period of analysis.

B.8.1.5.4. Rounding and Totals

Some parts of the study analysis were performed using spreadsheet software. Arithmetic operations and totals were taken to full decimal accuracy within the spreadsheet. Tables found within this report have been rounded to a specified level of accuracy after the mathematical computations have been performed; therefore, rounded totals may not equal the summation of rounded values.

B.8.1.6. Participants

The Hydropower Analysis Center (HAC) of the Northwestern Division, North Pacific Region, Corps of Engineers prepared this revised appendix, for the Little Rock District, Corps of Engineers. For the original appendix dated May 2003, Jim Fredericks performed the incremental energy and dependable capacity studies. Dinh Quan performed the thermal alternative screening analysis and prepared the unit capacity values, which are based on procedures developed by the Federal Energy Regulatory Commission (FERC). Dinh Quan also performed the PROSYM studies and utilized output from the model to prepare the unit energy values. Jim Fredericks drafted the original hydropower analysis text, tables and figures and also served as project manager for HAC. John Johannis was responsible for the internal technical review of the hydropower analysis. Kamau Sadiki updated the revised hydropower analysis.

B.8.2. Energy Output

B.8.2.1. General

The energy and capacity output for the run-of-river projects, for each study component, was developed through the use of a spreadsheet analysis, with the main input to the spreadsheet consisting of:

- Period-of-record daily output from SUPER Model, a hydro regulation model that simulates the operation of the of Arkansas River storage projects over the historic period from 1940 through 2000.
- Plant performance data for each hydropower project under study. For storage projects, performance data from SUPER Model was utilized.

A brief description of the spreadsheet analysis operation, input and output is presented below, followed by a summary of the average annual energy estimates that were obtained from the spreadsheet output and SUPER Model. A summary of the dependable capacity estimates that were obtained from the spreadsheet output is presented in Section 8.3. Since the generating units on the MKARNS have in the past been operated predominately at or near the maximum output point and are expected to continue to do so in the future, it was decided to base the average annual energy and dependable capacity estimates obtained in this study on maximum output operation.

B.8.2.2. Spreadsheet Analysis Operation, Input and Output

Daily estimates of energy and capacity output under each study component, and with all plants and units assumed available, were developed in the spreadsheet analysis by applying the following steps to each day in the period of record:

(1) Obtain the daily total discharge QSUPER Model for the run-of-river projects from SUPER Model. Estimate the head using the average forebay elevation and the tailwater curve for the project.
(2) Determine the powerhouse discharge QPH and output PPLANT corresponding to the head by utilizing plant performance data for the run-of-river project being analyzed. If flow is above the maximum powerhouse discharge, identify QSPILL.
(3) Utilize the previous results to determine the powerhouse discharge QPH and output PPH corresponding to the hydropower project.

The following example illustrates how the above steps were utilized to estimate Robert S. Kerr daily energy and capacity output.

Example 1:
Consider the maximum-output operation of the Robert S. Kerr powerhouse on August 18th, 1940 with four units available. From the SUPER Model simulated operation of the project under current operating assumptions and the project tailwater curve, we obtain Head = 43.65´ and QSUPER Model = 37.825 kcfs. According to the plant performance data, the powerhouse discharge and output corresponding to a head of 43.65´ are QPH = 33.39 kcfs and PPLANT = 111.5 MW. Because QSUPER Model exceeds QPH, QSPILL = 4.43 kcfs.

B.8.2.3. Annual Energy Results

By utilizing on a day-by-day basis the steps summarized in the previous section, the spreadsheet analysis determined the period-of-record daily energy and capacity output for each run-of-river project under each study component. For the storage projects on the MKARNS, daily energy and capacity output was used directly from the SUPER Model. For each study component, the period-of-record daily energy output results were used to develop the corresponding estimate of project average annual energy. Table 8-2 summarizes the average annual energy estimates obtained for the components as well as the corresponding annual energy gain relative to base case.

Table 8-2. Annual Generation Computation – For Components

Components	Plant Capacity (MW) All Projects	Average Annual Energy (GWh)			
		Storage Projects	Run-of-River Projects	All Projects	Annual Energy Gain Relative to the Baseline
FM-NA	1,095	1,503	2,683	4,186	-
FM-175	1,095	1,494	2,726	4,219	33
FM-200	1,095	1,491	2,720	4,211	25
FM-OPS	1,095	1,504	2,691	4,196	10

B.8.3. Dependable Capacity

B.8.3.1. General

Dependable capacity was computed for each component using the average availability method. This method, which is described in *Proceedings, Waterpower '89*, "Determining Hydro Project Dependable Capacity", is the most appropriate method for a hydropower project that is operated in a thermal-based power system such as the Southwest Power Pool (SPP).

B.8.3.2. Definition of Dependable Capacity

Under the average availability method, dependable capacity is defined as the average usable capacity for the peak demand months over the available hydrologic period of record. For the SPP area, the peak demand months are June through September. Monthly data on energy output and machine capability for the project were developed from the results of the spreadsheet analysis described in Section 8.2.

B.8.3.3. Procedure

The procedure consists of computing the average usable capacity for the peak demand months for each year in the period of record. For capacity to be usable, sufficient energy must be available to enable it to carry an increment of the system peak load.

Discussions with the Southwestern Power Administration (SWPA) indicated that capacity would need to be available five hours each weekday in order for it to be marketable in their system. Therefore, for this study it was assumed that 5.0 hours of daily peak generation would be needed each weekday in order for the capacity to be classified as supportable capacity.

Dependable capacity was computed for each component by averaging the supportable capacity values computed for each of the peak demand months (June through September) over the historical streamflow period 1940 – 2000. Supportable capacity values were computed for each month in this period based on an average peaking requirement of 5.0 hours for each weekday in the month.

Monthly average energy values were used instead of the daily values that appear in the energy analysis in order to reflect the flexibility in scheduling releases to meet the varying demand for power. SWPA does not rigidly schedule five hours of generation each weekday, but varies the output depending on load conditions. For example, during heat storms, when demand is high, they may call for more than five hours of generation, drafting water from pondage and upstream storage to support this generation. Later when loads drop off, generation would be reduced, either by reducing the number of hours per day or by reducing the number of units on line. But the average generation that must be produced over the month to meet SWPA's requirements is assumed 5.0 hours per weekday at full output.

For each peak demand month, a comparison was made between the "potential" supportable capacity [15] and the project machine capability for that month with all units available. The capacity that could actually be supported was limited to that portion of the potential supportable capacity was calculated as follows:

For example, consider the year 1940 for Robert S. Kerr, where the project average weekly energy output during June through September is 7,415 MWh and the potential supportable capacity during this period is

7,415 MWh / 25 hours = 296.6 MW

Although sufficient energy is available to support 296.6 MW during this period, the project machine capability is only 111.5 MW. Therefore, the actual supportable capacity during 1940 is 111.5 MW. This represents the usable capacity for that year.

In another example, consider the year 1956, where the project average monthly energy output during June through September is 1,873 MWh and the potential supportable capacity during this period is

1,873 MWh / 25 hours = 74.9 MW

Although the project machine capability is 111.5 MW during this period, the actual supportable capacity during 1956 is limited by the available energy to 74.9 MW. This represents the usable capacity for that year.

B.8.3.4. Dependable Capacity Results

The procedure described in the previous section was used to calculate the usable capacity for each year in the period of record, for each of the study components. For each component, the

[15] The capacity that could be supported with the available energy if the project machine capability was unlimited.

usable capacity results over the period of record were averaged in order to compute the dependable capacity for that component.

Table 8-3 summarizes the dependable capacity estimates obtained for the components as well as the corresponding dependable capacity gain relative to the existing condition.

Table 8-3. Dependable Capacity - For Components

Component	Plant Capacity (MW)	Run-of-River Dependable Capacity (MW)	Storage Dependable Capacity (MW)	Total Dependable Capacity (MW)	Dependable Capacity Gain Relative to the Existing Condition (MW)
FM-NA	1,095	584.9	463.9	1,049	-
FM-175	1,095	587.1	463.9	1,051	2
FM-200	1,095	587.0	463.9	1,051	2
FM-OPS	1,095	585.7	464.5	1,050	1

B.8.4. Energy Value

B.8.4.1. General

The energy benefits attributable to the hydropower project are based on the system cost of producing the same amount of energy as the hydro projects. To obtain a unit energy value applicable to the 15 different projects, a system analysis is performed in which the area power system is modeled under two different conditions: one that includes the hydro project in the power system, and one that excludes representative hydro projects from the power system. The unit energy value is then determined by dividing the difference in system operating costs for the two conditions by the hydro project's annual energy output. The objective is to obtain an energy value that is representative of the 15 different hydropower projects.

B.8.4.2. Procedure

Since energy benefits are computed by utilizing an average (levelized) energy value over the project economic life, a single unit energy value representing the entire period of analysis was developed for use in computing the MKARNS system energy benefits.

Unit energy values were obtained for the MKARNS project by first modeling the area power system with and without some hydropower plants to determine the total system operating cost for each condition. The PROSYM production cost model was used to perform these system operation studies. The difference in system operating costs for the two conditions was then divided by the project's annual energy output in order to determine the unit energy value.

Unit energy values were developed for five representative load years: 2005, 2010, 2015, 2020, and 2025. PROSYM modeling of the area power system was limited to every five years due to the amount of effort required to model the system for a single year. The use of interpolation for the years not modeled does not significantly affect the accuracy of the levelized unit energy value, since the yearly energy values do not vary much from year to year. Also, due to the high degree of uncertainty in projecting power market conditions in the future (such as system load

demand, fuel costs and changes in technology), power system simulations were not performed beyond the year 2025. Instead, the PROSYM results for the year 2025 were utilized for the remainder of the period of analysis.

The present-worth of the yearly energy values was computed then levelized over the project economic life by applying the appropriate amortization factor. These last results were used to develop the levelized unit energy value.

Sections 9.4.3 through 9.4.7 describe the PROSYM model and studies, and Section 9.4.8 summarizes the resulting energy values.

B.8.4.3. PROSYM Production Cost Model

To develop the system operating costs, the area power system was modeled using the PROSYM computer model, a proprietary model that was developed and is maintained by Henwood Energy Services of Sacramento, California. PROSYM is a chronological hourly production cost model. The PROSYM model dispatches system generating resources to meet hourly system loads in the same manner as a power system dispatcher would in actual system operation, thereby developing system operating costs for the specified load and resource conditions. In PROSYM, one load year is analyzed at a time, with the model dispatching resources hour-by-hour over one-week periods.

B.8.4.4. Power Market Area and Loads

Discussions with the Southwestern Power Administration indicated that the power generated at projects on the MKARNS would be marketed to preference customers located throughout the Southwest Power Pool (SPP) region. This region includes the states of Oklahoma, Kansas, parts of Arkansas and Missouri, eastern and northern Texas, and Louisiana. Therefore, the output of the MKARNS projects was modeled with PROSYM within the SPP system.

Plant and annual load projections for the SPP system were based on the *Southwest Power Pool EIA-411 Report*, dated April 1, 1999, and on Henwood Energy Services' North American Electric Reliability Council (NERC) database. These annual peak loads and energy demands were then converted into an hourly load shape for a typical load year, using historical 1993 - 2000 load shapes for the SPP utilities.

B.8.4.5. PROSYM Input Data

The basic PROSYM data set utilized for this analysis was developed by Henwood and will be available for future studies in the SPP system. Henwood's NERC database was based on the EIA-411 report. However, Henwood was able to obtain additional information on thermal plants that were not included in the EIA-411 report that were then included in the data set.

For each load year modeled in PROSYM, generic thermal resources were added to the system as needed to insure that resources were balanced to the load with a 10% peak load reserve margin. Based on an analysis of the SPP region, planned and unplanned resource additions for the next

20 years, it was determined that future resource additions would most likely be comprised of a mix of approximately 20% gas-fired combined cycle (CC) and 80% gas-fired combustion turbine (CT) capacity.

Hydropower input data for the remaining hydropower plants in the system were obtained from Henwood's NERC database and consisted of monthly energy output and monthly capacity output. Henwood's monthly energy output was developed from a five-year average of the historical monthly generation for 1996-2000, as reported in the publication *EIA Electric Power Monthly (DOE/EIA-0226)*. Henwood's monthly capacity output was developed from information contained in the SPP system EIA-411 report for 1999.

Two sets of input data were assembled for each simulated year, one including all the SPP projects and one without 1,041 MW of hydropower from the SPP system. The latter input data set excluded hydropower generation from plants that were representative of those likely to be impacted by the components. This effectively removed the projects contribution to the total weekly hydropower energy and capacity of the system. The same hydropower data was used for all load year simulations.

B.8.4.6. Fuel Prices

Fuel prices for the five-year period 1996 – 2000, as reported on the FERC Form 423, were obtained from Henwood's NERC database. These SPP region fuel prices included coal, natural gas, distillate oil, residual oil, and nuclear prices. The corresponding five-year average fuel prices were then computed and utilized as input to PROSYM. The 2004 level fuel prices were obtained by indexing the 2000 PROSYM system production cost values for the SPP to 2004. In accordance with Section 2-4i of ER 1105-2-100, Guidance for Conducting Civil Works Planning Studies (22 April 2000), this study did not utilize real fuel cost escalation, and the 2004 level fuel prices were assumed to apply over the entire period of analysis.

B.8.4.7. PROSYM Computer Runs

PROSYM runs were made for each of the five load years (2005, 2010, 2015, 2020, and 2025) for two sets of conditions: one with all SPP projects included in the system (base condition simulation) and one with 1,041 MW of SPP hydropower removed from the system (alternate condition simulation). The base condition simulations included all project units. In the alternate condition simulations, the generation contributed by 1,041 MW of SPP hydropower was replaced by generation from the most economical mix of system resources to serve the same increment of system load as that served by the project.

B.8.4.8. Unit Energy Value Utilized in Computing Energy Benefits

Two PROSYM simulations were performed for each of the five simulated load years in order to determine the system operating costs for the with- and without hydropower conditions. For each load year, the difference in system operating costs for the two conditions was divided by the annual energy output of the 1,041 MW hydropower system of projects in order to derive the unit energy value for that year.

Addendum A2 shows the PROSYM summary output and the derivation of the unit energy value for each of the five load years, and Table 8-4 summarizes the unit energy value in $/MWh for each year in the period of analysis. Values for un-simulated years prior to 2025 were estimated by interpolation. The value for year 2025 was assumed representative of the value for un-simulated years beyond 2025.

To obtain an average (levelized) energy value for use over the period of analysis, the 2005 present-worth of the unit energy value for each year was computed then levelized by applying an amortization factor over the project economic life (50 years). Table 8-4 also shows this value, $30.82/MWh, which was utilized in the model for the computation of energy benefits.

B.8.5. Capacity Value

B.8.5.1. General

The benefits attributable to a hydropower projects are based on the cost of the most likely thermal-power alternative that would carry the same increment of load as the hydropower projects. Capacity benefits are intended to measure the investment cost of thermal plant capacity that would be deferred by implementation of the hydropower plan. Capacity benefits are computed as the product of the dependable capacity of the hydropower project and a capacity value, which is based on the unit cost of constructing the most likely thermal-power alternative to the hydropower project under study.

B.8.5.2. Most Likely Alternative

A screening curve analysis was conducted to determine the mix of thermal resources that would be the most likely, least-cost alternative to the type of projects on the MKARNS. The type of alternative plants considered were coal-fired steam (CO) (used for meeting base loads), gas-fired combined cycle (CC) (used for meeting base and intermediate loads), and gas-fired combustion turbine (CT) (used for meeting peak loads). The screening curve analysis for the MKARNS projects is described in Section 8.5.4.

B.8.5.3. Capacity and Energy Values Used in Screening Curve Analysis

Unit capacity values for coal-fired steam, gas-fired combined cycle and gas-fired combustion turbine plants were computed using procedures developed by the Federal Energy Regulatory Commission (FERC). Capacity values were computed for three states located in the SPP region: Oklahoma, Arkansas, and Missouri. The capacity values for the three states were then averaged in order to develop the corresponding adjusted capacity values used to represent the SPP region. This latter computational process is shown below for each of the three thermal plant types.

Table 8-4. Levelized Energy Value Computation [16]			
Interest Date: 5.375	POL Date: 2005	End of Economic Life: 2054	
FISCAL YEAR	PRESENT WORTH FACTOR	ENERGY VALUE ($/MWh)	PW ENERGY VALUE
2001	1.0000	-----	-----
2002	1.0000	-----	-----
2003	1.0000	-----	-----
2004	1.0000	-----	-----
2005	0.9490	28.92	27.44
2006	0.9006	28.96	26.08
2007	0.8546	29.00	24.78
2008	0.8111	29.04	23.55
2009	0.7697	29.08	22.38
2010	0.7304	29.12	21.27
2011	0.6932	29.39	20.37
2012	0.6578	29.66	19.51
2013	0.6243	29.94	18.69
2014	0.5924	30.21	17.90
2015	0.5622	30.48	17.14
2016	0.5335	30.80	16.43
2017	0.5063	31.12	15.76
2018	0.4805	31.44	15.11
2019	0.4560	31.76	14.48
2020	0.4327	32.08	13.88
2021	0.4106	32.14	13.20
2022	0.3897	32.21	12.55
2023	0.3698	32.27	11.93
2024	0.3510	32.34	11.35
2025	0.3331	32.40	10.79
To	-	-	-
2054	0.0730	32.40	2.42
Total			531.38
Period of Analysis (years)			50
Levelized Energy Value ($/MWh)			30.81

Table 8-5. SPP Unit Capacity Values				
Thermal Alternative Plant Type	**Arkansas Adjusted Capacity Value ($/kW-yr)**	**Missouri Adjusted Capacity Value ($/kW-yr)**	**Oklahoma Adjusted Capacity Value ($/kW-yr)**	**Three State Average Adjusted Capacity Value ($/kW-yr)**
Coal-Fired Steam (CO)	236.71	247.91	236.52	240.38
Combined Cycle (CC)	114.22	115.01	114.22	114.48
CombustionTurbine (CT)	62.18	64.31	62.18	62.89

[16] Energy values for 2005, 2010, 2015, 2020 and 2025 from PROSYM studies; values for intermediate years obtained by linear interpolation; 2025 value assumed to be representative of remaining years.

The adjusted capacity values that are computed using FERC procedures include an adjustment to the value of the alternative thermals. The adjustment takes into account the added reliability and flexibility of hydropower as compared to the alternative thermal. The three factors (HMA, TMA and F) that FERC includes in the adjusted capacity values were then removed from the three SPP region capacity values using FERC procedures to obtain the corresponding unadjusted capacity values for use in the screening curve analysis.

$$Capacity\ Benefits = (DC)(CV)\left(\frac{HMA}{TMA}\right)(1 + F)$$

where: DC = dependable capacity of the hydro generating unit, in MW
CV = unit cost of the most likely thermal alternative, in $/kW-year (also sometimes called the unadjusted capacity value)
HMA = mechanical/electrical availability of the hydro generating unit (computed as 1 - FOR, where FOR = unit forced-outage rate)
TMA = mechanical/electrical availability of the thermal alternative
F = operational flexibility adjustment factor

The SPP region adjusted and unadjusted unit capacity values, based on a Federal interest rate of 5.375% and January 2004 price levels, are shown in Table 8-6. A summary of the input data used in computing the adjusted capacity values for each of the states is included in Addendum A1.

Table 8-6. Unit Capacity Values - (Adjusted and Unadjusted)

Thermal Alternative Plant Type	Adjusted Capacity Value ($/kW-yr)	FERC Adjustments			Unadjusted Capacity Value ($/kW-yr)
		HMA	TMA	F	
Coal-Fired Steam (CO)	240.38	0.98	0.85	0.050	198.56
Combined Cycle (CC)	114.48	0.98	0.90	0.025	102.57
CombustionTurbine (CT)	62.89	0.98	0.90	0.025	56.35

Unit energy values for coal-fired steam, gas-fired combined cycle and gas-fired combustion turbine plants were also computed using FERC-based procedures. Energy values were computed for three states located within the SPP region: Oklahoma, Arkansas, and Missouri. The energy values for the three states were then averaged in order to develop the corresponding energy values used to represent the SPP region. This latter computational process is shown below for each of the three thermal plant types.

Table 8-7. SPP Energy Values

Thermal Alternative Plant Type	Arkansas Energy Value ($/MWh)	Missouri Energy Value ($/MWh)	Oklahoma Energy Value ($/MWh)	Three State Average Energy Value ($/MWh)
Coal-Fired Steam (CO)	16.57	12.24	13.52	14.11
Combined Cycle (CC)	35.21	35.27	35.56	35.37
CombustionTurbine (CT)	55.12	55.22	55.68	55.34

The types of information utilized in the computation of the FERC-based energy values included fuel costs, heat rates and variable O&M costs. The information was obtained from the publication *EIA Electric Power Monthly (DOE/EIA-0226)* and from other sources. A summary

of the input data utilized in computing the energy values for each of the three states is included in Addendum A1. The SPP region unit energy values, computed above and summarized in Table 8-8, are based on January 2004 price levels.

Table 8-8. Unit Energy Values	
Thermal Alternative Plant Type	**Energy Value ($/MWh)**
Coal-Fired Steam	14.11
Combined Cycle	35.37
Combustion Turbine	55.34

B.8.5.4. Screening Curve Analysis

A screening curve analysis consists of the following steps:

- Construct a total plant cost (in $/kW-year) versus annual plant factor (in percent) diagram (screening curve) which includes a curve for each type of thermal plant available for addition to the system; this screening curve will show which type of plant is least costly in each plant factor range.
- Construct a load-duration curve for the increment of load being analyzed; this curve should be based on hourly loads for the entire year.
- From the screening curve, determine the "breakpoints" (the plant factors at which the least costly plant type changes).
- Find the points on the load-duration curve where the percent of time load is equaled or exceeded is numerically identical to the plant factor breakpoints defined in the preceding step; these intersection points define the portion of the load that would be carried by each plant type.

The unadjusted unit capacity values from Table 8-6 and unit energy values from Table 8-8 were utilized in order to develop a plot of total plant cost (capital + operating) versus annual plant factor for each of the thermal alternatives under consideration. The plot for each thermal alternative was developed by computing the annual plant cost for various plant factors ranging from 0% - 100%. The annual costs were computed using the following equation: [17]

$$AC = CV + (0.0876 * PF * EV)$$

Where: AC = thermal plant total cost ($/kW-year)
CV = thermal plant capacity value ($/kW-year)
EV = thermal plant energy value ($/MWh)
PF = annual plant factor (percent)

The resulting curves are shown in Figure 8-1. The point of intersection (1st breakpoint) between the combined cycle curve and the combustion turbine curve occurs at a plant factor of 26.5%, while the point of intersection (2nd breakpoint) between the combined cycle curve and the coal curve occurs at a plant factor of 51.5%. Thus, gas-fired combustion turbine plants are more

[17] The product 0.0876 * PF is the factor used to convert EV from $/MWh to $/kW-year so that CV and EV have the same units.

economical for plant factors less than 26.5%, coal-fired steam plants are more economical for plant factors greater than 51.5%, and gas-fired combined cycle plants are more economical for plant factors between 26.5% and 51.5%.

Figure 8-1: Thermal Alternative Screening Curve

B.8.5.5. Least-Cost Thermal Mix

Because of the large number of hydropower plants that could be possibly affected by the alternatives on MKARNS, it was decided to develop two typical generation duration curves. The plants were broken into two groups, one for projects that operate at a plant factor (PF) below 60% and another for projects that operate above a plant factor of 65%. The generation-duration curves shown in Figure 8-2 and Figure 8-3 were developed after examining actual generation duration curves of the hydropower plants. These curves were selected since they are considered representative of typical operation in terms of both power generation and river flows.

The breakpoint plant factors (26.5% and 51.5%) obtained from the screening curve were matched to the same percent exceedance on the generation-duration curves in order to determine the MW of generation for the three types of plants. For the plants with a plant factor below 60%, a generation value of 54.8 MW was obtained for the 26.5% breakpoint, while a generation value of 6 MW was obtained for the 51.5% breakpoint. The generation value was then used to divide the generation-duration curve into three components: a 14.2 MW (69 MW – 54.8 MW) combustion-turbine (upper) component, a 48.8 MW (54.8 MW – 6 MW) combined-cycle component, and a 6 MW (6 MW – 0 MW) coal component. Thus the most likely, least-cost thermal alternative to the plants with a plant factor below 60% consists of 21% gas-fired combustion turbine, 71% gas-fired combined cycle, and 8% of coal.

For the projects with a plant factor above 65%, a generation value of 76.0 MW was obtained for the 26% breakpoint, while a generation value of 51.0 MW was obtained for the 51.0% breakpoint. The two generation values were then used to divide the generation-duration curve into three components: a 22.8 MW (98.8 MW – 76.0 MW) combustion-turbine (upper) component, a 25.0 MW (76.0 MW – 51.0 MW) combined-cycle (middle) component, and a 51.0 MW (51.0 MW - 0 MW) coal-fired steam (lower) component. Thus the most likely, least-cost thermal alternative to the projects with a plant factor above 65% consists of 23% gas-fired combustion turbine, 25% gas-fired combined cycle, and 52% coal-fired steam.

Figure 8-2: Annual Generation-Duration Curve for Projects with a PF below 60%

Figure 8-3: Annual Generation-Duration Curve for Projects with a PF above 65%

B.8.5.6. Composite Unit Capacity Value

The unit capacity value utilized in the analysis for the computation of capacity benefits was derived by applying the capacity components of the least-cost thermal alternative as weighting factors to the corresponding adjusted unit capacity values from Table 8-6. The derivation of the composite unit capacity value is shown below.

Adjusted Capacity Values:

CO $198.56/kW-yr
CC 105.57/kW-yr
CT $56.35/kW-yr

Least-Cost Thermal Alternative Capacity for Projects with a PF below 60%:

CO 6 MW
CC 48.8 MW
CT 14.2 MW

Calculation of Composite Unit Capacity Value for Projects with a PF below 60%:

CO Capacity Value = $198.56/kW-yr * [6 MW / (14.2 MW + 48.8 MW + 6 MW)]
(Weighted) = $ 17.27 /kW-yr

CC Capacity Value = $105.57/kW-yr *[48.8 MW / (14.2 MW + 48.8 MW + 6 MW)]
(Weighted) = $ 74.66/kW-yr

CT Capacity Value = $56.35/kW-yr * [14.2 MW / (14.2 MW + 48.8 MW + 6 MW)]
(Weighted) = $ 11.59/kW-yr

Composite Unit Capacity Value for Projects with a PF below 60%

$17.27/kW-yr + $74.66/kW-yr + $11.59/kW-yr = $103.52/kW-yr

Least-Cost Thermal Alternative Capacity for Projects with a PF above 65%:

CO 51.0 MW
CC 25.0 MW
CT 22.8 MW

Calculation of Composite Unit Capacity Value for Projects with a PF above 65%:

CO Capacity Value = $198.56/kW-yr * [51 MW / (51 MW + 25.0 MW + 22.8 MW)]
(Weighted) = $ 102.49/kW-yr

CC Capacity Value = $105.57/kW-yr *[25 MW / (51 MW +25.0 MW + 22.8 MW)]
(Weighted) = $ 26.71/kW-yr

CT Capacity Value = $56.35/kW-yr * [22.8 MW / (51 MW + 25 MW + 22.8 MW)]
(Weighted) = $ 13.00/kW-yr

Composite Unit Capacity Value for Plants with a PF above 65%

$102.49/kW-yr + $26.71/kW-yr + $13.00/kW-yr = $142.20/kW-yr

B.8.6. Summary of Benefits

B.8.6.1. General

The flow management components being considered will result in relatively minor changes in energy and capacity benefits for hydropower projects on the MKARNS. The basis for any changes in hydropower benefits are related to:

- Reduced spill – with lower peak releases, less flow exceeds the powerhouse capacity resulting in slightly higher power generation generally for run-of-river projects.
- Reduced average daily flow at storage projects, resulting in slightly less generation at most storage projects.

The magnitude of the energy and capacity benefits, which would depend upon the nature and timing of the component implemented, were computed by HAC. A summary of the power benefits that are associated with each flow management component is presented below.

B.8.6.2. Energy Benefits

Energy benefits for the Arkansas River Navigation Study were computed for each flow management component under consideration. The model used applied the levelized energy value from 8-4 to the average annual generation values from Table 8-2, in order to compute project energy benefits for each year of the project life. The net gain in energy benefits attributable to a particular component was then determined by subtracting the base condition energy benefits from the component energy benefits. Table 8-9 illustrates the magnitude of the annual energy benefits that were calculated within the model. The last column of the table shows the annual gain in energy benefits relative to the existing condition.

Table 8-9. Annual Energy Benefits - For Components				
Component	**Avg. Annual Energy (GWh)**	**Levelized Energy Value ($/MWh)**	**Annual Energy Benefits (FY04 $1,000)**	**Energy Benefit Gain Relative to Base Condition (FY04 $1,000)**
Base Condition				
Run-of-River Projects	2,683.2	30.81	82,669	-----
Storage Projects	1,503.0	30.81	46,307	-----
TOTAL			**128,976**	
FM-175				
Run-of-River Projects	2,725.8	30.81	83,982	1,313
Storage Projects	1,493.7	30.81	46,021	(286)
TOTAL			**130,003**	**1,027**
FM-200				
Run-of-River Projects	2,720.1	30.81	83,806	1,137
Storage Projects	1,490.7	30.81	45,928	(379)
TOTAL			**129,734**	**758**
FM-OPS				
Run-of-River Projects	2,691.3	30.81	82,919	250
Storage Projects	1,504.3	30.81	46,347	40
TOTAL			**129,266**	**290**

B.8.6.3. Capacity Benefits

Capacity benefits for the Arkansas River Navigation Study were computed for each component under consideration. The value of capacity includes an adjustment to account for the flexibility and reduced outages associated with hydropower as compared to other thermal alternatives. In order to determine the capacity benefits for a particular component, the model computed benefits for each year over the historical 1940 – 2000 period. The benefits were averaged over this time period to derive average annual capacity benefits. The net gain in capacity benefits attributable to a particular component was then determined by subtracting the base condition capacity benefits from the component capacity benefits.

B.8.6.3.1. Dependable Capacity (DC)

Dependable capacity was estimated for each study component using the average availability method. A description of the procedure used is presented in Section 8.3.3, and the results are shown in Table 8-3.

B.8.6.3.2. Capacity Value (CV)

The value of capacity for the peaking plants was based on the least-cost mix of thermal resources that would most likely replace the project capacity if it were unavailable. By developing a thermal-alternative screening curve, the optimum thermal replacement consists of 21% gas-fired combustion turbine, 71% gas-fired combined cycle, and 8% coal (see Section 8.5.5). The weighted capacity value for the peaking plants is $103.52/kW-yr.

For the intermediate load plants the most likely, least-cost thermal alternative to the intermediate load plant consists of 23% gas-fired combustion turbine, 25% gas-fired combined cycle, and

51% coal-fired steam (see Section 8.5.5). The adjusted capacity value for the intermediate load plants is $142.20.82/kW-year. The derivation of the CV values is presented in Section 8.5.6.

B.8.6.3.3. Calculation of Annual Capacity Benefits

Table 8-10 illustrates the magnitude of the annual capacity benefits that were calculated within the model. The last column of the table shows the annual gain in capacity benefits relative to the Base Case. The values shown in the table were obtained by applying the composite unit capacity value developed in Section 8.5.6 to the dependable capacity values summarized in Table 8-3. Note that the capacity benefit values shown in the table do take into account the availability and flexibility adjustment factors.

Table 8-10. Annual Capacity Benefits - For Flow Management Components

Component	Dependable Capacity (MW)	Composite Capacity Value ($/kW-yr)	Annual Capacity Benefits (FY04 $1,000)	Capacity Benefit Gain Relative to the Base Case (FY04 $1,000)
Base Condition				
Peaking Projects	463.9	103.52	48,023	-----
Intermediate Load Projects	584.9	142.20	83,173	-----
TOTAL			**131,196**	
FM-175				
Peaking Projects	463.9	103.52	48,023	0
Intermediate Load Projects	587.1	142.20	83.486	313
TOTAL			**131,509**	**313**
FM-200				
Peaking Projects	463.9	103.52	48,023	0
Intermediate Load Projects	587.0	142.20	83,471	298
TOTAL			**131,494**	**298**
FM-OPS				
Peaking Projects	464.5	103.52	48,085	62
Intermediate Load Projects	585.7	142.20	83,287	114
TOTAL			**131,372**	**176**

B.8.6.4. Total Hydropower Benefits

Table 8-11 illustrates the magnitude of the annual hydropower benefits that are obtained when the annual energy benefits from Table 8-9 and the annual capacity benefits from Table 8-10 are combined. The last column of the table shows the annual gain in hydropower benefits relative to the base condition.

Table 8-11. Annual Hydropower Benefits - For Alternative Flow Management Scenarios

Component	Annual Energy Benefits (FY04 $1,000)	Annual Capacity Benefits (FY04 $1,000)	Total Annual Hydropower Benefits (FY04 $1,000)	Hydropower Benefit Gain Relative to FM-NA (FY04 $1,000)
FM-NA	129,018	131,196	260,214	
FM-175	130,045	131,509	261,554	1,340
FM-200	129,776	131,494	261,270	1,056
FM-OPS	129,308	131,372	260,680	466

B.9. Flood Damages

An inventory of structures and application of the Hydrologic Engineering Center Flood Damage Analysis model (HEC-FDA) was used to determine structure damages under each component. Flood damages are greatest under FM-200 with an estimated $1 million in additional annual damages compared to the No Action component (baseline conditions). The majority of these damages would occur in the Arkansas portion of the study area. Additional annual structure damages under FM-175 approximate $0.5 million compared to the No Action component (baseline conditions), with no additional damages under FM-OPS.

According to the Hydrology and Hydraulics Report: Appendix A, Section 4.3, "The results of the backwater modeling indicate that there are negligible impacts to the 2-year and 100-year water surface elevations." Therefore, no additional flood damages occur under navigation channel deepening components.

B.9.1. Flood Damages - Oklahoma

B.9.1.1. Introduction

The purpose of the flood damage economic evaluation in Oklahoma is to determine the value and extent of potential flood damages to structures and crops that lie within the floodplain of the Arkansas River from the confluence of the Grand (Neosho), Verdigris, and Arkansas rivers, known as 'Three Forks,' to the Oklahoma-Arkansas state line under the existing or without-project condition and with the components under consideration. The inventory of structures and crops occurred within the floodplain designated as the greater of the 1986 or the 1990 flood in Oklahoma. Data obtained from that inventory were used to evaluate each component under consideration. Preliminary screening of components early in the study eliminated all potential components except FM-175, the FM-200, and FM-OPS.

B.9.1.2. Existing Projects and Description of System

Flows on the main stem of the Arkansas River are modified primarily by 11 reservoir projects that provide about 7.7 million acre-feet of flood control storage. That storage represents in excess of 70% of the total flood control storage in the basin. The 11 projects are listed in Table 9-1 and shown on Figure 9-1. Runoff on about 7,500 square miles of drainage area below the 11 projects and above Van Buren, Arkansas is uncontrolled.

Table 9-1. Principal Upstream Flood Control Lakes, Arkansas River Basin, Oklahoma		
Lake	**River**	**Flood Control Storage (acre-feet)**
Hulah	Caney	257,900
Copan	Little Caney	184,300
Kaw	Arkansas	919,400
Keystone	Arkansas	1,180,000
Oologah	Verdigris	965,600
Pensacola (Grand)	Grand (Neosho)	525,000
Hudson	Grand (Neosho)	244,200
Fort Gibson	Grand (Neosho)	919,200
Tenkiller	Illinois	576,700
Eufaula	Canadian	1,510,800
Wister	Poteau	386,800
Total		**7,669,900**

ARKANSAS RIVER BASIN, ARKANSAS AND OKLAHOMA, FEASIBILITY REPORT

Figure

The primary purpose of the system water control plan is to achieve a reasonable balance of the purposes for which the projects are operated. The operating plans attempt to optimize flood damage reduction and navigation benefits as well as hydropower and recreation, and to minimize adverse impacts to the environment and fish and wildlife. Fort Smith/Van Buren, Arkansas, near the Oklahoma-Arkansas State line, is the primary control point for the lower Arkansas River Basin. The 11 major upstream storage projects are operated to maintain flow targets at the Van Buren gage, since all the flow releases pass this point. Upon completion of the McClellan-Kerr Arkansas River Navigation System, the system was operated for a 22-foot flood stage at Van Buren, which is currently in the range of about 120,000 to 130,000 cfs. However, the relationship between discharge and stage constantly changes on the Arkansas River. The actual non-damaging discharge for Van Buren is that discharge that produces a 22-foot stage at the gage. Between 1980 and 1990, the stage-discharge relationship has improved such that the discharge is about 125,000 cfs.

B.9.1.3. Flood History

Flood damages, particularly crop damages, result from above normal flows. Within the Arkansas River Basin in Oklahoma, about 410,000 acres experience periodic flooding. Present residual flood damages, agricultural and non-agricultural, amount to about $16 million annually. The Arkansas River Basin and tributaries in the study area from Three Forks to the State line have had recurrent flooding. Major floods in 1986 and in 1990 have caused significant damages throughout the basin. In 1986, total flood damages in the Arkansas River Basin in Oklahoma were about $160 million. It is estimated that in Oklahoma and Arkansas about $725 million in flood damages were prevented by projects in Oklahoma and Kansas, including levees. About $27 million in actual damages occurred along the main stem of the Arkansas River from Bixby, Oklahoma, to the state line.

In the spring of 1990, an unusual amount of rain produced record or near-record flooding during April and May in northeastern Texas, southeastern Oklahoma, western Arkansas, and along the Red River in Louisiana. In Oklahoma, the statewide average precipitation for the first four months of 1990 was the largest total reported since record keeping began in 1892. The late April rains, which fell on saturated soils, produced widespread flooding, and near record flow occurred in early May 1990. Most of the upstream reservoirs were at or near capacity. Floods the magnitude of 100 year or greater recurrence interval occurred on many streams. Discharges of 359,000 cfs occurred at Robert S. Kerr on May 4, and the peak discharge was 400,000 cfs at Van Buren, Arkansas, on May 5. For the four-state area, 17 deaths and millions of dollars in damage to public and private property occurred as a result of these floods. In Arkansas and Oklahoma, the homes of more than 2,000 families were damaged. Agricultural losses were extensive.

B.9.1.4. Evaluation of Operating Components

B.9.1.4.1. Preliminary Evaluation Using SUPER Model

Descriptions of the operational components are generally in terms of operating for control at the Van Buren gage. The preliminary evaluation of components utilized a system of programs known as the Southwestern Division Reservoir System Regulation Model, or “SUPER Model”,

which allows a hydrologic and economic evaluation of various regulation schemes on flood damage reduction, hydropower, water supply, low flow requirements, and navigation.

SUPER is not a risk-based model, but is used to operate the system of reservoirs in Oklahoma, Kansas, and Arkansas. This model does have an economics component that determines potential flood damages, losses or gains in hydropower, recreation, navigation, and was used to screen out many components. The model is discussed in the H&H Appendix. The model operates on a 61-year period of record. This model is recognized by the Corps for its primary purpose, operation of projects. SUPER is used for determining flood damages prevented by existing projects in the system. These values give credit to operating projects for flood damages prevented and are reported in the annual Chief of Engineers Report to Congress.

SUPER operates by using daily average flows. Hydrologic data are developed for each location of interest in the Arkansas River system. These points of interest, or control points, may be hydrologic stream gages, damage centers, or reservoirs. The control point data are developed from U. S. Geological Survey (USGS) flow records, reservoir content records, regulation reports, recording charts, and other available hydrologic data. The period of record for the Arkansas River Basin SUPER Model is January 1940 to 2002. SUPER utilizes a mathematical model that describes the physical attributes of each reservoir and control point with their linked relationships, which translates or routes reservoir releases with uncontrolled flows. In the regulation scheme, the hydrologic database is superimposed onto a given reservoir configuration by simulating a daily operation using a specific regulation scheme with specific system demands. The scheme includes a description of the flow capacities below each reservoir and at each control point, with water supply and hydropower demands and low flow requirements. The regulation plan may involve a reservoir being regulated as an individual reservoir for one or more control points or a reservoir being operated as part of a system for a particular control point. The control point regulation criteria can be as constant as the Van Buren or Muskogee control point of 150,000 cfs, can vary with reservoir storage, as in the case of Tenkiller Lake with 3,300 cfs above elevation 636 and then to 10,800 cfs, or may vary with the percent full of a system of reservoirs, such as Van Buren. Each regulation type may change with season. The preliminary screening of components in this study ranged to 300,000 cfs at Van Buren, with intervening flows, and is discussed more fully in the hydrology and hydraulic section of this report.

The hydrologic analysis of each regulation plan also involved a corresponding economic analysis. Each output parameter from the regulation simulation was applied to the economic model to develop damages and losses incurred. The economic description in the system was updated to current conditions in the 1980's. Update factors, such as the Engineering New Record (ENR) index system, are used to update values to current price levels. The damages derived from a simulation do not represent actual damages that occurred for a specific flood event but represent the damages that would result from a specific flood routed by a specific regulation scheme through that specific reservoir configuration for the economic conditions that have been described for a particular point in time. In this case, the damages for a particular operating plan are those that would occur if the flows over the period of record were routed through the existing system of reservoirs and evaluated for current economic conditions. SUPER can estimate damages for existing conditions based on a 61 year period of record; however, most

of the damage data in SUPER is updated based on price indices from data and information obtained by project and flood survey, over the last several decades depending on the stream. For that reason, the flood damage portion of the Appendix was based on a new flood plain survey that could be incorporated into a frequency and risk-based analysis using HEC-FDA, for the final components. In the screening process, using SUPER allowed an estimate of the three most critical components that should be evaluated further to determine their relative value compared to each other.

B.9.1.4.2. Final Components

FM-NA, the No Action component, is operating the system with a flow of 150,000 cfs at Van Buren. This is the existing condition or without-project component. This means that releases from upstream projects will be made such that the combined flow at Van Buren will be as near 150,000 cfs as is reasonably possible when the system is 40% - 50% full or higher. When the system is at a lower percent full, it would be operated at 105,000 cfs. When the system falls below 6% full, there would be a transition back to normal conservation operations.

FM-175, the 175,000 cfs component, refers to operating the system with a flow at Van Buren and Sallisaw gages of 175,000 cfs as is reasonably possible. In addition, this component would replace the 75,000 cfs bench with a 60,000 cfs bench operation.

FM-200, the 200,000 cfs component refers to operating the system with a flow at Van Buren and Sallisaw gages of 200,000 cfs as is reasonably possible. In addition, this component would replace the 75,000 cfs bench with a 60,000 cfs bench operation.

FM-OPS, the Operations Only component refers to operating Sallisaw and Van Buren at 150,000 cfs, or a 22-foot stage at Van Buren. A 60,000 cfs bench would replace the 75,000 cfs bench. Van Buren and Sallisaw would also be operated for 150,000 cfs to 250,000 cfs at 75% system storage. The regulating discharge would depend upon the highest flow achieved from local runoff at Van Buren that would be greater than 150,000 cfs and less than or equal to 250,000 cfs. After this component was developed and evaluated, another plan with only a 60,000 cfs bench was evaluated. This component is the same as the existing operations plan except that the 75,000 cfs bench is being replaced with a 60,000 bench. In addition, this component contains a 3% lower system storage. There is no change from the existing condition plan in regards to discharge frequency, pool elevation frequency, and duration.

B.9.1.5. Future Baseline Conditions

Federal guidelines for water resources planning studies require that study reports explicitly quantify and describe the conditions considered most likely to exist in the study area over the period of analysis in the absence of any proposed project (baseline) or change in existing law or policy. The without-project condition is used as the baseline for measuring incremental benefits, costs, and other effects of components. The without-project condition should provide for the most effective use of the resource in question over time. In this case, the resource is the waterway system. Consideration of other than economic conditions, such as safety, environmental concerns, and public acceptance, can enter into the decision on the most effective

operating plan. The current operating plan represents the future without-project base condition from which other operational effects are measured.

Present residual flood losses in the Arkansas River Basin are estimated at about $16 million annually. This level of damages can be expected to recur under future conditions without a major Federal project or a change in the operating plan. Flood damages are estimates of damages to crops (agriculture) and to structures and contents.

The Oklahoma study area was developed based on floods that occurred most recently in 1986 and 1990, depending on the locations where overflows occurred. The screening process indicated that differences in operating plans would be apparent below the confluence of the Arkansas, Verdigris, and Grand (Neosho) Rivers at Muskogee, Oklahoma. The 1990 flood was used in the lower reaches near Fort Smith as the flood of greater magnitude in terms of area inundated.

Early in the study, the study team determined that the economic data in the SUPER Model program needed to be updated to current conditions. The SUPER Model economics were utilized for preliminary screening efforts; however, a current assessment of floodplain properties was required in conjunction with a National Economic Development (NED) analysis. In addition, a frequency analysis of flood events was required so that flood damages could be described in terms of average annual flood damages. The SUPER Model period of record was extensive, about 66 years of flood data, but was not in terms of probability of occurrence or frequency for a range of flood events from the 1-year to the 1,000-year. If mitigating flood damage reduction measures are required, those measures should be evaluated in terms of average annual benefits and costs of implementation. Damages to structures and contents in the floodplain are based on a floodplain inventory conducted by Texas A&M University in 2001-2002. The floodplain inventory data were used to establish the base values of properties that are at flood risk. It is assumed that there would be no further significant development of property within the floodplain areas along the river unless the area was flood proofed. Urbanization in the Fort Smith-Van Buren, Arkansas, area, on the Oklahoma side, would most likely be outside the floodplain. Average annual flood losses to structures and contents were calculated by reach for each component and for the without-project condition using standardized damage-loss functions and simulated using the HEC-FDA computer program.

Agricultural crop losses are based on crop-specific damage functions that incorporate seasonal factors with economic data to produce crop loss estimates. Cropping patterns and other economic data, such as crop prices, yields, harvesting costs, were used to derive crop values. The economic data for the without-project base condition were developed from field surveys and from information gathered from local county extension agents and others in the counties affected. The data were compiled by Texas A&M University for the study. Elevation-area flooded data were developed by reach for the study area and used with the economic data and probability of flooding information to derive average annual crop losses. Land use in the study area is not expected to change significantly over the period of analysis, although cropping patterns may shift depending on agricultural policy and prices. Flood damages to crops can be expected to change to replicate historical experience. Average annual flood losses for crops

were calculated using the Hydrologic Engineering Center's Flood Impact Analysis (HEC-FIA) and Flood Damage Analysis (HEC-FDA) computer programs.

B.9.1.6. Floodplain Inventory: Structural and Agricultural Properties

B.9.1.6.1. Introduction

The Texas Agricultural Experiment Station (TAES) in cooperation with the U.S. Army Corps of Engineers, Tulsa District office initially undertook a reconnaissance level examination of available data and estimated costs for obtaining such data to determine flood damages within affected areas of the Arkansas River Basin within Oklahoma and Arkansas. This report summarizes the effort to obtain and process that data for use in HEC-FDA and Agricultural Flood Damage Analysis (AGDAM) flood damage assessment computer programs for the Oklahoma portion of the Arkansas River floodplain. Possible alterations to the operation of reservoirs in Oklahoma are under consideration to increase navigable river days for barge traffic on the Arkansas River.

A major portion of this effort was to obtain relevant Geographic Information System (GIS) coverages as well as tax assessor data to determine which structures lay within the relevant floodplain. An additional key component was to assimilate and process the associated tax assessor data with the ultimate goal of providing needed input data for use in the Corps' flood damage assessment model (HEC-FDA). Similar efforts were required for ascertaining what crops are grown within the expected floodplain and for collecting economic data required for assessing the potential damage to the cropland. Eventual use of the Corp's Agricultural Damage or AGDAM crop damage assessment model was the goal here. Products provided by this effort include: 1) GIS coverage (data layers) collected and developed for the study, 2) input data developed for the HEC-FDA and AGDAM damage assessment models, and 3) a description of the methodology employed and suggestions for how to update the study in the future.

During the course of the study, after the contract with TAES had been initiated, it was determined that the flood plain areas impacted by the components would be below Three Forks, where the Verdigris, Grand, and Arkansas rivers merge at Muskogee Oklahoma, and that the best tool to use for the agricultural evaluations would be recently the available HEC-FIA. Accordingly, although initial runs were made using AGDAM for the existing condition, HEC-FIA was used in the final analysis.

Figure 9-2: Study Area

B.9.1.6.2. Methodology for Determining Structure Locations

Tulsa District hydrologists specified 11 counties in northeastern Oklahoma (Figure 9-2) for the study area. TAES personnel traveled to each county and interviewed tax assessor personnel to determine the nature of available data and what would be required to extract the data. It quickly became apparent that the data could best be obtained by dealing with the commercial firm of Oklahoma Appraisal and Assessment of Claremore, Oklahoma. This firm handled and resold data for all 11 counties. Tax assessor datasets were purchased for each of those counties. Plat map books were obtained for ten of the 11 original counties from Marceline Mapping Company of Marceline, Missouri. These map books were to aid efforts to geo-reference the structure locations. A plat map book was not purchased for McIntosh County due to the extremely small amount of land that lies within the original floodplain. Detailed examination of the aerial photos and the relevant floodplain also led to the conclusion that no affected structures lay within the floodplain for McIntosh County. Subsequent review of the expected relevant floodplain for the proposed reservoir operation changes also excluded Mayes County from consideration and study for this effort.

Figure 9-3: Sample Map for Structures Within the Floodplain

Five of the 11 counties (Haskell, Leflore, Sequoyah, Tulsa, and Rogers) had GIS coverage or CAD (Computer Aided Design) files that provided parcel outlines. These files greatly aided in determining which parcels had structures within the floodplain. A sample for a portion of Haskell County appears in Figure 2. The CAD/GIS files did not provide the exact structure location, but the accompanying database provided information as to the type of parcel (i.e., rural ag, urban residential) as well as data on the improvement value. Parcels with positive improved values were selected from the database at large, and, as a first approximation, a GIS point coverage was generated with points at the centroid of the parcel polygon. Legal descriptions and digital ortho-quarter-quad photos were then consulted to more accurately determine the precise location of the structures and whether they were in the floodplain. Figure 9-3 depicts Haskell County, showing only the structure locations for parcels within the predicted floodplain.

Georeferencing structures within the remaining four counties (Osage, Washington, Muskogee, and Wagoner) proved a much more arduous task. The floodplain coverage provided by the U.S. Army Corps of Engineers, Tulsa District office was combined with a USGS coverage depicting section, township, and range. Sections within the floodplain were enumerated and used as a selection criterion to sort out entries within the tax assessor database. Rural properties were geo-coded to the centroid of the relevant section while addresses matching components of ArcInfo/ArcView were employed to determine first cut approximate locations for urban properties. Poor quality road coverages led to a good deal of error in these initial geocoding

efforts, and the DOQ photos and detailed legal descriptions were employed to more accurately determine the location of both urban and rural structures. The plat map books also aided in this process.

B.9.1.6.3. Reach Definitions

In addition to the efforts noted above, reach definitions were required for both the AGDAM and HEC-FDA runs. Such reaches provide a regional unit for analysis, and results of the damage model estimates are generally reported by reach and then aggregated as needed. Table 9-2 summarizes the river mile markers chosen to serve as boundaries for the 29 reaches selected, with the aid of Corps personnel, for the analysis. River cross-sections (GIS coverage *mergesect)*, also provided by the Corps, aided in this selection. Figures 9-4 and 9-5 depict these boundaries graphically. Reach names were numbered sequentially, starting at the mouth of each respective river, and list the name of the county in which the lowest portion of the reach resides for more easy identification as to location. Only reaches Ark1 through Ark7 were pertinent in the flood damage evaluations.

Table 9-2. Reach Definition Mile Markers

Reach	From River Mile	To River Mile		Reach	From River Mile	To River Mile
Ark1-Seq	305.45	319.64		Caney1-Rog	0.34	16.03
Ark2-Seq	319.64	336.25		Caney2-Rog	16.03	34.73
Ark3-Seq	336.25	353.4		Caney3-Wash	34.73	54.2
Ark4-Seq	353.4	362.11		Caney4-Wash	54.2	64.65
Ark5-Seq	362.11	366.57		Caney5-Wash	64.65	78.29
Ark6-Musk	366.57	387.04		Cndn1-Hask	1	18
Ark7-Musk	387.04	392.5		Cndn2-Hask	18	28
Ark8-Musk	392.5	401.5		Ill1-Seq	2.82	12.2
Ark9-Musk	401.5	418.83		Verdg1-Wag	397.44	402.83
Ark10-Musk	418.83	426.29		Verdg2-Wag	402.83	422.41
Ark11-Wag	426.29	434.17		Verdg3-Wag	422.41	431.75
Ark12-Tulsa	434.17	508.41		Verdg4-Rog	431.75	0.001
Ark13-Tulsa	508.41	519.7		Verdg5-Rog	0.001	10.291
Ark14-Tulsa	519.7	523.71		Verdg6-Rog	10.291	22.658
Ark15-Tulsa	523.71	530.35				

Figure 9-4: Reach Boundaries, Upper Counties

Figure 9-5: Reach Boundaries, Lower Counties

B.9.1.6.4. Tax Assessor Data and HEC-FDA Input Data Preparation

The HEC-FDA flood damage program requires numerous input variables (see Table 1-1 of Addendum B1). Three major types, based on importance, appear: 1) informational types which provide insight for the user; 2) those requiring special calculations, such as replacement cost less depreciation; and 3) those variables which are locationally specific and which likely are best assigned using the GIS. The following explanation addresses the nature of the tax assessor data and its use. A discussion of the methods employed in using the GIS to determine locationally specific variables follows.

Historically, USACE analyses have focused on replacement cost less depreciation as the appropriate measure for assigning the current value of structures within the floodplain, and computer programs such as Marshall and Swift's (M&S) Residential Estimator have been used to obtain estimates of such values. M&S has specific data needs of its own (see Table 1-2 of Addendum B1), and key variables within that list include the effective age of the property as well as fairly specific data describing the property itself. Many of the informational type variables needed for HEC-FDA are also needed in making M&S estimates. The tax assessor data provided the vast majority of such data. Figure 9-6 portrays the layout of those databases, which generally consist of several tables linked by the property id. The three highlighted tables at the top of the diagram were the most useful in the current effort. The AAData table contained general information on the property owner, assessed and market values of land and improvements, legal description, and in some cases property address. This information was critical in helping to geo-reference the structures. The CAMA Data table contained detailed information on the primary structures on the property, including roof type, wall type, foundation, number of bathrooms, etc. The AREA table in turn provided additional information on square footage of supplemental structures, such as porches, garages and carports, and storage sheds. Information from all three tables was linked together via the property id and used as potential input into the M&S cost calculator program to obtain an estimate of replacement cost less depreciation. Information in the remaining three tables was not generally needed, although some data in the MH (mobile home) table might be of help. The DRAW and LEGAL tables provide limited information on drawings for the property as well as a separate legal description.

Figure 9-6: Tax Assessor Database Tables

Overall quality of the tax assessor databases varied greatly across and within counties, and, in many cases, missing data for a given structure would preclude explicit use of the M&S program. In light of this potential dilemma and the large number of properties within the study area, another approach was determined for providing M&S type estimates. All available data were assimilated for the parcels within the floodplain, and the parcels with the most reliable and full datasets were considered for possible M&S estimation. For counties with a relatively small number of structures within the floodplain (generally less than 50), all structures with reliable data were estimated. For counties with large numbers of parcels with reasonably reliable parcel data, a subset of approximately 50 residential properties was chosen for M&S estimation. The full set of residential properties was first sorted, from low to high, in terms of tax assessor specified market value for improvements. This would provide the widest possible range of values for the M&S estimation. A subset of approximately 50 was then selected from this ordered ranking and M&S estimates obtained.

A primary required input variable for M&S includes the effective age of the structure. Availability of this variable varied greatly across the counties. In cases where it was not available, structures built before 1980 were assumed to have an effective age of 80% of their

given age. Structures built after 1980 were assumed to have an effective age equal to their current age.

Two key additional steps provided the final components of the proxy M&S estimation procedure developed for this study. Once obtained, preliminary M&S cost estimates were compared to the market values shown in the original database. A ratio of the two was calculated and compared to expected values of from 1.0 to 2.5. In general, one would expect the replacement cost to be somewhat above, yet not too much above, the tax assessor market value. This caveat applies, especially in light of recent Oklahoma State law, which allows only a maximum increase of 5% per year in assessed market values. Preliminary ratios ranged in some cases from .5 to well above 6. M&S values outside the range (1.0, 2.5) were excluded, and two regressions were calculated with the remaining observations. The first regression, termed REG1, simply regressed the estimated M&S value against the tax assessor provided Market Value of the improvement. REG1 included an intercept term. Table 9-3 provides estimates for the REG1 coefficients as well as a second regression (NOINT, or no intercept) for each county. This second regression was required for properties with generally small market values and was applied to those with market values less than the intercept term of REG1. Blind application of REG1 to these smaller valued structures would result in inflated values for those structures. For example, use of a REG1 regression with intercept term 10,000 would grossly overvalue a structure with an original market value of $2,000. In addition to the regression coefficients, Table 9-3 lists the number of observations used in developing the regressions as well as the number of properties within each county for which the regressions were used to estimate the M&S value.

Table 9-3. Marshall and Swift Regression Results

County	REG1 Int	REG1 MktVal	NOINT MktVal	No. of Observations	No. of Properties Applied To
Haskell	12,414.2185	0.4909	1.4992	4	2
LeFlore	10,867.7271	1.1220	1.3357	17	8
Muskogee	16,755.7331	1.0859	1.3738	29	49
Sequoyah	678.0959	1.4814	1.4977	47	87
Tulsa	5,804.3105	1.0655	1.1616	20	5,347
Wagoner	25,892.1850	0.9514	1.3369	31	32
Rogers	10,856.4178	1.1105	1.2978	39	221
Washington	10,435.1899	1.3164	1.4787	32	714

This methodology, using the REG1 and NOINT regressions, was applied to the residential properties with poor input data and to the commercial and miscellaneous agricultural properties as well. This assumes that the average difference between the market value and the replacement cost less depreciation for the county is captured in the regressions. Three versions of the M&S program exist, one for each type of property (residential, commercial, and agricultural). Only the residential estimator was used in this analysis, using the procedures outlined above. Use of the other two was not deemed necessary, especially given the relatively poor information available for commercial and miscellaneous-agricultural type properties. In addition, an indicator variable "MSSource" was created within the structure GIS coverage with values of ACTUAL, REG1, or NOINT to indicate the origin of the assigned value for the variable "Struc_val" in the data.

GIS techniques were also very useful in assigning values to many of the variables for use in both the M&S estimations as well as the final HEC-FDA data. For example, a key component of the M&S process is the zip code of the affected structure. The M&S program maintains an internal cost database, indexed by zip code, to determine site-specific building costs. These cost values are updated quarterly, and an accurate M&S cost estimate requires the zip code for the structure. A zip code polygon coverage was therefore obtained and converted to the appropriate coordinate system (UTM-NAD83-zone 15), and the GIS was used to attach the proper zip code attribute to the GIS database table portion of the structure coverage. Thus, the GIS allowed a more accurate cost calculation for the structures.

Several other tasks were performed using GIS based functions. HEC-FDA requires a right or left bank specification by reach. This was accomplished by heads-up manual selection of all structures within a reach on the desired side of the stream. Once those structures had been selected, a new variable, "Bank," was created and the proper designation (right or left) was assigned. Similar efforts were used to assign the values of the variables "Stream", "County", and "SID_Reach". More automated means were employed to assign values to the variables "grnd_stage", "Xval", "Yval", and "sec_no". An ArcView script (basically a small computer program) was used to add the X, Y, and Z coordinates to the database table portion of the structure coverage. The X and Y components apply for the coordinate system for the project, and the Z value pulls the elevation from a digital elevation model or GRID file developed for the region. This Z value, once attached to the structure coverage, was simply renamed to the HEC-FDA name of "grnd_stage". A similar script was employed to determine which cross section was the closest to each structure. The script attached the name of the nearest cross section to the database table. Manual and automated tasks such as those described here are some of the major advantages of using a GIS. One can assign data en masse with relatively little effort.

Several additional facets of data development merit discussion. For the final HEC-FDA input data files, structures were separated into four major categories (residential, commercial, exempt, and miscellaneous-agricultural) with the latter being structures such as barns or sheds. In addition, unique structure IDs were assigned to each parcel id. These IDs appear in the main GIS coverage for the structures (*bggenexp*) and consist of three parts: 1) a county identifier, 2) a type of property identifier, and 3) a unique structure number. An example would be "ROGR-RS-084.00" which would indicate a residential structure in Rogers County with a randomly assigned number of 84.00. Two digits were added after the decimal to allow for the eventual possibility of numerous structures associated with the same leading integer number or parcel. Classification abbreviations for the structure type included

RS = residential,
CM = commercial,
EX = exempt, and
MA = miscellaneous urban and/or agricultural.

These structure ids were assigned to each parcel and served as the variable Struc_name for the HEC-FDA input data. Care should be taken to maintain the integrity of both the tax assessor designated parcel id as well as the GIS related Struc_name. Both may be used as query fields

when searching for particular structural records, but the Struc_name is unique across all counties while the parcel id from the tax assessor data may not be unique.

Exempt properties often have zero improvement values within most tax assessor datasets due to the county's lack of need to track that variable. Property IDs for these parcels, along with owner name and legal description, do appear in the final GIS parcel coverage (bggenexp), but do not generally have an estimate of replacement value less depreciation, as do the mainline residential and commercial structures. These properties are marked as exempt and will serve as a shortlist for additional work to determine whether any structures exist on the property and the value of those structures.

HEC-FDA also has custom damage functions for the various types of properties based upon the type of firm or structure. For those observations with missing commercial information (i.e., SIC codes), the owner field in the tax data was referenced. Values for the Occ_name variable, corresponding to the specification of type of damage function to be used, were assigned based upon the best available information. The owner field in the tax database provided some insight in some cases. Default values for those observations with no relevant type of firm/structure information were assigned as follows: 1) GES, or general contractor for the miscellaneous-agricultural properties, and 2) RCS, rental company for the commercial entities. The default RCS value was chosen due to its midrange content percentage.

B.9.1.6.5. Structure Summary

A very great deal of processing was required to build the input data for the HEC-FDA program and for the general partitioning of the structures into the subset within the floodplain. The effort was a combination of database and GIS work, coupled with additional Excel spreadsheet work due to the very varied nature of the data and the presence of many nonstandard values for the desired variables. Table 9-4 provides a summary of the final number of structures by type and county for the prepared HEC-FDA input datasets. Over 7,400 structures lie within the affected floodplain, and they have an estimated replacement cost less depreciation exceeding $445 million. *This is an underestimate given the numerous exempt properties in the data that have no assigned value*.

Table 9-4. Summary of Structure Count and Value

County	Residential	Commercial	Exempt	Misc & Ag.	Total Count	Value (FY01$)
Haskell	4			2	6	92,481
LeFlore	8			6	14	593,364
Muskogee	55	4	1	17	77	4,307,747
Rogers	202	13		44	259	22,250,671
Sequoyah	86	19	10	29	144	5,595,025
Tulsa	4,615	667	716	85	6,083	373,059,545
Wagoner	54			9	63	3,524,258
Washington	649	48	18	50	765	36,318,647
Study Total	**5,673**	**751**	**745**	**242**	**7,411**	**445,741,738**

In addition, Table 3-1 in Addendum B3 provides a sample portion of the data delivered as Excel spreadsheets for each county and the final HEC-FDA input files. The latter are only partial input files for HEC-FDA, with several values such as "Oth_Val" and "1F_Stage" left blank. The first floor stage values were based on the type of foundation in the database, such that a slab on grade would have a floor correction factor of 1´, a foundation would be 2´, and a mobile home would be 3´ from ground elevation to first floor elevation.

B.9.1.6.6. Agricultural Data Collection and Processing

Potential damages to agricultural cropland are a second source of damages within the area. For such work, reliable estimates of the acreages of crops as well as the specific crops within the floodplain were required. In the past, this task has been quite burdensome as year-to-year variation in crops grown as well as their location has been generally unavailable. One recently developed land use dataset helped overcome at least a portion of these past shortcomings. The so-called GAP Analysis (http://www.gap.uidaho.edu/) is a USGS sponsored effort to classify land use for the entire nation. Pertinent data within that effort includes 30-meter resolution classification of satellite photo pixels. Two classifications are useful for the study undertaken: 1) warm season crops, and 2) improved pasture. These correspond to land use codes 147 and 149 in the GAP classification system (see Addendum B2, Table 2-1). The Oklahoma related data were obtained from personnel at the Oklahoma State GAP Analysis Center at Oklahoma State University in Stillwater (http://www.gap.uidaho.edu/Projects/States/NewContacts.asp?StateID=36).

Figure 9-7 portrays a sample portion of the Oklahoma GAP analysis classification image for reach Ark1-SEQ (both banks), with portions of Sequoyah and Leflore counties shown. The image has been clipped by the relevant floodplain and color-coded by land use type. Each pixel represents a 30X30 meter or 900-square-meter area (.2224 acres) and has been classified as to primary land use (Table 2-1). Cropland is shown in red, pasture in green, cities in magenta, and water in blue. The remaining gray area represents all remaining GAP classifications aggregated together. Count data for the individual pixel classifications for cropland and pasture were then used as an estimate of the area within the floodplain.

Figure 9-7: Sample GAP Land Use Classification

More specific crop mix data were requested from Natural Resource Conservation Service (NRCS) personnel in each county. Only a portion of the county personnel responded, and the crop mix data provided were supplemented with crop mix data from the 1997 Census of Agriculture (U.S. Department of Commerce, 1998). Table 9-5 summarizes the resulting assumed crop mixes and acreage estimates corresponding to each crop. GAP pixel data for the two land uses noted above for each reach (both left and right banks) were calculated and then inflated to reflect potential pecan acreages. GAP classifications were not refined enough to partition out the pecan acreages, and the county level proportions were used to estimate proportions within the floodplain.

In addition to the crop mix data depicted in Table 9-5, several other types of data are required, including economic data such as crop yield, output price, harvest cost, area-elevation curve data, and flood damage functions for the crop by days of flooding.

Table 9-5. Crop Acreage Summary by Reach												
Reach/Bank	Acres	Wheat Ac (Prop)	Corn Ac (Prop)	Soybeans Ac (Prop)	Imp Past Ac (Prop)	Alfalfa Ac (Prop)	Pecans Ac (Prop)	Sorghum Ac (Prop)	Cotton Ac (Prop)	Fall Veg Ac (Prop)	Spring Veg Ac (Prop)	Wht Wildlife Ac (Prop)
ARK1-SEQ-L	8,124	894 (0.11)	2,031 (0.25)	2,275 (0.28)	2,681 (0.33)					244 (0.03)		
ARK1-SEQ-R	7,929	1,189 (0.15)	476 (0.06)	3,330 (0.42)	2,696 (0.34)	79 (0.01)		79 (0.01)	79 (0.01)			
ARK2-SEQ-L	3,655	256 (0.07)	621 (0.17)	658 (0.18)	2,047 (0.56)					73 (0.02)		
ARK2-SEQ-R	10,098	1,212 (0.12)	505 (0.05)	3,736 (0.37)	2,323 (0.23)	101 (0.01)				1,111 (0.11)	1,111 (0.11)	
ARK3-SEQ-L	1,249	87 (0.07)	200 (0.16)	225 (0.18)	712 (0.57)					25 (0.02)		
ARK3-SEQ-R	207	2 (0.01)			201 (0.97)			2 (0.01)				2 (0.01)
ARK4-SEQ-L	407	33 (0.08)	81 (0.20)	90 (0.22)	191 (0.47)					12 (0.03)		
ARK4-SEQ-R	1,538	215 (0.14)		123 (0.08)	677 (0.44)			215 (0.14)				308 (0.20)
ARK5-SEQ-L	225	16 (0.07)	36 (0.16)	41 (0.18)	128 (0.57)					5 (0.02)		
ARK5-SEQ-R	218	13 (0.06)		41 (0.19)	155 (0.71)		7 (0.03)	2 (0.01)				
ARK6-MUSK-L	3,040	426 (0.14)		1,307 (0.43)	1,003 (0.33)		213 (0.07)	91 (0.03)				
ARK6-MUSK-R	1,337	174 (0.13)		548 (0.41)	495 (0.37)		80 (0.06)	40 (0.03)				
ARK7-MUSK-L	2,335	327 (0.14)		934 (0.40)	887 (0.38)		140 (0.06)	47 (0.02)				
ARK7-MUSK-R	202	6 (0.03)		16 (0.08)	176 (0.87)		2 (0.01)	2 (0.01)				
ARK8-MUSK-L	4,060	325 (0.08)	81 (0.02)	1,340 (0.33)	2,152 (0.53)	41 (0.01)	41 (0.01)	81 (0.02)				
ARK8-MUSK-R	1,327	133 (0.10)	93 (0.07)	398 (0.30)	597 (0.45)	40 (0.03)	13 (0.01)	40 (0.03)		13 (0.01)		
ARK9-MUSK-L	1,825	146 (0.08)	55 (0.03)	639 (0.35)	913 (0.50)	18 (0.01)	18 (0.01)	37 (0.02)				
ARK9-MUSK-R	1,522	183 (0.12)	137 (0.09)	517 (0.34)	502 (0.33)	61 (0.04)	30 (0.02)	61 (0.04)		30 (0.02)		

Table 9-5. Crop Acreage Summary by Reach												
Reach/Bank	Acres	Wheat Ac (Prop)	Corn Ac (Prop)	Soybeans Ac (Prop)	Imp Past Ac (Prop)	Alfalfa Ac (Prop)	Pecans Ac (Prop)	Sorghum Ac (Prop)	Cotton Ac (Prop)	Fall Veg Ac (Prop)	Spring Veg Ac (Prop)	Wht Wildlife Ac (Prop)
ARK10-MUSK-L	3,533	424 (0.12)	141 (0.04)	1,767 (0.50)	919 (0.26)	71 (0.02)	71 (0.02)	106 (0.03)		35 (0.01)		
ARK10-MUSK-R	1,447	174 (0.12)	43 (0.03)	666 (0.46)	449 (0.31)	29 (0.02)	29 (0.02)	43 (0.03)		14 (0.01)		
ARK11-WAG-L	1,275	102 (0.08)	26 (0.02)	383 (0.30)	714 (0.56)	13 (0.01)	13 (0.01)	26 (0.02)				
ARK11-WAG-R	695	70 (0.10)	21 (0.03)	278 (0.40)	285 (0.41)	14 (0.02)	7 (0.01)	14 (0.02)		7 (0.01)		
ARK12-TULSA-L	3,363	370 (0.11)		706 (0.21)	1,345 (0.40)	101 (0.03)	706 (0.21)			135 (0.04)		
ARK12-TULSA-R	6,776	678 (0.10)		1,355 (0.20)	3,117 (0.46)	136 (0.02)	1,287 (0.19)			203 (0.03)		
ARK13-TULSA-L	1,091	120 (0.11)		229 (0.21)	436 (0.40)	33 (0.03)	229 (0.21)			44 (0.04)		
ARK13-TULSA-R	1,857	167 (0.09)		353 (0.19)	910 (0.49)	37 (0.02)	334 (0.18)			56 (0.03)		
ARK14-TULSA-L	58	4 (0.07)		8 (0.14)	35 (0.61)	1 (0.02)	8 (0.14)			1 (0.02)		
ARK14-TULSA-R	84	8 (0.09)		14 (0.17)	45 (0.53)	2 (0.02)	13 (0.16)			3 (0.03)		
ARK15-TULSA-R	286	29 (0.10)		57 (0.20)	132 (0.46)	6 (0.02)	54 (0.19)			9 (0.03)		
CANEY1-ROG-L	18,834	753 (0.04)		753 (0.04)	16,009 (0.85)		1,318 (0.07)					
CANEY1-ROG-R	1,221	49 (0.04)		49 (0.04)	1,038 (0.85)		85 (0.07)					
CANEY2-ROG-L	1,504	30 (0.02)		105 (0.07)	1,324 (0.88)		45 (0.03)					
CANEY2-ROG-R	3,712	148 (0.04)		445 (0.12)	2,895 (0.78)		223 (0.06)					
CANEY3-WASH-L	4,272	128 (0.03)		427 (0.10)	3,503 (0.82)		214 (0.05)					
CANEY3-WASH-R	2,780	250 (0.09)		806 (0.29)	1,307 (0.47)		417 (0.15)					
CANEY4-WASH-L	1,563	47 (0.03)		125 (0.08)	1,329 (0.85)		63 (0.04)					

Table 9-5. Crop Acreage Summary by Reach												
Reach/Bank	Acres	Wheat Ac (Prop)	Corn Ac (Prop)	Soybeans Ac (Prop)	Imp Past Ac (Prop)	Alfalfa Ac (Prop)	Pecans Ac (Prop)	Sorghum Ac (Prop)	Cotton Ac (Prop)	Fall Veg Ac (Prop)	Spring Veg Ac (Prop)	Wht Wildlife Ac (Prop)
CANEY4-WASH-R	1,486	45 (0.03)		119 (0.08)	1,263 (0.85)		59 (0.04)					
CANEY5-WASH-L	2,024	142 (0.07)		425 (0.21)	1,235 (0.61)		223 (0.11)					
CANEY5-WASH-R	1,054	95 (0.09)		316 (0.30)	485 (0.46)		158 (0.15)					
CNDN1-HASK-L	3,899	546 (0.14)		312 (0.08)	1,716 (0.44)			546 (0.14)				780 (0.20)
CNDN1-HASK-R	2,835	255 (0.09)		170 (0.06)	1,786 (0.63)			255 (0.09)				369 (0.13)
CNDN2-HASK-L	1,293	91 (0.07)		52 (0.04)	931 (0.72)			91 (0.07)				129 (0.10)
CNDN2-HASK-R	1,520	106 (0.07)		61 (0.04)	1,110 (0.73)			106 (0.07)				137 (0.09)
ILL1-SEQ-L	408	37 (0.09)	86 (0.21)	98 (0.24)	180 (0.44)					8 (0.02)		
ILL1-SEQ-R	554	44 (0.08)	100 (0.18)	111 (0.20)	288 (0.52)					11 (0.02)		
VERDG1-WAG-L	1,671	100 (0.06)	33 (0.02)	384 (0.23)	1,103 (0.66)	17 (0.01)	17 (0.01)	17 (0.01)				
VERDG1-WAG-R	1,123	101 (0.09)	34 (0.03)	393 (0.35)	528 (0.47)	22 (0.02)	22 (0.02)	22 (0.02)				
VERDG2-WAG-L	7,823	469 (0.06)	156 (0.02)	1,799 (0.23)	5,163 (0.66)	78 (0.01)	78 (0.01)	78 (0.01)				
VERDG2-WAG-R	7,391	665 (0.09)	148 (0.02)	2,439 (0.33)	3,843 (0.52)	74 (0.01)	74 (0.01)	148 (0.02)				
VERDG3-WAG-L	1,852	74 (0.04)		74 (0.04)	1,574 (0.85)		130 (0.07)					
VERDG3-WAG-R	10,036	1,305 (0.13)		1,305 (0.13)	4,717 (0.47)		2,710 (0.27)					
VERDG4-ROG-L	3,894	117 (0.03)		156 (0.04)	3,388 (0.87)		234 (0.06)					
VERDG4-ROG-R	1,887	38 (0.02)		57 (0.03)	1,717 (0.91)		75 (0.04)					
VERDG5-ROG-L	1,303	65 (0.05)		65 (0.05)	1,042 (0.80)		130 (0.10)					

Table 9-5. Crop Acreage Summary by Reach												
Reach/Bank	**Acres**	**Wheat Ac (Prop)**	**Corn Ac (Prop)**	**Soybeans Ac (Prop)**	**Imp Past Ac (Prop)**	**Alfalfa Ac (Prop)**	**Pecans Ac (Prop)**	**Sorghum Ac (Prop)**	**Cotton Ac (Prop)**	**Fall Veg Ac (Prop)**	**Spring Veg Ac (Prop)**	**Wht Wildlife Ac (Prop)**
VERDG5-ROG-R	1,823	128 (0.07)		146 (0.08)	1,276 (0.70)		273 (0.15)					
VERDG6-ROG-L	2,638	211 (0.08)		211 (0.08)	1,820 (0.69)		396 (0.15)					
VERDG6-ROG-R	1,631	82 (0.05)		82 (0.05)	1,305 (0.80)		163 (0.10)					
Total	**162,238**	**13,940 (0.09)**	**5,104 (0.03)**	**33,594 (0.21)**	**91,029 (0.56)**	**981 (0.01)**	**10,475 (0.06)**	**2,149 (0.01)**	**79 (0.00)**	**2,052 (0.01)**	**1,111 (0.01)**	**1,724 (0.01)**

Three sets of possible damage functions for crops to be used in setting up the agricultural damage program input file data were developed. These sets roughly correspond with three sub-regions (eastern, central, and upper portions) of the study area. Table 9-6 lists the reaches associated with those sub-regions.

Table 9-6. Damage Function Sub-regions			
	Sub-region		
Sub-region	**Section 1**	**Section 2**	**Section 3**
General Area	Eastern	Central	Upper
Included Reaches	Ark1-Seq	Ark8-Musk	Verdg1-Wag
	Ark2-Seq	Ark9-Musk	Verdg2-Wag
	Ark3-Seq	Ark10-Musk	Verdg3-Wag
	Ark4-Seq	Ark11-Wag	Verdg4-Rog
	Ark5-Seq	Ark12-Tulsa	Verdg5-Rog
	Ark6-Musk	Ark13-Tulsa	Verdg6-Rog
	Ark7-Musk	Ark14-Tulsa	Caney1-Rog
	Cndn1-Hask	Ark15-Tulsa	Caney2-Rog
	Cndn2-Hask		Caney3-Wash
	Ill1-Seq		Caney4-Wash
			Caney5-Wash

Area-elevation curves were also developed for each bank of the 29 reaches in the study area. These curves provide the amount of land, at or below a given elevation, within the area of interest. Development of such curves was greatly facilitated by the GIS tools employed. Each bank of the GAP data for a given reach was first clipped to isolate the land use classified pixels within that area. The "tabulate areas" option of the Spatial Analyst extension associated with the ArcView 3.2 software was then used to process the clipped GAP GRID file and a corresponding OKDEM GRID file, which similarly lists elevation by location. The result of this processing provided a database table listing the number of pixels for all combinations of elevation and land use within the reach (by river bank side). This process was repeated for each of the 29 reaches for 58 files, one for each bank.

Additional processing was required to convert the tables developed above into a usable form for AGDAM. Area-elevation data for the two land use classifications (types 147 and 149, crops and improved pasture) were first isolated. AGDAM is an older FORTRAN based program with maximum limits on the number of data points one can specify for the various components. In this case, only 18 combinations of cumulative area at or below each elevation could be specified. Data for the two land use classifications were therefore imported into an Excel spreadsheet and natural breakpoints were chosen by hand. Pixel counts were converted to acreage estimates, and the cumulative area at or below the chosen elevation breakpoints was calculated. Breakpoints were chosen to remain within the limit of 18 data area-elevation pairs while providing as much detail as possible. As noted in the crop mix discussion, these areas were inflated to reflect assumed pecan acreage proportions within the reach as well.

Economic and yield data for AGDAM originated from three major sources. Custom budget cost estimates were derived for each sub-region based upon the Oklahoma State University Crop Budget computer program. These are Excel spreadsheets, which allow specification of the

county, yield, and output price for selected crops. Representative runs were made for each sub-region to determine the harvest cost. Output prices correspond to the officially designated State normalized prices to be used in analyzing Federal projects. Prices for non-standard crops such as spinach or alfalfa were assigned based on historical data and interviews with NRCS personnel. The latter also assisted in determining representative yields.

One should note that the output price for cotton does not correspond to the designated output price to be used for Federal projects. Cotton is a multi-product crop and includes cottonseed. As such, the output price was increased to reflect the additional income to be derived from cottonseed based upon the assigned yield of cotton lint. Historically, each pound of lint corresponds to an average 1.6 lbs. of cottonseed, and the output price of lint was increased to reflect this potential revenue.

Addendum B3 Table 3-2 contains a sample of one of those files for Section 1 of the study area and includes the crop related yield and economic information as well as the damage functions and area-elevation curve data for each reach and river bank side.

B.9.1.6.7. Analysis Products

Numerous products, both primary and secondary, were developed or collected during the overall effort to produce the needed GIS coverage and the input files for the AGDAM and HEC-FDA programs. Table 9-7 summarizes those products, classifying them as primary or secondary nature. In addition, Addendum B4 contains more detail on the GIS related products. DOQ photos, while used extensively in the analysis, were not provided as products to the Tulsa District due to their large size and that office already having copies.

Table 9-7. Analysis Product Listing	
Primary Product Name	**Form**
HEC-FDA input data	Excel spreadsheets, by county
AGDAM input data	Column formatted text files organized for three sub-regions
Bggenexp	GIS point coverage with HEC-FDA input data as attributes
OKDEM	GIS Grid file: elev. model data for the entire study area
Tax Assessor databases	Original MS Access files
Secondary Product Name	
Bdjurpol	County Boundaries
Cdrelpar	GIS polygon coverage: parcel boundaries for selected counties
Cdreltrs	GIS line coverage: township-range-sections within the floodplain
Gdsgsqud	7.5-foot quadrangle boundaries. Used to determine needed DOQ photos
Hysurwbd	Major watercourses and water bodies of the Arkansas River and some tributaries
Hyflpflz	Historical floodplain designated by Tulsa District
OKGAP	Oklahoma GAP analysis classified land use raster image
Reach Area Elev Tables	DB tables by reach and bank (i.e., Ark1_left_elev.dbf)
Reachname	GIS point coverage giving reach name
Reachdefn	GIS line coverage depicting boundary cross sections for reaches
Trvehcl	Primary and secondary roads
Zip codes	Polygon coverage of zip code areas
Additional Products Employed	
OK State Crop Enterprise Budgets	Marshall and Swift Residential Estimator 7.0
ArcView 3.2, Spatial Analyst	Erdas Imagine 8.4
Plat Map Books, various counties	USGS Digital Ortho-Quarter-Quad Photos

In addition, once the existing condition and alternative scenarios are run in either AGDAM or HEC-FDA, one will desire to import the flood damage estimates back into the GIS and analyze/portray those results graphically. This is an easy process when using ArcView. Results for the damage estimates may be stored as a database file and linked back to the parent GIS coverage (bggenexp for structures or even the particular reach if results have been aggregated). Results may then be graphed as an overlay to the reach, perhaps in bar charts for various flood events or alternative management scenarios.

B.9.1.6.8. Analysis Overview

Numerous steps were required/followed in developing the two major datasets and associated GIS coverage in this effort, and it is easy to lose sight of the process when looking at individual steps. Tables 9-8 and 9-9 summarize the needed data acquisition and processing steps undertaken in the current effort.

Table 9-8. Recommended Steps for Data Acquisition and Processing	
1.	Determine relevant floodplain and affected sections within each township- range. Create a GIS coverage with those sections designated as such. Determine appropriate reaches and name them. Create a GIS coverage depicting those reaches.
2.	Acquire all relevant DOQ photos and DEM's. Convert DEM's to a grid if necessary using ERDAS Imagine or a similar product.
3.	Obtain entire relevant county tax assessor databases. Also obtain data descriptions and details on exempt property data extraction. Some counties may have digital copies of plat maps. Obtain if possible and convert to UTM, NAD83, Zone 15 Projection.
4.	Obtain most recent plat map books.
5.	Obtain best available road coverage to aid in geocoding structures in urban areas.
6.	Select the tax assessor database entries (both exempt and non-exempt) that lie within the flood designated sections of each county's township/range. Use geocoding software to obtain a first time approximation to urban property locations. Supplement actual locations with use of DOQ photos as a backdrop. Corrections may be required due to poor quality of road coverages. For rural properties, geocode their position to the centroid of the section. Correct this first approximation utilizing the DOQ photos and legal descriptions. Plat map books may also aid in location of the parcels and structures.
7.	Depending on the database format, exempt properties may or may not have assigned improvement values. It may also be difficult to determine whether a structure exists on a particular exempt parcel. Exempt properties that actually have structures, whether they are in the projected floodplain, and their value were not determined at this time; however, in the final evaluation of the lower reaches values were estimated for those structures in the floodplain.
8.	Select residential properties with quality information for possible M&S estimation. May have to make some assumption concerning effective age if no good values exist. Sort observations by market value of improvements and select a subset for M&S estimation. Following estimation, delete observations whose M&S value varies markedly from market value. Regress M&S predicted value against market value (both with and without an intercept) using the remaining M&S observations. Use the resulting two regressions to assign a proxy M&S value for the properties with poor input data. Use the NOINT regression for observations whose market value is less than the intercept term of the REG1 regression. Assign values to MSSOURCE such as actual, REG1 or NOINT to keep track of origination of M&S estimate for variable "Struc_val".
9.	Use tax assessor data to assign values to the remaining pertinent input variables for HEC-FDA. Play close attention to "Occu_name" which specifies the damage function type, primarily for commercial properties. Also use the GIS to assign values wholesale for terms such as "Bank", "section", and "Sid_reach".
10.	Determine values for other variables such as elevation offset for 1F_stage as well as cont_val and Oth_val. Finalize HEC-FDA files with hydrology variables and run existing and alternative scenarios.

Table 9-9. AGDAM Input Data Processing Summary	
1.	Assimilate all available crop mix data after consulting with NRCS or county extension personnel. Refine as much as you can spatially including for elevation. May supplement with county statistical or U.S. Census of Agriculture data.
2.	Update crop budget information and output prices. Verify harvest costs with the budget generator and determine appropriate yields by reach if possible.
3.	Update and verify crop damage function parameters, especially harvest dates, date of last cultivation, and growing season.
4.	Use spatial tools in ArcView, coupled with GAP grid data and a DEM grid or Tin to build a database table listing pixels counts for all combinations of land use and elevation.
5.	Select the land use classifications of interest (cropland and improved pasture) and convert pixel counts to acres. Also select breakpoints in the elevation values and sum the cumulative area up to that elevation. Do not exceed the AGDAM induced maximum of 18 pairs of elevation-area values.
6.	Convert the economic, crop damage function, and area-elevation data to the fixed format needed for input to the FORTRAN based AGDAM program. One set of damage functions may apply for several reaches. Crop mixes will likely vary by reach and bank. Supplement the data above with the hydrology and perform the analysis.

Although the AGDAM software was not used in the final agricultural analysis, the types of data and process are similar to what is required for the HEC-FIA program with the major change being the utilization of area-elevation data developed by Tulsa District. Since the development of crop acreages is by percent within a reach, the fact that the elevation area data is different than that developed by the contractor, the crop acreages by specific crop would differ than what is presented in Table 9-5.

B.9.1.7. Structural Evaluation

B.9.1.7.1. Methodology

The methodology used to evaluate flood damages to structures follows Corps of Engineers procedures as outlined in Engineer Regulation (ER) 1105-2-100, revised 22 April 2000. All prices are FY2002 price levels with a FY2004 Federal discount rate of 5.375%, when required. Damages were updated to July 2004 price levels using the FY2004 Federal discount rate of 5.375%. The HEC-FDA program was utilized to perform an integrated hydrologic engineering and economic analysis during evaluation of the operating plans. Water surface profiles were developed that described the river hydraulics using HEC-RAS (River Analysis System) for the study area from Three Forks to the Oklahoma-Arkansas State line. The HEC-RAS files for the existing condition, 200,000 cfs, 175,000 cfs, and Operations Only alternatives consist of the 1-, 2-, 5-, 10-, 25-, 50-, 100-, 500-, and 1,000-year flood events. After preliminary evaluations using the SUPER model, flood impacts between plans could only be described from Three Forks to the state line. Seven reaches from Three Forks to the State line, left bank and right bank (14 total reaches), were established and described previously. An Excel spreadsheet was constructed with the pertinent economic data required for input into HEC-FDA. Addendum B5 displays the HEC-FDA input data.

B.9.1.7.2. Value of Floodplain Property

The floodplain property inventory identified about 241 structures that could be impacted by the operating plans from Three Forks to the State line. Most structures are residential, including

mobile homes, except in the Moffet, Oklahoma community where commercial, industrial, and public properties are located. The property table in Addendum B5 describes these types of structures.

A summation of the number and value of flood plain structures is shown in Table 9-10. These structures were utilized in the final FDA evaluation.

Table 9-10. Value of Floodplain Property – Oklahoma, Three Forks to State Line

Impact Area (Reach)	Number	Value (FY02 $1,000)
1-Left	190	7224.1
1-Right	10	572.4
2-Left	6	274.6
2-Right	4	222.8
3-Left	18	1241.1
3-Right	0	0.00
Total	**228**	**9,535.0**

The value of contents and/or inventory was estimated based on relationships of structure value to content/inventory value from flood studies conducted by US Army Corps of EngineersGalveston District.

B.9.1.7.3. Structural Depth-Damage Relationships

The structural depth-damage relationships are also shown in Addendum B5. The generic depth-damage relationships for residential structures are taken from "Economic Guidance Memorandum (EGM) 01-03, Generic Depth-Damage Relationships" dated 4 December 2000. Depth-damage relationships for other than residential structures are taken from Tulsa District files and have been used in other flood reduction studies.

B.9.1.7.4. Evaluation

The evaluation using HEC-FDA was conducted within the model with risk and uncertainty, in values of property (20% uncertainty), uncertainty in first floor elevation (1-foot), and uncertainty in depth-damage percent relationships. Addendum B5 shows the FDA output by flood elevation. FDA output tables showing flood damages for the existing condition by reach and category are shown in Table 9-11. Damage categories include commercial structures and contents; agricultural related structures and contents, such as farms; public structures and contents; and residential structures and contents, including mobile homes. Reaches or impact areas not shown have no properties damaged under existing operations. Flood damages under existing operating conditions are based on a frequency type of analysis. These damages occur in the lower reaches in Oklahoma below the Robert S. Kerr Lock and Dam. Most of the potential damages occur in the Moffett, Oklahoma, area near Fort Smith, Arkansas, and are residential.

Table 9-11. OK Expected Annual Structural Flood Damages by Damage Categories and Damage Reaches Without-Project Condition, with Uncertainty (FY02$)					
	Damage Category				
Damage Reach	Commercial	Misc-Agric	Public	Residential	Total
1-Left Bank	$22,497	$3,383	$3,849	$50,705	$80,434
1-Right Bank	$0	$0	$0	$8,844	$8,844
2-Left Bank	$0	$5,781	$0	$0	$5,781
2-Right Bank	$0	$0	$0	$3,770	$3,770
Total	**$22,497**	**$9,164**	**$3,849**	**$63,319**	**$98,829**

B.9.1.7.5. Summary of Structural Flood Damages by Component

A summary of expected annual structural flood damages reduced for each component is shown in Table 9-12. Damages were updated to July 2004 price levels using the FY2004 Federal discount rate of 5.375%.

Table 9-12. OK Expected Annual Structural Flood Damages Reduced, with Uncertainty (FY02$)						
	Expected Annual Damage			Probability Damage Reduced Exceeds Indicated Values		
Component	Total Baseline	Total With Project	Damage Reduced	0.75	0.50	0.25
FM-NA	$98,829	$98,829	$0	$0	$0	$0
FM-175	$98,829	$100,428	($1,598)	($4,125)	($2,134)	$6
FM-200	$98,829	$105,562	($6,733)	($14,191)	($8,494)	($1,027)
FM-OPS	$98,829	$98,829	$0	$0	$0	$0
OK Expected Annual Structural Flood Damages Reduced (July 2004 $)						
FM-NA	$109,739	$109,739	$0			
FM-175	$109,739	$111,514	($1,776)			
FM-200	$109,739	$117,215	($7,476)			
FM-OPS	$109,739	$109,739	$0			

B.9.1.8. Agricultural Evaluation

B.9.1.8.1. Methodology

Agricultural crop losses are based on crop-specific damage functions that incorporate seasonal factors with economic data to produce crop loss estimates. Cropping patterns and other economic data, such as crop prices, yields, and harvesting costs, were used to derive crop values. The economic data for the without-project base condition were developed from field surveys and from information from local county extension agents and others in the counties affected and were compiled by Texas A&M University for the study. Elevation-area flooded data were developed by reach for the study area and were used with the economic data and probability of flooding information to derive average annual crop losses. Land use in the study area is not expected to change significantly over the period of analysis, although cropping patterns may shift depending on agricultural policy and prices. Flood damages to crops can be expected to change to replicate historical experience. Average annual flood losses for crops were calculated using the HEC-FIA and HEC-FDA computer programs. Initial efforts were to develop flood losses and area flooded

by frequency using the AGDAM program. However, due to the requirements of hydrograph input by frequency in AGDAM, and the recent release of HEC-FIA, it was decided to use the FIA software to determine crop losses by frequency and season.

B.9.1.8.2. Crop Data

Texas A&M University obtained crop data during the course of the floodplain inventory along the Arkansas River and affected tributaries. Crop information and data used to compute flood losses on a crop-by-crop and seasonal basis were input into HEC-FIA. The data include crop prices, crop yields, and harvest costs by acre. Crop prices are FY 2001 normalized prices where available for a specific crop. Crop budgets for Southeast Oklahoma were used where available to obtain harvesting costs. Crop yield data were obtained either from the crop budgets or from county extension agents. The data are summarized in Table 9-13.

Table 9-13. Oklahoma Crop Data

Crop	Price CNP	Yield Per Acre	Unit	Harvest Cost Per Acre	Budget
Alfalfa	105	5	tons	20	Southeast Okla
Corn	2.63	120	bushel	30	Southeast Okla
Garden, Truck	100	6	tons	19	Southeast Okla
Grain Sorghum	4.04	37.5	cwt	15.28	Southeast Okla
Native Hay	78.13	5	tons	110	Southeast Okla
Oats	2.14	55	bushel	19	Southeast Okla
Tame Hay	70	4	tons	110	Southeast Okla
Tame Pasture	26	5	aums	20	Southeast Okla
Wheat	3.31	30	bushel	60	Southeast Okla
Soybeans	5.77	40	bushel	18.18	Southeast Okla
Cotton, lint	0.557	420	pound	28.44	Southeast Okla
Cotton, seed	93.3	64	cwt	28.44	Southeast Okla
Spring spinach	100	6	tons	20	Southeast Okla
Fall spinach	100	6	tons	20	Southeast Okla

B.9.1.8.3. Elevation-Area Data

Elevation-area flooded data were initially obtained from Texas A&M University on a reach-by-reach basis, based on the area-flooded delineation for the 1986 and/or 1990 floods. After initial FIA runs and calibration of the model based on frequency of flooding and area flooded, another set of area flooded data, elevation versus acres flooded, by reach was developed by Tulsa District. This second set was used in the FIA model. The elevation-area flooded data by reach are shown in Table 9-14.

Table 9-14. Oklahoma Area Flooded by Elevation and Reach, FIA Input					
Reach	**FIA Input Elevation**	**Area (acres)**	**Reach**	**Elevation**	**Area (acres)**
1-Left	405.44	0	**5-Left**	467.42	0
	410.74	1,572		471.50	54
	417.66	10,466		478.02	287
	417.75	12,049		478.05	487
1-Right	405.44	0	**5-Right**	467.42	0
	410.74	3,827		471.50	88
	417.66	8,970		478.02	340
	417.75	10,614		478.05	404
2-Left	423.21	0	**6-left**	490.33	0
	429.47	2,310		490.78	106
	437.1	4,698		492.14	413
	439.71	5,765		508.11	4,272
2-Right	423.21	0	**6-Right**	490.33	0
	429.47	4,550		490.78	81
	437.1	10,118		492.14	213
	439.71	13,750		508.11	2,364
3-Left	461.13	0	**7-Left**	490.99	0
	462.36	230		492.03	36
	465.15	523		495.15	137
	471.09	1,577		512.03	3,841
3-Right	461.13	0	**7-Right**	490.99	0
	462.36	230		492.03	18
	465.15	523		495.15	44
	471.09	1,577		512.03	599
4-Left	463.76	0			
	466.28	136			
	470.63	593			
	472.98	639			
4-Right	463.76	0			
	466.28	206			
	470.63	1,278			
	472.98	1,410			

B.9.1.8.4. Crop Percent Damage Relationships

Crop percent damage relationships describe the percent loss of a crop by time of year based on planting date, growth cycle, maturity level, and time of harvest. In addition, flood duration, generally from one to five days or more, will affect the crop loss per acre. A late plant and replant time window of 14 days is assumed within the growth cycle of a crop depending on time of year. These data were taken from Tulsa District curves for the region and input into the FIA program. A typical percent loss curve for soybeans is shown in Figure 9-8 followed by a duration loss curve in Figure 9-9.

Figure 9-8.

Figure 9-9.

B.9.1.8.5. Plan Evaluation Using FIA

The FIA model was run for each of four seasons for each flood frequency. These seasons are designated in the FIA model as January 1 to March 31, April 1 to June 30, July 1 to September 30, and October 1 to December 31. Each season used a look back period of 14 days to account for late planting decisions. Including the 1,000-year flood, 36 FIA runs were used to compute losses for the existing condition and the 200,000 cfs flow condition. The area flooded and the dollar flood losses for each frequency by reach and season were weighted by the probability of the given frequency flood occurring during that season. Based on this weighting, frequency damage data by reach were input into FDA program. Table 9-15 shows this data by reach and flood frequency for the existing condition hydrograph. Table 9-16 shows this data by reach and flood frequency for the 200,000 cfs hydrograph.

Table 9-15. OK, Summary of Crop Losses by Frequency and Reach, Revised 8 Nov 2002, FIA Output, Existing Hydrograph (FY01$, Acres)																		
	Frequency																	
	1-Year		2-Year		5-Year		10-Year		25-Year		50-Year		100-Year		500-Year		1,000-Year	
Reach	$1,000	Acres	$1,000	Acres	$1,000	Acres	$1,000	Acres	$1,000	Acres	$1,000	Acres	$1,000	Acres	$1,000	Acres	$1,000	Acres
1 Seq-Left	7.47	315	106.08	789	135.96	1561	221.13	5891	423.00	11170	496.34	12048	503.35	12048	735.00	12048	750.50	12048
1 Seq-Right	12.80	758	78.90	1754	251.90	3760	258.90	6260	323.80	96.3	386.00	10508	422.80	7649	530.30	10508	586.10	10508
2 Seq-Left	11.80	622	33.40	1017	135.20	1517	217.00	3196	270.70	4485	258.40	5445	301.70	5765	389.00	5765	389.00	5765
2 Seq-Right	29.30	1200	72.20	1965	297.50	2929	445.60	6492	642.80	9446	675.40	12416	761.50	13476	935.70	13476	1159.60	13476
3 Seq-Left	1.60	88	3.50	126	15.20	200	25.90	360	32.80	532	31.60	727	47.10	905	70.70	1312	78.50	1470
3 Seq-Right	0.23	26	0.53	36	3.10	59	4.40	107	6.50	159	5.96	195	7.10	227	11.30	302	13.60	351
4 Seq-Left	1.30	62	4.00	83	10.40	114	23.10	379	31.30	590	38.80	620	34.80	639	39.70	639	37.40	639
4 Seq-Right	1.10	93	12.40	126	7.90	174	19.50	777	33.30	1271	41.70	1355	37.80	1409	42.60	1409	39.10	1409
5 Seq-Left	0.40	24	1.30	33	3.80	48	8.50	173	16.60	488	22.30	488	24.00	488	18.15	488	26.10	488
5 Seq-Right	0.40	39	0.97	55	5.50	76	7.20	212	14.60	392	14.20	392	14.70	392	16.60	392	16.10	392
6 Seq-Left	0.20	14	1.30	65	4.40	106	8.96	200	16.60	392	22.40	580	35.30	792	53.30	1282	64.40	1521
6 Seq-Right	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	11.60	310	18.80	429	21.40	707	35.30	841
7 Seq-Left	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	71.70	1686	84.90	2070
7 Seq-Right	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	0.00	0
Total All Reaches	**$67**	**3241**	**$315**	**6049**	**$871**	**10544**	**$1,240**	**24047**	**$1,812**	**29021**	**$2,005**	**45084**	**$2,209**	**44219**	**$2,935**	**50014**	**$3,281**	**50978**
Loss Per Acre	**$20.55**		**$52.01**		**$82.59**		**$51.57**		**$62.44**		**$44.47**		**$49.95**		**$58.69**		**$64.35**	

Table 9-16. OK, Summary of Crop Losses by Frequency and Reach, FIA Output, 200,000 cfs hydrograph (FY01$, Acres)																		
	Frequency																	
	1-Year		2-Year		5-Year		10-Year		25-Year		50-Year		100-Year		500-Year		1000-Year	
Reach	$1,000	Acres	$1,000	Acres	$1,000	Acres	$1,000	Acres	$1,000	Acres	$1,000	Acres	$1,000	Acres	$1,000	Acres	$1,000	Acres
1 Seq-Left	0.00	0	45.59	1521	139.90	2719	238.90	5891	429.40	11170	484.90	12048	570.10	12048	779.90	12048	854.60	12048
1 Seq-Right	0.00	0	83.30	3659	224.50	4446	274.00	6260	322.70	9603	345.20	10508	405.60	10508	502.10	10508	546.40	10508
2 Seq-Left	0.00	0	40.80	2154	142.40	2418	173.00	3196	193.80	4485	214.80	5441	229.10	5765	272.50	5765	271.10	5765
2 Seq-Right	0.00	0	101.60	4158	314.20	4710	366.90	6492	407.20	9446	469.40	12400	532.60	13476	578.30	13476	648.90	13476
3 Seq-Left	0.00	0	4.90	258	17.20	282	22.80	360	25.90	532	24.30	727	32.30	905	55.40	1312	64.30	1470
3 Seq-Right	0.00	0	0.70	77	3.90	83	4.10	107	6.50	159	6.10	194	6.80	227	10.00	302	11.90	351
4 Seq-Left	0.00	0	3.90	184	13.70	227	20.10	379	29.40	590	27.30	620	25.30	639	28.20	639	28.10	639
4 Seq-Right	0.00	0	3.70	318	14.00	419	19.90	777	33.90	1271	31.90	1355	30.00	1409	34.30	1409	33.60	1409
5 Seq-Left	0.00	0	2.30	79	5.60	100	8.30	173	17.00	488	18.30	488	17.60	488	22.00	488	20.60	488
5 Seq-Right	0.00	0	2.00	112	6.20	133	7.80	212	13.10	392	13.20	392	11.50	392	13.60	392	12.70	392
6 Seq-Left	0.00	0	2.10	93	6.10	121	7.10	200	15.80	392	21.60	580	28.40	792	57.30	1282	70.50	1521
6 Seq-Right	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	5.40	310	14.60	429	33.00	707	39.20	841
7 Seq-Left	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	42.40	1686	63.30	2070
7 Seq-Right	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	0.00	0
Total All Reaches	**$0**	**0**	**$291**	**12613**	**$888**	**15658**	**$1,143**	**24047**	**$1,495**	**38528**	**$1,662**	**45063**	**$1,904**	**47078**	**$2,429**	**50014**	**$2,665**	**50978**
Loss Per Acre	**$0.00**		**$23.06**		**$56.69**		**$47.53**		**$38.80**		**$36.89**		**$40.44**		**$48.57**		**$52.28**	

B.9.1.8.6. Alternative Plan Evaluation Using HEC-FDA

The HEC-FDA model was used to develop expected annual flood damages for FM-NA, FM-175, FM-200, and FM-OPS. Water surface profiles are developed for each component using HEC-RAS software, as explained in the Hydrology and Hydraulics appendix, and imported into HEC-FDA. Simulations were performed with uncertainty.

B.9.1.8.7. Summary of Agricultural Crop Damages

Table 9-17 shows expected annual flood damages by reach for agricultural crop damage for existing hydrographs.

Table 9-17. OK, Summary of Expected Annual Crop Damages by Reach, FM-NA; existing hydrographs

Reach	Annual Damages (FY01 $1,000)
1-Left	$124
1-Right	$134
2-Left	$81
2-Right	$181
3-Left	$11
3-Right	$2
4-Left	$9
4-Right	$10
5-Left	$3
5-Right	$1
6-Left	$7
6-Right	$1
7-Left	$0
7-Right	$1
Total*	**$564**

**Total differs from sum due to rounding.*

Table 9-18 summarizes these damages by component based on existing conditions flood hydrographs used in FIA.

Table 9-18. OK, Summary of Expected Annual Crop Damages by Alternative, existing hydrographs

Component	Annual Damages (FY01 $1,000)
FM-NA	$564
FM-175	$674
FM-200	$790
FM-OPS	$564

Table 9-19 shows expected annual flood damages by reach for agricultural crop damage for the 200,000 cfs component using the 200,000 cfs hydrograph in FIA.

Table 9-19. Summary of Expected Annual Crop Damages by Reach, FM-NA; 200,000 cfs hydrograph

Reach	Annual Damages (FY01 $1,000)
1-Left	$0
1-Right	$128
2-Left	$75
2-Right	$169
3-Left	$11
3-Right	$2
4-Left	$9
4-Right	$10
5-Left	$4
5-Right	$1
6-Left	$7
6-Right	$1
7-Left	$0
7-Right	$0
Total	**$418**

**Total differs from sum due to rounding.*

Table 9-20 summarizes these damages by component based on 200,000 cfs flood hydrographs used in FIA.

Table 9-20. Summary of Expected Annual Crop Damages by Plan; 200,000 cfs hydrograph in FIA

Component	Annual Damages (FY01 $1,000)
FM-NA	$418
FM-175	$515
FM-200	$607
FM-OPS	$418

B.9.1.8.8. Summary of Total Flood Damages: Oklahoma

Total flood damages to structures and crops as described previously are shown in Table 9-21. Crop damages were updated to July 2004 price levels using the Parity Ratio from the National Agricultural Statistics Service (FY2001=40.5, July 2004=44)[18].

Table 9-21. Summary of Average Annual Equivalent Damages By Component, Oklahoma, (FY01 $1,000)					
		FM-NA	**FM-175**	**FM-200**	**FM-OPS**
Flood Damages					
	Structures	$98.83	$100.43	$105.56	$98.83
	Crops	$564.00	$674.00	$790.00	$564.00
	Total	$662.83	$774.43	$895.56	$662.83
Summary of Average Annual Equivalent Benefits by Component					
Oklahoma			**FM-175**	**FM-200**	**FM-OPS**
Flood Damages Reduction					
	Structures		($1.60)	($6.73)	$0
	Crops		($110.00)	($226.00)	$0
	Total		($111.60)	($232.73)	$0
Summary of Average Annual Equivalent Damages By Plan, Oklahoma, (Indexed to July 2004 $)					
		FM-NA	**FM-175**	**FM-200**	**FM-OPS**
Flood Damages					
	Structures	$109.74	$111.51	$117.22	$109.74
	Crops	$612.74	$732.25	$858.27	$612.74
	Total	$109.74	$111.51	$117.22	$109.74
Summary of Average Annual Equivalent Benefits by Component					
Oklahoma			**FM-175**	**FM-200**	**FM-OPS**
Flood Damages Reduction					
	Structures		($1.77)	($7.48)	$0
	Crops		($119.51)	($245.53)	$0
	Total		($121.28)	($253.01)	$0
**Totals differ due to rounding.*					

[18] Parity Ratio is the ratio of index of prices received by farmers to index of prices paid for commodities and services, interest, taxes, and wage rates. Agricultural Prices Report, January 2005, NASS, USDA.

B.9.2. Flood Damages - Arkansas

B.9.2.1. Methodology for Determining Structure Location

The approach for determining structure locations within the McClellan-Kerr Arkansas River Navigation System flood plain within the Arkansas portion of the study area was driven by data quality, completeness, and data lineage. At the time of analysis, a complete data set was not present. Little Rock District provided data sets from other projects and sources. Therefore, in using data that was designed and created for other projects, Assumptions were made based on existing data and appropriate methodologies for working around data problems, inconsistencies, and gaps were developed. These work-around procedures included data transformation and conversion, as well as identification and scrutiny of alternate data sources for missing information. Inconsistencies with data led to three iterations of the structure identification process.

The lineage and validity of some of the original TAMU data were initially questioned. Specifically, the 100-year flood plain consisting of two parts: The first part, "hyflpflz," is a flood zone covering 11 counties from Crawford and Sebastian Counties in the northwest corner of Arkansas to Pulaski County in the middle of the state, while the second part, "hyflpflz_FEMA," is a flood zone based on 2000 FEMA flood insurance reports for Jefferson County only. These flood zones were obviously of unrelated lineage and could not be validated as being a true 100-year flood zone. These flood zones were considered equal to a 100-year flood zone for the Arkansas River. The first iteration of structure identification and location was undertaken.

Later, it was deemed that hyflpflz and hyflpflz_FEMA were not appropriate or accurate representations of the 100-year flood plain and alternate data was provided, on a pool-by-pool basis (lock to lock), for three different flow rates:

Ozark:	175	200	225
Dardanelle	205	240	NA
Pools 9 & 8	205	240	260
Pools 7 – 2	215	240	NA

Data used to create the 175cfs were: Ozark_175000, Dard_205000, pools 2-7_215000, pools 8-9_205000. Data used for the 200cfs flood zone were: Ozark_200000, Dard_240000, pools 2-9_240000. At this time, the second iteration of structure identification and location was undertaken.

After several weeks, the pool data was reevaluated and the flood zones were reconfigured for a third and final time. Upon this change a few new pieces of data were provided: Dardanelle_260000 and pools 2-7_260000 were added as well as data for the Van Buren lock; Van Buren_150000, Van Buren_175000, Van Buren_200000. Additional data processing was required to work around data 'blowing up' upon magnification. The new and complete data set contains:

Van Buren:	150	175	200
Ozark:	175	200	225
Dardanelle	205	240	260
Pools 9 & 8	205	240	260
Pools 7 – 2	215	240	260

The final flood zone configurations are as follows:

150000cfs	175000cfs	200000cfs
Dard_205	Dard_240	Dard_260
Ozark_175	Ozark_200	Ozark_225
Pools 2-7_215	Pools 2-7_240	Pools 2-7_260
Pools 8-9_205	Pools 8-9_240	Pools 8-9_260

Additionally, while confusion over appropriate pool data often required different approaches and data processing, other data was determined to be unusable for various reasons. Elevation data, "hsline," took hours to open in ArcINFO and always resulted in program crashes. Since USGS 7.5 Minute Topographic quadrangles were already available, they were the best possible data set at that time. USGS 7.5' contour intervals range from 5´ to 20´.

Likewise, 1-foot resolution aerial photography performed admirably, but being created for another Corps project, the photography had been clipped off or was altogether missing in several places. These data gaps were ultimately filled using 10-meter resolution photography downloaded from the GEOSTOR website.

While the methodology often changed for handling and processing data, the methods for locating structures within the flood zones were consistent throughout all three iterations. Individual pool data was merged into three separate coverages; 150,000 cfs, 175,000 cfs, and 200,000 cfs, and loaded into ArcMap. Each coverage was made 75% transparent and placed on top of the 1-foot aerial photographs. Points were placed where structures intersected or were contained by each flood zone. As directed by the project manager, only houses and significant commercial property were identified within each flood zone. The 200,000 cfs flood zone was the first processed. The resulting 200,000 cfs point file was queried by location, where its points intersected with the 175,000 cfs and 150,000 cfs flood zones. The resulting shapefiles provide locations for structures in those flood zones.

Finally, a 1:2500 grid was loaded into ArcMap and placed over the entire project area for the purpose of individual map production. Considering each flood zone separately, a map was created for each grid cell that contained structures that fell within that flood zone. The resulting information was placed into a layout and printed for the next phase of the project.

B.9.2.2. Tax Assessor Data and Marshall & Swift Model Input Data Preparation

County Assessor records were accessed for each of the twelve impacted counties within the study area. Structures identified on aerial photographs as being within the 150,000 cfs, 175,000

cfs and 200,000 cfs flow areas were subsequently plotted on USGS quadrangles. The identification of these structures by township/range/section location on the USGS maps provided the basis for subsequent identification of the respective required county plat maps that are organized on a township/range/section basis. The aerial photos and USGS quadrangles were taken to the County Assessor Offices where the applicable county plat maps were initially identified for subsequent parcel and parcel number identification. The parcel numbers were subsequently used to retrieve the respective assessor cards that contain economic and physical data relevant to the parcel. Relevant data on the assessor cards include type of structure (e.g. residential, commercial/industrial, exempt); appraised valuation of improvements; effective age of primary improvement(s); and information related to the physical attributes of the structure (e.g. foundation type, floor type, roof type, siding type, plumbing fixtures, and improvement amenities).

The quality and comprehensiveness of data from the respective County Assessor offices varied greatly between the counties. The urbanized counties generally have more complete data and plat map coverage, while the rural counties tend to have incomplete data for many properties and, in many cases, lack any type of plat map or other maps for certain areas. In addition, numerous properties identified with primary structure improvements indicated no such improvements on the County Assessor records. In such instances, valuation estimates had to be made for certain property improvements. In other instances, when no plat map existed for correlating structures with parcel numbers, an estimate had to be made regarding the location of a particular structure.

Data collected from the County Assessor offices were subsequently used as inputs into the Marshall and Swift Residential Estimator Program for obtaining "replacement cost new" less depreciation values for each primary structure. Key inputs into this program include effective physical age of the improvement; type of structure; physical attributes of the structure, such as foundation type, roof type, siding type, etc.; and zip code. The Marshall & Swift Program maintains an internal cost database that is indexed by zip code to determine site-specific building costs.

Tax assessor data collected from the County Assessor offices includes appraised valuations for parcel improvements for the most recent appraisal year. The appraised valuation of the parcel's improvement(s) was compared to the Marshall & Swift Residential 7 Estimator Program "replacement cost new less depreciation" value resulting from inputting the parcel's physical attribute data into the model. A sample of approximately 8% of the affected structures was used for Marshall & Swift valuation estimation. The resulting Marshall & Swift values generated varied from the County's appraised valuation, with the variances ranging from 1.2 to 2.5 the county's appraised valuation. The overall average variation approximated 1.5. Thus, the factor of 1.5 was applied to the county's 2002 appraised valuation to arrive at an estimated valuation of the parcel's improvement for flood damage assessment purposes.

The above data inventoried for each county in addition to other data unique to each structure were incorporated into spreadsheets for subsequent use in the HEC-FDA Model for flood damage assessment. Data incorporated into these spreadsheets include the following for each structure: county/USGS quad/aerial photo identification; structure ID; parcel ID; left or right

bank location; river mile; elevation; occupant name and category name; levee location; tax exempt status; most recent appraised valuations; and Marshall & Swift adjustment for "replacement cost new less depreciation" values.

An important input into the HEC-FDA model is the first floor elevation or stage value of a structure. Since only a small field sampling of structures was conducted, an estimate had to be made of the first floor elevations. These estimates were based on typical first floor elevations observed during field visits, and conversations with local county assessors regarding first floor elevations typically associated with different foundation types. The first floor stage values were adjusted based on the type of foundation noted in the county assessor database, such as slab-on-grade, elevated slab, and piers. These adjustments, or first floor correction factors from ground elevation to first floor, were 1/2′ for slab-on-grade; 2′ for elevated slab; and 3′ for piers. All mobile homes have a first floor correction factor of 2′ since the foundation type was not typically indicated in the county assessor database.

B.9.2.3. HEC-FDA Model Input Data Preparation

The HEC-FDA modeling program was utilized to estimate the difference in expected annual damages resulting from the three alternative components when compared to existing conditions. The two main forms of input required for HEC-FDA are economic input and hydraulic input.

B.9.2.3.1. Economic Input

Economic input consists of a structure inventory within the study area. Each structure was classified into one of the following four Damage Categories: Residential (RES), Commercial (COM), Industrial (IND) or Public (PUB), and then further defined by an Occupancy Code. Table 9-23 lists the Occupancy Codes as they are divided between Damage Categories. Each Occupancy Code was assigned a damage curve that described the percent of structural damage and content damage incurred by each incremental foot of flooding. A standard error distribution associated with the curves was also assigned. Prior flood studies within the District provided these relationships. Where no exact match in Occupancy Code for a type of structure was available, the curves from a similar type of building were used.

The structure inventory spreadsheets created for each county were combined into a text file that was then imported directly into HEC-FDA. Some structure data that was collected during the structure inventory was not required to run HEC-FDA; since the model was not intended as a reference for additional structure data, the extraneous data was omitted. Information such as the aerial photo identification, tax-exempt status, and unadjusted appraised value can still be found on the structure inventory spreadsheets. The data imported into the model consisted of the fields listed in Tables 9-22 and 9-23.

Table 9-22. Occupancy Codes		
Damage Category	**Occupancy Code**	**Description of Occupancy Code**
RES	SF1P	Single Family Residential, 1-story on piers
RES	SF1ES	Single Family Residential, 1-story elevated slab
RES	SF1G	Single Family Residential, 1-story slab on grade
RES	SF2P	Single Family Residential, 1.5 story on piers
RES	SF2ES	Single Family Residential, 1.5-story elevated slab
RES	SF2G	Single Family Residential, 1.5-story slab on grade
RES	SF3P	Single Family Residential, 2-story on piers
RES	SF3ES	Single Family Residential, 2-story elevated slab
RES	SF3G	Single Family Residential, 2-story slab on grade
RES	MH1	Single Family Residential, Mobile home (also used for campers)
COM	OFS	Commercial Office
COM	AUS	Auto Parts Dealer
COM	WHSE	Commercial Warehouse
COM	SHOP	Commercial Shop
COM	PYS	Private Storage
IND	OUT	Industrial Outbuilding
IND	WHSE	Industrial Warehouse
IND	OFS	Industrial Office
IND	BLDG	Industrial Building
IND	CSS	Cabinet shop, manufacturing
IND	BAR	Barge Terminal
PUB	CUS	Church
PUB	RFS	Recreational Facility

Table 9-23. Imported Structure Inventory Data for HEC-FDA	
HEC-FDA Field Name	**Description**
Struc_Name	Unique identification of each structure in inventory, usually the parcel number. Where parcel numbers were unavailable, a name was assigned consisting of the county abbreviation and a number (i.e. ARK1)
Notes	County name and USGS quad sheet name
Bank	Side of the stream the structure is located on (either Left or Right)
Station	Location of structure by nearest river mile along the Arkansas River
Grnd_Stage	Elevation of ground (in feet) at the structure
Found_Ht	Distance (in feet) above the ground to the first floor elevation of the structure
Occ_Name	Occupancy code for the structure
Cat_Name	Damage category name
Struc_Val	Estimated structure value, adjusted by Marshall & Swift factor

The most inclusive structure inventory limits for the Arkansas part of this project were the 200k Floodplain boundaries. This inventory included 428 structures; 409 of these were residential, five were commercial, 11 were industrial, and five were public. This total is an underestimate due to the incompleteness of county records.

B.9.2.3.2. Hydraulic Input

HEC-RAS River Analysis System hydraulic models were provided by the Little Rock District for each of the eleven pools along the Arkansas River through the state of Arkansas. The downstream limit of the Arkansas study area is located at the downstream end of the HEC-RAS model for Pool 2, which is River Mile 17. The upstream limit of the HEC-RAS modeling for the

study area is located at River Mile 319.56, which is the upstream end of the HEC-RAS model for Pool 13.

Each HEC-RAS model included data to evaluate the flow management components: FM-NA, FM-175, FM-200 and FM-OPS. For each component, a range of flood frequencies from the 1-year recurrence interval to the 1000-year recurrence interval was analyzed. River mile, flow and water surface elevation data was exported from these eleven models and combined into one continuous profile for each component. The resulting text file was imported into the HEC-FDA model.

B.9.2.4. HEC-FDA Analysis

The Arkansas River had to be broken down into reaches to facilitate evaluation in HEC-FDA. The logical division into reaches followed the HEC-RAS model limitations, which was by river pool. Table 9-24 defines the reaches used for the HEC-FDA evaluation. Some reaches were divided into left bank and right bank if the presence of a levee impacted the level of protection of structures in the floodplain on one side of the river.

Table 9-24. HEC-FDA Reach Designation

Reach No.	Reach Name	River Mile Range
1	Pool 2	17 to 50
2	Pool 3	51.18 to 65.63
3	Pool 4	66.15 to 86.04
4	Pool 5	86.5 to 107.85
5	Pool 6	108.35 to 125.2
6	Pool 7	125.45 to 155.65
7	Pool 8	156.05 to 176.65
8	Pool 9	177.03 to 205.25
9	Dardanelle	205.6 to 256.43
10	Ozark	256.9 to 292.5
11	Pool 13	292.84 to 319.56

The HEC-FDA analysis for Arkansas included risk and uncertainty for property values, first floor elevations and depth-damage relationships. Consistent with the assumptions made for the Oklahoma HEC-FDA analysis, an uncertainty of 20% was applied to property values. An uncertainty of 5′ was applied to first floor elevation estimates, however, due to the error associated with the average contour interval of 10′ on the topographic maps used to estimate ground elevation for each structure.

FDA output tables showing flood damages for the No Action component (FM-NA) by reach and category are shown in Table 9-25. Prices are FY2002 price levels with a FY2004 Federal discount rate of 5.375%, when required. Reaches not shown in the table (Reaches 8 and 10) contained no properties damaged under existing conditions. Results of the FM-NA analysis indicate that approximately $6.4 million in average annual flood damages occur under existing operating conditions, based on a frequency type of analysis.

Table 9-25. AR Expected Annual Structural Flood Damages FM-NA (FY02 $1,000)					
	Damage Category				
Damage Reach	Residential	Commercial	Public	Industrial	Total
Reach 1, Pool 2	$835.0	$0	$0	$0	$835.0
Reach 2, Pool 3	$31.2	$0	$0	$0	$31.2
Reach 3, Pool 4	$1,488.8	$259.5	$0	$0	$1,748.3
Reach 4, Pool 5	$25.8	$0	$0	$0	$25.8
Reach 5, Pool 6	$84.9	$0	$128.1	$273.4	$486.5
Reach 6, Pool 7	$346.6	$0	$762.4	$0	$1,109.0
Reach 7, Pool 8	$324.6	$961.1	$0	$0	$1,285.7
Reach 9, Dardanelle	$25.8	$0	$0	$0	$25.8
Reach 11, Pool 13	$38.1	$2.6	$0	$804.1	$844.8
Total*	**$3,200.7**	**$1,223.2**	**$890.5**	**$1,077.5**	**$6,392.0**
**Total differs from sum due to rounding.*					

B.9.2.5. Summary of Structural Flood Damages by Component

A summary of impact on expected annual structural flood damages for each component is shown in Table 9-26. Damages were updated to July 2004 price levels using the FY2004 Federal discount rate of 5.375%.

Table 9-26. AR Expected Annual Structural Flood Damages Reduced, with Uncertainty (FY02$)						
	Expected Annual Damage			Probability Damage Reduced Exceeds Indicated Values		
Plan Name	Total Baseline	Total With Project	Damage Reduced	0.75	0.5	0.25
FM-NA	$6,391,909	$6,391,909	$0	$0	$0	$0
FM-175	$6,391,909	$6,546,122	($154,213)	($115,285)	($156,200)	($188,785)
FM-200	$6,391,909	$6,739,401	($347,492)	($272,595)	($355,847)	($419,294)
FM-OPS	$6,391,909	$6,407,296	($15,387)	($8,127)	($15,706)	($21,968)
AR Expected Annual Structural Flood Damages Reduced (July 2004 $)						
FM-NA	$7,097,506	$7,097,506	$0			
FM-175	$7,097,506	$7,268,742	($171,236)			
FM-200	$7,097,506	$7,483,357	($385,851)			
FM-OPS	$7,097,506	$7,114,591	($17,086)			

B.9.2.6. Agricultural Property Damages

B.9.2.6.1. Introduction

Agricultural flood damages along the Arkansas portion of the Arkansas River represent a significant loss not only to the farmers, but also to the State economy. This assessment of crop losses due to flooding is a constrained evaluation with respect to impacts and scope in that it attempts to describe the specific effects of alternative river regulation plans on the agricultural environment. Several areas of data constraints were evident in the evaluation and those constraints are described in the appropriate sections. While the data constraints impact the

specificity of the evaluation, they do not affect the order of magnitude or the direction of the impacts.

B.9.2.6.2. Agricultural Data Collection

There are fourteen counties impacted by the Arkansas River between river mile 319.5 and river mile 17.0. Desha County was eliminated due to the small area impacted between river miles 25.8 and 17.0. Table 9-27 shows the major row crops and the percent distribution of crops for the affected counties. These data reflect the 2001 county estimates of the Arkansas Agricultural Statistics Service. Some specialty and vegetable crops were not evaluated due to the limited acreage. Because of the limited scope of the flow management components, there are not expected to be any changes in agricultural operations. Current agricultural practices are expected to continue with respect to crop types and methods. No increase or decrease in yield is expected to be attributed to the components. As mentioned earlier, there are several data constraints and mapping is a constraint. Unlike the GIS data of the upper reaches, the Arkansas reaches rely on United States Geological Survey maps at a scale of 1:24,000 with a contour interval of 10´ supplemented by 5´ intervals. Because of this grossness of the mapping, no attempt was made to stratify the floodplain with regard to crop types. Each acre is represented as the typical acre in proportion to the percent crop distribution for the county.

B.9.2.6.2.1. Crop Budgets

The next step in the crop damage assessment is the development of crop budgets in order to determine the gross and incremental net returns along with the harvest costs. On the crop price side, there is a requirement to use the "Current Normalized Prices" for row crops developed by the Department of Agriculture in all water resource studies involving agricultural impacts. These normalized prices smooth out the effects of short-term fluctuations in current prices in the national–level prices and are then converted to state-level prices. Table-9-28 displays the normalized prices used in this evaluation. Addendum C1 contains an example crop budget for an affected county. Several anomalies were noted in the crop budgets due to the use of normalized prices and that is the appearance of negative incremental net returns in some cases.

Table 9-27. Crop Yields And Percent Crop Distribution					
COUNTY /CROP	**YIELD**	**PERCENT**	**COUNTY / CROP**	**YIELD**	**PERCENT**
Arkansas:			**Conway**:		
Rice (cwt.)	69	31	Corn (bu.)	148	5
Wheat (bu.)	64	20	Wheat (bu.)	50	28
Soybeans (bu.)	40	49	Soybeans (bu.)	30	63
			Grain Sorghum (cwt.)	57	4
Lincoln:					
Rice (cwt.)	61.5	23	**Pope**:		
Cotton (lbs.)	789	29	Wheat (bu.)	56	33
Wheat (bu.)	50	10	Soybeans (bu.)	29	67
Soybeans (bu.)	34	36			
Grain Sorghum (cwt.)	49.8	2	**Yell**:		
			Rice (cwt.)	56	23
Jefferson:			Corn (bu.)	120	10
Rice (cwt.)	63	25	Wheat (bu.)	56	17
Cotton (lbs.)	828	19	Soybeans (bu.)	25	50
Wheat (bu.)	49	14			
Soybeans (bu.)	34	40	**Johnson**:		
Grain Sorghum (cwt.)	50.4	2	Corn (bu.)	130	23
			Wheat (bu.)	50	23
Pulaski:			Soybeans (bu.)	31	54
Rice (cwt.)	61.5	12			
Wheat (bu.)	47	28	**Logan**:		
Soybeans (bu.)	34	54	Corn (bu.)	127	23
Grain Sorghum (cwt.)	40.3	6	Wheat (bu.)	60	27
			Soybeans (bu.)	33	55
Faulkner:					
Rice (cwt.)	62	28	**Franklin**:		
Wheat (bu.)	55	28	Soybeans (bu.)	28	100
Soybeans (bu.)	28	44			
			Crawford:		
Perry:			Wheat (bu.)	52	26
Wheat (bu.)	62	33	Soybeans (bu.)	21	10
Soybeans (bu.)	32	67	Grain Sorghum (cwt.)	42	64
			Sebastian:		
			Soybeans (bu.)	21	100

Table 9-28. Current Normalized Crop Prices - Arkansas (FY02$)		
CROP	**UNIT**	**PRICE**
Wheat	Bushel	$2.94
Rice	Cwt.	$7.93
Corn	Bushel	$2.04
Grain Sorghum	Cwt	$3.60
Cotton	Pound	$0.614
Soybeans	Bushel	$5.95

B.9.2.6.2.2. Elevation–Area Data

Given the lack of GIS data for the Arkansas portion of the study area and the gross USGS mapping (1:24,000) with 10-foot contour elevations, the evaluation relied on the HEC-RAS hydrologic model of water surface profiles, top width elevations, and channel cross-sections for the various flood frequency events. An additional complicating factor is the existence of levees along both sides of the river. The locations, degree of protection, and their effectiveness all impact the determination of average annual acres flooded. The feasibility report titled Arkansas River Basin, Arkansas and Oklahoma ,May 1991, described 40 levee districts, both federal and private throughout the Arkansas portion of the river. Those levees provided unspecified levels of protection to a reported 753,180 acres. A more recent assessment of the downstream levees identifies 26 districts protecting 720,110 acres to varying degrees. Further complicating the issue of levee protection is their classification 10 – acceptable, 12 – minimally acceptable, and 4 – unacceptable. The assumption for the agricultural areas is that the levees will perform up to the event with a recurrence interval of 5-years. With the hydrologic impacts of the alternative regulation plans limited to the 25-year event and below the relevant range for impact evaluation and assessment is bound by the 25-year and the 5-year recurrence events.

Addendum C2 displays the detailed derivation of the acres flooded by elevation and the average annual acres flooded. Table-3 shows the summary by reach of the average annual acres flooded for each of the alternative regulation plans. Table-4 displays the differences in average annual acres flooded for the alternative regulation plans versus the existing "Baseline" condition.

B.9.2.6.3. Damage Model

Several potential crop damage models were investigated for the evaluation process, each with their own advantages and disadvantages. HEC-AGDAM was considered because of the advantages of the flood frequency approach but rejected because of the cumbersome hydrologic requirements. An alternative approach was the Computerized Agricultural Crop Flood Damage Assessment System developed jointly by Mississippi State University and the U. S. Army Corps of Engineers Vicksburg District. This methodology employs a daily period of record (POR) river stages and where sufficient period of record exists, affords a detailed analysis of both water surface elevation and duration in concert with the physical aspects of crop maturation. This model also requires specific hydrologic data in terms of a POR, which defines the baseline or current condition and a synthetic POR that describes each of the flow management components. No synthetic POR data were available for this type of specific crop damage modeling. With 300 plus miles of river in 11 different reaches and 14 counties to model, an easily adaptable mechanism was required. The damage assessment is a combination of the specific crop attributes in the Arkansas region and the damage functions developed for the Oklahoma portion of the study area utilizing the event oriented HEC-FIA model. The eastern sub-region was judged the most appropriate for the Arkansas evaluation.

Table 9-29. Acres Flooded By Reach				
Reach	**Average Annual Acres Flooded**			
	FM-NA	**FM-175**	**FM-200**	**FM-OPS**
Reach 1 RM 17-50	15,770	15,845	16,260	15,770
Reach 2 RM 50-65.63	13,065	13,083	13,119	13,065
Reach 3 RM 65.63-86.04	7,344	7,348	7,414	7,344
Reach 4 RM 86.04-107.85	8,036	8,191	8,450	8,040
Reach 5 RM 107.85-125.2	8,364	8,417	8,615	8,364
Reach 6 RM 125.2-155.65	6,167	6,185	6,209	6,167
Reach 7 RM 155.65-176.65	4,929	5,017	5,140	4,934
Reach 8 RM 176.65-205.25	6,242	6,255	6,262	6,237
Reach 9 RM 205.25-256.4	438	449	452	440
Reach 10 RM 256.4-292.5	13,830	14,732	15,106	13,941
Reach 11 RM 292.5-319.5	11,213	11,936	12,424	11,490
TOTAL	**95,398**	**97,458**	**99,451**	**95,792**

Table 9-30. Component Comparison – Difference From Baseline			
Reach	**Average Annual Acres Flooded**		
	FM-175	**FM-200**	**FM-OPS**
Reach 1 RM 17-50	75	490	0
Reach 2 RM 50-65.63	18	54	0
Reach 3 RM 65.63-86.04	4	70	0
Reach 4 RM 86.04-107.85	155	414	4
Reach 5 RM 107.85-125.2	53	251	0
Reach 6 RM 125.2-155.65	18	42	0
Reach 7 RM 155.65-176.65	88	211	5
Reach 8 RM 176.65-205.25	13	20	-5
Reach 9 RM 205.25-256.4	11	14	2
Reach 10 RM 256.4-292.5	902	1276	111
Reach 11 RM 292.5-319.5	723	1211	277
TOTAL	**2,060**	**4,053**	**394**

B.9.2.6.4. Average Annual Crop Damages

Table 9-31 displays the average annual crop damages based on the specific crop attributes and a weighted crop-damage per acre. The weighting takes into account both the water surface elevation and the duration of historical flood events.

Table 9-31. Average Annual Flood Damages By Reach				
Reach	**Average Annual Crop Damages (FY02 $1,000)**			
	FM-NA	**FM-175**	**FM-200**	**FM-OPS**
Reach 1 RM 17-50	$801.8	$806.9	$838.1	$801.8
Reach 2 RM 50-65.63	$678.6	$679.8	$682.3	$678.6
Reach 3 RM 65.63-86.04	$361.9	$362.2	$366.9	$361.9
Reach 4 RM 86.04-107.85	$338.5	$349.0	$367.0	$338.6
Reach 5 RM 107.85-125.2	$408.5	$412.1	$425.9	$408.5
Reach 6 RM 125.2-155.65	$281.7	$283.0	$284.6	$281.7
Reach 7 RM 155.65-176.65	$223.2	$229.3	$238.6	$223.4
Reach 8 RM 176.65-205.25	$330.8	$331.6	$332.2	$330.6
Reach 9 RM 205.25-256.4	$11.3	$12.1	$12.3	$11.5
Reach 10 RM 256.4-292.5	$675.7	$741.5	$769.5	$683.2
Reach 11 RM 292.5-319.5	$443.1	$482.5	$516.9	$452.8
TOTAL	**$4,555.1**	**$4,690.0**	**$4,834.3**	**$4,572.6**

Table 9-32 presents the difference in average annual damages for each of the alternative regulation plans versus the "Baseline" existing condition.

Table 9-32. Component Comparison – Difference From Baseline			
Reach	**Average Annual Crop Damages (FY02 $1,000)**		
	FM-175	**FM-200**	**FM-OPS**
Reach 1 RM 17-50	$5.1	$36.3	$ 0
Reach 2 RM 50-65.63	$1.2	$3.7	$ 0
Reach 3 RM 65.63-86.04	$0.3	$5.0	$ 0
Reach 4 RM 86.04-107.85	$10.5	$28.5	$ 0.1
Reach 5 RM 107.85-125.2	$3.6	$17.4	$ 0
Reach 6 RM 125.2-155.65	$1.3	$2.9	$ 0
Reach 7 RM 155.65-176.65	$6.1	$15.4	$ 0.2
Reach 8 RM 176.65-205.25	$0.8	$1.4	- $ 0.2
Reach 9 RM 205.25-256.4	$0.8	$1.0	$ 0.2
Reach 10 RM 256.4-292.5	$65.8	$93.8	$ 7.5
Reach 11 RM 292.5-319.5	$39.4	$73.8	$ 9.7
TOTAL	**$134.9**	**$279.2**	**$17.5**

B.9.2.7. Summary of Total Flood Damages: Arkansas

Total flood damages to structures and crops as described previously are shown in Table 9-33. Crop damages were updated to July 2004 price levels using the Parity Ratio from the National Agricultural Statistics Service (FY2002=41, July 2004=44)[19].

Table 9-33. Summary of Average Annual Damages By Plan, Arkansas, (FY02 $1,000)					
		FM-NA	**FM-175**	**FM-200**	**FM-OPS**
Flood Damages					
	Structures	$6,391.90	$6,546.10	$6,739.40	$6,407.30
	Crops	$4,555.10	$4,690.00	$4,834.30	$4,572.60
	Total	$10,947.10	$11,236.10	$11,573.70	$10,979.90
Summary of Average Annual Benefits by Plan					
			FM-175	**FM-200**	**FM-OPS**
Flood Damages Reduction					
	Structures		($154.20)	($347.50)	($15.40)
	Crops		($134.90)	($279.20)	($17.50)
	Total		($289.10)	($626.70)	($32.90)
Summary of Average Annual Damages By Plan, Arkansas, (Indexed to July 2004 $1,000)					
		FM-NA	**FM-175**	**FM-200**	**FM-OPS**
Flood Damages					
	Structures	$7,097.50	$7,268.72	$7,483.36	$7,114.60
	Crops	$4,888.40	$5,033.17	$5,188.03	$4,907.18
	Total	$11,985.90	$12,301.89	$12,671.39	$12,021.78
Summary of Average Annual Benefits by Plan					
			FM-175	**FM-200**	**FM-OPS**
Flood Damages Reduction					
	Structures		($171.22)	($385.86)	($17.10)
	Crops		($144.77)	($299.63)	($18.78)
	Total		($315.99)	($685.49)	($35.88)

[19] Parity Ratio is the ratio of index of prices received by farmers to index of prices paid for commodities and services, interest, taxes, and wage rates. Agricultural Prices Report, January 2005, NASS, USDA.

B.10. Risk and Uncertainty

B.10.1. Introduction

Uncertainty and variability are inherent in water resources planning. Risk and uncertainty arise from measurement errors and from the underlying variability of complex natural, social, and economic situations. Some future economic, hydrologic, and meteorological events are essentially unpredictable because they are subject to random influences. If there is a historical database that is applicable to the future, distributions can be described or approximated by objective techniques. If there is no such historical database, the probability of random future events can be described subjectively, based upon the best available insight and judgment. It is the goal of this section to best identify the uncertainty inherent in important hydrologic, design, economic, and environmental variables.

B.10.2. Economic Analysis

The uncertainty and variability of economic variables used in benefit calculations are presented in Table 10-1.

Table 10.1. Risk and Uncertainty Factors		
Factor	**Approach**	**Reference**
Operations & Maintenance Cost for Tow Haulage Equipment	3 cost scenarios; mid-cost used, high-cost in sensitivity analysis, navigation benefits calculated with operable and non-operable tow haulage equipment	B33
Hydropower System Modeling	Simulations performed until year 2025, results from year 2025 were utilized for the rest of the period of analysis	B132 - 135
Flood Damages - Oklahoma	20% uncertainty on property values, 1-foot uncertainty in first-floor elevations, uncertainty in FDA model for depth-damage percent relationships	B174
Flood Damages - Arkansas	20% uncertainty on property values, 5-foot uncertainty in first-floor elevations, uncertainty in FDA model for depth-damage percent relationships	B190
Navigation Traffic Projections	3 forecast scenarios; mid-growth used, high growth and low growth in sensitivity analysis	B47-48, B337-339, B371-376, Tables 12-1 to 12-7
Induced Traffic	Range of potential induced traffic for different channel depths based on reduction of transportation costs for high-volume commodities	B48 B50-51, B89-90, B356-361
Barge Impacts	Added 20 and 36 minutes for slower entry and exiting to mitigate increased barge impact effects; further study in PED phase	B95, B98-99, B363, B400
Environmental Mitigation Costs	MCASES estimate used, incremental cost analysis in Economics Appendix Addendum H	B200-201

B.10.3. Hydrologic and Hydraulic Analysis

The risk-based analysis was performed on the graphical discharge frequency curves using the method defined in the ETL 1110-2-537, "Uncertainty Estimates for Nonanalytic Frequency Curves" dated October 31, 1997. The economic program HEC-FDA used this method to compute uncertainty for each of the graphical discharge frequency curves based upon the probability ordinates and equivalent record length of 61 years.

Hydrology and hydraulic investigations were performed to assess the impacts of a deeper navigation channel for the MKARNS. Possible impacts to the existing locks and to the channel stability were investigated. However in order to accommodate the funding and schedule limits of this study, the hydrology and hydraulics (H&H) study approach was scaled back from the typical feasibility level of detail. The H&H study focuses on conceptual structure designs, a sediment impact assessment and identifying the needed detailed studies to be done during the Pre-construction, Engineering, and Design (PED) Phase. The conceptual design approach was accomplished using the available original design information, past experience, and engineering judgment. In addition, a 2-D numerical sediment transport model was developed for the upper 10 miles of Pool 2. For additional areas requiring channel deepening, the approach of the study was to extrapolate and correlate the findings from the 2-D modeling for the remainder of the study area. The 2-D modeling results were correlated to results from HEC-RAS models to size the necessary hydraulic structures for providing a maintenance-free navigation channel. Due to this conceptual design approach, lack of design criteria, and the uncertainty in designing alluvial river systems, it will be necessary to verify the estimated structures (size, location, and impacts) with proposed 2-D numerical or physical modeling in the PED phase of the study. More-detailed surveys will be required in order to build these models. Also, the deeper drafting barges have unknown impacts to the present lock designs. Prototype testing at Lock 2 lead to the following findings: for barges that draft 11.5´: (1) There will be a negligible chance of the barges striking the downstream lock sill when the minimum expected tailwater depth of 14´ occurs at the MKARNS projects. (2) It is highly unlikely that the barges will strike the downstream lock sill at Lock #2 due to surging in the canal. (3) Some operational changes at Lock #2 will be required in order to reduce the chance of a barge striking the upstream miter gate. (4) The current filling and emptying operations will be satisfactory for all the side port system locks, except the Ozark and Webbers Falls projects due to the greater lifts of 34´ and 30´, respectively. US Army Corps of Engineers Engineer Research and Development Center (ERDC) recommends using the numerical models HAWSER and LOCKSIM to determine the impacts to hawser forces and lock filling and emptying times for these projects. (5) The results of the tests on the barges moored downstream of the lock discharge are not available at this time. Also, ERDC conducted an evaluation of all the upstream lock approaches. This evaluation was based on guidance in EM 1110-2-1611 and the results of recently completed Lock Approach Guidance research, ERDC/CHL TR-04-4. Based on this review, ERDC recommends that the projects having the highest potential for approach problems be evaluated with the use of a physical model. This evaluation may require only a single model study, but possibly as many as four model studies may be needed to answer the effects of the deeper draft vessels on navigation conditions in the upper lock approaches.

B.10.4. Environmental Mitigation

The Corps is continuing to coordinate with the U.S. Fish and Wildlife Service (USFWS) and state resource agencies to ensure compliance with the National Environmental Policy Act (NEPA), Fish and Wildlife Coordination Act, Endangered Species Act, Clean Water Act, National Historic Preservation Act, and Clean Air Act. The USFWS provided a Final Fish and Wildlife Coordination Act Report (FWCAR) on June 24, 2005, which outlines their concerns, recommendations, and position. The USFWS will submit a supplemental letter to the FWCAR after review of the Final Environmental Impact Statement.

USFWS's general concerns center around the expedited schedule for the Environmental Impact Statement (EIS) and the constraints it places upon collecting sufficient data to adequately assess impacts and make decisions regarding a final mitigation plan. They are also concerned about funds being properly allocated for long term monitoring and an adaptive management plan and requested that the Corps seek additional authorization from Congress for an Environmental Management Program (EMP). In an August 25, 2004 letter, the USFWS Regional Administrator stated that the expedited schedule would preclude an adequate assessment of the proposed project's environmental impacts, and adverse impacts would either be unanticipated or underestimated in the decision document. Their specific concerns include adverse impacts to aquatic communities and wildlife resources resulting from open water and terrestrial dredge disposal, increased sedimentation rates in side channel/slack water areas due to dredging and raising river training structures, dredging of in-stream gravel areas that serve as spawning and feeding habitat for riverine fishes, and adverse impacts to freshwater mussels and the Federally Endangered Least Tern.

In response to their concerns, the Corps agrees that given the current schedule there is not time to adequately assess all potential impacts and answer all questions, therefore, a long term monitoring and adaptive management plan have been included as part of the mitigation. The Corps contracted with the Engineer Research and Development Center (ERDC), who put together a team of experts to gather as much baseline information as possible and perform the best possible terrestrial, aquatic and geomorphologic study and impact analyses in the time frame allotted. Additionally, the Corps contracted with Parsons Engineering to assist with the evaluation and produce the EIS and Ecological Specialists Incorporated to perform an intensive freshwater mussel survey.

In addition to the resource agency concerns, the Arkansas Wildlife Federation (AWF), Bass Anglers Sportsman Society (BASS) and several individuals have written letters requesting that the Corps address those same environmental concerns. The AWF has expressed concerns about following the correct NEPA procedures and the alleged influence they feel the navigation industry is having on the schedule as well as the entire project. The AWF did request that the Corps consider combining the Phase I and II projects into one phase and after careful evaluation the Corps agreed that the public

would be better served by one report and EIS. However, they now contend that scope of the project has been revised to the extent that the NEPA process should have started over when the Corps combined the phases.

The final mitigation plan was developed utilizing ERDC's terrestrial and aquatic Habitat Evaluation Procedure (HEP) analyses which assesses impacts both, quantitatively and qualitatively. An interagency team consisting of the Corps, USFWS, Oklahoma Department of Wildlife Conservation, and the Arkansas Game and Fish Commission was formed to assist with the HEP and perform the standard mitigation sequencing process of avoid, minimize, and compensate. Since very little baseline information exists on the biota of the Arkansas River following the construction of the MKARNS, a modified HEP analysis was developed by ERDC utilizing the experience of the team. Several of the HEP parameters (habitat suitability, depth of backwaters, etc.) were obtained using the Delphi approach which was based on the experience of the interagency team. Parameters such as dike field filling rates were extrapolated from a combination of numbers included historical dredging records, remaining capacity of dike field, and active disposal. Percent of effectiveness of dike notches was assumed and agreed upon by the team. All of these things combined, present some degree of uncertainty in the final analyses of impacts and mitigation. Therefore the only solution to insure adequate mitigation is through long term monitoring and adaptive management.

B.10.5. Cost Estimates

The total costs of implementing the navigation channel deepening alternatives include construction costs, lands, easements, rights-of-way, mitigation features, and supervision and administration. Petroleum prices impact the cost of production of materials such as rock riprap. The cost of petroleum is unstable; with recent prices of oil peaking over $60 a barrel and the price dependent on worldwide events, the cost estimate is sensitive to fluctuation. As described in section B.10.3, due to the conceptual design approach and the uncertainty in designing alluvial river systems, it will be necessary to verify the estimated structures (size, location, and impacts) with proposed 2-D numerical or physical modeling in the next phase of the project study, PED.

B.10.6 Assumptions

Assumptions were made not only in the work detailed in this appendix, but also by other members of the study team.

B.10.6.1. Hydrology and Hydraulics

1. Hydrology model was based on a 61-year period of record.

2. Hydraulic models (HEC-RAS) were estimated that the standard deviation of the stage uncertainty to be 0.5′ with the 10-yr profile being the stage at which this becomes constant.

3. The 2-D sediment transport model was calibrated to a 70,000 cfs profile that was measured by the USGS. The model was only run for flows up to the channel forming design flow and was verified against the calibrated HEC-RAS model.

4. The sediment transport simulations were run in a quasi-steady mode, but should be representative for evaluating the change between base and plan conditions.

5. For the sediment transport model, inflowing suspended sediment concentrations and bedload rate were estimated for the simulations due to lack of data, but the estimated concentrations were similar to three measurements obtained in January and March 2004.

6. Channel forming and design discharge used was estimated to be the 2-yr event.

7. Channel scouring was assumed to be the same for all the reaches based on the results in the 2-D sediment transport model. The 2-D model channel bed shear values were compared to those determined in HEC-RAS models. It was assumed that similar percent change in bed shear correlated to similar scour depths.

8. Sediment transport capacity and deposition was assumed to be similar for all reaches based on the results of the 2-D sediment transport model of having similar percent change in transport capacity potential as determined in the HD module of the HEC-RAS models. Assumed that sediment transport capacity will not change, but it is predicted that there will be minor changes in the location of sediment deposits in the proposed project areas. Sediments will be moved downstream a short distance with most deposits occurring in the dike fields.

9. The comparisons of water surface elevations between the existing conditions and the plan conditions indicated negligible differences in elevations and was assumed to have no impact to flood heights for the range of flows from the 2-yr to the 100-yr.

10. No detailed surveys were obtained for the structures that are to be modified.

11. More detailed surveys and 2-D modeling will be done during PED.

12. The 1995 -2002 average maintenance dredging was expected to continue at the same rate for the next 50 years.

13. The reduced average maintenance dredging is due to a reduced sediment load as the system approaches equilibrium.

14. Original design of the structures (dikes and revetments and lock & Dams) was to provide a minimum of a 12-ft deep channel below the navigation pool.

15. Under existing conditions, the dike field (to top of dike) will be filled at the same rate as estimated to have occurred during the last 20 years.

16. The sediment deposition rates in Pool 7 are, although not calibrated, are representative of the actual amounts and that the relative amounts between existing and plan are indicative of expected impacts.

17. Sediment transport deposition is increased in the modified reaches by 50%.

18. The prototype testing on lock 2 is applicable to all locks as stated in the following results:

(1) It is unlikely that barges drafting 11.5-ft on the MKARNS will strike any downstream lock sill provided some operational procedures are followed. Conclusion is that no modifications to the downstream sill will be required and only the minor change of reducing tow entering and exiting speeds will be required for 11.5-ft drafts.

(2) Hawser forces in the lock should not increase, except for the additional forces due to the increase in barge mass (+11.5/8.5 or +35%), under current lock filling and emptying operations at all locks except Ozark and Weber Falls, where additional tests should be done due to lifts of 34 and 30 ft, respectively.

(3) Hawser forces on the downstream moored barges showed a significant increase in force. However, there is minimal guidance on the allowable forces and the forces could be reduced by slowing the emptying time if required at site-specific projects.

(4) The effects of out drafts, draw, pinning are unknown and further investigation (physical model) is warranted for the project(s) with the highest potential for approach problems.

B.10.6.2. Channel Maintenance Dredging, Operations

1. All of the areas will be dredged initially to the specified channel depth, 10´, 11´, or 12´.

2. Corps of Engineers marine terminals will clam the downstream lock approaches to maintain required depth until the maintenance dredge arrives. This work will require three additional dump barges to expedite excavation and disposal time.

3. A modification to the existing contract or another contract may be necessary to remove large shoals that could form during a fast recession on the MKARNS.

4. If the new structures designed for a deeper channel do not scour the channel, additional dredging will be required.

5. Structures may move sediment from one place in the navigation channel to another downstream.

6. Montgomery Point Lock and Dam will significantly decrease dredging in the White River Entrance Channel.

7. The amount of dredging required may be significant during the first 5 years, decreasing to remain constant for the life of the project.

8. Dredging Program will be adequately funded.

9. No initial modifications will be made to the tow haulage system. When maintenance is needed on the tow haulage system, Operations Division will receive the needed funding.

B.10.6.3. Design

1. It is assumed that there will be no electrical changes to the miter gates or tainter gates.

2. We will continue to use the existing tow haulage systems and have increased the O&M costs in the cost estimate to account for the increase in maintenance costs.

3. An investigation of underwater telephone river crossings in the dredged areas was performed using the MKARNS navigation charts initially and then contacting each of the telephone companies individually by phone or email. The only transmission lines that need to be removed are located at River Mile 61.

4. Disposal area pumping station is located on the right bank just upstream of Lock 2. It is assumed that there will be 4 - 50 horsepower pumps. There is an existing overhead 3-phase power line within close proximity to the proposed location for the new station that will provide sufficient power for these pumps.

5. Maintenance and/or replacement of existing gate hydraulic machinery and piping due to aging is not a part of this study.

6. All real estate needed for disposal areas will be available for use.

7. Assumed no modifications will be needed to earthen embankments/levees at lock locations.

B.11. Economics Benefits Summary

B.11.1. Flow Management Feature

Table 11-1 provides a summary of the annual benefits and costs associated with each of the elements discussed for each flow management component.

B.11.1.1. Flow Management - No Action Component (FM-NA)

No additional cumulative positive or negative incremental net economic impacts are anticipated to occur under this component, as existing impacts would continue as under current conditions. The No Action component has been considered in this document, and the EIS, in order to establish baseline conditions against which the flow management components may be evaluated and compared.

B.11.1.2. Flow Management - 175,000 cfs Component (FM-175)

There would be annual incremental net benefits approximating $7.9 million under this component compared to FM-NA. Positive economic benefits would be associated with navigation and hydropower, while negative economic impacts would be associated with real estate, tourism and recreation, non-agricultural and agricultural properties. Annual navigation benefits would approximate $9.2 million under this component, with the remaining annual net benefits associated with hydropower ($1.3 million).

Tourism and recreation costs ($1.4 million) comprise over 50% the negative impacts under this component. Annual real estate costs would approximate an additional $0.7 million compared to FM-NA (baseline conditions), while annual non-agricultural and agricultural property damages would approximate $0.5 million.

B.11.1.3. Flow Management - 200,000 cfs Component (FM-200)

There would be annual incremental net benefits approximating $7.5 million under this component compared to FM-NA. Positive economic benefits would be associated with navigation and hydropower, while negative economic impacts would be associated with real estate, tourism and recreation, non-agricultural and agricultural properties. Annual navigation benefits would approximate $9.2 million under this component, with the remaining annual net benefits associated with hydropower ($1 million).

Tourism and recreation losses ($0.8 million) comprise about 30% of the negative impacts under this component. Annual average real estate costs would approximate an additional $0.9 million compared to FM-NA (baseline conditions). Non-agricultural and agricultural property damages would approximate $1 million.

B.11.1.4. Flow Management - Operations Only Component (FM-OPS)

There would be annual net benefits approximating $8.8 million with the implementation of this component compared to FM-NA, and almost $1 million greater annual net benefits than FM-175. Thus, FM-OPS represents the flow management component that would provide the greatest annual net benefits.

Similar to FM-175 and FM-200, much of the net benefits would be associated with navigation and hydropower. Annual navigation benefits would approximate $8.4 million, comprising 95% of the benefits under this component. The remaining benefits would be associated with hydropower ($0.5 million).

Minor negative impacts would be associated with non-agricultural and agricultural properties, while there would be no change in economic impacts for real estate or tourism/recreation compared to FM-NA. Annual average non-agricultural and agricultural property would be an additional $36,000 as compared to FM-NA.

Table 11-1. Summary of Net Incremental Benefits and Costs Flow Management Components – Reaches 1 through 6 Average Annual Equivalent Values (July 2004 $) 5.375% Discount Rate, 50-year Period of Analysis			
	FM-175	**FM-200**	**FM-OPS**
Period of Analysis (years)	50	50	50
Construction Period (years)	1	1	1
Interest Rate (percent)	5.375%	5.375%	5.375%
Project First Costs[1,2]	12,105,000	16,094,000	0
Interest During Construction	295,400	392,700	0
Total Project Cost	**$12,400,400**	**$16,486,700**	**$0**
Annual Costs:			
Interest	666,500	886,200	0
Amortization	52,500	69,000	0
Operations & Maintenance	0	0	0
Total Annual Costs	**$719,000**	**$955,900**	**$0**
Annual Benefits[3]:			
Navigation benefits	9,220,700	9,176,100	8,372,100
Recreation	-1,436,900	-790,200	0
Hydropower	1,340,000	1,056,000	466,000
Non-Ag. Property Damage			
Oklahoma	-1,800	-7,500	0
Arkansas	-171,200	-385,900	-17,100
Recreation Facilities OK	-76,500	-29,300	-5,500
Recreation Facilities AR	-13,800	-30,000	4,000
Ag. Property Damages			
Oklahoma	-119,500	-245,500	0
Arkansas	-144,800	-299,600	-18,800
Total Annual Benefits	**$8,596,200**	**$8,444,100**	**$8,800,700**
Incremental Net Benefits	**$7,877,200**	**$7,488,200**	**$8,800,700**

[1] *Real Estate costs from Table 4-1.*
[2] *Incremental Costs - costs in addition to those existing with current flow management.*
[3] *Incremental Benefits - benefits in addition to those existing with current flow management.*
Source: USACE, Tulsa and Little Rock Districts, Hydropower Analysis Center, Parsons.

B.11.2. Navigation Channel Deepening Feature

Benefits and costs for the navigation channel deepening components were incrementally calculated for the MKARNS. Tables 11-2 through 11-14 show the incremental costs, benefits, and net benefits of the components, starting at the mouth of the MKARNS (Reach 1) and progressing upstream (Reach 6). The NCD-10 and NCD-11 components are not economically justified for any incremental stretch of the MKARNS. The NCD-12 component is economically justified when all reaches are deepened.

Table 11-2. Summary of Incremental Costs, Navigation Channel Deepening Components – Reach 1 (July 2004 $)			
Mouth of White River, AR to Pine Bluff, AR (NM 0.0 to NM 75.2)	**Depth of Channel**		
	10 foot	**11 foot**	**12 foot**
Construction			
02.03 Demolition	1,473,430	1,473,430	1,473,430
05.62 Locks - Pin Guide Walls	1,819,083	1,819,083	1,819,083
09.01.16 Dredging and Rock Removal	1,481,144	1,911,719	3,109,358
09.01.20 Dredged Material Disposal Areas	8,623,850	8,623,850	8,623,850
09.01.30 Dikes and Jetties	7,509,407	8,078,326	9,609,054
Subtotal	**$20,906,914**	**$21,906,408**	**$24,634,775**
01. Real Estate - Dredge Material Disposal Areas	1,107,760	1,107,760	1,107,760
06. Mitigation	$4,440,544	$4,440,544	$4,440,544
06. Environmental Sustainability	$299,844	$299,844	$299,844
Subtotal	**$5,848,148**	**$5,848,148**	**$5,848,148**
12. Investment by Ports (Non-Federal)	0	18,842	20,669
18. Cultural/Archeological Surveys	189,180	189,180	189,180
30. Planning Engineering and Design	2,677,317	2,689,929	3,392,596
31. Contract Administration	1,664,784	1,740,456	1,942,248
Total	**$31,286,343**	**$32,392,963**	**$36,027,616**
Note: Contingency included in the total above is	5,411,257	5,600,096	6,212,456
Escalation included in the total above is	1,193,225	1,241,964	1,384,416
Operations and Maintenance (O&M) (Annual Cost)			
Dredging	49,606	101,651	180,622
Locks, Tow Haulage	33,002	65,905	96,021
Dikes and Jetties	80,496	80,496	80,496
Mitigation and Monitoring	122,163	122,163	122,163
Engineering and Design	11,655	16,079	17,267
Contract Administration	13,031	17,977	19,304
Total Annual O&M	**$309,953**	**$404,271**	**$515,873**
Note: Based on MCACES cost estimates prepared 15 July 2005.			

Table 11-3. Summary of Net Incremental Benefits and Costs Navigation Channel Deepening Components – Reach 1 Average Annual Equivalent Values (July 2004 $)			
Mouth of White River, AR to Pine Bluff, AR (NM 0.0 to NM 75.2)	**Depth of Channel**		
	NCD-10	**NCD-11**	**NCD-12**
Period of Analysis (years)	50	50	50
Construction Period (years)	4	4	4
Interest Rate (percent)	5.375%	5.375%	5.375%
Project First Costs[1,2]	30,093,100	31,132,200	34,622,500
Interest During Construction	3,310,100	3,424,400	3,808,300
Associated Non-Federal Requirements:			
Local Facilities	0	18,800	20,700
Local Facilities IDC	0	2,100	2,300
Total Project Cost	**$33,403,200**	**$34,577,500**	**$38,453,800**
Annual Costs:			
Interest	1,795,400	1,858,500	2,066,900
Amortization	141,300	146,300	162,700
Operations & Maintenance	310,000	404,300	515,900
Total Annual Costs	**$2,246,700**	**$2,409,100**	**$2,745,500**
Annual Benefits[3]:			
Navigation benefits	**$339,200**	**$933,200**	**$1,250,200**
Benefit-to-Cost Ratio	**0.151**	**0.39**	**0.46**
Net Benefits	**($1,907,500)**	**($1,475,900)**	**($1,495,300)**

[1] From previous table: Project First Costs = "Total" – "Escalation" – "Investment by Ports"
[2] Incremental Costs - costs in addition to those existing with 9' channel.
[3] Incremental Benefits - benefits in addition to those existing with 9' channel.

Table 11-4. Summary of Incremental Costs, Navigation Channel Deepening Components – Reach 2 (July 2004 $)			
Pine Bluff, AR to Little Rock, AR (NM 75.2 to NM 119.5)	**Depth of Channel**		
	10 foot	**11 foot**	**12 foot**
Construction			
02.03 Demolition	0	0	0
05.62 Locks - Pin Guide Walls	454,771	454,771	454,771
09.01.16 Dredging and Rock Removal	185,334	422,485	835,530
09.01.20 Dredged Material Disposal Areas	0	0	0
09.01.30 Dikes and Jetties	3,583,477	4,061,662	4,933,846
Subtotal	**$4,223,582**	**$4,938,918**	**$6,224,147**
01. Real Estate - Dredge Material Disposal Areas	0	0	0
06. Mitigation	$2,564,886	$2,564,886	$2,564,886
06. Environmental Sustainability	$320,272	$320,272	$320,272
Subtotal	**$2,885,158**	**$2,885,158**	**$2,885,158**
12. Investment by Ports (Non-Federal)	0	20,871	24,726
18. Cultural/Archeological Surveys	63,060	63,060	63,060
30. Planning Engineering and Design	1,053,711	1,059,025	980,762
31. Contract Administration	454,234	507,223	602,345
Total	**$8,679,745**	**$9,474,255**	**$10,780,198**
Note: Contingency included above is	1,625,031	1,765,055	1,996,560
Escalation included in the total above is	347,034	379,843	430,930
Operations and Maintenance (O&M) (Annual Cost)			
Dredging	42,863	83,708	147,597
Locks, Tow Haulage	5,654	11,293	16,459
Dikes and Jetties	57,505	57,505	57,505
Mitigation and Monitoring	13,783	13,783	13,783
Engineering and Design	8,956	12,429	13,530
Contract Administration	10,014	13,896	15,127
Total Annual O&M	**$138,775**	**$192,614**	**$264,001**
Note: Based on MCACES cost estimates prepared 15 July 2005.			

Table 11-5. Summary of Net Incremental Benefits and Costs Navigation Channel Deepening Components – Reaches 1 through 2 Average Annual Equivalent Values (July 2004 $)			
Mouth of White River, AR to Little Rock, AR (NM 00.0 to NM 119.5)	**Depth of Channel**		
	NCD-10	**NCD-11**	**NCD-12**
Period of Analysis (years)	50	50	50
Construction Period (years)	4	4	4
Interest Rate (percent)	5.375%	5.375%	5.375%
Project First Costs[1, 2]	38,425,800	40,205,700	44,947,100
Interest During Construction	4,226,600	4,422,400	4,943,900
Associated Non-Federal Requirements:			
Local Facilities	0	39,700	45,400
Local Facilities IDC	0	4,400	5,000
Total Project Cost	**$42,652,400**	**$44,672,200**	**$49,941,400**
Annual Costs:			
Interest	2,292,600	2,401,100	2,684,300
Amortization	180,400	189,000	211,300
Operations & Maintenance	448,700	596,900	779,900
Total Annual Costs	**$2,921,700**	**$3,187,000**	**$3,675,500**
Annual Benefits[3]:			
Navigation benefits	**$514,600**	**$1,493,900**	**$2,053,600**
Benefit-to-Cost Ratio	**0.18**	**0.47**	**0.56**
Net Benefits	**($2,407,100)**	**($1,693,100)**	**($1,621,900)**

[1] From previous tables: Project First Costs = "Total" – "Escalation" – "Investment by Ports"
[2] Incremental Costs - costs in addition to those existing with 9' channel.
[3] Incremental Benefits - benefits in addition to those existing with 9' channel

Table 11-6. Summary of Incremental Costs, Navigation Channel Deepening Components – Reach 3 (July 2004 $)			
Little Rock, AR to Dardanelle, AR (NM 119.5 to NM 220.3)	**Depth of Channel**		
	10 foot	**11 foot**	**12 foot**
Construction			
02.03 Demolition	0	0	0
05.62 Locks - Pin Guide Walls	454,771	454,771	454,771
09.01.16 Dredging and Rock Removal	368,083	799,621	1,937,738
09.01.20 Dredged Material Disposal Areas	0	0	0
09.01.30 Dikes and Jetties	2,171,773	5,476,284	9,233,573
Subtotal	**$2,994,627**	**$6,730,676**	**$11,626,082**
01. Real Estate - Dredge Material Disposal Areas	0	0	0
06. Mitigation	$4,626,095	$4,626,095	$4,626,095
06. Environmental Sustainability	$0	$0	$0
Subtotal	**$4,626,095**	**$4,626,095**	**$4,626,095**
12. Investment by Ports (Non-Federal)	22,157	27,299	32,440
18. Cultural/Archeological Surveys	$0	$0	$0
30. Planning Engineering and Design	1,222,993	1,394,600	1,837,679
31. Contract Administration	$477,846	749,544	1,109,138
Total	**$9,343,718**	**$13,528,214**	**$19,231,434**
Note: Contingency included above is	1,808,677	2,600,867	3,635,152
Escalation included in the total above is	391,538	557,201	782,712
Operations and Maintenance (O&M) (Annual Cost)			
Dredging	49,728	129,375	276,245
Locks, Tow Haulage	22,620	45,172	65,834
Dikes and Jetties	28,747	28,747	28,747
Mitigation and Monitoring	19,828	19,828	19,828
Engineering and Design	6,884	13,654	19,803
Contract Administration	7,696	15,266	22,140
Total Annual O&M	**$135,503**	**$252,042**	**$432,597**
Note: Based on MCACES cost estimates prepared 15 July 2005.			

Table 11-7. Summary of Net Incrementeal Benefits and Costs Navigation Channel Deepening Components – Reaches 1 through 3 Average Annual Equivalent Values (July 2004 $)			
Mouth of White River, AR to Dardanelle, AR (NM 00.0 to NM 220.3)	**Depth of Channel**		
	NCD-10	**NCD-11**	**NCD-12**
Period of Analysis (years)	50	50	50
Construction Period (years)	4	4	4
Interest Rate (percent)	5.375%	5.375%	5.375%
Project First Costs[1,2]	47,355,900	53,149,400	63,363,400
Interest During Construction	5,208,900	5,846,100	6,969,600
Associated Non-Federal Requirements:			
Local Facilities	22,200	67,000	77,800
Local Facilities IDC	2,400	7,400	8,600
Total Project Cost	**$52,589,400**	**$59,069,900**	**$70,419,400**
Annual Costs:			
Interest	2,826,700	3,175,000	3,785,000
Amortization	222,500	249,900	297,900
Operations & Maintenance	584,200	848,900	1,212,500
Total Annual Costs	**$3,633,400**	**$4,273,800**	**$5,295,400**
Annual Benefits[3]:			
Navigation benefits	**$1,003,500**	**$2,660,500**	**$3,488,300**
Benefit-to-Cost Ratio	**0.28**	**0.62**	**0.66**
Net Benefits	**($2,629,900)**	**($1,613,300)**	**($1,807,100)**

[1] From previous tables: Project First Costs = "Total" – "Escalation" – "Investment by Ports"
[2] Incremental Costs - costs in addition to those existing with 9' channel.
[3]Incremental Benefits - benefits in addition to those existing with 9' channel

Table 11-8. Summary of Incremental Costs, Navigation Channel Deepening Components – Reach 4 (July 2004 $)			
Dardanelle, AR to Fort Smith, AR (NM 220.0 to NM 308.7)	**Depth of Channel**		
	10 foot	**11 foot**	**12 foot**
Construction			
02.03 Demolition	0	0	0
05.62 Locks - Pin Guide Walls	0	0	0
09.01.16 Dredging and Rock Removal	708,897	1,133,412	2,153,482
09.01.20 Dredged Material Disposal Areas	0	0	0
09.01.30 Dikes and Jetties	6,043,480	6,704,204	10,182,717
Subtotal	**$6,752,377**	**$7,837,616**	**$12,336,199**
01. Real Estate - Dredge Material Disposal Areas	0	0	0
06. Mitigation	$1,851,146	$1,851,146	$1,851,146
06. Environmental Sustainability	$0	$0	$0
Subtotal	**$1,851,146**	**$1,851,146**	**$1,851,146**
12. Investment by Ports (Non-Federal)	0	20,873	24,728
18. Cultural/Archeological Surveys	0	$0	$0
30. Planning Engineering and Design	1,047,736	1,079,002	1,617,133
31. Contract Administration	533,976	614,771	945,056
Total	**$10,185,235**	**$11,403,408**	**$16,774,262**
Note: Contingency included above is	1,873,304	2,082,976	3,057,110
Escalation included in the total above is	403,338	452,276	665,628
Operations and Maintenance (O&M) (Annual Cost)			
Dredging	255,324	385,117	520,238
Locks, Tow Haulage	11,310	22,586	32,916
Dikes and Jetties	17,251	17,251	17,251
Mitigation and Monitoring	5,269	5,269	5,269
Engineering and Design	23,299	34,332	34,710
Contract Administration	26,048	38,383	38,807
Total Annual O&M	**$338,501**	**$502,938**	**$649,191**
Note: Based on MCACES cost estimates prepared 15 July 2005.			

Table 11-9. Summary of Net Incremental Benefits and Costs Navigation Channel Deepening Components – Reaches 1 through 4 Average Annual Equivalent Values (July 2004 $)			
Mouth of White River, AR to Fort Smith, AR (NM 00.0 to NM 308.7)	**Depth of Channel**		
	NCD-10	**NCD-11**	**NCD-12**
Period of Analysis (years)	50	50	50
Construction Period (years)	4	4	4
Interest Rate (percent)	5.375%	5.375%	5.375%
Project First Costs[1,2]	57,137,700	64,079,700	79,447,300
Interest During Construction	6,284,800	7,048,400	8,738,700
Associated Non-Federal Requirements:			
Local Facilities	22,200	87,900	102,600
Local Facilities IDC	2,400	9,700	11,300
Total Project Cost	**$63,447,100**	**$71,225,700**	**$88,299,900**
Annual Costs[3]:			
Interest	3,410,300	3,828,400	4,746,100
Amortization	268,400	301,300	373,600
Operations & Maintenance	922,700	1,351,900	1,861,700
Total Annual Costs	**$4,601,400**	**$5,481,600**	**$6,981,400**
Annual Benefits:			
Navigation benefits	**$1,069,300**	**$2,831,800**	**$3,714,500**
Benefit-to-Cost Ratio	**0.23**	**0.52**	**0.53**
Net Benefits	**($3,532,100)**	**($2,649,800)**	**($3,266,900)**

[1] *From previous tables: Project First Costs = "Total" – "Escalation" – "Investment by Ports"*
[2] *Incremental Costs - costs in addition to those existing with 9' channel.*
[3] *Incremental Benefits - benefits in addition to those existing with 9' channel*

Table 11-10. Summary of Incremental Costs, Navigation Channel Deepening Components – Reach 5 (July 2004 $)			
Ft. Smith, AR to Muskogee, OK (NM 308.7 to NM 394.0)	**Depth of Channel**		
	10 foot	**11 foot**	**12 foot**
Construction			
02. Demolition	0	0	0
05.62 Locks - Pin Guide Walls	599,000	599,100	599,100
09.01.16 Dredging and Rock Removal	7,870,900	16,676,900	16,977,200
09.01.20 Dredged Material Disposal Areas	6,429,100	13,862,800	16,479,800
09.01.30 Dikes and Jetties	2,655,900	3,761,600	4,900,800
Subtotal	**$17,554,900**	**$34,900,400**	**$38,956,900**
01. Real Estate - Dredge Material Disposal Areas	2,142,900	2,142,900	2,142,900
06. Mitigation	$2,503,000	$2,761,100	$2,761,100
06. Environmental Sustainability	$0	$0	$0
Subtotal	**$4,645,900**	**$4,904,000**	**$4,904,000**
12. Investment by Ports (Non-Federal)	20,400	34,000	246,500
18. Cultural/Archeological Surveys	315,200	315,200	315,200
30. Planning Engineering and Design	1,518,400	2,482,200	3,274,200
31. Contract Administration	1,364,200	2,268,000	3,007,800
Total	**$25,419,000**	**$44,903,800**	**$50,704,600**
Note: Contingency included above is	3,417,500	6,181,500	7,017,200
Escalation included in the total above is	1,129,500	2,078,800	2,356,500
Operations and Maintenance (O&M) (Annual Cost)			
Dredging	250,000	300,000	334,000
Locks, Tow Haulage	0	0	0
Dikes and Jetties	168,000	168,000	168,000
Mitigation and Monitoring	7,500	7,500	7,500
Engineering and Design	19,573	21,873	23,437
Contract Administration	20,424	22,824	24,456
Total Annual O&M	**$465,497**	**$520,197**	**$557,393**
Note: Based on MCACES cost estimates prepared 15 July 2005.			

Table 11-11. Summary of Net Incremental Benefits and Costs
Navigation Channel Deepening Components – Reaches 1 through 5
Average Annual Equivalent Values (July 2004 $)

Mouth of White River, AR to Muskogee, OK (NM 00.0 to NM 394.0)	Depth of Channel		
	NCD-10	NCD-11	NCD-12
Period of Analysis (years)	50	50	50
Construction Period (years)	4	4	4
Interest Rate (percent)	5.375%	5.375%	5.375%
Project First Costs[1,2]	81,406,800	106,870,700	127,548,900
Interest During Construction	8,954,300	11,755,200	14,029,700
Associated Non-Federal Requirements:			
Local Facilities	42,600	121,900	349,100
Local Facilities IDC	4,700	13,400	38,400
Total Project Cost	**$90,408,400**	**$118,761,200**	**$141,966,100**
Annual Costs[3]:			
Interest	4,859,500	6,383,400	7,630,700
Amortization	382,500	502,400	600,600
Operations & Maintenance	1,388,200	1,872,100	2,419,100
Total Annual Costs	**$6,630,200**	**$8,757,900**	**$10,650,400**
Annual Benefits:			
Navigation benefits	**$1,303,700**	**$3,438,800**	**$4,552,800**
Benefit-to-Cost Ratio	**0.20**	**0.39**	**0.43**
Net Benefits	**($5,326,500)**	**($5,319,100)**	**($6,097,600)**

[1] From previous tables: Project First Costs = "Total" – "Escalation" – "Investment by Ports"
[2] Incremental Costs - costs in addition to those existing with 9' channel.
[3] Incremental Benefits - benefits in addition to those existing with 9' channel

Table 11-12. Summary of Incremental Costs, Navigation Channel Deepening Components – Reach 6 (July 2004 $)			
Muskogee, OK to Catoosa, OK (NM 394.0 to NM 445.2)	**Depth of Channel**		
	10 foot	**11 foot**	**12 foot**
Construction			
02. Demolition	0	0	0
05.62 Locks - Pin Guide Walls	0	0	0
09.01.16 Dredging and Rock Removal	2,008,100	3,151,900	5,722,900
09.01.20 Dredged Material Disposal Areas	3,709,900	4,636,600	6,547,300
09.01.30 Dikes and Jetties	0	0	0
Subtotal	**$5,718,000**	**$7,788,500**	**$12,270,200**
01. Real Estate - Dredge Material Disposal Areas	1,071,400	1,071,400	1,071,400
06. Mitigation	$6,798,700	$6,798,700	$6,798,700
06. Environmental Sustainability	$0	$0	$0
Subtotal	**$7,870,100**	**$7,870,100**	**$7,870,100**
12. Investment by Ports (Non-Federal)	204,000	408,100	612,100
18. Cultural/Archeological Surveys	315,400	315,400	315,400
30. Planning Engineering and Design	547,600	720,100	1,087,600
31. Contract Administration	436,500	598,200	942,800
Total	**$15,091,600**	**$17,700,400**	**$23,098,200**
Note: Contingency included above is	1,433,300	1,738,300	2,505,700
Escalation included in the total above is	680,300	806,900	1,068,800
Operations and Maintenance (O&M) (Annual Cost)			
Dredging	200,000	275,000	314,000
Locks, Tow Haulage	0	0	0
Dikes and Jetties	32,000	32,000	32,000
Mitigation and Monitoring	23,909	23,909	23,909
Engineering and Design	11,772	15,222	17,016
Contract Administration	12,284	15,884	17,756
Total Annual O&M	**$279,965**	**$362,015**	**$404,681**
Note: Based on MCACES cost estimates prepared 15 July 2005.			

Table 11-13. Summary of Incremental Costs Navigation Channel Deepening Components Reaches 1 through 6 (July 2004 $)			
Mouth of White River, AR to Catoosa, OK (NM 0.0 to NM 444.8)	**Depth of Channel**		
	10 foot	**11 foot**	**12 foot**
Construction			
02.03 Demolition	1,473,430	1,473,430	1,473,430
05.62 Locks - Pin Guide Walls	3,327,625	3,327,725	3,327,725
09.01.16 Dredging and Rock Removal	12,622,458	24,096,037	30,736,208
09.01.20 Dredged Material Disposal Areas	18,762,850	27,123,250	31,650,950
09.01.30 Dikes and Jetties	21,964,037	28,082,076	38,859,990
Subtotal	**$58,150,400**	**$84,102,518**	**$106,048,303**
01. Real Estate - Dredge Material Disposal Areas	4,322,060	4,322,060	4,322,060
06. Mitigation	$22,784,371	$23,042,471	$23,042,471
06. Environmental Sustainability	$620,116	$620,116	$620,116
Subtotal	**$27,726,547**	**$27,984,647**	**$27,984,647**
12. Investment by Ports (Non-Federal)	246,557	529,985	961,163
18. Cultural/Archeological Surveys	882,840	882,840	882,840
30. Planning Engineering and Design	8,067,757	9,424,856	12,189,970
31. Contract Administration	4,931,540	6,478,194	8,549,387
Total	**$100,005,641**	**$129,403,040**	**$156,616,310**
Note: Contingency included in the total above is	15,569,069	19,968,794	24,424,178
Escalation included in the total above is	4,144,935	5,516,984	6,688,986
Operations and Maintenance (O&M) (Annual Cost)			
Dredging	847,521	1,274,851	1,772,702
Locks, Tow Haulage	72,586	144,956	211,230
Dikes and Jetties	383,999	383,999	383,999
Mitigation and Monitoring	192,452	192,452	192,452
Engineering and Design	82,139	113,589	125,763
Contract Administration	89,497	124,230	137,590
Total Annual O&M	**$1,668,194**	**$2,234,077**	**$2,823,736**
Note: Based on MCACES cost estimates prepared 15 July 2005.			

Table 11-14. Summary of Net Incremental Benefits and Costs Navigation Channel Deepening Components – Reaches 1 through 6 Average Annual Equivalent Values (July 2004 $)			
Mouth of White River, AR to Catoosa, OK (NM 0.0 to NM 444.8)	**Depth of Channel**		
	NCD-10	**NCD-11**	**NCD-12**
Period of Analysis (years)	50	50	50
Construction Period (years)	4	4	4
Interest Rate (percent)	5.375%	5.375%	5.375%
Project First Costs[1,2]	95,614,100	123,356,100	148,966,200
Interest During Construction	10,517,000	13,568,500	16,385,400
Associated Non-Federal Requirements:			
Local Facilities	246,600	530,000	961,200
Local Facilities IDC	27,100	58,300	105,700
Total Project Cost	**$106,404,800**	**$137,512,900**	**$166,418,500**
Annual Costs[3]:			
Interest	5,719,300	7,391,300	8,945,000
Amortization	450,200	581,800	704,100
Operations and Maintenance	1,668,200	2,234,100	2,823,700
Total Annual Costs	**$7,837,700**	**$10,207,200**	**$12,472,800**
Annual Benefits:			
Navigation Benefits	**$4,022,200**	**$10,173,500**	**$13,482,600**
Benefit-to-Cost Ratio	**0.51**	**0.99**	**1.08**
Net Benefits	**($3,815,500)**	**($33,700)**	**$1,009,800**

[1] From previous table: Project First Costs = "Total" – "Escalation" – "Investment by Ports"
[2] Incremental Costs - costs in addition to those existing with 9' channel.
[3] Incremental Benefits - benefits in addition to those existing with 9' channel

B.11.3. Navigation Channel Depth Maintenance Feature

Two action components were evaluated in detail. The maintenance dredged material disposal in new disposal sites component was clearly the most favorable component among the maintenance dredging and disposal features. This component achieved the purpose with fewer adverse environmental impacts compared to the other action component evaluated. Therefore, NCDM-2, dredge material disposal in new disposal sites, is the only component of the maintenance dredging and disposal features that was carried forward as a part of the decision alternatives analyses.

Existing dredging and disposal to maintain a 9′ navigation channel will continue under this component. After existing dredge disposal sites reach their holding capacity, dredged material will be disposed of in new designated disposal sites. Areas with high quality habitat such as forest, wetlands, and high quality grassland will be avoided.

B.11.4. Study Alternatives Evaluated

Alternatives, including the No Action Alternative, were developed by combining components of the three features to achieve, in varying degrees, the proposed action. Table 11-15 summarizes the components used in the five alternatives selected for evaluation.

Table 11-15. Components of Decision Alternatives

	Navigation Channel Maintenance*	Flow Management Operations Only	Navigation Channel Deepening 11 Ft.	Navigation Channel Deepening 12 Ft.
Alternative A No Action (Dredge disposal sites approved in 1974)	X			
Alternative B Maintenance Only (New dredge disposal sites including those in-stream)	X			
Alternative C Maintenance & Ops Only Flow Management	X	X		
Alternative D Maintenance & Ops Only Flow Management & 11 Foot Navigation Channel	X	X	X	
Alternative E Maintenance & Ops Only Flow Management & 12 Foot Navigation Channel	X	X		X

* Navigation channel maintenance activities would occur in the same manner under Alternatives B, C, D, and E. The Navigation channel depth to be maintained would be 9 feet for Alternatives A, B and C, 11 feet for Alternative D, and 12 feet for Alternative E.
Source: USACE 2005

B.11.4.1. Alternative A

Alternative A is based on measures that are currently in place and available for implementation with minimal additional administrative action. This alternative assumes that the existing 9′ channel would be maintained throughout the period of analysis using dredging techniques and disposal areas described in the 1974 Operations and Maintenance Plan (O&M plan) for which an EIS was prepared and a ROD signed.

Subsequent to, and in accordance with the 1974 O&M plan, in-river disposal of dredge materials has been used in Arkansas with the exception of the White River Entrance Channel, where terrestrial sites are utilized. Terrestrial disposal sites have also been acquired for use as needed in Oklahoma. These designated sites are sufficient to contain the dredge material projected to be required through the 50-year period of analysis used in 1974. However, projections indicate that the currently used terrestrial sites in Oklahoma would not be adequate to meet disposal area needs through the 50-year period of analysis for the present study, i.e., 2010 through 2060. Additional currently unused disposal areas in Oklahoma that were approved in the 1974 O&M plan, would be needed to meet the projected dredge material disposal needs to maintain a 9′ channel through 2060. Natural succession of habitats in these unused disposal sites has occurred for approximately three decades. These areas are now covered by substantial tracts of mature floodplain forests that are essential components to the region's complex mosaic of riparian, wetland, and floodplain habitats. Use of the sites would require additional NEPA documentation and additional coordination with Federal and state fish and wildlife management agencies because of the significant changes in the habitats of the dredge material disposal sites. Given the increased emphasis on the importance of high quality floodplain habitats since 1974, it is reasonable to assume that substantial mitigation would be necessary. In addition, under provisions of the Clean Water Act, the Oklahoma portion of the MKARNS has been designated an impaired stream. As a designated impaired stream, in-river dredge material disposal in the Oklahoma reach has been closely regulated by the State of Oklahoma, and rarely, if ever, allowed to occur. Alternative A assumes that the impaired stream designation is not likely to be changed in the immediate future, and also assumes that in-river dredge material disposal in the Oklahoma reach of the MKARNS would not be allowed by the State of Oklahoma. This alternative also assumes that disposal of dredge material on the Arkansas portion of the MKARNS would continue in accordance with the 1974 O&M plan.

Alternative A presents a projection of future conditions that accounts for and considers uncertainties about future changes in operation and maintenance of the navigation system, without the measures considered in the "with action alternatives" (Alternatives C, D and E). This scenario, although conservative, provides a reasonable perspective that accentuates the significance of adverse effects to the natural environment. Since no significant changes to the current approved 1974 O&M plan are proposed, Alternative A is titled and considered the "no action alternative." Key features and assumptions of Alternative A are:

- Maintenance of the 9′ channel by dredging would continue throughout the MKARNS.
- There would be no change in reservoir releases or channel deepening.
- Dredge materials would be disposed in existing designated dredge material disposal sites.

- Upland dredge material disposal sites in Oklahoma and in-river sites in Arkansas would be extended in accordance with the approved 1974 O&M plan, and supplementing the Operations and Maintenance EIS.
- Modifications incidental to dredging operations of existing wing dikes, revetments, etc., would continue.
- Only measures within current authority and established practices would be considered.

B.11.4.2. Alternative B

Alternative B includes consideration of all the measures included in Alternative A, except that it assumes that in-river disposal of dredge materials would be allowed in Oklahoma. Unused upland dredge material disposal sites, approved in the 1974 O&M plan, would not be utilized and the need to mitigate adverse effects to these now valuable sites would be avoided. Alternative B assumes that essentially all future disposal in Oklahoma would be in-river, in currently used terrestrial sites, or in newly identified terrestrial sites of low habitat value. Future disposal in Arkansas would continue to be in-stream except on the White River Entrance Channel where terrestrial sites are, and would continue to be utilized. The Little Rock and Tulsa Districts of the Corps both currently believe that in-river disposal in both states is a realistic possibility, but until the necessary concurrence from the State of Oklahoma is received by the Corps, it is possible that this alternative may be only slightly more likely to occur than Alternative A. However, because of Alternative B's slightly greater likelihood of occurrence when compared to Alternative A, Alternative B is the plan against which Alternatives C, D, and E, are compared economically. Key features and assumptions of Alternative B are:

- Maintenance of the 9′ channel by dredging would continue throughout the system.
- There would be no change in reservoir releases or channel deepening.
- Dredge materials would be disposed in existing designated dredge material disposal sites to the extent practicable, consistent with current statutes, regulations, and policies.
- Upland dredge material disposal sites in Oklahoma and Arkansas would be extended or added by amending the approved 1974 O&M plan, and supplementing the Operation and Maintenance EIS.
- Modifications incidental to dredging operations of existing wing dikes, revetments, etc. would continue.
- Measures within current authority and established practices would be considered, and in-river disposal of dredge materials would be allowed in both Oklahoma and Arkansas.

B.11.4.3. Alternative C

Alternative C consists of adding new dredged material disposal sites in Oklahoma to supplement disposal site capacity, which is expected to reach capacity at some locations along the MKARNS in the near future and replacing the existing flow management plan with the Operations Only Flow Management Plan. The existing depth of the navigation channel would remain unchanged. The following characterizes what would occur for each study feature/component under Alternative C:

- Navigation Channel Maintenance: Existing dredging and disposal to maintain the navigation channel would continue under this alternative. After currently utilized dredged material disposal sites reach their holding capacity, dredged material would be disposed of in new disposal sites designated in the 2003 long-term DMMP. Under this alternative, areas with high quality habitat such as forest, wetlands, and high quality grassland would be avoided wherever practical.
- Flow Management: The Operations Only component entails modifying the current operations plan to better meet the objectives of the proposed action. The Operations Only component is defined as the existing plan with a modified 60,000 cfs bench in place of the 75,000 cfs bench beginning at 3% lower system storage except during June 15 through October 1.
- Navigation Channel Depth: No change from the current 9′ navigation channel.

There would be annual incremental net benefits approximating $8.8 million with the implementation of this alternative compared to Alternative B. Much of the incremental net economic benefits would be associated with navigation and hydropower. Annual incremental navigation benefits would approximate $8.4 million, comprising 95% of the benefits under this alternative. The remaining incremental benefits would be associated with hydropower ($0.5 million).

Minor negative impacts would be associated with non-agricultural and agricultural properties, while there would be no change in economic impacts for real estate or tourism/recreation compared to Alternative B. Average annual non-agricultural and agricultural property damages would be an additional $36,000 as compared to Alternative B.

Table 11-16. Summary of Incremental Net Benefits and Costs Alternative C Average Annual Equivalent Values (July 2004 $) 5.375% Discount Rate, 50-year Period of Analysis	
	Flow Management Operations
Period of Analysis (years)	50
Construction Period (years)	1
Interest Rate (percent)	5.375%
Project First Costs[1]	0
Interest During Construction	0
Total Project Cost	**$0**
Annual Costs:	
Interest	0
Amortization	0
Operations & Maintenance	0
Total Annual Costs	**$0**
Annual Benefits[2]:	
Navigation benefits	8,372,100
Recreation	0
Hydropower	466,000
Non-Ag. Property Damage	
Oklahoma	0
Arkansas	-17,100
Recreation Facilities OK	-5,500
Recreation Facilities AR	4,000
Ag. Property Damages	
Oklahoma	0
Arkansas	-18,800
Total Annual Benefits	**$8,800,700**
Incremental Net Benefits for Flow Management Component	$8,800,700
Incremental Net Benefits for Alternative C	**$8,800,700**
Benefit-to-Cost Ratio for Flow Management Component	incalculable
Benefit-to-Cost Ratio for Alternative C	**incalculable**
[1] *Incremental Costs - costs in addition to those existing under Alternative B.* [2]*Incremental Benefits - benefits in addition to those existing under Alternative B.* Source: USACE, Tulsa and Little Rock Districts, Hydropower Analysis Center, Parsons.	

B.11.4.4. Alternative D

Alternative D consists of 1) adding new dredged material disposal sites in Oklahoma to supplement disposal site capacity which is expected to reach capacity at some locations along the MKARNS in the near future, 2) replacing the existing flow management plan with the Operations Only Flow Management Plan, and 3) increasing the depth of the navigation channel throughout the MKARNS from 9′ to 11′. The following characterizes what would occur for each study feature/component under Alternative D:

- Navigation Channel Maintenance: Existing dredging and disposal to maintain the navigation channel would continue under this alternative. After currently utilized dredged material disposal sites reach their holding capacity, dredged material would be disposed of in new disposal sites designated in the 2003 long-term DMMP. Under this alternative, areas with high quality habitat such as forest, wetlands, and high quality grassland would be avoided wherever practical.
- Flow Management: The Operations Only component entails modifying the current operations plan to better meet the objectives of the proposed action. The Operations Only component is defined as the existing plan with a modified 60,000 cfs bench in place of the 75,000 cfs bench beginning at 3% lower system storage except during June 15 through October 1.
- Navigation Channel Depth: The current 9′ navigation channel would be deepened to an 11′ navigation channel throughout the entire length of the MKARNS.

For Alternative D, major incremental costs are associated with the construction of new dikes and jetties ($28.1 million), dredging and rock removal ($24.1 million), construction of dredge disposal areas ($27.1 million), and environmental mitigation and sustainability ($23.6 million). Incremental O&M Costs for Alternative D equal $2.2 million. Average annual incremental costs for Alternative D equal $10.2 million

For Alternative D, annual incremental benefits equal $19 million. Annual incremental net benefits equal $8.8 million with the implementation of this alternative as compared to Alternative B. The major economic benefit would come from navigation savings. The remaining economic benefits would come from hydropower ($0.5 million). Alternative D has a benefit-to-cost ratio of 1.9. Tables 11-13 and 11-17 summarize the information.

Table 11-17. Summary of Incremental Net Benefits and Costs Alternative D Average Annual Equivalent Values (July 2004 $) 5.375% Discount Rate, 50-year Period of Analysis			
	Flow Management Operations	**Channel Deepening 11′**	**Alternative D**
Period of Analysis (years)	50	50	
Construction Period (years)	1	4	
Interest Rate (percent)	5.375%	5.375%	
Project First Costs[1]	0	$123,356,100	$123,356,100
Interest During Construction	0	13,568,500	$13,568,500
Associated Non-Federal Requirements:			
Local Facilities	0	530,000	$530,000
Local Facilities IDC	0	58,300	$58,300
Total Project Cost	**$0**	**$137,512,900**	**$137,512,900**
Annual Costs:			
Interest	0	$7,391,300	$7,391,300
Amortization	0	581,800	$581,800
Operations & Maintenance	0	2,234,100	$2,234,100
Total Annual Costs	**$0**	**$10,207,200**	**$10,207,200**
Annual Benefits[2]:			
Navigation	8,372,100	10,173,500	$18,545,600
Recreation	0	0	$0
Hydropower	466,000	0	$466,000
Non-Ag. Property Damage			
Oklahoma	0	0	$0
Arkansas	(17,100)	0	($17,100)
Recreation Facilities OK	(5,500)	0	($5,500)
Recreation Facilities AR	4,000	0	$4,000
Ag. Property Damages			
Oklahoma	0	0	$0
Arkansas	(18,800)	0	($18,800)
Total Annual Benefits	**$8,800,700**	**$10,173,500**	**$18,974,200**
Incremental Net Benefits for Components	$8,800,700	($33,700)	
Incremental Net Benefits for Alt. D			**$8,767,000**
Benefit-to-Cost Ratio for Components	incalculable	0.997	
Benefit-to-Cost Ratio for Alt. D			**1.9**

[1] *Incremental Costs - costs in addition to those existing under Alternative B.*

[2] *Incremental Benefits - benefits in addition to those existing under Alternative B.*

Source: USACE, Tulsa and Little Rock Districts, Hydropower Analysis Center, Parsons.

B.11.4.5. Alternative E

Alternative E consists of 1) adding new dredged material disposal sites in Oklahoma to supplement disposal site capacity which is expected to reach capacity at some locations along the MKARNS in the near future, 2) replacing the existing flow management plan with the Operations Only component, and 3) increasing the depth of the navigation channel throughout the MKARNS from 9´ to 12´. The following characterizes what would occur for each study feature/component under Alternative E:

- Navigation Channel Maintenance: Existing dredging and disposal to maintain the navigation channel would continue under this alternative. After currently utilized dredged material disposal sites reach their holding capacity, dredged material would be disposed of in new disposal sites designated in the 2003 long-term DMMP. Under this alternative, areas with high quality habitat such as forest, wetlands, and high quality grassland would be avoided wherever practical.
- Flow Management: The Operations Only component entails modifying the current operations plan to better meet the objectives of the proposed action. The Operations Only component is defined as the existing plan with a modified 60,000 cfs bench in place of the 75,000 cfs bench beginning at 3% lower system storage except during June 15 through October 1.
- Navigation Channel Depth: The current 9´ navigation channel would be deepened to a 12´ navigation channel throughout the entire length of the MKARNS.

For Alternative E, major incremental costs are associated with the construction of new dikes and jetties ($38.9 million), dredging and rock removal ($30.7 million), construction of dredge disposal areas ($31.7 million), and environmental mitigation and sustainability ($23.7 million). Incremental O&M Costs for Alternative E equal $2.8 million. Average annual incremental costs for Alternative E equal $12.5 million.

For Alternative E, annual incremental benefits equal $22.3 million. Annual incremental net benefits equal $9.8 million with the implementation of this alternative as compared to Alternative B. The major economic benefit would come from navigation savings. The remaining economic benefits would come from hydropower ($0.5 million). Alternative E has a benefit-to-cost ratio of 1.8. Tables 11-13 and 11-18 summarize the information.

Table 11-18. Summary of Incremental Net Benefits and Costs Alternative E Average Annual Equivalent Values (July 2004 $) 5.375% Discount Rate, 50-year Period of Analysis			
	Flow Management Operations	**Channel Deepening 12′**	**Alternative E**
Period of Analysis (years)	50	50	
Construction Period (years)	1	4	
Interest Rate (percent)	5.375%	5.375%	
Project First Costs[1]	0	$148,966,200	$148,966,200
Interest During Construction	0	16,385,400	$16,385,400
Associated Non-Federal Requirements:			
Local Facilities	0	961,200	$961,200
Local Facilities IDC	0	105,700	$105,700
Total Project Cost	**$0**	**$166,418,500**	**$166,418,500**
Annual Costs:			
Interest	0	$8,945,000	$8,945,000
Amortization	0	704,100	$704,100
Operations & Maintenance	0	2,823,700	$2,823,700
Total Annual Costs	**$0**	**$12,472,800**	**$12,472,800**
Annual Benefits[2]:			
Navigation	8,372,100	$13,482,600	$21,854,700
Recreation	0	0	$0
Hydropower	466,000	0	$466,000
Non-Ag. Property Damage			
Oklahoma	0	0	$0
Arkansas	(17,100)	0	($17,100)
Recreation Facilities OK	(5,500)	0	($5,500)
Recreation Facilities AR	4,000	0	$4,000
Ag. Property Damages			
Oklahoma	0	0	$0
Arkansas	(18,800)	0	($18,800)
Total Annual Benefits	**$8,800,700**	**$13,482,600**	**$22,283,300**
Incremental Net Benefits for Components	$8,800,700	$1,009,800	
Incremental Net Benefits for Alt. E			**$9,810,500**
Benefit-to-Cost Ratio for Components	incalculable	1.08	
Benefit-to-Cost Ratio for Alt. E			**1.8**

[1] *Incremental Costs - costs in addition to those existing under Alternative B.*

[2] *Incremental Benefits - benefits in addition to those existing under Alternative B.*

Source: USACE, Tulsa and Little Rock Districts, Hydropower Analysis Center, Parsons.

B.11.5. National Economic Development (NED) Plan

A plan that reasonably maximizes net national economic development benefits, consistent with the Federal objective, is identified as the NED plan. Alternative E produces annual net benefits of approximately $9.8 million. Alternative D produces annual incremental net benefits of approximately $8.8 million; Alternative C produces annual incremental net benefits of approximately $8.8 million. The plan that maximizes net NED benefits is Alternative E.

B.11.6. Recommended Plan

In keeping with the NED objective of water resources planning, the plan that has the greatest excess benefits over cost, the NED plan, will be selected for implementation unless there are compelling reasons not to do so. Therefore, the NED plan, Alternative E (Navigation Channel Depth Maintenance, Operations Only Flow Management, and 12´ Navigation Channel), is also the recommended plan.

B.12. Sensitivity Analysis

Navigation benefits were calculated based on "the most probable" with project and without project conditions. It is possible, however for economic variables to greatly exceed or fail to meet "probable" values. In calculating net benefits for a project, it is important to recognize that the true value of net benefits exists within a range of possible values. To have a better understanding of the range of possible values for this study, several variables were tested. A summary of the sensitivity results is in Table 12-1.

The first test of sensitivity was for tonnage forecasting. In the Commercial Navigation section (B.6.) three forecast scenarios were produced. While the net benefit calculations presented in the previous section were based on the middle forecast scenario, results could be presented for the range of benefits possible under the high and low forecast scenarios. As seen in Table 12-2, none of the navigation channel deepening components are economically justified with low-growth (no growth) forecasts. Without an economically justified navigation channel deepening component, NED plan would switch from Alternative E to Alternative C. As seen in Table 12-5, only NCD-12 is economically justified with high-growth forecasts. With growth similar to other high-traffic rivers, Alternative E performs better than under the mid-range forecast. Alternative E would remain as the NED plan.

The second test of sensitivity was for Operations & Maintenance costs for the tow haulage equipment in the Little Rock District. As discussed in Section B.5. and shown in Table 5-2, estimates of incremental O&M costs for tow haulage for NCD-12 range from $100,000 to $200,000 per year. As seen in Table 12-9 and 12-10, NCD-11 and NCD-12 are economically justified with high forecast of tow haulage O&M costs. Alternative E would remain as the NED plan.

The third test of sensitivity is for a higher Federal discount rate. Testing an interest rate of 7%, as seen in Table 12-11, NCD-12 is economically justified. However, Alternative C provides greater incremental net benefits, and would be the NED plan.

Table 12-1. Summary of Sensitivity Analysis			
	Alternative C	**Alternative D**	**Alternative E**
Summary of Economic Analysis			
Incremental Net Benefits	$8,800,700	$8,767,000	$9,810,500
Benefit to Cost Ratio	incalculable	1.9	1.8
Low Tonnage Forecast Scenario			
Incremental Net Benefits	$8,800,700	$6,348,600	$6,649,300
Benefit to Cost Ratio	incalculable	1.6	1.5
High Tonnage Forecast Scenario			
Incremental Net Benefits	$8,800,700	$6,751,600	$17,361,000
Benefit to Cost Ratio	incalculable	1.7	2.4
High Cost Tow Haulage O&M Scenario			
Incremental Net Benefits	$8,800,700	$8,612,200	$9,571,700
Benefit to Cost Ratio	incalculable	1.8	1.8
Interest Rate 7%			
Incremental Net Benefits	$6,791,000	*	$2,405,200
Benefit to Cost Ratio	incalculable	*	1.16
*Note: Sum of present value of navigation benefit for 11' channel less than for 12' channel. Therefore, Incremental Net Benefits and Benefit-to-Cost Ratio for Alternative D is less than for Alternative E.			

Table 12-2. Summary of Net Incremental Benefits and Costs
Navigation Channel Deepening Components – Reaches 1 through 6
Low Tonnage Forecast Scenario
Average Annual Equivalent Values (July 2004 $)

Mouth of White River, AR to Catoosa, OK (NM 0.0 to NM 444.8)	Depth of Channel		
	NCD-10	NCD-11	NCD-12
Period of Analysis (years)	50	50	50
Construction Period (years)	4	4	4
Interest Rate (percent)	5.375%	5.375%	5.375%
Project First Costs[1,2]	95,614,100	123,356,100	148,966,200
Interest During Construction	10,517,000	13,568,500	16,385,400
Associated Non-Federal Requirements:			
Local Facilities	246,600	530,000	961,200
Local Facilities IDC	27,100	58,300	105,700
Total Project Cost	**106,404,800**	**137,512,900**	**166,418,500**
Annual Costs[3]:			
Interest	5,719,300	7,391,300	8,945,000
Amortization	450,200	581,800	704,100
Operations and Maintenance	1,668,200	2,234,100	2,823,700
Total Annual Costs	**7,837,700**	**10,207,200**	**12,472,800**
Annual Benefits:			
Navigation Benefits	**3,066,700**	**7,755,100**	**10,321,400**
Benefit-to-Cost Ratio	**0.39**	**0.76**	**0.83**
Net Benefits	**($4,771,000)**	**($2,452,100)**	**($2,151,400)**

[1] *From previous table: Project First Costs = "Total" – "Escalation" – "Investment by Ports"*
[2] *Incremental Costs - costs in addition to those existing with 9' channel.*
[3] *Incremental Benefits - benefits in addition to those existing with 9' channel*

Table 12-3. Summary of Incremental Net Benefits and Costs Alternative D - Low Tonnage Forecast Scenario Average Annual Equivalent Values (July 2004 $) 5.375% Discount Rate, 50-year Period of Analysis			
	Flow Management Operations	**Channel Deepening 11′**	**Alternative D**
Period of Analysis (years)	50	50	
Construction Period (years)	1	4	
Interest Rate (percent)	5.375%	5.375%	
Project First Costs[1]	0	123,356,100	123,356,100
Interest During Construction	0	13,568,500	13,568,500
Associated Non-Federal Requirements:			
Local Facilities	0	530,000	530,000
Local Facilities IDC	0	58,300	58,300
Total Project Cost	**$0**	**137,512,900**	**137,512,900**
Annual Costs:			
Interest	0	7,391,300	7,391,300
Amortization	0	581,800	581,800
Operations & Maintenance	0	2,234,100	2,234,100
Total Annual Costs	**$0**	**10,207,200**	**10,207,200**
Annual Benefits[2]:			
Navigation	8,372,100	7,755,100	16,127,200
Recreation	0	0	0
Hydropower	466,000	0	466,000
Non-Ag. Property Damage			
Oklahoma	0	0	0
Arkansas	-17,100	0	-17,100
Recreation Facilities OK	-5,500	0	-5,500
Recreation Facilities AR	4,000	0	4,000
Ag. Property Damages			
Oklahoma	0	0	0
Arkansas	-18,800	0	-18,800
Total Annual Benefits	**$8,800,700**	**$7,755,100**	**$16,555,800**
Incremental Net Benefits for Components	$8,800,700	($2,452,100)	
Incremental Net Benefits for Alt. D			**$6,348,600**
Benefit-to-Cost Ratio for Components	incalculable	0.76	
Benefit-to-Cost Ratio for Alt. D			**1.6**

[1] *Incremental Costs - costs in addition to those existing under Alternative B.*

[2] *Incremental Benefits - benefits in addition to those existing under Alternative B.*

Source: USACE, Tulsa and Little Rock Districts, Hydropower Analysis Center, Parsons.

Table 12-4. Summary of Incremental Net Benefits and Costs Alternative E - Low Tonnage Forecast Scenario Average Annual Equivalent Values (July 2004 $) 5.375% Discount Rate, 50-year Period of Analysis			
	Flow Management Operations	**Channel Deepening 12′**	**Alternative E**
Period of Analysis (years)	50	50	
Construction Period (years)	1	4	
Interest Rate (percent)	5.375%	5.375%	
Project First Costs[1]	0	148,966,200	148,966,200
Interest During Construction	0	16,385,400	16,385,400
Associated Non-Federal Requirements:			
Local Facilities	0	961,200	961,200
Local Facilities IDC	0	105,700	105,700
Total Project Cost	**$0**	**$166,418,500**	**$166,418,500**
Annual Costs:			
Interest	0	8,945,000	8,945,000
Amortization	0	704,100	704,100
Operations & Maintenance	0	2,823,700	2,823,700
Total Annual Costs	**$0**	**$12,472,800**	**$12,472,800**
Annual Benefits[2]:			
Navigation	8,372,100	10,321,400	18,693,500
Recreation	0	0	0
Hydropower	466,000	0	466,000
Non-Ag. Property Damage			
Oklahoma	0	0	0
Arkansas	-17,100	0	-17,100
Recreation Facilities OK	-5,500	0	-5,500
Recreation Facilities AR	4,000	0	4,000
Ag. Property Damages			
Oklahoma	0	0	0
Arkansas	-18,800	0	-18,800
Total Annual Benefits	**$8,800,700**	**$10,321,400**	**$19,122,100**
Incremental Net Benefits for Components	$8,800,700	($2,151,400)	
Incremental Net Benefits for Alt. E			**$6,649,300**
Benefit-to-Cost Ratio for Components	incalculable	0.83	
Benefit-to-Cost Ratio for Alt. E			**1.5**

[1] *Incremental Costs - costs in addition to those existing under Alternative B.*

[2] *Incremental Benefits - benefits in addition to those existing under Alternative B.*

Source: USACE, Tulsa and Little Rock Districts, Hydropower Analysis Center, Parsons.

Table 12-5. Summary of Net Incremental Benefits and Costs
Navigation Channel Deepening Components – Reaches 1 through 6
High Tonnage Forecast Scenario
Average Annual Equivalent Values (July 2004 $)

Mouth of White River, AR to Catoosa, OK (NM 0.0 to NM 444.8)	Depth of Channel		
	NCD-10	NCD-11	NCD-12
Period of Analysis (years)	50	50	50
Construction Period (years)	4	4	4
Interest Rate (percent)	5.375%	5.375%	5.375%
Project First Costs[1,2]	95,614,100	123,356,100	148,966,200
Interest During Construction	10,517,000	13,568,500	16,385,400
Associated Non-Federal Requirements:			
Local Facilities	246,600	530,000	961,200
Local Facilities IDC	27,100	58,300	105,700
Total Project Cost	**106,404,800**	**137,512,900**	**166,418,500**
Annual Costs[3]:			
Interest	5,719,300	7,391,300	8,945,000
Amortization	450,200	581,800	704,100
Operations and Maintenance	1,668,200	2,234,100	2,823,700
Total Annual Costs	**7,837,700**	**10,207,200**	**12,472,800**
Annual Benefits:			
Navigation Benefits	**(8,548,400)**	**8,158,100**	**21,033,100**
Benefit-to-Cost Ratio	**-1.09**	**0.80**	**1.7**
Net Benefits	**($16,386,100)**	**($2,049,100)**	**$8,560,300**

[1] *From previous table: Project First Costs = "Total" – "Escalation" – "Investment by Ports"*
[2] *Incremental Costs - costs in addition to those existing with 9' channel.*
[3] *Incremental Benefits - benefits in addition to those existing with 9' channel*

Table 12-6 Summary of Incremental Net Benefits and Costs Alternative D - High Tonnage Forecast Scenario Average Annual Equivalent Values (July 2004 $) 5.375% Discount Rate, 50-year Period of Analysis			
	Flow Management Operations	**Channel Deepening 11′**	**Alternative D**
Period of Analysis (years)	50	50	
Construction Period (years)	1	4	
Interest Rate (percent)	5.375%	5.375%	
Project First Costs[1]	0	123,356,100	123,356,100
Interest During Construction	0	13,568,500	13,568,500
Associated Non-Federal Requirements:			
Local Facilities	0	530,000	530,000
Local Facilities IDC	0	58,300	58,300
Total Project Cost	**$0**	**137,512,900**	**137,512,900**
Annual Costs:			
Interest	0	7,391,300	7,391,300
Amortization	0	581,800	581,800
Operations & Maintenance	0	2,234,100	2,234,100
Total Annual Costs	**$0**	**10,207,200**	**10,207,200**
Annual Benefits[2]:			
Navigation	8,372,100	8,158,100	16,530,200
Recreation	0	0	0
Hydropower	466,000	0	466,000
Non-Ag. Property Damage			
Oklahoma	0	0	0
Arkansas	-17,100	0	-17,100
Recreation Facilities OK	-5,500	0	-5,500
Recreation Facilities AR	4,000	0	4,000
Ag. Property Damages			
Oklahoma	0	0	0
Arkansas	-18,800	0	-18,800
Total Annual Benefits	**$8,800,700**	**$8,158,100**	**$16,958,800**
Incremental Net Benefits for Components	$8,800,700	($2,049,100)	
Incremental Net Benefits for Alt. D			**$6,751,600**
Benefit-to-Cost Ratio for Components	incalculable	0.80	
Benefit-to-Cost Ratio for Alt. D			**1.7**

[1] *Incremental Costs - costs in addition to those existing under Alternative B.*

[2] *Incremental Benefits - benefits in addition to those existing under Alternative B.*

Source: USACE, Tulsa and Little Rock Districts, Hydropower Analysis Center, Parsons.

Table 12-7 Summary of Incremental Net Benefits and Costs Alternative E - High Tonnage Forecast Scenario Average Annual Equivalent Values (July 2004 $) 5.375% Discount Rate, 50-year Period of Analysis			
	Flow Management Operations	**Channel Deepening 12′**	**Alternative E**
Period of Analysis (years)	50	50	
Construction Period (years)	1	4	
Interest Rate (percent)	5.375%	5.375%	
Project First Costs[1]	0	148,966,200	148,966,200
Interest During Construction	0	16,385,400	16,385,400
Associated Non-Federal Requirements:			
Local Facilities	0	961,200	961,200
Local Facilities IDC	0	105,700	105,700
Total Project Cost	**$0**	**166,418,500**	**166,418,500**
Annual Costs:			
Interest	0	8,945,000	8,945,000
Amortization	0	704,100	704,100
Operations & Maintenance	0	2,823,700	2,823,700
Total Annual Costs	**$0**	**$12,472,800**	**$12,472,800**
Annual Benefits[2]:			
Navigation	8,372,100	21,033,100	29,405,200
Recreation	0	0	0
Hydropower	466,000	0	466,000
Non-Ag. Property Damage			
Oklahoma	0	0	0
Arkansas	-17,100	0	-17,100
Recreation Facilities OK	-5,500	0	-5,500
Recreation Facilities AR	4,000	0	4,000
Ag. Property Damages			
Oklahoma	0	0	0
Arkansas	-18,800	0	-18,800
Total Annual Benefits	**$8,800,700**	**$21,033,100**	**$29,833,800**
Incremental Net Benefits for Components	$8,800,700	$8,560,300	
Incremental Net Benefits for Alt. E			**$17,361,000**
Benefit-to-Cost Ratio for Components	incalculable	1.7	
Benefit-to-Cost Ratio for Alt. E			**2.4**

[1] *Incremental Costs - costs in addition to those existing under Alternative B.*

[2] *Incremental Benefits - benefits in addition to those existing under Alternative B.*

Source: USACE, Tulsa and Little Rock Districts, Hydropower Analysis Center, Parsons.

Table 12-8 Summary of Incremental Costs, Navigation Channel Deepening Components Reach 1 through 6 - High Tow Haulage O&M Scenario (July 2004 $)			
Mouth of White River, AR to Catoosa, OK (NM 0.0 to NM 444.8)	**Depth of Channel**		
	10 foot	**11 foot**	**12 foot**
Construction			
02.03 Demolition	1,473,430	1,473,430	1,473,430
05.62 Locks - Pin Guide Walls	3,327,625	3,327,725	3,327,725
09.01.16 Dredging and Rock Removal	12,622,458	24,096,037	30,736,208
09.01.20 Dredged Material Disposal Areas	18,762,850	27,123,250	31,650,950
09.01.30 Dikes and Jetties	21,964,037	28,082,076	38,859,990
Subtotal	**$58,150,400**	**$84,102,518**	**$106,048,303**
01. Real Estate - Dredge Material Disposal Areas	4,322,060	4,322,060	4,322,060
06. Mitigation	23,404,487	23,662,587	23,662,587
Subtotal	**$27,726,547**	**$27,984,647**	**$27,984,647**
12. Investment by Ports (Non-Federal)	246,557	529,985	961,163
18. Cultural Resource Preservation	882,840	882,840	882,840
30. Planning Engineering and Design	8,067,757	9,424,856	12,189,970
31. Contract Administration	4,931,540	6,478,194	8,549,387
Total	**$100,005,641**	**$129,403,040**	**$156,616,310**
Note: Contingency included in the total above is	15,569,069	19,968,794	24,424,178
Escalation included in the total above is	4,144,935	5,516,984	6,688,986
Operations and Maintenance (O&M) (Annual Cost)			
Dredging	847,521	1,274,851	1,772,702
Locks, Tow Haulage	145,000	300,000	450,000
Dikes and Jetties	383,999	383,999	383,999
Mitigation and Monitoring	192,452	192,452	192,452
Engineering and Design	82,139	113,589	125,763
Contract Administration	89,497	124,230	137,590
Total Annual O&M	**1,740,608**	**$2,389,121**	**$3,062,506**
Note: Based on MCACES cost estimates prepared 15 July 2005.			

Table 12-9. Summary of Incremental Net Benefits and Costs Alternative D - High Tow Haulage O&M Scenario Average Annual Equivalent Values (July 2004 $) 5.375% Discount Rate, 50-year Period of Analysis			
	Flow Management Operations	**Channel Deepening 11′**	**Alternative D**
Period of Analysis (years)	50	50	
Construction Period (years)	1	4	
Interest Rate (percent)	5.375%	5.375%	
Project First Costs[1]	0	$123,356,100	$123,356,100
Interest During Construction	0	$13,568,500	$13,568,500
Associated Non-Federal Requirements:			
Local Facilities	0	$530,000	$530,000
Local Facilities IDC	0	$58,300	$58,300
Total Project Cost	**$0**	**$137,512,900**	**$137,512,900**
Annual Costs:			
Interest	0	$7,391,300	$7,391,300
Amortization	0	$581,800	$581,800
Operations & Maintenance	0	$2,389,100	$2,389,100
Total Annual Costs	**$0**	**$10,362,200**	**$10,362,200**
Annual Benefits[2]:			
Navigation	8,372,100	10,173,500	18,545,600
Recreation	0	0	0
Hydropower	466,000	0	466,000
Non-Ag. Property Damage			
Oklahoma	0	0	0
Arkansas	-17,100	0	-17,100
Recreation Facilities OK	-5,500	0	-5,500
Recreation Facilities AR	4,000	0	4,000
Ag. Property Damages			
Oklahoma	0	0	0
Arkansas	-18,800	0	-18,800
Total Annual Benefits	**$8,800,700**	**$10,173,500**	**$18,974,200**
Incremental Net Benefits for Components	$8,800,700	($188,700)	
Incremental Net Benefits for Alt. D			**$8,612,000**
Benefit-to-Cost Ratio for Components	incalculable	0.98	
Benefit-to-Cost Ratio for Alt. D			**1.8**

[1] *Incremental Costs - costs in addition to those existing under Alternative B.*

[2] *Incremental Benefits - benefits in addition to those existing under Alternative B.*

Source: USACE, Tulsa and Little Rock Districts, Hydropower Analysis Center, Parsons.

Table 12-10. Summary of Incremental Net Benefits and Costs Alternative E - High Tow Haulage O&M Scenario Average Annual Equivalent Values (July 2004 $) 5.375% Discount Rate, 50-year Period of Analysis			
	Flow Management Operations	**Channel Deepening 12′**	**Alternative E**
Period of Analysis (years)	50	50	
Construction Period (years)	1	4	
Interest Rate (percent)	5.375%	5.375%	
Project First Costs[1]	0	$148,966,200	$148,966,200
Interest During Construction	0	$16,385,400	$16,385,400
Associated Non-Federal Requirements:			
Local Facilities	0	$961,200	$961,200
Local Facilities IDC	0	$105,700	$105,700
Total Project Cost	**$0**	**$166,418,500**	**$166,418,500**
Annual Costs:			
Interest	0	$8,945,000	$8,945,000
Amortization	0	$704,100	$704,100
Operations & Maintenance	0	$3,062,500	$3,062,500
Total Annual Costs	**$0**	**$12,711,600**	**$12,711,600**
Annual Benefits[2]:			
Navigation	8,372,100	13,482,600	21,854,700
Recreation	0	0	0
Hydropower	466,000	0	466,000
Non-Ag. Property Damage			
Oklahoma	0	0	0
Arkansas	-17,100	0	-17,100
Recreation Facilities OK	-5,500	0	-5,500
Recreation Facilities AR	4,000	0	4,000
Ag. Property Damages			
Oklahoma	0	0	0
Arkansas	-18,800	0	-18,800
Total Annual Benefits	**$8,800,700**	**$13,482,600**	**$22,283,300**
Incremental Net Benefits for Components	$8,800,700	$771,000	
Incremental Net Benefits for Alt. E			**$9,571,700**
Benefit-to-Cost Ratio for Components	incalculable	1.06	
Benefit-to-Cost Ratio for Alt. E			**1.8**

[1] *Incremental Costs - costs in addition to those existing under Alternative B.*

[2] *Incremental Benefits - benefits in addition to those existing under Alternative B.*

Source: USACE, Tulsa and Little Rock Districts, Hydropower Analysis Center, Parsons.

Table 12-11. Summary of Incremental Net Benefits and Costs Alternative E - Sensitivity to Interest Rate Average Annual Equivalent Values (July 2004 $) 7% Discount Rate, 50-year Period of Analysis			
	Flow Management Operations	**Channel Deepening 12′**	**Alternative E**
Period of Analysis (years)	50	50	
Construction Period (years)	1	4	
Interest Rate (percent)	7%	7%	
Project First Costs[1]	0	148,966,200	148,966,200
Interest During Construction	0	21,624,300	21,624,300
Associated Non-Federal Requirements:			
Local Facilities	0	961,200	961,200
Local Facilities IDC	0	139,500	139,500
Total Project Cost	**$0**	**$171,691,300**	**$171,691,300**
Annual Costs:			
Interest	0	12,018,400	12,018,400
Amortization	0	422,300	422,300
Operations & Maintenance	0	2,823,700	2,823,700
Total Annual Costs	**$0**	**$15,264,400**	**$15,264,400**
Annual Benefits[2]:			
Navigation	6,541,400	10,878,600	17,420,000
Recreation	0	0	0
Hydropower	287,000	0	287,000
Non-Ag. Property Damage			
Oklahoma	0	0	0
Arkansas	-17,100	0	-17,100
Recreation Facilities OK	-5,500	0	-5,500
Recreation Facilities AR	4,000	0	4,000
Ag. Property Damages			
Oklahoma	0	0	0
Arkansas	-18,800	0	-18,800
Total Annual Benefits	**$6,791,000**	**$10,878,600**	**$17,669,600**
Incremental Net Benefits for Components	$6,791,000	($4,385,800)	
Incremental Net Benefits for Alt. E			**$2,405,200**
Benefit-to-Cost Ratio for Components	incalculable	0.71	
Benefit-to-Cost Ratio for Alt. E			**1.16**

[1] *Incremental Costs - costs in addition to those existing under Alternative B.*

[2] *Incremental Benefits - benefits in addition to those existing under Alternative B.*

Source: USACE, Tulsa and Little Rock Districts, Hydropower Analysis Center, Parsons.

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ADDENDUM A1

Adjusted Capacity Values Using Federal Energy Regulatory Commission (FERC) Based Procedures

COAL-FIRED STEAM POWER VALUE
Date Run: 12/15/04

PROJECT NAME: ARKANSAS RIVER
LOCATION: SPP – AR, MO, OK
FINANCING: FEDERAL @ **5.375** %

Capacity Value $**236.71** per kW-yr Energy Value $**16.57** per MWh

PROGRAM INPUT DATA			
		State Index Number	4
Cost Level Date	01/01/04	State Location	AR
Single Unit Capacity	600	H-W Index Region No.	4
Capacity Factor	0.65	ROW ($/acre)	2449
Transformer Voltage	345	Clearing % of ROW	0.60
Transformer MVA	200	Receiving Sub. Land Cost	23033
No. of Transformers	6	Plant Investment	1551
No. of Transformer Positions	2	FC Moving-Avg. Time Frame	60
Single or Three Phase	1	Fuel Cost	115.2
Length Line 1	50	Heat Rate	10730
Length Line 2	0	Variable O&M	2.67
Line 1: Total Circuits	3	Fixed O&M	65.74
No. of Single Circuit	1	O&M Update	2.83
No. of Double Circuit	1	Plant Update	2.41
Line 2: Total Circuits	0	Transmission Update	2.22
No. of Single Circuit	0	Depreciation Plant (%)	1.41
No. of Double Circuit	0	Depreciation Substation (%)	1.41
		Depreciation Trans. Tower (%)	0.39
Cost of Money (%)	5.375	Depreciation Trans. Pole (%)	1.41
Plant Life	30		
Substation Life	30	Federal Income Tax (%)	0.000
Transmission (Towers) Life	50	Federal Misc. Tax (%)	0.000
Transmission (Poles) Life	30	State & Local Tax (%)	0.000
Plant Insurance (%)	0.25	Hydro Flexibility Adjustment	0.050
Transmission Insurance (%)	0.10	Alt. Mechanical Avail.	0.850
Substation Insurance (%)	0.25	Hydro Mechanical Avail.	0.980
		Mechanical Avail. Adjust.	0.153

COAL-FIRED STEAM POWER VALUE
Date Run: 12/15/04

PROJECT NAME: ARKANSAS RIVER
LOCATION: SPP – AR, MO, OK
FINANCING: FEDERAL @ **5.375** %

Capacity Value $**247.91** per kW-yr Energy Value $**12.24** per MWh

PROGRAM INPUT DATA			
		State Index Number	26
Cost Level Date	01/01/04	State Location	MO
Single Unit Capacity	600	H-W Index Region No.	3
Capacity Factor	0.65	ROW ($/acre)	2449
Transformer Voltage	345	Clearing % of ROW	0.60
Transformer MVA	200	Receiving Sub. Land Cost	23033
No. of Transformers	6	Plant Investment	1669
No. of Transformer Positions	2	FC Moving-Avg. Time Frame	60
Single or Three Phase	1	Fuel Cost	92.4
Length Line 1	50	Heat Rate	10130
Length Line 2	0	Variable O&M	2.89
Line 1: Total Circuits	3	Fixed O&M	65.91
No. of Single Circuit	1	O&M Update	2.83
No. of Double Circuit	1	Plant Update	2.65
Line 2: Total Circuits	0	Transmission Update	2.71
No. of Single Circuit	0	Depreciation Plant (%)	1.41
No. of Double Circuit	0	Depreciation Substation (%)	1.41
		Depreciation Trans. Tower (%)	0.42
Cost of Money (%)	5.375	Depreciation Trans. Pole (%)	1.41
Plant Life	30		
Substation Life	30	Federal Income Tax (%)	0.000
Transmission (Towers) Life	50	Federal Misc. Tax (%)	0.000
Transmission (Poles) Life	30	State & Local Tax (%)	0.000
Plant Insurance (%)	0.25	Hydro Flexibility Adjustment	0.050
Transmission Insurance (%)	0.10	Alt. Mechanical Avail.	0.850
Substation Insurance (%)	0.25	Hydro Mechanical Avail.	0.980
		Mechanical Avail. Adjust.	0.153

COAL-FIRED STEAM POWER VALUE
Date Run: 12/15/04

PROJECT NAME: ARKANSAS RIVER
LOCATION: SPP – AR, MO, OK
FINANCING: FEDERAL @ **5.375** %

Capacity Value $**236.52** per kW-yr Energy Value $**13.52** per MWh

PROGRAM INPUT DATA			
		State Index Number	37
Cost Level Date	01/01/04	State Location	OK
Single Unit Capacity	600	H-W Index Region No.	4
Capacity Factor	0.65	ROW ($/acre)	2449
Transformer Voltage	345	Clearing % of ROW	0.60
Transformer MVA	200	Receiving Sub. Land Cost	23033
No. of Transformers	6	Plant Investment	1551
No. of Transformer Positions	2	FC Moving-Avg. Time Frame	60
Single or Three Phase	1	Fuel Cost	93.1
Length Line 1	50	Heat Rate	10730
Length Line 2	0	Variable O&M	2.67
Line 1: Total Circuits	3	Fixed O&M	65.74
No. of Single Circuit	1	O&M Update	2.83
No. of Double Circuit	1	Plant Update	2.41
Line 2: Total Circuits	0	Transmission Update	2.22
No. of Single Circuit	0	Depreciation Plant (%)	1.41
No. of Double Circuit	0	Depreciation Substation (%)	1.41
		Depreciation Trans. Tower (%)	0.42
Cost of Money (%)	5.375	Depreciation Trans. Pole (%)	1.41
Plant Life	30		
Substation Life	30	Federal Income Tax (%)	0.000
Transmission (Towers) Life	50	Federal Misc. Tax (%)	0.000
Transmission (Poles) Life	30	State & Local Tax (%)	0.000
Plant Insurance (%)	0.25	Hydro Flexibility Adjustment	0.050
Transmission Insurance (%)	0.10	Alt. Mechanical Avail.	0.850
Substation Insurance (%)	0.25	Hydro Mechanical Avail.	0.980
		Mechanical Avail. Adjust.	0.153

COMBINED CYCLE POWER VALUE
Date Run: 12/15/04

PROJECT NAME: ARKANSAS RIVER
LOCATION: SPP – AR, MO, OK
FINANCING: FEDERAL @ **5.375** %

Capacity Value $**114.22** per kW-yr Energy Value $**35.21** per MWh

PROGRAM INPUT DATA			
		State Index Number	4
Cost Level Date	01/01/04	State Location	AR
Single Unit Capacity	150	H-W Index Region No.	4
Capacity Factor	0.20	ROW ($/acre)	2449
Transformer Voltage	230	Clearing % of ROW	0.60
Transformer MVA	200	Receiving Sub. Land Cost	23033
No. of Transformers	1	Plant Investment	740
No. of Transformer Positions	1	FC Moving-Avg. Time Frame	60
Single or Three Phase	3	Fuel Cost	426.4
Length Line 1	0	Heat Rate	8030
Length Line 2	0	Variable O&M	0.97
Line 1: Total Circuits	0	Fixed O&M	45.73
No. of Single Circuit	0	O&M Update	2.83
No. of Double Circuit	0	Plant Update	2.41
Line 2: Total Circuits	0	Transmission Update	2.22
No. of Single Circuit	0	Depreciation Plant (%)	1.41
No. of Double Circuit	0	Depreciation Substation (%)	1.41
		Depreciation Trans. Tower (%)	0.42
Cost of Money (%)	5.375	Depreciation Trans. Pole (%)	1.41
Plant Life	30		
Substation Life	30	Federal Income Tax (%)	0.000
Transmission (Towers) Life	50	Federal Misc. Tax (%)	0.000
Transmission (Poles) Life	30	State & Local Tax (%)	0.000
Plant Insurance (%)	0.25	Hydro Flexibility Adjustment	0.025
Transmission Insurance (%)	0.10	Alt. Mechanical Avail.	0.900
Substation Insurance (%)	0.25	Hydro Mechanical Avail.	0.980
		Mechanical Avail. Adjust.	0.089

COMBINED CYCLE POWER VALUE
Date Run: 12/15/04

PROJECT NAME: ARKANSAS RIVER
LOCATION: SPP – AR, MO, OK
FINANCING: FEDERAL @ **5.375** %

Capacity Value $**115.01** per kW-yr Energy Value $**35.27** per MWh

PROGRAM INPUT DATA			
		State Index Number	26
Cost Level Date	01/01/04	State Location	MO
Single Unit Capacity	150	H-W Index Region No.	3
Capacity Factor	0.20	ROW ($/acre)	2449
Transformer Voltage	230	Clearing % of ROW	0.60
Transformer MVA	200	Receiving Sub. Land Cost	23033
No. of Transformers	1	Plant Investment	748
No. of Transformer Positions	1	FC Moving-Avg. Time Frame	60
Single or Three Phase	3	Fuel Cost	427.2
Length Line 1	0	Heat Rate	8030
Length Line 2	0	Variable O&M	0.97
Line 1: Total Circuits	0	Fixed O&M	45.73
No. of Single Circuit	0	O&M Update	2.83
No. of Double Circuit	0	Plant Update	2.65
Line 2: Total Circuits	0	Transmission Update	2.71
No. of Single Circuit	0	Depreciation Plant (%)	1.41
No. of Double Circuit	0	Depreciation Substation (%)	1.41
		Depreciation Trans. Tower (%)	0.42
Cost of Money (%)	5.375	Depreciation Trans. Pole (%)	1.41
Plant Life	30		
Substation Life	30	Federal Income Tax (%)	0.000
Transmission (Towers) Life	50	Federal Misc. Tax (%)	0.000
Transmission (Poles) Life	30	State & Local Tax (%)	0.000
Plant Insurance (%)	0.25	Hydro Flexibility Adjustment	0.025
Transmission Insurance (%)	0.10	Alt. Mechanical Avail.	0.900
Substation Insurance (%)	0.25	Hydro Mechanical Avail.	0.980
		Mechanical Avail. Adjust.	0.089

COMBINED CYCLE POWER VALUE
Date Run: 12/15/04

PROJECT NAME: ARKANSAS RIVER
LOCATION: SPP – AR, MO, OK
FINANCING: FEDERAL @ **5.375** %

Capacity Value $**114.22** per kW-yr Energy Value $**35.56** per MWh

PROGRAM INPUT DATA			
		State Index Number	37
Cost Level Date	01/01/04	State Location	OK
Single Unit Capacity	150	H-W Index Region No.	4
Capacity Factor	0.20	ROW ($/acre)	2449
Transformer Voltage	230	Clearing % of ROW	0.60
Transformer MVA	200	Receiving Sub. Land Cost	23033
No. of Transformers	1	Plant Investment	740
No. of Transformer Positions	1	FC Moving-Avg. Time Frame	60
Single or Three Phase	3	Fuel Cost	430.8
Length Line 1	0	Heat Rate	8030
Length Line 2	0	Variable O&M	0.97
Line 1: Total Circuits	0	Fixed O&M	45.73
No. of Single Circuit	0	O&M Update	2.83
No. of Double Circuit	0	Plant Update	2.41
Line 2: Total Circuits	0	Transmission Update	2.22
No. of Single Circuit	0	Depreciation Plant (%)	1.41
No. of Double Circuit	0	Depreciation Substation (%)	1.41
		Depreciation Trans. Tower (%)	0.42
Cost of Money (%)	5.375	Depreciation Trans. Pole (%)	1.41
Plant Life	30		
Substation Life	30	Federal Income Tax (%)	0.000
Transmission (Towers) Life	50	Federal Misc. Tax (%)	0.000
Transmission (Poles) Life	30	State & Local Tax (%)	0.000
Plant Insurance (%)	0.25	Hydro Flexibility Adjustment	0.025
Transmission Insurance (%)	0.10	Alt. Mechanical Avail.	0.900
Substation Insurance (%)	0.25	Hydro Mechanical Avail.	0.980
		Mechanical Avail. Adjust.	0.089

COMBUSTION TURBINE POWER VALUE
Date Run: 12/15/04

PROJECT NAME: ARKANSAS RIVER
LOCATION: SPP – AR, MO, OK
FINANCING: FEDERAL @ **5.375** %

Capacity Value $**62.18** per kW-yr Energy Value $**55.12** per MWh

PROGRAM INPUT DATA			
		State Index Number	4
Cost Level Date	01/01/04	State Location	AR
Single Unit Capacity	100	H-W Index Region No.	4
Capacity Factor	0.10	ROW ($/acre)	2319
Transformer Voltage	230	Clearing % of ROW	0.60
Transformer MVA	125	Receiving Sub. Land Cost	21869
No. of Transformers	2	Plant Investment	457
No. of Transformer Positions	2	FC Moving-Avg. Time Frame	60
Single or Three Phase	3	Fuel Cost	442.0
Length Line 1	0	Heat Rate	12870
Length Line 2	0	Variable O&M	0.24
Line 1: Total Circuits	2	Fixed O&M	15.01
No. of Single Circuit	2	O&M Update	2.83
No. of Double Circuit	0	Plant Update	2.41
Line 2: Total Circuits	0	Transmission Update	2.22
No. of Single Circuit	0	Depreciation Plant (%)	1.41
No. of Double Circuit	0	Depreciation Substation (%)	1.41
		Depreciation Trans. Tower (%)	0.42
Cost of Money (%)	5.375	Depreciation Trans. Pole (%)	1.41
Plant Life	30		
Substation Life	30	Federal Income Tax (%)	0.000
Transmission (Towers) Life	50	Federal Misc. Tax (%)	0.000
Transmission (Poles) Life	30	State & Local Tax (%)	0.000
Plant Insurance (%)	0.25	Hydro Flexibility Adjustment	0.025
Transmission Insurance (%)	0.10	Alt. Mechanical Avail.	0.900
Substation Insurance (%)	0.25	Hydro Mechanical Avail.	0.980
		Mechanical Avail Adjust.	0.089

COMBUSTION TURBINE POWER VALUE
Date Run: 12/15/04

PROJECT NAME: ARKANSAS RIVER
LOCATION: SPP – AR, MO, OK
FINANCING: FEDERAL @ **5.375** %

Capacity Value $**62.95** per kW-yr Energy Value $**55.22** per MWh

PROGRAM INPUT DATA			
		State Index Number	26
Cost Level Date	01/01/04	State Location	MO
Single Unit Capacity	100	H-W Index Region No.	3
Capacity Factor	0.10	ROW ($/acre)	2319
Transformer Voltage	230	Clearing % of ROW	0.60
Transformer MVA	125	Receiving Sub. Land Cost	21869
No. of Transformers	2	Plant Investment	484
No. of Transformer Positions	2	FC Moving-Avg. Time Frame	60
Single or Three Phase	3	Fuel Cost	427.2
Length Line 1	0	Heat Rate	12870
Length Line 2	0	Variable O&M	0.24
Line 1: Total Circuits	2	Fixed O&M	15.01
No. of Single Circuit	2	O&M Update	2.83
No. of Double Circuit	0	Plant Update	2.67
Line 2: Total Circuits	0	Transmission Update	2.64
No. of Single Circuit	0	Depreciation Plant (%)	1.41
No. of Double Circuit	0	Depreciation Substation (%)	1.41
		Depreciation Trans. Tower (%)	0.42
Cost of Money (%)	5.375	Depreciation Trans. Pole (%)	1.42
Plant Life	30		
Substation Life	30	Federal Income Tax (%)	0.000
Transmission (Towers) Life	50	Federal Misc. Tax (%)	0.000
Transmission (Poles) Life	30	State & Local Tax (%)	0.000
Plant Insurance (%)	0.25	Hydro Flexibility Adjustment	0.025
Transmission Insurance (%)	0.10	Alt. Mechanical Avail.	0.900
Substation Insurance (%)	0.25	Hydro Mechanical Avail.	0.980
		Mechanical Avail Adjust.	0.089

COMBUSTION TURBINE POWER VALUE
Date Run: 12/15/04

PROJECT NAME: ARKANSAS RIVER
LOCATION: SPP – AR, MO, OK
FINANCING: FEDERAL @ **5.375** %

Capacity Value $**62.18** per kW-yr Energy Value $**55.68** per MWh

PROGRAM INPUT DATA			
		State Index Number	37
Cost Level Date	01/01/04	State Location	OK
Single Unit Capacity	100	H-W Index Region No.	4
Capacity Factor	0.10	ROW ($/acre)	2319
Transformer Voltage	230	Clearing % of ROW	0.60
Transformer MVA	125	Receiving Sub. Land Cost	21869
No. of Transformers	2	Plant Investment	479
No. of Transformer Positions	2	FC Moving-Avg. Time Frame	60
Single or Three Phase	3	Fuel Cost	430.8
Length Line 1	0	Heat Rate	12870
Length Line 2	0	Variable O&M	0.24
Line 1: Total Circuits	2	Fixed O&M	15.01
No. of Single Circuit	2	O&M Update	2.83
No. of Double Circuit	0	Plant Update	2.42
Line 2: Total Circuits	0	Transmission Update	2.16
No. of Single Circuit	0	Depreciation Plant (%)	1.41
No. of Double Circuit	0	Depreciation Substation (%)	1.41
		Depreciation Trans. Tower (%)	0.42
Cost of Money (%)	5.375	Depreciation Trans. Pole (%)	1.41
Plant Life	30		
Substation Life	30	Federal Income Tax (%)	0.000
Transmission (Towers) Life	50	Federal Misc. Tax (%)	0.000
Transmission (Poles) Life	30	State & Local Tax (%)	0.000
Plant Insurance (%)	0.25	Hydro Flexibility Adjustment	0.025
Transmission Insurance (%)	0.10	Alt. Mechanical Avail.	0.900
Substation Insurance (%)	0.25	Hydro Mechanical Avail.	0.980
		Mechanical Avail Adjust.	0.089

ADDENDUM A2

PROSYM Output Summaries

ARKANSAS RIVER : GENSUM TABLE
8/13/02
STUDY YR. JAN 2005

System with Arkansas River Hydro

Type of Plant	Energy (GWh)	Cost ($1000)	mills/kwh	Capacity	PF
1 Natural Gas	16,644.2	519,934	31.24	8,005	23.8%
2 Coal Southeast	14,464.9	291,481	20.15	2,382	69.5%
3 FO #2	54.0	11,601	214.83	1,545	0.4%
4 INTLOAD	0.0	0	0.00	0	0.0%
5 Coal	4,187.0	69,114	16.51	611	78.4%
6 NG ENTERGY	55,867.4	1,591,098	28.48	21,901	29.2%
7 Nuclear	39,460.8	722,900	18.32	5,058	89.3%
8 DCLM	0.0	0	0.00	0	0.0%
9 Coal ENTR	27,570.6	495,427	17.97	3,839	82.2%
10 NG Central SPP	27,375.1	781,730	28.56	10,411	30.1%
11 Coal Central	67,141.4	970,695	14.46	9,828	78.2%
12 WhtArkThrRep	0.0	0	0.00	0	0.0%
13 NG North SPP	4,041.3	117,290	29.02	2,162	21.4%
14 Coal North	56,844.0	757,081	13.32	8,331	78.1%
15 FO #6	0.0	0	0.00	0	0.0%
16 Wind	240.9	5,656	23.48	28	100.0%
17 NG ENTR	9.8	816	83.27	102	1.1%
18 Pump Storage	371.2	742	2.00	447	9.5%
19 Hydro	5,357.9	26,789	5.00	1,737	35.3%
20 HydroStudy	3,118.3	15,592	5.00	1,041	34.3%
21 Transaction	-336.8	1,613	-4.79	-107	36.2%
Totals	314,272.6	6,335,565	20.16	74,652	48.1%
Unserved Energy	0.0	3	0.00	--	--
Net Total	314,272.6	6,335,568	20.16	--	--

System without Arkansas River Hydro

Type of Plant	Energy (GWh)	Cost ($1000)	mills/kwh	Capacity	PF	Ch Enrgy	Ch Cost	mills/kWh	% C Sav	% E Sav	mills/kWh component
1 Natural Gas	16,731.3	522,595	31.23	8,013	23.9%	87.1	2,661	30.55	3	3	0.85
2 Coal Southeast	14,457.9	291,355	20.15	2,381	69.5%	-7.0	-126	18.00	0	0	-0.04
3 FO #2	54.2	11,611	214.23	1,551	0.4%	0.2	10	50.00	0	0	0.00
4 INTLOAD	0.0	0	0.00	0	0.0%	0.0	0	0.00	0	0	0.00
5 Coal	4,186.9	69,118	16.51	611	78.4%	-0.1	4	-40.00	0	0	0.00
6 NG ENTERGY	55,872.3	1,591,210	28.48	21,903	29.2%	4.9	112	0.00	0	0	0.00
7 Nuclear	39,460.8	722,900	18.32	5,058	89.3%	0.0	0	0.00	0	0	0.00
8 DCLM	0.0	0	0.00	0	0.0%	0.0	0	0.00	0	0	0.00
9 Coal ENTR	27,573.7	495,474	17.97	3,840	82.2%	3.1	47	15.16	0	0	0.01
10 NG Central SPP	28,179.7	804,940	28.56	10,439	30.9%	804.6	23,210	28.85	28	26	7.39
11 Coal Central	67,170.6	971,149	14.46	9,820	78.3%	29.2	454	15.55	1	1	0.14
12 WhtArkThrRep	2,072.7	55,622	26.84	1,045	22.7%	2,072.7	55,622	26.84	66	66	17.72
13 NG North SPP	4,071.3	118,062	29.00	2,158	21.6%	30.0	772	25.73	1	1	0.25
14 Coal North	56,944.4	758,372	13.32	8,325	78.3%	100.4	1,291	12.86	2	3	0.41
15 FO #6	0.0	0	0.00	0	0.0%	0.0	0	0.00	0	0	0.00
16 Wind	240.9	5,656	23.48	28	100.0%	0.0	0	0.00	0	0	0.00
17 NG ENTR	10.4	836	80.38	108	1.1%	0.6	20	33.33	0	0	0.01
18 Pump Storage	385.6	771	2.00	446	9.9%	14.4	29	2.01	0	0	0.01
19 Hydro	5,357.9	26,789	5.00	1,737	35.3%	0.0	0	0.00	0	0	0.00
20 HydroStudy	0.0	0	0.00	0	0.0%	-3,118.3	-15,592	5.00	-19	-99	-4.97
21 Transaction	-336.8	1,613	-4.79	-107	36.2%	0.0	0	0.00	0	0	0.00
Totals	317,412.7	6,419,671	20.22	75,726	47.8%	3,140.1	84,106	26.97	100	3	26.75
Unserved Energy	0.0	0	0.00	--	--	0.0	0	0.00		--	--
Net Total	317,412.7	6,419,671	20.22	--	--	3,140.1	84,106	26.97		--	--

HYDROPOWER ENERGY VALUE: 26.97 mills/kWh

HYDROPOWER ENERGY BENEFIT: 84,106

ARKANSAS RIVER : GENSUM TABLE
8/13/02
STUDY YR. JAN 2010

System with Arkansas River Hydro

Type of Plant	Energy (GWh)	Cost ($1000)	mills/kwh	Capacity	PF
1 Natural Gas	25,917.6	796,568	30.73	10,266	28.9%
2 Coal Southeast	15,488.2	308,487	19.92	2,383	74.4%
3 FO #2	121.3	13,717	113.08	1,543	0.9%
4 INTLOAD	0.0	7	0.00	0	0.0%
5 Coal	3,381.0	56,105	16.59	551	70.3%
6 NG ENTERGY	68,559.5	2,021,385	29.48	20,984	37.4%
7 Nuclear	38,747.8	699,369	18.05	5,057	87.7%
8 DCLM	0.0	0	0.00	0	0.0%
9 Coal ENTR	28,211.3	507,865	18.00	3,840	84.1%
10 NG Central SPP	32,230.5	955,688	29.65	10,756	34.3%
11 Coal Central	68,084.8	986,687	14.49	9,828	79.3%
12 WhtArkThrRep	0.0	0	0.00	0	0.0%
13 NG North SPP	8,963.9	262,257	29.26	3,247	31.6%
14 Coal North	57,036.8	757,140	13.27	8,192	79.7%
15 Wind	240.9	5,656	23.48	28	100.0%
16 NG ENTR	29.4	1,720	58.50	105	3.2%
17 Pump Storage	428.7	857	2.00	446	11.0%
18 Hydro	5,358.3	26,791	5.00	1,738	35.3%
19 HydroStudy	3,118.3	15,592	5.00	1,041	34.3%
20 Transaction	-380.3	1,612	-4.24	-101	42.9%
Totals	352,800.0	7,400,299	20.98	78,963	51.0%
Unserved Energy	0.0	0	0.00	--	--
Net Total	352,800.0	7,400,299	20.98	--	--

System without Arkansas River Hydro

Type of Plant	Energy (GWh)	Cost ($1000)	mills/kwh	Capacity	PF	Ch Enrgy	Ch Cost	mills/kWh	% C Sav	% E Sav	mills/kWh component
1 Natural Gas	25,924.6	797,228	30.75	10,268	28.9%	7.0	660	94.29	1	0	0.21
2 Coal Southeast	15,496.0	308,616	19.92	2,381	74.5%	7.8	129	16.54	0	0	0.04
3 FO #2	119.8	13,640	113.86	1,524	0.9%	-1.5	-77	51.33	0	0	-0.02
4 INTLOAD	0.0	0	0.00	0	0.0%	0.0	-7	0.00	0	0	0.00
5 Coal	3,380.8	56,104	16.59	550	70.3%	-0.2	-1	5.00	0	0	0.00
6 NG ENTERGY	68,499.3	2,019,982	29.49	20,965	37.4%	-60.2	-1,403	0.00	-2	-2	0.00
7 Nuclear	38,747.8	699,369	18.05	5,057	87.7%	0.0	0	0.00	0	0	0.00
8 DCLM	0.0	0	0.00	0	0.0%	0.0	0	0.00	0	0	0.00
9 Coal ENTR	28,216.5	507,946	18.00	3,841	84.1%	5.2	81	15.58	0	0	0.03
10 NG Central SPP	32,614.6	966,173	29.62	10,759	34.7%	384.1	10,485	27.30	12	12	3.35
11 Coal Central	68,131.6	987,480	14.49	9,822	79.4%	46.8	793	16.94	1	1	0.25
12 WhtArkThrRep	2,733.7	74,527	27.26	1,047	29.9%	2,733.7	74,527	27.26	88	87	23.81
13 NG North SPP	8,910.9	260,966	29.29	3,238	31.5%	-53.0	-1,291	24.36	-2	-2	-0.41
14 Coal North	57,097.7	757,895	13.27	8,190	79.8%	60.9	755	12.40	1	2	0.24
15 Wind	240.9	5,656	23.48	28	100.0%	0.0	0	0.00	0	0	0.00
16 NG ENTR	29.4	1,716	58.37	105	3.2%	0.0	-4	0.00	0	0	0.00
17 Pump Storage	453.8	908	2.00	448	11.6%	25.1	51	2.03	0	1	0.02
18 Hydro	5,358.3	26,791	5.00	1,738	35.3%	0.0	0	0.00	0	0	0.00
19 HydroStudy	0.0	0	0.00	0	0.0%	-3,118.3	-15,592	5.00	-18	-100	-4.98
20 Transaction	-380.3	1,612	-4.24	-101	42.9%	0.0	0	0.00	0	0	0.00
Totals	355,955.7	7,484,997	21.03	79,961	50.8%	3,155.7	84,698	27.16	100	-2	22.53
Unserved Energy	0.0	0	0.00	--	--	0.0	0	0.00		--	--
Net Total	355,955.7	7,484,997	21.03	--	--	3,155.7	84,698	27.16		--	--

HYDROPOWER ENERGY VALUE: 27.16 mills/kWh

HYDROPOWER ENERGY BENEFIT: 84,698

ARKANSAS RIVER : GENSUM TABLE
8/13/02
STUDY YR. JAN 2015

System with Arkansas River Hydro

Type of Plant	Energy (GWh)	Cost ($1000)	mills/kwh	Capacity	PF
1 Natural Gas	44,550.2	1,316,690	29.56	13,672	37.3%
2 Coal Southeast	16,037.9	318,167	19.84	2,381	77.1%
3 INTLOAD	2.5	373	149.20	0	0.0%
4 FO #2	71.7	10,526	146.81	1,368	0.6%
5 Coal	3,894.9	63,859	16.40	550	81.0%
6 NG ENTERGY	81,873.3	2,531,313	30.92	21,846	42.9%
7 Nuclear	37,580.5	672,969	17.91	5,055	85.1%
8 DCLM	0.0	0	0.00	0	0.0%
9 Coal ENTR	26,802.1	485,248	18.10	3,840	79.9%
10 NG Central SPP	28,979.8	884,998	30.54	10,531	31.5%
11 Coal Central	66,425.2	964,921	14.53	9,824	77.4%
12 WhtArkThrRep	0.0	0	0.00	0	0.0%
13 NG North SPP	21,117.1	634,291	30.04	7,027	34.4%
14 Coal North	56,345.5	739,986	13.13	7,924	81.4%
15 Wind	240.9	5,656	23.48	28	100.0%
16 NG ENTR	12.9	974	75.50	105	1.4%
17 Pump Storage	478.6	957	2.00	445	12.3%
18 Hydro	5,358.7	26,794	5.00	1,738	35.3%
19 HydroStudy	3,118.3	15,592	5.00	1,041	34.3%
20 Transaction	-380.1	1,608	-4.23	-101	43.0%
Totals	389,771.8	8,657,722	22.21	86,334	51.5%
Unserved Energy	0.0	0	0.00	--	--
Net Total	389,771.8	8,657,722	22.21	--	--

System without Arkansas River Hydro

Type of Plant	Energy (GWh)	Cost ($1000)	mills/kwh	Capacity	PF	Ch Enrgy	Ch Cost	mills/kWh	% C Sav	% E Sav	mills/kWh component
1 Natural Gas	44,385.5	1,312,400	29.57	13,658	37.2%	-164.7	-4,290	26.05	-5	-5	0.00
2 Coal Southeast	16,052.3	318,415	19.84	2,380	77.2%	14.4	248	17.22	0	0	0.08
3 INTLOAD	2.6	393	151.15	0	0.0%	0.1	20	200.00	0	0	0.01
4 FO #2	66.5	10,229	153.82	1,522	0.5%	-5.2	-297	57.12	0	0	-0.09
5 Coal	3,896.1	63,877	16.40	551	81.0%	1.2	18	15.00	0	0	0.01
6 NG ENTERGY	81,895.4	2,531,829	30.92	21,852	42.9%	22.1	516	0.00	1	1	0.00
7 Nuclear	37,580.5	672,969	17.91	5,055	85.1%	0.0	0	0.00	0	0	0.00
8 DCLM	0.0	0	0.00	0	0.0%	0.0	0	0.00	0	0	0.00
9 Coal ENTR	26,809.2	485,360	18.10	3,841	79.9%	7.1	112	15.77	0	0	0.04
10 NG Central SPP	29,455.6	899,454	30.54	10,537	32.0%	475.8	14,456	30.38	16	15	4.62
11 Coal Central	66,469.9	965,649	14.53	9,818	77.5%	44.7	728	16.29	1	1	0.23
12 WhtArkThrRep	2,712.8	76,494	28.20	1,046	29.7%	2,712.8	76,494	28.20	87	87	24.43
13 NG North SPP	21,086.6	633,604	30.05	7,017	34.4%	-30.5	-687	22.52	-1	-1	-0.22
14 Coal North	56,399.9	740,653	13.13	7,922	81.5%	54.4	667	12.26	1	2	0.21
15 Wind	240.9	5,656	23.48	28	100.0%	0.0	0	0.00	0	0	0.00
16 NG ENTR	12.2	943	77.30	107	1.3%	-0.7	-31	44.29	0	0	-0.01
17 Pump Storage	507.2	1,014	2.00	447	13.0%	28.6	57	1.99	0	1	0.02
18 Hydro	5,358.7	26,794	5.00	1,738	35.3%	0.0	0	0.00	0	0	0.00
19 HydroStudy	0.0	0	0.00	0	0.0%	-3,118.3	-15,592	5.00	-18	-100	-4.98
20 Transaction	-380.1	1,608	-4.23	-101	43.0%	0.0	0	0.00	0	0	0.00
Totals	392,931.9	8,745,733	22.26	87,516	51.3%	3,160.1	88,011	28.22	100	-4	29.31
Unserved Energy	0.1	600	6,000.00	--	--	0.1	600	6,000.00		--	--
Net Total	392,932.0	8,746,333	22.26	--	--	3,160.2	88,611	28.42		--	--

HYDROPOWER ENERGY VALUE: 28.42 mills/kWh

HYDROPOWER ENERGY BENEFIT: 88,611

ARKANSAS RIVER : GENSUM TABLE
8/13/02
STUDY YR. JAN 2020

System with Arkansas River Hydro

Type of Plant	Energy (GWh)	Cost ($1000)	mills/kwh	Capacity	PF
1 Natural Gas	59,882.9	1,830,187	30.56	16,129	42.5%
2 Coal Southeast	16,176.6	320,641	19.82	2,389	77.5%
3 INTLOAD	0.1	12	120.00	0	0.0%
4 FO #2	42.0	8,683	206.74	1,603	0.3%
5 Coal	3,567.3	58,839	16.49	552	74.0%
6 NG ENTERGY	97,949.9	3,092,598	31.57	24,861	45.1%
7 Nuclear	37,185.9	660,672	17.77	5,073	83.9%
8 DCLM	0.0	0	0.00	0	0.0%
9 Coal ENTR	29,231.5	523,222	17.90	3,851	86.9%
10 NG Central SPP	25,382.1	815,933	32.15	10,527	27.6%
11 Coal Central	67,793.1	986,039	14.54	9,848	78.8%
12 WhtArkThrRep	0.0	0	0.00	0	0.0%
13 NG North SPP	35,122.2	1,087,663	30.97	10,362	38.8%
14 Coal North	52,678.6	691,037	13.12	7,556	79.8%
15 Wind	241.6	5,672	23.48	28	100.0%
16 NG ENTR	11.5	952	82.78	101	1.3%
17 Pump Storage	540.7	1,081	2.00	449	13.8%
18 Hydro	5,358.7	26,794	5.00	1,743	35.2%
19 HydroStudy	3,118.3	15,592	5.00	1,041	34.3%
20 Transaction	-378.5	1,606	-4.24	-101	42.8%
Totals	431,164.7	10,110,025	23.45	95,071	51.8%
Unserved Energy	0.0	0	0.00	--	--
Net Total	431,164.7	10,110,025	23.45	--	--

System without Arkansas River Hydro

Type of Plant	Energy (GWh)	Cost ($1000)	mills/kwh	Capacity	PF	Ch Enrgy	Ch Cost	mills/kWh	% C Sav	% E Sav	mills/kWh component
1 Natural Gas	59,705.6	1,826,143	30.59	16,157	42.3%	-177.3	-4,044	22.81	-4	-6	0.00
2 Coal Southeast	16,196.5	320,971	19.82	2,389	77.6%	19.9	330	16.58	0	1	0.11
3 INTLOAD	0.1	13	130.00	0	0.0%	0.0	1	0.00	0	0	0.00
4 FO #2	43.6	8,780	201.38	1,664	0.3%	1.6	97	60.62	0	0	0.03
5 Coal	3,570.8	58,890	16.49	552	74.0%	3.5	51	14.57	0	0	0.02
6 NG ENTERGY	97,976.2	3,093,347	31.57	24,867	45.1%	26.3	749	0.00	1	1	0.00
7 Nuclear	37,185.9	660,672	17.77	5,073	83.9%	0.0	0	0.00	0	0	0.00
8 DCLM	0.0	0	0.00	0	0.0%	0.0	0	0.00	0	0	0.00
9 Coal ENTR	29,238.0	523,329	17.90	3,851	86.9%	6.5	107	16.46	0	0	0.03
10 NG Central SPP	26,130.1	839,003	32.11	10,532	28.4%	748.0	23,070	30.84	25	24	7.37
11 Coal Central	67,850.1	986,986	14.55	9,844	78.9%	57.0	947	16.61	1	2	0.30
12 WhtArkThrRep	2,387.0	71,153	29.81	1,047	26.1%	2,387.0	71,153	29.81	76	76	22.72
13 NG North SPP	35,106.9	1,087,505	30.98	10,357	38.8%	-15.3	-158	10.33	0	0	-0.05
14 Coal North	52,752.5	691,960	13.12	7,558	79.9%	73.9	923	12.49	1	2	0.29
15 Wind	241.6	5,672	23.48	28	100.0%	0.0	0	0.00	0	0	0.00
16 NG ENTR	11.8	964	81.69	104	1.3%	0.3	12	40.00	0	0	0.00
17 Pump Storage	566.8	1,134	2.00	447	14.5%	26.1	53	2.03	0	1	0.02
18 Hydro	5,358.7	26,794	5.00	1,743	35.2%	0.0	0	0.00	0	0	0.00
19 HydroStudy	0.0	0	0.00	0	0.0%	-3,118.3	-15,592	5.00	-17	-100	-4.98
20 Transaction	-378.5	1,606	-4.24	-101	42.8%	0.0	0	0.00	0	0	0.00
Totals	434,322.2	10,203,316	23.49	96,214	51.5%	3,157.5	93,291	29.92	100	-4	30.84
Unserved Energy	0.0	7	0.00	--	--	0.0	0	0.00		--	--
Net Total	434,322.2	10,203,323	23.49	--	--	3,157.5	93,291	29.92		--	--

HYDROPOWER ENERGY VALUE: 29.92 mills/kWh

HYDROPOWER ENERGY BENEFIT: 93,291

ARKANSAS RIVER : GENSUM TABLE
8/13/02
STUDY YR. JAN 2025

System with Arkansas River Hydro

Type of Plant	Energy (GWh)	Cost ($1000)	mills/kwh	Capacity	PF
1 Natural Gas	77,239.1	2,432,260	31.49	19,561	45.2%
2 Coal Southeast	16,995.9	335,727	19.75	2,381	81.7%
3 INTLOAD	1.1	160	145.45	0	0.0%
4 Coal	3,843.0	63,087	16.42	551	79.9%
5 NG ENTERGY	124,075.4	3,953,546	31.86	30,478	46.6%
6 Nuclear	22,360.3	403,422	18.04	2,788	91.8%
7 DCLM	0.6	62	103.33	0	0.0%
8 Coal ENTR	27,484.3	496,064	18.05	3,841	81.9%
9 FO #2	38.3	7,777	203.05	1,461	0.3%
10 NG Central SPP	25,574.0	830,234	32.46	10,883	26.9%
11 Coal Central	67,216.6	979,280	14.57	9,827	78.3%
12 WhtArkThrRep	0.0	0	0.00	0	0.0%
13 NG North SPP	54,493.4	1,727,928	31.71	14,923	41.8%
14 Coal North	52,047.5	672,949	12.93	7,144	83.4%
15 Wind	240.9	5,656	23.48	28	100.0%
16 NG ENTR	10.7	944	88.22	102	1.2%
17 Pump Storage	590.3	1,181	2.00	447	15.1%
18 Hydro	5,359.0	26,795	5.00	1,738	35.3%
19 HydroStudy	3,118.3	15,592	5.00	1,041	34.3%
20 Transaction	-379.4	1,602	-4.22	-101	43.1%
Totals	477,570.4	11,937,072	25.00	106,152	51.4%
Unserved Energy	0.0	425	0.00	--	--
Net Total	477,570.4	11,937,497	25.00	--	--

System without Arkansas River Hydro

Type of Plant	Energy (GWh)	Cost ($1000)	mills/kwh	Capacity	PF	Ch Enrgy	Ch Cost	mills/kWh	% C Sav	% E Sav	mills/kWh component
1 Natural Gas	77,269.8	2,433,070	31.49	19,569	45.2%	30.7	810	26.38	1	1	0.26
2 Coal Southeast	17,009.5	335,971	19.75	2,380	81.8%	13.6	244	17.94	0	0	0.08
3 INTLOAD	1.1	161	146.36	0	0.0%	0.0	1	0.00	0	0	0.00
4 Coal	3,867.4	63,785	16.49	781	56.7%	24.4	698	28.61	1	1	0.22
5 NG ENTERGY	124,109.5	3,954,297	31.86	30,486	46.6%	34.1	751	22.02	1	1	0.24
6 Nuclear	22,360.3	403,422	18.04	2,788	91.8%	0.0	0	0.00	0	0	0.00
7 DCLM	0.6	62	103.33	0	0.0%	0.0	0	0.00	0	0	0.00
8 Coal ENTR	27,485.3	496,081	18.05	3,842	81.9%	1.0	17	17.00	0	0	0.01
9 FO #2	38.1	7,764	203.78	1,454	0.3%	-0.2	-13	65.00	0	0	0.00
10 NG Central SPP	26,253.8	851,657	32.44	10,889	27.6%	679.8	21,423	31.51	23	22	6.84
11 Coal Central	67,264.9	980,051	14.57	9,821	78.4%	48.3	771	15.96	1	2	0.25
12 WhtArkThrRep	2,266.7	69,174	30.52	816	31.8%	2,266.7	69,174	30.52	73	72	22.10
13 NG North SPP	54,488.4	1,727,767	31.71	14,922	41.8%	-5.0	-161	32.20	0	0	-0.05
14 Coal North	52,084.5	673,401	12.93	7,149	83.4%	37.0	452	12.22	0	1	0.14
15 Wind	240.9	5,656	23.48	28	100.0%	0.0	0	0.00	0	0	0.00
16 NG ENTR	10.8	949	87.87	103	1.2%	0.1	5	50.00	0	0	0.00
17 Pump Storage	613.4	1,227	2.00	447	15.7%	23.1	46	1.99	0	1	0.01
18 Hydro	5,359.0	26,795	5.00	1,738	35.3%	0.0	0	0.00	0	0	0.00
19 HydroStudy	0.0	0	0.00	0	0.0%	-3,118.3	-15,592	5.00	-17	-100	-4.98
20 Transaction	-379.4	1,602	-4.22	-101	43.1%	0.0	0	0.00	0	0	0.00
Totals	480,724.0	12,031,290	25.03	107,211	51.2%	3,153.6	94,218	30.21	100	3	30.10
Unserved Energy	0.0	425	0.00	--	--	0.0	0	0.00		--	--
Net Total	480,724.0	12,031,715	25.03	--	--	3,153.6	94,218	30.21		--	--

HYDROPOWER ENERGY VALUE: 30.21 mills/kWh

HYDROPOWER ENERGY BENEFIT: 94,218

ADDENDUM B1

Assessment of

Arkansas River Floodplain Data Requirements for

HEC-FDA

and

Marshall & Swift Residential Estimator

Table B1-1. Variables Collected or Derived for HEC-FDA input			
Variable	**Description**	**Importance**	**Source**
Struc_name	structure name	req. for HEC-FDA	unique, derived
account	tax db property id	req. for overall analysis	tax db
cat_name	type of damage category	req. for HEC-FDA	general damage category: RES, COM, EXEMPT, MISC-AG
Stream	stream name	req. for HEC-FDA	locational
Occ_Name	damage function type	req. for HEC-FDA	assigned based on type of residential or commercial structure
station	river mile for structure (numeric value)	req. for HEC-FDA	locational, assigned using GIS
BANK	left or right bank, looking downstream	req. for HEC-FDA	locational, assigned using GIS
yrblt	year built	informational for HEC-FDA	tax db
TOTVAL	tax db improvement value (mkt)	suppl. Info	tax db
Struc_val	replacement cost less depreciation	req. for HEC-FDA	Marshall & Swift estimate (actual or proxy)
cont_val	content value	req. for HEC-FDA	Estimated
oth_val	other property value	req. for HEC-FDA	Estimated
1F_stage	first floor elev, corrected for foundation ht.	req. for HEC-FDA	ground stage adjusted for foundation type
grnd_stage	elevation of structure foundation	req. for HEC-FDA	assigned using GIS
foundation	type of foundation	suppl info	tax db
SID_REACH	reach in which the structure lies	req. for HEC-FDA	locational, assigned using GIS
XVAL	x coordinant	informational for HEC-FDA	assigned using GIS
YVAL	y coordinant	informational for HEC-FDA	assigned using GIS
MSSOURCE	M&S value source	suppl info	actual, REG1, or NOINT
sec_no	nearest cross section name	suppl info	locational, assigned using GIS
owner	owner name	informational for HEC-FDA	tax db
PARCELZIP	zip code	suppl info	locational, assigned using GIS
COUNTY	county	suppl info	locational, assigned using GIS
luse	land use code	suppl info	tax db
zone	Coord. System zone	informational for HEC-FDA	locational, assigned using GIS
legal	legal description	suppl info	tax db

Table B1-2. Variables Collected or Derived for Marshall and Swift Cost Estimator
structure id
owner name
zip code
occupancy type such as single family, multi-family
number of stories
quality of construction: poor, average, economy, good, luxury
Condition: worn out to excellent
foundation type
exterior wall type
effective age
total floor area
roofing material
heating/cooling type
garage: attached/detached sq. ft
carport if applicable
porch: type and sq. ft.

ADDENDUM B2

Oklahoma GAP Analysis
Key To Land Use Classifications

Table B2-1. Oklahoma GAP Analysis Classification Codes	
Code	**Classification**
5	Shortleaf Pine Forest
6	Shortleaf Pine - Oak Forest
7	Loblolly Pine Forest
8	Loblolly Pine - Oak Forest
14	Oak - Hickory - Pine Forests
15	Oak - Pine Forests
16	Oak - Cedar Forests
19	Eastern Crosstimbers
20	Central Crosstimbers
21	Western Crosstimbers
22	White Oak - Hickory Forests
28	Western Bottomland Forests
29	Central Bottomland Forests
30	Eastern Bottomland Forests
31	East Central Bottomland Forests
42	Pine - Oak Woodland
44	One-seed Juniper Woodland
51	Eastern Red Cedar Woodland
52	Eastern Red Cedar - Oak Woodland
56	Oak - Pine Woodland
59	Oak Woodland
67	Sandsage Prairie
71	Shinnery Oak Shrubland
80	Mesquite Shrubland
85	Tallgrass Oak Savanna
91	Tall Grass Prairie
102	Midgrass Oak Savanna
104	Gypsum Grasslands
107	Midgrass Sand Prairie
109	Midgrass Sandsage Prairie
112	Midgrass Prairie
116	Shrub layer of deciduous thorny shrubs
117	Mesquite Savanna
120	Grama - Buffalograss Prairie
134	Barren - a majority of ground is bare
135	Dry salt flats
136	Sandy areas
145	Agriculture
147	Crop - Warm Season
149	Improved/Introduced Pasture; Warm Season
153	Residential/Industrial
156	Riverine
157	Lake/Reservoir
158	Pond
160	Loblolly Pine For.- Planted/Cultivated
162	Tallgrass Cedar Savanna
163	Sandsage Savanna

ADDENDUM B3

Sample HEC-FDA and AGDAM Input Data Developed

Table B3-1. Sample Portion of Final HEC-FDA Input Data				
Struc_Name	**Account**	**Cat_Name**	**Stream**	**Occ_Name**
ROGR-CM-284.00	24553	COMM	Verdigris	RCS
ROGR-CM-285.00	14899	COMM	Verdigris	RCS
ROGR-CM-288.00	14908	COMM	Verdigris	CGS
ROGR-CM-289.00	11425	COMM	Verdigris	TES
ROGR-CM-290.00	10357	COMM	Verdigris	AUS
station	**BANK**	**yrblt**	**TOTVAL**	**Struc_val**
444.440	right	1950	$38,546	$53,662
444.000	left	1970	$49,776	$66,133
444.440	left	1981	$93,094	$114,238
440.590	left	0000	$100,033	$121,944
444.000	left	0000	$145,955	$172,941
cont_val	**oth_val**	**1F_stage**	**grnd_stage**	**foundation**
			568	assume slab
			559	assume slab
			573	assume slab
			568	assume slab
			568	assume slab
SID_REACH	**XVAL**	**YVAL**	**MSSOURCE**	**sec_no**
Verdg4-ROG	253354.695066	4008556.683937	REG1	lowervg-444.44
Verdg4-ROG	255647.794193	4010537.122556	REG1	lowervg-444.00
Verdg4-ROG	255046.504725	4010817.830106	REG1	lowervg-444.44
Verdg4-ROG	259546.544904	4011846.842087	REG1	lowervg-440.59
Verdg4-ROG	257267.436803	4012390.765296	REG1	lowervg-444.00
owner	**PARCELZIP**	**COUNTY**	**luse**	**Zone**
POORBOY, WILLIAM G	74015	Rogers	Urban Commercial	15
MOORE, JOE T	74015	Rogers	Rural Commercial	15
ROGERS TERMINAL INC	74017	Rogers	Rural Commercial	15
U.S. CELLULAR	74017	Rogers	Rural Commercial	15
TIME AUTO PARTS, INC	74017	Rogers	Rural Commercial	15
Legal				
020010-013002-000000	***29-20 -15 *** ALL LOT 1 & 2 LESS S 67' LOT 2& VAC. ROLLINS ST			
50116C-000200-000000	***16-20 -15 *** TR IN LOT 4, BEG: AT SW/C SEC,E ALG S BOUND OF SE/C 287.50'			
50116C-000600-000000	***16-20 -15 *** ALL TH PT OF LOT 3 LYING W OFHWY 66 LESS TR			
50111C-000300-000000	***11-20 -15 *** SW SW SW LESS .81 AC TO TPK			
50110B-000200-000000	***10-20 -15 *** TR IN PT SE NW & PT NE SW, BEG67.92' N SE/C SE NW, SD PT			

Table B3-2. Sample AGDAM Input Data Developed .

```
T1 Arkansas River, LOWER SECTION
T2 SEQUOYAH, LEFLORE, HASKELL AND PART OF MUSKOGEE COUNTIES
T3  EXISTING CONDITIONS
CR  ALF1    5.00    TONS   78.13       0     100     110     111  113.76
CT     1     110     111     135     151     161     181     196     197     212
CT   243     258     259     273     304     319     320     365
CB  0.22    0.22    0.67    0.67    0.52    0.52    0.52    0.52    0.40    0.40
CB  0.40    0.40    0.30    0.30    0.30    0.30    0.22    0.22    0.00    0.00
CD     0       1       5
C1  0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
C1  0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
C2  0.25    0.25    0.25    0.25    0.25    0.25    0.25    0.25    0.25    0.25
C2  0.25    0.25    0.25    0.25    0.25    0.25    0.25    0.25    0.00    0.00
C3  1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00
C3  1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    0.00    0.00
CR  PEC1    8.00     CWT   75.00    274     290     300  147.00
CT     1      90     180     274     290     300     310     325     340     345
CB  0.00    0.00    0.00    0.57    0.57    0.55    0.40    0.20    0.00    0.00
CD     0       1       2       3       4       5       6       7
C1  0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
C2  0.00    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.00    0.00
C3  0.00    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.00    0.00
C4  0.00    0.30    0.30    0.30    0.30    0.30    0.30    0.30    0.00    0.00
C5  0.00    0.40    0.40    0.40    0.40    0.40    0.40    0.40    0.00    0.00
C6  0.00    0.50    0.50    0.50    0.50    0.50    0.50    0.50    0.00    0.00
CR CORN1   90.00      BU    2.63       0     135     227     230   28.92
CT     1      31      59      90     120     135     140     145     151     152
CT   273     283     293     304     314     324     334
CB  0.00    0.04    0.11    0.20    0.25    0.27    0.35    0.47    0.57    0.80
CB  0.80    0.67    0.54    0.40    0.27    0.13    0.00    0.00    0.00    0.00
CD     0       1       2       3       4
C1  1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    0.25    0.25
C1  0.25    0.25    0.25    0.25    0.25    0.25    1.00    0.00    0.00    0.00
C2  1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    0.51    0.51
C2  0.51    0.51    0.51    0.51    0.51    0.51    1.00    0.00    0.00    0.00
C3  1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    0.75    0.75
C3  0.75    0.75    0.75    0.75    0.75    0.75    1.00    0.00    0.00    0.00
C4  1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00
C4  1.00    1.00    1.00    1.00    1.00    1.00    1.00    0.00    0.00    0.00
CR SVEG1    6.00    TONS  120.00       0      67      70      72   35.00
CT     1      20      31      46      56      59      63      67      69      70
CT   105     120     135     151     161     166     176
CB  0.00    0.02    0.03    0.04    0.05    0.08    0.10    0.15    0.22    0.43
CB  0.43    0.43    0.34    0.21    0.13    0.09    0.00    0.00    0.00    0.00
CD     0       1       2
C1  0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
C1  0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
C2  0.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    0.50    0.50
C2  0.50    0.50    0.50    0.50    0.50    0.50    1.00    0.00    0.00    0.00
C3  0.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    0.75    0.75
C3  0.75    0.75    0.75    0.75    0.75    0.75    1.00    0.00    0.00    0.00
CR  COT1  750.00     LBS    0.63       0      91     305     310   90.00
CT     1      69      90     110     134     144     151     152     243     263
CT   273     293     304     324
CB  0.00    0.08    0.10    0.12    0.30    0.40    0.56    0.62    0.62    0.40
CB  0.30    0.14    0.07    0.00    0.00    0.00    0.00    0.00    0.00    0.00
CD     0       1       2       3       4
C1  0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
C1  0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
C2  0.00    0.08    0.10    0.12    0.30    0.25    0.25    0.25    0.25    0.25
C2  0.25    0.25    0.25    0.00    0.00    0.00    0.00    0.00    0.00    0.00
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C3  0.00    0.08    0.10    0.12    0.30    0.50    0.50    0.50    0.50    0.50
C3  0.50    0.50    0.50    0.00    0.00    0.00    0.00    0.00    0.00    0.00
C4  0.00    0.08    0.10    0.12    0.30    0.75    0.75    0.75    0.75    0.75
C4  0.75    0.75    0.75    0.00    0.00    0.00    0.00    0.00    0.00    0.00
C5  0.00    0.08    0.10    0.12    0.30    1.00    1.00    1.00    1.00    1.00
CR  WHT1      29  BUSHEL    3.31    335     166     170   16.59
CT     1     31     51     90    107    120    135    151    196    227
CT   237    253    293    365
CB    .3     .3     .3     .3     .4    .52    .69    .69      0    .08
CB   .13    .16     .3     .3
CD     0      1      2      3      4
C1     0      0      0      0      0      0      0      0      0      0
C1     0      0      0      0
C2   .25    .25    .25     .5     .5     .5      1      1      0      1
C2     1      1    .25    .25
C3   .25     .5     .5     .5     .5     .5      1      1      0      1
C3     1      1     .5     .5
C4   .75    .75    .75    .75    .75    .75      1      1      0      1
C4     1      1    .75    .75
C5     1      1      1      1      1      1      1      1      0      1
C5     1      1      1      1
CRWHTWD1      10  BUSHEL    3.31    335     166     170    33.1
CT     1     31     51     90    107    120    135    151    196    227
CT   237    253    293    365
CB    .3     .3     .3     .3     .4    .52    .69    .69      0    .08
CB   .13    .16     .3     .3
CD     0      1      2      3      4
C1     0      0      0      0      0      0      0      0      0      0
C1     0      0      0      0
C2   .25    .25    .25     .5     .5     .5      1      1      0      1
C2     1      1    .25    .25
C3   .25     .5     .5     .5     .5     .5      1      1      0      1
C3     1      1     .5     .5
C4   .75    .75    .75    .75    .75    .75      1      1      0      1
C4     1      1    .75    .75
C5     1      1      1      1      1      1      1      1      0      1
C5     1      1      1      1
CR  SOY1      25 BUSHELS    5.77    240     293     300   31.95
CT     1    120    121    166    196    201    202    212    273    304
CT   334
CB     0    .04    .54    .54    .56    .27    .70    .46    .46    .13
CB     0
CD     0      1      2      3
C1     0      0      0      0      0      0      0      0      0      0
C1     0
C2     0    .04    .30    .30    .30    .30    .30    .30    .46    .13
C2     0
C3     0    .04    .60    .60    .60    .60    .60    .60    .46    .13
C3     0
C4     0    .04      1      1      1      1      1      1    .46    .13
C4     0
CR FVEG1    6.00    TONS   75.00      0    274    290    295   35.00
CT     1     20     67     69    105    120    135    151    161    253
CT   283    289    293    294    354    356
CB  0.37    0.16    0.16    0.16    0.16    0.12    0.08    0.03    0.00    0.00
CB  0.05    0.10    0.16    0.47    0.47    0.36    0.00    0.00    0.00    0.00
CD     0      1      2
C1  0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
C1  0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
C2  1.00    1.00    1.00    0.50    0.50    0.50    0.50    0.50    1.00    1.00
C2  1.00    1.00    0.50    0.50    0.50    0.50    0.00    0.00    0.00    0.00
C3  1.00    1.00    1.00    0.75    0.75    0.75    0.75    0.75    1.00    1.00
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C3  1.00    1.00    0.75    0.75    0.75    0.75    0.00    0.00    0.00    0.0
CR SORG1      28     CWT    4.04    180     264     274   16.93
CT   110     135     166     181     182     258     273     298
CB     0    .15     .23     .29     .80     .80     .50      0.
CD     0      1       2       3       4
C1     0      0       0       0       0       0       0       0
C2     0      1       1     .25     .25     .25     .25       0
C3     0      1       1      .5      .5      .5      .5       0
C4     0      1       1     .75     .75     .75     .75       0
C5     0      1       1       1       1       1       1       0
CRIPAST1     1.8     TON      90      79     135     243   63.68
CT    56      78      85      90      91     152     182     213     244     334
CB     0     .05      .1      .2       1     .71     .67     .42     .28       0
CD     0       1       2       3       4       5
C1     0       0       0       0       0       0       0       0       0       0
C2     0       0       1       1      .2      .2      .2      .2      .2       0
C3     0       0       1       1      .4      .4      .4      .4      .4       0
C4     0       0       1       1      .6      .6      .6      .6      .6       0
C5     0       0       1       1      .8      .8      .8      .8      .8       0
C6     0       1       1       1       1       1       1       1       1       0
*******************************************************************************
CROP ELEV-AREA TABLES AND CROP MIX DATA
*******************************************************************************
DRARK1LT
DT    REACH ARK1-SEQ LEFT BANK (SEQUOYAH COUNTY)
EL   389     390     393     396     399     402     405     408     411     414
EL   417     420     423     426     429     432     435     438
AR     0      50      70     138     333     502     763    3489    5082    6355
AR  7080    7883    8098    8105    8115    8121    8124    8124
CP  WHT1      11
CP FVEG1       3
CP CORN1      25
CP  SOY1      28
CPIPAST1      33
*******************************************************************************
DRARK1RT
DT     REACH ARK1-SEQ RIGHT BANK (LEFLORE COUNTY)
E    389     392     395     398     401     404     407     410     413     416
EL   419     422     425     428     431     434
AR     0      79     141     204     395     632     971    2868    4295    5566
AR  6730    7798    7899    7914    7926    7929
CP  WHT1      15
CP CORN1       6
CP  SOY1      42
CPIPAST1      34
CP SORG1       1
CP  COT1       1
CP  ALF1       1
*********************************
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ADDENDUM B4

GIS Coverage Descriptions and Development

GIS Theme Sources and Processing

The Geographic Information System (GIS) datasets incorporated into the Arkansas River Navigation Project represent a variety of spatial entities for the analysis of potential flooding and the associated economic impacts. Most data themes were developed from existing sources of digital geographic information. In these cases, data were re-projected and clipped to satisfy the needed geographic extents. For this project, Transverse Mercator (UTM) zone 15 North, North American Datum 1983, meters, parameters were utilized.

Bdjurpol

The political boundary theme illustrates county boundaries within the study area. This theme was originally developed by the US Census Bureau as a TIGER/Line file (1998). From the native TIGER/Line format, the file was processed into an ArcView shape file using the tgr2shp utility and ArcView 3.2. County boundaries were processed individually and later merged into a seamless theme.

After downloading this shape file, it was re-projected and incorporated into the project for use as a reference theme. This file was obtained from the U.S. Army Corps of Engineers, Tulsa District.

Bggenexp

This theme represents the final point coverage depicting structure locations for improvements within the floodplain. The accompanying data tables and associated tax assessor data form the basis of much of the needed data for the eventual damage assessment using the Corp software program HEC-FDA. Centroids for individual sections or parcels were generated and repositioned utilizing individual observation and the relevant DOQ photos. Geocoding routines within ArcView were also employed to provide an initial estimate of structure location for highly urban subsections of the study area. Those initial estimates were also corrected/repositioned using the DOQ photos and individual heads/up processing.

Cdrelpar

This theme represents parcel outlines for the counties that had such coverages available. The counties provided either CAD drawings or ArcView shape files that were re-projected to NAD83, UTM, Zone 15 coordinate system. Centroids (theme ***Working***) were created for each parcel, with the elements of that theme serving as an initial approximation of possible structure location. The centroids were then repositioned by examination of the relevant DOQ aerial photo.

Cdreltrs

This theme represents the U.S. township, range, and section boundaries included within the relevant floodplain. This file contains section boundaries for the Public Land Survey System (PLSS) derived from USGS 1:100,000 digital line graphs (DLG). These data were collected as part of the National Mapping Program and was originally developed by the USGS and further processed into ESRI compatible format. The Tulsa District Office of the U.S. Army Corps of Engineers provided the original coverage, which was clipped to include only those Township/Range/Sections pertaining to the relevant floodplain.

Gdsgsqud

This GIS theme shows the USGS 7.5′ quadrangle boundaries that intersect the 100-year floodplain. The original files were produced in DLG format by the USGS and later converted to an ESRI ArcView shape file.

The 7.5′ quadrangle shape file was then re-projected and queried to determine the quadrangles intersecting the relevant floodplain. The "select by theme" option in ArcView 3.2 was utilized for this operation. Once the appropriate quads were selected, a new shape file was developed that contained the necessary quadrangle boundaries.

Hysurwbd

This theme illustrates the major watercourses and water bodies of the Arkansas River and some tributaries. The dataset was compiled from digital coverages originally produced by the USGS as part of the National Hydrography Dataset. Themes are split by hydrological cataloging units (CU) and can be downloaded by identifying the appropriate CU identification number. This information can be obtained and data can be downloaded from: http://nhd.usgs.gov/data.html. All CU watersheds were downloaded for the Oklahoma portion of the Arkansas River in ArcInfo export format. The *.e00 files were imported, merged and re-projected to develop a seamless picture of the surface water along the Arkansas River and some tributaries.

Hyflpflz

This theme represents a heads up digitization of the historic floods of the 1980's for the Oklahoma portion of the Arkansas River, coupled with additional backwater modeling for selected tributaries. Aerial photos for the historic flood events provided the basis for the digitization. The Tulsa District Office of the U.S. Army Corps of Engineers provided this theme.

MERGESECT

Numerous line coverages delineating hydrological cross sections for the study area were provided by the Tulsa District. These cross sections were merged into a single coverage for the study area and used in determining the nearest cross section when developing the HEC-FDA input data.

OKDEM

This theme consists of a grid coverage created using the ERDAS Imagine program from USGS digital elevation model (DEM) data for the region. The grid provides elevation data by pixel for the study area and varies in accuracy depending on the original DEM data.

OKGAP

This theme consists of a grid coverage representing land use classified pixels (30 m resolution). The USGS and the Oklahoma GAP project developed this classified coverage based on satellite photos and numerous groundtruth points. A total of 44 land use classifications are possible with the relevant classes of interest for this analysis being

147 Warm Season Crop
149 Improved Pasture

The grid was obtained from the USGS and re-projected into a UTM, NAD83, Zone 15 coordinate system. Addendum B2 presents the entire key to the classification scheme. ***Source:*** (http://www.gap.uidaho.edu/Projects/FTP.htm).

Reachnames

This point theme simply serves as an identification coverage to identity the 29 reaches designated for the study.

Reachdefn

This theme selected a subset of the numerous cross sections (line coverages) provided by the Corps for the hydrological portion of the study. Designation of reaches, primarily for a unit of analysis and aggregation of results, resulted in several cross sections being chosen as the boundaries of each reach.

Trvehcl

This theme illustrates the transportation infrastructure, in terms of roads, for counties adjacent to the Arkansas River. This dataset was developed by the Oklahoma Department of Transportation and provided by the Tulsa District Office of the U.S. Army Corps of Engineers. The statewide coverage was re-projected and clipped by the county boundary theme (*bdjurpol*). The final shape file was used as a general reference theme.

ADDENDUM B5

Input Data for HEC-FDA

Cat_Name	Cat_Description	Cost_Factor																	
RESID	Residential Structures	1																	
COMM	Commercial Structures	1																	
IND	Industrial Structures	1																	
PUB	Public Structures	1																	
VAC	Vacant	1																	
Occ_Name	Cat_Name	Occ_Description	Para-meter	Start_Data															
SF1	RESID	Single-family Residential, one-story	STAGE	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
			S	0	10	21	27	32	37	43	46	50	54	58	60	63	67	70	74
			C	0	8	42	60	71	77	82	85	86	87	88	88	88	89	90	90
			O	0	0	50	100	100	100	100	100	100	100	100	100	100	100	100	100
SF3	RESID	Single-family Residential, two-story	S	0	5	21	27	31	34	37	39	40	40	42	44	47	49	52	55
			C	0	4	24	34	40	47	53	56	58	58	58	61	66	68	76	81
			O	0	0	50	100	100	100	100	100	100	100	100	100	100	100	100	100
MF1	RESID	Multi-family Residential, one-story	S	0	5	18	25	30	34	38	41	43	46	48	50	52	54	55	57
			C	0	6	34	44	55	67	77	87	97	100	100	100	100	100	100	100
			O	0	0	50	100	100	100	100	100	100	100	100	100	100	100	100	100
MH1	RESID	Mobile Home	S	0	14	19	31	54	93	96	96	97	97	97	98	98	98	98	98
			C	0	3	23	36	43	55	66	78	86	100	100	100	100	100	100	100
			O	0	0	50	100	100	100	100	100	100	100	100	100	100	100	100	100
AUS	COMM	Auto parts dealer	S	0	0	5	5	5	5	7	10	14	19	25	32	40	50	57	63
			C	0	0	18	30	59	70	90	100	100	100	100	100	100	100	100	100
CYS	COMM	Country club, clubhouse	S	0	0	7	8	8	9	10	11	12	13	14	15	18	21	24	28
			C	0	38	41	44	47	52	66	62	67	74	80	87	94	100	100	100
OFS	COMM	Office	S	0	12	14	17	19	23	27	31	35	41	50	55	59	63	67	71
			C	0	16	21	24	25	26	28	31	36	42	50	71	84	100	100	100
GUS	COMM	Grocery store	S	0	3	4	5	6	7	10	14	20	29	37	44	50	55	59	63
			C	0	22	44	74	96	100	100	100	100	100	100	100	100	100	100	100
RNS	COMM	Restaurant, regular	S	0	15	18	20	23	25	27	28	30	33	37	43	50	58	64	68

Cat_Name	Cat_Description	Cost_Factor																	
			C	0	73	88	100	100	100	100	100	100	100	100	100	100	100	100	100
PAS	COMM	Paint Store	S	0	0	30	37	43	55	60	67	75	80	83	86	90	90	90	90
			C	0	0	20	40	60	70	73	76	80	80	80	80	80	80	80	80
NRS	COMM	Nursery, plant	S	0	2	3	6	10	15	22	27	32	37	41	46	50	54	58	62
			C	0	5	20	79	88	95	100	100	100	100	100	100	100	100	100	100
TVS	COMM	Tavern	S	0	15	18	20	22	24	27	31	34	38	42	46	50	54	58	62
			C	42	53	78	92	97	100	100	100	100	100	100	100	100	100	100	100
VTS	COMM	Veterinary Clinic	S	0	1	3	4	6	9	11	14	17	20	24	29	35	42	50	57
			C	25	50	90	100	100	100	100	100	100	100	100	100	100	100	100	100
SSS	COMM	Service Station	S	0	0	1	3	5	7	10	13	16	19	23	27	33	38	49	60
			C	0	25	42	62	90	100	100	100	100	100	100	100	100	100	100	100
UBS	COMM	Building, vacant	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS	COMM	Auto service	S	0	0	3	3	3	4	5	8	12	17	23	31	40	48	56	64
			C	0	10	40	60	85	100	100	100	100	100	100	100	100	100	100	100
COS	COMM	Contractor, roofing	S	0	0	14	21	25	27	28	30	30	30	30	30	32	34	35	36
			C	0	0	15	27	36	43	48	50	50	50	50	50	51	51	51	51
ARS	COMM	Auto repair	S	0	0	3	3	3	4	5	8	12	17	23	31	40	48	56	64
			C	0	50	80	95	100	100	100	100	100	100	100	100	100	100	100	100
CSS	COMM	Cabinet shop, mfg	S	0	0	20	22	24	26	28	30	35	40	43	46	50	50	50	50
			C	0	0	20	25	30	35	40	45	50	55	65	65	65	65	65	65
CFS	COMM	Carpet	S	0	0	30	30	30	30	30	30	30	30	30	30	30	30	30	30
			C	0	0	15	50	51	53	54	55	56	56	56	56	56	56	56	56
EQS	COMM	Equipment storage, heavy	S	0	0	0	3	5	6	7	8	10	13	17	21	25	30	40	50
			C	0	14	17	20	23	25	29	35	38	42	51	63	77	100	100	100
HWS	COMM	Hardware	S	0	12	12	12	12	12	12	14	15	18	21	25	30	35	40	46
			C	0	33	52	70	75	88	100	100	100	100	100	100	100	100	100	100
LMS	COMM	Lumber Yard	S	0	1	1	1	1	1	4	4	5	5	7	9	13	17	21	27
			C	0	20	30	45	60	75	90	100	100	100	100	100	100	100	100	100
PYS	COMM	Private storage	S	0	0	4	8	12	16	20	25	30	35	40	45	50	50	50	50
			C	0	11	16	19	21	23	28	35	47	67	85	90	90	90	90	90

Cat_Name	Cat_Description	Cost_Factor																	
RFS	COMM	Recreation facility	S	0	0	0	2	5	10	10	15	15	20	20	25	25	35	35	45
			C	0	25	50	50	75	100	100	100	100	100	100	100	100	100	100	100
TCS	COMM	Transport company	S	0	9	11	12	16	20	24	28	30	30	30	30	30	30	30	30
			C	0	60	75	90	90	90	90	90	90	90	90	90	90	90	90	90
OMS	COMM	Office, manufacturing	S	0	2	10	15	28	32	39	43	44	45	51	58	62	65	65	65
			C	0	0	16	21	30	40	45	50	60	75	85	90	90	100	100	100
CTS	PUB	City Hall	S	0	1	1	1	2	2	3	4	6	8	12	17	19	24	30	38
			C	0	35	75	85	95	100	100	100	100	100	100	100	100	100	100	100
CUS	PUB	Church	S	0	0	10	11	11	12	12	13	14	14	15	17	19	24	30	38
			C	0	10	10	28	54	70	84	90	97	99	100	100	100	100	100	100
SPS	PUB	School	S	0	8	12	15	15	16	17	19	22	25	28	32	36	40	45	49
			C	0	18	26	30	33	35	39	44	50	58	66	76	88	100	100	100
LOT	VAC	Vacant Lot	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GES	MISC_AG	Contractor-General	S	0	0	20	25	30	35	40	45	50	60	60	60	60	60	60	60
			C	0	0	10	10	10	10	40	40	40	40	80	80	80	80	80	80

Struc_Name	Cat_Name	Stream_Name	Occ_Name	Station	Bank	Year	Struc_Val	Cont_Val	Other_Val	Grnd_ Stage	Found _Ht	Street	City	State	Zip	SID_Rch	X_val	Y_val	Zone
HASK-AG-0006.00	MISC_AG	Canadian	GES	20.00	Right		$6,450	3225		499	1					Cndn2-HASK	292957.0938	3905352.75	15
HASK-RS-0001.00	RESID	Canadian	SF1	18.00	Right	1958	27216	27216		521	2					Cndn2-HASK	296291.9816	3904382.984	15
HASK-AG-0007.00	MISC_AG	Canadian	GES	9.00	Right		$23,991	$11,996		470	1					Cndn1-HASK	305351.9326	3915170.123	15
HASK-RS-0002.00	RESID	Canadian	SF1	9.00	Right	1940	14024	14024		481	2					Cndn1-HASK	305407.5938	3914245.303	15
HASK-RS-0004.00	RESID	Canadian	SF1	19.00	Right	1955	21819	21819		512	2					Cndn2-HASK	295101.6626	3902959.799	15
HASK-RS-0005.00	RESID	Canadian	SF1	19.00	Right	1935	10139	10139		516	1					Cndn2-HASK	295132.399	3902938.15	15
LEFL-MH-0014.01	RESID	Arkansas	MH1	324.37	Right	1970	$93,174	$93,174		428.16	3					Ark2-SEQ	354719.5069	3905886.771	15
LEFL-RS-0009.01	RESID	Arkansas	SF1	315.65	Right	1945	$29,542	$29,542		413.43	2					Ark1-SEQ	365488.3691	3907818.751	15
LEFL-RS-0002.00	RESID	Arkansas	SF1	329.86	Right	1945	$33,413	$33,413		437.11	1					Ark2-SEQ	346487.4036	3909667.03	15
LEFL-RS-0006.01	RESID	Arkansas	SF1	315.65	Right	1976	$83,338	$83,338		415.68	1					Ark1-SEQ	366868.7063	3909097.706	15
LEFL-RS-0010.01	RESID	Arkansas	SF1	315.65	Right	1966	$49,805	$49,805		420.52	1					Ark1-SEQ	365494.4471	3907628.461	15
LEFL-RS-0008.00	RESID	Arkansas	SF1	315.65	Right	1955	$29,126	$29,126		420.7	1					Ark1-SEQ	365468.403	3907495.887	15
LEFL-RS-0012.00	RESID	Arkansas	SF1	317.15	Right	1989	$107,585	$107,585		418.56	1					Ark1-SEQ	361886.4585	3903631.495	15
LEFL-MA-0004.00	MISC_AG	Arkansas	GES	312.34	Right		$8,752	$4,376		415.63	1					Ark1-SEQ	366902.7963	3911966.629	15
LEFL-MA-0005.00	MISC_AG	Arkansas	GES	313.67	Right		$1,389	$695		414.54	1					Ark1-SEQ	366556.5914	3910001.044	15
LEFL-MA-0003.00	MISC_AG	Arkansas	GES	312.34	Right		$39,339	$19,669		413.27	1					Ark1-SEQ	367252.6583	3911869.89	15
LEFL-MA-0011.00	MISC_AG	Arkansas	GES	315.65	Right		$2,084	$1,042		416.12	1					Ark1-SEQ	366822.7547	3906884.959	15
LEFL-MA-0007.00	MISC_AG	Arkansas	GES	315.65	Right		$1,389	$695		420.4	1					Ark1-SEQ	365646.347	3907530.834	15
LEFL-MH-0013.00	RESID	Arkansas	MH1	317.15	Right	1989	$64,471	$64,471		415.52	3					Ark1-SEQ	361401.4544	3903497.821	15
LEFL-MA-0001.00	MISC_AG	Arkansas	GES	331.56	Right	1982	$49,957	$24,979		434.75	1					Ark2-SEQ	343196.3206	3911365.626	15
MUSK-RS-0073.00	RESID	Arkansas	SF1	418.83	right		$63,297	$63,297		561	2					Ark10-MUSK	260115.1052	3967317.186	15
MUSK-RS-0074.00	RESID	Arkansas	SF1	418.83	right		$43,882	$43,882		564	2					Ark10-MUSK	260118.3125	3967230.867	15
MUSK-RS-0075.00	RESID	Arkansas	SF1	418.83	right		$123,751	$123,751		547	2					Ark10-MUSK	260898.7502	3967206.987	15
MUSK-MA-0011.00	MISC_AG	Arkansas	GES	398.62	right		$8,765	$4,383		510	0					Ark8-MUSK	286505.3798	3963847.812	15
MUSK-MA-0012.00	MISC_AG	Arkansas	GES	398.62	right		$4,760	$2,380		510	0					Ark8-MUSK	286505.3798	3963847.812	15
MUSK-MA-0014.00	MISC_AG	Arkansas	GES	396.37	left		$1,157	$578		515	0					Ark8-MUSK	289279.4748	3964785.318	15
MUSK-MH-0032.00	RESID	Arkansas	MH1	396.37	left		$59,243	$59,243		510	3					Ark8-MUSK	289310.1719	3964969.5	15
MUSK-MH-0031.00	RESID	Arkansas	MH1	396.37	left		$51,148	$51,148		510	3					Ark8-MUSK	289310.1719	3964969.5	15
MUSK-MH-0030.00	RESID	Arkansas	MH1	396.37	left		$1,511	$1,511		510	3					Ark8-MUSK	289310.1719	3964969.5	15
MUSK-RS-0043.00	RESID	Arkansas	SF1	393.55	left		$39,437	$39,437		521	2					Ark8-MUSK	291831.125	3961681	15

Struc_Name	Cat_Name	Stream_Name	Occ_Name	Station	Bank	Year	Struc_Val	Cont_Val	Other_Val	Grnd_ Stage	Found _Ht	Street	City	State	Zip	SID_Rch	X_val	Y_val	Zone
MUSK-MA-0018.00	MISC_AG	Arkansas	GES	393.55	left		$2,473	$1,236		521	0					Ark8-MUSK	291831.125	3961681	15
MUSK-MH-0042.00	RESID	Arkansas	MH1	393.55	left		$5,381	$5,381		521	3					Ark8-MUSK	291831.125	3961681	15
MUSK-CM-0004.00	COMM	Arkansas	WSS	393.55	left		$620,053	$496,042		521	1					Ark8-MUSK	291831.125	3961681	15
MUSK-RS-0044.00	RESID	Arkansas	SF1	393.55	left		$88,954	$88,954		521	2					Ark8-MUSK	291831.125	3961681	15
MUSK-RS-0045.00	RESID	Arkansas	SF1	392.50	left		$66,795	$66,795		513	2					Ark8-MUSK	292410.9584	3961077.291	15
MUSK-RS-0050.00	RESID	Arkansas	SF1	392.50	left		$14,737	$14,737		516	2					Ark8-MUSK	292441.6554	3961012.486	15
MUSK-CM-0005.00	RESID	Arkansas	MF1	392.50	left		$53,396	$53,396		516	2					Ark8-MUSK	292479.1741	3961032.951	15
MUSK-RS-0048.00	RESID	Arkansas	SF1	392.50	left		$62,628	$62,628		512	2					Ark8-MUSK	292489.4064	3961213.723	15
MUSK-MA-0013.00	MISC_AG	Arkansas	GES	395.00	left		$282	$141		510	0					Ark8-MUSK	292749.9046	3965299.276	15
MUSK-RS-0029.00	RESID	Arkansas	SF1	395.00	left		$54,916	$54,916		510	2					Ark8-MUSK	292749.9046	3965299.276	15
MUSK-RS-0046.00	RESID	Arkansas	SF1	393.55	left		$56,155	$56,155		505	2					Ark8-MUSK	292806.6094	3961527.515	15
MUSK-RS-0026.00	RESID	Arkansas	SF1	390.61	right		$39,663	$39,663		511	2					Ark7-MUSK	292973.3939	3955774.73	15
MUSK-RS-0025.00	RESID	Arkansas	SF1	390.61	right		$23,470	$23,470		511	2					Ark7-MUSK	292973.3939	3955774.73	15
MUSK-EX-0027.00	PUB	Arkansas	RCS	390.61	right		19714.61			511	2					Ark7-MUSK	292973.3939	3955774.73	15
MUSK-RS-0024.00	RESID	Arkansas	SF1	390.61	right		$26,962	$26,962		511	2					Ark7-MUSK	292973.3939	3955774.73	15
MUSK-MH-0049.00	RESID	Arkansas	MH1	393.55	left		$46,712	$46,712		509	3					Ark8-MUSK	293011.2564	3961469.531	15
MUSK-RS-0047.00	RESID	Arkansas	SF1	393.55	left		$85,313	$85,313		510	2					Ark8-MUSK	293024.8996	3961565.033	15
MUSK-RS-0041.00	RESID	Arkansas	SF1	393.55	left		$30,982	$30,982		511	2					Ark8-MUSK	293308.5856	3961596.767	15
MUSK-RS-0028.00	RESID	Arkansas	SF1	395.00	left		$35,405	$35,405		520	2					Ark8-MUSK	293510.6354	3965376.457	15
MUSK-RS-0053.00	RESID	Arkansas	SF1	392.50	left		$96,143	$96,143		510	2					Ark7-MUSK	293996.2969	3960014.625	15
MUSK-RS-0052.00	RESID	Arkansas	SF1	392.50	left		$50,296	$50,296		510	2					Ark7-MUSK	293996.2969	3960014.625	15
MUSK-RS-0051.00	RESID	Arkansas	SF1	392.50	left		$29,197	$29,197		510	1					Ark7-MUSK	293996.2969	3960014.625	15
MUSK-MA-0017.00	MISC_AG	Arkansas	GES	392.50	left		$40,446	$20,223		510	2					Ark8-MUSK	294144.2278	3960914.61	15
MUSK-RS-0034.00	RESID	Arkansas	SF1	393.55	left		$126,548	$126,548		510	2					Ark8-MUSK	294788.6879	3962480.507	15
MUSK-RS-0033.00	RESID	Arkansas	SF1	393.55	left		$81,738	$81,738		510	2					Ark8-MUSK	294788.6879	3962480.507	15
MUSK-CM-0003.00	COMM	Arkansas	RCS	392.50	left		$247,208	$197,767		510	2					Ark8-MUSK	294802.5092	3960883.913	15
MUSK-MH-0040.00	RESID	Arkansas	MH1	393.55	left		$49,964	$49,964		511	3					Ark8-MUSK	294812.7415	3962142.493	15
MUSK-MH-0067.00	RESID	Arkansas	MH1	388.70	left		$64,953	$64,953		508	3					Ark7-MUSK	294838.1316	3958623.334	15
MUSK-RS-0065.00	RESID	Arkansas	SF1	388.70	left		$23,781	$23,781		510	2					Ark7-MUSK	294842.6925	3958563.623	15
MUSK-RS-0064.00	RESID	Arkansas	SF1	388.70	left		$22,963	$22,963		500	2					Ark7-MUSK	294845.9507	3958805.58	15

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MUSK-MA-0015.00	MISC_AG	Arkansas	GES	392.50	left		$41,033	$20,516		510	1					Ark8-MUSK	294909.1949	3960877.986	15
MUSK-RS-0037.00	RESID	Arkansas	SF1	393.55	left		$25,967	$25,967		511	2					Ark8-MUSK	294939.892	3962150.208	15
MUSK-RS-0039.00	RESID	Arkansas	SF1	392.50	left		$39,740	$39,740		511	2					Ark8-MUSK	294950.1243	3961311.155	15
MUSK-RS-0068.00	RESID	Arkansas	SF1	388.70	left		$33,986	$33,986		509	2					Ark7-MUSK	294955.2021	3958568.935	15
MUSK-RS-0063.00	RESID	Arkansas	SF1	388.70	left		$22,848	$22,848		506	1					Ark7-MUSK	295012.0665	3958523.06	15
MUSK-RS-0038.00	RESID	Arkansas	SF1	392.50	left		$104,742	$104,742		506	2					Ark8-MUSK	295120.6636	3961543.089	15
MUSK-MA-0016.00	MISC_AG	Arkansas	GES	392.50	left		$7,726	$3,863		510	1					Ark8-MUSK	295182.0577	3960946.201	15
MUSK-RS-0066.00	RESID	Arkansas	SF1	388.70	left		$69,270	$69,270		509	2					Ark7-MUSK	295216.9516	3958505.883	15
MUSK-RS-0077.00	RESID	Canadian	SF1	19.00	left		$11,411	$11,411		500	2					Cndn2-HASK	295236.4989	3906481.413	15
MUSK-RS-0036.00	RESID	Arkansas	SF1	393.55	left		$58,546	$58,546		509	2					Ark8-MUSK	295308.2567	3962310.515	15
MUSK-MA-0019.00	MISC_AG	Arkansas	GES	388.70	left		$12,557	$6,278		510	1					Ark7-MUSK	295593.0156	3959970.625	15
MUSK-MA-0020.00	MISC_AG	Arkansas	GES	388.70	left		$11,276	$5,638		510	1					Ark7-MUSK	295593.0156	3959970.625	15
MUSK-RS-0061.00	RESID	Arkansas	SF1	388.70	left		$66,989	$66,989		510	2					Ark7-MUSK	295593.0156	3959970.625	15
MUSK-RS-0058.00	RESID	Arkansas	SF1	388.70	left		$84,161	$84,161		510	2					Ark7-MUSK	295593.0156	3959970.625	15
MUSK-MH-0059.00	RESID	Arkansas	MH1	388.70	left		$39,199	$39,199		510	3					Ark7-MUSK	295593.0156	3959970.625	15
MUSK-MH-0060.00	RESID	Arkansas	MH1	388.70	left		$49,531	$49,531		510	3					Ark7-MUSK	295593.0156	3959970.625	15
MUSK-RS-0054.00	RESID	Arkansas	SF1	388.70	left		$232,953	$232,953		510	2					Ark7-MUSK	295593.0156	3959970.625	15
MUSK-MH-0055.00	RESID	Arkansas	MH1	388.70	left		$42,328	$42,328		510	3					Ark7-MUSK	295593.0156	3959970.625	15
MUSK-RS-0056.00	RESID	Arkansas	SF1	388.70	left		$19,006	$19,006		510	2					Ark7-MUSK	295593.0156	3959970.625	15
MUSK-RS-0057.00	RESID	Arkansas	SF1	388.70	left		$60,957	$60,957		510	2					Ark7-MUSK	295593.0156	3959970.625	15
MUSK-RS-0035.00	RESID	Arkansas	SF1	394.00	left		$129,673	$129,673		512	2					Ark8-MUSK	295775.2472	3963322.489	15
MUSK-MA-0009.00	MISC_AG	Arkansas	GES	378.53	left		$2,630	$1,315		506	1					Ark5-SEQ	295833.8269	3946181.975	15
MUSK-MA-0010.00	MISC_AG	Arkansas	GES	378.53	left		$2,967	$1,484		507	1					Ark5-SEQ	296067.2565	3946295.874	15
MUSK-CM-0001.00	COMM	Arkansas	VSS	392.50	left		$76,053	$60,843		508	1					Ark8-MUSK	296120.0234	3961563.553	15
MUSK-MA-0022.00	MISC_AG	Arkansas	GES	387.80	left		$4,189	$2,094		501	1					Ark7-MUSK	296267.1766	3958636.65	15
MUSK-CM-0002.00	COMM	Arkansas	OFS	390.61	left		$6,552	$5,241		506	1					Ark7-MUSK	296375.8323	3961106.508	15
MUSK-RS-0078.00	RESID	Canadian	SF1	19.00	left		$139,238	$139,238		505	1					Cndn1-HASK	296475.8224	3906907.349	15
MUSK-MA-0021.00	MISC_AG	Arkansas	GES	387.80	left		$14,013	$7,007		500	1					Ark7-MUSK	296476.6373	3959004.734	15
MUSK-MH-0062.00	RESID	Arkansas	MH1	387.80	left		$18,473	$18,473		497	3					Ark7-MUSK	296928.0566	3959239.415	15
MUSK-RS-0072.00	RESID	Arkansas	SF1	387.04	left		$74,627	$74,627		492	1					Ark7-MUSK	298497.8497	3959655.038	15

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MUSK-RS-0071.00	RESID	Arkansas	SF1	387.04	left		$100,504	$100,504		500	1					Ark7-MUSK	298677.0938	3960017.925	15
MUSK-MH-0069.00	RESID	Arkansas	MH1	387.04	left		$36,734	$36,734		511	3					Ark7-MUSK	298824.8088	3960095.586	15
MUSK-RS-0070.00	RESID	Arkansas	SF1	387.04	left		$92,730	$92,730		507	2					Ark7-MUSK	298829.4757	3960045.046	15
MUSK-RS-0076.00	RESID	Canadian	SF1	10.00	left		$5,193	$5,193		480	2					Cndn1-HASK	303509.8771	3915006.899	15
MUSK-MA-0007.00	MISC_AG	Arkansas	GES	362.11	right		$1,992	$996		484	2					Ark4-SEQ	306392.3941	3929463.245	15
MUSK-MA-0008.00	MISC_AG	Arkansas	GES	362.11	right		$1,710	$855		484	2					Ark4-SEQ	306545.4476	3928768.905	15
MUSK-MA-0006.00	MISC_AG	Arkansas	GES	362.11	right		$2,061	$1,030		470	2					Ark4-SEQ	306552.9136	3929761.886	15
SEQU-CM-0087.00	COMM	Arkansas	RCS	306.36	Left	1992	151335.11	$121,068		407.08	1					Ark1-SEQ	369597.7046	3920581.921	15
SEQU-CM-0088.00	COMM	Arkansas	HRS	308.38	Left		1269633.83	$1,015,707		413.04	1					Ark1-SEQ	369288.19	3918368.116	15
SEQU-CM-0089.00	COMM	Arkansas	GES	308.38	Left	1979	61280.139	$49,024		415.71	1					Ark1-SEQ	367382.2267	3918813.692	15
SEQU-CM-0090.00	COMM	Arkansas	RCS	308.38	Left	1978	88214.7096	$70,572		415.27	1					Ark1-SEQ	367341.6302	3918814.433	15
SEQU-CM-0091.00	COMM	Arkansas	RCS	308.38	Left	1987	100819.828	$80,656		416.81	1					Ark1-SEQ	367267.8509	3918815.518	15
SEQU-CM-0092.00	COMM	Arkansas	RCS	308.38	Left	1993	254098.896	$203,279		414.63	1					Ark1-SEQ	367119.0403	3918817.734	15
SEQU-CM-0093.00	COMM	Arkansas	RCS	308.38	Left	0000	61280.139	$49,024		415.8	1					Ark1-SEQ	367312.2108	3918814.86	15
SEQU-CM-0094.00	COMM	Arkansas	RCS	308.38	Left	1985	273826.521	$219,061		415.15	1					Ark1-SEQ	367204.0753	3918816.461	15
SEQU-CM-0095.00	COMM	Arkansas	RCS	343.00	Left	1977	197702.51	$158,162		488	1					Ark3-SEQ	335006.0234	3916596.621	15
SEQU-CM-0096.00	COMM	Arkansas	RCS	308.38	Left	1960	3371.2566	$2,697		411.42	1					Ark1-SEQ	368977.7456	3917476.23	15
SEQU-CM-0097.00	COMM	Arkansas	RCS	308.38	Left	0	7410.9978	$5,929		411.84	1					Ark1-SEQ	368941.8672	3917470.975	15
SEQU-CM-0098.00	COMM	Arkansas	RCS	308.38	Left	0000	11452.2204	$9,162		411.17	1					Ark1-SEQ	368859.4484	3917496.746	15
SEQU-CM-0099.00	COMM	Arkansas	RCS	308.38	Left		17041.4919	$13,633		412.31	1					Ark1-SEQ	368808.5632	3917481.331	15
SEQU-CM-0100.00	COMM	Arkansas	RCS	308.38	Left	0000	162284.038	$129,827		409.89	1					Ark1-SEQ	368582.7244	3917497.796	15
SEQU-CM-0101.00	COMM	Arkansas	RCS	308.38	Left	1984	87945.0973	$70,356		412.42	1					Ark1-SEQ	368402.5571	3917331.818	15
SEQU-CM-0102.00	COMM	Arkansas	RCS	308.38	Left	0000	7410.9978	$5,929		411.12	1					Ark1-SEQ	368865.6692	3917431.739	15
SEQU-CM-0103.00	COMM	Arkansas	RCS	308.38	Left	0000	27612.6665	$22,090		412.78	1					Ark1-SEQ	368986.0345	3917427.293	15
SEQU-CM-0104.00	COMM	Arkansas	RCS	308.38	Left	0000	24919.5057	$19,936		411.53	1					Ark1-SEQ	368737.4386	3917279.6	15
SEQU-CM-0105.00	COMM	Arkansas	RCS	308.38	Left	0	3707.5314	$2,966		413.43	1					Ark1-SEQ	368623.5609	3917268.874	15
SEQU-EX-0142.00	PUB	Arkansas	CTS	308.38	Left	0	60000	30000		411.85	2					Ark1-SEQ	368842.4489	3917483.369	15
SEQU-EX-0143.00	PUB	Arkansas	HPS	308.38	Left	0	60000	30000		411.45	2					Ark1-SEQ	368527.4496	3917372.747	15
SEQU-EX-0144.00	PUB	Arkansas	CUS	308.38	Left	0	60000	30000		411.95	2					Ark1-SEQ	368574.4837	3917355.408	15
SEQU-EX-0145.00	PUB	Arkansas	CUS	308.38	Left	0	60000	30000		411.67	2					Ark1-SEQ	368788.5107	3917437.943	15

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SEQU-EX-0146.00	PUB	Arkansas	CUS	308.38	Left	0000	60000	30000		411.76	2					Ark1-SEQ	368776.1539	3917435.904	15
SEQU-EX-0147.00	PUB	Arkansas	CUS	308.38	Left	0	60000	30000		411.91	2					Ark1-SEQ	368755.7555	3917421.781	15
SEQU-EX-0148.00	PUB	Arkansas	CUS	308.38	Left	0	60000	30000		412.09	2					Ark1-SEQ	368732.6111	3917408.052	15
SEQU-EX-0149.00	PUB	Arkansas	CUS	308.38	Left	0	60000	30000		413.72	2					Ark1-SEQ	368791.0605	3917273.5	15
SEQU-EX-0150.00	PUB	Arkansas	CUS	308.38	Left	0	60000	30000		411.07	2					Ark1-SEQ	368699.6597	3917277.423	15
SEQU-EX-0151.00	PUB	Illinois	MUS	9.6	Right	0	60000	30000		504	2					Ill1-SEQ	313114.8047	3940197.159	15
SEQU-MA-0108.00	MISC_AG	Illinois	GES	4.50	Right	0	57510.0102	28755.0051		474	1					Ill1-SEQ	310789.1065	3934481.369	15
SEQU-MA-0109.00	MISC_AG	Arkansas	GES	331.56	Left	0	35678.8163	17839.40815		424.05	1					Ark2-SEQ	347167.7661	3912351.424	15
SEQU-MA-0110.00	MISC_AG	Illinois	GES	2.82	Left	0	74889.6375	37444.81875		485	1					Ill1-SEQ	311358.9226	3932748.155	15
SEQU-MA-0111.00	MISC_AG	Arkansas	GES	329.86	Left	0	6262.9232	3131.4616		427.54	1					Ark2-SEQ	347360.7289	3912017.954	15
SEQU-MA-0112.00	MISC_AG	Arkansas	GES	319.64	Left	0	524.1993	262.09965		430.37	1					Ark2-SEQ	356813.5632	3912524.837	15
SEQU-MA-0114.00	MISC_AG	Arkansas	GES	306.36	Left	0	673.9706	336.9853		409.09	1					Ark1-SEQ	366618.9233	3921972.281	15
SEQU-MA-0116.00	MISC_AG	Arkansas	GES	308.38	Left	0	9196.0686	4598.0343		420.15	1					Ark1-SEQ	367520.3034	3918869.054	15
SEQU-MA-0119.00	MISC_AG	Arkansas	GES	343.00	Left		206442.69	103221.3452		504	1					Ark3-SEQ	334098.7145	3917377.576	15
SEQU-MA-0120.00	MISC_AG	Arkansas	GES	343.00	Left	0	4381.5623	2190.78115		498	1					Ark3-SEQ	333827.827	3917277.474	15
SEQU-MA-0123.00	MISC_AG	Arkansas	GES	308.38	Left	0000	12798.8008	6399.4004		411.92	1					Ark1-SEQ	368884.2854	3917492.911	15
SEQU-MA-0124.00	MISC_AG	Arkansas	GES	308.38	Left	0	4448.2247	2224.11235		412.69	1					Ark1-SEQ	368624.7457	3917357.531	15
SEQU-MA-0125.00	MISC_AG	Arkansas	GES	308.38	Left	0	17121.4868	8560.7434		412.67	1					Ark1-SEQ	368701.6391	3917371.733	15
SEQU-MA-0126.00	MISC_AG	Arkansas	GES	308.38	Left	0	18185.1223	9092.56115		411.55	1					Ark1-SEQ	368812.5802	3917369.237	15
SEQU-MA-0127.00	MISC_AG	Arkansas	GES	308.38	Left	0	1755.0639	877.53195		412.44	1					Ark1-SEQ	368839.799	3917340.806	15
SEQU-MA-0128.00	MISC_AG	Arkansas	GES	308.38	Left	0	20878.2831	10439.14155		412.31	1					Ark1-SEQ	368908.9143	3917377.901	15
SEQU-MA-0129.00	MISC_AG	Arkansas	GES	308.38	Left	0	4448.2247	2224.11235		412.77	2					Ark1-SEQ	368946.0691	3917328.103	15
SEQU-MA-0130.00	MISC_AG	Arkansas	GES	308.38	Left	0	12798.8008	6399.4004		403.21	1					Ark1-SEQ	368999.1838	3917333.992	15
SEQU-MA-0131.00	MISC_AG	Arkansas	GES	308.38	Left	0000	6873.2545	3436.62725		406.65	1					Ark1-SEQ	368994.2267	3917359.149	15
SEQU-MA-0132.00	MISC_AG	Arkansas	GES	308.38	Left	0	2024.6762	1012.3381		409.01	1					Ark1-SEQ	368915.9694	3917291.829	15
SEQU-MA-0133.00	MISC_AG	Arkansas	GES	308.38	Left	0	20205.7336	10102.8668		411.99	1					Ark1-SEQ	368665.8443	3917211.66	15
SEQU-MA-0134.00	MISC_AG	Arkansas	GES	308.38	Left	0	11452.2204	5726.1102		413.13	1					Ark1-SEQ	368560.198	3917223.849	15
SEQU-MA-0135.00	MISC_AG	Arkansas	GES	308.38	Left	0	4448.2247	2224.11235		412.49	1					Ark1-SEQ	368419.4348	3917289.641	15
SEQU-MA-0136.00	MISC_AG	Arkansas	GES	308.38	Left	0	5257.0617	2628.53085		412.77	1					Ark1-SEQ	368405.1545	3917290.151	15
SEQU-MA-0137.00	MISC_AG	Arkansas	GES	308.38	Left	0	6199.2236	3099.6118		412.1	1					Ark1-SEQ	368617.1636	3917129.456	15

Struc_Name	Cat_Name	Stream_Name	Occ_Name	Station	Bank	Year	Struc_Val	Cont_Val	Other_Val	Grnd_ Stage	Found _Ht	Street	City	State	Zip	SID_Rch	X_val	Y_val	Zone
SEQU-MA-0138.00	MISC_AG	Arkansas	GES	308.38	Left	0	22224.8635	11112.43175		411.82	1					Ark1-SEQ	368739.7219	3917172.848	15
SEQU-MA-0139.00	MISC_AG	Arkansas	GES	308.38	Left	0	15491.9616	7745.9808		408.56	1					Ark1-SEQ	368594.5684	3917074.223	15
SEQU-MA-0140.00	MISC_AG	Arkansas	GES	308.38	Left	0	20878.2831	10439.14155		414.27	2					Ark1-SEQ	368400.0747	3917080.735	15
SEQU-MA-0141.00	MISC_AG	Arkansas	GES	308.38	Left	0	11862.5645	5931.28225		415.77	2					Ark1-SEQ	368428.5563	3917010.831	15
SEQU-MA-152.00	MISC_AG	Arkansas	GES	308.38	Left	0	4448.2247	2224.11235		412.43	1					Ark1-SEQ	368623.6271	3917386.74	15
SEQU-MH-0010.00	RESID	Arkansas	MH1	308.38	Left	0000	11452.2204	11452.2204		412.5	3					Ark1-SEQ	369098.8811	3917490.352	15
SEQU-MH-0080.00	RESID	Arkansas	MH1	343.00	Left	1995	42586.5219	42586.5219		490	3					Ark3-SEQ	333759.1327	3917182.979	15
SEQU-MH-0081.00	RESID	Arkansas	MH1	343.00	Left	1988	36146.9345	36146.9345		471	3					Ark3-SEQ	331790.1774	3919011.045	15
SEQU-MH-0082.00	RESID	Illinois	MH1	10.10	Left	0	39800.0338	39800.0338		501	3					Ill1-SEQ	313423.06	3940047.913	15
SEQU-MH-0083.00	RESID	Arkansas	MH1	308.38	Left	0000	14145.3812	14145.3812		412.3	3					Ark1-SEQ	368723.9116	3917174.888	15
SEQU-MH-0084.00	RESID	Arkansas	MH1	308.38	Left	1985	14145.3812	14145.3812		413.62	3					Ark1-SEQ	368619.3082	3917218.639	15
SEQU-MH-0085.00	RESID	Arkansas	MH1	343.00	Left	1985	12529.1884	12529.1884		482	3					Ark3-SEQ	331660.0475	3918857.548	15
SEQU-MH-0086.00	RESID	Arkansas	MH1	308.38	Left	1986	8759.0596	8759.0596		413.21	3					Ark1-SEQ	368949.5016	3917368.589	15
SEQU-RS-0001.00	RESID	Arkansas	SF1	339.45	Left		23572.9253	23572.9253		478	1					Ark3-SEQ	335105.3804	3916095.908	15
SEQU-RS-0002.00	RESID	Arkansas	SF1	339.45	Left	1992	94170	94170		473	1					Ark3-SEQ	335233.2113	3915796.458	15
SEQU-RS-0003.00	RESID	Arkansas	SF1	339.45	Left	1998	87134	87134		483	1					Ark3-SEQ	335264.1792	3916204.842	15
SEQU-RS-0004.00	RESID	Arkansas	SF1	343.00	Left	1990	33103	33103		481	1					Ark3-SEQ	331651.7621	3918903.841	15
SEQU-RS-0005.00	RESID	Arkansas	SF1	343.00	Left	1963	12523	12523		493	2					Ark3-SEQ	333578.8683	3917090.559	15
SEQU-RS-0006.00	RESID	Arkansas	SF1	339.45	Left	1960	32683	32683		493	1					Ark3-SEQ	335149.8486	3916339.337	15
SEQU-RS-0007.00	RESID	Arkansas	SF1	343.00	Left	1984	61225	61225		510	1					Ark3-SEQ	333841.5402	3917419.035	15
SEQU-RS-0008.00	RESID	Arkansas	SF1	343.00	Left	1983	96332	96332		481	2					Ark3-SEQ	333648.51	3916634.185	15
SEQU-RS-0009.00	RESID	Arkansas	SF1	343.00	Left	1981	65807	65807		493	1					Ark3-SEQ	333822.019	3917199.692	15
SEQU-RS-0011.00	RESID	Arkansas	SF1	308.38	Left	1958	9970.8338	9970.8338		413.05	2					Ark1-SEQ	369021.0532	3917472.15	15
SEQU-RS-0012.00	RESID	Arkansas	SF1	308.38	Left	0000	6791	6791		411.95	2					Ark1-SEQ	368963.2293	3917481.117	15
SEQU-RS-0013.00	RESID	Arkansas	SF1	308.38	Left	0000	13032	13032		412.39	2					Ark1-SEQ	368903.8711	3917477.242	15
SEQU-RS-0014.00	RESID	Arkansas	SF1	308.38	Left	0000	11452.2204	11452.2204		411.83	2					Ark1-SEQ	368407.0731	3917369.482	15
SEQU-RS-0015.00	RESID	Arkansas	SF1	308.38	Left	0000	42285	42285		412.5	2					Ark1-SEQ	368473.4723	3917382.517	15
SEQU-RS-0016.00	RESID	Arkansas	SF1	308.38	Left	0000	18030	18030		412.1	2					Ark1-SEQ	368515.5392	3917389.917	15
SEQU-RS-0017.00	RESID	Arkansas	SF1	308.38	Left	0000	52914	52914		412.02	2					Ark1-SEQ	368532.981	3917329.54	15
SEQU-RS-0018.00	RESID	Arkansas	SF1	308.38	Left	0000	7205	7205		412.38	2					Ark1-SEQ	368558.6526	3917314.714	15

Struc_Name	Cat_Name	Stream_Name	Occ_Name	Station	Bank	Year	Struc_Val	Cont_Val	Other_Val	Grnd_ Stage	Found _Ht	Street	City	State	Zip	SID_Rch	X_val	Y_val	Zone
SEQU-RS-0019.00	RESID	Arkansas	SF1	308.38	Left	0000	6657	6657		412.44	2					Ark1-SEQ	368586.6073	3917324.509	15
SEQU-RS-0020.00	RESID	Arkansas	SF1	308.38	Left	1965	30539	30539		412.26	2					Ark1-SEQ	368588.7186	3917341.614	15
SEQU-RS-0021.00	RESID	Arkansas	SF1	308.38	Left	0000	15491.9616	15491.9616		412.09	2					Ark1-SEQ	368595.981	3917376.356	15
SEQU-RS-0022.00	RESID	Arkansas	SF1	308.38	Left	0000	8367	8367		411.38	2					Ark1-SEQ	368671.7695	3917313.574	15
SEQU-RS-0023.00	RESID	Arkansas	SF1	308.38	Left	0000	12949	12949		412.01	2					Ark1-SEQ	368693.0509	3917334.703	15
SEQU-RS-0024.00	RESID	Arkansas	SF1	308.38	Left	0000	15491.9616	15491.9616		412.81	1					Ark1-SEQ	368694.0283	3917345.944	15
SEQU-RS-0025.00	RESID	Arkansas	SF1	308.38	Left	0000	18859.1532	18859.1532		412.76	2					Ark1-SEQ	368694.8595	3917362.945	15
SEQU-RS-0026.00	RESID	Arkansas	SF1	308.38	Left	0000	8697	8697		412.16	2					Ark1-SEQ	368732.3813	3917385.703	15
SEQU-RS-0027.00	RESID	Arkansas	SF1	308.38	Left	0000	23572.9253	23572.9253		412.2	2					Ark1-SEQ	368734.5626	3917368.833	15
SEQU-RS-0028.00	RESID	Arkansas	SF1	308.38	Left	0000	17512.5728	17512.5728		411.94	2					Ark1-SEQ	368759.9646	3917353.565	15
SEQU-RS-0029.00	RESID	Arkansas	SF1	308.38	Left	0000	10744	10744		412.36	2					Ark1-SEQ	368732.4705	3917343.506	15
SEQU-RS-0030.00	RESID	Arkansas	SF1	308.38	Left	1945	24245.4748	24245.4748		411.62	2					Ark1-SEQ	368801.2923	3917385.179	15
SEQU-RS-0031.00	RESID	Arkansas	SF1	308.38	Left	0000	20878.2831	20878.2831		411.75	2					Ark1-SEQ	368917.2936	3917427.696	15
SEQU-RS-0032.00	RESID	Arkansas	SF1	308.38	Left	0000	15491.9616	15491.9616		412.24	2					Ark1-SEQ	368884.3848	3917431.739	15
SEQU-RS-0033.00	RESID	Arkansas	SF1	308.38	Left	0000	6478	6478		411.23	2					Ark1-SEQ	368850.9356	3917433.332	15
SEQU-RS-0034.00	RESID	Arkansas	SF1	308.38	Left	0000	9813	9813		411.3	2					Ark1-SEQ	368840.1841	3917433.332	15
SEQU-RS-0035.00	RESID	Arkansas	SF1	308.38	Left	0000	11452.2204	11452.2204		411.37	2					Ark1-SEQ	368833.0866	3917417.343	15
SEQU-RS-0036.00	RESID	Arkansas	SF1	308.38	Left	0000	16084.5162	16084.5162		412.41	2					Ark1-SEQ	368839.7471	3917363.279	15
SEQU-RS-0037.00	RESID	Arkansas	SF1	308.38	Left	0000	14106	14106		411.78	2					Ark1-SEQ	368841.7091	3917321.605	15
SEQU-RS-0038.00	RESID	Arkansas	SF1	308.38	Left	1964	13539.4941	13539.4941		412.65	2					Ark1-SEQ	368905.502	3917323.013	15
SEQU-RS-0039.00	RESID	Arkansas	SF1	308.38	Left	0000	9380	9380		412.43	2					Ark1-SEQ	368974.2936	3917424.763	15
SEQU-RS-0040.00	RESID	Arkansas	SF1	308.38	Left	0000	6078	6078		413.24	2					Ark1-SEQ	368953.9695	3917424.663	15
SEQU-RS-0041.00	RESID	Arkansas	SF1	308.38	Left	0000	18185.1223	18185.1223		411.81	2					Ark1-SEQ	368943.8528	3917425.077	15
SEQU-RS-0042.00	RESID	Arkansas	SF1	308.38	Left	0000	9464	9464		404.64	1					Ark1-SEQ	368997.8667	3917344.579	15
SEQU-RS-0043.00	RESID	Arkansas	SF1	308.38	Left	0000	8080	8080		411.76	2					Ark1-SEQ	368886.3076	3917278.095	15
SEQU-RS-0044.00	RESID	Arkansas	SF1	308.38	Left	0000	13050	13050		412.38	2					Ark1-SEQ	368725.8631	3917227.234	15
SEQU-RS-0045.00	RESID	Arkansas	SF1	308.38	Left	0000	15491.9616	15491.9616		412.91	2					Ark1-SEQ	368743.502	3917211.249	15
SEQU-RS-0046.00	RESID	Arkansas	SF1	308.38	Left	0000	9264	9264		412.85	1					Ark1-SEQ	368653.349	3917218.044	15
SEQU-RS-0047.00	RESID	Arkansas	SF1	308.38	Left	1972	15491.9616	15491.9616		413	1					Ark1-SEQ	368592.4157	3917276.95	15
SEQU-RS-0048.00	RESID	Arkansas	SF1	308.38	Left	1974	26655	26655		412.71	1					Ark1-SEQ	368577.3603	3917290.144	15

Struc_Name	Cat_Name	Stream_Name	Occ_Name	Station	Bank	Year	Struc_Val	Cont_Val	Other_Val	Grnd_ Stage	Found _Ht	Street	City	State	Zip	SID_Rch	X_val	Y_val	Zone
SEQU-RS-0049.00	RESID	Arkansas	SF1	308.38	Left	0000	6427	6427		412.49	2					Ark1-SEQ	368544.8976	3917291.426	15
SEQU-RS-0050.00	RESID	Arkansas	SF1	308.38	Left	0000	14145.3812	14145.3812		412.39	2					Ark1-SEQ	368528.9598	3917289.513	15
SEQU-RS-0051.00	RESID	Arkansas	SF1	308.38	Left	0000	6738.4483	6738.4483		412.23	2					Ark1-SEQ	368454.6256	3917290.661	15
SEQU-RS-0052.00	RESID	Arkansas	SF1	308.38	Left	0000	30573	30573		411.96	2					Ark1-SEQ	368434.2252	3917221.809	15
SEQU-RS-0053.00	RESID	Arkansas	SF1	308.38	Left	0000	12865.4632	12865.4632		412.23	2					Ark1-SEQ	368452.5856	3917183.048	15
SEQU-RS-0054.00	RESID	Arkansas	SF1	308.38	Left	0000	17512.5728	17512.5728		412.08	2					Ark1-SEQ	368413.309	3917185.649	15
SEQU-RS-0055.00	RESID	Arkansas	SF1	308.38	Left	0000	9840	9840		412.03	2					Ark1-SEQ	368398.9736	3917186.445	15
SEQU-RS-0056.00	RESID	Arkansas	SF1	308.38	Left	0000	20878.2831	20878.2831		413.05	2					Ark1-SEQ	368404.6445	3917137.147	15
SEQU-RS-0057.00	RESID	Arkansas	SF1	308.38	Left	0000	13606.1564	13606.1564		413.8	2					Ark1-SEQ	368424.4074	3917110.372	15
SEQU-RS-0058.00	RESID	Arkansas	SF1	308.38	Left	0000	7212	7212		414.11	2					Ark1-SEQ	368459.4707	3917105.272	15
SEQU-RS-0059.00	RESID	Arkansas	SF1	308.38	Left	1973	37788	37788		413.92	2					Ark1-SEQ	368588.8861	3917185.598	15
SEQU-RS-0060.00	RESID	Arkansas	SF1	308.38	Left	0000	13606.1564	13606.1564		412.92	2					Ark1-SEQ	368560.8355	3917181.136	15
SEQU-RS-0061.00	RESID	Arkansas	SF1	308.38	Left	0000	35762	35762		412.69	2					Ark1-SEQ	368525.2649	3917185.644	15
SEQU-RS-0062.00	RESID	Arkansas	SF1	308.38	Left	0000	10121	10121		412.14	2					Ark1-SEQ	368511.682	3917185.066	15
SEQU-RS-0063.00	RESID	Arkansas	SF1	308.38	Left	0000	12798.8008	12798.8008		414.25	2					Ark1-SEQ	368513.0219	3917114.197	15
SEQU-RS-0064.00	RESID	Arkansas	SF1	308.38	Left	0000	26306	26306		411.5	1					Ark1-SEQ	368565.2981	3917116.747	15
SEQU-RS-0065.00	RESID	Arkansas	SF1	308.38	Left	0000	47812.8537	47812.8537		413.27	2					Ark1-SEQ	368703.0011	3917181.518	15
SEQU-RS-0066.00	RESID	Arkansas	SF1	308.38	Left	0000	9754	9754		413.28	2					Ark1-SEQ	368640.7003	3917179.354	15
SEQU-RS-0067.00	RESID	Arkansas	SF1	308.38	Left	0000	18185.1223	18185.1223		413.95	2					Ark1-SEQ	368624.0677	3917177.785	15
SEQU-RS-0068.00	RESID	Arkansas	SF1	308.38	Left	0000	7821	7821		411.72	2					Ark1-SEQ	368755.0223	3917184.068	15
SEQU-RS-0069.00	RESID	Arkansas	SF1	308.38	Left	0000	22898.8944	22898.8944		412.6	2					Ark1-SEQ	368517.9957	3917072.34	15
SEQU-RS-0070.00	RESID	Arkansas	SF1	308.38	Left	0000	12124.7699	12124.7699		414.9	2					Ark1-SEQ	368450.9527	3917077.582	15
SEQU-RS-0071.00	RESID	Arkansas	SF1	308.38	Left	0000	12359	12359		414.82	2					Ark1-SEQ	368437.2799	3917076.633	15
SEQU-RS-0072.00	RESID	Arkansas	SF1	312.34	Left	1962	44724	44724		408.35	1					Ark1-SEQ	364246.958	3915008.676	15
SEQU-RS-0073.00	RESID	Arkansas	SF1	321.52	Left	1976	117675	117675		438.9	2					Ark2-SEQ	355203.6305	3912777.127	15
SEQU-RS-0074.00	RESID	Arkansas	SF1	311.07	Left	0000	46464	46464		414.51	2					Ark1-SEQ	363155.9269	3917020.954	15
SEQU-RS-0075.00	RESID	Arkansas	SF1	343.00	Left	1992	141266	141266		489	1					Ark3-SEQ	334297.149	3917215.058	15
SEQU-RS-0076.00	RESID	Arkansas	SF1	343.00	Left	1955	51341.5165	51341.5165		480	2					Ark3-SEQ	334225.0353	3916986.214	15
SEQU-RS-0077.00	RESID	Arkansas	SF1	344.40	Left	1950	42156.9198	42156.9198		501	2					Ark3-SEQ	331164.6217	3920504.641	15
SEQU-RS-0078.00	RESID	Arkansas	SF1	321.52	Left	0000	11774	11774		434.4	2					Ark2-SEQ	356465.3104	3911505.207	15

Struc_Name	Cat_Name	Stream_Name	Occ_Name	Station	Bank	Year	Struc_Val	Cont_Val	Other_Val	Grnd_ Stage	Found _Ht	Street	City	State	Zip	SID_Rch	X_val	Y_val	Zone
SEQU-RS-0079.00	RESID	Arkansas	SF1	311.07	Left	1945	21875	21875		413.77	2					Ark1-SEQ	364545.3	3917457.164	15

ADDENDUM C1

Example Crop Budget, Arkansas Soybeans

Table C1-1. Crop Budgets: Arkansas			
	Weighted Incremental Net Returns		
County: Sebastian	Soybeans Bu	Soybeans Replant	Soybeans Low Mgt
Yield Level	25	25	20
Total Cost	$134.87		
Price	$5.99	$5.99	$5.99
Gross	$149.75	$149.75	$119.8
Net Returns	$14.88		
Distribution	1		
Weighted Incremental Net	$14.88		
Total Weighted			
Incremental Net	14.88		

ADDENDUM C2

Agricultural Data

Table C2-1. 200,000 cfs: Acres Flooded (Arkansas)

REACH 1	R. M.	17	50			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	178.6	204.03	191.32	6868	8625	23414
500	177.6	202.11	189.86	6867	8625	23412
100	173.3	195.04	184.17	6690	8606	23020
50	172.5	193.61	183.06	6642	8597	22906
25	169.5	191.54	180.52	6410	8583	22414
10	167.2	189.56	178.38	6304	7231	19498
5	166.7	188.39	177.55	6282	6987	18966
2	163.8	185.71	174.76	5222	6429	15730
1	162.1	183.55	172.83	4076	4344	9268

REACH 2	R. M.	51.18	65.63			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	202	231.38	216.69	10087	15200	18264
500	200.5	228.68	214.59	10070	15200	18249
100	195	219.08	207.04	10008	15200	18195
50	193.8	217.28	205.54	9983	15191	18165
25	191.6	214	202.8	9550	15136	17738
10	189.1	211.78	200.44	7047	15083	15499
5	187.8	210.84	199.32	6374	15060	14890
2	185.1	208.56	196.83	4933	15006	13580
1	183.3	206.73	195.02	4061	14962	12778

REACH 3	R. M.	66.15	86.04			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	215.3	234.84	225.07	13721	3503	16681
500	213.5	232.11	222.81	13688	3475	16608
100	206	223.37	214.69	13095	2782	15057
50	204.7	221.75	213.23	11146	2394	12240
25	202.1	218.7	210.4	10134	1651	10125
10	200.4	216.74	208.57	9899	1526	9691
5	199.5	215.79	207.65	8590	1365	7919
2	197.6	213.46	205.53	7982	1281	7084
1	196.2	211.57	203.89	7534	1255	6513

REACH 4	R. M.	86.5	107.85			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	235.5	250.72	243.11	15566	7432	24999
500	233.6	248.55	241.08	15533	7393	24906
100	225.7	241.55	233.63	12965	7251	21399
50	224	239.84	231.92	10344	7218	17965
25	220.5	237.59	229.05	8235	7173	15178
10	218.2	235.85	227.03	6673	7138	13111

5	216.9	234.77	225.84	5550	5080	8995
2	214.7	232.38	223.54	3454	4049	4949
1	213.5	230.36	221.93	3032	3182	3281

REACH 5	R. M.	108.35	125.2			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	252	278.72	265.36	9590	7113	14184
500	250.4	274.48	262.44	9575	7080	14135
100	243.9	261.25	252.58	9503	6752	13726
50	242.6	258.97	250.79	9453	6569	13488
25	240	254.48	247.24	9006	6342	12800
10	238	251.38	244.69	8494	5621	11541
5	236.7	249.78	243.24	7812	4526	9726
2	234.1	246.3	240.2	6580	3577	7499
1	232.1	243.59	237.85	4985	2559	4830

REACH 6	R. M.	125.45	155.65			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	274.2	297.99	286.1	5995	7442	18235
500	271.8	294.99	283.4	5995	5426	14545
100	261.8	284.45	273.13	5943	5168	13978
50	260.8	282.87	271.84	5886	5128	13800
25	256.2	279.26	267.73	5665	5039	13233
10	253.5	276.79	265.15	5360	1628	6432
5	252.1	275.57	263.84	5223	1590	6111
2	250.2	272.88	261.54	5134	1507	5797
1	249.1	270.57	259.84	5091	1436	5588

REACH 7	R. M.	156.05	176.65			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	297.7	315.41	306.56	6442	4553	10970
500	295.8	312.34	304.07	6423	4553	10947
100	288.1	301.77	294.94	6065	4389	10295
50	286.5	300.1	293.3	5998	4355	10169
25	283	296.39	289.7	5409	3553	8432
10	281.6	294.48	288.04	5019	2778	6978
5	280.3	293.43	286.87	4710	2677	6466
2	276	290.37	283.19	2598	1869	2820
1	272.9	288	280.45	1272	1572	794

REACH 8	R. M.	177.08	205.25			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	315.3	337.33	326.32	6050	2370	9721
500	313.3	334.03	323.67	6050	2367	9716
100	306.3	325.27	315.79	5627	2292	8866
50	304.5	323.92	314.21	5470	2282	8581

25	299.5	319.73	309.62	4787	2249	7358
10	297.3	317.81	307.56	4732	2234	7239
5	295	315.86	305.43	4673	2217	7109
2	291.11	311.29	301.2	4575	2169	6860
1	288.1	307.69	297.9	1464	2131	1484

REACH 9	R. M.	205.6	256.4			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	338	382.71	360.36	2297	3050	4855
500	338	380.07	359.04	2297	3050	4855
100	338	373.94	355.97	2297	2417	2906
50	338	373.04	355.52	2297	2323	2617
25	338	368.46	353.23	2297	1846	1148
10	338	366.28	352.14	2297	1618	446
5	338	364.99	351.5	2297	1584	342
2	338	361.14	349.57	2297	1511	117
1	338	357.86	347.93	2297	1491	55

REACH 10	R. M.	256.9	292.5			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	383.21	413.75	398.48	1460	11623	22592
500	381.16	411.27	396.22	1442	11623	22553
100	377.18	405.23	391.21	1318	11601	22238
50	376.04	403.15	389.6	1314	11473	21953
25	374.33	399.41	386.87	1309	11030	20987
10	373.68	397.28	385.48	1307	10136	19054
5	373.34	395.79	384.57	1306	9276	17196
2	372.94	393.5	383.22	1304	8002	14443
1	372.53	390.04	381.29	1303	3950	5698

REACH 11	R. M.	292.9	319.5			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	411.5	430.05	420.78	4196	20959	36639
500	409.75	428.68	419.22	4057	20518	35704
100	406.25	426.12	416.19	3527	19681	33500
50	404.5	424.84	414.67	2988	19261	31954
25	400.68	421.3	410.99	2805	17978	29590
10	397.9	418.3	408.1	2357	9607	15373
5	395.45	416.02	405.74	2322	7579	12047
2	393.27	413.45	403.36	2218	5467	8475
1	393	410.9	401.95	2119	3565	5249

Table C2-2. 175,000 cfs: Acres Flooded (Arkansas)

REACH 1	R. M.	17	50			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	178.6	204.03	191.32	6868	8625	23414
500	177.6	202.11	189.86	6867	8625	23412
100	173.3	195.04	184.17	6690	8606	23020
50	172.5	193.61	183.06	6642	8597	22906
25	169.5	191.54	180.52	6410	8583	22414
10	167.2	189.56	178.38	6304	7231	19498
5	166.5	188.13	177.32	6249	6932	18790
2	163	185.41	174.21	4577	6367	14316
1	162.1	183.55	172.83	4076	4344	9268

REACH 2	R. M.	51.18	65.63			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	202	231.38	216.69	10087	15200	18264
500	200.5	228.68	214.59	10070	15200	18249
100	195	219.08	207.04	10008	15200	18195
50	193.8	217.28	205.54	9983	15191	18165
25	191.6	214	202.8	9550	15136	17738
10	189.1	211.78	200.44	7047	15083	15499
5	187.5	210.63	199.07	6301	15055	14821
2	184.9	208.31	196.61	4885	15000	13533
1	183.3	206.73	195.02	4061	14962	12778

REACH 3	R. M.	66.15	86.04			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	215.3	234.84	225.07	13721	3503	16681
500	213.5	232.11	222.81	13688	3475	16608
100	206	223.37	214.69	13095	2782	15057
50	204.7	221.75	213.23	11146	2394	12240
25	202.1	218.7	210.4	10134	1651	10125
10	200.4	216.74	208.57	9899	1526	9691
5	199.2	215.57	207.39	8494	1357	7793
2	197.4	213.24	205.32	7918	1273	6998
1	196.2	211.57	203.89	7534	1255	6513

REACH 4	R. M.	86.5	107.85			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	235.5	250.72	243.11	15566	7432	24999
500	233.6	248.55	241.08	15533	7393	24906
100	225.7	241.45	233.58	12965	7251	21399
50	224	239.84	231.92	10344	7218	17965
25	220.5	237.59	229.05	8235	7173	15178
10	218.2	235.85	227.03	6673	7138	13111

5	216.6	234.53	225.57	5214	4980	8431
2	214.4	232.11	223.26	3379	3935	4705
1	213.5	230.36	221.93	3032	3182	3281

REACH 5	R. M.	108.35	125.2			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	252	278.72	265.36	9590	7113	14184
500	250.4	274.48	262.44	9575	7080	14135
100	243.9	261.25	252.58	9503	6752	13726
50	242.6	258.97	250.79	9453	6569	13488
25	240	254.48	247.24	9006	6342	12800
10	238	251.38	244.69	8494	5621	11541
5	236.5	249.46	242.98	7715	4230	9325
2	233.8	245.91	239.86	6441	3494	7272
1	232.1	243.59	237.85	4985	2559	4830

REACH 6	R. M.	125.45	155.65			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	274.2	297.99	286.1	5995	7442	18235
500	271.8	294.99	283.4	5995	5426	14545
100	261.8	284.5	273.15	5943	5168	13978
50	260	282.87	271.44	5886	5128	13800
25	256.2	279.26	267.73	5665	5039	13233
10	253.5	276.79	265.15	5360	1628	6432
5	251.8	275.34	263.57	5204	1583	6064
2	250	272.56	261.28	5129	1498	5771
1	249.1	270.57	259.84	5091	1436	5588

REACH 7	R. M.	156.05	176.65			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	297.7	315.41	306.56	6442	4553	10970
500	295.8	312.34	304.07	6423	4553	10947
100	288.1	301.77	294.94	6065	4389	10295
50	286.5	300.1	293.3	5998	4355	10169
25	283	296.39	289.7	5409	3533	8407
10	281.6	294.48	288.04	5019	2778	6978
5	280.3	293.27	286.79	4710	2652	6435
2	275.6	289.81	282.71	2411	1697	2372
1	272.5	287.33	279.92	1270	1517	723

REACH 8	R. M.	177.08	205.25			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	315.3	337.33	326.32	6050	2370	9721
500	313.3	334.03	323.67	6050	2367	9716
100	306.3	325.27	315.79	5627	2292	8866
50	304.5	323.92	314.21	5470	2282	8581

25	299.5	319.73	309.62	4787	2249	7358
10	297.3	317.31	307.31	4732	2234	7239
5	295.3	315.92	305.61	4681	2220	7128
2	290.3	310.43	300.37	4554	2157	6803
1	287.8	307.26	297.53	1451	2127	1455

REACH 9	R. M.	205.6	256.4			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	340.73	382.71	361.72	2304	3050	4877
500	340.15	380.07	360.11	2302	3050	4871
100	339.19	373.94	356.57	2300	2417	2916
50	339.13	373.04	356.09	2299	2323	2623
25	338.67	368.46	353.57	2298	1846	1151
10	338.51	366.28	352.4	2298	1618	450
5	338.43	364.99	351.71	2298	1584	345
2	338.24	360.45	349.35	2297	1505	99
1	338.16	357.46	347.81	2297	1488	46

REACH 10	R. M.	256.9	292.5			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	383.21	413.75	398.48	1460	11623	22592
500	381.16	411.27	396.22	1442	11623	22553
100	377.18	405.23	391.21	1318	11601	22238
50	376.04	403.15	389.6	1314	11473	21953
25	374.33	399.41	386.87	1309	11030	20987
10	373.63	397.09	385.36	1307	10096	18967
5	373.34	395.79	384.57	1306	9276	17196
2	372.82	392.69	382.76	1304	7332	12997
1	372.53	390.04	381.29	1303	3949	5696

REACH 11	R. M.	292.9	319.5			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	411.5	430.05	420.78	4296	20959	36800
500	406.75	428.68	417.72	4057	20518	35704
100	406.25	426.12	416.19	3527	19681	33500
50	404.5	424.84	414.67	2988	19261	31954
25	400.68	421.3	410.99	2805	17978	29590
10	397.9	418.3	408.1	2357	9607	15373
5	394.9	415.35	405.13	2314	6986	11078
2	393	413.11	403.06	2119	5193	7874
1	393	410.9	401.95	2119	3564	5247

Table C2-3. Operations Plan Only: Acres Flooded (Arkansas)

REACH 1	R. M.	17	50			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	178.6	204.03	191.32	6868	8625	23414
500	177.6	202.11	189.86	6867	8625	23412
100	173.3	195.04	184.17	6690	8606	23020
50	172.5	193.61	183.06	6642	8597	22906
25	169.5	191.54	180.52	6410	8583	22414
10	167.2	189.56	178.38	6304	7231	19498
5	166.2	187.87	177.04	6194	6880	18576
2	163	185.41	174.21	4577	6367	14316
1	162	182.91	172.46	4072	4228	9028

REACH 2	R. M.	51.18	65.63			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	202	231.38	216.69	10087	15200	18264
500	200.5	228.68	214.59	10070	15200	18249
100	195	219.08	207.04	10008	15200	18195
50	193.8	217.28	205.54	9983	15191	18165
25	191.6	214	202.8	9550	15136	17738
10	189.1	211.78	200.44	7047	15083	15499
5	187.3	210.41	198.86	6246	15050	14769
2	184.9	208.31	196.61	4885	15000	13533
1	182.5	206.15	194.33	3628	14948	12387

REACH 3	R. M.	66.15	86.04			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	215.3	234.84	225.07	13721	3503	16681
500	213.5	232.11	222.81	13688	3475	16608
100	206	223.37	214.69	13095	2782	15057
50	204.7	221.75	213.23	11146	2394	12240
25	202.1	218.7	210.4	10134	1651	10125
10	200.4	216.74	208.57	9899	1526	9691
5	199.2	215.37	207.29	8494	1350	7785
2	197.4	213.24	205.32	7918	1273	6998
1	196	210.97	203.49	7470	1248	6427

REACH 4	R. M.	86.5	107.85			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	235.5	250.72	243.11	15566	7432	24999
500	233.6	248.55	241.08	15533	7393	24906
100	225.7	241.45	233.58	12965	7521	21749
50	224	239.84	231.92	10344	7218	17965
25	220.5	237.59	229.05	8235	7173	15178
10	218.2	235.85	227.03	6673	7138	13111

5	216.4	234.33	225.37	4957	4893	7986
2	214.4	232.11	223.26	3379	3935	4705
1	213	229.75	221.38	2878	2478	2171

REACH 5	R. M.	108.35	125.2			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	252	278.72	265.36	9590	7113	14184
500	250.4	274.48	262.44	9575	7080	14135
100	243.9	261.25	252.58	9503	6752	13726
50	242.6	258.97	250.79	9453	6569	13488
25	240	254.48	247.24	9006	6342	12800
10	238	251.38	244.69	8494	5621	11541
5	236.4	249.16	242.78	7663	4133	9173
2	233.8	245.91	239.86	6441	3494	7272
1	231.4	242.73	237.07	4534	2482	4291

REACH 6	R. M.	125.45	155.65			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	274.2	297.99	286.1	5995	7442	18235
500	271.8	294.99	283.4	5995	5426	14545
100	261.8	284.5	273.15	5943	5168	13978
50	260	282.87	271.44	5886	5128	13800
25	256.2	279.26	267.73	5665	5039	13233
10	253.5	276.79	265.15	5360	1628	6432
5	251.5	275.08	263.29	5183	1575	6011
2	250	272.56	261.28	5129	1498	5771
1	249	269.85	259.43	5086	1414	5538

REACH 7	R. M.	156.05	176.65			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	297.7	315.41	306.56	6442	4553	10970
500	295.8	312.34	304.07	6423	4553	10947
100	288.1	301.77	294.94	6065	4389	10295
50	286.5	300.1	293.3	5998	4355	10169
25	283	296.39	289.7	5409	3533	8407
10	281.6	294.48	288.04	5019	2778	6978
5	280	293.2	286.6	4643	2642	6339
2	275.1	289.72	282.41	2257	1691	2172
1	272.2	287.28	279.74	1269	1514	718

REACH 8	R. M.	177.08	205.25			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	315.3	337.33	326.32	6050	2370	9721
500	313.3	334.03	323.67	6050	2367	9716
100	306.3	325.27	315.79	5627	2292	8866
50	304.5	323.92	314.21	5470	2282	8581

25	299.5	319.73	309.62	4787	2249	7358
10	296.6	317.31	306.96	4714	2230	7201
5	295	315.56	305.28	4673	2217	7109
2	289.6	309.54	299.57	4554	2146	6785
1	287.5	308.85	298.18	1438	2124	1427

REACH 9	R. M.	205.6	256.4			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	338	382.71	360.36	2297	3050	4855
500	338	380.07	359.04	2297	3050	4855
100	338	373.94	355.97	2297	2417	2906
50	338	373.04	355.52	2297	2323	2617
25	338	368.46	353.23	2297	1846	1148
10	338	366.28	352.14	2297	1618	446
5	338	364.7	351.35	2297	1580	329
2	338	359.74	348.87	2297	1501	86
1	338	357.07	347.54	2297	1486	40

REACH 10	R. M.	256.9	292.5			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	383.21	413.75	398.48	1460	11623	22592
500	381.16	411.27	396.22	1442	11623	22553
100	377.18	405.23	391.21	1318	11601	22238
50	376.04	403.15	389.6	1314	11473	21953
25	374.33	399.41	386.87	1309	11030	20987
10	373.63	397.09	385.36	1307	10096	18967
5	373.25	395.3	384.28	1305	8954	16499
2	372.71	391.85	382.28	1304	6316	10805
1	372.53	390.04	381.29	1303	3950	5698

REACH 11	R. M.	292.9	319.5			
	BEG	END	MID	TOP WIDTH		AREA
FREQ	ELEV	ELEV	POINT	BEG	END	ACRES
1000	411.5	430.05	420.78	4196	20959	36639
500	409.75	428.68	419.22	4057	20518	35704
100	406.25	426.12	416.19	3527	19681	33500
50	404.5	424.84	414.67	2988	19261	31954
25	400.68	421.3	410.99	2805	17978	29590
10	397.45	417.88	407.67	2349	9226	14746
5	394.9	415.35	405.13	2314	6986	11078
2	393	412.04	402.52	2119	4322	6469
1	393	410.09	401.55	2119	3565	5249

ADDENDUM C3

Plan Comparison: Acres Flooded (Arkansas)

Table C3-1. Flow Management Component Comparison: Acres Flooded (Arkansas)

		NO ACTION COMPONENT	175,000 cfs COMPONENT	200,000 cfs COMPONENT	OPS ONLY COMPONENT	175,000 cfs COMPONENT	200,000 cfs COMPONENT	OPS ONLY COMPONENT
	FREQ	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES
REACH 1	1000	47	47	47	47	0	0	0
	500	232	232	232	232	0	0	0
	100	459	459	459	459	0	0	0
	50	906	906	906	906	0	0	0
	25	2096	2096	2096	2096	0	0	0
	10	3807	3829	3846	3807	22	39	0
	5	8223	8276	8674	8223	53	451	0
	2	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
TOTAL		**15770**	**15845**	**16260**	**15770**	**75**	**490**	**0**

	FREQ	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES
REACH 2	1000	37	37	37	37	0	0	0
	500	182	182	182	182	0	0	0
	100	364	364	364	364	0	0	0
	50	718	718	718	718	0	0	0
	25	1662	1662	1662	1662	0	0	0
	10	3027	3032	3039	3027	5	12	0
	5	7075	7088	7117	7075	13	42	0
	2	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
TOTAL		**13065**	**13083**	**13119**	**13065**	**18**	**54**	**0**

Table C3-1. Flow Management Component Comparison: Acres Flooded (Arkansas)

	FREQ	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES
REACH 3	1000	33	33	33	33	0	0	0
	500	158	158	158	158	0	0	0
	100	273	273	273	273	0	0	0
	50	447	447	447	447	0	0	0
	25	991	991	991	991	0	0	0
	10	1747	1748	1761	1747	1	14	0
	5	3695	3698	3751	3695	3	56	0
	2	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
TOTAL		**7344**	**7348**	**7414**	**7344**	**4**	**70**	**0**

	FREQ	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES
REACH 4	1000	50	50	50	50	0	0	0
	500	232	232	232	232	0	0	0
	100	394	394	394	394	0	0	0
	50	663	663	663	663	0	0	0
	25	1414	1414	1414	1414	0	0	0
	10	2110	2154	2211	2110	44	101	0
	5	3173	3284	3486	3173	111	313	0
	2	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
TOTAL		**8036**	**8191**	**8450**	**8036**	**155**	**414**	**0**
	FREQ	**AVG ANN ACRES**	**AVG ANN ACRES**	**AVG ANN ACRES**	**AVG ANN ACRES**	**DIFF AVG ANN ACRES**	**DIFF AVG ANN ACRES**	**DIFF AVG ANN ACRES**
REACH 5	1000	28	28	28	28	0	0	0
	500	139	139	139	139	0	0	0
	100	272	272	272	272	0	0	0
	50	526	526	526	526	0	0	0
	25	1217	1217	1217	1217	0	0	0
	10	2071	2086	2127	2071	15	56	0
	5	4111	4149	4306	4111	38	195	0
	2	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
TOTAL		**8364**	**8417**	**8615**	**8364**	**53**	**251**	**0**

Table C3-1. Flow Management Component Comparison: Acres Flooded (Arkansas)

	FREQ	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES
REACH 6	1000	33	33	33	33	0	0	0
	500	143	143	143	143	0	0	0
	100	278	278	278	278	0	0	0
	50	541	541	541	541	0	0	0
	25	983	983	983	983	0	0	0
	10	1244	1249	1254	1244	5	10	0
	5	2945	2958	2977	2945	13	32	0
	2	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
TOTAL		**6167**	**6185**	**6209**	**6167**	**18**	**42**	**0**

	FREQ	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES
REACH 7	1000	22	22	22	22	0	0	0
	500	106	106	106	106	0	0	0
	100	205	205	205	205	0	0	0
	50	370	372	372	370	2	2	0
	25	766	769	770	766	3	4	0
	10	1332	1341	1344	1332	9	12	0
	5	2128	2202	2321	2128	74	193	0
	2	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
TOTAL		**4929**	**5017**	**5140**	**4929**	**88**	**211**	**0**

	FREQ	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES
REACH 8	1000	19	19	19	19	0	0	0
	500	93	93	93	93	0	0	0
	100	174	174	174	174	0	0	0
	50	319	319	319	319	0	0	0
	25	730	730	730	730	0	0	0
	10	1433	1437	1435	1433	4	2	0
	5	3474	3483	3492	3474	9	18	0
	2	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
TOTAL		**6242**	**6255**	**6262**	**6242**	**13**	**20**	**0**

Table C3-1. Flow Management Component Comparison: Acres Flooded (Arkansas)

	FREQ	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES
REACH 9	1000	10	10	10	10	0	0	0
	500	39	39	39	39	0	0	0
	100	55	55	55	55	0	0	0
	50	75	75	75	75	0	0	0
	25	80	80	80	80	0	0	0
	10	77	79	79	77	2	2	0
	5	102	111	114	102	9	12	0
	2	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
TOTAL		**438**	**449**	**452**	**438**	**11**	**14**	**0**

	FREQ	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES
REACH 10	1000	45	45	45	45	0	0	0
	500	224	224	224	224	0	0	0
	100	442	442	442	442	0	0	0
	50	859	859	859	859	0	0	0
	25	1998	1998	2002	1998	0	4	0
	10	3515	3616	3625	3515	101	110	0
	5	6747	7548	7909	6747	801	1162	0
	2	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
TOTAL		**13830**	**14732**	**15106**	**13830**	**902**	**1276**	**0**

	FREQ	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES	DIFF AVG ANN ACRES
REACH 11	1000	72	73	72	72	1	0	0
	500	346	346	346	346	0	0	0
	100	655	655	655	655	0	0	0
	50	1231	1231	1231	1231	0	0	0
	25	2217	2248	2248	2217	31	31	0
	10	2503	2645	2742	2503	142	239	0
	5	4189	4738	5130	4189	549	941	0
	2	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
TOTAL		**11213**	**11936**	**12424**	**11213**	**723**	**1211**	**0**

ADDENDUM D1:

Example of Arkansas Structure Inventory

Structure Inventory Example Import File, Arkansas County

Struc_Name	Notes	Stream_Name	Bank	Station	Grnd_Stage	Found_Ht	Occ_Name	Cat_Name	Struc_Val
002-04198-003	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	3	SF1P	RES	11158.1658
002-04198-004	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	3	SF1P	RES	11136.1536
002-04198-005	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	3	SF1P	RES	15366.2507
002-04198-009	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	2	MH1	RES	3374.592
002-04198-010	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	2	MH1	RES	3374.592
002-04198-015	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	2	MH1	RES	19766.6126
002-04198-019	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	2	MH1	RES	3922.9632
002-04198-020	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	3	SF1P	RES	10616.9606
002-04198-022	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	2	MH1	RES	4454.46144
002-04198-025	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	2	MH1	RES	1669.296
002-04198-029	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	3	SF1P	RES	26132.8713
002-04198-028	Arkansas County, Gillett Quad	Arkansas	LEFT	31	175	3	SF1P	RES	18762.9315
002-04198-029	Arkansas County, Gillett Quad	Arkansas	LEFT	31	175	2	MH1	RES	5865.536
002-04198-030	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	2	MH1	RES	1669.296
002-04198-031	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	3	SF1P	RES	21501.2713
002-04198-039	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	2	MH1	RES	48408.5222
002-04198-036	Arkansas County, Gillett Quad	Arkansas	LEFT	31	175	2	MH1	RES	2012.8512
002-04198-038	Arkansas County, Gillett Quad	Arkansas	LEFT	31	175	2	MH1	RES	3374.592
002-04198-040	Arkansas County, Gillett Quad	Arkansas	LEFT	31	175	2	MH1	RES	3374.592
002-04198-042	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	2	MH1	RES	4218.24
002-04198-043	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	2	MH1	RES	5230.6176
002-04198-048	Arkansas County, Gillett Quad	Arkansas	LEFT	31	175	3	SF1P	RES	13016.544
002-04198-050	Arkansas County, Gillett Quad	Arkansas	LEFT	31	175	3	SF1P	RES	3359.31904
002-04198-052	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	2	MH1	RES	8432.648
002-04198-057	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	2	MH1	RES	1055.60064
002-04198-058	Arkansas County, Gillett Quad	Arkansas	LEFT	31	165	2	MH1	RES	6451.65952
002-04198-062	Arkansas County, Gillett Quad	Arkansas	LEFT	31	175	2	MH1	RES	10444.3622
002-04198-063	Arkansas County, Gillett Quad	Arkansas	LEFT	30.8	165	0.5	SF1G	RES	16692.96
002-04198-012	Arkansas County, Gillett Quad	Arkansas	LEFT	30.8	165	3	SF1P	RES	20986.936
002-04198-071A	Arkansas County, Gillett Quad	Arkansas	LEFT	30.8	165	2	MH1	RES	12907.5144
002-04198-071B	Arkansas County, Gillett Quad	Arkansas	LEFT	30.8	175	2	MH1	RES	3374.592
002-04198-081	Arkansas County, Gillett Quad	Arkansas	LEFT	30.8	165	2	MH1	RES	3880.1608
002-04198-083	Arkansas County, Gillett Quad	Arkansas	LEFT	30.8	165	3	SF1P	RES	12623.8496
002-04198-084	Arkansas County, Gillett Quad	Arkansas	LEFT	30.8	165	2	MH1	RES	168.1296
002-04198-086A	Arkansas County, Gillett Quad	Arkansas	LEFT	30.8	165	3	SF1P	RES	17021.842
002-04198-086B	Arkansas County, Gillett Quad	Arkansas	LEFT	30.8	165	2	MH1	RES	3374.592
002-04198-087	Arkansas County, Gillett Quad	Arkansas	LEFT	30.8	165	2	MH1	RES	5061.888
002-04801-001	Arkansas County, Gillett Quad	Arkansas	LEFT	30.8	165	2	MH1	RES	1669.296
002-04801-002	Arkansas County, Gillett Quad	Arkansas	LEFT	30.8	165	2	MH1	RES	11102.4070
002-04801-003	Arkansas County, Gillett Quad	Arkansas	LEFT	30.8	165	2	MH1	RES	3374.592
002-04198-011	Arkansas County, Gillett Quad	Arkansas	LEFT	30.8	165	3	SF1P	RES	41700
002-04198-013	Arkansas County, Gillett Quad	Arkansas	LEFT	30.8	165	3	MH1P	RES	1139
ARK2	Arkansas County, Gillett Quad	Arkansas	LEFT	30.4	165	3	SF1P	RES	12180
ARK3	Arkansas County, Gillett Quad	Arkansas	LEFT	30.4	165	3	SF1P	RES	12168
ARK4	Arkansas County, Gillett Quad	Arkansas	LEFT	25	170	2	MH1	RES	1629
ARK5	Arkansas County, Gillett Quad	Arkansas	LEFT	25	170	2	MH1	RES	1785
ARK6	Arkansas County, Gillett Quad	Arkansas	LEFT	25	170	2	MH1	RES	812
ARK7	Arkansas County, Gillett Quad	Arkansas	LEFT	25	170	2	MH1	RES	1628
ARK8	Arkansas County, Gillett Quad	Arkansas	LEFT	25	170	2	MH1	RES	1628
ARK9	Arkansas County, Gillett Quad	Arkansas	LEFT	25	170	2	MH1	RES	10902
ARK10	Arkansas County, Gillett Quad	Arkansas	LEFT	25	170	2	MH1	RES	1628
ARK11	Arkansas County, Gillett Quad	Arkansas	LEFT	25	170	2	MH1	RES	2438
ARK12	Arkansas County, Gillett Quad	Arkansas	LEFT	25	170	2	MH1	RES	1211
ARK13	Arkansas County, Gillett Quad	Arkansas	LEFT	25	170	2	MH1	RES	3245
ARK14	Arkansas County, Gillett Quad	Arkansas	LEFT	25	170	2	MH1	RES	812
ARK15	Arkansas County, Gillett Quad	Arkansas	LEFT	25	170	2	MH1	RES	486
ARK16	Arkansas County, Gillett Quad	Arkansas	LEFT	25	180	3	SF1P	RES	1622
ARK17	Arkansas County, Gillett Quad	Arkansas	LEFT	26	180	3	SF1P	RES	1622
ARK18	Arkansas County, Gillett Quad	Arkansas	LEFT	25	180	3	SF1P	RES	1622
ARK19	Arkansas County, Gillett Quad	Arkansas	LEFT	25	180	3	SF1P	RES	16224
ARK20	Arkansas County, Gillett Quad	Arkansas	LEFT	25	165	2	MH1	RES	4868
ARK21	Arkansas County, Gillett Quad	Arkansas	LEFT	25	165	3	SF1P	RES	1622

ADDENDUM D2:

Example of Hydraulic Data

Table D2-1. Hydraulic Data Example Import File, Reach 2

Profile Output Table - HEC-FDA
HEC-RAS Plan: Baseline-QF River: Arkansas Reach: Pool 3
Rivers = 1
Hydraulic Reaches = 1
River Stations = 22
Plans = 1
Profiles = 8

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft.)
Pool 3	51.18	865000.00	156.10	200.50
Pool 3	51.18	505000.00	156.10	195.00
Pool 3	51.18	450000.00	156.10	193.80
Pool 3	51.18	355000.00	156.10	191.60
Pool 3	51.18	300000.00	156.10	189.10
Pool 3	51.18	265000.00	156.10	187.30
Pool 3	51.18	220000.00	156.10	184.90
Pool 3	51.18	180000.00	156.10	182.50
Pool 3	52.35	865000.00	150.10	201.07
Pool 3	52.35	505000.00	150.10	195.47
Pool 3	52.35	450000.00	150.10	194.27
Pool 3	52.35	355000.00	150.10	192.06
Pool 3	52.35	300000.00	150.10	189.63
Pool 3	52.35	265000.00	150.10	187.94
Pool 3	52.35	220000.00	150.10	185.66
Pool 3	52.35	180000.00	150.10	183.41
Pool 3	52.97	865000.00	150.16	201.28
Pool 3	52.97	505000.00	150.16	195.67
Pool 3	52.97	450000.00	150.16	194.48
Pool 3	52.97	355000.00	150.16	192.29
Pool 3	52.97	300000.00	150.16	189.91
Pool 3	52.97	265000.00	150.16	188.27
Pool 3	52.97	220000.00	150.16	186.07
Pool 3	52.97	180000.00	150.16	183.91
Pool 3	53.69	865000.00	150.30	201.84
Pool 3	53.69	505000.00	150.30	196.03

Table D2-1. Hydraulic Data Example Import File, Reach 2

Pool 3	53.69	450000.00	150.30	194.84
Pool 3	53.69	355000.00	150.30	192.66
Pool 3	53.69	300000.00	150.30	190.31
Pool 3	53.69	265000.00	150.30	188.73
Pool 3	53.69	220000.00	150.30	186.58
Pool 3	53.69	180000.00	150.30	184.47
Pool 3	54.92	865000.00	131.10	202.57
Pool 3	54.92	505000.00	131.10	196.45
Pool 3	54.92	450000.00	131.10	195.23
Pool 3	54.92	355000.00	131.10	193.00
Pool 3	54.92	300000.00	131.10	190.67
Pool 3	54.92	265000.00	131.10	189.13
Pool 3	54.92	220000.00	131.10	187.03
Pool 3	54.92	180000.00	131.10	184.95
Pool 3	55.23	865000.00	135.70	203.30
Pool 3	55.23	505000.00	135.70	196.92
Pool 3	55.23	450000.00	135.70	195.65
Pool 3	55.23	355000.00	135.70	193.29
Pool 3	55.23	300000.00	135.70	190.91
Pool 3	55.23	265000.00	135.70	189.36
Pool 3	55.23	220000.00	135.70	187.23
Pool 3	55.23	180000.00	135.70	185.11
Pool 3	55.54	865000.00	140.32	203.69
Pool 3	55.54	505000.00	140.32	197.18
Pool 3	55.54	450000.00	140.32	195.90
Pool 3	55.54	355000.00	140.32	193.50
Pool 3	55.54	300000.00	140.32	191.11
Pool 3	55.54	265000.00	140.32	189.55
Pool 3	55.54	220000.00	140.32	187.41
Pool 3	55.54	180000.00	140.32	185.28
Pool 3	55.85	865000.00	144.82	203.83
Pool 3	55.85	505000.00	144.82	197.32
Pool 3	55.85	450000.00	144.82	196.04
Pool 3	55.85	355000.00	144.82	193.64
Pool 3	55.85	300000.00	144.82	191.25
Pool 3	55.85	265000.00	144.82	189.71
Pool 3	55.85	220000.00	144.82	187.59
Pool 3	55.85	180000.00	144.82	185.47

Table D2-1. Hydraulic Data Example Import File, Reach 2

Pool 3	56.37	865000.00	152.30	203.98
Pool 3	56.37	505000.00	152.30	197.41
Pool 3	56.37	450000.00	152.30	196.12
Pool 3	56.37	355000.00	152.30	193.72
Pool 3	56.37	300000.00	152.30	191.34
Pool 3	56.37	265000.00	152.30	189.83
Pool 3	56.37	220000.00	152.30	187.75
Pool 3	56.37	180000.00	152.30	185.66
Pool 3	57.39	865000.00	142.10	204.20
Pool 3	57.39	505000.00	142.10	197.61
Pool 3	57.39	450000.00	142.10	196.36
Pool 3	57.39	355000.00	142.10	194.05
Pool 3	57.39	300000.00	142.10	191.73
Pool 3	57.39	265000.00	142.10	190.33
Pool 3	57.39	220000.00	142.10	188.35
Pool 3	57.39	180000.00	142.10	186.32
Pool 3	58.46	865000.00	147.87	205.18
Pool 3	58.46	505000.00	147.87	198.43
Pool 3	58.46	450000.00	147.87	197.12
Pool 3	58.46	355000.00	147.87	194.75
Pool 3	58.46	300000.00	147.87	192.49
Pool 3	58.46	265000.00	147.87	191.10
Pool 3	58.46	220000.00	147.87	189.13
Pool 3	58.46	180000.00	147.87	187.07
Pool 3	58.69	865000.00	154.10	205.84
Pool 3	58.69	505000.00	154.10	198.99
Pool 3	58.69	450000.00	154.10	197.68
Pool 3	58.69	355000.00	154.10	195.27
Pool 3	58.69	300000.00	154.10	193.05
Pool 3	58.69	265000.00	154.10	191.73
Pool 3	58.69	220000.00	154.10	189.81
Pool 3	58.69	180000.00	154.10	187.79
Pool 3	59.3	865000.00	156.07	205.90
Pool 3	59.3	505000.00	156.07	199.11
Pool 3	59.3	450000.00	156.07	197.81
Pool 3	59.3	355000.00	156.07	195.45
Pool 3	59.3	300000.00	156.07	193.26

Table D2-1. Hydraulic Data Example Import File, Reach 2

Pool 3	59.3	265000.00	156.07	192.00
Pool 3	59.3	220000.00	156.07	190.16
Pool 3	59.3	180000.00	156.07	188.22
Pool 3	59.93	865000.00	158.30	207.43
Pool 3	59.93	505000.00	158.30	200.34
Pool 3	59.93	450000.00	158.30	199.00
Pool 3	59.93	355000.00	158.30	196.51
Pool 3	59.93	300000.00	158.30	194.32
Pool 3	59.93	265000.00	158.30	193.04
Pool 3	59.93	220000.00	158.30	191.16
Pool 3	59.93	180000.00	158.30	189.17
Pool 3	61.12	865000.00	150.80	207.66
Pool 3	61.12	505000.00	150.80	200.69
Pool 3	61.12	450000.00	150.80	199.36
Pool 3	61.12	355000.00	150.80	196.92
Pool 3	61.12	300000.00	150.80	194.75
Pool 3	61.12	265000.00	150.80	193.51
Pool 3	61.12	220000.00	150.80	191.68
Pool 3	61.12	180000.00	150.80	189.71
Pool 3	62.13	865000.00	155.80	208.39
Pool 3	62.13	505000.00	155.80	201.19
Pool 3	62.13	450000.00	155.80	199.85
Pool 3	62.13	355000.00	155.80	197.39
Pool 3	62.13	300000.00	155.80	195.22
Pool 3	62.13	265000.00	155.80	194.02
Pool 3	62.13	220000.00	155.80	192.22
Pool 3	62.13	180000.00	155.80	190.28
Pool 3	62.93	865000.00	156.53	209.91
Pool 3	62.93	505000.00	156.53	202.10
Pool 3	62.93	450000.00	156.53	200.65
Pool 3	62.93	355000.00	156.53	198.06
Pool 3	62.93	300000.00	156.53	195.83
Pool 3	62.93	265000.00	156.53	194.62
Pool 3	62.93	220000.00	156.53	192.81
Pool 3	62.93	180000.00	156.53	190.83
Pool 3	63.7	865000.00	157.30	210.45
Pool 3	63.7	505000.00	157.30	202.82

Table D2-1. Hydraulic Data Example Import File, Reach 2

Pool 3	63.7	450000.00	157.30	201.32
Pool 3	63.7	355000.00	157.30	198.64
Pool 3	63.7	300000.00	157.30	196.41
Pool 3	63.7	265000.00	157.30	195.22
Pool 3	63.7	220000.00	157.30	193.40
Pool 3	63.7	180000.00	157.30	191.39
Pool 3	64.13	865000.00	158.40	210.78
Pool 3	64.13	505000.00	158.40	203.51
Pool 3	64.13	450000.00	158.40	202.04
Pool 3	64.13	355000.00	158.40	199.32
Pool 3	64.13	300000.00	158.40	197.13
Pool 3	64.13	265000.00	158.40	195.92
Pool 3	64.13	220000.00	158.40	194.07
Pool 3	64.13	180000.00	158.40	192.04
Pool 3	64.46	865000.00	159.20	211.19
Pool 3	64.46	505000.00	159.20	203.80
Pool 3	64.46	450000.00	159.20	202.36
Pool 3	64.46	355000.00	159.20	199.70
Pool 3	64.46	300000.00	159.20	197.57
Pool 3	64.46	265000.00	159.20	196.38
Pool 3	64.46	220000.00	159.20	194.56
Pool 3	64.46	180000.00	159.20	192.52
Pool 3	65.22	865000.00	162.90	211.36
Pool 3	65.22	505000.00	162.90	204.08
Pool 3	65.22	450000.00	162.90	202.65
Pool 3	65.22	355000.00	162.90	200.01
Pool 3	65.22	300000.00	162.90	197.92
Pool 3	65.22	265000.00	162.90	196.78
Pool 3	65.22	220000.00	162.90	195.03
Pool 3	65.22	180000.00	162.90	193.05
Pool 3	65.63	865000.00	166.00	212.19
Pool 3	65.63	505000.00	166.00	204.65
Pool 3	65.63	450000.00	166.00	203.16
Pool 3	65.63	355000.00	166.00	200.42
Pool 3	65.63	300000.00	166.00	198.33
Pool 3	65.63	265000.00	166.00	197.20
Pool 3	65.63	220000.00	166.00	195.48
Pool 3	65.63	180000.00	166.00	193.52

ADDENDUM E1

Traffic – Historic and Projected

1. Historic Traffic

Historic traffic is discussed in terms of the volume, types, and origin to destination shipping patterns on the MKARNS.

(1) Total Volume

Traffic on the Arkansas River system generally ranged between 500,000 and 1 million tons a year in the twenty years before the completion of MKARNS. Construction of MKARNS was completed in 1970 and traffic increased rapidly through 1978 up to nearly 10 million tons. Traffic declined and then stabilized for the next ten years at a level of about 8 million tons. Traffic again increased in the 1990's to its current estimated level in 2003 of 11,900,000 tons.

Table E1-1. Historic Tonnage: 1950 – 2004: (thousands of tons)					
Year	**Tons**	**Year**	**Tons**	**Year**	**Tons**
1950	627	1970	3,995	1990	8,786
1951	744	1971	4,294	1991	9,014
1952	805	1972	5,337	1992	8,526
1953	513	1973	4,955	1993	9,382
1954	433	1974	6,000	1994	10,706
1955	738	1975	5,157	1995	10,348
1956	602	1976	6,538	1996	10,551
1957	644	1977	9,146	1997	11,154
1958	676	1978	9,852	1998	12,036
1959	761	1979	8,411	1999	11,716
1960	813	1980	8,461	2000	10,733
1961	838	1981	7,674	2001	11,206
1962	1,591	1982	7,823	2002	11,903
1963	707	1983	7,568	2003	12,988
1964	1,030	1984	8,521	2004*	12,897
1965	1,310	1985	7,725		
1966	1,162	1986	8,396		
1967	739	1987	7,915		
1968	1,238	1988	6,678		
1969	2,906	1989	7,927		

*Preliminary estimate of tonnage provided by Little Rock District Operations personnel.

Lock level data are available back to the year 1980. The annual growth rate in river traffic from 1980 to 2003 was 1.4%. The comparable growth rates at each of the navigation projects are listed in the table below, along with the tonnage for each year. The growth rates range from 0.4% - 1.7%, with the largest number of projects experiencing growth in the range of 1.5%, or near the river average.

Table E1-2. Tonnage by Lock
(thousands of tons)

	Norrell	L&D 2	Hardin	Sanders	L&D 5	Terry	Murray	Toad Suck Ferry	Ormond	Dardanelle	Ozark	Trimble	Mayo	Kerr	Webber Falls	Chouteau	Graham
1980	6,267	6,351	6,198	6,168	5,427	5,461	4,825	4,852	4,620	4,732	4,545	4,841	4,304	4,325	3,802	2,833	2,741
1981	7,267	7,236	7,032	6,864	5,933	5,921	5,297	5,299	5,225	4,942	4,929	4,989	4,655	4,653	4,193	2,744	2,622
1982	6,139	6,044	5,790	5,693	4,968	4,984	4,328	4,289	4,329	4,168	4,095	4,165	3,893	3,936	3,445	2,717	2,674
1983	5,838	5,849	5,711	5,502	4,833	4,797	4,173	4,158	4,104	4,206	3,981	4,038	3,670	3,670	3,100	2,512	2,423
1984	6,357	6,485	6,270	6,162	5,642	5,493	4,880	4,796	4,846	4,796	4,675	4,763	4,435	4,418	3,834	3,106	3,029
1985	5,293	5,302	5,015	4,847	4,431	4,374	3,719	3,693	3,767	3,709	3,567	3,844	3,317	3,272	2,841	2,408	2,345
1986	5,798	5,851	5,570	5,407	4,728	4,690	3,617	3,578	3,539	3,493	3,439	3,866	2,886	2,902	2,506	2,502	2,443
1987	5,497	5,589	5,262	5,201	4,816	4,729	3,812	3,755	3,753	3,712	3,574	3,727	3,393	3,390	3,283	3,113	3,039
1988	5,163	5,186	4,958	4,987	4,282	4,100	3,801	3,472	3,289	3,402	3,251	3,491	3,047	3,028	3,062	2,800	2,733
1989	6,014	5,980	5,896	5,816	5,171	5,185	4,158	4,107	4,154	3,943	3,994	4,129	3,770	3,705	3,650	3,229	3,113
1990	5,823	5,851	5,474	5,216	4,728	4,739	4,008	3,881	4,079	3,696	3,714	4,067	3,490	3,493	3,451	3,003	2,874
1991	6,464	6,525	6,236	6,044	5,499	5,232	4,618	4,549	4,570	4,456	4,469	4,645	4,052	4,125	4,039	3,662	3,379
1992	6,516	6,640	6,226	6,018	5,650	5,616	5,019	4,869	4,813	4,693	4,188	4,311	3,781	3,799	3,736	3,221	2,992
1993	6,664	6,687	6,381	6,337	5,634	5,795	5,017	5,042	5,036	4,773	3,725	3,902	3,268	3,405	3,328	2,807	2,664
1994	7,545	7,592	7,006	7,046	6,216	6,464	5,570	5,652	5,561	5,469	4,113	4,094	3,730	3,761	3,708	3,033	2,888
1995	7,445	7,480	6,886	6,854	6,219	6,236	5,353	5,153	5,458	5,239	3,647	3,502	3,116	3,107	3,036	2,535	2,416
1996	8,125	8,138	7,401	7,359	6,757	6,698	5,875	5,630	5,461	5,362	4,062	4,039	3,347	3,346	3,307	2,867	2,735
1997	8,696	8,737	8,229	8,219	7,494	7,511	6,602	6,367	6,124	6,036	4,674	4,882	4,130	4,139	4,041	3,488	3,071
1998	9,444	9,392	8,858	8,753	8,046	7,737	6,868	6,809	6,282	6,183	4,900	5,107	4,427	4,411	4,219	3,648	3,510
1999	8,797	8,827	8,049	8,043	7,431	7,388	6,490	6,364	5,973	5,993	4,361	4,608	4,132	4,156	4,007	3,509	3,350
2000	8,301	8,359	7,877	7,982	7,135	6,881	6,156	5,908	5,561	5,735	4,316	4,203	4,109	4,045	3,897	3,542	3,278
2001	8,696	8,691	8,086	8,100	7,548	7,493	6,744	6,527	6,503	6,751	4,600	4,611	4,325	4,340	4,184	3,633	3,480
2002	8,851	8,853	8,172	8,214	8,088	7,999	7,149	7,007	7,116	7,173	5,073	5,031	4,698	4,675	4,416	3,828	3,732
2003	9,139	9,126	8,380	8,358	8,158	8,102	7,108	7,111	7,137	7,106	5,300	5,322	4,979	5,024	4,759	4,066	3,914
Ann Rate:	1.6%	1.5%	1.3%	1.3%	1.7%	1.7%	1.6%	1.6%	1.8%	1.7%	0.6%	0.4%	0.6%	0.6%	0.9%	1.5%	1.5%

Source: LPMS data provided by IWR.

Traffic consists of different commodities that can be grouped based on similar physical characteristics and markets. Historic traffic by commodity group is listed in the table below. The largest groups in terms of tonnage are non-metallic minerals, farm products and agricultural chemicals (fertilizers). The overall annual rate of growth for all traffic over the past 28 years was 3%.

Table E1-3. Historic Traffic by Commodity Group

(thousands of tons)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Farm Products	0.75	1.03	1.22	1.17	1.22	1.80	1.83	2.21	2.15	2.03	1.80	1.77	1.53	1.74	2.11
Metals	0.58	0.67	1.13	0.86	0.59	0.72	0.60	0.52	0.50	0.69	0.67	0.64	0.72	0.70	0.77
Coal	0.15	0.24	0.52	1.49	0.80	0.72	1.02	0.92	0.95	1.27	0.72	0.65	0.48	0.10	0.09
Crude Petroleum	0.00	0.03	0.02	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Nonmetallic Minerals	2.29	2.29	2.77	2.96	2.89	2.24	1.69	1.62	1.84	2.33	2.43	2.69	2.59	1.84	2.19
Forest Products	0.17	0.19	0.13	0.17	0.14	0.17	0.17	0.24	0.16	0.16	0.09	0.07	0.06	0.06	0.09
Industrial Chemicals	0.16	0.19	0.26	0.41	0.57	0.36	0.24	0.30	0.32	0.43	0.34	0.46	0.58	0.40	0.36
Agricultural Chemicals	0.29	0.23	0.35	0.33	0.44	0.63	0.39	0.38	0.51	0.64	0.87	1.13	1.19	1.20	1.30
Petroleum Products	0.45	1.27	2.07	1.98	1.66	1.77	1.66	1.48	1.09	0.95	0.71	0.85	0.63	0.55	0.99
Other	0.33	0.41	0.68	0.47	0.12	0.04	0.06	0.16	0.04	0.03	0.09	0.09	0.13	0.08	0.05
Total	**5.16**	**6.54**	**9.15**	**9.85**	**8.41**	**8.46**	**7.67**	**7.82**	**7.57**	**8.52**	**7.73**	**8.40**	**7.91**	**6.68**	**7.93**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	wtd av	Rate
Farm Products	2.04	2.95	2.62	2.51	2.81	2.27	2.34	2.61	2.76	2.72	2.32	2.58	2.81	2.48	5.0%
Metals	0.79	0.77	0.73	0.81	0.89	0.84	0.94	1.09	1.28	0.97	1.08	0.96	1.24	0.97	2.9%
Coal	0.19	0.20	0.14	0.16	0.19	0.15	0.08	0.13	0.47	0.19	0.14	0.20	0.27	0.13	2.3%
Crude Petroleum	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Nonmetallic Minerals	3.27	2.58	2.56	3.49	4.15	4.54	3.95	4.23	4.35	4.93	4.42	4.79	4.73	4.20	2.7%
Forest Products	0.07	0.09	0.08	0.12	0.13	0.19	0.71	0.72	0.54	0.43	0.44	0.13	0.09	0.55	-2.2%
Industrial Chemicals	0.38	0.25	0.21	0.22	0.17	0.17	0.24	0.26	0.33	0.30	0.26	0.19	0.24	0.22	1.6%
Agricultural Chemicals	1.36	1.48	1.48	1.52	1.70	1.53	1.56	1.59	1.65	1.59	1.52	1.84	1.87	1.58	7.1%
Petroleum Products	0.67	0.66	0.69	0.54	0.65	0.65	0.73	0.52	0.64	0.58	0.54	0.51	0.52	0.62	0.6%
Other	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08	0.01	-5.2%
Total	**8.79**	**9.00**	**8.51**	**9.38**	**10.71**	**10.35**	**10.55**	**11.15**	**12.04**	**11.72**	**10.73**	**11.20**	**11.86**	**10.77**	**3.1%**

Source: Army Corps of Engineers; Institute for Water Resources

(2) Types of Commodities

The individual types of commodities that moved on the waterway in 2001 are listed in the following table. Four commodities were shipped in quantities of more than one million tons: 1) sand and gravel; 2) waterway improvement material; 3) wheat; and 4) nitrogenous fertilizer. Together, these commodities account for 63% of all tonnage shipped on the river system.

Table E1-4. Types of Commodities and Tonnage – 2001 (thousands of tons)			
Farm Products	**2,582**	**Agricultural Chemicals**	**1,838**
Wheat	1,328	Ammonia	193
Rice	227	Double Salts	1
Maize	132	Ammonium Sulfate	6
Oats	28	Urea Fertilizer	800
Grain	254	Mineral/Chem Fertilizer	275
Buckwheat	1	Basic Slag Fertilizer	1
Meal & Flour	1	Superphosphate	15
Molasses	44	Mineral-Phosph	77
Bran	34	Mineral-Posta.	101
Oil-Cake	38	Diammonium	213
Flour	9	Monoammonium	36
Food Wastes	2	Fertilizer-Tablet	2
Soya Beans	479	Fertilizer-NEC	118
Flour	6	**Nonmetallic Minerals**	**4,787**
Metals	**960**	Limes	34
Ferrous Wastes	108	Gypsum	5
Aluminum Ores	49	Sands	2,232
Manganese Ore	3	Pebbles	94
Ores - Others	1	Material-Waterway*	2,172
Pig Iron	26	Clays	7
Other Ferrous Alloys	5	Sodium	19
Ingots	3	Slag, Dross	8
Flat-rolled Prod.	352	Slag Ash	39
Iron & Steel Bars	159	Vermiculite	10
Wire	123	Portland Aluminous	165
Tubes	110	Glass	1
Aluminum	14	Glassware	0
Zinc	6	**Petroleum and Products**	**508**
Coal	**149**	Other Light Oils	127
Coal	36	Fuel	52
Coke	113	Lubricating Oils	3
Forest Products	**130**	Pitch	94
Wood Particles	111	Petro Coke	187
Pulp	2	Petro - NEC	45
Rubber	0	**Crude Petroleum**	**0**
Kraft	1	**Other**	**67**
Paper	16	Manufactured Goods	56
Industrial Chemicals	**184**	Machinery	10
Manganese Oxides	30	Pumps	1
Ammonium Nitrate	98	Electrical Equipment	0
Sodium Chloride	3		
Calcium Chloride	4		
Sodium Sulfide	49	**Total****	**11,206**

* 1.4 of the 2.2 million tons was subsequently reclassified as "Sands" and gravel.
** Totals differ due to rounding.

Source: Waterborne Commerce files

(3) Directional Flows of Traffic

The directional flows of traffic for each commodity are listed below under the headings inbound, outbound, through, and intra. Through traffic is minimal and represents traffic with an origin or destination upstream of the defined navigation system on the White River. Internal traffic is traffic that moves between points on the MKARNS. Inbound and outbound are as the terms imply.

Outbound shipments account for 41% of tonnage, inbound shipments for 33%, internal for 23%, and the small remainder is classified as through traffic. The major outbound shipments are farm products and construction materials, the major inbound shipments are fertilizers and the major internal movements are shipments of sand and gravel.
#

Table E1-5. 2001 Traffic (thousand tons)

		Inbound	Outbound	Through		Internal		Grand
		Up	Down	Up	Down	Up	Down	Total
Farm Products								
	wheat	151	1,176	0	0	2	0	1,328
	corn	127	5	0	0	0	0	132
	rice	4	222	0	0	0	0	226
	oats	28	0	0	0	0	0	28
	sorghum grains	9	244	0	0	0	0	253
	soybeans	115	363	0	0	0	0	479
	oilseeds nec	3	2	0	0	1	0	6
	wheat flour	1	0	0	0	0	0	1
	molasses	44	0	0	0	0	0	44
	bran	34	0	0	0	0	0	34
	oil-cake	36	2	0	0	0	0	38
	flour	9	0	0	0	0	0	9
	food wastes	0	2	0	0	0	0	2
	buckwheat	0	1	0	0	0	0	1
Metals								
	iron & steel scrap	4	102	0	0	2	0	108
	aluminum ore	44	0	0	0	5	0	49
	manganese ore	3	0	0	0	0	0	3
	non-ferrous ores nec	1	0	0	0	0	0	1
	pig iron	26	0	0	0	0	0	26
	ferro alloys	5	0	0	0	0	0	5
	i&s ingots	0	3	0	0	0	0	3
	i&s flat rolled	352	0	0	0	0	0	352
	i&s bars	157	2	0	0	0	0	159
	i&s tubes	96	14	0	0	0	0	110
	wire	123	0	0	0	0	0	123
	aluminum	14	0	0	0	0	0	14
	zinc	6	0	0	0	0	0	6
Coal								
	coal	36	0	0	0	0	0	36
	coke	107	6	0	0	0	0	113
Crude Petroleum		0	0	0	0	0	0	0

Nonmetallic Minerals								
	limestone	6	28	0	0	0	0	34
	gypsum	0	5	0	0	0	0	5
	sand	2	1	0	0	1,040	1,189	2,232
	pebbles	6	26	0	2	49	11	94
	waterway improv mat	0	1,680	0	244	19	230	2,173
	clays	7	0	0	0	0	0	7
	sodium	19	0	0	0	0	0	19
	slag dross	8	0	0	0	0	0	8
	slag ash	0	39	0	0	0	0	39
	vermiculite	10	0	0	0	0	0	10
	portland aluminous	160	6	0	0	0	0	166
	glass	1	0	0	0	0	0	1
Forest Products								
	wood chips	24	87	0	0	0	0	130
	pulp	0	2	0	0	0	0	2
	rubber	0	0	0	0	0	0	0
	kraft	0	1	0	0	0	0	1
	paper	0	16	0	0	0	0	16
Industrial Chemicals								
	manganese oxides	0	30	0	0	0	0	30
	ammonium nitrate	98	0	0	0	0	0	98
	sodium chloride	3	0	0	0	0	0	3
	calcium chloride	53	0	0	0	0	0	53
Agricultural Chemicals								
	ammonia	185	8	0	0	0	0	193
	double salts	1	0	0	0	0	0	1
	ammonium sulfate	6	0	0	0	0	0	6
	urea fertilizer	707	89	0	0	5		801
	mineral/chem fert	9	258	0	0	0	8	275
	basic slag fert	1	0	0	0	0	0	1
	superphosphate	15	0	0	0	0	0	15
	mineral-phosph	77	0	0	0	0	0	77
	mineral-posta	99	0	0	0	1	0	101
	diammonium	213	0	0	0	0	0	213
	monoammonium	36	0	0	0	0	0	36
	fertilizer-tablet	2	0	0	0	0	0	2
	fertilizer-nec	107	4	0	0	2	5	118
Petroleum and Petroleum Products								
	other light oils	127	0	0	0	0	0	127
	fuel	0	44	0	0	0	7	51
	lubricating oils	2	2	0	0	0	0	4
	pitch	83	11	0	0	0	0	94
	petroleum coke	64	121	0	0	1	0	186
	petro products nec	2	33	0	0	0	10	45
Other								
	manufactured goods	52	4	0	0	0	0	56
	machinery (not elec)	2	8	0	0	0	0	10
	pumps	0	1	0	0	0	0	1
	electrical equipment	0	0	0	0	0	0	0

Group Totals							
Farm Products	561	2,018	0	0	3	0	2,582
Metals	833	125	0	0	7	0	1,015
Coal	143	6	0	0	0	0	149
Crude Petroleum	0	0	0	0	0	0	0
Nonmetallic Minerals	219	1,785	0	245	1,107	1,431	4,787
Forest Products	24	106	0	0	0	0	130
Industrial Chemicals	155	30	0	0	0	0	185
Agricultural Chemicals	1,460	359	0	0	8	12	1,838
Petroleum and Petroleum Products	278	212	0	0	1	17	508
Other	55	12	0	0	0	0	179
Total, all commodities	**3,726**	**4,649**	**0**	**245**	**1,126**	**1,460**	**11,206**

Source: Waterborne Commerce of the United States, Part 2 – Waterways and Harbors, Gulf Coast, Mississippi River System and Antilles. Dept of Army, Corps of Engineers, Water Resources Support Center.

(4) Regional Flows of Traffic

The major regional flow of traffic is from the Arkansas area to the Lower Miss with 3.8 million tons and 34% of all tonnage. Two other flows are significant: 1) internal movements on the Arkansas River; and 2) shipments from the Lower Miss to the Arkansas River. Each of the latter two flows is approximately 2.5 million tons and 22% of total tonnage. Combined, the shipments between the MKARNS and Lower Miss amount to 6.3 million tons and 56% of all tonnage shipments.

Table E1-6. All Traffic – Regional Flows of Traffic 2001

Origin	Destination	Tons
ARKANSAS RIVER	ARKANSAS RIVER	2,585,941
ARKANSAS RIVER	GIWW EAST	23,884
ARKANSAS RIVER	GIWW WEST	183,561
ARKANSAS RIVER	LOWER MISS	3,786,393
ARKANSAS RIVER	OHIO	166,556
ARKANSAS RIVER	TENNESSEE	150,601
ARKANSAS RIVER	TENN-TOM	53,510
ARKANSAS RIVER	UPPER MISS	242,354
ARKANSAS RIVER	WHITE RIVER	41,808
GIWW EAST	ARKANSAS RIVER	128,366
GIWW WEST	ARKANSAS RIVER	100,625
LOWER MISS	ARKANSAS RIVER	2,459,060
LOWER MISS	WHITE RIVER	8,531
OHIO	ARKANSAS RIVER	401,342
TENNESSEE	ARKANSAS RIVER	20,993
TENN-TOM	ARKANSAS RIVER	30,103
UPPER MISS	ARKANSAS RIVER	308,422
UPPER MISS	WHITE RIVER	245,315
WHITE RIVER	LOWER MISS	269,028
Total		**11,206,393**

A detailed description of current commodity and commodity group traffic is provided in the following paragraphs.

Group 1. Farm Products: Farm products account for the largest amount of the tonnage shipped on the MKARNS at about 23% of total tonnage. The principle commodities are wheat, soybeans, sorghum grains and rice. The two states along the MKARNS – Arkansas and Oklahoma – produced over 9% of the nation's wheat, 45% of the rice, and 7% of the production of the four commodities as a group in the year 2000.

Table E1-7. Production of Farm Products
Year 2000; Millions of Short Tons

		Arkansas	Oklahoma	Subtotal	U.S.
Wheat		1.8	4.3	6.1	67.0
	% of U.S.	2.7%	6.4%	9.1%	100.0%
Soybeans		2.4	0.1	2.5	82.7
	% of U.S.	2.9%	0.2%	3.1%	100.0%
Sorghum Grains		0.3	0.4	0.7	14.1
	% of U.S.	2.1%	2.9%	5.0%	100.0%
Rice		2.6	-	2.6	5.7
	% of U.S.	45.1%	0.0%	45.1%	100.0%
Total		**7.1**	**4.8**	**11.9**	**169.5**
	% of U.S.	**4.2%**	**2.8%**	**7.0%**	**100.0%**

Source: http://www.nass.usda.gov:81/ipedb/

Of the 2.6 million tons of farm products shipped on the MKARNS in 2001, approximately 78% was outbound, 11% was inbound, and about 11% was internal. Outbound traffic was destined primarily for New Orleans and the export market. Inbound traffic consisted largely of corn destined for chicken producing facilities.

Table E1-8. Farm Product Traffic – 2001
(thousand tons)

	Inbound	Outbound	Through		Internal		Grand
	Up	Down	Up	Down	Up	Down	Total
Farm Products	**561**	**2,018**	**0**	**0**	**3**	**0**	**2,582**
wheat	151	1,176	0	0	3	0	1,328
rice	4	222	0	0	0	0	227
maize	127	5	0	0	0	0	132
oats	28	0	0	0	0	0	28
grain	9	244	0	0	0	0	254
buckwheat	0	1	0	0	0	0	1
meal & flour	1	0	0	0	0	0	1
molasses	44	0	0	0	0	0	44
bran	34	0	0	0	0	0	34
oil-cake	36	2	0	0	0	0	38
flour	9	0	0	0	0	0	9
soybeans	115	363	0	0	0	0	479
oilseeds nec	3	2	0	0	1	0	6

The regional origins and destinations of farm product movements are listed in the table below. Seventy-one percent of the traffic moved from the MKARNS to the Lower Miss. The second largest movement consists of movements from the White River Basin to the Lower Miss and accounts for 10% of the traffic.

Table E1-9. Farm Products – Regional Flows of Traffic - 2001

Origin	Destination	Tons
ARKANSAS RIVER	ARKANSAS RIVER	2,888
ARKANSAS RIVER	GIWW EAST	4,293
ARKANSAS RIVER	GIWW WEST	38,351
ARKANSAS RIVER	LOWER MISS	1,831,311
ARKANSAS RIVER	OHIO	4,348
ARKANSAS RIVER	TENNESSEE	139,667
GIWW WEST	ARKANSAS RIVER	13,899
LOWER MISS	ARKANSAS RIVER	136,438
OHIO	ARKANSAS RIVER	53,299
UPPER MISS	ARKANSAS RIVER	88,538
WHITE RIVER	LOWER MISS	269,028
Total		**2,582,060**

Group 2. Metals: The metals group consists mainly of iron and steel sheets and bars shipped to fabricating plants in the Fort Smith, Arkansas and Tulsa, Oklahoma areas. Inbound shipment account for 87% of the group tonnage shipped on the river.

Table E1-10. Metals Traffic - 2001
(thousand tons)

		Inbound	Outbound	Through		Internal		Grand
		Up	Down	Up	Down	Up	Down	Total
Metals		**833**	**121**	**0**	**0**	**6**	**0**	**960**
	iron & steel scrap	4	102	0	0	2	0	108
	aluminum ore	44	0	0	0	5	0	49
	manganese ore	3	0	0	0	0	0	3
	non-ferrous ores nec	1	0	0	0	0	0	1
	pig iron	26	0	0	0	0	0	26
	ferro alloys	5	0	0	0	0	0	5
	i&s ingots	0	3	0	0	0	0	3
	i&s flat rolled	352	0	0	0	0	0	352
	i&s bars	157	2	0	0	0	0	159
	i&s tubes	96	14	0	0	0	0	110
	wire	123	0	0	0	0	0	123
	aluminum	14	0	0	0	0	0	14
	zinc	6	0	0	0	0	0	6

The principle origins of the inbound traffic are the Lower Miss at 43% of the total and the Ohio Basin area at 28%. The tonnages out of the Lower Miss are imports.

Table E1-11. Metals – Regional Flows of Traffic 2001

Origin	Destination	Tons
ARKANSAS RIVER	ARKANSAS RIVER	6,245
ARKANSAS RIVER	GIWW EAST	5,800
ARKANSAS RIVER	GIWW WEST	4,074
ARKANSAS RIVER	LOWER MISS	81,896
ARKANSAS RIVER	OHIO	15,157
ARKANSAS RIVER	TENN-TOM	2,886
ARKANSAS RIVER	UPPER MISS	11,152
GIWW EAST	ARKANSAS RIVER	40,265
GIWW WEST	ARKANSAS RIVER	7,391
LOWER MISS	ARKANSAS RIVER	415,254
OHIO	ARKANSAS RIVER	266,591
TENNESSEE	ARKANSAS RIVER	3,272
TENN-TOM	ARKANSAS RIVER	6,218
UPPER MISS	ARKANSAS RIVER	93,589
Total		**959,790**

Group 3. Coal/Coke: Coal/coke tonnage is relatively insignificant. It amounts to 113,000 tons and 1% of total tonnage. Two-thirds is coke coming out of the Gulf Coast.

Table E1-12. Coal/Coke Traffic 2001
(thousand tons)

		Inbound	Outbound	Through		Internal		Grand
		Up	Down	Up	Down	Up	Down	Total
Coal		**143**	**6**	**0**	**0**	**0**	**0**	**149**
	coal	36	0	0	0	0	0	36
	coke	107	6	0	0	0	0	113

The regional flows of coal/coke traffic are provided below.

Table E1-13. Coal – Regional Flows of Traffic 2001

Origin	Destination	Tons
ARKANSAS RIVER	GIWW WEST	1,602
ARKANSAS RIVER	LOWER MISS	4,807
LOWER MISS	ARKANSAS RIVER	106,045
OHIO	ARKANSAS RIVER	37,040
Total		**149,494**

Group 4. Crude Petroleum: There were no shipments of crude petroleum on the MKARNS in the year 2001 or other recent years.

Group 5. Non-Metallic Minerals: Non-metallic minerals consist largely of stone-like materials that are used in its raw or in a processed state such as concrete and roadbed materials in the

construction industry. In terms of volume, non-metallic minerals are number one in terms of production in the United States, exceeding the production of coal by a ratio of 3 to 1. Production in the two principle MKARNS states is about 120 million tons a year.

Table E1-14. Major Non-Metallic Minerals Production
Year 2000; Millions of Short Tons

		Arkansas	Oklahoma	Subtotal	U.S.
Sand & Gravel		11.8	12.8	24.6	1,289.3
	% of U.S.	0.9%	1.0%	1.9%	100.0%
Crushed Stone		36.4	60.6	97.0	1,752.2
	% of U.S.	2.1%	3.5%	5.5%	100.0%
Total		**48.2**	**73.4**	**121.5**	**3,041.5**
	% of U.S.	**1.6%**	**2.4%**	**4.0%**	**100.0%**

Source: http://minerals.usgs.gov/minerals/

The non-metallic minerals group represents the largest group in terms of tonnage that moves on the MKARNS at 4.6 million tons and 41% of all tonnage. Fifty-five percent of the shipments are between points on the MKARNS. The major external movements are outbound shipments.

Table E1-15. Non-Metallic Minerals Traffic 2001
(thousand tons)

	Inbound	Outbound	Through		Internal		Grand
	Up	Down	Up	Down	Up	Down	Total
Nonmetallic Minerals	**219**	**1,785**	**0**	**245**	**1,107**	**1,431**	**4,787**
limestone	6	28	0	0	0	0	34
gypsum	0	5	0	0	0	0	5
sands	2	1	0	0	1,040	1,189	2,232
pebbles	6	26	0	2	49	11	94
waterway improv mat	0	1,680	0	244	19	230	2,172
clay & refrac. Mat.	7	0	0	0	0	0	7
sodium	19	0	0	0	0	0	19
slag dross	8	0	0	0	0	0	8
slag ash	0	39	0	0	0	0	39
vermiculite	10	0	0	0	0	0	10
portland aluminous	160	6	0	0	0	0	166
glass	1	0	0	0	0	0	1

As stated previously, the largest volume shipments of non-metallic minerals are from the MKARNS to the Lower Miss area where it is used in construction.

Table E1-16. Non-Metallic Minerals – Regional Flows of Traffic 2001

Origin	Destination	Tons
ARKANSAS RIVER	ARKANSAS RIVER	2,538,101
ARKANSAS RIVER	GIWW EAST	6,281
ARKANSAS RIVER	GIWW WEST	66,300
ARKANSAS RIVER	LOWER MISS	1,631,021
ARKANSAS RIVER	OHIO	10,554
ARKANSAS RIVER	TENNESSEE	4,841
ARKANSAS RIVER	UPPER MISS	29,345
ARKANSAS RIVER	WHITE RIVER	36,400
GIWW EAST	ARKANSAS RIVER	6,382
GIWW WEST	ARKANSAS RIVER	18,613
LOWER MISS	ARKANSAS RIVER	113,001
OHIO	ARKANSAS RIVER	3,173
TENNESSEE	ARKANSAS RIVER	6,291
UPPER MISS	ARKANSAS RIVER	71,484
UPPER MISS	WHITE RIVER	245,315
Total		**4,787,102**

Group 6. Forest Products: Shipments of forest products on MKARNS are negligible. Shipments totaled 130,000 tons, or 1% of total river tonnage in 2001. Eighty-one percent of the tonnage was shipped outbound.

Table E1-17. Forest Products Traffic 2001 (thousand tons)

	Inbound	Outbound	Through		Internal		Grand
	Up	Down	Up	Down	Up	Down	Total
Forest Products	**24**	**106**	**0**	**0**	**0**	**0**	**130**
wood chips	24	87	0	0	0	0	110
pulp	0	2	0	0	0	0	2
rubber	0	0	0	0	0	0	0
kraft	0	1	0	0	0	0	1
paper	0	16	0	0	0	0	16

The major destination of the forest product shipments is the Upper Miss area.

Table E1-18. Forest Products – Regional Flows of Traffic 2001

Origin	Destination	Tons
ARKANSAS RIVER	LOWER MISS	19,233
ARKANSAS RIVER	OHIO	1,274
ARKANSAS RIVER	UPPER MISS	85,278
TENN-TOM	ARKANSAS RIVER	23,885
Total		**129,670**

Group 7. Industrial Chemicals: Traffic in industrial chemicals is limited on MKARNS, amounting to 184,000 tons and about 2% of total tonnage. Eighty-four percent of industrial chemical traffic is inbound.

Table E1-19. Industrial Chemicals Traffic 2001 (thousand tons)

	Inbound	Outbound	Through		Internal		Grand
	Up	Down	Up	Down	Up	Down	Total
Industrial Chemicals	**155**	**30**	**0**	**0**	**0**	**0**	**185**
manganese oxides	0	30	0	0	0	0	30
ammonium nitrate	98	0	0	0	0	0	98
sodium chloride	3	0	0	0	0	0	3
calcium chloride	53	0	0	0	0	0	53

The major flow is from the petro-chemical complex along the Lower Miss to the MKARNS.

Table E1-20. Industrial Chemicals – Regional Flows of Traffic 2001

Origin	Destination	Tons
ARKANSAS RIVER	GIWW WEST	10,000
ARKANSAS RIVER	OHIO	20,011
GIWW WEST	ARKANSAS RIVER	39,021
LOWER MISS	ARKANSAS RIVER	115,569
Total		**184,601**

Group 8. Agricultural Chemicals: Agricultural chemicals are mostly fertilizers. Like industrial chemicals, most of the agricultural chemicals originate at refinery complexes on the Gulf Coast. Most of the chemical fertilizers are shipped to terminals for distribution to local and regional retailers.

Table E1-21. Agricultural Chemicals Traffic 2001 (thousand tons)

	Inbound	Outbound	Through		Internal		Grand
	Up	Down	Up	Down	Up	Down	Total
Agricultural Chemicals	**1,460**	**359**	**0**	**0**	**8**	**12**	**1,838**
ammonia	185	8	0	0	0	0	193
double salts	1	0	0	0	0	0	1
ammonium sulfate	6	0	0	0	0	0	6
urea fertilizer	707	89	0	0	5		801
mineral/chem fert	9	258	0	0	0	8	275
basic slag fert	1	0	0	0	0	0	1
superphosphate	15	0	0	0	0	0	15
mineral-phosph	77	0	0	0	0	0	77
mineral-posta	99	0	0	0	1	0	101
diammonium	213	0	0	0	0	0	213
monoammonium	36	0	0	0	0	0	36
fertilizer-tablet	2	0	0	0	0	0	2
fertilizer-nec	107	4	0	0	2	5	118

The principle shipment of agricultural chemicals is from the production facilities along the Lower Miss to the terminals in the Arkansas River Basin. This movement accounts for over 70% of all agricultural chemical traffic.

Table E1-22. Agricultural Chemicals Regional Flows of Traffic 2001

Origin	Destination	Tons
ARKANSAS RIVER	ARKANSAS RIVER	19,946
ARKANSAS RIVER	GIWW WEST	22,490
ARKANSAS RIVER	LOWER MISS	139,392
ARKANSAS RIVER	OHIO	81,382
ARKANSAS RIVER	TENNESSEE	6,093
ARKANSAS RIVER	UPPER MISS	103,941
ARKANSAS RIVER	WHITE RIVER	5,408
GIWW EAST	ARKANSAS RIVER	81,719
GIWW WEST	ARKANSAS RIVER	21,221
LOWER MISS	ARKANSAS RIVER	1,297,766
LOWER MISS	WHITE RIVER	8,531
OHIO	ARKANSAS RIVER	41,239
UPPER MISS	ARKANSAS RIVER	9,132
Total		**1,838,260**

Group 9. Petroleum and Petroleum Products: Petroleum products traffic totaled 507,000 tons in 2003, representing about 5% of all tonnage. Petroleum coke is the largest component of the group at 186,000 tons, or 37% of the group's total tonnage.

Table E1-23. Petroleum Products Traffic 2001 (thousand tons)

	Inbound	Outbound	Through		Internal		Grand
	Up	Down	Up	Down	Up	Down	Total
Petro and Petro Products	**278**	**212**	**0**	**0**	**1**	**17**	**508**
other light oils	127	0	0	0	0	0	127
fuel	0	44	0	0	0	7	51
lubricating oils	2	2	0	0	0	0	4
pitch	83	11	0	0	0	0	94
petroleum coke	64	121	0	0	1	0	186
petro products nec	2	33	0	0	0	10	45

The principle shipment is from the Lower Miss to the MKARNS.

Table E1-24. Petroleum Products – Regional Flows of Traffic 2001		
Origin	**Destination**	**Tons**
ARKANSAS RIVER	ARKANSAS RIVER	18,761
ARKANSAS RIVER	GIWW EAST	5,910
ARKANSAS RIVER	GIWW WEST	38,507
ARKANSAS RIVER	LOWER MISS	76,378
ARKANSAS RIVER	OHIO	29,030
ARKANSAS RIVER	TENN-TOM	50,624
ARKANSAS RIVER	UPPER MISS	11,238
LOWER MISS	ARKANSAS RIVER	231,747
TENNESSEE	ARKANSAS RIVER	500
UPPER MISS	ARKANSAS RIVER	45,679
Total		**508,374**

Group 10. Other: The all others category accounted for about 179,000 tons or 1.6% of total MKARNS commodity traffic in 2001. The primary commodities in this group were cement and concrete, which accounted for 93% of the group's tonnage.

Table E1-25. Other Commodities Traffic 2001 (thousand tons)							
	Inbound	**Outbound**	**Through**		**Internal**		**Grand**
	Up	**Down**	**Up**	**Down**	**Up**	**Down**	**Total**
Other	**55**	**12**	**0**	**0**	**0**	**0**	**67**
manufactured goods	52	4	0	0	0	0	56
machinery (not elec)	2	8	0	0	0	0	10
pumps	0	1	0	0	0	0	1
electrical equipment	0	0	0	0	0	0	0

The "others" commodities are shipped between a wide array of origins and destinations. The dominant movement is from the Lower Miss to the MKARNS.

Table E1-26. Other Commodities – Regional Flows of Traffic 2001		
Origin	**Destination**	**Tons**
ARKANSAS RIVER	GIWW EAST	1,600
ARKANSAS RIVER	GIWW WEST	2,237
ARKANSAS RIVER	LOWER MISS	2,355
ARKANSAS RIVER	OHIO	4,800
ARKANSAS RIVER	UPPER MISS	1,400
GIWW WEST	ARKANSAS RIVER	480
LOWER MISS	ARKANSAS RIVER	43,240
TENNESSEE	ARKANSAS RIVER	10,930
Total		**67,042**

2. Base Year Traffic

Base year traffic is traffic that is "normalized" in terms of volumes, commodity types, origins and destinations to serve as a basis of traffic forecasts. The normalization process consists of making appropriate adjustments to a current list of commodity shipments to eliminate anomalies from the list and to factor into the list near-term changes indicated by waterway shippers. For this study, the most current set of data available at the time of the initiation of the study was for the year 2001 and so this was the initial base year. Subsequently, data became available for the years 2002 and 2003 which differed somewhat from the year 2001 data and which therefore needed to be considered in estimating base year tonnage.

The normalization process typically begins with the acquisition of two sets of traffic data: waterborne commerce data and lock performance monitoring system (LPMS) data. The data are obtained for multiple years with the greater the number of years that are obtained the better it is for discerning trends and anomalies. Waterborne commerce data are reported annually by the shippers to the Corps Navigation Data Center and contain origin, destination, commodity type, and annual tonnage data. The data are typically available about six months after the end of the calendar year with the lag due to the time needed to compile and submit the data. The LPMS data are collected at each project for each vessel as it transits the lock and includes the commodity type and tonnage. The data are typically available with a lag of about one month. The important difference to note is that the waterborne commerce data include origin and destination information, but the LPMS do not. This is important because the forecasts are made for individual commodity shipments with specific origin, destinations, and commodity characteristics. Therefore, the LPMS data can be used to identify the likelihood of recent changes in shipping patterns, but are of limited use in identifying the actual change. This must be done using the waterborne commerce data.

The starting point for the development of base year traffic was to examine recent traffic trends at the river and project levels to identify upward, downward, or "no" trends in traffic. The waterborne commerce data showed that river tonnage peaked in 1998, declined in 1999, and increased since then through the year 2002, the last year for which waterborne river tonnages are available. The same pattern is true at the lock level. The trend analysis indicates that using an average river tonnage, computed over the past several years, would negatively bias base year traffic if the average were used as the base, since current traffic is on an upward trend. Therefore, upward adjustments were made to the 2001 shipment list to create a base year 2003 shipment list.

The first task was to compare total tonnage and tonnage by commodity group in the years 2001 and 2002 using the waterborne commerce data. Total tonnage increased 4 percent, which is somewhat higher than the historic annual increase of 3.0 percent. The largest absolute increases were in farm products and metals, which both increased over 200,000 tons. The largest absolute decreases were in non-metallic minerals (sand & gravel, etc) and forest products, which decreased by 39,000 to 59,000 tons.

Table E1-27 – River Traffic in 2001 and 2002 (thousands of tons)				
	2001	2002	Change	% Change
Farm Products	2,582	2,809	227	9%
Metals	960	1,162	202	21%
Coal	149	199	50	33%
Crude Petroleum	-	-	-	
Non-Metallic Minerals	4,787	4,728	(59)	-1%
Forest Products	130	91	(39)	-30%
Industrial Chemicals	185	243	58	32%
Agricultural Chemicals	1,838	1,871	32	2%
Petroleum Products	508	523	14	3%
Others	67	77	10	15%
All Commodities	**11,206**	**11,702**	**496**	**4%**
Source: Waterborne Commerce data provided by the Navigation CX.				

Lock data was then examined for the years 2001, 2002, and 2003 with special focus on the changes between 2002 and 2003. Again, 2003 data were available at the lock level from LPMS but not for individual shipments, which is only available from the waterborne commerce data. The comparison showed a further significant increase in traffic at most of the locks, with the greatest increase being at the projects furthest upriver. A simple indexation such as done to adjust 2001 tonnages to 2002 levels was performed but proved inappropriate when viewed from the lock level. Specifically, the lock tonnages using indexed shipments were significantly different from actual 2003 lock tonnages. Therefore, an alternative approach was followed which involved adjusting the tonnage in selected movements such that lock tonnages were close to the actual 2003 values. The results are shown in the table below in terms of commodity group tonnage.

Table E1-28. Estimated Base Year (2003) Tonnage (thousands of tons)				
	2001	2002	2003*	Percent Change 2001-2003
Farm Products	2,582	2,809	2,809	8.8%
Metals	960	1,162	1,242	29.4%
Coal	149	199	273	82.8%
Crude Petroleum	-	-	-	-
Non-Metallic Minerals	4,787	4,728	4,728	-1.2%
Forest Products	130	91	91	-30.2%
Industrial Chemicals	185	243	243	31.6%
Agricultural Chemicals	1,838	1,871	1,871	1.8%
Petroleum Products	508	523	523	2.8%
Others	67	77	77	14.8%
All Commodities	**11,206**	**11,702**	**11,856**	**5.8%**
Note: added 74k to coal and 80k to metals tonnages in 2002 to estimate 2003. * 2003 is an approximation; 2001 and 2002 are actual waterborne tonnages.				

The results in terms of lock tonnages are listed below. The percent differences are all less than 6 percent with some above and some below the actual 2003 tonnage levels. The adjustments are

not perfect, but they were considered better than using older data and ignoring recent trends entirely. Given normal variations in traffic levels and well as differences due to possible errors in the data, the approximated 2003 traffic was considered adequate for use as "base" year traffic.

Table E1-29. Actual and Modeled Lock Data (thousands of tons)

	2001	2002	2003	Modeled 2003	% Difference 2003
GRAHAM	3,480	3,732	3,914	3,803	-2.8%
CHOUTEAU	3,633	3,828	4,066	3,997	-1.7%
WEBER	4,184	4,416	4,759	4,556	-4.3%
KERR	4,340	4,675	5,024	4,736	-5.7%
MAYO	4,325	4,698	4,979	4,736	-4.9%
TRIMBLE	4,611	5,031	5,322	5,018	-5.7%
OZARK	4,600	5,073	5,300	5,019	-5.3%
DARDANELLE	6,751	7,173	7,106	6,935	-2.4%
ORMOND	6,503	7,116	7,137	7,024	-1.6%
TOAD SUCK	6,527	7,007	7,111	7,095	-0.2%
MURRAY	6,744	7,149	7,108	7,146	0.5%
TERRY	7,493	7,999	8,102	8,035	-0.8%
L&D 5	7,548	8,088	8,158	8,041	-1.4%
SANDERS	8,100	8,214	8,358	8,712	4.2%
HARDIN	8,086	8,172	8,380	8,836	5.4%
L&D 2	8,691	8,853	9,126	9,317	2.1%
NORRELL	8,696	8,851	9,139	9,317	2.0%

3. Projected Traffic

Traffic projections are critical to the development of plans for possible development of MKARNS. By their nature, however, projections are also subject to a high degree of uncertainty. Because of their importance, considerable effort was expended in developing the projections. Because of the uncertainties, a range of forecasts was developed. The forecasts were then compared to forecasts developed for other sections of the inland navigation system to ensure general consistency in outlooks.

(1) Procedure: The development of traffic forecasts is generally a top-down/bottom-up procedure with the bottom being actual current traffic levels and the top being macro-level projections of the U.S. economy. Each commodity is linked to a market to assist in determining future levels of demand. In some cases, a single commodity may be linked to several markets such as coal being linked to the electric generating industry where it is burned to generate electricity and to the steel industry where it is converted into coke for use in steel production. The distinction is based on the type of facility at the destination of the coal, i.e. a coke plant or power plant. Similarly, grains may be linked to the domestic market where they are destined for human consumption or for animal feeds, or to the export market. Again, the market is typically discerned from the facility at the destination.

The next step is to perform an information search regarding the industries and markets that ship and/or receive waterborne transported commodities. The search typically focuses on the future prospects for growth in the industry/market, and the key items that are likely to affect the future level of demand. For example, the future level of demand for utility coal is affected by the future level of demand for electricity, with some of the key factors that cause deviations from a one-to-one relationship being the amount of electricity generation from nuclear, gas, and other types of generating plants. Similarly, shipments of grains for export depend on worldwide demands, with the U.S. share depending on relative prices and on production levels in other countries.

The terminals and/or production facilities along the waterway may then be contacted to ascertain whether their future prospects differ from the overall industry prospects. If affirmative, then the particulars for the local companies will be factored into the forecasts. Likewise, if the companies indicate changes in the sourcing or destination of their waterborne shipments from those that currently exist, then the changes will be factored into the forecasts.

Generally, industry and company forecasts extend at most to between five and ten years into the future. For years where specific forecasts are not available, commodity demands will be linked to sectoral economic forecasts developed by industry and Government sources. These "macro" levels forecasts may be further disaggregated to regional, state, and county levels of detail. Commodity demands will then be linked to the most appropriate economic and geographic sector. These, in turn, will be converted into indices, which are then applied to "base" year commodity traffic to develop long-term traffic forecasts. This, in simple terms, is the general procedure used by the Corps to develop waterway traffic forecasts.

(2) Information Search: Farm product and fertilizer shipments are the major commodity movements on the MKARNS. Therefore, the initial information search focused on the agricultural situation both nationally and within the Arkansas River Basin. The first site accessed was the U.S. Department of Agriculture (USDA) website, which contains a plethora of agricultural statistics at both the national, state, and county levels. The site also contained a document developed by USDA that provided their forecasts of grain exports from the U.S. through the year 2012. The statistics and documents were valuable in contributing to an understanding of the outlook for farm products, and of the key factors that affect the outlook for domestic and foreign demand for farm products.

The information search extended to a review of documents related to waterborne commerce demands and forecasts developed by the Corps' Institute for Water Resources (IWR), the Upper Mississippi study team, and the Ohio River study team. The Upper Miss forecasts were especially useful since the key commodity movement on both the Arkansas and Upper Miss are farm product shipments to New Orleans for export. The Ohio River reports were helpful in identifying the factors that affect waterway traffic for aggregates and other commodities shipped on both waterway segments.

The information search then extended to the companies in the immediate study area of MKARNS. Tennessee Valley Authority (TVA) conducted an extensive survey of over three hundred companies located along the MKARNS, both waterway shippers and rail/truck shippers, to determine the products shipped, the mode of shipment, and the possible use of the waterway

system by those who currently ship by rail/truck. The information from the survey was important in determining not only the possibility of inducing traffic onto the river system, but in determining which commodities might benefit from a deeper channel.

A follow-up telephone survey was conducted by the Corps to obtain company and facility level forecasts of waterway traffic. The survey focused on the major ports, since they are a filter for the farmers and may have to make investments if traffic is expected to increase.

(3) Macro-Level Forecasts: Macro-level forecasts were obtained from the U.S. Census Bureau, the USDA, the Department of Energy (DOE), and NPA Data Services. Census, USDA, and DOE are all fairly limited in focus to population, grain production and energy markets respectively. The NPA forecasts are more expansive, and are similar to the OBERS forecasts that used to be developed by the Federal Government but are no longer. The NPA forecasts are also generally used by other Government entities in developing forecasts, such as the Oak Ridge National Laboratory (ORNL) in their transportation analysis for the Department of Transportation. The NPA forecasts were used for the development of short-term projections for some commodities, and for medium and long-term projections for all commodities except grain exports. The latter were obtained from the Upper Miss navigation study.

The near-term growth rates developed by NPA are higher than the long-term growth rates, which explain the high near-term projected growth in traffic. Both the short-term and long-term projected growth rates were viewed within the context of the historic growth in traffic, current development in the area, and the long-term rates developed for other waterway segments to determine if they appeared to be reasonable. Overall, they appeared to be reasonable. Nonetheless, given the high degree of uncertainty in forecasting waterway traffic, two additional sets of forecasts were developed and used to estimate navigation benefits for deepening. A discussion of some of the major uncertainties and assumptions in macro-level forecasts is provided in Addendum E2.

(4) Regional Areas: Commodity traffic can be driven by local, regional, or national demands, depending on the commodity. If a commodity is driven primarily by local demands, such milk consumption, then local activity may be a good indicator of short-term demands. However, in the mid and long-terms, there is generally more variability and uncertainty in the accuracy of forecasts when the geographic area is smaller. For this reason, the MKARNS forecasts were linked to activity in regional areas and, in some cases, to national level activity. The regional areas used in the MKARNS study are listed below. The regions were selected based on MKARNS traffic patterns, and on the depth of the region's waterway system; i.e. the Lower Miss can normally accommodate 12′ draft barges whereas the Upper Miss can normally only accommodate 9′ barges. In a few cases, the same state is included in two different regions since it lies within more than one river basin and could ship or receive goods on more than one river. If a state was within a basin area, but only marginally, then it was excluded.

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Table E1-30. Regional Areas		
Region Number	**Region**	**States**
1	Arkansas River	Arkansas, Oklahoma
2	GIWW East	Florida, Alabama, Georgia, Mississippi
3	GIWW West	Texas
4	Lower Miss	Louisiana, Mississippi
5	Ohio River	Indiana, Kentucky, Ohio, Pennsylvania, West Virginia
6	Tennessee River	Tennessee
7	Tenn.-Tom Waterway	Tennessee, Alabama
8	Upper Miss	Illinois, Missouri, Wisconsin, Minnesota, Indiana, Iowa
9	White River	Arkansas, Oklahoma

(5) Commodity Groups

Group 1. Farm Products: Farm products are the major commodity group shipped on MKARNS. The river lies within or near major production areas in Kansas, Oklahoma and Arkansas. The following table lists the number of total acres, farm acres, and population in the counties that lie adjacent or once removed from MKARNS.

Table E1-31. Farm Area and Population			
		1997	2001
	Acres	Land in Farms	Population
Arkansas			
Arkansas	632,660	426,363	20,588
Conway	355,981	162,732	20,404
Crawford	381,119	138,811	54,246
Desha	489,624	275,954	15,052
Faulkner	414,315	211,467	88,010
Franklin	390,142	171,391	17,867
Grant	404,367	32,519	16,714
Jefferson	566,267	288,655	83,565
Johnson	423,815	114,579	22,793
Lincoln	142,609	17,769	14,235
Logan	454,349	199,294	22,374
Lonoke	489,921	390,705	54,349
Perry	352,614	72,711	10,381
Pope	519,651	152,100	54,746
Pulaski	494,419	110,830	361,474
Saline	463,847	50,225	85,698
Sebastian	343,273	114,950	115,674
Van Buren	455,395	132,417	16,347
Yell	593,853	188,480	21,077
Oklahoma			
Adair	368,640	225,322	21,118
Cherokee	480,696	237,558	42,697
Haskell	369,319	267,655	11,763
LeFlore	1,015,059	407,359	48,041
McIntosh	396,800	253,667	19,522
Muskogee	520,877	332,556	69,887
Rogers	431,999	312,870	74,066
Sequoyah	432,281	293,366	39,262
Tulsa	365,011	142,978	564,079
Wagoner	360,359	240,660	59,059
Ark Sub	8,368,221	3,251,952	1,095,594
Ok Sub	4,372,401	2,488,669	928,376
Basin	**12,740,622**	**5,740,621**	**2,023,970**
Ark Tot	33,328,208	14,364,955	2,692,090
Ok Tot	43,960,947	33,218,677	3,460,097
Two States	**77,289,155**	**47,583,632**	**6,152,187**
U.S.	**2,264,404,500**	**931,795,255**	**284,796,887**

Farm data: USDA National Agricultural Statistics Service – selected states.
Population: Census Bureau; http://quickfacts.census.gov/qfd/states/40/40079.html

Farm product shipments can be categorized under two general headings: exports and domestic. Each was keyed to a different end-use market indicator.

a. Exports: The near-term projected change in the level of MKARNS grain exports was based on grain export projections developed by USDA. The current set of USDA export projections extends through the year 2012 for what they considered the most likely scenario. The growth rate per year was calculated from the USDA projections and applied to base year MKARNS export tonnage to develop forecasts through 2010. Post 2010 forecasts were developed by converging the USDA growth rate to the growth rate for exports developed for the Upper Miss study by the Sparks Consulting Company.

USDA and Upper Miss projections were also referenced with respect to developing high and low farm product exports for MKARNS. A search failed to locate high and low forecasts by USDA. The Upper Miss "least favorable" and "most favorable" scenarios resulted in the grain export growth rates listed in the following table. These growth rates were applied to the base traffic level of grain exports to develop the high and low forecasts for this study. The Upper Miss projections are for barge shipments of grain out of the Upper Miss region to central Gulf ports for export. The grain export growth rates from the Upper Miss study were also used in the Ohio River Mainstem Study. The projections and growth rates are listed below.

Table E1-32. Upper Miss Study – Projected Growth Rates for Grain Exports

	01-05	05-10	10-20	20-30	30-40	40-50	01-50
High	1.1%	0.8%	1.5%	1.3%	1.3%	-0.2%	0.9%
Medium (USDA)	0.9% (1.4%)	0.9% (1.4%)	1.0%	0.8%	0.7%	0.6%	0.8%
Low	-3.9%	-2.4%	-1.1%	-1.2%	-1.0%	-4.1%	-1.9%

Source: Upper Mississippi River and Illinois Waterway Navigation Study, 1 May 2002, Sparks Report on Future Traffic Demands, Table 22.

The major farm products in the export market are corn, soybeans, wheat, and meal. The forecasts in the Upper Miss Study (Sparks Report) were that corn and soybean exports would increase and wheat and meal exports would decrease. Separate indices were not developed for each product since it is expected that the producers along the MKARNS would adjust to changes in demands. For informational purposes, the product specific export projections of the central scenario of the Upper Miss study are listed below.

Table E1-33. Grain Exports (metric tons)

	2000	2025	2050	Ann. % Change
Corn	35.9	51.6	63.6	1.2%
Soybeans	19.4	25.9	31.5	1.0%
Wheat	6.6	4.3	2.5	-1.9%
Meal	4.9	3.4	3.0	-1.0%
Total	**66.8**	**85.3**	**100.6**	**0.8%**

Source: Upper Mississippi River and Illinois Waterway Navigation Study, 1 May 2002, Sparks Report on Future Traffic Demands, Central Scenario, Table 22.

b. Domestic: Domestic shipments of farm products consist mostly of corn originating out of the Upper Miss region and shipped to poultry farms in Arkansas. The processed chickens are distributed nationwide. Therefore, national population growth was considered the prime driver of future demands for domestically consumed farm products.

Group 2. Metals: The metals group consists mainly of iron and steel sheets and bars shipped inbound to fabricating plants in the Fort Smith, Arkansas and Tulsa, Oklahoma areas. Inbound shipment account for 87% of the metals group tonnage moving on the river. It is commonly recognized that steel consumption tends to rise with the level of economic output in an industrialized society, but that the relationship is not a linear one. According to the ORMSS report, an industry consultant indicated that steel consumption at the national level increases at a rate one-half to two-thirds the rate of growth in GDP. For the purposes of the current analysis, MKARNS metal traffic was allowed to grow, over both the short and long term, at one-half the rate of growth in U.S. GDP as forecast by NPA.

Group 3. Coal/Coke: Coal and coke traffic on MKARNS is relatively insignificant. The MKARNS traffic is not destined for use in electric generating or coke producing plants. Consistent with the Ohio River Mainstem Study (ORMSS) this traffic was linked to manufacturing earnings in the region of destination.

Group 4. Crude Petroleum: There are no shipments of crude petroleum on the MKARNS nor are there projected to be in the foreseeable future. Therefore, it was not necessary to analyze the market and identify the drivers of crude petroleum traffic.

Group 5. Non-Metallic Minerals: Non-metallic minerals consist largely of stone-like material that is used as is or that is processed into concrete and roadbed materials for use in the construction industry. Sand and gravel are low-priced commodities that cannot withstand high transportation costs. Consequently, it is advantageous for sand and gravel producers to be located as close as possible to their market areas, with truck being the primary mode of delivery. Much of the MKARNS traffic is an exception to this general rule, since it frequently travels a long distance to market. The reason is that the area is the closest region to the aggregate-deficit Gulf Coast, and therefore significant tons are shipped relatively long distances to meet Gulf Coast market demands.

Further analysis of the data indicated that internal shipments of non-metallic minerals increased by nearly 600,000 tons. The suspicion was that the destination might be the construction site at Montgomery Point or some point nearby. However, the data did not show any large shipments to the construction site. The Project Manager of Montgomery Point was queried on the subject and he indicated that the principle source of construction materials was quarries in Missouri and it was transported by barge down the Mississippi to the construction site. It didn't lock through any projects on the MKARNS and was not included in waterborne statistics for MKARNS. The ORMSS study included a comprehensive investigation of aggregate traffic and included surveys of aggregate shippers and users. As a result of this effort, they linked long-term growth to construction employment. The first-cut development of forecasts for this study initially did likewise. However, the growth rate was significantly less than the historic rate. For this reason, a composite rate was developed by averaging the growth rate in construction employment and

construction earnings. The rate was still lower than the historic rate but appeared more consistent with the historic rate.

Group 6. Forest Products: The shipment of forest products is negligible. The shipments totaled 130,000 tons, or 1 percent of total river tonnage. Eighty-one percent of the tonnage is shipped outbound. Forest product shipments were linked to population changes in the receipt region.

Group 7. Industrial Chemicals: Industrial chemicals are used in a wide range of goods from paints, to clothes, to cleaning materials, and other such items. Traffic in industrial chemicals is limited on MKARNS, amounting to 184,000 tons and about 2% of total tonnage. Eighty-four percent of the traffic is inbound. Industrial chemicals and other downstream chemicals of some variety enter into most manufacturing processes. In light of this, the short and long term forecasts of industrial chemicals traffic were keyed to manufacturing earnings.

Group 8. Agricultural Chemicals: Agricultural chemicals are, for the most part, fertilizers. Similar to the industrial chemicals, most of the agricultural chemicals on the MKARNS originate at refinery complexes on the Gulf Coast and are destined for fertilizer terminals along the MKARNS. The growth in agricultural chemicals was assumed equal to the growth in farm product shipments.

Group 9. Petroleum and Petroleum Products: The main drivers of petroleum production consumption were assumed the size of the population in the region of destination.

Group 10. Other: Ninety-three percent of the "others" group is cement and concrete. According to the ORMSS report, these two commodities are most logically linked to construction earnings. Since other commodities make up a relatively insignificant share of the "others" group's total tonnage, growth in the "others" group was linked to construction earnings.

4. Summary

Each commodity group was linked to the economic and/or demographic sector that most affects its demand. Farm products were further subdivided into shipments destined for export and domestic markets, since the farm product group is the most important group and since each segment of the market is expected to have its own unique growth rate. The USDA projections were the basis for the near-term export growth rates and the Upper Miss forecasts were the basis for the long-term export growth rates. Domestic shipments of grains were linked to national population growth. Metals consist largely of iron and steel inputs and products that are driven by national demands. Metal traffic was projected to grow at one-half the project growth rate in Gross Domestic Product (GDP). Coal movements are largely inbound and used for a variety of purposes, excluding use in power plants and coke plants. Coal shipments were expected to grow at the regional rate of manufacturing earnings. There are no existing or projected crude petroleum shipments. Non-metallic minerals consist mainly of sand and gravel and other construction-related materials that are linked to regional construction activity. Future growth in non-metallic mineral traffic was linked to regional construction employment and earnings. Forest products are used in construction and paper-product production, which are linked most closely to population changes in the state of destination. Therefore, the projected growth rate in

the size of each region's population was used to forecast future forest project shipments. Industrial chemicals are used in a wide array of industrial activities. Therefore, the growth rate in regional manufacturing earnings was used to project industrial chemical traffic. Agricultural chemicals are primarily fertilizers used in crop production; therefore, agricultural chemical traffic was projected to grow at the same rate as farm product shipments. Traffic in the "others" groups consists mainly of cement and concrete; future growth in the "other" traffic was linked to the projected growth rate in construction employment. Table E1-34 summarizes the economic and geographic sectors that were used to develop forecasts of commodity traffic on MKARNS. The macro-level forecasts by NPA extend to year 2050. Traffic was projected through 2080 using the projected annual growth rates of 2040 to 2050.

Table E1-34. Indicators of Future Traffic Demands

	Prime Driver	Secondary Adjustment	Geographic Area
Farm Products			
1) Foreign exports	USDA/Upper Miss forecasts	None	None
2) Domestic	Population	None	National
Metals	Gross Domestic Product	50% of GDP rate	National
Coal	Manufacturing earnings	None	Receipt Region
Crude Petroleum	Population	None	Receipt Region
Nonmetallic Minerals	Construction employment Construction earnings	Average of two	Receipt Region
Forest Products	Population	None	Receipt Region
Industrial Chemicals	Manufacturing earnings	None	Receipt Region
Agricultural Chemicals	Farm Product Shipments	None	Receipt Region
Petroleum and Petroleum Products	Population	None	Receipt Region
Other	Construction employment	None	Receipt Region

Source: USDA: "USDA Agricultural Baseline Projections to 2012", USDA Staff Report WAOB-2003-1; Feb 2003.
Upper Miss: Upper Mississippi River and Illinois Waterway Navigation Study, 1 May 2002, Sparks Report on Future Traffic Demands, Table 22.
Ohio River: Ohio River Mainstem Study, In-Progress Review Package, Dec 2003.

The rates using the mid-projections that were developed for each commodity group/commodity were applied to base-year traffic. The overall rates in traffic growth are listed in the table below. The growth rates are highest for coal and industrial chemicals at annual rates of 1.5% or higher and lowest for forest product, petroleum products and "others" at 0.6% to 0.7%. The growth rate for the remainder of the commodity groups is between 0.9% and 1.2% with the overall growth rate at 1.1% a year. The comparable rates for the low and high forecasts are listed in Addendum E7. For purposes of comparison, the rates of the mid-set of projections currently in use in the Upper Miss and Ohio River Mainstem studies are provided in Addendum E3.

Table E1-35. Projected Growth Rates for Middle Set of Forecasts

	Annual Growth Rate		
	2003-2010	**2003-2030**	**2003-2060**
Farm Products	2.0%	0.9%	0.9%
Metals	2.0%	0.9%	0.9%
Coal	3.1%	1.4%	1.9%
Crude Petroleum	-	-	-
Non-Metallic Minerals	3.6%	1.4%	1.2%
Forest Products	0.9%	0.5%	0.6%
Industrial Chemicals	2.9%	1.3%	1.8%
Agricultural Chemicals	2.5%	0.9%	0.9%
Petroleum Products	1.3%	0.6%	0.7%
Others	2.6%	0.9%	0.6%
All Commodities	**2.8%**	**1.1%**	**1.1%**

ADDENDUM E2

Discussion of Macro-Level Forecasts

Most macro-level forecasts almost always use the mid series population projections of the U.S. Census Bureau as their starting point since these are highly accepted and provide a common base for all forecasters. The key variables in the Census projections for the nation are the future birth and immigration rates. Because of uncertainty in these future rates, Census develops a range of projections based on different assumptions regarding the rates. The resulting range is shown in the following table. In the year 2020, the high forecasts are nearly 10% higher and the low forecasts are nearly 10% lower than the mid-forecasts. In numeric terms, there is a 50-million person difference between the low and high forecasts. This illustrates the uncertainty in even the most fundamental items.

For comparison purposes, the population forecasts used by NPA are also listed in the table. The NPA population forecasts are obtained from the Census Department, but differ from the forecasts listed for Census because they are an older set of Census forecasts.

While the population forecasts are largely the same, models begin to deviate significantly as different assumptions are made regarding labor force participation rates and productivity rates. In lieu of Census-based income forecasts, which do not exist, the table includes Department of Energy forecasts, which were considered a reasonable representation of Government economic forecasts and which are based on the mid-level Census projections. As shown in the table below, the DOE and NPA forecasts of total income are significantly different. Also, the variation of the high and the low forecasts from the mid-level forecasts is greater for income than for population, reflecting greater uncertainty. For example, the high population forecasts of NPA are 32% higher than the middle forecasts in 2050; on the other hand, the high-income forecasts are 156% higher than the mid-income forecasts. Depending on which set of forecasts were selected as indicators of the demand for water-borne commodity traffic, the projected traffic levels would be significantly different.

Table E2-1. U.S. Population Forecasts (1,000's)						
	Census			National Planning Associates		
	Low	Mid	High	Low	Mid	High
2000	274,853	275,306	275,816	272,602	274,573	275,975
2010	291,413	299,862	310,910	284,387	298,415	306,121
2020	303,664	324,927	354,642	295,589	326,133	346,104
2030	311,656	351,070	409,604	305,613	356,225	398,174
2040	314,673	377,350	475,949	312,246	383,527	452,258
2050	313,546	403,687	552,757	315,386	409,425	510,472
% Annual	0.3%	0.8%	1.4%	0.3%	0.8%	1.2%

Source: http://www.census.gov/population/projections/nation/summary/np-t1.txt
Source: "Alternative Long-Term Projections for the U.S. Economy and the States, 1970-2050", NPA Data Services, 1999.

U.S. Total Income Forecasts						
	Annual Energy Outlook 2003			National Planning Associates		
	Low	Mid	High	Low	Mid	High
2000		6,663,000		6,373,980	6,546,369	6,754,488
2010	8,336,999	8,637,000	9,004,000	7,210,917	8,196,266	9,858,933
2020	10,830,000	11,713,000	12,545,000	7,838,134	10,315,587	14,398,273
2030				8,149,782	12,309,711	20,614,264
2040				8,223,623	14,196,635	29,215,415
2050				8,174,490	16,269,321	41,685,144
% Annual	2.5%	2.9%	3.2%	0.5%	1.8%	3.7%

Source: http://www.eia.doe.gov/oiaf/aeo/pdf/appb.pdf
Source: "Alternative Long-Term Projections for the U.S. Economy
Note: the AEO forecasts are disposable personnel income and NPA are total income.

The state level population projections for Arkansas and Oklahoma by Census and in the NPA report are listed in the table below.

Table E2-2. Arkansas and Oklahoma Population Projections (thousands)

	Census			National Planning Associates		
	Arkansas	**Oklahoma**	**Both**	**Arkansas**	**Oklahoma**	**Both**
2000	2,631	3,373	6,004	2,577	3,390	5,967
2010	2,825	3,650	6,475	2,801	3,620	6,421
2020	2,989	3,923	6,912	3,050	3,882	6,932

Source: Census – http://www.census.gov/population/projections/state/stpjpop.txt
Source: "Alternative Long-Term Projections for the U.S. Economy and the States, 1970-2050", NPA Data Services, 1999.

ADDENDUM E3

Projected Growth Rates of Traffic on Other Rivers

Projected growth rates for river traffic obtained from current studies of the Upper Miss and Ohio River are listed below. The forecasts are for the "middle" set of forecasts from each study.

Table E3-1. Projected Growth Rates of Traffic on Other Rivers				
Upper Miss- Central Scenario				
	2000	2025	2050	% ann 00-50
Farm Products	66.8	85.3	100.6	0.8%
Coal	8.2	9	10.9	0.6%
Petro	8.5	9.4	9.1	0.1%
Fertilizer	3.1	2.9	2.6	-0.4%
Const Material	10	11.4	13.6	0.6%
Industrial Chemicals	4.1	6.8	12	2.2%
Iron & Steel	6.4	7.4	9	0.7%
Other	4.7	6.8	9.1	1.3%
Total	**111.8**	**139**	**166.9**	**0.8%**
Ohio - Utility Based Scenario				
Farm Products	10.8		20.4	1.3%
Coal	121.8		182.2	0.8%
Petro	14.1		17.7	0.5%
Fertilizer				
Const Material	38.9		65.4	1.0%
Chemicals	10.8		16.3	0.8%
Iron & Steel	14.3		22.9	0.9%
Other	18.9		27.1	0.7%
Crude	0.4		0.4	0.0%
Ores	9.1		15.6	1.1%
Total	**239.1**		**368**	**0.9%**

Table E3-2. Institute of Water Resources Traffic Forecasts for Arkansas River (million tons)											
	Weighted Average	**Actual**		**2005**			**2010**			**2020**	
	94-97	**2001**	**Low**	**Med**	**High**	**Low**	**Med**	**High**	**Low**	**Med**	**High**
Farm Products	2.5	2.6	2.5	2.9	3.3	2.6	3.1	3.5	3.0	3.5	4.0
Metals	1.0	1.0	0.9	1.2	1.4	1.0	1.3	1.6	1.2	1.5	1.8
Coal	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Crude Petroleum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nonmetallic Minerals	4.2	4.6	4.4	5.1	5.7	4.8	5.4	6.1	5.3	6.1	6.8
Forest Products	0.6	0.1	0.7	0.8	0.9	0.7	0.8	0.9	0.8	0.9	1.0
Industrial Chemicals	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4
Agricultural Chemicals	1.6	1.8	1.4	1.7	2.0	1.5	1.8	2.1	1.6	1.9	2.3
Petroleum Products	0.6	0.5	0.6	0.7	0.7	0.6	0.7	0.8	0.7	0.8	0.9
Other	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**10.8**	**11.2**	**10.8**	**12.6**	**14.5**	**11.6**	**13.5**	**15.5**	**13.0**	**15.2**	**17.4**

ADDENDUM E4

Barge Characteristics
Including Draft Per Loading

The following table is a working table obtained from a major towing company.

Jumbo Box Barge
Hull = 195′ x 35′ x 12′
Barge Weight = 304 Tons
Light Draft = 1′ 4”

Table E4-1. Cargo Tonnage by Draft of Barge												
Feet	**Inches**											
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	0	0	0	0	0	6	23	41	59	78	96	114
2	132	150	169	187	205	223	241	260	278	296	314	332
3	350	369	387	405	423	441	460	478	496	614	532	651
4	569	687	605	523	642	660	678	696	715	733	761	769
5	787	606	824	842	860	878	897	916	933	951	969	988
6	1,006	1,024	1,042	1,060	1,079	1,097	1,116	1,133	1,152	1,170	1,188	1,206
7	1,224	1,243	1,261	1,279	1,297	1,316	1,334	1,352	1,370	1,388	1,407	1,426
8	1,443	1,461	1,480	1,498	1,516	1,534	1,552	1,571	1,589	1,607	1,625	1,644
9	1,662	1,680	1,698	1,716	1,735	1,753	1,771	1,789	1,808	1,826	1,844	1,862
10	1,881	1,899	1,917	1,935	1,963	1,972	1,990	2,006	2,026	2,045	2,063	2,081
11	2,099	2,118	2,136	2,164	2,172	2,190	2,209	2,227	2,245	2,263	2,282	2,300
12	2,318											

ADDENDUM E5

Induced Traffic

1. Definition: Induced traffic is traffic that would be induced to move onto the waterway due to the reduction in waterborne transportation costs that would result from the proposed improvement. Either it can be traffic that shifts from an overland mode to the waterway system, traffic that develops to take advantage of the lower cost waterway system by changing the origins or destinations of shipments, or traffic that develops because some firm locates in the area and uses the waterway system because of the reduced transportation cost.

2. Identification of Potential Induced Traffic: The Tennessee Valley Authority (TVA) conducted a comprehensive mail, phone, and in-person survey of 75 terminals on the MKARNS and 369 firms in the counties bordering the river system. The firms included both those that ship by barge and those that ship via rail and/or truck. The survey was conducted in the Fall 2001.

The survey responses were reviewed as part of the current economic study to identify those firms that indicated the possibility that they might shift from rail/truck to barge transportation. The review noted that seven firms that indicated the potential to ship 3.0 million tons of products on the waterway that might move on the waterway system if conditions were more favorable. Attempts were made to contact these seven firms and one other new firm that opened on the river in 2003 to obtain additional information regarding developments since the 2001 survey and current thinking on the subject of the likelihood of traffic being "induced" onto the system.

3. Summary: The results of conversations with several of the firms indicated that the "inducement" of traffic onto the waterway system is dependent upon a large number of factors, including but not limited to transportation costs. In one case, which involved over 2.0 million tons of traffic or two-thirds of all potential induced traffic, the situation did not develop in a manner that would allow the traffic to move on the river system, at least in the foreseeable future. This potential traffic was coal that could potentially be shipped to an electric generating station. The decision was to continue to receive the coal from the Power River Basin, which necessarily is by rail. Thus the required "shift of origin" necessary for waterway traffic did not occur. Responses from the other shippers were generally that the potential "inducement" of traffic onto the river system is certainly enhanced by reduced transportation costs, but that it is difficult to predict with any high degree of certainty what movements might materialize. Overall, this is an area of high uncertainty.

4. Procedure: Given the uncertainty over the materialization of "induced" traffic if the project is deepened but the general expectation that lower transportation costs would have some beneficial impact on the selection of waterway shipments, a procedure was followed to develop a range of potential "induced" traffic. The procedure considered the percentage reduction in waterway transportation costs for different depth channels, and the commodities with the greatest volumes that could potentially be "induced" onto the system.

5. Transportation Costs: Transportation costs for the existing waterway system and for the system with improvements in the form of deepening are listed in the table below. Deepening would lower the overall water-routing costs by 3.2% to 5.6% depending on the depth. Assuming unitary elasticity between water-routing costs and traffic volumes, the reductions would result in the "inducement" of 358,000 to 627,000 tons based on the volume of traffic in the year 2001. Assuming perfect inelasticity, the lower costs would not have any effect on traffic volumes (zero

induced tonnage). This range of zero to 358,000 to 627,000 tons was used as the probable tonnage range for induced traffic.

Table E5-1. Elasticity of Demand			
	Waterway Costs (thousands $)	**Percent Reduction**	**Equivalent Percent of Traffic (thousands tons)**
Existing	148,021		
10´	143,241	3.2%	358
11´	140,669	4.9%	549
12´	139,744	5.6%	627

6. Potential Commodities: The commodities that move in large volumes in the study area are likely candidates for inducement onto the waterway system. These commodities include coal, grains, fertilizers, and aggregates. With the exception of coal, all move in significant volumes on MKARNS. Coal moves in very large volumes in the area, but very little moves on the waterway.

(1) Coal: There are five coal-fired generating units in Arkansas that burn about 15 million tons per year and ten units in Oklahoma that burn about 20 million tons per year. Currently, nearly all of the coal is railed from Wyoming. Thirty-five million tons is a significant volume such that even a small percentage modal shift would represent a large increase in MKARNS traffic. For the range of percent reductions listed in the table above, the equivalent volumes of coal would be 1.1 million tons, 1.7 million tons, and 2.0 million tons. This would appear to be an area of potential traffic, but would likely require some logistical change such as a change in the origin of the coal.

Table E5-2. Coal-fired Electric Generating Capacity (tons in thousands)					
Company/Plant	**Unit**	**Nameplate Capacity (megawatts)**	**Western Coal Equivalent**	**Eastern Coal Equivalent**	**County**
Arkansas					
Energy Arkansas					
Independence	1	850	2,420.0	3,218.5	Independence
	2	850	2,420.0	3,218.5	
White Bluff	1	850	2,420.0	3,218.5	Jefferson
	2	850	2,420.0	3,218.5	
Southwestern			-	-	
Flint Creek	1	480	1,366.6	1,817.5	Benton
			-	-	
Oklahoma			-	-	
Grand River Dam			-	-	
GRDA	1	490	1,395.0	1,855.4	Mayes
	2	520	1,480.4	1,969.0	
Ok Gas & Electric			-	-	
Muskogee	4	572	1,628.5	2,165.9	Muskogee
	5	572	1,628.5	2,165.9	
	6	572	1,628.5	2,165.9	
Sooner	1	568	1,617.1	2,150.7	Noble
	2	568	1,617.1	2,150.7	
Public Service of OK			-	-	
Northeastern	3	441	1,255.5	1,669.9	Rogers
	4	441	1,255.5	1,669.9	
Western Farmers Elec			-	-	
Hugo	1	400	1,138.8	1,514.6	Choctaw
Total			**25,691.3**	**34,170.8**	
Source: Inventory of Electric Utility Power Plants in the U.S. 2000, EIA					

(2) Grains: Grain shipments already account for a significant portion of waterway shipments and the volumes have continued to increase over the years. Nonetheless, 2.2 million tons of waterway shipments represent only 22% of the grains produced in Arkansas and Oklahoma. Assuming unitary elasticity and the shift of 627,000 tons of grains onto the river system, the percentage would increase to 24%.

Table E5-3. Major Farm Product Production Year 2000; Millions of Short Tons				
	Arkansas	**Oklahoma**	**Subtotal**	**U.S.**
Wheat	1.8	4.3	6.1	67.0
Soybeans	2.4	0.1	2.5	82.7
Sorghum Grains	0.3	0.4	0.7	14.1
Rice	2.6	-	2.6	5.7
Total	**7.1**	**4.8**	**11.9**	**169.5**
Source: http://www.nass.usda.gov:81/ipedb/				

(3) Other Products: The shipper survey indicated a large range of commodities that could potentially be induced onto the waterway system that are not particularly large volume movements now. These include additional animal feed shipments, and shipments of aggregates out of Oklahoma to the New Orleans market where they are currently not competitive because of costs. All of these commodities have the potential for their movements to be 'induced' onto the waterway system because of lower waterway transportation costs. However, the specifics of any one shipment in terms of tonnage and docks of origin and destination are speculatory at this time.

7. Induced Traffic:

(1) Volumes: The determination of how much, if any, traffic would be induced onto the waterway system due to lower waterway transportation costs is subject to a high degree of uncertainty. The survey indicated a potential volume of 3.0 million tons, but it is impossible to determine how much of this is due to lower transportation costs and how much is due to the other 99 factors considered in the decision making process. Given this, the consensus remains that lower transportation costs will increase the competitiveness of waterway transportation. Given the uncertainty over the extent of the impact, a range of the volume of induced traffic was developed between zero and 627,000 tons, which represents the range between complete inelasticity of traffic to transportation cost changes and unitary elasticity, which is the point where the percentage increase in traffic equals the percentage reduction in transportation costs for the 12´ channel.

(2) Shipments: The specific commodities, volumes, and origins and destinations could be based on the survey responses, but these are highly uncertain, even in the estimation of the responders. If the list of potential induced traffic was developed from this list and the shipments did not develop exactly as currently expected, then it could distort the incremental analysis by overestimating the benefits of improving some sections of the river system and underestimating others. Given the high degree of uncertainty regarding how new shipments may develop, the risk of distorting the economic analysis by using specific "induced" shipments appeared too high.

An alternative is to recognize the uncertainty in determining the precise commodity type, origin and destination of "induced" shipments and allowing allow all existing shipments to share some portion of the induced traffic. This approach minimizes the severity of errors associated with

using a few specific shipments that may never materialize. A listing of the maximum induced tonnage, by commodity group and channel depth based on year 2001 tonnage levels, is provided below.

	Table 5-4			
	Induced Traffic			
	(thsds of tons)			
	2001	**Deepening Alternatives**		
	9-ft	**10-ft**	**11-ft**	**12-ft**
Farm Products	2,578	82	126	144
Metals	1,015	32	50	57
Coal	149	5	7	8
Crude Petroleum	0	0	0	0
Nonmetallic Minerals	4,621	148	227	259
Forest Products	130	4	6	7
Industrial Chem	184	6	9	10
Agricultural Chem	1,837	59	90	103
Petroleum Products	507	16	25	28
Other	179	6	9	10
Total	**11,200**	**358**	**549**	**627**

(3) Time-Phasing of Traffic: There is expected to be a time lag between the completion of the deepening work and the shift of tonnage onto the waterway system. Based on an expected completion date of 2006, it was assumed that zero traffic would shift through the year 2009, 50% by the year 2010, and 100% by 2020.

(4) Transportation Costs: The waterway transportation costs were calculated as the overland transportation costs minus one-half of the reduction in waterway costs due to deepening. For example, if the overland cost for a shipment is $15 per ton and the reduction in waterway costs due to deepening is $2 per ton, then the waterway costs for the induced shipment is $14 per ton ($15 – 0.5*$2.0). It was assumed that the reduction in waterway costs was the maximum savings, and that the range was from zero to the maximum with the mean being the midpoint; thus the 50% adjustment factor.

ADDENDUM E6

Lock Simulation Model

1. Purpose: The purpose of developing the model was to estimate the effects of future projected traffic on lockage and delays times at each project.

2. Description: The model was written in Fortran computer language. The key input to the model was the number of tow arrivals at a lock. The number of tows was used to generate arrival times at the project assuming the arrivals can occur at any time throughout the day, week, and year. The result is a list of tow arrivals with arrival times within the year.

The second step was to assign characteristics to the tow, particularly whether the tow would require a one-cut or two-cut lockage operation. The percentage of one and two-cut lockage tows was based on actual 2001 data, and the likelihood of any one tow requiring one or tow-cuts was randomly determined. In addition, the percentage was allowed to range plus or minus 10% in any given year to reflect uncertainty. For example, if the data for Norrell lock indicated that 75% required a one-cut lockage and 25% required a two-cut lockage in 2001, the percentage range of one-cut lockages in future years ranged between 65% and 85% with the actual percentage being randomly determined. Conversely, the percentage of two-cut lockages would range between 15% and 35%.

The third step was to include recreational boats in the vessel arrival list. The number of recreational lockages was the number recorded at the lock in the year 2001, and was held constant over the simulation period. However, unlike tows the recreational craft were not assumed to arrive randomly throughout the year. Rather, their arrivals were restricted to the summer months with heavy concentrations on the weekends.

The fourth step was to determine lockage times at the projects. Average lockage times for each project were obtained from summary statistics of the 2001 lock performance monitoring system (LPMS) data for one-cut, two-cut, and recreational craft lockages. A review of the average data indicated a possible aggregation or reporting error with the LPMS data in the time for two-cut lockages since the time was about one-half the comparable time for projects with the same size lock chambers (and tow haulage systems) on the Ohio River. Therefore, the matter was further investigated by extracting a detailed lockage time log for a two-cut lockage at Norrell L&D and comparing it with the times from the other sources. The time from the detailed lockage log was nearly identical to the Ohio River times. As a result, it was decided to adjust the LPMS times to a more realistic value by doubling the LPMS time. The resulting two-cut lockage time was about 131 minutes, which compares favorably with the detailed record LPMS time of 137 minutes and the Ohio project time of 133 minutes. The simulated lockage times were allowed to vary between plus and minus 25% to reflect the actual range in times. A 15-minute lockage time was used for recreational boats.

The “with” project condition lockage times are different than the existing lockage times due to safety consideration and the likelihood that the tow-haulage equipment was underpowered for barges loaded to greater than 9′ . Based on the expert opinion of operations and engineering personnel, it was estimated that safety concerns would add about 20 minutes to one-cut lockage times and 36 minutes to two-cut lockage times. In addition, the inability to use tow haulage equipment for two-cut lockage operations would add about 54 minutes to the two-cut lockage time.

The fifth step was to include some probability of downtime at the lock. The values used were 1.3% for the probability of an 8-hour or less closure and 0.75% for a closure of between 8 and 48 hours.

The sixth step was to assign hourly costs to the tows. The costs were obtained from the TVA analysts who developed the transportation rates and equaled $180 per hour for one-cut lockage tows and $235 per hour for two-cut lockage tows. No costs were assigned to recreational craft.

The seventh and final step was to run the simulation and record the results. The model was run as a batch job, first cycling through all 18 projects and then through the current and future decadal years. The data for each project was specific to the project based on 2001 statistics, with the exception of Montgomery Point which is currently under construction. Lockage times for Norrell, which is the project immediately upstream of Montgomery Point, were used for Montgomery Point. However, it is estimated that Montgomery Point will operate as an open pass structure about 70% of the time.

3. Data: The data regarding tows and recreational boats described above was obtained from LPMS either directly from the raw data or indirectly from summary reports published by the Navigation Data Center in Washington. Generally, the detailed data regarding the number and lockage times for one and two-cut lockages was of necessity obtained from the raw data. The general data for the number of tows, number of recreational boat lockage, and average delays in 2001 were obtained from the summary files. Again, the data are lock specific.

Table E6-1. One and Two-Cut Lockage Percentages and Times

	% Single	% Double	Minutes to Lock a Single	Minutes to Lock a Double	Recreation Boat Lockages
Montgomery Pt.	66	34	37	64	198
Norrell	66	34	37	64	198
L&D 2	67	33	39	64	167
Hardin	62	38	40	61	330
Sanders	57	43	40	66	290
L&D 5	60	40	43	61	416
Terry	60	40	40	63	616
Murray	62	38	41	59	517
Toad Suck	51	49	45	65	153
Ormond	72	28	40	52	133
Dardanelle	63	37	46	67	179
Ozark	69	31	46	67	158
Trimble	71	29	44	69	204
Mayo	72	28	39	68	0
Kerr	60	40	48	71	0
Weber	65	35	52	72	0
Chouteau	78	22	44	71	0
Graham	84	16	45	69	0

Table E6-2. Lockage Times "Without" and "With" Project (Average for all Projects)		
	Without (existing)	With (>9´)
One-cut	45	45 + 20 = 65
Two-cut	131	131 + 36 + 54 = 221
Recreation boat	15	15

4. Outputs: Two files were output from the simulation runs: a summary file that lists the lockage, delay, and total cost for the system by decadal year; and a detailed file that lists the same information for each project. A partial representative summary file is listed below. The actual file includes data out to the year 2060.

Table E6-3. Simulated Processing Costs for System				
	2001	**2005**	**2010**	**2020**
Delay costs:	71,285.6	90,118.5	88,862.9	144,999.1
Lockage costs:	109,556.1	114,130.9	130,171.5	149,841.1
Total lockage and delay costs	180,841.6	204,249.4	219,034.5	294,840.2

The following table lists the units for the values in the simulation output file.

Table E6-4. Processing Time and Cost for System		
System		**Units**
Total Tows:	15,014	Number
Total Simulated Delay:	323.8	Days
Total Actual Delays in 2001:	337.2	Days
Total Lockage Time:	520.1	Days
Average Delay per Tow:	0.5	Hrs/Tow
Average Lockage Time:	0.8	Hrs/Tow
Total Delay Cost:	62,662.8	Dollars
Total Lockage Cost:	100,512.8	Dollars
Total Cost at All Locks:	163,175.6	Dollars

A partial listing of a detailed simulation file is listed below. The listing is for the year 2001; future years are identical in format but differ in values due to different number of tow arrivals. In addition to cost data, the detailed file also includes the number of tows, the delay per tow, and the lockage time per tow as simulated and the actual values in the year 2001.

Table E6-5. Processing Statistics for Each Project	
Project: GRAHAM	
Total Tows:	471
Total Delay:	5.31
Total Lockage Time:	15.56
Average Delay per Tow:	0.27
Av Delay per Tow in 2001	0.15
Ave Lockage Time:	0.79
Ave Lock Time/Tow in 2001	0.9
Total Delay Cost:	954.98
Total Lockage Cost:	2801.1
Total Cost at Lock:	3756.08
Project: CHOUTEAU	
Total Tows:	487
Total Delay:	6.43
Total Lockage Time:	17.08
Average Delay per Tow:	0.32
Av Delay per Tow in 2001	0.03
Ave Lockage Time:	0.84
Ave Lock Time/Tow in 2001	0.9
Total Delay Cost:	1512.02
Total Lockage Cost:	4014.18
Total Cost at Lock:	5526.2
Project: WEBER	
Total Tows:	503
Total Delay:	3.83
Total Lockage Time:	20.6
Average Delay per Tow:	0.18
Av Delay per Tow in 2001	0.02
Ave Lockage Time:	0.98
Ave Lock Time/Tow in 2001	0.9
Total Delay Cost:	689.35
Total Lockage Cost:	3708.67
Total Cost at Lock:	4398.02
Project: KERR	
Total Tows:	503
Total Delay:	4.05
Total Lockage Time:	19.93
Average Delay per Tow:	0.19
Av Delay per Tow in 2001	0.07
Ave Lockage Time:	0.95
Ave Lock Time/Tow in 2001	0.88
Total Delay Cost:	728.83
Total Lockage Cost:	3587.83
Total Cost at Lock:	4316.66

Project:	MAYO
Total Tows:	500
Total Delay:	1.55
Total Lockage Time:	16.33
Average Delay per Tow:	0.07
Av Delay per Tow in 2001	0.17
Ave Lockage Time:	0.78
Ave Lock Time/Tow in 2001	0.95
Total Delay Cost:	364.85
Total Lockage Cost:	3837.54
Total Cost at Lock:	4202.39

Project:	TRIMBLE
Total Tows:	756
Total Delay:	27.66
Total Lockage Time:	25.46
Average Delay per Tow:	0.88
Av Delay per Tow in 2001	0.49
Ave Lockage Time:	0.81
Ave Lock Time/Tow in 2001	0.63
Total Delay Cost:	4978.93
Total Lockage Cost:	4583.02
Total Cost at Lock:	9561.95

Project:	OZARK
Total Tows:	674
Total Delay:	5.84
Total Lockage Time:	23.72
Average Delay per Tow:	0.21
Av Delay per Tow in 2001	0.75
Ave Lockage Time:	0.84
Ave Lock Time/Tow in 2001	0.77
Total Delay Cost:	1051.34
Total Lockage Cost:	4270.19
Total Cost at Lock:	5321.52

Project:	DARDANELLE
Total Tows:	1007
Total Delay:	8.98
Total Lockage Time:	36.56
Average Delay per Tow:	0.21
Av Delay per Tow in 2001	0.21
Ave Lockage Time:	0.87
Ave Lock Time/Tow in 2001	0.83
Total Delay Cost:	1616.61
Total Lockage Cost:	6580.2
Total Cost at Lock:	8196.82

Project:	ORMOND
Total Tows:	911
Total Delay:	7.88
Total Lockage Time:	27.15
Average Delay per Tow:	0.21
Av Delay per Tow in 2001	0.88
Ave Lockage Time:	0.72
Ave Lock Time/Tow in 2001	0.88
Total Delay Cost:	1419.11
Total Lockage Cost:	4886.41
Total Cost at Lock:	6305.52

Project:	TOAD SUCK
Total Tows:	938
Total Delay:	34.75
Total Lockage Time:	34.53
Average Delay per Tow:	0.89
Av Delay per Tow in 2001	0.38
Ave Lockage Time:	0.88
Ave Lock Time/Tow in 2001	0.85
Total Delay Cost:	6254.15
Total Lockage Cost:	6214.6
Total Cost at Lock:	12468.76

Project:	MURRAY
Total Tows:	1303
Total Delay:	72.09
Total Lockage Time:	40.56
Average Delay per Tow:	1.33
Av Delay per Tow in 2001	0.51
Ave Lockage Time:	0.75
Ave Lock Time/Tow in 2001	0.68
Total Delay Cost:	12975.4
Total Lockage Cost:	7300.27
Total Cost at Lock:	20275.68

Project:	TERRY
Total Tows:	1480
Total Delay:	47.96
Total Lockage Time:	47.11
Average Delay per Tow:	0.78
Av Delay per Tow in 2001	0.54
Ave Lockage Time:	0.76
Ave Lock Time/Tow in 2001	0.65
Total Delay Cost:	8633.05
Total Lockage Cost:	8479.55
Total Cost at Lock:	17112.6

Project:	L&D 5
Total Tows:	1293
Total Delay:	47.41
Total Lockage Time:	42.9
Average Delay per Tow:	0.88
Av Delay per Tow in 2001	0.55
Ave Lockage Time:	0.8
Ave Lock Time/Tow in 2001	0.67
Total Delay Cost:	8534.33
Total Lockage Cost:	7722.53
Total Cost at Lock:	16256.86

Project:	SANDERS
Total Tows:	1276
Total Delay:	34.22
Total Lockage Time:	43
Average Delay per Tow:	0.64
Av Delay per Tow in 2001	0.89
Ave Lockage Time:	0.81
Ave Lock Time/Tow in 2001	0.72
Total Delay Cost:	6159.54
Total Lockage Cost:	7740.33
Total Cost at Lock:	13899.87

Project:	HARDIN
Total Tows:	1275
Total Delay:	24.66
Total Lockage Time:	40.23
Average Delay per Tow:	0.46
Av Delay per Tow in 2001	0.94
Ave Lockage Time:	0.76
Ave Lock Time/Tow in 2001	0.75
Total Delay Cost:	4439.31
Total Lockage Cost:	7241.21
Total Cost at Lock:	11680.52

Project:	L&D 2
Total Tows:	1299
Total Delay:	6.11
Total Lockage Time:	41.01
Average Delay per Tow:	0.11
Av Delay per Tow in 2001	0.88
Ave Lockage Time:	0.76
Ave Lock Time/Tow in 2001	0.73
Total Delay Cost:	1100.47
Total Lockage Cost:	7380.93
Total Cost at Lock:	8481.4

Project: NORRELL	
Total Tows:	1331
Total Delay:	29.32
Total Lockage Time:	41.24
Average Delay per Tow:	0.53
Av Delay per Tow in 2001	0.62
Ave Lockage Time:	0.74
Ave Lock Time/Tow in 2001	0.62
Total Delay Cost:	5276.97
Total Lockage Cost:	7423.79
Total Cost at Lock:	12700.76
Project: MONTGOMERY	
Total Tows:	1133
Total Delay:	19.56
Total Lockage Time:	50.14
Average Delay per Tow:	0.41
Av Delay per Tow in 2001	0.62
Ave Lockage Time:	1.06
Ave Lock Time/Tow in 2001	0
Total Delay Cost:	4596.33
Total Lockage Cost:	11783.69
Total Cost at Lock:	16380.03
System	
Total Tows:	17140
Total Delay:	387.61
Total Delay in 2001:	401.7
Total Lockage Time:	583.11
Tot Lock Time in 2001:	501.23
Average Delay per Tow:	0.54
Average Lockage Time:	0.82
Total Delay Cost:	71285.58
Total Lockage Cost:	109556.1
Total Cost at All Locks:	180841.6

ADDENDUM E7

High, Medium, and Low Traffic Forecasts

1. Purpose: The purpose of developing high, middle and low traffic forecasts is to provide a reasonable range of benefits given their high degree of dependence on traffic forecasts and the high degree of uncertainty regarding future levels of traffic.

2. Low Forecasts: The MKARNS forecasts are heavily dependent on expected future levels of farm product exports from the United States. Given increased competition from Brazil and other emerging agricultural nations, grain exports from the United States may be relatively flat or decline in the future. An example of a similar occurrence is the international coal market, where the United States turned from a major exporter with high prospects of continued export growth to a nation with declining exports and increasing imports. Because of the possibility of flat or declining grain exports, the lower bound of forecasts used in this study was the current 2003 traffic level, held constant throughout the future.

3. High Forecasts: According to some reports, the prospects for growth in international trade have risen because of declining production and increased demand in China, which enjoys a major trade surplus with the United States. Given the trade linkage, the prospects for growth in grain exports to China appear to be bright.

However, it should be noted that U.S. grain exports do not have to increase at all for MKARNS traffic to increase, if MKARNS captures a larger share of the nation's export market. There are some reports that grain shipments on the MKARNS already represent a larger share of the export total as some shippers abandon the Missouri River due to changes in reservoir operations that adversely affect navigation. Given the controversy over the Upper Mississippi Navigation System, a further shift towards the MKARNS production area could occur if the controversy causes a real or perceived reduction in the reliability of the Upper Miss Navigation system. Because of the high volume of Upper Miss grain exports, a small shift could significantly increase MKARNS traffic.

The upper bound of MKARNS traffic is unknown and unknowable at the present time. What is known is the volume of traffic on similar but more mature river systems in the United States. These river systems include the Illinois and Tennessee, both of which move about 40 million tons a year and both of which were built in the 1930's, which makes them about 40 years older than the MKARNS. As an upper bound to MKARNS traffic, it was assumed that its tonnage volume could approximate the tonnage volumes currently shipped on the Illinois and Tennessee Rivers. The high growth in shipments could be driven by higher levels of U.S. exports or a higher share of exports from the MKARNS region, or some combination of the two. The technical computation of the "high" forecasts was accomplished by doubling the rate of growth of the middle set of forecasts. The results provide traffic forecasts in the 2050 to 2060 time period that are near the current volumes on the Illinois and Tennessee Rivers.

4. Projected Growth in Existing Traffic: Projections of total river traffic for shipments that currently move on the system are summarized below. Induced traffic is not included.

Table E7-1. High, Middle and Low Traffic Projections								
	Base 03	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**03-60 Ann. %**
High	11,884.3	21,558.2	31,993.6	34,711.9	37,415.1	40,353.4	43,550.7	2.1%
Middle	11,884.3	14,372.1	15,996.8	17,355.9	18,707.6	20,176.7	21,775.3	1.0%
Low	11,884.3	11,884.3	11,884.3	11,884.3	11,884.3	11,884.3	11,884.3	0.0%

The high, middle and low forecasts by river reach are listed in the table below. The numbers per reach are not additive, since one ton can move on several reaches. The dividing line in terms of traffic is the Ozark to Fort Smith reach, where approximately one-half of the traffic moves on the upstream reaches. The upstream oriented traffic moves downriver to join with the downstream oriented traffic to the point where the total amount of traffic moving on the downstream portion of the river is nearly equal to total river traffic. In other words, the majority of the upstream traffic travels the entire length of the river.

Table E7-2. High, Middle and Low Traffic Projections								
	Base 03	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**03-60 Ann. %**
High								
Pine Bluff	11,591.6	21,049.5	31,244.5	33,900.6	36,553.8	39,439.0	42,579.9	2.1%
Little Rock	10,447.3	19,063.7	28,307.9	30,674.7	33,052.6	35,632.1	38,432.8	2.1%
Ozark	8,672.5	15,773.7	23,405.9	25,364.8	27,328.6	29,460.4	31,776.8	2.1%
Fort Smith	6,183.4	11,017.6	16,234.6	17,587.0	18,910.6	20,349.2	21,915.3	2.0%
Muskogee	4,894.9	8,564.7	12,543.5	13,572.6	14,567.9	15,651.2	16,832.5	2.0%
Catoosa	4,258.6	7,473.3	10,956.8	11,866.9	12,746.1	13,704.7	14,751.8	2.0%
White	301.4	521.7	766.5	828.6	878.6	931.7	988.1	1.9%
Total	**11,884.3**	**21,558.2**	**31,993.6**	**34,711.9**	**37,415.1**	**40,353.4**	**43,550.7**	**2.1%**
Middle								
Pine Bluff	11,591.6	14,033.0	15,622.3	16,950.3	18,276.9	19,719.5	21,290.0	1.0%
Little Rock	10,447.3	12,709.1	14,154.0	15,337.4	16,526.3	17,816.1	19,216.4	1.0%
Ozark	8,672.5	10,515.8	11,702.9	12,682.4	13,664.3	14,730.2	15,888.4	1.0%
Fort Smith	6,183.4	7,345.0	8,117.3	8,793.5	9,455.3	10,174.6	10,957.6	0.9%
Muskogee	4,894.9	5,709.8	6,271.7	6,786.3	7,284.0	7,825.6	8,416.3	0.9%
Catoosa	4,258.6	4,982.2	5,478.4	5,933.4	6,373.0	6,852.3	7,375.9	0.9%
White	301.4	347.8	383.2	414.3	439.3	465.9	494.0	0.8%
Total	**11,884.3**	**14,372.1**	**15,996.8**	**17,355.9**	**18,707.6**	**20,176.7**	**21,775.3**	**1.0%**
Low								
Pine Bluff	11,591.6	11,591.6	11,591.6	11,591.6	11,591.6	11,591.6	11,591.6	0.0%
Little Rock	10,447.3	10,447.3	10,447.3	10,447.3	10,447.3	10,447.3	10,447.3	0.0%
Ozark	8,672.5	8,672.5	8,672.5	8,672.5	8,672.5	8,672.5	8,672.5	0.0%
Fort Smith	6,183.4	6,183.4	6,183.4	6,183.4	6,183.4	6,183.4	6,183.4	0.0%
Muskogee	4,894.9	4,894.9	4,894.9	4,894.9	4,894.9	4,894.9	4,894.9	0.0%
Catoosa	4,258.6	4,258.6	4,258.6	4,258.6	4,258.6	4,258.6	4,258.6	0.0%
White	301.4	301.4	301.4	301.4	301.4	301.4	301.4	0.0%
Total	**11,884.3**	**11,884.3**	**11,884.3**	**11,884.3**	**11,884.3**	**11,884.3**	**11,884.3**	**0.0%**

5. Induced traffic: Traffic may be induced to shift onto the system given the reduction in water routing transportation costs that result from river deepening. The amounts "induced" vary with the projections scenario and with the potential depth of deepening. The total induced tonnages by scenario and depth are listed below.

Table E7-3. High, Middle and Low Induced Traffic Projections								
	Base 03	2010	2020	2030	2040	2050	2060	03-60 Ann. %
High								
10′	0.0	344.9	1,023.8	1,110.8	1,197.3	1,291.3	1,393.6	2.8%
11′	0.0	528.2	1,567.7	1,700.9	1,833.3	1,977.3	2,134.0	2.8%
12′	0.0	603.6	1,791.6	1,943.9	2,095.2	2,259.8	2,438.8	2.8%
Medium								
10′	0.0	230.0	511.9	555.4	598.6	645.7	696.8	2.2%
11′	0.0	352.1	783.8	850.4	916.7	988.7	1,067.0	2.2%
12′	0.0	402.4	895.8	971.9	1,047.6	1,129.9	1,219.4	2.2%
Low								
10′	0.0	190.1	380.2	380.2	380.2	380.2	380.2	1.4%
11′	0.0	291.2	582.4	582.4	582.4	582.4	582.4	1.4%
12′	0.0	332.8	665.6	665.6	665.6	665.6	665.6	1.4%

Induced tonnage is displayed by river reach for each scenario and depth in the table below.

Table E7-4. High, Middle and Low Traffic Projections – Induced and by Depth								
	Base 03	2010	2020	2030	2040	2050	2060	03-60 Ann. %
High – 10′								
Pine Bluff	0.0	336.8	999.8	1,084.8	1,169.7	1,262.0	1,362.6	2.8%
Little Rock	0.0	305.0	905.9	981.6	1,057.7	1,140.2	1,229.9	2.8%
Ozark	0.0	252.4	749.0	811.7	874.5	942.7	1,016.9	2.8%
Fort Smith	0.0	176.3	519.5	562.8	605.1	651.2	701.3	2.8%
Muskogee	0.0	137.0	401.4	434.3	466.2	500.8	538.6	2.8%
Catoosa	0.0	119.6	350.6	379.7	407.9	438.5	472.1	2.8%
White	0.0	8.3	24.5	26.5	28.1	29.8	31.6	2.7%
Total	**0.0**	**344.9**	**1,023.8**	**1,110.8**	**1,197.3**	**1,291.3**	**1,393.6**	**2.8%**
High – 11′								
Pine Bluff	0.0	515.7	1,531.0	1,661.1	1,791.1	1,932.5	2,086.4	2.8%
Little Rock	0.0	467.1	1,387.1	1,503.1	1,619.6	1,746.0	1,883.2	2.8%
Ozark	0.0	386.5	1,146.9	1,242.9	1,339.1	1,443.6	1,557.1	2.8%
Fort Smith	0.0	269.9	795.5	861.8	926.6	997.1	1,073.8	2.8%
Muskogee	0.0	209.8	614.6	665.1	713.8	766.9	824.8	2.8%
Catoosa	0.0	183.1	536.9	581.5	624.6	671.5	722.8	2.8%
White	0.0	12.8	37.6	40.6	43.1	45.7	48.4	2.7%
Total	**0.0**	**528.2**	**1,567.7**	**1,700.9**	**1,833.3**	**1,977.3**	**2,134.0**	**2.8%**
High – 12′								
Pine Bluff	0.0	589.4	1,749.7	1,898.4	2,047.0	2,208.6	2,384.5	2.8%
Little Rock	0.0	533.8	1,585.2	1,717.8	1,850.9	1,995.4	2,152.2	2.8%
Ozark	0.0	441.7	1,310.7	1,420.4	1,530.4	1,649.8	1,779.5	2.8%
Fort Smith	0.0	308.5	909.1	984.9	1,059.0	1,139.6	1,227.3	2.8%
Muskogee	0.0	239.8	702.4	760.1	815.8	876.5	942.6	2.8%
Catoosa	0.0	209.3	613.6	664.5	713.8	767.5	826.1	2.8%
White	0.0	14.6	42.9	46.4	49.2	52.2	55.3	2.7%
Total	**0.0**	**603.6**	**1,791.6**	**1,943.9**	**2,095.2**	**2,259.8**	**2,438.8**	**2.8%**

Medium-10´								
Pine Bluff	0.0	224.5	499.9	542.4	584.9	631	681.3	2.2%
Little Rock	0.0	203.3	452.9	490.8	528.8	570.1	614.9	2.2%
Ozark	0.0	168.3	374.5	405.8	437.3	471.4	508.4	2.2%
Fort Smith	0.0	117.5	259.8	281.4	302.6	325.6	350.6	2.2%
Muskogee	0.0	91.4	200.7	217.2	233.1	250.4	269.3	2.2%
Catoosa	0.0	79.7	175.3	189.9	203.9	219.3	236	2.2%
White	0.0	5.6	12.3	13.3	14.1	14.9	15.8	2.1%
Total	**0.0**	**230.0**	**511.9**	**555.4**	**598.6**	**645.7**	**696.8**	**2.2%**
Medium-11´								
Pine Bluff	0.0	343.8	765.5	830.6	895.6	966.3	1,043.2	2.2%
Little Rock	0.0	311.4	693.5	751.5	809.8	873.0	941.6	2.2%
Ozark	0.0	257.6	573.4	621.4	669.6	721.8	778.5	2.2%
Fort Smith	0.0	180.0	397.7	430.9	463.3	498.6	536.9	2.2%
Muskogee	0.0	139.9	307.3	332.5	356.9	383.5	412.4	2.2%
Catoosa	0.0	122.1	268.4	290.7	312.3	335.8	361.4	2.2%
White	0.0	8.5	18.8	20.3	21.5	22.8	24.2	2.1%
Total	**0.0**	**352.1**	**783.8**	**850.4**	**916.7**	**988.7**	**1,067.0**	**2.2%**
Medium-12´								
Pine Bluff	0.0	392.9	874.8	949.2	1,023.5	1,104.3	1,192.2	2.2%
Little Rock	0.0	355.9	792.6	858.9	925.5	997.7	1,076.1	2.2%
Ozark	0.0	294.4	655.4	710.2	765.2	824.9	889.8	2.2%
Fort Smith	0.0	205.7	454.6	492.4	529.5	569.8	613.6	2.2%
Muskogee	0.0	159.9	351.2	380.0	407.9	438.2	471.3	2.2%
Catoosa	0.0	139.5	306.8	332.3	356.9	383.7	413.1	2.2%
White	0.0	9.7	21.5	23.2	24.6	26.1	27.7	2.1%
Total	**0.0**	**402.4**	**895.8**	**971.9**	**1,047.6**	**1,129.9**	**1,219.4**	**2.2%**
Low – 10´								
Pine Bluff	0.0	185.5	370.9	370.9	370.9	370.9	370.9	1.4%
Little Rock	0.0	167.2	334.3	334.3	334.3	334.3	334.3	1.4%
Ozark	0.0	138.8	277.5	277.5	277.5	277.5	277.5	1.4%
Fort Smith	0.0	98.9	197.9	197.9	197.9	197.9	197.9	1.4%
Muskogee	0.0	78.3	156.6	156.6	156.6	156.6	156.6	1.4%
Catoosa	0.0	68.1	136.3	136.3	136.3	136.3	136.3	1.4%
White	0.0	4.8	9.6	9.6	9.6	9.6	9.6	1.4%
Total	**0.0**	**190.1**	**380.2**	**380.2**	**380.2**	**380.2**	**380.2**	**1.4%**
Low – 11´								
Pine Bluff	0.0	284.0	568.0	568.0	568.0	568.0	568.0	1.4%
Little Rock	0.0	256.0	511.9	511.9	511.9	511.9	511.9	1.4%
Ozark	0.0	212.5	425.0	425.0	425.0	425.0	425.0	1.4%
Fort Smith	0.0	151.5	303.0	303.0	303.0	303.0	303.0	1.4%
Muskogee	0.0	119.9	239.9	239.9	239.9	239.9	239.9	1.4%
Catoosa	0.0	104.3	208.7	208.7	208.7	208.7	208.7	1.4%
White	0.0	7.4	14.8	14.8	14.8	14.8	14.8	1.4%
Total	**0.0**	**291.2**	**582.4**	**582.4**	**582.4**	**582.4**	**582.4**	**1.4%**

Low – 12´								
Pine Bluff	0.0	324.6	649.1	649.1	649.1	649.1	649.1	1.4%
Little Rock	0.0	292.5	585.0	585.0	585.0	585.0	585.0	1.4%
Ozark	0.0	242.8	485.7	485.7	485.7	485.7	485.7	1.4%
Fort Smith	0.0	173.1	346.3	346.3	346.3	346.3	346.3	1.4%
Muskogee	0.0	137.1	274.1	274.1	274.1	274.1	274.1	1.4%
Catoosa	0.0	119.2	238.5	238.5	238.5	238.5	238.5	1.4%
White	0.0	8.4	16.9	16.9	16.9	16.9	16.9	1.4%
Total	**0.0**	**332.8**	**665.6**	**665.6**	**665.6**	**665.6**	**665.6**	**1.4%**

ADDENDUM E8

Towboat Traffic

1. Purpose: The principle purposes of providing towboat trip data is for use in the environmental assessment and to estimate processing times given changing traffic levels.

2. Procedure to Estimate the Number of Tows: The number of tows was estimated based on tonnage levels, the number of barges per tow and the number of tons per barge. The process began with LPMS data for each lock in terms of tonnage processed, the number of tows, and the number of barges. The data are listed below.

Table E8-1. Traffic Data at the Projects - 2001

Project	Tows	Barges	Barges per Tow	Tons (thousands)	Tons per Tow	Tons per Barge
GRAHAM	582	3,068	5.3	3,480	5,979	1,134
CHOUTEAU	596	3,169	5.3	3,633	6,096	1,146
WEBER	608	3,480	5.7	4,184	6,882	1,202
KERR	606	3,641	6.0	4,340	7,162	1,192
MAYO	602	3,617	6.0	4,325	7,184	1,196
TRIMBLE	662	4,048	6.1	4,611	6,965	1,139
OZARK	617	3,998	6.5	4,600	7,455	1,151
DARDANELLE	976	7,103	7.3	6,751	6,917	950
ORMOND	905	7,076	7.8	6,503	7,186	919
TOAD SUCK	910	7,137	7.8	6,527	7,173	915
MURRAY	912	7,063	7.7	6,744	7,395	955
TERRY	1,013	7,764	7.7	7,493	7,397	965
L&D 5	1,023	7,794	7.6	7,548	7,378	968
SANDERS	1,159	8,458	7.3	8,100	6,989	958
HARDIN	1,111	8,401	7.6	8,086	7,278	963
L&D 2	1,341	9,008	6.7	8,691	6,481	965
NORRELL	1,347	9,016	6.7	8,696	6,456	965
MONTGOMERY	-	-	0.0	-		
TOTAL	**14,970**	**103,841**	**6.9**	**104,312**	**6,968**	**1,005**

The second step was to determine the number of tows that would have passed through each lock on the system assuming changes in the reservoir operations and for each of the proposed deepening components. Changes in the reservoir operations are expected to result in an additional one barge per tow and the deepening components would allow barges to be more fully loaded. The Phase 1/FM-OPS effect was computed by adding the average barge per tow to the existing average tons per tow. This was done separately for each project. As an example, the existing number of barges per tow at Graham is expected to increase from the current 5.3 to 6.3. The existing tons-per-tow is 5,979 tons and the existing tons-per-barge is 1,134. Adding another barge, therefore, would increase the tons per tow from 5,979 to 7,113. This, in turn, would reduce the number of tows required to transport the 3.4 million tons of cargo from 582 to 489 (divide 3.4 million tons by 7,113 tons per tow). Again, the computations were project specific.

Unlike the increase in tow size expected from changes in the reservoir operations (Phase 1/FM-OPS), the deepening components are expected to result in increased barge loadings. This, in turn, would decrease the number of tows required to move the traffic since each tow could haul more cargo. The different initial effects required different procedures to measure the effects. Specifically, the effect of deepening on the number of tows was estimated using pro-rationing techniques keyed to the percent reduction in barge line-haul costs. For example, if

deepening from 9′ to 10′ resulted in a 7% decrease in barge line-haul costs, then the number of tows required to move the goods was reduced by 7%. For Graham, the estimated number of tows assuming deepening to 10′ would have been 541 (582 multiplied by 0.93). The tow adjustment factors used for the deepening components are listed in the right-hand column of the following table.

Table E8-2. Tow Adjustment Factors for Deeper Channel Components

Component	Barge line-haul Costs (thousands)	Tow Adjustment Factor
9′ (existing)	$68,599.3	100
10′	$65,552.0	96
11′	$61,053.0	89
12′	$58,480.0	85

The numbers of tows for components involving the effects of FM-OPS changes combined with deepening were estimated in the same manner, except the FM-OPS number of tows (489) rather than the existing 582 tows were adjusted. For example, under FM-OPS the number of tows in 2001 would have been 489. If the project were deepened to 10′ , then the number of tows would have been 469 (489 times 0.96).

The procedure described above was used to estimate the number of tows for six components; the three deepening components without reservoir operations changes and the three deepening components with reservoir operations changes. In addition, the number of tows, assuming neither reservoir operation changes nor deepening, was estimated by simply dividing tonnage by the existing tons per tow. The numbers of tows by project are listed below.

Table E8-3. Number of Tows for Each Component in Base Year 2003								
	Without FM-OPS Changes				With FM-OPS Changes			
Project	9´	10´	11´	12´	9´	10´	11´	12´
Graham	636	607	566	542	535	511	476	456
Chouteau	656	626	583	559	552	527	491	470
Weber	662	632	589	564	564	538	501	480
Kerr	661	631	588	563	567	541	504	483
Mayo	659	629	586	561	565	539	502	481
Trimble	720	688	640	613	619	591	550	527
Ozark	673	643	598	573	583	557	518	496
Dardanelle	1,003	958	892	855	881	841	784	751
Ormond	977	933	869	832	867	828	771	739
Toad Suck	989	945	880	843	877	838	780	747
Murray	966	923	859	823	856	817	761	729
Terry	1,086	1,037	966	925	961	918	855	819
L&D 5	1,090	1,041	970	929	963	920	857	820
Sanders	1,247	1,191	1,109	1,063	1,096	1,047	975	934
Hardin	1,214	1,160	1,080	1,034	1,072	1,024	954	913
L&D 2	1,438	1,374	1,279	1,225	1,251	1,195	1,113	1,066
Norrell	1,443	1,378	1,284	1,230	1,256	1,200	1,117	1,070
Montgomery	1,443	1,378	1,284	1,230	1,256	1,200	1,117	1,070

The numbers of tows in future years for each lock were calculated by dividing the tonnage through the lock by the average tons per tow at the lock. The numbers of tow for the existing situation (9´ and no flow management changes) are shown below.

Table E8-4. Projected Tow Count per Lock – Existing Condition								
Project	2003 Base	2010	2020	2030	2040	2050	2060	% per Year
Graham	636	743	816	882	946	1,015	1,091	1.0%
Chouteau	656	766	841	909	974	1,045	1,122	0.9%
Weber	662	772	849	919	987	1,061	1,142	1.0%
Kerr	661	772	848	918	985	1,058	1,139	1.0%
Mayo	659	769	845	915	982	1,055	1,135	1.0%
Trimble	720	840	923	999	1,072	1,152	1,238	1.0%
Ozark	673	785	862	933	1,002	1,076	1,157	1.0%
Dardanelle	1,003	1,201	1,331	1,441	1,551	1,671	1,801	1.0%
Ormond	977	1,171	1,298	1,405	1,513	1,629	1,756	1.0%
Toad Suck	989	1,184	1,312	1,421	1,529	1,646	1,774	1.0%
Murray	966	1,157	1,283	1,389	1,495	1,610	1,735	1.0%
Terry	1,086	1,299	1,439	1,557	1,675	1,804	1,943	1.0%
L&D 5	1,090	1,304	1,444	1,563	1,681	1,810	1,949	1.0%
Sanders	1,247	1,488	1,648	1,784	1,920	2,068	2,228	1.0%
Hardin	1,214	1,449	1,606	1,741	1,875	2,021	2,180	1.0%
L&D 2	1,438	1,715	1,901	2,061	2,220	2,393	2,581	1.0%
Norrell	1,443	1,722	1,908	2,069	2,228	2,402	2,591	1.0%
Montgomery	1,443	1,722	1,908	2,069	2,228	2,402	2,591	1.0%

The tons per tow by reach were computed as a weighted average based on the tons and tows at the locks located within each reach. The tons per tow for each depth "with" and "without" FM-OPS changes are listed in the table below.

Table E8-5. Tons per Tow by Reach and Component				
Without FM-OPS Changes				
Reach	**9´**	**10´**	**11´**	**12´**
Pine Bluff	6,561	7,071	7,351	7,461
Little Rock	6,890	7,428	7,718	7,839
Ozark	7,388	7,966	8,278	8,403
Ft. Smith	7,166	7,728	8,030	8,153
Muskogee	7,205	7,768	8,081	8,200
Catoosa	6,667	7,190	7,473	7,587
River Ave.	6,584	7,099	7,378	7,490
With FM-OPS Changes				
Reach	**9´**	**10´**	**11´**	**12´**
Pine Bluff	7,538	8,127	8,446	8,576
Little Rock	7,858	8,470	8,803	8,940
Ozark	8,355	9,011	9,363	9,501
Ft. Smith	8,101	8,736	9,076	9,219
Muskogee	8,350	9,001	9,362	9,504
Catoosa	7,843	8,457	8,794	8,927
River Ave.	7,567	8,159	8,479	8,610

3. Projected Tow Trips for Existing Movements: Projections of total tow traffic for shipments that currently move on the system are summarized below. Induced tow traffic is not included.

Table E8-6. High, Middle and Low Tow Trip Projections								
	Base 03	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**03-60 Ann. %**
High-9´	1,805	3,274	4,859	5,272	5,683	6,129	6,615	2.3%
9´,FM-OPS	1,571	2,849	4,228	4,587	4,945	5,333	5,755	2.3%
10´	1,457	2,642	3,921	4,254	4,586	4,946	5,338	2.3%
11´	1,402	2,543	3,773	4,094	4,413	4,759	5,136	2.3%
12´	1,380	2,504	3,716	4,032	4,346	4,687	5,058	2.3%
Middle-9´	1,805	2,183	2,430	2,636	2,841	3,065	3,307	1.1%
9´,FM-OPS	1,571	1,899	2,114	2,294	2,472	2,666	2,878	1.1%
10´	1,457	1,762	1,961	2,127	2,293	2,473	2,669	1.1%
11´	1,402	1,695	1,887	2,047	2,206	2,380	2,568	1.1%
12´	1,380	1,669	1,858	2,016	2,173	2,343	2,529	1.1%
Low-9´	1,805	1,805	1,805	1,805	1,805	1,805	1,805	0.0%
9´,FM-OPS	1,571	1,571	1,571	1,571	1,571	1,571	1,571	0.0%
10´	1,457	1,457	1,457	1,457	1,457	1,457	1,457	0.0%
11´	1,402	1,402	1,402	1,402	1,402	1,402	1,402	0.0%
12´	1,380	1,380	1,380	1,380	1,380	1,380	1,380	0.0%

The high, middle and low tow traffic forecasts by river reach are listed in the table below. The numbers per reach are not additive, since one tow can move on several reaches. As stated previously, the dividing line in terms of traffic is the Ozark to Fort Smith reach.

Table E8-7. High, Middle and Low Tow Trip Projections by Depth								
	Base 03	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**03-60 Ann. %**
High – 9´ (No FM-OPS)								
Pine Bluff	1,767	3,208	4,762	5,167	5,571	6,011	6,490	2.3%
Little Rock	1,516	2,767	4,109	4,452	4,797	5,172	5,578	2.3%
Ozark	1,174	2,135	3,168	3,433	3,699	3,988	4,301	2.3%
Fort Smith	863	1,538	2,266	2,454	2,639	2,840	3,058	2.2%
Muskogee	679	1,189	1,741	1,884	2,022	2,172	2,336	2.2%
Catoosa	639	1,121	1,643	1,780	1,912	2,056	2,213	2.2%
White	46	80	117	126	134	142	151	2.1%
Total	1,805	3,274	4,859	5,272	5,683	6,129	6,615	2.3%
High – 9´ – FM-OPS								
Pine Bluff	1,538	2,793	4,145	4,497	4,849	5,232	5,649	2.3%
Little Rock	1,330	2,426	3,602	3,904	4,206	4,535	4,891	2.3%
Ozark	1,038	1,888	2,801	3,036	3,271	3,526	3,803	2.3%
Fort Smith	763	1,360	2,004	2,171	2,334	2,512	2,705	2.2%
Muskogee	586	1,026	1,502	1,626	1,745	1,874	2,016	2.2%
Catoosa	543	953	1,397	1,513	1,625	1,747	1,881	2.2%
White	40	69	102	110	117	124	131	2.1%
Total	1,571	2,849	4,228	4,587	4,945	5,333	5,755	2.3%
High – 10´ – FM-OPS								
Pine Bluff	1,426	2,590	3,845	4,171	4,498	4,853	5,239	2.3%
Little Rock	1,233	2,251	3,342	3,622	3,902	4,207	4,538	2.3%
Ozark	962	1,751	2,598	2,815	3,033	3,269	3,526	2.3%
Fort Smith	708	1,261	1,858	2,013	2,165	2,329	2,509	2.2%
Muskogee	544	952	1,394	1,508	1,619	1,739	1,870	2.2%
Catoosa	504	884	1,296	1,403	1,507	1,621	1,744	2.2%
White	37	64	94	102	108	115	122	2.1%
Total	1,457	2,642	3,921	4,254	4,586	4,946	5,338	2.3%
High – 11´ – FM-OPS								
Pine Bluff	1,372	2,492	3,699	4,014	4,328	4,670	5,041	2.3%
Little Rock	1,187	2,166	3,216	3,485	3,755	4,048	4,366	2.3%
Ozark	926	1,685	2,500	2,709	2,919	3,147	3,394	2.3%
Fort Smith	681	1,214	1,789	1,938	2,084	2,242	2,415	2.2%
Muskogee	523	915	1,340	1,450	1,556	1,672	1,798	2.2%
Catoosa	484	850	1,246	1,349	1,449	1,558	1,678	2.2%
White	36	62	91	98	104	110	117	2.1%
Total	1,402	2,543	3,773	4,094	4,413	4,759	5,136	2.3%
High – 12´ – FM-OPS								
Pine Bluff	1,352	2,455	3,643	3,953	4,262	4,599	4,965	2.3%
Little Rock	1,169	2,132	3,166	3,431	3,697	3,986	4,299	2.3%
Ozark	913	1,660	2,464	2,670	2,876	3,101	3,345	2.3%
Fort Smith	671	1,195	1,761	1,908	2,051	2,207	2,377	2.2%
Muskogee	515	901	1,320	1,428	1,533	1,647	1,771	2.2%
Catoosa	477	837	1,227	1,329	1,428	1,535	1,653	2.2%
White	35	61	89	97	103	109	115	2.1%
Total	1,380	2,504	3,716	4,032	4,346	4,687	5,058	2.3%

Medium - 9´ (No FM-OPS)								
Pine Bluff	1,767	2,139	2,381	2,584	2,786	3,006	3,245	1.1%
Little Rock	1,516	1,845	2,054	2,226	2,399	2,586	2,789	1.1%
Ozark	1,174	1,423	1,584	1,717	1,850	1,994	2,151	1.1%
Fort Smith	863	1,025	1,133	1,227	1,320	1,420	1,529	1.0%
Muskogee	679	793	871	942	1,011	1,086	1,168	1.0%
Catoosa	639	747	822	890	956	1,028	1,106	1.0%
White	46	53	58	63	67	71	75	0.9%
Total	1,805	2,183	2,430	2,636	2,841	3,065	3,307	1.1%
Medium - 9´ – FM-OPS								
Pine Bluff	1,538	1,862	2,073	2,249	2,425	2,616	2,824	1.1%
Little Rock	1,330	1,617	1,801	1,952	2,103	2,267	2,446	1.1%
Ozark	1,038	1,259	1,401	1,518	1,636	1,763	1,902	1.1%
Fort Smith	763	907	1,002	1,086	1,167	1,256	1,353	1.0%
Muskogee	586	684	751	813	872	937	1,008	1.0%
Catoosa	543	635	699	757	813	874	940	1.0%
White	40	46	51	55	58	62	66	0.9%
Total	1,571	1,899	2,114	2,294	2,472	2,666	2,878	1.1%
Medium-10´ – FM-OPS								
Pine Bluff	1,426	1,727	1,922	2,086	2,249	2,426	2,620	1.1%
Little Rock	1,233	1,501	1,671	1,811	1,951	2,103	2,269	1.1%
Ozark	962	1,167	1,299	1,407	1,516	1,635	1,763	1.1%
Fort Smith	708	841	929	1,007	1,082	1,165	1,254	1.0%
Muskogee	544	634	697	754	809	869	935	1.0%
Catoosa	504	589	648	702	754	810	872	1.0%
White	37	43	47	51	54	57	61	0.9%
Total	1,457	1,762	1,961	2,127	2,293	2,473	2,669	1.1%
Medium-11´ – FM-OPS								
Pine Bluff	1,372	1,662	1,850	2,007	2,164	2,335	2,521	1.1%
Little Rock	1,187	1,444	1,608	1,742	1,877	2,024	2,183	1.1%
Ozark	926	1,123	1,250	1,355	1,459	1,573	1,697	1.1%
Fort Smith	681	809	894	969	1,042	1,121	1,207	1.0%
Muskogee	523	610	670	725	778	836	899	1.0%
Catoosa	484	567	623	675	725	779	839	1.0%
White	36	41	45	49	52	55	59	0.9%
Total	1,402	1,695	1,887	2,047	2,206	2,380	2,568	1.1%
Medium-12´ – FM-OPS								
Pine Bluff	1,352	1,636	1,822	1,977	2,131	2,299	2,483	1.1%
Little Rock	1,169	1,422	1,583	1,716	1,849	1,993	2,150	1.1%
Ozark	913	1,107	1,232	1,335	1,438	1,550	1,672	1.1%
Fort Smith	671	797	881	954	1,026	1,104	1,189	1.0%
Muskogee	515	601	660	714	766	823	886	1.0%
Catoosa	477	558	614	665	714	768	826	1.0%
White	35	41	45	48	51	54	58	0.9%
Total	1,380	1,669	1,858	2,016	2,173	2,343	2,529	1.1%
Low – 9´ (No FM-OPS)								
Pine Bluff	1,767	1,767	1,767	1,767	1,767	1,767	1,767	0.0%
Little Rock	1,516	1,516	1,516	1,516	1,516	1,516	1,516	0.0%
Ozark	1,174	1,174	1,174	1,174	1,174	1,174	1,174	0.0%
Fort Smith	863	863	863	863	863	863	863	0.0%
Muskogee	679	679	679	679	679	679	679	0.0%
Catoosa	639	639	639	639	639	639	639	0.0%
White	46	46	46	46	46	46	46	0.0%

Total	1,805	1,805	1,805	1,805	1,805	1,805	1,805	0.0%
Low–9´ – FM-OPS								
Pine Bluff	1,538	1,538	1,538	1,538	1,538	1,538	1,538	0.0%
Little Rock	1,330	1,330	1,330	1,330	1,330	1,330	1,330	0.0%
Ozark	1,038	1,038	1,038	1,038	1,038	1,038	1,038	0.0%
Fort Smith	763	763	763	763	763	763	763	0.0%
Muskogee	586	586	586	586	586	586	586	0.0%
Catoosa	543	543	543	543	543	543	543	0.0%
White	40	40	40	40	40	40	40	0.0%
Total	1,571	1,571	1,571	1,571	1,571	1,571	1,571	0.0%
Low – 10´ – FM-OPS								
Pine Bluff	1,426	1,426	1,426	1,426	1,426	1,426	1,426	0.0%
Little Rock	1,233	1,233	1,233	1,233	1,233	1,233	1,233	0.0%
Ozark	962	962	962	962	962	962	962	0.0%
Fort Smith	708	708	708	708	708	708	708	0.0%
Muskogee	544	544	544	544	544	544	544	0.0%
Catoosa	504	504	504	504	504	504	504	0.0%
White	37	37	37	37	37	37	37	0.0%
Total	1,457	1,457	1,457	1,457	1,457	1,457	1,457	0.0%
Low – 11´ – FM-OPS								
Pine Bluff	1,372	1,372	1,372	1,372	1,372	1,372	1,372	0.0%
Little Rock	1,187	1,187	1,187	1,187	1,187	1,187	1,187	0.0%
Ozark	926	926	926	926	926	926	926	0.0%
Fort Smith	681	681	681	681	681	681	681	0.0%
Muskogee	523	523	523	523	523	523	523	0.0%
Catoosa	484	484	484	484	484	484	484	0.0%
White	36	36	36	36	36	36	36	0.0%
Total	1,402	1,402	1,402	1,402	1,402	1,402	1,402	0.0%
Low – 12´ – FM-OPS								
Pine Bluff	1,352	1,352	1,352	1,352	1,352	1,352	1,352	0.0%
Little Rock	1,169	1,169	1,169	1,169	1,169	1,169	1,169	0.0%
Ozark	913	913	913	913	913	913	913	0.0%
Fort Smith	671	671	671	671	671	671	671	0.0%
Muskogee	515	515	515	515	515	515	515	0.0%
Catoosa	477	477	477	477	477	477	477	0.0%
White	35	35	35	35	35	35	35	0.0%
Total	1,380	1,380	1,380	1,380	1,380	1,380	1,380	0.0%

4. Additional Number of Tows due to Induced Traffic: Traffic may be induced to shift onto the system given the reduction in water routing transportation costs that result from river deepening. The numbers of tows required to move the "induced" tonnage on the waterway by scenario and depth are listed below. The numbers are increments from a "without" project condition that includes the changes in the reservoir operations schedules.

Table E8-6. High, Middle and Low Tow Trip Projections – Induced and by Depth (changes in the reservoir operations schedule)								
	Base 03	2010	2020	2030	2040	2050	2060	10-60 Ann. %
High – 10´ – FM-OPS								
Pine Bluff	0	41	123	134	144	155	168	3.0%
Little Rock	0	36	107	116	125	135	145	3.0%
Ozark	0	28	83	90	97	105	113	3.0%
Fort Smith	0	20	60	64	69	75	80	3.0%
Muskogee	0	15	45	48	52	56	60	3.0%
Catoosa	0	14	42	45	48	52	56	3.0%
White	0	1	3	3	4	4	4	2.9%
Total	0	42	126	136	147	158	171	3.0%
High – 11´ – FM-OPS								
Pine Bluff	0	61	181	197	212	229	247	3.0%
Little Rock	0	53	158	171	184	198	214	3.0%
Ozark	0	41	123	133	143	154	166	3.0%
Fort Smith	0	30	88	95	102	110	118	3.0%
Muskogee	0	22	66	71	76	82	88	3.0%
Catoosa	0	21	61	66	71	76	82	3.0%
White	0	2	4	5	5	5	6	2.9%
Total	0	62	185	201	216	233	252	3.0%
High – 12´ – FM-OPS								
Pine Bluff	0	69	204	221	239	258	278	3.0%
Little Rock	0	60	177	192	207	223	241	3.0%
Ozark	0	47	138	150	161	174	187	3.0%
Fort Smith	0	34	99	107	115	124	133	3.0%
Muskogee	0	25	74	80	86	92	99	3.0%
Catoosa	0	23	69	74	80	86	93	3.0%
White	0	2	5	5	6	6	7	2.9%
Total	0	70	208	226	243	263	283	3.0%
Medium-10´ – FM-OPS								
Pine Bluff	0	28	62	67	72	78	84	2.4%
Little Rock	0	24	54	58	62	67	73	2.4%
Ozark	0	19	42	45	49	52	56	2.4%
Fort Smith	0	14	30	32	35	37	40	2.3%
Muskogee	0	10	22	24	26	28	30	2.3%
Catoosa	0	9	21	23	24	26	28	2.3%
White	0	1	2	2	2	2	2	2.1%
Total	0	28	63	68	73	79	85	2.4%
Medium-11´ – FM-OPS								
Pine Bluff	0	41	91	98	106	114	124	2.4%
Little Rock	0	35	79	85	92	99	107	2.4%
Ozark	0	28	61	66	72	77	83	2.4%
Fort Smith	0	20	44	48	51	55	59	2.4%
Muskogee	0	15	33	36	38	41	44	2.3%
Catoosa	0	14	31	33	36	38	41	2.3%
White	0	1	2	2	3	3	3	2.3%
Total	0	42	92	100	108	117	126	2.4%

Medium-12´ – FM-OPS								
Pine Bluff	0	46	102	111	119	129	139	2.4%
Little Rock	0	40	89	96	104	112	120	2.4%
Ozark	0	31	69	75	81	87	94	2.4%
Fort Smith	0	22	49	53	57	62	67	2.4%
Muskogee	0	17	37	40	43	46	50	2.3%
Catoosa	0	16	34	37	40	43	46	2.3%
White	0	1	3	3	3	3	3	2.3%
Total	0	47	104	113	122	131	142	2.4%
Low – 10´ – FM-OPS								
Pine Bluff	0	23	46	46	46	46	46	1.5%
Little Rock	0	20	40	40	40	40	40	1.5%
Ozark	0	15	31	31	31	31	31	1.5%
Fort Smith	0	11	23	23	23	23	23	1.5%
Muskogee	0	9	17	17	17	17	17	1.5%
Catoosa	0	8	16	16	16	16	16	1.5%
White	0	1	1	1	1	1	1	1.5%
Total	0	23	47	47	47	47	47	1.5%
Low – 11´ – FM-OPS								
Pine Bluff	0	34	67	67	67	67	67	1.5%
Little Rock	0	29	58	58	58	58	58	1.5%
Ozark	0	23	45	45	45	45	45	1.5%
Fort Smith	0	17	33	33	33	33	33	1.5%
Muskogee	0	13	26	26	26	26	26	1.5%
Catoosa	0	12	24	24	24	24	24	1.5%
White	0	1	2	2	2	2	2	1.5%
Total	0	34	69	69	69	69	69	1.5%
Low – 12´ – FM-OPS								
Pine Bluff	0	38	76	76	76	76	76	1.5%
Little Rock	0	33	65	65	65	65	65	1.5%
Ozark	0	26	51	51	51	51	51	1.5%
Fort Smith	0	19	38	38	38	38	38	1.5%
Muskogee	0	14	29	29	29	29	29	1.5%
Catoosa	0	13	27	27	27	27	27	1.5%
White	0	1	2	2	2	2	2	1.5%
Total	0	39	77	77	77	77	77	1.5%

ADDENDUM E9

High, Medium, and Low Benefits

1. Purpose: The purpose of estimating low and high benefits was to provide a range of benefits for the possible range of traffic that may traverse the waterway in the future. The benefits listed in the following tables are the originally estimated benefits "without" adjustment for the occasional restriction in depth on the Lower Mississippi River. Based on gauge readings at the Vicksburg Station, it was estimated that 9′ is available nearly 100% of the time and 12′ about 96% of the time. The percents of time that 10′ and 11′ of depth are available were interpolated. The depth and percent of time that each depth is available is shown in Table E9-1. The benefits listed in the main report on inland navigation economics are the originally estimated benefits adjusted by the percentages listed below. The benefits were adjusted separately according to line-haul (existing and induced traffic) and processing (lockage times) so that the overall affect on benefits is not necessarily identical to the values that would result by multiplying the percentages by the sum total values, although they are generally close.

Table E9-1. Depth of Lower Mississippi River

Depth	Percent of Time Available
9	100.0
10	98.7
11	97.3
12	96.0

The benefits for all three traffic scenarios with and without induced traffic are listed below.

Table E9-2. Average Annual Equivalent Benefits for Three Traffic Scenarios (Oct 2003 $1,000; 5.375%; 50 yr)

		No Induced	With Induced
Low Forecasts			
	10′	2,877.4	2,880.6
	11′	7,445.1	7,548.9
	12′	10,022.9	10,222.7
Middle Forecasts			
	10′	3,627.2	3,663.5
	11′	9,700.0	9,820.5
	12′	13,082.6	13,279.9
High Forecasts			
	10′	(11,996.2)	(36,821.7)
	11′	(4,089.7)	(19,691.7)
	12′	6,407.0	(5,373.3)

A more detailed breakdown of benefits for each traffic scenario is provided in the following paragraphs and tables.

2. Middle Benefits:

a. With Induced Traffic

Table E9-3. Summary of Annualized NED Benefits for Navigation Channel Deepening Components; Middle Forecasts with Induced Traffic (Oct 2003 $1,000; 5.375%; 50 yr)				
	10´	**11´**	**12´**	**Widening**
Cost reduction	$3,607.8	$9,609.9	$13,009.2	
1. Existing	4,006.1	9,907.3	13,268.9	
2. Processing	-398.2	-297.4	-259.8	
Shift of mode	55.7	210.6	270.7	
Shift in O/D	0.0	0.0	0.0	
New Movement	0.0	0.0	0.0	
Total	$3,663.5	$9,820.5	$13,279.9	$516.5

Table E9-4. Incremental Benefits by Depth and Reach; Middle Forecasts and Induced Traffic (Oct 2003 $1,000; 5.375%; 50 yr)						
	10´		**11´**		**12´**	
Reach	**Incremental**	**Cumulative Incremental**	**Incremental**	**Cumulative Incremental**	**Incremental**	**Cumulative Incremental**
1	209.9	209.9	823.8	823.8	1,164.9	1,164.9
2	92.6	302.6	499.8	1,323.6	749.8	1,914.7
3	442.6	745.2	1,114.0	2,437.7	1,403.4	3,318.2
4	59.5	804.7	164.5	2,602.2	221.7	3,539.9
5	221.4	1,026.1	591.9	3,194.1	831.3	4,371.2
6	2,637.3	3,663.4	6,626.3	9,820.5	8,908.6	13,279.9
Total	**3,663.5**		**9,820.5**		**13,279.9**	

b. Without Induced Traffic

Table E9-5. Summary of Annualized NED Benefits for Navigation Channel Deepening Components; Middle Forecasts without Induced Traffic (Oct 2003 $1,000; 5.375%; 50 yr)				
	10´	**11´**	**12´**	**Widening**
Cost reduction	$3,627.2	$9,700.0	$13,082.6	
a. Existing	4,006.1	9,907.3	13,269.9	
b. Processing	-378.9	-207.3	-186.3	
Shift of mode	0.0	0.0	0.0	
Shift in O/D	0.0	0.0	0.0	
New Movement	0.0	0.0	0.0	
Total	**$3,627.2**	**$9,700.0**	**$13,082.6**	**$514.9**

Table E9-6. Incremental Benefits by Depth and Reach; Middle Forecasts Without Induced Traffic (Oct 2003 $1,000; 5.375%; 50 yr)						
	10´		11´		12´	
Reach	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental
1	221.3	221.3	861.8	861.8	1,184.6	1,184.6
2	91.6	312.9	489.2	1,350.9	734.3	1,918.9
3	432.8	745.7	1,121.1	2,472.0	1,415.0	3,333.8
4	58.7	804.4	162.8	2,634.8	223.1	3,556.9
5	221.8	1,026.2	578.6	3,213.4	812.1	4,369.0
6	2,600.9	3,627.2	6,486.5	9,700.0	8,713.2	13,082.2
Total	**3,627.2**		**9,700.0**		**13,082.6**	

3. High Benefits

a. With Induced Traffic

Table E9-7. Summary of Annualized NED Benefits for Navigation Channel Deepening Components; High Forecasts with Induced Traffic (Oct 2003 $1,000; 5.375%; 50 yr)				
	10´	11´	12´	Widening
Cost reduction	($36,928.9)	($20,079.3)	($5,946.6)	
1) Existing	7,240.1	17,904.2	23,977.2	
2) Processing	(44,169.0)	(38,001.5)	(29,923.8)	
Shift of mode	107.2	405.6	573.3	
Shift in O/D	0.0	0.0	0.0	
New Movement	0.0	0.0	0.0	
Total	**(36,821.7)**	**(19,691.7)**	**(5,373.3)**	**973.1**

Table E9-8. Incremental Benefits by Depth and Reach; High Forecasts and Induced Traffic (Oct 2003 $1,.000's; 5.375%; 50 yr)						
	10´		11´		12´	
Reach	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental
1	(39,164.2)	(39,164.2)	(32,579.3)	(32,579.3)	(24,691.8)	(24,691.8)
2	(2,951.3)	(42,115.4)	(1,825.0)	(34,404.3)	(829.0)	(25,520.8)
3	65.4	(42,050.1)	1,412.4	(32,992.0)	2,136.9	(23,384.0)
4	73.1	(41,977.0)	266.4	(32,725.6)	374.8	(23,009.2)
5	336.1	(41,640.9)	1,006.1	(31,719.4)	1,444.8	(21,564.4)
6	4,744.5	(36,821.7)	11,963.6	(19,691.7)	16,091.0	(5,373.3)
Total	**(36,821.7)**		**(19,691.7)**		**(5,373.3)**	

b. Without Induced Traffic

Table E9-9. Summary of Annualized NED Benefits for Navigation Channel Deepening Components; High Forecasts without Induced Traffic (Oct 2003 $1,000; 5.375%; 50 yr)				
	10´	**11´**	**12´**	**Widening**
Cost reduction	($11,996.2)	($4,089.7)	$6,407.0	
a. Existing	7,240.1	17,904.2	23,977.2	
b. Processing	(19,236.3)	(21,993.8)	-17,570.1	
Shift of mode	0.0	0.0	0.0	
Shift in O/D	0.0	0.0	0.0	
New Movement	0.0	0.0	0.0	
Total	**(11,996.2)**	**(4,089.7)**	**6,407.0**	**970.2**

Table E9-10. Incremental Benefits by Depth and Reach; High Forecasts without Induced Traffic (Oct 2003 $1,000; 5.375%; 50 yr)						
	10´		**11´**		**12´**	
Reach	**Incremental**	**Cumulative Incremental**	**Incremental**	**Cumulative Incremental**	**Incremental**	**Cumulative Incremental**
1	(16,634.7)	(16,634.7)	(17,195.9)	(17,195.9)	(12,966.9)	(12,966.9)
2	(2,806.6)	(19,441.3)	(1,000.9)	(18,196.8)	(271.9)	(13,238.8)
3	314.5	(19,126.8)	1,682.6	(16,514.2)	2,393.5	(10,845.3)
4	81.8	(19,045.0)	261.9	(16,252.2)	376.7	(10,468.7)
5	337.5	(18,707.5)	991.1	(15,261.1)	1,422.6	(9,046.1)
6	4,669.8	(11,996.2)	11,695.3	(4,089.7)	15,722.9	6,407.0
Total	**(11,996.2)**		**(4,089.7)**		**6,407.0**	

5. Low Benefits

a. With Induced Traffic

Table E9-11. Summary of Annualized NED Benefits for Navigation Channel Deepening Components; Low Forecasts with Induced Traffic (Oct 2003 $1,000; 5.375%; 50 yr)				
	10´	**11´**	**12´**	**Widening**
Cost reduction	$2,841.1	$7,399.2	$10,002.1	
c. Existing	3,047.5	7,546.6	10,119.7	
d. Processing	-206.4	-147.4	-117.6	
Shift of mode	39.5	149.6	220.6	
Shift in O/D	0.0	0.0	0.0	
New Movement	0.0	0.0	0.0	
Total	**2,880.6**	**7,548.9**	**10,222.7**	**400.5**

Table E9-12. Incremental Benefits by Depth and Reach; Low Forecasts and Induced Traffic (Oct 2003 $1,000; 5.375%; 50 yr)						
	10´		11´		12´	
Reach	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental
1	217.6	217.6	679.6	679.6	941.9	941.9
2	118.4	336.0	398.1	1,077.8	602.8	1,544.7
3	304.3	640.3	805.7	1,883.4	1,021.4	2,566.0
4	44.4	684.7	125.7	2,009.1	172.4	2,738.4
5	172.4	857.1	456.4	2,465.5	642.2	3,380.6
6	2,023.4	2,880.6	5,083.4	7,548.9	6,842.2	10,222.8
Total	**2,880.6**		**7,548.9**		**10,222.7**	

b. Without Induced Traffic

Table E9-13. Summary of Annualized NED Benefits for Navigation Channel Deepening Components; Low Forecasts without Induced Traffic (Oct 2003 $1,000; 5.375%; 50 yr)				
	10´	11´	12´	Widening
Cost reduction	$2,877.4	$7,445.1	$10,022.9	
e. Existing	3,045.7	7,546.6	10,119.7	
f. Processing	-170.1	-101.5	-96.8	
Shift of mode	0.0	0.0	0.0	
Shift in O/D	0.0	0.0	0.0	
New Movement	0.0	0.0	0.0	
Total	**2,877.4**	**7,445.1**	**10,022.9**	**400.5**

Table E9-14. Incremental Benefits by Depth and Reach; Low Forecasts without Induced Traffic (Oct 2003 $1,000; 5.375%; 50 yr)						
	10´		11´		12´	
Reach	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental	Incremental	Cumulative Incremental
1	229.5	229.5	686.1	686.1	926.2	926.2
2	124.8	354.3	402.9	1,089.0	593.0	1,519.2
3	310.8	665.1	794.5	1,883.5	1,004.8	2,524.0
4	43.5	708.6	124.9	2,008.4	168.8	2,692.8
5	170.7	879.3	451.5	2,459.9	631.8	3,324.7
6	1,998.1	2,877.4	4,985.1	7,445.1	6,696.9	10,022.9
Total	**2,877.4**		**7,445.1**		**10,022.9**	

ADDENDUM E10

Sensitivity Analysis – Navigation Forecast

1. Purpose: The principle purpose of the sensitivity analysis is to show the sensitivity of project economics to changes in selected key factors, particularly those factors that are subject to a high degree of uncertainty. A secondary purpose is to provide the project economics based on a common set of assumptions with similar studies for comparison purposes.

2. Pre-Specified Sensitivity Analysis: The following sensitivity analyses are required by ER 1105-2-100, page E-36.

(1) Current tonnage, new waterway. MKARNS is not a "new" waterway and this analysis is therefore not required. However, the analysis was performed since the "low" forecast is the continuation of the current traffic level over time.
(2) Current rates, fleet. "For both new and existing waterways, compute benefits for the recommended alternative on the basis of tonnage over time, current rates, and current fleet." The current rates and fleet are held constant over time in the "without" project condition and therefore the report complies with this requirement.
(3) Growth beyond 20-year period. Compute the benefits for alternatives carried forward for final display assuming no growth in tonnage or changes in fleet characteristics beyond 20 years in the future.
(4) Interest rate. "For projects whose authorized discount rate is different from the current discount rate, compute annualized benefits using the current rate." The current rate is the "authorized" rate if the recommendation is approved. Therefore, no additional analysis is required.
(5) User Charges. "Estimate the effect on benefits of full recovery through user charges."

The required sensitivity analyses for this study were numbers 3 and 5 listed above.

3. No Growth beyond 20-Years. The purpose of this scenario is to assess the sensitivity of project benefits to projected traffic forecasts. The sensitivity of benefits to traffic forecasts has already been assessed by the computation of benefits for three alternative traffic scenarios. The most restrictive of these – the low forecast scenario – assumes no growth from the current traffic level. Therefore, it meets the criteria for this required sensitivity.

4. User Charges. Project benefits are the reduction in transportation costs attributable to improvements to the navigation system. Project costs are the costs of making the improvements. Recovery of project costs through a user charge assessed against the users of the system would be an additional cost of transportation, much like the fuel tax. As such, it would raise the cost of barge transportation and therefore lower the benefits of improvements to the navigation system. At the point where costs equal benefits, the effect of a user charge would negate the benefits of improvements. Given this situation, the towing companies would probably opt to invest the money elsewhere assuming more positive investment opportunities are available. A breakeven point was computed. Specifically, the points where project costs equal project benefits were calculated. This was accomplished in the following manner. First, a capitalization factor was computed as the inverse of the interest and amortization factor. The capitalization factor was then multiplied by the average annual equivalent benefits to get an equivalent economic first cost. Interest during construction was estimated based on an assumed four-year construction period and the 5.375% discount rate. The interest during construction was then subtracted from

the equivalent economic first cost to get the total project cost. The total project cost is the actual amount that could be expended to return a benefit to cost ratio of 1 to 1, assuming no increase in operation and maintenance costs and an alternative set of costs assuming an increase of $1 million in annual operation and maintenance costs. This is likely to be the amount that would have to be recovered as a user charge pro-rated against each tow trip on the MKARNS.

Table E10-1. Project Affordability and Recovery Charges (July 2004 $1,000; 5.375%; 50 yr)										
		Average Annual Equivalent Benefits		First Project Cost		Interest during Construction		O&M	Total Project Cost	
		No Induced	With Induced	No Induced	With Induced	No Induced	With Induced	With or Without	No Induced	With Induced
Low Forecasts										
	10´	3,056.50	3,066.73	25,557.15	25,716.10	2,811.14	2,828.63	1,411.69	28,368.29	28,544.73
	11´	7,638.37	7,755.08	88,140.31	89,953.76	9,694.94	9,894.40	1,965.82	97,835.25	99,848.16
	12´	10,114.86	10,321.35	117,564.60	120,773.06	12,931.44	13,284.35	2,548.62	130,496.04	134,057.41
Middle Forecasts										
	10´	3,983.92	4,022.23	39,967.45	40,562.71	4,396.19	4,461.67	1,411.69	44,363,64	45,024.38
	11´	10,013.92	10,173.53	125,051.72	127,531.75	13,754.98	14,027.77	1,965.82	138,806.70	141,559,.52
	12´	13,252.68	13,482.55	166,320.20	169,891.93	18,294.28	18,687.15	2,548.62	184,614.48	188,579.08
High Forecasts										
	10´	(3,722.73)	(8,548.36)	n.a.	n.a.	n.a.	n.a.	1,411.69	n.a.	n.a.
	11´	16,684.26	8,158.14	228,695.78	96,216,52	25,155.24	10,583.27	1,965.82	253,851.02	106,799.79
	12´	22,370.29	21,033.13	307,990.05	287,213.20	33,877.16	31,591.83	2,548.62	341,867.21	318,805.03

ADDENDUM E11

System and Project Capacity

1. Definition: Capacity is the maximum physical amount of traffic that can be processed through a project in a given time period. Corps lock operators as the number of cuts that can be processed typically define capacity. A "cut" is the lockage of some navigational vessel or piece of equipment from one pool to the opposite pool. A lockage requires the gates to be opened and closed and the chamber to be filled or emptied. To the lock operators, it does not matter if the barges are loaded or empty, whether a cut is a complete tow or one-half of a large tow, or whether there is one barge or several barges.

Corps planning personnel, on the other hand, typically define capacity in terms of the number of tons that can be locked through the project in a given time period. Imbedded in this definition are assumptions regarding the number of loaded and empty barges, the number of one-cut and two-cut lockages, and the number of barges per tow. Generally these values are averages over recent past years or the value in the most current year available.

This section will express the capacity of the existing projects in terms of cuts, tows, and tons for comparison purposes. Capacities assuming deepening of the channel will be expressed only in tons.

2. Factors that Affect Capacity: The key factors that affect the capacity of a lock to process traffic are the dimensions of the locks, lockage times, the extent to which barges are loaded, and lock downtime due to accidents and maintenance.

Table E11-1. Factors that Affect Capacity (2001 Statistics)

	% Single	% Double	Minutes to Lock a Single	Minutes to Lock a Double	Tons per Tow	Barges per Tow
Montgomery Pt.	66	34	37	64 x 2 = 128	6,456	6.7
Norrell	66	34	37	64 x 2 = 128	6,456	6.7
L&D 2	67	33	39	64 x 2 = 128	6,481	6.7
Hardin	62	38	40	61 x 2 = 122	7,278	7.6
Sanders	57	43	40	66 x 2 = 132	6,989	7.3
L&D 5	60	40	43	61 x 2 = 122	7,378	7.6
Terry	60	40	40	63 x 2 = 126	7,397	7.7
Murray	62	38	41	59 x 2 = 118	7,395	7.7
Toad Suck	51	49	45	65 x 2 = 130	7,173	7.8
Ormond	72	28	40	52 x 2 = 104	7,186	7.8
Dardanelle	63	37	46	67 x 2 = 134	6,917	7.3
Ozark	69	31	46	67 x 2 = 134	7,455	6.5
Trimble	71	29	44	69 x 2 = 138	6,965	6.1
Mayo	72	28	39	68 x 2 = 136	7,184	6.0
Kerr	60	40	48	71 x 2 = 142	7,162	6.0
Weber	65	35	52	72 x 2 = 144	6,882	5.7
Chouteau	78	22	44	71 x 2 = 142	6,096	5.3
Graham	84	16	45	69 x 2 = 138	5,979	5.3
Average			**43**	**65 x 2 = 130**	**6,968**	**6.9**

3. Estimated Project Capacities: The data above were used to estimate the capacity of the existing projects in the following manner. A pro-rated lockage time per tow was computed; i.e.(66% * 37 minutes) + (34% * 128 minutes). The inverse of this amount is the number of tows that can be processed per hour. The tows per hour were multiplied by 24 hours per day and 365 days per year to obtain the number of tows per year, which are listed in the second column of the following table. The number of cuts was similarly computed but with the time for a two-cut lockage divided by two for each of the two-cut lockage operations. Finally, the number of tows was multiplied by the tons per tow to obtain the capacity of the projects in terms of annual tonnage. Again, these are high-side estimates. The comparable estimates of capacity in terms of tonnage for the majority of 600´ x 110´ locks on the Ohio River are generally in the range of 45 to 65 million tons.

Table E11-2. Existing Project Capacity

Project	Tows	Cuts	Existing (million tons)
Montgomery Pt.	7,736	11,382	49.9
Norrell	7,736	11,382	49.9
L&D 2	7,688	11,124	49.8
Hardin	7,386	10,955	53.8
Sanders	6,984	10,720	48.8
L&D 5	6,687	10,069	49.3
Terry	7,065	10,683	52.3
Murray	7,481	10,987	55.3
Toad Suck	6,066	9,591	43.5
Ormond	9,075	12,122	65.2
Dardanelle	6,690	9,775	46.3
Ozark	7,172	10,010	53.5
Trimble	7,376	10,256	51.4
Mayo	7,944	11,154	57.1
Kerr	6,140	9,189	44.0
Weber	6,242	8,908	43.0
Chouteau	8,017	10,525	48.9
Graham	8,778	10,762	52.5
Average	**7,261**	**10,470**	**50.6**

Capacities in tons assuming the implementation of FM-OPS and for the deepening components are listed in the table below. FM-OPS will increase the number of barges per tow by an average of one, which will increase by the number of tons per tow by a proportional amount. Likewise, deepening will allow barges to be more fully loaded, thus increasing the tons per tow and the capacity of the projects. If all tows were loaded to 10´, 11´, or 12´ depending on the component, then the capacities would increase by 11%, 22%, and 33% respectively. For example, the capacity of Montgomery Point with a 12´ channel would be 104.2 million tons.

Table E11-3. Unadjusted Capacity of Components (without Lockage Time Adjustments) (millions of tons)

Project	9´ FM-OPS	10´ FM-OPS	11´ FM-OPS	12´ FM-OPS
Montgomery Pt.	53.2	57.3	59.5	60.4
Norrell	54.2	58.4	60.7	61.6
L&D 2	60.8	65.5	68.1	69.1
Hardin	59.9	64.5	67.0	68.1
Sanders	57.0	61.5	63.9	64.9
L&D 5	52.7	56.8	59.0	59.9
Terry	59.5	64.1	66.6	67.7
Murray	58.5	63.0	65.5	66.5
Toad Suck	49.2	53.0	55.1	55.9
Ormond	73.4	79.1	82.2	83.5
Dardanelle	56.3	60.6	63.0	64.0
Ozark	61.2	66.0	68.6	69.6
Trimble	63.3	68.2	70.9	72.0
Mayo	64.8	69.8	72.5	73.6
Kerr	52.1	56.2	58.4	59.3
Weber	47.6	51.2	53.3	54.1
Chouteau	61.5	66.3	68.9	69.9
Graham	67.4	72.6	75.4	76.6
Average	57.9	62.4	64.9	65.9

Depth over sill clearances will be significantly reduced if barges are more heavily laden to take advantage of a deeper channel. Various safety measures have been investigated by the Corps, with the one considered most likely are slower entries and exits from the chamber. It was estimated that these measures would add 20 minutes to the lockage time for tows requiring one-cut lockage operations and 36 minutes for double lockages. Longer lockage times reduce the number of tows that can be processed in a given time period. The effects are a reduction in capacity of about 28%, as shown in the following table. The lockage times of the existing 9´ channel depth are not affected by the safety considerations.

Table E11-4. Capacity of Components with Lockage Time Adjustments (millions of tons)				
Project	**9´ FM-OPS**	**10´ FM-OPS**	**11´ FM-OPS**	**12´ FM-OPS**
Montgomery Pt.	53.2	42.8	43.6	44.2
Norrell	54.2	43.7	44.4	45.1
L&D 2	60.8	49.1	50.0	50.7
Hardin	59.9	48.4	49.3	50.0
Sanders	57.0	46.4	47.3	47.9
L&D 5	52.7	43.4	44.2	44.8
Terry	59.5	48.5	49.4	50.1
Murray	58.5	47.2	48.0	48.7
Toad Suck	49.2	40.9	41.6	42.2
Ormond	73.4	57.5	58.6	59.4
Dardanelle	56.3	46.5	47.4	48.0
Ozark	61.2	50.3	51.2	51.9
Trimble	63.3	51.9	52.8	53.6
Mayo	64.8	52.3	53.3	54.0
Kerr	52.1	43.7	44.5	45.1
Weber	47.6	40.0	40.7	41.3
Chouteau	61.5	50.0	50.9	51.6
Graham	67.4	54.2	55.2	55.9
Average	57.9	47.3	48.1	48.8

The existing tow haulage systems were not designed to extract barges loaded to more than 9´. If this proves to be the case, then lockage times will further increase due to the need to process large tows according to a procedure known as double tripping. Double tripping requires a long tow to split into two segments. The towboat will push the first segment to the lock, disconnect from the barges, re-lock to retrieve the other segment, push this segment through the lock, and reconnect the two segments into a single tow. Based on historic data prior to the installation of tow haulage systems, the procedure adds another 54 minutes to the lockage process for tows that require two-cuts. The capacities of the projects assuming "no operable tow haulage systems" are listed below. The effect is a further 14% reduction in capacity.

Table E11-5. Capacity of Components with Additional Entry/Exit Times without Tow Haulage (millions of tons)				
Project	**9´ FM-OPS**	**10´ FM-OPS**	**11´ FM-OPS**	**12´ FM-OPS**
Montgomery Pt.	53.2	36.9	37.6	38.1
Norrell	54.2	37.7	38.3	38.9
L&D 2	60.8	42.6	43.3	43.9
Hardin	59.9	41.4	42.1	42.7
Sanders	57.0	39.2	39.9	40.5
L&D 5	52.7	37.3	37.9	38.5
Terry	59.5	41.3	42.1	42.7
Murray	58.5	40.2	41.0	41.5
Toad Suck	49.2	34.5	35.1	35.6
Ormond	73.4	50.0	50.9	51.7
Dardanelle	56.3	40.3	41.1	41.6
Ozark	61.2	44.2	45.0	45.7
Trimble	63.3	45.9	46.7	47.3
Mayo	64.8	46.1	46.9	47.6
Kerr	52.1	37.8	38.5	39.1
Weber	47.6	35.1	35.8	36.2
Chouteau	61.5	45.1	46.0	46.6
Graham	67.4	49.9	50.9	51.6
Average	**57.9**	**41.0**	**41.8**	**42.4**

4. Estimated System Capacity: The capacity of the system is greater than the capacity of any one individual project as long as every single tow does not pass through every single project on MKARNS. In other words, as long as all traffic does not have an origin above Graham and a destination below Montgomery Point or vice versa. Clearly this is not the case as evidenced by the fact that the locks currently have different amounts of traffic due to a multitude of origins and destinations along the river. However, the restrictive project on the river would be Norrell, since more traffic will pass through this project than any other single project assuming future traffic patterns reflect current traffic patterns. Given this, the capacity of the system can be defined as the capacity of Norrell; i.e. about 54.2 million tons for the "without" project condition.

5. Capacity Utilization Rates: A comparison of capacity and traffic is provided below. The comparison indicates that the project utilization rates are currently below 20%. The utilizations rates in the year 2060 remain at less than 20% for the "no growth" forecast scenario, at less than 33% for the middle traffic growth scenario, and less than 67% for the high traffic growth scenario.

Table E11-6. Capacity Utilization in "Without" Condition				
		Based on Projected 2060 Traffic		
Project	**2003**	**Low**	**Middle**	**High**
Montgomery Pt.	20.3%	20.3%	37.1%	74.2%
Norrell	20.3%	20.3%	37.1%	74.2%
L&D 2	18.0%	18.0%	33.0%	66.0%
Hardin	16.8%	16.8%	31.7%	63.5%
Sanders	17.4%	17.4%	32.5%	65.0%
L&D 5	18.2%	18.2%	32.1%	64.1%
Terry	16.2%	16.2%	28.7%	57.4%
Murray	14.6%	14.6%	26.3%	52.7%
Toad Suck	16.8%	16.8%	30.1%	60.3%
Ormond	12.0%	12.0%	21.2%	42.5%
Dardanelle	14.8%	14.8%	25.9%	51.9%
Ozark	10.2%	10.2%	16.6%	33.2%
Trimble	9.9%	9.9%	16.1%	32.2%
Mayo	9.2%	9.2%	15.1%	30.2%
Kerr	11.1%	11.1%	18.1%	36.2%
Weber	11.5%	11.5%	19.1%	38.1%
Chouteau	7.9%	7.9%	13.2%	26.5%
Graham	7.0%	7.0%	11.7%	23.3%

The percent utilization is slightly higher for the "with 12′ " channel because the longer lockage times reduce capacity more than the increased barge loadings increases capacity. Under the high forecasts, the percent utilizations of the projects are in the 25% to 75% range.

Table E11-7. Capacity Utilization with 12´ Channel				
		Based on Projected 2060 Traffic		
Project	**2003**	**Low**	**Middle**	**High**
Montgomery Pt.		14.3%	26.1%	52.2%
Norrell	12.4%	14.3%	26.1%	52.2%
L&D 2	12.7%	12.8%	23.5%	47.0%
Hardin	10.5%	11.6%	22.0%	44.1%
Sanders	11.6%	12.1%	22.5%	45.1%
L&D 5	10.6%	12.1%	21.3%	42.5%
Terry	10.3%	11.0%	19.6%	39.1%
Murray	8.7%	10.2%	18.4%	36.9%
Toad Suck	10.3%	10.9%	19.6%	39.1%
Ormond	8.2%	9.2%	16.3%	32.5%
Dardanelle	10.5%	10.4%	18.2%	36.4%
Ozark	7.1%	7.5%	12.2%	24.4%
Trimble	7.5%	7.3%	11.9%	23.8%
Mayo	6.2%	6.8%	11.1%	22.2%
Kerr	7.6%	7.6%	12.4%	24.8%
Weber	7.8%	8.3%	13.6%	27.3%
Chouteau	6.3%	6.1%	10.3%	20.7%
Graham	6.1%	5.8%	9.7%	19.4%

Again, the capacity estimates are high-side estimates based on simplifying assumptions that ignore the reality of recreational lockages and periodic maintenance closures. Using a downward adjustment factor of 25 percent, the MKARNS estimates would be near the Ohio River estimates. This is probably a more reasonable estimate of capacity. The adjusted capacity estimates are listed below.

Table E11-8. Capacity Adjusted Downward by 25% (millions of tons)				
Project	**Phase 1 - Without**	**10´**	**11´**	**12´**
Montgomery Pt.	58.7	45.7	46.5	47.1
Norrell	59.8	46.6	47.4	48.1
L&D 2	66.0	51.7	52.6	53.3
Hardin	66.6	52.3	53.3	54.0
Sanders	62.9	50.2	51.1	51.8
L&D 5	61.9	49.2	50.0	50.7
Terry	67.5	53.3	54.3	55.1
Murray	64.4	50.6	51.5	52.2
Toad Suck	58.3	47.2	48.1	48.8
Ormond	73.6	56.4	57.4	58.2
Dardanelle	61.6	49.7	50.6	51.3
Ozark	64.1	51.4	52.3	53.1
Trimble	66.1	52.7	53.7	54.4
Mayo	68.2	53.4	54.3	55.1
Kerr	58.5	47.8	48.7	49.4
Weber	50.9	41.9	42.6	43.2
Chouteau	60.6	48.0	48.9	49.6
Graham	61.9	48.9	49.8	50.5
Average	**62.6**	**49.7**	**50.7**	**51.4**

ADDENDUM E12

Optimization of the Timing of Construction

1. An analysis was performed to determine the optimum future time period for constructing the project. The optimum time period was identified as the future time period with the highest positive net benefits for deepening. The important factors that affect future net benefits are traffic levels, overland and waterway transportation rates, and the discount factor. The analysis was performed for the 12-foot alternative, "with" induced traffic, "with" operable tow-haulage systems, and the middle set of traffic forecasts.

2. Procedure: The procedure was a three step process. The first step was to convert construction costs into equivalent average annual costs for different construction time periods. The second step was to calculate the equivalent average annual benefits assuming different future construction dates. The third step was to compute the difference between benefits and costs which is the net benefit. The future time period of construction that yields the highest positive net benefits is the optimum time period for construction of the project. Timing analysis was also performed for each reach of river.

3. Project Costs: Project costs include construction costs, engineering and design (ed) costs, contract administration (ca) costs and the costs of all other activities necessary for implementation of the project. Project costs were converted into economic costs by adding interest during construction to project costs. Interest during construction was calculated based on a four-year construction period, a 5.375% discount rate, and mid-construction period discounting. Project economic costs were converted into equivalent annual average cost using an amortization factor of 0.057981 based on 5.375% and a 50-year project life. The increased amount of annual operation and maintenance costs attributable to the 12' channel was then added to average annual project economic costs to obtain the total average annual economic cost. The increased O&M costs include dredging costs for maintenance between 9' and 12' and the increased operating costs for tow-haulage equipment. The economic costs if the project would have been completed in 2006 are listed in Table E12-1. The computations were performed as follows.

Table E12-1: Project Costs (July 2004 $1,000)

	1	2	3	4	5	6	Total
Project Costs	34,643.2	10,349.3	18,448.7	16,108.6	48,348.1	22,029.4	149,927.4
Interest During Construction (IDC)	3,810.6	1,138.4	2,629.3	1,771.8	5,318.0	2,423.1	16,491.1
Economic Costs (sum of project and IDC)	38,453.8	11,487.6	20,478.0	17,880.4	53,666.1	24,452.5	166,418.5
Average Annual	2,229.6	666.1	1,187.3	1,306.7	3,111.6	1,417.7	9,649.1
O&M Cost	515.9	264.0	432.6	649.2	557.4	404.7	2,823.7
Total Average Annual.	2,745.5	930.1	1,619.9	1,685.9	3,669.0	1,822.4	12,472.8

Economic costs for future construction completion dates were computed in an identical manner as those shown in Table E12-1, i.e., project economic costs (excluding interest

during construction) except that the average annual project cost for future years was first discounted to equivalent 2006 costs using the factors listed in Table E12-2.

Table E12-2: Discount Factors, 5.375%		
Year	**Years used to Compute Present Value Factor**	**Present Value Factor**
2006	0.5	1.027
2007	-0.5	0.974
2008	-1.5	0.924
2009	-2.5	0.877
2010	-3.5	0.833

To illustrate, the average annual economic cost of $ 9.2 million (excluding O&M) was multiplied by the 2007 present value number of 0.974 to obtain $ 8.9 million. O&M was added to obtain the total average annual economic cost of $11.6 million (0.974 x $9.2 + $2.7). The average annual economic costs for completion of the project from the present to 2020 are listed in Table E12-3.

Table E12-3: Average Annual Costs by Year Including Increased O&M Costs (July 2004 $1,000)							
	1	**2**	**3**	**4**	**5**	**6**	**Total**
O&M	515.9	264.0	432.6	649.2	557.4	404.7	2,823.7
2006	2,829.3	956.2	1,667.5	1,726.3	3,813.3	1,887.9	12,880.6
2007	2,769.6	938.3	1,635.6	1,698.5	3,729.2	1,849.6	12,620.8
2008	2,654.6	904.0	1,574.2	1,645.0	3,567.4	1,775.9	12,121.0
2009	2,545.5	871.3	1,516.0	1,594.2	3,413.9	1,705.9	11,646.8
2010	2,442.0	840.3	1,460.7	1,546.0	3,268.2	1,639.6	11,196.8
2011	2,343.7	810.9	1,408.3	1,500.2	3,129.9	1,576.6	10,769.7
2012	2,250.5	783.0	1,358.5	1,456.8	2,998.7	1,516.8	10,364.4
2013	2,162.0	756.6	1,311.3	1,415.6	2,874.1	1,460.1	9,979.7
2014	2,078.0	731.4	1,266.5	1,376.5	2,756.0	1,406.2	9,614.7
2015	1,998.4	707.6	1,223.9	1,339.4	2,643.8	1,355.1	9,268.3
2016	1,922.7	685.0	1,183.6	1,304.2	2,537.4	1,306.7	8,939.6
2017	1,851.0	663.5	1,145.3	1,270.8	2,436.4	1,260.7	8,627.6
2018	1,782.9	643.1	1,108.9	1,239.1	2,340.6	1,217.0	8,331.6
2019	1,718.3	623.8	1,074.4	1,209.0	2,249.6	1,175.6	8,050.6
2020	1,656.9	605.4	1,041.7	1,180.5	2,163.3	1,136.2	7,784.0

4. Project Benefits: The benefits per year for a 12' channel are listed in Table E12-4. The benefits represent the reduction in transportation costs if MKARNS was at a 12' depth in the years listed in the first column.

Table E12-4: Project Benefits (July 2004 $1,000)							
	Reach						
	1	2	3	4	5	6	Total
2005	1,045.5	682.7	1,121.8	189.2	689.7	7,300.3	11,029.2
2006	1,071.3	700.3	1,165.4	194.0	706.5	7,480.2	11,317.7
2007	1,097.0	717.9	1,209.1	198.9	723.2	7,660.0	11,606.1
2008	1,122.8	735.5	1,252.7	203.8	740.0	7,839.8	11,894.6
2009	1,148.5	753.0	1,296.3	208.7	756.8	8,019.7	12,183.1
2010	1,174.3	770.6	1,340.0	213.6	773.5	8,199.5	12,471.5
2011	1,186.8	778.1	1,357.1	215.8	781.0	8,283.2	12,601.9
2012	1,199.2	785.6	1,374.2	218.0	788.4	8,366.9	12,732.2
2013	1,211.6	793.1	1,391.3	220.2	795.8	8,450.6	12,862.6
2014	1,224.1	800.6	1,408.4	222.4	803.2	8,534.3	12,993.0
2015	1,236.5	808.0	1,425.5	224.5	810.7	8,618.0	13,123.3
2016	1,249.0	815.5	1,442.6	226.7	818.1	8,701.8	13,253.7
2017	1,261.4	823.0	1,459.7	228.9	825.5	8,785.5	13,384.1
2018	1,273.9	830.5	1,476.9	231.1	832.9	8,869.2	13,514.4
2019	1,286.3	838.0	1,494.0	233.3	840.3	8,952.9	13,644.8
2020	1,298.7	845.5	1,511.1	235.5	847.8	9,036.6	13,775.2
2021	1,310.2	851.6	1,523.4	237.5	854.5	9,113.3	13,890.5
2022	1,321.7	857.7	1,535.7	239.5	861.2	9,190.0	14,005.8
2023	1,333.1	863.9	1,548.0	241.6	867.9	9,266.7	14,121.1
2024	1,344.6	870.0	1,560.3	243.6	874.6	9,343.3	14,236.5
2025	1,356.1	876.2	1,572.6	245.6	881.3	9,420.0	14,351.8
2026	1,367.5	882.3	1,584.9	247.6	888.0	9,496.7	14,467.1
2027	1,379.0	888.4	1,597.2	249.6	894.8	9,573.4	14,582.4
2028	1,390.4	894.6	1,609.5	251.6	901.5	9,650.1	14,697.7
2029	1,401.9	900.7	1,621.8	253.6	908.2	9,726.8	14,813.1
2030	1,413.4	906.9	1,634.2	255.7	914.9	9,803.5	14,928.4
2031	1,423.7	912.9	1,647.3	257.5	921.5	9,875.8	15,038.8
2032	1,434.1	919.0	1,660.4	259.4	928.1	9,948.2	15,149.3
2033	1,444.5	925.1	1,673.6	261.2	934.7	10,020.6	15,259.8
2034	1,454.9	931.2	1,686.7	263.0	941.4	10,093.0	15,370.2
2035	1,465.2	937.3	1,699.9	264.9	948.0	10,165.4	15,480.7
2036	1,475.6	943.4	1,713.0	266.7	954.6	10,237.8	15,591.1
2037	1,486.0	949.5	1,726.2	268.6	961.2	10,310.2	15,701.6
2038	1,496.4	955.5	1,739.3	270.4	967.8	10,382.5	15,812.0
2039	1,506.8	961.6	1,752.4	272.3	974.5	10,454.9	15,922.5
2040	1,517.1	967.7	1,765.6	274.1	981.1	10,527.3	16,033.0
2041	1,528.4	974.2	1,779.8	276.1	988.2	10,606.1	16,152.9
2042	1,539.6	980.7	1,794.0	278.1	995.4	10,684.9	16,272.8
2043	1,550.9	987.2	1,808.2	280.1	1,002.5	10,763.8	16,392.7
2044	1,562.1	993.6	1,822.4	282.2	1,009.7	10,842.6	16,512.6
2045	1,573.3	1,000.1	1,836.6	284.2	1,016.8	10,921.4	16,632.5
2046	1,584.6	1,006.6	1,850.8	286.2	1,024.0	11,000.2	16,752.4
2047	1,595.8	1,013.1	1,865.0	288.2	1,031.1	11,079.0	16,872.3
2048	1,607.1	1,019.6	1,879.2	290.2	1,038.3	11,157.8	16,992.2
2049	1,618.3	1,026.1	1,893.5	292.2	1,045.4	11,236.7	17,112.1
2050	1,629.6	1,032.5	1,907.7	294.2	1,052.6	11,315.5	17,232.0
2051	1,641.8	1,039.5	1,923.0	296.4	1,060.4	11,401.4	17,362.4
2052	1,653.9	1,046.4	1,938.4	298.6	1,068.1	11,487.3	17,492.8

2053	1,666.1	1,053.4	1,953.7	300.8	1,075.9	11,573.3	17,623.2
2054	1,678.3	1,060.4	1,969.0	302.9	1,083.7	11,659.2	17,753.5
2055	1,690.5	1,067.3	1,984.4	305.1	1,091.4	11,745.2	17,883.9
2056	1,702.7	1,074.3	1,999.7	307.3	1,099.2	11,831.1	18,014.3
2057	1,714.9	1,081.2	2,015.1	309.5	1,107.0	11,917.0	18,144.7
2058	1,727.1	1,088.2	2,030.4	311.7	1,114.7	12,003.0	18,275.1
2059	1,739.3	1,095.1	2,045.8	313.9	1,122.5	12,088.9	18,405.5
2060	1,751.5	1,102.1	2,061.1	316.1	1,130.3	12,174.8	18,535.9

Benefits in each year were converted into present value equivalents using 5.375% and end of year discounting. The present value equivalents of the benefits per year were summed over 50-year periods to obtain cumulative present value numbers. Cumulative benefits were then converted into average annual equivalent benefits using an amortization factor based on 5.375% and 50 years (.057981 is actual interest and amortization factor). For an end-of-year construction completion date in 2006, benefits would first accrue in 2007. The benefits for 2007 and the following 49 years through 2056 were converted to present value equivalents using end-of-year discounting and a 5.375% percent discount rate. For a construction completion date of 2007, the benefits were summed for the years from 2008 to 2057 and so on. Average annual equivalent benefits for different base years following completion of the project are provided in Table E12-5.

Table E12-5: Average Annual Equivalent Benefits for Different Base Years (July 2004 $1,000)

	Reach						
	1	**2**	**3**	**4**	**5**	**6**	**Total**
2006							
2007	1,270.5	823.5	1,459.6	230.3	829.5	8,842.6	13,456.0
2008	1,219.3	789.9	1,404.5	221.0	795.6	8,484.9	12,915.2
2009	1,169.4	757.1	1,350.0	211.9	762.7	8,136.5	12,387.7
2010	1,120.9	725.2	1,296.2	203.1	730.6	7,797.5	11,873.5
2011	1,073.7	694.1	1,243.2	194.5	699.4	7,467.7	11,372.7
2012	1,027.8	663.8	1,191.1	186.2	669.1	7,147.2	10,885.2
2013	984.0	635.0	1,141.2	178.2	640.2	6,841.4	10,420.1
2014	942.3	607.5	1,093.5	170.6	612.7	6,550.0	9,976.7
2015	902.5	581.3	1,048.0	163.4	586.5	6,272.3	9,554.0
2016	864.6	556.3	1,004.5	156.5	561.6	6,007.8	9,151.2
2017	828.4	532.6	963.0	149.9	537.8	5,755.9	8,767.6
2018	794.0	510.0	923.4	143.7	515.2	5,516.1	8,402.5
2019	761.3	488.5	885.6	137.7	493.8	5,288.1	8,055.0
2020	730.2	468.1	849.6	132.1	473.4	5,071.2	7,724.5

5. Optimization: The optimum time period for construction is identified as the time period of construction that provides the maximum positive net benefits. The computations begin with the calculation of the difference between the average annual equivalent cost and benefits. This was done as follows for assumed completion of the deepening project in year x: the total annual average cost of completion in year x were subtracted from the average annual equivalent benefits computed over the years for x + 1 thru x + 51. For example, the costs for completion in year 2006 shown in Table E12-3 were subtracted from the benefits listed for the year 2007 in

Table E12-5 to compute the net benefits of $1.0192 million ($12.9152 - $11.896). This was done for all completion dates in the years between 2006 and 2020 with the results listed in
Table E12-6. The declining net benefits indicate that near-term construction is economically preferable to later construction. The net benefits by reach also indicate that partial deepening of the river is not feasible since the majority of the net benefits are not realized until the project extends up the river through Reach 6.

The economics of constructing the project in different years were computed by computing the difference between average annual equivalent benefits and average annual costs. Economic costs for future construction completion dates were computed in an identical manner as those shown in Table E12-1 for a year 2006 completion date, i.e., project economic costs (excluding interest during construction) were discounted to equivalent 2006 costs using the factors listed in Table E12-3. The economic costs were then converted into annual average equivalent costs by multiplying the discounted cost by the interest and amortization rate for 5.375% and 50 years (i.e. 0.057981). O&M costs were then added to the amount to obtain the average annual economic cost.

Table E12-6: Net Benefits for Different Completion Years (July 2004 $1,000)

	Reach						
	1	**2**	**3**	**4**	**5**	**6**	**Total**
2007	-1,610.0	-166.3	-263.0	-1,505.3	-3,017.7	6,597.0	34.6
2008	-1,600.1	-181.2	-285.6	-1,486.6	-2,966.5	6,287.0	-233.1
2009	-1,533.7	-178.8	-278.0	-1,441.8	-2,836.8	6,021.6	-247.5
2010	-1,471.8	-177.2	-272.8	-1,399.6	-2,714.5	5,761.8	-274.1
2011	-1,414.2	-176.5	-269.7	-1,359.8	-2,599.1	5,507.6	-311.6
2012	-1,359.7	-176.0	-267.1	-1,322.0	-2,489.7	5,264.9	-349.5
2013	-1,308.2	-175.6	-265.0	-1,286.2	-2,386.0	5,033.2	-387.7
2014	-1,259.5	-175.3	-263.3	-1,252.2	-2,287.6	4,812.2	-425.8
2015	-1,213.5	-175.1	-262.0	-1,220.0	-2,194.4	4,601.5	-463.5
2016	-1,169.9	-175.0	-261.0	-1,189.5	-2,106.0	4,400.7	-500.7
2017	-1,128.7	-175.0	-260.2	-1,160.5	-2,022.2	4,209.5	-537.1
2018	-1,089.7	-175.0	-259.7	-1,133.1	-1,942.6	4,027.4	-572.6
2019	-1,052.7	-175.0	-259.3	-1,107.0	-1,867.2	3,854.2	-607.1
2020	-1,017.7	-175.1	-259.1	-1,082.3	-1,795.6	3,689.6	-640.3

ADDENDUM F1

Memorandum for Record
Jan Tran
12 November 2002

CESWT-PE-P (Rossman) November 12, 2002

Memorandum for Record

Subject: Phone Conversation with staff from Little Rock and Tulsa Districts and John Janoush, Jan Tran Barge Company

1. Background. In September 2002, towing operators on the Arkansas River were sent a questionnaire regarding the three final [components] for the [Phase 1] Arkansas River Navigation Feasibility Study. Specifically, questions dealt with the towing industry changing their operations in relation to modifications in river flow purposed in the study's three [components]. Based on the responses, Little Rock and Tulsa District staff decided to have a follow-up telephone call with the largest operators on the river. On November 12, 2002, staff from Little Rock and Tulsa Districts contacted John Janoush, operations manager of Jan Tran, Inc. of Rosedale, Mississippi. Lee Bass and Cherilyn Gibbs, Little Rock District and Greg Estep and Ed Rossman, Tulsa District, were included in the conference call. The call was conducted between 10:00 and 10:30 AM. The call was part of the data gathering supporting the navigation benefits estimation that is part of the Arkansas River Navigation Feasibility Study.

2. Discussion.

a. Lee Bass started the telephone conversation by stating the purpose of the call. Specifically he stated that the Districts needed to have information on two sets of questions. The first set of questions focused on the likelihood of Jan Tran increasing the number of barges in a tow under each of the [components]. The second set focused on the changes in vessel fleet in terms of horsepower of the tow boats under each [component].

b. Greg Estep explained each of the [components]. He stressed that all three of the [components] would increase the number of days of flow that were under 100,000 and 60,000 cubic feet per second cfs at the Van Buren, AR gage, as compared to current conditions. He stated that under the [component], with a maximum flow rule of 175,000 cfs, there would 15 more average navigation days below 100K and nine days under 60,000 cfs. Under the [component] of 200,000 cfs rule, the results would be similar to the other [component] except for two additional days below 100,000 cfs. He stated one [component] modifies the existing operations plan only by changing the "bench" from 75,000 cfs to 60,000 cfs. That [component] would result in an average of 15 more days of flows less that 60,000 cfs and no impact on the number of days above 100,000 cfs.

c. Mr. Janoush stated that there would not be a change in horsepower of boats under any of the [components]. However, he stated that when the flows were below 60,000 cfs, his company could increase tow sizes by a third. He stated that flows above 100,000 cfs were difficult to navigate and flows at 150,000 navigation were unsafe. He also stated that during the Webbers Fall Bridge collapse in the summer of 2002, the estimated lost to his business was $35,000 a day while the system was not usable.

3. Further Discussion. Little Rock and Tulsa District agree to contact Pine Bluff Sand and Gravel Company and ask the same clarifications requested from JanTran. According to Little Rock District staff, Pine Bluff Sand and Gravel would be available the week of November 25, 2002.

Ed Rossman, Tulsa District
Social Scientist

ADDENDUM F2

Memorandum for Record
Pine Bluff Sand & Gravel
13 February 2003

CESWL-PR-P (Gibbs) February 13, 2003

Memorandum for Record

Subject: Phone Conversation with John Hoopaugh, Transportation Manager of Pine Bluff Sand & Gravel

1. Background. In November 2002, Pine Bluff Sand & Gravel was sent a questionnaire regarding the three final [components] for the [Phase 1] Arkansas River Navigation Feasibility Study. Specifically, questions dealt with the towing industry changing their operations in relation to modifications in river flow purposed in the study's three alternatives. On February 10, 2003, I contacted John Hoopaugh, Transportation Manager of Pine Bluff Sand & Gravel. The call was part of the data gathering supporting the navigation benefits estimation that is part of the Arkansas River Navigation Feasibility Study.
2. Discussion. Mr. Hoopaugh started the telephone conversation by stating that he had received clarification of the plans from Greg Estep of the Tulsa District office. After Mr. Estep had explained each of the [components], Mr. Hoopaugh was willing to supply his survey estimates. He stated that under the current operations there are several days that are inoperable from high flows. Many navigation problems occur at Lock 9. For Pine Bluff Sand & Gravel, there is not much difference between Plan 2 (175,000 cfs) and Plan 3 (200,000 cfs). Increasing the number of days below 100,000 [cfs] would be beneficial to Pine Bluff Sand & Gravel, but they would not change their tow configurations. They believe that Plan 4 (Operations Only) will be beneficial. Mr. Hoopaugh stated that they "agree 100% with replacing the bench." A change in the bench puts them at a transitional point in tow configuration. According to Mr. Hoopaugh, boats with a 12-configuration are reduced to an 8-configuration at 75,000 cfs. Mr. Hoopaugh will fax his decision matrix to the Little Rock District office for documentation purposes.

Cherilyn Gibbs, Little Rock District
Economist

ADDENDUM F3

Memorandum for Record
Pine Bluff Sand & Gravel
Operations Documentation

TO: Ms. Cherilyn Gibbs

FROM: John Hoopaugh

DATE: 2-14-03

Pine Bluff Sand & Gravel Company has a quarry at mile 218 on the Arkansas River. We have four boats that routinely operate on the river. One 3800 hp boat pushes up to 15 barges and no fewer than six. Two 3000 hp boats that push up to 12 barges and no fewer than four. One 1800 hp that pushes up to eight barges and no fewer than four.

All our vessels reduce tow size according to the attached chart. We do not stop navigating at 100,000 cfs. However, Lock #9 closes at a certain headwater elevation which approximates 190,000 cfs.

In general, the more days the river flows are below the proposed benchmark of 60,000 the more days we can operate at maximum tow size. 60,000 cfs at Van Buren equates to 75,000 cfs in Little Rock. The attached chart is based on flows in Little Rock.

I appreciate the opportunity to participate in this study. Please call if you need additional information.

# 195' x 35' Barges		m/v White Wing 3800 HP	m/v Sioux 3000 HP	m/v Jake West 3000 HP	m/v George Rowe 1800 HP
FROM	TO				
15	12	cfs 60,000 ↑	N/A	N/A	N/A
12	8	cfs 95,000 ↑	75,000 ↑	85,000 ↑	N/A
8	6	115,000 ↑	100,000 ↑	100,000 ↑	80,000 ↑
6	4	N/A	150,000 ↑	150,000 ↑	120,000 ↑

ADDENDUM G1

Example Transportation Rates

TRANSPORTATION RATE ANALYSIS

Ref No.: 465 (Page 1)

Commodity	Pebbles, Gravel, Crushed Stone (Specialized Use)		
WCSC Gp.	27340	Tonnage	1,300
River Origin	64218010	Riv. Dest	20241010
Origin Port Code	ARKANSAS RIVER MILE :	Dest Port Code	LOWER MISS RIVER MILE
Origin WW Mile	ARK :	Dest WW Mile	LM :
Off-River Orig.		Off-River Dest	

WATER ROUTE

	Mode	Miles	Cost
(1) Loading at origin			1.25
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	BARGE	576	4.88 a/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			1.25
(10) Other			
(11) Total		576	7.38

LAND ROUTE

	Mode	Miles	Cost
(1) Loading at origin			1.25
(2) Charge to transfer point			
(3) Transfer charge			
(4) Line-haul charge	RAIL	480	11.81 b/x/
(5) Transfer charge			
(6) Final leg to destination			
(7) Unloading at destination			1.25
(8) Other			
(9) Total		480	14.31

AUTHORITIES FOR CHARGES AND EXPLANATION OF REFERENCE MARKS

a/ TVA Barge Costing Model 10% ROI 9 ft draft
b/ Reebie RCAM Russellville-Baton Rouge UP Single Car 97 Tons 143% VC
x/ URCS costs are: Variable 8.26 Full 11.10

TRANSPORTATION RATE ANALYSIS

Ref No.: 465 (Page 2)

Commodity	Pebbles, Gravel, Crushed Stone (Specialized Use)		
WCSC Gp.	27340	Tonnage	1,300
River Origin	64218010	Riv. Dest	20241010
Origin WW Mile	ARK	Dest WW Mile	LM
Off-River Orig.		Off-River Dest	

ALTERNATE ROUTE (1)

	Mode	Miles	Cost
(1) Loading at origin			1.25
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	BARGE	576	3.46 a/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			1.25
(10) Other			
(11) Total		576	5.96

ALTERNATE ROUTE (2)

	Mode	Miles	Cost
(1) Loading at origin			1.25
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	BARGE	576	3.05 b/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			1.25
(10) Other			
(11) Total		576	5.55

AUTHORITIES FOR CHARGES AND EXPLANATION OF REFERENCE MARKS

a/ TVA Barge Costing Model 10% ROI 10 ft draft
b/ TVA Barge Costing Model 10% ROI 11 ft draft

TRANSPORTATION RATE ANALYSIS

Ref No.: 465 (Page 3)

Commodity	Pebbles, Gravel, Crushed Stone (Specialized Use)		
WCSC Gp.	27340	Tonnage	1,300
River Origin	64218010	Riv. Dest	20241010
Origin WW Mile	ARK	Dest WW Mile	LM
Off-River Orig.		Off-River Dest	

ALTERNATE ROUTE (3)

	Mode	Miles	Cost
(1) Loading at origin			1.25
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	BARGE	576	2.89 a/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			1.25
(10) Other			
(11) Total		576	5.39

SUMMARY

	Cost
(1) Water Route	7.38
(2) Land Route	14.31
(3) Alternate Route (1)	5.96
(4) Alternate Route (2)	5.55
(5) Alternate Route (3)	5.39

AUTHORITIES FOR CHARGES AND EXPLANATION OF REFERENCE MARKS

a/ TVA Barge Costing Model 10% ROI 12 ft draft

TRANSPORTATION RATE ANALYSIS

Ref No.: 809 (Page 1)

Commodity	Urea Fertilizers		
WCSC Gp.	56216	Tonnage	1,625
River Origin	20133302	Riv. Dest	61350351
Origin Port Code	LOWER MISS RIVER MILE	Dest Port Code	VERDIGRIS RIVER MILE
Origin WW Mile	LM	Dest WW Mile	ARK
Off-River Orig.	Import Vessel	Off-River Dest	

WATER ROUTE

	Mode	Miles	Cost
(1) Loading at origin			2.25
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	BARGE	911	6.56 a/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			2.75
(10) Other			
(11) Total		911	11.56

LAND ROUTE

	Mode	Miles	Cost
(1) Loading at origin			3.50
(2) Charge to transfer point			
(3) Transfer charge			
(4) Line-haul charge	RAIL	788	30.20 b/x/
(5) Transfer charge			
(6) Final leg to destination			
(7) Unloading at destination			2.25
(8) Other			
(9) Total		788	35.95

AUTHORITIES FOR CHARGES AND EXPLANATION OF REFERENCE MARKS

a/ TVA Barge Costing Model 10% ROI 9 ft draft
b/ Reebie RCAM New Orleans-Catoosa NOPB New Orleans UP Tulsa SKOL Single Car 97 tons 196% VC
x/ URCS cost are: Variable 15.41 Full 20.81

TRANSPORTATION RATE ANALYSIS

Ref No.: 809 (Page 2)

Commodity	Urea Fertilizers		
WCSC Gp.	56216	Tonnage	1,625
River Origin	20133302	Riv. Dest	61350351
Origin WW Mile	LM 1	Dest WW Mile	ARK
Off-River Orig.	Import Vessel	Off-River Dest	

ALTERNATE ROUTE (1)

	Mode	Miles	Cost
(1) Loading at origin			2.25
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	BARGE	911	5.35 a/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			2.75
(10) Other			
(11) Total		911	10.35

ALTERNATE ROUTE (2)

	Mode	Miles	Cost
(1) Loading at origin			2.25
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	BARGE	911	4.73 b/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			2.75
(10) Other			
(11) Total		911	9.73

AUTHORITIES FOR CHARGES AND EXPLANATION OF REFERENCE MARKS

a/ TVA Barge Costing Model 10% ROI 10 ft draft
b/ TVA Barge Costing Model 10% ROI 11 ft draft

TRANSPORTATION RATE ANALYSIS

Ref No.: 809 (Page 3)

Commodity	Urea Fertilizers		
WCSC Gp.	56216	Tonnage	1,625
River Origin	20133302	Riv. Dest	61350351
Origin WW Mile	LM	Dest WW Mile	ARK
Off-River Orig.	Import Vessel	Off-River Dest	

ALTERNATE ROUTE (3)

	Mode	Miles	Cost
(1) Loading at origin			2.25
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	BARGE	911	4.47 a/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			2.75
(10) Other			
(11) Total		911	9.47

SUMMARY

	Cost
(1) Water Route	11.56
(2) Land Route	35.95
(3) Alternate Route (1)	10.35
(4) Alternate Route (2)	9.73
(5) Alternate Route (3)	9.47

AUTHORITIES FOR CHARGES AND EXPLANATION OF REFERENCE MARKS

a/ TVA Barge Costing Model 10% ROI 12 ft draft

TRANSPORTATION RATE ANALYSIS

Ref No.: 1226 (Page 1)

Commodity	Iron and Steel Bars,Rods,Angles,Shapes & Sections		
WCSC Gp.	67600	Tonnage	30,435
River Origin	15495101	Riv. Dest	61101711
Origin Port Code	MOBILE RIVER CHANNEL	Dest Port Code	POTEAU RIVER MILE
Origin WW Mile	MOB	Dest WW Mile	ARK
Off-River Orig.	Import Vessel	Off-River Dest	

WATER ROUTE

	Mode	Miles	Cost
(1) Loading at origin			6.50 a/
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	BARGE	973	9.42 b/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			3.25
(10) Other			
(11) Total		973	19.17

LAND ROUTE

	Mode	Miles	Cost
(1) Loading at origin			9.50 a/
(2) Charge to transfer point			
(3) Transfer charge			
(4) Line-haul charge	RAIL	658	21.11 c/x/
(5) Transfer charge			
(6) Final leg to destination			
(7) Unloading at destination			3.25
(8) Other			
(9) Total		658	33.86

AUTHORITIES FOR CHARGES AND EXPLANATION OF REFERENCE MARKS

a/ Supplied by Port Authority at origin
b/ TVA Barge Costing Model 10% ROI 9 ft draft
c/ Reebie RCAM Mobile-Ft Smith TASD Mobile CN Jackson KCS Ft Smith AM Multi Car 89 tons 162%VC
x/ URCS cost are: Variable 13.03 Full 18.70

TRANSPORTATION RATE ANALYSIS

Ref No.: 1226 (Page 2)

Commodity	Iron and Steel Bars,Rods,Angles,Shapes & Sections		
WCSC Gp.	67600	Tonnage	30,435
River Origin	15495101	Riv. Dest	61101711
Origin WW Mile	MOB	Dest WW Mile	ARK
Off-River Orig.	Import Vessel	Off-River Dest	

ALTERNATE ROUTE (1)

	Mode	Miles	Cost
(1) Loading at origin			6.50 a/
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	BARGE	973	7.68 b/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			3.25
(10) Other			
(11) Total		973	17.43

ALTERNATE ROUTE (2)

	Mode	Miles	Cost
(1) Loading at origin			6.50 a/
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	BARGE	973	6.79 c/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			3.25
(10) Other			
(11) Total		973	16.54

AUTHORITIES FOR CHARGES AND EXPLANATION OF REFERENCE MARKS

a/ Supplied by Port Authority at origin
b/ TVA Barge Costing Model 10% ROI 10 ft draft
c/ TVA Barge Costing Model 10% ROI 11 ft draft

TRANSPORTATION RATE ANALYSIS

Ref No.: 1226 (Page 3)

Commodity	Iron and Steel Bars,Rods,Angles,Shapes & Sections		
WCSC Gp.	67600	Tonnage	30,435
River Origin	15495101	Riv. Dest	61101711
Origin WW Mile	MOB	Dest WW Mile	ARK 1
Off-River Orig.	Import Vessel	Off-River Dest	

ALTERNATE ROUTE (3)

	Mode	Miles	Cost
(1) Loading at origin			6.50 a/
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	barge	973	6.42 b/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			3.25
(10) Other			
(11) Total		973	16.17

SUMMARY

	Cost
(1) Water Route	19.17
(2) Land Route	33.86
(3) Alternate Route (1)	17.43
(4) Alternate Route (2)	16.54
(5) Alternate Route (3)	16.17

AUTHORITIES FOR CHARGES AND EXPLANATION OF REFERENCE MARKS

a/ Supplied by Port Authority at origin
b/ TVA Barge Costing Model 10% ROI 12 ft draft

TRANSPORTATION RATE ANALYSIS

Ref No.: 1179 (Page 1)

Commodity	Flat-Rolled Products of Iron & Steel,Not Clad,Pltd		
WCSC Gp.	67300	Tonnage	3,283
River Origin	15504309	Riv. Dest	61350311
Origin Port Code	BLACK WARRIOR AND TOMBIG	Dest Port Code	VERDIGRIS RIVER MILE
Origin WW Mile	B/W	Dest WW Mile	ARK
Off-River Orig.		Off-River Dest	

WATER ROUTE

	Mode	Miles	Cost
(1) Loading at origin			3.25
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	BARGE	1452	15.32 a/
(7) Handling at river destination			3.25
(8) Charge ex river	TRUCK	1	2.50 b/
(9) Unloading at destination			2.50
(10) Other			
(11) Total		1453	26.82

LAND ROUTE

	Mode	Miles	Cost
(1) Loading at origin			3.25 a/
(2) Charge to transfer point			
(3) Transfer charge			
(4) Line-haul charge	RAIL	840	27.97 c/x/
(5) Transfer charge			
(6) Final leg to destination			
(7) Unloading at destination			3.25
(8) Other			
(9) Total		840	34.47

AUTHORITIES FOR CHARGES AND EXPLANATION OF REFERENCE MARKS

a/ TVA Barge Costing Model 10% ROI 9 ft draft
b/ Truck from terminal to steel fabricator
c/ Reebie RCAM Tuscaloosa-Catoosa KCS Tulsa SKOL Single Car 85 tons 156% VC
x/ URCS cost are: Variable 17.93 Full 25.71

TRANSPORTATION RATE ANALYSIS

Ref No.: 1179 (Page 2)

Commodity	Flat-Rolled Products of Iron & Steel,Not Clad,Pltd		
WCSC Gp.	67300	Tonnage	3,283
River Origin	15504309	Riv. Dest	61350311
Origin WW Mile	B/W:	Dest WW Mile	ARK
Off-River Orig.		Off-River Dest	

ALTERNATE ROUTE (1)

	Mode	Miles	Cost
(1) Loading at origin			3.25
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	BARGE	1452	15.32 a/
(7) Handling at river destination			3.25
(8) Charge ex river	TRUCK	1	2.50 b/
(9) Unloading at destination			2.50
(10) Other			
(11) Total		1453	26.82

ALTERNATE ROUTE (2)

	Mode	Miles	Cost
(1) Loading at origin			3.25
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	BARGE	1452	15.32 a/
(7) Handling at river destination			3.25
(8) Charge ex river	TRUCK	1	2.50 b/
(9) Unloading at destination			2.50
(10) Other			
(11) Total		1453	26.82

AUTHORITIES FOR CHARGES AND EXPLANATION OF REFERENCE MARKS

a/ TVA Barge Costing Model 10% ROI 9 ft draft
b/ Truck from terminal to steel fabricator

TRANSPORTATION RATE ANALYSIS

Ref No.: 1179 (Page 3)

Commodity	Flat-Rolled Products of Iron & Steel,Not Clad,Pltd		
WCSC Gp.	67300	Tonnage	3,283
River Origin	15504309	Riv. Dest	61350311
Origin WW Mile	B/W	Dest WW Mile	ARK !
Off-River Orig.		Off-River Dest	

ALTERNATE ROUTE (3)

	Mode	Miles	Cost
(1) Loading at origin			3.25
(2) Charge to transfer point			
(3) Transfer charge			
(4) Charge to river			
(5) Handling at river origin			
(6) Line haul charge	BARGE	1452	15.32 a/
(7) Handling at river destination			3.25
(8) Charge ex river	TRUCK	1	2.50 b/
(9) Unloading at destination			2.50
(10) Other			
(11) Total		1453	26.82

SUMMARY

	Cost
(1) Water Route	26.82
(2) Land Route	34.47
(3) Alternate Route (1)	26.82
(4) Alternate Route (2)	26.82
(5) Alternate Route (3)	26.82

AUTHORITIES FOR CHARGES AND EXPLANATION OF REFERENCE MARKS

a/ TVA Barge Costing Model 10% ROI 9 ft draft
b/ Truck from terminal to steel fabricator

TRANSPORTATION RATE ANALYSIS

Ref No.: 50 (Page 1)

Commodity	Wheat (Including Spelt) and Meslin, Unmilled		
WCSC Gp.	4100	Tonnage	20,012
River Origin	61337821	Riv. Dest	20139402
Origin Port Code	VERDIGRIS RIVER MILE	Dest Port Code	LOWER MISS RIVER MILE
Origin WW Mile	ARK	Dest WW Mile	LM
Off-River Orig.	Wagoner, OK	Off-River Dest	Export Vessel

WATER ROUTE

	Mode	Miles	Cost
(1) Loading at origin			0.50
(2) Charge to transfer point	TRUCK	20	2.00 a/
(3) Transfer charge			1.67
(4) Charge to river	TRUCK	100	5.21 b/
(5) Handling at river origin			1.33
(6) Line haul charge	BARGE	892	6.53 c/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			2.27
(10) Other			
(11) Total		1012	19.51

LAND ROUTE

	Mode	Miles	Cost
(1) Loading at origin			0.50
(2) Charge to transfer point	TRUCK	120	8.88 d/
(3) Transfer charge			1.67
(4) Line-haul charge	RAIL	762	21.51 e/x/
(5) Transfer charge			
(6) Final leg to destination			
(7) Unloading at destination			2.50
(8) Other			
(9) Total		882	35.06

AUTHORITIES FOR CHARGES AND EXPLANATION OF REFERENCE MARKS

a/ Truck from farm to country elevator
b/ Truck rate $1.25 loaded mile 24 ton minimum
c/ TVA Barge Costing Model 10% ROI 9 ft draft
d/ Truck from farm to country elevator plus truck to rail head elevator at Wagoner, OK
e/ UP 4052 (8043-A) : Reebie RCAM Wagoner-Ama UP Unit Train 105 tons 242% VC $20.91
x/ URCS cost are: Variable 8.64 Full 11.61

TRANSPORTATION RATE ANALYSIS

Ref No.: 50 (Page 2)

Commodity	Wheat (Including Spelt) and Meslin, Unmilled		
WCSC Gp.	4100	Tonnage	20,012
River Origin	61337821	Riv. Dest	20139402
Origin WW Mile	ARK	Dest WW Mile	LM
Off-River Orig.	Wagoner, OK	Off-River Dest	Export Vessel

ALTERNATE ROUTE (1)

	Mode	Miles	Cost
(1) Loading at origin			0.50
(2) Charge to transfer point	TRUCK	20	2.00 a/
(3) Transfer charge			1.67
(4) Charge to river	TRUCK	100	5.21 b/
(5) Handling at river origin			1.33
(6) Line haul charge	BARGE	892	5.33 c/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			2.27
(10) Other			
(11) Total		1012	18.31

ALTERNATE ROUTE (2)

	Mode	Miles	Cost
(1) Loading at origin			0.50
(2) Charge to transfer point	TRUCK	20	2.00 a/
(3) Transfer charge			1.67
(4) Charge to river	TRUCK	100	5.21 b/
(5) Handling at river origin			1.33
(6) Line haul charge	BARGE	892	4.71 d/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			2.27
(10) Other			
(11) Total		1012	17.69

AUTHORITIES FOR CHARGES AND EXPLANATION OF REFERENCE MARKS

a/ Truck from farm to country elevator
b/ Truck rate $1.25 loaded mile 24 ton minimum
c/ TVA Barge Costing Model 10% ROI 10 ft draft
d/ TVA Barge Costing Model 10% ROI 11 ft draft

TRANSPORTATION RATE ANALYSIS

Ref No.: 50 (Page 3)

Commodity	Wheat (Including Spelt) and Meslin, Unmilled		
WCSC Gp.	4100	Tonnage	20,012
River Origin	61337821	Riv. Dest	20139402
Origin WW Mile	ARK	Dest WW Mile	LM
Off-River Orig.	Wagoner, OK	Off-River Dest	Export Vessel

ALTERNATE ROUTE (3)

	Mode	Miles	Cost
(1) Loading at origin			0.50
(2) Charge to transfer point	TRUCK	20	2.00 a/
(3) Transfer charge			1.67
(4) Charge to river	TRUCK	100	5.21 b/
(5) Handling at river origin			1.33
(6) Line haul charge	BARGE	892	4.45 c/
(7) Handling at river destination			
(8) Charge ex river			
(9) Unloading at destination			2.27
(10) Other			
(11) Total		1012	17.43

SUMMARY

	Cost
(1) Water Route	19.51
(2) Land Route	35.06
(3) Alternate Route (1)	18.31
(4) Alternate Route (2)	17.69
(5) Alternate Route (3)	17.43

AUTHORITIES FOR CHARGES AND EXPLANATION OF REFERENCE MARKS

a/ Truck from farm to country elevator
b/ Truck rate $1.25 loaded mile 24 ton minimum
c/ TVA Barge Costing Model 10% ROI 12 ft draft

ADDENDUM H1

Cost Effectiveness and Incremental Cost Analysis
Aquatic Mitigation

Following identification of the recommended plan, including consideration of estimated environmental impacts in habitat units, cost estimates were developed for the individual mitigation measures. As required by ER 1105-2-100, C-3.e., mitigation costs must be justified by demonstrating cost effectiveness and reasonableness of incremental costs. The mitigation measures (described in Chapter 8 of the EIS) were developed by the inter-agency collaboration team for numerous potential mitigation sites and activities. The team evaluated impacts and benefits in habitat units, and focused on best development of the site based on combined professional expertise and familiarity with riverine processes and habitat. Thus the team evaluation produced what may be termed optimum development for each measure, thereby creating a single of measure that is the cost effective alternative for the site or activity. The measures were further screened for engineering and other technical feasibility, reducing the number of options available to meet the mitigation targets for the lower waterway (Arkansas) and the upper waterway (Oklahoma).

The incremental cost analysis (ICA) was performed by dividing implementation costs for each item by its average annual habitat units to estimate the cost per AAHU. The measures were sorted in ascending order of Cost per AAHU so that the incremental cost of each succeeding measure is greater than the previous measure. The amount of change from existing HUs were accumulated measure by measure until the mitigation targets were achieved This ensures that the incremental costs of the measures included in the aquatic mitigation plan are the least costly of the measures available. ICA results are shown in the following tables.

For this analysis, IWR-Plan software was not as appropriate as the development of sorted matrices in spreadsheets presented in this report. The number of measures exceeded the 26 solutions (or plans) that the software allows. Each IWR-Plan solution/plan may have up to 20 scales. As noted above, an optimum/single scale was identified for each measure. The value of IWR-Plan is in being to analyze assorted combinations of measures at various scales to identify the incremental cost of each plan. IWR Report 94-PS-2 (Cost Effectiveness Analysis for Planners) notes that "ICA is not applicable in avoidance planning since only one level of output is considered" (page 56). Additionally the IWR report says, "if you have a defined target level of output ...then you may also use "lowest cost" as the selection rule...In this case, selection of the lowest cost solution (either lowest average cost or lowest total cost) makes economic sense" (page 58). The ICA presented here combines the measures with lowest average cost resulting in the lowest total cost being the recommended mitigation plan.

Table H1-1. Aquatic Mitigation Features – Arkansas Portion

Nav. Mile	Project	Future without Project AAHUs	Total AAHUs with 12-ft Project	AAHUs Affected by 12-ft Project	Total AAHUs with Mitigated 12-ft Project	Change in Mitigated 12-ft AAHUs Relative to Baseline (1)	Cost	Cost Per AAHU	Running Total AAHUs	Percent Mitigation	Running Total Cost	Incremental Change in AAHUs	Incremental Cost
23.6 R	Avoid RB disposal	3.558	3.145	-0.413	0.948	-2.610	$0.00	$0.00	0.948	0.03%	$0.00	0.948	$0.00
27L	Avoid aquatic disposal, utilize land	2.453	1.677	-0.776	1.677	-0.776	$0.00	$0.00	2.625	0.08%	$0.00	1.677	$0.00
35R	Notch modified dikes (2)	6.439	6.439	0.000	6.439	0.000	$0.00	$0.00	9.064	0.27%	$0.00	6.439	$0.00
36.4-37.0R	Extend disposal area u/s to 38.1R, avoid blocking entrance to chute at 36.4R and 38.1R	5.692	5.031	-0.661	3.434	-2.258	$0.00	$0.00	12.498	0.38%	$0.00	3.434	$0.00
37.8-38.4L	Avoid disposal, utilize RB.	5.692	5.031	-0.661	3.203	-2.489	$0.00	$0.00	15.701	0.47%	$0.00	3.203	$0.00
40R	Notch existing revetment/dike (1)	1.533	1.533	0.000	1.533	0.000	$0.00	$0.00	17.235	0.52%	$0.00	1.533	$0.00
39.8-40.0L	Avoid disposal, utilize right bank	1.518	1.342	-0.176	1.221	-0.297	$0.00	$0.00	18.455	0.55%	$0.00	1.221	$0.00
44-44.7R	Utilize AR44.3R-D for disposal and extend d/s to 43.0R	0.854	0.755	-0.099	0.755	-0.099	$0.00	$0.00	19.210	0.58%	$0.00	0.755	$0.00
45.4-46L	Avoid disposal in aquatic areas of AR45.3L-D, dispose on land or preferably on RB	8.348	7.379	-0.969	5.045	-3.304	$0.00	$0.00	24.254	0.73%	$0.00	5.045	$0.00
46.8-49.2L	Utilize land within cells for disposal at AR48.0L-D, avoid aquatic areas	11.289	9.979	-1.311	9.979	-1.311	$0.00	$0.00	34.233	1.03%	$0.00	9.979	$0.00
49.6-49.9	Utilize existing in-channel disposal	1.044	0.922	-0.121	0.922	-0.121	$0.00	$0.00	35.156	1.06%	$0.00	0.922	$0.00
64.8-65.3L	Utilize AR65.2L-D or in-channel disposal at AR65.5Channel-D	10.084	7.595	-2.489	7.595	-2.489	$0.00	$0.00	42.751	1.29%	$0.00	7.595	$0.00
65.2-65.6	Utilize AR65.2L-D or in-channel disposal at AR65.5Channel-D	2.548	1.919	-0.629	1.919	-0.629	$0.00	$0.00	44.670	1.34%	$0.00	1.919	$0.00
85.5-85.8R	Avoid disposal if possible and utilize in-channel disposal	6.210	5.033	-1.176	4.952	-1.258	$0.00	$0.00	49.621	1.49%	$0.00	4.952	$0.00

Table H1-1. Aquatic Mitigation Features – Arkansas Portion

Nav. Mile	Project	Future without Project AAHUs	Total AAHUs with 12-ft Project	AAHUs Affected by 12-ft Project	Total AAHUs with Mitigated 12-ft Project	Change in Mitigated 12-ft AAHUs Relative to Baseline (1)	Cost	Cost Per AAHU	Running Total AAHUs	Percent Mitigation	Running Total Cost	Incremental Change in AAHUs	Incremental Cost
85.6-85.8	Utilize in-channel disposal	0.430	0.349	-0.081	0.349	-0.081	$0.00	$0.00	49.970	1.50%	$0.00	0.349	$0.00
87.7L	Investigate dredging channel into oxbow lake	69.697	69.697	0.000	69.697	0.000	$0.00	$0.00	119.667	3.60%	$0.00	69.697	$0.00
91.5L	Bank stab and revetment at 91.5 is needed (current – 0.3)	2.291	2.291	0.000	3.636	1.344	$0.00	$0.00	123.302	3.71%	$0.00	3.636	$0.00
96.0-98.2R	Enlarge and utilize RB disposal, investigate disposing behind modified revetment and dikes, investigate terrestrial disposal if needed	5.347	3.165	-2.181	3.165	-2.181	$0.00	$0.00	126.468	3.80%	$0.00	3.165	$0.00
100.6-101.3R	Utilize this area as alternative disposal site	4.710	2.788	-1.922	2.788	-1.922	$0.00	$0.00	129.256	3.89%	$0.00	2.788	$0.00
106.5-107.7L	Avoid aquatic disposal in AR107.1L, utilize land areas or in-channel disposal	49.007	33.483	-15.524	33.483	-15.524	$0.00	$0.00	162.739	4.89%	$0.00	33.483	$0.00
124.2-124.5L	Avoid disposal in AR124.8L-D, utilize in-channel disposal	3.500	3.500	0.000	0.133	-3.366	$0.00	$0.00	162.873	4.90%	$0.00	0.133	$0.00
124.8-125.1	Utilize in-channel disposal at AR124.8 Channel-D	2.800	2.800	0.000	2.933	0.133	$0.00	$0.00	165.806	4.99%	$0.00	2.933	$0.00
126.6-127.0R	Avoid disposal on RB	8.220	6.892	-1.327	6.892	-1.327	$0.00	$0.00	172.698	5.19%	$0.00	6.892	$0.00
139.5-141R	Avoid disposal from 140R u/s to 141R to prevent blockage of opening between islands, utilize 140R d/s to tip of island	12.991	10.893	-2.098	8.912	-4.079	$0.00	$0.00	181.609	5.46%	$0.00	8.912	$0.00
141.5-142.5R	Utilize disposal behind raised and extended L-dikes at 142.0R	6.897	5.783	-1.114	0.000	-6.897	$0.00	$0.00	181.609	5.46%	$0.00	0.000	$0.00
143.7-144.2L	Construct L-dike or revetment and use disposal to slope and protect bank	6.509	3.833	-2.677	5.110	-1.399	$0.00	$0.00	186.720	5.61%	$0.00	5.110	$0.00
146.3R	Avoid disposal in this area	22.218	17.652	-4.566	16.823	-5.395	$0.00	$0.00	203.542	6.12%	$0.00	16.823	$0.00
146.6-147.8R	Utilize land within disposal cells	4.651	3.900	-0.751	3.900	-0.751	$0.00	$0.00	207.442	6.24%	$0.00	3.900	$0.00

Table H1-1. Aquatic Mitigation Features – Arkansas Portion

Nav. Mile	Project	Future without Project AAHUs	Total AAHUs with 12-ft Project	AAHUs Affected by 12-ft Project	Total AAHUs with Mitigated 12-ft Project	Change in Mitigated 12-ft AAHUs Relative to Baseline (1)	Cost	Cost Per AAHU	Running Total AAHUs	Percent Mitigation	Running Total Cost	Incremental Change in AAHUs	Incremental Cost
147.8-150L	Avoid disposal from 149-150L that would block the entrance to backwater area, utilize disposal area d/s of 149L	28.322	16.676	-11.646	5.005	-23.316	$0.00	$0.00	212.448	6.39%	$0.00	5.005	$0.00
154-154.6L	Avoid RB disposal, Utilize land disposal within cells at AR154.1L-D	0.000	0.000	0.000	0.000	0.000	$0.00	$0.00	212.448	6.39%	$0.00	0.000	$0.00
155.4L	Utilize land within cell at AR155.4L-D	0.000	0.000	0.000	0.000	0.000	$0.00	$0.00	212.448	6.39%	$0.00	0.000	$0.00
163.6-165.2R	163.6-165.3 - Revetment is needed for bank stabilization	1.059	0.751	-0.307	0.751	-0.307	$0.00	$0.00	213.199	6.41%	$0.00	0.751	$0.00
164.2-164.7L	Avoid LB disposal, utilize disposal behind revetment on RB	11.379	8.076	-3.303	5.157	-6.221	$0.00	$0.00	218.356	6.57%	$0.00	5.157	$0.00
165.5-166.2R	Avoid disposal in AR166.0R-D	22.440	15.927	-6.513	13.008	-9.432	$0.00	$0.00	231.365	6.96%	$0.00	13.008	$0.00
176.2-176.4	Avoid disposal in AR176.2L-D, utilize RB land disposal on Lentz property	2.420	2.104	-0.316	2.104	-0.316	$0.00	$0.00	233.468	7.02%	$0.00	2.104	$0.00
179.3-179.7R	Utilize disposal at 179.6R behind revetment	11.010	6.602	-4.408	2.723	-8.287	$0.00	$0.00	236.191	7.10%	$0.00	2.723	$0.00
185.8-186.4	Avoid disposal in AR186.2L-D, create artificial gravel bar downstream of dikes from 185L-186L	7.446	5.282	-2.164	2.591	-4.855	$0.00	$0.00	238.782	7.18%	$0.00	2.591	$0.00
186.9-189.9R	*Existing least tern island - avoid construction during nesting, limited disposal to avoid elevating island and maintain fish access to backwater, notch revetment and dikes (3-6) for flow-through, fish passage and access	201.663	143.045	-58.618	143.045	-58.618	$0.00	$0.00	381.827	11.48%	$0.00	143.045	$0.00

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190.5-192R	New dredge disposal alternative to 189.5L will create elevated vegetated shoreline on Sweeden Island	4.918	2.949	-1.969	5.262	0.344	$0.00	$0.00	387.089	11.64%	$0.00	5.262	$0.00
200.2L	Utilize land disposal within cells from 200.8L d/s to 200L, avoid disposal u/s of 200.8L	25.323	15.185	-10.138	15.185	-10.138	$0.00	$0.00	402.274	12.10%	$0.00	15.185	$0.00
204.6-205.1R	Utilize in-channel disposal (gravel)	18.615	13.204	-5.411	13.204	-5.411	$0.00	$0.00	415.478	12.49%	$0.00	13.204	$0.00
232R	No adverse impact, bank stabilization is needed at this area	0.364	0.364	0.000	0.349	-0.015	$0.00	$0.00	415.827	12.50%	$0.00	0.349	$0.00
233L	Utilize land disposal in AR233.0L-D if needed	0.000	0.000	0.000	0.000	0.000	$0.00	$0.00	415.827	12.50%	$0.00	0.000	$0.00
236.6L	Utilize this site for disposal	0.000	0.000	0.000	0.000	0.000	$0.00	$0.00	415.827	12.50%	$0.00	0.000	$0.00
239.5R	239RB-Maintain fish access through revetment. Modified revetment along RB will have no adverse impacts	27.373	27.373	0.000	26.266	-1.107	$0.00	$0.00	442.093	13.29%	$0.00	26.266	$0.00
241.8-242.2R	Utilize this site for disposal	5.685	3.777	-1.907	0.000	-5.685	$0.00	$0.00	442.093	13.29%	$0.00	0.000	$0.00
243.8-246.8L	Avoid disposal (none currently scheduled) in AR245.6L-D, notch dike d/s of most d/s island at 244.5L	88.234	49.229	-39.005	49.229	-39.005	$0.00	$0.00	491.322	14.77%	$0.00	49.229	$0.00
249.7L	Alternative disposal site for AR248.0R-D	0.874	0.487	-0.386	-0.060	-0.933	$0.00	$0.00	491.262	14.77%	$0.00	-0.060	$0.00
254.1-254.5L	Alternative disposal site inside closed revetment at 254.1L, no previously approved disposal area indicated on map	0.728	0.406	-0.322	-0.193	-0.921	$0.00	$0.00	491.069	14.77%	$0.00	-0.193	$0.00
255.7-256.1R	Avoid, use AR256.2L-D for disposal instead of AR256.0R-D	1.467	0.975	-0.492	0.975	-0.492	$0.00	$0.00	492.044	14.79%	$0.00	0.975	$0.00

Table H1-1. Aquatic Mitigation Features – Arkansas Portion

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255.9-256.2L	Prefer to use this terrestrial area for disposal	0.000	0.000	0.000	0.000	0.000	$0.00	$0.00	492.044	14.79%	$0.00	0.000	$0.00
271.2-273R	Utilize this RB site for disposal	1.323	0.559	-0.763	-1.028	-2.351	$0.00	$0.00	491.016	14.76%	$0.00	-1.028	$0.00
278.9-280.3L	At AR279.5L-D avoid disposal in aquatic areas, utilize land within disposal area and AR280.0R-D,	131.189	85.914	-45.275	85.914	-45.275	$0.00	$0.00	576.930	17.35%	$0.00	85.914	$0.00
283.5-284.7R	Recommend constructing new disposal at 284R	1.746	0.738	-1.007	0.738	-1.007	$0.00	$0.00	577.668	17.37%	$0.00	0.738	$0.00
284.7-287.4	Avoid disposal in d/s cells on LB and RB, prefer disposal d/s in new area	46.658	19.733	-26.924	15.704	-30.954	$0.00	$0.00	593.372	17.84%	$0.00	15.704	$0.00
288.4-289L	Avoid disposal in AR289.0L-D and place dredged gravel along right bank downstream and extend downstream gravel bar at 289.7R	7.776	3.289	-4.487	-0.741	-8.517	$0.00	$0.00	592.631	17.82%	$0.00	-0.741	$0.00
288.8-289.8R	Utilize this alternative disposal area	6.348	2.685	-3.663	-1.345	-7.693	$0.00	$0.00	591.287	17.78%	$0.00	-1.345	$0.00
290.5-291.4R	Utilize dry cells in this disposal area	1.640	1.074	-0.566	0.000	-1.640	$0.00	$0.00	591.287	17.78%	$0.00	0.000	$0.00
291.8-292.3L	Avoid disposal at 292.3L	5.261	3.446	-1.816	3.446	-1.816	$0.00	$0.00	594.732	17.88%	$0.00	3.446	$0.00
189.2	189.2 - Notch revetment and dikes for fish passage and access to backwater	67.852	67.852	0.000	88.160	20.309	$726.00	$8.23	682.893	20.53%	$726.00	88.160	$8.23
187.2R	Notch long L-dike at 187.2R (2)	82.208	82.208	0.000	82.208	0.000	$726.00	$8.83	765.101	23.00%	$1,452.00	82.208	$8.83
283.1-283.9L	283.9L - Notch modified revetment in upper cell (High priority)	21.579	21.579	0.000	41.715	20.135	$726.00	$17.40	806.815	24.26%	$2,178.00	41.715	$17.40
135-138.2R	Avoid disposal in aquatic areas, utilize island disposal, (*potential existing tern site), notch two lower dikes	86.607	72.621	-13.987	81.698	-4.909	$1,452.00	$17.77	888.513	26.72%	$3,630.00	81.698	$17.77
24-25L	Notch modified revetment (2)	92.917	92.917	0.000	118.441	25.524	$2,178.00	$18.39	1006.954	30.28%	$5,808.00	118.441	$18.39

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	and modified dike (1)												
134.5R	Notch existing dike (1) at 134.7R for fish passage and access to Mill Bayou	35.402	35.402	0.000	35.402	0.000	$726.00	$20.51	1042.356	31.34%	$6,534.00	35.402	$20.51
235-236.8R	Notch existing dike and raised dike (2-3) in AR236.0R-D, place dredged material on existing islands within disposal area	105.624	70.187	-35.437	100.346	-5.278	$2,178.00	$21.70	1142.702	34.36%	$8,712.00	100.346	$21.70
238.5-241.2	Maintain and/or notch existing and modified dikes (3)	74.279	74.279	0.000	96.925	22.646	$2,178.00	$22.47	1239.627	37.27%	$10,890.00	96.925	$22.47
279-280.1L	Notch modified revetment at 279L and 280.2L to maintain high value for backwater area	67.644	67.644	0.000	91.534	23.890	$2,178.00	$23.79	1331.161	40.02%	$13,068.00	91.534	$23.79
58.3L	Notch revetment at 58.3L	17.112	17.112	0.000	28.093	10.981	$726.00	$25.84	1359.254	40.87%	$13,794.00	28.093	$25.84
180.2R	Notch existing dike at 180.2R for fish passage and access to backwater	15.414	15.414	0.000	22.889	7.475	$726.00	$31.72	1382.143	41.56%	$14,520.00	22.889	$31.72
134.2R	Notch existing revetment (1) at 134.2R and	13.247	13.247	0.000	22.012	8.765	$726.00	$32.98	1404.155	42.22%	$15,246.00	22.012	$32.98
305.3-306R	Notch revetment at 305.7 and 306R	24.497	24.497	0.000	38.550	14.054	$1,278.00	$33.15	1442.705	43.38%	$16,524.00	38.550	$33.15
32L	Notch revetment (4) and existing dike (1)	84.322	84.322	0.000	107.485	23.163	$3,630.00	$33.77	1550.190	46.61%	$20,154.00	107.485	$33.77
100.3-101.1L	Notch existing dikes (2), *Existing tern island on LB, avoid work during nesting season	39.718	39.718	0.000	39.718	0.000	$1,452.00	$36.56	1589.908	47.80%	$21,606.00	39.718	$36.56
19.8L	Notch existing revetment (1)	9.505	9.505	0.000	16.963	7.458	$726.00	$42.80	1606.871	48.31%	$22,332.00	16.963	$42.80
27.8-28.5L	Notch modified revetment (1) and existing dike (1)	33.116	22.641	-10.474	32.256	-0.859	$1,452.00	$45.01	1639.127	49.28%	$23,784.00	32.256	$45.01
275.2-276.6R	Notch dikes (2) that connect to shoreline	31.740	31.740	0.000	31.740	0.000	$1,452.00	$45.75	1670.867	50.24%	$25,236.00	31.740	$45.75
39.8L	Notch modified revetment at	24.469	24.469	0.000	31.190	6.722	$1,452.00	$46.55	1702.057	51.18%	$26,688.00	31.190	$46.55

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Nav. Mile	Project	Future without Project AAHUs	Total AAHUs with 12-ft Project	AAHUs Affected by 12-ft Project	Total AAHUs with Mitigated 12-ft Project	Change in Mitigated 12-ft AAHUs Relative to Baseline (1)	Cost	Cost Per AAHU	Running Total AAHUs	Percent Mitigation	Running Total Cost	Incremental Change in AAHUs	Incremental Cost
	39.3L and 39.7L												
148.7-150.4R	Avoid disposal, notch dike at 149R	22.383	13.179	-9.204	13.537	-8.846	$726.00	$53.63	1715.594	51.58%	$27,414.00	13.537	$53.63
290R	Notch existing dike if feasible	13.490	13.490	0.000	13.490	0.000	$726.00	$53.82	1729.084	51.99%	$28,140.00	13.489	$53.82
238.5-239.9L	*Existing tern island at 239.5L, avoid disposal in AR238.5L-D, alternately use 240.1-241.0 L, investigate terrestrial disposal, create and/or extend island, notch land side of dikes, do not cut off backwater at 241.1L	89.120	59.221	-29.900	78.331	-10.790	$4,303.93	$54.95	1807.414	54.34%	$32,443.93	78.331	$54.95
70.0-70.7L	Notch two longest existing dikes (2)	14.815	14.815	0.000	23.203	8.387	$1,452.00	$62.58	1830.617	55.04%	$33,895.93	23.203	$62.58
37.5-38.6L	Notch raised L-dikes	10.671	10.671	0.000	10.671	0.000	$726.00	$68.04	1841.288	55.36%	$34,621.93	10.671	$68.04
242-244.1L	Avoid disposal in AR242.2L-D at entrance to Hartman Lake, utilize AR241.8R-D and AR244.0R-D if needed, deepen notch in modified revetment	12.531	8.327	-4.204	9.118	-3.413	$726.00	$79.63	1850.405	55.64%	$35,347.93	9.118	$79.63
142.5-143.4R	Notch modified dikes (2) at entrance to beaver dam channel for flow-through	11.991	11.991	0.000	18.217	6.226	$1,452.00	$79.71	1868.622	56.19%	$36,799.93	18.217	$79.71
27.5-29R	Notch modified dikes (4) and existing dike (1)	43.173	29.517	-13.656	42.052	-1.120	$3,630.00	$86.32	1910.675	57.45%	$40,429.93	42.052	$86.32
31.8-33.1L	Avoid LB disposal, utilize RB, notch modified revetment (4) and existing dike (1) across backwater	38.022	25.995	-12.026	29.703	-8.319	$3,630.00	$122.21	1940.377	58.34%	$44,059.93	29.703	$122.21
189.9.190.5L	Notch modified revetment in two places (2)	13.525	13.525	0.000	10.995	-2.530	$1,452.00	$132.06	1951.372	58.67%	$45,511.93	10.995	$132.06
101.5-103.7L	Avoid disposal, notch existing dikes (10-12) for flow-through and to enhance	82.702	54.599	-28.102	54.599	-28.102	$7,260.00	$132.97	2005.971	60.31%	$52,771.93	54.599	$132.97

Table H1-1. Aquatic Mitigation Features – Arkansas Portion

Nav. Mile	Project	Future without Project AAHUs	Total AAHUs with 12-ft Project	AAHUs Affected by 12-ft Project	Total AAHUs with Mitigated 12-ft Project	Change in Mitigated 12-ft AAHUs Relative to Baseline (1)	Cost	Cost Per AAHU	Running Total AAHUs	Percent Mitigation	Running Total Cost	Incremental Change in AAHUs	Incremental Cost
	diversity												
105.2-106.0L	*Existing tern island(s), avoid work during nesting season, construct high water notches in dikes (4) to restore and maintain islands	2.162	2.162	0.000	21.582	19.420	$2,904.00	$134.56	2027.554	60.96%	$55,675.93	21.582	$134.56
280.6-280.9	280.8L - Notch modified dikes (3)	11.850	11.850	0.000	16.034	4.185	$2,178.00	$135.83	2043.588	61.45%	$57,853.93	16.034	$135.83
161.2-162.2L	Notch existing dikes (3-4) from 161.2-162.2L	13.337	13.337	0.000	20.621	7.284	$2,904.00	$140.83	2064.209	62.07%	$60,757.93	20.621	$140.83
275-276L	Notch modified dikes (3)	10.157	10.157	0.000	13.744	3.587	$2,178.00	$158.47	2077.953	62.48%	$62,935.93	13.744	$158.47
48.7-50.2R	Utilize land within cells for disposal in 49.4R-D, avoid aquatic areas, notch existing revetments/dikes in two most u/s cells (2)	5.118	4.524	-0.594	8.593	3.475	$1,452.00	$168.97	2086.546	62.74%	$64,387.93	8.593	$168.97
64-65R	Avoid disposal in AR64.5R-D, notch existing revetments and/or dikes (3)	11.677	8.794	-2.882	12.105	0.428	$2,178.00	$179.93	2098.651	63.10%	$66,565.93	12.105	$179.93
150-151.7L	Avoid disposal from 150-151L that would block side channel and backwater entrance, construct a series of tern islands where feasible, notch existing dike at 150.8L for fish passage and backwater entrance	62.810	36.983	-25.827	76.463	13.653	$13,805.40	$180.55	2175.113	65.40%	$80,371.33	76.463	$180.55
145.2-146.2L	Notch modified dikes (7)	17.130	17.130	0.000	26.566	9.436	$5,082.00	$191.30	2201.679	66.20%	$85,453.33	26.566	$191.30
113-114L	Notch underwater dikes on backside of islands (4)	9.040	9.040	0.000	14.853	5.813	$2,904.00	$195.51	2216.533	66.65%	$88,357.33	14.853	$195.51
38.8L	Avoid disposal, utilize RB, notch modified revetment	4.269	3.774	-0.496	3.652	-0.617	$726.00	$198.78	2220.185	66.76%	$89,083.33	3.652	$198.78
131.8-132.5R	Notch upper end of modified revetment (1)	3.540	3.540	0.000	3.540	0.000	$726.00	$205.07	2223.725	66.86%	$89,809.33	3.540	$205.07

Table H1-1. Aquatic Mitigation Features – Arkansas Portion

Nav. Mile	Project	Future without Project AAHUs	Total AAHUs with 12-ft Project	AAHUs Affected by 12-ft Project	Total AAHUs with Mitigated 12-ft Project	Change in Mitigated 12-ft AAHUs Relative to Baseline (1)	Cost	Cost Per AAHU	Running Total AAHUs	Percent Mitigation	Running Total Cost	Incremental Change in AAHUs	Incremental Cost
174.1-176.7R	Utilize land disposal on Lentz property, notch existing dikes (4))	7.943	6.905	-1.039	12.314	4.370	$2,904.00	$235.84	2236.039	67.23%	$92,713.33	12.314	$235.84
43.4-44.1L	Avoid disposal in LB aquatic areas, utilize land and RB disposal, notch existing dikes/revetments (3)	10.388	9.182	-1.206	9.182	-1.206	$2,178.00	$237.20	2245.221	67.51%	$94,891.33	9.182	$237.20
82.5-85.5R	Notch existing dikes along RB (14)	23.570	23.570	0.000	37.968	14.398	$10,164.00	$267.70	2283.189	68.65%	$105,055.33	37.968	$267.70
126.7-127.4L	Utilize LB for disposal and notch modified dikes (4)	3.609	3.026	-0.583	10.734	7.125	$2,904.00	$270.54	2293.923	68.97%	$107,959.33	10.734	$270.54
165.8-167.0L	Avoid aquatic disposal, dispose on land within cells, notch existing revetment (4)	9.262	6.574	-2.688	10.718	1.456	$2,904.00	$270.94	2304.642	69.30%	$110,863.33	10.718	$270.94
91.4-91.7R	Recommend constructing island downstream at 90.5-91.0L behind underwater revetment, if proposed location must be utilized, place disposal off bank and create island(s) and notch backside of existing dikes	29.788	17.635	-12.154	28.207	-1.581	$7,669.67	$271.91	2332.849	70.14%	$118,533.00	28.207	$271.91
122.9-123.6R	Notch existing dikes (2-4) for flow-through and access	4.374	4.374	0.000	7.986	3.611	$2,178.00	$272.74	2340.834	70.38%	$120,711.00	7.986	$272.74
94	Notch existing revetment (1)	1.591	1.591	0.000	2.383	0.792	$726.00	$304.69	2343.217	70.45%	$121,437.00	2.383	$304.69
169.6-172L	Notch raised dike at 170.1L and existing dikes at 170.7L and 171L, utilize land within cells for disposal or create/enhance tern island, (*existing tern island)	45.727	32.455	-13.272	32.455	-13.272	$9,929.60	$305.95	2375.672	71.43%	$131,366.60	32.455	$305.95
251.8-253.8L	Notch dikes (5-10) on left and right bank up and downstream	14.982	14.982	0.000	22.545	7.563	$7,260.00	$322.02	2398.217	72.11%	$138,626.60	22.545	$322.02

Table H1-1. Aquatic Mitigation Features – Arkansas Portion

Nav. Mile	Project	Future without Project AAHUs	Total AAHUs with 12-ft Project	AAHUs Affected by 12-ft Project	Total AAHUs with Mitigated 12-ft Project	Change in Mitigated 12-ft AAHUs Relative to Baseline (1)	Cost	Cost Per AAHU	Running Total AAHUs	Percent Mitigation	Running Total Cost	Incremental Change in AAHUs	Incremental Cost
133.5-135.2L	Avoid aquatic disposal on LB, utilize land disposal on island or construct another island on RB, notch longest existing dike for flow-through (*potential existing tern site)	23.015	19.298	-3.717	15.561	-7.455	$5,327.80	$342.39	2413.778	72.58%	$143,954.40	15.561	$342.39
188.9-190.4L	*Existing least tern island, avoid disposal, notch raised revetment (1) and existing dike (1), utilize area upstream at 191R for disposal	40.705	28.873	-11.832	41.166	0.461	$14,600.00	$354.66	2454.944	73.81%	$158,554.40	41.166	$354.66
116.6-116.8R	Notch existing dikes 116.6 to 116.8R (2) *may have already been done	2.333	2.333	0.000	3.993	1.660	$1,452.00	$363.65	2458.936	73.93%	$160,006.40	3.993	$363.65
36-36.5L	Notch modified dikes (3) and existing dike (1)	7.727	7.727	0.000	7.727	0.000	$2,904.00	$375.83	2466.663	74.17%	$162,910.40	7.727	$375.83
82.6R	Notch existing dike and maintain entrance to backwater at 82.6R by periodically dredging	18.425	18.425	0.000	44.376	25.951	$17,388.00	$391.83	2511.039	75.50%	$180,298.40	44.376	$391.83
155.6R	Notch existing revetment (2)	2.056	2.056	0.000	3.416	1.360	$1,452.00	$425.10	2514.455	75.60%	$181,750.40	3.416	$425.10
31.7-32.8R	*Existing tern island – enhance/create islands where feasible and avoid June-August construction, utilize disposal area and extend d/s to NM 31.0R	27.474	18.784	-8.690	21.941	-5.533	$9,622.25	$438.56	2536.396	76.26%	$191,372.65	21.941	$438.56
193.6-195L	Notch existing dikes (5) in AR194.1L-D	5.475	3.283	-2.192	7.021	1.546	$3,630.00	$517.00	2543.417	76.47%	$195,002.65	7.021	$517.00
46.5-46.7L	Notch modified revetment (1)	1.227	1.227	0.000	1.227	0.000	$726.00	$591.93	2544.643	76.51%	$195,728.65	1.227	$591.93
80.0-82.0L	Place disposal along dike fields to create islands and notch backside of dikes (9) at 80-82L	10.786	10.786	0.000	10.786	0.000	$6,534.00	$605.81	2555.429	76.84%	$202,262.65	10.786	$605.81

Table H1-1. Aquatic Mitigation Features – Arkansas Portion

Nav. Mile	Project	Future without Project AAHUs	Total AAHUs with 12-ft Project	AAHUs Affected by 12-ft Project	Total AAHUs with Mitigated 12-ft Project	Change in Mitigated 12-ft AAHUs Relative to Baseline (1)	Cost	Cost Per AAHU	Running Total AAHUs	Percent Mitigation	Running Total Cost	Incremental Change in AAHUs	Incremental Cost
123.7L	Notch existing dike for access and fish passage	0.875	0.875	0.000	1.198	0.323	$726.00	$606.08	2556.627	76.87%	$202,988.65	1.198	$606.08
281.9-283.3L	Place disposal on lower end of disposal area on existing sand bars, construct islands where feasible, avoid disposal from 283.2-283.5L	33.481	21.926	-11.555	17.398	-16.082	$10,732.17	$616.85	2574.025	77.39%	$213,720.82	17.398	$616.85
244R	Utilize two downstream cells for disposal if needed and notch two existing upper dikes for fish passage and access	2.184	1.219	-0.965	2.323	0.139	$1,452.00	$625.10	2576.348	77.46%	$215,172.82	2.323	$625.10
48.7-48.9R	Notch modified dikes (4)	3.496	3.496	0.000	4.456	0.960	$2,904.00	$651.74	2580.804	77.60%	$218,076.82	4.456	$651.74
45.4-47.3R	Construct islands where feasible in AR46.5R-D, utilize two most d/s cells for disposal first, notch dikes/revetments (4-8)	32.255	28.511	-3.744	28.511	-3.744	$19,244.50	$674.99	2609.315	78.46%	$237,321.32	28.511	$674.99
35.3-36.5L	*Existing tern island – enhance/create islands where feasible and avoid June-August construction	13.803	12.201	-1.602	28.469	14.666	$19,244.50	$675.98	2637.784	79.31%	$256,565.82	28.469	$675.98
42.8-44.6R	Notch existing and modified dikes (10-12)	10.671	10.671	0.000	10.671	0.000	$7,260.00	$680.38	2648.454	79.63%	$263,825.82	10.671	$680.38
117.1-117.7R	Notch existing dikes (3)	1.750	1.750	0.000	3.194	1.445	$2,178.00	$681.84	2651.648	79.73%	$266,003.82	3.194	$681.84
98.5R	Notch existing revetment to access backwater (1)	0.637	0.637	0.000	0.953	0.317	$726.00	$761.72	2652.602	79.76%	$266,729.82	0.953	$761.72
94.3-96.3L	Avoid aquatic disposal in uppermost cells of AR95.5L-D, extend disposal area d/s to create a series of islands for a braided system and terns, notch existing dikes (5) to enhance backwater areas	65.750	43.408	-22.342	60.160	-5.591	$46,017.99	$764.93	2712.761	81.57%	$312,747.81	60.160	$764.93
23-24L	Construct string of islands	15.938	14.088	-1.850	18.468	2.530	$14,433.38	$781.54	2731.229	82.12%	$327,181.19	18.468	$781.54

Table H1-1. Aquatic Mitigation Features – Arkansas Portion

Nav. Mile	Project	Future without Project AAHUs	Total AAHUs with 12-ft Project	AAHUs Affected by 12-ft Project	Total AAHUs with Mitigated 12-ft Project	Change in Mitigated 12-ft AAHUs Relative to Baseline (1)	Cost	Cost Per AAHU	Running Total AAHUs	Percent Mitigation	Running Total Cost	Incremental Change in AAHUs	Incremental Cost
181.8-184.9R	Notch existing and raised dikes (8-10) and create a series of islands for braided system and terns	37.027	26.265	-10.763	36.261	-0.767	$30,269.00	$834.76	2767.490	83.21%	$357,450.19	36.261	$834.76
23-24L	Construct string of islands	13.282	11.740	-1.542	15.390	2.108	$14,433.38	$937.84	2782.880	83.67%	$371,883.57	15.390	$937.84
99.4L	Notch existing revetment to access backwater (1)	0.382	0.382	0.000	0.635	0.254	$726.00	$1,142.58	2783.515	83.69%	$372,609.57	0.635	$1,142.58
164.5-165.2L	165 - Notch on upstream end of revetment for flow in and out of Plummerville cutoff, and notch raised dikes (3), maintain entrance by periodically dredging	29.056	29.056	0.000	43.676	14.620	$50,500.00	$1,156.24	2827.192	85.01%	$423,109.57	43.676	$1,156.24
275.7-276.4R	Notch modified dikes (2) that connect to shoreline and extend RB disposal downstream within dike field	1.913	1.253	-0.660	1.253	-0.660	$1,452.00	$1,158.90	2828.444	85.04%	$424,561.57	1.253	$1,158.90
169.4-169.7L	Notch raised dikes (4)	1.799	1.799	0.000	2.434	0.635	$2,904.00	$1,192.90	2830.879	85.12%	$427,465.57	2.434	$1,192.90
42.3-43.3L	Construct islands and notch existing (3) dikes	4.743	4.193	-0.551	17.920	13.177	$21,422.50	$1,195.45	2848.799	85.66%	$448,888.07	17.920	$1,195.45
22.8R	Maintain entrance to Coal Pile by periodically dredging	118.280	118.280	0.000	140.595	22.315	$193,784.00	$1,378.32	2989.393	89.88%	$642,672.07	140.595	$1,378.32
61.0-62.1L	*Probable tern island on RB, avoid aquatic areas in AR61.4L-D, utilize land within disposal cells or enhance/create tern islands on RB	9.978	7.515	-2.463	6.913	-3.065	$9,622.25	$1,391.97	2996.306	90.09%	$652,294.32	6.913	$1,391.97
78.7L	Dredge mouth of Pastoria Bend chute and periodically dredge to maintain and notch existing dike (1) if needed to open access to backwater	11.504	11.504	0.000	21.621	10.116	$30,274.00	$1,400.23	3017.927	90.74%	$682,568.32	21.621	$1,400.23
38.8-39.6R	*Existing tern island, notch existing dikes (5) and enhance/construct tern islands	1.755	1.551	-0.204	13.651	11.896	$19,244.50	$1,409.77	3031.578	91.15%	$701,812.82	13.651	$1,409.77

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	where feasible												
50.9L	Maintain entrance to Swan Lake by periodically dredging	38.463	38.463	0.000	42.991	4.528	$61,202.00	$1,423.59	3074.569	92.44%	$763,014.82	42.991	$1,423.59
279-280.1R	Utilize AR280.0R-D for disposal and construction of string of islands, notch modified dikes (4) to create and maintain backwater channel	9.737	6.376	-3.360	7.423	-2.314	$10,732.17	$1,445.84	3081.992	92.67%	$773,746.99	7.423	$1,445.84
180.4-181.3R	Extend disposal area upstream to raised dike at 181.5R and dispose along bank downstream of dike, notch existing dikes (2)	5.285	3.169	-2.116	1.344	-3.940	$2,178.00	$1,619.94	3083.336	92.71%	$775,924.99	1.344	$1,619.94
273.7-276L	Avoid disposal in AR274.0L-D and AR275.0L-D, alternatively use RB disposal to create or enlarge islands,	6.559	4.296	-2.264	3.939	-2.621	$6,708.00	$1,703.11	3087.275	92.83%	$782,632.99	3.939	$1,703.11
46.2R	Notch modified revetment/dike (1)	0.368	0.368	0.000	0.368	0.000	$726.00	$1,973.09	3087.643	92.84%	$783,358.99	0.368	$1,973.09
78.9-79.7L	79.0L - First option - Inquire about upland disposal on Pine Bluff Arsenal property first to avoid any impacts, second option - investigate island disposal upstream on LB at 80.1, third option to place in proposed location and notch modified dikes (4)	2.247	0.872	-1.375	1.243	-1.004	$2,904.00	$2,336.25	3088.886	92.88%	$786,262.99	1.243	$2,336.25
19.0R	Construct island	7.969	7.044	-0.925	7.044	-0.925	$19,244.50	$2,732.09	3095.930	93.09%	$805,507.49	7.044	$2,732.09
92.6L	Notch existing revetment (1) and maintain entrance to backwater by periodically dredging	3.310	3.310	0.000	6.195	2.885	$17,188.00	$2,774.41	3102.125	93.27%	$822,695.49	6.195	$2,774.41

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276.8-277.5R	Avoid backwater disposal in 277.0R-D, place disposal on land and d/s along bottom end to extend island	1.162	0.761	-0.401	0.761	-0.401	$2,236.00	$2,939.41	3102.886	93.30%	$824,931.49	0.761	$2,939.41
42.1-42.7L	*Existing tern island, use disposal to enhance/construct tern islands, notch backside of existing dikes to maintain flow and islands 42.5L	5.408	4.780	-0.628	6.259	0.851	$19,244.50	$3,074.71	3109.145	93.48%	$844,175.99	6.259	$3,074.71
168.7-169.5L	Utilize AR169.4R-D for disposal first, AR169.0L-D second, construct tern islands where feasible	1.426	1.240	-0.186	4.205	2.779	$13,148.00	$3,126.82	3113.350	93.61%	$857,323.99	4.205	$3,126.82
146.5-147.5L	* Existing tern island – enhance/construct a series of islands along LB where feasible, notch dikes (5), move disposal from LB to RB for excess disposal	5.448	4.568	-0.880	7.273	1.826	$23,009.00	$3,163.52	3120.623	93.83%	$880,332.99	7.273	$3,163.52
110.4	Install culvert through structure at Willow Beach Lake for fish passage	27.191	27.191	0.000	46.537	19.346	$156,898.00	$4,472.00	3167.160	95.23%	$1,037,230.99	46.537	$4,472.00
90.5-91.0L	Construct island(s) at 90.5-91.0L behind underwater revetment	2.673	1.583	-1.091	1.583	-1.091	$7,669.67	$4,472.00	3168.742	95.28%	$1,044,900.66	1.583	$4,472.00
42.8-43R	Utilize this disposal area, notch existing and modified dikes (10-12) and extend disposal u/s	1.423	1.258	-0.165	1.258	-0.165	$7,260.00	$5,771.83	3170.000	95.31%	$1,052,160.66	1.258	$5,771.83
70.6L	Maintain channel to backwater by periodically dredging	12.583	12.583	0.000	14.939	2.356	$88,053.00	$5,894.16	3184.939	95.76%	$1,140,213.66	14.939	$5,894.16
132.2L	Maintain entrance to Rector Chute by periodically dredging	13.082	13.082	0.000	15.532	2.450	$91,787.00	$5,909.43	3200.471	96.23%	$1,232,000.66	15.532	$5,909.43

Table H1-1. Aquatic Mitigation Features – Arkansas Portion

Nav. Mile	Project	Future without Project AAHUs	Total AAHUs with 12-ft Project	AAHUs Affected by 12-ft Project	Total AAHUs with Mitigated 12-ft Project	Change in Mitigated 12-ft AAHUs Relative to Baseline (1)	Cost	Cost Per AAHU	Running Total AAHUs	Percent Mitigation	Running Total Cost	Incremental Change in AAHUs	Incremental Cost
169.2-169.8R	Utilize AR169.4R-D for disposal first, AR169.0L-D second, construct tern islands where feasible	2.506	2.179	-0.328	2.179	-0.328	$13,148.00	$6,034.83	3202.650	96.30%	$1,245,148.66	2.179	$6,034.83
243.7-244.2L	Notch revetment and dike at u/s end to Hartman lake to allow flow-through and fish passage	16.727	16.727	0.000	51.738	35.011	$321,000.00	$6,204.31	3254.388	97.85%	$1,566,148.66	51.738	$6,204.31
285.6-286.2L	Extend disposal area to 286.2L dike, place disposal behind dikes on LB from 286.2-285.6L to create islands and maintain gravel instream, notch modified (2) and existing (2) dikes	7.036	2.976	-4.060	0.974	-6.062	$6,708.00	$6,887.38	3255.362	97.88%	$1,572,856.66	0.974	$6,887.38
75.3L	Maintain channel to backwater by periodically dredging	2.022	2.022	0.000	2.401	0.379	$16,662.00	$6,939.85	3257.763	97.95%	$1,589,518.66	2.401	$6,939.85
44.6L	Maintain a 1/2 mile boating lane at the entrance to Little Bayou Meto (44.6L) and 1/2 mile lane at u/s end of Bayou Meto by periodically dredging	28.100	28.100	0.000	33.401	5.301	$237,977.00	$7,124.87	3291.164	98.96%	$1,827,495.66	33.401	$7,124.87
222.5R	Construct islands along RB if feasible	0.000	0.000	0.000	0.000	0.000	$7,155.86	$7,155.86	3291.164	98.96%	$1,834,651.52	0.000	$7,155.86
225.5L	Construct islands along LB if feasible	0.000	0.000	0.000	0.000	0.000	$7,155.86	$7,155.86	3291.164	98.96%	$1,841,807.38	0.000	$7,155.86
88.2R	Maintain entrance to Tar Camp Creek by periodically dredging	8.987	8.987	0.000	10.694	1.708	$96,892.00	$9,060.02	3301.858	99.28%	$1,938,699.38	10.694	$9,060.02
276.0R	Maintain entrance to Courthouse Slough by periodically dredging	7.046	7.046	0.000	8.299	1.253	$91,787.00	$11,059.37	3310.158	99.53%	$2,030,486.38	8.299	$11,180.00
102-104R	Utilize RB disposal as alternative, construct/enhance tern islands if feasible	5.283	3.128	-2.155	3.128	-2.155	$30,678.66	$11,180.00	3313.285	99.62%	$2,061,165.04	3.128	$9,809.31

Table H1-1. Aquatic Mitigation Features – Arkansas Portion

Nav. Mile	Project	Future without Project AAHUs	Total AAHUs with 12-ft Project	AAHUs Affected by 12-ft Project	Total AAHUs with Mitigated 12-ft Project	Change in Mitigated 12-ft AAHUs Relative to Baseline (1)	Cost	Cost Per AAHU	Running Total AAHUs	Percent Mitigation	Running Total Cost	Incremental Change in AAHUs	Incremental Cost
158.8-159.2R	Utilize existing island for disposal and/or construct tern islands	2.382	1.690	-0.691	-0.076	-2.458	$1,000.00	$13,122.35	3313.209	99.62%	$2,062,165.04	-0.076	$13,122.35
15.3R	Reconnect Lower Merrisach Lake to Canal with culvert or water control structure for fish passage	22.055	22.055	0.000	26.216	4.161	$356,639.00	$13,603.96	3339.425	100.41%	$2,418,804.04	26.216	$356,639.00
*227.2,229,230,233.5,233.3, 234	Construct islands where feasible in Lake Dardanelle	0.000	0.000	0.000	0.000	0.000	$14,311.72	$14,311.72	3339.425	100.41%	$2,433,115.76	0.000	$14,311.72
**32.2R	Maintain entrance to oxbow lake by avoiding disposal and periodically dredging	2.146	2.146	0.000	2.041	-0.105	$39,111.00	$19,162.20	3341.466	100.47%	$2,472,226.76	2.041	$19,162.20
*61.5-62.5R	Place disposal in string of islands along RB	3.280	1.839	-1.441	0.758	-2.521	$19,244.50	$25,373.60	3342.225	100.49%	$2,491,471.26	0.758	$25,373.60
**71.3L	Dredge canals at Lake Langhofer	5.618	5.618	0.000	7.239	1.622	$299,844.00	$41,418.56	3349.464	100.71%	$2,791,315.26	7.239	$41,418.56
**110.4L	Install culvert through land mass at Willow Beach Park to connect oxbow lake to river	3.263	3.263	0.000	5.584	2.321	$320,272.00	$57,351.03	3355.048	100.88%	$3,111,587.26	5.584	$57,351.03
***131.0L	Dredge upper end of Rector Brake to improve habitat	5.139	5.139	0.000	8.136	2.997	$533,708.00	$65,602.34	3363.184	101.12%	$3,645,295.26	8.136	$65,602.34
***116.2R	Dredge backwater at 116.2R	0.350	0.350	0.000	0.733	0.383	$96,895.00	$132,145.16	3363.917	101.15%	$3,742,190.26	0.733	$132,145.16
		Mitigation Target HU											
Totals		3325.836	2728.237	-597.599	3363.917	38.081	$3,742,190.26						

Cut-off point for 100% mitigation (1) Negative numbers represent minimization of impacts by implementing mitigation measure. Island creation benefits T&E species

*** Features retained due to terrestrial and T&E species habitat improvement opportunities**

**** Features retained for contribution to environmental sustainability**

***** Mitigation Features dropped from consideration due to Incremental Cost Analysis (ICA)**

Table H1-2. Aquatic Mitigation Features – Oklahoma Portion

Nav. Mile	Project	Future without Project AAHUs	Total AAHUs with 12-ft Project	AAHUs Effected by 12-ft Project	Total AAHUs with Mitigated 12-ft Project	Change in Mitigated 12-ft AAHUs Relative to Baseline (1)	Cost	Cost Per AAHU	Running Total AAHUs	Percent Mitigation	Running Total Cost	Incremental Change in AAHUs	Incremental Cost
311.5-313.7	New Dikes, designed to maintain variable habitat (J-hook)	0.758	0.720	-0.038	2.034	1.276	$0.00	$0.00	$2.03	0.3863%	$0.00	2.034	$0.000
314.8-315.8	New & existing dikes LD recommend J-hook design	0.875	0.831	-0.044	1.445	0.570	$0.00	$0.00	$3.48	0.6607%	$0.00	1.445	$0.000
348.3	Add to existing island + riprap (beneficial use of dredge material)	15.941	6.444	-9.497	3.222	-12.719	$0.00	$0.00	$6.70	1.2726%	$0.00	3.222	$0.000
353.5-354.3	Restore bank, stabilize w/riprap (beneficial use of dredge material)	0.996	0.403	-0.594	0.403	-0.594	$0.00	$0.00	$7.10	1.3491%	$0.00	0.403	$0.000
355	Create 3 - 10 acre tern island w/riprap (beneficial use of dredge material)	12.011	4.855	-7.156	4.039	-7.972	$0.00	$0.00	$11.14	2.1162%	$0.00	4.039	$0.000
sbc 6.6	expand island, design to avoid impacts to mussels; height of disposal will be 1 - 2 ft below water surface (beneficial use of dredge material)	2.214	0.895	-1.319	0.895	-1.319	$0.00	$0.00	$12.04	2.2862%	$0.00	0.895	$0.000
sbc 6.9	expand island, design to avoid impacts to mussels; height of disposal will be 1 - 2 ft below water surface (beneficial use of dredge material)	2.214	0.895	-1.319	0.895	-1.319	$0.00	$0.00	$12.93	2.4561%	$0.00	0.895	$0.000
395 - 401.4	Impacts to Verdigris	9.000	0.000	-9.000	0.000	-9.000	$0.00	$0.00	$12.93	2.4561%	$0.00	0.000	$0.000
367.4	alternative disposal site for 367.5 - create tern island/w riprap	6.310	2.551	-3.759	2.551	-3.759	$0.00	$0.00	$15.48	2.9405%	$0.00	2.551	$0.000
392.1-393.0	Notch and design new dikes to create variable habitat, create tern island in middle cell	13.284	5.370	-7.914	5.126	-8.158	$0.00	$0.00	$20.61	3.9141%	$0.00	5.126	$0.000
393.8-394.6	Notch added dikes to avoid fill, design to minimize fill (J-hook)	9.686	9.201	-0.485	10.033	0.347	$0.00	$0.00	$30.64	5.8196%	$0.00	10.033	$0.000
401.4 - 421.7	Impacts to Verdigris	29.000	0.000	-29.000	0.000	-29.000	$0.00	$0.00	$30.64	5.8196%	$0.00	0.000	$0.000
421.7 - 445	Impacts to Verdigris	33.900	0.000	-33.900	0.000	-33.900	$0.00	$0.00	$30.64	5.8196%	$0.00	0.000	$0.000

Table H1-2. Aquatic Mitigation Features – Oklahoma Portion

Nav. Mile	Project	Future without Project AAHUs	Total AAHUs with 12-ft Project	AAHUs Effected by 12-ft Project	Total AAHUs with Mitigated 12-ft Project	Change in Mitigated 12-ft AAHUs Relative to Baseline (1)	Cost	Cost Per AAHU	Running Total AAHUs	Percent Mitigation	Running Total Cost	Incremental Change in AAHUs	Incremental Cost
379 - 380	dredge upper end of oxbow; maintain upper/lower openings to reconnect to backwater area	89.667	89.667	0.000	127.760	38.093	$10,000.00	$78.27	$158.40	30.0838%	$10,000.00	127.760	$78.272
408.9	dredge mouth of Billy Creek Cutoff to reconnect to backwater area	39.923	39.923	0.000	57.432	17.508	$5,000.00	$87.06	$215.83	40.9912%	$15,000.00	57.432	$87.060
320-321	Notch 3 interior dikes to create variable habitat	14.127	14.127	0.000	22.434	8.307	$2,190.00	$97.62	$238.27	45.2519%	$17,190.00	22.434	$97.620
321-323	Notch 5 dikes to create variable habitat	23.614	23.614	0.000	31.640	8.026	$3,650.00	$115.36	$269.91	51.2609%	$20,840.00	31.640	$115.361
310.4	Notch parallel dikes (1) for scour	3.033	3.033	0.000	5.972	2.939	$730.00	$122.24	$275.88	52.3950%	$21,570.00	5.972	$122.244
323-324	Notch 9 dikes to create variable habitat	33.576	33.576	0.000	45.702	12.126	$6,570.00	$143.76	$321.58	61.0747%	$28,140.00	45.702	$143.758
414.7	Dredge at culvert structure to reconnect backwater area	25.169	25.169	0.000	30.172	5.003	$5,000.00	$165.71	$351.75	66.8051%	$33,140.00	30.172	$165.715
326.7-328.1	Notch 7 dikes interior/exterior to create variable habitat	16.620	16.620	0.000	27.712	11.092	$5,110.00	$184.39	$379.47	72.0682%	$38,250.00	27.712	$184.394
309.8-310.3	Notch 4 dikes for scour to create variable habitat	6.999	6.999	0.000	14.700	7.701	$2,950.00	$200.69	$394.17	74.8599%	$41,200.00	14.700	$200.687
360.6	Notch 2 dike to create variable habitat	3.321	3.321	0.000	6.298	2.977	$1,460.00	$231.83	$400.46	76.0560%	$42,660.00	6.298	$231.832
442	Dredge lower end of oxbow to reconnect backwater area	6.365	6.365	0.000	6.365	0.000	$1,667.00	$261.92	$406.83	77.2648%	$44,327.00	6.365	$261.917
419.5	Dredge mouth of Bull Creek to reconnect tributary	9.836	9.836	0.000	14.150	4.314	$5,000.00	$353.36	$420.98	79.9521%	$49,327.00	14.150	$353.362
323.7 - 323.9	Notch 2 dikes to create variable habitat	2.909	2.909	0.000	4.041	1.133	$1,460.00	$361.26	$425.02	80.7196%	$50,787.00	4.041	$361.261
393.2 - 394.1	1st priority dispose in terrestrial cell, notch internal & lower end dikes to create variable habitat; 2nd priority dispose in dike cell above and below bridge.	15.111	6.108	-9.003	9.804	-5.307	$3,650.00	$372.30	$434.82	82.5816%	$54,437.00	9.804	$372.299
408.8	Dredge mouth of Strawberry Creek to reconnect tributary	6.654	6.654	0.000	7.977	1.323	$5,000.00	$626.83	$442.80	84.0965%	$59,437.00	7.977	$626.833
426.7	Dredge mouth of Commodore Creek to reconnect tributary	2.604	2.604	0.000	2.604	0.000	$1,667.00	$640.24	$445.40	84.5910%	$61,104.00	2.604	$640.243

Table H1-2. Aquatic Mitigation Features – Oklahoma Portion

Nav. Mile	Project	Future without Project AAHUs	Total AAHUs with 12-ft Project	AAHUs Effected by 12-ft Project	Total AAHUs with Mitigated 12-ft Project	Change in Mitigated 12-ft AAHUs Relative to Baseline (1)	Cost	Cost Per AAHU	Running Total AAHUs	Percent Mitigation	Running Total Cost	Incremental Change in AAHUs	Incremental Cost
439.7	Dredge lower end of oxbow to reconnect backwater area	2.314	2.314	0.000	2.314	0.000	$1,667.00	$720.27	$447.72	85.0306%	$62,771.00	2.314	$720.273
416.7	Dredge/rework culvert structure to reconnect to backwater area	35.295	35.295	0.000	42.311	7.016	$50,000.00	$1,181.73	$490.03	93.0662%	$112,771.00	42.311	$1,181.735
sbc 0.4	Aquatic disposal; create HQ marsh; variable depth 6-in - 2 ft; mussels will be protected from impacts resulting from disposal (beneficial use of dredge material	22.140	8.949	-13.191	13.424	-8.716	$35,000.00	$2,607.26	$503.45	95.6157%	$147,771.00	13.424	$2,607.263
418.8	Dredge/rework culvert structure to reconnect to backwater area	10.415	10.415	0.000	12.485	2.070	$50,000.00	$4,004.77	$515.94	97.9869%	$197,771.00	12.485	$4,004.768
sbc.4.8	Site will be designed to preserve mussel patch; aquatic disposal will only occur if mussels won't be impacted; create HQ marsh; variable depth 1 - 2 ft; (beneficial use of dredge material)	19.926	8.054	-11.872	8.054	-11.872	$35,000.00	$4,345.44	$523.99	99.5166%	$232,771.00	8.054	$4,345.438
383.2	Dredge mouth of Hopewell Creek to reconnect tributary	0.221	0.221	0.000	0.210	-0.011	$5,000.00	$23,775.03	$524.20	99.5565%	$237,771.00	0.210	$23,775.033
407	Dredge Upper/lower end Tullahassee Loop; rework culvert structure to reconnect backwater area	0.289	0.289	0.000	0.347	0.058	$55,000.00	$158,588.81	$524.55	99.6224%	$292,771.00	0.347	$158,588.811
398.8	Dredge upper/lower end Okay oxbow install culvert structure to reconnect to backwater area	0.221	0.221	0.000	0.263	0.041	$55,000.00	$209,220.29	$524.81	99.6723%	$347,771.00	0.263	$209,220.287
		Mitigation Target HU											
		526.537	**388.447**	**-138.090**	**524.812**	**-1.726**	**$347,771.00**						
		(1) Negative numbers represent minimization of impacts by implementing mitigation measure. Island creation benefits T&E species											