SECTION II - PROJECT DESCRIPTION

2.01 LOCATION

Clarence Cannon Dam and Mark Twain Lake are located on the Salt River in northeastern Missouri, generally in Monroe and Ralls Counties. The main dam site is located at mile 63.0 on the Salt River, about 12 miles southeast of Monroe City, in Ralls County, Missouri. A re-regulation dam is located 9.5 miles downstream from the main dam site. The project area is served on the north by U.S. Highway 24 and on the south by State Highway 154. State Highway 107 runs north and south through the project area, providing a major reservoir crossing near Florida, Missouri. State Highway J crosses the main dam and is a major north-south reservoir route on the east end of the lake.

2.02 LAKE DATA

a. Climatological Data. The climate of the area is considered moderate.

(1) Temperature. The summers are generally mild with occasional temperatures slightly in excess of 100 degrees Fahrenheit. Periods of extreme heat are usually short, if accompanied by sufficient rainfall. Winters are usually moderate, although periods of extremely cold weather are experienced. Weather changes and temperature fluctuations are frequent throughout the year with the extremes varying from 116 to -31 degrees Fahrenheit. Average temperatures by months during the recreation season in counties contiguous to the reservoir in degrees Fahrenheit are as follows: April 54^{o}, May 64^{o}, June 74^{o}, July 78^{o}, August 76^{o}, and September 68^{o}.

(2) Wind. The maximum wind movement occurs in March and the minimum in August. The average wind velocity is about 10.3 miles per hour. The prevailing winds over the basin are generally from the south.

(3) Humidity. The relative humidity varies from about 59 percent to 86 percent in the winter and from 51 percent to 89 percent during the remainder of the year.

(4) Precipitation. The annual average precipitation over the drainage area above the dam site is about 37.1 inches. Two-thirds of the annual rainfall normally occurs during the spring and summer, with local cellular storms occurring generally in July and August. Average annual snowfall amounts to about 21 inches and is usually limited to the period from November to March. The snow cover seldom lasts for more than a few days at a time.

b. Lake Shoreline, Length, and General Character. The topography at Mark Twain Lake reaches a maximum elevation of about 780 feet NGVD[1] in the southwestern portion of the project to a minimum of approximately 520 feet NGVD along the main stream of the Salt River. The North Fork, Middle Fork, Elk Fork and South Fork are the main tributaries of the Salt River within the project boundaries and have a maximum elevation of 675 feet NGVD in the western part of the project. The sides of the major valleys are dissected by short tributaries whose gradients extend from the flat uplands to the valley bottoms, and the divides between these tributaries form a continuous belt of hills along either side of the major valleys. The land adjoining the project is relatively flat farmland. The reservoir covers approximately 18,600 acres and has a shoreline of approximately 285 miles at the normal pool level of 606. The average depth of the pool at the 606 feet NGVD is 29 feet.

c. Project Structures. Project structures include components of the Clarence Cannon Dam and the Re-regulation Dam.

(1) Clarence Cannon Dam. Clarence Cannon Dam consists of a compacted earth embankment, a gated concrete spillway, a concrete hydroelectric power plant and a water temperature control weir. State Highway J crosses the top of the Dam. The total length of the dam is 1,940 feet with the centerline of the dam running in a near north-south direction. The concrete portion of the dam is 845.75 feet in length and it abuts the southern rim of the valley.

(a) Earth Embankment. The compacted earth embankment, which is topped by State Highway J, has a crest elevation of 653.0 NGVD. The embankment is about 1,094 feet in length.

(b) Spillway. The spillway is part of the concrete portion of the dam and is 230 feet in length. It begins 360 feet from the southern rim of the valley. The spillway is topped by four 50-foot wide by 39-foot high tainter gates separated by 10-foot wide piers. The spillway crest elevation is 600.0 feet NGVD. A 230-foot wide by 198.86-foot long stilling basin, with two rows of baffle piers and an end sill, is provided for the purpose of energy dissipation. The stilling basin floor is at elevation 508 feet NGVD.

(c) Power Plant. The power plant is part of the concrete portion of the dam and is located immediately north of the spillway. The power plant is 222.75 feet in length. The power plant contains a Kaplan 27,000-KW turbine generator and a Francis 31,000-KW pump turbine generator. The invert elevation of the intake structure is 520.0 feet NGVD. The invert elevation of the outlet structure is 483.0 feet NGVD.

[1] Note: All elevations cited are in terms of the National Geodetic Vertical Datum (NGVD)

(d) Water Temperature Control Weir. A water temperature control weir constructed of rolled earth is located 400 feet upstream of the centerline of the concrete portion of the dam. The crest elevation of the weir is 580.0 feet NGVD and is approximately 780 feet in length.

(2) Re-regulation Dam. The Re-regulation dam is located 9.5 miles downstream from the main dam and consists of a compacted earth embankment, a gated concrete spillway, a sluice and an operating house. The total length of the dam is 1,550 feet.

(a) Earth Embankment. The crest elevation of the compacted earth embankment is 537.0 feet NGVD. The embankment is 1430 feet in length.

(b) Spillway. The concrete spillway is 119.5 feet in length. The spillway is topped by two 32 by 31 foot-high tainter gates separated by an 8 foot wide pier. The spillway crest elevation is 499.0 feet NGVD. A 68 foot by 40 foot stilling basin with an end wall is provided for the purpose of energy dissipation. The stilling basin floor is at elevation 494.0 feet NGVD. The operating house is located at the west end of the spillway.

(3) Saddle Dams. Two small saddle dams are located just north of the entrance to the Frank Russell Recreation Area.

2.03 LAKE REGULATION

a. General Objective. The objective for regulating the Clarence Cannon Dam is to provide flood control, hydroelectric power generation, water supply, minimum releases for downstream water quality control, water temperature control for fish and wildlife, and recreation. There are also incidental benefits to Mississippi River navigation. The pool at elevation 606.0 feet NGVD retains one hundred percent of the joint-use storage for the other project purposes, namely hydroelectric power generation, water supply, water quality, recreation, and fish and wildlife enhancement and has one hundred percent of the flood-control pool for floodwater storage available. Figure 2-1 shows the duration of the pool elevation for the period of record, while Figure 2-2 shows the frequency curve using the annual peak lake elevations. The curve was created using Weibull plotting positions.

b. Reservoir Regulation and Hydroelectric Power Generation. Normal drawdown of the conservation pool resulting from power production will be limited throughout the year, with a more significant limitation during the crop season. The Southwestern Power Administration (SWPA), Department of Energy, schedules hydropower generation in cooperation with water control managers in the St. Louis District. The various levels of pool storage within Mark Twain Lake are defined below. Figure 2-3 shows the water control regulation diagram for the different pool elevations.

(1) The controlling release (i.e. maximum) release rate from the Re-regulation Pool is 12,000 cfs (cubic feet per second) during the dormant season (i.e. October through March), while the minimum release, at all times, is 50 cfs.

(2) During the crop season, the release rate from the Re-regulation Pool will normally vary between 50 cfs and 6,000 cfs. However, the release rate from the Main Dam may be as high as 12,000 cfs if the Mark Twain pool elevation is at or above 615.0 feet NGVD. The nature of hydroelectric power generation is such that the release rate from Cannon Dam will normally vary between 0 cfs and 12,000 cfs.

Figure 2-1

FREQUENCY AND DURATION OF DAILY OBSERVED STAGE
SALT RIVER AT MARK TWAIN LAKE
COMPUTED OVER YEARS 1984 TO 2001 BETWEEN DAYS 01JAN AND 31DEC

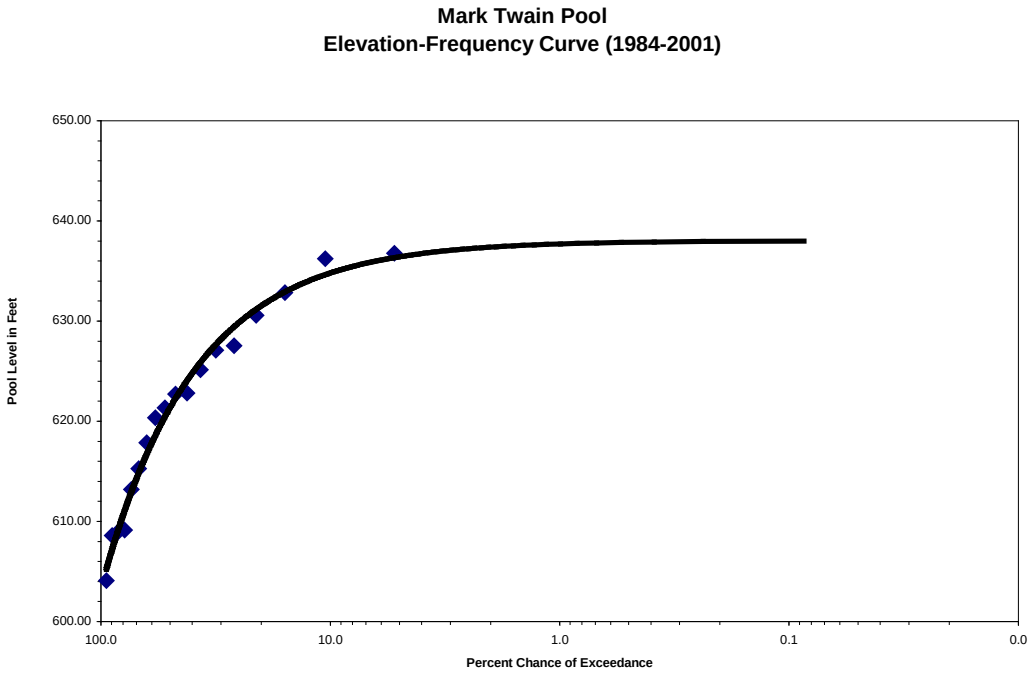
Level	Duration	Percent	Level	Duration	Percent
637	0	0.00	615	742	11.30
636	7	0.10	614	875	13.30
635	12	0.20	613	1008	15.30
634	24	0.40	612	1142	17.40
633	43	0.70	611	1287	19.60
632	55	0.80	610	1462	22.20
631	68	1.00	609	1671	25.40
630	90	1.40	608	1954	29.70
629	113	1.70	607	2447	37.20
628	129	2.00	606	3085	46.90
627	149	2.30	605	3584	54.50
626	174	2.60	604	4018	61.10
625	206	3.10	603	4400	66.90
624	252	3.80	602	4832	73.50
623	306	4.70	601	5396	82.10
622	348	5.30	600	5757	87.60
621	387	5.90	599	6029	91.70
620	421	6.40	598	6384	97.10
619	461	7.00	597	6474	98.50
618	514	7.80	596	6555	99.70
617	568	8.60		6573	100.00
616	629	9.60			

NOTE: 2 values (0.0%) missing from 6575 values in time interval

(a) The maximum release will be restricted to 2,000 cfs if the stage of the Mississippi River at Louisiana or at St. Louis is forecast to be at flood stage and the Mississippi River hydrograph is not on its recession side.

(b) In an attempt to prevent the Mark Twain Lake pool elevation from reaching 615.0 feet NGVD, which would automatically require a change in the maximum release to 12,000 cfs, the maximum release may be increased to 10,000 cfs under either of the conditions given below.

FIGURE 2-2



1. If the pool elevation is forecast to rise to 615.0 feet NGVD, it may be determined to increase the release up to 10,000 cfs after consultation with local downstream interests.

2. If the flood event is over and if favorable weather and river forecast conditions exist, the decision may be made to increase the release to 10,000 cfs after consultation with local downstream interests.

3. Every year, the Missouri Department of Conservation notifies the Corps of Engineers when the fish spawn begins. If conditions are favorable, the pool elevation of the lake will be monitored and controlled to minimize the amount of fluctuation. Ideally the pool is stabilized from 1 May to 15 June to enhance the fish spawn. For an example of this operation, see Figure 2-4.

FIGURE 2-3

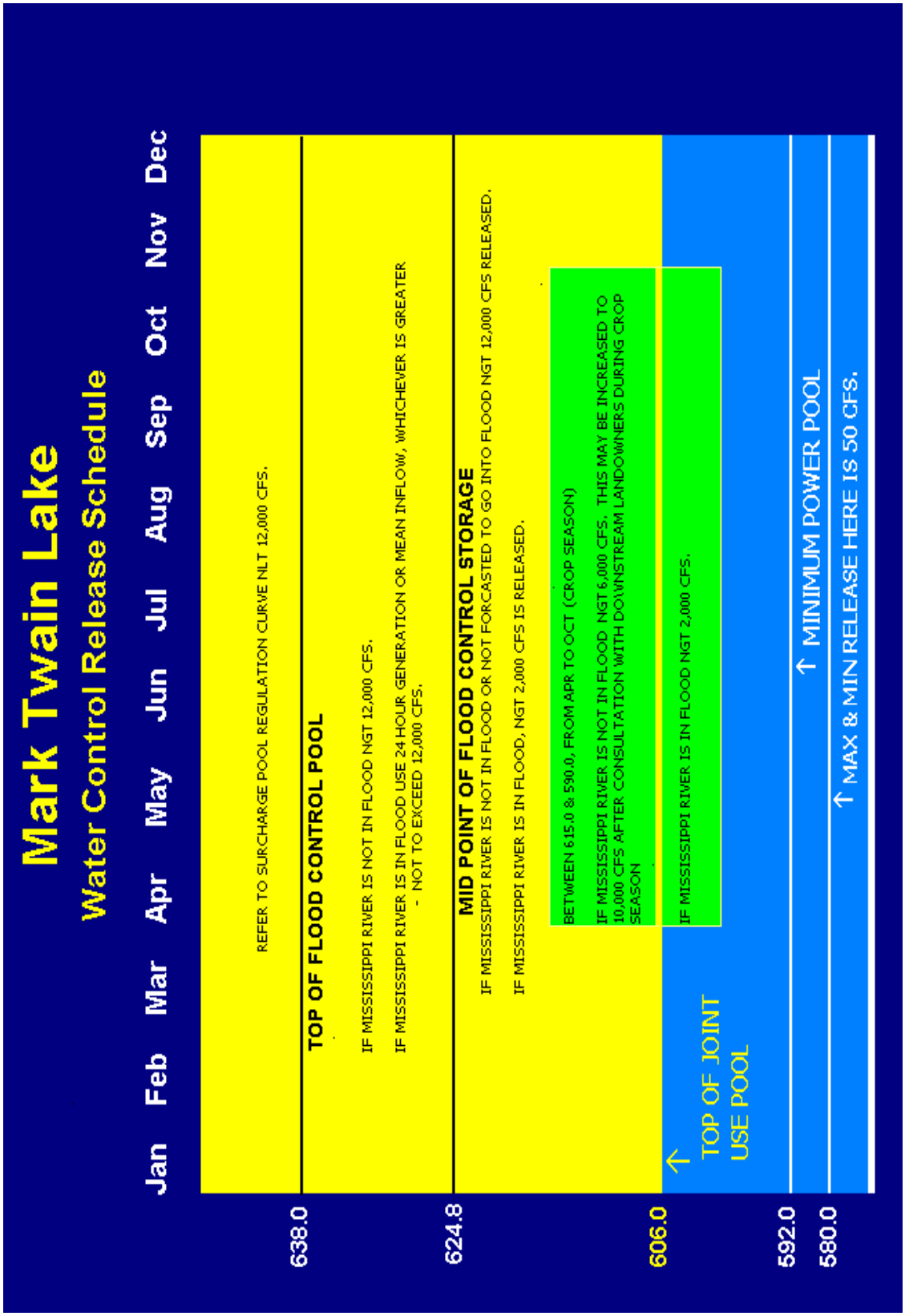
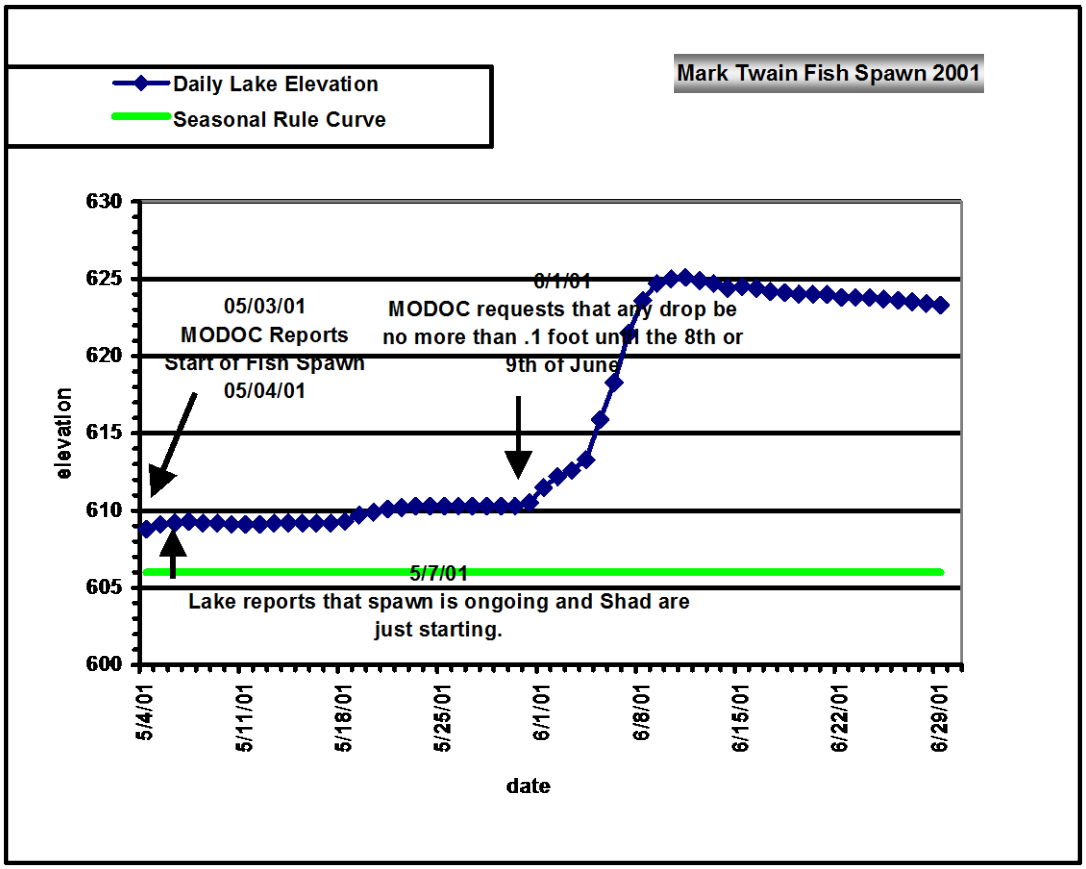

Mark Twain Lake
Water Control Release Schedule
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
638.0
624.8
606.0
592.0
580.0
REFER TO SURCHARGE POOL REGULATION CURVE NLT 12,000 CFS.
TOP OF FLOOD CONTROL POOL
IF MISSISSIPPI RIVER IS NOT IN FLOOD NGT 12,000 CFS.
IF MISSISSIPPI RIVER IS IN FLOOD USE 24 HOUR GENERATION OR MEAN INFLOW, WHICHEVER IS GREATER - NOT TO EXCEED 12,000 CFS.
MID POINT OF FLOOD CONTROL STORAGE
IF MISSISSIPPI RIVER IS NOT IN FLOOD OR NOT FORCASTED TO GO INTO FLOOD NGT 12,000 CFS RELEASED.
IF MISSISSIPPI RIVER IS IN FLOOD, NGT 2,000 CFS IS RELEASED.
BETWEEN 615.0 & 590.0, FROM APR TO OCT (CROP SEASON)
IF MISSISSIPPI RIVER IS NOT IN FLOOD NGT 6,000 CFS. THIS MAY BE INCREASED TO 10,000 CFS AFTER CONSULTATION WITH DOWNSTREAM LANDOWNERS DURING CROP SEASON
IF MISSISSIPPI RIVER IS IN FLOOD NGT 2,000 CFS.
↑ TOP OF JOINT USE POOL
↑ MINIMUM POWER POOL
↑ MAX & MIN RELEASE HERE IS 50 CFS.

FIGURE 2-4



MARK TWAIN LAKE WATER CONTROL VARIOUS POOLS DEFINITION

Inactive Pool (520-567.2 feet NGVD): 87,000 Acre-ft. Storage used to accommodate the effect of sedimentation in the lake.

Conservation Pool (567.2 – 606.0 feet NGVD): 457,000 Acre-ft. Storage used to provide for hydropower, water supply (20,000 Acre-ft.), fish and wildlife conservation, recreation, water quality enhancement, and incidental navigation on the Mississippi River.

Hydroelectric Pool (592.0-606.0 feet NGVD): No set storage allocation. This is a subset of the conservation pool and is defined solely by elevation.

Flood Control Pool (lower) (606.0 – 624.8 feet NGVD): 442,000 acre-ft (3.58 inches of runoff). Storage set aside to provide flood damage reduction on the lower Salt River and the Upper Mississippi River.

Flood Control Pool (upper) (624.8 – 638.0 feet NGVD): 442,000 acre-ft (3.58 inches of runoff). Storage set aside to provide flood damage reduction on the lower Salt River and the Upper Mississippi River.

Induced Surcharge Pool (638.0 –642.0): 164,700 acre-ft (1.33 inches of runoff). This is a subset of the entire surcharge pool. Storage set aside to allow discharge to increase up to inflow or spillway capacity (gates out of the water).

Surcharge Pool (638.0 – 648.0): 433,800 acre-ft (3.51 inches of runoff). After the induced surcharge pool has been used this storage passes the spillway design flood (Peak inflow = 476,000 cfs, peak outflow 276,500 cfs).

Freeboard (648.0 –653.0): 257,120 acre-ft (2.08 inches of runoff). The storage needed to prevent wave wash from overtopping the dam.

c. Water Quality Regulation. A minimum release of approximately 50 cfs will be maintained at all times through the Re-regulation Dam, regardless of the Mark Twain Lake pool elevation, to ensure satisfactory downstream water quality conditions.

d. Flood Control and Hydropower Interface.

Flood Control. The objective is to provide a high degree of protection for areas along the Salt River and the Mississippi River downstream of the project. The two components of this project (Cannon Dam and the Re-regulation Dam) will be regulated as one project. The average releases from the flood control pool will normally vary between 2,000 and 12,000 cfs. The release depends upon the pool elevation of Mark Twain Lake, the inflow rate, the downstream runoff, the stages on the Lower Salt River and on Spencer Creek, and the stages on the Mississippi River at Louisiana and at St. Louis. However, the release may be temporarily reduced to 50 cfs in the event of an emergency or other unusual condition. An unusual condition may include threats to the safety of human life or to the integrity of the project, inspection and maintenance of the project, or maintaining a constant pool elevation during fish spawning season. When the pool elevation is above 606.0 feet, the portion of the flood release that can be used for power generation will be passed through the penstocks and the remainder of the release will be passed through the spillway.

During the growing season (i.e., April through October), the flood release will normally be 6,000 cfs or less until elevation 615.0 is exceeded. When practical, the growing season shall be considered to be in effect when a significant amount of crops are in the field as determined by consultation with local farming interests. Releases may be restricted because of the flooding on the Lower Salt River or on the Mississippi River at Louisiana or at St. Louis.

A limited amount of storage, approximately 1510 dsf (day-second-feet or daily average of cfs), is provided in the Re-regulation Pool between elevations 521.0 feet and 528.0 feet. This storage is used to attenuate releases from Mark

Twain Lake, to store releases from Mark Twain Lake for pumpback operations, and to provide water quality releases. Operation of the Re-regulation Dam must be coordinated closely with Mark Twain Lake releases and with local inflow to the Re-regulation Pool. The outflow from the Re-regulation Pool does not need to be maintained at a constant rate.

Hydroelectric power. The objective is to obtain the maximum amount of power generation revenue the project is capable of producing without conflicting with the achievement of other project purposes. When within the conservation pool, hydroelectric power will be scheduled so as to meet the needs of SWPA. Normal lake drawdown within the conservation pool as the result of power production will be limited to 2.0 feet per calendar week (i.e., Sunday through Saturday) or 4.0 feet per month (i.e., any consecutive four calendar week period) during May through October. During the remainder of the year, normal lake drawdown will be limited to 2.0 feet per week with no monthly maximum. Care will be taken to meet the power needs of SWPA everyday, but final control always rests with the Regulating Office. Cannon Dam Power Plant was designed to produce 58,000 KW of electrical power (installed capacity) as a peaking plant.

2.04 VISITATION DATA.

a. General. Visitation at the Clarence Cannon Dam and Mark Twain Lake project has been estimated since 1984 by the use of traffic counters and statistical analysis based on visitor use surveys. Visitation was estimated in recreation days until 1991. Then, the Visitor Estimation Reporting System (VERS) was installed at the lake project to administer visitation reporting. Two of the important units of measurement in VERS are visitor hours and visits.

Visitor hours represent the presence of one of more persons recreating on land or water for periods of time aggregating to sixty minutes. It takes into consideration the number of participants and duration of stay and provides a good estimate of the amount of use.

Visits are simply a ‘head count’ of visitors to a project or recreation area but do not reflect the amount of use or length of stay. It represents the entry of one person into a recreation area or site to carry on one or more recreation activities.

A recreation day is similar to a visit but reflects the duration of the visit in days. It is the unit of measure for determining recreation benefits at water resource development projects, but has not been officially used by the Corps since 1991.

b. Past and Current Visitation. Visitation to Clarence Cannon Dam and Mark Twain Lake increased dramatically until the late 1980s, when it began to level off around 2 million recreation use days. Visitation increased from 665,000 in

1984 to over 2 million in 1988. The lowest visitation years of 1993 and 1998 for Mark Twain Lake reflect the impacts of high water events. Visitation has rebounded since 1998 to set a new record in 2002 with almost 2,600,000 visitors, a reflection of favorable recreation seasons.

TABLE 2-1

CLARENCE CANNON DAM AND MARK TWAIN LAKE ACTUAL VISITATION DATA, 1976 - 2002

Year	Visits	Rec-Use Days	Visitor Hours
1976		220,536	
1977		146,023	
1978		295,021	
1979		229,300	
1980		215,171	
1981		139,741	
1982		258,057	
1983		424,339	
1984		□ 665,577	
1985		850,700	
1986		1,684,372	
1987		1,863,104	
1988		2,030,000	
1989		1,865,980	
1990	1,834,157	1,738,052	
1991	1,849,844	1,814,947	
1992	1,648,429	1,638,246	19,586,956
1993	1,423,489	1,352,581	◊16,230,968
1994	1,696,376	1,567,938	18,815,259
1995	1,685,983	1,602,029	19,224,351
1996	1,636,607	1,516,801	18,201,614
1997	1,664,087	1,466,293	17,595,516
1998	1,218,199	1,111,057	13,332,681
1999	1,794,386	2,200,366	26,404,389
2000	1,836,028	1,877,135	22,525,623
2001	1,806,966	2,116,511	25,398,112
2002	2,594,626	2,306,286	27,675,436

□ Note: Clarence Cannon Dam was completed in 1983 and Mark Twain Lake reached recreational pool in March of 1984. The 1984 visitation data represents the first full year of lake recreational use at the project

◊ Missing September visitation

Yearly visitation totals are affected by a number of factors including changes in weather conditions, fluctuations in lake levels, cost and supply of gasoline, general economic conditions, and the availability of recreational facilities at the lake. TABLE 2-1 presents a summary of actual visitation from 1976 -2002. TABLE 2-2 presents the percentage of users traveling from various mileage distances to the major recreation areas at Mark Twain Lake. This information is from a 1988 recreation area user survey. The project zone of influence is considered to extend 125 miles from the lake.

TABLE 2-2
DISTANCE OF VISITOR TRAVELS TO MAJOR RECREATION AREAS AT MARK TWAIN LAKE

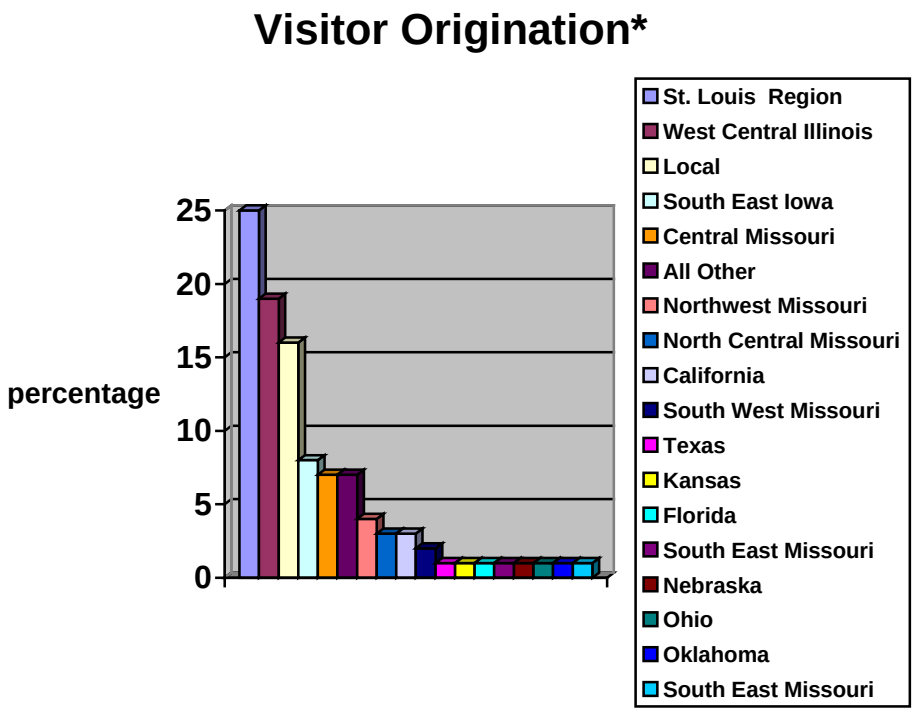
Area	Within 50 Miles	51-125 Miles w/o St. Louis	St. Louis Area	Other
M.W. Boudreaux	14.60%	13.30%	38.60%	33.50%
Ray Behrens	23.20%	6.30%	48.20%	22.30%
Robert Allen	45.50%	0	36.40%	18.10%
South Fork	71.50%	7.10%	14.30%	7.10%
Stoutsville	11.10%	22.20%	50%	16.70%
Indian Creek	28.60%	7.10%	29.40%	34.90%
John Spalding Day Use Boat Ramp	33.80%	8%	30.80%	27.40%
Spillway North & Overlook	28.20%	13%	22.60%	36.20%
Bluff View	57.10%	4.80%	9.50%	28.60%

c. Projected visitation. A discussion of projected visitation at Mark Twain Lake is presented in Section 6.12.

Figures 2-5 to 2-7 below were created by sampling visitor logs and camper registrations. Additional information was obtained from a study performed by the University of Missouri for the Northeast region of Missouri. Visitors originate from the St. Louis area, West Central Illinois, and Southeast

Iowa. By state, Missouri (78 percent) and Illinois (13 percent) are the points of origin for most campers.

Figure 2-5



*Based on informal sampling of Boudreaux Visitor Center 2001 visitor logs.

Figure 2-6

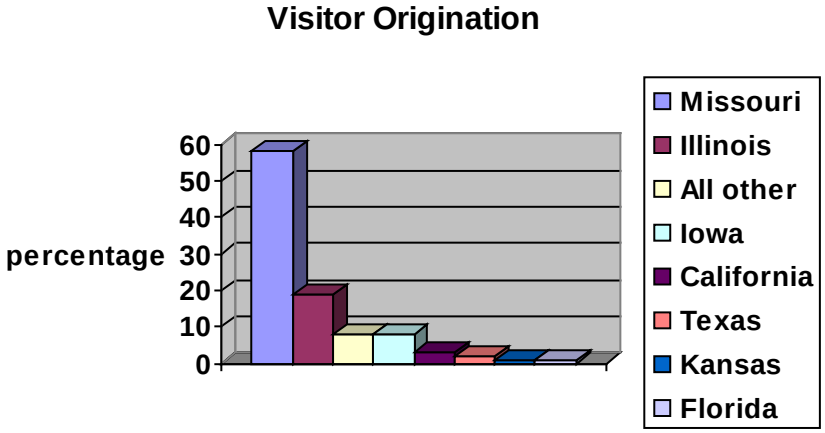
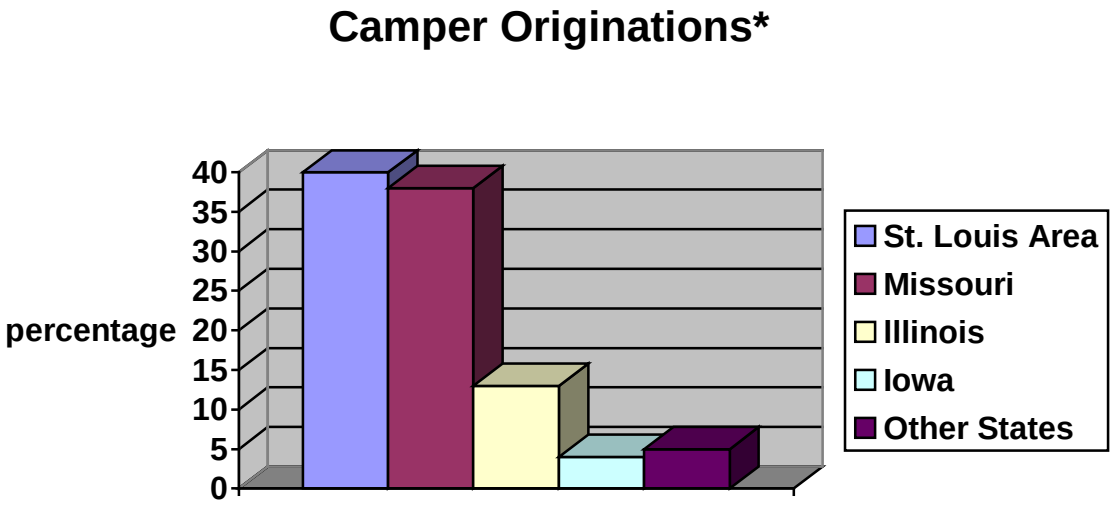


FIGURE 2-7



*Based on informal sampling of 2001 camper registrations.