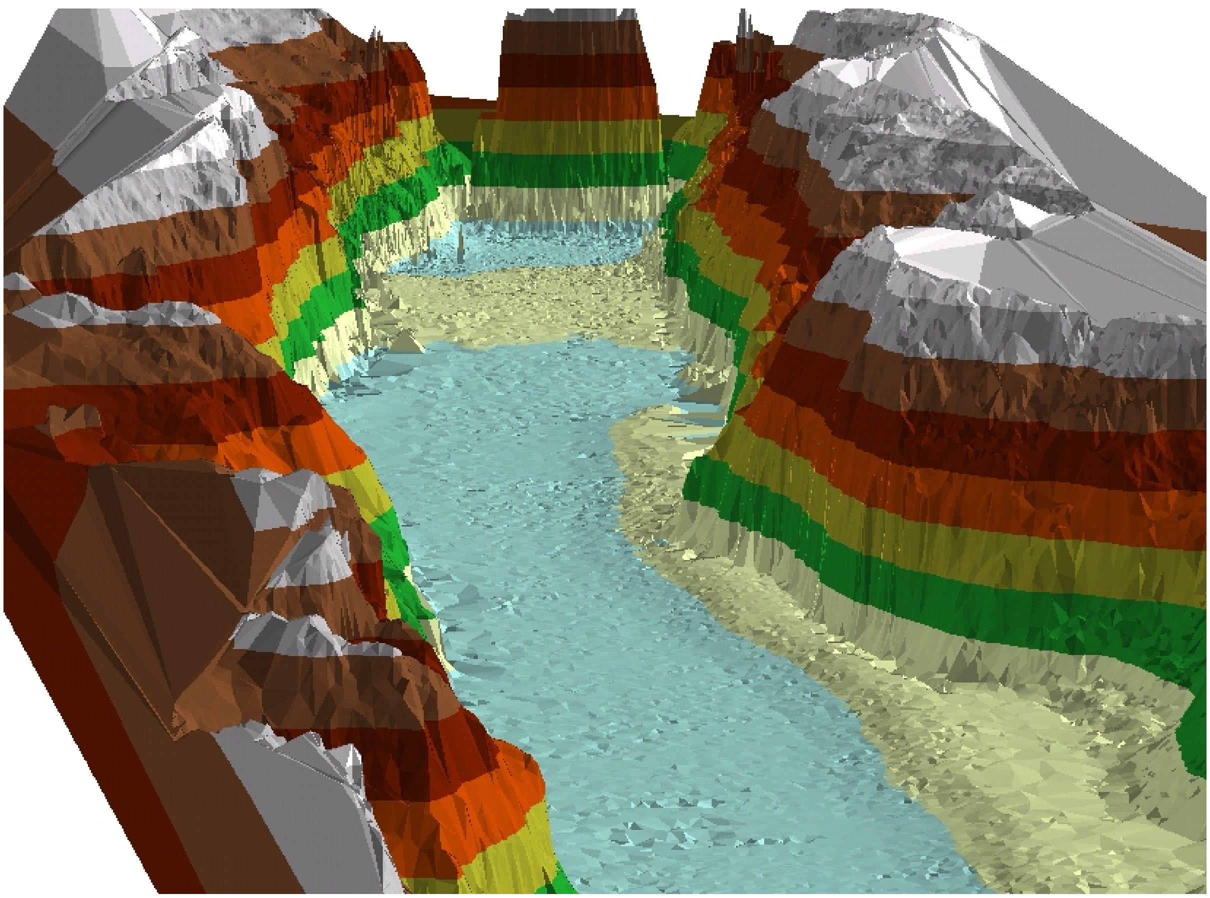
RECLAMATION

Managing Water in the West

2001 Lake Mead Sedimentation Survey



U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

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2001 Lake Mead Sedimentation Survey

prepared by

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U.S. Department of the Interior
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Technical Service Center
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Denver, Colorado

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Reclamation Report

This report was produced by the Bureau of Reclamation's Sedimentation and River Hydraulics Group (Mail Code 86-68540), PO Box 25007, Denver, Colorado 80225-0007. **http://www.usbr.gov/pmts/sediment/**

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Cover – Multibeam data topographic image looking downstream towards Hoover Dam (developed by Steve Belew, LCR).

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14. ABSTRACT

The 2001 Lake Mead survey measured an increase in reservoir capacity of 219,150 acre-feet since the 1963-64 (1963) reservoir survey. The increased capacity was attributed to a significant decrease of sediment inflow due to the March 1963 closure of Glen Canyon Dam, located upstream of Lake Mead, and compaction of the previous sediment deposition. Since Hoover Dam closure in 1935, the 2001 study measured 2,402,770 acre-feet of sediment deposition compared to the 1963 survey result of 2,621,920 acre-feet. As of September 2001, at water surface elevation 1,229.0, the surface area was 162,548 acres with a total capacity of 29,979,010 acre-feet. The 2001 study measured an average annual rate of sediment accumulation, since dam closure, of 36,024 acre-feet compared to the 1963 average annual rate of 88,028 acre-feet. Since the 1963 closure of Glen Canyon Dam and the significant trapping of the Colorado River sediments within Lake Powell, the Lake Mead average sediment inflow rate has significantly decreased to an estimated rate of less than 10,000 acre-feet per year.

Reclamation's Sedimentation Group surveyed Lake Mead in 2001 to develop a storage-elevation relationship. The underwater survey, conducted over 22 days between April 5 and May 16, used a multibeam depth sounder interfaced with a global positioning system (GPS) that gave continuous sounding positions throughout the reservoir covered by the survey vessel. Updated topography of Lake Mead was developed by combining the 2001 survey data and original digital data from the U.S. Geological Survey quadrangle (USGS quad). A complete hydrographic survey, above and below water, would provide the most accurate reservoir topography. However, cost prohibits or delays such data collections. Over the years limited budgets have affected survey frequencies resulting in limited knowledge of our nation's reservoirs. Reconnaissance techniques combine streamlined collection and analysis procedures with modern instrumentation to produce quality results in a timely and effective manner by surveying only where the majority of the sediment accumulates. The technique requires original digital reservoir topography to guide the survey vessel along the sediment deposit areas and for computing the updated reservoir information. Reconnaissance techniques for the 2001 survey of Lake Mead greatly reduced collection and analysis costs, but still produced quality results. The reconnaissance techniques presented in this report illustrate how to update the area and capacity on reservoirs like Lake Mead more frequently, but at a much lower cost than a complete hydrographic survey.

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2001 Lake Mead Sedimentation Survey

Abstract

Reclamation's Sedimentation Group surveyed Lake Mead in spring 2001 to develop a storage-elevation relationship. This report was produced by the Sedimentation Group summarizes the 2001 Lake Mead survey results that utilized reconnaissance procedures for collection and analysis (Ferrari, 2006). The 2001 study measured 2,402,770 acre-feet of sediment deposition since closure of Hoover Dam and initial filling of Lake Mead in February 1935. The 2001 survey measured a 219,150 acre-feet increase in reservoir capacity since the last survey of Lake Mead in 1963 (Lara and Sanders, 1970). This study addressed the capacity increase phenomenon, concluding the occurrence was due to significant reduction of sediment inflow since the 1963 upstream closure of Glen Canyon Dam and significant compaction of Lake Mead's previous measured deposited sediments in the lower elevation portions of the reservoir.

The underwater survey was conducted over 22 days between April 5th and May 16th of 2001. The survey used a multibeam depth sounder interfaced with GPS that provided continuous sounding positions throughout the reservoir covered by the survey vessel. Reconnaissance techniques utilized a streamlined collection procedure that concentrates on areas of known reservoir sediment accumulation from past surveys of Lake Mead and surveys of other similar reservoirs. Updated topography of Lake Mead was developed by combining the 2001 survey data with the original digital data from the USGS quads. Reconnaissance techniques for the 2001 survey of Lake Mead greatly reduced collection and analysis costs while producing quality results including current area and capacity relationships and showing the loss of reservoir capacity due to sediment accumulation.

Dam and Reservoir

Hoover Dam, on the Arizona-Nevada state line in the Black Canyon of the Colorado River, forms Lake Mead located in Clark and Mohave counties about 6 miles from Boulder City and 30 miles east of Las Vegas, Nevada (figure 1). Formation of Lake Mead provided improvements to navigation, river regulation, flood control, and water storage for irrigation, beneficial consumptive uses, and releases for electric power generation. The dam and reservoir, part of the Boulder Canyon Project, are operated and maintained by the Reclamation's LCR Office located near Hoover Dam in Boulder City, Nevada, figure 2.

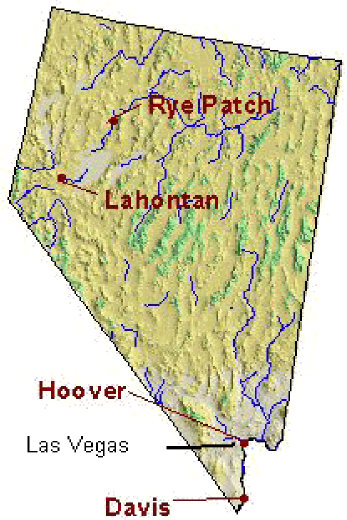

Figure 1 - Reclamation Dam locations in Nevada.

Figure 2 - Hoover Dam and Lake Mead.

Construction on Hoover Dam began in 1931. The dam began water storage on February 1, 1935 and was dedicated on September 30, 1935. The dam is a concrete gravity arched structure with the following dimensions:

- Hydraulic height[1] 592.0 feet
- Top width 45 feet
- Top Dam, elev.[2] 1,232.0 feet
- Structural height 726.4 feet
- Crest length 1,244 feet
- Top parapet wall, elev. 1,236.0

Hoover Dam has two identical spillways located on the Arizona and Nevada canyon walls. Each spillway has a crest elevation of 1,205.4, a length of 400 feet, and has four 100-foot long steel drum gates that are 16-feet high with a crest elevation of 1,221.4 in their fully raised position. At reservoir water surface elevation 1,229.0, the combined capacity of the spillways is 63,000 cubic feet per second (cfs). With gates in fully lowered position (crest elevation 1,205.3, and reservoir at maximum water surface elevation 1,232.0), the combined spillway capacity is 400,000 cfs (figure 3).

Figure 3 - Hoover Dam downstream releases.

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[1] Definition of such terms as hydraulic height, structural height, etc. may be found in manuals such as Reclamation's *Design of Small Dams* and *Guide for Preparation of Standing Operating Procedures for Dams and Reservoirs*, and ASCE's *Nomenclature for Hydraulics.*

[2] All elevations in this report are shown in feet unless otherwise noted. Elevations based on dam's construction datum from1935 survey. Add 0.55 feet to convert to National Geodetic Vertical Datum of 1929 (NGVD29) (Lara and Sanders, 1970).

On August 6 of 1941, Lake Mead's water level was within one-foot of the spillway crest when the Arizona spillway gates were lowered allowing flows for the first time. When halted in early December 1941, an inspection of the spillway tunnel revealed a 38- by 112-foot eroded section of tunnel lining due to flow cavitation that required repairs.

Completion of Glen Canyon Dam on the Colorado River, near the Arizona-Utah border, significantly altered the flood control operation of Hoover Dam and removed around two thirds of the previous sediment contributing drainage area above Lake Mead. The 710-foot high Glen Canyon Dam, completed in 1963, controls the Colorado River flows and traps nearly 100-percent of its upstream drainage sediments within Lake Powell. In 1983, heavy winter snows within the Colorado River basin created runoff 150 percent of normal, causing the first real use of the Glen Canyon and Hoover Dam spillways since 1941. This event caused significant cavitation damage to the spillway tunnels at both Hoover and Glen Canyon Dams that was similar to the 1941 damage. During spillway repairs design modifications were implemented to prevent future cavitation damage. Although the 1983 floods caused appreciable damage along the Colorado River, the damage would have been much greater without the network of basin dams.

The outlet works are composed of four penstocks, each originating at one of the four intake towers upstream of the dam, and then tunneling behind the abutments before outleting for downstream releases. Each 395 foot tower has an outside base diameter of 82 feet at elevation 894. The intakes of the towers are at elevations 895.0 and 1,045.0 respectfully. The combined outlet works capacity is 45,000 cfs at reservoir water surface elevation 1,232.0 (figures 4 and 5).

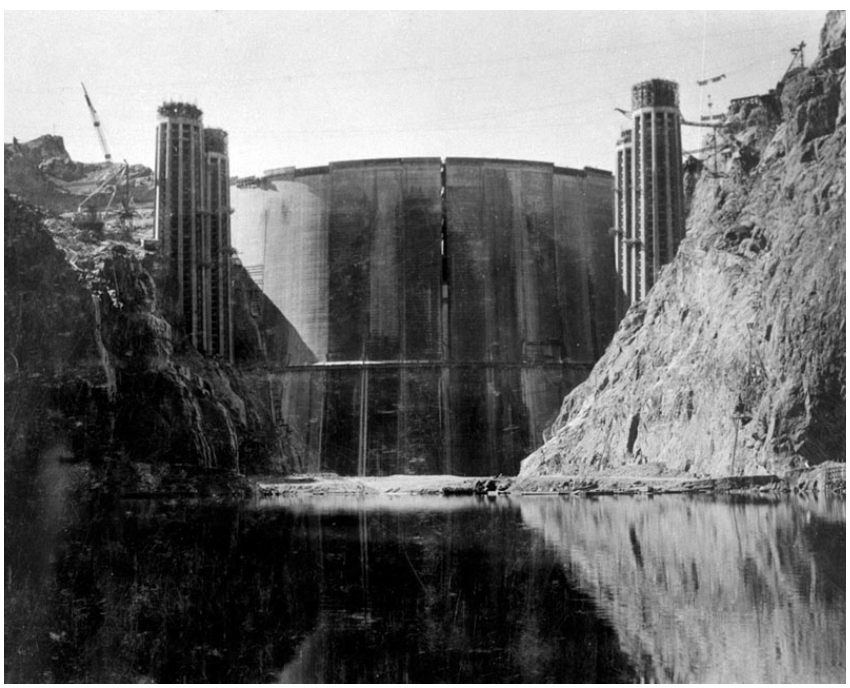


Figure 4 - Hoover Dam intake towers and top of cofferdam.

Figure 5 - Upstream face of Hoover Dam and four intake towers.

Cofferdams

Upstream and downstream cofferdams were placed for protection during Hoover Dam construction (figure 6). The upper cofferdam construction began in September 1932 and was completed soon after the Arizona diversion tunnels. The upper cofferdam was located approximately 600 feet down river from the inlet portals of the diversion tunnels, stood 98 feet high, and reached about 30 feet above the top of the diversion tunnels. The upstream face was protected by a 6-inch thick concrete paving laid over a 3 foot rock blanket. The downstream face was covered by a thick rockfill. The cofferdam design allowed the diversion tunnels to discharge 200,000 cfs with the water 13 feet below the crest. The lower cofferdam was 66 feet tall and built out of compressed earthfill material. There were concerns that during flooding, backwash from the outlet portals could damage the lower cofferdam, even with a thick rockfill covering the downstream face. To lessen the concern, a 54-foot rock barrier was built approximately 350 feet downriver. The design drawing, 45-D-13857, labeled the top of the upper cofferdam at crest elevation 720. The 2001 survey measured the crest of this cofferdam (see report cover) at elevation 735 while previous surveys indicated the cofferdam was buried by sediment deposition. The Sedimentation Group's analysis confirmed the measured 2001 top sediment elevation results with the general conclusion that sediment had accumulated upstream, downstream (between the dam and cofferdam) and on top of the cofferdam. It was the general conclusion that the previously deposited sediment in this area consolidated over time and the deposition raised the original top elevation of the cofferdam.

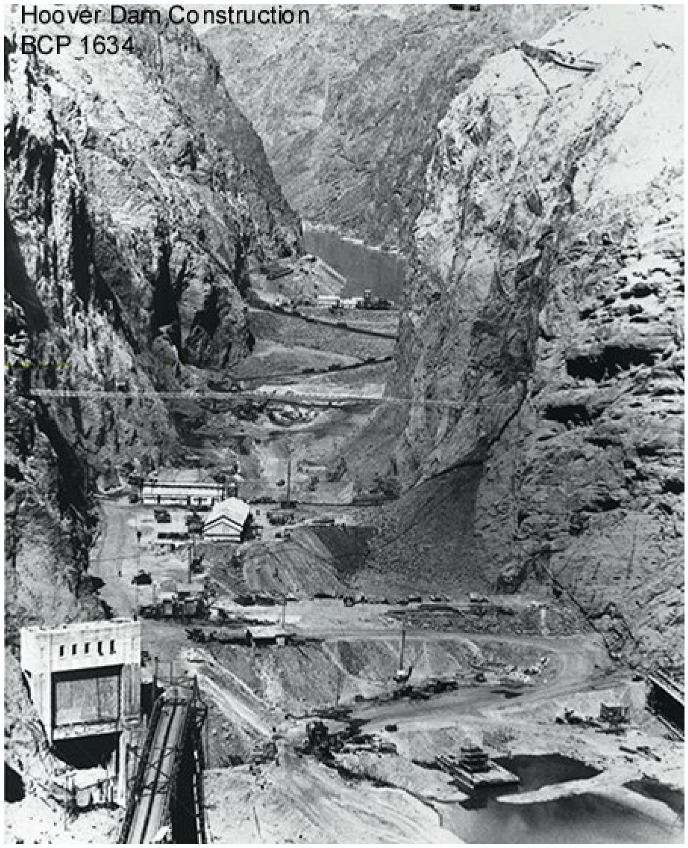


Figure 6 - Hoover Dam cofferdams.

Drainage Area

The total sediment contributing drainage area above Hoover Dam from February 1935 through March 1963 was 171,500 square miles, with 3,959 square miles considered naturally non-contributing (USGS, 2001). Since closure of Glen Canyon Dam and formation of Lake Powell in March 1963, the Colorado River and resulting sediment inflows have been regulated by Lake Powell. Lake Powell drainage area is 111,700 square miles, reducing the initial sediment contributing drainage area above Lake Mead by nearly two thirds to 59,800 square miles. The 2001 Lake Mead study calculated the net sediment contributing area from 1935 through 2001 as 105,550 square miles taking into account the total drainage area above Hoover Dam and the ratio of time since Glen Canyon Dam began controlling the Colorado River sediments upstream. Lake Mead's width averages 1.65 miles, varying from several hundred feet in the canyons to a maximum width of about 8 miles in the Boulder Basin area. Lake Mead's total length is 152 miles, combining the lengths of the Colorado (115 miles) and Overton reaches. Figure 7 provides an outline of the total Colorado River Basin which covers more than 242,000 square miles within the United States and includes parts of Wyoming, Colorado, Utah, New Mexico, Nevada, Arizona, and California. The California portion of the basin only contributes downstream of Hoover Dam.

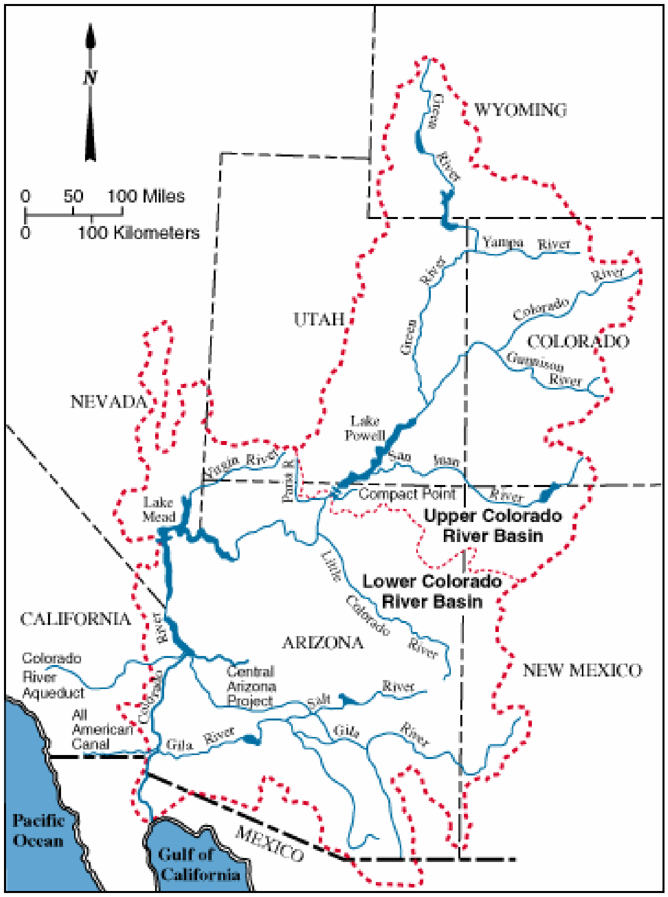


Figure 7 - Colorado River drainage area (Dettinger, M.D. 1995).

Summary and Conclusions

This Reclamation report presents the 2001 Sedimentation Group's results from the survey of Lake Mead. The primary objectives of the survey and analysis were to gather data needed to:

- develop reservoir topography
- compute area-capacity relationships
- estimate storage depletion by sediment deposition since dam closure
- estimate capacity change since 1963 closure of Glen Canyon Dam
- explain reservoir capacity increase since the 1963 survey.

A Real-Time Kinematic (RTK) GPS control survey established a temporary horizontal and vertical control point near Lake Mead Marina that was used for the survey of the lower portion of the reservoir including Boulder Basin and Las Vegas Bay. The horizontal control was established in Universal Transverse Mercator (UTM) coordinate zone 11 in the North American Datum of 1983 (NAD83). The RTK GPS control survey was conducted with the base set on a

National Geodetic Survey (NGS) control point located downstream of the dam. Additional temporary control points were established, but due to time limitations, a decision was made to use a military issued GPS unit with horizontal accuracies of ±4 meters from a single GPS receiver. This accuracy (±4 meters) met requirements for this survey as the study focused on measuring original bottom change from mostly flat-lying sediment deposition.

The underwater survey was conducted over 22 days, from April 5 through May 15 of 2001 between reservoir water surface elevations 1,189 and 1,194. The survey was conducted by a 2-person crew over the course of several days compared to previous surveys requiring large survey crews working for many months over a two year period. The bathymetric survey was conducted using sonic depth recording equipment interfaced with GPS capable of determining sounding locations within the reservoir. The system continuously recorded depth and horizontal coordinates as the survey boat navigated along pre-established grid lines covering Lake Mead. The positioning system provided information to allow the boat operator to maintain a course along these grid lines. Water surface elevations recorded by the reservoir gauge (tied to the Hoover Dam powerhouse datum) during the time of collection were used to convert the sonic depth measurements to reservoir bottom elevations.

The above-water topography was developed from digital data of the original (prefill) topography scanned from USGS quad maps of the reservoir area. Additionally, a small portion of the upper reservoir area on the Colorado River was mapped using aerial collection techniques in 2001. The 2001 Lake Mead analysis utilized GIS tools for processing these large data sets. The 2001 Lake Mead topography was developed from a combination of the original and 2001 data sets by plotting the 2001 data on top of the original data and deleting all original data overlaid by the 2001 data. Previously surveyed cross sections for a biological monitoring program on the Colorado River were used to complete the analysis of the reach of Lake Mead upstream of the 2001 aerial data by measuring change from the original river topography. The Sedimentation Group processed the 2001 topography data map by map for the entire reservoir by looking for change from the original measured map surface areas due to sediment deposition. When the 2001 data indicated no change due to sedimentation, the contour surface area was marked as no change, and the original surface area for the 10-foot contour interval was used. This approach, similar to that used in previous studies, was the best means to compare the 2001 results with the original, 1948-49 (1948) and 1963 results.

As of September 2001, at reservoir elevation 1,229.0, the surface area was 162,548 acres with a total capacity of 29,979,010 acre-feet. Since initial filling in February 1935, the 2001 study calculated 2,402,770 acre-feet of Lake Mead sediment accumulation with an average annual rate of 36,024 acre-feet for the 66.7 year period compared to the 1963 computed average annual rate of 88,280 acre-feet for the first 29.7 years of reservoir operation.

The 2001 survey, at elevation 1,229.0, measured an increase in Lake Mead capacity of 219,150 acre-feet since the 1963 survey. The increase capacity was attributed to the significant compaction of the previous Lake Mead sediment deposition, the major decrease of sediment inflow since the 1963 closure of Glen Canyon Dam began trapping sediments in Lake Powell, and the ongoing compaction of the fine sediments that continue to deposit throughout the reservoir down to Hoover Dam. The study concluded the depth measurement methods for the different surveys were not a significant factor in the measured differences. The 2001 study did measure an increase in sediment deposition in the upper delta of the Colorado River from Greg Basin upstream, showing the face of the delta growing downstream towards the dam.

The 2001 survey measured the greatest volume increase, due to compaction, in the Boulder and Virgin Basins. The greatest decrease in volume, due to sediment deposition, was measured in the upper reach of the reservoir downstream to the Pierce and Greg Basins. Compaction of sediment deposition occurs overtime throughout the reservoir, with the greatest compaction in the lower reservoir areas near the dam where the majority of the finer silt type sediments have deposited since initial filling. These finer sediments will continue to deposit throughout the reservoir down to the dam as confirmed by a 1998 program that collected sediment samples, in the lower reaches of the reservoir, consisting mainly of fine materials (Covay and Beck, 2001).

The original published capacity of Lake Mead was 32,471,000 acre-feet at elevation 1,229.0. For the purpose of computing sediment deposition, the original capacity was recomputed, using the original surface areas and same computer program used to compute the 2001 values, resulting in a recomputed original capacity of 32,381,780 acre-feet. If Glen Canyon Dam and Lake Powell continue to trap Colorado River sediment at the same rate they have since 1963, and if current sediment inflow rates continue in the future, it will be several thousand years before Lake Mead fills with sediment. As noted previously, the first 30 years of reservoir life occurred before closure of Glen Canyon Dam. Glen Canyon Dam closure in 1963 was followed by 37 years of Lake Powell capturing a large percentage of the Colorado River drainage sediments. The above reservoir life expectancy computations assumed the same sediment inflow and 100 percent Lake Mead and Lake Powell sediment trap efficiency. With the continual trapping of sediments in Lake Powell, the 2001 computed average annual rate of sediment inflow (36,023 acre-feet) since Hoover Dam closure will decrease over time until Lake Powell can no longer trap all sediments. Future measurements will better refine the average annual rate. Ongoing extensive data collection and studies in the Grand Canyon could also be used to better refine the current sediment inflow rate. Even though the projected Lake Mead life expectancy is thousand of years, sediment deposition will affect dam operations years prior.

2001 Lake Mead Sedimentation Survey

A rough estimate of Lake Mead's present annual sediment accumulation, since Glen Canyon Dam closure, is less than 10,000 acre-feet. This estimate assumes the continual trapping of sediments in Lake Powell and ongoing consolidation of the finer sediments entering Lake Mead. One unknown is the amount of finer material entering and settling in the lower reaches of the reservoir. In the future, the impact of consolidation of Lake Mead sediments will be significantly reduced due to the major reduction of sediment inflow and compaction of the previous deposits that has already occurred. Since 1963, the 2001 survey data estimated 7,200 acre-feet of annual sediment delta growth had occurred in the very upper delta portion of the reservoir on the Colorado River alone. More research and data would be necessary to better estimate sediment deposit in the other reaches, such as Overton and Las Vegas Wash. However, until the closure of Glen Canyon Dam these other sediment sources were insignificant compared to the total sediment inflow contributed from the Colorado River drainage basin.

The 1986 Lake Powell survey measured an annual sediment inflow rate of 36,946 acre-feet (Ferrari, 1988), significantly less than the 88,280 acre-foot average annual rate computed from the 1963 Lake Mead survey conducted prior to formation of Lake Powell. The 1986 Lake Powell rate may be less due to the other reservoirs developed in the upper basin in the 1960's along with better land management practices. There have been some recent surveys and research conducted on Lake Powell that suggest the computed 1986 Lake Powell sediment inflow rate has continued (Clarke Hughes, 2005 and Pratson, 2007). Studies within the Grand Canyon indicate that the Colorado River is sediment deprived, and with no other major tributaries contributing sediment to Lake Mead, the significant drop in annual sediment rate will continue in the future. As this report demonstrates, future surveys can be conducted in less time using reconnaissance procedures for the collection and analysis, but still generate accurate results for monitoring change due to sediment deposition (Ferrari, 2006).

The 2001 Lake Mead survey and analysis provided a unique opportunity in reservoir sediment monitoring. The previous survey in 1963 monitored the first 30 years of reservoir operation with the upper drainage basin in a run of the river condition with minimal sediment control by upstream dams. After the 1963 closure of Glen Canyon Dam, 63 percent of the sediment previously contributed by the drainage area was blocked and began depositing into Lake Powell. The 2001 survey monitored the period of reservoir operation since this closure and provided an insight into the compaction of the previous sediment that had deposited in Lake Mead since closure of Hoover Dam. A bottom sampling program would need to be implemented to confirm and develop a better understanding of the compaction that has and will continue to occur within these deposited sediments.

The 2001 survey did measure a buildup of the upstream sediment delta in the Colorado River reach of the reservoir. The deposition mainly consists of the heavier material, sand size and greater, that initially drops out due to the decrease transport capacity of the river as it enters the upper reservoir. During this deposition process the heavier material becomes sorted, where future compaction is minimal, and mostly remains in place until the reservoir level drops, allowing the river to erode the material and transport it further downstream into the reservoir. The 1998 sediment sampling program, though limited, showed that sediments continue to accumulate in the lower reaches of the reservoir towards the dam. These materials mainly consist of silt that is transported downstream by density currents where it eventually settles out and over the years will consolidate.

Along with a bottom sampling program, future surveys will help in monitoring the consolidation of the bottom sediments. The surveys will be necessary to also calculate the current annual sediment inflow (estimated to be less than 10,000 acre-feet per year in 2001). Future surveys will also assist in measuring the redistribution of sediment since the 2001 survey. Since the 2001 survey, the reservoir level has dropped over 80 feet, meaning a large portion of the previous sediment materials in the upper reservoir have been eroded downstream into the current operational reservoir range.

Reservoir Operations

Hoover Dam operates to provide flood control, power generation, and regulation of Colorado River flows downstream. The September 2001 capacity table shows 29,979,010 acre-feet of total storage below flood control water surface elevation 1,229.0. The 2001 survey measured a minimum lake bottom near elevation 689. The following values (from elevation 1229.0 and below) are from the September 2001 capacity table:

- 482,000 acre-feet surcharge, elevation 1,229.0 through 1,232.0[3]
- 1,498,140 acre-feet flood control, elevation 1,219.6 through 1,229.0
- 5,673,240 acre-feet joint use storage, elevation 1,083.0 through 1,219.6
- 10,261,098 acre-feet inactive storage, elevation 895.0 through 1,083.0
- 2,546,532 acre-feet dead storage, below elevation 895.0

Lake Mead's computed annual inflow and reservoir stage records are listed by water year on table 4 for operation period 1935 through 2001. The water inflow values show the annual fluctuation with a computed average inflow of 10,900,000 acre-feet per year between 1935 and 2001. The computed average inflow prior to closure of Glen Canyon Dam, 1935 through 1963, was 11,337,000 acre-feet. The computed average inflow for 1964-2001 was 10,549,000 acre-feet, indicating that Glen Canyon Dam had minimal impact to the annual water inflow compared to its significant impact on reduction of sediment inflows to Lake Mead. It must be pointed out that from 1983 through 1987 the Colorado River drainage basin

[3] Capacity value, between elevation 1,229.0 and 1,232.0 (July 1977 Reservoir Capacity Allocation). The 2001 study assumed no change in this elevation zone due to sediment deposition and shoreline erosion.

runoff was significantly above average, with water years 1984 and 1985 the greatest listed runoffs since Hoover Dam closure. The initial filling of Lake Powell in 1963 and 1964 significantly reduced the flow of water into Lake Mead. Water years 1963 and 1964 inflows were less than fifty percent of the previous lowest Lake Mead inflow recorded in 1954. The maximum Lake Mead elevation was 1,225.8 during water year 1983 and, since initial filling, the minimum elevation was 1,083.2 during water year 1956. Since the 2001 survey, Lake Mead drainage has been in a prolonged drought with the reservoir level dropping to elevation 1,100 in September 2007.

Purpose of Reservoir Surveys

Reservoirs come in all shapes and sizes and are designed for purposes such as retention for flood control, debris/sediment storage, irrigation and municipal water supply, power production, recreation, navigation, conservation, and water-quality control. The reservoir size, shape, and operation affect the location and nature of the sediment deposition (figure 8). Reservoir sedimentation is an ongoing natural depositional process that can remain invisible for a significant portion of the life of a reservoir. However, lack of visual evidence does not reduce the potential impacts of sedimentation on functional operations of a reservoir (Lin, 1997). As sediment deposition depletes reservoir storage volume, periodic reallocation of available storage at various pool levels may be necessary to satisfy the operational requirements of water users.

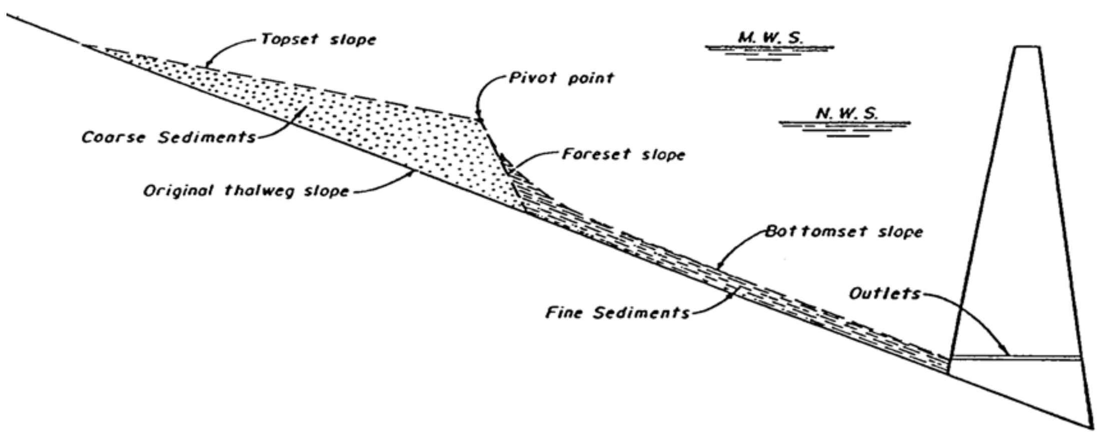


Figure 8 - Profile of reservoir delta formation.

As rivers and streams enter a reservoir, the flow depth increases and the velocity decreases resulting in a loss in the sediment transport capacity of the inflow. The loss of sediment transport capacity and the damming effect of the reservoir may cause deposition of sediment in the stream channels above the reservoir water surface and in the upper reservoir area. The sediment deposition process in reservoirs generally follows the same basic pattern, with coarser sediments settling first in the upper reservoir area as the river inflow velocities decrease, forming a delta. As seen in figure 9, the early filling of Lake Mead in the 1940's developed a typical delta formation. This included the heavier sediment, sands and gravel, settling in the upper reservoir area from Pierce Basin upstream, along with the finer sediments of silt and clays depositing throughout the original river channel alignment towards the dam (USGS, 1960).

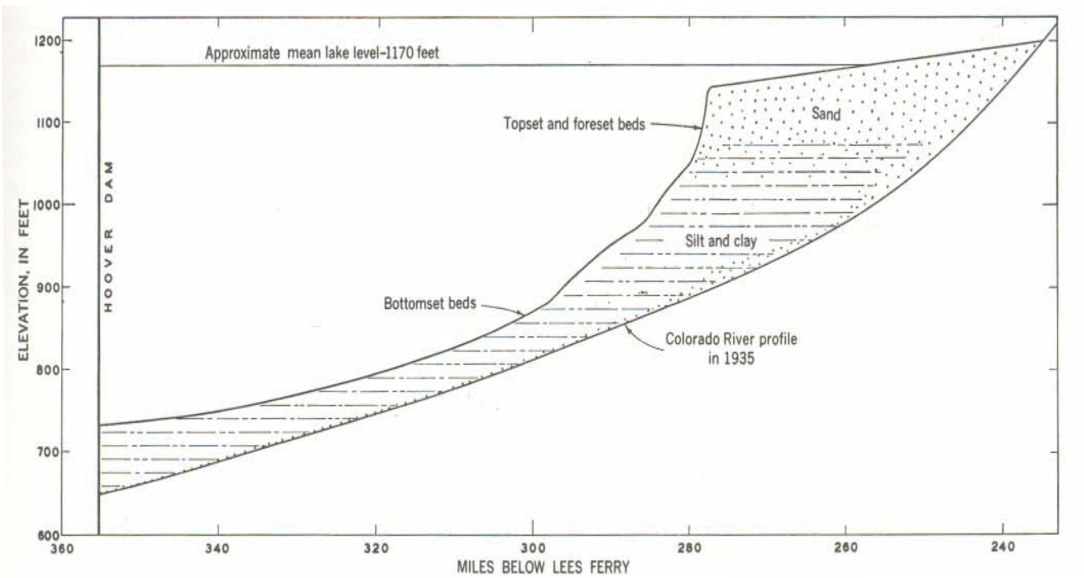


Figure 9 - Lake Meads' longitudinal section through the Colorado delta, showing relation of bottomset beds to the topset and foreset beds. (USGS, 1960).

The USGS 1960 report, Comprehensive Survey of Sedimentation in Lake Mead, describes the growth and structure of the delta beginning with Hoover Dam closure, on February 1, 1935, and continuing through December 1948. Initially the reservoir rose to elevation 700 and maintained that level for several months causing delta development and sand deposition from elevation 700 to the dam. With the 1935 spring runoff, the lake rose from elevation 700 to elevation 925 in July 1935 where, at this elevation, the Colorado River entered the reservoir in Pierce Basin about 75 river miles upstream of Hoover Dam. The reservoir elevation remained fairly constant until the following spring runoff. The delta continued to grow from 1936 through 1948 as the reservoir rose to a maximum elevation of 1,220.4 in July 1941, extending 110 miles upstream of the dam. Core samples found the surfaces of the topset bed to be hard compact sand and the bottomset bed to be extremely soft mud with solid particles composed of silt and clay. It is these areas of the reservoir, the soft mud and fine sediments consisting of silt and clay, that have consolidated the greatest overtime.

The process through which inflowing fine sediment is transported downstream into the lower portions of Lake Mead can be explained by density currents. Other conditions, such as reservoir drawdown, can cause higher inflow velocities to erode the upper reservoir sediment delta and transport material further downstream. However, sediments eroded from the delta are primarily composed of the coarser material that deposits soon after entering the new reservoir pool. The density current influence occurs where one fluid flows over or under another due to differences in their density. In reservoirs, the density difference can cause warm water to flow as a surface current across the top of the colder denser water. Alternatively, the cooler inflowing turbid water may plunge below the warmer reservoir surface water (figure 10) and travel across the top of the thermocline downstream towards the dam (Morris and Fan, 1997).

Figure 10 – Colder Colorado River inflow interface, upper Lake Powell.

Initial evidence of density currents within Lake Mead emerge within months after Hoover Dam closure. Evidence of the density currents flowing through the entire reservoir length was documented during the first 15 months of operation (Grover and Howard, 1938). These findings led to additional investigation from 1936 through 1949 summarized in the 1948 Lake Mead survey report (USGS, 1960). The studies found that spikes in suspended sediment measurements in the Colorado River in the Grand Canyon were followed days later by corresponding spikes in suspended sediment measurements in the Colorado River below Hoover Dam. When a measurement spike decreased at the Grand Canyon, the downstream suspend measurements below the dam decreased days later. These studies were performed with the reservoir length at nearly 90 miles and with downstream flow releases through the bypass tunnels located near the bottom of the dam at around elevation 700. The studies concluded that the colder turbid water flowed through the reservoir along the bottom and remained essentially unmixed. In May 1936 the bypass tunnel was permanently plugged and since then, the majority of releases have been through the intake towers with a minimum elevation of 895.0. The tunnel closure prevented the downstream releases of the highly turbid water, effectively trapping it in the lower reservoir zone. Density currents were continually monitored by measuring the top of the sediment surfaces at the intake towers, figure 11. The results indicated that during periods of high suspended sediments in the Colorado River, the top elevation of the sediment deposition at the dam increased. It appears that the turbid flows impacted the barrier formed by the dam and exploded into a plume of suspended material, temporarily causing higher measured bottom elevations. Eventually the initial plume settled to the reservoir bottom resulting in lower measurements again. Over time these presumably fine sediments consolidated in place forming a more solid reservoir bottom where additional turbid flows of suspended material subsequently deposit.

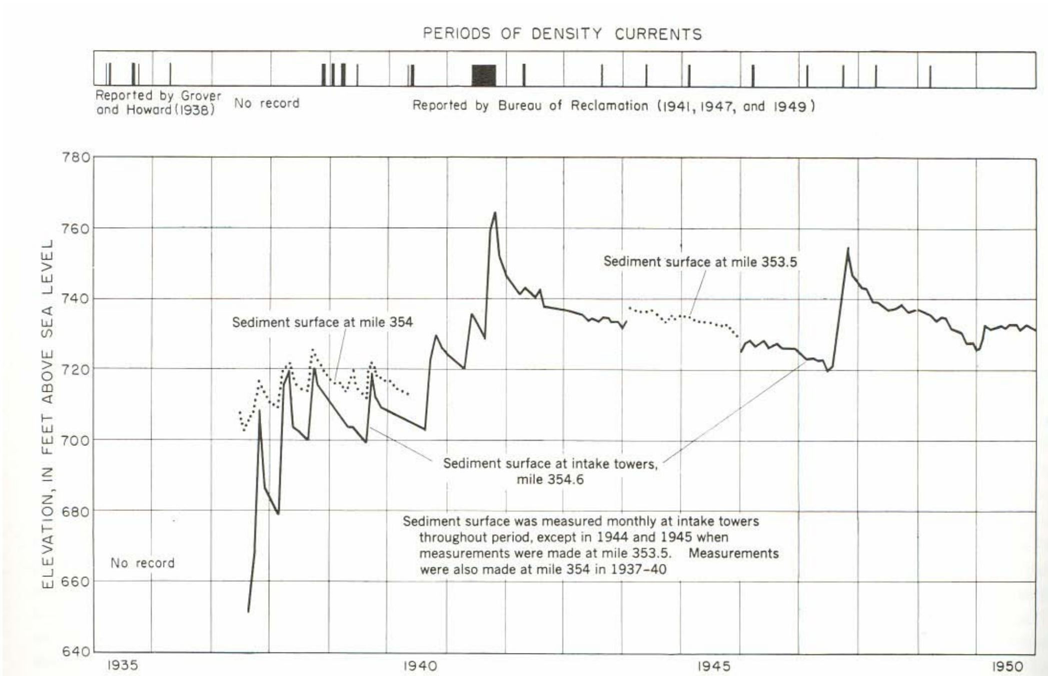


Figure 11 - Periods of reported density currents and elevation of sediment surface at Hoover Dam, 1935 through 1950 (USGS, 1960).

Reservoir sediment deposition continues from upstream to downstream with the sediment gradation becoming finer as the deposition progresses in the downstream direction throughout the length of the reservoir to the dam. Some of the inflowing fine sediments (silts and clays) may stay in suspension and discharge through the dam outlets and spillways, as seen from the early Lake Mead releases through the bypass tunnels. However with the minimum intake elevation raised 195 feet from the dam base to the bottom of the towers, the suspended sediment releases have been greatly reduced with nearly 100 percent trapped behind Hoover Dam. Over the years as sediment deposits nearer the dam inlets, some will eventually be discharged downstream, even though the majority of the sediment currently settles on the reservoir bottom and consolidates in place.

In the United States, reservoir sedimentation seldom receives attention until the reservoir capacity has been significantly reduced or the reservoir operation and surrounding area is affected. The delta formation can cause local problems before sediment deposition significantly reduces reservoir capacity or causes operational problems at the dam. Some local problems that have been attributed to sediment deltas are increased elevation of the flood stage and groundwater table, silting of pumping and intake structures, and blockage of navigation passages. Once at the dam, the released sediments may have downstream impacts on river fisheries and municipal water systems. Even though the 2001 Lake Mead study measured an increase in reservoir capacity, the delta in the upper end of the reservoir continues to grow and cause access issues for users of the upper reservoir and lower reaches of the Colorado River in the Grand Canyon.

The primary objective of a reservoir survey is to measure the current area and capacity. The main cause of storage capacity change is sediment deposition or erosion. Typical results from a reservoir survey and analysis include the measured sediment deposition since dam closure and previous surveys, the sediment yield from the contributing drainage, and the future storage-depletion trends. Survey results can also include location of deposited sediment (lateral and longitudinal distribution), sediment density, reservoir trap efficiency, and evaluation of project operation.

The Sedimentation Group typically computes reservoir sediment accumulation by comparing the measured original capacity, prior to inundation, to the updated measured capacity. This method calculates a long-term sediment deposition value used for future sediment projections. Making comparisons to the original survey, rather than comparing to the previous survey only, prevents errors that might exist in previous resurvey results from being included in the analysis. During the analysis all previous survey results are compared to study trends. The calculations typically rely on accurate original reservoir topography available for many of Reclamation’s reservoirs, but are evaluated on a case-by-case basis. Modifications to the analysis and study objectives are made for cases where accurate original reservoir topography is not available. Examples of studies where accurate original reservoir topography was unavailable include the 1995 Theodore Roosevelt (Roosevelt) Reservoir survey (Lyons-Lest, 1996) and the 2002 Deadwood Reservoir survey (Ferrari, 2003).

The Roosevelt and Deadwood Reservoir resurveys measured better detail than the original survey data. The 1995 Roosevelt survey was the eighth survey since dam closure in 1909, but the first survey to use aerial photography providing more detail of the upper reservoir elevations than the original 1909 survey (which used land-surveying techniques) and other previous resurveys. Comparing the detailed 1995 survey with previous mapping information was not an acceptable method for computing sediment accumulation due to the major accuracy differences between the surveys. However, the previous resurveys of Roosevelt Reservoir were valid for computing sediment inflow since they utilized a range line collection method that monitored the same range line location over the years. The changes at these locations were compared to the original topography for estimating the sediment deposition. The detailed 1995 Roosevelt Reservoir survey should now be used as the basis for future comparisons. The same was true of the 2002 Deadwood Reservoir resurvey where the detailed aerial and multibeam data from the 2002 survey could not be compared to the much less detailed original data for computing sediment accumulation.

The 2001 study of Lake Mead collected very detailed survey data, but only about 30 percent of the total reservoir surface area was covered (LCR, 2003). A combination of aerial and underwater collection would be necessary to obtain total reservoir topography providing the most accurate area and capacity results. Improved technologies may allow full reservoir surveys in a more effective manner in the future, but for the 2001 survey, these technologies were not yet available. The 2001 Lake Mead study analysis used the 2001 detailed data to adjust the original measured surface by map boundary and to compute updated reservoir capacity and resulting loss due to sediment deposition. The detailed 2001 survey collection focused on known areas of sediment accumulation. The 2001 analysis assumed the original computed surface areas were correct, using them as the base for measuring change. There were only minor issues in dealing with accuracy differences between the data sets.

Additional objectives of the Sedimentation Group's reservoir survey studies are to develop reservoir topography, estimate reservoir economic life, and resolve storage capacity conflicts. The resulting study information is beneficial for describing existing conditions for a specific reservoir, monitoring upstream land management practices, evaluating current operation of a reservoir, and planning future reservoirs. The results from the study can provide insight for such operational objectives as sluicing sediment deposits to increase reservoir volume and possibly enhancing the downstream river environment, establishing bench marks for forecasting future reservoir depletion rates, revising intake or outlet design, assessing water quality control methods, and designing recreation facilities, structures, and operational schedules.

Reservoir sediment accumulation and distribution can be approximated theoretically. However, an accurate reservoir survey is the best means for monitoring current reservoir sedimentation and for projecting future sediment inflow and deposition. The most accurate data requires measurement of the complete reservoir area, or as much of the sediment delta as possible. As seen in figure 8, the majority of the delta usually forms in the upper reaches of the reservoir with inflowing sediments eventually depositing throughout the reservoir. Full coverage requires both above and below water measurements that significantly increase field collection time and cost.

The reconnaissance method presented for the 2001 Lake Mead collection focused the underwater collection on the known sediment deposition zones of the reservoir, significantly reducing the effort and associated costs. The 2001 collected data was used along with the best available alternate data sources to complete the sediment analysis. The main goal was to obtain up-to-date valid information within allowed time and budget that otherwise would not be collected (Ferrari, 2006). This report summarizes the techniques applied and the final results of the 2001 Lake Mead survey conducted by Reclamation's Sedimentation Group.

Hydrographic Survey Equipment and Method

Hydrographic survey equipment has transformed dramatically throughout history, with the greatest changes occurring over the last few decades (Ferrari and Collins, 2006). The latest major change in horizontal positioning is the use of GPS technology that is more accurate and less costly to operate than past survey equipment. GPS has been rapidly adapted to hydrographic collection systems. The most recent significant development in depth sounding is the multibeam system that allows massive amounts of data to be collected. The multibeam system provides the option of complete coverage of the underwater areas, thus, removing the unknowns of previously unmapped underwater areas.

The hydrographic survey equipment was mounted in the cabin of a 24-foot tri-hull aluminum vessel equipped with twin in-board motors, figure 12. The hydrographic system included a GPS receiver with built-in radio, depth sounder, helmsman display for navigation, computer, and hydrographic system software for collecting the underwater data. An on-board generator supplied power to all the equipment. When differential GPS was used, the shore equipment included a second GPS receiver (base) with an external radio. The base GPS receiver and antenna were mounted on a survey tripod over a known datum point and a 12-volt battery provided the power.

The Sedimentation and River Hydraulics Group uses RTK GPS with the major benefit being precise heights measured in real time to monitor water surface elevation changes. The basic output from a RTK receiver are precise 3D coordinates in latitude, longitude, and height with accuracies on the order of 2 centimeters horizontally and 3 centimeters vertically. The RTK GPS system employs two receivers that track the same satellites simultaneously, just like with differential GPS. The output was on the GPS datum of WGS-84 which the

Figure 12 - Survey vessel with mounted instrumentation on Jackson Lake, Wyoming.

hydrographic collection software converted into UTM zone 12 coordinates in NAD83. For the Lake Mead study the regional office requested the collection be conducted in UTM and depths in meters to conform to ongoing USGS studies (Twichell, 1999). For the Sedimentation Group's analysis, the resulting data was converted to English units for comparing with the original and previously collected data. The survey also used a military issue GPS system for collecting position information with a horizontal accuracy of $\pm$ 4 meters.

The 2001 Lake Mead survey was the first by the Sedimentation Group utilizing the integrated multibeam hydrographic survey system. The system consists of a single transducer mounted on the center bow or forward portion of the boat. From the single transducer a fan array of narrow beams generates a detailed cross section of bottom geometry as the survey vessel passed over the areas to be mapped. The system generates 80 separate 1.5 degree slant beams resulting in a 120-degree swath from the transducer. With a fan of 120 degrees, the bottom sweep width is around 100 feet in 30 feet of depth and around 1,400 feet in 400 feet of depth. The 200 kHz high-resolution multibeam echosounder system measured the relative water depth across the wide swath perpendicular to the vessel's track. The multibeam system illuminates a swath of the sea floor that is about 3.5 times as wide as the water depth below the transducer (figure 13).

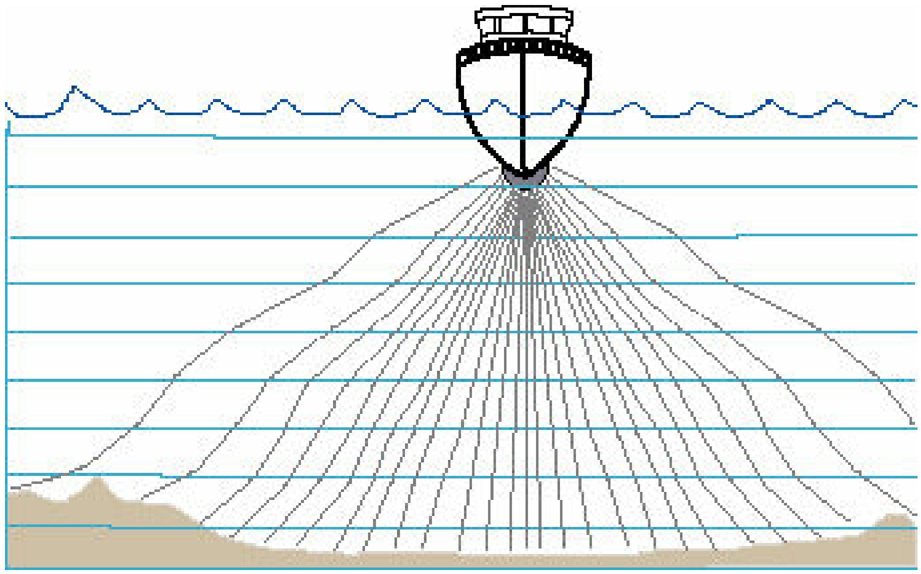


Figure 13 - Multibeam collection system.

The multibeam system is composed of several instruments that are all in constant communication with a central on-board notebook computer. The components included the GPS for positioning; a motion reference unit to measure the heave, pitch, and roll of the survey vessel; a gyro to measure yaw or vessel attitude; and a velocity meter to measure the speed of sound through the reservoir water column. With the proper calibration, the data processing software utilizes all the incoming information to provide an accurate and detailed x, y, z data set of the lake bottom covered by the survey vessel.

The Lake Mead bathymetric survey collection was conducted over 22 days from April 5 through May 15 of 2001 between water surface elevation 1,189 and 1,194 (project datum). The survey was run using GPS and multibeam system instrumentation as described above. The survey system software continuously recorded reservoir depths and horizontal coordinates as the survey vessel moved across closely-spaced grid lines covering the reservoir area. Most transects (grid lines) were run along the original river alignment of the reservoir where the multibeam swaths overlapped each other. The overlapping swaths assured complete coverage in the deeper portions of the reservoir and were used during processing to confirm that motion detector data was applied correctly. In the shallower depths, around thirty feet and less, the swaths did not overlap. The multibeam system could have provided full bottom coverage in this depth zone, but time, budget, and access did not allow this. Due to the cost and sensitivity of the multibeam transducer, the collection crew usually limits data collection to depths of 10 feet and greater. The loss of these additional data points did not significantly impact the area computations since it usually occurred in shallower areas where the bottom topography was generally flatter due to the sediment deposition.

The 2001 bathymetry included some single beam data in the shallow water areas of the reservoir, primarily in the Overton Arm, that was used for mapping these areas. A longitudinal profile of single beam depths was collected from the upper Overton Arm downstream to the Colorado River confluence. Comparisons between the single beam and multibeam data found that the depths for the two systems generally agreed within a foot, providing further validation of the multibeam collected depths.

During the 2001 survey of Lake Mead's Grand Bay area, a ridge was measured as the survey vessel maneuvered from the main channel of the Colorado River into Grand Bay. The collection crew also observed a significant difference in the clarity of the water in Grand Bay versus the main stem of the reservoir. As the vessel mapped upstream into Grand Bay, the depths increased slightly. It appears the sediment deposition along the original river channel created levee or berm type features along the channel banks as the lake level lowered. This barrier at the confluence of Grand Bay blocks the water in the bay preventing the Grand Bay sediments from entering the Colorado River portion of the reservoir and preventing the Colorado River sediments from depositing in Grand Bay during periods of lower reservoir elevations. The 2001 map showed two independent water bodies within the Lake Mead boundary. Since the 2001 survey, Lake Mead has significantly dropped in elevation exposing the upper reservoir area, figure 14. As seen from the image, the previously formed dike at Grand Bay became a barrier forming an independent water body within Grand Bay. If the lake were to continue to drop, this condition would also occur at some of the other tributaries such as the Overton Arm and Las Vegas Bay. These sediment formed barriers will likely remain until a high tributary flow over tops and scours the formation.

The single beam system was calibrated by bar check and the multibeam system by velocity profiler, providing independent checks of the two depth systems. Both systems were also checked by dropping a marked cable with weighted pod over the side of the boat in calm water conditions. Even in these ideal conditions, the length of the marked cable limited this check to less than 200 feet of water. The collection crew attempted to collect single beam data near the dam, but the onboard single beam instrument did not allow collection greater than 400 feet. As explained in the analysis section, additional checks and comparisons were made with other independent data sets to assure quality depth data was collected by both the single beam and multibeam collection systems.

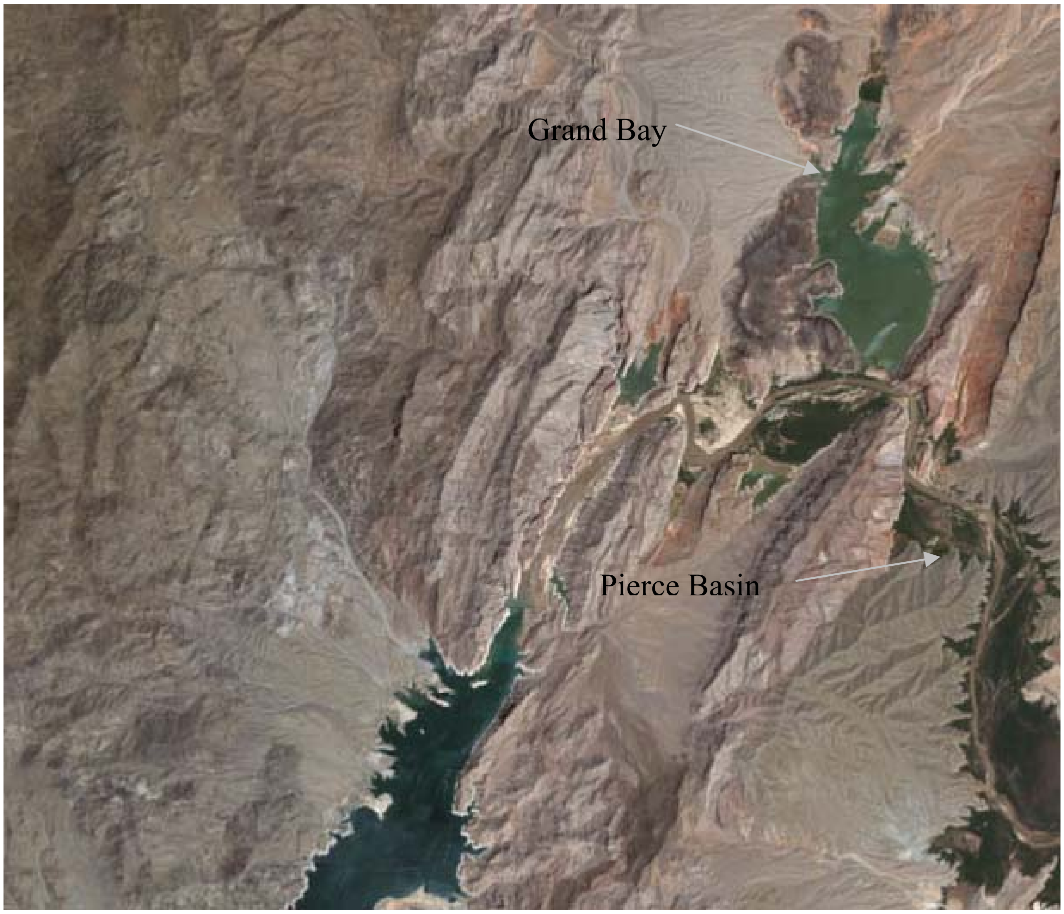


Figure 14 - Upper end of Lake Mead after significant drop of reservoir content since 2001 survey. Exposed Pierce Basin sediment delta, lower right. Grand Bay water body formed by sediment dike, top right corner (NASA, Visible Earth, visibleearth.nasa.gov).

Methodology

The Sedimentation Group continuously upgrades their technical procedures to reflect the latest data collection technology and analysis procedures. Prior to computerized data collection and analysis systems, the range-line method was viewed as the only practical method for collection due to its relatively low field and analysis costs. The range-line method was used most often on medium to large reservoirs such as Lake Mead (Lara and Sanders, 1970) and Lake Powell (Ferrari, 1988). The collection and analysis consists of determining sediment depths along predetermined range-lines. Analysis required detailed and accurate original reservoir topography. The range-line method is still a valid means of conducting survey studies for certain reservoir conditions. For the 1986 Lake Powell Survey, the range-line method was used due to deep, greater than five hundred feet at the dam, vertical wall conditions and good original topographic maps. It now is possible to completely map reservoirs such as Lake Mead and Lake Powell using GPS, multibeam system, and aerial collection, but the range-line method of analysis can still be considered for collection and analysis. A multibeam survey can cover in days what took months in 1986 on Lake Powell and resulted in range–line-type data at a much higher density (Ferrari, 2006).

The contour method has become the preferred method for data collection and analysis with the development of electronic collection and analysis systems. It requires large amounts of collected data to obtain accurate results, something present systems can handle. The contour method results in more accurate reservoir topography and computed volumes than the range-line method. The most accurate contour method is the survey of both the above and below water portions of the reservoir area. The ideal contour map is developed by photogrammetry (aerial) when the reservoir is empty exposing all areas to be measured, but this condition seldom occurs, making a combination of aerial and bathymetric surveys necessary. To reduce the time and cost associated with underwater data collection, the aerial data should be collected when the reservoir is as low as possible and the bathymetric survey conducted when the reservoir is as full as possible, providing maximum overlap of the two data sets. Surveying the underwater portion after the aerial survey with a large overlap reduces the time and cost as the survey boat does not have to maneuver in shallow water portions mapped by the aerial survey.

GPS Technology

GPS collection techniques can vary depending on cost, need, and availability. Absolute positioning normally involves a single GPS receiver and at one time was not accurate enough for use in hydrographic positioning. Previously, a large error source in GPS collection was false signal projection implemented by the US Government to discourage use of the satellite system as a guidance tool by hostile forces. When active, the errors were up to $\pm$100 meters horizontally. This practice was eliminated by Presidentional order in May of 2000, resulting in absolute positioning errors of around $\pm$8 meters which still may not satisfy all hydrographic surveying requirements.

A method of collection to resolve or cancel the inherent errors of GPS is called differential GPS (DGPS). Differential surveying is the positioning of one point in reference to another with the basic principal being that errors calculated by GPS receiver at a known point or datum would have common errors with other GPS receivers in the general area. DGPS determines the position of one receiver in reference to another and is a method of increasing position accuracies by eliminating or minimizing the uncertainties. Differential positioning is not concerned with the absolute position of each unit, but with the relative difference between the positions of the two units that simultaneously observe the same satellites.

Real-time DGPS, the current standard for hydrographic positioning, is where a master receiver is stationed over a known datum as it computes, formats, and transmits correction information through a data link to the mobile GPS receiver on the survey vessel. There are community base stations maintained by United States Federal, state and local government offices and commercial services that transmit GPS correction information. The main weakness in real-time collection systems is the communication link between the master and mobile GPS receivers. Surveying on open water removes most obstacles, but communication problems can occur with all systems when surveying in areas with obstructions such as mountains, cliffs, vegetation, and structures along the shoreline. When these situations occur, the flexibility of the hydrographic survey crew being able to move the master receiver to new locations makes it more viable, but at times, more costly.

RTK GPS in hydrographic surveying provides the highest precision of GPS positioning. The major benefit of RTK versus DGPS is that precise heights can be measured in real-time. This is a major benefit for surveys in tidal and river conditions, but not as necessary on reservoirs with more stable daily water surfaces. The basic output from an RTK receiver are precise three-dimensional coordinates with accuracies on order of two centimeters horizontally and three centimeters vertically. RTK GPS employs at least two receivers that track the same satellites simultaneously, just like with DGPS. To obtain high accuracies, the base station must be near the survey vessel.

A positioning technique available to the military is called precise positioning service (PPS) that obtains $\pm$4 meter accuracy from a single GPS receiver. With Department of Defense (DOD) authorization, a nonmilitary Government agency can utilize PPS. The Sedimentation Group used PPS for navigation in the upper area of Lake Mead above Boulder Basin. The reconnaissance techniques used on Lake Mead were not adversely affected by the GPS methods since the analysis was only concerned with bottom change due to the flat lying sediments.

The Sedimentation Group's goal for all surveys is to collect the most accurate data possible within a reasonable budget. The results of the Lake Powell and Lake Mead collections appear to show that any of the GPS methods will adequately map the bottom sediments in the original river channel alignment. As long as the study is mainly measuring the change within the original digital contours due to the flat lying sediments, absolute GPS position solutions should be adequate. If full bottom mapping or more accurate location of features is needed, then much higher GPS position solutions are necessary. It is recommended that the differential positioning method be used via commercial or Governmental broadcast, but there could still be areas these signals cannot be obtained due to signal blockage by the surrounding topography or other obstructions.

Depth Measurements

Over the last 60 years, the majority of all hydrographic surveys have been conducted using some form of acoustic depth sounder that provides a digital record (the 1940's and 1960's Lake Mead surveys used this type of system). These echo sounders have the capability of recording continuous profiles of the reservoir bottom, providing an analog bottom profile chart, and digital computer records. The computer system software matches these depths with other digital information such as horizontal positioning and heave components. The basic components of a depth sounding system are the data recorder, transmitting and receiving transducer, and power supply. With careful calibration and correct collection techniques, a high degree of bottom profile accuracy can be obtained and recorded.

Calibrations of the echo sounder are critical in assuring high-quality depth measurements by the bathymetric survey system. The largest and most critical correction results from the variability of the sound velocity in water due to temperature changes, but other factors such as water density, salinity, turbidity, and depth also affect the sound velocity. Most reservoirs exhibit large variations in temperature with depth, meaning the velocity of the sound wave will not be constant over the distance from the depth sounder's transducer to the bottom depth and back. The effect of the variation can be significant, a temperature change of 10 ^{o}F can change the velocity 70 feet per second, changing the depth measurement 0.8 feet per fifty feet of depth. For reservoirs such as Lake Mead and Lake Powell, the summer water temperatures near the surface can be in the high 70-degree range while temperatures at the bottom depths are in the 40-degree range causing a significant change in the sound velocity through the vertical zones.

For most single beam, shallow water, echo sounding work, an average velocity of sound can be used. Bar-check calibration determines the actual depth at the study area, and the sound velocity on the echo sounder is adjusted to measure the correct depth. If the study is conducted in areas with known large variations in velocity by depth or location, the sounder should be set to measure the average or deeper depths that will be encountered during that survey over the area being covered. For these types of conditions, frequent calibrations are needed. The sound velocity can be determined by a bar check calibration or measured directly using a velocity probe. Many velocity probes can measure the sound velocity at every foot of depth. An average value can be computed from these measurements, or with hydrographic software, the depth incremented velocity measurements can be recorded, stored, and used during postprocessing to adjust sounder measurements to actual depths. The method of using a velocity probe for measuring depth-related sound velocities is more critical for multibeam systems when correcting the field readings, mainly for the outer beam depth adjustments.

For the 2001 Lake Mead survey, a velocity meter with a 100-meter-long cable was used to obtain readings at 1 meter increments. Besides the collection of velocity profiles on a consist basis, the multibeam measurements were further verified by more conventional methods. During calm reservoir conditions, an end weighted calibrated cable was lowered from the survey vessel in around 180 feet of depth. The results compared well with the corrected multibeam depths. The multibeam depths also compared well with the deeper single beam depths at the confluence of the Overton and Colorado River. The single beam sounder was calibrated using a standard bar check and was evaluated independent of the multibeam soundings, further confirming the resulting elevations.

The Lake Mead survey was the first use of a multibeam system by the Sedimentation Group. Multibeam was used to measure the sediment deposition from the dam to the upper shallow water areas of the reservoir. For navigation-type surveys, it is recommended there be a 50 percent overlap of the survey sweeps for quality control. For reservoir sediment surveys, the overlap can be reduced in the deeper portions of the reservoir, but the overlap should be enough to assure the outer beams of the two sweeps are collecting high quality data. The 2001 Lake Mead final product included filtered x, y, z data points resulting in cross sections every 2 to 5 meters for the underwater reservoir areas covered by the survey vessel.

Additional Studies and Information

Original Topography of Lake Mead

The early topography of Lake Mead was based on the John Wesley Powell surveys of 1869 (Brown, 1941). In 1922 and 1923, the USGS, in cooperation with Reclamation, conducted profile surveys of the Colorado River from the mouth of the Green River to Needles, California, under leadership of Colonel C. H. Birdseye. Using plane table survey methods, topographic maps were made with 50-foot contours at a scale of 2 inches to 1 mile from Black Canyon upstream to the Lower Granite Gorge. The contours were developed to elevation 1,250 (Brown, 1941).

In 1930, additional topographic maps were developed around the proposed dam site at a scale of 1 inch equals 400 feet with 5-foot contour intervals. These maps and mosaics were made by Brock and Weymouth of Philadelphia and were found to conform to the standards maintained for the 1935 survey of the entire Lake Mead area (Brown, 1941).

With Hoover Dam closure on February 1 of 1935, it became critical for aerial photographic methods to be considered for the reservoir mapping to be extended beyond the 1930 aerial coverage. The contract was awarded to Fairchild Aerial

Surveys on February 23 of 1935, and five hours later, photographs were taken of the critical areas before they were inundated by the filling reservoir. The basic aerial photography of the entire reservoir area was completed on February 27 of 1935. To complete the map processing required extensive control and other ground surveys that are summarized in the report “Mapping Lake Mead “(Brown, 1941). The maps were developed at a scale of 1 inch equals 1,000 feet with 10-foot contours on 45 map sheets. There were 5-foot contours developed near the dam from the 1930’s survey.

The measurements of the contour areas were completed by the Division of Cartography of the Soil Conservation Service using an alternative method confirmed by standard planimetered measurements. It was estimated that the planimetered measurements, acceptable standard at that time, would have involved 436 man weeks at an estimated 1930’s cost of $18,749. An alternative method was proposed for measuring the irregular parcels called the weight apportioning method that consists of actually cutting out each individual area and weighing each on a highly sensitive analytical balance and computing the proportion of the weight of each area to the whole area. The coordinates of the survey control were used to compute the total acreage. The work on the map sheets began in April 1939 and was completed in March 1940 at a cost of $2,500.

To complete the process, each 5-minute quadrangle was photostated without change in scale and exceptional care was taken to prevent expansion and contraction of the paper. Numerous tests were made of the uniformity in weight of the different samples and when necessary, small corrective factors were applied. As a check to the weight-apportioning method, each 100-foot contour was planimetered and in every case the resulting area agreed within one percent. The surface area results, with some adjustment from the original calculations, are listed in the 1963 report (Lara and Sanders, 1970). In 1935 the Soil Conservation Service, in cooperation with Reclamation, computed the original capacity of Lake Mead from these 10-foot incremented surface areas (SCS, 1940). Table 1 is a recreation of table 3-3 of the 1963 report that lists the original surface areas, by indicated map, measured at 10-foot elevation increments.

10 - Foot Contour Areas in Acres

Sheet No	Elevation (feet)															
	660	670	680	690	700	710	720	730	740	750	760	770	780	790	800	810
1,2,3																
4			73.82	136.86	205.08	241.55	277.71	313.89	358.26	400.65	464.69	511.99	552.07	589.10	626.17	677.03
5		128.00	190.16	423.44	460.82	519.06	582.59	652.13	715.86	769.55	813.95	858.84	913.62	998.06	1,142.80	1,288.78
6,7			365.79	663.69	1,106.57	1,388.97	1,643.85	1,813.78	1,990.57	2,166.27	2,426.19	2,662.51	2,828.78	2,978.71	3,123.76	3,273.92
8	227.62	734.97	913.19	1,178.06	1,326.15	1,400.32	1,466.88	1,525.43	1,578.10	1,621.83	1,677.21	1,734.17	1,790.08	1,852.62	1,907.14	1,965.81
9		3.98	23.47	134.02	386.26	457.04	520.57	582.76	640.55	678.27	717.17	744.17	768.88	795.09	824.35	870.59
10																
11,12					36.54	123.61	275.83	382.95	610.64	874.94	993.54	1,099.84	1,254.24	1,423.30	1,553.69	1,650.14
14																
15																
16																
17																
18															156.42	319.11
19									288.62	1,209.54	1,448.00	1,874.06	2,245.40	2,598.30	3,111.04	3,535.90
20,21																
22																
23																
24																
25																
26													100.12	264.28	571.49	834.60
27									2.59	345.01	542.03	707.01	839.14	937.80	1,026.25	1,117.35
28																
30																
31																
32																
33																
34										118.93	174.88	198.54	238.42	274.31	296.51	317.23
35											12.55	122.87	392.85	670.02	849.63	974.35
36														83.99	242.09	266.41
37																
38												1.35	13.72	33.29	98.91	179.55
39																
40																
41																
42																
43																
44																
45																
46																
47																
48																
49																
50																
51																
52																
Total	227.62	866.95	1,566.43	2,536.07	3,521.42	4,130.55	4,767.43	5,270.94	6,185.19	8,184.99	9,270.21	10,515.35	11,937.32	13,498.87	15,530.25	17,270.77

Table 1-1935 Lake Mead Surface Areas (1 of 4).

10-Foot contour Areas in Acres

Sheet No	Elevation (feet)														
	820	830	840	850	860	870	880	890	900	910	920	930	940	950	960
1,2,3															
4	729.08	781.26	829.21	881.54	940.89	1,018.71	1,112.06	1,208.88	1,321.97	1,448.63	1,586.39	1,727.66	1,865.56	1,996.06	2,148.18
5	1,422.75	1,577.07	1,719.89	1,862.11	2,006.37	2,197.14	2,318.83	2,503.16	2,710.80	2,940.59	3,099.03	3,235.06	3,423.35	3,636.03	3,828.17
6,7	3,407.43	3,541.45	3,698.77	3,858.52	4,034.51	4,213.40	4,433.06	4,608.68	4,727.52	4,918.80	5,094.28	5,276.14	5,485.66	5,640.54	5,817.96
8	2,031.74	2,089.03	2,147.32	2,211.16	2,279.50	2,341.28	2,403.01	2,455.15	2,512.82	2,587.73	2,643.16	2,690.08	2,757.98	2,816.12	2,879.64
9	918.26	956.16	993.69	1,045.35	1,098.46	1,151.75	1,206.41	1,261.06	1,318.28	1,385.41	1,455.04	1,520.45	1,578.76	1,638.30	1,710.65
10															
11,12	1,728.29	1,809.59	1,873.10	1,946.31	2,021.43	2,088.52	2,163.52	2,253.84	2,338.08	2,456.98	2,533.51	2,620.56	2,689.11	2,772.36	2,870.26
14															
15															
16															
17															
18	499.46	635.73	798.29	901.72	998.58	1,066.86	1,149.05	1,190.72	1,225.00	1,313.95	1,360.66	1,441.79	1,513.57	1,586.55	1,665.87
19	4,034.76	4,380.65	4,637.82	5,025.43	5,301.62	5,449.20	5,758.26	5,983.84	6,203.50	6,445.21	6,688.94	6,901.47	7,134.02	7,349.67	7,625.83
20,21															
22															
23															
24															
25							2.32	72.52	149.19	223.52	358.91	503.04	720.49	1,061.88	1,494.60
26	1,008.90	1,076.59	1,172.77	1,275.23	1,429.11	1,622.95	1,771.95	1,912.45	2,057.28	2,228.68	2,381.62	2,528.41	2,672.27	2,835.28	2,995.05
27	1,214.39	1,373.38	1,516.04	1,804.83	1,998.98	2,159.17	2,327.55	2,517.89	2,695.22	2,938.69	3,319.14	3,727.00	3,998.30	4,218.70	4,417.29
28															
30															
31															
32															
33															
34	336.09	354.05	371.30	396.61	418.52	453.20	478.99	510.19	544.53	596.56	643.33	700.13	746.46	808.94	872.27
35	1,103.07	1,226.74	1,351.58	1,481.77	1,607.14	1,734.94	1,873.57	2,036.65	2,206.25	2,372.14	2,513.49	2,669.70	2,828.77	3,004.62	3,199.49
36	303.01	327.31	350.83	385.28	407.63	434.12	454.84	498.56	509.53	529.81	578.21	605.73	634.70	665.20	714.66
37	6.23	76.07	227.26	409.61	654.77	851.32	980.47	1,104.45	1,244.67	1,366.97	1,470.43	1,584.50	1,689.39	1,813.68	1,923.24
38	303.03	570.55	783.64	1,199.20	1,350.00	1,445.00	1,527.15	1,632.56	1,716.95	1,832.32	1,917.41	2,008.18	2,115.71	2,231.71	2,320.91
39															
40			1.94	26.87	109.48	202.70	295.91	419.78	543.63	595.62	647.58	697.13	746.68	809.56	872.43
41					16.89	60.72	89.90	102.14	110.32	118.64	124.23	132.94	138.77	147.88	153.95
42							9.43	76.34	119.42	148.00	169.00	185.40	199.50	211.34	224.00
43							3.42	41.96	136.07	386.72	590.91	682.71	771.44	841.88	914.47
44									2.12	53.30	128.05	217.20	278.15	339.63	390.31
45															
46												0.23	0.57	1.10	7.53
47															
48															
49															
50															
51															
52															
Total	19,046.49	20,775.63	22,473.45	24,711.54	26,673.88	28,490.98	30,359.70	32,390.82	34,393.15	36,888.27	39,303.32	41,655.51	43,989.21	46,427.03	49,046.76

Table 1 - 1935 Lake Mead Surface Areas (2 of 4).

10-Foot contour Areas in Acres

Sheet No	Elevation (feet)													
	970	980	990	1000	1010	1020	1030	1040	1050	1060	1070	1080	1090	1100
1,2,3							14.86	30.26	50.42	78.07	111.64	150.54	202.77	282.61
4	2,303.37	2,479.31	2,671.47	2,876.36	3,078.50	3,299.77	3,519.95	3,739.29	3,978.76	4,221.40	4,434.55	4,658.49	4,906.59	5,187.61
5	4,014.64	4,168.55	4,343.44	4,484.45	4,714.97	4,876.11	5,014.37	5,148.99	5,290.08	5,419.92	5,510.58	5,616.46	5,751.28	5,901.89
6,7	5,989.21	6,157.86	6,293.96	6,435.16	6,603.63	6,769.31	6,940.60	7,123.96	7,286.93	7,476.59	7,659.63	7,838.72	8,041.90	8,234.25
8	2,936.30	2,999.47	3,061.14	3,144.25	3,208.44	3,263.76	3,322.21	3,362.06	3,416.20	3,483.80	3,550.74	3,613.71	3,689.97	3,712.58
9	1,781.38	1,850.18	1,906.19	1,965.44	2,047.38	2,126.50	2,196.21	2,260.09	2,331.74	2,410.99	2,488.68	2,565.88	2,633.59	2,700.62
10												1.45	3.55	5.24
11,12	2,958.63	3,078.72	3,182.09	3,278.30	3,379.79	3,470.00	3,565.06	3,667.21	3,767.17	3,884.94	3,994.71	4,105.58	4,218.23	4,332.81
14														
15														
16											0.50	1.60	2.10	11.85
17												0.46	3.06	12.76
18	1,731.99	1,797.87	1,874.74	1,946.04	2,040.84	2,114.78	2,202.87	2,283.71	2,368.15	2,442.06	2,507.12	2,592.42	2,680.49	2,776.78
19	7,895.94	8,156.88	8,420.82	8,734.72	9,095.69	9,449.17	9,803.25	10,155.49	10,469.13	10,732.07	11,024.89	11,317.31	11,600.02	11,844.38
20,21	1.45	25.40	49.88	87.21	119.38	162.56	215.53	270.30	352.61	429.72	502.59	584.19	662.61	748.19
22														
23										252.75	738.84	1,172.75	1,722.36	2,033.08
24		276.33	791.23	1,302.29	1,932.94	2,591.91	3,165.02	3,910.89	4,674.38	5,444.82	5,993.35	6,492.64	6,901.62	7,252.96
25	1,809.28	2,157.99	2,349.73	2,570.31	2,772.34	2,961.07	3,179.57	3,403.60	3,644.20	3,918.79	4,185.91	4,437.74	4,664.09	4,951.04
26	3,156.53	3,320.02	3,489.59	3,655.31	3,842.08	4,021.64	4,234.23	4,449.59	4,640.20	4,823.00	5,030.26	5,230.80	5,398.99	5,560.53
27	4,602.62	4,786.35	4,979.05	5,173.67	5,371.07	5,556.68	5,789.77	5,989.44	6,166.09	6,350.05	6,558.83	6,768.83	7,044.24	7,265.14
28	2.42	4.42	6.93	12.51	17.20	22.74	30.87	37.85	50.35	65.88	83.60	102.75	124.04	149.24
30														
31														
32											5.16	16.94	30.69	51.15
33														21.37
34	937.68	987.36	1,045.85	1,111.17	1,187.05	1,253.00	1,330.22	1,404.44	1,484.37	1,578.60	1,666.37	1,756.10	1,866.13	1,959.73
35	3,368.07	3,564.56	3,789.87	4,013.26	4,248.20	4,368.11	4,582.97	4,765.20	4,985.08	5,208.41	5,456.20	5,672.51	5,904.95	6,140.54
36	729.93	760.99	816.67	830.89	899.44	932.06	975.87	1,017.69	1,060.91	1,104.03	1,137.98	1,177.03	1,192.57	1,281.18
37	2,030.17	2,149.46	2,281.05	2,407.93	2,533.18	2,639.07	2,798.33	2,925.84	3,087.23	3,231.03	3,388.31	3,529.17	3,694.68	3,845.37
38	2,410.33	2,491.38	2,590.77	2,687.41	2,789.50	2,882.70	2,980.04	3,108.18	3,223.87	3,373.38	3,484.70	3,560.73	3,705.63	3,876.22
39														
40	953.09	1,033.74	1,113.72	1,196.08	1,278.97	1,373.34	1,448.75	1,551.85	1,662.98	1,773.33	1,903.14	2,033.93	2,181.23	2,323.58
41	161.00	165.70	172.70	177.40	184.10	188.61	195.47	200.07	206.29	210.45	218.19	223.38	233.27	239.83
42	238.00	251.50	266.30	281.06	296.00	310.00	325.00	339.50	354.17	373.09	396.41	416.01	448.28	471.14
43	992.95	1,063.50	1,140.59	1,213.59	1,320.06	1,403.30	1,505.72	1,601.42	1,752.09	1,879.43	2,044.49	2,195.67	2,343.05	2,492.81
44	436.34	470.50	505.56	541.21	576.36	599.81	634.94	658.34	695.60	720.51	755.02	778.06	811.33	833.76
45		185.10	221.25	260.28	291.51	317.24	344.67	372.51	404.80	434.88	467.40	500.28	539.77	578.16
46	36.05	55.10	79.66	96.05	111.25	121.40	136.93	147.27	162.02	171.87	184.69	193.27	201.66	207.26
47			25.99	43.31	86.24	114.87	148.00	170.12	195.96	213.19	227.63	237.27	254.35	265.70
48		0.45	1.66	2.46	10.50	33.96	56.35	77.36	106.01	123.82	139.73	153.47	167.85	178.93
49								4.23	26.75	41.79	54.92	63.67	87.37	103.15
50														
51														
52														
Total	51,477.37	54,438.69	57,471.90	60,528.12	64,036.61	67,223.47	70,657.63	74,176.75	77,894.54	81,872.66	85,906.76	89,759.81	93,914.31	97,833.44

Table 1 - 1935 Lake Mead Surface Areas (3 of 4).

10-Foot contour Areas in Acres

Sheet No	Elevation (feet)												
	1110	1120	1130	1140	1150	1160	1170	1180	1190	1200	1210	1220	1230
1,2,3	376.42	464.77	548.47	643.40	738.41	842.71	949.69	1,064.19	1,175.46	1,336.17	1,510.52	1,662.74	1,839.37
4	5,505.20	5,834.84	6,154.83	6,352.18	6,656.44	6,866.41	7,255.04	7,536.44	7,794.41	8,072.43	8,404.44	8,712.67	8,971.24
5	6,021.44	6,153.35	6,295.57	6,428.69	6,572.55	6,724.99	6,879.33	7,046.18	7,227.96	7,403.83	7,617.46	7,809.37	7,997.67
6,7	8,384.30	8,549.14	8,714.64	8,890.94	9,051.65	9,249.34	9,403.96	9,591.52	9,788.03	9,965.52	10,177.46	10,372.41	10,545.71
8	3,789.67	3,854.53	3,918.67	3,968.08	4,037.77	4,100.81	4,163.85	4,227.09	4,295.15	4,356.23	4,413.15	4,467.30	4,529.01
9	2,804.81	2,902.72	2,972.54	3,047.79	3,124.29	3,197.49	3,276.61	3,352.59	3,429.93	3,502.23	3,596.92	3,679.74	3,762.12
10	7.39	9.59	13.57	16.39	19.61	24.95	32.11	39.74	47.56	54.63	65.87	77.34	86.94
11,12	4,463.51	4,561.10	4,661.28	4,764.58	4,863.69	4,976.20	5,060.50	5,174.32	5,302.95	5,433.08	5,570.32	5,714.99	5,847.93
14												4.93	328.31
15												17.26	34.38
16	51.33	109.32	168.77	234.05	283.29	373.42	447.96	536.40	630.08	738.54	860.08	1,042.89	1,088.43
17	42.89	73.69	118.99	163.87	210.45	281.44	378.74	503.18	626.53	783.76	903.83	1,010.69	1,130.44
18	2,868.58	2,959.18	3,030.15	3,094.66	3,161.92	3,255.87	3,321.25	3,402.83	3,471.79	3,557.72	3,645.39	3,720.54	3,792.36
19	12,139.95	12,423.55	12,716.82	13,058.49	13,453.99	13,873.64	14,220.79	14,592.83	14,908.13	15,231.37	15,578.01	15,847.51	16,097.32
20,21	811.45	877.79	951.29	1,046.21	1,153.23	1,308.33	1,478.00	1,657.03	1,798.93	1,945.96	2,192.31	2,456.78	2,847.86
22					85.71	292.01	485.00	715.10	1,113.48	1,570.88	1,962.07	2,317.85	2,990.30
23	2,330.58	2,793.97	3,160.35	3,610.58	4,138.85	4,576.17	5,120.53	5,834.75	6,315.91	6,723.40	7,114.30	7,460.01	7,806.97
24	7,566.60	7,885.97	8,220.90	8,524.35	8,864.49	9,161.94	9,533.25	9,842.54	10,211.79	10,509.61	10,861.42	11,200.06	11,377.18
25	5,240.86	5,466.76	5,734.86	5,972.36	6,234.97	6,490.34	6,743.52	6,992.47	7,239.45	7,470.78	7,735.76	7,990.28	8,252.33
26	5,754.98	5,913.35	6,068.29	6,215.72	6,379.44	6,546.21	6,703.58	6,855.28	7,015.10	7,159.21	7,323.34	7,470.42	7,605.02
27	7,472.58	7,667.74	7,890.85	8,097.95	8,320.98	8,550.27	8,781.12	9,031.87	9,333.50	9,598.33	9,972.77	10,282.85	10,618.80
28	188.35	215.87	248.09	280.73	344.33	386.83	442.15	494.78	549.93	611.25	668.95	733.85	824.89
30								0.85	2.16	3.04	94.25	234.79	472.48
31					11.94	51.42	76.22	141.45	287.64	453.98	681.91	1,007.26	1,150.15
32	79.79	131.08	221.42	369.36	548.65	802.34	792.03	886.67	934.26	1,021.07	1,130.60	1,166.91	1,364.67
33	53.61	91.26	151.90	204.27	275.40	373.31	468.42	554.03	652.61	750.52	852.99	959.97	1,061.72
34	2,092.16	2,186.27	2,271.48	2,345.75	2,450.14	2,543.63	2,631.18	2,704.71	2,796.43	2,884.72	2,992.32	3,064.80	3,156.03
35	6,373.59	6,580.00	6,831.93	7,043.52	7,277.95	7,482.72	7,660.84	7,875.84	8,083.62	8,305.19	8,505.38	8,636.93	8,852.11
36	1,353.77	1,380.53	1,446.38	1,467.87	1,552.06	1,593.39	1,657.41	1,707.50	1,812.77	1,866.68	1,993.61	2,039.23	2,169.10
37	4,005.74	4,162.30	4,334.36	4,487.78	4,655.25	4,832.41	4,970.05	5,107.24	5,264.57	5,424.23	5,594.30	5,735.24	5,886.26
38	4,017.82	4,125.15	4,243.11	4,347.40	4,481.33	4,594.49	4,689.27	4,797.82	4,877.64	4,991.33	5,104.99	5,175.53	5,285.58
39										13.45	38.71	68.57	99.04
40	2,461.66	2,604.56	2,775.95	2,948.70	3,121.77	3,302.32	3,470.68	3,627.55	3,787.59	3,939.46	4,101.59	4,233.45	4,382.74
41	248.89	254.91	263.48	269.21	278.76	285.17	297.12	305.10	326.60	340.99	375.86	408.91	451.55
42	515.77	555.80	611.16	660.19	726.39	803.05	829.91	887.61	920.07	989.07	1,057.42	1,104.30	1,170.77
43	2,692.78	2,854.33	3,039.15	3,215.77	3,432.04	3,635.23	3,851.84	4,054.35	4,281.07	4,502.36	4,693.49	4,876.98	5,085.47
44	863.79	883.80	918.00	940.82	985.40	1,015.15	1,054.25	1,080.28	1,118.29	1,143.65	1,180.99	1,205.91	1,238.72
45	616.69	645.76	682.46	721.62	769.00	815.00	863.07	895.13	942.09	973.37	1,013.55	1,040.38	1,076.52
46	219.17	228.40	238.21	244.79	255.08	261.96	273.40	281.18	293.82	302.82	320.75	331.55	345.47
47	290.96	307.79	326.10	338.28	360.06	374.55	397.11	412.14	435.63	451.29	480.41	499.79	524.97
48	198.87	212.12	234.95	251.29	268.88	280.62	301.33	315.15	335.48	350.03	374.27	390.47	412.84
49	138.01	161.27	201.68	228.62	273.12	302.82	337.28	360.29	383.11	398.30	431.49	453.61	481.98
50				13.14	28.81	41.51	60.35	79.13	94.22	109.31	127.90	146.54	180.75
51													
52													
Total	102,043.96	106,082.56	110,380.65	114,509.40	119,448.09	124,470.46	129,358.74	134,565.15	139,905.74	145,239.79	151,321.15	156,833.60	163,223.50

Table 1 - 1935 Lake Mead Surface Areas (4 of 4).

1948-49 Lake Mead Sedimentation Survey

The purpose of the 1948 Lake Mead study was the collection of basic data in conjunction with previous pertinent data collected that permitted analysis of the effects of the development of this huge reservoir (USGS, 1960). The 1960 report is one of the most extensive on reservoir sedimentation and provides a summary of the collection, including extensive bottom sediment sampling, and the analysis. The survey and resulting analysis report was a collaboration of Reclamation, U.S. Department of the Navy, U.S. Department of Commerce, Coastal and Geodetic Survey, University of California, and Scripps Institution of Oceanography providing study results and future predictions. Considering the technology available, the 1948 Lake Mead sedimentation survey was an extensive effort.

The echo-sounding equipment provided continuous sounding along designated lines that varied from 200 to 1,200 feet apart. Three different types of echo-sounders were used. A low enough frequency (14.25 kilocycles) depth sounder was used to determine the interface between the sediment deposition and the original bottom. In 1935, Lake Mead had a computed total capacity of 32,381,780 acre-feet and a usable capacity of 29,177,249 acre-feet. By 1948, the total capacity had been reduced to 31,047,000 acre-feet and the average sediment inflow, 1935 through 1948, was computed to be 97,429 acre-feet. There are several facts within the report that were invaluable for the 2001 study:

(1) The 1948 maximum measured sediment thickness in Pierce Basin was 270 feet. The 2001 survey measured a similar thickness in Pierce Basin, but with the delta growth extending further downstream as well.

(2) From the first 14 years of sediment inflow data it was estimated the reservoir would fill with sediment in the next four centuries. The 2001 results showed that filling will be far beyond the predicted four centuries due to the closure of Glen Canyon Dam.

(3) Sediment was confined almost entirely within the old river channel in 1948. The 2001 survey confirmed that is still the case until the channel becomes completely inundated with sediment, causing additional inflowing sediment to settle parallel to the original river channel alignment in the deeper portions of the reservoir.

(4) Sediment compaction will have an extremely important bearing on the rate of depletion of water-storage volume and life expectancy of the reservoir (USGS, 1960, page 217). The 2001 results documented this condition with the greatest effect in the lower reaches of the reservoir where the water is deepest.

(5) Extensive sediment sampling program provided valuable information on the initial sediment deposition.

1963-64 (1963) Lake Mead Sedimentation Survey

As part of the 1948 survey, Reclamation engineers concluded that Lake Mead should be resurveyed to coincide with closure of Glen Canyon Dam located about 370 miles upstream of Hoover Dam (Lara and Sanders, 1970). The 1963 survey was similar to the 1948 survey and collected sufficient data to compute reservoir information below elevation 1,230. The biggest difference between the surveys was in the reservoir condition, the 1963 survey was conducted at much lower water content.

The reservoir was divided into two areas and the hydrographic survey was conducted using different techniques. The main part of the reservoir from Pierce Ferry downstream to Hoover Dam was surveyed using echo-sounding equipment from elevation 1,150 and below. The exposed portions of the reservoir were measured by standard land and photogrammetric surveying procedures on the main part of the reservoir. The combined survey sets were used to develop new topography along with updated surface areas and volumes.

The lower Granite Gorge area, from Pierce Ferry upstream, was surveyed by a six person crew resurveying the same 174 river sections surveyed in 1948. Of the 174 range-lines, 148 were recovered and the other 26 were reestablished. The crosses marking each range-line were repainted for the recovered sections and new white crosses were painted for each of the reestablished ranges. The 2001 survey computations relied on a biological monitoring program that collected cross sections in this reach. There were only ten cross sections for this large reach of the reservoir, but they were of adequate detail to estimate the volume there.

The contour areas for the main reservoir at 10-foot contours below elevation 1,150 were determined from the updated topographic sheets from the 1963 survey data. Portions of the 1935 topographic maps were used to trace contour areas above elevation 1,150. Each 10-foot contour on the topographic sheets was planimetered a minimum of three times to obtain an average surface area of the contours and additional checks were conducted to determine the accuracy of these initial planimetered results.

The 1963 survey of Lake Mead was conducted primarily to determine the capacity of the reservoir along with volume loss since the original and 1948 surveys. As part of the study, sediment samples were also collected. The study determined that since dam closure, the Lake Mead sediment accumulation was 2,612,920 acre-feet. The annual sediment inflow during the 1935 through 1964 period was computed to be 88,200 acre-feet.

1998 Sediment Sampling

In May 1998, the U.S. Geological Survey in cooperation with the University of Nevada, Las Vegas (UNLV) investigated rates of sediment deposition and concentrations of selected synthetic organic compounds at four sites within Lake Mead (Covay and Beck, 2001). Sediment cores provided data on deposition rates, age-dating, and chemical analyses of the collected samples. The collected cores ranged from 1.5 to 5 feet, providing information on the top layer of the sediment deposition. An extensive deep drilling program covering the entire sediment deposit would be necessary to obtain information on changes since the 1963 sediment survey. The 1998 samples in the lower portion of the reservoir found sediment deposition was an ongoing process throughout the reservoir since closure of Glen Canyon Dam.

The collected samples were described as saturated, medium saturation, or minimal saturation and some as silt core layers. The porosity was calculated for the cores in relationship to the sediment depth below the bottom surface. For the deep water sample at the Las Vegas Bay near the Colorado River confluence, the porosity at 2.5 centimeters was 0.79, at 102.5 centimeters 0.75, and at 127.5 centimeters 0.38. For the sample at the Colorado River and Virgin River confluence, the surface porosity was 0.95 and at 113 centimeters 0.39. The deepest portion or bottom of the core may have been material from the original reservoir bottom, but it is assumed the layer consisted of consolidated sediment deposited previously.

Biological Monitoring Cross Sections

As part of a monitoring program, LCR had a biological contract for studying the Willow Fly Catcher. The monitoring included cross sections at 10 locations in the Lower Gorge Basin for determining the effect of the changing reservoir levels on the sediment formed banks used as bird habitat. The cross section locations started in the upper Pierce Basin and ended near Separation Canyon in the upper area of the Lower Gorge Basin. The LCR provided the data that included up to four different sets at some of the ten locations. During the later part of September 2001, a collection trip was planned by the Sedimentation Group to collect additional data using RTK GPS and single beam sounder. After 9/11, this trip was cancelled since not all participants could get onsite to complete the data collection before the end of the month. A few days after 9/11, the biological field crew took this author to the ten cross sections during their collected trip. This provided a visual evaluation of the river throughout the Lower Gorge Basin that greatly helped during the analysis. A handheld GPS unit provided locations of the cross sections.

The cross section data included one set from 1999 and up to three sets from 2001 for the ten collection sites. The data files included distance and depth points, but there was no vertical control near the study sites to tie the depths to the Lake Mead elevation datum. The 1999 data set was collected when the reservoir was nearly full, over elevation 1,205. For this analysis, elevation 1,205 was assumed as the vertical datum at each site for converting the 1999 depths to bottom elevations. The 2001 data sets were collected when the reservoir was at a lower level, meaning some of the locations were in a river condition and the reservoir elevation at the time of collection could not be used for depth to elevation conversion. For the 2001 data sets, comparison plots were developed with the 1999 data set. Using common areas of the cross sections that did not appear to change over time, the 2001 cross section elevations were estimated from the 1999 cross section data. These combined cross section results were used during the 2001 analysis to estimate the loss of upstream reservoir area due to sediment accumulation.

2000 Preliminary Meeting

In July 2000, a preliminary meeting was held between Reclamation's Sedimentation Group and LCR personnel in Boulder City Nevada to discuss the upcoming survey of Lake Mead that was to be funded in fiscal year 2001. The group also met with the USGS and UNLV study team that had been conducting extensive surveys on Las Vegas Wash and the lower portion of the reservoir since 1999 (Twichell, 1999). In 2001, the USGS and UNLV collection was extended throughout the rest of Lake Mead accessible by the survey vessel utilizing low frequency single beam and side scan sounders (Twichell, 2003).

Reclamation's Sedimentation Group proposed to survey Lake Mead using a multibeam collection system. With the proposed limited budget it was decided to concentrate the collection along the original river channel alignment. Based on review of previous Lake Mead surveys and the experience of the Sedimentation Group on multiple reservoir surveys, such as the 1986 Lake Powell survey (Ferrari, 1988), it was assumed that the majority of change due to sediment accumulation on Lake Mead would initially occur along the original river channel alignment. The previous Lake Mead surveys documented the initial sediment filling the original river channel. As the sediment inflow continued, it buried the channel under accumulated sediment lying fairly flat from bank to bank. The 2001 survey concentrated collection on these locations, making in-the-field decisions as to the extent of the outer boundary of the bottom measurements.

2001 Lake Mead Field Survey

Reclamation's Sedimentation Group surveyed Lake Mead Reservoir in the spring of 2001 to develop a present storage-elevation relationship (area and capacity tables). This was the first multibeam survey conducted by the Sedimentation Group and the first known multibeam survey of Lake Mead. During the July 2000 planning meeting, it was proposed to survey Lake Mead using reconnaissance techniques and a multibeam collection system that would map the known areas of sediment deposition (Ferrari, 2006). The Sedimentation Group has evaluated sediment on numerous reservoirs over the last century and based on experience, has modified collection and analysis techniques to obtain the best results within available budgets. Upon LCR approval for the Lake Mead survey, the multibeam collection system was requisitioned, providing one of the latest technologies for underwater collection.

Previous surveys of Lake Mead in 1948 and 1963, the 1986 survey of Lake Powell, and numerous reservoir surveys conducted by the Sedimentation Group found the majority of sediment accumulates in the upper delta and deeper portions of the reservoirs along the original river channel alignment towards the dam. The 2001 multibeam survey of Lake Mead focused on the original channel alignment to measure the known areas of sediment deposition. During the field collection, judgments where made as to the outer boundary of the existing sediments. The multibeam sweeps covered the sediment deposition and were extended beyond the deposition outer boundary to assure the bottom changes from the original topography were documented.

The Lake Powell 1986 range line survey found the sediment distributed laterally across the original river channel alignment of the reservoir. Although a few of the Lake Powell range lines measured channel cuts through the deposited sediments, the majority measured the sediment lying horizontally in the deeper original river channel geometry (Ferrari, 1988). Between 1999 and 2002, extensive sidescan sonar imagery, seismic-reflection profiling, and bottom sampling were conducted on Lake Mead by the USGS from Woods Hole, Massachusetts and the Lake Mead/Mojave Research Institute out of the University of Nevada. There are numerous Lake Mead publications summarizing the methods of collection and results from these surveys and research. These studies noted the post-impoundment sediments mainly covering the floors of the former streambeds of Lake Mead with the remaining reservoir bottom consisting of rock outcrops with no major change due to sediment accumulation (Twitchel, 1999).

The LCR Office contracted with the Sedimentation Group to conduct the Lake Mead 2001 survey with the primary objective to map the areas of sediment accumulation since closure of Hoover Dam in February of 1935. The underwater survey covered the known areas of sediment deposition accessible by the survey vessel in 22 days during April and May of 2001. The LC Regional Office provided assistance during a large portion of the collection and conducted the Geographic Information Systems (GIS) analysis of the x, y, z multibeam data sets provided by the Sedimentation Group (LCR, 2003). In the fall of 2001, a limited aerial light detecting and ranging (LiDAR) survey was conducted in the Grand Bay and Pierce Basin area of the upper reservoir. Due to 9/11, a scheduled Sedimentation Group range line survey was not conducted in the lower Granite Gorge. Previous Lake Mead sediment surveys indicated a large portion of the reservoir was lost due to sediment deposition during initial filling in the 1940's, but the upper elevation zones still had available area for water storage. The upper reservoir zone, from Pierce Basin upstream in the Lower Granite Gorge above elevation 1,180, is 40 miles of reservoir volume that was estimated in this study. The Lower Granite Gorge is narrow compared to the rest of the reservoir, but has available capacity as measured by the previous surveys of Lake Mead. The Sedimentation Group obtained data for this area through a contractor studying the effect of the reservoir on bird nesting areas along the Colorado River. Their study included cross sections, collected between 1999 and 2001, that were used to estimate the sediment accumulation in this reach of the reservoir at the time of this study.

Prior to the underwater collection, a RTK GPS control survey with centimeter accuracy was conducted to establish a temporary horizontal and vertical control point near the Lake Mead Marina. This control point was used as the base of the RTK GPS system and was used for the survey of the lower portion of the reservoir in the Boulder Basin and Las Vegas Bay (figure 15). It was requested by the regional office that the horizontal control be established in UTM coordinates, Zone 11 in the North American Datum of 1983 (NAD83). A temporary control point was also established on the Overton Arm of the reservoir near Echo Bay Marina, but due to time limitations, a military issued GPS unit with horizontal accuracy of $\pm$4 meters was used to map the remaining portion of the reservoir. All depths were converted to elevations using reservoir water surface records tied to the Hoover Dam spillway datum.

The 2001 survey utilized a high-resolution multibeam mapping system to collect x,y,z data of Lake Mead bottom from depths of 3 meters, in the upper portions of the lake, to greater than 140 meters near Hoover Dam. From the single transducer a fan array of narrow beams generated detailed cross sections of bottom geometry as the survey vessel passed. A 2-person crew that consisted of personnel from Reclamation's Denver and Boulder City offices operated the boat and collection system with the Sedimentation Group as the lead of the field expedition.

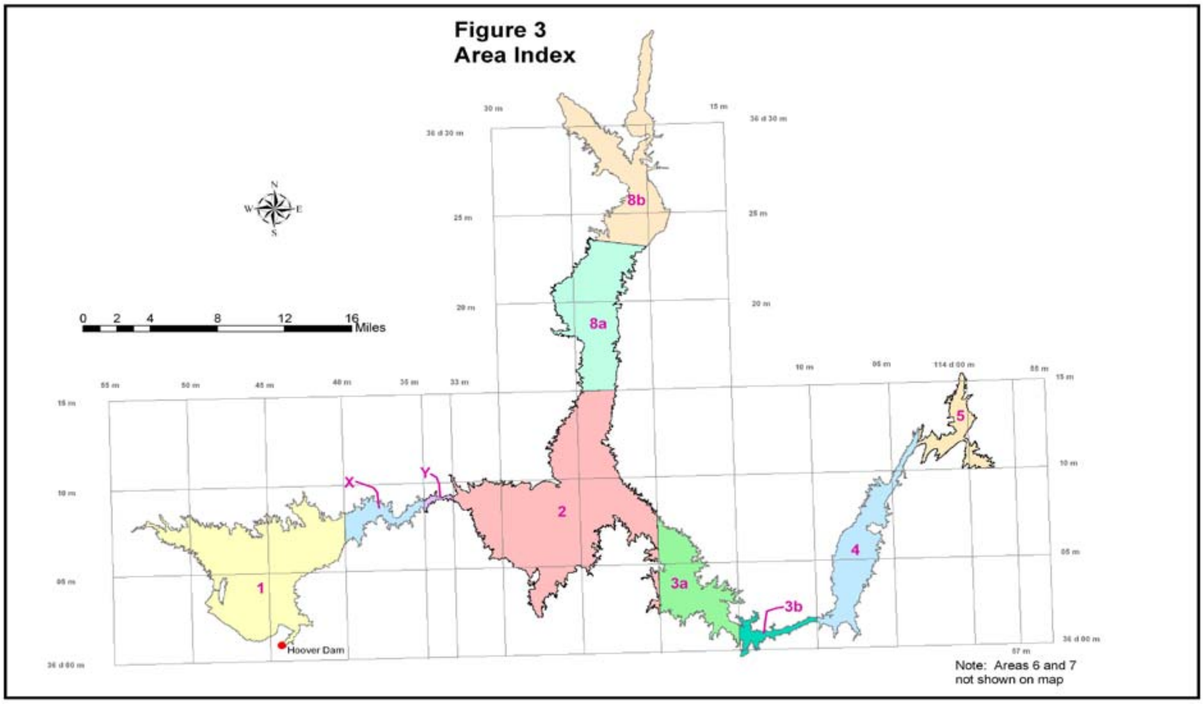


Figure 15-Lake Mead Basins, figure 3 from 2001 LCR report.

Figure 15 is a map index from the 2001 LCR report. The different areas of Lake Mead were given the following designations for mapping purposes (LCR, 2003):

- Area 1, x, y, and 2 – Boulder and Virgin Basins
- Area 3a and 3b – Temple Bar and Virgin Canyon
- Area 4 – Gregg Basin
- Area 5 – Grand Bay Basin
- Area 6 – Pierce Basin (not shown on figure 15)
- Area 7 – Lower Granite Gorge Basin (not shown on figure 15)
- Area 8a and 8b – Overton Arm

Areas surveyed include the underwater river channels of the Las Vegas and Overton Arms along with the Colorado River channel from the dam to just downstream of Pierce Ferry where shallow depths prevented the survey vessel from proceeding further upstream. Limiting the survey to the areas of reservoir sediment deposition, significantly reduced the required collection time. For example, mapping the full extent of Las Vegas Wash would have taken many days to complete in detail with either a single or multibeam system. Since this study was mapping just the areas of sediment accumulation, the Las Vegas Wash area that included the large confluence as it entered the original Colorado River, was mapped in a little over one day's time using the multibeam system. For the deeper portions of the reservoir, the procedure consisted of running parallel survey lines along the original river channel alignment. The distance between the parallel survey lines was depth dependent and was set to provide overlap of the data sweeps. In the deepest water, one sweep from the system covered more than 1,500 feet of the reservoir bottom. Parallel survey lines were run to ensure that complete mapping of the deposited sediments would be obtained in the deepest portion of the reservoir. As the survey vessels mapped the shallow water areas in the upper reaches of the reservoir, the overlap of the data sweeps was abandoned due to the time it would have taken to ensure full bottom coverage. Since the sediment deposits in the upper reaches were measured flat, it was determined that the areas missed could be projected during analysis. The areas covered by the 2001 survey are plotted within basins on figure 16. The figure was generated for the LCR 2001 report using the same basin boundaries as the 1948 and 1963 studies (LCR, 2003). Appendix I provides more detail of the basin and the mapping boundary outlines.

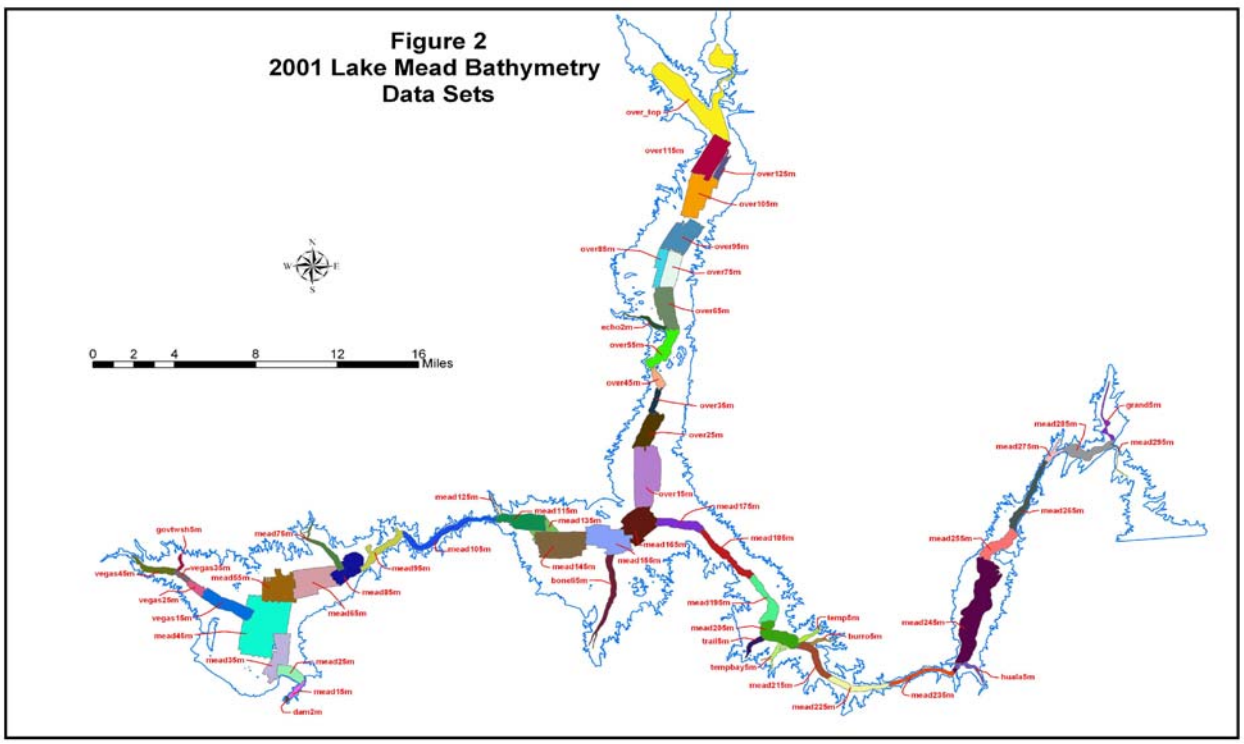


Figure 16 - 2001 Lake Mead bathymetry data sets, figure 2 from LCR 2001 report.

The multibeam survey measured the majority of the sediment deposits lying very flat. Due to the flat lying sediment, the collection speed could have been increased and the amount of overlap of the collection profiles could have been reduced without affecting the quality of the data collection and final analysis results. However, since this was the first multibeam survey performed by the Sedimentation Group, an extensive overlap of the profiles was maintained and the collection speed was held below seven miles per hour to provide quality assurance. During data processing, it was found that one multibeam profile happened to map an area of the Overton Arm of Lake Mead where a B29 military aircraft had crashed in 1948. A private diving team conducting research and sidescan collection pinpointed the location of the B29, where it was found to have settled on a ridge just above the original Overton River channel, (B29, 2002). The plane was found in around 300-feet of water and pictures from the dive team clearly show images of the plane and interior instruments with little or no silt material. These images further indicate the inflowing sediments travel along the original river channel alignment where they first settle in the deeper portions of the original river alignment. Figure 17 is an unfiltered image from one profile of the multibeam collection system revealing the general outline of the plane. A more detailed image could have been generated by the multibeam system if more profiles would have covered the aircraft.

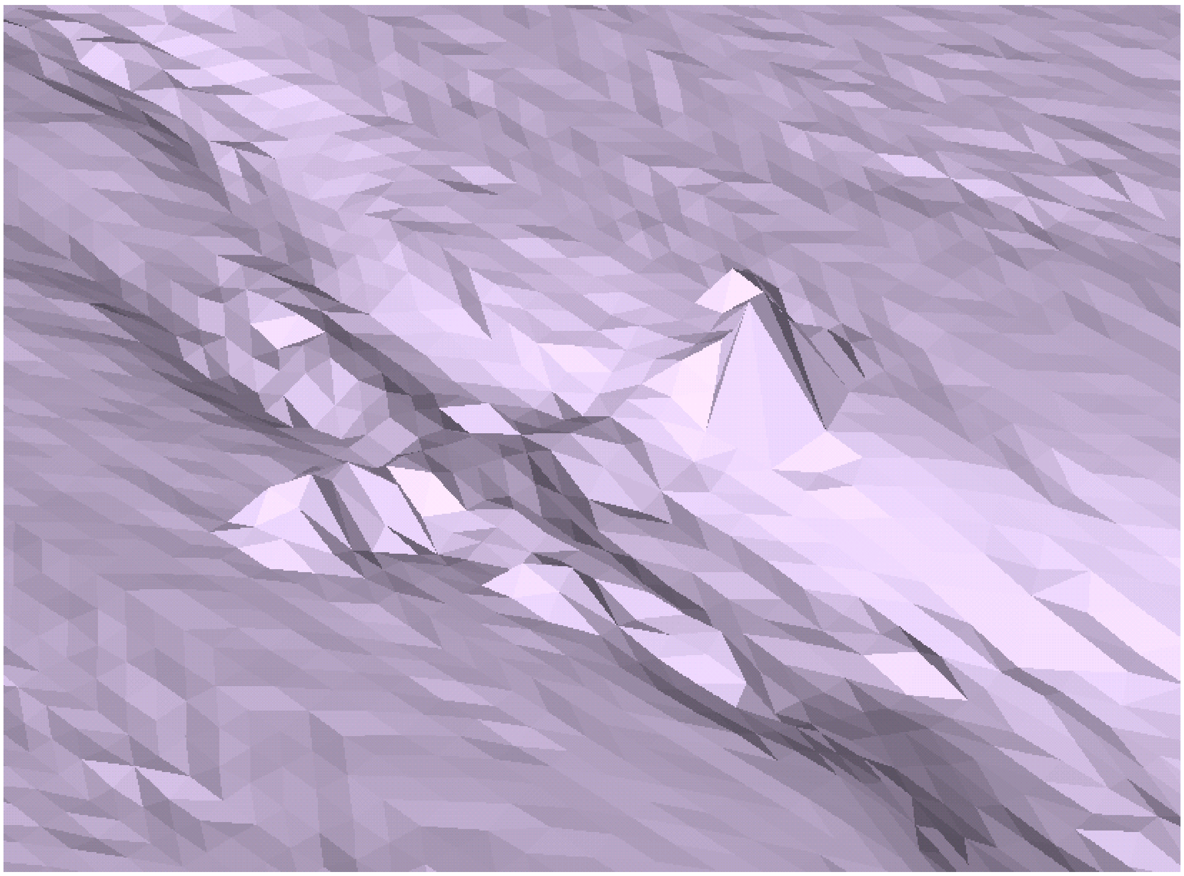


Figure 17 - B29 Multibeam image from Lake Mead, developed by LCR.

Due to shallow depths, the upper reservoir area on the Colorado River could not be surveyed by the large survey vessel. Part of the data collection plan was to survey the reach from Pierce Ferry upstream to Separation Canyon using aerial LiDAR (Light Detection and Ranging). Since air space access to the Grand Canyon portion of this reach could not be obtained from the National Park Service in time, the LiDAR collection was limited to the Pierce Basin area covered by the National Park Service within the Lake Mead boundary. The aerial survey was conducted in September of 2001 measuring no area from elevation 1,180 and below and no major change from original from elevation 1,200 and above. Surface areas at elevation 1,190 were generated by GIS methodology and were part of the final 2001 area and capacity calculations by the Sedimentation Group.

Future collection should consider airborne LiDAR hydrographic surveying as a method for collecting above and below water data. The Sedimentation Group and other agencies have successfully used the bathymetric LiDAR method to conduct shallow water river surveys (Hilldale, 2004). The primary constraint of this method is water clarity. This method has been successful at collecting depths of 2 to 3 times the visible depth through as much as 60-meters of clear water. In more turbid waters such as Lake Mead, the collection would have to be timed for ideal conditions. Utilizing bathymetric LiDAR combined with underwater collection methods such as multibeam, complete coverage could be obtained, resulting in the most accurate reservoir topography.

Since the LiDAR was limited to the Pierce Basin area only, the Sedimentation Group proposed to survey the reservoir area from Pierce Basin upstream by the range line method using RTK GPS and a single beam depth sounder. The survey was scheduled for the middle of September 2001 using available end-of-the-year funds. Due to 9/11, the trip was delayed and eventually canceled when it was determined the trip could not be completed before the end of the budget year on September 30, 2001.

Previous Lake Mead sediment surveys in the 1940's and 1960's indicated a large portion of the upper reservoir area on the Colorado River was lost due to sediment deposition, but the survey results did show some upper elevation zones were available for water storage. The upper zone, from elevation 1,180 and above, is 40 miles of reservoir volume that was accounted for by this analysis. This area, named Lower Granite Gorge, is narrow compared to the rest of the reservoir, but still has available capacity.

Data for the lower Granite Gorge area of the Colorado River were obtained through cross section surveys, collected between 1999 through 2001, by a biological contractor studying the reservoir effects on the nesting areas of Southwester Willow Flycatcher birds. Part of the monitoring program was the survey of ten cross sections from Pierce Basin to Separation Canyon. The cross sections general horizontal locations were tied to absolute GPS measurements with the elevations tied to the measured Lake Mead water surface at time of the survey. The Sedimentation Group developed cross sections with elevations from all available information for the ten locations. The reservoir elevation during the cross section surveys varied from elevation 1,190 to over 1,200. Overlapping plots of the cross sections allowed judgments to be made as to the true reservoir bottom elevations for each cross section location. This cross section data was used to estimate the area lost for this entire reservoir reach from Pierce Basin to Separation Canyon due to sediment accumulation.

2001 Lake Mead Analysis

The initial processing of the 2001 multibeam data was conducted after each day's collection by the Sedimentation Group. This included computer backup and visual inspection to assure system components were working properly. Upon completion of 2001 Lake Mead underwater collection, intense processing of the entire data set was conducted by the Sedimentation Group. This included applying the motion sensor measurements, the reservoir water surface elevations, and the sounding velocity profile files to correct the depth soundings to compute true lake bottom elevations. The editing processing was conducted in phases. The first phase consisted of viewing and editing the tide, heave, pitch, roll, heading, sound velocity, and positioning data. The second phase provided views of the multibeam sweeps that allowed editing of the individual points. The third phase sorted the data into matrix files that allowed multiple overlapping sweeps to be viewed and further edited. All elevation data were tied to the Hoover Dam powerhouse datum that is 0.55 feet lower than NGVD29 (Lara and Sanders, 1970).

To make the massive amount of multibeam underwater data more manageable, a filtering routine was applied within the analysis software during initial processing. This was accomplished by sorting the data into grids or cells and saving the maximum depth within each cell at its actual measured location. For the narrow canyon reach from the dam upstream to where it widens in Boulder Basin, the grid size was 2 meters. For the rest of the reservoir, the grid size was set at 5 meters. Quality control and assurance of the data set was provided by conducting field calibration as required by the multibeam system and comparing the final elevations to other independent data sets. The final 53 data sets included 20 million x,y,z points that covered about 30 percent of the underwater portion of Lake Mead (LCR, 2003).

At the first part of July 2001, these final processed x,y,z data files were forwarded by the Sedimentation Group to the GIS Branch of the LCR Boulder City Office for topographic development. Following is a summary of the LCR analysis report located in Appendix VII (LCR, 2003). The report outlines the topographic map processing and lists where the processed data can be obtained.

Topographic Processing by LCR

The LCR processing generated original (1935) and 2001 reservoir bottom topography within the individual map sheet boundaries as defined by the 1963 Lake Mead survey report (Lara and Sanders, 1970). The boundaries for all 45 maps are shown on figure 18, listed as maps 1 through 52 with no map 13 and 29. In some cases, single maps were labeled with multiple numbers: 1-2-3, 6-7, 11-12, and 20-21. Appendix I has a breakdown of the basins by map boundaries initially developed for the 1948 and 1963 studies and used by this study for the

2001 analysis. All horizontal data for the 2001 study was collected and processed in the UTM Zone 11 North in NAD83 coordinated system with the map boundaries cut along the original UTM grid lines with elevations tied to the project or Hoover Dam's power house vertical datum in meters.

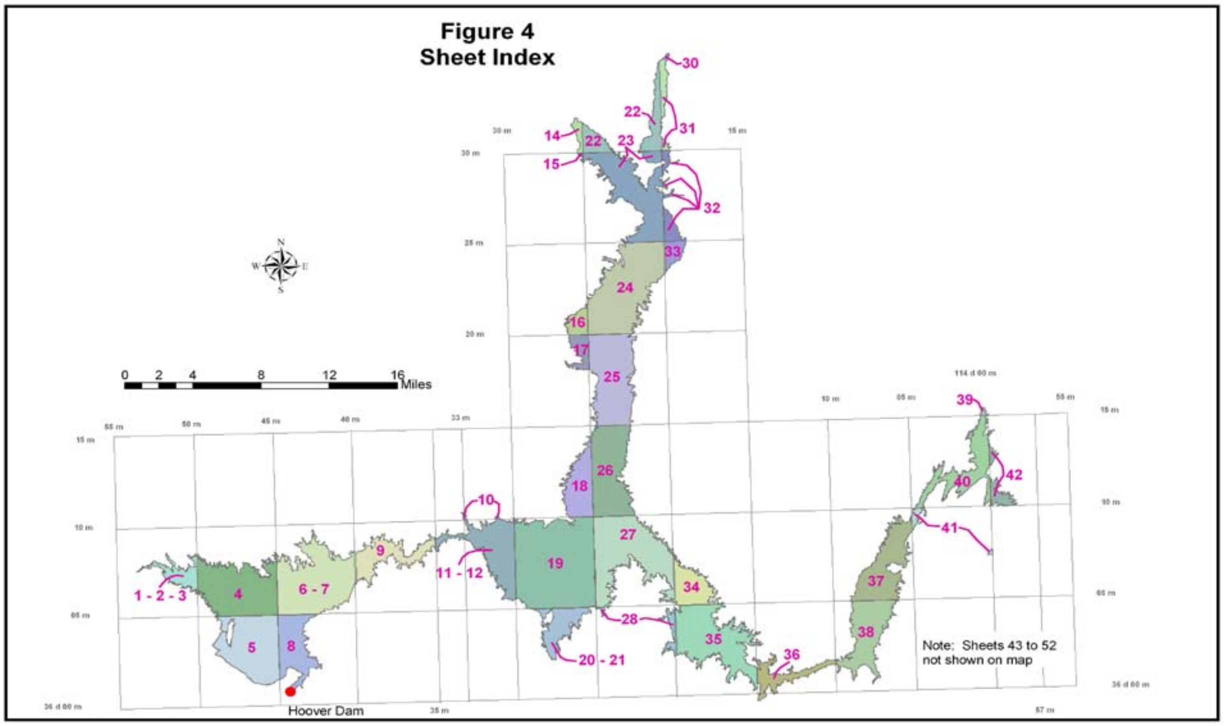


Figure 18 - Map sheet boundaries, figure 4 of 2001 LCR report.

Generating the 1935 Topographic Surfaces

The GIS analysis of the Lake Mead bathymetry began with the regeneration of the 1935 or original surface area topography using ARCGIS routines and tools (ESRI, 2001). The original topography was regenerated from the Lake Mead 10-meter digital elevation model (DEM) USGS quadrangle maps. The original DEM topography information was only available from Pierce Basin downstream to Hoover Dam. These USGS quadrangle map contours were developed from the original, 1935, five and ten foot original reservoir contours and presented as 10-meter DEM's. The USGS quadrangle maps are available above Pierce Ferry, but were developed from aerial data collected after closure of Hoover Dam and after this portion of the reservoir area had been dramatically altered due to sediment deposition.

For the purpose of comparing results with the original Lake Mead information, all ARC GIS data in metric units were converted to English units. The resulting individual map areas and volumes were consistently within 2 percent or less of the original published values listed in the 1963 report. This close correlation of surface area values validated the use of USGS DEM's as a reasonable method of computing the original and 2001 area and capacity values for the individual maps where both data sets were available in a digital format. The LCR analysis computed the 2001 capacity and resulting sediment deposition assuming no 2001 reservoir volume, or complete loss of capacity, from Pierce Basin upstream due to aggradation (LCR, 2003).

The LCR study developed spread sheets for comparison of the original and 2001 values for maps 1 through 41 (figure 18). Their analysis did not include map 30 located in the upper Overton Arm reach, but since the analysis made comparison of only the maps with available data this was not an issue. Following are comparisons of GIS computed surface areas for the original and 1963 studies: at elevation 1,230 the GIS computed area was 149,882 acres compared to the original published surface area of 152,233 acres, or 1.5 percent less; at elevation 1,100 the original surface area was 92,702 acres compared to the GIS surface area of 91,574 acres or 1.3 percent less; at elevation 1,000 the original surface area was 58,090 acres compared to the GIS area of 57,728, or 0.7 percent less. Comparison of the 2001 GIS developed original capacity values and the original capacity values published in 1963 for maps 1 through 41 at elevation 1,229.0 shows nearly 252,000 less acre-feet than the original published capacity values, about a 1 percent difference. This comparison indicates that the computed surface area values are slightly less, but very close to the original values. For computing the total sediment deposition, the original and 2001 GIS developed values were compared for differences. The principle limitation of the GIS comparison approach was that the original maps could not be regenerated for the entire reservoir. The main portion of the reservoir without original DEM data was from Pierce Basin upstream, which also happens to be the area of the reservoir impacted the most by sediment deposition. This is the main reason that it was assumed no 2001 capacity existed in these upstream basins.

Generating the 2001 Surfaces by LCR

The LCR analysis generated the 2001 contours and resulting surface areas for each available map sheet by combining the original DEM with the 2001 bottom elevation data. Using the original DEM's for the individual sheets, the 2001 underwater data was merged within the original map DEM by deleting the underlying original points. The resulting TIN contours and surface became the 2001 Lake Mead TINs, contours, and computed surface areas for the maps with original DEM data and 2001 collected data sets. These were the map sheets, along the original map boundaries, used for this analysis. It was assumed that the original map areas outside of the 2001 collection data remained unchanged.

Using ARC GIS tools, surface areas were calculated from the developed TIN's. The surface areas were calculated in metric units in vertical increments to match the 10-foot contour interval of the original. Surface areas were computed using the ARC GIS volume command with the option to calculate the area and volume below the given elevation. The resulting 2001 surface area values, at 10-foot increments, were imported into a spread sheet in square meters and converted to acres to match the units in Table 3-3 of the 1963 survey report.

LCR Volume and Sediment Computations

The 2001 LC Regional Office analysis assumed the original reservoir area above Pierce Basin was totally filled with sediment, meaning as of 2001 there was no available reservoir capacity there. The 1948 and 1963 survey results found that the majority of this area was silted in, but as seen on the longitudinal profile and cross section plots for these studies, there are over 40 miles of upper reservoir area from elevation 1,180 and above with available reservoir space. Portions of the upper elevation zones showed little to no measured sediment accumulation. Since there was no original DEM or 2001data available for this area of the reservoir, the LCR assumption of no 2001 capacity was valid for their sediment analysis.

Table 2 is a summary of the LCR Lake Mead capacity by reservoir basin, for the 1935 and 2001 results. As seen on the table, the 2001 capacities were set at zero for the Pierce and Lower Granite Gorge basins. The 1935 listed capacities for these basins are from the 1963 report and the last column shows the total capacity for the listed years. At elevation 1,230, the original 1935 capacity of 32,547,000 acre-feet is around 1 percent greater than the combined GIS 1935 values computed in the LCR analysis. This is a good comparison for the use of the DEM data with a total capacity difference between the two different computational approaches of over 250,000 acre-feet at elevation 1. The LCR sediment deposition value compared the GIS 1935 value to the 2001 computations was explained previously. At elevation 1,230 the computed sedimentation deposition was 2,675,382 acre-feet for the 66.7 years of reservoir operation since Hoover Dam closure.

As part of the LCR analysis a cooperative agreement was entered into with the USGS and University of Las Vegas. The agreement included the sharing of the Sedimentations Group's processed data and analysis time. The extensive data sets from the LCR/USGS processing are available online. The web site is titled "Mapping the floor of Lake Mead (Nevada and Arizona)." The site contains preliminary discussion of their processing methods and the link to the released GIS data sets processed by LCR. The online report is labeled, USGS Open-File Report 03-320, authored by David C. Twichell and VeeAnn A. Cross of the USGS and Stephen D. Belew of Reclamation.

http://pubs.usgs.gov/of/2003/of03-320/htmldocs/contents.htm

Elevation	Boulder and Virgin Basins		Temple Bar/ Virgin Canyon		Gregg Basin		Grand Bay		Pierce Basin		Lower Granite Gorge		Overton Arm		Total Original*	Total GIS**	Total
	1935	2001	1935	2001	1935	2001	1935	2001	1935	2001	1935	2001	1935	2001	1935	1935	2001
660	1,000	0		0		0		0		0		0		0	1,000	2,562	0
670	7,000	0		0		0		0		0		0		0	7,000	10,007	0
680	21,000	0		0		0		0		0		0		0	21,000	23,815	0
690	43,000	0		0		0		0		0		0		0	43,000	47,328	0
700	73,000	1		0		0		0		0		0		0	73,000	79,318	1
710	111,000	26		0		0		0		0		0		0	111,000	118,067	26
720	156,000	202		0		0		0		0		0		0	156,000	163,409	202
730	207,000	5,199		0		0		0		0		0		0	207,000	215,611	5,199
740	265,000	28,417		0		0		0		0		0		0	265,000	277,446	28,417
750	336,000	67,440		0		0		0		0		0		0	336,000	351,385	67,440
760	422,000	121,482	1,000	0		0		0		0		0		0	423,000	438,625	121,482
770	518,000	185,741	3,000	0		0		0		0		0		0	521,000	538,951	185,741
780	626,000	260,074	7,000	0		0		0		0		0		0	633,000	651,900	260,074
790	745,000	349,344	15,000	0		0		0		0		0		0	760,000	779,990	349,344
800	877,000	465,444	27,000	0	1,000	0		0		0		0		0	905,000	925,986	465,444
810	1,026,000	609,651	41,000	0	2,000	0		0		0		0		0	1,069,000	1,091,429	609,651
820	1,189,000	772,023	57,000	311	3,000	0		0		0		0		0	1,249,000	1,273,389	772,335
830	1,365,000	948,535	76,000	3,383	7,000	0		0		0		0		0	1,448,000	1,471,891	951,919
840	1,553,000	1,137,661	95,000	11,856	15,000	0		0		0		0		0	1,663,000	1,686,458	1,149,517
850	1,755,000	1,338,350	116,000	26,439	28,000	0		0		0		0		0	1,899,000	1,919,277	1,364,789
860	1,970,000	1,553,308	139,000	46,118	46,000	3	1,000	0		0		0		0	2,156,000	2,176,093	1,599,429
870	2,197,000	1,780,139	164,000	70,271	68,000	14	2,000	0		0		0		0	2,431,000	2,451,564	1,850,424
880	2,437,000	2,016,372	191,000	97,383	92,000	312	5,000	0		0		0		4	2,725,000	2,743,872	2,114,072
890	2,690,000	2,266,939	220,000	126,993	120,000	1,468	9,000	0		0		0		330	3,039,000	3,058,139	2,395,731
900	2,955,000	2,532,757	251,000	159,127	150,000	5,661	15,000	0	1,000	0		0	1,000	1,335	3,373,000	3,396,024	2,698,880
910	3,234,000	2,809,297	285,000	193,250	182,000	15,381	21,000	0	3,000	0	1,000	0	3,000	2,875	3,729,000	3,752,285	3,020,803
920	3,529,000	3,098,525	321,000	229,529	215,000	29,891	29,000	0	6,000	0	4,000	0	6,000	5,235	4,110,000	4,130,691	3,363,180
930	3,837,000	3,408,734	360,000	268,951	251,000	48,994	38,000	0	11,000	0	7,000	0	11,000	8,891	4,515,000	4,540,826	3,735,570
940	4,161,000	3,729,848	401,000	310,657	291,000	72,132	47,000	0	16,000	0	11,000	0	16,000	14,301	4,943,000	4,970,327	4,126,939
950	4,498,000	4,060,698	445,000	354,469	332,000	99,441	57,000	0	22,000	0	16,000	0	25,000	22,368	5,395,000	5,419,942	4,536,976
960	4,851,000	4,411,053	491,000	401,683	375,000	130,911	67,000	0	29,000	0	22,000	0	38,000	34,430	5,873,000	5,902,264	4,978,078
970	5,218,000	4,773,929	540,000	451,295	419,000	165,932	79,000	0	36,000	0	29,000	0	55,000	51,121	6,376,000	6,407,202	5,442,277
980	5,598,000	5,146,619	591,000	502,870	467,000	204,436	91,000	0	44,000	0	37,000	0	76,000	72,019	6,904,000	6,934,001	5,925,945
990	5,994,000	5,539,157	647,000	558,125	516,000	247,432	104,000	0	52,000	0	48,000	0	104,000	98,799	7,465,000	7,497,639	6,443,513
1000	6,405,000	5,949,161	705,000	616,882	567,000	294,171	118,000	0	61,000	0	59,000	0	139,000	132,399	8,054,000	8,093,489	6,992,614
1010	6,832,000	6,371,475	766,000	678,198	621,000	343,577	132,000	0	71,000	0	73,000	0	182,000	172,788	8,677,000	8,718,614	7,566,038
1020	7,275,000	6,810,939	830,000	742,827	678,000	396,076	148,000	0	81,000	0	87,000	0	233,000	221,097	9,332,000	9,374,888	8,170,939
1030	7,735,000	7,272,098	899,000	811,669	736,000	452,414	166,000	0	91,000	0	103,000	0	292,000	277,469	10,022,000	10,071,220	8,813,650
1040	8,212,000	7,746,866	969,000	883,214	797,000	511,422	184,000	0	103,000	0	120,000	0	361,000	340,449	10,746,000	10,799,581	9,481,951
1050	8,704,000	8,234,073	1,043,000	957,244	861,000	572,816	204,000	0	117,000	0	138,000	0	439,000	412,947	11,506,000	11,563,711	10,177,079
1060	9,214,000	8,745,095	1,121,000	1,035,952	928,000	638,896	224,000	0	131,000	0	159,000	0	528,000	500,534	12,305,000	12,375,329	10,920,478
1070	9,739,000	9,271,537	1,202,000	1,117,814	998,000	707,989	247,000	0	146,000	0	181,000	0	631,000	599,803	13,144,000	13,219,149	11,697,143
1080	10,281,000	9,806,529	1,288,000	1,201,761	1,069,000	779,053	271,000	0	163,000	0	204,000	0	746,000	707,879	14,022,000	14,092,516	12,495,222
1090	10,841,000	10,366,905	1,377,000	1,291,333	1,144,000	855,132	296,000	0	181,000	0	228,000	0	874,000	829,858	14,941,000	15,014,574	13,343,229
1100	11,418,000	10,943,941	1,470,000	1,384,839	1,222,000	934,789	323,000	0	200,000	0	255,000	0	1,012,000	960,927	15,900,000	15,973,851	14,224,496
1110	12,013,000	11,531,586	1,567,000	1,480,933	1,303,000	1,017,119	352,000	6	222,000	0	282,000	0	1,160,000	1,100,163	16,899,000	16,968,520	15,129,807
1120	12,625,000	12,143,336	1,669,000	1,581,944	1,387,000	1,104,654	383,000	346	244,000	0	311,000	0	1,320,000	1,255,559	17,939,000	18,013,804	16,085,839
1130	13,256,000	12,772,751	1,775,000	1,686,792	1,474,000	1,196,037	415,000	1,223	268,000	0	342,000	0	1,492,000	1,424,589	19,022,000	19,098,866	17,081,392
1140	13,904,000	13,416,975	1,885,000	1,794,681	1,564,000	1,290,126	450,000	5,179	293,000	0	375,000	0	1,675,000	1,602,716	20,146,000	20,222,180	18,109,677
1150	14,569,000	14,077,141	1,999,000	1,905,641	1,656,000	1,386,788	488,000	15,307	319,000	0	410,000	0	1,874,000	1,793,545	21,315,000	21,396,173	19,178,422
1160	15,254,000	14,766,195	2,116,000	2,021,194	1,752,000	1,487,286	527,000	32,248	349,000	0	447,000	0	2,089,000	2,005,734	22,534,000	22,629,094	20,312,657
1170	15,959,000	15,468,756	2,239,000	2,139,245	1,851,000	1,589,795	570,000	58,962	378,000	0	486,000	0	2,320,000	2,228,868	23,803,000	23,896,792	21,485,627
1180	16,685,000	16,182,627	2,365,000	2,259,375	1,951,000	1,693,943	613,000	91,313	411,000	0	526,000	0	2,570,000	2,467,610	25,121,000	25,217,529	22,694,867
1190	17,432,000	16,930,140	2,495,000	2,384,444	2,055,000	1,802,251	660,000	131,473	445,000	0	569,000	0	2,840,000	2,739,307	26,496,000	26,602,933	23,987,616
1200	18,197,000	17,695,217	2,630,000	2,512,678	2,161,000	1,913,578	708,000	174,034	481,000	0	614,000	0	3,129,000	3,025,862	27,920,000	28,031,392	25,321,370
1210	18,984,000	18,475,718	2,769,000	2,643,844	2,270,000	2,027,725	758,000	218,686	519,000	0	661,000	0	3,442,000	3,325,737	29,403,000	29,514,040	26,691,710
1220	19,797,000	19,283,171	2,912,000	2,779,228	2,381,000	2,145,561	812,000	265,371	558,000	0	710,000	0	3,775,000	3,652,704	30,945,000	31,059,363	28,126,035
1230	20,632,000	20,111,593	3,059,000	2,917,917	2,495,000	2,266,010	867,000	313,681	600,000	0	760,000	0	4,134,000	4,002,787	32,547,000	32,287,371	29,611,988

* Original capacity from 1963-64 study.

** GIS computed capacity execpt for Grand Bay, Peirce, and Lower Granite Gorge Basins. Used 1963-64 data for listed basins due to no original digital data

Table 2 - LCR computation results.

Generating the 2001 Surface Areas by the Sedimentation Group

During the 2001 Lake Mead study, the Sedimentation Group recommended a slightly different approach to the data analysis, but time and budget constraints prevented the recommended analysis from being performed at that time. After the LCR analysis was completed, the Sedimentation Group was able to acquire staff-days and funds to cover a portion of the alternative analysis presented here. The primary concern of the Sedimentation Group was the measurement of bottom elevations in 2001 being lower than the 1963 bottom elevations measured in the Boulder, Virgin, and Temple Bar Basins. For most studies, measuring lower elevations than previous surveys usually indicates an error in the survey, but later investigations by the Sedimentation Group supported the 2001 Lake Mead survey results. Rather than assuming zero reservoir capacity above Pierce Basin (as was assumed in the LCR analysis), the Sedimentation Group proposed to use available data to estimate the 2001 reservoir capacity in the upper basins. The Sedimentation Group was not questioning the results or approach of the LCR analysis, but took different approaches to address the question of the increase capacity in the lower elevations of the reservoir since 1963 and to include the available capacity of Lake Mead from Pierce Basin upstream.

In 2005-2006, the Sedimentation Group developed reconnaissance techniques for reservoir surveys that provided additional analysis of the 2001 Lake Mead results (Ferrari, 2006). Upon completion of the 2006 report, and when time allowed, a more detailed analysis of the Lake Mead data was conducted by the Sedimentation Group. Following is a summary of surface area and resulting 2001 Lake Mead capacity computations from the additional analysis. The Sedimentation Group's methodology differed from the LCR procedure in that the analysis was conducted map by map for the entire reservoir using all available data and previous experience to generate a 2001 Lake Mead area and capacity table along with resulting sediment computations. The approach looked for change from the original measured surface areas due to sediment deposition and did not make the assumption that the upper reservoir area from Pierce Basin upstream had completely filled with sediment leaving zero capacity there. The original individual map surface areas at the 10-foot elevation increments, as documented in the 1963 report, were used for the analysis. If the 2001 data indicated no change due to sediment at the original 10-foot contour interval, the contour surface area was marked as no change and the original surface area value from the 1963 report was used for the individual zone being analyzed.

The Sedimentation Group received the initial processed data set from LCR in spring 2002, prior to a meeting that was held in Boulder City between Reclamation and the USGS. The USGS conducted the Lake Mead survey using different collection technology and had been working with the LCR on data processing (Twitchel, 1999). The LCR also developed digital images from the 2001 multibeam data, figures 19 and 20. The images were developed using only the 2001 multibeam x,y,z data of the Colorado River data from Hoover Dam to about one mile upstream. The data set was filtered into 2-meter grids for this reach of the reservoir. Due to the extreme size of the data sets, the majority of the 2001 multibeam data was filtered into 5-meter grids for the LCR processing, but in the dam channel reach, the grids were set smaller to obtain more detail of the vertical wall topography. The first image (figure 19) shows the cofferdam located just upstream from the dam face and the second image (figure 20) shows the base of two intake towers located on the left bank looking towards the dam. The top of the cofferdam was not expected to be exposed within the image as previous survey results of the river thalweg showed the cofferdam completely buried by sediment deposition. A literature search on the construction of Hoover Dam uncovered a design drawing with the top of the cofferdam labeled elevation 720.

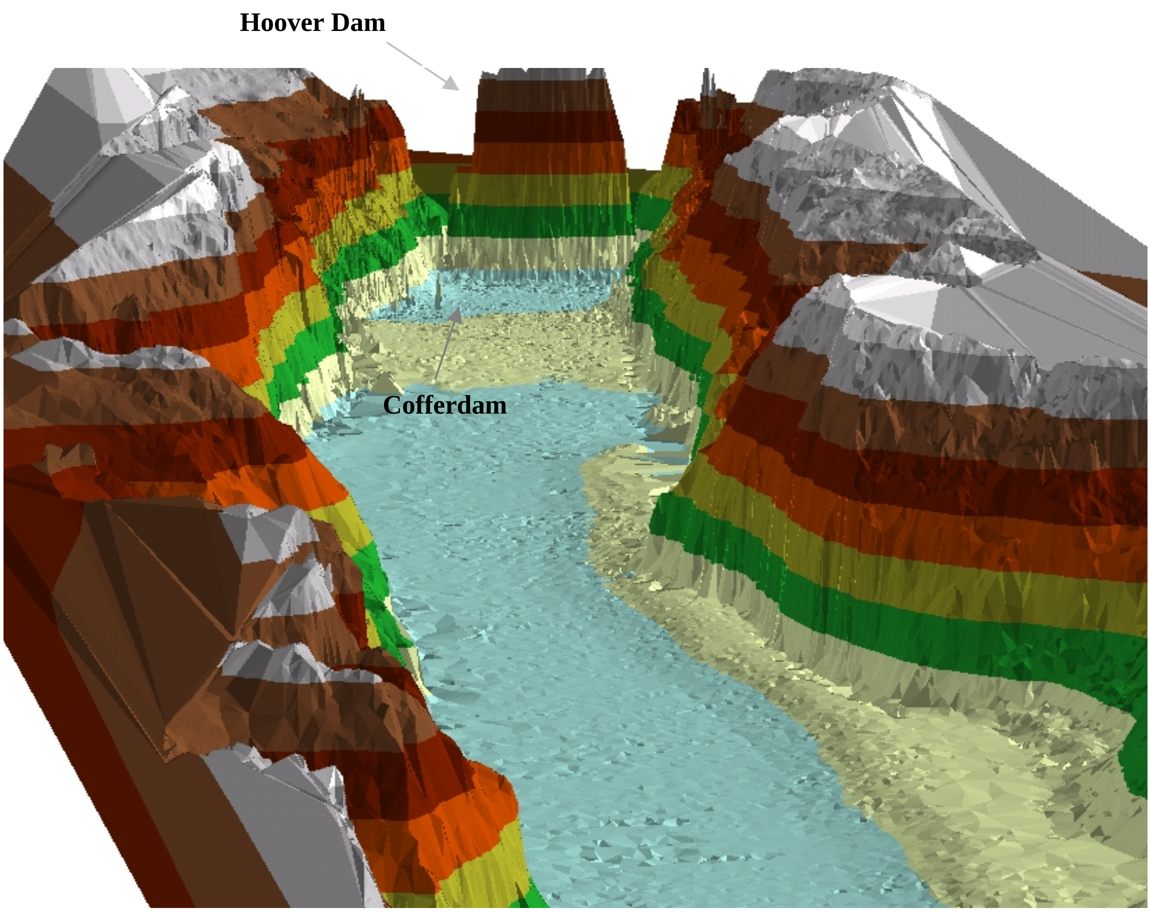


Figure 19 -Multibeam data of Colorado River upstream of Hoover Dam.

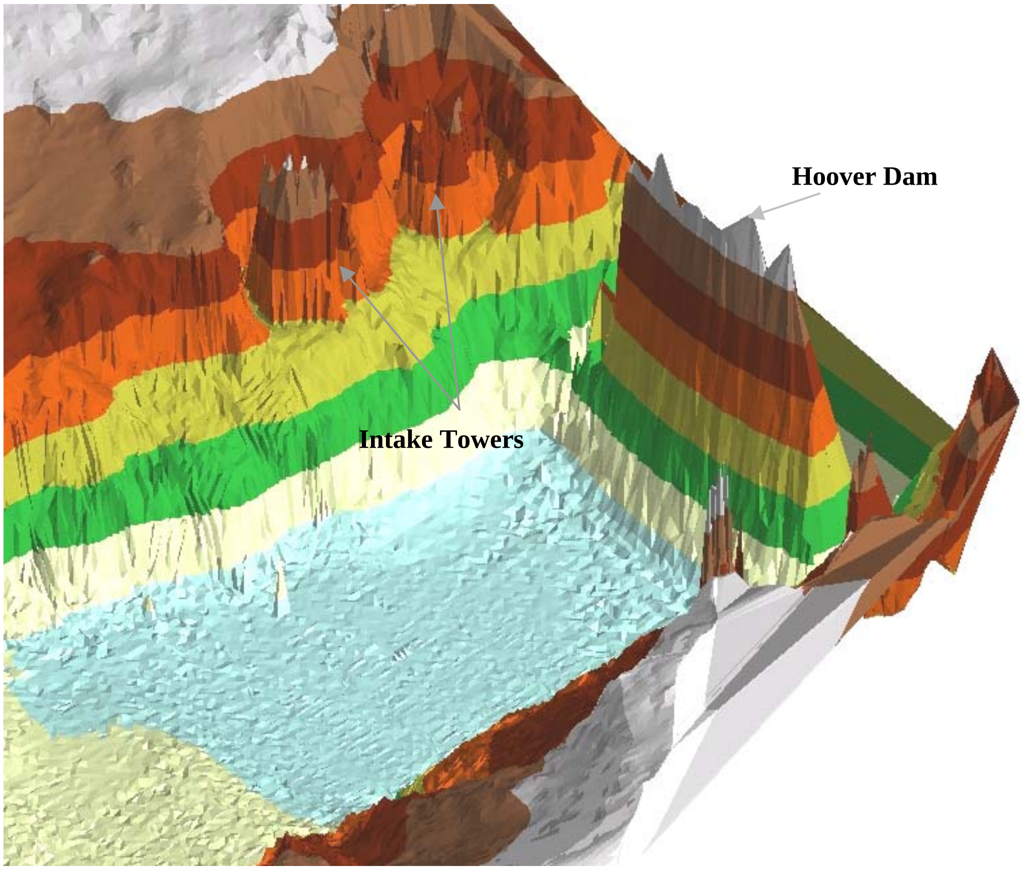


Figure 20 - Multibeam generated image of Hoover Dam and intake towers.

Upon receiving the data set from the LCR in spring 2002, a few days were spent evaluating the data and results prior to the scheduled meeting with the USGS. Using ARC GIS tools and the 2001 developed TIN's, a crude longitudinal profile was developed for the Colorado River, Las Vegas Wash, and Overton Arm of Lake Mead. These plots provided visual images of changes that had occurred since the original profiles were surveyed. For the meeting, the 2001 thalweg profile of the Colorado River was plotted against previous surveyed profiles from the 1963 report. There was not enough time prior to the meeting to conduct further analysis, but the thalweg plots generated considerable discussion. The main item of interest was the 2001 Colorado River thalweg plotted at a lower elevation than the previous survey data in the lower reaches of the reservoir.

After the Boulder City meeting, the longitudinal profiles were electronically generated and presented in this report. Figures 21 and 22 contain the longitudinal profiles measured for the 1935 (original) and 2001 data for Las Vegas Wash and the Overton Arm of Lake Mead. Both of these tributary plots show the thalweg change, over 66 years of reservoir operations, due to sediment accumulation from the respective drainage basins. The profiles show the classic build-up of the sediment delta in the upper basin area and the accumulation of sediments in the lower basin area at the confluence with the Colorado River. As shown previously on the Grand Bay drainage basin, the sediment barrier at the confluence consisted mainly of Colorado River drainage basin sediments. If the reservoir were to significantly drop in elevation, these deposited dikes, dams, or sediment plugs could hold back the waters in the tributary basins, forming a separate water body from Lake Mead. These barriers would also affect any density currents within these drainages and would likely remain intact until tributary inflows were great enough to overtop and erode the sediment barrier. Further investigation of the formation of these barriers would be necessary to determine their full effect.

The thalweg plots show the minimum build up of sediment in the Overton Arm and Las Vegas Wash tributaries since closure of Hoover Dam and provide evidence of the total amount of sediment the Colorado River has contributed to Lake Mead. As illustrated on these plots, the total sediment contribution from the tributaries is minimal compared to the Colorado River drainage. Studies of the sediment yield of Las Vegas basin to Lake Mead have confirmed that the contribution is minimal compared to the Colorado River source prior to and even since the closure of Glen Canyon Dam. Since the closure of Glen Canyon Dam in 1963, the main source of Lake Mead sediments has been significantly reduced. The Colorado River thalweg plot showed a build up of the upper delta for all surveys and with this information a better estimate of the total amount of sediment contribution during the survey periods could be generated. Also numerous studies in the Grand Canyon have documented the area below Glen Canyon Dam as being sediment deprived. Information from these studies could be used to better estimate and understand the current sediment inflow to Lake Mead.

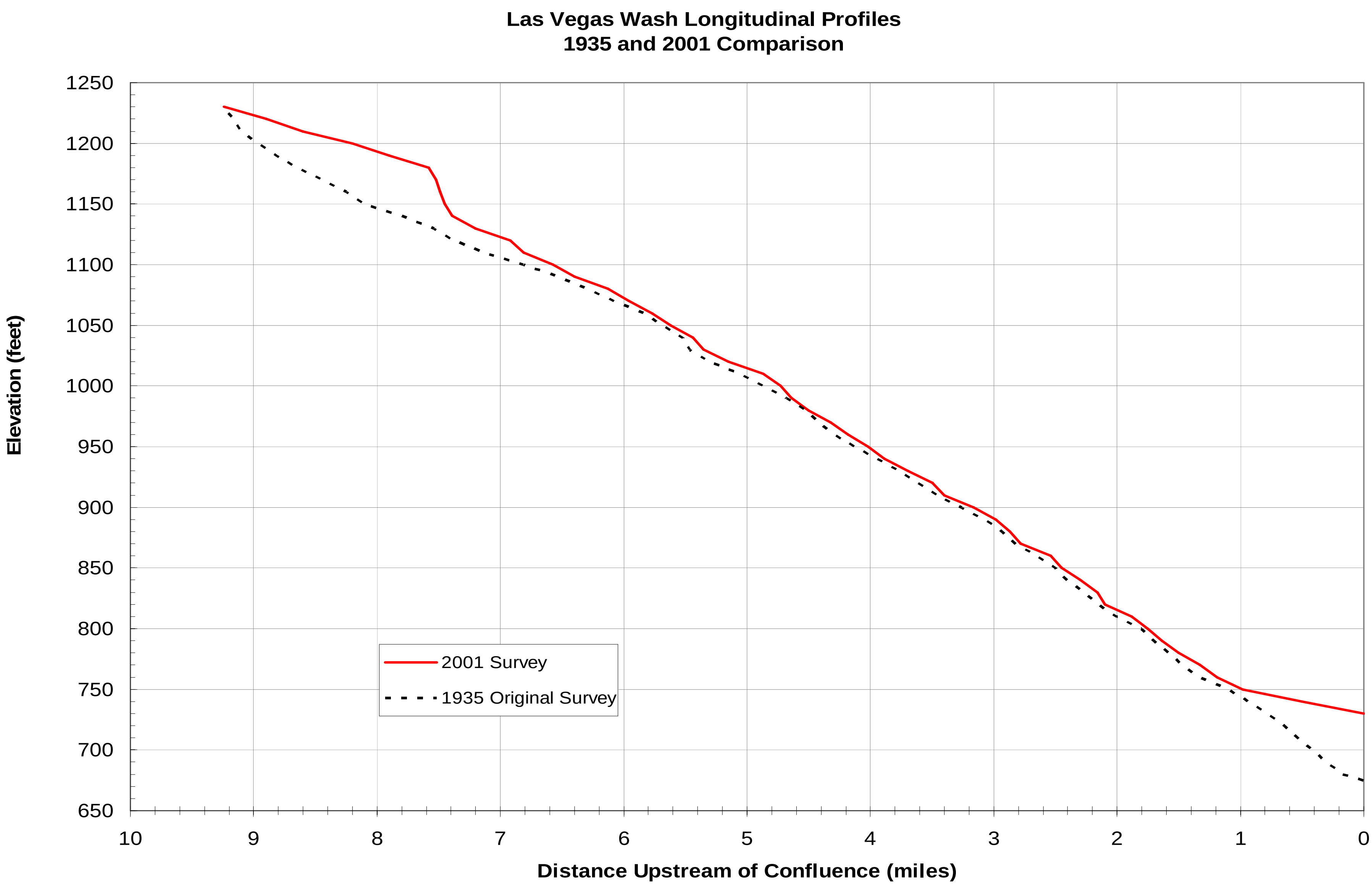


Figure 21 - Las Vegas Wash longitudinal profile.

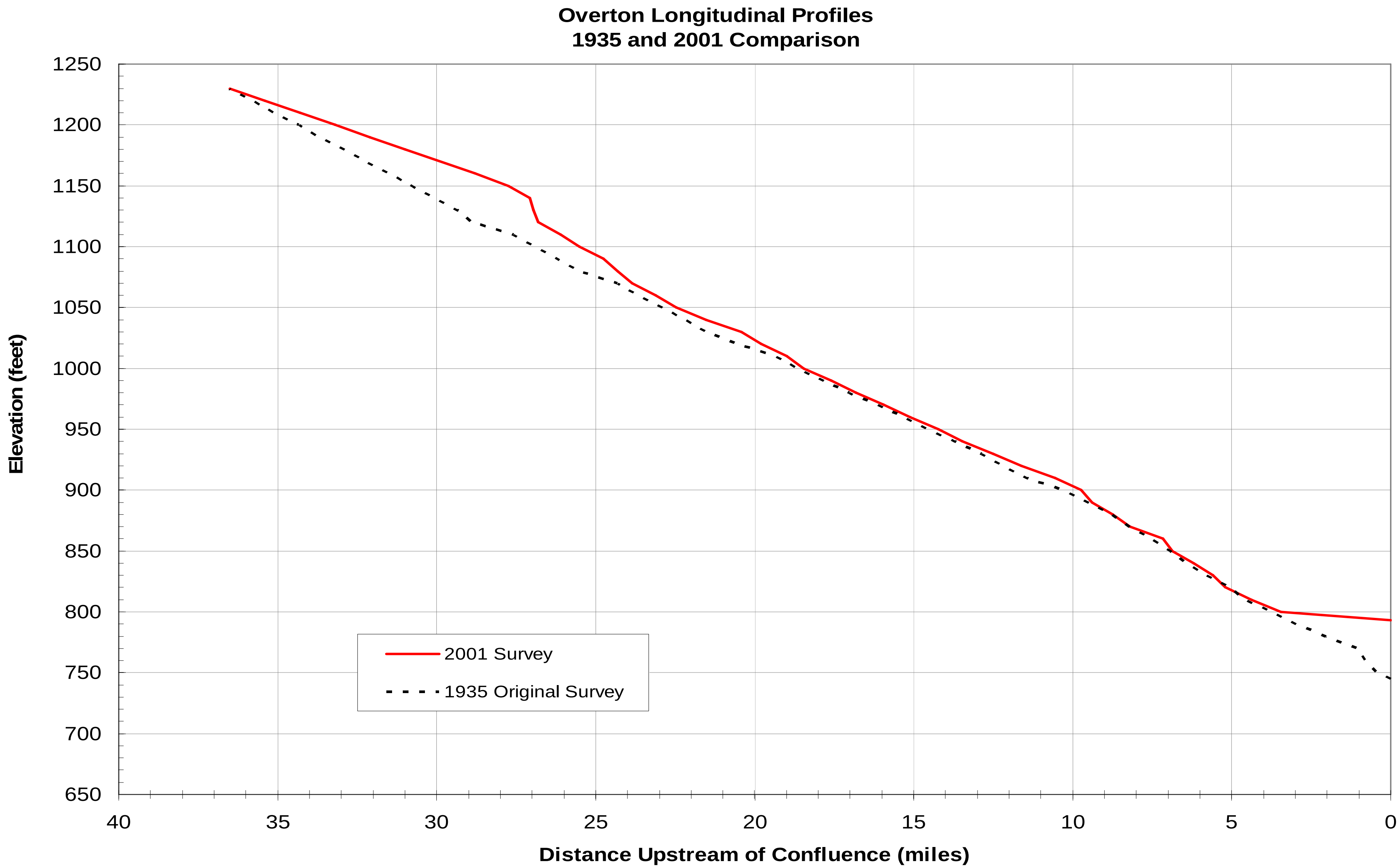


Figure 22 - Overton longitudinal profile.

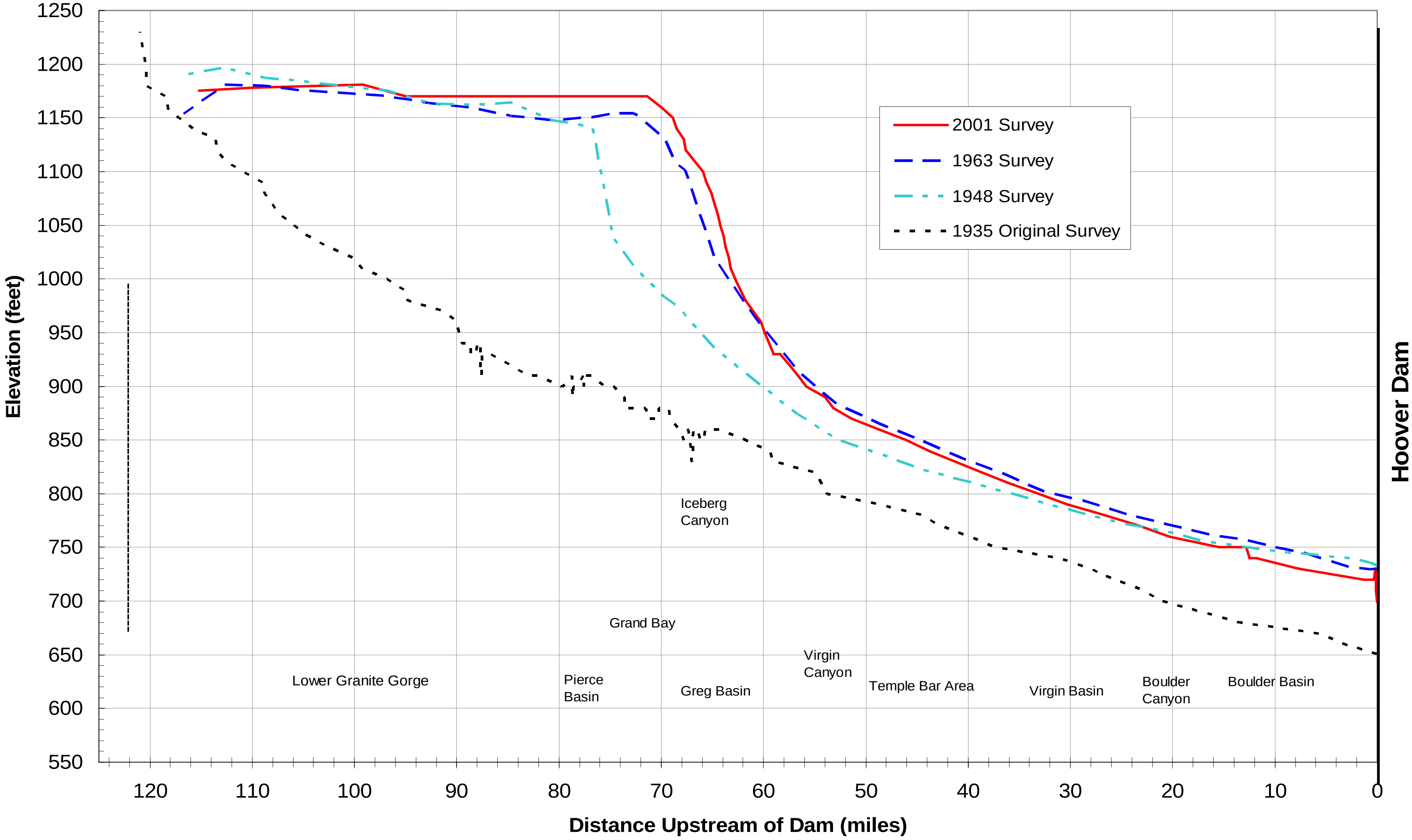


Figure 23 - Colorado River longitudinal profile.

The Colorado River longitudinal profile on Lake Mead compares the 1935, 1948, 1963 and 2001 survey results, figure 23. The 2001 profile of the Lower Granite Gorge above Pierce Basin was developed from the cross section data collected by the LCR biological contractor studying the effect of the upper reservoir on bird nesting habitat. Ten cross sections representing the gorge were collected by the biologists without a true vertical datum, but based on previous experience and knowledge of the reservoir delta formation relative to pool elevation; the cross sections were adjusted to complete the thalweg profile from Pierce Basin upstream. About 40 reservoir miles were developed from the cross sections where the reservoir boundary is confined to a narrow corridor by the natural topography until it widens out into Pierce Basin. The majority of the upper delta first began to develop at the Pierce Basin expansion due to the drastic decrease in river velocity. The Pierce Basin area was covered by the 2001 LiDAR collection, providing the Sedimentation Group with an accurate representation of the delta development as of September 2001 for their analysis. The 1948 and 1963 longitudinal profiles were developed by scaling the distance and elevation from the longitudinal profiles presented in the 1963 study report.

The Colorado River longitudinal plot revealed some interesting results. The 2001 bottom data plotted lower than the 1948 and 1963 longitudinal profiles in the lower reservoir area from Hoover Dam upstream. The 1963-64 thalweg plotted lower than the 1948 thalweg for the first six miles upstream of the dam and in the very upper end of the reservoir within the Lower Granite Gorge basin. The lower 1963 thalweg elevation at the dam indicated sediment consolidation between the two surveys. The 1963 survey was conducted when the reservoir pool was much lower than the 1948 survey. Due to the lower reservoir condition, a portion of the sediment deposition in the upper reach measured in 1948 was eroded and carried further downstream, moving the upper sediment delta pivot point downstream.

During the processing of the data, prior to the spring 2002 meeting, it was discovered that the 2001 map boundaries did not match the original map boundaries. This did not affect the development of the longitudinal profiles, but it did impact the computed surface areas and resulting capacities when comparing the original and 2001 results. The 2001 map boundaries were regenerated by LCR and forward to the Sedimentation Group in September of 2002. Data showing the measured 2001 bottom elevations lower than the previous two surveys was presented at the spring 2002 meeting, but at that time no clear explanation had been formulated. There was some discussion of potential depth errors in the previous surveys, but this author took the approach of confirming the accuracy of the 2001 data first.

Upper Reservoir Delta Deposition and Formation

Several publications that describe the general formation of sediment deltas within reservoirs used previous surveys of Lake Mead to generate conclusions (Fan and Morris, 1992; Strand and Pemberton, 1982). Reservoir deltas typically grow in the downstream direction, but fluctuating reservoir operations can result in vertical and upstream growth dependent on the normal reservoir operational water level. The original upstream area of Lake Mead was shallow with little storage capacity compared to the rest of the reservoir. During initial filling in this zone of the reservoir, the longitudinal growth of the delta was very rapid. The Colorado River longitudinal plot in figure 23 shows that the elevation of the upper delta formation for the different surveys was affected by the normal annual reservoir operation level. The 1963 survey was conducted at a lower normal pool elevation than the 1948 survey. Prior to the 1963 survey, the reservoir pool started to drop and the upper reservoir began functioning in a river condition, eroding a portion of the previously deposited sediments and transporting them downstream where they eventually deposited at the new normal reservoir pool elevation. The Colorado River longitudinal plot in figure 23 shows the 1963 upper profile plotting lower than the other surveys due to the lower mean or normal reservoir water level and subsequent bed erosion. The Lake Mead delta falls along the typical delta formation pattern with an abrupt change between the slope of topset and foreset deposits, figure 9. Reservoir bottom sampling conducted for the 1948 study identified a corresponding abrupt change in particle diameter between the coarser topset and finer foreset deposits, figure 24 (USGS, 1960). The sediment information indicated that as the upper delta formed and eroded due to reservoir operations, the upper delta and delta face grew downstream and consisted of heavier sand, gravel, and cobble material. The 1998 USGS sampling program in the deeper, lower reach of the reservoir found the top sediment layer consisted of unconsolidated silt deposits.

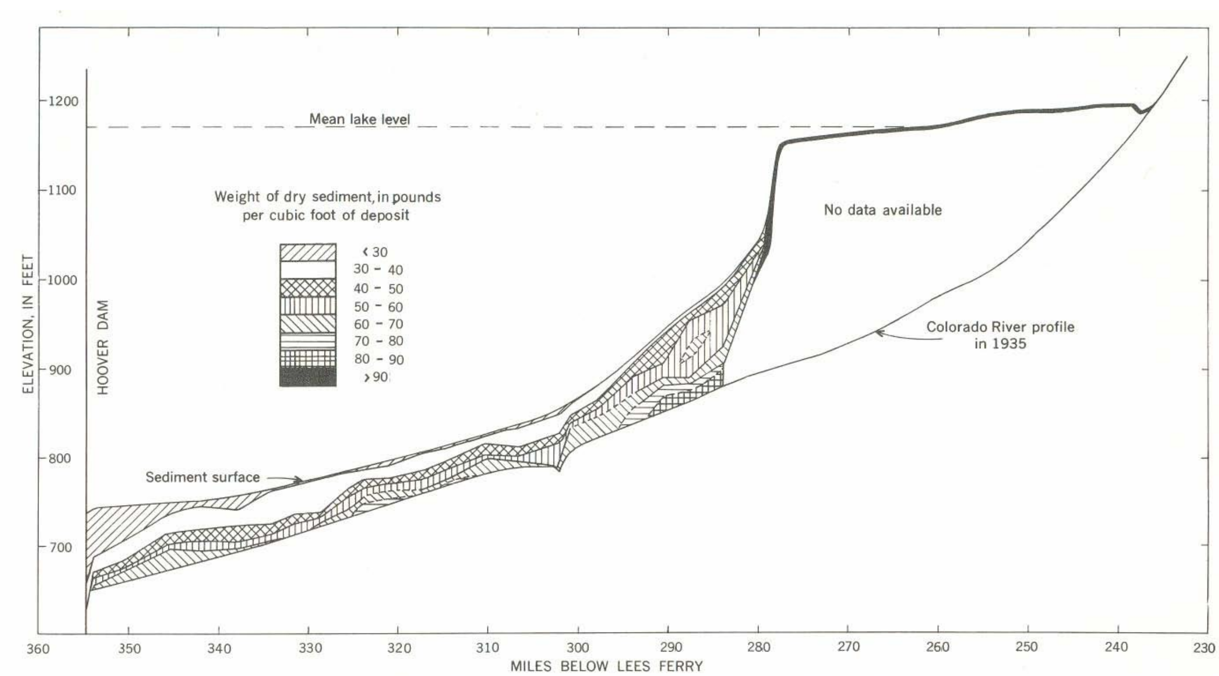


Figure 24 - Reservoir sediment density location zones (1935 to 1948).

2001 Measured Depth Analysis

Reservoir bottom elevations measured along the downstream portion of the original river channel alignment during the 2001 survey were lower than those measured during the previous two surveys in 1948 and 1963, figure 23. Measuring lower elevations than previous surveys typically indicates a data collection or analysis error, but investigation by the Sedimentation Group supported the 2001 bottom elevation results. Investigations included checks of the quality of data collected by the previous surveys and comparison of the 2001 elevations with known elevations such as the base of the intake towers and the top of the cofferdam. The 2001 bottom data results were also compared with other independent depth measurements to further support the 2001 multibeam bottom results. These analyses concluded that over time, compaction of the previous measured accumulated bottom sediments had occurred, resulting in the lower 2001 measured elevations. Mathematical means have been developed to compute the compaction rate that occurs overtime and are presented in the Consolidation of Bottom Sediments section of this report (Strand and Pemberton, 1982). Appendix II contains example comparisons of the 2001 depth measurements to other available information that resulted in further confirmation of the 2001 depth results.

According to Hoover Dam design drawings, the toes of the intake towers are around elevation 894. The 2001 multibeam elevations match very well with the design drawings, such as Reclamation drawing 45-D-13857. One elevation that did not compare as well was the top of cofferdam elevation. The 2001 survey measured the top of cofferdam at elevation 735, compared to the design drawing elevation 720. Limited research into the construction records found no evidence of the cofferdam being raised to such levels, but some documents indicated that the faces of the cofferdams were reinforced by construction crews due to concerns about their holding strength. It is also possible that the top of the upper cofferdam was raised during construction. Thalweg plots from previous surveys indicate that the cofferdam was completely buried at the time those surveys were conducted, but the top of the cofferdam is visible in the 2001 multibeam data. One explanation might be the consolidation of previously deposited sediment throughout the reach containing the cofferdam. Due to the compacted soil comprising the cofferdam, silt and clay sediment deposits upstream and downstream experienced greater consolidation over time than deposits along the top of the cofferdam. Figure 11 shows the top of the sediment at the intake towers around elevation 735 in 1950 following a density current event in 1949. It is assumed that after this period, additional sediment depth accumulated in this area, but no records reporting the extent of the deposition were located. The 1963 longitudinal profile put the thalweg around elevation 735, but the exact locations of the 1963 cross sections were not documented, resulting in many unknowns in the dam area of the reservoir. Deep core bottom sampling would be needed to better support the theory of top of cofferdam elevation change due to sediment consolidation, but the 2001 survey shows the surrounding sediments compacted upstream and downstream of the structure. Analysis of previous sampling and surveys, along with the mathematical results, led to the sediment consolidation conclusion in the lower reaches of the reservoir.

Consolidation of Bottom Sediments

Previous surveys of Lake Mead consisted of collected cross sections throughout the reservoir. These individual cross section locations were not available for this analysis. The only data available was what was presented in the two reports consisting of station distances between the cross sections varying from hundreds to thousands of feet. From the 1963 report, the Colorado River longitudinal plot showed a deep spike in the 1963 data between the dam face and the next collected cross section. The 1963 thalweg also plotted below the 1948 profile for about five miles upstream of the dam, indicating consolidation of the sediment surveyed in 1948. The 2001 data was collected by multibeam depth sounder and resulted in cross sections every two meters from the dam upstream for the first few miles and every 5 meters from that point upstream to just below the Pierce Ferry. The 2001 survey collected detailed data along the original river channel alignment where the sediment deposition had occurred and that data was used to develop the 2001 thalweg plot.

The 2001 data measured the top of the deposited sediment from the dam face upstream to the toe of the cofferdam near elevation 702. This is similar to location of the spike in the 1963 thalweg data. In 2001 top of the cofferdam was measured at elevation 735 with the upstream toe of the cofferdam around elevation 719. Since cross sections from the previous surveys were not located along the crest of the cofferdam, the top elevation was not known except from design drawings labeling top of cofferdam at elevation 720. The Colorado River longitudinal plot, figure 23, shows that the 1948 survey was near elevation 735 at the face of the dam and the plot of the 1963 survey started near elevation 720, jumped to elevation 730, then sloped gradually upstream. The 2001 survey results show an elevation of 702 at the upstream face of Hoover Dam and a 17-foot elevation difference between the downstream and upstream toes of the cofferdam. It is assumed that during initial filling a large load of sediment was deposited upstream of the cofferdam that consisted of sand, clay, and silt material. As the reservoir pool rose, the sand material was deposited further and further upstream of the cofferdam forming a sand/clay/silt deposition lens from the cofferdam upstream. Once the reservoir water level overtopped the cofferdam and became controlled by Hoover Dam, the cofferdam continued to act as a coarse sediment barrier, allowing only the fine silt/clay sediment mix to enter the zone between Hoover Dam and the cofferdam. If the initial top of the cofferdam was at elevation 720, then the upper portion of the reservoir was entering the Boulder Canyon and Virgin Basin portions of the reservoir at that elevation. Heavier sediments, such as the sands and gravels, would have mainly settled in this upper area of the reservoir. As explained in the density current studies, after initial filling, the sediments transported downstream were primarily the finer silt/clays that deposited upstream and downstream of the cofferdam. Over time, these fine sediment deposits consolidated and since the material between the two dams consisted mainly of the finer sediment with a relatively low initial density, more consolidation occurred there.

The sampling of deposited sediments in reservoirs provides the most useful information on the density of deposits (Strand and Pemberton, 1982). The 2001 survey conducted by the Sedimentation Group did not conduct a reservoir sediment bottom sampling program like the 1948 and 1963 surveys. The Woodhole USGS study conducted a sampling program in 2002, but the results were not available at the time of this analysis. There was a 1998 USGS sediment sampling program and the results of that study, along with the previous sampling results, were used to generate the conclusions for this analysis (Covay and Beck, 2001). The 1998 sampling was only conducted at four sites from near the dam upstream to the confluence of the Overton Arm and Colorado River, but the results indicated that density currents are an ongoing process, transporting fine sediments from the upper end of the reservoir and depositing them throughout the reservoir towards the dam. The results show that even though the major source of sediment has been cut off due to closure of Glen Canyon Dam, there are still inflowing sediments that continue to deposit throughout Lake Mead. The collected samples were described as saturated, medium saturation, or minimal saturation and some were classified as silt core layers. The porosity of the cores was calculated relative to the length of the reservoir. Surface porosities near 0.8 were computed for locations such as the confluence of Las Vegas Bay with the Colorado River. The sampled porosity at the Colorado River and Virgin River confluence was 0.95, meaning a great amount of space between the sediment particles were available for future consolidation. The higher sampled surface porosity indicated density currents were continuing to move the fine sediment from the inflowing drainage basins toward Hoover Dam.

The longitudinal plot, figure 24, created for the 1948 study illustrates the initial deposition of the inflowing sediment. As the river enters the reservoir the velocity is reduced along with the transport capacity, causing the coarser sediment material to drop out and deposit in the upper delta area. These materials settle and sort themselves resulting in an initial high density formation in the upper delta. Future density change due to consolidation is minimal in the coarse deposits. The bulk of the finer materials are carried downstream where it begins to settle. In some cases, the reservoir density currents carry the finer material along the original river channel alignment all of the way to the dam. As described in the 1948 report, during initial filling when the diversion tunnels where still open, the density currents carried a portion of this fine material downstream of Hoover Dam. Since the permanent closure of the diversion tunnels located upstream of the cofferdam at the original level of the Colorado River, the majority of this fine material now eventually settles on the reservoir bottom. Over time this material, whose top of elevation was measured by high frequency depth sounders, begins a natural compression, filling the previous voids between the sediment particles.

2001 Lake Mead Sedimentation Survey

The density of the deposited sediment material stored in the reservoir increases over time, changing the current and future capacity of the reservoir. There are basic factors that influence the density of sediment deposits in a reservoir, such as the manner in which the reservoir is operated. Lake Mead's water storage is directly affected by the upstream drainage runoff. Even before the creation of Lake Powell, it took years to fill Lake Mead during normal water-years while maintaining obligated downstream annual releases. Once Lake Powell initially filled, the obligated compact annual releases from Glen Canyon Dam became almost nine million acre-feet during normal water years and these required releases only increase during high runoff years. Under these conditions, the reservoir operation runs in cycles. At times there will be several consecutive years of low reservoir content followed by operation near full capacity after years of above average runoff. These changes in reservoir level affect the location and average top elevation of the upstream delta, but the initial density of these deposits changes little over time since they consist of the coarser sand/gravel/cobble/boulder mix. The 2001 survey measured the most reservoir bottom change since the previous surveys in the basins more near the dam that have been submerged since initial filling.

The inflowing sediment texture varies from large material to very fine. The fines have been found to enter the upper reach more than 100 miles upstream of Hoover Dam then the density currents push them downstream. The larger material drops initially in the upper delta and mostly remains in place until conditions change. Such as a drop in the reservoir level increasing the transport capacity in the upper reservoir, pushing eroded material further downstream until it enters the reservoir environment again.

The upper delta has little consolidation since it consists of mainly coarser material that drops out as the river velocity slows due to the flow expansion entering the reservoir. The fine material eventually settles on the reservoir bottom throughout the reservoir and initially settles very loosely according to previous sediment sampling results. Over time this finer material consolidates in place and additional loosely compacted fine material settles on top. In many reservoirs, sediment deposits are subjected to considerable drawdown, exposing them for long periods of time. Exposed sediments can undergo a great amount of consolidation from drying out. This is an ongoing process in most reservoirs, but in Lake Mead the majority of the fine material typically settles in deeper portions of the reservoir that have not been exposed since initial filling. The accumulation of new sediment on top of previously deposited sediment changes the density of earlier deposits. This consolidation increases the average sediment density over the life of the reservoir and was measured by the 2001 survey. A method that takes into account many factors in determining the density of deposited sediment is demonstrated in Reclamation guidelines and was used to estimate the potential consolidation with the information available for this analysis (Sedimentation Group, 2006). Appendix IV has a more detailed summary of the reservoir sediment compaction analysis conducted using these guidelines.

For this analysis, Lake Mead operation was classified as always submerging or nearly submerging the sediment with a big factor in the consolidation computations being the density of the initial sediment deposition. Including or excluding sand can also influence the results significantly. During the initial filling sand was deposited from the dam upstream, but since then, the analysis assumed the deposited material contained no sand. Results from previous sampling programs and profiles plotted in figure 24 indicate the surface density could be less than 30 lb/ft^3, but the thickness of the deposition to which that density applies is unknown.

The following equations were used to show the effect of consolidation over time on Lake Mead. With more information, a better result could be obtained to more accurately resemble the 2001 survey results. More than 1,300 samples were statistically analyzed by Lara and Pemberton (1965) to determine the mathematical equations for density variation of the deposits (unit weight or specific weight) for each type of reservoir operation. Additional data on density of deposited material from numerous reservoir resurveys have supported the Lara and Pemberton equations. In determining the density of sediment deposits in reservoirs following a certain type of reservoir operation, Lara and Pemberton recognized that a portion of the sediment will deposit in the reservoir during each year of operation, and each year's sediment deposit will have a different compaction time. Miller's (1953) approximation of the integral for determining the average density of all sediment deposited over the entire period of operation was used for this analysis.

There are many factors affecting the sediment deposits within Lake Mead and additional extensive studies could be conducted to better address many of them. Since the 2001 study was mainly concerned with current reservoir capacity and future rate of loss due to inflowing sediments, studying these factors was of interest, but was not required for development of the 2001 results and conclusions. In general, the specific weight is determined by the grain size and thickness of the deposit. The consolidation of the sediment deposition is a time dependent process that increases the specific weight. The deeper reservoir sediments consolidate due to the passage of time and additional sediment deposition on top. For the upper delta, the heavier and coarser sediment particles rest directly against one another when they are initially deposited. The void spaces between the coarse grains are large enough for water to flow through, allowing this heavier material to remain in place. If the upper reservoir carrying capacity increases due to reservoir drawdown followed by high inflows, a portion of the previously deposited materials are pushed further downstream. The silt/clay materials are carried further downstream and initially settle loosely with many voids that are initially filled with water. Over time and as additional layers of weighted sediment are deposited, these voids begin to collapse replacing the water with sediment material as they compress (Morris and Fang, 1997). This is the ongoing process occurring in Lake Mead and was measured during the 2001 survey, resulting in lower bottom elevations in some areas of the reservoir. Since closure of Glen Canyon Dam, the compaction still continues, but at a reduced rate due to the decreased sediment inflow. As the fine materials continue to be transported downstream to the dam by density currents, they will eventually deposit and compact over time.

Compaction analysis

The following calculations refer to Reclamation guideline, "Reservoir Sedimentation" (Strand and Pemberton, 1982) and Reclamation manual, Erosion and Sedimentation Manual (Sedimentation Group, 2006).

Reservoir operation: Sediment always submerged or nearly submerged.

Estimate the density of the sediment deposits.

$$W = W_c p_c + W_m p_m + W_s + p_s$$

Where:

W = unit weight in pounds in cubic feet

p_c, p_m, p_s = percentages of clay, silt, and sand, respectively, of the incoming sediment

W_c, W_m, W_s = coefficients of clay, silt, and sand, respectively. Obtain from reference

For a classified reservoir operation of 1

W_c = 26 (initial weight in lb/ft^3)
W_m = 70 (initial weight in lb/ft^3)
W_s = 97 (initial weight in lb/ft^3)

From 1963 Lake Mead study, the reported sampling was

Clay = 60%
Silt = 28%
Sand = 12%

$$W = 26(.60) + 70\ (.28) + 97\ (.12) = 46.84$$

In determining density of sediment deposits in reservoirs over time of reservoir operation, it is recognized that portions of the sediment will deposit over each operational year "T" and each year's deposits will have a different compaction time.

$W_T = W_1 + 0.4343K \left[T / (T-1) \ (\log_e T)-1 \right]$

Where:

W_T = average density after "T" years of reservoir operation

W_1 = initial unit weight (density) as derived from first equation

K = constant based on type of reservoir operation and sediment size analysis as obtained from table for different reservoir operations

For reservoir operation number 1

K (sand) = 0 inch-pound
K (silt) = 5.7 inch-pound
K (clay) = 16 inch-pound

K = 16(0.60) + 5.7(.28) + (0)(.12) = 11.196

For <u>66 years</u> of Lake Mead operations since dam closure

$$W_{66} = 46.84 + 0.434\ (11.196) \left[66 / (66-1)\ (4.19) - 1\right]$$
$$= 46.84 + (4.86)\ (3.25)$$
$$= 62.63 \text{ lb/ft}^3$$

Assumed some sediment at dam occurred during construction and initial filling. Since 1963, <u>38 years</u> of operation with sediments submerged.

$$W_{38} = 46.84 + 0.4343(11.196) \left[38 / (38-1)\ (3.64) - 1\right]$$
$$= 46.84 + 4.86(2.74)$$
$$= 60.15 \text{ lb/ft}^3$$

After <u>13 years</u> of operations (1935 – 1948):

$$W_{13} = 46.84 + 0.4343\ (11.196) \left[13 / (13 - 1)\ (\log_e (12) - 1\right]$$
$$= 53.6$$

<u>From 1948 – 64</u>:

$$W_{16} = 53/6 + 0.4343(11.196) \left[16 / (16-1)(\log_e 16) - 1\right]$$
$$= 62.2$$

After 37 years (1964-2001)

$$W_{37} = 62 + (0.4343)(11.196)\left[(37 / (37-1)\log_e(37) - 1\right]$$
$$= 75$$

From field survey results

1948 survey measured around 80 feet of sediment deposition near the dam.

1963 survey measured around 75 feet of sediment deposition near the dam.

For 1963: (53.6/62.2)(80 feet) = 69 ft

For 2001: (62/75)(75 feet) = 62 feet

From equations:

69 ft – 62 ft = 7 feet of consolidation

The 2001 survey analysis computed about 10 feet of consolidation. The calculations made several assumptions and many factors have changed in Lake Mead since initial filling. Such as the 1963 closure of Glen Canyon Dam cutting off the primary source of sediment inflow. The calculations considered sand in the initial sediment source, but since initial reservoir filling, the material in the lower basins mainly consists of a clay/silt mix. Under current conditions, the amount of sand flowing into the lower basins of the reservoir could be considered zero. As seen on figure 24 and in the 1998 sediment sampling results, the top layer of the sediment is initially deposited in a loosely compacted state that increases in density as new layers of sediment are deposited on top. The above example calculations demonstrate the ongoing consolidation process and how all the survey results could be used to better define the current condition of Lake Mead.

Summary of Sedimentation Group's Processing

By agreement, the final x,y,z formatted data was forwarded to the LCR for GIS analysis in July 2001 upon completion of the multibeam data processing by the Sedimentation Group. The Sedimentation Group and LCR remained in communication during the analysis period and the first extensive data set was delivered to Denver in March 2002. As previously described, the GIS analysis generated the original and 2001 map boundary data using 10-meter DEM data from the USGS quadrangle maps and 2001 multibeam data. The LCR GIS analysis utilized the DEM to redevelop the original contours and resulting surface areas in metric increments. The resulting surface area values were imported into spreadsheets in square meters and converted to acres to match the English units in Table 3-3 of the 1963 report. The LCR GIS original surface area computations at 10-foot increments were within two percent or less of the original published surface areas. This was considered a very close match, but for the large volume of Lake Mead, a one percent difference translates to more than 300,000 acre-feet at full capacity.

Due to the lack of original and 2001 data, the LCR GIS analysis assumed the original volume from Pierce Basin upstream had been totally lost due to sediment deposition. From previously collected cross section data and study results, the Sedimentation Group's analysis showed that the reservoir area from Pierce Basin upstream is largely lost due to sediment deposition, but there is available reservoir capacity remaining that was accounted for in their analysis. The original volume from Pierce Basin upstream was over 1,400,000 acre-feet prior to Hoover Dam closure, but soon after closure, sediment deposition began to fill a large portion of this area. The 1948 study measured 725,000 acre-feet and the 1963 study measured 921,000 acre-feet of sediment in this portion of the reservoir, table 6. As discovered in these previous studies, the surface areas in the very upper elevation zones (elevation 1,200 and above) were not drastically affected by sediment deposition. This is illustrated on the longitudinal plot of the Colorado River on figure 23, along with the cross sections developed by the LCR analysis, figures 25 and 26. Appendix III contains plots of additional cross sections located throughout the reservoir. Due to the lack of original and 2001 data, none of these plotted cross sections were located from Pierce Basin upstream. The 1963 report has several cross section plots located in this portion of the reservoir that compare the original, 1948, and 1963 survey results. At several cross sections the 1963 sediment surface elevation plotted below the 1948 results. The 1963 survey was conducted with a drawn down reservoir, meaning a portion of the previous sediment deposits in the upper reservoir had been eroded since the 1948 survey. In most cases the top of the sediment deposition for both surveys plotted below elevation 1,200. This further signifies little to no change from the original capacity in these upper elevation zones of the reservoir.

The Sedimentation Group computed the 2001 reservoir capacity and resulting sediment deposition for the upper reservoir area using the original hard copy map contours, 2001 LiDAR, and the Biological cross section data for the areas from Pierce Basin upstream. Even though the majority of this volume area is lost due to sediment deposition, a 40 mile reach of surface area remains in the upper elevation zones and was included in the 2001 final surface area and capacity computations. The 2001 survey measured around 337,500 acre-feet of available volume from Pierce Basin upstream. Since the 2001 survey, the reservoir water content has dramatically decreased due to the ongoing draught within the Colorado River drainage basin. The pool elevation has dropped to Gregg Basin and continues to move further downstream. The lower reservoir levels have subjected the upper basin sediment delta to alteration by the Colorado River. Since the 2001 survey, a portion of the previously deposited delta sediments have been eroded and transported downstream toward the dam, increasing storage capacity in these upper basins. In the future, these areas of increased volume will refill with sediment as they become inundated by the reservoir again. This ongoing cyclical process will continue throughout the varying operational scenarios of Lake Mead. As illustrated by the Sedimentation Group's 2001 analysis, a certain zone of reservoir capacity will exists in the upper basin at all reservoir operational levels.

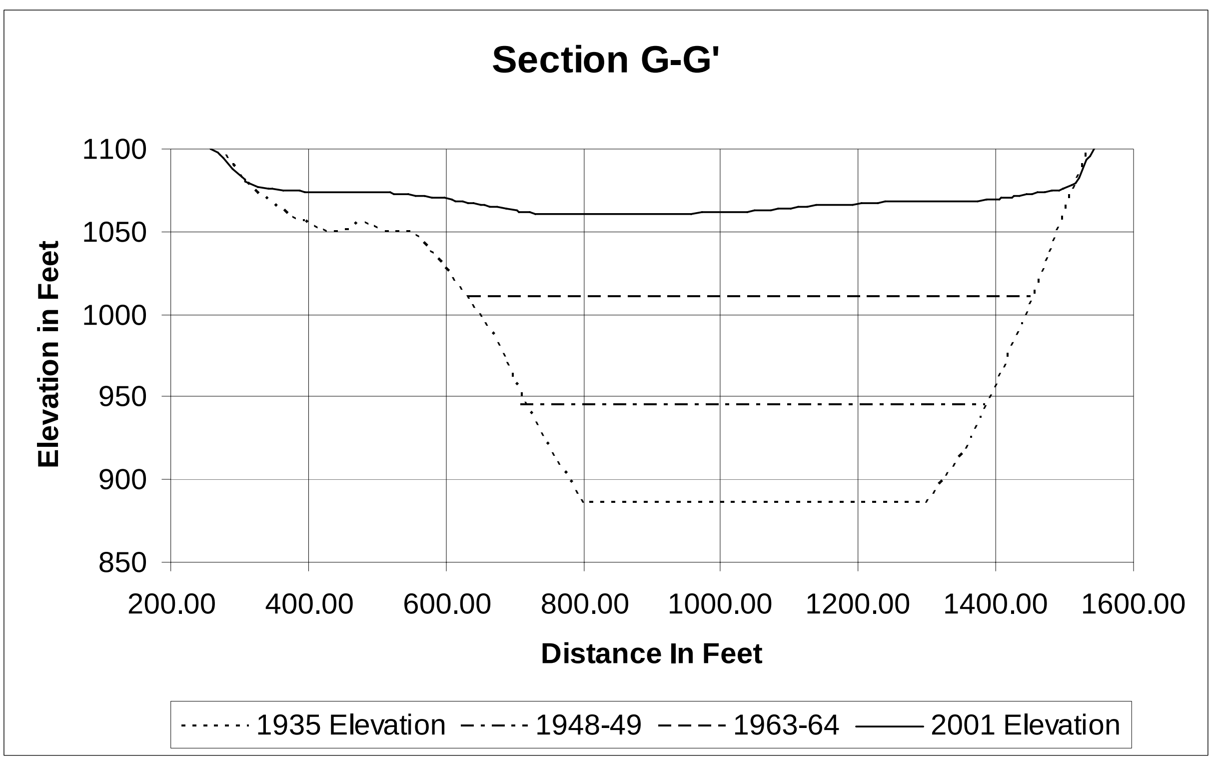


Figure 25 - Gregg Basin section G-G

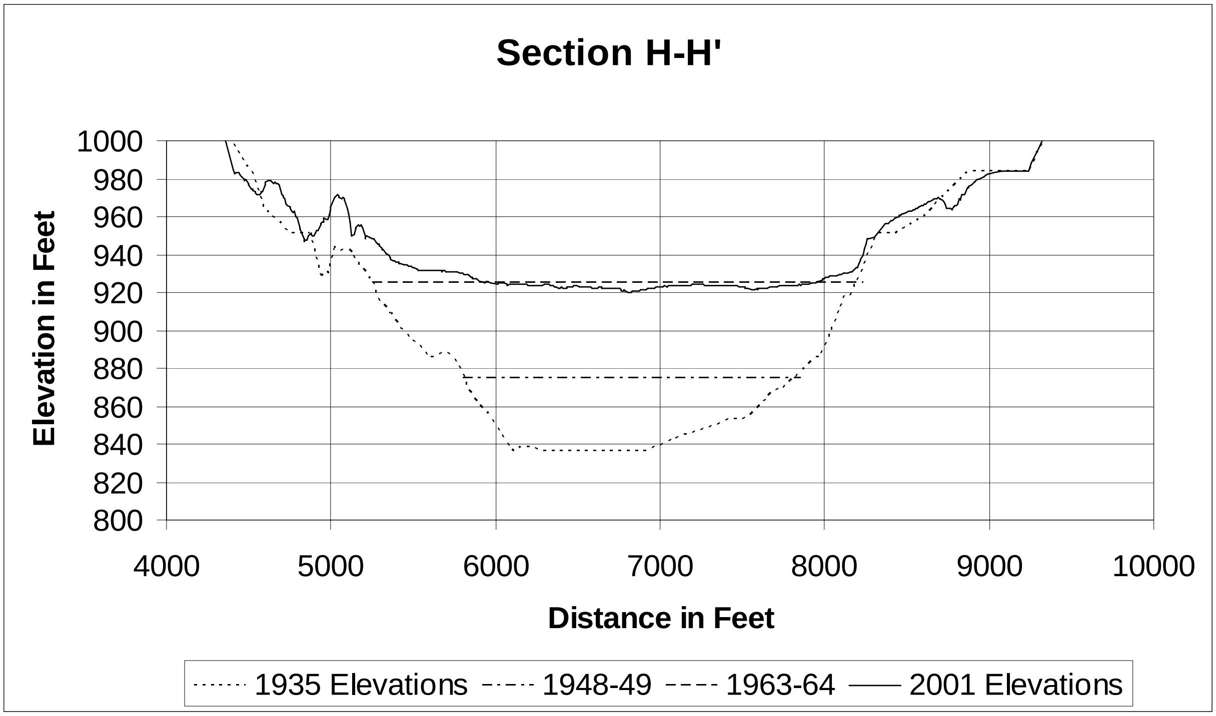


Figure 26 - Gregg Basin section H-H

The reconnaissance method of collection and analysis was applied to the 2001 Lake Mead study by the Sedimentation Group (Ferrari, 2006). When compared to the LCR approach, the Sedimentation Group's analysis resulted in only a slight difference in the sediment deposition values for maps 1 through 41 (Appendix V). The biggest difference was the analysis method used in the upper reservoir area, from Pierce Basin upstream, and in the upper reach of the Overton Arm. The Sedimentation Group analyzed each individual map over the total reservoir, computing the capacity and sediment deposition for the total reservoir. The only means to truly measure the current volume of the reservoir would be through a combination of detailed above and below water surveys. Detailed surveys for an entire reservoir the size of Lake Mead would be cost prohibitive. Utilization of reconnaissance techniques and methods provided the tools necessary for collection and analysis of the 2001 Lake Mead survey data in a cost effective and accurate manner. The reconnaissance method was similar to the previous sediment surveys of Lake Mead where these methods were based on changes from the original topography.

Using ARC GIS tools with the TIN's LCR developed for the individual maps, contours and surface areas were developed at 10-foot intervals to match the original elevation increments. During the processing it was determined that the TIN's, contours, and resulting surface areas developed from the USGS DEM's did not provide sufficient detail at some lower elevation contours and in small coves to match the original map details and resulting surface areas. The lack of detail was a concern initially because the 2001 collected data was merged with the original USGS DEM data to develop the updated contours and surface areas for the available maps. However, the 2001 data found that most of these smaller areas had silted in, easing the initial concerns. The Sedimentation Group's analysis treated the original reported surface areas (listed in the 1963 report by map, at 10-foot contour intervals) as the base surface areas and focused their analysis on identifying changes from these values. The 1948 and 1963 studies used the same approach, allowing the 2001 Sedimentation Group results to better determine changes over time due to sedimentation deposition. Even though the 2001 data was of much greater detail in the areas of sediment deposition than the previous surveys, the Sedimentation Group's approach allowed for confident comparisons with previous results.

The 2001 LiDAR data merged with the 2001 depth data and previously collected biological cross sections provided adequate detail for estimating changes from the original topography on maps 40, 42, and 43 in the upper reservoir. The 2001 analysis computed surface areas for these maps using the LiDAR data (with elevations adjusted to match the Lake Mead vertical datum) along with the other merged data sets. The 2001 results showed that much of the upper reservoir area was lost due to sediment deposition, but just as the 1948 and 1963 surveys revealed, reaches of available reservoir capacity still remain, table 6 and table 7.

For most reservoir maps, the 2001 multibeam survey data provided adequate detail for GIS development of the entire 10-foot contour elevation within the map boundary. The 2001 GIS measured surface areas were used for the analysis on those maps. Using the GIS computed surface areas accounted for sediment deposition that may have occurred along the canyon walls, figure 27. When the 2001 data indicated little to no change due to sediment deposition, the original surface area was used for the 10-foot contour interval being examined on that map. The smaller river channels covered by the Las Vegas Wash and Overton Arm maps were analyzed using the 2001 survey data collected primarily along the original thalweg. No change due to sediment deposition was assumed in the remaining surface areas of the Overton and Las Vegas maps. This assumption was supported by the 2001 survey and by previous cross section surveys of Lake Mead measuring the change due to sedimentation primarily in the deeper original river channel portion of the maps. Using ARC GIS tools, the 2001 contours in the river channel zone were digitized to compute the updated surface areas reported at each 10-foot elevation increment. Table 3 presents the results of the 2001 Sedimentation Group's analysis. The original surface areas listed in table 1 provided the basis for table 3. Surface area values by map and elevation were changed as the 2001 computations indicated. Appendix V contains a map by map summary of results from the analysis conducted by the Sedimentation Group.

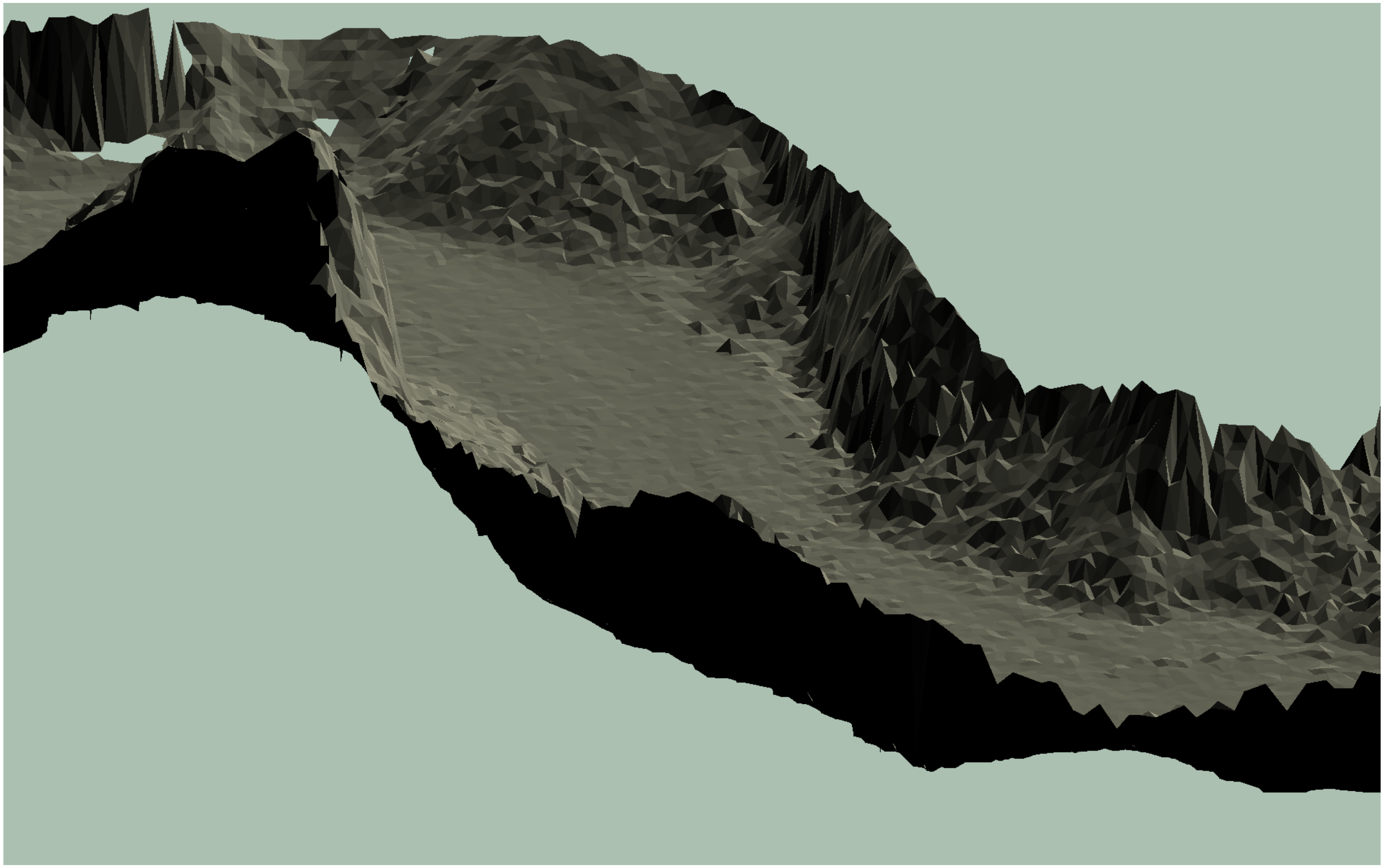


Figure 27 - Multibeam data of Navajo Canyon on Lake Powell showing deposition along toe of vertical walls.

10-Foot contour Areas in Acres

####.##	GIS computed
####.##	Digitized areas

Sheet No	Elevation (feet)														
	660	670	680	690	700	710	720	730	740	750	760	770	780	790	800
1,2,3															
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	76.84	269.97	400.65	457.40	506.30	548.80	586.70	621.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	329.28	551.65	754.17	813.95	858.84	913.62	998.06	1,142.80
6,7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	46.29	987.44	1,873.93	2,355.17	2,662.51	2,828.78	2,978.71	3,123.76
8	0.00	0.00	0.00	0.02	0.47	3.90	53.69	897.15	1,339.46	1,621.83	1,677.21	1,734.17	1,790.08	1,852.62	1,907.14
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	13.16	128.95	607.48	734.58	765.77	795.09	824.35
10															
11,12	0.00	0.00	0.00	0.00	0.00	0.03	0.16	0.39	0.67	1.21	73.08	410.62	1,236.24	1,423.30	1,553.69
14															
15															
16															
17															
18															156.42
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	1.32	139.87	1,025.85	3,085.51
20,21															
22															
23															
24															
25															
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	547.91
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.35	303.19
28															
30															
31															
32															
33															
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39															
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43															
44															
45															
46															
47															
48															
49															
50															
51															
52															
Total	0.00	0.00	0.00	0.02	0.47	3.94	53.87	1,349.98	3,162.35	4,780.75	5,984.68	6,908.34	8,223.16	9,664.30	13,265.77

Table 3 - 2001 Lake Mead surface areas (1 of 4).

10-Foot contour Areas in Acres

####.##	GIS computed
####.##	Digitized areas

Sheet No	Elevation (feet)														
	810	820	830	840	850	860	870	880	890	900	910	920	930	940	950
1,2,3															
4	665.60	720.00	771.00	820.10	871.60	934.20	1,011.50	1,102.60	1,205.30	1,312.70	1,444.10	1,580.10	1,723.00	1,859.20	1,988.70
5	1,288.78	1,422.75	1,577.07	1,719.89	1,862.11	2,006.37	2,197.14	2,318.83	2,503.16	2,710.80	2,940.59	3,099.03	3,235.06	3,423.35	3,636.03
6,7	3,273.92	3,407.43	3,541.45	3,698.77	3,858.52	4,034.51	4,213.40	4,433.06	4,608.68	4,727.52	4,918.80	5,094.28	5,276.14	5,485.66	5,640.54
8	1,965.81	2,031.74	2,089.03	2,147.32	2,211.16	2,279.50	2,341.28	2,403.01	2,455.15	2,512.82	2,587.73	2,643.16	2,690.08	2,757.98	2,816.12
9	870.59	918.26	956.16	993.69	1,045.35	1,098.46	1,151.75	1,206.41	1,261.06	1,318.28	1,385.41	1,455.04	1,520.45	1,578.76	1,638.30
10															
11,12	1,650.14	1,728.29	1,809.59	1,873.10	1,946.31	2,021.43	2,088.52	2,163.52	2,253.84	2,338.08	2,456.98	2,533.51	2,620.56	2,689.11	2,772.36
14															
15															
16															
17															
18	319.11	499.46	635.73	798.29	901.72	998.58	1,066.86	1,149.05	1,190.72	1,225.00	1,313.95	1,360.66	1,441.79	1,513.57	1,586.55
19	3,535.90	4,034.76	4,380.65	4,637.82	5,025.43	5,301.62	5,449.20	5,758.26	5,983.84	6,203.50	6,445.21	6,688.94	6,901.47	7,134.02	7,349.67
20,21															
22															
23															
24															
25								2.32	60.10	128.20	188.60	319.20	473.20	678.20	989.40
26	817.64	1,008.90	1,069.00	1,167.20	1,272.80	1,422.60	1,620.80	1,771.95	1,912.45	2,057.28	2,228.68	2,381.62	2,528.41	2,672.27	2,835.28
27	846.99	1,214.39	1,373.38	1,516.04	1,804.83	1,998.98	2,159.17	2,327.55	2,517.89	2,695.22	2,938.69	3,319.14	3,727.00	3,998.30	4,218.70
28															
30															
31															
32															
33															
34	0.08	101.14	326.70	371.30	396.61	418.52	453.20	478.99	510.19	544.53	596.56	643.33	700.13	746.46	808.94
35	0.00	0.03	193.19	812.56	1,342.20	1,607.14	1,734.94	1,873.57	2,036.65	2,206.25	2,372.14	2,513.49	2,669.70	2,828.77	3,004.62
36	0.00	0.00	0.70	1.21	1.81	173.29	386.12	454.84	498.56	509.53	529.81	578.21	605.73	634.70	665.20
37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.87	3.53	5.51	19.23	154.18	479.79	771.55
38	0.00	0.00	0.00	0.00	0.00	0.60	3.08	59.24	191.93	659.20	1,211.92	1,693.24	1,936.46	2,046.41	2,146.96
39															
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43								0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44										0.00	0.00	0.00	0.00	0.00	0.00
45															
46													0.00	0.00	0.00
47															
48															
49															
50															
51															
52															
Total	15,234.55	17,087.14	18,723.65	20,557.29	22,540.45	24,295.79	25,876.97	27,503.20	29,191.39	31,152.43	33,564.68	35,922.18	38,203.36	40,526.55	42,868.91

Table 3 -2001 Lake Mead surface areas (2 of 4).

10-Foot contour Areas in Acres

####.##	GIS computed
####.##	Digitized areas

Sheet No	Elevation (feet) 960	970	980	990	1000	1010	1020	1030	1040	1050	1060	1070	1080	1090
1,2,3								4.50	24.30	46.40	76.40	109.20	145.40	197.80
4	2,142.00	2,296.40	2,475.70	2,666.30	2,869.00	3,067.50	3,286.40	3,519.95	3,739.29	3,978.76	4,221.40	4,434.55	4,658.49	4,906.59
5	3,828.17	4,014.64	4,168.55	4,343.44	4,484.45	4,714.97	4,876.11	5,014.37	5,148.99	5,290.08	5,419.92	5,510.58	5,616.46	5,751.28
6,7	5,817.96	5,989.21	6,157.86	6,293.96	6,435.16	6,603.63	6,769.31	6,940.60	7,123.96	7,286.93	7,476.59	7,659.63	7,838.72	8,041.90
8	2,879.64	2,936.30	2,999.47	3,061.14	3,144.25	3,208.44	3,263.76	3,322.21	3,362.06	3,416.20	3,483.80	3,550.74	3,613.71	3,689.97
9	1,710.65	1,781.38	1,850.18	1,906.19	1,965.44	2,047.38	2,126.50	2,196.21	2,260.09	2,331.74	2,410.99	2,488.68	2,565.88	2,633.59
10													1.45	3.55
11,12	2,870.26	2,958.63	3,078.72	3,182.09	3,278.30	3,379.79	3,470.00	3,565.06	3,667.21	3,767.17	3,884.94	3,994.71	4,105.58	4,218.23
14														
15														
16												0.50	1.60	2.10
17													0.46	3.06
18	1,665.87	1,731.99	1,797.87	1,874.74	1,946.04	2,040.84	2,114.78	2,202.87	2,283.71	2,368.15	2,442.06	2,507.12	2,592.42	2,680.49
19	7,625.83	7,895.94	8,156.88	8,420.82	8,734.72	9,095.69	9,449.17	9,803.25	10,155.49	10,469.13	10,732.07	11,024.89	11,317.31	11,600.02
20,21		1.45	25.40	49.88	87.21	119.38	162.56	215.53	270.30	352.61	429.72	502.59	584.19	662.61
22														
23											66.80	541.20	893.40	1,178.70
24			198.65	720.60	1,229.70	1,756.60	2,408.30	2,963.30	3,695.00	4,518.20	5,444.82	5,993.35	6,492.64	6,901.62
25	1,409.70	1,775.30	2,157.99	2,349.73	2,570.31	2,772.34	2,961.07	3,179.57	3,403.60	3,644.20	3,918.79	4,185.91	4,437.74	4,664.09
26	2,995.05	3,156.53	3,320.02	3,489.59	3,655.31	3,842.08	4,021.64	4,234.23	4,449.59	4,640.20	4,823.00	5,030.26	5,230.80	5,398.99
27	4,417.29	4,602.62	4,786.35	4,979.05	5,173.67	5,371.07	5,556.68	5,789.77	5,989.44	6,166.09	6,350.05	6,558.83	6,768.83	7,044.24
28		2.42	4.42	6.93	12.51	17.20	22.74	30.87	37.85	50.35	65.88	83.60	102.75	124.04
30														
31														
32												0.00	0.00	0.00
33														
34	872.27	937.68	987.36	1,045.85	1,111.17	1,187.05	1,253.00	1,330.22	1,404.44	1,484.37	1,578.60	1,666.37	1,756.10	1,866.13
35	3,199.49	3,368.07	3,564.56	3,789.87	4,013.26	4,248.20	4,368.11	4,582.97	4,765.20	4,985.08	5,208.41	5,456.20	5,672.51	5,904.95
36	714.66	729.93	760.99	816.67	830.89	899.44	932.06	975.87	1,017.69	1,060.91	1,104.03	1,137.98	1,177.03	1,192.57
37	1,052.45	1,316.80	1,598.15	1,929.98	2,145.52	2,314.36	2,608.28	2,772.24	2,920.88	3,087.23	3,231.03	3,388.31	3,529.17	3,694.68
38	2,259.66	2,351.30	2,435.74	2,590.77	2,687.41	2,789.50	2,882.70	2,980.04	3,108.18	3,223.87	3,373.38	3,484.70	3,560.73	3,705.63
39														
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.12	57.93
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.76	40.26	92.04	136.92	177.64	233.27
42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49									0.00	0.00	0.00	0.00	0.00	0.00
50														
51														
52														
Total	45,460.95	47,846.59	50,524.86	53,517.60	56,374.32	59,475.46	62,533.17	65,623.63	68,834.02	72,207.93	75,834.72	79,446.82	82,849.13	86,358.03

Table 3 - 2001 Lake Mead surface areas (3 of 4)

10-Foot contour Areas in Acres -

####.## GIS computed
####.## Digitized areas

Sheet No	Elevation (feet)													
	1100	1110	1120	1130	1140	1150	1160	1170	1180	1190	1200	1210	1220	1230
1,2,3	254.20	333.00	431.00	520.10	617.00	699.80	787.70	881.60	989.20	1,116.00	1,298.90	1,494.40	1,654.40	1,839.37
4	5,187.61	5,505.20	5,834.84	6,154.83	6,352.18	6,656.44	6,866.41	7,255.04	7,536.44	7,794.41	8,072.43	8,404.44	8,712.67	8,971.24
5	5,901.89	6,021.44	6,153.35	6,295.57	6,428.69	6,572.55	6,724.99	6,879.33	7,046.18	7,227.96	7,403.83	7,617.46	7,809.37	7,997.67
6,7	8,234.25	8,384.30	8,549.14	8,714.64	8,890.94	9,051.65	9,249.34	9,403.96	9,591.52	9,788.03	9,965.52	10,177.46	10,372.41	10,545.71
8	3,712.58	3,789.67	3,854.53	3,918.67	3,968.08	4,037.77	4,100.81	4,163.85	4,227.09	4,295.15	4,356.23	4,413.15	4,467.30	4,529.01
9	2,700.62	2,804.81	2,902.72	2,972.54	3,047.79	3,124.29	3,197.49	3,276.61	3,352.59	3,429.93	3,502.23	3,596.92	3,679.74	3,762.12
10	5.24	7.39	9.59	13.57	16.39	19.61	24.95	32.11	39.74	47.56	54.63	65.87	77.34	86.94
11,12	4,332.81	4,463.51	4,561.10	4,661.28	4,764.58	4,863.69	4,976.20	5,060.50	5,174.32	5,302.95	5,433.08	5,570.32	5,714.99	5,847.93
14													4.93	328.31
15													17.26	34.38
16	11.85	51.33	109.32	168.77	234.05	283.29	373.42	447.96	536.40	630.08	738.54	860.08	1,042.89	1,088.43
17	12.00	38.10	73.20	117.10	159.70	210.45	281.44	378.74	503.18	626.53	783.76	903.83	1,010.69	1,130.44
18	2,776.78	2,868.58	2,959.18	3,030.15	3,094.66	3,161.92	3,255.87	3,321.25	3,402.83	3,471.79	3,557.72	3,645.39	3,720.54	3,792.36
19	11,844.38	12,139.95	12,423.55	12,716.82	13,058.49	13,453.99	13,873.64	14,220.79	14,592.83	14,908.13	15,231.37	15,578.01	15,847.51	16,097.32
20,21	748.19	811.45	877.79	951.29	1,046.21	1,153.23	1,308.33	1,478.00	1,657.03	1,798.93	1,945.96	2,192.31	2,456.78	2,847.86
22						0.00	0.00	0.00	345.10	814.10	1,392.20	1,841.70	2,309.60	2,990.30
23	1,439.30	1,983.40	2,462.10	2,834.60	3,292.00	3,790.80	4,226.90	4,844.90	5,834.75	6,315.91	6,723.40	7,114.30	7,460.01	7,806.97
24	7,252.96	7,566.60	7,885.97	8,220.90	8,524.35	8,864.49	9,161.94	9,533.25	9,842.54	10,211.79	10,509.61	10,861.42	11,200.06	11,377.18
25	4,951.04	5,240.86	5,466.76	5,734.86	5,972.36	6,234.97	6,490.34	6,743.52	6,992.47	7,239.45	7,470.78	7,735.76	7,990.28	8,252.33
26	5,560.53	5,754.98	5,913.35	6,068.29	6,215.72	6,379.44	6,546.21	6,703.58	6,855.28	7,015.10	7,159.21	7,323.34	7,470.42	7,605.02
27	7,265.14	7,472.58	7,667.74	7,890.85	8,097.95	8,320.98	8,550.27	8,781.12	9,031.87	9,333.50	9,598.33	9,972.77	10,282.85	10,618.80
28	149.24	188.35	215.87	248.09	280.73	344.33	386.83	442.15	494.78	549.93	611.25	668.95	733.85	824.89
30									0.00	0.00	0.00	0.00	0.00	472.48
31						0.00	0.00	0.00	51.50	124.30	227.20	518.90	902.90	1,150.15
32	13.70	79.79	131.08	208.42	264.60	402.00	610.50	705.00	886.67	934.26	1,021.07	1,130.60	1,166.91	1,364.67
33	21.37	53.61	91.26	151.90	204.27	275.40	373.31	468.42	554.03	652.61	750.52	852.99	959.97	1,061.72
34	1,959.73	2,092.16	2,186.27	2,271.48	2,345.75	2,450.14	2,543.63	2,631.18	2,704.71	2,796.43	2,884.72	2,992.32	3,064.80	3,156.03
35	6,140.54	6,373.59	6,580.00	6,831.93	7,043.52	7,277.95	7,482.72	7,660.84	7,875.84	8,083.62	8,305.19	8,505.38	8,636.93	8,852.11
36	1,281.18	1,353.77	1,380.53	1,446.38	1,467.87	1,552.06	1,593.39	1,657.41	1,707.50	1,812.77	1,866.68	1,993.61	2,039.23	2,169.10
37	3,845.37	4,005.74	4,162.30	4,334.36	4,487.78	4,655.25	4,832.41	4,970.05	5,107.24	5,264.57	5,424.23	5,594.30	5,735.24	5,886.26
38	3,876.22	4,017.82	4,125.15	4,243.11	4,347.40	4,481.33	4,594.49	4,689.27	4,797.82	4,877.64	4,991.33	5,104.99	5,175.53	5,285.58
39											0.00	30.50	63.40	99.04
40	95.45	209.21	471.25	606.10	1,331.89	2,459.30	2,983.40	3,383.60	3,541.52	3,787.59	3,939.46	4,101.59	4,233.45	4,382.74
41	239.83	248.89	254.91	263.48	269.21	278.76	285.17	297.12	305.10	326.60	340.99	375.86	408.91	451.55
42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	646.40	920.07	989.07	1,057.42	1,104.30	1,170.77
43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,599.00	4,502.36	4,693.49	4,876.98	5,085.47
44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	229.00	374.00	453.70	1,180.99	1,205.91	1,238.72
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	67.00	363.00	446.00	1,013.55	1,040.38	1,076.52
46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	64.00	154.00	302.82	320.75	331.55	345.47
47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	199.00	451.29	480.41	499.79	524.97
48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.00	350.03	374.27	390.47	412.84
49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	208.00	398.30	431.49	453.61	481.98
50					0.00	0.00	0.00	0.00	79.13	94.22	109.31	127.90	146.54	180.75
51														
52														
Total	89,814.00	93,860.08	97,733.85	101,590.08	105,824.16	111,055.88	115,682.10	120,311.15	126,663.60	135,554.91	143,563.25	150,919.19	156,472.69	163,223.50

Table 3 - 2001 Lake Mead surface areas (4 of 4)

Reservoir Area and Capacity

2001 Topography Development

As described in the LCR analysis section, TIN's along with resulting computations were developed for the areas of Lake Mead that had both original and 2001 data sets. The LCR analysis was completed by map area boundaries using the available USGS original DEM values and patching in the 2001 survey data where it overlapped. For this report, no final topographic map products are presented. The LCR developed digital data is available online (Twitchel, 2003).

Development of the Contour Areas and Reservoir Volume

The Sedimentation Group computes storage-elevation relationships, based on TIN generated surface areas, using the area and capacity computer program ACAP (Bureau of Reclamation, 1985). The surface area information, as described previously, was used to establish control parameters for computing the updated reservoir capacity. Since the 2001 study had no above-water data, the original or previously measured surface areas above a certain elevation were used to complete the area and capacity tables. Due to the lack of updated above-water data for Lake Mead, this study assumed no change since the 1963 computations for the highest elevation upstream reaches unless available information indicated a change had occurred. The upper Colorado River reach of the reservoir above Pierce Basin was the only reach that had additional data to consider. This included the 2001 LiDAR and Biological surveyed cross section data. This is also the reach of the reservoir where sediment deposition is a major factor in computing the overall reservoir capacity loss.

The ACAP program computes the area and capacity at designated elevation increments of 0.01- to 1.0-foot by linear interpolation between the given contour surface areas. The program begins by testing the initial capacity equation over successive intervals to ensure that the equation fits within an allowable error limit. The capacity equation is then used over the full range of intervals fitting within this allowable error limit. For the first interval at which the initial allowable error limit is exceeded, a new capacity equation (integrated from a basic area curve over that interval) is utilized until it exceeds the error limit. Thus, the capacity curve is defined by a series of curves, each fitting a certain region of data. By differentiating the capacity equations, which are of second order polynomial form, the final area equations are derived:

$$y = a_1 + a_2x + a_3x^2$$

where:

y = capacity
x = elevation above a reference base
a_1 = intercept
a_2 and a_3 = coefficients

For Lake Mead, surface area data was computed at 10-foot elevation increments for the original and 2001 survey results. Results of the 2001 ACAP reservoir area and capacity computations were compared to the original surface areas and recomputed ACAP original capacities for estimating the sediment deposition in the different reservoir elevation zones, tables 4 and tables 5. A separate set of area and capacity tables can be published for the 0.01, 0.1 and 1-foot elevation increments. In this report, the 2001 area and capacity table is presented at 0.1-foot elevation increments in Appendix VI. Descriptions of the computations and output coefficients from the ACAP program are included with these tables.

2001 Reservoir Sediment Analyses

Results of the 2001 Lake Mead area and capacity computations are listed in table 4 and in columns 8 and 9 of table 5. Columns 2 and 3 of table 5 list the original area and capacity values and the remaining columns list the values of the 1948 and 1963 surveys and the comparisons between all of the measured values. Column 10 lists the capacity differences between the original and 1963 survey results and column 11 lists the original and 2001 survey result differences due to sediment deposition. Column 12 lists the differences between the 1963 and 2001 surveys showing measured differences between the surveys with the consolidation of the previous sediments occurring in the lower reaches starting at elevation 700 and peaking near elevation 1,125 where the measured reservoir volume increased by 421,680 acre-feet since 1963. Figure 28 is a plot of the Lake Mead surface area and capacity values for all surveys and illustrates the differences that have occurred over the years.

The estimated 100-year sediment accumulation for Lake Mead was 1.25 percent or around 3,710,000 acre-feet. This corresponds to an annual loss of 37,100 acre-feet. It is unknown if this 100-year estimate considered additional reservoir development upstream of Lake Mead. Table 4 shows that the 2001 survey measured an average annual loss of 36,024 acre-feet since closure of Hoover Dam in 1935. This estimate was developed for the first 66.7 years of Lake Mead operation with only 29.7 of those years before development of Lake Powell. The significantly lower average annual loss measured by the 2001 survey, compared to the 1963 survey result of 88,280 acre-feet, was attributed to the closure of Glen Canyon Dam and the compaction of the previously deposited sediments. Since closure of Glen Canyon Dam and trapping of sediments within Lake Powell, the average sediment inflow is estimated to be less than 10,000 acre-feet per year. Future surveys will be needed to obtain a better estimate of the current sediment inflow, but if an annual 10,000 acre-feet were projected for the next 33.3 years; the annual projected sediment inflow would be around 27,000 acre-feet for the first 100 years of operation.

Table 6 consists of eight pages that provide a breakdown of the computed capacity and sediment deposition by basin, elevation, and survey year. Page eight of this table provides the total capacity information for all the basins that make up Lake Mead. The 1963-2001 computed sediment volume shows the change that occurred due to compaction of sediment and the significant trapping of sediments within Lake Powell. The table indicates that the maximum change occurred at elevation 1,130 and the gain in capacity was 421,480 acre-feet. The Colorado River thalweg plot in figure 23 shows the change that has occurred between surveys. As seen from the plot, the elevation change due to compaction between 1963 and 2001 occurred from Virgin Canyon Basin downstream to Hoover Dam. Even though the table shows an increase in capacity up to elevation 1,230, figure 23 shows the upstream sediment delta growing as the delta face progresses further downstream toward the dam. The breakdown of the basins within table 6 shows that between 1963 and 2001 the basins of Grand Bay, Pierce, and Lower Granite Gorge have decreased in capacity due to sediment deposition. During this period the capacity decrease within these basins was around 267,300 acre-feet or around 7,200 acre-feet per year at elevation 1,230. These computations are only for the Colorado River and do not take into account the Overton and Las Vegas Wash drainage areas or the fine sediments that have been transported towards the dam by density currents. Considering all of the factors not accounted for, an annual Lake Mead sediment inflow of less than 10,000 acre-feet, since closure of Glen Canyon Dam, was estimated for this study.

Table 7 contains computed surface areas listed by elevation increments and date of survey. The 1948-1935 and 1963-1948 data comparisons show surface area losses throughout all elevation zones from 1,230 and below. The 1948-1935 column (table 7) does show a surface area increase at elevation 1,230 that appears to be due to rounding of the surface area values for the 1948 survey. Elevations 1170 through 1220 of the 1963-1948 comparison also identify a gain in surface area between the two surveys. The 1963 survey was conducted at a much lower reservoir elevation, meaning some of the previously deposited sediment in the upper basins on the Colorado River was eroded and transported downstream to the lower elevation zones of the reservoir between 1948 and 1963. The 2001 survey was conducted when the reservoir was at a higher content than in 1963 and the 2001-1963 analysis calculated a loss of surface area due to the upstream growth of the sediment delta above elevation 1,130. However, the 1963 and 2001 data indicate minimal loss due to sediment delta growth in the extreme upper elevations above 1,200. These upper elevation zones may have actually increased in surface area due to shoreline erosion that has occurred to different extents throughout the reservoir. The only means of measuring the current surface area of the upper elevation zone would be an aerial survey covering the entire reservoir.

Consolidation of sediments is an ongoing process in all reservoirs. Due to its relatively large size, Lake Mead provided a unique opportunity to observe and measure the impact of sediment consolidation. The current and future geometry of many other reservoirs has been altered by upstream development, but the impact of removing a substantial portion of inflowing sediment for 40 years is measured on a much larger scale at Lake Mead. Future surveys should focus more on better measurement of the current sediment inflow and the redistribution of the previous sediment deposits. Given the current drought situation, the reservoir has dropped over 80 feet in elevation since the 2001 survey. This drop has allowed river inflows to erode a portion of the previous sediment deposits and carry them into the lower elevation portions of the reservoir where they are redeposited. Future surveys would be necessary to measure the redistribution and current sediment deposition rate. The 2001 survey utilized state of the art technology for measuring the underwater sediment deposition. Future technology may provide additional tools for more detailed measurements in a costly matter. With the current reservoir drawn down so low, above water data collection options should be explored. One option that should be considered is satellite imagery of the reservoir. Satellite images at different reservoir levels could be used to develop accurate water surface contours in the areas where little change has occurred due to sediment deposition. Of course a full detailed aerial survey would provide the most accurate and complete data set.

RESERVOIR SEDIMENT
DATA SUMMARY

Lake Mead (Hoover Dam)
NAME OF RESERVOIR

1
DATA SHEET NO.

DAM	1. OWNER Bureau of Reclamation	2. STREAM Colorado River	3. STATE Arizona - Nevada
	4. SEC 3 TWP. 30N RANGE 23 W	5. NEAREST P.O. Boulder City	6. COUNTY Clark-Mohave
	7. LAT 36 ° 00 ' 58 " LONG 114 ° 44 ' 13 "	8. TOP OF DAM ELEVATION 1232.0 [1]	9. SPILLWAY CREST EL 1205.4 [2]

RESERVOIR	10. STORAGE ALLOCATION	11. ELEVATION TOP OF POOL	12. ORIGINAL SURFACE AREA, AC-FT	13. ORIGINAL CAPACITY, AC-FT	14. GROSS STORAGE ACRE-FEET	15 DATE STORAGE BEGAN
	a. SURCHARGE	1,232.0 [3]		482,000	32,863,780	2/1/35
	b. FLOOD CONTROL	1,229.0	162,585	1,498,503	32,381,780	
	c. POWER					
	d. JOINT USE	1,219.6	156,619	16,587,427	30,883,277	16 DATE NORMAL OPERATIONS BEGAN
	e. CONSERVATION					
	f. INACTIVE	1,083.0	91,006	11,091,319	14,295,850	
	g. DEAD	895.0	33,392	3,204,531	3,204,531	3/1/36
	17. LENGTH OF RESERVOIR 152 [4] MILES		AVG. WIDTH OF RESERVOIR 1.65 MILES			

BASIN	18. TOTAL DRAINAGE AREA 171,700 [5] SQUARE MILES	22. MEAN ANNUAL PRECIPITATION 10 [6] INCHES	
	19. NET SEDIMENT CONTRIBUTING AREA 105,550 [5] SQUARE MILES	23. MEAN ANNUAL RUNOFF 1.22 [7] INCHES	
	20. LENGTH 305 MILES	AVG. WIDTH 85 MILES	24. MEAN ANNUAL RUNOFF 10,900,000 [8] ACRE-FEET
	21. MAX. ELEVATION 14,400	MIN. ELEVATION 895[9]	25. ANNUAL TEMP, MEAN 73 °F RANGE 26 °F to 107 °F

SURVEY DATA

26. DATE OF SURVEY	27. PER. YRS	28. PER. YRS	29. TYPE OF SURVEY	30. NO. OF RANGES OR INTERVALS	31. SURFACE AREA, AC.	32. CAPACITY ACRE - FEET	33. C/ RATIO AF/AF
2/1/35			Contour (D)	10-ft	162,585 [10]	32,381,780 [11]	2.97
9/30/48	13.7	13.7	Contour (D)	10-ft	162,677 [10]	31,047,000 [11]	2.85
10/14/64	16	29.7	Contour (D)	10-ft	162,608 [10]	29,759,860 [11]	2.73
9/01	37	66.7	Contour (D)	10-ft	162,548 [12]	29,979,010 [12]	2.75

26. DATE OF SURVEY	34. PERIOD ANNUAL PRECIPITATION	35. PERIOD WATER INFLOW, ACRE-FEET a. MEAN ANN.	b. MAX. ANN.	c. TOTAL	36 WATER INFLOW TO DATE, AF a. MEAN ANN.	b. TOTAL
9/30/48		12,526,000	17,260,000	175,362,000	12,526,000	175,362,000
10/14/64		10,083,000	18,160,000	161,335,000	11,337,000	336,697,000
9/01		10,549,000	20,758,000 [13]	390,320,000	10,900,000	727,017,000

26. DATE OF SURVEY	37. PERIOD CAPACITY LOSS, ACRE-FEET a. TOTAL	b. AVG. ANN.	c. /MI.^{2}-YR.	38. TOTAL SEDIMENT DEPOSITS TO DATE, AF a. TOTAL	b. AVG. ANN.	c. /MI.^{2}-YR.
9/30/48	1,334,780 [14]	97,429	0.58	1,334,780	97,429 [14]	0.92
10/14/64	1,287,140 [14]	80,446	0.48	2,621,920	88,280 [14]	0.84
9/01	-219,150 [15]	-5,923	-0.06	2,402,770	36,024 [15]	0.34

26. DATE OF SURVEY	39. AVG. DRY WT. (#/FT^3)	40. SED. DEP. TONS/MI.^{2}-YR a. PERIOD	b. TOTAL TO DATE	41. STORAGE LOSS, PCT. a. AVG. ANNUAL	b. TOTAL TO DATE	42 SEDIMENT INFLOW, PPM a. PER.	b. TOT.
9/30/48	65 [6]	879	879	0.30	4.1	8,460	8,460
10/14/64	70.3 [6]	572	714	0.27	8.1	7,700	7,760
9/01				0.11	7.4		

43. DEPTH DESIGNATION RANGE BY DEPTH

26. DATE OF SURVEY	650-895	895-950	950-1,000	1000-1,083	1083-1,100	1100-1,150	1150-1,200	1200-1,220	1219.6-1,229
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN DEPTH DESIGNATION								
10/64	31.5	9.7	10.0	20.9	5.3	16.3	6.3	0.0	0.0
9/01	27.4	7.7	7.9	18.9	5.4	17.6	14.4	0.6	0.1

44. REACH DESIGNATION PERCENT OF TOTAL ORIGINAL LENGTH OF RESERVOIR

26. DATE OF SURVEY	0-10	10-20	20-30	30-40	50-60	60-70	70-80	80-90	90-100	100-105	105-111	110-115	115-120	120-125
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN REACH DESIGNATION													

Table 4 - Reservoir sediment data summary (page 1 of 2).

45. RANGE IN RESERVOIR OPERATION

YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF	YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF
1935	928.4	673.5		1936	1,025.8	905.2	12,320,000
1937	1,102.9	1,021.9	12,410,000	1938	1,173.9	1,094.6	15,630,000
1939	1,183.4	1,156.1	9,618,000	1940	1182.2	1,164.2	7,435,000
1941	1,220.4	1,166.8	16,940,000	1942	1,213.4	1,171.0	17,260,000
1943	1,202.4	1,176.7	11,430,000	1944	1,200.4	1,157.2	13,530,000
1945	1,182.5	1,146.6	11,870,000	1946	1,164.3	1,146.5	9,089,000
1947	1,180.2	1,133.9	13,740,000	1948	1,192.8	1,154.5	13,870,000
1949	1,196.6	1,145.5	14,370,000	1950	1,177.5	1,150.0	11,080,000
1951	1,169.0	1,141.2	9,839,000	1952	1,201.1	1,133.2	18,160,000
1953	1,169.0	1,145.8	8,879,000	1954	1,145.7	1,105.4	6,229,000
1955	1,106.7	1,089.5	7,580,000	1956	1,117.0	1,083.2	8,860,000
1957	1,184.1	1,089.6	17,500,000	1958	1,205.9	1,161.0	14,550,000
1959	1,185.8	1,167.3	6,935,000	1960	1,184.2	1,163.0	9,584,000
1961	1,165.1	1,152.9	7,050,000	1962	1,204.2	1,153.1	15,250,000
1963	1,193.1	1,136.8	2,742,000	1964	1,136.8	1,088.1	2,727,000
1965	1,129.7	1,088.0	10,980,000	1966	1,133.8	1,127.2	8,328,000
1967	1,133.8	1,127.8	8,257,000	1968	1,139.6	1,129.8	8,939,000
1969	1,152.5	1,139.4	9,286,000	1970	1,154.2	1,150.4	9,123,000
1971	1,160.1	1,148.0	8,837,000	1972	1,168.4	1,154.0	9,540,000
1973	1,187.0	1,168.4	11,230,000	1974	1,180.2	1,168.8	8,449,000
1975	1,181.0	1,173.6	9,529,000	1976	1,188.3	1,177.6	8,735,000
1977	1,193.8	1,175.8	8,537,000	1978	1,193.3	1,180.8	8,457,000
1979	1,202.8	1,193.4	9,068,000	1980	1,205.0	1,197.6	11,440,000
1981	1,204.8	1,192.4	8,224,000	1982	1,208.4	1,196.2	8,788,000
1983	1,225.8	1,206.8	17,680,000	1984	1,213.7	1,205.7	20,758,000
1985	1,214.4	1,205.5	19,320,000	1986	1,213.2	1,201.4	17,240,000
1987	1,210.8	1,205.6	13,680,000	1988	1,211.8	1,199.1	6,937,000
1989	1,202.6	1,189.0	8,275,000	1990	1,191.8	1,177.9	8,446,000
1991	1,180.2	1,172.7	8,544,000	1992	1,180.6	1,173.4	8,487,000
1993	1,193.8	1,176.9	8,815,000	1994	1,191.0	1,175.7	8,387,000
1995	1,190.0	1,176.6	9,671,000	1996	1,195.0	1,189.7	11,860,000
1997	1,214.6	1,194.4	12,240,000	1998	1,216.0	1,211.4	13,800,000
1999	1,214.0	1,206.4	11,700,000	2000	1,214.4	1,196.3	9,936,000
2001	1,197.5	1,177.2	8,797,000				

46. ELEVATION - AREA - CAPACITY - DATA FOR **Original Capacity** [16]

ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY
650	0	0	660	228	1,138	670	867	6,611
680	1,566	18,778	690	2,536	39,290	700	3,521	69,578
710	4,131	107,838	720	4,767	152,328	730	5,271	202,519
740	6,185	259,800	750	8,185	331,651	760	9,270	418,927
770	10,515	517,855	780	11,937	630,118	790	13,499	757,299
800	15,530	902,445	810	17,271	1,066,450	820	19,046	1,248,036
830	20,776	1,447,147	840	22,473	1,663,392	850	24,712	1,899,317
860	26,674	2,156,244	870	28,491	2,432,068	880	30,360	2,726,322
890	32,391	3,040,074	895	33,392	3,204,531	900	34,393	3,373,994
910	36,888	3,730,401	920	39,303	4,111,359	930	41,656	4,516,153
940	43,989	4,944,377	950	46,427	5,396,458	960	49,047	5,873,827
970	51,477	6,376,447	980	54,439	6,906,028	990	57,472	7,465,581
1,000	60,528	8,055,581	1,010	64,037	8,678,404	1,020	67,223	9,334,704
1,030	70,658	10,024,110	1,040	74,177	10,748,280	1,050	77,895	11,508,640
1,060	81,873	12,307,470	1,070	85,907	13,146,370	1,080	89,760	14,024,700
1,083	91,006	14,295,850	1,090	93,914	14,943,080	1,100	97,833	15,901,810
1,110	102,044	16,901,200	1,120	106,083	17,941,830	1,130	110,381	19,024,150
1,140	114,509	20,148,600	1,150	119,448	21,318,380	1,160	124,470	22,537,980
1,170	129,359	23,807,120	1,180	134,565	25,126,740	1,190	139,506	26,497,100
1,200	145,240	27,920,820	1,210	151,321	29,403,630	1,219.6	156,250	28,480,870
1,220	156,834	30,944,400	1,229	162,585	32,381,780	1,230	163,224	32,544,690

46. ELEVATION - AREA - CAPACITY - DATA FOR **2001 Capacity**

ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY
650	0	0	660	0	0	670	0	0
680	0	0	690	0	0	700	0	3
710	4	25	720	54	314	730	1,350	7,333
740	3,162	29,895	750	4,781	69,610	760	5,985	123,437
770	6,908	187,902	780	8,223	263,560	790	9,664	352,997
800	13,266	467,648	810	15,235	610,149	820	17,087	771,758
830	18,724	950,812	840	20,557	1,147,216	850	22,540	1,362,705
860	24,296	1,596,886	870	25,877	1,847,750	880	27,503	2,114,651
890	29,191	2,398,124	895	30,172	2,546,532	900	31,152	2,699,843
910	33,565	3,023,428	920	35,922	3,370,863	930	38,203	3,741,490
940	40,527	4,135,140	950	42,869	4,552,117	960	45,461	4,993,767
970	47,847	5,460,304	980	50,525	5,952,162	990	53,518	6,472,374
1,000	56,374	7,021,833	1,010	59,475	7,601,082	1,020	62,533	8,211,125
1,030	65,624	8,851,909	1,040	68,834	9,524,197	1,050	72,208	10,229,410
1,060	75,832	10,969,620	1,070	79,451	11,746,040	1,080	82,849	12,557,510
1,083	83,902	12,807,630	1,090	86,358	13,403,540	1,100	89,814	14,284,400
1,110	93,860	15,202,770	1,120	97,731	16,160,740	1,130	101,596	17,157,370
1,140	105,824	18,194,440	1,150	111,056	19,278,840	1,160	115,683	20,412,530
1,170	120,310	21,592,490	1,180	126,664	22,827,370	1,190	135,555	24,138,460
1,200	143,563	25,534,050	1,210	150,919	27,006,460	1,219.6	156,250	28,480,870
1,220	156,473	28,543,420	1,229	162,548	29,979,010	1,230	163,223	30,141,900

47. REMARKS AND REFERENCES

[1] All elevations (El.) are project datum, referred to as powerhouse datum. Add 0.55 feet to convert to NGVD29. Top parapet wall, El. 1,236.0.
[2] Top spillway gate in raised position of overflow weir for each abutment is El. 1,221.4.
[3] Values for El. 1229.0 and below, original surface areas and recomputed capacity using ACAP. El. 1232 value from Allocation Tables.
[4] Values from 1963-64 report. Colorado River about 121 miles and Overton Arm about 31 miles.
[5] Previous studies report total drainage area as 167,800 mi^2. USGS gage data at dam indicate 171,700 mi^2 with 3,959 mi^2 located above Lake Powell as non contributing. 1963-64 study indicated net sediment contributing area of 167,00 mi^2. The 1963-64 study completed prior to the closure of Glen Canyon Dam, 3/63, with a total drainage area of 111,700 square miles. The net sediment contributing area for 1935-2001 study period is 171,700 mi^2 - (3,959 $mi^{2)}$ - (38.5 years/66.7 years)(107,741 mi^2). 66.7 years since Hoover Dam Closure. 38.5 years since Glen Canyon Dam closure.
[6] Values from 1963-64 report.
[7] Calculated using mean annual runoff value of 10,900,000 AF (item 24).
[8] Estimated mean annual runoff for 2/35 through 9/01 equals 10,900,000 AF, measured by USGS gage, Colorado River near Grand Canyon located about 145 river miles above Lake Mead.
[9] Dead pool elevation.
[10] Surface area in acres at elevation 1,229.0. Trouble locating 1948 area/capacity tables that matched different past reports.
[11] Capacity at El. 1,229.0 for given year. Capacity recomputed for 1935 and 1964 using BOR program ACAP.
[12] Reported as 10-ft contour survey. 2001 survey used multibeam collection system to develop detailed contours of the original river channel area affected by sediment deposition from the dam to the upper reaches just below El.1,190. Previous collected cross sections (1999-2001) were used to measure change on the Colorado River above El 1,190 in the Lower Gorge.
[13] Value from 1963-64 report and USGS gage, Colorado River near Grand Canyon located about 145 river miles above Lake Mead.
[14] Item 37c from 1948 and 1964 used net sediment contributing area of 167,600 square miles as reported in 1964 study.
[15] 9/01 study reported greater capacities than 63-64 study. Attributed to significant decrease of sediment inflow due to closure of Glen Canyon Dam and 37 years of compaction of the sediment deposition since 1963-64 survey. Different methods of collection and analysis between the studies attributes to some of the differences, but even though 2001 survey collected much greater detail the reported computed results in this table used similar analysis approach as the 1948-49 and 1963-64 studies. Analyze of the upper Colorado River delta growth measured around 267,000 AF of sediment deposition since 1963-64. Resulting in an annual average sediment inflow of 7,200 AF. This calculation for only Colorado River upper delta growth. Additional analyses needed to calculate other tributaries and lower reservoir area.
[16] Original surface areas as listed in the 1963-64 study report. Capacities recomputed using BOR program ACAP.

48. AGENCY MAKING SURVEY Bureau of Reclamation
49. AGENCY SUPPLYING DATA Bureau of Reclamation DATE February 2008

Table 4 - Reservoir sediment data summary (page 2 of 2).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
												Percent	Percent	
	Original	Original	1947-48	1947-48	1963-64	1963-64	2001	2001	Sediment	Sediment	Sediment	Sediment	Sediment	Percent
Elevation	Survey	Capacity	Survey	Survey	Survey	Survey	Survey	Survey	Orig - 1964	Orig - 2001	1963-2001	Total	Total	Reservoir
Feet	Acres	Ac-Ft	Acres	Ac-Ft	Acres	Ac-Ft	Acres	Ac-Ft	Ac - Ft	Ac-Ft	Ac-Ft	Orig-1964	Orig-2001	Depth
1,229.0	162,585	32,381,780	162,677	31,047,000	162,608	29,759,860	162,548	29,979,010	2,621,920	2,402,770	-219,150	100.0	100.0	100.0
1,220.0	156,834	30,944,400	157,736	29,606,000	157,073	28,321,300	156,473	28,543,420	2,623,100	2,400,980	-222,120	100.0	99.9	98.4
1,219.6	156,613	30,881,710	156,839	29,458,000	156,839	28,258,510	156,250	28,480,870	2,623,200	2,400,840	-222,360	100.0	99.9	98.4
1,200.0	145,240	27,920,820	145,100	26,583,000	144,892	25,299,240	143,563	25,534,050	2,621,580	2,386,770	-234,810	100.0	99.3	95.0
1,175.0	131,962	24,460,420	128,960	23,152,000	128,960	21,871,640	123,487	22,201,990	2,588,780	2,258,430	-330,350	98.7	94.0	90.7
1,150.0	119,448	21,318,380	115,500	20,103,000	111,551	18,861,810	111,056	19,278,840	2,456,570	2,039,540	-417,030	93.7	84.9	86.4
1,125.0	108,232	18,477,620	99,540	17,350,000	99,540	16,232,550	99,663	16,654,230	2,245,070	1,823,390	-421,680	85.6	75.9	82.0
1,100.0	97,833	15,901,810	94,700	14,852,000	89,471	13,872,210	89,814	14,284,400	2,029,600	1,617,410	-412,190	77.4	67.3	77.7
1,083.0	91,006	14,295,850	83,261	13,297,000	83,261	12,405,420	83,902	12,807,630	1,890,430	1,488,220	-402,210	72.1	61.9	74.8
1,075.0	87,833	13,580,720	80,431	12,604,000	80,431	11,750,510	81,148	12,147,520	1,830,210	1,433,200	-397,010	69.8	59.6	73.4
1,050.0	77,895	11,508,640	75,400	10,594,000	71,160	9,852,651	72,208	10,229,410	1,655,989	1,279,230	-376,759	63.2	53.2	69.1
1,025.0	68,941	9,675,114	62,712	8,822,000	62,712	8,183,496	64,078	8,527,654	1,491,618	1,147,460	-344,158	56.9	47.8	64.8
1,000.0	60,528	8,055,581	58,300	7,262,000	54,816	6,712,890	56,374	7,021,833	1,342,691	1,033,748	-308,943	51.2	43.0	60.4
975.0	52,958	6,637,536	47,898	5,902,000	47,898	5,434,287	49,186	5,702,885	1,203,249	934,651	-268,598	45.9	38.9	56.1
950.0	46,427	5,396,458	41,567	4,715,000	41,567	4,314,975	42,869	4,552,117	1,081,483	844,341	-237,142	41.2	35.1	51.8
925.0	40,479	4,310,816	35,762	3,679,000	35,762	3,349,568	37,063	3,553,325	961,248	757,491	-203,757	36.7	31.5	47.5
900.0	34,393	3,373,994	29,950	2,783,000	29,950	2,526,955	31,152	2,699,843	847,039	674,151	-172,888	32.3	28.1	43.2
895.0	33,392	3,204,531	28,911	2,620,000	28,911	2,379,801	30,172	2,546,532	824,730	657,999	-166,731	31.5	27.4	42.3
875.0	29,425	2,576,859	27,000	1,500,000	25,598	1,837,206	26,690	1,979,168	739,653	597,691	-141,962	28.2	24.9	38.9
850.0	24,712	1,899,317	23,000	1,200,000	21,530	1,246,022	22,540	1,362,705	653,295	536,612	-116,683	24.9	22.3	34.5
825.0	19,911	1,345,430	18,000	700,000	16,914	767,712	17,905	859,239	577,718	486,191	-91,527	22.0	20.2	30.2
800.0	15,530	902,445	13,000	400,000	12,326	397,744	13,266	467,648	504,701	434,797	-69,904	19.2	18.1	25.9
775.0	11,226	572,209	7,500	178,000	6,702	178,186	7,566	224,088	394,023	348,121	-45,902	15.0	14.5	21.6
750.0	8,185	331,651	7,000	42,300	4,151	42,282	4,781	69,610	289,369	262,041	-27,328	11.0	10.9	17.3
725.0	5,019	176,794	10	400	31	387	702	2,203	176,407	174,591	-1,816	6.7	7.3	13.0
700.0	3,521	69,578	0	0	0	0	0	3	69,578	69,575	-3	2.7	2.9	8.6
675.0	1,217	11,820	0	0	0	0	0	0	11,820	11,820	0	0.5	0.5	4.3
650.0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0

1	Elevation of reservoir water surface. Tied to "Power House" datum. Add 0.55 feet to convert to NGVD29, from leveling of 1935.
2	Original reservoir surface areas, in acres.
3	Original reservoir capacity recomputed using ACAP, in acre-feet.
4	1947-48 measured reservoir surface area, in acres. Questions on surface areas to use. Published results varied slightly.
5	1947-48 reservoir capacity in acre-feet. Found slightly different published results. Some values projected from 1963-64 report.
6	1963-64 measured reservoir surface areas in acres.
7	1963-64 reservoir capacity recomputed by ACAP, in acre-feet.
8	2001 measured reservoir surface areas, in acres.
9	2001 reservoir capacity computed by ACAP, in acre-feet.
10	Computed sediment volume from original (1935) through 1964, acre-feet.
11	Computed sediment volume from original (1935) through 2001, acre-feet.
12	2001 change in volume, column (7) - column (9). Negative values indicate increase in capacity due to sediment compaction and much less
13	Measured sediment in percentage my elevation from original to 2006. Total sediment volume of 6,473 acre-feet.
	sediment inflow due to closure of Glen Canyon Dam in 1963.
14	Measured sediment in percent from original, 1935, to 2001. Total sediment volume 2,402,770 acre-feet.
15	Depth of reservoir expressed in percentage of total depth (579).

Table 5 - Reservoir sediment summary.

Elevation	Boulder and Virgin Basins							
	1935	1948	1963	2001	1935-1948	1948-1963	1963-2001	1935-2001
	Reservoir Capacity (AF)				Computed Sediment Volume (AF)			
660	1,138				1,138			1,138
670	6,611				6,611			6,611
680	18,778				18,778			18,778
690	39,290			0	39,290		0	39,290
700	69,578		0	3	69,578	0	-3	69,575
710	107,838		62	25	107,838	-62	37	107,813
720	152,328		247	314	152,328	-247	-67	152,014
730	202,519		557	7,333	202,519	-557	-6,776	195,186
740	259,800	0	11,136	29,894	259,800	-11,136	-18,758	229,906
750	331,651	15,000	42,282	69,610	316,651	-27,282	-27,328	262,041
760	417,937	69,000	89,148	123,437	348,937	-20,148	-34,289	294,500
770	514,873	124,000	146,041	187,902	390,873	-22,041	-41,861	326,971
780	623,150	213,000	213,060	263,560	410,150	-60	-50,500	359,590
790	742,352	312,000	292,705	352,997	430,352	19,295	-60,292	389,355
800	874,524	441,000	397,744	467,648	433,524	43,256	-69,904	406,876
810	1,023,552	589,000	531,832	610,149	434,552	57,168	-78,317	413,403
820	1,188,082	752,000	685,001	771,251	436,082	66,999	-86,250	416,831
830	1,364,196	928,000	852,783	947,196	436,196	75,217	-94,413	417,000
840	1,553,366	1,116,000	1,033,058	1,135,072	437,366	82,942	-102,014	418,294
850	1,755,293	1,318,000	1,226,231	1,335,932	437,293	91,769	-109,701	419,361
860	1,970,223	1,533,000	1,433,023	1,550,413	437,223	99,977	-117,390	419,810
870	2,197,965	1,760,000	1,652,515	1,777,392	437,965	107,485	-124,877	420,573
880	2,438,182	2,000,000	1,883,848	2,017,082	438,182	116,152	-133,234	421,100
890	2,690,951	2,253,000	2,126,659	2,269,693	437,951	126,341	-143,034	421,258
900	2,955,871	2,518,000	2,382,025	2,534,660	437,871	135,975	-152,635	421,211
910	3,235,215	2,797,000	2,651,111	2,813,466	438,215	145,889	-162,355	421,749
920	3,530,167	3,092,000	2,935,024	3,107,545	438,167	156,976	-172,521	422,622
930	3,837,980	3,400,000	3,234,794	3,416,642	437,980	165,206	-181,848	421,338
940	4,162,159	3,724,000	3,549,390	3,740,523	438,159	174,610	-191,133	421,636
950	4,499,216	4,061,000	3,877,572	4,078,495	438,216	183,428	-200,923	420,721
960	4,851,683	4,414,000	4,220,395	4,430,670	437,683	193,605	-210,275	421,013
970	5,218,366	4,781,000	4,577,565	4,797,271	437,366	203,435	-219,706	421,095
980	5,599,644	5,161,000	4,948,799	5,178,216	438,644	212,201	-229,417	421,428
990	5,994,466	5,557,000	5,334,186	5,573,694	437,466	222,814	-239,508	420,772
1000	6,406,257	5,968,000	5,734,763	5,983,994	438,257	233,237	-249,231	422,263
1010	6,833,105	6,395,000	6,152,535	6,410,464	438,105	242,465	-257,929	422,641
1020	7,277,108	6,838,000	6,587,004	6,853,602	439,108	250,996	-266,598	423,506
1030	7,736,628	7,298,000	7,037,820	7,313,398	438,628	260,180	-275,578	423,230
1040	8,213,743	7,775,000	7,505,226	7,790,156	438,743	269,774	-284,930	423,587
1050	8,705,997	8,267,000	7,989,441	8,283,536	438,997	277,559	-294,095	422,461
1060	9,215,849	8,777,000	8,491,653	8,793,439	438,849	285,347	-301,786	422,410
1070	9,740,756	9,302,000	9,018,219	9,319,801	438,756	283,781	-301,582	420,955
1080	10,282,980	9,844,000	9,544,624	9,862,788	438,980	299,376	-318,164	420,192
1090	10,842,509	10,404,000	10,095,815	10,423,264	438,509	308,185	-327,449	419,245
1100	11,419,299	10,981,000	10,664,746	11,001,398	438,299	316,254	-336,652	417,901
1110	12,014,564	11,576,000	11,251,489	11,597,491	438,564	324,511	-346,002	417,073
1120	12,626,992	12,188,000	11,854,039	12,211,986	438,992	333,961	-357,947	415,006
1130	13,257,498	12,819,000	12,472,062	12,844,541	438,498	346,938	-372,479	412,957
1140	13,905,795	13,467,000	13,106,619	13,494,717	438,795	360,381	-388,098	411,078
1150	14,571,311	14,132,000	13,761,553	14,163,314	439,311	370,447	-401,761	407,997
1160	15,256,694	14,872,000	14,445,823	14,851,758	384,694	426,177	-405,935	404,936
1170	15,961,763	15,522,000	15,149,340	15,560,503	439,763	372,660	-411,163	401,260
1180	16,688,812	16,248,000	15,872,538	16,289,961	440,812	375,462	-417,423	398,851
1190	17,432,724	16,995,000	16,615,865	17,040,320	437,724	379,135	-424,455	392,404
1200	18,197,534	17,760,000	17,379,212	17,811,666	437,534	380,788	-432,454	385,868
1210	18,984,407	18,547,000	18,165,052	18,606,224	437,407	381,948	-441,172	378,183
1220	19,796,616	19,360,000	18,974,393	19,424,828	436,616	385,607	-450,435	371,788
1230	20,630,536	20,195,000	19,806,002	20,266,660	435,536	388,998	-460,658	363,876

Table 6 - Sediment analysis by basins, page 1 of 8.

Elevation	Temple Bar area and Virgin Canyon							
	1935	1948	1963	2001	1935-1948	1948-1963	1963-2001	1935-2001
	Reservoir Capacity (AF)				Computed Sediment Volume (AF)			
660								
670								
680								
690								
700								
710								
720								
730								
740								
750					0			0
760	990				990			990
770	2,982				2,982			2,982
780	6,968				6,968			6,968
790	14,947				14,947			14,947
800	26,924				26,924			26,924
810	40,902		0	0	40,902	0	0	40,902
820	56,956	6,000	47	507	50,956	5,953	-460	56,449
830	75,955	19,000	1,402	3,616	56,955	17,598	-2,214	72,339
840	95,022	36,000	7,410	12,144	59,022	28,590	-4,734	82,878
850	116,019	57,000	19,791	26,773	59,019	37,209	-6,982	89,246
860	139,016	80,000	37,072	46,470	59,016	42,928	-9,398	92,546
870	164,072	105,000	58,466	70,336	59,072	46,534	-11,870	93,736
880	191,093	132,000	83,106	97,224	59,093	48,894	-14,118	93,869
890	220,078	161,000	110,331	126,508	59,078	50,669	-16,177	93,570
900	251,074	192,000	139,931	158,037	59,074	52,069	-18,106	93,037
910	285,107	226,000	171,729	191,831	59,107	54,271	-20,102	93,276
920	321,106	262,000	205,629	227,998	59,106	56,371	-22,369	93,108
930	360,092	301,000	241,638	266,551	59,092	59,362	-24,913	93,541
940	401,112	342,000	279,827	307,479	59,112	62,173	-27,652	93,633
950	445,120	386,000	320,665	350,922	59,120	65,335	-30,257	94,198
960	491,069	432,000	364,387	397,248	59,069	67,613	-32,861	93,821
970	540,038	481,000	410,912	446,359	59,038	70,088	-35,447	93,679
980	591,174	532,000	459,917	498,102	59,174	72,083	-38,185	93,072
990	647,050	588,000	511,418	552,928	59,050	76,582	-41,510	94,122
1000	705,138	646,000	565,916	610,967	59,138	80,084	-45,051	94,171
1010	766,124	707,000	624,023	672,417	59,124	82,977	-48,394	93,707
1020	830,241	771,000	685,763	736,856	59,241	85,237	-51,093	93,385
1030	899,189	840,000	750,955	804,067	59,189	89,045	-53,112	95,122
1040	969,206	910,000	819,825	874,449	59,206	90,175	-54,624	94,757
1050	1,043,239	984,000	892,160	948,037	59,239	91,840	-55,877	95,202
1060	1,121,225	1,062,000	968,214	1,025,144	59,225	93,786	-56,930	96,081
1070	1,202,217	1,143,000	1,049,252	1,105,902	59,217	93,748	-56,650	96,315
1080	1,288,248	1,229,000	1,132,296	1,190,233	59,248	96,704	-57,937	98,015
1090	1,377,192	1,318,000	1,220,070	1,278,080	59,192	97,930	-58,010	99,112
1100	1,470,167	1,411,000	1,312,151	1,369,820	59,167	98,849	-57,669	100,347
1110	1,567,204	1,508,000	1,408,990	1,465,840	59,204	99,010	-56,850	101,364
1120	1,669,263	1,610,000	1,510,767	1,565,672	59,263	99,233	-54,905	103,591
1130	1,775,201	1,716,000	1,617,266	1,669,155	59,201	98,734	-51,889	106,046
1140	1,885,243	1,826,000	1,727,956	1,776,190	59,243	98,044	-48,234	109,053
1150	1,999,317	1,940,000	1,843,322	1,886,876	59,317	96,678	-43,554	112,441
1160	2,116,374	2,057,000	1,963,857	2,001,376	59,374	93,143	-37,519	114,998
1170	2,239,388	2,180,000	2,087,846	2,119,221	59,388	92,154	-31,375	120,167
1180	2,365,540	2,306,000	2,215,790	2,240,409	59,540	90,210	-24,619	125,131
1190	2,495,104	2,436,000	2,348,127	2,365,313	59,104	87,873	-17,186	129,791
1200	2,630,077	2,571,000	2,484,998	2,494,060	59,077	86,002	-9,062	136,017
1210	2,769,059	2,710,000	2,626,564	2,626,800	59,059	83,436	-236	142,259
1220	2,911,944	2,853,000	2,772,075	2,762,961	58,944	80,925	9,114	148,983
1230	3,058,783	3,000,000	2,921,521	2,902,552	58,783	78,479	18,969	156,231

Table 6 – Sediment analysis by basin, page 2 of 8.

Elevation	Gregg Basin							
	1935	1948	1963	2001	1935-1948	1948-1963	1963-2001	1935-2001
	Reservoir Capacity (AF)				Computed Sediment Volume (AF)			
660								
670								
680								
690								
700								
710								
720								
730								
740								
750								
760								
770								
780								
790	0				0			0
800	997				997			997
810	1,995				1,995			1,995
820	2,998				2,998			2,998
830	6,996				6,996			6,996
840	15,004				15,004			15,004
850	28,005	0		0	28,005	0	0	28,005
860	46,005	1,000		3	45,005	1,000	-3	46,002
870	68,030	5,000	0	22	63,030	5,000	-22	68,008
880	92,045	15,000	3	333	77,045	14,997	-330	91,712
890	120,042	31,000	613	1,598	89,042	30,387	-985	118,444
900	150,044	53,000	3,923	5,881	97,044	49,077	-1,958	144,163
910	182,068	79,000	13,327	15,282	103,068	65,673	-1,955	166,786
920	215,071	108,000	28,477	29,931	107,071	79,523	-1,454	185,140
930	251,064	141,000	47,200	48,947	110,064	93,800	-1,747	202,117
940	291,081	178,000	69,753	72,031	113,081	108,247	-2,278	219,050
950	332,090	218,000	96,799	99,254	114,090	121,201	-2,455	232,836
960	375,053	261,000	127,863	130,407	114,053	133,137	-2,544	244,646
970	419,029	305,000	162,558	165,308	114,029	142,442	-2,750	253,721
980	467,137	353,000	200,814	203,818	114,137	152,186	-3,004	263,319
990	516,040	402,000	242,534	246,592	114,040	159,466	-4,058	269,448
1000	567,111	453,000	287,541	293,360	114,111	165,459	-5,819	273,751
1010	621,100	507,000	336,159	343,044	114,100	170,841	-6,885	278,056
1020	678,196	564,000	388,598	396,018	114,196	175,402	-7,420	282,178
1030	736,155	622,000	444,241	452,234	114,155	177,759	-7,993	283,921
1040	797,169	683,000	502,594	511,175	114,169	180,406	-8,581	285,994
1050	861,198	747,000	564,040	573,111	114,198	182,960	-9,071	288,087
1060	928,186	814,000	628,829	638,350	114,186	185,171	-9,521	289,836
1070	998,180	884,000	697,282	706,882	114,180	186,718	-9,600	291,298
1080	1,069,206	955,000	767,260	778,269	114,206	187,740	-11,009	290,937
1090	1,144,159	1,030,000	840,586	852,775	114,159	189,414	-12,189	291,384
1100	1,222,139	1,108,000	917,103	930,750	114,139	190,897	-13,647	291,389
1110	1,303,170	1,189,000	997,000	1,011,919	114,170	192,000	-14,919	291,251
1120	1,387,219	1,273,000	1,079,892	1,095,993	114,219	193,108	-16,101	291,226
1130	1,474,167	1,360,000	1,165,461	1,182,910	114,167	194,539	-17,449	291,257
1140	1,564,202	1,450,000	1,253,848	1,272,636	114,202	196,152	-18,788	291,566
1150	1,656,263	1,542,000	1,345,955	1,365,235	114,263	196,045	-19,280	291,028
1160	1,752,309	1,638,000	1,442,077	1,460,872	114,309	195,923	-18,795	291,437
1170	1,851,320	1,737,000	1,540,446	1,559,214	114,320	196,554	-18,768	292,106
1180	1,951,446	1,837,000	1,641,248	1,660,047	114,446	195,752	-18,799	291,399
1190	2,055,085	1,941,000	1,744,566	1,763,442	114,085	196,434	-18,876	291,643
1200	2,161,063	2,047,000	1,850,547	1,869,569	114,063	196,453	-19,022	291,494
1210	2,270,049	2,156,000	1,959,459	1,978,728	114,049	196,541	-19,269	291,321
1220	2,380,954	2,267,000	2,070,959	2,090,702	113,954	196,041	-19,743	290,252
1230	2,494,823	2,381,000	2,184,907	2,205,417	113,823	196,093	-20,510	289,406

Table 6 – Sediment analysis by basin, page 3 of 8.

Elevation	Grand Bay							
	1935	1948	1963	2001	1935-1948	1948-1963	1963-2001	1935-2001
	Reservoir Capacity (AF)				Computed Sediment Volume (AF)			
660								
670								
680								
690								
700								
710								
720								
730								
740								
750								
760								
770								
780								
790								
800								
810								
820								
830								
840								
850	0				0			0
860	1,000				1,000			1,000
870	2,001				2,001			2,001
880	5,002				5,002			5,002
890	9,003				9,003			9,003
900	15,004				15,004			15,004
910	21,008				21,008			21,008
920	29,010				29,010			29,010
930	38,010				38,010			38,010
940	47,013				47,013			47,013
950	57,015	0			57,015	0		57,015
960	67,009	1,000			66,009	1,000		67,009
970	79,006	3,000			76,006	3,000		79,006
980	91,027	7,000			84,027	7,000		91,027
990	104,008	14,000			90,008	14,000		104,008
1000	118,023	24,000			94,023	24,000		118,023
1010	132,021	36,000	0		96,021	36,000	0	132,021
1020	148,043	51,000	2		97,043	50,998	2	148,043
1030	166,035	69,000	402		97,035	68,598	402	166,035
1040	184,039	87,000	1,582		97,039	85,418	1,582	184,039
1050	204,047	107,000	3,784		97,047	103,216	3,784	204,047
1060	224,045	127,000	7,064		97,045	119,936	7,064	224,045
1070	247,045	150,000	1,162	0	97,045	148,838	1,162	247,045
1080	271,052	174,000	16,600	41	97,052	157,400	16,559	271,011
1090	296,041	199,000	23,463	371	97,041	175,537	23,092	295,670
1100	323,037	226,000	31,226	1,138	97,037	194,774	30,088	321,899
1110	352,046	255,000	40,534	2,661	97,046	214,466	37,873	349,385
1120	383,060	286,000	53,019	6,063	97,060	232,981	46,956	376,997
1130	415,047	318,000	73,216	11,450	97,047	244,784	61,766	403,597
1140	450,058	353,000	101,770	21,140	97,058	251,230	80,630	428,918
1150	488,077	391,000	134,746	40,096	97,077	256,254	94,650	447,981
1160	527,093	430,000	172,461	67,310	97,093	257,539	105,151	459,783
1170	570,099	473,000	214,479	99,144	97,099	258,521	115,335	470,955
1180	613,140	516,000	258,808	137,002	97,140	257,192	121,806	476,138
1190	660,027	563,000	305,162	181,480	97,027	257,838	123,682	478,547
1200	708,021	611,000	353,708	229,661	97,021	257,292	124,047	478,360
1210	758,016	661,000	404,777	280,251	97,016	256,223	124,526	477,765
1220	811,984	715,000	458,309	333,204	96,984	256,691	125,105	478,780
1230	866,938	770,000	514,246	388,473	96,938	255,754	125,773	478,465

Table 6 – Sediment analysis by basin, page 4 of 8.

Elevation	Pierce Basin							
	1935	1948	1963	2001	1935-1948	1948-1963	1963-2001	1935-2001
	Reservoir Capacity (AF)				Computed Sediment Volume (AF)			
660								
670								
680								
690								
700								
710								
720								
730								
740								
750								
760								
770								
780								
790								
800								
810								
820								
830								
840								
850								
860								
870								
880								
890	0				0			0
900	1,000				1,000			1,000
910	3,001				3,001			3,001
920	6,002				6,002			6,002
930	11,003				11,003			11,003
940	16,004				16,004			16,004
950	22,006				22,006			22,006
960	29,004				29,004			29,004
970	36,003				36,003			36,003
980	44,013				44,013			44,013
990	52,004				52,004			52,004
1000	61,012				61,012			61,012
1010	71,011				71,011			71,011
1020	81,023				81,023			81,023
1030	91,019	0			91,019	0		91,019
1040	103,022	3,000			100,022	3,000		103,022
1050	117,027	9,000			108,027	9,000		117,027
1060	131,026	16,000			115,026	16,000		131,026
1070	146,026	27,000			119,026	27,000		146,026
1080	163,031	40,000			123,031	40,000		163,031
1090	181,025	54,000			127,025	54,000		181,025
1100	200,023	70,000			130,023	70,000		200,023
1110	222,029	88,000			134,029	88,000		222,029
1120	244,039	107,000			137,039	107,000		244,039
1130	268,030	129,000			139,030	129,000		268,030
1140	293,038	152,000			141,038	152,000		293,038
1150	319,051	177,000	0		142,051	177,000	0	319,051
1160	349,062	205,000	652		144,062	204,348	652	349,062
1170	378,065	234,000	21,992		144,065	212,008	21,992	378,065
1180	411,094	267,000	54,078	0	144,094	212,922	54,078	411,094
1190	445,018	301,000	88,548	12,995	144,018	212,452	75,553	432,023
1200	481,014	337,000	124,761	48,502	144,014	212,239	76,259	432,512
1210	519,011	375,000	162,686	94,481	144,011	212,314	68,205	424,530
1220	557,989	414,000	202,404	142,333	143,989	211,596	60,071	415,656
1230	599,957	456,000	244,127	192,146	143,957	211,873	51,981	407,811

Table 6 – Sediment analysis by basin, page 5 of 8.

Elevation	Lower Granite Gorge							
	1935	1948	1963	2001	1935-1948	1948-1963	1963-2001	1935-2001
	Reservoir Capacity (AF)				Computed Sediment Volume (AF)			
660								
670								
680								
690								
700								
710								
720								
730								
740								
750								
760								
770								
780								
790								
800								
810								
820								
830								
840								
850								
860								
870								
880								
890								
900	0				0			0
910	1,000				1,000			1,000
920	4,001				4,001			4,001
930	7,002				7,002			7,002
940	11,003				11,003			11,003
950	16,004				16,004			16,004
960	22,003				22,003			22,003
970	29,002				29,002			29,002
980	37,011				37,011			37,011
990	48,004				48,004			48,004
1000	59,012				59,012			59,012
1010	73,012				73,012			73,012
1020	87,025				87,025			87,025
1030	103,022				103,022			103,022
1040	120,025				120,025			120,025
1050	138,032				138,032			138,032
1060	159,032				159,032			159,032
1070	181,033				181,033			181,033
1080	204,039				204,039			204,039
1090	228,032				228,032			228,032
1100	255,029				255,029			255,029
1110	282,037				282,037			282,037
1120	311,049				311,049			311,049
1130	342,039				342,039			342,039
1140	375,048		0		375,048	0	0	375,048
1150	410,065		4		410,065	-4	4	410,065
1160	447,079		1,142		447,079	-1,142	1,142	447,079
1170	486,084	0	6,040	0	486,084	-6,040	6,040	486,084
1180	526,120	14,000	21,007	2,196	512,120	-7,007	18,811	523,924
1190	569,024	40,000	51,167	11,682	529,024	-11,167	39,485	557,342
1200	614,018	77,000	92,227	31,531	537,018	-15,227	60,696	582,487
1210	661,014	122,000	137,466	63,735	539,014	-15,466	73,731	597,279
1220	709,986	169,000	185,155	103,723	540,986	-16,155	81,432	606,263
1230	759,946	219,000	234,884	145,370	540,946	-15,884	89,514	614,576

Table 6 – Sediment analysis by basin, page 6 of 8.

Elevation	Overton Arm							
	1935	1948	1963	2001	1935-1948	1948-1963	1963-2001	1935-2001
	Reservoir Capacity (AF)				Computed Sediment Volume (AF)			
660								
670								
680								
690								
700								
710								
720								
730								
740								
750								
760								
770								
780								
790								
800								
810								
820								
830								
840								
850								
860								
870			0	0		0	0	0
880			1	12		-1	-11	-12
890	0	0	237	325		-237	-88	-325
900	1,000	1,000	1,077	1,265	0	-77	-188	-265
910	3,001	3,000	2,470	2,849	1	530	-379	152
920	6,002	6,000	4,503	5,389	2	1,497	-886	613
930	11,003	11,000	7,616	9,350	3	3,384	-1,734	1,653
940	16,004	16,000	12,499	15,107	4	3,501	-2,608	897
950	25,007	25,000	19,940	23,446	7	5,060	-3,506	1,561
960	38,005	38,000	30,996	35,442	5	7,004	-4,446	2,563
970	55,004	55,000	46,818	51,366	4	8,182	-4,548	3,638
980	76,022	76,000	67,299	72,026	22	8,701	-4,727	3,996
990	104,008	104,000	92,481	99,160	8	11,519	-6,679	4,848
1000	139,027	139,000	124,670	133,512	27	14,330	-8,842	5,515
1010	182,029	182,000	164,794	175,157	29	17,206	-10,363	6,872
1020	233,068	233,000	212,461	224,649	68	20,539	-12,188	8,419
1030	292,061	292,000	267,527	282,210	61	24,473	-14,683	9,851
1040	361,077	361,000	330,344	348,417	77	30,656	-18,073	12,660
1050	439,101	439,000	403,226	424,726	101	35,774	-21,500	14,375
1060	528,106	528,000	488,340	512,687	106	39,660	-24,347	15,419
1070	631,114	630,000	586,955	613,455	1,114	43,045	-26,500	17,659
1080	745,143	744,000	696,400	726,179	1,143	47,600	-29,779	18,964
1090	874,122	869,000	816,676	849,050	5,122	52,324	-32,374	25,072
1100	1,012,116	1,004,000	946,883	981,294	8,116	57,117	-34,411	30,822
1110	1,160,151	1,150,000	1,088,808	1,124,859	10,151	61,192	-36,051	35,292
1120	1,320,208	1,309,000	1,242,773	1,281,026	11,208	66,227	-38,253	39,182
1130	1,492,169	1,480,000	1,407,886	1,449,314	12,169	72,114	-41,428	42,855
1140	1,675,215	1,662,000	1,584,277	1,629,757	13,215	77,723	-45,480	45,458
1150	1,874,297	1,857,000	1,776,230	1,823,319	17,297	80,770	-47,089	50,978
1160	2,089,369	2,069,000	1,987,227	2,031,214	20,369	81,773	-43,987	58,155
1170	2,320,402	2,297,000	2,214,987	2,254,408	23,402	82,013	-39,421	65,994
1180	2,570,587	2,544,000	2,461,241	2,497,755	26,587	82,759	-36,514	72,832
1190	2,840,118	2,812,000	2,727,006	2,763,228	28,118	84,994	-36,222	76,890
1200	3,129,092	3,099,000	3,013,787	3,049,061	30,092	85,213	-35,274	80,031
1210	3,442,074	3,410,000	3,323,816	3,356,241	32,074	86,184	-32,425	85,833
1220	3,774,927	3,742,000	3,658,004	3,685,669	32,927	83,996	-27,665	89,258
1230	4,133,707	4,100,000	4,017,092	4,041,282	33,707	82,908	-24,190	92,425

Table 6 – Sediment analysis by basin, page 7 of 8.

Elevation	Total All Basins							
	1935	1948	1963	2001	1935-1948	1948-1963	1963-2001	1935-2001
	Reservoir Capacity (AF)				Computed Sediment Volume (AF)			
660	1,138	0	0	0	1,138	0	0	1,138
670	6,611	0	0	0	6,611	0	0	6,611
680	18,778	0	0	0	18,778	0	0	18,778
690	39,290	0	0	0	39,290	0	0	39,290
700	69,578	0	0	3	69,578	0	-3	69,575
710	107,838	0	62	25	107,838	-62	37	107,813
720	152,328	0	247	314	152,328	-247	-67	152,014
730	202,519	0	557	7,333	202,519	-557	-6,776	195,186
740	259,800	0	11,136	29,894	259,800	-11,136	-18,758	229,906
750	331,651	15,000	42,282	69,610	316,651	-27,282	-27,328	262,041
760	418,927	69,000	89,148	123,437	349,927	-20,148	-34,289	295,490
770	517,855	124,000	146,041	187,902	393,855	-22,041	-41,861	329,953
780	630,118	213,000	213,060	263,560	417,118	-60	-50,500	366,558
790	757,299	312,000	292,705	352,997	445,299	19,295	-60,292	404,302
800	902,445	441,000	397,744	467,648	461,445	43,256	-69,904	434,797
810	1,066,450	589,000	531,832	610,149	477,450	57,168	-78,317	456,301
820	1,248,036	758,000	685,048	771,758	490,036	72,952	-86,710	476,278
830	1,447,147	947,000	854,185	950,812	500,147	92,815	-96,627	496,335
840	1,663,392	1,152,000	1,040,468	1,147,216	511,392	111,532	-106,748	516,176
850	1,899,317	1,375,000	1,246,022	1,362,705	524,317	128,978	-116,683	536,612
860	2,156,244	1,614,000	1,470,095	1,596,886	542,244	143,905	-126,791	559,358
870	2,432,068	1,870,000	1,710,981	1,847,750	562,068	159,019	-136,769	584,318
880	2,726,322	2,147,000	1,966,958	2,114,651	579,322	180,042	-147,693	611,671
890	3,040,074	2,445,000	2,237,840	2,398,124	595,074	207,160	-160,284	641,950
900	3,373,994	2,764,000	2,526,955	2,699,843	609,994	237,045	-172,888	674,151
910	3,730,401	3,105,000	2,838,636	3,023,428	625,401	266,364	-184,792	706,973
920	4,111,359	3,468,000	3,173,633	3,370,863	643,359	294,367	-197,230	740,496
930	4,516,153	3,853,000	3,531,247	3,741,490	663,153	321,753	-210,243	774,663
940	4,944,377	4,260,000	3,911,468	4,135,140	684,377	348,532	-223,672	809,237
950	5,396,458	4,690,000	4,314,975	4,552,117	706,458	375,025	-237,142	844,341
960	5,873,827	5,146,000	4,743,642	4,993,767	727,827	402,358	-250,125	880,060
970	6,376,447	5,625,000	5,197,853	5,460,304	751,447	427,147	-262,451	916,143
980	6,906,028	6,129,000	5,676,830	5,952,162	777,028	452,170	-275,332	953,866
990	7,465,581	6,665,000	6,180,620	6,472,374	800,581	484,380	-291,754	993,207
1000	8,055,581	7,230,000	6,712,890	7,021,833	825,581	517,110	-308,943	1,033,748
1010	8,678,404	7,827,000	7,277,511	7,601,082	851,404	549,489	-323,571	1,077,322
1020	9,334,704	8,457,000	7,873,828	8,211,125	877,704	583,172	-337,297	1,123,579
1030	10,024,110	9,121,000	8,500,946	8,851,909	903,110	620,054	-350,963	1,172,201
1040	10,748,280	9,819,000	9,159,571	9,524,197	929,280	659,429	-364,626	1,224,083
1050	11,508,640	10,553,000	9,852,651	10,229,410	955,640	700,349	-376,759	1,279,230
1060	12,307,470	11,426,000	10,584,100	10,969,620	881,470	841,900	-385,520	1,337,850
1070	13,146,370	12,250,000	11,352,870	11,746,040	896,370	897,130	-393,170	1,400,330
1080	14,023,700	13,111,000	12,157,180	12,557,510	912,700	953,820	-400,330	1,466,190
1090	14,943,080	14,009,000	12,996,610	13,403,540	934,080	1,012,390	-406,930	1,539,540
1100	15,901,810	14,946,000	13,872,110	14,284,400	955,810	1,073,890	-412,290	1,617,410
1110	16,901,200	15,925,000	14,786,820	15,202,770	976,200	1,138,180	-415,950	1,698,430
1120	17,941,830	16,944,000	15,740,490	16,160,740	997,830	1,203,510	-420,250	1,781,090
1130	19,024,150	18,004,000	16,735,890	17,157,370	1,020,150	1,268,110	-421,480	1,866,780
1140	20,148,600	19,105,000	17,774,470	18,194,440	1,043,600	1,330,530	-419,970	1,954,160
1150	21,318,380	20,251,000	18,861,810	19,278,840	1,067,380	1,389,190	-417,030	2,039,540
1160	22,537,980	21,499,000	20,013,240	20,412,530	1,038,980	1,485,760	-399,290	2,125,450
1170	23,807,120	22,690,000	21,235,130	21,592,490	1,117,120	1,454,870	-357,360	2,214,630
1180	25,126,740	24,000,000	22,524,710	22,827,370	1,126,740	1,475,290	-302,660	2,299,370
1190	26,497,100	25,375,000	23,880,440	24,138,460	1,122,100	1,494,560	-258,020	2,358,640
1200	27,920,820	26,813,000	25,299,240	25,534,050	1,107,820	1,513,760	-234,810	2,386,770
1210	29,403,630	28,313,000	26,779,820	27,006,460	1,090,630	1,533,180	-226,640	2,397,170
1220	30,944,400	29,878,000	28,321,300	28,543,420	1,066,400	1,556,700	-222,120	2,400,980
1230	32,544,690	31,121,000	29,922,780	30,141,900	1,423,690	1,198,220	-219,120	2,402,790

Table 6 – Sediment analysis for all basins, page 8 of 8.

Elevation Feet	1935 Contour Area Acres	1948-49 Contour Area Acres	1963-64 Contour Area Acres	2001 Contour Area Acres	1948-1935 Contour Area Acres	1963-1948 Contour Area Acres	2001-1963 Contour Area Acres	2001-1935 Contour Area Acres
660	228	0	0	0	-228	0	0	-228
670	867	0	0	0	-867	0	0	-867
680	1,566	0	0	0	-1,566	0	0	-1,566
690	2,536	0	0	0	-2,536	0	0	-2,536
700	3,521	0	0	0	-3,521	0	0	-3,521
710	4,131	0	12	4	-4,131	12	-8	-4,127
720	4,767	0	25	54	-4,767	25	29	-4,713
730	5,271	0	37	1,350	-5,271	37	1,313	-3,921
740	6,185	0	2,079	3,162	-6,185	2,079	1,083	-3,023
750	8,185	4,300	4,151	4,781	-3,885	-149	630	-3,404
760	9,270	6,000	5,223	5,985	-3,270	-777	762	-3,285
770	10,515	7,100	6,156	6,908	-3,415	-944	752	-3,607
780	11,937	8,700	7,248	8,223	-3,237	-1,452	975	-3,714
790	13,499	11,800	8,681	9,664	-1,699	-3,119	983	-3,835
800	15,530	13,800	12,326	13,266	-1,730	-1,474	940	-2,264
810	17,271	15,800	14,491	15,235	-1,471	-1,309	744	-2,036
820	19,046	18,000	16,152	17,087	-1,046	-1,848	935	-1,959
830	20,776	19,800	17,675	18,724	-976	-2,125	1,049	-2,052
840	22,473	21,400	19,581	20,557	-1,073	-1,819	976	-1,916
850	24,712	23,100	21,530	22,540	-1,612	-1,570	1,010	-2,172
860	26,674	24,800	23,285	24,296	-1,874	-1,515	1,011	-2,378
870	28,491	26,600	24,892	25,877	-1,891	-1,708	985	-2,614
880	30,360	28,800	26,303	27,503	-1,560	-2,497	1,200	-2,857
890	32,391	30,800	27,873	29,191	-1,591	-2,927	1,318	-3,200
900	34,393	33,000	29,950	31,152	-1,393	-3,050	1,202	-3,241
910	36,888	35,200	32,386	33,565	-1,688	-2,814	1,179	-3,323
920	39,303	37,400	34,613	35,922	-1,903	-2,787	1,309	-3,381
930	41,656	39,600	36,910	38,203	-2,056	-2,690	1,293	-3,453
940	43,989	41,900	39,134	40,527	-2,089	-2,766	1,393	-3,462
950	46,427	44,200	41,567	42,869	-2,227	-2,633	1,302	-3,558
960	49,047	46,800	44,166	45,461	-2,247	-2,634	1,295	-3,586
970	51,477	49,100	46,676	47,847	-2,377	-2,424	1,171	-3,630
980	54,439	51,900	49,119	50,525	-2,539	-2,781	1,406	-3,914
990	57,472	55,000	51,639	53,518	-2,472	-3,361	1,879	-3,954
1000	60,528	58,100	54,816	56,374	-2,428	-3,284	1,558	-4,154
1010	64,037	61,500	58,108	59,475	-2,537	-3,392	1,367	-4,562
1020	67,223	64,600	61,155	62,533	-2,623	-3,445	1,378	-4,690
1030	70,658	68,000	64,269	65,624	-2,658	-3,731	1,355	-5,034
1040	74,177	71,600	67,456	68,834	-2,577	-4,144	1,378	-5,343
1050	77,895	75,200	71,160	72,208	-2,695	-4,040	1,048	-5,687
1060	81,873	79,200	75,130	75,832	-2,673	-4,070	702	-6,041
1070	85,907	83,200	78,625	79,451	-2,707	-4,575	826	-6,456
1080	89,760	86,800	82,237	82,849	-2,960	-4,563	612	-6,911
1090	93,914	90,700	85,650	86,358	-3,214	-5,050	708	-7,556
1100	97,833	94,500	89,471	89,814	-3,333	-5,029	343	-8,019
1110	102,044	98,700	93,452	93,860	-3,344	-5,248	408	-8,184
1120	106,083	102,800	97,281	97,731	-3,283	-5,519	450	-8,352
1130	110,381	106,900	101,799	101,596	-3,481	-5,101	-203	-8,785
1140	114,509	110,800	105,917	105,824	-3,709	-4,883	-93	-8,685
1150	119,448	115,200	111,551	111,056	-4,248	-3,649	-495	-8,392
1160	124,470	120,200	118,733	115,683	-4,270	-1,467	-3,050	-8,787
1170	129,359	125,100	125,645	120,310	-4,259	545	-5,335	-9,049
1180	134,565	132,100	132,267	126,664	-2,465	167	-5,603	-7,901
1190	139,506	138,500	138,879	135,555	-1,006	379	-3,324	-3,951
1200	145,240	144,700	144,892	143,563	-540	192	-1,329	-1,677
1210	151,321	151,000	151,224	150,919	-321	224	-305	-402
1220	156,834	156,700	157,073	156,473	-134	373	-600	-361
1230	163,224	163,300	163,224	163,223	77	-76	-1	-1

Table 7 - Computed Contour Surface Area by Survey

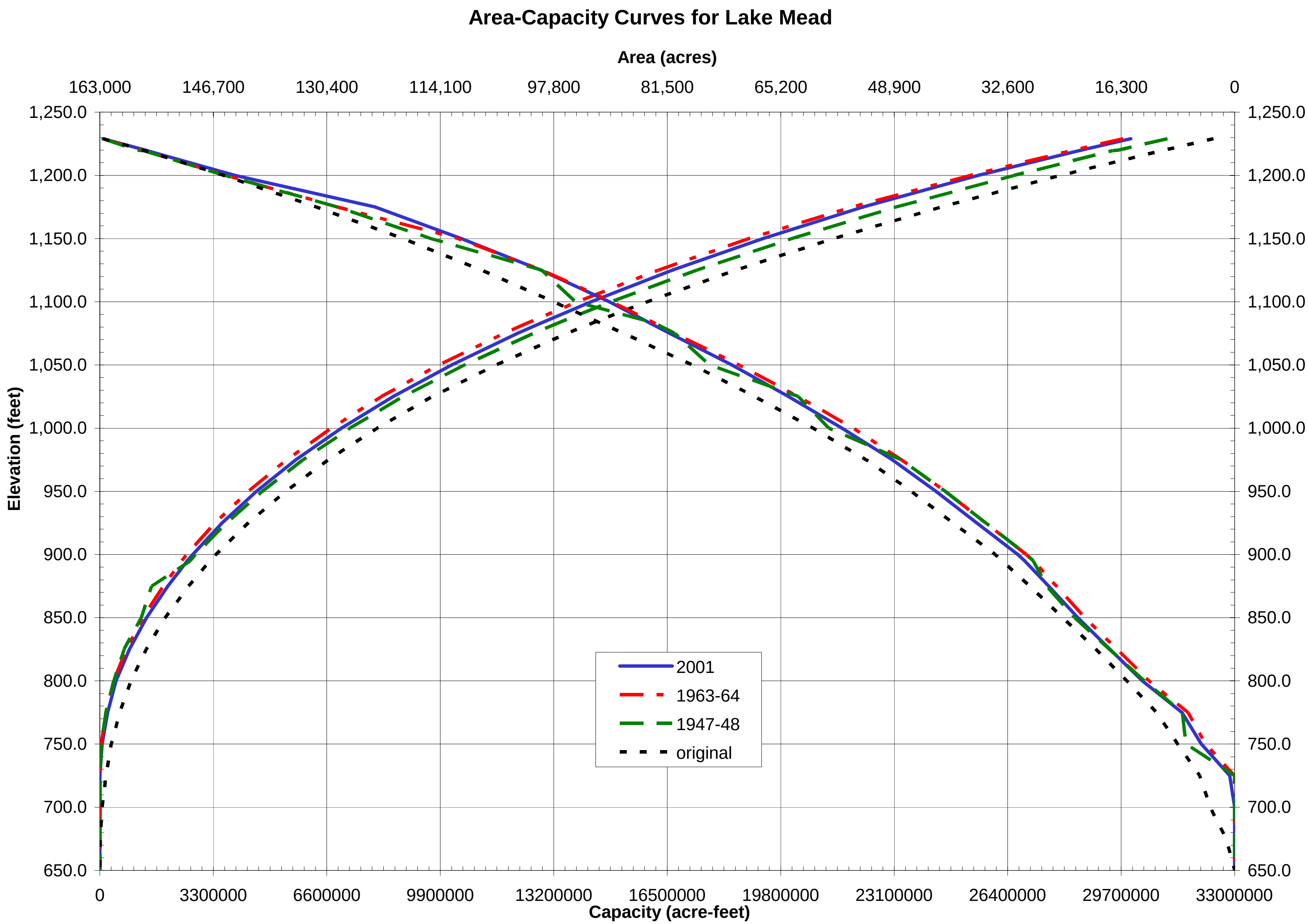


Figure 28 - Lake Mead Area and Capacity Curves.

Elevation	Boulder and Virgin Basins 1935	1948	1963	2001	Temple Bar area and Virgin Canyon 1935	1948	1963	2001	Gregg Basin 1935	1948	1963	2001	Grand Bay 1935	1948	1963	2001
660	1,138															
670	6,611															
680	18,778															
690	39,290			0												
700	69,578			3												
710	107,838		62	25												
720	152,328		247	314												
730	202,519		557	7,333												
740	259,800		11,136	29,895												
750	331,651	15,000	42,282	69,610												
760	417,937	69,000	89,148	123,437	990											
770	514,873	124,000	146,041	187,902	2,982											
780	623,150	213,000	213,060	263,560	6,968											
790	742,352	312,000	292,705	352,997	14,947											
800	874,524	441,000	397,744	467,648	26,924				997							
810	1,023,552	589,000	531,832	610,149	40,902		0	0	1,995							
820	1,188,082	752,000	685,001	771,251	56,956	6,000	47	507	2,998							
830	1,364,196	928,000	852,783	947,196	75,955	19,000	1,402	3,616	6,996							
840	1,553,366	1,116,000	1,033,058	1,135,072	95,022	36,000	7,410	12,144	15,004							
850	1,755,293	1,318,000	1,226,231	1,335,932	116,019	57,000	19,791	26,773	28,005			0				
860	1,970,223	1,533,000	1,433,023	1,550,413	139,016	80,000	37,072	46,470	46,005	1,000		3	1,000			
870	2,197,965	1,760,000	1,652,515	1,777,392	164,072	105,000	58,466	70,336	68,030	5,000		22	2,001			
880	2,438,182	2,000,000	1,883,848	2,017,082	191,093	132,000	83,106	97,224	92,045	15,000	3	333	5,002			
890	2,690,951	2,253,000	2,126,659	2,269,693	220,078	161,000	110,331	126,508	120,042	31,000	613	1,598	9,003			
900	2,955,871	2,518,000	2,382,025	2,534,660	251,074	192,000	139,931	158,037	150,044	53,000	3,923	5,881	15,004			
910	3,235,215	2,797,000	2,651,111	2,813,466	285,107	226,000	171,729	191,831	182,068	79,000	13,327	15,282	21,008			
920	3,530,167	3,092,000	2,935,024	3,107,545	321,106	262,000	205,629	227,998	215,071	108,000	28,477	29,931	29,010			
930	3,837,980	3,400,000	3,234,794	3,416,642	360,092	301,000	241,638	266,551	251,064	141,000	47,200	48,947	38,010			
940	4,162,159	3,724,000	3,549,390	3,740,523	401,112	342,000	279,827	307,479	291,081	178,000	69,753	72,031	47,013			
950	4,499,216	4,061,000	3,877,572	4,078,495	445,120	386,000	320,665	350,922	332,090	218,000	96,799	99,254	57,015			
960	4,851,683	4,414,000	4,220,395	4,430,670	491,069	432,000	364,387	397,248	375,053	261,000	127,863	130,407	67,009	1,000		
970	5,218,366	4,781,000	4,577,565	4,797,271	540,038	481,000	410,912	446,359	419,029	305,000	162,558	165,308	79,006	3,000		
980	5,599,644	5,161,000	4,948,799	5,178,216	591,174	532,000	459,917	498,102	467,137	353,000	200,814	203,818	91,027	7,000		
990	5,994,466	5,557,000	5,334,186	5,573,694	647,050	588,000	511,418	552,928	516,040	402,000	242,534	246,592	104,008	14,000		
1000	6,406,257	5,968,000	5,734,763	5,983,994	705,138	646,000	565,916	610,967	567,111	453,000	287,541	293,360	118,023	24,000		
1010	6,833,105	6,395,000	6,152,535	6,410,464	766,124	707,000	624,023	672,417	621,100	507,000	336,159	343,044	132,021	36,000		
1020	7,277,108	6,338,000	6,587,004	6,853,602	830,241	771,000	685,763	736,856	678,196	564,000	388,598	396,018	148,043	51,000	2	
1030	7,736,628	7,298,000	7,037,820	7,313,398	899,189	840,000	750,955	804,067	736,155	622,000	444,241	452,234	166,035	69,000	402	
1040	8,213,743	7,775,000	7,505,226	7,790,156	969,206	910,000	819,825	874,449	797,169	683,000	502,594	511,175	184,039	87,000	1,582	
1050	8,705,997	8,267,000	7,989,441	8,283,536	1,043,239	984,000	892,160	948,037	861,198	747,000	564,040	573,111	204,047	107,000	3,784	
1060	9,215,849	8,777,000	8,491,653	8,793,439	1,121,225	1,062,000	968,214	1,025,144	928,186	814,000	628,829	638,350	224,045	127,000	7,064	
1070	9,740,756	9,302,000	9,018,219	9,319,801	1,202,217	1,143,000	1,049,252	1,105,902	998,180	884,000	697,282	706,882	247,045	150,000	1,162	0
1080	10,282,980	9,844,000	9,544,624	9,862,788	1,288,248	1,229,000	1,132,296	1,190,233	1,069,206	955,000	767,260	778,269	271,052	174,000	16,600	41
1090	10,842,509	10,404,000	10,095,815	10,423,264	1,377,192	1,318,000	1,220,070	1,278,080	1,144,159	1,030,000	840,586	852,775	296,041	199,000	23,463	371
1100	11,419,299	10,981,000	10,664,746	11,001,398	1,470,167	1,411,000	1,312,151	1,369,820	1,222,139	1,108,000	917,103	930,750	323,037	226,000	31,226	1,138
1110	12,014,564	11,576,000	11,251,489	11,597,491	1,567,204	1,508,000	1,408,990	1,465,840	1,303,170	1,189,000	997,000	1,011,919	352,046	255,000	40,534	2,661
1120	12,626,992	12,188,000	11,854,039	12,211,986	1,669,263	1,610,000	1,510,767	1,565,672	1,387,219	1,273,000	1,079,892	1,095,993	383,060	286,000	53,019	6,063
1130	13,257,498	12,819,000	12,472,062	12,844,541	1,775,201	1,716,000	1,617,266	1,669,155	1,474,167	1,360,000	1,165,461	1,182,910	415,047	318,000	73,216	11,450
1140	13,905,795	13,467,000	13,106,619	13,494,717	1,885,243	1,826,000	1,727,956	1,776,190	1,564,202	1,450,000	1,253,848	1,272,636	450,058	353,000	101,770	21,140
1150	14,571,311	14,132,000	13,761,553	14,163,314	1,999,317	1,940,000	1,843,322	1,886,876	1,656,263	1,542,000	1,345,955	1,365,235	488,077	391,000	134,746	40,096
1160	15,256,694	14,872,000	14,445,823	14,851,758	2,116,374	2,057,000	1,963,857	2,001,376	1,752,309	1,638,000	1,442,077	1,460,872	527,093	430,000	172,461	67,310
1170	15,961,763	15,522,000	15,149,340	15,560,503	2,239,388	2,180,000	2,087,846	2,119,221	1,851,320	1,737,000	1,540,446	1,559,214	570,099	473,000	214,479	99,144
1180	16,688,812	16,248,000	15,872,538	16,289,961	2,365,540	2,306,000	2,215,790	2,240,409	1,951,446	1,837,000	1,641,248	1,660,047	613,140	516,000	258,808	137,002
1190	17,432,724	16,995,000	16,615,865	17,040,320	2,495,104	2,436,000	2,348,127	2,365,313	2,055,085	1,941,000	1,744,566	1,763,442	660,027	563,000	305,162	181,480
1200	18,197,534	17,760,000	17,379,212	17,811,666	2,630,077	2,571,000	2,484,998	2,494,060	2,161,063	2,047,000	1,850,547	1,869,569	708,021	611,000	353,708	229,661
1210	18,984,407	18,547,000	18,165,052	18,606,224	2,769,059	2,710,000	2,626,564	2,626,800	2,270,049	2,156,000	1,959,459	1,978,728	758,016	661,000	404,777	280,251
1220	19,796,616	19,360,000	18,974,393	19,424,820	2,911,944	2,853,000	2,772,075	2,762,960	2,380,954	2,267,000	2,070,959	2,090,700	811,984	715,000	458,309	333,200
1230	20,630,536	20,195,000	19,806,002	20,266,660	3,058,783	3,000,000	2,921,521	2,902,552	2,494,823	2,381,000	2,184,907	2,205,417	866,938	770,000	514,246	388,473

Elevation	Pierce Basin 1935	1948	1963	2001	Lower Granite Gorge 1935	1948	1963	2001	Overton Arm 1935	1948	1963	2001	Totals 1935	1948	1963	2001
660													1,138	0	0	0
670													6,611	0	0	0
680													18,778	0	0	0
690													39,290	0	0	0
700													69,578	0	0	3
710													107,838	0	62	25
720													152,328	0	247	314
730													202,519	0	557	7,333
740													259,800	0	11,136	29,895
750													331,651	15,000	42,282	69,610
760													418,927	69,000	89,148	123,437
770													517,855	124,000	146,041	187,902
780													630,118	213,000	213,060	263,560
790													757,299	312,000	292,705	352,997
800													902,445	441,000	397,744	467,648
810													1,066,450	589,000	531,832	610,149
820													1,248,036	758,000	685,048	771,758
830													1,447,147	947,000	854,185	950,812
840													1,663,392	1,152,000	1,040,468	1,147,216
850													1,899,317	1,375,000	1,246,022	1,362,705
860													2,156,244	1,614,000	1,470,095	1,596,886
870												0	2,432,068	1,870,000	1,710,981	1,847,750
880											1	12	2,726,322	2,147,000	1,966,958	2,114,651
890											237	325	3,040,074	2,445,000	2,237,840	2,398,124
900	1,000								1,000	1,000	1,077	1,265	3,373,994	2,764,000	2,526,955	2,699,843
910	3,001				1,000				3,001	3,000	2,470	2,849	3,730,401	3,105,000	2,838,636	3,023,428
920	6,002				4,001				6,002	6,000	4,503	5,389	4,111,359	3,468,000	3,173,633	3,370,863
930	11,003				7,002				11,003	11,000	7,616	9,350	4,516,153	3,853,000	3,531,247	3,741,490
940	16,004				11,003				16,004	16,000	12,499	15,107	4,944,377	4,260,000	3,911,468	4,135,140
950	22,006				16,004				25,007	25,000	19,940	23,446	5,396,458	4,690,000	4,314,975	4,552,117
960	29,004				22,003				38,005	38,000	30,996	35,442	5,873,827	5,146,000	4,743,642	4,993,767
970	36,003				29,002				55,004	55,000	46,818	51,366	6,376,447	5,625,000	5,197,853	5,460,304
980	44,013				37,011				76,022	76,000	67,299	72,026	6,906,028	6,129,000	5,676,830	5,952,162
990	52,004				48,004				104,008	104,000	92,481	99,160	7,465,581	6,665,000	6,180,620	6,472,374
1000	61,012				59,012				139,027	139,000	124,670	133,512	8,055,581	7,230,000	6,712,890	7,021,833
1010	71,011				73,012				182,029	182,000	164,794	175,157	8,678,404	7,827,000	7,277,511	7,601,082
1020	81,023				87,025				233,068	233,000	212,461	224,649	9,334,704	7,957,000	7,873,828	8,211,125
1030	91,019				103,022				292,061	292,000	267,527	282,210	10,024,110	9,121,000	8,500,946	8,851,909
1040	103,022	3,000			120,025				361,077	361,000	330,344	348,417	10,748,280	9,819,000	9,159,571	9,524,197
1050	117,027	9,000			138,032				439,101	439,000	403,226	424,726	11,508,640	10,553,000	9,852,651	10,229,410
1060	131,026	16,000			159,032				528,106	528,000	488,340	512,687	12,307,470	11,426,000	10,584,100	10,969,620
1070	146,026	27,000			181,033				631,114	630,000	586,955	613,455	13,146,370	12,250,000	11,352,870	11,746,040
1080	163,031	40,000			204,039				745,143	744,000	696,400	726,179	14,023,700	13,111,000	12,157,180	12,557,510
1090	181,025	54,000			228,032				874,122	869,000	816,676	849,050	14,943,080	14,009,000	12,996,610	13,403,540
1100	200,023	70,000			255,029				1,012,116	1,004,000	946,883	981,294	15,901,810	14,946,000	13,872,110	14,284,400
1110	222,029	88,000			282,037				1,160,151	1,150,000	1,088,808	1,124,859	16,901,200	15,925,000	14,786,820	15,202,770
1120	244,039	107,000			311,049				1,320,208	1,309,000	1,242,773	1,281,026	17,941,830	16,944,000	15,740,490	16,160,740
1130	268,030	129,000			342,039				1,492,169	1,480,000	1,407,886	1,449,314	19,024,150	18,004,000	16,735,890	17,157,370
1140	293,038	152,000			375,048				1,675,215	1,662,000	1,584,277	1,629,757	20,148,600	19,105,000	17,774,470	18,194,440
1150	319,051	177,000			410,065		4		1,874,297	1,857,000	1,776,230	1,823,319	21,318,380	20,251,000	18,861,810	19,278,840
1160	349,062	205,000	652		447,079		1,142		2,089,369	2,069,000	1,987,227	2,031,214	22,537,980	21,499,000	20,013,240	20,412,530
1170	378,065	234,000	21,992		486,084		6,040	0	2,320,402	2,297,000	2,214,987	2,254,408	23,807,120	22,690,000	21,235,130	21,592,490
1180	411,094	267,000	54,078	0	526,120	14,000	21,007	2,196	2,570,587	2,544,000	2,461,241	2,497,755	25,126,740	24,000,000	22,524,710	22,827,370
1190	445,018	301,000	88,548	12,995	569,024	40,000	51,167	11,682	2,840,118	2,812,000	2,727,006	2,763,228	26,497,100	25,375,000	23,880,440	24,138,460
1200	481,014	337,000	124,761	48,502	614,018	77,000	92,227	31,531	3,129,092	3,099,000	3,013,787	3,049,061	27,920,820	26,813,000	25,299,240	25,534,050
1210	519,011	375,000	162,686	94,481	661,014	122,000	137,466	63,735	3,442,074	3,410,000	3,323,816	3,356,241	29,403,630	28,313,000	26,779,820	27,006,460
1220	557,989	414,000	202,404	142,330	709,986	169,000	185,155	103,720	3,774,927	3,742,000	3,658,004	3,685,690	30,944,400	29,878,000	28,321,300	28,543,420
1230	599,957	456,000	244,127	192,146	759,946	219,000	234,884	145,370	4,133,707	4,100,000	4,017,092	4,041,282	32,544,690	31,121,000	29,922,780	30,141,900

Table 8 - Total capacity by basin and year.

References

American Society of Civil Engineers, 1962. ***Nomenclature for Hydraulics***, ASCE Headquarters, New York.

ASTM, 2008. ***Annual Book of Standards***, Section 11, Volumes 11.01 and 11.02, ASTM, West Conshohocken, PA.

Blanton, J.O. III, 1982. ***Procedures for Monitoring Reservoir Sedimentation***: Technical Guideline for Bureau of Reclamation, Denver, CO.

Brown, C., July 1941. ***Mapping Lake Mead,*** U.S. Soil Conservation Service

Bureau of Reclamation, 2001. ***The Boulder Canyon Project Hoover Dam,*** Lower Colorado Regional Office, Boulder City, NV.

Bureau of Reclamation, 1981. ***Project Data,*** Denver Office, Denver CO.

Bureau of Reclamation, 1985. Surface Water Branch, ***ACAP85 User's Manual***, Technical Service Center, Denver CO.

Bureau of Reclamation, 1987(a). ***Guide for Preparation of Standing Operating Procedures for Bureau of Reclamation Dams and Reservoirs***, U.S. Government Printing Office, Denver, CO.

Bureau of Reclamation, 1987(b). ***Design of Small Dams***, U.S. Government Printing Office, Denver CO.

B29, In Depth Consulting, 2002. http://www.indepthconsulting.com/B29/B29Lost.htm

Clarke Hughes, J. E., (2005) ***Lake Powell Multibeam Mapping 2005,*** University of New Brunswick, Canada.

Corps of Engineers, April 2004. *Engineer and Design* - ***Hydrographic Surveying***, EM 1110-2-1003, Department of the Army, Washington DC, (www.usace.army.mil/inet/usace-docs/eng-manuals/).

Covay, K. and Beck, D., 2001. ***Sediment-Deposition Rates and Organic Compounds in Bottom Sediment at Four Sites in Lake Mead in May 1998,*** Open-File Report 01-282, U.S. Geological Survey.

Dettinger, M.D. (1995). ***Coping With Severe and Sustained Drought in Southwest,*** U.S. Geological Survey.

Environmental Systems Research Institute, Inc. (ESRI). (1992). ***ARC Command References***.

Ferrari, R.L. (1988). "***1986 Lake Powell Survey***," REC-ERC-88-6. Bureau of Reclamation, Sedimentation and River Hydraulics Group. Denver, Colorado.

Ferrari, R.L. (2003). ***Deadwood Reservoir 2002 Survey,*** Bureau of Reclamation, Sedimentation and River Hydraulics Group. Denver, Colorado.

Ferrari, R.L. (2006). ***Reconnaissance Techniques for Reservoir Survey,*** Bureau of Reclamation, Sedimentation and River Hydraulics Group. Denver, Colorado. www.usbr.gov/pmts/sediment

Ferrari, R.L. and Collins, K. (2006). ***Reservoir Survey and Data Analysis,*** Chapter 9, Erosion and Sedimentation Manual, Bureau of Reclamation, Sedimentation and River Hydraulics Group. Denver, Colorado. www.usbr.gov/pmts/sediment

Goodson and Associates, Inc., 1981. ***Technical Data Workbook Abstract Report for Hoover Dam Boulder Canyon Project Arizona-Nevada.*** Lower Colorado Region. Aurora, Colorado.

Grove, N.C., and Howard, C.S. 1938, **The Passage of Turbid Water Through Lake Mead.** American Society Civil Engineer transcripts, Volume 103, page 720 – 790.

HYPACK, Inc. (2005). ***HYPACK for Windows***, (www.hypack.com).

Hilldale, R.C. (2004). ***Collection of River Bathymetry in Shallow Water Conditions Using Airborne LiDAR,*** Bureau of Reclamation, Sedimentation and River Hydraulics Group. Denver, Colorado.

International Hydrographic Organization, IHO (May 2005). ***Manual on Hydrography, M-13.*** www.iho.shom.fr.

Lara, J. M. and Sanders, J. I. (1970). ***The 1963-64 Lake Mead Survey,*** Bureau of Reclamation, Sedimentation and River Hydraulics Group. Denver, Colorado.

Lara, J. M. and Pemberton, E. L. (1965). ***Initial Unit Weight of Deposited Sediments,*** Reservoir Sedimentation Technical Guideline for Bureau of Reclamation, Sedimentation and River Hydraulics Group. Denver, Colorado.

Lin, S.S. (1997). ***Strategies for Management of Reservoir Sedimentation***. Virginia Dam Safety Program, Richmond, Virginia.

Lower Colorado Regional (LCR) Office, 2003. ***The 2001 Lake Mead Bathymetry Study,*** Bureau of Reclamation, Lower Colorado Regional Office, Boulder City, NV.

Lyons, J. and Lest, L. (1996). ***Theodore Roosevelt Reservoir,*** Bureau of Reclamation. Sedimentation and River Hydraulics Group. Denver, Colorado.

Miller, C. R. (1953). "Determination of the Unit Weight of Sediment for Use in Sediment Volume Computations," Bureau of Reclamation, Denver, Colorado.

Morris, G. L. and Fan, J. (1997). ***Reservoir Sedimentation Handbook,*** Gregory L. Morris and Assoc. San Juan, Puerto Rico and Institute of Water Conservancy, Beijing, China.

Pratson, Lincoln (2007). ***Effects of Subaqueous Gravity Flows on Timing and Patterns of Basin Infilling as Documented in Lake Powell During a Drought,*** Professor of Sedimentary Geology *Earth & Ocean Sciences,* Duke University, Durham, NC. (2/2008 currently under review for publication).

SCS (Soil Conservation Service) (May 1940). ***Original Area and Capacity Table for Lake Mead,*** Washington D.C.

Sedimentation Group (2006), ***Erosion and Sedimentation Manual,*** (Sedimentation Manual), U.S. Bureau of Reclamation, Sedimentation and River Hydraulics Group, Denver, Colorado.

Strand, R.I., and E.L. Pemberton. (October 1982). **Reservoir Sedimentation**, U.S. Bureau of Reclamation, Sedimentation and River Hydraulics Group, Denver, Colorado.

Twichell D. C., Cross, V.A., Rudin M. J. and Parolski, K.F. (1999). **Surficial Geology and Distribution of Post-Impoundment Sediment of the Western Park of Lake Mead Based on a Sidescan Sonar and High-Resolution Seismic-Reflection Survey**, Open-File Report 99-581, University of Nevada at Las Vegas and U.S. Geological Survey.

Twichell, D.C., Cross, V.A., and Belew, S.D. (2003). **Mapping the floor of Lake Mead** (Nevada and Arizona): Preliminary discussion and GIS data release: USGS Open-File Report 03-320, 1 CD-ROM.

USGS. (1960). Comprehensive Survey of Sedimentation in Lake Mead, 1948-49. Geological Survey Professional Paper 295.

USGS (2001). ***Water Resources Data Arizona Water Year 2001***, Water-Data Report Arizona 2001, U.S. Geological Survey, Phoenix, AR.

Appendix I

Basins by Map Numbers

As part of the 1963 analysis, Lake Mead was divided into basins, figure 29. The basins were outlined along the boundaries of maps covering the entire reservoir, figure 29.

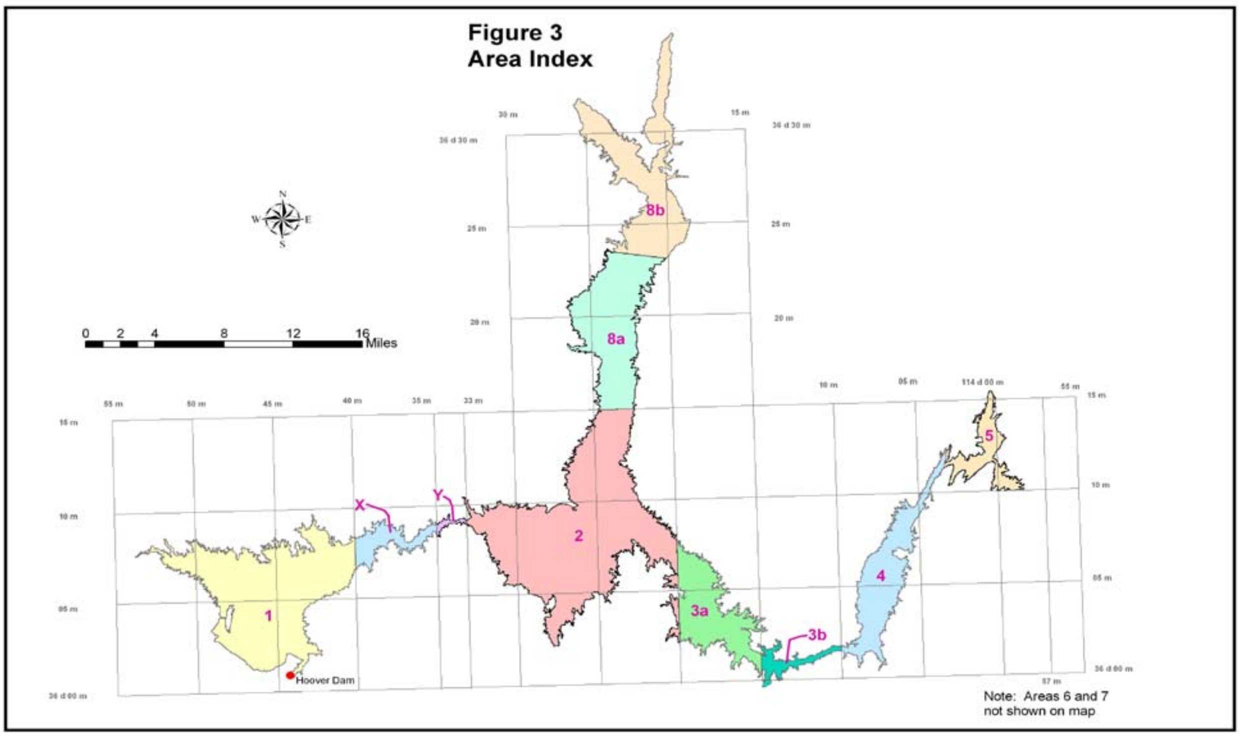


Figure 29 - Lake Mead divided by subbasins, LCR 2003 report.

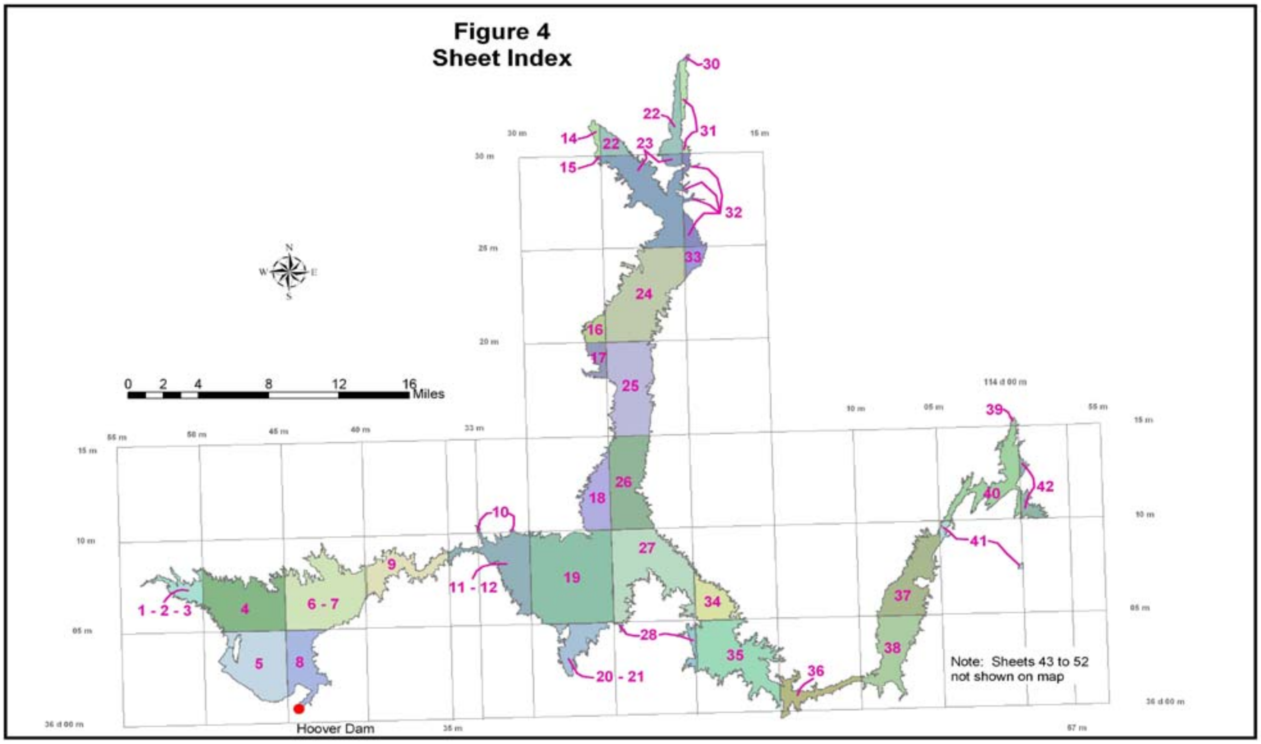


Figure 30 - Lake Mead divided by submaps, LCR 2003 report.

Following are the map numbers that are within the listed basins, some of the listed basins were combined as part of the final analysis:

Boulder and Virgin Basin

Subbasins - Areas 1, x, y, and 2
Maps 123, 4, 5, 6-7, 8, 9, 10, 11-12, 19, 20-21, 28, 27, 18, and 26

Temple Bar and Virgin Canyon

Subbasins - Areas 3a and 3b
Maps 34, 35, and 36

Gregg Basin

Subbasin - Area 4
Maps 37, 38, and 41

Grand Bay

Subbasin - Area 5
Maps 40, 42, and 39

Pierce Basin

Subbasin - Area 6
Map 43

Lower Granite Gorge

Subbasin - Area 7
Maps 44 through 52

Overton Arm

Subbasins - Areas 8a and 8b
Maps 14, 15, 16, 17, 22, 23, 24, 25, 30, 31, 32, and 33

Appendix II

Depth Measurements

Calibration and checks

During field collection daily velocity profile readings of reservoir were conducted along with limited bar checks. The velocity profiles were collected with a digital meter with attached probe on 100 meters of power cable. For the lake zone below 100 meters of depth, the speed of sound was extrapolated.

During analysis of the bottom data, concerns arose about the depth measurements from Hoover Dam upstream to the Temple Bar area because the final elevations from the 2001 analysis were found to be lower than the 1963 study. Multiple checks were performed to confirm the resulting elevations:

1. Contacted Reclamation's Ecological Research and Investigations Group of the TSC concerning their collection on Lake Mead.

Received several files with depth information.

All data in WGS84, converted to conform to 2001 Sedimentation data.

a. Collection date: **1/17/01**

Lake elevation 1,196.15 = 364.6m
=114.6 m (measured depth)
elevation 250 meters

Location

36.0917546	North 3,996,391
(-)114.7873464	East 699,205

Located in Vegas Wash

Plot on 2001 ARC Maps ******* elevations match*************

b. Collection data: **1/17/01**

Lake elevation = 364.6
143.7 (measured depths)
bottom elevation 220.9 meters

Location

36.0611852	N 3,993,098
(-)114.7402076	E 703,528

Upstream of Sentinel Island ************ **Good Check*************

Additional data was checked from 2/01 collection, also with good results.

2. Bar checks

Single Beam Data

Single beam data was collected with a digital sounder calibrated by a standard bar check. Data was collected from the upper Overton Arm downstream to the confluence of the Colorado River. In flat areas of the reservoir bottom, there were good checks throughout the whole reach.

3. Elevations at base of the intake towers located upstream of Hoover Dam and top of cofferdam.

a. Base of intake tower on drawing file, elevation 894 feet. The processed multibeam data measured the base of the intake tower around elevation 894. (Good check).

b. Top of cofferdam on drawing around elevation 720 feet. The processed multibeam data measured the top of cofferdam near elevation 735. Limited research into the cofferdam did not find detailed information on the cofferdams. Some of this is listed within this report such as comments about concerns of overtopping during construction, possible the top of cofferdam was raised higher then listed on drawings.

Appendix III

Lake Mead Cross Sections

Cross sections were cut through the original (1935) and 2001 Lake Mead topography throughout the reservoir, figure 30. The LCR GIS group developed the cross sections using ARCGIS tools, locating some near cross sections shown in the 1963 report.

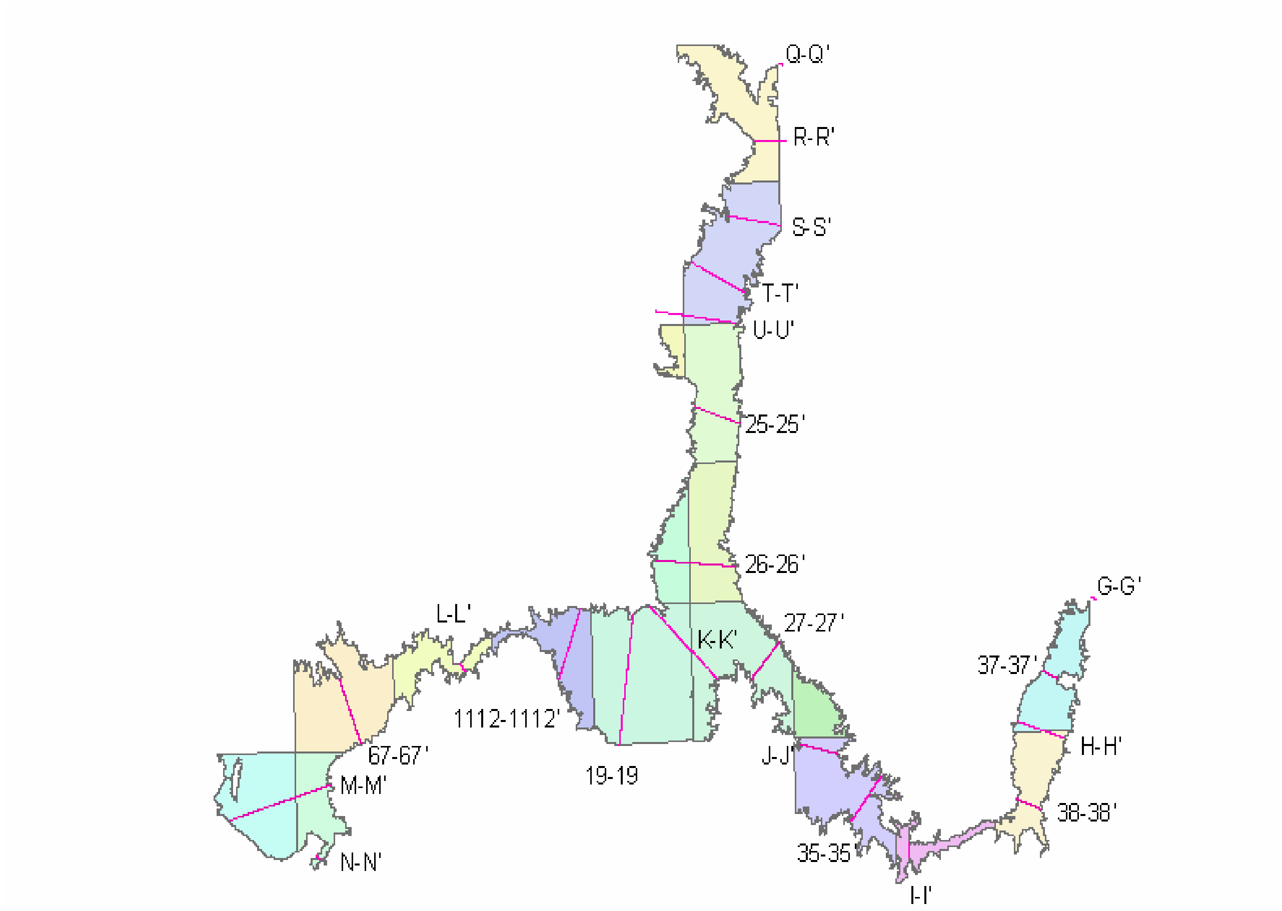


Figure 31 - Location of Lake Mead cross sections

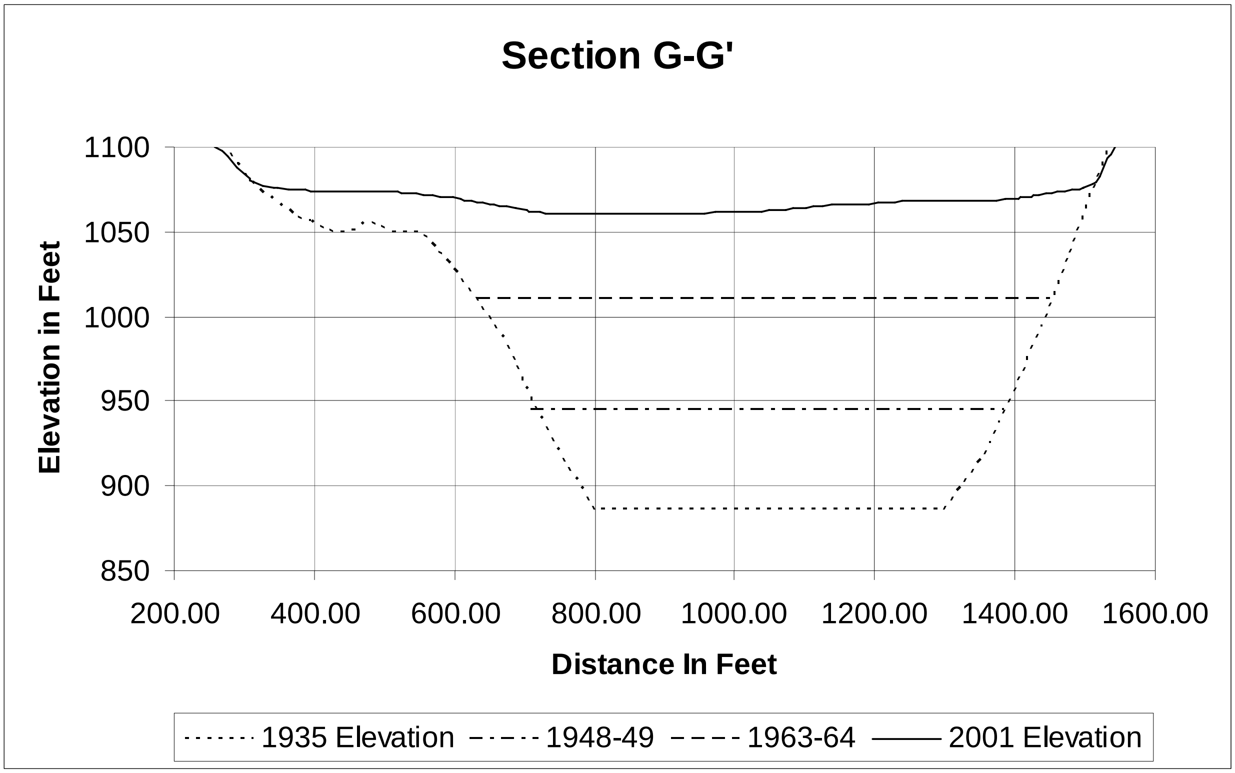


Figure 32 - Gregg Basin section G-G

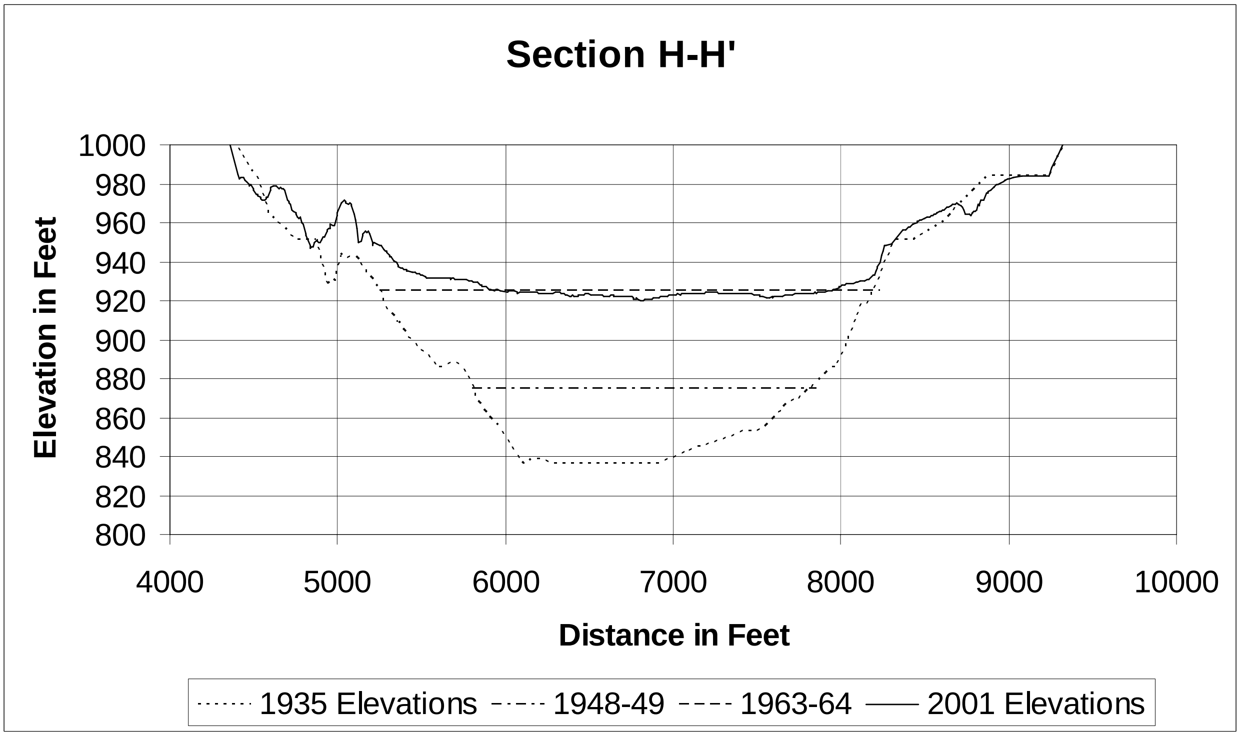


Figure 33 - Gregg Basin section H-H

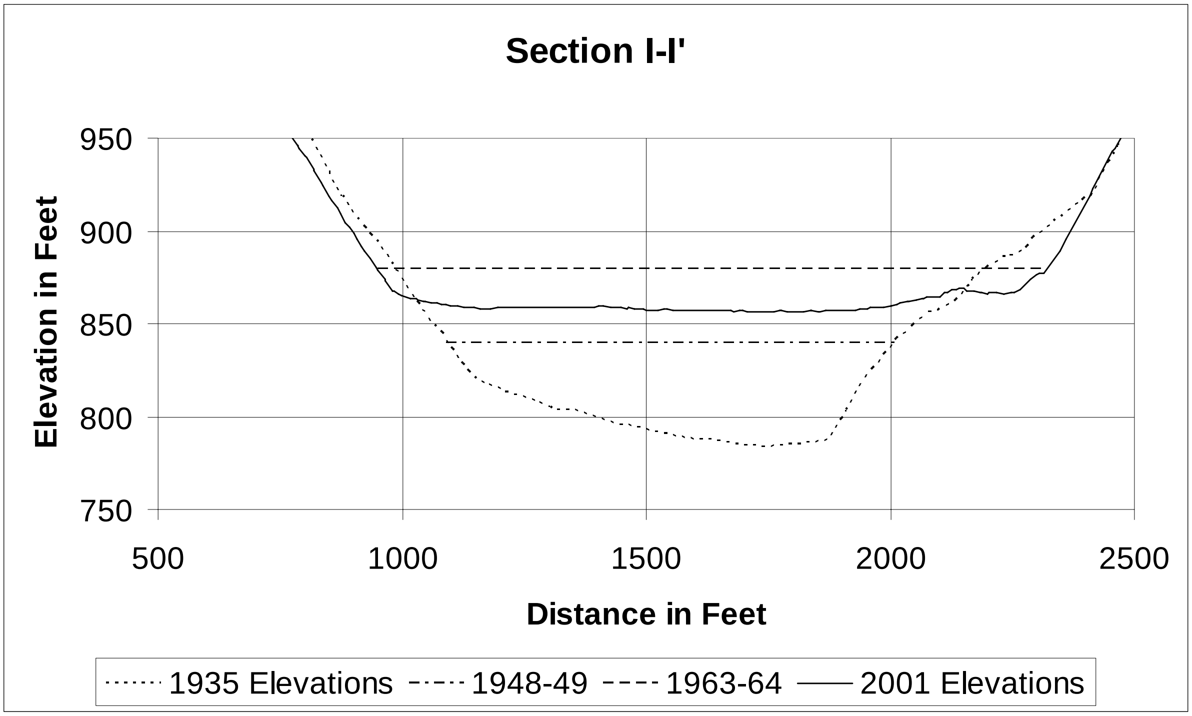


Figure 34- Temple Bar section I-I

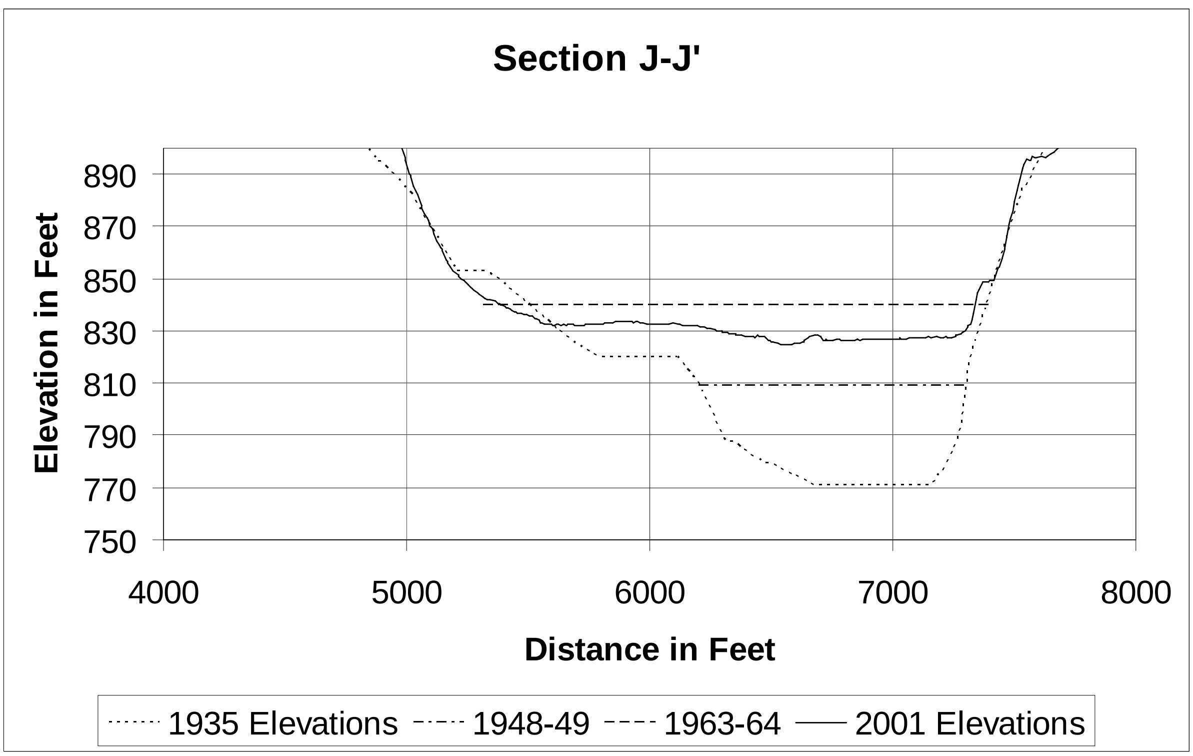


Figure 35 - Temple Bar section J-J

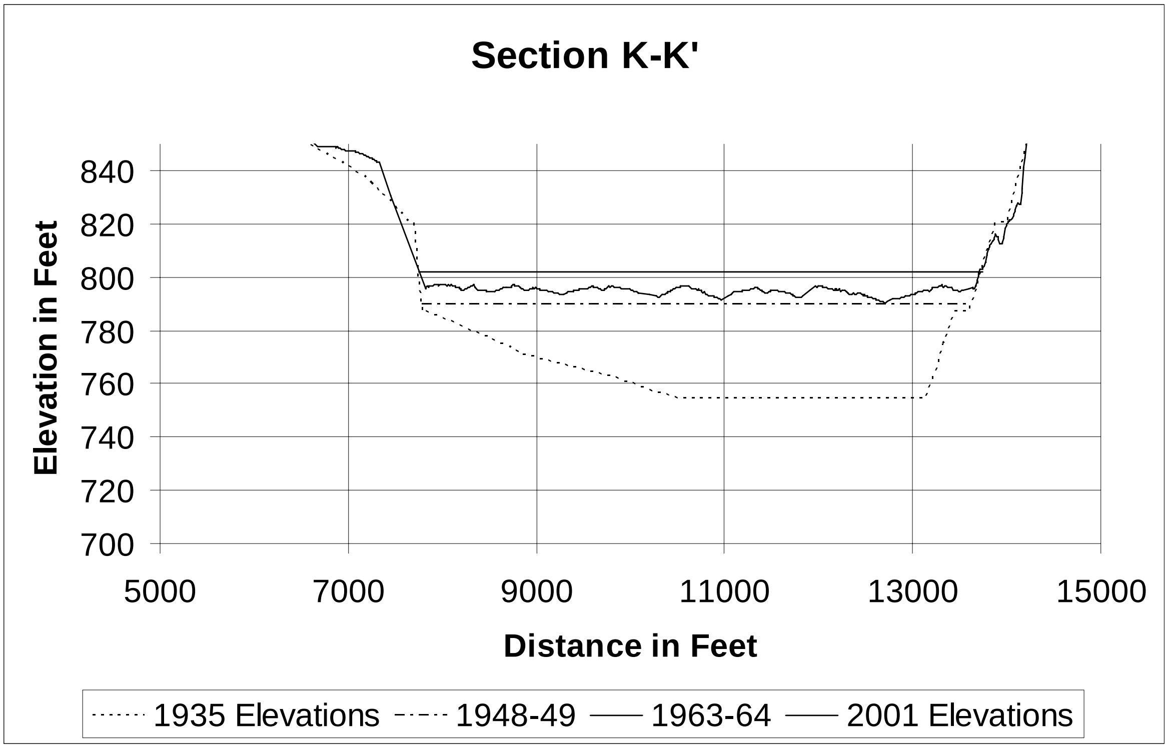


Figure 36 - Virgin Basin section K-K

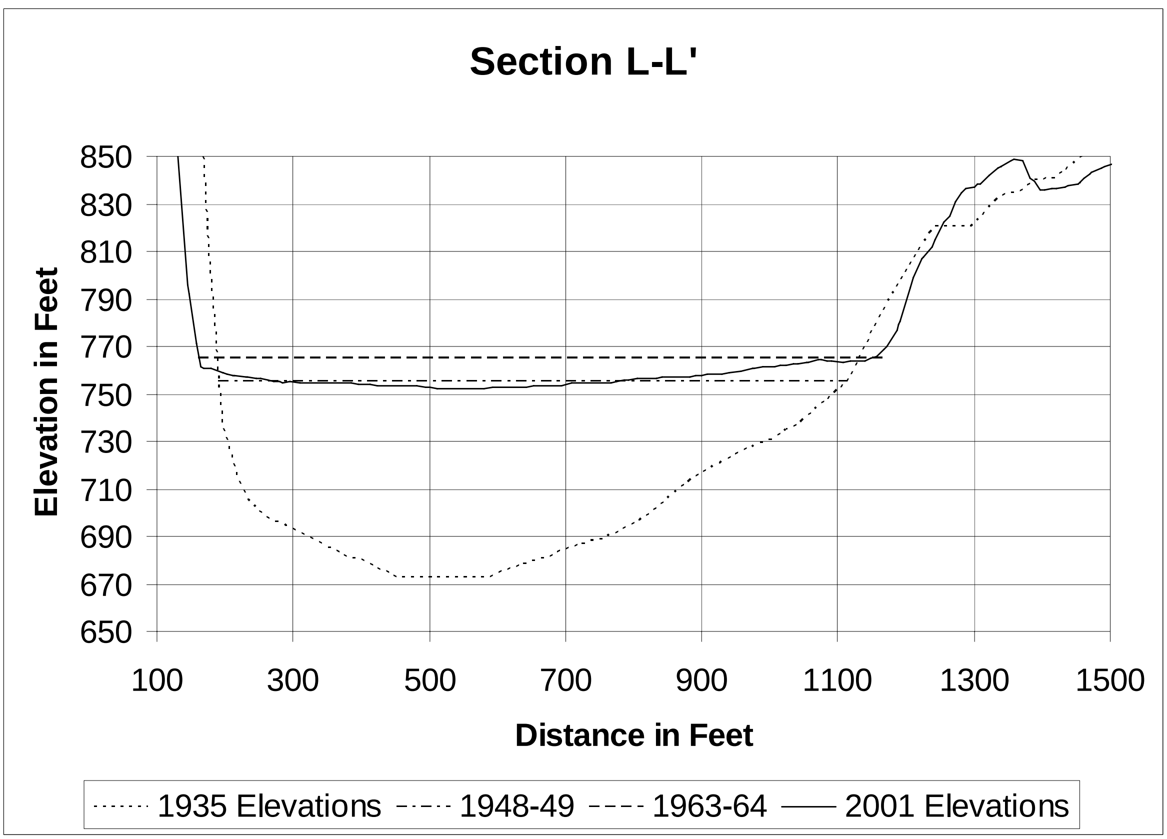


Figure 37 - Boulder Canyon section L-L.

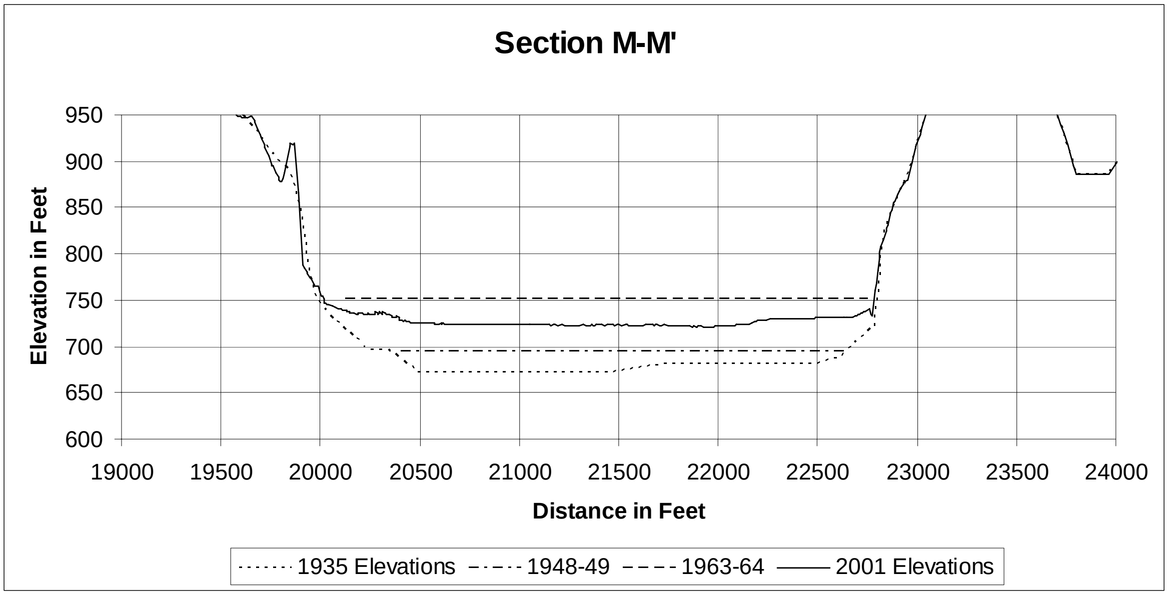


Figure 38 - Boulder Basin, section M-M

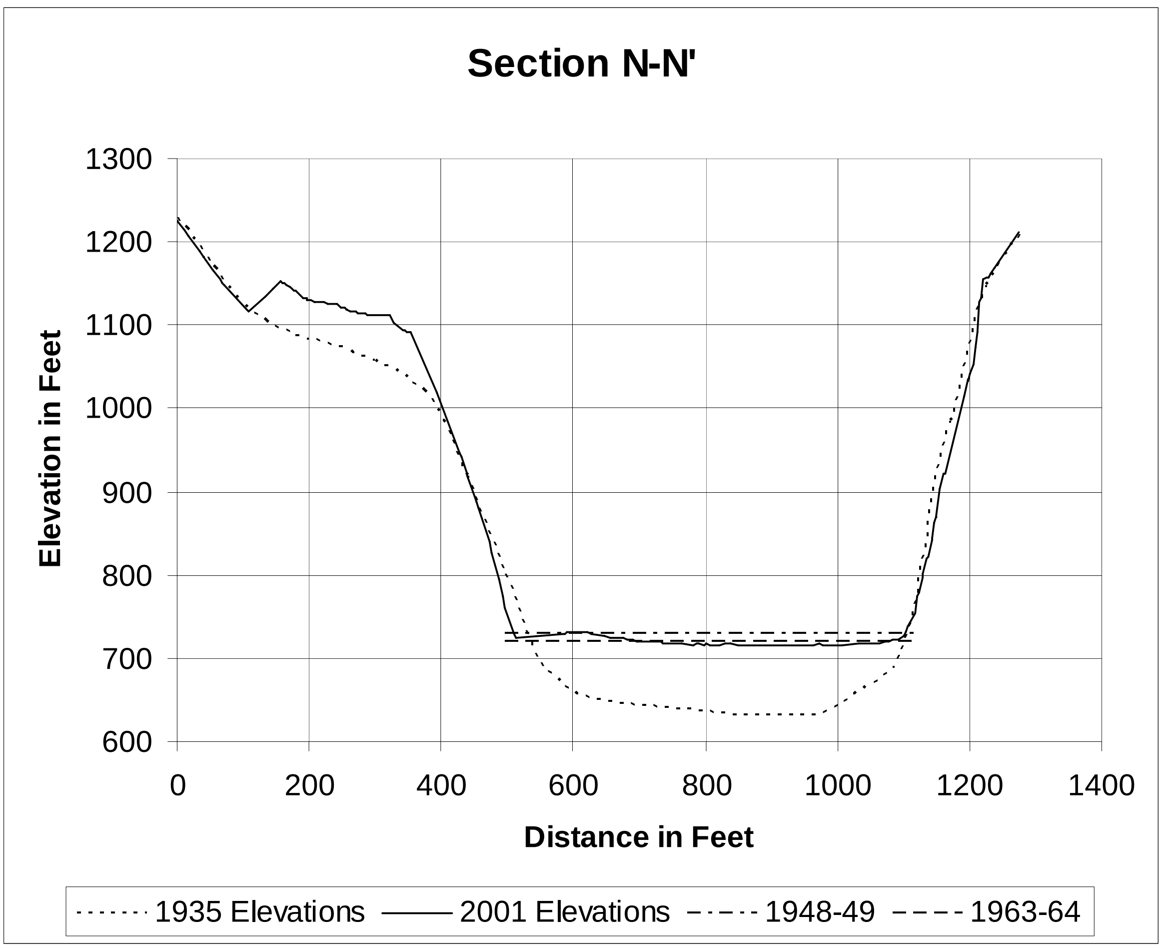


Figure 39 - Boulder Basin near dam, section N-N. 1963 survey plotted below 1948.

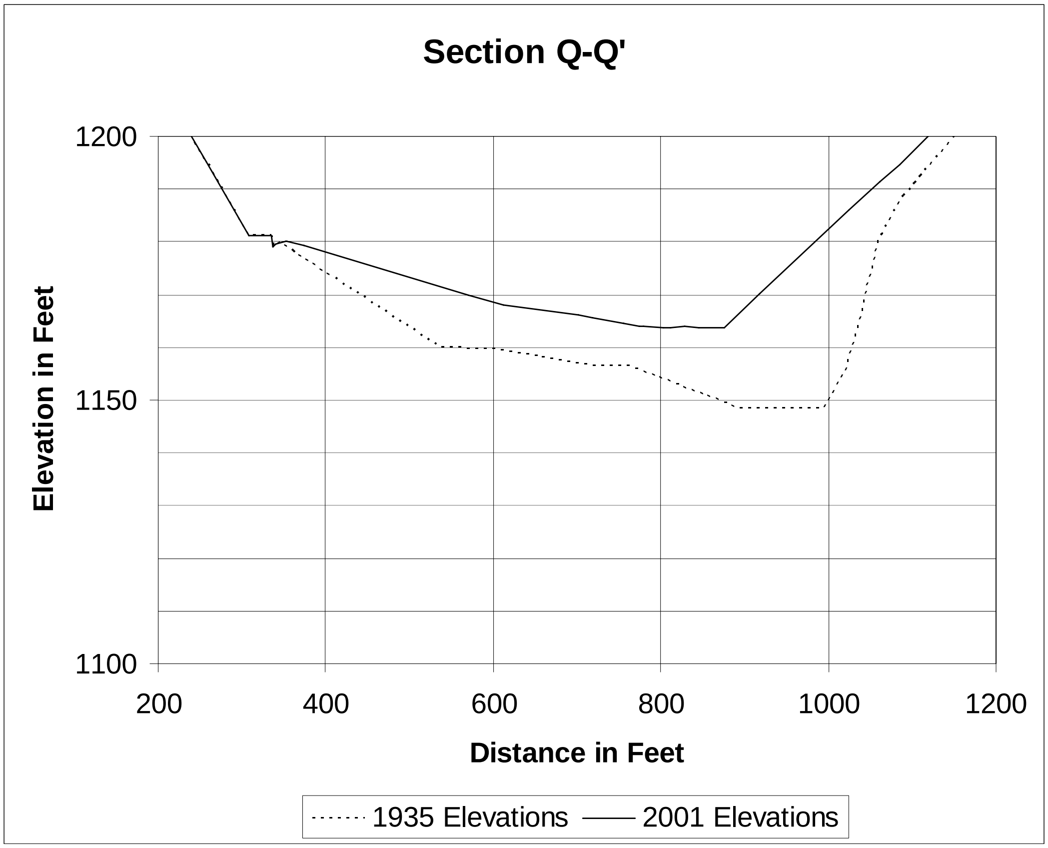


Figure 40 - Overton Arm, section Q-Q

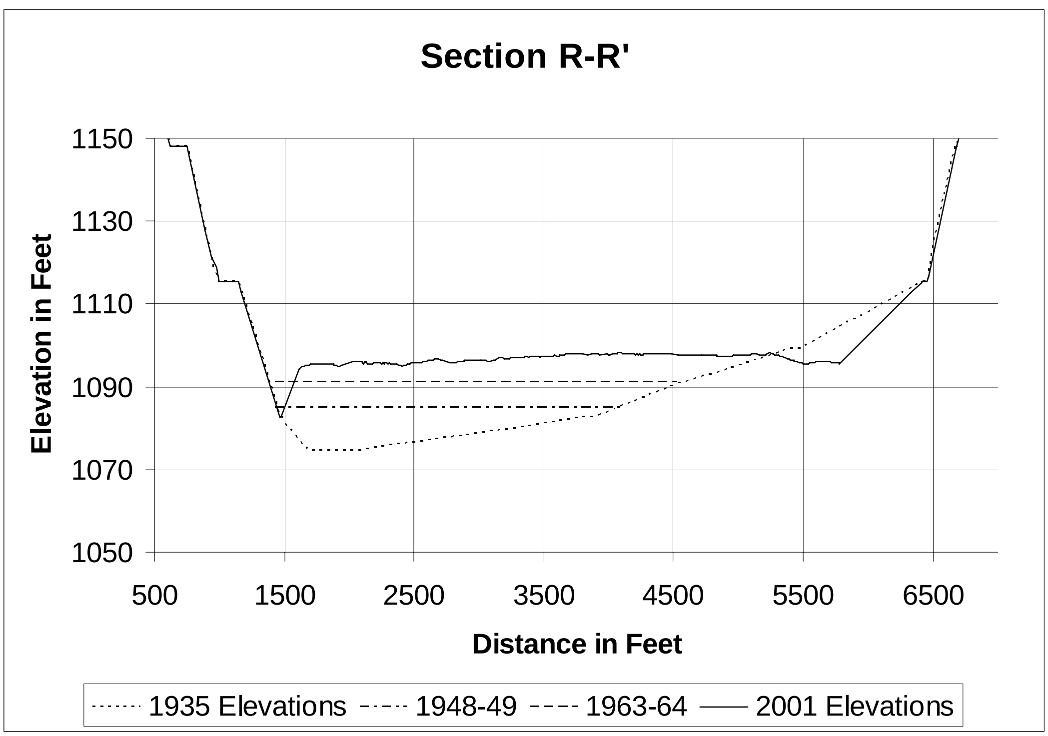


Figure 41 - Overton Arm, section R-R.

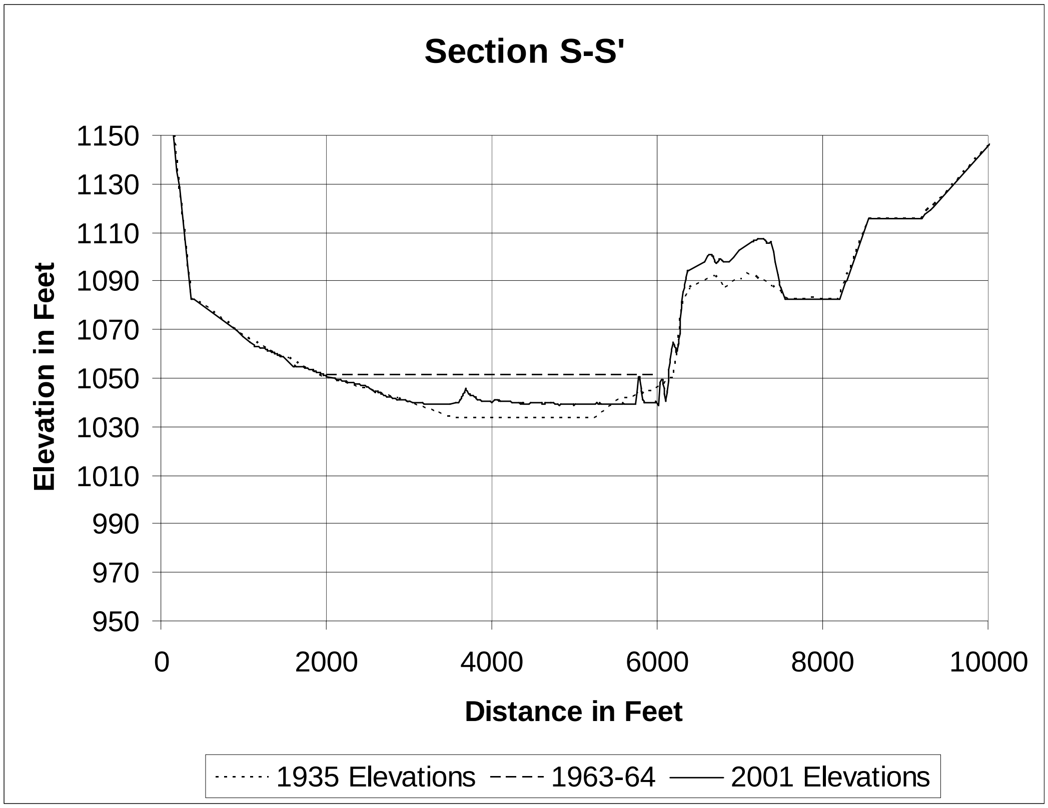


Figure 42- Overton Arm, section S-S.

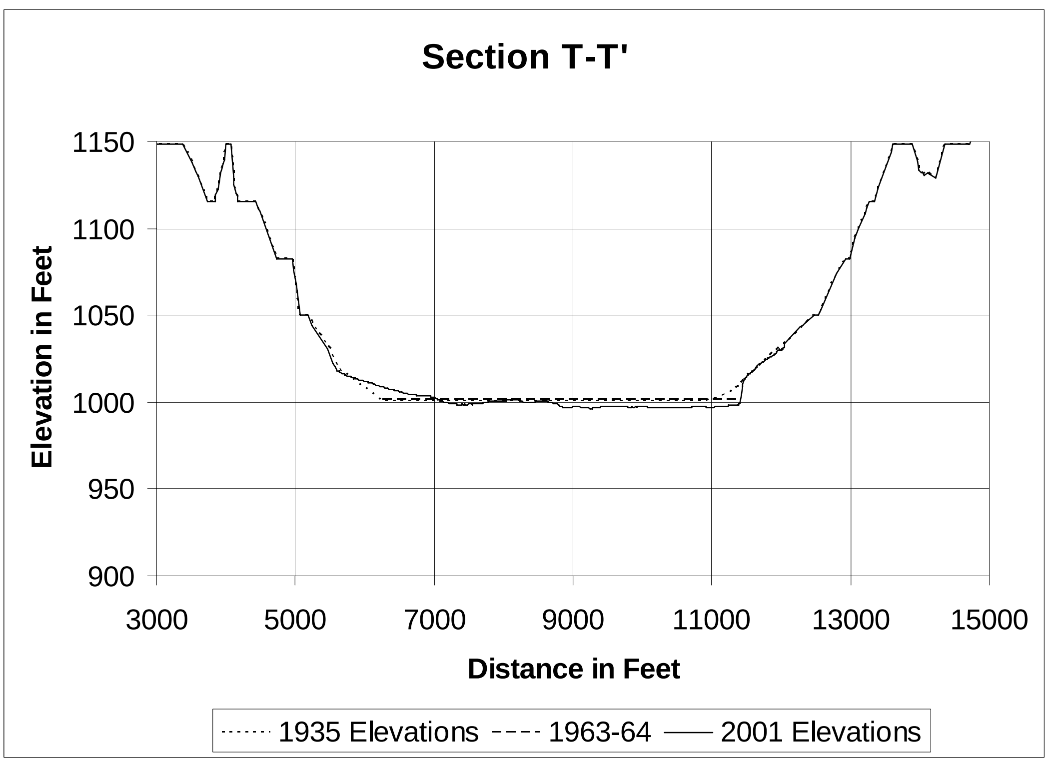


Figure 43 - Overton Arm, section T-T.

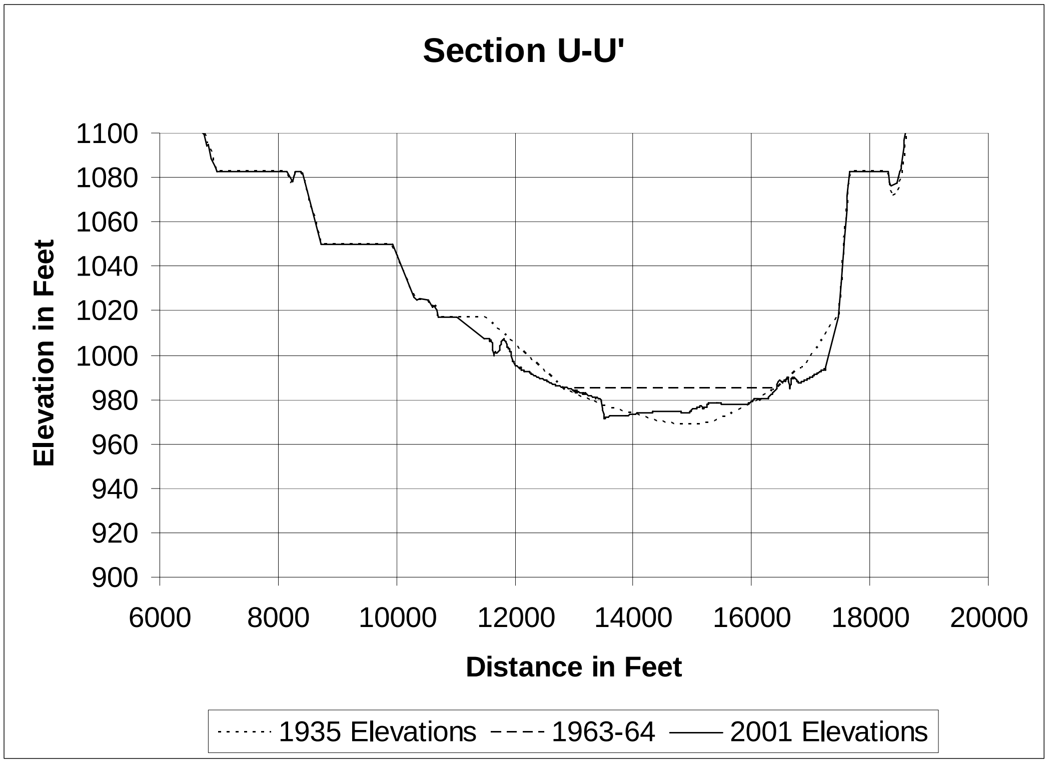


Figure 44 - Overton Arm, section U-U.

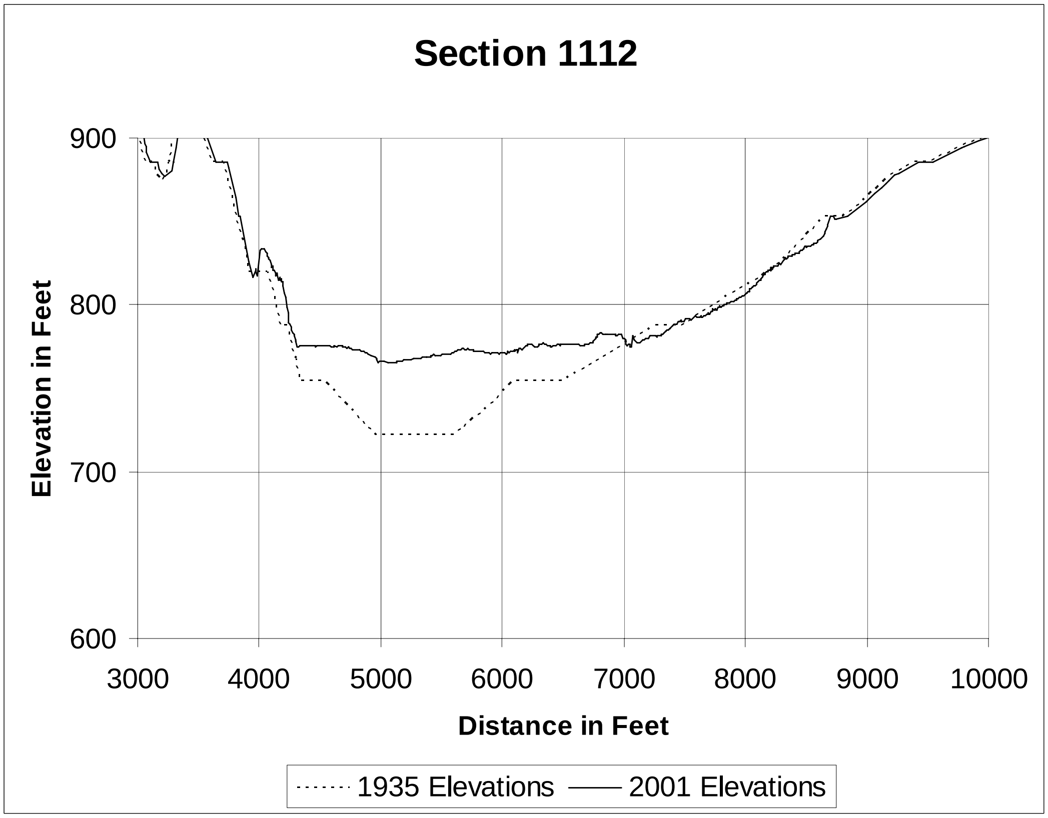


Figure 45 - Section 1112.

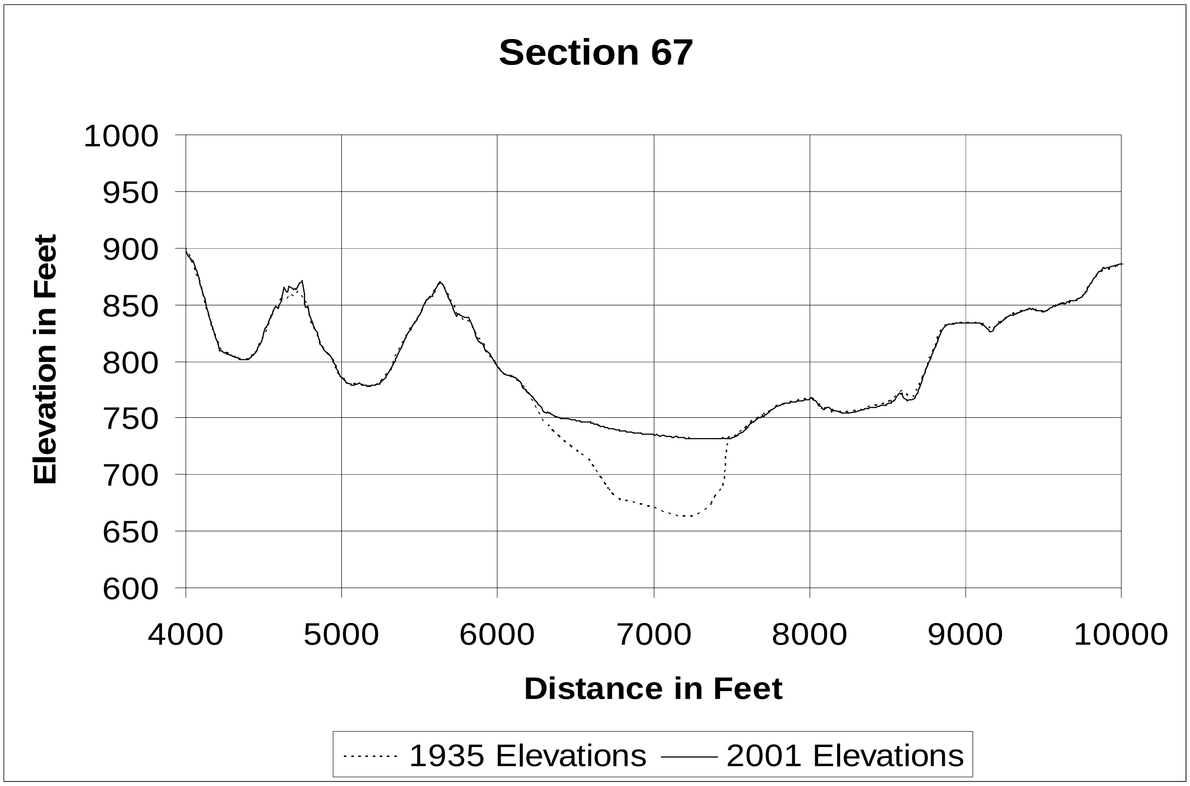


Figure 46 - Section 67.

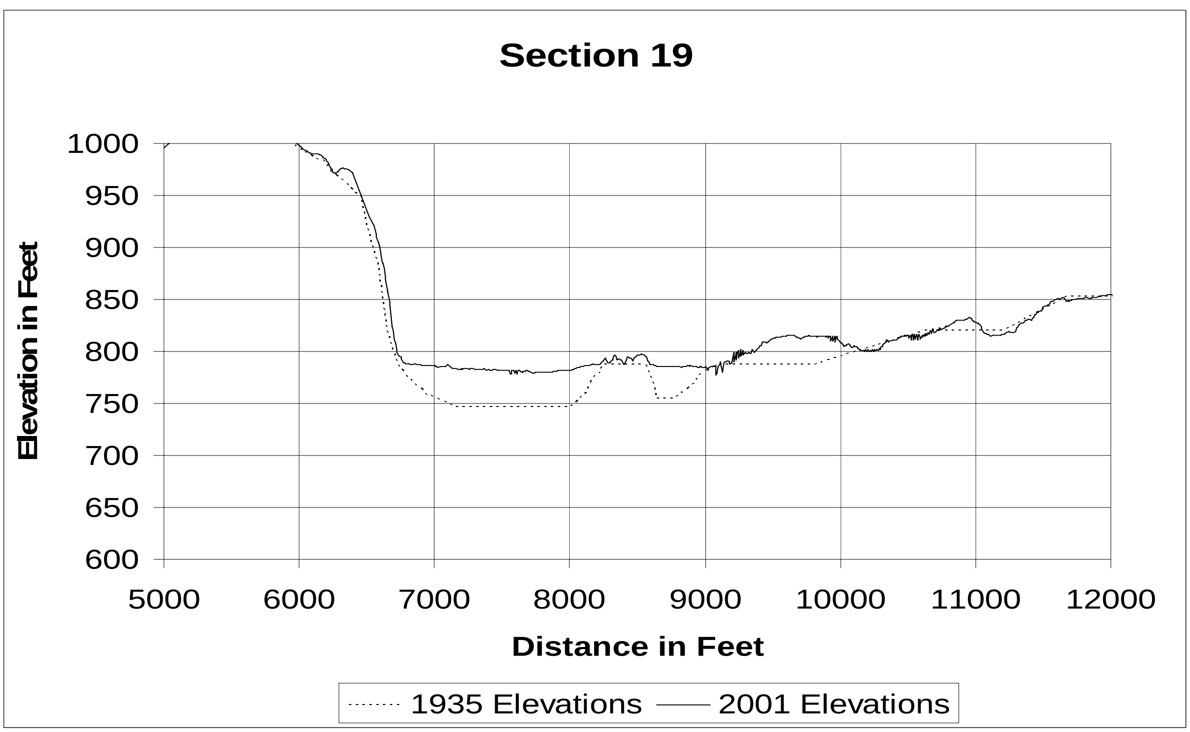


Figure 47 - Section 19.

Figure 48 - Section 27.

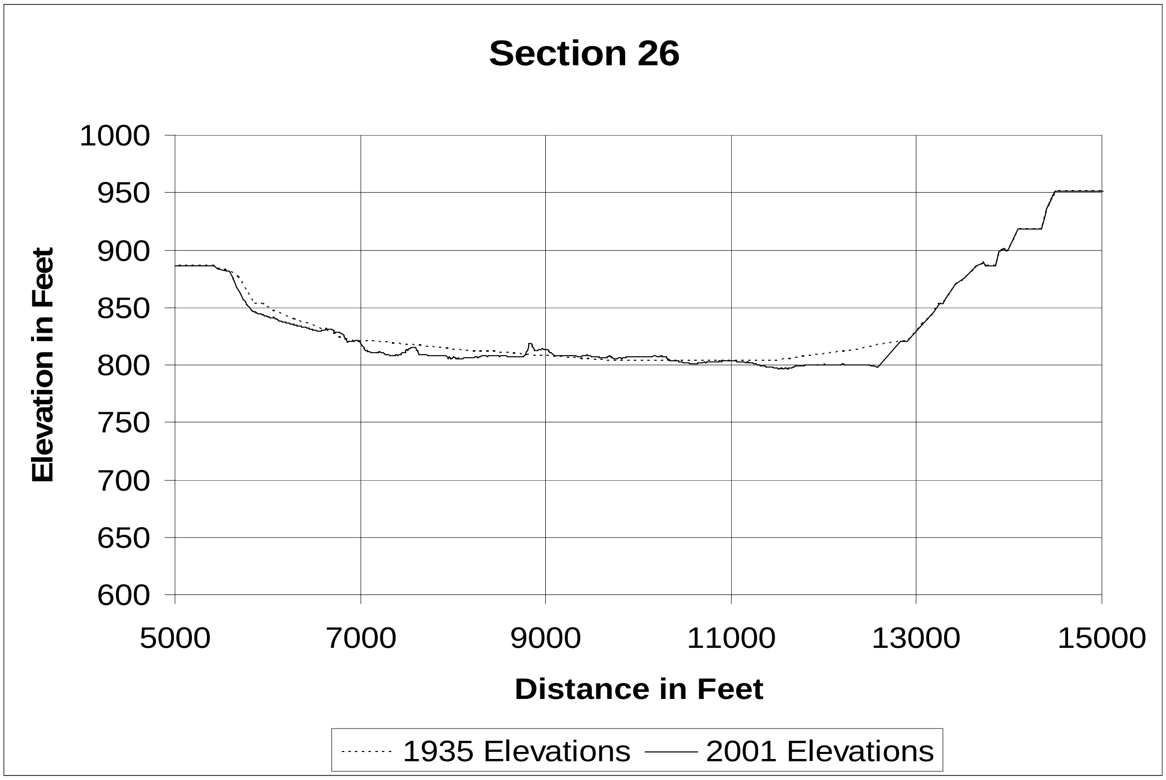


Figure 49 - Section 26.

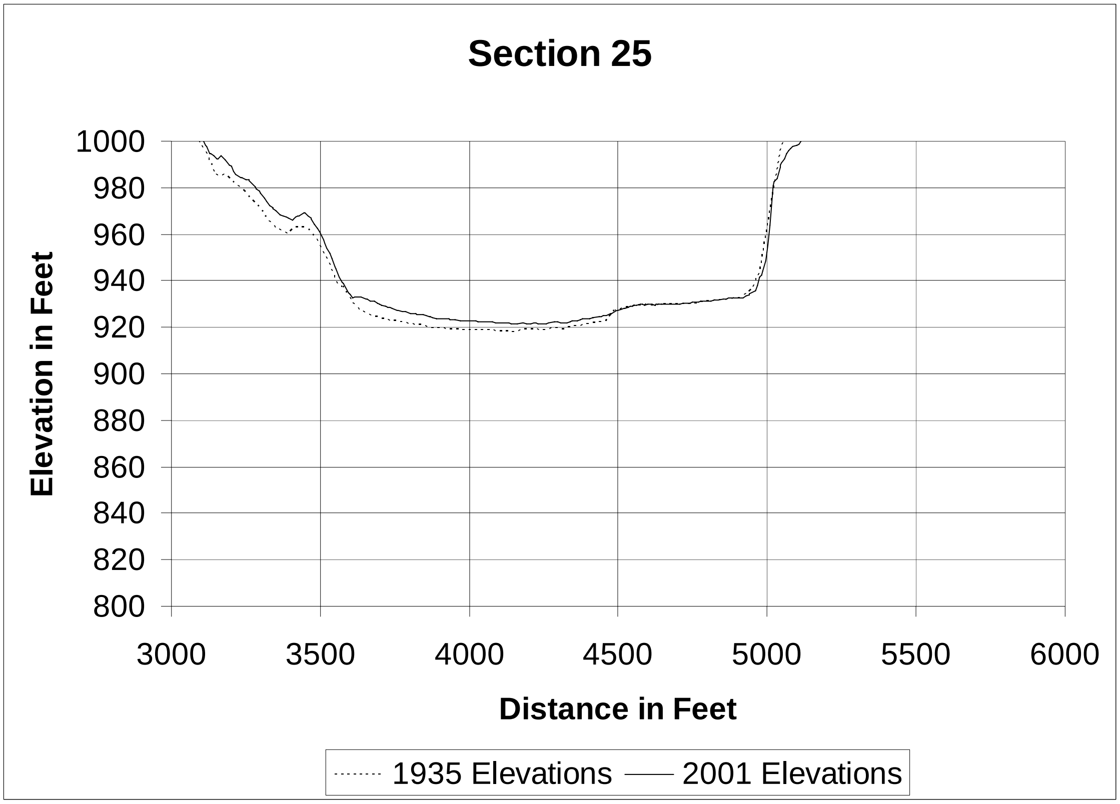


Figure 50 - Section 25.

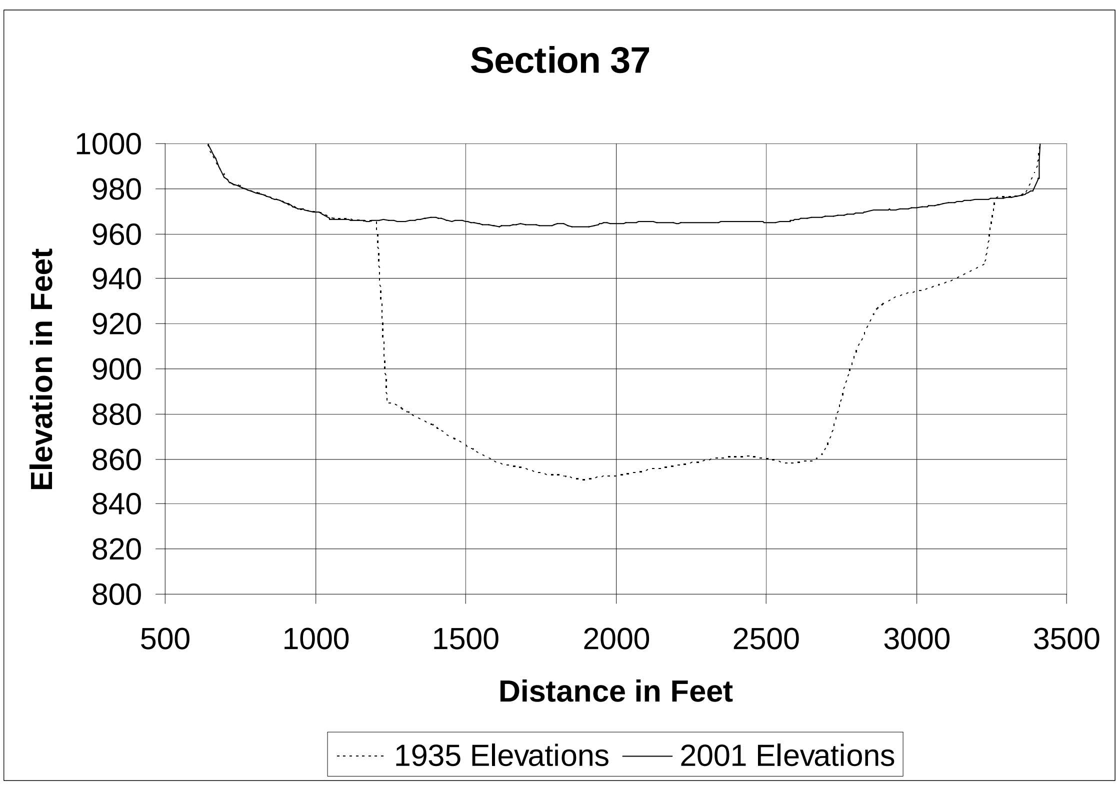


Figure 51 - Section 37.

Appendix IV

Reservoir Sediment Compaction Analysis

The following compaction analysis and computations refer to the Reclamation report "Reservoir Sedimentation" authored by Mr. Robert Strand and Mr. Ernie Pemberton. A literature search was conducted by internet, but information on reservoir compaction was limited.

Previous surveys on Lake Mead included extensive sediment sampling programs, focused primarily in the upper reservoir area. The upper delta experienced limited compaction because the majority of material deposited consists of higher density sediment, not the fines that drift further downstream towards the dam. The initial porosity of the sediment deposited downstream is greater than the initial porosity of the upstream deposits. Also, the upper delta has been dewatered and partially dried out during reservoir drawdown. Subsequent inflowing sediment deposits on the delta as the river transport capacity geometry allows (Strand and Pemberton, 1982).

Compaction analysis

Reservoir operation has most influence in determining compaction of the deposited sediments. There are four operations to consider:

1 – Sediment always submerged or nearly submerged
2 – Normally moderate to considerable reservoir drawdown
3 – Reservoir normally empty
4 – Riverbed sediments

Analyzing the annual reservoir operation, since initial filling the Lake Mead, the sediments in question are classified as number 1 (always submerged).

The following equations were used to estimate the density of the sediment deposits.

$$W = W_c p_c + W_m p_m + W_s + p_s$$

Where:

W = unit weight in pounds in cubic feet
p_c, p_m, p_s = percentages of clay, silt, and sand, respectively, of the incoming sediment
W_c, W_m, W_s = coefficients of clay, silt, and sand, respectively that is obtain from the reference

For a classified reservoir operation of 1

W_c = 26 (initial weight in lb/ft^3)
W_m = 70 (initial weight in lb/ft^3)
W_s = 97 (initial weight in lb/ft^3)

From 1963 study the reported sampling was:

Clay = 60%
Silt = 28%
Sand = 12%

$$W = 26(.60) + 70\,(.28) + 97\,(.12) = 46.84$$

In determining density of sediment deposits in reservoirs over time of reservoir operation, it is recognized that portions of the sediment will deposit over each operation year "T" and each year's deposits will have a different compaction time. Miller (1953), developed an approximation of the integral for determining the average density of all sediment deposited in "T" years of operation as:

$$W_T = W_1 + 0.4343K \left[T / (T-1)\ (\log_e T) - 1 \right]$$

Where:

W_T = average density after "T" years of reservoir operation
W_1 = initial unit weight (density) as derived from first equation
K = constant based on type of reservoir operation and sediment size analysis as obtained from table for different reservoir operations

<u>For reservoir operation number 1</u>

K (sand) = 0 inch-pound
K (silt) = 5.7 inch-pound
K (clay) = 16 inch-pound

$$K = 16(0.60) + 5.7(.28) + (0)(.12) = 11.196$$

<u>For 66 years of Lake Mead operations since closure</u>:

$$W_{66} = 46.84 + 0.434\,(11.196) \left[66 / (66-1)\,(4.19) - 1 \right]$$
$$= 46.84 + (4.86)\,(3.25)$$
$$= 62.63 \text{ lb/ft}^3$$

Assumed some sediment deposition occurred at dam during construction and initial filling. Since 1963, 38 years of operation with sediments submerged.

W_{38} = 46.84 +0.4343(11.196) $\Big[$ 38 / (38-1) (3.64)-1$\Big]$
= 46.84 + 4.86(2.74)
= 60.15 lb/ft^3

After 13 years of operations (1935 – 1948)

W_{13} = 46.84 + 0.4343 (11.196) $\Big[$13 / (13 – 1) (log$_e$ (12)-1$\Big]$
= 53.6

From 1948 – 64

W_{16} = 53/6 + 0.4343(11.196) $\Big[$16 / (16-1)(log$_e$16)-1$\Big]$
=62.2

After 37 years (1964-2001)

W_{37} = 62 + (0.4343)(11.196) $\Big[$(37 / (37-1) log$_e$(37) - 1$\Big]$
= 75

From field survey results

1948 survey measured around 80 feet of sediment near dam

1963 survey measured around 75 feet of sediment near dam

For 1963 - (53.6/62.2)(80 feet) = 69 ft

For 2001 - (62/75)(75 feet) = 62 feet

Around 7 feet of consolidation from equations. The 2001 survey measured about 10 feet of consolidation. Must be noted that after closure of Glen Canyon Dam in 1963 a large source of previous sediment inflow was cut off.

Appendix V

Summary of Analysis by TSC

Following is a summary of surface area computations conducted by the Sedimentation Group in September of 2002. The process was conducted, map by map, with the approach of looking for change from the original measured surface areas due to sediment deposition. When the 2001 data indicated no change due to sediment, at the 10-foot contour interval, the contour was marked as no change and the original surface area listed in the 1963 report was used.

Using ARC tools, version 8.1.2, developed TIN coverages and resulting contours by the LCR were used for this analysis. The initial Sedimentation analysis determined the DEM developed TIN's, contours, and resulting surface areas did not provide sufficient detail, mainly for lower elevations and small coves, to match the original map detail and resulting surface areas. In most cases however, the surface areas were very close to the original published surface areas (within 2 percent).

The Sedimentation Group took the approach that the original surface areas by map at the 10-foot contour intervals were correct. Even though the GIS computed surface areas using the DEM data are very close, there is a difference that is attributed more to the limited detail of the DEM data rather than errors in the original measured data. Another issue was that the DEM original data was not available for all the maps that cover Lake Mead. This included the maps from the Pierce Ferry area upstream. Since these areas of Lake Mead contain available capacity not completely lost due to sediment deposition, an approach was taken to estimate the available capacity in these areas and the total sediment deposition within Lake Mead.

The previous studies, 1948 and 1963, used the original maps and surface areas as the initial base for measuring change. The Sedimentation Group used the same approach for the 2001 analysis. Following information was used for the Sedimentation Group's map analysis.

1. The 2001 LiDAR data, when combined with the multibeam and single beam data and the previously collected Biological cross sections, provided enough detailed coverage of maps 40, 42, and 43 for estimating change since the original topography was measured. Some interpretation was required and the vertical elevations of the LiDAR data were adjusted to match the Lake Mead vertical datum.

2. The analysis refers to results from the 1963 reservoir survey that included only the thalweg and a few cross section plots. The 2001 survey results indicate there were only minor changes in the reach above Pierce Ferry since the 1963 and the 1948 studies. There is around 30 miles of reservoir

length and volume that is small compared to rest of the reservoir, but this analysis estimated the available capacity of this portion of the reservoir.

The following analysis is listed by map and was conducted by Ron Ferrari of the Sedimentation Group. When the 2001 multibeam survey data provided enough detail for the contour elevation being measured, the GIS computed surface area was used. When 2001 data was not available or when the information indicated little to no change due to sediment deposition, the original surface area was used. For maps that covered areas such as Las Vegas Wash and the Overton Arm, the survey and analysis mainly focused on the relatively small river channels. The remaining map areas were assumed to have no change due to sediment deposition. That assumption was supported by the 2001 survey and previous cross section surveys of the reservoir. The 2001 survey measured changes due to sediment deposition, mainly confined to original river channel areas. These 2001 river channel contours were digitized to measure the new surface areas.

The final surface area analysis conducted in September of 2002 is summarized here. Previous analysis of the GIS developed maps in the spring of 2002 found that the map boundary was slightly off. This was corrected and forwarded to the Sedimentation Group in September 2002 allowing limited time for the analyses.

1. The original map surface areas, as listed in the 1963 report, were used as the base for this analysis.

    a. When the original developed DEM contours were overlaid with the scanned original maps, the DEM developed maps did not show the detail in the narrow canyons and channels. Comparisons of the original and GIS computed surface areas were usually within 2 percent.

    b. The Excel spread sheet containing the GIS developed original surface areas for maps 1 through 41, did not include values for map 30. At elevation 1,230 the original surface area was 152,233 acres compared to a GIS computed surface area of 149,882 acres. For elevation 1,100 the original surface area was 92,702 acres compared to the GIS computed area of 91,574 acres. For elevation 1,000 the original surface area was 58,090 acres compared to the GIS computed area of 57,728 acres.

The general conclusion was the differences were due to the differences of detail between the two data sets, not errors from either of the analyses. The 10 meter DEM's were developed by scanning the original maps and did not provide enough detail to match the original 5- and 10-foot map contours.

NOTE: The difference in most cases was 2 percent or less which is considered very close. The main problem for the sediment analysis was that the original maps were not available for all of Lake Mead in a digital format. If all were available, a reliable sediment computation could be developed by comparing the GIS developed original and 2001 values. Even if all maps were available there would still be some question as to accuracy of the GIS computed surface area and resulting capacities.

Map Analysis

UTM Zone 11, NAD83

During the analysis of the 1935 and 2001 GIS developed contours, judgments were made if no change had occurred.

Map123 (Upper Vegas Wash)

Note: Computations for this map was computed by digitizing areas to be removed (unless noted differently). GIS values of the total map were not used since the 2001 data only covered the main river channel with little overlap.

Note: Elevation 1,180 was last contour developed with 2001 data due to low water surface during time of collection. Projected location of rest of contours assumes no change at elevation 1,230.

Map 4

Includes main channel and Las Vegas Wash. In main channel no change from elevation 750 and above. Changes in Las Vegas Wash starting at elevation 760. Use ARC 8.1 digitizing routines to measure changes in Vegas Wash.

Note: Data collected in Government Wash, but doesn't appear to develop good contours for doing comparisons and surface losses?

Elevation 1,030 and above, NO CHANGE.

Map 5

From thalweg plot, little to no change from elevation 750 and above.
No change elevation 760 and above.
All changes from elevation 660 through 750 from GIS computations

Map 6-7

Includes Callville Bay, a plot of 2001 versus scan map shows some changes in the Callville Bay but too small to digitize.

Changes in main channel only.
No change for elevations 770 and above.
Area from elevation 660 through 760 from GIS computations

Map 8

2001 GIS match well with elevation 750 and greater, no change for elevation 750 and greater
GIS computations for elevation 660 through 740

Map 9

Original map elevation 680 is the minimum.
Original GIS map, elevation 670 with islands
No change elevation 790 and above.
Areas for elevations 660 through 780 from GIS computations

Map 10

NO CHANGE

Map 11-12

Elevation 760 and 770 end in map
No change 790 and greater
Areas for elevation 660 through 780 from GIS computations

Map 14

No change

Map 15

No change

Map 16

No change
No 2001 data points

Map 17 (Echo Bay)

Note: not enough 2001 data to support showing changes elevation 1150 and greater

No change elevation 1,080 and 1,090.

Map 18

Overton Mouth on south side
2001 data is showing larger areas for contours 800 and above
Assume no change elevation 800 and above

Map 19

Original map had contours for elevations 720, 730, and 740, but table only had elevation 740 and greater
GIS of original only showed small area for 750.
No change elevation 810 and above. Includes Bonelli Bay with upper contour being elevation 970. Comparison with scan original showed very little change in Bonelli Bay.
Area changes from elevation 660 to 800 from GIS computations.

Map 20 – 21

Has Bonelli Bay, from plot of 2001 versus scan there appears to be little change in Bonelli Bay
No Change

Map 22

2001 data is limited, but goes into map area

Contour 1,180 crosses within map, some developed for elevation 1,150 through 1,170 but 2001 data does not support it

No change on muddy creek arm, limited 2001 data but indicates little change
Virgin Arm digitized

Map 23

Digitized areas lost

No change elevation 1,180 and above

Map 24

Digitized areas lost

Map 25

Digitize loss assume change only in river channel upper portion of contours
No change elevation 980 and above.

Map 26

No change elevation 880 and above

Map 27

Area start @ 740 in report and also in GIS
Some of map area is in Overton Arm
For 2001 coverage, small portion for elevation 800 and 810
No change for elevation 820 and greater

Map 27

Portion of map in Overton Arm. GIS original only shows partial at elevation 750.
Original maps shows complete contour.
No change elevation 820 and above
Area changes from elevation 660 through 810 from GIS computations

Map 28

NO CHANGE

Map 30

No change, elevation 1230. All others zero (used thalweg plot to project)

Map 31

No change elevation 1230. All others losses digitized.

Map 32

No change elevation 1,180 and above.
Changed areas digitized

Map 33

No change
No 2001 points

Map 34

No change elevation 840 and greater
GIS computed surface areas from elevation 830 and below

Map 35

Not able to detect changes in Temple tributary with 2001 data
No change elevation 860 and greater

Map 36

No change 880 and greater

Map 37

GIS computed areas from elevation 1,040 and less
No change elevation 1,050 and greater

Map 38

GIS computed areas from elevation 980 and less
No change elevation 990 and greater
Hualpai Wash on map, 2001 survey data

Map 39

From LiDAR, projected contour elevation 1,210 and 1,220
Elevation 1,200 = zero area, no change elevation 1,230

Map 40

Developed GIS contours for elevations 1,080; 1,090; 1,100; 1,110; 1,120; 1,130; 1,140; 1,150; and 1,160
Assume no loss elevation 1,190 and higher
Limited amount of underwater data in Grand Wash and very upper Colorado River. Will use computed losses from GIS, but also removed additional area in Upper Colorado Arm not covered by LiDAR using cross section data
GIS computed areas for elevation 1,080 and greater with some digitized surfaces due to limited 2001 data

Map 41

<u>Iceberg Canyon</u>

Elevation 1,040 – 1,070 end on map, GIS computations
No change elevation 1,090 and above

Map 42

No 2001 GIS computations
No area, elevation 1,170 and less
No change, elevation 1,190 and greater
Elevation 1,180 ends within map, estimated location

Map 43

Portion mapped by LiDAR assumed no change in surface area elevation 1200 and above.
Assume no area elevation 1180 and less
Elevation 1,190 contour appears to have changes in upper end only,

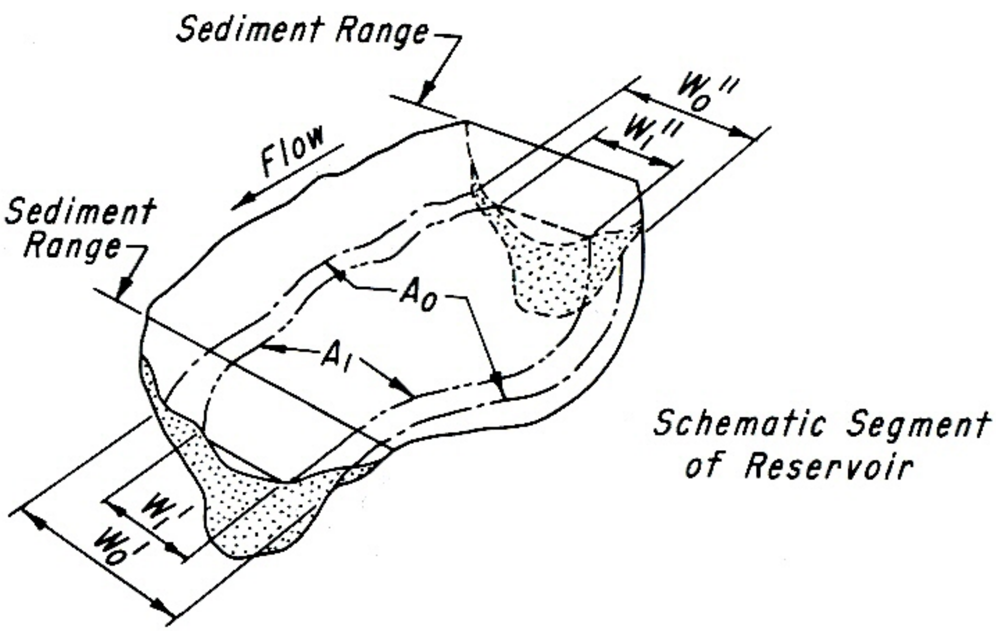
Note: Biological range lines located on map. Showed areas for elevation 1,180 and even elevation 1,170. For elevation 1,190 the width = 375 feet

Original width = 1,400 feet

Cross sections show no change for elevation 1,200 and above

River cross sections by Biological contract

Cross section data started 3/18/99
2001 cross section data is after lake level dropped 20 plus feet since 1999. Means some cross sections in river conditions and previous delta cut down in river change pushing sediments downstream.



Initial Survey	*New Survey*
A_o = Contour Area	*A_1 = Contour Area (Computed)*
W_o' = Downstream Width	*W_1' = Downstream Width*
W_o'' = Upstream Width	*W_1'' = Upstream Width*

$$A_1 = \left[\frac{\left(W_1' + W_1''\right)}{\left(W_0' + W_0''\right)}\right]$$

Map 44

No area elevation 1,170 and below
No change elevation 1,210 and above

Map 45

Left bank delta height around 8 feet
Right bank delta height around 6 feet
No area elevation 1,170 and below

Map 46

No Area elevation 1,170 and below
No change elevation 1,200 and above

Map47

No change elevation 1,200 and above
No area elevation 1,180 and less

Map 48

No area elevation 1,180 and less
No change elevation 1,200 and greater

Map 49

From field trip on 9/01, noted little delta on shore
No change elevation 1,200 and greater
No area elevation 1,180 and less

Map 50

1999 to 2001 cross section from Biological contract work
1999 collected lake elevation around elevation 1,207.
2001 collection near lake elevation of 1,185.
No vertical control
Cross sections about every 4 miles
Use width adjustment method to adjust areas

Map 51 (No areas)

Map 52 (No areas)

Appendix VI

RECLAMATION
Managing Water in the West

Boulder Canyon Project

Arizona - Nevada

Lake Mead

Area and Capacity Tables

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

September 2001

The tables for Lake Mead were generated by means of the area-capacity program ACAP, using the least squares method of curve fitting developed by the Bureau of Reclamation Technical Service Center. This program computes area at 1.0-, 0.1-, and 0.01-foot increments by linear interpolation between basic data contours. The respective capacities and capacity equations are than obtained by integration of the area equations. The initial capacity equation is tested over successive intervals to check whether it fits within an allowable error term. At the next interval beyond, a new capacity equation (integrated from the basic area equation over that interval) begins testing the fit until it too exceeds the error term. The capacity curve thus becomes a series of curves, each fitting a certain region of data. The final area equations are obtained by differentiation of the capacity equations. Capacity equations are of the form $y = a_1 + a_2x + a_3x^2$ where y is capacity and x is the elevation above an elevation base. The capacity equation coefficients for the reservoir are shown below (ε = 0.000001).

Lake Mead – Boulder City, Nevada
2001 AREA-CAPACITY TABLES

EQUATION NUMBER	ELEVATION BASE	CAPACITY BASE	COEFFICIENT A1(INTERCEPT)	COEFFICIENT A2(1ST TERM)	COEFFICIENT A3(2ND TERM)
1	689.00	0	.0000	.0000	.0214
2	700.00	2	2.5850	.4700	.1735
3	710.00	24	24.6350	3.9400	2.4965
4	720.00	313	313.6850	53.8700	64.8055
5	730.00	7332	7332.9351	1349.9799	90.6185
6	740.00	29894	29894.5856	3162.3502	80.9200
7	750.00	69610	69610.0856	4780.7504	60.1965
8	760.00	123437	123437.2352	5984.6798	46.1830
9	770.00	187902	187902.3430	6908.3402	65.7410
10	780.00	263559	263559.8441	8223.1596	72.0570
11	790.00	352997	352997.1530	9664.3015	180.0733
12	800.00	467647	467647.5054	13265.7664	98.4393
13	810.00	610149	610149.1243	15234.5496	92.6296
14	820.00	771757	771757.5513	17087.1446	81.8251
15	830.00	950811	950811.5023	18723.6476	91.6823
16	840.00	1147216	1147216.2444	20557.2881	99.1583
17	850.00	1362705	1362704.9997	22540.4477	87.7673
18	860.00	1596886	1596886.2471	24295.7913	79.0589
19	870.00	1847750	1847749.9932	25876.9750	81.3110
20	880.00	2114650	2114650.7579	27503.1967	84.4095
21	890.00	2398123	2398123.7567	29191.3923	98.0515
22	900.00	2699842	2699842.7347	31152.4384	120.6118
23	910.00	3023428	3023428.2471	33564.6823	117.8746
24	920.00	3370862	3370862.4578	35922.1949	114.0576
25	930.00	3741490	3741490.2490	38203.3648	116.1590
26	940.00	4135139	4135139.7336	40526.5637	117.1168
27	950.00	4552117	4552116.9987	42868.9264	129.6001
28	960.00	4993766	4993766.5250	45460.9585	119.2805
29	970.00	5460304	5460303.9549	47846.6107	133.9119
30	980.00	5952161	5952161.0500	50524.8367	149.6390
31	990.00	6472373	6472373.4856	53517.6081	142.8348
32	1000.00	7021833	7021833.0510	56374.2961	155.0589
33	1010.00	7601082	7601081.9688	59475.4651	152.8856
34	1020.00	8211125	8211124.9745	62533.2097	154.5183
35	1030.00	8851909	8851909.0491	65623.6358	160.5176
36	1040.00	9524197	9524197.0229	68833.9746	168.7013
37	1050.00	10229407	10229398.0206	72212.4885	180.9724
38	1070.00	11746028	11746027.8345	79446.8825	170.1110
39	1080.00	12557508	12557508.0923	82849.0959	175.4484
40	1090.00	13403544	13403543.9883	86358.0260	172.7990
41	1100.00	14284404	14284403.8536	89814.0504	202.3005
42	1110.00	15202774	15202763.0956	93865.5801	193.2496
43	1130.00	17157364	17157363.9512	101590.0839	211.7038
44	1140.00	18194436	18194436.3419	105823.9563	261.6056
45	1150.00	19278836	19278837.8807	111054.9756	231.3824
46	1170.00	21592492	21592491.9673	120311.1217	317.6273
47	1180.00	22827366	22827365.8649	126663.6832	444.5582
48	1190.00	24138458	24138458.0334	135554.8647	400.4211
49	1200.00	25534048	25534047.9970	143563.1981	367.8014
50	1210.00	27006460	27006459.9038	150919.2564	277.6681
51	1220.00	28543420	28543419.8791	156472.7638	337.5337

Lake Mead survey in spring 2001 used the contour method to obtain the basic data for these tables. The underwater portion of the reservoir was collected by standard surveying techniques using a global positioning system and multibeam sounder. The above-water portion was determined from limited aerial LiDAR and original reservoir topography. These surveys provided measured surface areas at 10-foot increments for the reservoir area. The underwater survey was run by personnel from the Sedimentation and River Hydraulics Group of the Technical Service Center and Lower Colorado Regional Office. Reduction of the data was completed by the Sedimentation Group and the Lower Colorado Regional Office. The analysis for developing the surface areas for the attach table development was completed by the Sedimentation Group in Denver, Colorado. All data for these tables are tied to the project vertical datum that is 0.55 feet less than NGVD29.

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2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED
2001 AREA-CAPACITY TABLES

THE AREA TABLE IS IN ACRES THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
689	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
690	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
691	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
692	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
693	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
694	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
695	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
696	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
697	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
698	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
699	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
700	0.	1.	1.	1.	1.	1.	1.	1.	1.	1.
701	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
702	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
703	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
704	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
705	2.	2.	2.	2.	2.	2.	2.	2.	2.	3.
706	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
707	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
708	3.	3.	3.	3.	3.	3.	3.	3.	4.	4.
709	4.	4.	4.	4.	4.	4.	4.	4.	4.	4.
710	4.	4.	5.	5.	6.	6.	7.	7.	8.	8.
711	9.	9.	10.	10.	11.	11.	12.	12.	13.	13.
712	14.	14.	15.	15.	16.	16.	17.	17.	18.	18.
713	19.	19.	20.	20.	21.	21.	22.	22.	23.	23.
714	24.	24.	25.	25.	26.	26.	27.	27.	28.	28.
715	29.	29.	30.	30.	31.	31.	32.	32.	33.	33.
716	34.	34.	35.	35.	36.	36.	37.	37.	38.	38.
717	39.	39.	40.	40.	41.	41.	42.	42.	43.	43.
718	44.	44.	45.	45.	46.	46.	47.	47.	48.	48.
719	49.	49.	50.	50.	51.	51.	52.	52.	53.	53.
720	54.	67.	80.	93.	106.	119.	132.	145.	158.	171.
721	183.	196.	209.	222.	235.	248.	261.	274.	287.	300.
722	313.	326.	339.	352.	365.	378.	391.	404.	417.	430.
723	443.	456.	469.	482.	495.	508.	520.	533.	546.	559.
724	572.	585.	598.	611.	624.	637.	650.	663.	676.	689.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED
2001 AREA-CAPACITY TABLES

THE AREA TABLE IS IN ACRES THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
725	702.	715.	728.	741.	754.	767.	780.	793.	806.	819.
726	832.	844.	857.	870.	883.	896.	909.	922.	935.	948.
727	961.	974.	987.	1000.	1013.	1026.	1039.	1052.	1065.	1078.
728	1091.	1104.	1117.	1130.	1143.	1156.	1169.	1181.	1194.	1207.
729	1220.	1233.	1246.	1259.	1272.	1285.	1298.	1311.	1324.	1337.
730	1350.	1368.	1386.	1404.	1422.	1441.	1459.	1477.	1495.	1513.
731	1531.	1549.	1567.	1586.	1604.	1622.	1640.	1658.	1676.	1694.
732	1712.	1731.	1749.	1767.	1785.	1803.	1821.	1839.	1857.	1876.
733	1894.	1912.	1930.	1948.	1966.	1984.	2002.	2021.	2039.	2057.
734	2075.	2093.	2111.	2129.	2147.	2166.	2184.	2202.	2220.	2238.
735	2256.	2274.	2292.	2311.	2329.	2347.	2365.	2383.	2401.	2419.
736	2437.	2456.	2474.	2492.	2510.	2528.	2546.	2564.	2582.	2601.
737	2619.	2637.	2655.	2673.	2691.	2709.	2727.	2746.	2764.	2782.
738	2800.	2818.	2836.	2854.	2872.	2890.	2909.	2927.	2945.	2963.
739	2981.	2999.	3017.	3035.	3054.	3072.	3090.	3108.	3126.	3144.
740	3162.	3179.	3195.	3211.	3227.	3243.	3259.	3276.	3292.	3308.
741	3324.	3340.	3357.	3373.	3389.	3405.	3421.	3437.	3454.	3470.
742	3486.	3502.	3518.	3535.	3551.	3567.	3583.	3599.	3616.	3632.
743	3648.	3664.	3680.	3696.	3713.	3729.	3745.	3761.	3777.	3794.
744	3810.	3826.	3842.	3858.	3874.	3891.	3907.	3923.	3939.	3955.
745	3972.	3988.	4004.	4020.	4036.	4052.	4069.	4085.	4101.	4117.
746	4133.	4150.	4166.	4182.	4198.	4214.	4230.	4247.	4263.	4279.
747	4295.	4311.	4328.	4344.	4360.	4376.	4392.	4409.	4425.	4441.
748	4457.	4473.	4489.	4506.	4522.	4538.	4554.	4570.	4587.	4603.
749	4619.	4635.	4651.	4667.	4684.	4700.	4716.	4732.	4748.	4765.
750	4781.	4793.	4805.	4817.	4829.	4841.	4853.	4865.	4877.	4889.
751	4901.	4913.	4925.	4937.	4949.	4961.	4973.	4985.	4997.	5009.
752	5022.	5034.	5046.	5058.	5070.	5082.	5094.	5106.	5118.	5130.
753	5142.	5154.	5166.	5178.	5190.	5202.	5214.	5226.	5238.	5250.
754	5262.	5274.	5286.	5298.	5310.	5323.	5335.	5347.	5359.	5371.
755	5383.	5395.	5407.	5419.	5431.	5443.	5455.	5467.	5479.	5491.
756	5503.	5515.	5527.	5539.	5551.	5563.	5575.	5587.	5599.	5611.
757	5624.	5636.	5648.	5660.	5672.	5684.	5696.	5708.	5720.	5732.
758	5744.	5756.	5768.	5780.	5792.	5804.	5816.	5828.	5840.	5852.
759	5864.	5876.	5888.	5900.	5912.	5924.	5937.	5949.	5961.	5973.
760	5985.	5994.	6003.	6012.	6022.	6031.	6040.	6049.	6059.	6068.
761	6077.	6086.	6096.	6105.	6114.	6123.	6132.	6142.	6151.	6160.
762	6169.	6179.	6188.	6197.	6206.	6216.	6225.	6234.	6243.	6253.
763	6262.	6271.	6280.	6289.	6299.	6308.	6317.	6326.	6336.	6345.
764	6354.	6363.	6373.	6382.	6391.	6400.	6410.	6419.	6428.	6437.

THE AREA TABLE IS IN ACRES

THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
765	6447.	6456.	6465.	6474.	6483.	6493.	6502.	6511.	6520.	6530.
766	6539.	6548.	6557.	6567.	6576.	6585.	6594.	6604.	6613.	6622.
767	6631.	6640.	6650.	6659.	6668.	6677.	6687.	6696.	6705.	6714.
768	6724.	6733.	6742.	6751.	6761.	6770.	6779.	6788.	6798.	6807.
769	6816.	6825.	6834.	6844.	6853.	6862.	6871.	6881.	6890.	6899.
770	6908.	6921.	6935.	6948.	6961.	6974.	6987.	7000.	7014.	7027.
771	7040.	7053.	7066.	7079.	7092.	7106.	7119.	7132.	7145.	7158.
772	7171.	7184.	7198.	7211.	7224.	7237.	7250.	7263.	7276.	7290.
773	7303.	7316.	7329.	7342.	7355.	7369.	7382.	7395.	7408.	7421.
774	7434.	7447.	7461.	7474.	7487.	7500.	7513.	7526.	7539.	7553.
775	7566.	7579.	7592.	7605.	7618.	7631.	7645.	7658.	7671.	7684.
776	7697.	7710.	7724.	7737.	7750.	7763.	7776.	7789.	7802.	7816.
777	7829.	7842.	7855.	7868.	7881.	7894.	7908.	7921.	7934.	7947.
778	7960.	7973.	7986.	8000.	8013.	8026.	8039.	8052.	8065.	8079.
779	8092.	8105.	8118.	8131.	8144.	8157.	8171.	8184.	8197.	8210.
780	8223.	8238.	8252.	8266.	8281.	8295.	8310.	8324.	8338.	8353.
781	8367.	8382.	8396.	8411.	8425.	8439.	8454.	8468.	8483.	8497.
782	8511.	8526.	8540.	8555.	8569.	8583.	8598.	8612.	8627.	8641.
783	8656.	8670.	8684.	8699.	8713.	8728.	8742.	8756.	8771.	8785.
784	8800.	8814.	8828.	8843.	8857.	8872.	8886.	8900.	8915.	8929.
785	8944.	8958.	8973.	8987.	9001.	9016.	9030.	9045.	9059.	9073.
786	9088.	9102.	9117.	9131.	9145.	9160.	9174.	9189.	9203.	9218.
787	9232.	9246.	9261.	9275.	9290.	9304.	9318.	9333.	9347.	9362.
788	9376.	9390.	9405.	9419.	9434.	9448.	9463.	9477.	9491.	9506.
789	9520.	9535.	9549.	9563.	9578.	9592.	9607.	9621.	9635.	9650.
790	9664.	9700.	9736.	9772.	9808.	9844.	9880.	9916.	9952.	9988.
791	10024.	10060.	10096.	10132.	10169.	10205.	10241.	10277.	10313.	10349.
792	10385.	10421.	10457.	10493.	10529.	10565.	10601.	10637.	10673.	10709.
793	10745.	10781.	10817.	10853.	10889.	10925.	10961.	10997.	11033.	11069.
794	11105.	11141.	11177.	11213.	11249.	11285.	11321.	11357.	11393.	11429.
795	11465.	11501.	11537.	11573.	11609.	11645.	11681.	11717.	11753.	11789.
796	11825.	11861.	11897.	11933.	11969.	12005.	12041.	12077.	12113.	12149.
797	12185.	12221.	12257.	12293.	12329.	12365.	12401.	12437.	12473.	12509.
798	12545.	12581.	12618.	12654.	12690.	12726.	12762.	12798.	12834.	12870.
799	12906.	12942.	12978.	13014.	13050.	13086.	13122.	13158.	13194.	13230.
800	13266.	13285.	13305.	13325.	13345.	13364.	13384.	13404.	13423.	13443.
801	13463.	13482.	13502.	13522.	13541.	13561.	13581.	13600.	13620.	13640.
802	13660.	13679.	13699.	13719.	13738.	13758.	13778.	13797.	13817.	13837.
803	13856.	13876.	13896.	13915.	13935.	13955.	13975.	13994.	14014.	14034.
804	14053.	14073.	14093.	14112.	14132.	14152.	14171.	14191.	14211.	14230.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED
2001 AREA-CAPACITY TABLES

THE AREA TABLE IS IN ACRES THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
805	14250.	14270.	14290.	14309.	14329.	14349.	14368.	14388.	14408.	14427.
806	14447.	14467.	14486.	14506.	14526.	14545.	14565.	14585.	14605.	14624.
807	14644.	14664.	14683.	14703.	14723.	14742.	14762.	14782.	14801.	14821.
808	14841.	14860.	14880.	14900.	14920.	14939.	14959.	14979.	14998.	15018.
809	15038.	15057.	15077.	15097.	15116.	15136.	15156.	15175.	15195.	15215.
810	15235.	15253.	15272.	15290.	15309.	15327.	15346.	15364.	15383.	15401.
811	15420.	15438.	15457.	15475.	15494.	15512.	15531.	15549.	15568.	15587.
812	15605.	15624.	15642.	15661.	15679.	15698.	15716.	15735.	15753.	15772.
813	15790.	15809.	15827.	15846.	15864.	15883.	15901.	15920.	15939.	15957.
814	15976.	15994.	16013.	16031.	16050.	16068.	16087.	16105.	16124.	16142.
815	16161.	16179.	16198.	16216.	16235.	16253.	16272.	16291.	16309.	16328.
816	16346.	16365.	16383.	16402.	16420.	16439.	16457.	16476.	16494.	16513.
817	16531.	16550.	16568.	16587.	16605.	16624.	16643.	16661.	16680.	16698.
818	16717.	16735.	16754.	16772.	16791.	16809.	16828.	16846.	16865.	16883.
819	16902.	16920.	16939.	16957.	16976.	16995.	17013.	17032.	17050.	17069.
820	17087.	17104.	17120.	17136.	17153.	17169.	17185.	17202.	17218.	17234.
821	17251.	17267.	17284.	17300.	17316.	17333.	17349.	17365.	17382.	17398.
822	17414.	17431.	17447.	17464.	17480.	17496.	17513.	17529.	17545.	17562.
823	17578.	17594.	17611.	17627.	17644.	17660.	17676.	17693.	17709.	17725.
824	17742.	17758.	17774.	17791.	17807.	17824.	17840.	17856.	17873.	17889.
825	17905.	17922.	17938.	17954.	17971.	17987.	18004.	18020.	18036.	18053.
826	18069.	18085.	18102.	18118.	18135.	18151.	18167.	18184.	18200.	18216.
827	18233.	18249.	18265.	18282.	18298.	18315.	18331.	18347.	18364.	18380.
828	18396.	18413.	18429.	18445.	18462.	18478.	18495.	18511.	18527.	18544.
829	18560.	18576.	18593.	18609.	18625.	18642.	18658.	18675.	18691.	18707.
830	18724.	18742.	18760.	18779.	18797.	18815.	18834.	18852.	18870.	18889.
831	18907.	18925.	18944.	18962.	18980.	18999.	19017.	19035.	19054.	19072.
832	19090.	19109.	19127.	19145.	19164.	19182.	19200.	19219.	19237.	19255.
833	19274.	19292.	19310.	19329.	19347.	19365.	19384.	19402.	19420.	19439.
834	19457.	19475.	19494.	19512.	19530.	19549.	19567.	19585.	19604.	19622.
835	19640.	19659.	19677.	19695.	19714.	19732.	19750.	19769.	19787.	19805.
836	19824.	19842.	19861.	19879.	19897.	19916.	19934.	19952.	19971.	19989.
837	20007.	20026.	20044.	20062.	20081.	20099.	20117.	20136.	20154.	20172.
838	20191.	20209.	20227.	20246.	20264.	20282.	20301.	20319.	20337.	20356.
839	20374.	20392.	20411.	20429.	20447.	20466.	20484.	20502.	20521.	20539.
840	20557.	20577.	20597.	20617.	20637.	20656.	20676.	20696.	20716.	20736.
841	20756.	20775.	20795.	20815.	20835.	20855.	20875.	20894.	20914.	20934.
842	20954.	20974.	20994.	21013.	21033.	21053.	21073.	21093.	21113.	21132.
843	21152.	21172.	21192.	21212.	21232.	21251.	21271.	21291.	21311.	21331.
844	21351.	21370.	21390.	21410.	21430.	21450.	21470.	21489.	21509.	21529.

THE AREA TABLE IS IN ACRES

THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
845	21549.	21569.	21589.	21608.	21628.	21648.	21668.	21688.	21708.	21727.
846	21747.	21767.	21787.	21807.	21827.	21846.	21866.	21886.	21906.	21926.
847	21946.	21965.	21985.	22005.	22025.	22045.	22064.	22084.	22104.	22124.
848	22144.	22164.	22183.	22203.	22223.	22243.	22263.	22283.	22302.	22322.
849	22342.	22362.	22382.	22402.	22421.	22441.	22461.	22481.	22501.	22521.
850	22540.	22558.	22576.	22593.	22611.	22628.	22646.	22663.	22681.	22698.
851	22716.	22734.	22751.	22769.	22786.	22804.	22821.	22839.	22856.	22874.
852	22892.	22909.	22927.	22944.	22962.	22979.	22997.	23014.	23032.	23049.
853	23067.	23085.	23102.	23120.	23137.	23155.	23172.	23190.	23207.	23225.
854	23243.	23260.	23278.	23295.	23313.	23330.	23348.	23365.	23383.	23401.
855	23418.	23436.	23453.	23471.	23488.	23506.	23523.	23541.	23559.	23576.
856	23594.	23611.	23629.	23646.	23664.	23681.	23699.	23717.	23734.	23752.
857	23769.	23787.	23804.	23822.	23839.	23857.	23875.	23892.	23910.	23927.
858	23945.	23962.	23980.	23997.	24015.	24032.	24050.	24068.	24085.	24103.
859	24120.	24138.	24155.	24173.	24190.	24208.	24226.	24243.	24261.	24278.
860	24296.	24312.	24327.	24343.	24359.	24375.	24391.	24406.	24422.	24438.
861	24454.	24470.	24486.	24501.	24517.	24533.	24549.	24565.	24580.	24596.
862	24612.	24628.	24644.	24659.	24675.	24691.	24707.	24723.	24739.	24754.
863	24770.	24786.	24802.	24818.	24833.	24849.	24865.	24881.	24897.	24912.
864	24928.	24944.	24960.	24976.	24992.	25007.	25023.	25039.	25055.	25071.
865	25086.	25102.	25118.	25134.	25150.	25165.	25181.	25197.	25213.	25229.
866	25244.	25260.	25276.	25292.	25308.	25324.	25339.	25355.	25371.	25387.
867	25403.	25418.	25434.	25450.	25466.	25482.	25497.	25513.	25529.	25545.
868	25561.	25577.	25592.	25608.	25624.	25640.	25656.	25671.	25687.	25703.
869	25719.	25735.	25750.	25766.	25782.	25798.	25814.	25830.	25845.	25861.
870	25877.	25893.	25910.	25926.	25942.	25958.	25975.	25991.	26007.	26023.
871	26040.	26056.	26072.	26088.	26105.	26121.	26137.	26153.	26170.	26186.
872	26202.	26218.	26235.	26251.	26267.	26284.	26300.	26316.	26332.	26349.
873	26365.	26381.	26397.	26414.	26430.	26446.	26462.	26479.	26495.	26511.
874	26527.	26544.	26560.	26576.	26593.	26609.	26625.	26641.	26658.	26674.
875	26690.	26706.	26723.	26739.	26755.	26771.	26788.	26804.	26820.	26836.
876	26853.	26869.	26885.	26901.	26918.	26934.	26950.	26967.	26983.	26999.
877	27015.	27032.	27048.	27064.	27080.	27097.	27113.	27129.	27145.	27162.
878	27178.	27194.	27210.	27227.	27243.	27259.	27276.	27292.	27308.	27324.
879	27341.	27357.	27373.	27389.	27406.	27422.	27438.	27454.	27471.	27487.
880	27503.	27520.	27537.	27554.	27571.	27588.	27604.	27621.	27638.	27655.
881	27672.	27689.	27706.	27723.	27740.	27756.	27773.	27790.	27807.	27824.
882	27841.	27858.	27875.	27891.	27908.	27925.	27942.	27959.	27976.	27993.
883	28010.	28027.	28043.	28060.	28077.	28094.	28111.	28128.	28145.	28162.
884	28178.	28195.	28212.	28229.	28246.	28263.	28280.	28297.	28314.	28330.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED
2001 AREA-CAPACITY TABLES 10: 2:30

THE AREA TABLE IS IN ACRES THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
885	28347.	28364.	28381.	28398.	28415.	28432.	28449.	28465.	28482.	28499.
886	28516.	28533.	28550.	28567.	28584.	28601.	28617.	28634.	28651.	28668.
887	28685.	28702.	28719.	28736.	28752.	28769.	28786.	28803.	28820.	28837.
888	28854.	28871.	28888.	28904.	28921.	28938.	28955.	28972.	28989.	29006.
889	29023.	29039.	29056.	29073.	29090.	29107.	29124.	29141.	29158.	29175.
890	29191.	29211.	29231.	29250.	29270.	29289.	29309.	29329.	29348.	29368.
891	29387.	29407.	29427.	29446.	29466.	29486.	29505.	29525.	29544.	29564.
892	29584.	29603.	29623.	29642.	29662.	29682.	29701.	29721.	29740.	29760.
893	29780.	29799.	29819.	29839.	29858.	29878.	29897.	29917.	29937.	29956.
894	29976.	29995.	30015.	30035.	30054.	30074.	30093.	30113.	30133.	30152.
895	30172.	30192.	30211.	30231.	30250.	30270.	30290.	30309.	30329.	30348.
896	30368.	30388.	30407.	30427.	30446.	30466.	30486.	30505.	30525.	30545.
897	30564.	30584.	30603.	30623.	30643.	30662.	30682.	30701.	30721.	30741.
898	30760.	30780.	30799.	30819.	30839.	30858.	30878.	30897.	30917.	30937.
899	30956.	30976.	30996.	31015.	31035.	31054.	31074.	31094.	31113.	31133.
900	31152.	31177.	31201.	31225.	31249.	31273.	31297.	31321.	31345.	31370.
901	31394.	31418.	31442.	31466.	31490.	31514.	31538.	31563.	31587.	31611.
902	31635.	31659.	31683.	31707.	31731.	31755.	31780.	31804.	31828.	31852.
903	31876.	31900.	31924.	31948.	31973.	31997.	32021.	32045.	32069.	32093.
904	32117.	32141.	32166.	32190.	32214.	32238.	32262.	32286.	32310.	32334.
905	32359.	32383.	32407.	32431.	32455.	32479.	32503.	32527.	32552.	32576.
906	32600.	32624.	32648.	32672.	32696.	32720.	32745.	32769.	32793.	32817.
907	32841.	32865.	32889.	32913.	32937.	32962.	32986.	33010.	33034.	33058.
908	33082.	33106.	33130.	33155.	33179.	33203.	33227.	33251.	33275.	33299.
909	33323.	33348.	33372.	33396.	33420.	33444.	33468.	33492.	33516.	33541.
910	33565.	33588.	33612.	33635.	33659.	33683.	33706.	33730.	33753.	33777.
911	33800.	33824.	33848.	33871.	33895.	33918.	33942.	33965.	33989.	34013.
912	34036.	34060.	34083.	34107.	34130.	34154.	34178.	34201.	34225.	34248.
913	34272.	34296.	34319.	34343.	34366.	34390.	34413.	34437.	34461.	34484.
914	34508.	34531.	34555.	34578.	34602.	34626.	34649.	34673.	34696.	34720.
915	34743.	34767.	34791.	34814.	34838.	34861.	34885.	34908.	34932.	34956.
916	34979.	35003.	35026.	35050.	35073.	35097.	35121.	35144.	35168.	35191.
917	35215.	35239.	35262.	35286.	35309.	35333.	35356.	35380.	35404.	35427.
918	35451.	35474.	35498.	35521.	35545.	35569.	35592.	35616.	35639.	35663.
919	35686.	35710.	35734.	35757.	35781.	35804.	35828.	35851.	35875.	35899.
920	35922.	35945.	35968.	35991.	36013.	36036.	36059.	36082.	36105.	36128.
921	36150.	36173.	36196.	36219.	36242.	36264.	36287.	36310.	36333.	36356.
922	36378.	36401.	36424.	36447.	36470.	36492.	36515.	36538.	36561.	36584.
923	36607.	36629.	36652.	36675.	36698.	36721.	36743.	36766.	36789.	36812.
924	36835.	36857.	36880.	36903.	36926.	36949.	36972.	36994.	37017.	37040.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED

2001 AREA-CAPACITY TABLES

THE AREA TABLE IS IN ACRES THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
925	37063.	37086.	37108.	37131.	37154.	37177.	37200.	37222.	37245.	37268.
926	37291.	37314.	37337.	37359.	37382.	37405.	37428.	37451.	37473.	37496.
927	37519.	37542.	37565.	37587.	37610.	37633.	37656.	37679.	37701.	37724.
928	37747.	37770.	37793.	37816.	37838.	37861.	37884.	37907.	37930.	37952.
929	37975.	37998.	38021.	38044.	38066.	38089.	38112.	38135.	38158.	38181.
930	38203.	38227.	38250.	38273.	38296.	38320.	38343.	38366.	38389.	38412.
931	38436.	38459.	38482.	38505.	38529.	38552.	38575.	38598.	38622.	38645.
932	38668.	38691.	38714.	38738.	38761.	38784.	38807.	38831.	38854.	38877.
933	38900.	38924.	38947.	38970.	38993.	39016.	39040.	39063.	39086.	39109.
934	39133.	39156.	39179.	39202.	39226.	39249.	39272.	39295.	39318.	39342.
935	39365.	39388.	39411.	39435.	39458.	39481.	39504.	39528.	39551.	39574.
936	39597.	39621.	39644.	39667.	39690.	39713.	39737.	39760.	39783.	39806.
937	39830.	39853.	39876.	39899.	39923.	39946.	39969.	39992.	40015.	40039.
938	40062.	40085.	40108.	40132.	40155.	40178.	40201.	40225.	40248.	40271.
939	40294.	40317.	40341.	40364.	40387.	40410.	40434.	40457.	40480.	40503.
940	40527.	40550.	40573.	40597.	40620.	40644.	40667.	40691.	40714.	40737.
941	40761.	40784.	40808.	40831.	40854.	40878.	40901.	40925.	40948.	40972.
942	40995.	41018.	41042.	41065.	41089.	41112.	41136.	41159.	41182.	41206.
943	41229.	41253.	41276.	41300.	41323.	41346.	41370.	41393.	41417.	41440.
944	41463.	41487.	41510.	41534.	41557.	41581.	41604.	41627.	41651.	41674.
945	41698.	41721.	41745.	41768.	41791.	41815.	41838.	41862.	41885.	41909.
946	41932.	41955.	41979.	42002.	42026.	42049.	42073.	42096.	42119.	42143.
947	42166.	42190.	42213.	42236.	42260.	42283.	42307.	42330.	42354.	42377.
948	42400.	42424.	42447.	42471.	42494.	42518.	42541.	42564.	42588.	42611.
949	42635.	42658.	42682.	42705.	42728.	42752.	42775.	42799.	42822.	42845.
950	42869.	42895.	42921.	42947.	42973.	42999.	43024.	43050.	43076.	43102.
951	43128.	43154.	43180.	43206.	43232.	43258.	43284.	43310.	43335.	43361.
952	43387.	43413.	43439.	43465.	43491.	43517.	43543.	43569.	43595.	43621.
953	43647.	43672.	43698.	43724.	43750.	43776.	43802.	43828.	43854.	43880.
954	43906.	43932.	43958.	43983.	44009.	44035.	44061.	44087.	44113.	44139.
955	44165.	44191.	44217.	44243.	44269.	44295.	44320.	44346.	44372.	44398.
956	44424.	44450.	44476.	44502.	44528.	44554.	44580.	44606.	44631.	44657.
957	44683.	44709.	44735.	44761.	44787.	44813.	44839.	44865.	44891.	44917.
958	44943.	44968.	44994.	45020.	45046.	45072.	45098.	45124.	45150.	45176.
959	45202.	45228.	45254.	45279.	45305.	45331.	45357.	45383.	45409.	45435.
960	45461.	45485.	45509.	45533.	45556.	45580.	45604.	45628.	45652.	45676.
961	45700.	45723.	45747.	45771.	45795.	45819.	45843.	45867.	45890.	45914.
962	45938.	45962.	45986.	46010.	46034.	46057.	46081.	46105.	46129.	46153.
963	46177.	46200.	46224.	46248.	46272.	46296.	46320.	46344.	46367.	46391.
964	46415.	46439.	46463.	46487.	46511.	46534.	46558.	46582.	46606.	46630.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED
2001 AREA-CAPACITY TABLES

THE AREA TABLE IS IN ACRES THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
965	46654.	46678.	46701.	46725.	46749.	46773.	46797.	46821.	46845.	46868.
966	46892.	46916.	46940.	46964.	46988.	47012.	47035.	47059.	47083.	47107.
967	47131.	47155.	47179.	47202.	47226.	47250.	47274.	47298.	47322.	47346.
968	47369.	47393.	47417.	47441.	47465.	47489.	47513.	47536.	47560.	47584.
969	47608.	47632.	47656.	47680.	47703.	47727.	47751.	47775.	47799.	47823.
970	47847.	47873.	47900.	47927.	47954.	47981.	48007.	48034.	48061.	48088.
971	48114.	48141.	48168.	48195.	48222.	48248.	48275.	48302.	48329.	48355.
972	48382.	48409.	48436.	48463.	48489.	48516.	48543.	48570.	48597.	48623.
973	48650.	48677.	48704.	48730.	48757.	48784.	48811.	48838.	48864.	48891.
974	48918.	48945.	48971.	48998.	49025.	49052.	49079.	49105.	49132.	49159.
975	49186.	49213.	49239.	49266.	49293.	49320.	49346.	49373.	49400.	49427.
976	49454.	49480.	49507.	49534.	49561.	49587.	49614.	49641.	49668.	49695.
977	49721.	49748.	49775.	49802.	49829.	49855.	49882.	49909.	49936.	49962.
978	49989.	50016.	50043.	50070.	50096.	50123.	50150.	50177.	50203.	50230.
979	50257.	50284.	50311.	50337.	50364.	50391.	50418.	50445.	50471.	50498.
980	50525.	50555.	50585.	50615.	50645.	50674.	50704.	50734.	50764.	50794.
981	50824.	50854.	50884.	50914.	50944.	50974.	51004.	51034.	51064.	51093.
982	51123.	51153.	51183.	51213.	51243.	51273.	51303.	51333.	51363.	51393.
983	51423.	51453.	51483.	51512.	51542.	51572.	51602.	51632.	51662.	51692.
984	51722.	51752.	51782.	51812.	51842.	51872.	51902.	51931.	51961.	51991.
985	52021.	52051.	52081.	52111.	52141.	52171.	52201.	52231.	52261.	52291.
986	52321.	52350.	52380.	52410.	52440.	52470.	52500.	52530.	52560.	52590.
987	52620.	52650.	52680.	52710.	52739.	52769.	52799.	52829.	52859.	52889.
988	52919.	52949.	52979.	53009.	53039.	53069.	53099.	53129.	53158.	53188.
989	53218.	53248.	53278.	53308.	53338.	53368.	53398.	53428.	53458.	53488.
990	53518.	53546.	53575.	53603.	53632.	53660.	53689.	53718.	53746.	53775.
991	53803.	53832.	53860.	53889.	53918.	53946.	53975.	54003.	54032.	54060.
992	54089.	54118.	54146.	54175.	54203.	54232.	54260.	54289.	54317.	54346.
993	54375.	54403.	54432.	54460.	54489.	54517.	54546.	54575.	54603.	54632.
994	54660.	54689.	54717.	54746.	54775.	54803.	54832.	54860.	54889.	54917.
995	54946.	54975.	55003.	55032.	55060.	55089.	55117.	55146.	55174.	55203.
996	55232.	55260.	55289.	55317.	55346.	55374.	55403.	55432.	55460.	55489.
997	55517.	55546.	55574.	55603.	55632.	55660.	55689.	55717.	55746.	55774.
998	55803.	55832.	55860.	55889.	55917.	55946.	55974.	56003.	56032.	56060.
999	56089.	56117.	56146.	56174.	56203.	56231.	56260.	56289.	56317.	56346.
1000	56374.	56405.	56436.	56467.	56498.	56529.	56560.	56591.	56622.	56653.
1001	56684.	56715.	56746.	56777.	56808.	56839.	56870.	56901.	56933.	56964.
1002	56995.	57026.	57057.	57088.	57119.	57150.	57181.	57212.	57243.	57274.
1003	57305.	57336.	57367.	57398.	57429.	57460.	57491.	57522.	57553.	57584.
1004	57615.	57646.	57677.	57708.	57739.	57770.	57801.	57832.	57863.	57894.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED 12/ 6/2002

2001 AREA-CAPACITY TABLES 10: 2:30

THE AREA TABLE IS IN ACRES

THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1005	57925.	57956.	57987.	58018.	58049.	58080.	58111.	58142.	58173.	58204.
1006	58235.	58266.	58297.	58328.	58359.	58390.	58421.	58452.	58483.	58514.
1007	58545.	58576.	58607.	58638.	58669.	58700.	58731.	58762.	58793.	58824.
1008	58855.	58886.	58917.	58948.	58979.	59010.	59041.	59072.	59103.	59134.
1009	59165.	59196.	59227.	59258.	59289.	59320.	59351.	59382.	59413.	59444.
1010	59475.	59506.	59537.	59567.	59598.	59628.	59659.	59690.	59720.	59751.
1011	59781.	59812.	59842.	59873.	59904.	59934.	59965.	59995.	60026.	60056.
1012	60087.	60118.	60148.	60179.	60209.	60240.	60270.	60301.	60332.	60362.
1013	60393.	60423.	60454.	60485.	60515.	60546.	60576.	60607.	60637.	60668.
1014	60699.	60729.	60760.	60790.	60821.	60851.	60882.	60913.	60943.	60974.
1015	61004.	61035.	61065.	61096.	61127.	61157.	61188.	61218.	61249.	61280.
1016	61310.	61341.	61371.	61402.	61432.	61463.	61494.	61524.	61555.	61585.
1017	61616.	61646.	61677.	61708.	61738.	61769.	61799.	61830.	61860.	61891.
1018	61922.	61952.	61983.	62013.	62044.	62075.	62105.	62136.	62166.	62197.
1019	62227.	62258.	62289.	62319.	62350.	62380.	62411.	62441.	62472.	62503.
1020	62533.	62564.	62595.	62626.	62657.	62688.	62719.	62750.	62780.	62811.
1021	62842.	62873.	62904.	62935.	62966.	62997.	63028.	63059.	63089.	63120.
1022	63151.	63182.	63213.	63244.	63275.	63306.	63337.	63368.	63399.	63429.
1023	63460.	63491.	63522.	63553.	63584.	63615.	63646.	63677.	63708.	63738.
1024	63769.	63800.	63831.	63862.	63893.	63924.	63955.	63986.	64017.	64047.
1025	64078.	64109.	64140.	64171.	64202.	64233.	64264.	64295.	64326.	64357.
1026	64387.	64418.	64449.	64480.	64511.	64542.	64573.	64604.	64635.	64666.
1027	64696.	64727.	64758.	64789.	64820.	64851.	64882.	64913.	64944.	64975.
1028	65006.	65036.	65067.	65098.	65129.	65160.	65191.	65222.	65253.	65284.
1029	65315.	65345.	65376.	65407.	65438.	65469.	65500.	65531.	65562.	65593.
1030	65624.	65656.	65688.	65720.	65752.	65784.	65816.	65848.	65880.	65913.
1031	65945.	65977.	66009.	66041.	66073.	66105.	66137.	66169.	66202.	66234.
1032	66266.	66298.	66330.	66362.	66394.	66426.	66458.	66490.	66523.	66555.
1033	66587.	66619.	66651.	66683.	66715.	66747.	66779.	66811.	66844.	66876.
1034	66908.	66940.	66972.	67004.	67036.	67068.	67100.	67133.	67165.	67197.
1035	67229.	67261.	67293.	67325.	67357.	67389.	67421.	67454.	67486.	67518.
1036	67550.	67582.	67614.	67646.	67678.	67710.	67742.	67775.	67807.	67839.
1037	67871.	67903.	67935.	67967.	67999.	68031.	68064.	68096.	68128.	68160.
1038	68192.	68224.	68256.	68288.	68320.	68352.	68385.	68417.	68449.	68481.
1039	68513.	68545.	68577.	68609.	68641.	68673.	68706.	68738.	68770.	68802.
1040	68834.	68868.	68901.	68935.	68969.	69003.	69036.	69070.	69104.	69138.
1041	69171.	69205.	69239.	69273.	69306.	69340.	69374.	69408.	69441.	69475.
1042	69509.	69543.	69576.	69610.	69644.	69677.	69711.	69745.	69779.	69812.
1043	69846.	69880.	69914.	69947.	69981.	70015.	70049.	70082.	70116.	70150.

1044	70184.	70217.	70251.	70285.	70319.	70352.	70386.	70420.	70454.	70487.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED

2001 AREA-CAPACITY TABLES

THE AREA TABLE IS IN ACRES THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1045	70521.	70555.	70588.	70622.	70656.	70690.	70723.	70757.	70791.	70825.
1046	70858.	70892.	70926.	70960.	70993.	71027.	71061.	71095.	71128.	71162.
1047	71196.	71230.	71263.	71297.	71331.	71364.	71398.	71432.	71466.	71499.
1048	71533.	71567.	71601.	71634.	71668.	71702.	71736.	71769.	71803.	71837.
1049	71871.	71904.	71938.	71972.	72006.	72039.	72073.	72107.	72141.	72174.
1050	72208.	72249.	72285.	72321.	72357.	72393.	72430.	72466.	72502.	72538.
1051	72574.	72611.	72647.	72683.	72719.	72755.	72792.	72828.	72864.	72900.
1052	72936.	72973.	73009.	73045.	73081.	73117.	73154.	73190.	73226.	73262.
1053	73298.	73335.	73371.	73407.	73443.	73479.	73515.	73552.	73588.	73624.
1054	73660.	73696.	73733.	73769.	73805.	73841.	73877.	73914.	73950.	73986.
1055	74022.	74058.	74095.	74131.	74167.	74203.	74239.	74276.	74312.	74348.
1056	74384.	74420.	74457.	74493.	74529.	74565.	74601.	74638.	74674.	74710.
1057	74746.	74782.	74818.	74855.	74891.	74927.	74963.	74999.	75036.	75072.
1058	75108.	75144.	75180.	75217.	75253.	75289.	75325.	75361.	75398.	75434.
1059	75470.	75506.	75542.	75579.	75615.	75651.	75687.	75723.	75760.	75796.
1060	75832.	75868.	75904.	75941.	75977.	76013.	76049.	76085.	76121.	76158.
1061	76194.	76230.	76266.	76302.	76339.	76375.	76411.	76447.	76483.	76520.
1062	76556.	76592.	76628.	76664.	76701.	76737.	76773.	76809.	76845.	76882.
1063	76918.	76954.	76990.	77026.	77063.	77099.	77135.	77171.	77207.	77244.
1064	77280.	77316.	77352.	77388.	77424.	77461.	77497.	77533.	77569.	77605.
1065	77642.	77678.	77714.	77750.	77786.	77823.	77859.	77895.	77931.	77967.
1066	78004.	78040.	78076.	78112.	78148.	78185.	78221.	78257.	78293.	78329.
1067	78366.	78402.	78438.	78474.	78510.	78547.	78583.	78619.	78655.	78691.
1068	78727.	78764.	78800.	78836.	78872.	78908.	78945.	78981.	79017.	79053.
1069	79089.	79126.	79162.	79198.	79234.	79270.	79307.	79343.	79379.	79415.
1070	79451.	79481.	79515.	79549.	79583.	79617.	79651.	79685.	79719.	79753.
1071	79787.	79821.	79855.	79889.	79923.	79957.	79991.	80025.	80059.	80093.
1072	80127.	80161.	80195.	80229.	80263.	80297.	80331.	80365.	80400.	80434.
1073	80468.	80502.	80536.	80570.	80604.	80638.	80672.	80706.	80740.	80774.
1074	80808.	80842.	80876.	80910.	80944.	80978.	81012.	81046.	81080.	81114.
1075	81148.	81182.	81216.	81250.	81284.	81318.	81352.	81386.	81420.	81454.
1076	81488.	81522.	81556.	81590.	81624.	81658.	81692.	81726.	81760.	81794.
1077	81828.	81862.	81896.	81931.	81965.	81999.	82033.	82067.	82101.	82135.
1078	82169.	82203.	82237.	82271.	82305.	82339.	82373.	82407.	82441.	82475.
1079	82509.	82543.	82577.	82611.	82645.	82679.	82713.	82747.	82781.	82815.
1080	82849.	82884.	82919.	82954.	82989.	83025.	83060.	83095.	83130.	83165.
1081	83200.	83235.	83270.	83305.	83340.	83375.	83411.	83446.	83481.	83516.
1082	83551.	83586.	83621.	83656.	83691.	83726.	83761.	83797.	83832.	83867.
1083	83902.	83937.	83972.	84007.	84042.	84077.	84112.	84147.	84183.	84218.
1084	84253.	84288.	84323.	84358.	84393.	84428.	84463.	84498.	84533.	84568.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED
2001 AREA-CAPACITY TABLES

THE AREA TABLE IS IN ACRES

THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1085	84604.	84639.	84674.	84709.	84744.	84779.	84814.	84849.	84884.	84919.
1086	84954.	84990.	85025.	85060.	85095.	85130.	85165.	85200.	85235.	85270.
1087	85305.	85340.	85376.	85411.	85446.	85481.	85516.	85551.	85586.	85621.
1088	85656.	85691.	85726.	85762.	85797.	85832.	85867.	85902.	85937.	85972.
1089	86007.	86042.	86077.	86112.	86148.	86183.	86218.	86253.	86288.	86323.
1090	86358.	86393.	86427.	86462.	86496.	86531.	86565.	86600.	86635.	86669.
1091	86704.	86738.	86773.	86807.	86842.	86876.	86911.	86946.	86980.	87015.
1092	87049.	87084.	87118.	87153.	87187.	87222.	87257.	87291.	87326.	87360.
1093	87395.	87429.	87464.	87499.	87533.	87568.	87602.	87637.	87671.	87706.
1094	87740.	87775.	87810.	87844.	87879.	87913.	87948.	87982.	88017.	88051.
1095	88086.	88121.	88155.	88190.	88224.	88259.	88293.	88328.	88362.	88397.
1096	88432.	88466.	88501.	88535.	88570.	88604.	88639.	88674.	88708.	88743.
1097	88777.	88812.	88846.	88881.	88915.	88950.	88985.	89019.	89054.	89088.
1098	89123.	89157.	89192.	89226.	89261.	89296.	89330.	89365.	89399.	89434.
1099	89468.	89503.	89538.	89572.	89607.	89641.	89676.	89710.	89745.	89779.
1100	89814.	89855.	89895.	89935.	89976.	90016.	90057.	90097.	90138.	90178.
1101	90219.	90259.	90300.	90340.	90380.	90421.	90461.	90502.	90542.	90583.
1102	90623.	90664.	90704.	90745.	90785.	90826.	90866.	90906.	90947.	90987.
1103	91028.	91068.	91109.	91149.	91190.	91230.	91271.	91311.	91352.	91392.
1104	91432.	91473.	91513.	91554.	91594.	91635.	91675.	91716.	91756.	91797.
1105	91837.	91878.	91918.	91958.	91999.	92039.	92080.	92120.	92161.	92201.
1106	92242.	92282.	92323.	92363.	92404.	92444.	92484.	92525.	92565.	92606.
1107	92646.	92687.	92727.	92768.	92808.	92849.	92889.	92929.	92970.	93010.
1108	93051.	93091.	93132.	93172.	93213.	93253.	93294.	93334.	93375.	93415.
1109	93455.	93496.	93536.	93577.	93617.	93658.	93698.	93739.	93779.	93820.
1110	93860.	93904.	93943.	93982.	94020.	94059.	94097.	94136.	94175.	94213.
1111	94252.	94291.	94329.	94368.	94407.	94445.	94484.	94523.	94561.	94600.
1112	94639.	94677.	94716.	94755.	94793.	94832.	94870.	94909.	94948.	94986.
1113	95025.	95064.	95102.	95141.	95180.	95218.	95257.	95296.	95334.	95373.
1114	95412.	95450.	95489.	95528.	95566.	95605.	95643.	95682.	95721.	95759.
1115	95798.	95837.	95875.	95914.	95953.	95991.	96030.	96069.	96107.	96146.
1116	96185.	96223.	96262.	96301.	96339.	96378.	96416.	96455.	96494.	96532.
1117	96571.	96610.	96648.	96687.	96726.	96764.	96803.	96842.	96880.	96919.
1118	96958.	96996.	97035.	97074.	97112.	97151.	97189.	97228.	97267.	97305.
1119	97344.	97383.	97421.	97460.	97499.	97537.	97576.	97615.	97653.	97692.
1120	97731.	97769.	97808.	97847.	97885.	97924.	97962.	98001.	98040.	98078.
1121	98117.	98156.	98194.	98233.	98272.	98310.	98349.	98388.	98426.	98465.
1122	98504.	98542.	98581.	98620.	98658.	98697.	98735.	98774.	98813.	98851.
1123	98890.	98929.	98967.	99006.	99045.	99083.	99122.	99161.	99199.	99238.
1124	99277.	99315.	99354.	99393.	99431.	99470.	99508.	99547.	99586.	99624.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED

2001 AREA-CAPACITY TABLES

THE AREA TABLE IS IN ACRES THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1125	99663.	99702.	99740.	99779.	99818.	99856.	99895.	99934.	99972.	100011.
1126	100050.	100088.	100127.	100166.	100204.	100243.	100281.	100320.	100359.	100397.
1127	100436.	100475.	100513.	100552.	100591.	100629.	100668.	100707.	100745.	100784.
1128	100823.	100861.	100900.	100939.	100977.	101016.	101054.	101093.	101132.	101170.
1129	101209.	101248.	101286.	101325.	101364.	101402.	101441.	101480.	101518.	101557.
1130	101596.	101632.	101675.	101717.	101759.	101802.	101844.	101886.	101929.	101971.
1131	102013.	102056.	102098.	102141.	102183.	102225.	102268.	102310.	102352.	102395.
1132	102437.	102479.	102522.	102564.	102606.	102649.	102691.	102733.	102776.	102818.
1133	102860.	102903.	102945.	102987.	103030.	103072.	103114.	103157.	103199.	103241.
1134	103284.	103326.	103368.	103411.	103453.	103495.	103538.	103580.	103622.	103665.
1135	103707.	103749.	103792.	103834.	103876.	103919.	103961.	104004.	104046.	104088.
1136	104131.	104173.	104215.	104258.	104300.	104342.	104385.	104427.	104469.	104512.
1137	104554.	104596.	104639.	104681.	104723.	104766.	104808.	104850.	104893.	104935.
1138	104977.	105020.	105062.	105104.	105147.	105189.	105231.	105274.	105316.	105358.
1139	105401.	105443.	105485.	105528.	105570.	105612.	105655.	105697.	105739.	105782.
1140	105824.	105876.	105929.	105981.	106033.	106086.	106138.	106190.	106243.	106295.
1141	106347.	106399.	106452.	106504.	106556.	106609.	106661.	106713.	106766.	106818.
1142	106870.	106923.	106975.	107027.	107080.	107132.	107184.	107237.	107289.	107341.
1143	107394.	107446.	107498.	107551.	107603.	107655.	107708.	107760.	107812.	107864.
1144	107917.	107969.	108021.	108074.	108126.	108178.	108231.	108283.	108335.	108388.
1145	108440.	108492.	108545.	108597.	108649.	108702.	108754.	108806.	108859.	108911.
1146	108963.	109016.	109068.	109120.	109173.	109225.	109277.	109329.	109382.	109434.
1147	109486.	109539.	109591.	109643.	109696.	109748.	109800.	109853.	109905.	109957.
1148	110010.	110062.	110114.	110167.	110219.	110271.	110324.	110376.	110428.	110481.
1149	110533.	110585.	110638.	110690.	110742.	110794.	110847.	110899.	110951.	111004.
1150	111056.	111101.	111148.	111194.	111240.	111286.	111333.	111379.	111425.	111471.
1151	111518.	111564.	111610.	111657.	111703.	111749.	111795.	111842.	111888.	111934.
1152	111981.	112027.	112073.	112119.	112166.	112212.	112258.	112304.	112351.	112397.
1153	112443.	112490.	112536.	112582.	112628.	112675.	112721.	112767.	112813.	112860.
1154	112906.	112952.	112999.	113045.	113091.	113137.	113184.	113230.	113276.	113323.
1155	113369.	113415.	113461.	113508.	113554.	113600.	113646.	113693.	113739.	113785.
1156	113832.	113878.	113924.	113970.	114017.	114063.	114109.	114156.	114202.	114248.
1157	114294.	114341.	114387.	114433.	114479.	114526.	114572.	114618.	114665.	114711.
1158	114757.	114803.	114850.	114896.	114942.	114988.	115035.	115081.	115127.	115174.
1159	115220.	115266.	115312.	115359.	115405.	115451.	115498.	115544.	115590.	115636.
1160	115683.	115729.	115775.	115821.	115868.	115914.	115960.	116007.	116053.	116099.
1161	116145.	116192.	116238.	116284.	116330.	116377.	116423.	116469.	116516.	116562.
1162	116608.	116654.	116701.	116747.	116793.	116840.	116886.	116932.	116978.	117025.
1163	117071.	117117.	117163.	117210.	117256.	117302.	117349.	117395.	117441.	117487.
1164	117534.	117580.	117626.	117673.	117719.	117765.	117811.	117858.	117904.	117950.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED

2001 AREA-CAPACITY TABLES

THE AREA TABLE IS IN ACRES THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1165	117996.	118043.	118089.	118135.	118182.	118228.	118274.	118320.	118367.	118413.
1166	118459.	118505.	118552.	118598.	118644.	118691.	118737.	118783.	118829.	118876.
1167	118922.	118968.	119015.	119061.	119107.	119153.	119200.	119246.	119292.	119338.
1168	119385.	119431.	119477.	119524.	119570.	119616.	119662.	119709.	119755.	119801.
1169	119848.	119894.	119940.	119986.	120033.	120079.	120125.	120171.	120218.	120264.
1170	120310.	120375.	120438.	120502.	120565.	120629.	120692.	120756.	120819.	120883.
1171	120946.	121010.	121073.	121137.	121200.	121264.	121328.	121391.	121455.	121518.
1172	121582.	121645.	121709.	121772.	121836.	121899.	121963.	122026.	122090.	122153.
1173	122217.	122280.	122344.	122407.	122471.	122535.	122598.	122662.	122725.	122789.
1174	122852.	122916.	122979.	123043.	123106.	123170.	123233.	123297.	123360.	123424.
1175	123487.	123551.	123614.	123678.	123742.	123805.	123869.	123932.	123996.	124059.
1176	124123.	124186.	124250.	124313.	124377.	124440.	124504.	124567.	124631.	124694.
1177	124758.	124821.	124885.	124948.	125012.	125076.	125139.	125203.	125266.	125330.
1178	125393.	125457.	125520.	125584.	125647.	125711.	125774.	125838.	125901.	125965.
1179	126028.	126092.	126155.	126219.	126283.	126346.	126410.	126473.	126537.	126600.
1180	126664.	126753.	126842.	126930.	127019.	127108.	127197.	127286.	127375.	127464.
1181	127553.	127642.	127731.	127820.	127908.	127997.	128086.	128175.	128264.	128353.
1182	128442.	128531.	128620.	128709.	128798.	128886.	128975.	129064.	129153.	129242.
1183	129331.	129420.	129509.	129598.	129687.	129776.	129865.	129953.	130042.	130131.
1184	130220.	130309.	130398.	130487.	130576.	130665.	130754.	130843.	130931.	131020.
1185	131109.	131198.	131287.	131376.	131465.	131554.	131643.	131732.	131821.	131909.
1186	131998.	132087.	132176.	132265.	132354.	132443.	132532.	132621.	132710.	132799.
1187	132888.	132976.	133065.	133154.	133243.	133332.	133421.	133510.	133599.	133688.
1188	133777.	133866.	133954.	134043.	134132.	134221.	134310.	134399.	134488.	134577.
1189	134666.	134755.	134844.	134932.	135021.	135110.	135199.	135288.	135377.	135466.
1190	135555.	135635.	135715.	135795.	135875.	135955.	136035.	136115.	136196.	136276.
1191	136356.	136436.	136516.	136596.	136676.	136756.	136836.	136916.	136996.	137076.
1192	137157.	137237.	137317.	137397.	137477.	137557.	137637.	137717.	137797.	137877.
1193	137957.	138037.	138118.	138198.	138278.	138358.	138438.	138518.	138598.	138678.
1194	138758.	138838.	138918.	138998.	139079.	139159.	139239.	139319.	139399.	139479.
1195	139559.	139639.	139719.	139799.	139879.	139960.	140040.	140120.	140200.	140280.
1196	140360.	140440.	140520.	140600.	140680.	140760.	140840.	140921.	141001.	141081.
1197	141161.	141241.	141321.	141401.	141481.	141561.	141641.	141721.	141801.	141882.
1198	141962.	142042.	142122.	142202.	142282.	142362.	142442.	142522.	142602.	142682.
1199	142762.	142843.	142923.	143003.	143083.	143163.	143243.	143323.	143403.	143483.
1200	143563.	143637.	143710.	143784.	143857.	143931.	144005.	144078.	144152.	144225.
1201	144299.	144372.	144446.	144519.	144593.	144667.	144740.	144814.	144887.	144961.
1202	145034.	145108.	145182.	145255.	145329.	145402.	145476.	145549.	145623.	145696.
1203	145770.	145844.	145917.	145991.	146064.	146138.	146211.	146285.	146358.	146432.
1204	146506.	146579.	146653.	146726.	146800.	146873.	146947.	147021.	147094.	147168.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED
2001 AREA-CAPACITY TABLES 10: 2:30

THE AREA TABLE IS IN ACRES THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1205	147241.	147315.	147388.	147462.	147535.	147609.	147683.	147756.	147830.	147903.
1206	147977.	148050.	148124.	148198.	148271.	148345.	148418.	148492.	148565.	148639.
1207	148712.	148786.	148860.	148933.	149007.	149080.	149154.	149227.	149301.	149374.
1208	149448.	149522.	149595.	149669.	149742.	149816.	149889.	149963.	150037.	150110.
1209	150184.	150257.	150331.	150404.	150478.	150551.	150625.	150699.	150772.	150846.
1210	150919.	150975.	151030.	151086.	151141.	151197.	151252.	151308.	151364.	151419.
1211	151475.	151530.	151586.	151641.	151697.	151752.	151808.	151863.	151919.	151974.
1212	152030.	152085.	152141.	152197.	152252.	152308.	152363.	152419.	152474.	152530.
1213	152585.	152641.	152696.	152752.	152807.	152863.	152918.	152974.	153030.	153085.
1214	153141.	153196.	153252.	153307.	153363.	153418.	153474.	153529.	153585.	153640.
1215	153696.	153751.	153807.	153863.	153918.	153974.	154029.	154085.	154140.	154196.
1216	154251.	154307.	154362.	154418.	154473.	154529.	154584.	154640.	154696.	154751.
1217	154807.	154862.	154918.	154973.	155029.	155084.	155140.	155195.	155251.	155306.
1218	155362.	155417.	155473.	155529.	155584.	155640.	155695.	155751.	155806.	155862.
1219	155917.	155973.	156028.	156084.	156139.	156195.	156250.	156306.	156362.	156417.
1220	156473.	156540.	156608.	156675.	156743.	156810.	156878.	156945.	157013.	157080.
1221	157148.	157215.	157283.	157350.	157418.	157485.	157553.	157620.	157688.	157755.
1222	157823.	157890.	157958.	158025.	158093.	158160.	158228.	158295.	158363.	158430.
1223	158498.	158565.	158633.	158700.	158768.	158836.	158903.	158971.	159038.	159106.
1224	159173.	159241.	159308.	159376.	159443.	159511.	159578.	159646.	159713.	159781.
1225	159848.	159916.	159983.	160051.	160118.	160186.	160253.	160321.	160388.	160456.
1226	160523.	160591.	160658.	160726.	160793.	160861.	160928.	160996.	161063.	161131.
1227	161198.	161266.	161333.	161401.	161468.	161536.	161603.	161671.	161738.	161806.
1228	161873.	161941.	162008.	162076.	162143.	162211.	162278.	162346.	162413.	162481.
1229	162548.	162616.	162683.	162751.	162818.	162886.	162953.	163021.	163088.	163156.
1230	163223.									

THE CAPACITY TABLE IS IN ACRE FEET

THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
689	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
690	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
691	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
692	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
693	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
694	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
695	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
696	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
697	1.	1.	1.	1.	2.	2.	2.	2.	2.	2.
698	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
699	2.	2.	2.	2.	2.	2.	2.	2.	2.	3.
700	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
701	3.	3.	3.	3.	4.	4.	4.	4.	4.	4.
702	4.	4.	4.	5.	5.	5.	5.	5.	5.	5.
703	6.	6.	6.	6.	6.	6.	7.	7.	7.	7.
704	7.	7.	8.	8.	8.	8.	8.	9.	9.	9.
705	9.	9.	10.	10.	10.	10.	11.	11.	11.	11.
706	12.	12.	12.	12.	13.	13.	13.	14.	14.	14.
707	14.	15.	15.	15.	16.	16.	16.	16.	17.	17.
708	17.	18.	18.	18.	19.	19.	19.	20.	20.	21.
709	21.	21.	22.	22.	22.	23.	23.	23.	24.	24.
710	25.	25.	26.	26.	27.	27.	28.	29.	29.	30.
711	31.	32.	33.	34.	35.	36.	37.	39.	40.	41.
712	43.	44.	45.	47.	48.	50.	52.	53.	55.	57.
713	59.	61.	63.	65.	67.	69.	71.	73.	76.	78.
714	80.	83.	85.	88.	90.	93.	96.	98.	101.	104.
715	107.	110.	113.	116.	119.	122.	125.	128.	131.	135.
716	138.	142.	145.	149.	152.	156.	159.	163.	167.	171.
717	175.	178.	182.	186.	190.	195.	199.	203.	207.	212.
718	216.	220.	225.	229.	234.	238.	243.	248.	253.	257.
719	262.	267.	272.	277.	282.	287.	293.	298.	303.	308.
720	314.	320.	327.	336.	346.	357.	369.	383.	398.	415.
721	432.	451.	472.	493.	516.	540.	566.	593.	621.	650.
722	681.	713.	746.	780.	816.	853.	892.	932.	973.	1015.
723	1059.	1103.	1150.	1197.	1246.	1296.	1347.	1400.	1454.	1509.
724	1566.	1624.	1683.	1744.	1805.	1868.	1933.	1998.	2065.	2134.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED
2001 AREA-CAPACITY TABLES 10: 2:30

THE CAPACITY TABLE IS IN ACRE FEET THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
725	2203.	2274.	2346.	2420.	2494.	2570.	2648.	2726.	2806.	2887.
726	2970.	3054.	3139.	3225.	3313.	3402.	3492.	3584.	3677.	3771.
727	3866.	3963.	4061.	4160.	4261.	4363.	4466.	4571.	4677.	4784.
728	4892.	5002.	5113.	5225.	5339.	5454.	5570.	5687.	5806.	5926.
729	6048.	6170.	6294.	6420.	6546.	6674.	6803.	6934.	7066.	7199.
730	7333.	7469.	7607.	7746.	7887.	8031.	8176.	8322.	8471.	8621.
731	8774.	8928.	9083.	9241.	9401.	9562.	9725.	9890.	10057.	10225.
732	10395.	10568.	10741.	10917.	11095.	11274.	11455.	11638.	11823.	12010.
733	12198.	12389.	12581.	12775.	12970.	13168.	13367.	13568.	13771.	13976.
734	14183.	14391.	14601.	14813.	15027.	15243.	15460.	15680.	15901.	16124.
735	16348.	16575.	16803.	17033.	17265.	17499.	17735.	17972.	18211.	18452.
736	18695.	18940.	19186.	19434.	19685.	19936.	20190.	20446.	20703.	20962.
737	21223.	21486.	21750.	22017.	22285.	22555.	22827.	23101.	23376.	23653.
738	23932.	24213.	24496.	24780.	25067.	25355.	25645.	25937.	26230.	26526.
739	26823.	27122.	27423.	27725.	28030.	28336.	28644.	28954.	29266.	29579.
740	29895.	30212.	30530.	30851.	31172.	31496.	31821.	32148.	32476.	32806.
741	33138.	33471.	33806.	34142.	34480.	34820.	35162.	35504.	35849.	36195.
742	36543.	36892.	37243.	37596.	37950.	38306.	38664.	39023.	39384.	39746.
743	40110.	40476.	40843.	41212.	41582.	41954.	42328.	42703.	43080.	43459.
744	43839.	44220.	44604.	44989.	45376.	45764.	46154.	46545.	46938.	47333.
745	47729.	48127.	48527.	48928.	49331.	49735.	50141.	50549.	50958.	51369.
746	51782.	52196.	52612.	53029.	53448.	53869.	54291.	54715.	55140.	55567.
747	55996.	56426.	56858.	57292.	57727.	58164.	58602.	59042.	59484.	59927.
748	60372.	60819.	61267.	61717.	62168.	62621.	63076.	63532.	63990.	64449.
749	64910.	65373.	65837.	66303.	66771.	67240.	67711.	68183.	68657.	69133.
750	69610.	70089.	70569.	71050.	71532.	72016.	72500.	72986.	73473.	73962.
751	74451.	74942.	75434.	75927.	76421.	76917.	77413.	77911.	78410.	78911.
752	79412.	79915.	80419.	80924.	81431.	81938.	82447.	82957.	83468.	83981.
753	84494.	85009.	85525.	86042.	86561.	87080.	87601.	88123.	88646.	89171.
754	89696.	90223.	90751.	91280.	91811.	92342.	92875.	93409.	93945.	94481.
755	95019.	95558.	96098.	96639.	97181.	97725.	98270.	98816.	99363.	99912.
756	100462.	101013.	101565.	102118.	102673.	103228.	103785.	104343.	104903.	105463.
757	106025.	106588.	107152.	107717.	108284.	108852.	109421.	109991.	110562.	111135.
758	111709.	112284.	112860.	113437.	114016.	114596.	115177.	115759.	116342.	116927.
759	117513.	118100.	118688.	119277.	119868.	120460.	121053.	121647.	122243.	122839.
760	123437.	124036.	124636.	125237.	125839.	126441.	127045.	127649.	128255.	128861.
761	129468.	130076.	130685.	131295.	131906.	132518.	133131.	133745.	134359.	134975.
762	135591.	136209.	136827.	137446.	138066.	138688.	139310.	139933.	140556.	141181.
763	141807.	142434.	143061.	143690.	144319.	144949.	145581.	146213.	146846.	147480.
764	148115.	148751.	149388.	150025.	150664.	151304.	151944.	152585.	153228.	153871.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED

2001 AREA-CAPACITY TABLES

THE CAPACITY TABLE IS IN ACRE FEET THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
765	154515.	155160.	155806.	156453.	157101.	157750.	158400.	159050.	159702.	160354.
766	161008.	161662.	162318.	162974.	163631.	164289.	164948.	165608.	166269.	166930.
767	167593.	168257.	168921.	169586.	170253.	170920.	171588.	172257.	172928.	173598.
768	174270.	174943.	175617.	176292.	176967.	177644.	178321.	179000.	179679.	180359.
769	181040.	181722.	182405.	183089.	183774.	184460.	185146.	185834.	186523.	187212.
770	187902.	188594.	189287.	189981.	190676.	191373.	192071.	192770.	193471.	194173.
771	194876.	195581.	196287.	196994.	197703.	198413.	199124.	199837.	200550.	201266.
772	201982.	202700.	203419.	204139.	204861.	205584.	206308.	207034.	207761.	208489.
773	209219.	209950.	210682.	211416.	212151.	212887.	213624.	214363.	215103.	215845.
774	216588.	217332.	218077.	218824.	219572.	220321.	221072.	221824.	222577.	223332.
775	224088.	224845.	225603.	226363.	227124.	227887.	228651.	229416.	230182.	230950.
776	231719.	232489.	233261.	234034.	234808.	235584.	236361.	237139.	237919.	238700.
777	239482.	240266.	241050.	241837.	242624.	243413.	244203.	244994.	245787.	246581.
778	247376.	248173.	248971.	249770.	250571.	251373.	252176.	252981.	253787.	254594.
779	255402.	256212.	257023.	257836.	258650.	259465.	260281.	261099.	261918.	262738.
780	263560.	264383.	265207.	266033.	266861.	267689.	268520.	269351.	270185.	271019.
781	271855.	272693.	273531.	274372.	275214.	276057.	276901.	277747.	278595.	279444.
782	280294.	281146.	282000.	282854.	283710.	284568.	285427.	286288.	287150.	288013.
783	288878.	289744.	290612.	291481.	292352.	293224.	294097.	294972.	295848.	296726.
784	297605.	298486.	299368.	300252.	301137.	302023.	302911.	303800.	304691.	305583.
785	306477.	307372.	308269.	309167.	310066.	310967.	311869.	312773.	313678.	314585.
786	315493.	316402.	317313.	318226.	319140.	320055.	320972.	321890.	322809.	323730.
787	324653.	325577.	326502.	327429.	328357.	329287.	330218.	331150.	332084.	333020.
788	333957.	334895.	335835.	336776.	337719.	338663.	339608.	340555.	341504.	342454.
789	343405.	344358.	345312.	346267.	347224.	348183.	349143.	350104.	351067.	352031.
790	352997.	353965.	354937.	355913.	356892.	357874.	358861.	359850.	360844.	361841.
791	362842.	363846.	364854.	365865.	366880.	367899.	368921.	369947.	370976.	372009.
792	373046.	374086.	375130.	376178.	377229.	378283.	379342.	380404.	381469.	382538.
793	383611.	384687.	385767.	386850.	387937.	389028.	390122.	391220.	392322.	393427.
794	394536.	395648.	396764.	397883.	399006.	400133.	401263.	402397.	403535.	404676.
795	405820.	406969.	408121.	409276.	410435.	411598.	412764.	413934.	415108.	416285.
796	417466.	418650.	419838.	421029.	422224.	423423.	424626.	425831.	427041.	428254.
797	429471.	430691.	431915.	433143.	434374.	435609.	436847.	438089.	439334.	440584.
798	441836.	443093.	444353.	445616.	446883.	448154.	449428.	450706.	451988.	453273.
799	454562.	455854.	457150.	458450.	459753.	461060.	462370.	463684.	465002.	466323.
800	467648.	468975.	470305.	471636.	472970.	474305.	475642.	476982.	478323.	479666.
801	481012.	482359.	483708.	485059.	486413.	487768.	489125.	490484.	491845.	493208.
802	494573.	495940.	497309.	498680.	500052.	501427.	502804.	504183.	505563.	506946.
803	508331.	509717.	511106.	512497.	513889.	515284.	516680.	518078.	519479.	520881.
804	522286.	523692.	525100.	526510.	527923.	529337.	530753.	532171.	533591.	535013.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED
2001 AREA-CAPACITY TABLES 10: 2:30

THE CAPACITY TABLE IS IN ACRE FEET THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
805	536437.	537863.	539291.	540721.	542153.	543587.	545023.	546461.	547900.	549342.
806	550786.	552232.	553679.	555129.	556581.	558034.	559490.	560947.	562407.	563868.
807	565331.	566797.	568264.	569733.	571205.	572678.	574153.	575630.	577110.	578591.
808	580074.	581559.	583046.	584535.	586026.	587519.	589014.	590511.	592009.	593510.
809	595013.	596518.	598024.	599533.	601044.	602556.	604071.	605588.	607106.	608627.
810	610149.	611674.	613200.	614728.	616258.	617790.	619323.	620859.	622396.	623935.
811	625476.	627019.	628564.	630111.	631659.	633209.	634762.	636316.	637871.	639429.
812	640989.	642550.	644113.	645679.	647246.	648814.	650385.	651958.	653532.	655108.
813	656686.	658266.	659848.	661432.	663017.	664605.	666194.	667785.	669378.	670973.
814	672569.	674168.	675768.	677370.	678974.	680580.	682188.	683798.	685409.	687022.
815	688638.	690255.	691874.	693494.	695117.	696741.	698367.	699996.	701626.	703257.
816	704891.	706527.	708164.	709803.	711444.	713087.	714732.	716379.	718027.	719678.
817	721330.	722984.	724640.	726298.	727957.	729619.	731282.	732947.	734614.	736283.
818	737954.	739626.	741301.	742977.	744655.	746335.	748017.	749701.	751386.	753074.
819	754763.	756454.	758147.	759842.	761539.	763237.	764938.	766640.	768344.	770050.
820	771758.	773467.	775178.	776891.	778606.	780322.	782039.	783759.	785480.	787202.
821	788927.	790652.	792380.	794109.	795840.	797572.	799306.	801042.	802780.	804519.
822	806259.	808001.	809745.	811491.	813238.	814987.	816737.	818489.	820243.	821998.
823	823755.	825514.	827274.	829036.	830800.	832565.	834332.	836100.	837870.	839642.
824	841415.	843190.	844967.	846745.	848525.	850307.	852090.	853875.	855661.	857449.
825	859239.	861030.	862823.	864618.	866414.	868212.	870012.	871813.	873616.	875420.
826	877226.	879034.	880843.	882654.	884467.	886281.	888097.	889915.	891734.	893555.
827	895377.	897201.	899027.	900854.	902683.	904514.	906346.	908180.	910016.	911853.
828	913692.	915532.	917374.	919218.	921063.	922910.	924759.	926609.	928461.	930315.
829	932170.	934027.	935885.	937745.	939607.	941470.	943335.	945202.	947070.	948940.
830	950812.	952685.	954560.	956437.	958316.	960196.	962079.	963963.	965849.	967737.
831	969627.	971518.	973412.	975307.	977204.	979103.	981004.	982907.	984811.	986717.
832	988626.	990536.	992447.	994361.	996276.	998194.	1000113.	1002034.	1003957.	1005881.
833	1007808.	1009736.	1011666.	1013598.	1015532.	1017467.	1019405.	1021344.	1023285.	1025228.
834	1027173.	1029120.	1031068.	1033018.	1034971.	1036925.	1038880.	1040838.	1042797.	1044759.
835	1046722.	1048687.	1050654.	1052622.	1054593.	1056565.	1058539.	1060515.	1062493.	1064473.
836	1066454.	1068437.	1070422.	1072409.	1074398.	1076389.	1078381.	1080376.	1082372.	1084370.
837	1086370.	1088371.	1090375.	1092380.	1094387.	1096396.	1098407.	1100419.	1102434.	1104450.
838	1106468.	1108488.	1110510.	1112534.	1114559.	1116587.	1118616.	1120647.	1122680.	1124714.
839	1126751.	1128789.	1130829.	1132871.	1134915.	1136961.	1139008.	1141057.	1143108.	1145161.
840	1147216.	1149273.	1151332.	1153392.	1155455.	1157520.	1159586.	1161655.	1163726.	1165798.
841	1167873.	1169949.	1172028.	1174108.	1176191.	1178275.	1180362.	1182450.	1184541.	1186633.
842	1188728.	1190824.	1192922.	1195023.	1197125.	1199229.	1201336.	1203444.	1205554.	1207666.
843	1209781.	1211897.	1214015.	1216135.	1218257.	1220382.	1222508.	1224636.	1226766.	1228898.
844	1231032.	1233168.	1235306.	1237446.	1239588.	1241732.	1243878.	1246026.	1248176.	1250328.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED
2001 AREA-CAPACITY TABLES 10: 2:30
THE CAPACITY TABLE IS IN ACRE FEET THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
845	1252482.	1254638.	1256795.	1258955.	1261117.	1263281.	1265447.	1267615.	1269784.	1271956.
846	1274130.	1276305.	1278483.	1280663.	1282844.	1285028.	1287214.	1289401.	1291591.	1293783.
847	1295976.	1298172.	1300369.	1302569.	1304770.	1306974.	1309179.	1311387.	1313596.	1315807.
848	1318021.	1320236.	1322453.	1324673.	1326894.	1329117.	1331343.	1333570.	1335799.	1338031.
849	1340264.	1342499.	1344736.	1346975.	1349216.	1351460.	1353705.	1355952.	1358201.	1360452.
850	1362705.	1364960.	1367217.	1369475.	1371735.	1373997.	1376261.	1378526.	1380794.	1383063.
851	1385333.	1387606.	1389880.	1392156.	1394434.	1396713.	1398994.	1401278.	1403562.	1405849.
852	1408137.	1410427.	1412719.	1415012.	1417308.	1419605.	1421904.	1424204.	1426506.	1428810.
853	1431116.	1433424.	1435733.	1438044.	1440357.	1442672.	1444988.	1447306.	1449626.	1451948.
854	1454271.	1456596.	1458923.	1461252.	1463582.	1465914.	1468248.	1470584.	1472921.	1475261.
855	1477602.	1479944.	1482289.	1484635.	1486983.	1489332.	1491684.	1494037.	1496392.	1498749.
856	1501107.	1503468.	1505830.	1508193.	1510559.	1512926.	1515295.	1517666.	1520038.	1522413.
857	1524789.	1527167.	1529546.	1531927.	1534311.	1536695.	1539082.	1541470.	1543860.	1546252.
858	1548646.	1551041.	1553438.	1555837.	1558238.	1560640.	1563044.	1565450.	1567858.	1570267.
859	1572678.	1575091.	1577506.	1579922.	1582340.	1584760.	1587182.	1589606.	1592031.	1594458.
860	1596886.	1599317.	1601749.	1604182.	1606617.	1609054.	1611492.	1613932.	1616374.	1618817.
861	1621261.	1623707.	1626155.	1628604.	1631055.	1633508.	1635962.	1638418.	1640875.	1643334.
862	1645794.	1648256.	1650720.	1653185.	1655652.	1658120.	1660590.	1663061.	1665534.	1668009.
863	1670485.	1672963.	1675442.	1677923.	1680406.	1682890.	1685376.	1687863.	1690352.	1692842.
864	1695334.	1697828.	1700323.	1702820.	1705318.	1707818.	1710320.	1712823.	1715328.	1717834.
865	1720342.	1722851.	1725362.	1727875.	1730389.	1732905.	1735422.	1737941.	1740462.	1742984.
866	1745507.	1748032.	1750559.	1753088.	1755618.	1758149.	1760682.	1763217.	1765753.	1768291.
867	1770831.	1773372.	1775914.	1778459.	1781004.	1783552.	1786101.	1788651.	1791203.	1793757.
868	1796312.	1798869.	1801428.	1803988.	1806549.	1809113.	1811677.	1814244.	1816812.	1819381.
869	1821952.	1824525.	1827099.	1829675.	1832252.	1834831.	1837412.	1839994.	1842578.	1845163.
870	1847750.	1850339.	1852929.	1855520.	1858114.	1860709.	1863306.	1865904.	1868504.	1871105.
871	1873708.	1876313.	1878920.	1881528.	1884137.	1886748.	1889361.	1891976.	1894592.	1897210.
872	1899829.	1902450.	1905073.	1907697.	1910323.	1912951.	1915580.	1918211.	1920843.	1923477.
873	1926113.	1928750.	1931389.	1934030.	1936672.	1939316.	1941961.	1944608.	1947257.	1949907.
874	1952559.	1955212.	1957868.	1960524.	1963183.	1965843.	1968505.	1971168.	1973833.	1976500.
875	1979168.	1981838.	1984509.	1987182.	1989857.	1992533.	1995211.	1997891.	2000572.	2003255.
876	2005939.	2008625.	2011313.	2014002.	2016693.	2019386.	2022080.	2024776.	2027473.	2030172.
877	2032873.	2035575.	2038279.	2040985.	2043692.	2046401.	2049112.	2051824.	2054538.	2057253.
878	2059970.	2062688.	2065409.	2068130.	2070854.	2073579.	2076306.	2079034.	2081764.	2084496.
879	2087229.	2089964.	2092700.	2095439.	2098178.	2100920.	2103663.	2106407.	2109154.	2111901.
880	2114651.	2117402.	2120155.	2122909.	2125666.	2128424.	2131183.	2133944.	2136707.	2139472.
881	2142238.	2145007.	2147776.	2150548.	2153321.	2156096.	2158872.	2161650.	2164430.	2167212.
882	2169995.	2172780.	2175566.	2178355.	2181145.	2183936.	2186730.	2189525.	2192322.	2195120.
883	2197920.	2200722.	2203525.	2206331.	2209138.	2211946.	2214756.	2217568.	2220382.	2223197.
884	2226014.	2228833.	2231653.	2234475.	2237299.	2240125.	2242952.	2245781.	2248611.	2251443.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED
2001 AREA-CAPACITY TABLES 10: 2:30

THE CAPACITY TABLE IS IN ACRE FEET THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
885	2254277.	2257113.	2259950.	2262789.	2265630.	2268472.	2271316.	2274162.	2277009.	2279858.
886	2282709.	2285561.	2288415.	2291271.	2294129.	2296988.	2299849.	2302711.	2305576.	2308442.
887	2311309.	2314179.	2317050.	2319922.	2322797.	2325673.	2328551.	2331430.	2334311.	2337194.
888	2340079.	2342965.	2345853.	2348742.	2351634.	2354527.	2357421.	2360318.	2363216.	2366115.
889	2369017.	2371920.	2374825.	2377731.	2380639.	2383549.	2386461.	2389374.	2392289.	2395206.
890	2398124.	2401044.	2403966.	2406890.	2409816.	2412744.	2415674.	2418606.	2421540.	2424476.
891	2427413.	2430353.	2433295.	2436238.	2439184.	2442132.	2445081.	2448033.	2450986.	2453941.
892	2456899.	2459858.	2462820.	2465783.	2468748.	2471715.	2474684.	2477655.	2480629.	2483604.
893	2486581.	2489559.	2492540.	2495523.	2498508.	2501495.	2504484.	2507474.	2510467.	2513462.
894	2516458.	2519457.	2522457.	2525460.	2528464.	2531471.	2534479.	2537489.	2540502.	2543516.
895	2546532.	2549550.	2552570.	2555593.	2558617.	2561643.	2564671.	2567701.	2570732.	2573766.
896	2576802.	2579840.	2582880.	2585921.	2588965.	2592011.	2595058.	2598108.	2601159.	2604213.
897	2607268.	2610326.	2613385.	2616446.	2619509.	2622575.	2625642.	2628711.	2631782.	2634855.
898	2637930.	2641007.	2644086.	2647167.	2650250.	2653335.	2656422.	2659511.	2662601.	2665694.
899	2668789.	2671885.	2674984.	2678084.	2681187.	2684291.	2687398.	2690506.	2693616.	2696729.
900	2699843.	2702959.	2706078.	2709199.	2712323.	2715449.	2718578.	2721709.	2724842.	2727978.
901	2731116.	2734256.	2737399.	2740545.	2743693.	2746843.	2749996.	2753151.	2756308.	2759468.
902	2762630.	2765795.	2768962.	2772132.	2775303.	2778478.	2781655.	2784834.	2788015.	2791199.
903	2794386.	2797575.	2800766.	2803959.	2807155.	2810354.	2813555.	2816758.	2819964.	2823172.
904	2826383.	2829595.	2832811.	2836028.	2839249.	2842471.	2845696.	2848924.	2852153.	2855386.
905	2858620.	2861857.	2865097.	2868339.	2871583.	2874830.	2878079.	2881330.	2884584.	2887841.
906	2891100.	2894361.	2897624.	2900890.	2904159.	2907430.	2910703.	2913978.	2917257.	2920537.
907	2923820.	2927105.	2930393.	2933683.	2936975.	2940271.	2943568.	2946868.	2950170.	2953475.
908	2956782.	2960091.	2963403.	2966717.	2970034.	2973353.	2976674.	2979998.	2983324.	2986653.
909	2989984.	2993318.	2996654.	2999992.	3003333.	3006676.	3010022.	3013370.	3016720.	3020073.
910	3023428.	3026786.	3030146.	3033508.	3036873.	3040240.	3043610.	3046981.	3050356.	3053732.
911	3057111.	3060492.	3063876.	3067262.	3070650.	3074041.	3077434.	3080829.	3084227.	3087627.
912	3091029.	3094434.	3097841.	3101251.	3104663.	3108077.	3111493.	3114912.	3118334.	3121757.
913	3125183.	3128612.	3132042.	3135475.	3138911.	3142349.	3145789.	3149231.	3152676.	3156124.
914	3159573.	3163025.	3166479.	3169936.	3173395.	3176856.	3180320.	3183786.	3187255.	3190725.
915	3194199.	3197674.	3201152.	3204632.	3208115.	3211600.	3215087.	3218577.	3222069.	3225563.
916	3229060.	3232559.	3236061.	3239564.	3243071.	3246579.	3250090.	3253603.	3257119.	3260637.
917	3264157.	3267679.	3271205.	3274732.	3278262.	3281794.	3285328.	3288865.	3292404.	3295946.
918	3299490.	3303036.	3306585.	3310135.	3313689.	3317245.	3320803.	3324363.	3327926.	3331491.
919	3335058.	3338628.	3342200.	3345775.	3349352.	3352931.	3356513.	3360097.	3363683.	3367271.
920	3370863.	3374456.	3378052.	3381650.	3385250.	3388852.	3392457.	3396064.	3399673.	3403285.
921	3406899.	3410515.	3414133.	3417754.	3421377.	3425003.	3428630.	3432260.	3435892.	3439527.
922	3443163.	3446802.	3450443.	3454087.	3457733.	3461381.	3465031.	3468684.	3472339.	3475996.
923	3479655.	3483317.	3486982.	3490648.	3494317.	3497987.	3501661.	3505336.	3509014.	3512694.
924	3516376.	3520061.	3523748.	3527437.	3531128.	3534822.	3538518.	3542216.	3545917.	3549620.

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2001 AREA-CAPACITY TABLES 10: 2:30

THE CAPACITY TABLE IS IN ACRE FEET THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
925	3553325.	3557032.	3560742.	3564454.	3568168.	3571885.	3575604.	3579325.	3583048.	3586774.
926	3590502.	3594232.	3597965.	3601699.	3605436.	3609176.	3612917.	3616661.	3620407.	3624156.
927	3627907.	3631660.	3635415.	3639173.	3642933.	3646695.	3650459.	3654226.	3657995.	3661767.
928	3665540.	3669316.	3673094.	3676874.	3680657.	3684442.	3688229.	3692019.	3695811.	3699605.
929	3703401.	3707199.	3711001.	3714804.	3718609.	3722417.	3726227.	3730039.	3733854.	3737671.
930	3741490.	3745312.	3749135.	3752962.	3756791.	3760621.	3764454.	3768290.	3772127.	3775967.
931	3779810.	3783655.	3787502.	3791351.	3795203.	3799057.	3802913.	3806772.	3810633.	3814496.
932	3818362.	3822230.	3826100.	3829973.	3833847.	3837725.	3841604.	3845487.	3849370.	3853257.
933	3857146.	3861037.	3864931.	3868826.	3872725.	3876625.	3880528.	3884433.	3888340.	3892250.
934	3896162.	3900077.	3903994.	3907913.	3911834.	3915758.	3919684.	3923612.	3927543.	3931476.
935	3935411.	3939349.	3943289.	3947231.	3951175.	3955123.	3959072.	3963023.	3966977.	3970934.
936	3974892.	3978853.	3982816.	3986782.	3990750.	3994720.	3998692.	4002667.	4006644.	4010624.
937	4014606.	4018590.	4022576.	4026565.	4030556.	4034550.	4038545.	4042543.	4046543.	4050546.
938	4054551.	4058559.	4062568.	4066580.	4070595.	4074611.	4078631.	4082652.	4086675.	4090701.
939	4094730.	4098760.	4102793.	4106828.	4110866.	4114906.	4118948.	4122992.	4127039.	4131088.
940	4135140.	4139194.	4143250.	4147308.	4151369.	4155432.	4159498.	4163566.	4167636.	4171709.
941	4175783.	4179861.	4183940.	4188023.	4192107.	4196193.	4200282.	4204374.	4208467.	4212563.
942	4216662.	4220762.	4224865.	4228971.	4233078.	4237188.	4241301.	4245415.	4249533.	4253652.
943	4257774.	4261898.	4266024.	4270153.	4274284.	4278418.	4282553.	4286692.	4290832.	4294975.
944	4299120.	4303268.	4307417.	4311570.	4315724.	4319881.	4324040.	4328202.	4332366.	4336532.
945	4340701.	4344872.	4349045.	4353221.	4357399.	4361579.	4365762.	4369947.	4374134.	4378324.
946	4382516.	4386710.	4390907.	4395106.	4399307.	4403511.	4407717.	4411925.	4416136.	4420349.
947	4424565.	4428782.	4433003.	4437225.	4441450.	4445677.	4449907.	4454138.	4458373.	4462609.
948	4466848.	4471089.	4475333.	4479579.	4483827.	4488077.	4492330.	4496586.	4500843.	4505103.
949	4509366.	4513630.	4517897.	4522166.	4526438.	4530712.	4534988.	4539267.	4543548.	4547832.
950	4552117.	4556405.	4560696.	4564990.	4569286.	4573584.	4577885.	4582189.	4586495.	4590804.
951	4595116.	4599430.	4603747.	4608066.	4612388.	4616712.	4621039.	4625369.	4629701.	4634036.
952	4638374.	4642714.	4647056.	4651401.	4655749.	4660100.	4664453.	4668808.	4673166.	4677527.
953	4681890.	4686256.	4690625.	4694996.	4699370.	4703746.	4708125.	4712507.	4716891.	4721277.
954	4725667.	4730058.	4734453.	4738850.	4743250.	4747652.	4752057.	4756464.	4760874.	4765287.
955	4769702.	4774120.	4778540.	4782963.	4787389.	4791817.	4796247.	4800681.	4805117.	4809555.
956	4813996.	4818440.	4822886.	4827335.	4831787.	4836241.	4840698.	4845157.	4849619.	4854083.
957	4858550.	4863020.	4867492.	4871967.	4876444.	4880924.	4885407.	4889892.	4894380.	4898870.
958	4903363.	4907859.	4912357.	4916857.	4921361.	4925867.	4930375.	4934886.	4939400.	4943916.
959	4948435.	4952957.	4957481.	4962007.	4966537.	4971068.	4975603.	4980140.	4984680.	4989222.
960	4993767.	4998314.	5002864.	5007416.	5011970.	5016527.	5021086.	5025648.	5030212.	5034778.
961	5039347.	5043918.	5048492.	5053068.	5057646.	5062227.	5066810.	5071395.	5075983.	5080573.
962	5085166.	5089761.	5094358.	5098958.	5103560.	5108165.	5112772.	5117381.	5121993.	5126607.
963	5131223.	5135842.	5140463.	5145087.	5149713.	5154341.	5158972.	5163605.	5168241.	5172879.
964	5177519.	5182162.	5186807.	5191454.	5196104.	5200757.	5205411.	5210068.	5214728.	5219389.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED
2001 AREA-CAPACITY TABLES 10: 2:30

THE CAPACITY TABLE IS IN ACRE FEET THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
965	5224054.	5228720.	5233389.	5238060.	5242734.	5247410.	5252089.	5256770.	5261453.	5266139.
966	5270827.	5275517.	5280210.	5284905.	5289603.	5294303.	5299005.	5303710.	5308417.	5313126.
967	5317838.	5322553.	5327269.	5331988.	5336710.	5341433.	5346160.	5350888.	5355619.	5360353.
968	5365088.	5369827.	5374567.	5379310.	5384055.	5388803.	5393554.	5398306.	5403060.	5407818.
969	5412578.	5417339.	5422103.	5426870.	5431639.	5436410.	5441185.	5445961.	5450739.	5455521.
970	5460304.	5465090.	5469879.	5474670.	5479464.	5484261.	5489060.	5493862.	5498667.	5503475.
971	5508285.	5513098.	5517913.	5522731.	5527552.	5532375.	5537202.	5542030.	5546862.	5551696.
972	5556533.	5561373.	5566215.	5571059.	5575907.	5580758.	5585610.	5590466.	5595325.	5600186.
973	5605049.	5609916.	5614785.	5619656.	5624531.	5629408.	5634288.	5639170.	5644055.	5648943.
974	5653833.	5658726.	5663622.	5668521.	5673422.	5678326.	5683232.	5688141.	5693053.	5697968.
975	5702885.	5707805.	5712728.	5717653.	5722581.	5727511.	5732445.	5737381.	5742319.	5747261.
976	5752205.	5757151.	5762101.	5767053.	5772008.	5776965.	5781925.	5786888.	5791853.	5796821.
977	5801792.	5806766.	5811742.	5816721.	5821702.	5826686.	5831673.	5836663.	5841655.	5846650.
978	5851647.	5856648.	5861651.	5866656.	5871665.	5876675.	5881689.	5886706.	5891725.	5896746.
979	5901770.	5906798.	5911827.	5916860.	5921895.	5926933.	5931973.	5937017.	5942062.	5947110.
980	5952162.	5957215.	5962272.	5967332.	5972395.	5977461.	5982530.	5987602.	5992677.	5997754.
981	6002835.	6007920.	6013007.	6018096.	6023189.	6028285.	6033384.	6038486.	6043591.	6048698.
982	6053810.	6058923.	6064040.	6069160.	6074282.	6079409.	6084537.	6089669.	6094804.	6099942.
983	6105082.	6110226.	6115373.	6120522.	6125676.	6130831.	6135990.	6141152.	6146316.	6151484.
984	6156655.	6161829.	6167005.	6172185.	6177368.	6182553.	6187742.	6192934.	6198128.	6203326.
985	6208526.	6213730.	6218937.	6224146.	6229359.	6234574.	6239794.	6245015.	6250239.	6255466.
986	6260697.	6265930.	6271167.	6276407.	6281650.	6286895.	6292143.	6297395.	6302649.	6307907.
987	6313167.	6318431.	6323698.	6328967.	6334239.	6339514.	6344793.	6350074.	6355359.	6360646.
988	6365937.	6371230.	6376527.	6381826.	6387129.	6392434.	6397742.	6403054.	6408368.	6413685.
989	6419006.	6424329.	6429655.	6434985.	6440317.	6445652.	6450990.	6456332.	6461676.	6467023.
990	6472374.	6477727.	6483082.	6488442.	6493804.	6499168.	6504536.	6509906.	6515279.	6520655.
991	6526034.	6531416.	6536801.	6542188.	6547578.	6552972.	6558368.	6563766.	6569168.	6574573.
992	6579980.	6585391.	6590803.	6596220.	6601639.	6607060.	6612485.	6617913.	6623343.	6628776.
993	6634212.	6639651.	6645093.	6650537.	6655985.	6661435.	6666888.	6672345.	6677803.	6683265.
994	6688730.	6694197.	6699667.	6705140.	6710617.	6716095.	6721577.	6727062.	6732549.	6738039.
995	6743533.	6749029.	6754528.	6760029.	6765534.	6771042.	6776552.	6782065.	6787581.	6793100.
996	6798621.	6804146.	6809673.	6815203.	6820737.	6826273.	6831811.	6837354.	6842898.	6848446.
997	6853996.	6859549.	6865106.	6870664.	6876226.	6881790.	6887358.	6892928.	6898501.	6904077.
998	6909657.	6915238.	6920822.	6926410.	6932000.	6937593.	6943189.	6948788.	6954390.	6959994.
999	6965602.	6971212.	6976825.	6982441.	6988060.	6993682.	6999306.	7004934.	7010564.	7016197.
1000	7021833.	7027472.	7033114.	7038760.	7044408.	7050059.	7055714.	7061371.	7067032.	7072696.
1001	7078362.	7084033.	7089706.	7095382.	7101061.	7106744.	7112429.	7118118.	7123810.	7129504.
1002	7135202.	7140903.	7146607.	7152314.	7158025.	7163738.	7169455.	7175174.	7180897.	7186623.
1003	7192352.	7198083.	7203818.	7209557.	7215298.	7221043.	7226790.	7232541.	7238295.	7244051.
1004	7249811.	7255574.	7261341.	7267110.	7272882.	7278658.	7284436.	7290218.	7296002.	7301790.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED
2001 AREA-CAPACITY TABLES 10: 2:30
THE CAPACITY TABLE IS IN ACRE FEET THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1005	7307581.	7313375.	7319172.	7324973.	7330777.	7336582.	7342393.	7348205.	7354020.	7359839.
1006	7365661.	7371486.	7377314.	7383146.	7388980.	7394818.	7400658.	7406502.	7412348.	7418198.
1007	7424051.	7429907.	7435766.	7441629.	7447494.	7453363.	7459234.	7465109.	7470986.	7476867.
1008	7482751.	7488639.	7494529.	7500422.	7506318.	7512218.	7518120.	7524026.	7529935.	7535847.
1009	7541762.	7547680.	7553602.	7559525.	7565453.	7571383.	7577317.	7583253.	7589193.	7595136.
1010	7601082.	7607031.	7612983.	7618938.	7624897.	7630858.	7636823.	7642790.	7648761.	7654734.
1011	7660711.	7666690.	7672673.	7678659.	7684648.	7690639.	7696634.	7702632.	7708633.	7714638.
1012	7720645.	7726655.	7732668.	7738685.	7744704.	7750726.	7756752.	7762781.	7768812.	7774847.
1013	7780885.	7786925.	7792969.	7799016.	7805066.	7811119.	7817175.	7823234.	7829297.	7835362.
1014	7841430.	7847502.	7853576.	7859654.	7865734.	7871818.	7877904.	7883994.	7890087.	7896183.
1015	7902282.	7908384.	7914489.	7920597.	7926707.	7932822.	7938939.	7945059.	7951183.	7957309.
1016	7963439.	7969571.	7975707.	7981846.	7987987.	7994132.	8000280.	8006431.	8012585.	8018742.
1017	8024902.	8031065.	8037231.	8043400.	8049573.	8055748.	8061926.	8068108.	8074292.	8080480.
1018	8086671.	8092864.	8099061.	8105261.	8111464.	8117670.	8123879.	8130090.	8136306.	8142524.
1019	8148745.	8154969.	8161197.	8167427.	8173661.	8179897.	8186137.	8192379.	8198625.	8204874.
1020	8211125.	8217380.	8223638.	8229899.	8236163.	8242430.	8248701.	8254974.	8261251.	8267530.
1021	8273813.	8280099.	8286387.	8292680.	8298975.	8305273.	8311574.	8317878.	8324186.	8330496.
1022	8336810.	8343126.	8349446.	8355769.	8362095.	8368424.	8374756.	8381091.	8387430.	8393771.
1023	8400115.	8406463.	8412814.	8419167.	8425524.	8431884.	8438247.	8444613.	8450982.	8457355.
1024	8463730.	8470109.	8476490.	8482875.	8489263.	8495653.	8502047.	8508444.	8514844.	8521248.
1025	8527654.	8534063.	8540476.	8546891.	8553310.	8559732.	8566157.	8572585.	8579016.	8585450.
1026	8591887.	8598327.	8604771.	8611217.	8617667.	8624119.	8630575.	8637034.	8643496.	8649961.
1027	8656429.	8662900.	8669374.	8675852.	8682332.	8688816.	8695302.	8701792.	8708285.	8714781.
1028	8721280.	8727782.	8734287.	8740795.	8747307.	8753821.	8760339.	8766859.	8773383.	8779910.
1029	8786440.	8792973.	8799509.	8806048.	8812590.	8819136.	8825684.	8832236.	8838790.	8845348.
1030	8851909.	8858473.	8865040.	8871611.	8878184.	8884761.	8891341.	8897924.	8904511.	8911100.
1031	8917693.	8924289.	8930889.	8937491.	8944097.	8950706.	8957318.	8963933.	8970552.	8977173.
1032	8983798.	8990427.	8997058.	9003693.	9010330.	9016971.	9023616.	9030263.	9036914.	9043568.
1033	9050225.	9056885.	9063548.	9070215.	9076885.	9083558.	9090234.	9096914.	9103597.	9110283.
1034	9116972.	9123664.	9130360.	9137059.	9143761.	9150466.	9157174.	9163886.	9170601.	9177319.
1035	9184040.	9190765.	9197492.	9204223.	9210957.	9217695.	9224435.	9231179.	9237926.	9244676.
1036	9251429.	9258186.	9264946.	9271709.	9278475.	9285245.	9292017.	9298793.	9305572.	9312354.
1037	9319140.	9325929.	9332720.	9339516.	9346314.	9353115.	9359920.	9366728.	9373539.	9380354.
1038	9387171.	9393992.	9400816.	9407643.	9414474.	9421307.	9428144.	9434984.	9441828.	9448674.
1039	9455524.	9462377.	9469233.	9476092.	9482955.	9489820.	9496689.	9503561.	9510437.	9517315.
1040	9524197.	9531082.	9537971.	9544862.	9551758.	9558656.	9565558.	9572463.	9579372.	9586284.
1041	9593200.	9600119.	9607041.	9613966.	9620895.	9627828.	9634763.	9641702.	9648645.	9655591.
1042	9662540.	9669492.	9676448.	9683408.	9690370.	9697336.	9704306.	9711279.	9718255.	9725234.
1043	9732217.	9739204.	9746193.	9753186.	9760183.	9767183.	9774186.	9781192.	9788202.	9795215.
1044	9802232.	9809252.	9816276.	9823302.	9830333.	9837366.	9844403.	9851443.	9858487.	9865534.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED
2001 AREA-CAPACITY TABLES 10: 2:30

THE CAPACITY TABLE IS IN ACRE FEET THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1045	9872584.	9879638.	9886695.	9893756.	9900820.	9907887.	9914958.	9922032.	9929109.	9936190.
1046	9943274.	9950362.	9957453.	9964547.	9971644.	9978745.	9985850.	9992958.	10000070.	10007180.
1047	10014300.	10021420.	10028550.	10035680.	10042810.	10049940.	10057080.	10064220.	10071370.	10078510.
1048	10085670.	10092820.	10099980.	10107140.	10114310.	10121470.	10128650.	10135820.	10143000.	10150180.
1049	10157370.	10164560.	10171750.	10178940.	10186140.	10193350.	10200550.	10207760.	10214970.	10222190.
1050	10229410.	10236620.	10243850.	10251080.	10258310.	10265550.	10272790.	10280040.	10287280.	10294540.
1051	10301790.	10309050.	10316310.	10323580.	10330850.	10338120.	10345400.	10352680.	10359970.	10367260.
1052	10374550.	10381840.	10389140.	10396440.	10403750.	10411060.	10418370.	10425690.	10433010.	10440340.
1053	10447660.	10455000.	10462330.	10469670.	10477010.	10484360.	10491710.	10499060.	10506420.	10513780.
1054	10521140.	10528510.	10535880.	10543260.	10550640.	10558020.	10565410.	10572790.	10580190.	10587580.
1055	10594990.	10602390.	10609800.	10617210.	10624620.	10632040.	10639460.	10646890.	10654320.	10661750.
1056	10669190.	10676630.	10684070.	10691520.	10698970.	10706430.	10713880.	10721350.	10728810.	10736280.
1057	10743750.	10751230.	10758710.	10766190.	10773680.	10781170.	10788670.	10796160.	10803670.	10811170.
1058	10818680.	10826190.	10833710.	10841230.	10848750.	10856280.	10863810.	10871350.	10878880.	10886420.
1059	10893970.	10901520.	10909070.	10916630.	10924190.	10931750.	10939320.	10946890.	10954460.	10962040.
1060	10969620.	10977200.	10984790.	10992390.	10999980.	11007580.	11015180.	11022790.	11030400.	11038020.
1061	11045630.	11053250.	11060880.	11068510.	11076140.	11083780.	11091420.	11099060.	11106700.	11114350.
1062	11122010.	11129670.	11137330.	11144990.	11152660.	11160330.	11168010.	11175690.	11183370.	11191060.
1063	11198750.	11206440.	11214140.	11221840.	11229540.	11237250.	11244960.	11252680.	11260400.	11268120.
1064	11275840.	11283570.	11291310.	11299040.	11306780.	11314530.	11322280.	11330030.	11337780.	11345540.
1065	11353300.	11361070.	11368840.	11376610.	11384390.	11392170.	11399950.	11407740.	11415530.	11423330.
1066	11431130.	11438930.	11446740.	11454540.	11462360.	11470170.	11477990.	11485820.	11493650.	11501480.
1067	11509310.	11517150.	11524990.	11532840.	11540690.	11548540.	11556400.	11564260.	11572120.	11579990.
1068	11587860.	11595730.	11603610.	11611490.	11619380.	11627270.	11635160.	11643060.	11650960.	11658860.
1069	11666770.	11674680.	11682590.	11690510.	11698430.	11706360.	11714290.	11722220.	11730150.	11738090.
1070	11746040.	11753970.	11761920.	11769880.	11777830.	11785800.	11793760.	11801720.	11809690.	11817670.
1071	11825650.	11833630.	11841610.	11849600.	11857590.	11865580.	11873580.	11881580.	11889580.	11897590.
1072	11905600.	11913620.	11921640.	11929660.	11937680.	11945710.	11953740.	11961780.	11969810.	11977850.
1073	11985900.	11993950.	12002000.	12010050.	12018120.	12026180.	12034240.	12042310.	12050380.	12058460.
1074	12066540.	12074620.	12082710.	12090800.	12098890.	12106980.	12115080.	12123190.	12131290.	12139400.
1075	12147520.	12155630.	12163750.	12171880.	12180000.	12188130.	12196270.	12204400.	12212540.	12220690.
1076	12228830.	12236980.	12245140.	12253300.	12261460.	12269620.	12277790.	12285960.	12294130.	12302310.
1077	12310490.	12318680.	12326860.	12335060.	12343250.	12351450.	12359650.	12367860.	12376060.	12384280.
1078	12392490.	12400710.	12408930.	12417160.	12425390.	12433620.	12441850.	12450090.	12458330.	12466580.
1079	12474830.	12483080.	12491340.	12499600.	12507860.	12516130.	12524400.	12532670.	12540950.	12549230.
1080	12557510.	12565800.	12574090.	12582380.	12590680.	12598980.	12607280.	12615590.	12623900.	12632210.
1081	12640530.	12648850.	12657180.	12665510.	12673840.	12682180.	12690520.	12698860.	12707210.	12715560.
1082	12723910.	12732270.	12740630.	12748990.	12757360.	12765730.	12774100.	12782480.	12790860.	12799250.
1083	12807630.	12816030.	12824420.	12832820.	12841220.	12849630.	12858040.	12866450.	12874870.	12883290.
1084	12891710.	12900140.	12908570.	12917000.	12925440.	12933880.	12942330.	12950770.	12959230.	12967680.

THE CAPACITY TABLE IS IN ACRE FEET THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1085	12976140.	12984600.	12993070.	13001540.	13010010.	13018480.	13026960.	13035450.	13043940.	13052430.
1086	13060920.	13069420.	13077920.	13086420.	13094930.	13103440.	13111960.	13120470.	13129000.	13137520.
1087	13146050.	13154580.	13163120.	13171660.	13180200.	13188750.	13197300.	13205850.	13214410.	13222970.
1088	13231530.	13240100.	13248670.	13257240.	13265820.	13274400.	13282990.	13291580.	13300170.	13308760.
1089	13317360.	13325960.	13334570.	13343180.	13351790.	13360410.	13369030.	13377650.	13386280.	13394910.
1090	13403540.	13412180.	13420820.	13429470.	13438120.	13446770.	13455420.	13464080.	13472740.	13481410.
1091	13490080.	13498750.	13507420.	13516100.	13524790.	13533470.	13542160.	13550850.	13559550.	13568250.
1092	13576950.	13585660.	13594370.	13603080.	13611800.	13620520.	13629240.	13637970.	13646700.	13655440.
1093	13664170.	13672910.	13681660.	13690410.	13699160.	13707910.	13716670.	13725430.	13734200.	13742970.
1094	13751740.	13760520.	13769300.	13778080.	13786870.	13795650.	13804450.	13813240.	13822040.	13830850.
1095	13839650.	13848460.	13857280.	13866100.	13874920.	13883740.	13892570.	13901400.	13910230.	13919070.
1096	13927910.	13936760.	13945610.	13954460.	13963310.	13972170.	13981030.	13989900.	13998770.	14007640.
1097	14016520.	14025400.	14034280.	14043170.	14052060.	14060950.	14069850.	14078750.	14087650.	14096560.
1098	14105470.	14114380.	14123300.	14132220.	14141140.	14150070.	14159000.	14167940.	14176880.	14185820.
1099	14194760.	14203710.	14212660.	14221620.	14230580.	14239540.	14248510.	14257480.	14266450.	14275420.
1100	14284400.	14293390.	14302370.	14311370.	14320360.	14329360.	14338370.	14347370.	14356390.	14365400.
1101	14374420.	14383440.	14392470.	14401500.	14410540.	14419580.	14428620.	14437670.	14446730.	14455780.
1102	14464840.	14473910.	14482970.	14492050.	14501120.	14510200.	14519290.	14528380.	14537470.	14546570.
1103	14555670.	14564770.	14573880.	14582990.	14592110.	14601230.	14610360.	14619490.	14628620.	14637760.
1104	14646900.	14656040.	14665190.	14674350.	14683500.	14692660.	14701830.	14711000.	14720170.	14729350.
1105	14738530.	14747720.	14756910.	14766100.	14775300.	14784500.	14793710.	14802920.	14812130.	14821350.
1106	14830570.	14839800.	14849030.	14858260.	14867500.	14876740.	14885990.	14895240.	14904490.	14913750.
1107	14923010.	14932280.	14941550.	14950830.	14960110.	14969390.	14978680.	14987970.	14997260.	15006560.
1108	15015860.	15025170.	15034480.	15043800.	15053120.	15062440.	15071770.	15081100.	15090440.	15099770.
1109	15109120.	15118460.	15127820.	15137170.	15146530.	15155900.	15165260.	15174640.	15184010.	15193390.
1110	15202770.	15212150.	15221540.	15230940.	15240340.	15249740.	15259150.	15268560.	15277980.	15287400.
1111	15296820.	15306250.	15315680.	15325120.	15334550.	15344000.	15353440.	15362890.	15372350.	15381810.
1112	15391270.	15400730.	15410200.	15419680.	15429160.	15438640.	15448120.	15457610.	15467100.	15476600.
1113	15486100.	15495600.	15505110.	15514620.	15524140.	15533660.	15543180.	15552710.	15562240.	15571780.
1114	15581320.	15590860.	15600410.	15609960.	15619510.	15629070.	15638630.	15648200.	15657770.	15667340.
1115	15676920.	15686500.	15696090.	15705680.	15715270.	15724870.	15734470.	15744080.	15753680.	15763300.
1116	15772910.	15782530.	15792160.	15801790.	15811420.	15821050.	15830690.	15840340.	15849990.	15859640.
1117	15869290.	15878950.	15888610.	15898280.	15907950.	15917630.	15927300.	15936990.	15946670.	15956360.
1118	15966060.	15975750.	15985460.	15995160.	16004870.	16014580.	16024300.	16034020.	16043750.	16053480.
1119	16063210.	16072940.	16082680.	16092430.	16102180.	16111930.	16121680.	16131440.	16141200.	16150970.
1120	16160740.	16170520.	16180300.	16190080.	16199870.	16209660.	16219450.	16229250.	16239050.	16248860.
1121	16258670.	16268480.	16278300.	16288120.	16297950.	16307780.	16317610.	16327440.	16337290.	16347130.
1122	16356980.	16366830.	16376690.	16386550.	16396410.	16406280.	16416150.	16426030.	16435910.	16445790.
1123	16455680.	16465570.	16475460.	16485360.	16495260.	16505170.	16515080.	16524990.	16534910.	16544830.
1124	16554760.	16564690.	16574620.	16584560.	16594500.	16604450.	16614390.	16624350.	16634300.	16644260.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED

2001 AREA-CAPACITY TABLES 10: 2:30

THE CAPACITY TABLE IS IN ACRE FEET THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1125	16654230.	16664200.	16674170.	16684150.	16694120.	16704110.	16714100.	16724090.	16734080.	16744080.
1126	16754080.	16764090.	16774100.	16784120.	16794140.	16804160.	16814180.	16824210.	16834250.	16844290.
1127	16854330.	16864370.	16874420.	16884480.	16894530.	16904590.	16914660.	16924730.	16934800.	16944880.
1128	16954960.	16965040.	16975130.	16985220.	16995320.	17005420.	17015520.	17025630.	17035740.	17045850.
1129	17055970.	17066100.	17076220.	17086350.	17096490.	17106630.	17116770.	17126910.	17137060.	17147220.
1130	17157370.	17167530.	17177690.	17187860.	17198030.	17208210.	17218390.	17228580.	17238770.	17248970.
1131	17259170.	17269370.	17279580.	17289790.	17300010.	17310230.	17320450.	17330680.	17340910.	17351150.
1132	17361390.	17371640.	17381890.	17392140.	17402400.	17412660.	17422930.	17433200.	17443480.	17453760.
1133	17464040.	17474330.	17484620.	17494920.	17505220.	17515520.	17525830.	17536150.	17546460.	17556790.
1134	17567110.	17577440.	17587780.	17598120.	17608460.	17618810.	17629160.	17639510.	17649870.	17660240.
1135	17670610.	17680980.	17691360.	17701740.	17712120.	17722510.	17732910.	17743310.	17753710.	17764110.
1136	17774530.	17784940.	17795360.	17805780.	17816210.	17826640.	17837080.	17847520.	17857970.	17868410.
1137	17878870.	17889330.	17899790.	17910250.	17920720.	17931200.	17941680.	17952160.	17962650.	17973140.
1138	17983630.	17994130.	18004640.	18015150.	18025660.	18036180.	18046700.	18057220.	18067750.	18078280.
1139	18088820.	18099360.	18109910.	18120460.	18131020.	18141580.	18152140.	18162710.	18173280.	18183850.
1140	18194440.	18205020.	18215610.	18226210.	18236810.	18247410.	18258020.	18268640.	18279260.	18289890.
1141	18300520.	18311160.	18321800.	18332450.	18343100.	18353760.	18364420.	18375090.	18385770.	18396450.
1142	18407130.	18417820.	18428520.	18439220.	18449920.	18460630.	18471350.	18482070.	18492790.	18503530.
1143	18514260.	18525000.	18535750.	18546500.	18557260.	18568020.	18578790.	18589570.	18600340.	18611130.
1144	18621920.	18632710.	18643510.	18654320.	18665130.	18675940.	18686760.	18697590.	18708420.	18719250.
1145	18730100.	18740940.	18751790.	18762650.	18773510.	18784380.	18795250.	18806130.	18817020.	18827900.
1146	18838800.	18849700.	18860600.	18871510.	18882430.	18893340.	18904270.	18915200.	18926140.	18937080.
1147	18948020.	18958970.	18969930.	18980890.	18991860.	19002830.	19013810.	19024790.	19035780.	19046770.
1148	19057770.	19068770.	19079780.	19090800.	19101820.	19112840.	19123870.	19134910.	19145950.	19156990.
1149	19168040.	19179100.	19190160.	19201230.	19212300.	19223370.	19234460.	19245540.	19256640.	19267730.
1150	19278840.	19289950.	19301060.	19312180.	19323300.	19334420.	19345550.	19356690.	19367830.	19378970.
1151	19390120.	19401280.	19412440.	19423600.	19434770.	19445940.	19457120.	19468300.	19479490.	19490680.
1152	19501870.	19513070.	19524280.	19535490.	19546700.	19557920.	19569140.	19580370.	19591610.	19602840.
1153	19614090.	19625330.	19636580.	19647840.	19659100.	19670360.	19681630.	19692910.	19704190.	19715470.
1154	19726760.	19738050.	19749350.	19760650.	19771960.	19783270.	19794590.	19805910.	19817230.	19828560.
1155	19839900.	19851240.	19862580.	19873930.	19885280.	19896640.	19908000.	19919370.	19930740.	19942120.
1156	19953500.	19964880.	19976270.	19987670.	19999070.	20010470.	20021880.	20033290.	20044710.	20056130.
1157	20067560.	20078990.	20090430.	20101870.	20113320.	20124770.	20136220.	20147680.	20159140.	20170610.
1158	20182090.	20193560.	20205050.	20216530.	20228030.	20239520.	20251020.	20262530.	20274040.	20285550.
1159	20297070.	20308600.	20320130.	20331660.	20343200.	20354740.	20366290.	20377840.	20389400.	20400960.
1160	20412530.	20424100.	20435670.	20447250.	20458840.	20470430.	20482020.	20493620.	20505220.	20516830.
1161	20528440.	20540060.	20551680.	20563300.	20574940.	20586570.	20598210.	20609860.	20621500.	20633160.
1162	20644820.	20656480.	20668150.	20679820.	20691500.	20703180.	20714860.	20726560.	20738250.	20749950.
1163	20761660.	20773370.	20785080.	20796800.	20808520.	20820250.	20831980.	20843720.	20855460.	20867210.
1164	20878960.	20890710.	20902470.	20914240.	20926010.	20937780.	20949560.	20961350.	20973130.	20984930.

THE CAPACITY TABLE IS IN ACRE FEET THE ELEVATION INCREMENT IS ONE TENTH FOOT

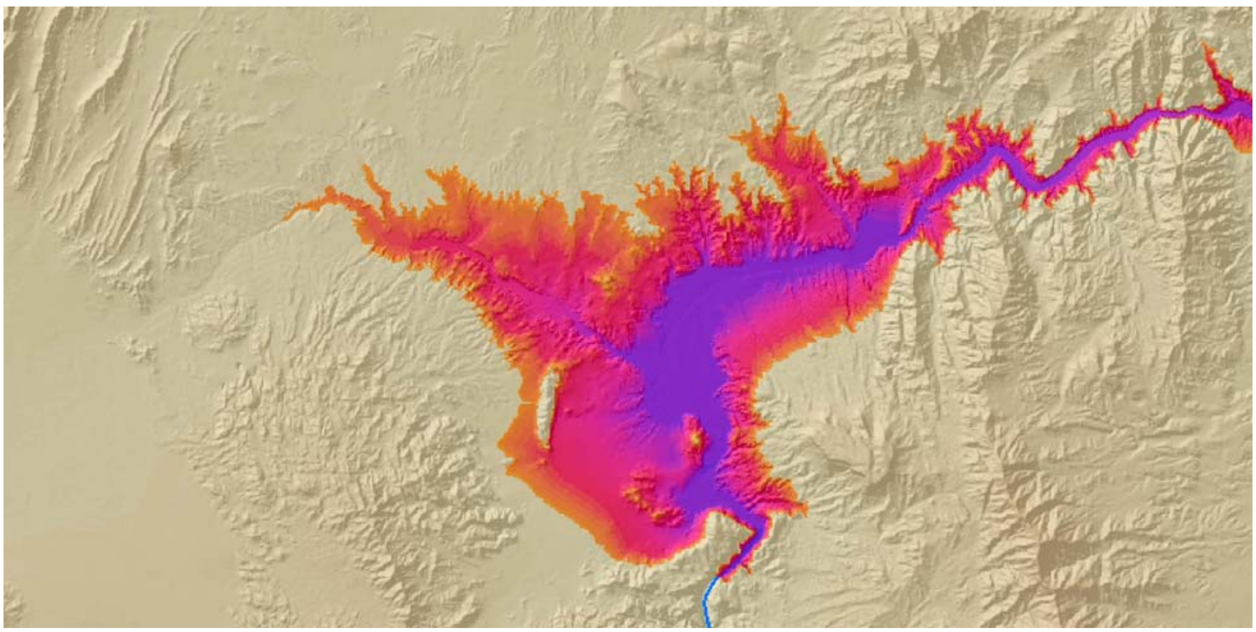
ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1165	20996720.	21008530.	21020330.	21032140.	21043960.	21055780.	21067600.	21079430.	21091270.	21103110.
1166	21114950.	21126800.	21138650.	21150510.	21162370.	21174240.	21186110.	21197990.	21209870.	21221750.
1167	21233640.	21245540.	21257440.	21269340.	21281250.	21293160.	21305080.	21317000.	21328930.	21340860.
1168	21352800.	21364740.	21376680.	21388630.	21400590.	21412550.	21424510.	21436480.	21448450.	21460430.
1169	21472410.	21484400.	21496390.	21508390.	21520390.	21532390.	21544400.	21556420.	21568440.	21580460.
1170	21592490.	21604530.	21616570.	21628610.	21640670.	21652730.	21664790.	21676870.	21688940.	21701030.
1171	21713120.	21725220.	21737320.	21749430.	21761550.	21773670.	21785800.	21797940.	21810080.	21822230.
1172	21834380.	21846550.	21858710.	21870890.	21883070.	21895260.	21907450.	21919650.	21931850.	21944070.
1173	21956280.	21968510.	21980740.	21992980.	22005220.	22017470.	22029730.	22041990.	22054260.	22066540.
1174	22078820.	22091110.	22103400.	22115700.	22128010.	22140320.	22152650.	22164970.	22177300.	22189640.
1175	22201990.	22214340.	22226700.	22239060.	22251430.	22263810.	22276200.	22288590.	22300980.	22313380.
1176	22325790.	22338210.	22350630.	22363060.	22375490.	22387930.	22400380.	22412830.	22425290.	22437760.
1177	22450230.	22462710.	22475200.	22487690.	22500190.	22512690.	22525200.	22537720.	22550240.	22562770.
1178	22575310.	22587850.	22600400.	22612960.	22625520.	22638090.	22650660.	22663240.	22675830.	22688420.
1179	22701020.	22713630.	22726240.	22738860.	22751480.	22764110.	22776750.	22789400.	22802050.	22814700.
1180	22827370.	22840040.	22852720.	22865400.	22878100.	22890810.	22903520.	22916250.	22928980.	22941720.
1181	22954470.	22967230.	22980000.	22992780.	23005570.	23018360.	23031170.	23043980.	23056800.	23069630.
1182	23082470.	23095320.	23108180.	23121040.	23133920.	23146800.	23159700.	23172600.	23185510.	23198430.
1183	23211360.	23224300.	23237240.	23250200.	23263160.	23276130.	23289120.	23302110.	23315110.	23328120.
1184	23341130.	23354160.	23367200.	23380240.	23393290.	23406350.	23419430.	23432510.	23445590.	23458690.
1185	23471800.	23484920.	23498040.	23511170.	23524310.	23537460.	23550620.	23563790.	23576970.	23590160.
1186	23603350.	23616560.	23629770.	23642990.	23656220.	23669460.	23682710.	23695970.	23709240.	23722510.
1187	23735800.	23749090.	23762390.	23775700.	23789020.	23802350.	23815690.	23829030.	23842390.	23855750.
1188	23869130.	23882510.	23895900.	23909300.	23922710.	23936130.	23949560.	23962990.	23976430.	23989890.
1189	24003350.	24016820.	24030300.	24043790.	24057290.	24070790.	24084310.	24097830.	24111370.	24124910.
1190	24138460.	24152020.	24165590.	24179160.	24192740.	24206340.	24219930.	24233540.	24247160.	24260780.
1191	24274410.	24288050.	24301700.	24315360.	24329020.	24342690.	24356370.	24370060.	24383750.	24397460.
1192	24411170.	24424890.	24438620.	24452350.	24466100.	24479850.	24493610.	24507380.	24521150.	24534940.
1193	24548730.	24562530.	24576330.	24590150.	24603970.	24617800.	24631650.	24645490.	24659350.	24673210.
1194	24687080.	24700960.	24714850.	24728750.	24742650.	24756560.	24770480.	24784410.	24798350.	24812290.
1195	24826240.	24840200.	24854170.	24868150.	24882130.	24896120.	24910120.	24924130.	24938150.	24952170.
1196	24966200.	24980240.	24994290.	25008350.	25022410.	25036480.	25050560.	25064650.	25078750.	25092850.
1197	25106960.	25121080.	25135210.	25149350.	25163490.	25177640.	25191800.	25205970.	25220150.	25234330.
1198	25248520.	25262730.	25276930.	25291150.	25305370.	25319600.	25333850.	25348090.	25362350.	25376610.
1199	25390890.	25405170.	25419450.	25433750.	25448050.	25462370.	25476690.	25491020.	25505350.	25519700.
1200	25534050.	25548410.	25562780.	25577150.	25591530.	25605920.	25620320.	25634720.	25649130.	25663550.
1201	25677980.	25692410.	25706850.	25721300.	25735760.	25750220.	25764690.	25779170.	25793650.	25808150.
1202	25822650.	25837150.	25851670.	25866190.	25880720.	25895260.	25909800.	25924350.	25938910.	25953470.
1203	25968050.	25982630.	25997210.	26011810.	26026410.	26041020.	26055640.	26070270.	26084900.	26099540.
1204	26114190.	26128840.	26143500.	26158170.	26172850.	26187530.	26202220.	26216920.	26231630.	26246340.

2001 LAKE MEAD - BOULDER CITY, NEVADA (ACAP92) COMPUTED
2001 AREA-CAPACITY TABLES 10: 2:30
THE CAPACITY TABLE IS IN ACRE FEET THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1205	26261060.	26275790.	26290520.	26305260.	26320010.	26334770.	26349540.	26364310.	26379090.	26393870.
1206	26408670.	26423470.	26438280.	26453090.	26467920.	26482750.	26497590.	26512430.	26527280.	26542150.
1207	26557010.	26571890.	26586770.	26601660.	26616560.	26631460.	26646370.	26661290.	26676220.	26691150.
1208	26706090.	26721040.	26736000.	26750960.	26765930.	26780910.	26795890.	26810890.	26825890.	26840890.
1209	26855910.	26870930.	26885960.	26901000.	26916040.	26931090.	26946150.	26961220.	26976290.	26991370.
1210	27006460.	27021560.	27036650.	27051760.	27066870.	27081990.	27097110.	27112240.	27127370.	27142510.
1211	27157660.	27172810.	27187960.	27203120.	27218290.	27233460.	27248640.	27263830.	27279010.	27294210.
1212	27309410.	27324610.	27339830.	27355040.	27370270.	27385500.	27400730.	27415970.	27431210.	27446460.
1213	27461720.	27476980.	27492240.	27507520.	27522800.	27538080.	27553370.	27568660.	27583960.	27599270.
1214	27614580.	27629900.	27645220.	27660550.	27675880.	27691220.	27706570.	27721910.	27737270.	27752630.
1215	27768000.	27783370.	27798750.	27814130.	27829520.	27844920.	27860320.	27875720.	27891130.	27906550.
1216	27921970.	27937400.	27952830.	27968270.	27983720.	27999170.	28014620.	28030090.	28045550.	28061020.
1217	28076500.	28091980.	28107470.	28122970.	28138470.	28153970.	28169480.	28185000.	28200520.	28216050.
1218	28231580.	28247120.	28262670.	28278220.	28293770.	28309340.	28324900.	28340470.	28356050.	28371640.
1219	28387220.	28402820.	28418420.	28434020.	28449640.	28465250.	28480870.	28496500.	28512140.	28527770.
1220	28543420.	28559070.	28574730.	28590390.	28606060.	28621740.	28637430.	28653110.	28668810.	28684520.
1221	28700230.	28715950.	28731670.	28747400.	28763140.	28778890.	28794640.	28810400.	28826160.	28841940.
1222	28857720.	28873500.	28889290.	28905090.	28920900.	28936710.	28952530.	28968360.	28984190.	29000030.
1223	29015880.	29031730.	29047590.	29063450.	29079330.	29095210.	29111100.	29126990.	29142890.	29158800.
1224	29174710.	29190630.	29206560.	29222490.	29238430.	29254380.	29270340.	29286300.	29302270.	29318240.
1225	29334220.	29350210.	29366210.	29382210.	29398220.	29414230.	29430250.	29446280.	29462320.	29478360.
1226	29494410.	29510460.	29526530.	29542600.	29558670.	29574750.	29590840.	29606940.	29623040.	29639150.
1227	29655270.	29671390.	29687520.	29703660.	29719800.	29735950.	29752110.	29768270.	29784440.	29800620.
1228	29816800.	29832990.	29849190.	29865400.	29881610.	29897830.	29914050.	29930280.	29946520.	29962760.
1229	29979010.	29995270.	30011540.	30027810.	30044090.	30060380.	30076670.	30092960.	30109270.	30125580.
1230	30141900.									

Appendix VII

The 2001 Lake Mead Bathymetry Study



Lower Colorado Regional Office
L.C. Region GIS Group
Boulder City, Nevada
September 2003

Introduction

The Bureau of Reclamation (Reclamation) surveyed Lake Mead Reservoir in 2001 in order to develop a present day storage-elevation relationships. The major objective of the field collection was to map the areas of sediment accumulation since closure of Hoover Dam in February of 1935. The primary objective for conducting the reservoir survey was to measure the current reservoir area-capacity. The collected data can also be used to determine:

storage depletion caused by sediment deposition since closure of the dam
annual sediment yield rates
current location of sediment deposition
current reservoir topography
economic life of the reservoir

Previous sedimentation surveys of Lake Mead completed in 1948 and 1963, utilized the range line collection method. The 1963 survey generated new reservoir topography from range lines that were collected from 300 to 400 meters apart. Results of these collections measured the vast majority of the sediments as a flat bottom deposit within the original river channel geometry. A 1999 University of Nevada and USGS sidescan sonar survey of the lower portion of Lake Mead found the accumulation of sediments to be restricted to the original river beds of the Colorado River and Las Vegas Creek and also to be flat-lying.[4] This situation was also found during the 1986 Lake Powell survey that measured the majority of sediment deposits within the original channel geometry and to be flat in nature.[5] Utilizing these previous survey results, and working within the available budget for conducting the Lake Mead survey, the 2001 collection focus the measurements around the original river channel areas.

[4] Surficial Geology and Distribution of Post-Impoundment Sediment of the Western Park of Lake Mead Based on a Sidescan Sonar and High-Resolution Seismic-Reflection Survey, Open-File Report 99-581, University of Nevada at Las Vegas and U.S. Geological Survey.

[5] 1986 Lake Powell Survey, REC-ERC-88-6, USBR.

Data Collection

The 2001 survey utilized a high resolution multibeam mapping system for collecting x,y,z data of the Lake Mead bottom from depths of 3 meters in the upper portions of the lake to greater than 140 meters near Hoover Dam. The system consisted of a single transducer that was mounted on the center bow or forward portion of the boat . From the single transducer a fan array of narrow beams generated a detailed cross section of bottom geometry as the survey vessel passed over the areas to be mapped. The system used for this survey transmitted 80 separate 1 ½ degree slant beams resulting in a 120-degree swath from the transducer (Figure 1).

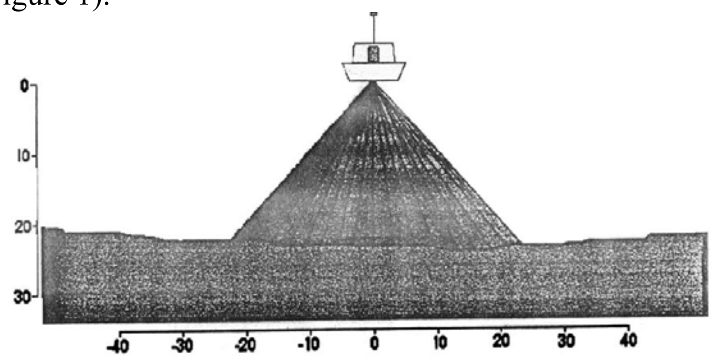


Figure 1

The system operates at 200 kHz and can generate up to 30 profiles per second. The bottom area covered by the swath is dependant on the depth of the water column, which for Lake Mead were at times up to 500 meters of the lake bottom being mapped by an individual sweep. The multibeam system could have been used to obtain 100% underwater bottom coverage, but much greater time and budget would have been required for data collection and analysis.

The multibeam system was composed of several instruments all in communication with a central on-board computer that utilized the latest version of collection and processing software. The components included:

- GPS for positioning

Note: RTK GPS techniques were used for the lower portion of the reservoir, from the dam upstream to the upper portion of the narrows. Stationary position accuracies of up to 1 to 2 centimeters are possible. This system requires the establishment of a local base station, and maintaining constant communication between the base and survey vessel receivers.

Note: The upper portion of the reservoir above the narrows was surveyed using a “precise positioning service” which requires DOD authorization.

The stationary position accuracies are around ±4 meters. This system was utilized to significantly reduce the collection time. The resulting lower accuracies were determined to be insignificant when measuring the location of the flat lying sediments.

- Motion reference unit (MRU) - measures the heave, pitch, and roll of the survey vessel during collection.

- Gyro - measures the yaw or vessel attitude.

With a proper calibration, the collection and data processing software utilizes all incoming information to provide a detailed x,y,z data set of the lake bottom.

The multibeam hydrographic survey system was mounted in the cabin of a 24-foot trihull aluminum vessel equipped with twin in-board motors and an on-board generator for power to the equipment. The multibeam system was installed, tested, and training was conducted in February of 2001 near Hoover Dam. The collection of underwater data on Lake Mead was conducted during a 2-week and 3-week period beginning in March and concluding in May of 2001. The areas covered included the underwater river channels of Las Vegas and Overton arms, and the Colorado River channel from the dam to just downstream of Pearce Ferry. The boat and system were operated by 2-person crews that consisted of personnel from Reclamation’s Denver and Boulder City offices. For the deeper portions of the reservoir, the procedure included running parallel survey lines whose alignment was somewhat longitudinal with the original river channel alignment. The distance between the parallel survey lines was depth dependent and was set to provide some overlap of the data sweeps. Enough parallel survey lines were run to ensure that complete mapping of the deposited sediments would be obtained. As the survey vessels mapped the shallow water areas in the upper reaches of the reservoir the overlapping of the data sweeps was abandoned due to the time it would have taken to ensure full coverage. As previously stated, the sediments were found to be flat lying so it was determined that the areas missed could be projected during final analysis.

Data collection areas were developed to provide data sets that were manageable for both collection and analysis. Figure 2 shows the extent of the 56 data sets collected in the 2001 bathymetry study.

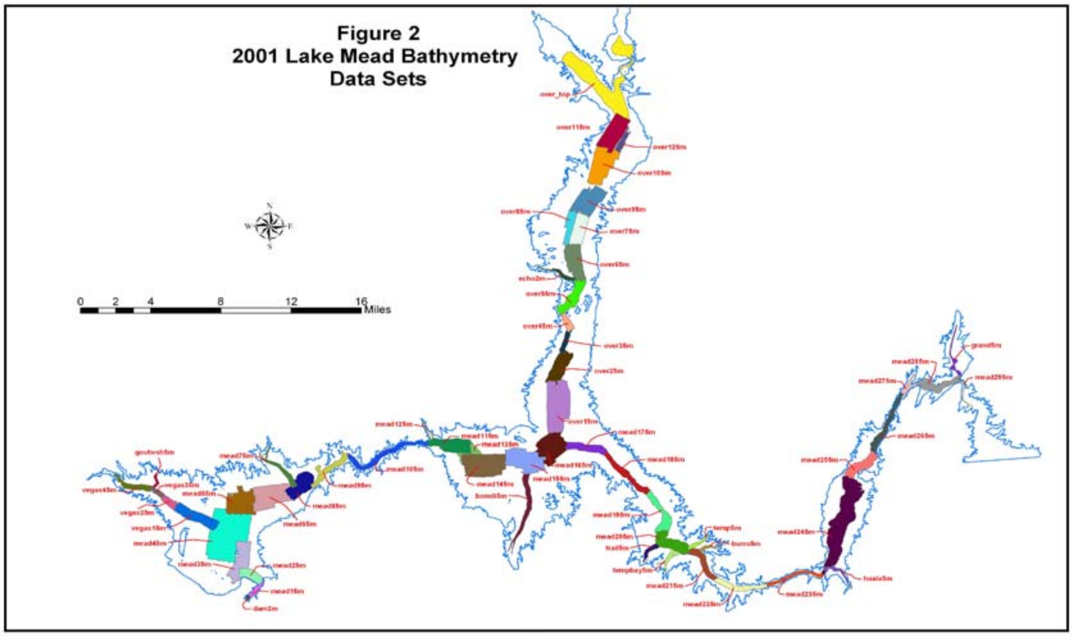


Figure 2
2001 Lake Mead Bathymetry Data Sets

Data Analysis

The first part of the analysis started with the processing of all the collected raw profile files of the bottom. This included applying all necessary correction information that was collected such as vessel location and the roll, pitch, and yaw effects on the survey vessel. Other corrections included applying the sound velocity and converting all depth data points to elevations. All elevations in the final analysis were tied to the measured water surface elevation at the time of collection. To be able to accomplish the analysis filtering of data was completed due to the massive amount of information that was collected by the multibeam system (Over 20 million data points were collected in the 2001 study). This was accomplished by filtering the data into 5-meter grids or cells and saving one sounding per cell. Quality control of the data set was accomplished by conducting field calibration as required by the multibeam system and collecting velocity profile data for the areas being surveyed.

The second part of the analysis consisted of building lake bottom surfaces based on the filtered data from the first step. This analysis was conducted utilizing the areas and sheet boundaries as defined in previous Lake Mead Surveys. The boundaries for the areas and the sheets are shown in Figures 3 and 4 respectively.

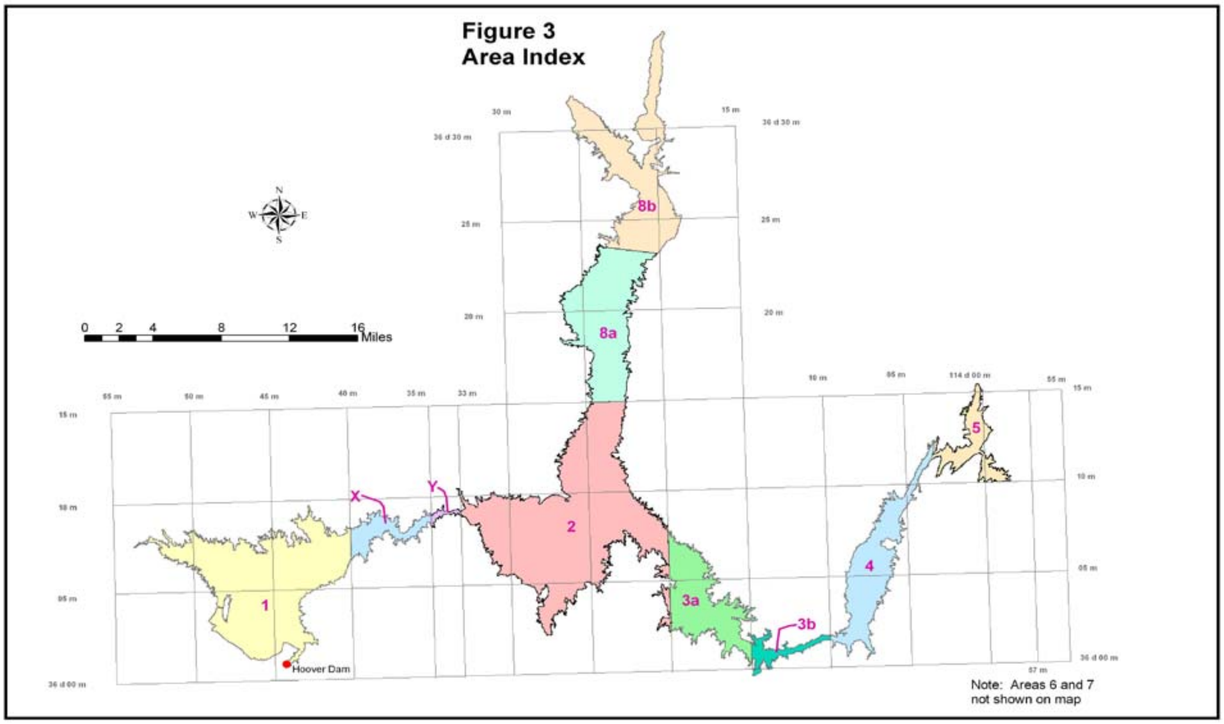


Figure 3
Area Index
Miles
Hoover Dam
1
2
3a
3b
4
5
8a
8b
X
Y
Note: Areas 6 and 7 not shown on map

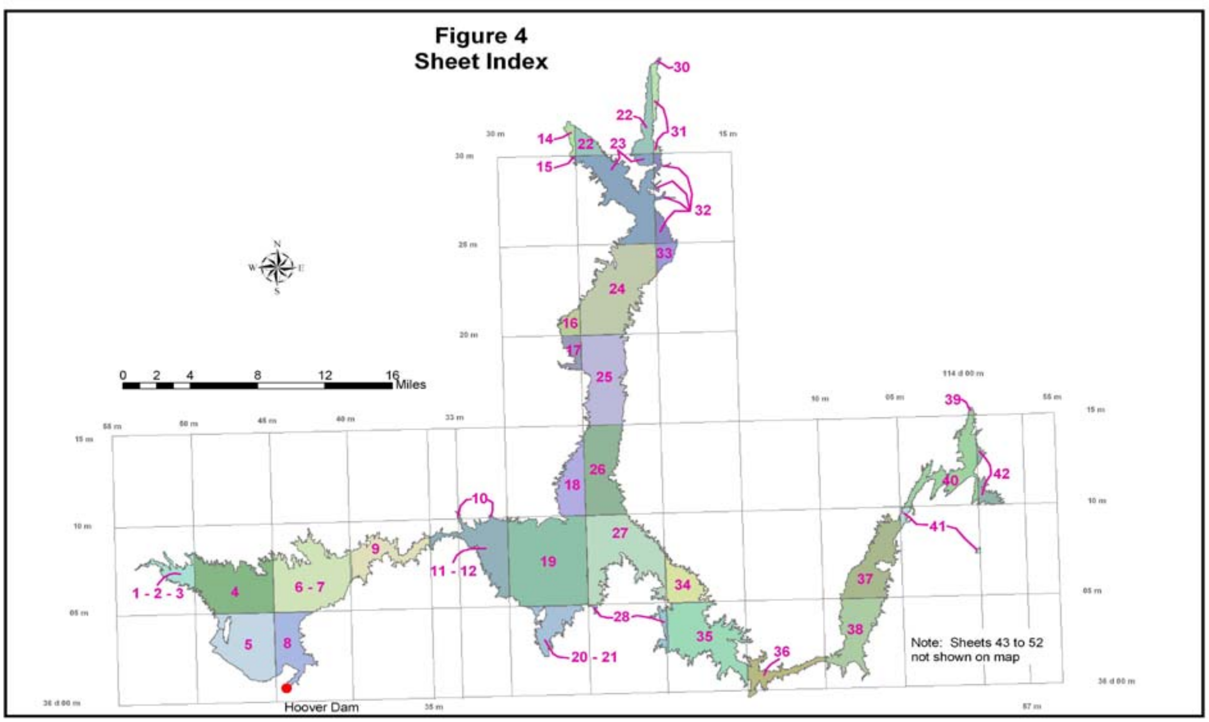


Figure 4
Sheet Index
Miles
Hoover Dam
1 - 2 - 3
4
5
6 - 7
8
9
10
11 - 12
19
20 - 21
Note: Sheets 43 to 52 not shown on map

The analysis of the 2001 bathymetric data first required the generation of the 1935 surface (also known as the original surface). Once the original surface was developed,[6] the data collected in the 2001 survey was overlaid on the original surface to produce the 2001 surface. Comparison of the original surface and the 2001 surface provided the quantity and location of sediment that has been deposited in Lake Mead since the construction of Hoover Dam.

All data was collected and processed in UTM Zone 11 North, NAD 83 coordinate system.

Generation of the 1935 surfaces:

The USGS 10 Meter Lake Mead Underwater DEMs were used to generate 10 Meter contours for the entire lake. This was completed using the Contour command from 3-D Analyst in Arc Map. The resulting coverage was called usgscon_83.

The 375 meter (1230 foot) contour was created using the USGS 10 Meter Lake Mead Underwater DEMs. This represented the high water mark for the entire lake. This was completed using the Contour command from 3-D Analyst in Arc Map. The resulting coverage was called usgscon375_83. (Note that the 1230 foot contour was designated as the high water mark for the lake in previous studies.)

Approximate 2.5 meter contours were developed in the original river channels of the Colorado and Virgin Rivers using the USGS 10 Meter Lake Mead Underwater DEMs. The contour coverage generated was called extra1_conts. The purpose of this coverage will be discussed later.

A polygon coverage was developed for each individual sheet identified in the 1963 study. This was done using Arc Info and the coordinates of the sheet corners noted on the Lake Mead overview sheet associated with the report. The coverage usgscon375_83 was used to define the extent of each sheet. These coverages were called asheetxx (for example asheet8 for sheet 8). See Figure 4 for an index of sheets.

A polygon coverage was developed for each individual area as identified in the 1963 study. This was done using Arc Info and the coordinates of the sheet corners noted in the report. The coverage usgscon375_83 was used to define the extent of each Area. For the 2001 analysis Areas 6 and 7 were not analyzed as they were assumed to have filled with sediment, and have no volume capacity. These coverages were called cutareax (for example cutarea1 for area 1).

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[6] Original surfaces created from data received from the USGS Rocky Mountain Data Center.

Contour coverages were generated for each individual sheet. This was done using the clip command in Arc Toolbox with usgscon_83 and each asheet coverage. These coverages were called asheetx_con (for example asheet8_con for the contours on sheet 8)

Contour coverages were generated for each individual area. This was done using the clip command in Arc Toolbox with usgscon_83 and each cutarea coverage. These coverages were called areax_con (for example area1_con for the contours in area 1).

Surfaces were developed for each individual sheet using the Create Tin command in 3-D Analyst with the following components: asheetx_con, (hard line option), extra1_conts (hard line option), usgscon375_83 (hard line option) and asheet (hard clip option). These surfaces were called asheetx_tin .

Surfaces were created for each individual area using the Create Tin command in 3-D Analyst with the following components: areax_con (hard line option), extra1_conts (hard line option), usgscon375_83 (hard line option), cutarea (hard clip option). These surfaces were called areax_tin.

The area for 10 foot increments for each sheet was calculated. This was done using the Volume command in Arc Info with the option to calculate area and volume below the datum. An Arc Macro Language (AML) script was created to step through the calculations and create an info table with the area and volume at each elevation. Arc Map was used to covert the info table to a dbase database. The database was imported into Microsoft Excel and areas in square meters converted to areas in acres to match the units in Table 3-3 of the 1963 bathymetry study.

The volume for 10 foot increments for each area was calculated. This was done using the Volume command in Arc Info with the option to calculate area and volume below the datum. An AML script was created to step through the calculations and create an info table with the area and volume at each elevation. Arc Map was used to covert the info table to a dbase database. The database was imported into Microsoft Excel and volumes in cubic meters converted to volumes in acre-feet to match with the units in Table 3-7 of the 1963 bathymetry study.

Area and volume calculations were completed on the original surface to compare to values in the 1963 Lake Mead Survey. Values calculated were consistently within 2 percent, and usually much closer to the values published in the 1963 study. This correlation of values provides a reasonable level of reliability for the methods used to perform the analysis for the 2001 survey.

Inclusion of Multi-beam data collected in 2001:

A Visual Basic routine was created to covert the raw X, Y, Z data files into a generate file that could be imported into an Arc Info Tin. Each raw data file was processed through this routine.

Tins were created for each data set using the Generate option in the Create Tin command in Arc Toolbox.

Point coverages of each data set were created using the Tin to Cover command in Arc Toolbox with the point option. (for example Mead125m_pt)

Polygon coverages of the extent of each point data were generated by digitizing lines around each data set. (Mead125m_bnd, for example).

The bounding polygons were merged to create a single polygon representing the data collection area for 2001. Due to a small gap in the data collection, an additional polygon resulted in the upper portion of the Overton Arm. The resulting coverage is called Mead_bound.

Generating the 2001 surfaces.

The 2001 surface was built using contours from the original surface (for areas where data was not collected in 2001) combined with the point coverages from the 2001 data. Contours for the 2001 surface were created for each sheet using the 1935 contours and the erase command with Mead_bound polygon as the erase coverage. The result was a coverage with the contours within the area of data collection removed, but the contours outside the area of data collection unchanged. The coverages called asheetx_con in the 2001 data set were created.

The 2001 surfaces for each area were created using the same technique as was used for each sheet. Contours for each 2001were developed using the 1935 contours for the area and the erase command with the Mead_bound polygon as the erase coverage. The result is a coverage with the contours within the area of data collection removed, but the contours outside the area of data collection unchanged. There coverages called areax_con in the 2001 data set were created.

To build the 2001 surface for each sheet it was necessary to determine which data collection set was included within each sheet. Arc Map was used for this determination, and the results summarized in Table 1.

Table 1.

Sheet Number	Data Sets Within or Overlapping the Sheet					
Sheet 1-2-3	Vegas45m					
Sheet 4	Over15m	Over25m	Over35m	Over45m	Govtwsh5m	Mead45m
Sheet 4 (cont)	Mead55m					
Sheet 5	Mead35m	Mead45m	Over15m			
Sheet 6-7	Mead45m	Mead55m	Mead65m	Mead75m	Mead85m	Mead95m
Sheet 8	Dam2m	Mead12m	Mead25m	Mead35m	Mead45m	
Sheet 9	Mead85m	Mead95m	Mead105m			
Sheet 10	Mead125m					
Sheet 11-12	Mead105m	Mead115m	Mead125m	Mead135m	Mead145m	
Sheet 17	Echo2m					
Sheet 18	Over15m	Over25m				
Sheet 19	Mead135m	Mead145m	Mead155m	Mead165m	Over15m	Boneli5m
Sheet 20-21	Boneli5m					
Sheet 22	Over_top					
Sheet 23	Over115m	Over125m	Over_top			
Sheet 24	Over75m	Over8b5m	Over95m	Over105m	Over115m	Over125m
Sheet 25	Over45m	Over55m	Over65m	Over75m	Over8b5m	Echo2m
Sheet 26	Over15m	Over25m	Over35m	Over45m		
Sheet 27	Over15m	Mead165m	Mead175m	Mead185m		
Sheet 32	Over_top					
Sheet 34	Mead185m	Mead195m				
Sheet 35	Mead195m	Mead205m	Mead215m	Mead225m	Burro5m	Temp5m
Sheet 35 (cont)	Tempbay5m	Trail5m				
Sheet 36	Mead225m	Mead235m				
Sheet 37	Mead245m	Mead255m	Mead265m			
Sheet 38	Mead235m	Mead245m	Huala5m			
Sheet 40	Mead265m	Mead275m	Mead285m	Mead295m	Grand5m	
Sheet 41	Mead265m					

To build the 2001 surface for each area it was necessary to determine which data collection set was included within each area. Arc Map was used for this determination, and the results summarized the in Table 2.

Table 2

Area	Data Sets Within the or overlapping the Area							
Area 1	Dam2m	Mead12m	Mead25m	Mead35m	Mead45m	Mead55m	Mead65m	Mead75m	Mead85m
Area 1 (cont)	Over15m	Over25m	Over35m	Over45m	Govtwsh5m				
Area 2	Mead105m	Mead115m	Mead125m	Mead135m	Mead145m	Mead155m	Mead165m	Mead175m	Mead185m
Area 2 (cont)	Over15m	Over25m	Over35m	Over45m	Boneli5m				
Area 3a	Mead185m	Mead195m	Mead205m	Mead215m	Mead225m	Burro5m	Temp5m	Tempbay5m	Trail5m
Area 3b	Mead225m	Mead235m							
Area 4	Mead235m	Mead245m	Mead255m	Mead265m	Mead275m	Huala5m			
Area 5	Mead275m	Mead285m	Mead295m	Grand5m					
Area 8a	Over45m	Over55m	Over65m	Over75m	Over8b5m	Over95m	Over105m	Echo2m	
Area 8b	Over105m	Over115m	Over125m	Over_top					
Area X	Mead85m	Mead95m	Mead105m						
Area Y	Mead105m								

The surface for each individual sheet was developed using the Create Tin command in 3-D Analyst with the following components: asheetx_con, (hard line option), usgscon375_83 (hard line option) and asheetx (hard clip option) and point coverages for the relevant data sets (points). The output tins wre called asheetx_tin tin.

The surface for each individual area was developed using the Create Tin command in 3-D Analyst with the following components: areax_con, (hard line option), usgscon375_83 (hard line option) and cutareax (hard clip option) and point coverages for the relevant data sets (points) . The output tins were called areax_tin tins.

The area for 10 foot increments for each sheet was calculated. This was done using the Volume command in Arc Info with the option to calculate area and volume below the datum. An AML script was created to step through the calculations and create an info table with the area and volume at each elevation. Arc Map was used to convert the info table to a dbase database. The database was imported into Microsoft Excel and areas in square meters converted to areas in acres to match the units in Table 3-3 of the 1963 bathymetry study. The results of the area calculations are summarized in Table 3 on the following pages.

The volume for 10 foot increments for each area was calculated. This was done using the Volume command in Arc Info with the option to calculate area and volume below the datum. An AML script was created to step through the calculations and create an info table with the area and volume at each elevation. Arc Map was used to covert the info table to a dbase database. The database was imported into Microsoft Excel and volumes in cubic meters converted to volumes in acre-feet to match the units in Table 3-7 of the 1963 bathymetry study. The results of the volume calculations are summarized in Table 4. Also included for reference are the volumes for the original 1935 surface as reported in the 1963 Lake Mead Survey.

A complete summary of volumes for 1935, 1948, 1963 and 2001 can be found in the Microsoft Excel file name Mead_Volumes.xls on the DVD Rom.

Data Included on the DVD:

Polygon coverage for Lake Mead Areas Polygon coverage for Lake Mead Sheets Line coverage of 375 meter (1230 foot) contour around Lake Mead Data sets for 1935

- Contours for each area and sheet
- 1935 surfaces (also known as the original surfaces)

Data sets from 2001

- point coverages for each data set
- polygon coverage showing extent of each data set
- 2001 surfaces

Table 3
10 Foot Contour Areas in Acres

Sheet No	Elevation 660	670	680	690	700	710	720	730	740	750
1,2,3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	76.84	269.97	415.86
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	329.28	551.65	754.17
6,7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	46.29	987.44	1,873.93
8	0.00	0.00	0.00	0.02	0.47	3.90	53.69	897.15	1,339.46	1,538.96
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	13.16	128.95
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11,12	0.00	0.00	0.00	0.00	0.00	0.03	0.16	0.39	0.67	1.21
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20,21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42 - 52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.02	0.47	3.94	53.87	1,349.98	3,162.35	4,713.08

Table 3 (continued)
10 Foot Contour Areas in Acres

Sheet No	Elevation									
	760	770	780	790	800	810	820	830	840	850
1,2,3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	500.83	549.20	587.39	623.41	659.48	703.03	752.02	798.01	845.61	897.58
5	850.62	904.43	973.14	1,098.43	1,230.64	1,361.64	1,504.31	1,670.13	1,811.84	1,942.51
6,7	2,355.17	2,565.14	2,740.22	2,905.14	3,063.96	3,216.72	3,369.35	3,533.64	3,695.57	3,848.57
8	1,616.86	1,676.60	1,734.08	1,791.60	1,847.54	1,902.93	1,956.91	2,016.28	2,067.31	2,117.84
9	607.48	734.58	765.77	796.79	827.09	858.45	891.20	937.37	977.54	1,019.53
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11,12	73.08	410.62	1,236.24	1,472.00	1,612.52	1,702.32	1,784.41	1,868.78	1,934.07	1,997.25
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	238.17	417.33	560.81	724.76	882.40	987.53
19	0.40	1.32	139.87	1,025.85	3,085.51	3,543.35	4,002.76	4,344.40	4,652.05	4,912.08
20,21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.62	547.91	817.64	950.32	1,009.83	1,085.42	1,187.93
27	0.00	0.00	0.00	3.35	303.19	846.99	1,218.16	1,403.46	1,548.08	1,728.11
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0.00	0.01	0.08	101.14	326.70	352.36	373.24
35	0.00	0.00	0.00	0.00	0.00	0.00	0.03	193.19	812.56	1,342.20
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	1.21	1.81
37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42 - 52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	6,004.44	6,841.90	8,176.71	9,717.19	13,415.99	15,370.46	17,091.42	18,827.25	20,666.02	22,356.17

Table 3 (continued) - 10 Foot Contour Areas in Acres

Sheet No	Elevation									
	860	870	880	890	900	910	920	930	940	950
1,2,3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	959.22	1,025.48	1,094.30	1,205.14	1,300.25	1,397.60	1,555.88	1,661.24	1,765.66	1,870.31
5	2,160.76	2,314.55	2,468.43	2,731.72	2,861.72	2,990.02	3,263.06	3,393.21	3,523.61	3,657.61
6,7	4,039.35	4,189.68	4,333.74	4,568.76	4,713.03	4,859.08	5,118.43	5,278.01	5,415.45	5,540.47
8	2,194.19	2,245.75	2,296.30	2,375.01	2,427.55	2,477.25	2,548.23	2,596.01	2,645.10	2,693.54
9	1,079.21	1,131.37	1,183.05	1,255.44	1,311.65	1,367.66	1,450.24	1,503.35	1,554.55	1,605.51
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11,12	2,088.16	2,151.99	2,214.13	2,337.49	2,413.29	2,483.49	2,608.53	2,668.81	2,730.14	2,792.25
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	1,064.52	1,118.59	1,168.26	1,260.40	1,309.58	1,359.86	1,479.85	1,526.63	1,572.95	1,620.02
19	5,258.81	5,464.75	5,656.53	6,056.46	6,232.11	6,402.19	6,805.17	6,947.34	7,093.55	7,248.50
20,21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	3.56	63.48	130.48	188.96	283.42	452.48	663.65	970.29
26	1,332.72	1,500.40	1,661.91	1,854.56	1,989.29	2,116.45	2,305.34	2,414.15	2,512.54	2,614.35
27	1,986.67	2,107.71	2,230.41	2,511.23	2,683.54	2,869.30	3,571.35	3,725.12	3,868.61	4,005.44
28	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.35	0.53	0.72
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	404.23	428.63	453.42	499.30	534.48	569.09	646.38	694.00	736.32	776.66
35	1,633.81	1,768.44	1,895.00	2,092.73	2,228.59	2,361.97	2,577.39	2,720.11	2,863.17	3,003.00
36	173.29	386.12	466.87	505.19	534.03	562.07	602.11	630.00	656.52	682.31
37	0.00	0.00	0.00	1.87	3.53	5.51	19.23	154.18	479.79	771.55
38	0.60	3.08	59.24	191.93	659.20	1,211.92	1,693.24	1,936.46	2,046.41	2,146.96
39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42 - 52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	24,375.54	25,836.55	27,185.14	29,510.71	31,332.31	33,222.42	36,528.02	38,301.45	40,128.55	41,999.46

Table 3 (continued) - 10 Foot Contour Areas in Acres

Sheet No	Elevation									
	960	970	980	990	1000	1010	1020	1030	1040	1050
1,2,3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.22	30.96	55.50
4	2,060.97	2,186.42	2,317.44	2,536.12	2,689.25	2,853.42	3,218.53	3,417.15	3,599.28	3,958.40
5	3,924.64	4,083.62	4,246.48	4,441.85	4,589.86	4,742.27	4,936.24	5,077.82	5,221.45	5,402.84
6,7	5,816.81	5,945.12	6,071.09	6,349.90	6,500.98	6,652.95	6,925.50	7,051.77	7,178.92	7,439.67
8	2,779.50	2,827.39	2,873.19	2,958.52	3,011.98	3,065.01	3,146.17	3,193.76	3,240.55	3,324.70
9	1,684.86	1,738.32	1,791.36	1,876.64	1,937.84	1,998.83	2,087.71	2,143.23	2,198.87	2,283.89
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11,12	2,943.17	3,011.13	3,079.42	3,275.84	3,347.48	3,418.73	3,576.29	3,645.26	3,714.70	3,887.05
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	1,737.95	1,787.37	1,836.75	1,984.23	2,042.41	2,098.11	2,243.35	2,297.49	2,351.08	2,479.70
19	7,653.41	7,837.23	8,012.06	8,580.42	8,806.73	9,042.62	9,680.13	9,903.90	10,125.32	10,611.06
20,21	0.00	0.00	10.34	39.60	61.19	89.37	165.37	206.27	243.86	370.69
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.18	198.65	658.15	1,178.64	1,691.55	2,351.22	2,806.86	3,402.45	4,537.39
25	1,417.64	1,904.49	2,131.11	2,361.66	2,523.77	2,684.05	3,005.41	3,171.87	3,340.98	3,704.39
26	2,858.60	2,986.77	3,114.00	3,411.27	3,546.73	3,683.49	4,061.54	4,183.05	4,302.48	4,649.66
27	4,338.42	4,479.49	4,622.06	4,964.34	5,099.41	5,232.29	5,633.95	5,761.22	5,887.01	6,194.91
28	1.18	1.57	1.99	9.14	12.62	16.45	30.30	37.47	44.69	63.42
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	857.46	897.61	936.60	1,039.33	1,090.93	1,141.58	1,268.39	1,319.80	1,370.47	1,482.78
35	3,254.53	3,400.20	3,545.21	3,860.26	4,031.05	4,199.11	4,534.43	4,693.24	4,850.22	5,172.78
36	714.13	740.20	766.03	803.47	833.21	862.68	913.38	947.59	981.20	1,025.29
37	1,052.45	1,316.80	1,598.15	1,929.98	2,145.52	2,314.36	2,608.28	2,772.24	2,920.88	3,160.34
38	2,259.66	2,351.30	2,435.74	2,572.99	2,651.43	2,730.37	2,893.92	2,976.82	3,060.11	3,256.66
39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.76	40.26
42 - 52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	45,355.38	47,495.21	49,587.68	53,653.74	56,101.04	58,517.24	63,280.09	65,611.04	68,072.23	73,101.39

Table 3 (continued) - 10 Foot Contour Areas in Acres

Sheet No	Elevation									
	1060	1070	1080	1090	1100	1110	1120	1130	1140	1150
1,2,3	85.50	119.99	156.03	210.66	258.78	326.58	410.59	486.26	559.45	701.88
4	4,119.37	4,290.42	4,472.16	4,922.14	5,079.86	5,238.01	5,748.25	5,953.32	6,163.19	6,687.67
5	5,514.01	5,629.15	5,746.86	5,917.08	6,021.01	6,125.75	6,306.17	6,414.52	6,524.90	6,708.44
6,7	7,567.41	7,691.31	7,811.89	8,086.20	8,218.47	8,347.21	8,609.85	8,727.27	8,843.22	9,115.45
8	3,372.31	3,418.46	3,463.43	3,556.43	3,609.69	3,662.45	3,755.22	3,803.46	3,850.84	3,944.41
9	2,341.74	2,399.73	2,457.17	2,554.70	2,616.86	2,678.15	2,767.57	2,818.51	2,868.57	2,931.90
10	0.27	1.06	2.23	3.67	5.33	7.44	10.00	12.18	14.41	17.04
11,12	3,964.66	4,042.70	4,121.08	4,323.39	4,400.04	4,478.02	4,672.48	4,744.84	4,819.61	4,999.32
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	9.14	17.16	49.94	137.06	177.15	224.79	363.25
17	0.00	0.00	0.00	8.89	14.77	25.80	101.34	126.76	155.03	261.04
18	2,532.78	2,583.88	2,632.44	2,779.30	2,841.86	2,903.14	3,052.61	3,111.98	3,169.74	3,293.34
19	10,811.42	11,010.85	11,207.20	11,666.91	11,888.30	12,107.02	12,667.73	12,879.87	13,092.30	13,742.31
20,21	436.11	490.25	548.43	678.47	726.00	786.71	914.95	972.11	1,037.76	1,254.25
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.98
23	66.88	541.29	893.44	1,178.72	1,496.98	2,060.26	2,528.33	2,833.91	3,195.28	3,994.43
24	5,422.17	5,827.31	6,180.96	6,798.94	7,030.48	7,252.72	7,983.51	8,184.04	8,387.00	9,020.73
25	3,869.37	4,036.32	4,204.78	4,740.93	4,909.35	5,074.11	5,548.86	5,711.86	5,875.95	6,310.42
26	4,761.13	4,873.95	4,986.69	5,298.78	5,408.44	5,517.22	5,807.04	5,913.61	6,019.66	6,308.58
27	6,335.89	6,478.38	6,620.70	7,030.99	7,179.50	7,322.57	7,659.94	7,792.97	7,924.10	8,313.95
28	74.95	87.47	100.83	148.57	173.72	199.96	264.08	290.26	317.68	380.18
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	2.32	20.97	132.17	191.03	255.85	393.12
33	0.00	0.00	0.00	0.00	0.00	0.00	95.87	138.45	186.57	287.58
34	1,544.61	1,607.68	1,671.13	1,865.81	1,941.04	2,012.23	2,174.27	2,238.25	2,300.36	2,442.50
35	5,333.78	5,491.41	5,650.31	6,019.50	6,188.76	6,353.13	6,700.75	6,858.74	7,013.75	7,299.15
36	1,062.21	1,098.81	1,135.26	1,196.11	1,237.70	1,279.27	1,344.21	1,386.80	1,429.13	1,485.49
37	3,276.91	3,383.77	3,484.52	3,748.21	3,862.32	3,974.41	4,240.06	4,357.67	4,474.57	4,715.90
38	3,350.01	3,442.09	3,533.00	3,761.97	3,866.93	3,970.72	4,181.75	4,271.97	4,360.78	4,521.82
39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	0.00	0.00	8.12	57.93	95.45	209.21	471.25	606.10	1,331.89	2,501.39
41	92.04	136.92	177.64	202.01	208.41	212.71	217.42	221.57	225.77	233.19
42 - 52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	75,935.53	78,683.20	81,266.33	86,765.46	89,299.52	92,195.69	98,503.33	101,225.46	104,622.16	112,242.7

Table 3 (continued) - 10 Foot Contour Areas in Acres

Sheet No	Elevation 1160	1170	1180	1190	1200	1210	1220	1230
1,2,3	770.02	838.77	915.76	1,134.64	1,228.53	1,328.48	1,593.17	1,681.21
4	6,931.98	7,177.18	7,424.59	7,964.22	8,133.08	8,302.79	8,671.16	8,812.95
5	6,842.32	6,980.97	7,123.50	7,338.47	7,504.22	7,682.08	7,906.27	8,060.99
6,7	9,227.99	9,336.29	9,446.90	9,700.68	9,834.83	9,962.86	10,212.63	10,392.97
8	3,991.80	4,038.07	4,083.54	4,179.17	4,230.04	4,279.00	4,330.22	4,380.27
9	2,981.04	3,029.98	3,078.57	3,177.91	3,258.52	3,337.77	3,469.12	3,592.40
10	19.54	21.40	23.17	32.49	38.43	44.50	52.54	60.93
11,12	5,067.79	5,135.03	5,200.87	5,375.87	5,466.15	5,557.82	5,755.81	5,871.92
14	0.00	0.00	0.00	0.00	0.00	0.00	97.93	347.09
15	0.00	0.00	0.00	0.00	0.00	0.00	13.18	31.98
16	406.39	456.31	513.11	706.22	771.27	841.73	1,016.89	1,078.14
17	314.69	371.05	439.99	685.36	767.90	851.13	1,064.77	1,132.64
18	3,348.48	3,401.45	3,452.10	3,560.68	3,624.33	3,686.58	3,807.81	3,868.09
19	13,955.00	14,165.75	14,374.02	14,966.37	15,185.24	15,384.46	15,881.89	16,058.96
20,21	1,332.72	1,420.85	1,530.83	1,850.95	1,961.56	2,081.57	2,573.93	2,752.73
22	32.80	52.80	345.14	979.61	1,238.06	1,550.75	2,554.41	2,977.29
23	4,449.33	5,028.05	5,788.23	6,463.32	6,746.92	7,055.01	7,737.18	7,990.32
24	9,228.69	9,434.59	9,638.42	10,252.55	10,469.90	10,674.78	11,061.20	11,247.32
25	6,468.51	6,623.86	6,776.79	7,247.17	7,457.08	7,661.64	8,052.56	8,206.43
26	6,408.99	6,509.23	6,609.40	6,875.23	7,001.21	7,127.88	7,363.49	7,463.02
27	8,465.95	8,615.22	8,761.67	9,241.49	9,442.85	9,638.63	10,161.05	10,359.86
28	410.14	440.28	470.35	540.59	580.55	621.15	733.18	790.99
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	1.57	7.32	67.82	129.75	151.09	177.41	520.00	636.78
32	463.78	596.68	735.59	881.24	958.24	1036.51	1252.03	1333.02
33	348.77	413.16	482.46	634.28	696.61	761.03	870.24	934.12
34	2,499.97	2,555.86	2,610.00	2,767.95	2,832.78	2,896.07	3,009.99	3,058.87
35	7,442.80	7,583.96	7,723.81	7,946.01	8,079.76	8,212.87	8,437.06	8,574.67
36	1,530.88	1,577.12	1,624.08	1,739.16	1,828.67	1,921.25	2,080.58	2,179.67
37	4,818.72	4,921.67	5,024.64	5,263.92	5,406.26	5,547.31	5,760.05	5,874.31
38	4,604.28	4,682.89	4,758.31	4,928.37	5,038.97	5,149.46	5,301.42	5,387.63
39	0.00	0.00	0.00	24.16	33.81	44.28	59.55	75.72
40	3,078.92	3,383.60	3,541.52	3,798.83	3,936.74	4,068.31	4,270.46	4,385.49
41	239.14	245.14	251.16	263.28	274.18	285.35	342.86	360.94
42 - 52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	115,683.0	119,044.5	122,816.3	130,650.0	134,177.8	137,770.4	146,014.6	149,959.7

Elevation	Boulder and Virgin Basins		Temple Bar/ Virgin Canyon		Gregg Basin		Grand Bay		Pierce Basin		Lower Granite Gorge		Overton Arm		Total Original*	Total GIS**	
	1935	2001	1935	2001	1935	2001	1935	2001	1935	2001	1935	2001	1935	2001	1935	1935	2001
660	1,000	0		0		0		0		0		0		0	1,000	2,562	0
670	7,000	0		0		0		0		0		0		0	7,000	10,007	0
680	21,000	0		0		0		0		0		0		0	21,000	23,815	0
690	43,000	0		0		0		0		0		0		0	43,000	47,328	0
700	73,000	1		0		0		0		0		0		0	73,000	79,318	1
710	111,000	26		0		0		0		0		0		0	111,000	118,067	26
720	156,000	202		0		0		0		0		0		0	156,000	163,409	202
730	207,000	5,199		0		0		0		0		0		0	207,000	215,611	5,199
740	265,000	28,417		0		0		0		0		0		0	265,000	277,446	28,417
750	336,000	67,440		0		0		0		0		0		0	336,000	351,385	67,440
760	422,000	121,482	1,000	0		0		0		0		0		0	423,000	438,625	121,482
770	518,000	185,741	3,000	0		0		0		0		0		0	521,000	538,951	185,741
780	626,000	260,074	7,000	0		0		0		0		0		0	633,000	651,900	260,074
790	745,000	349,344	15,000	0		0		0		0		0		0	760,000	779,990	349,344
800	877,000	465,444	27,000	0	1,000	0		0		0		0		0	905,000	925,986	465,444
810	1,026,000	609,651	41,000	0	2,000	0		0		0		0		0	1,069,000	1,091,429	609,651
820	1,189,000	772,023	57,000	311	3,000	0		0		0		0		0	1,249,000	1,273,389	772,335
830	1,365,000	948,535	76,000	3,383	7,000	0		0		0		0		0	1,448,000	1,471,891	951,919
840	1,553,000	1,137,661	95,000	11,856	15,000	0		0		0		0		0	1,663,000	1,686,458	1,149,517
850	1,755,000	1,338,350	116,000	26,439	28,000	0		0		0		0		0	1,899,000	1,919,277	1,364,789
860	1,970,000	1,553,308	139,000	46,118	46,000	3	1,000	0		0		0		0	2,156,000	2,176,093	1,599,429
870	2,197,000	1,780,139	164,000	70,271	68,000	14	2,000	0		0		0		0	2,431,000	2,451,564	1,850,424
880	2,437,000	2,016,372	191,000	97,383	92,000	312	5,000	0		0		0		4	2,725,000	2,743,872	2,114,072
890	2,690,000	2,266,939	220,000	126,993	120,000	1,468	9,000	0		0		0		330	3,039,000	3,058,139	2,395,731
900	2,955,000	2,532,757	251,000	159,127	150,000	5,661	15,000	0	1,000	0		0	1,000	1,335	3,373,000	3,396,024	2,698,880
910	3,234,000	2,809,297	285,000	193,250	182,000	15,381	21,000	0	3,000	0	1,000	0	3,000	2,875	3,729,000	3,752,285	3,020,803
920	3,529,000	3,098,525	321,000	229,529	215,000	29,891	29,000	0	6,000	0	4,000	0	6,000	5,235	4,110,000	4,130,691	3,363,180
930	3,837,000	3,408,734	360,000	268,951	251,000	48,994	38,000	0	11,000	0	7,000	0	11,000	8,891	4,515,000	4,540,826	3,735,570
940	4,161,000	3,729,848	401,000	310,657	291,000	72,132	47,000	0	16,000	0	11,000	0	16,000	14,301	4,943,000	4,970,327	4,126,939
950	4,498,000	4,060,698	445,000	354,469	332,000	99,441	57,000	0	22,000	0	16,000	0	25,000	22,368	5,395,000	5,419,942	4,536,976
960	4,851,000	4,411,053	491,000	401,683	375,000	130,911	67,000	0	29,000	0	22,000	0	38,000	34,430	5,873,000	5,902,264	4,978,078
970	5,218,000	4,773,929	540,000	451,295	419,000	165,932	79,000	0	36,000	0	29,000	0	55,000	51,121	6,376,000	6,407,202	5,442,277
980	5,598,000	5,146,619	591,000	502,870	467,000	204,436	91,000	0	44,000	0	37,000	0	76,000	72,019	6,904,000	6,934,001	5,925,945
990	5,994,000	5,539,157	647,000	558,125	516,000	247,432	104,000	0	52,000	0	48,000	0	104,000	98,799	7,465,000	7,497,639	6,443,513
1000	6,405,000	5,949,161	705,000	616,882	567,000	294,171	118,000	0	61,000	0	59,000	0	139,000	132,399	8,054,000	8,093,489	6,992,614
1010	6,832,000	6,371,475	766,000	678,198	621,000	343,577	132,000	0	71,000	0	73,000	0	182,000	172,788	8,677,000	8,718,614	7,566,038
1020	7,275,000	6,810,939	830,000	742,827	678,000	396,076	148,000	0	81,000	0	87,000	0	233,000	221,097	9,332,000	9,374,888	8,170,939
1030	7,735,000	7,272,098	899,000	811,669	736,000	452,414	166,000	0	91,000	0	103,000	0	292,000	277,469	10,022,000	10,071,220	8,813,650
1040	8,212,000	7,746,866	969,000	883,214	797,000	511,422	184,000	0	103,000	0	120,000	0	361,000	340,449	10,746,000	10,799,581	9,481,951
1050	8,704,000	8,234,073	1,043,000	957,244	861,000	572,816	204,000	0	117,000	0	138,000	0	439,000	412,947	11,506,000	11,563,711	10,177,079
1060	9,214,000	8,745,095	1,121,000	1,035,952	928,000	638,896	224,000	0	131,000	0	159,000	0	528,000	500,534	12,305,000	12,375,329	10,920,478
1070	9,739,000	9,271,537	1,202,000	1,117,814	998,000	707,989	247,000	0	146,000	0	181,000	0	631,000	599,803	13,144,000	13,219,149	11,697,143
1080	10,281,000	9,806,529	1,288,000	1,201,761	1,069,000	779,053	271,000	0	163,000	0	204,000	0	746,000	707,879	14,022,000	14,092,516	12,495,222
1090	10,841,000	10,366,905	1,377,000	1,291,333	1,144,000	855,132	296,000	0	181,000	0	228,000	0	874,000	829,858	14,941,000	15,014,574	13,343,229
1100	11,418,000	10,943,941	1,470,000	1,384,839	1,222,000	934,789	323,000	0	200,000	0	255,000	0	1,012,000	960,927	15,900,000	15,973,851	14,224,496
1110	12,013,000	11,531,586	1,567,000	1,480,933	1,303,000	1,017,119	352,000	6	222,000	0	282,000	0	1,160,000	1,100,163	16,899,000	16,968,520	15,129,807
1120	12,625,000	12,143,336	1,669,000	1,581,944	1,387,000	1,104,654	383,000	346	244,000	0	311,000	0	1,320,000	1,255,559	17,939,000	18,013,804	16,085,839
1130	13,256,000	12,772,751	1,775,000	1,686,792	1,474,000	1,196,037	415,000	1,223	268,000	0	342,000	0	1,492,000	1,424,589	19,022,000	19,098,866	17,081,392
1140	13,904,000	13,416,975	1,885,000	1,794,681	1,564,000	1,290,126	450,000	5,179	293,000	0	375,000	0	1,675,000	1,602,716	20,146,000	20,222,180	18,109,677
1150	14,569,000	14,077,141	1,999,000	1,905,641	1,656,000	1,386,788	488,000	15,307	319,000	0	410,000	0	1,874,000	1,793,545	21,315,000	21,396,173	19,178,422
1160	15,254,000	14,766,195	2,116,000	2,021,194	1,752,000	1,487,286	527,000	32,248	349,000	0	447,000	0	2,089,000	2,005,734	22,534,000	22,629,094	20,312,657
1170	15,959,000	15,468,756	2,239,000	2,139,245	1,851,000	1,589,795	570,000	58,962	378,000	0	486,000	0	2,320,000	2,228,868	23,803,000	23,896,792	21,485,627
1180	16,685,000	16,182,627	2,365,000	2,259,375	1,951,000	1,693,943	613,000	91,313	411,000	0	526,000	0	2,570,000	2,467,610	25,121,000	25,217,529	22,694,867
1190	17,432,000	16,930,140	2,495,000	2,384,444	2,055,000	1,802,251	660,000	131,473	445,000	0	569,000	0	2,840,000	2,739,307	26,496,000	26,602,933	23,987,616
1200	18,197,000	17,695,217	2,630,000	2,512,678	2,161,000	1,913,578	708,000	174,034	481,000	0	614,000	0	3,129,000	3,025,862	27,920,000	28,031,392	25,321,370
1210	18,984,000	18,475,718	2,769,000	2,643,844	2,270,000	2,027,725	758,000	218,686	519,000	0	661,000	0	3,442,000	3,325,737	29,403,000	29,514,040	26,691,710
1220	19,797,000	19,283,171	2,912,000	2,779,228	2,381,000	2,145,561	812,000	265,371	558,000	0	710,000	0	3,775,000	3,652,704	30,945,000	31,059,363	28,126,035
1230	20,632,000	20,111,593	3,059,000	2,917,917	2,495,000	2,266,010	867,000	313,681	600,000	0	760,000	0	4,134,000	4,002,787	32,547,000	32,287,371	29,611,988

* Original capacity from 1963-64 study.

** GIS computed capacity execpt for Grand Bay, Peirce, and Lower Granite Gorge Basins. Used 1963-64 data for listed basins due to no original digital data