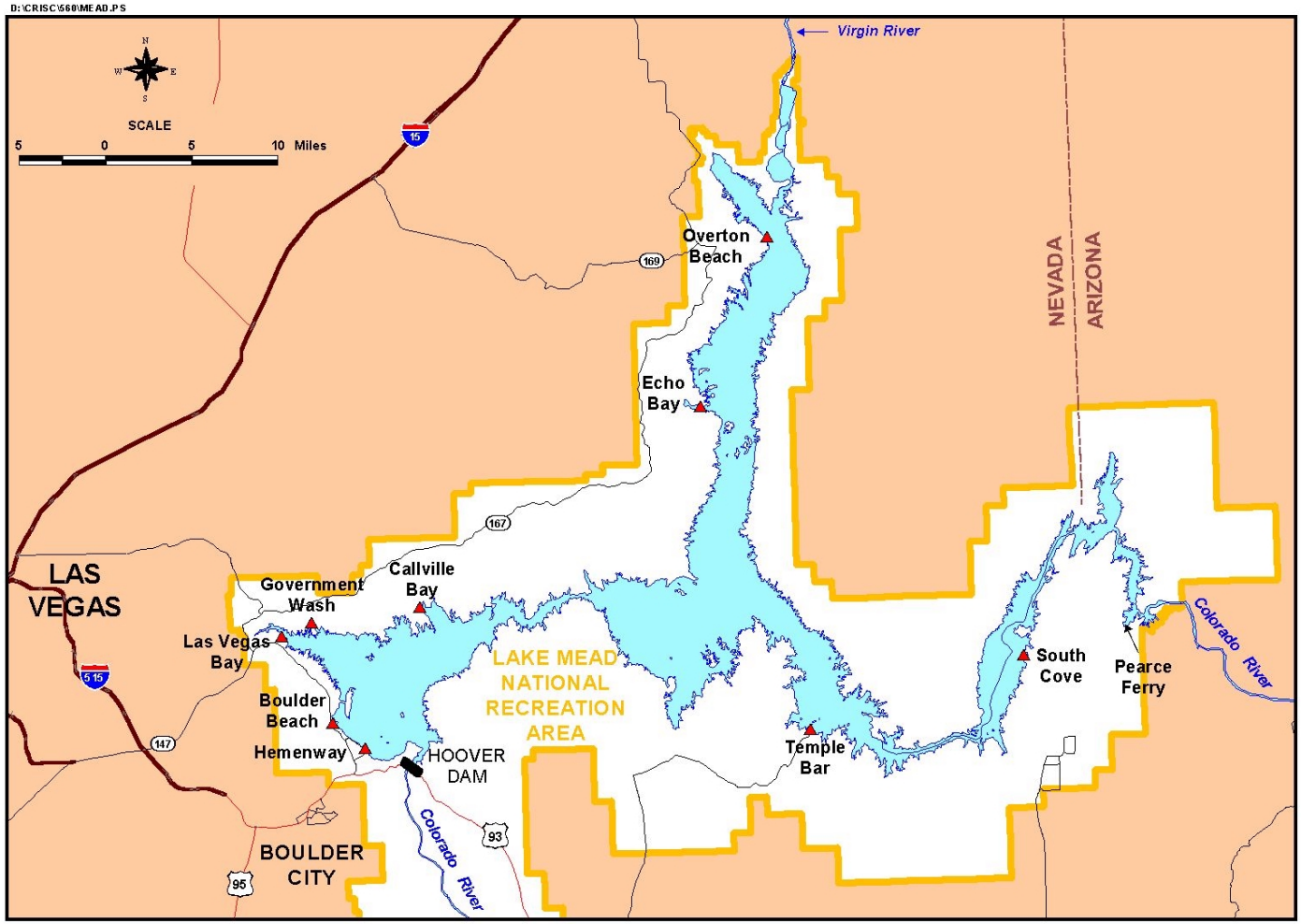
Map 3.9-2
Lake Mead and Associated Shoreline Recreation Facilities



Recreation boating is very popular at Lake Mead, and the shoreline public use facilities are associated with boating use. Most of the facilities shown in the Table 3.9-3 were designed to operate at full pool. However, NPS has determined costs associated with adjusting facilities based on lowered lake elevations. These facilities are out of their normal operating range at pool elevations of 1180 feet msl, requiring sizable capital expenditures to restore them to working order. In addition, there are additional costs associated with any 20-foot drop below this level.

Hemenway – The boat ramp facility at Hemenway is the closest to Hoover Dam and is located off Nevada Highway 166. There is one courtesy dock and a parking area (Henderson, 2000). In addition, campgrounds and a group campground are located at Hemenway. The group campground is for self-contained vehicles, such as trailers and motor homes. There are no restrooms or tables.

Boulder Beach – The facilities at Boulder Beach are located off of Lakeshore Scenic Drive, just off of Nevada Highway 167 outside of Boulder City, Nevada, and include restrooms, tables and grills. There is also a group campground at Boulder Beach for tent camping only with limited vehicle parking.

Las Vegas Bay – The facilities at Las Vegas Bay are located off Lakeshore Scenic Drive, just off Lake Mead Drive (Nevada Highway 167). According to a marina worker, when the lake elevation drops below 1190 feet msl, the boat ramps and floats have to be readjusted.

Government Wash – The boat ramp facility at Government Wash is located off Nevada Highway 167. There is one courtesy dock and a parking area (Henderson, 2000).

Calville Bay – The facilities at Calville Bay are located off Nevada Highway 167 on the north shore of Lake Mead, midway up Calville Bay.

Echo Bay – The facilities at Echo Bay are located off Nevada Highway 167, midway up Overton Arm.

Overton Beach – The facilities at Overton Beach are located off Nevada Highway 169, near the top of Overton Arm.

South Cove – The boat launching facilities at South Cove are located off Aztec Wash, which is off Interstate 93 in Arizona. There is one courtesy dock, picnic facilities, and unpaved parking (Henderson, 2000). In addition, there is an airstrip approximately four miles from the facilities at South Cove (Henderson, 2000).

Temple Bar – The facilities at Temple Bar are located on the south shore of Lake Mead at the end of an unnamed road off Interstate 93 in Arizona.

Pearce Ferry - This area is located near Aztec Wash, which is off Interstate 93 in Arizona at the eastern end of the LMNRA. The area is a large, gravel wash with a

gentle slope down to the water. Vehicles are driven down to the water's edge to load rafts and other small boats. There is parking and a year-round portable toilet, and primitive camping is allowed. There are no ramps, docks or other developed facilities at the site.

The Hualapai River Runners are one of the commercial guide services that use Pearce Ferry as a take out. The River Runners conduct guided whitewater trips that put in at Diamond Creek, and float trips that put in at Quartermaster Canyon. All of these trips take out at Pearce Ferry.

Comments from the Hualapai Tribe on the Draft EIS identified a Lake Mead pool elevation of 1183 feet msl as a threshold elevation for accessing the Pearce Ferry takeout. At this elevation and below, the river subdivides into smaller channels and large areas of silt and mud are exposed, prohibiting access to the take out.

When Pearce Ferry is inaccessible as a takeout, boaters must continue downstream to South Cove, an additional 16 miles. This costs river runners fuel (for motorized craft), time (one to two more hours on the river) and possible safety problems (due to fatigue). For commercial boaters, the additional travel time to South Cove can also result in lost business by preventing guides from meeting river tour schedules.

3.9.2.2.4.1 Threshold Elevations

The description of facilities above identifies several pool elevations where facilities or access to facilities would be affected. At Las Vegas Bay, 1190 feet msl was identified as an elevation at which facilities would require adjustment, but would continue to be operable. Elevation 1180 feet msl was identified by the NPS as the elevation at which most other developed facilities would require capital expenditures, rather than just an adjustment, in order to maintain operation. Elevation 1183 feet msl was identified by the Hualapai Tribe in their comments on the DEIS as a threshold elevation for using the undeveloped Pearce Ferry site as a takeout for rafts and other whitewater boats.

The DEIS evaluated the consequences of elevation 1180 feet msl for facilities at Lake Mead (Section 3.9.2.3.2). In response to the Hualapai Tribe's comment on the DEIS regarding the threshold elevation of 1183 for Pearce Ferry, this FEIS evaluates the consequences of 1183 feet msl instead of 1180 feet msl. Therefore, 1183 feet msl is used as a representative threshold elevation for shoreline facilities and public access at Lake Mead and is used in the Environmental Consequences section (Section 3.9.2.3.2) to evaluate the effects of baseline conditions and interim surplus criteria alternatives on shoreline facilities and public access at Lake Mead.

3.9.2.3 ENVIRONMENTAL CONSEQUENCES

Recreational boating on Lake Mead and Lake Powell is dependent upon access to the water via public shoreline facilities such as marinas, docks and boat ramps, as well as

undeveloped launch areas. Some fluctuation in water level is a normal aspect of reservoir operations, and facilities are designed and operated to accommodate it. However, decreased pool elevations or increased variations or rates in pool elevation fluctuation could result in increased operation costs, facility improvements, temporary closures, or possibly permanent closure of shoreline facilities.

As lake levels fluctuate, developed facilities must be adjusted accordingly. This could require moving and relocating docks, extending utility lines associated with shoreline facilities, increasing sewage pump capacity, reducing pressure on water supply lines to boats, adjusting and relocating buoys, moving breakwater barriers and channel markers, and extending launch and dock ramps (Combrink and Collins, 1992). If lake fluctuations exceed 25 feet, special adjustments to lake facilities would be necessary, including the relocation of anchors and the extension or reduction of utility lines and cables that provide utility service to floating facilities (Combrink and Collins, 1992).

In addition, if developed facilities are temporarily or permanently closed or relocated, or undeveloped sites are no longer accessible, there may be associated increases in reservoir boating congestion or longer wait times at sites that remain open. This could have an effect on boating satisfaction. The cost of relocating developed facilities in response to changes in reservoir pool elevations is discussed in Section 3.9.6.

3.9.2.3.1 Lake Powell

As discussed in the Affected Environment section above, pool elevations of 3677 feet msl and 3612 feet msl were identified as representative thresholds that are problematic for shoreline facilities at Lake Powell. Elevation 3677 feet msl was identified as a threshold elevation for the existing Antelope Point, and the NPS identified 3612 feet msl as a threshold for several other facilities. These are elevations below which facility adjustments or capital improvements would be required.

There are two other threshold elevations not treated directly below. Elevation 3626 feet msl has also been defined as a threshold elevation for the design boat ramp at Antelope Point. This elevation is discussed in Section 3.9.3.3.1. Facilities at Rainbow Bridge would be affected by pool elevations of 3650 feet msl or below, as described above in Section 3.9.2.2. Although specific probabilities of remaining above elevation 3650 feet msl were not determined, the probabilities that lake elevations would remain above 3650 feet msl would be between the probabilities for the threshold elevations of 3677 and 3612 feet msl, which are discussed below.

Figure 3.9-1 provides an overview of the differences in end-of-July water surface elevation trends under baseline conditions and the action alternatives over the period of analysis.

Figure 3.9-2 and Table 3.9-4 indicate the probability of Lake Powell elevation exceeding the threshold of 3677 feet msl in July. The probability would decrease the

Figure 3.9-1
Lake Powell End of July Water Elevations
Comparison of Surplus Alternatives to Baseline Conditions
90th, 50th and 10th Percentile Values

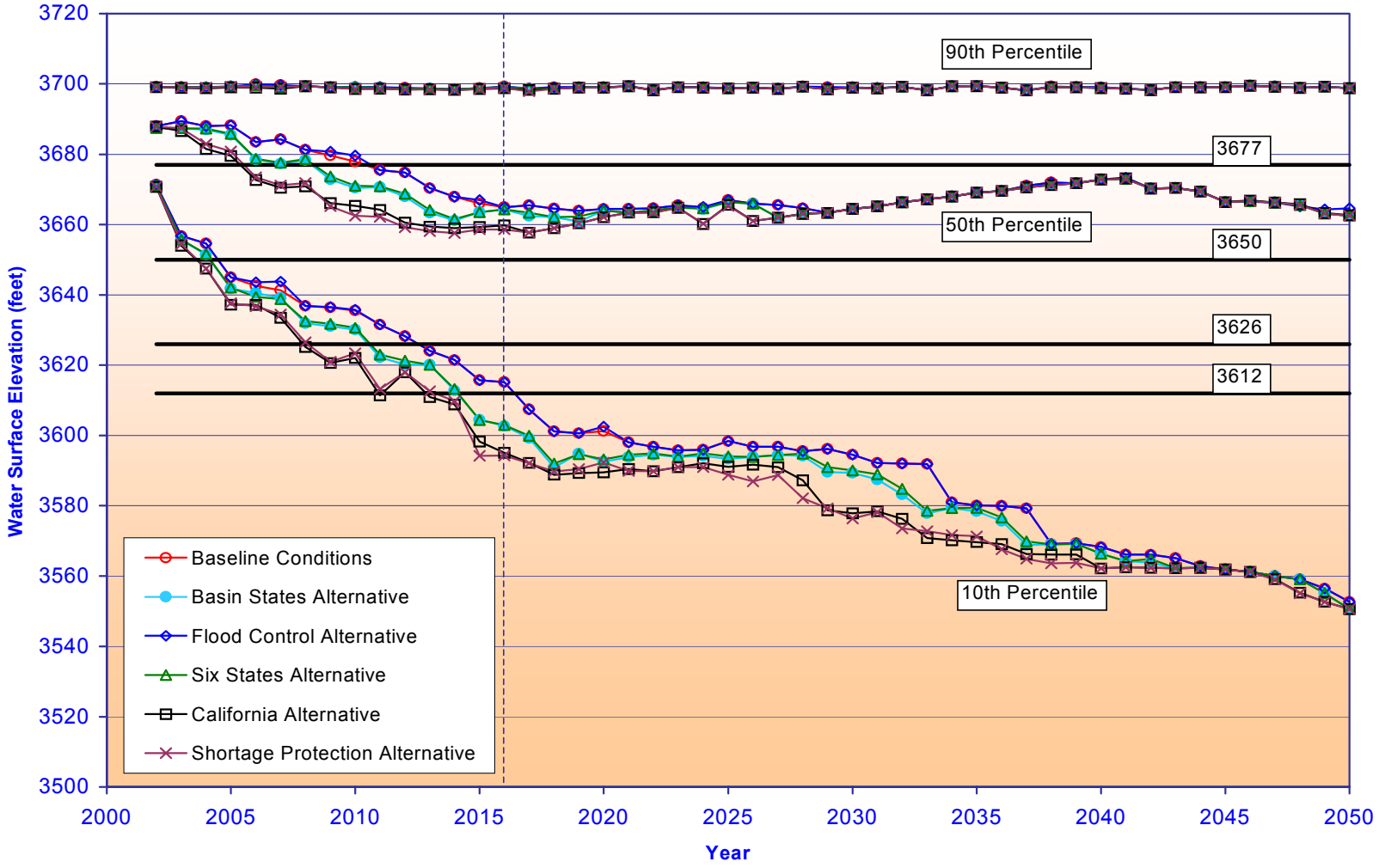
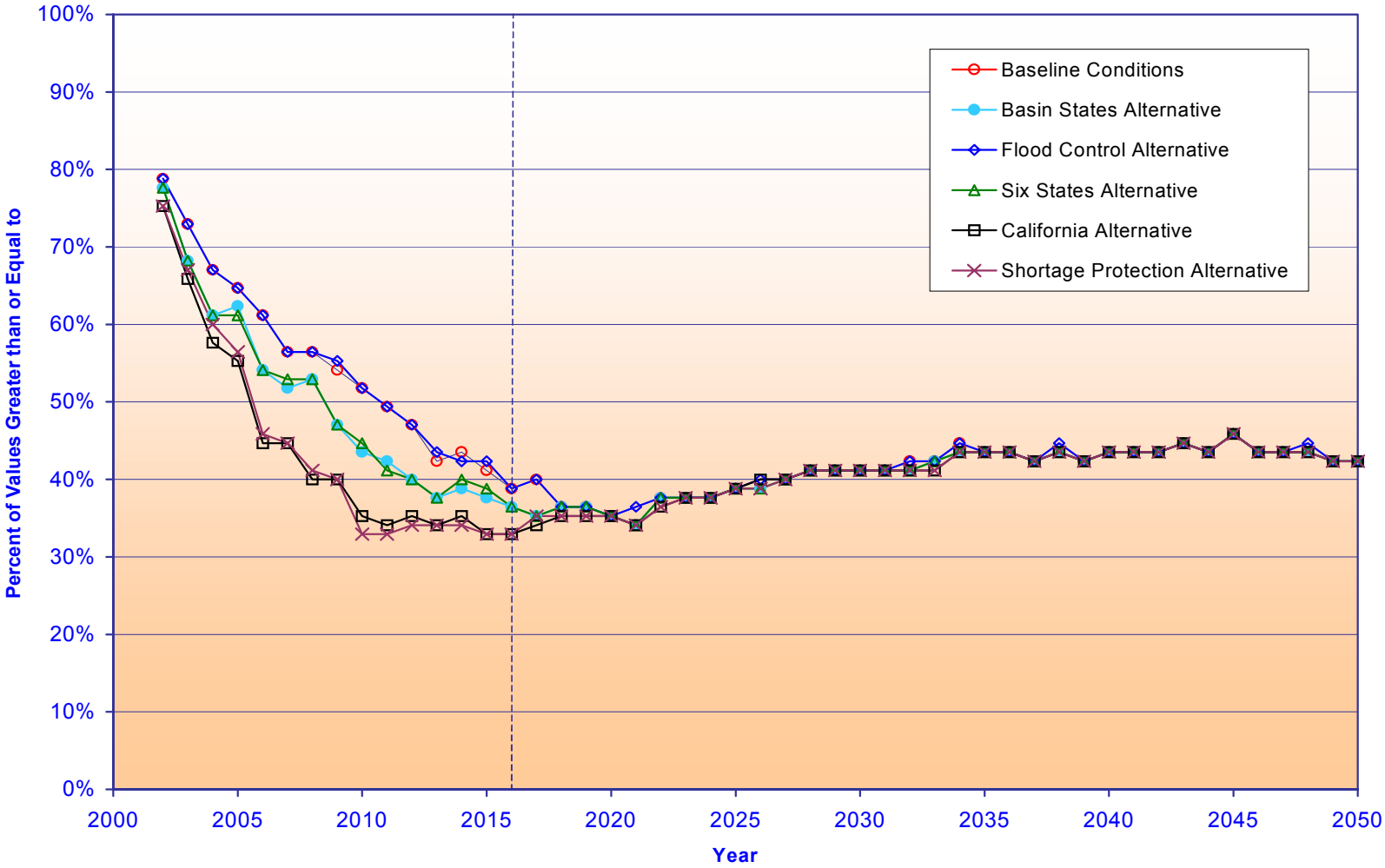


Figure 3.9-2
Lake Powell End of July Water Elevations
Comparison of Surplus Alternatives to Baseline Conditions
Percent of Values Greater than or Equal to 3677 Feet msl



most over the initial 15 years of the period of analysis. During this time, the probability would decline from nearly 80 percent to less than 40 percent under baseline conditions and the alternatives. During years 16 through 25 the effects of the alternatives would diminish, although the probability of exceeding elevation 3677 feet msl would remain low (roughly 30-40 percent). After year 25 there would be no discernable effect of the alternatives for the remainder of the analysis period; the probability of exceeding elevation 3677 feet msl would remain fairly low at around 40 to 45 percent.

The differences between the alternatives would be most apparent during the first 15 years. The greatest difference occurs in year nine, when the difference between baseline conditions and the Shortage Protection Alternative is 19 percent. The Flood Control Alternative, with results that are nearly identical to those of baseline conditions, has the lowest probability of pool elevations dropping below 3677 feet msl, whereas the Shortage Protection and California alternatives have the highest probability. The Basin States and Six States alternatives have probabilities between the baseline conditions and the Shortage Protection Alternative.

Table 3.9-4
Probabilities of Lake Powell Elevation Exceeding 3677 feet in July

Alternative	Range of Probability		
	Years 1-15	Years 16 - 25	Years 26 – 49
Baseline Conditions	79%-39%	40%-34%	46%-40%
Basin States Alternative	78%-36%	39%-34%	46%-40%
Flood Control Alternative	79%-39%	40%-35%	46%-40%
Six States Alternative	78%-36%	39%-34%	46%-40%
California Alternative	75%-33%	40%-34%	46%-40%
Shortage Protection Alternative	75%-33%	39%-34%	46%-40%

The probability of Lake Powell pool elevation exceeding the threshold of 3612 feet msl in July under baseline conditions and each of the alternatives is shown in Figure 3.9-3 and Table 3.9-5. The probability is greater than 70 percent throughout the period of analysis. The probability begins at 100 percent, due to the relatively full initial elevation, and declines gradually throughout the period of analysis. In general, probabilities decrease within a 10 to 15 percent range during the initial 15-year period, followed by an additional 10 to 15 percent decrease from years 16 through 34. For the remainder of the analysis period, decreases are around 5 percent.

The differences between the alternatives is slight, with the greatest difference in probabilities being about eight percent. The Flood Control Alternative has the same

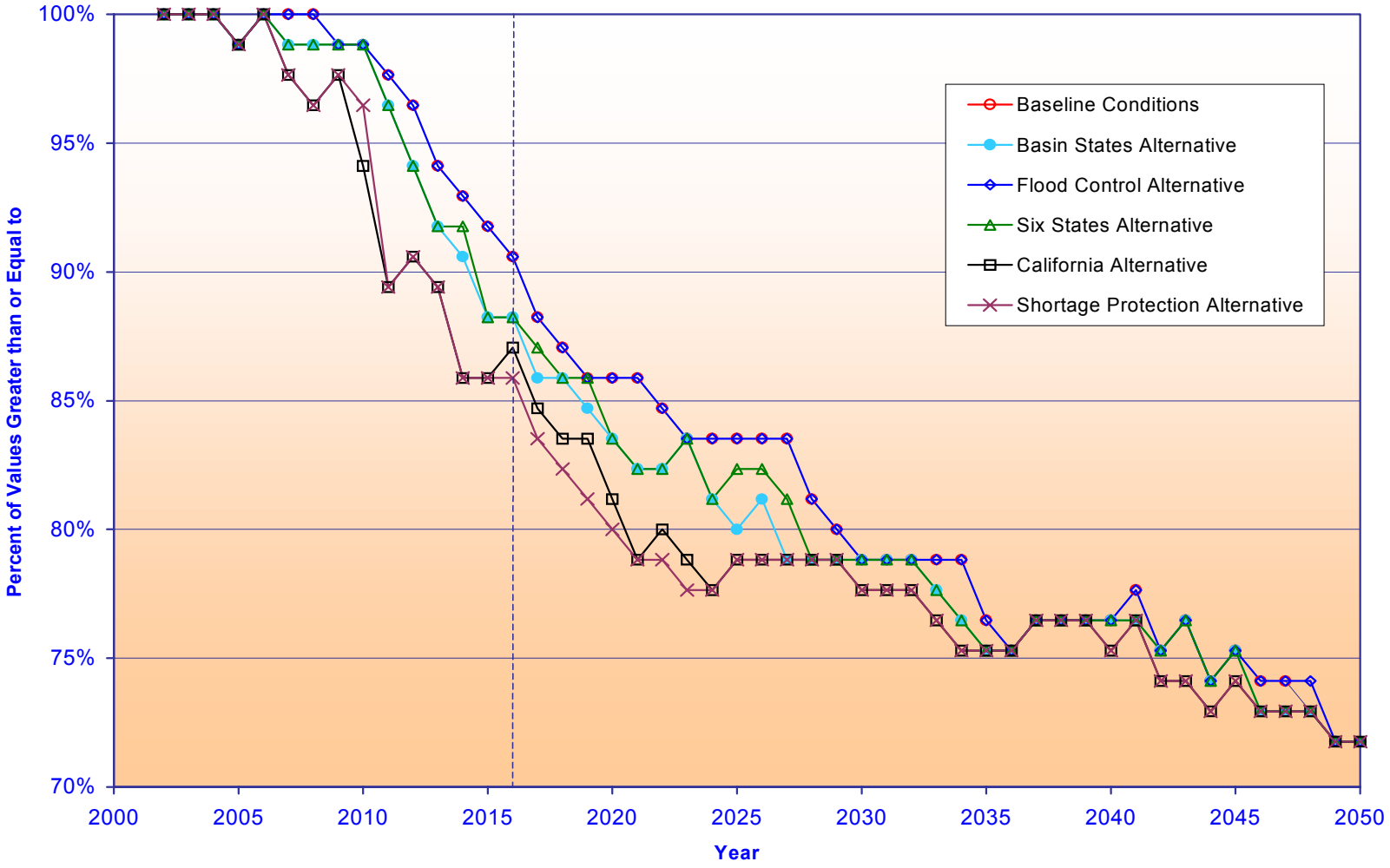
probabilities as baseline conditions and therefore would have no effect. The other alternatives have probabilities less than or equal to baseline conditions. The Shortage Protection and California Alternatives have effects similar to each other and result in the greatest departure (maximum eight percent) from baseline conditions. The Six States and Basin States alternatives are between the Shortage Protection Alternative and baseline conditions, and have a maximum departure of five percent from baseline conditions.

Each of the alternatives is discussed below in more detail with respect to the patterns indicated on Figures 3.9-2 and 3.9-3 and Tables 3.9-4 and 3.9-5.

Table 3.9-5
Probabilities of Lake Powell Elevation Exceeding 3612 feet in July

Alternative	Range of Probability		
	Years 1-15	Years 16-34	Years 35-49
Baseline Conditions	100%-91%	88%-76%	78%-72%
Basin States Alternative	100%-88%	86%-75%	76%-72%
Flood Control Alternative	100%-91%	88%-76%	78%-72%
Six States Alternative	100%-88%	87%-75%	76%-72%
California Alternative	100%-87%	85%-75%	76%-72%
Shortage Protection Alternative	100%-86%	84%-75%	76%-72%

Figure 3.9-3
Lake Powell End of July Water Elevations
Comparison of Surplus Alternatives to Baseline Conditions
Percent of Values Greater than or Equal to 3612 Feet msl



3.9.2.3.1.1 Baseline Conditions

The probability under baseline conditions that Lake Powell pool elevation is above 3677 feet msl in July decreases from 79 percent in year 1 to 39 percent in year 15. In years 16 through 25, the probability ranges between 40 and 34 percent. For the remainder of the analysis period the probability ranges between 40 and 46 percent. The early declining probabilities (for baseline conditions and alternatives) can be mostly attributed to increasing consumptive use of Colorado River water in the Upper Basin. The later rise is attributed to the suspension of equalization requirements between Lake Powell and Lake Mead (see Section 1.4.2).

There is a high probability that July Lake Powell pool elevation would exceed the threshold of 3612 feet msl for the baseline condition throughout the period of analysis. Between years 1 and 15, the probability decreases from 100 percent to 91 percent. Between years 16 and 34, the probability continues to decrease gradually from 88 percent to 76 percent. For the remainder of the analysis period, the probability decreases slightly, ranging between 78 and 72 percent. The declining trend of all probabilities (baseline conditions and alternatives) can be mostly attributed to increasing consumptive use of Colorado River water in the Upper Basin.

3.9.2.3.1.2 Basin States Alternative

The probability of the Lake Powell pool elevation exceeding 3677 feet msl in July is slightly lower under the Basin States Alternative than under baseline conditions. In the first 15 years, the probability decreases from 78 percent to 36 percent under the Basin States Alternative. The probability during this period is one percent to eight percent lower than under baseline conditions. In years 16 to 25, the probability decreases to a low of 34 percent, then rises to 39 percent. During this period, the probability is generally the same as for baseline conditions. For the remainder of the analysis period, probabilities fluctuate between 40 and 46 percent, and are generally the same as under baseline conditions.

The probability of Lake Powell elevation exceeding 3612 feet msl in July under the Basin States Alternative is slightly lower than for the baseline conditions. Between years 1 and 15, the probability decreases from 100 percent to 88 percent, compared to a 91 percent probability under baseline conditions. During this period, the probability is typically up to two percent less than under baseline conditions. Between years 16 and 34, the probability continues a gradual decline to 75 percent, and ranges between zero and five percent less, but typically between zero and two percent less, than under baseline conditions. For the remaining years of analysis, the probability continues to decline to a low of 72 percent in year 2050, and is within one percent of the probability under baseline conditions.

3.9.2.3.1.3 Flood Control Alternative

The probability of Lake Powell pool elevation exceeding 3677 feet msl under the Flood Control Alternative is approximately the same as for baseline conditions. In the first 15 years, the probability decreases from 79 to 39 percent, and is within one percent of the probability under baseline conditions. From years 16 to 25, the probability fluctuates between 40 and 35 percent. The probability during this period is typically the same as under baseline conditions. By the end of the period of analysis, the probability remains fairly constant, between 40 and 46 percent. During this period, the probability is typically the same as under baseline conditions.

The probability of Lake Powell pool elevation exceeding 3612 feet msl under the Flood Control Alternative is generally the same as that described for baseline conditions throughout the period of analysis.

3.9.2.3.1.4 Six States Alternative

The probability of Lake Powell pool elevation exceeding 3677 feet msl under the Six States Alternative is very similar to the Basin States Alternative discussed above. In early years, the probability is up to seven percent less than under baseline conditions. In later years, the probability is generally the same as under baseline conditions.

The probability of Lake Powell pool elevation exceeding 3612 feet msl under the Six States Alternative is also very similar to the Basin States Alternative. In early years, the probability is up to four percent less than under baseline conditions. In later years, the probability is typically the same as under baseline conditions.

3.9.2.3.1.5 California Alternative

The probability of Lake Powell pool elevation exceeding 3677 feet msl is lower under the California Alternative than under baseline conditions. In the first 15 years, the probability declines from 75 percent to a low of 33 percent, and ranges from 4 to 16 percent less than under baseline conditions. In years 16 to 25, the probability increases slightly, ranging from 34 to 40 percent, and is typically the same as under baseline conditions. For the remainder of the analysis period, the probability increases slightly, remaining between 40 and 46 percent, and is always within one percent of baseline conditions.

The probability of Lake Powell pool elevation exceeding 3612 feet msl under the California Alternative is slightly lower than under baseline conditions. Between years 1 and 15, the probability decreases from 100 percent to 87 percent and is from zero to eight percent less than under baseline conditions. The probability continues to decrease from 85 to 75 percent in years 16 through 34, and is up to seven percent less than under baseline conditions. For the remaining years of analysis, the probability ranges between 76 and 72 percent, and is from zero to two percent less than under baseline conditions.

3.9.2.3.1.6 Shortage Protection Alternative

The probability of Lake Powell pool elevation exceeding 3677 feet msl under the Shortage Protection Alternative is not significantly different from the California Alternative discussed above. In early years, the probability is up to 19 percent less than under baseline conditions. In later years, the probability is typically the same as under baseline conditions.

The probability of Lake Powell pool elevation exceeding 3612 feet msl under the Shortage Protection Alternative is not significantly different from the California Alternative discussed above. In early years, the probability is up to eight percent less than under baseline conditions. In later years, the probability is within two percent of the probability under baseline conditions.

3.9.2.3.2 Lake Mead

As discussed in the Affected Environment section above, a pool elevation of 1183 feet msl was identified as a representative threshold that is problematic for shoreline access at Lake Mead. Figure 3.9-4 provides an overview of the difference in end-of-year water surface elevations under baseline conditions and each of the action alternatives. Although elevations would typically be lower during the summer peak-use period, the differences between baseline conditions and action alternatives would be similar to those presented herein.

Figure 3.9-5 and Table 3.9-6 indicate the probability of Lake Mead elevation exceeding the threshold of 1183 feet msl at the end of the year. As shown in Figure 3.9-5, the probability is low over the period of analysis due primarily to effects associated with baseline conditions. In the initial 15 years of analysis, the probabilities under baseline conditions and the alternatives decline by more than 20 percent. Shortly after year 15, the probabilities under baseline conditions and the alternatives converge near 35 percent. Subsequently, a probability of 28 to 36 percent is maintained until the end of the analysis period.

Table 3.9-6
Comparison of Lake Mead Elevation Exceedance Probabilities for Elevation 1183 Feet

Alternative	Year 0-15	Years 16 - 49
Baseline Conditions	65%-36%	36%-29%
Basin States Alternative	55%-32%	35%-29%
Flood Control Alternative	65%-36%	38%-29%
Six States Alternative	55%-32%	35%-29%
California Alternative	45%-25%	35%-28%
Shortage Protection Alternative	47%-26%	34%-28%

Figure 3.9-4
Lake Mead End of December Water Elevations
Comparison of Surplus Alternative to Baseline Conditions
90th, 50th and 10th Percentile Values

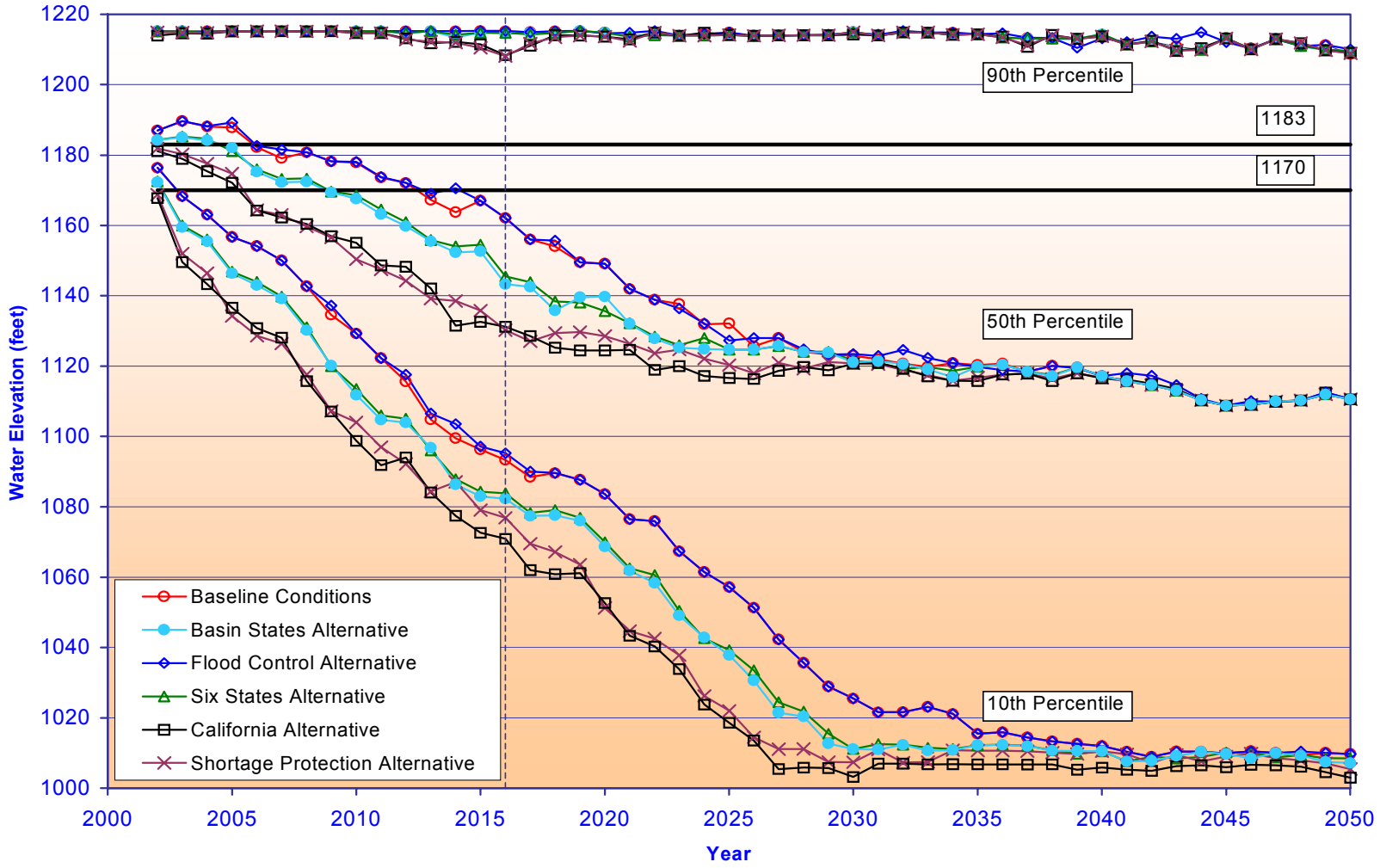
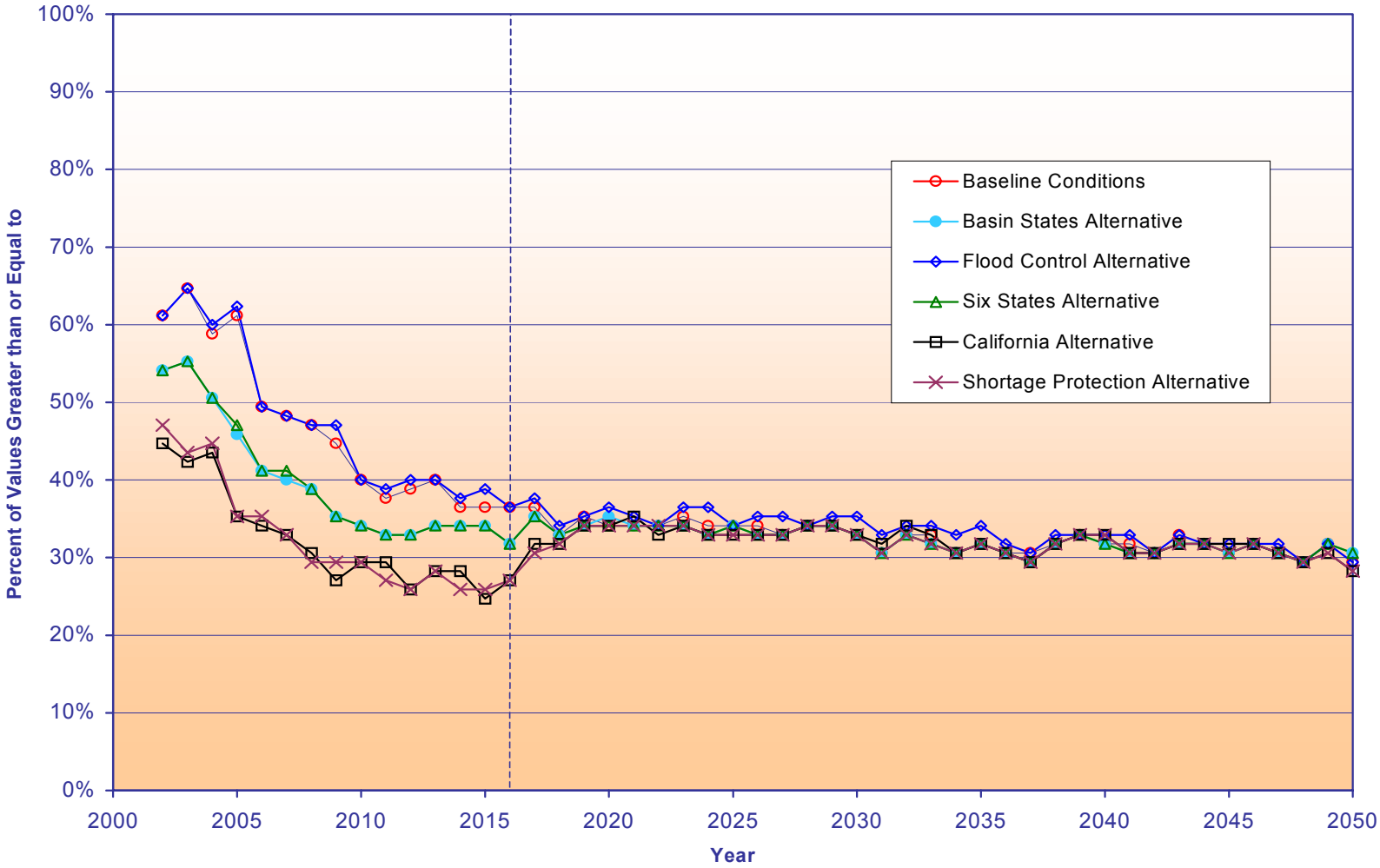


Figure 3.9-5
Lake Mead End of December Water Elevations
Comparison of Surplus Alternatives to Baseline Conditions
Percent of Values Greater than or Equal to 1183 Feet msl



3.9.2.3.2.1 Baseline Conditions

The probability of Lake Mead pool elevation exceeding 1183 feet msl declines from 65 percent to 36 percent under baseline conditions during the first 15 years of the analysis period. In the remaining years of the analysis period, the probability ranges between 36 and 29 percent. The general declining trend of Lake Mead elevations over time can be attributed to increases in Upper Basin use.

3.9.2.3.2.2 Basin States Alternative

The probability of Lake Mead pool elevation exceeding 1183 feet msl in the first 15 years of the analysis period declines from 55 percent to 36 percent under the Basin States Alternative. The probability during this period is typically up to nine percent less than under baseline conditions. In remaining years of the analysis period, the probability ranges between 35 and 29 percent. During this period, the probability is within one percent of the probability under baseline conditions.

3.9.2.3.2.3 Flood Control Alternative

The probability of Lake Mead pool elevation exceeding 1183 feet msl in the first 15 years of the analysis period declines from 65 percent to 36 percent under the Flood Control Alternative. In remaining years of the analysis period, the probability ranges between 38 and 29 percent. The probability of exceeding elevation 1183 feet msl under the Flood Control Alternative would be approximately the same as under baseline conditions throughout the entire analysis period.

3.9.2.3.2.4 Six States Alternative

The probability of Lake Mead pool elevation exceeding 1183 feet msl in the first 15 years of the analysis period declines from 55 percent to 32 percent under the Six States Alternative. In remaining years of the analysis period, the probability ranges between 35 and 29 percent. The probability is nearly identical to that for the Basin States Alternative discussed above.

3.9.2.3.2.5 California Alternative

The probability of Lake Mead pool elevation exceeding 1183 feet msl is lowest under the California Alternative in most years. In the first 15 years, the probability ranges between 45 and 25 percent. This is up to 26 percent lower than under baseline conditions. After year 16, the probability is within one percent of the probability under baseline conditions.

3.9.2.3.2.6 Shortage Protection Alternative

The probability of Lake Mead pool elevation exceeding 1183 feet msl under the Shortage Protection Alternative is nearly the same as under the California Alternative. In the first 15 years, the probability ranges between 47 and 27 percent and is up to 26 percent lower than under baseline conditions. After year 16, the probability associated with the Shortage Protection Alternative generally converges with baseline conditions and the other alternatives, similar to the California Alternative.

3.9.3 RESERVOIR BOATING/NAVIGATION

This section discusses potential effects of the interim surplus criteria on reservoir boating and navigation. This includes a discussion of areas on the reservoir that could become unsafe for boating at certain elevations due to exposed rocks or other obstructions, and safe boating densities that indicate the number of boats that can safely be accommodated on the reservoirs at one time.

Boating navigation and safe boating capacities on Lake Powell and Lake Mead are dependent upon water surface elevations. As lake levels decline, so does the available surface area. Hazards such as exposed rocks may become more evident, or changes in navigation patterns may be necessary. The area of the reservoirs available for boating is also reduced, which may affect the number of boats that can safely operate at one time. At low pool elevations, special buoys or markers may be placed to warn boaters of navigational hazards. In addition, signs may be placed in areas that are deemed unsuitable for navigation.

3.9.3.1 METHODOLOGY

Description of the affected environment is based on a literature review of published and unpublished documents and maps, and personal communications with NPS staff at the GCNRA and LMNRA. Information received includes the identification of navigation issues associated with recreational boating on Lake Powell and Lake Mead, such as navigation safety and safe boating densities. Low reservoir pool elevations identified in the literature or through discussions with NPS as being of concern for reservoir boating and navigation are discussed herein. Assessment of environmental consequences associated with implementing the interim surplus criteria alternatives is based on river system modeling and probability analyses of Lake Powell and Lake Mead pool elevations exceeding identified thresholds.

Safe boating capacity is another aspect of boating navigation and safety. Safe boating is one factor that can be used to assess the carrying capacity of a reservoir. To date, no determination of carrying capacity (number of boats at one time) has been made for either Lake Powell or Lake Mead. However, the NPS is currently developing a carrying capacity approach for managing water-based recreation on Lake Mead that is based on

the U.S. Forest Service Recreation Opportunity Spectrum system. Results of the NPS study were not available for this analysis.

A safe boating density of nine acres per boat was established for the GCNRA (USBR, 1995b) at Lake Powell. The safe boating density could be used to assess the effects of the interim surplus criteria alternatives on boating safety if daily boating levels for the reservoir were available. However, there is no known information on the level of daily or peak boating use, such as whether the current boating densities on the reservoirs have approached or exceeded the safe boating density (as discussed below). Without information on current reservoir boat densities, it is not known whether future reductions in pool elevations at Lake Powell and Lake Mead would result in unsafe boating conditions.

3.9.3.2 AFFECTED ENVIRONMENT

3.9.3.2.1 Lake Powell Boating Navigation and Safety

In 1986, the GCNRA developed an "Aids to Navigation Plan" for Lake Powell that identified boating safety issues on the reservoir and low pool elevations that could affect boating (NPS, 1986). The navigation system uses regulatory buoys and other marking devices to warn boat operators of hazardous conditions associated with subsurface obstructions or changes in subsurface conditions that could be hazardous for safe passage. Placement of many of these marking devices is dependent on the lake elevation.

At pool elevations below 3680 feet msl, there are several places that remain passable, although buoys are placed for safe navigation. At elevation 3626 feet msl and 3620 feet msl, there are two areas on the reservoir that are closed to commercial tour boats and recreational boats, respectively, because of hazardous obstructions to navigation. One of the areas is around Castle Rock, just east of the Wahweap Marina, and the other is around Gregory Butte, which is about midway to Dangling Marina from Wahweap (as shown on Map 3.9-1). At elevation 3626 feet msl commercial tour boats leaving the Wahweap Marina heading up reservoir (east) must detour 8.5 miles around the southern end of Antelope Island. At Gregory Butte, commercial tour boats must detour 4.5 miles around Padre and Gregory Buttes (NPS, 1986). The added mileage and increased travel time makes the more popular half-day trips of the area infeasible for commercial tour boat operators. In addition, the added mileage may influence recreational boaters to remain in the area of Wahweap Bay, which can result in congestion (Henderson, 2000).

In addition to buoys marking obstructions, the Aids to Navigation Plan also established a marked travel corridor to guide boat travel on Lake Powell. This primary travel corridor is the main channel of the old Colorado River bed and is marked with buoys along the entire length of the reservoir. Except for the reservoir mouth, there are no known pool elevations at which boat passage along this main travel corridor becomes restricted and affects boating.

Near the upstream end of the reservoir, where the San Juan River enters, a delta has formed that can affect river boaters coming into Lake Powell at low pool elevations. River boaters from the San Juan River paddle through Lake Powell to a location where a boat transports them 20 to 25 miles (depending on the pick-up location) to the Hite Marina. At low water surface elevations, the river boaters must travel further downstream to reach a location that is accessible to the transport company's boat.

Although this results in more miles to paddle to the takeout, there is usually enough current in the river to carry the boats. For some boaters, the added mileage is an opportunity to paddle additional rapids on the Colorado River in Cataract Canyon (Hyde, 2000). For others, the additional mileage is seen as exposure to additional navigational hazards, possibly requiring portaging of boats due to restricted channel widths and subsurface conditions.

3.9.3.2.1.1 Lake Powell Safe Boating Capacity

Recreational boating is the most frequent type of boating activity on Lake Powell, with an estimated 1.5 million boaters per year. One of the most popular activities at Lake Powell is to take houseboats and motor boats for multiple day excursions to explore the reservoir.

The number of boats that Lake Powell can safely accommodate at one time (i.e., safe boating capacity) is based on a 1977 Bureau of Outdoor Recreation standard of nine surface acres per boat (USBR, 1995b). The amount of water storage in Lake Powell directly influences the surface area of the reservoir and the number of boats that can safely be on the reservoir. Table 3.9-7 lists median July Lake Powell surface areas for baseline conditions and alternatives in the year 2016 and identifies the safe boating capacity of the reservoir at those elevations, based on an assumed maximum safe density of nine acres per boat. The surface area of Lake Powell is reduced by approximately 9 to 10 percent for each 20-foot drop.

Table 3.9-7
Lake Powell Safe Boating Capacity at Water Surface Elevations

Scenario	Median Elevation in July of Year 15 (feet msl)	Water Surface Area (acres)	Safe Boating Capacity[1]
Baseline Conditions	3665	134,600	14,956
Basin States Alternative	3664	134,100	14,900
Flood Control Alternative	3665	134,600	14,956
Six State Alternatives	3664	134.100	14,900
California Alternative	3660	130,800	14,533
Shortage Protection Alternative	3659	130,200	14,467

[1] Number of boats, assuming safe density of 9 acres per boat.

At full pool for Lake Powell (3700 feet msl), the surface area is 160,782 acres. Using the safe boating density of nine surface acres per boat, Lake Powell's safe boating capacity at full storage is approximately 17,865 boats. As pool elevation decreases, the surface area available for boats also decreases. While safe reservoir boating carrying capacity is reduced at lower lake elevations, there may be additional shoreline camping available due to more exposed beaches. However, boating capacity is more constrained by safe boating densities than by the availability of camping sites on Lake Powell (Combrink and Collins, 1992).

3.9.3.2.2 Lake Mead Boating Navigation and Safety

Similar to the navigation system on Lake Powell, regulatory buoys and other marking devices are used on Lake Mead to warn boat operators of dangers, obstructions, and changes in subsurface conditions in the main channel or side channels.

As with Lake Powell, the main channel of the old Colorado River bed forms the primary travel corridor on Lake Mead and is marked along its entire length with buoys for boating guidance. In addition, regulatory buoys are placed in areas where there may be a danger for safe passage.

Excursions from Lake Mead into the Grand Canyon are a popular activity. Boats entering the Grand Canyon usually launch at Pearce Ferry, South Cove or Temple Bar (refer to Map 3.9-2). There are no developed facilities at South Cove or Pearce Ferry. Points of interest in the Grand Canyon include Columbine Falls, Bat Cave, Spencer Creek, and Separation Canyon. In addition to sightseeing being a popular activity, many boaters include overnight camping stays on these excursions (USBR, 1995b).

The upper arms and inflow areas of Lake Mead are considered dangerous for navigation due to shifting subsurface sediments. In the main channel of the reservoir, the Grand

Wash Cliffs area is the beginning of dangerous navigation conditions, and no houseboats are allowed beyond this point (NPS, undated).

Over the years, sediment has built up in the section of the reservoir between Grand Wash and Pearce Ferry. When lake elevations drop below 1170 feet msl, the sediment is exposed as mud flats and there is no well-defined river channel. As a result, the area is too shallow for motor boats to navigate upstream and into the lower reaches of the Grand Canyon. With fluctuating flows, even smaller crafts have a difficult time accessing the area because of the shifting nature of the channel (USBR, 1995b). Based on this information, 1170 feet msl is considered a threshold elevation for safe boating navigation at Lake Mead.

While the area around Pearce Ferry is an issue for navigation at 1170 feet msl, it is also inaccessible as a take out for whitewater boaters at elevation 1183 feet msl and boaters must paddle an additional 16 miles to South Cove (Henderson, 2000). Paddling to South Cove includes paddling through the section of reservoir between Pearce Ferry and Grand Wash. (Refer to Section 3.9.2.2.3 for a description of the Pearce Ferry facility, and Section 3.9.2.3.2 for an analysis of environmental consequences associated with elevation 1183 feet msl.)

In addition to the boating navigation issues summarized above, there are swimmer safety issues at Lake Mead. At Gypsum Wash (between Las Vegas Bay and Government Wash), there are cliffs that are popular with recreationists for jumping into the lake. When lake elevations are below 1180 feet msl, the water is too shallow for cliff jumping from this location. Another jumping spot that was poplar during the late 1980's when reservoir levels were down is an area called "33 Hole." This location is popular for cliff jumping when the lake elevation reaches 1165 feet msl. Cliff jumping at both locations is discouraged by the NPS for safety reasons (Burke, 2000). Since the activity is discouraged, the identified elevations were not considered as thresholds for evaluation of effects.

3.9.3.2.3 Lake Mead Safe Boating Capacity

The LMNRA receives approximately ten million visitors annually. Of those that participate in water-based recreation, most either swim, boat, fish, sailboard, use paddlecraft, or scuba dive (USBR, 1996b). Since no boating capacity has been established for Lake Mead, the safe boating density of nine acres per boat established for Lake Powell was assumed; safe boating capacities were determined based on reservoir elevation/surface area relationships. There is no daily or peak boating use information available to establish the relationship between actual boating densities and the safe boating capacity values shown below in Table 3.9-8. This table shows Lake Mead surface area under the predicted pool elevations for baseline conditions and the alternatives at the end of 2016, and identifies the safe boating capacity of the reservoir based on an assumed maximum safe density of nine acres per boat.

Table 3.9-8
Lake Mead Safe Boating Capacity at Water Surface Elevations

Scenario	Median Elevation at End of Year 15 (feet msl)	Water Surface Area (acres)	Safe Boating Capacity[1]
Baseline Conditions	1162	120,200	13,356
Basin States Alternative	1143	108,100	12,011
Flood Control Alternative	1162	120,200	13,356
Six State Alternatives	1145	109,400	12,156
California Alternative	1131	102,100	11,344
Shortage Protection Alternative	1130	101,700	11,300

[1] Number of boats, assuming safe density of 9 acres per boat.

At full pool for Lake Mead, the operating surface area is 153,235 acres. Using the safe boating density of nine surface acres per boat, Lake Mead's safe boating capacity at full storage is approximately 17,000 boats. As pool elevation decreases, the safe boating capacity also decreases.

3.9.3.3 ENVIRONMENTAL CONSEQUENCES

Boating navigation and safe boating densities on Lake Powell and Lake Mead are dependent upon water surface elevations. As lake levels fluctuate, hazards, such as exposed rocks at lower pool elevations or different navigational patterns at higher elevations, may become evident. At low pool elevations, special buoys or markers may be placed to warn boaters of navigational hazards. In addition, signs may be placed in areas deemed unsuitable for navigation.

Assessment of environmental consequences of the alternatives on boating navigation and safety is based on river system model output, described in detail in Section 3.3. The probability of effects under baseline conditions and the alternatives was determined through identifying the probability of exceeding a representative "threshold" pool elevation during the period of analysis. The selection of the threshold pool elevation is based on the known boating navigation issues discussed in the Affected Environment section above. The probabilities of the reservoirs remaining above the identified threshold elevations are identified for baseline conditions and the interim surplus criteria alternatives, and differences between probabilities under baseline conditions and alternatives are compared.

In addition to navigation issues that occur at low pool elevations, the number of boats that can safely be accommodated on the reservoir at one time (safe boating capacity) is also a reservoir boating issue. As discussed previously, the lack of boating use data and spatial modeling of the effects of the alternatives on shoreline conditions precludes a quantitative or qualitative assessment of the impacts associated with the alternatives. In general, as pool elevations change, so does the reservoir surface area and the number of boats that can safely be accommodated on the reservoir. Therefore, the alternatives that

result in the greatest potential for lower surface elevations would tend to increase the likelihood of exceeding safe boating densities. Without current and projected boating use levels for comparison to surface areas under the alternatives, it cannot be determined whether the change in available surface area would result in an exceedance of the calculated safe boating capacities shown in Tables 3.9-7 and 3.9-8, so environmental consequences related to safe boating capacity are not analyzed further.

3.9.3.3.1 Lake Powell

For Lake Powell boating navigation, a reservoir pool elevation of 3626 feet msl was identified as a representative threshold in Section 3.9.3.2.1. Figure 3.9-1 (presented previously) shows elevation trends for baseline conditions and the alternatives over the period of analysis.

In addition, as discussed in the section on shoreline facilities (Section 3.9.2.2.2), elevation 3626 feet msl is also close to the elevation for a new proposed boat ramp at Antelope Point, which will extend down to 3620. Using an assumption of six feet for freeboard, the environmental consequences associated with elevation 3626 for navigation are applicable to the future operability of the proposed ramp at Antelope Point.

Figure 3.9-6 depicts the probability of pool elevations exceeding 3626 feet msl under baseline conditions and each of the alternatives. Table 3.9-9 presents a comparison of the probabilities associated with years 1 through 15, 16 through 28, and 29 through 49. The probability decreases (from 100 to 65 percent) during the analysis period under baseline conditions and all of the alternatives. The probability is greatest for baseline conditions and the Flood Control Alternative, and least for the California and Shortage Protection Alternatives. The Six States and Basin States alternatives have probabilities between the others.

Figure 3.9-6
Lake Powell End of July Water Elevations
Comparison of Surplus Alternatives to Baseline Conditions
Percentage of Values Greater than or Equal to 3626 Feet

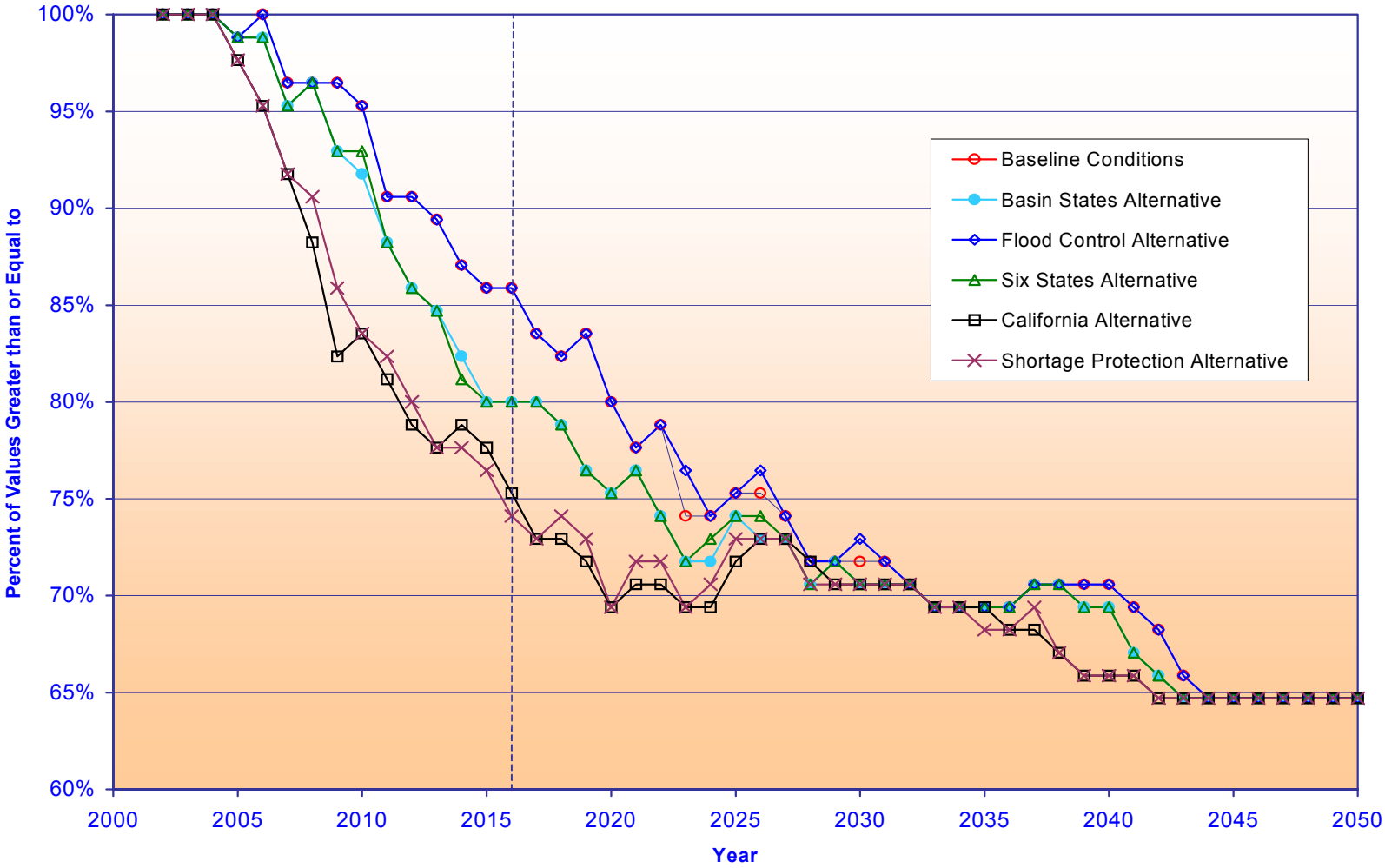


Table 3.9-9
Probabilities of Lake Powell Elevation Exceeding 3626 feet in July

Projected Condition	Range of Probability		
	Years 1 - 15	Years 16 - 28	Years 29 - 49
Baseline Conditions	100%-86%	84%-72%	72%-65%
Basin States Alternative	100%-80%	80%-71%	71%-65%
Flood Control Alternative	100%-86%	84%-72%	73%-65%
Six States Alternative	100%-80%	80%-71%	71%-65%
California Alternative	100%-75%	73%-69%	71%-65%
Shortage Protection Alternative	100%-74%	74%-69%	71%-65%

3.9.3.3.1.1 Baseline Conditions

The probability of Lake Powell pool exceeding the safe boating navigation elevation of 3626 feet msl in July gradually decreases from 100 percent to 65 percent under baseline conditions during the entire period of analysis. The probability decreases more slowly under baseline conditions and the Flood Control Alternative than under the other alternatives. In the first 15 years of the analysis period, the probability decreases from 100 to 86 percent. From years 16 to 28, the probability decreases from 84 to 72 percent. For the remainder of the analysis period, the probability continues to decrease, declining from 72 to 65 percent.

3.9.3.3.1.2 Basin States Alternative

The probability of Lake Powell pool elevation exceeding 3626 feet msl gradually decreases from 100 percent to 65 percent under the Basin States Alternative during the entire period of analysis. During the first 15 years, the probability declines more rapidly than under baseline conditions, dropping from 100 to 80 percent. The probability in year 15 is six percent less than under baseline conditions. Between years 16 and 28, the probability begins to converge with the probabilities of baseline and the other alternatives, and ranges between 80 and 71 percent. During this period, the probability is up to 7 percent less than under baseline conditions. For the remainder of the analysis period, the probability is similar to baseline conditions and the other alternatives, continuing to decline to a low of 65 percent.

3.9.3.3.1.3 Flood Control Alternative

For the Flood Control Alternative, the probability of Lake Powell pool elevation exceeding 3626 feet msl is practically the same as for baseline conditions throughout the analysis period. As shown in Figure 3.9-6, there are only three years in which the probability is different (within one to two percent) from baseline conditions.

3.9.3.3.1.4 Six States Alternative

The probability of Lake Powell elevation exceeding 3626 feet msl under the Six States Alternative is identical to the probability under the Basin States Alternative in all but four years, when there is a one percent difference.

3.9.3.3.1.5 California Alternative

The California Alternative results in the lowest probability of Lake Powell pool elevation exceeding 3626 feet msl. The probability decreases from 100 to 75 percent in the first 15 years of the analysis period. Between years 16 and 28, the probability begins to converge with the probabilities under baseline and the other alternatives, ranging between 73 and 69 percent. For the remainder of the analysis period, the probability is similar to baseline conditions and the other alternatives, continuing to decline to a low of 65 percent. During these three periods, the probability is up to 14 percent, 12 percent and 5 percent, respectively, below the probability under baseline conditions.

3.9.3.3.1.6 Shortage Protection Alternative

For the Shortage Protection Alternative, the probability of Lake Powell pool elevation exceeding 3626 feet msl is nearly the same as under the California Alternative throughout the analysis period. The probability is up to 12 percent less than under baseline conditions during the first 15 years of the analysis period. Between years 16 and 28, the probability begins to converge with the probabilities under baseline conditions and the other alternatives, and is up to 11 percent less than under baseline conditions. For the remainder of the analysis period, the probability is within 5 percent of baseline conditions.

3.9.3.3.2 Lake Mead

A reservoir pool elevation of 1170 feet msl was identified as the representative threshold for boating navigation at Lake Mead, as described in Section 3.9.3.2.2.

Figure 3.9-7 depicts the probability of Lake Mead end-of-December pool elevations exceeding 1170 feet msl for baseline conditions and the alternatives. Table 3.9-10 compares the probabilities associated with years 1 through 15, years 16-22, and years 23 through 49.

Figure 3.9-7
Lake Mead End of December Water Elevations
Comparison of Surplus Alternatives to Baseline Conditions
Percentage of Values Greater than or Equal to 1170 Feet

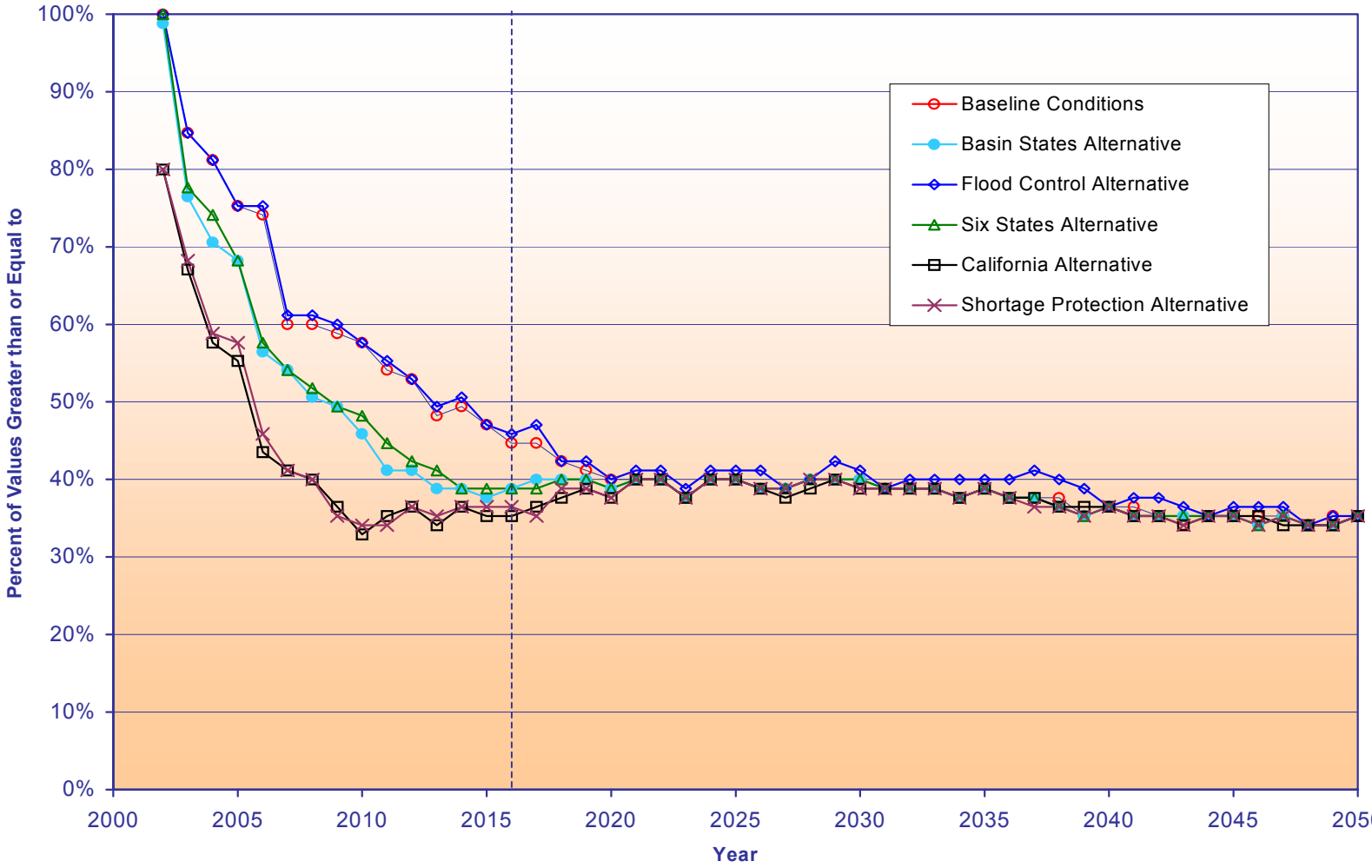


Table 3.9-10
Probabilities of Lake Mead End-of-December Elevation Exceeding 1170 feet

Projected Condition	Range of Probability		
	Years 1 – 15	Years 16 - 22	Years 23 - 49
Baseline Conditions	100%-45%	45%-38%	40%-34%
Basin States Alternative	99%-38%	40%-38%	40%-34%
Flood Control Alternative	100%-46%	47%-39%	42%-34%
Six States Alternative	100%-39%	40%-38%	40%-34%
California Alternative	80%-33%	40%-36%	40%-34%
Shortage Protection Alternative	80%-34%	40%-35%	40%-34%

Under baseline conditions and the alternatives, the probability of Lake Mead pool elevation exceeding 1170 feet msl declines during the interim period, then stabilizes for the remainder of the period of analysis. The probability is greatest for baseline conditions and the Flood Control Alternative, and least for the California and Shortage Protection Alternatives. The Basin States and Six States alternatives have probabilities between the others.

3.9.3.3.2.1 Baseline Conditions

The probability of Lake Mead pool elevation exceeding the safe boating and navigation elevation of 1170 feet msl at the end of the year declines from 100 to 34 percent under baseline conditions throughout the entire period of analysis. Probabilities decrease more slowly under baseline conditions than under all alternatives except for Flood Control. In the first 15 years of analysis, the probability declines from 100 to 45 percent. Between years 16 and 22, the probability continues to decline from 45 to 38 percent, as the alternatives converge with baseline conditions. For the remainder of the analysis period, the probability under baseline conditions is similar to the alternatives, ranging between 40 and 34 percent.

3.9.3.3.2.2 Basin States Alternative

The probability of Lake Mead pool elevation exceeding 1170 feet msl declines from 99 to 34 percent throughout the entire period of analysis for the Basin States Alternative. As with most other alternatives, the decrease occurs during the interim period and occurs more quickly than under baseline conditions. In the first 15 years of the analysis period, the probability drops from 99 percent to 39 percent and is typically up to 13 percent less than under baseline conditions. Between years 16 and 22, the probability stabilizes and converges with baseline conditions. The range of probability is from 40 to 38 percent, and is up to five percent less than under baseline conditions. For the

remainder of the analysis period, the probability is within one percent of baseline conditions, ranging between 40 and 34 percent.

3.9.3.3.2.3 Flood Control Alternative

The probability of Lake Mead pool elevation exceeding 1170 feet msl under the Flood Control Alternative is typically up to two percent greater than under baseline conditions. In the first 15 years of analysis, the probability decreases from 100 to 46 percent, and is within one percent of baseline conditions. Between years 16 and 22, the probability continues to decline, ranging between 47 and 39 percent, and is typically one percent greater than under baseline conditions. For the remainder of the analysis period, the probability is up to 4 percent greater than baseline conditions, ranging between 42 and 34 percent.

3.9.3.3.2.4 Six States Alternative

The effects of the Six States Alternative would be nearly the same as those for the Basin States Alternative. In the first 15 years of the analysis period, the probability of Lake Mead elevation exceeding 1170 feet msl is typically up to 11 percent less than under baseline conditions. Between years 16 and 22, the probability stabilizes and converges with baseline conditions. The probability is typically within two percent of baseline conditions. For the remainder of the analysis period, the probability is within one percent of baseline conditions, ranging between 40 and 34 percent.

3.9.3.3.2.5 California Alternative

The probability of Lake Mead pool elevation exceeding 1170 feet msl under the California Alternative is similar to that under the Shortage Protection Alternative and less than under baseline conditions and the other alternatives. In the first 15 years, the probability drops from 80 to 33 percent, then rises to 35 percent. The probability is up to 31 percent less than under baseline conditions. Between years 16 and 22, the probability rises slightly and converges with baseline conditions and the other alternatives. The probability ranges from eight percent less than to the same as under baseline conditions. For the remainder of the analysis period, the probability is within one percent of baseline conditions.

3.9.3.3.2.6 Shortage Protection Alternative

The effects of the Shortage Protection Alternative are very similar to those described for the California Alternative. The probability of Lake Mead pool elevation exceeding 1170 feet msl is generally within one percent of the probability under the California Alternative throughout the period of analysis.

3.9.4 RIVER AND WHITEWATER BOATING

The Grand Canyon Protection Act directs the Secretary to operate Glen Canyon Dam in accordance with the additional criteria and operating plans specified in Section 1804 of the Act, and to exercise other authorities under existing law in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established, including but not limited to natural and cultural resources and visitor use.

The Glen Canyon Dam Adaptive Management Program (AMP) was established as a Federal Advisory Committee to assist the Secretary in implementing the Grand Canyon Protection Act. As discussed in Section 3.2.2, the AMP provides a process for assessing the effects of current operations of Glen Canyon Dam on downstream resources and using the results to develop recommendations for modifying operating criteria and other resource management actions. While the interim surplus criteria could have an influence on releases from Glen Canyon Dam, such releases will be governed by the criteria in the Record of Decision, which was developed in full consideration of both the safety and quality of recreational experiences in Glen and Grand Canyons. A summary of the Glen Canyon Dam Record of Decision has been included as Attachment D of this FEIS.

The only effect that implementation of the interim surplus criteria alternatives would have on whitewater boaters would be the possibility of lowered pool elevations in Lake Powell and Lake Mead. Whitewater boaters on the San Juan River often end their trips at Lake Powell. While decreased levels in Lake Powell have effects on take out points in the Colorado and San Juan Rivers, they also may expose additional rapids in Cataract Canyon, which would expand whitewater rafting opportunities. Section 3.9.3.2.1 discusses boaters entering Lake Powell.

Whitewater boaters on the Colorado River often end their trips in Lake Mead. Pearce Ferry is the preferred Lake Mead take out for boaters, but it may not be accessible when the reservoir pool elevation is below 1183 feet msl. An analysis of this elevation is presented in Section 3.9.2.2. A take out is also available at Diamond Creek, upstream of Lake Mead at the Hualapai Reservation. The Hualapai Tribe maintains the take out area and road and charges a fee for take out. The Hualapai Tribe also conducts river trips from Diamond Creek (on the Colorado River) to Pearce Ferry. This concession may be affected if trips encounter changes in availability of the Pearce Ferry take out.

3.9.5 SPORT FISHING

This section considers potential effects of the interim surplus criteria alternatives on recreational opportunities associated with sport fishing at Lake Powell, Lake Mead and Lake Mohave (between Hoover and Davis Dam). Sport fishing in the Colorado River between Glen Canyon Dam and Lake Mead will not be affected by the interim surplus criteria action due to the protection afforded by the Adaptive Management Program (see

Section 3.9.4). Fluctuations in flows between Hoover Dam and the SIB under the alternatives would be within the historical operating range of the river. Therefore, changes in flows under the alternatives would not affect recreation within these areas. Adverse effects on sport fisheries from potential changes in water temperature below Hoover Dam would not be expected, as discussed in Section 3.7.3.

3.9.5.1 METHODOLOGY

The discussion of the affected environment for reservoir fishing is based on a review of published documents. Much of this information was derived from the following sources: for Lake Powell, the *Fish Management Plan, Glen Canyon National Recreation Area* (NPS, 1996); and for Lake Mead, the *Desert Lake View Newspaper, Fall/Winter 1999*. In addition, creel information and angler fishing data has been obtained from state agencies in Utah, Arizona, and Nevada responsible for managing the fisheries resources at Lake Mead, Lake Powell, and Lake Mohave.

Assessment of potential impacts on sport fishing in Lake Powell, Lake Mead and Lake Mohave is based on information presented in other sections of the document regarding sport fishery populations (Section 3.7), reservoir shoreline facilities (Section 3.9.2) and reservoir navigation (Section 3.9.3). There were no specific reservoir pool elevation thresholds related to sport fishing identified from the literature reviewed. Catch rates for reservoir fishing are assumed to be directly related to reservoir habitat discussed in Section 3.7, Aquatic Resources. Fishing satisfaction is assumed to be directly related to the general recreation issues of boating access to the water via shoreline facilities, and boating navigation potential for hazards or reservoir detours due to low pool elevations. As discussed in Section 3.7, catch rates are not expected to be affected by fluctuations in pool elevations.

3.9.5.2 AFFECTED ENVIRONMENT

3.9.5.2.1 Sport Fishing in Lake Powell

As discussed in Sections 3.7 and 3.8, native Colorado River species have not done well in the reservoir environment. While some native species may spawn in the reservoir, it is believed that the majority of young are eliminated by sport fish predators. The predominant sport fishery in Lake Powell revolves around striped bass. The striped bass depend on threadfin shad as a food source, so it is critical to maintain a balanced shad population for the striped bass. The threadfin shad in Lake Powell are at the northernmost portion of their range and are very sensitive to fluctuations in water temperature. In addition to striped bass, Lake Powell supports largemouth and smallmouth bass, walleye, channel catfish, bluegill, and black crappie. Lake Powell has been stocked with fish almost annually, beginning in 1963 (NPS, 1996).

Lake Powell is a popular fishing destination. Over three million people visit the GCNRA annually, and those that fish spend a total of close to two million angler hours in pursuit of a variety of sport fish.

Nearly all anglers fish by boat due to the cliff-like canyon walls of the reservoir. Shore angling is rare. Annual angler use, based on boat fishing, is estimated to average 72,608 days. The majority of anglers (42 percent) come from Utah, followed by Colorado (24 percent) and Arizona (23 percent). California and other states make up the remaining 11 percent (Gustaveson, 2000).

Currently, the catch rate is 0.3 fish per hour, a number that has declined in recent years due to angling pressure. Approximately one-half of the fish caught are harvested, which results in an average annual harvest of 300,000 fish (NPS, 1996). Fishing catch rates and harvest rates differ at Lake Powell due to changing public attitudes towards catch and release. Most anglers release smallmouth bass and harvest striped bass. In 1997, 86 percent of the smallmouth bass caught were returned, compared to only 28 percent of the 396,000 striped bass caught (Gustaveson, 2000).

Most Lake Powell anglers seek a fishing opportunity and would rather catch any fish, compared to a targeted individual species. However, when asked for a species preference, most anglers prefer to catch black bass or striped bass. Most anglers tend to target species they expect to catch most readily. (Gustaveson, 2000).

Recent studies have indicated a trend of increasing biocontaminant concentration in aquatic organisms near the dam. Selenium has been found in plankton and in striped bass. Although there have not yet been any apparent negative impacts on striped bass reproduction, selenium can pose a health risk to anglers from consumption. If the presence of selenium continues, educating the anglers and performing risk assessment studies may be necessary (NPS, 1996).

3.9.5.2.2 Sport Fishing in Lake Mead

Fishing is a favorite activity at Lake Mead. Largemouth bass, striped bass, channel catfish, rainbow trout, bullhead catfish, sunfish, crappie, and bluegill can be found in Lake Mead.

Lake Mead is famous for its striped bass, with an occasional catch weighing over 40 pounds, although weights of three to five pounds are more common. Angler survey results from NDOW indicate that since 1984, striped bass have been the species most sought after by anglers by a wide margin (62.7 percent) (NDOW, 2000). Fishing for striped bass or largemouth bass is good throughout the entire lake, but panfish and catfish are more prevalent in the upper Overton Arm.

The Nevada Division of Wildlife (NDOW) stocks rainbow trout from late December through the spring months. The razorback sucker, a protected fish species, must be

returned to the water immediately and carefully, if caught. Fishing is generally better in the fall months of September, October and November. Larger fish are caught by deep water trolling in spring from March through May.

To fish from shore, a valid license is required from the state where the fishing occurs. If fishing from a boat or other flotation device, a use stamp from the other state is required. Rainbow trout fishing also requires an additional stamp. Children under 14 are not required to have a license.

The NDOW conducts annual creel and angler use surveys of Nevada licensed anglers (resident and non-resident). While Arizona licensed anglers also fish in Lake Mead, it is estimated that roughly 80 percent of the fishing use on the reservoir is represented in the NDOW surveys (Sjöberg, 2000). NDOW's annual statewide angler questionnaire is mailed out to 10 percent of all Nevada licensed anglers, resident and non-resident. Table 3.9-11 presents data from 10 years of questionnaires.

Table 3.9-11
Nevada Division of Wildlife Annual Angler Questionnaire Results for Lake Mead

Year	Anglers	Angler Days	Fish Harvest (all species)	Days per Angler	Fish per Angler	Fish per Angler Day
1989	44,444	476,543	940,608	10.72	21.16	1.97
1990	41,012	488,381	934,807	11.91	22.79	1.91
1991	47,873	792,883	1,532,481	16.56	32.01	1.93
1992	46,460	558,301	1,314,508	12.02	28.29	2.35
1993	46,649	697,117	1,699,816	14.94	36.44	2.44
1994	45,507	648,928	1,710,412	14.26	37.59	2.64
1995	47,630	574,972	1,590,413	12.07	33.39	2.77
1996	42,715	554,625	1,410,440	12.98	33.02	2.54
1997	43,747	505,892	1,239,840	11.56	28.34	2.45
1998	43,831	612,551	1,568,676	13.98	35.79	2.56
Average	44,987	591,019	1,394,200	13.10	30.88	2.36

Source: NDOW, Statewide Angler Questionnaire Database, 1989 through 1998, cover letter dated 5 October, 2000.

The Arizona Department of Game and Fish estimated the Arizona licensed angler use for Lake Mead (based on Nevada survey results) to be 118,422 days in 1995. Combined with Nevada's use estimate for the same year, there were 693,394 angler days on Lake Mead in 1995 (83 percent from Nevada, and 17 percent from Arizona).

3.9.5.2.3 Sport Fishing in Lake Mohave

This section discusses sport fishing in Lake Mohave, below Hoover Dam. Table 3.9-12 shows the developed access sites and facilities at Lake Mohave.

Table 3.9-12
Lake Mohave Developed Recreation Facilities

Facilities	Willow Beach	Cottonwood Cove	Katherine
Ranger Station	•	•	•
Lodging	N/A	•	•
Trailer Village (fee)	N/A	•	•
Campground	N/A	•	•
Marina	•	•	•
Food Service	•	•	•
Grocery/Gift Shop	•	•	•
Gasoline	•	•	•
Picnic Area	•	•	•
Shower (fee)	N/A	•	•
Trailer Sewage Dump	•	•	•
Boat Sewage Dump	•	•	•
Self-service laundry	N/A	•	•
Propane Service	•	•	•
Houseboat Rentals	N/A	•	•

Source: NPS, 1995.
• indicates presence of improvement
N/A indicates no improvement

In Lake Mohave there are largemouth bass, striped bass, channel catfish, rainbow trout, bullhead catfish, sunfish, crappie and bluegill. Because Lake Mohave is within the LMNRA, the same fishing rules and requirements described above for Lake Mead apply to Lake Mohave. NDOW stocks rainbow trout in the lake from late December through the spring months. The USFWS stocks rainbow trout throughout the year, with concentrated stocking October through May.

Three protected species, including razorback sucker, Colorado squawfish, and bonytail chub, are the last of the native Colorado River fish and can be found in Lake Mohave.

When caught, these fish must be released. Fishing is open year round, but the best fishing generally occurs in September, October and November. For deep water trolling, March through May is best.

Fishing on Lake Mohave can be exceptional. Bass and trout often run three pounds, with some trout weighing as much as 10 or more pounds. Anglers fish for big trout at Willow Beach, while Cottonwood Cove and Katherine Landing offer both bass and trout fishing. Within the last few years, striped bass fishing has become very popular.

The NDOW conducts annual creel surveys at Cottonwood Cove and Willow Beach. In 1998, angler use for Lake Mohave was estimated at 155,654 angler days, about the same as in 1997. The 1998 lake-wide harvest was estimated at 414,954 fish. Of the species caught, 80 percent were striped bass and 12 percent were rainbow trout. Other species included largemouth bass, channel catfish, and sunfish.

3.9.5.3 ENVIRONMENTAL CONSEQUENCES

3.9.5.3.1 Sport Fishing in Lake Powell, Lake Mead and Lake Mohave

Reduced reservoir surface elevations could affect recreational reservoir fishing by decreasing the number of fishing days and angler satisfaction. The lower pool elevations could cause temporary or permanent closure or relocation of shoreline facilities, thus requiring the boat angler to either travel to another launch site, fish from the bank, or possibly forego fishing that day. Also, navigational issues, such as the closure of areas of the reservoirs, could increase travel times to desired fishing locations and result in reduced angler satisfaction. Lower pool elevations may make some shoreline fishing areas inaccessible. In addition, as discussed in Section 3.9.3.2, as pool elevations lower, the surface area available for boats and safe boat capacity decreases. The boat angler may need to call ahead for reservoir conditions. Lake Mohave surface elevations will not be affected by any of the alternatives.

No direct information on angler success rates or angler satisfaction in relationship to reservoir pool elevations is available. Therefore, potential effects were determined indirectly through consideration of potential effects on sport fishery production and water access for boat and shore anglers. The effects of the alternatives on sports fishery production are discussed in detail in Section 3.7.4. The effects on boating access, including shoreline facilities that provide access to the water for boat angling and navigational constraints on boating, are discussed in Sections 3.9.2 and 3.9.3.

As discussed in Section 3.7.4, Sport Fisheries, potential reductions in surface elevations associated with the interim surplus criteria alternatives are not expected to affect sport fishery composition or quantities within the reservoirs. As such, angler success rates at Lake Powell and Lake Mead would not be reduced.

3.9.6 RECREATIONAL FACILITIES OPERATIONAL COSTS

In order to keep reservoir marinas, boat launching, public use beaches and shoreline access operational, facility owners/operators and agencies providing utility connections must respond to fluctuating pool elevations. This section focuses on the operational and capital costs of keeping recreational facilities in operation as reservoir surface elevations change.

Potential revenue effects from changes in recreation use are not considered. As discussed above, it is not expected that baseline conditions or interim surplus criteria would result in facility closures, as most facilities can be relocated to maintain operation at lower reservoir elevations.

3.9.6.1 METHODOLOGY

Information in the affected environment section was compiled after review of available published and unpublished sources and through personal communication with NPS specialists. Available data do not cover all facilities. Furthermore, the analysis is generally based on professional judgment, extrapolating from limited historical data. However, the analysis provides a useful approximation of the order of magnitude of costs to recreational facilities that may be incurred under projections for each of the alternatives.

Using data associated with facility relocation costs, projections of the costs associated with declines were made using results of the river system modeling discussed in Section 3.3. Calculations of potential costs use model projections associated with the 50 percent exceedence probability elevations for years 2002 through 2016. This simplified methodology addresses multi-year changes in elevation, and does not consider costs associated with facility adjustments to accommodate monthly fluctuations.

3.9.6.2 AFFECTED ENVIRONMENT

The following sections discuss costs associated with relocation of reservoir marinas and boat launching facilities at Lake Powell and Lake Mead. Many of the facilities at Lake Powell and Lake Mead were constructed when the reservoirs were near their maximum pool elevations of 3700 feet msl and 1210 feet msl, respectively.

3.9.6.2.1 Lake Powell

The costs of fluctuating pool elevations on Lake Powell marinas and boat-launching facilities were calculated by Combrink and Collins (1992). The study calculated operating costs for one-foot fluctuations (termed “normal adjustments”) and for adjustments when the pool fluctuation exceeds 25 feet (termed “special adjustments”). The normal adjustments are adjustments made within the range of regular operations and are done routinely as water levels change during the year. Special adjustments

include relocations of anchors and extensions of cables and utilities. The study found that major capital investments would be needed; cost estimates were developed based on a 50-foot decline in pool elevations.

Additional data for the Antelope Point Marina has been provided by the Navajo Nation and National Park Service. Construction drawings have been prepared to allow extension of the ramp from 3677 to 3620 feet msl, with a reported capital cost estimate of approximately $500,000 (Bishop, Personal Communication, 2000). This cost has been included in NPS planning for Antelope Point.

Table 3.9-13 presents the costs incurred per adjustment in the form that the data was collected. In order to use the data to compare different alternatives, it has been converted into a cost per foot of fluctuation. Data collected in 1989 has been updated to 2000 price levels.

Table 3.9-13
Costs Associated with Adjustments to Lake Powell Recreation Facilities

Adjustment Cost Category[1]	Cost per Adjustment		Cost per Foot
	1989 Price Level [2]	2000 Price Level [3]	
Operating Cost for a Normal Adjustment (based on one-foot fluctuation)	$1,275	$1,721	$1,721
Operating Cost for a Special Adjustment (fluctuations exceeding 25 feet)	$33,460	$45,171	$1,807
Capital Cost for each 50-foot drop	$2,000,000	$2,700,000	$54,000
Total Cost per Foot			**$57,528**
Additional Capital Cost for drop below 3677 water surface elevation[4]		$500,000	

[1]. Operating costs are the cost of adjusting the existing facilities for fluctuations and consist of labor hours. Capital costs consist of construction of ramp extensions, utility line extensions and relocations.
[2] Combrink and Collins (1992).
[3] Consumer Price Index-All Urban Consumers. 1989 average is 124.0. March 2000 is 167.8. Adjustment factor: 167.8/124.0 = 1.35
[4] Capital cost to extend the toe of the existing Antelope Point Marina from 3677 to 3620 feet msl (Bishop, Personal Communication, 2000).

Table 3.9-13 indicates there are costs associated with even minor changes in pool elevations. However, the cost of capital improvements required to extend utilities and access below the range of elevations that can be accommodated by existing infrastructure is much larger than the operating costs incurred within the capacity of the existing infrastructure.

It should be noted that many of the Lake Powell shoreline facilities were extended in 1992/93 to accommodate reduced Lake Powell surface elevation down to 3612 feet msl. Due to these extensions, the actual costs of relocating facilities in the event of future

Lake Powell surface elevation declines may be lower than those indicated in the analysis.

3.9.6.2.2 Lake Mead

NPS provided information on costs associated with relocation of facilities at Lake Mead. The operating levels range between full pool elevation (1210 feet msl) and 1180 feet msl. When Lake Mead declines to 1180 feet msl, adjustments need to be made to the major facilities. Costs to make these adjustments for each of the major facilities at year 2000 price levels range from $560,000 to $970,000. NPS has also determined that additional incremental drops of 20 feet in elevation will incur additional costs, ranging from $480,000 to $800,000 (Henderson, 2000).

Costs associated with fluctuating pool elevations are available for federally-owned facilities at LMNRA from unpublished data assembled by the Resource Management Office, Lake Mead NRA (Henderson, Burke and Vanderford, April 17 and 18, 2000). In addition, Overton Beach Marina (letter dated March 29, 2000) and Lake Mead Resort (letter dated April 11, 2000) provided information to Reclamation indicating the costs associated with fluctuating reservoir elevations. Table 3.9-14 presents these costs.

Table 3.9-14
Costs Incurred to Recreational Facilities from Lake Mead Pool Fluctuations
(Year 2000 Price Level)

Line No.	Fluctuation	Cost per Increment
1	Cost to LMNRA facilities of surface elevation occurrence below 1180 feet msl [1]	$ 6,011,000
2	Cost to LMNRA facilities at 1160 feet msl and at each additional 20-foot drop [1]	$ 5,080,000
3	Cost to Lake Mead Resort Marina from a 20-foot drop in elevation [2]	$ 91,400
4	Cost to Overton Beach Marina facilities from a fluctuation from 1212 feet msl to 1150 feet msl (62 feet) [3]	$ 60,000
5	Cost to Overton Beach Marina Facilities from a fluctuation from 1150 feet msl to 1130 feet msl (20 feet) [3]	$ 425,000
6	Cost to Temple Bar Resort from a 10-foot drop [4]	$ 12,500
7	Cost to Echo Bay Resort from a 20-foot drop from 1213 feet msl to 1193 feet msl [5]	$ 38,400

[1] Unpublished data from Lake Mead NRA.
[2] Letter dated April 11, 2000, from Lake Mead Resort to Reclamation. The letter quantifies cost for a drop from current pool elevations. It also notes that a drop below 1150 would, in the NPS's judgement, require abandonment of the basin within which the resort is located.
[3] Letter dated March 29, 2000, from Overton Beach Marina to Reclamation.
[4] Letter dated March 27, 2000, from Temple Bar Resort. Midpoint of range ($10,000 to $15,000) is used. Letter further notes that a drop below 1125 feet msl would require a complete relocation of the marina, including buildings located on land.
[5] Letter dated March 16, 2000, from Echo Bay Resort to Reclamation.

3.9.6.3 ENVIRONMENTAL CONSEQUENCES

3.9.6.3.1 Lake Powell

As discussed in the methodology section, an estimate can be made of the cost impacts of the alternatives on Lake Powell recreational facilities under some basic conditions. Estimates in this section are for aggregate relocation costs associated with all identified Lake Powell shoreline facilities.

Table 3.9-15 shows estimated incremental costs that would be incurred from Lake Powell surface elevation decreases associated with the median elevation projections for baseline conditions and each alternative from 2002 through 2016 (Figure 3.9-1 presents these elevations graphically). These impacts are based on a cost of $57,528 per foot change in elevation, developed based on the information shown in Table 3.9-12.

Table 3.9-15
Costs Associated with Potential Relocation of Lake Powell Recreational Facilities Under Alternatives Compared to Baseline Conditions[1]
(Year 2000 Price Level)

Alternative	Median Elevation in Year 2016 (feet msl)[2]	Elevation Below Baseline Conditions (feet)	Incremental Cost during 15-Year Period[3]
Baseline Conditions	3665	0	---------
Basin States Alternative	3664	1	$ 747,864
Flood Control Alternative	3665	0	$ 0
Six States Alternative	3664	1	$ 747,864
California Alternative	3660	5	$1,208,088
Shortage Protection Alternative	3659	6	$1,438,200

[1] Assumes pool elevation decreases constantly over time, following 50% probability of exceedence elevation.
[2] Based on 50 percent probability of exceedence elevation projected from modeling on July 31 of each year.
[3] Table 3.9-13. $57,528 per foot for each facility. No incremental cost is included for extending the ramp at the Antelope Point Marina..

By 2050, the median elevation of all alternatives is within a two-foot range (3662.5 to 3664.6) and the difference in costs is small.

3.9.6.3.2 Lake Mead

As discussed in the methodology section, an estimate can be made of the cost impact of the alternatives on Lake Mead recreational facilities using certain assumptions.

Table 3.9-16 shows estimated incremental costs that would be incurred from Lake Mead surface elevation decreases associated with the median elevation projections for

each alternative as compared to baseline conditions from 2002 through 2016 (Figure 3.9-4 presents the median elevations graphically).

Table 3.9-16
Costs Associated with Potential Relocation of Lake Mead Recreational Facilities Under Alternatives Compared to Baseline Conditions[1]

Alternative	Elevation in Year 2016 (feet msl)[2]	Elevation Below Baseline Conditions	Incremental Cost during 15-Year Period
Baseline Conditions	1162	N/A	NA
Basin States Alternative	1143	19	$ 5,243,900[3]
Flood Control Alternative	1162	0	0
Six States Alternative	1146	16	$ 5,243,900[3]
California Alternative	1131	31	$ 10,348,900[4]
Shortage Protection Alternative	1130	32	$ 10,773,900[5]

1 Assumes pool elevation decreases constantly over time, following 50% probability of exceedence elevation.
2 Based on 50 percent probability of exceedence elevation on December 31 of each year projected from river system modeling.
3 Lines 2, 3, 4 and 6 from Table 3.9-14.
4 Two times Line 2, one times Line 3 and 4, and three times Line 6 from Table 3.9-14.
5 Two times Line 2, one times Lines 3, 4 and 5, and three times Line 6 from Table 3.9-14.

By 2050, the median elevation under all alternatives is the same (1110.6 feet msl), and no differences in cost would occur.