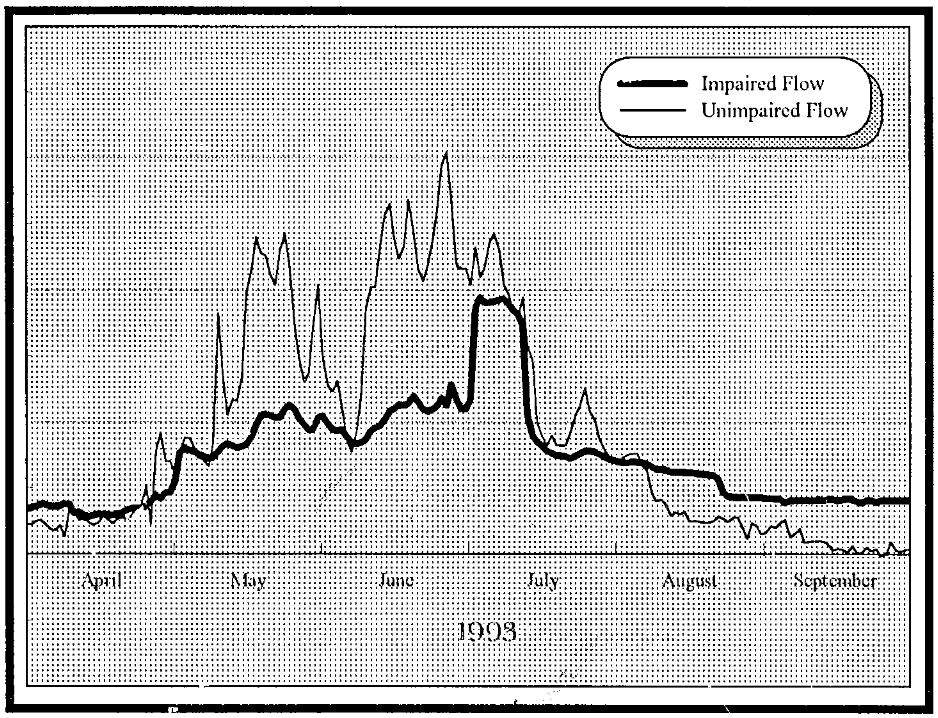
LOWER RUSH CREEK

Flow Analysis



by

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Hydrologic Background

Rush Creek and its tributaries form the largest stream system within the Mono Basin. It begins below the slopes of 13,114 foot-Mt. Lyell and the Lyell Glacier, and ends at the shore of Mono Lake. Tributaries to Rush Creek include Walker, Parker, Alger, Reversed, and Crest creeks. The setting of Rush Creek is shown in Figure 1. The average total gauged runoff for Rush Creek is 73,700 acre-feet per year, which is an average flow of 102 cfs. Figure 2 displays the annual gauged runoff amounts from 1940 to 1994.

The runoff for Rush Creek is gauged at the following locations (also listed is the average annual quantity):

Rush Creek above Grant Lake	59,200 acre-feet
Parker Creek tributary	9,100 acre-feet
Walker Creek tributary	5,400 acre-feet
Total	73,700 acre-feet

59,200 abv. TRIBS.

Because they enter Rush Creek below Grant Lake reservoir dam, Parker and Walker creeks are not considered in the Grant Lake analysis. They are added to the flow of Rush Creek above the Rush Creek bottomlands.

As is the case for most of the eastern Sierra Nevada streams, Rush Creek is a snowmelt driven basin. The majority of the precipitation occurs in the late fall and winter as snow. The table below lists the average monthly precipitation (in inches) for Gem Lake, located near the center of the Rush Creek drainage basin, along with the month's percentage of the annual total:

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
1.06	2.52	3.52	3.31	2.79	2.64	1.64	0.82	0.48	0.57	0.59	0.71
5%	12%	17%	16%	14%	13%	8%	4%	2%	3%	3%	3%

By the end of April of each water year (October through September), an average of 85% of the precipitation for the year has fallen. This precipitation data, along with snowpack measurements, allows for a fairly accurate prediction to be made about the amount of water available for the remainder of the year.

The snowpack typically begins to melt in April, with the melt increasing throughout the spring. The streamflow usually peaks between May and July. Once the snowpack has melted, usually by mid-August, the streamflow returns to its basal level during the fall and

Rush Creek Drainage Basin

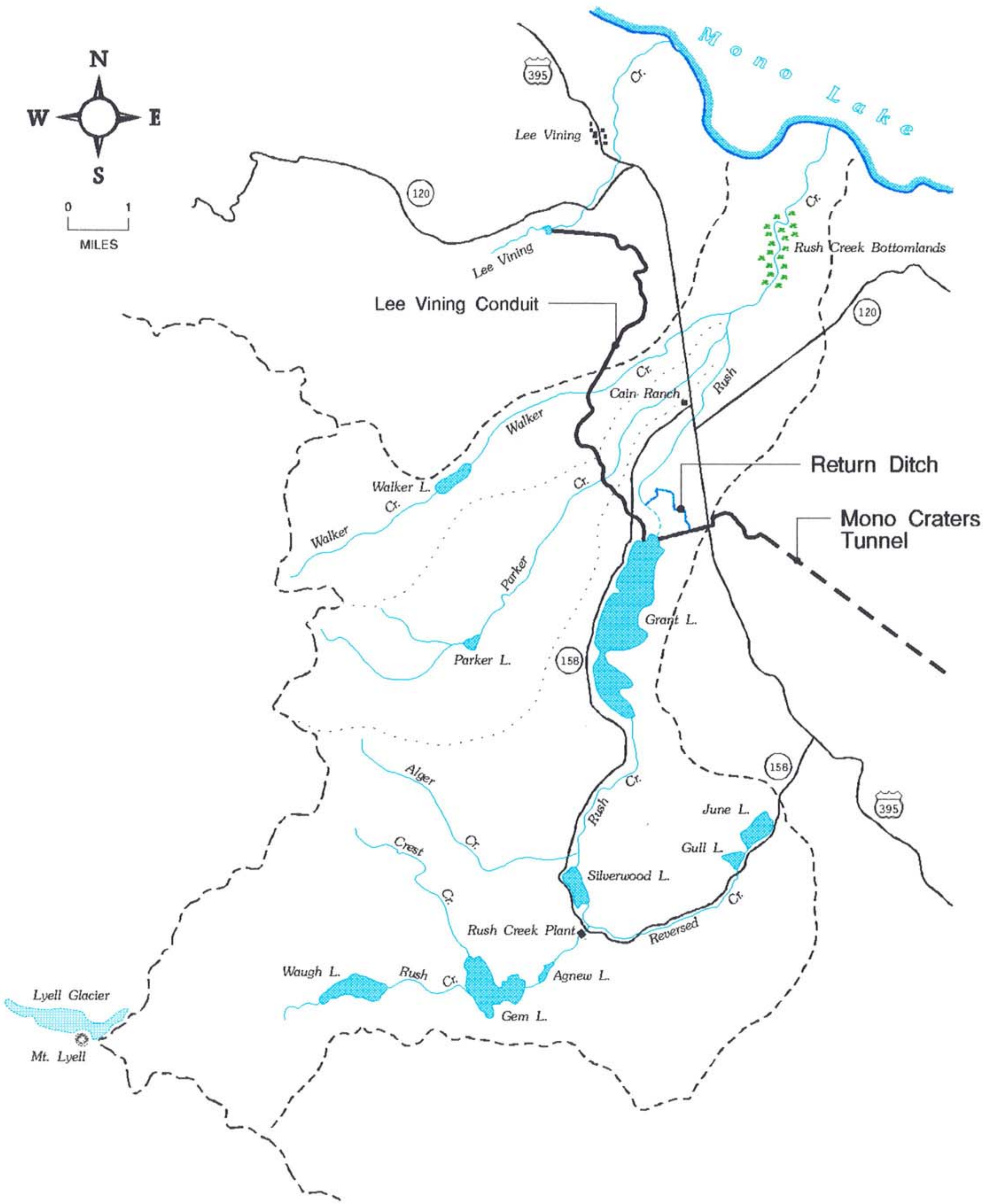
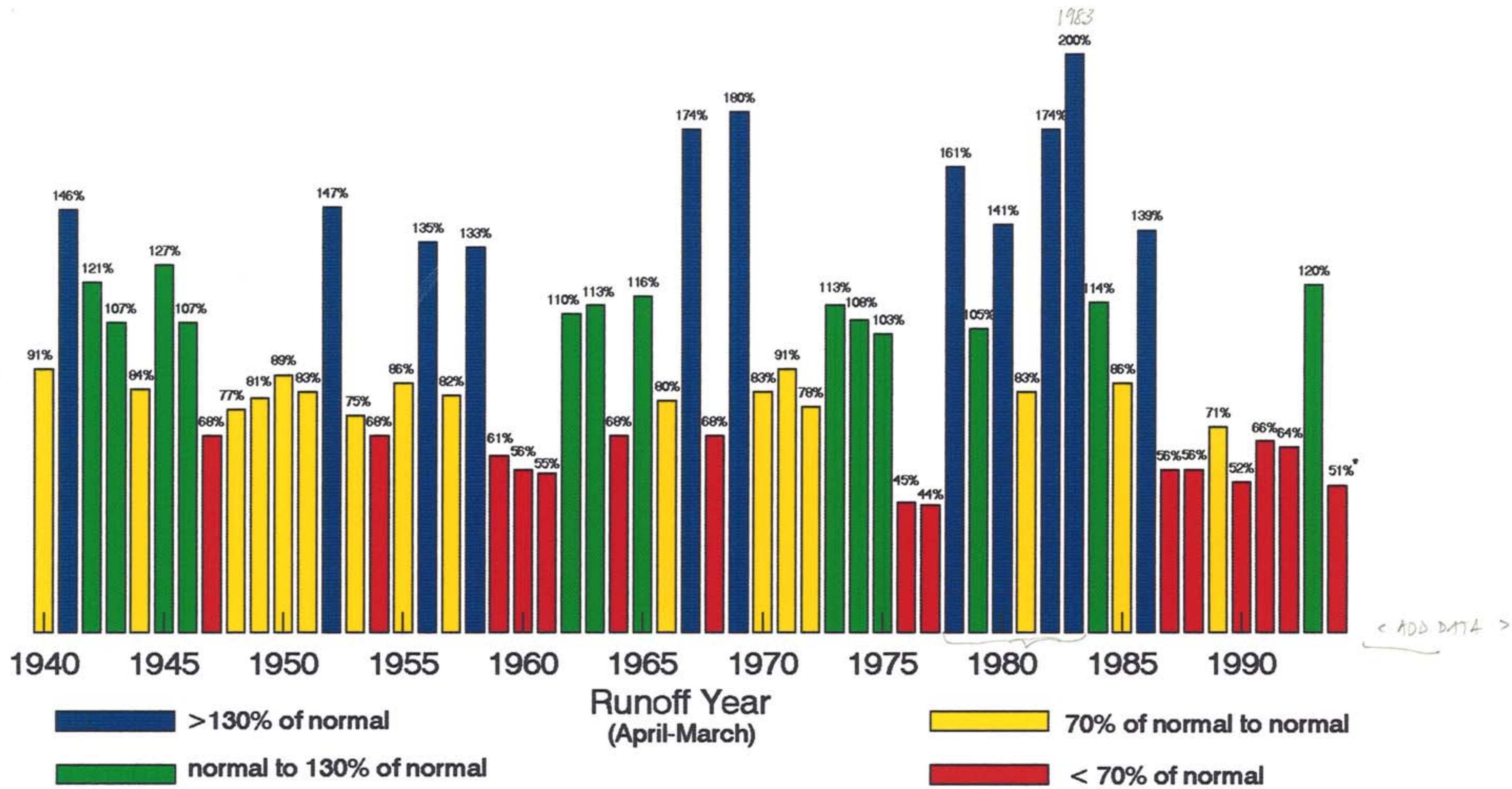


Figure 1

RUSH CREEK RUNOFF
(Including Tributaries)
Percent of Normal

The 1941-1990 normal = 73,653 acre-feet.

(RUSHTR94.DRW)
8/2/94



* May 1, 1994 forecast

Note: Tributaries are Walker and Parker Creeks.

Figure 2

winter period. The table below lists the average monthly natural flow for Rush Creek above Grant Lake (in cfs), along with the month's percentage of the annual total:

Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
69	228	305	169	55	24	17	20	23	21	22	27
7%	24%	31%	17%	6%	2%	2%	2%	2%	2%	2%	3%

The table above shows that over 70% of the natural runoff occurs between May and July. More water naturally flows down Rush Creek in June than from August to April combined. On a typical October day, about 17 cfs would be flowing in Rush Creek in the Grant Lake area under natural conditions.

Influence of SCE Reservoirs

In 1906, the Southern Sierra Power Company, predecessor to Southern California Edison, constructed three reservoirs on Rush Creek for power generation purposes. The reservoirs were built in series on the upper reaches of the creek. The reservoirs, along with their spillway elevation and capacity, are as follows:

Waugh Lake (Rush Meadows)	9,410 feet msl	4,980 acre-feet
Gem Lake	9,048 feet msl	17,060 acre-feet
Agnew Lake	8,492 feet msl	860 acre-feet
Total Capacity		22,900 acre-feet
		23,420 acre-ft (USGS)

Although there are three reservoirs, there is only one power plant on Rush Creek. It is the Rush Creek Power Plant, located near the confluence of Reversed and Rush creeks. Water flows from Agnew Lake directly into the penstock and is release back into the creek. The capacity of the penstock is about 110 cfs. In wet years, this capacity is often exceeded, and water must be spilled from Agnew Lake into the historic Rush Creek path.

Of the total annual runoff that reaches Grant Lake from Rush Creek, about 70% of it flows through Edison reservoirs. This water either flows through the Rush Creek Plant, or is spilled over Agnew Lake's crest into Rush Creek below the power plant. The remaining 30% originates mostly from two unregulated creeks: Alger Creek and Reversed Creek.

The Edison reservoirs on Rush Creek operate on an annual plan, and do not carry storage from year to year. An agreement between the predecessor to Edison and Los Angeles was formed in 1933 regarding the regulation of the power reservoirs. The agreement states that "the Grantors (currently Edison) shall not hold over from one seasonal year to another water stored in said reservoirs in excess of five percent of the total capacity of all reservoirs now constructed on said Rush Creek." Under the agreement, Edison is required to reduce its total storage to 1,140 acre-feet at some time before the snowmelt runoff begins, usually in April. The agreement, however, has been loosely enforced, and Edison has not always reduced its storage to the required minimum.

With or without the agreement, however, Edison would probably choose to operate its reservoir system in the same manner regardless. In normal runoff years, the reservoirs fill, and in wet years, the reservoirs spill. There is not a need to carry storage over to the next runoff year. If they did, they would likely increase the frequency of spills in their reservoirs. On April 1, at the beginning of the runoff year, total reservoir storage has averaged about 3,400 acre-feet. The reservoirs increase in storage through the spring and early summer, and usually reach maximum amounts around August 1, which averages 19,100 acre-feet of storage. Between August and March, the reservoirs slowly decrease in storage until they reach levels near the 5% requirement.

As Edison's reservoirs store and release water, the flow in Rush Creek is affected correspondingly. When Edison stores water, Rush Creek's flow is less than it would be naturally, while when they release water, the flow is augmented above natural levels. The attenuated flow in Rush Creek has more spring-like characteristics than does the natural flow pattern. The peak flow is dampened while the low flows are increased. The table below lists the average monthly impaired flow for Rush Creek above Grant Lake (in cfs), along with the month's percentage of the annual total:

Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
66	120	170	150	86	68	64	58	49	46	50	52
7%	12%	17%	15%	9%	7%	7%	6%	5%	5%	5%	5%

The table above shows that the average June flow was reduced from 305 cfs in natural conditions to 170 cfs under impaired flows. Conversely, October's natural flow of 17 cfs increased to an average of 64 cfs. Figure 3 compares the monthly average natural and impaired flow for Rush Creek above Grant Lake, and Figure 4 graphically shows the monthly percentage of annual total for the two conditions.

Rush Creek Daily Flow Pattern

The monthly runoff pattern for Rush Creek shows a smooth curve, with runoff increasing through June and decreasing through winter. On a daily basis, however, the runoff undergoes large flow fluctuations. As temperatures warm and cool, the snowpack rapidly melts and later may freeze over. There may be several smaller peaks in the hydrograph before the highest peak flow occurs.

Figure 5 shows the hydrograph for the 1993 snowmelt period. The graph shows both the measured flow of Rush Creek at Damsite, and the calculated natural flow at the same location. The natural flow is calculated from daily storage changes made on Edison reservoirs. Because measuring storage change is much less accurate than measuring flow

RUSH CREEK AVERAGE MONTHLY FLOWS (CFS)

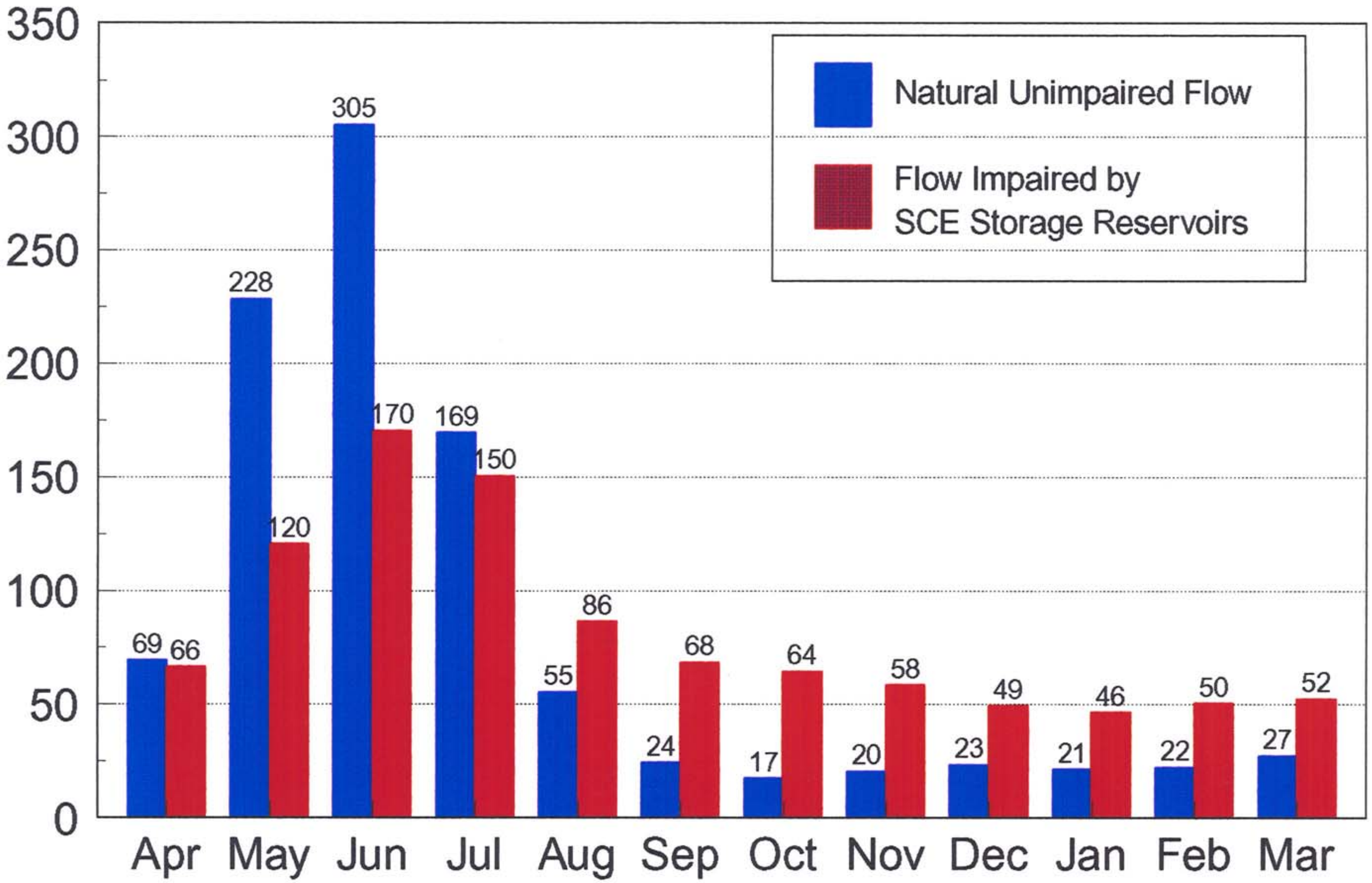
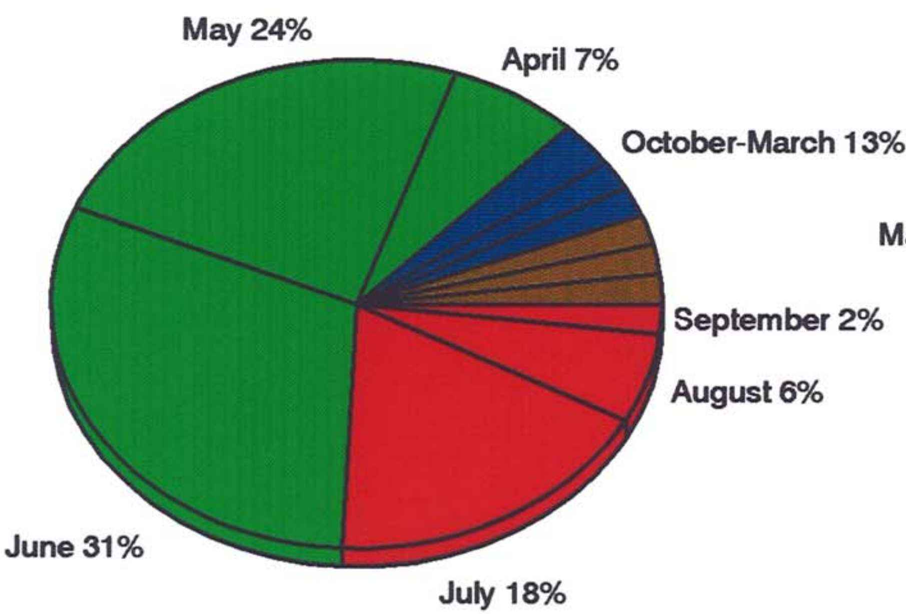
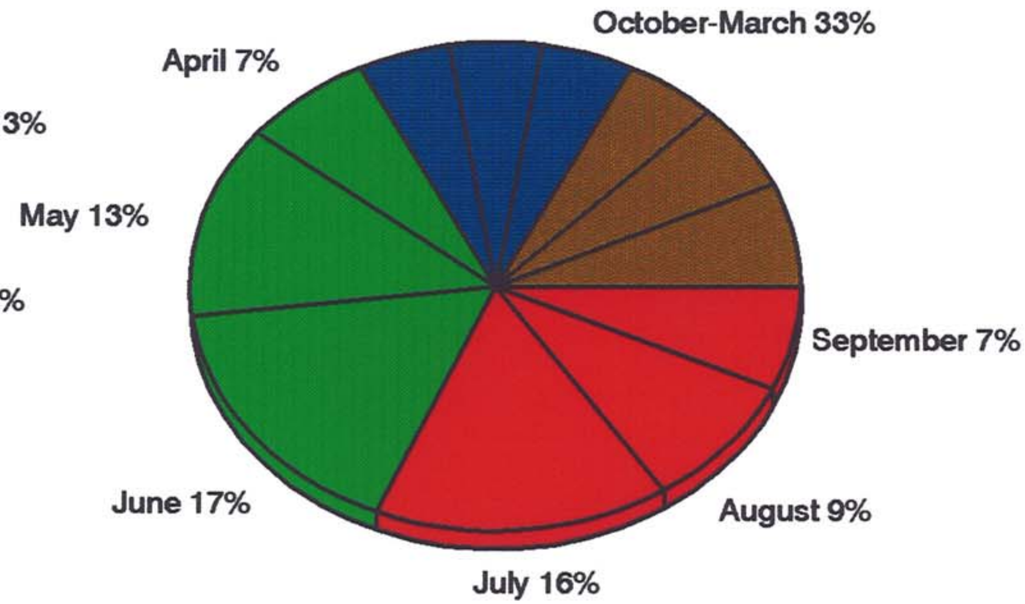


Figure 3

RUSH CREEK RUNOFF
MONTHLY DISTRIBUTION



NATURAL UNIMPAIRED FLOW



FLOW IMPAIRED BY
SCE STORAGE RESERVOIRS

Figure 4

Rush Creek Daily Hydrograph

Impaired vs. Unimpaired flow

(April - September 1993)

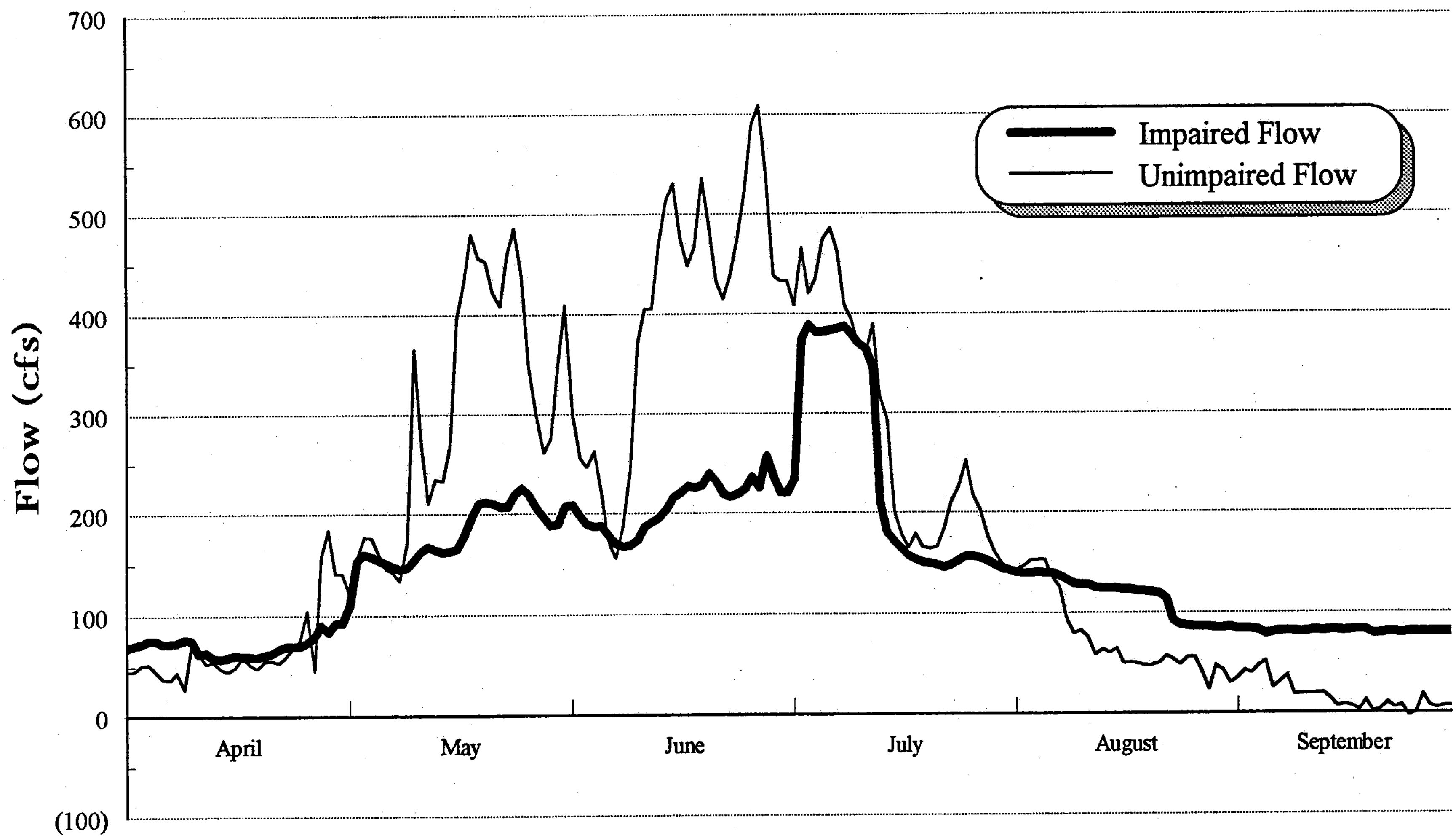


Figure 5

rates, the natural hydrograph is an approximation of natural flow, with ± 50 cfs uncertainty during the higher flows. Nonetheless, the figure depicts the daily impacts of flow that Edison has on Rush Creek.

The average daily peak flow occurred on July 3, and measured 389 cfs. The natural peak flow would have occurred on June 27, measuring 609 cfs. Edison's reservoirs served to delay and reduce the peak flow on Rush Creek. Edison began spilling its reservoir on July 2 and continued to spill until July 12. This period is easy to see on Figure 5, where the impaired flow rapidly increases to over 350 cfs and then rapidly declines back to under 200 cfs. During this time period, Rush Creek was nearly an unregulated creek, and the natural and impaired hydrographs are very similar.

Even though Edison's Rush Creek reservoirs filled and spilled in 1993, there was a tremendous disparity between the natural and impaired peak flow. The main reason for this is that the natural peak occurred while Edison was filling their reservoirs. By the time they were forced to spill, the natural flows had diminished somewhat, and a smaller amount of water flowed down Rush Creek than would have if Edison reservoirs had filled earlier in the year.

Peak Flow Frequencies on Rush Creek

The peak flows on Rush Creek from 1941 to 1990 were tabulated and graphed on a frequency analysis chart to determine the recurrence interval of peak flows. Figure 6 graphs the recurrence interval of flows on Rush Creek above Grant Lake, while Figure 7 graphs the calculated natural flow at the same location. The extremely high flow event on Figure 6 is the 1967 flow, when nearly 1000 cfs flowed down Rush Creek. This graph shows that this event is probably much more infrequent than once every fifty years. According to Figure 6, the 1967 event is closer to a one in a 150 year event.

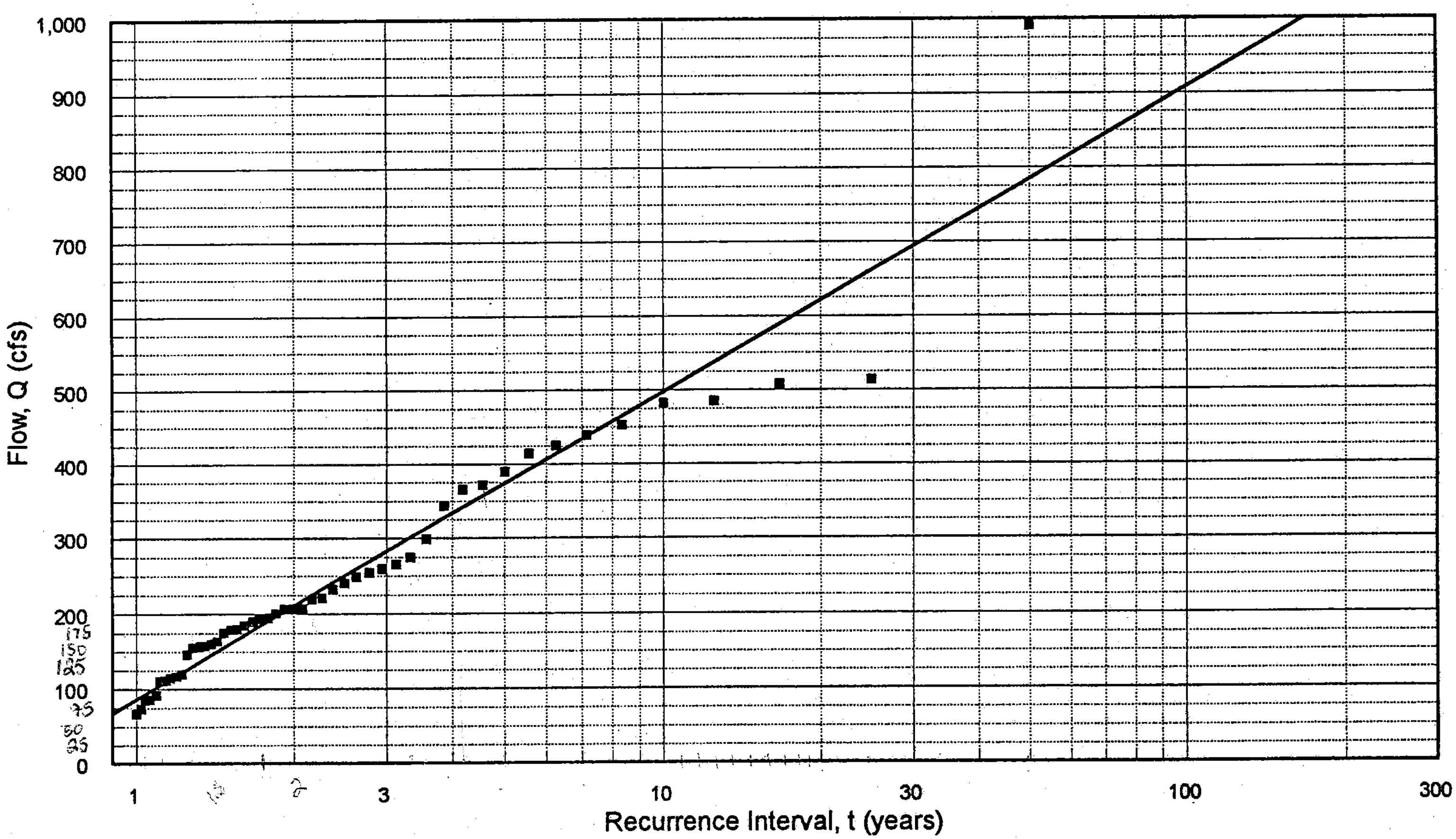
Figure 7 shows that there was no year when the calculated natural flows were far from the expected recurrence interval. It also shows the effects of Edison's reservoirs on the peak flows. For example, naturally a flow of 550 cfs occurred once every three years. With Edison's impacts, the flow occurs an average of once in 12 years. Edison effectively lowers the expected flood flows - even in years when the reservoirs are spilling.

Grant Lake Reservoir Complex Overview

In 1940, the LADWP completed construction of a new Grant Lake Dam, and a new Grant Lake reservoir slowly began to fill. The capacity of the reservoir was increased to 47,575 acre-feet. The reservoir can hold 80% of the average annual flow of Rush Creek above the reservoir. It increased the total reservoir storage capacity on Rush Creek to 70,500 acre-feet, which gives Rush Creek a storage to annual flow ratio of 1.19.

RUSH CREEK IMPAIRED PEAK FLOWS

Rush Creek @ Damsite
(1941-1990)



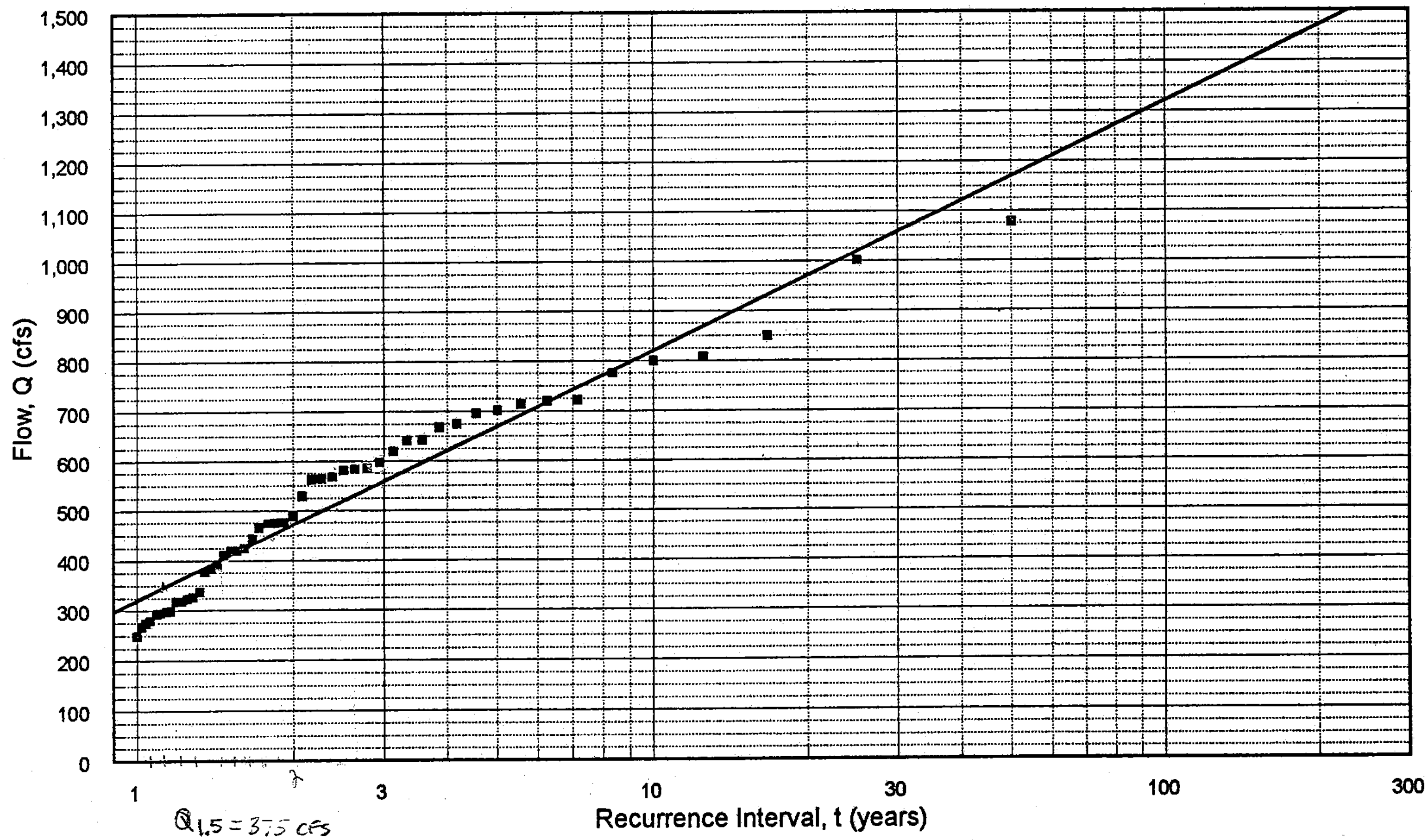
Equation: Q = 101.1 + 157.3(ln(t))
$R^2 = 0.97$

Figure 6

RUSH CREEK UNIMPAIRED PEAK FLOWS

Rush Creek @ Damsite + SCE Storage Change

(1941-1990)



Equation: Q = 319.5 + 217.3(ln(t))
$R^2 = 0.95$

Figure 7

Since it was constructed in 1940, Grant Lake reservoir has spilled in 11 different years, although six of them were relatively minor events of less that 5,000 acre-feet total. The larger spills occurred in 1952, 1965, 1967, 1982, and 1984. In 1983, the wettest year on record in the Mono Basin, the reservoir did not spill.

Besides receiving water from Rush Creek above the reservoir, Grant Lake is the terminus of the Lee Vining Conduit. This conduit has the option to divert water from Lee Vining Creek, and two tributaries to Rush Creek below Grant Lake - Walker and Parker creeks. This increases the total water available to Grant Lake to an annual average of 122,100 acre-feet. The historic capacity of the conduit at Grant Lake is just over 400 cfs, although this level has been exceeded in a few instances.

There are some minor inflows and outflows of the reservoir area and are needed to complete the available Grant Lake releases. A few ungaged creeks that flow directly into the reservoir and direct precipitation onto the reservoir add about 4,000 acre-feet per year to the system. Evaporation from the reservoir averages about 2,200 acre-feet per year. A total gain to the reservoir, therefore, averages about 1,800 acre-feet per year. In wet years, the figure rises while in drier years, it diminishes.

Water leaves the reservoir through a control valve near the Grant Lake Dam and flows into the Grant Lake Conduit. This is the only means of taking water out of the reservoir, unless the storage is in excess of capacity and water flows down the spillway into lower Rush Creek. The historic capacity of Grant Lake outflow is 475 cfs, although it has flowed over 400 cfs only on two occasions. About one-half mile from Grant Lake is Mono Gate #1, which is at the beginning of the Mono Return Ditch. Water can either be released out the gate, into the ditch and into lower Rush Creek, about one-half mile below Grant Lake Dam, or it can flow into the Mono Craters Tunnel and eventually into the upper Owens River. The historic capacity of the Mono Craters Tunnel is just under 300 cfs (including the 17 cfs Tunnel Make), while the Return Ditch historical high is 360 cfs.

Mono Gate Return Ditch

Grant Lake Reservoir is one of the few reservoirs that does not produce hydroelectricity when water is released from it. This is primarily because the reservoir was built so that it had just enough elevation head for the water to flow into the upper Owens River. It was not practical to build a power plant below the dam for releasing water into lower Rush Creek, since most of the water was to flow into the upper Owens River.

Because there was no power plant within the reservoir complex, the water which was to be occasionally released into lower Rush Creek had to lose its elevation head before it re-entered the creek. One option would have been to use cascades to dissipate the energy of the water, but the engineers chose to build a ditch which would slowly dissipate the energy through frictional losses as the water was to traverse the hillside before reaching the creek.

The Mono Return Ditch was then built and functions as both a vehicle to return water into Rush Creek and a dissipator of the energy stored behind Grant Lake dam.

The Mono Return Ditch's east bank consists of native materials which were excavated during channel construction. The invert of the ditch is below ground level and the water level typically remained at or below this level. The native material is relatively porous, and when higher flows were released, a small amount of seepage could be seen downgrade of some of the embankment material.

During the period of higher flows in the ditch, the embankments would slough and the eroded material would raise the invert of the channel. Historically, when the Mono Gate was closed and the ditch dewatered, the LADWP would dredge out the eroded sediments and place them on or near the embankment. This practice would maintain the original invert level and the integrity of the ditch. In 1983, the return ditch was stressed to its limit, and successfully flowed at capacity (about 350 cfs) for many months without incidence and kept Grant Lake from spilling during the wettest season on record.

In 1984, a court injunction prohibited the future dewatering of lower Rush Creek. This meant that a constant flow of water had to be maintained in the Mono Return Ditch, and the historical maintenance practices could not be continued. Since that time, sediment has not been removed from the ditch, and rock weirs have been placed at certain locations to enhance fish habitat. Because of the lack of maintenance, the LADWP staff engineers no longer believe that the ditch can carry its historical capacity. The Dams and Geology Group of the LADWP agreed and estimated that they are uncertain about the integrity of the ditch above 160 cfs. This flow is very similar to the Court's required channel maintenance flow of 165 cfs.

Operational studies of Grant Lake conclude that spills of the reservoir can be avoided if the Mono Return Ditch can carry up to 250 cfs flow. It will be essential, therefore, to ensure that the Return Ditch can safely transport 250 cfs. If the State Water Resources Control Board's draft water right decision, however, requires flows above 250 cfs in lower Rush Creek, more extensive work would have to be done on the ditch. A decision on what work will be undertaken and when it will be completed will be made after the Water Board's decision is adopted.

Analysis of Post-1940 Flows down Lower Rush Creek

Before Grant Lake Dam was constructed, portions of Rush Creek experienced long periods of stream dewatering. After the construction of the dam, the dewatering became more extensive. The longest period of total stream dewatering was five years, from June of 1973 to June of 1978. The last time the stream was dewatered was January 1983. After that, high flows required operational releases and a 1984 injunction have kept a varying flow of water in the stream.

Because of capacity and operational constraints, however, a substantial portion of water was released into lower Rush Creek in wetter years. Before the completion of the Second Los Angeles Aqueduct in 1970, an average of 33,100 acre-feet per year were released down Rush Creek - equivalent to 56% of the natural average. This water was released without regard to ramping rates or impacts to the creek. Between 1970 and 1984, less water was released into lower Rush Creek - an average of 27,300 acre feet per year, although most of this water was released during the record wet period between 1982 and 1984. Since 1984, the stream has not been dewatered, and ramping rates have been used when releasing the water.

The two runoff years after 1940 with the most flow released down lower Rush Creek were 1983 and 1967. The total amount of water released was 174,000 and 157,000 acre-feet, respectively. While the total quantity of water released was similar, the pattern of release was quite different. The flows in 1967, with the reservoir spilling, were of relatively short duration and very high magnitude, while in 1983, without the reservoir spilling, flows were of a much lower magnitude but held constant for almost the entire year. Figure 8 compares the hydrographs of the two events.

The Grant Lake Operations Model

In order to analyze future lower Rush Creek releases, a spreadsheet model was developed which simulates Grant Lake inflows, outflows, and reservoir storage. Although two monthly operational models have previously been created (the LAAMP model developed by Jones & Stokes Associates and the LAASM model developed by the LADWP), a daily model was necessary to accurately analyze the flow releases. The model uses daily historic runoff and simulates reservoir storage and releases. The following daily records are used as input to the model:

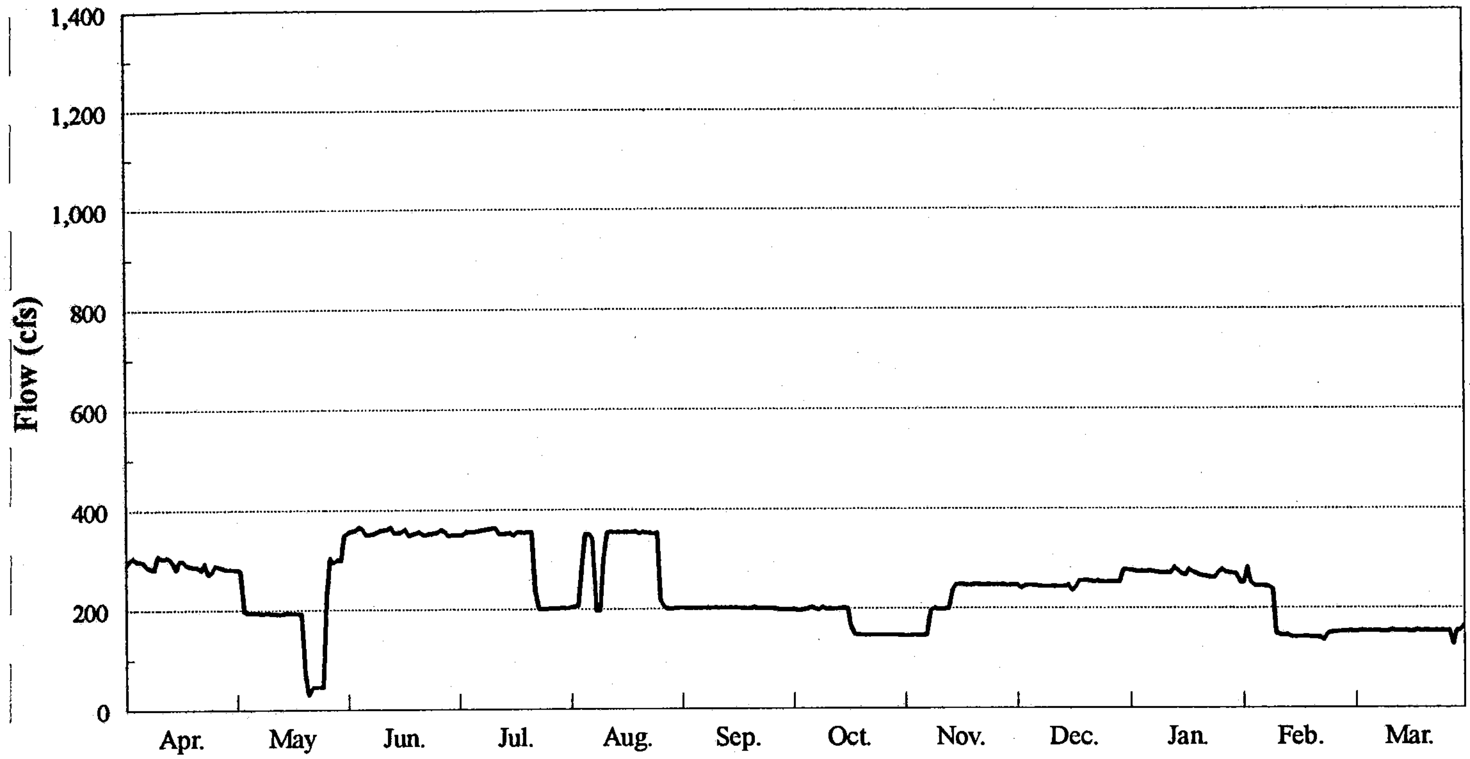
- Lee Vining Conduit Above Intake
- Walker Creek Above Conduit
- Parker Creek Above Conduit
- Rush Creek At Damsite

The model also calculates the ungaged inflow to Grant Lake, based on the flow in Rush Creek. The user then enters the following parameters:

- Maximum allowable flow down Lee Vining, Walker, and Parker creeks
- Initial Grant Lake reservoir storage
- Desired Grant Lake outflow amounts for the runoff year

Lower Rush Creek Releases

Runoff Year 1983-84



Runoff Year 1967-68

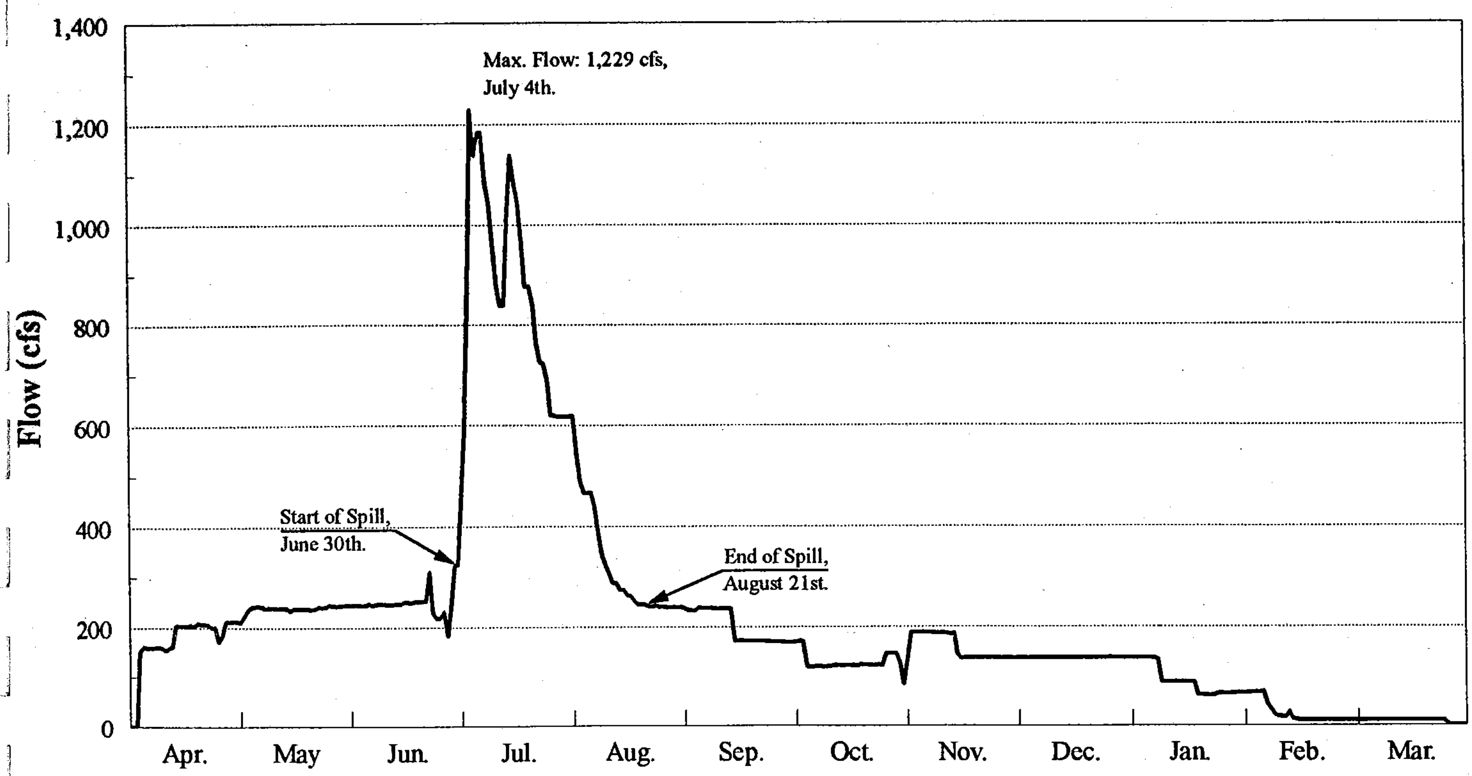


Figure 8

The model then uses the input data and the user entered parameters to determine:

- Lee Vining Conduit diversions (based on max. flow down creeks)
- Grant Lake reservoir evaporation (based on bathymetry)
- Daily Grant Lake reservoir storage
- Grant Lake reservoir spill, if any

Finally, the model tabulates and graphs the results. Refer to Appendix A for sample tables and graphs resulting from the model's output.

Inputs to Grant Lake Operations Model Simulations

The Grant Lake Operations Model was used to develop interim operational plans for releasing water from Grant Lake into lower Rush Creek during the interim period before the State Water Resources Control Board decision is finalized. The goal of the simulation runs is twofold:

1. To determine the maximum flows that will be expected in lower Rush Creek, and
2. To develop monthly release patterns which both mimic the natural hydrograph and maintain desired Grant Lake reservoir storage.

The following assumptions were made for the Grant Lake Operations Model simulation runs:

- Grant Lake storage change for the year would be near zero.
- Initial Grant Lake storage for the year is 20,000 acre-feet
- No water is exported from the Mono Basin
- Spilling water from Grant Lake is to be avoided
- The maximum flows allowed in each creek is as follows:

Lee Vining Creek	300 cfs
Walker Creek	30 cfs
Parker Creek	50 cfs
Rush Creek	250 cfs

- The Court's Interim Flow Order requirements are met, including:

  Minimum Rush Creek Release of: 28 cfs, Oct-Mar; 40 cfs, Apr-Sep
  Channel Maintenance (Flushing) Flow Released Every Even Year
  Flushing Flow of 165 cfs for 30 days, wet year; 3 days, dry year
  Ramping Rates of No More Than 25% Every Eight Hours
  (For practicality, ramping would be done once per day.)

Once the above assumptions were taken into consideration, operational rule curves were developed for the releases into lower Rush Creek. The releases developed are based on five runoff-year type classifications developed for the Mono Basin. The breakdown for

Rush Creek at Damsite

Daily Fluctuations

(July 8 - 15, 1993)

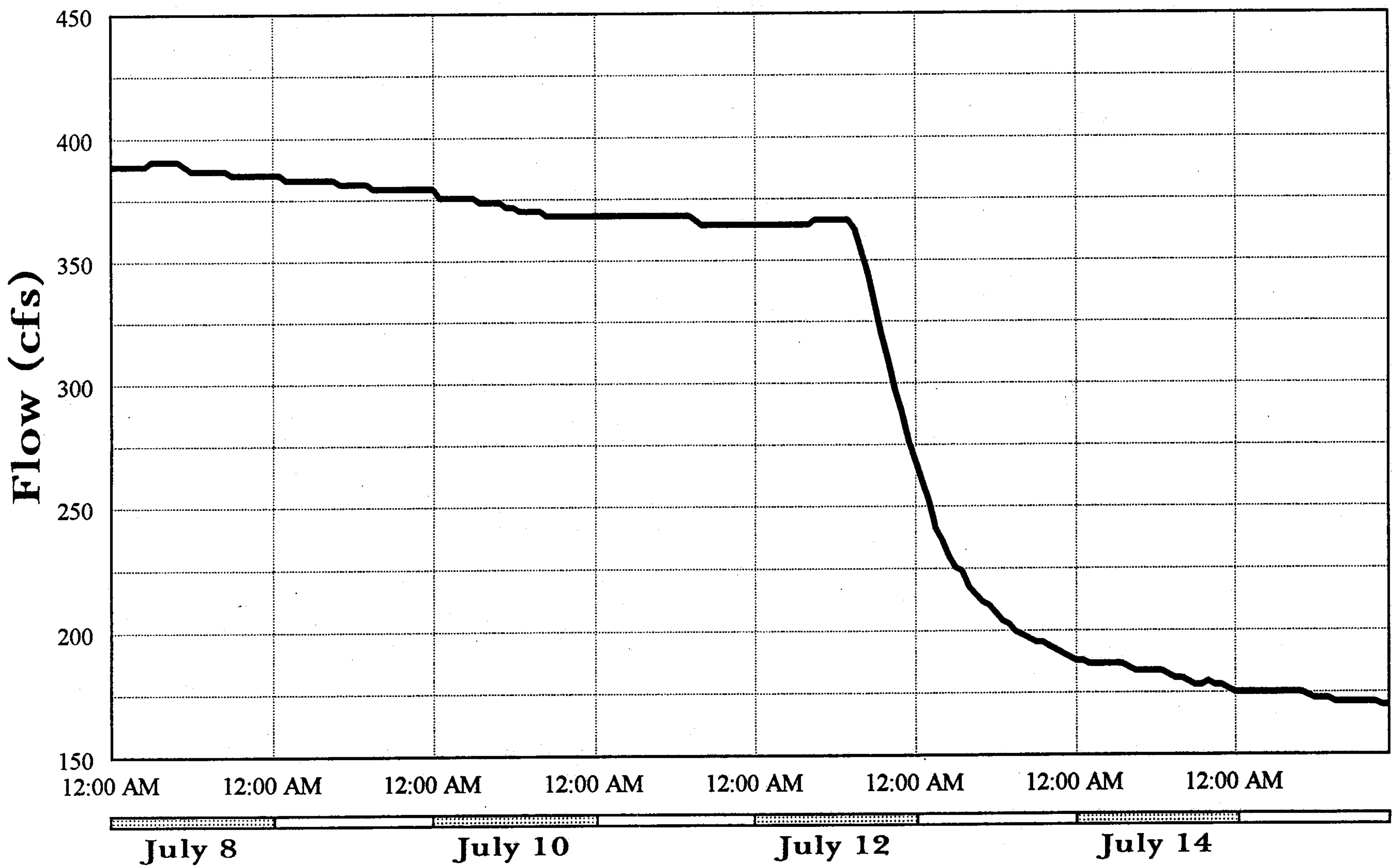


Figure 9

Lee Vining Creek above Intake

Daily Fluctuations

(June 25 - 30, 1993)

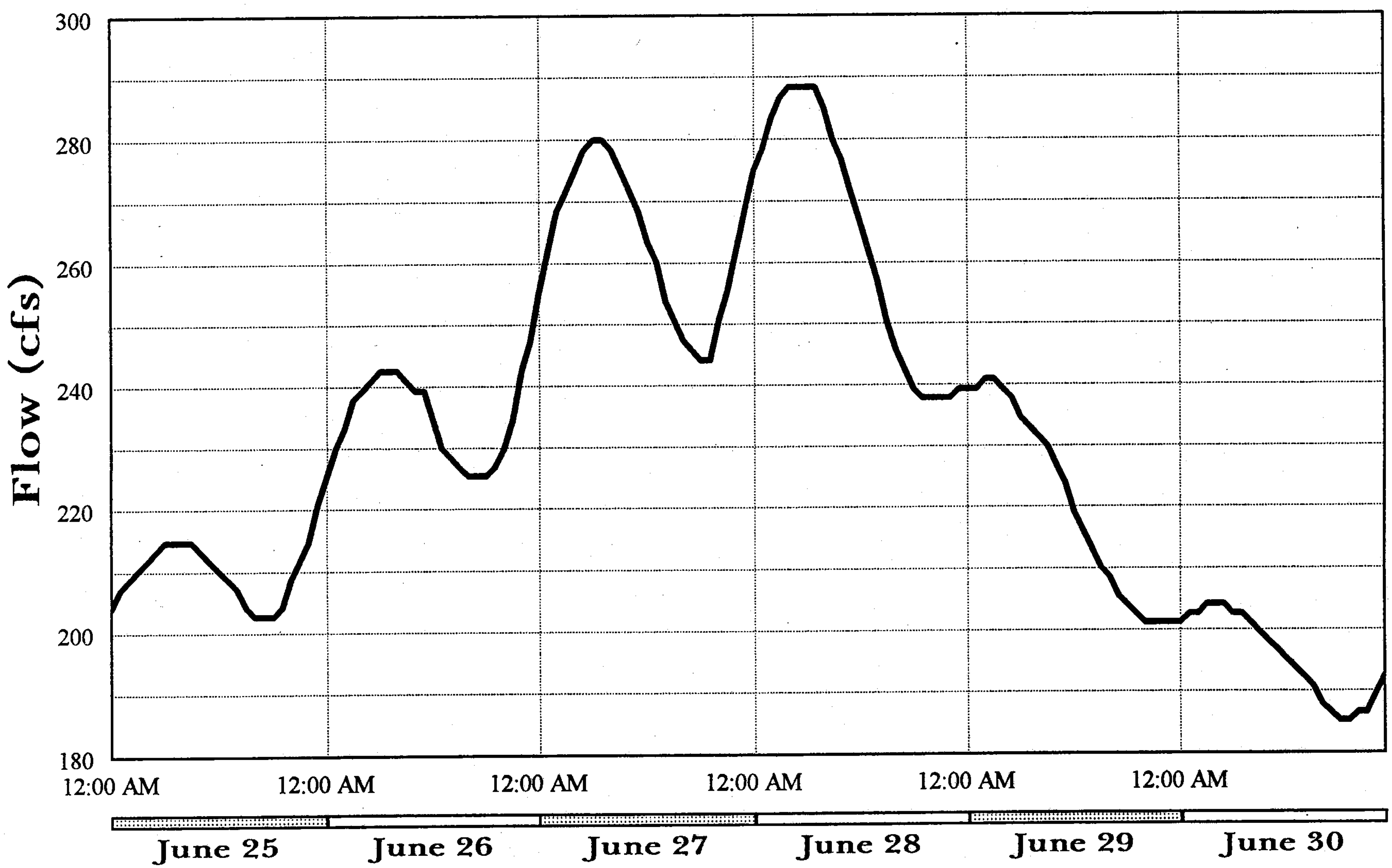


Figure 10

year types was done based on operational considerations for Grant Lake reservoir and not on fishery or channel maintenance flow requirements. The breakdown is as follows:

Dry	Runoff < 70% of average
Below Normal	70% < Runoff < 100%
Above Normal	100% < Runoff < 140%
Wet	140% < Runoff < 180%
Extreme	Runoff > 180% of average

The LADWP prepares runoff forecasts for the Mono Basin and Owens Valley beginning in February and ending in May. On April 1 of each runoff year, the forecast for the Mono Basin will fall into one of the above categories. Depending on the runoff year-type, flows during April will be released into lower Rush Creek. On May 1, when the final runoff forecast is made for the year, the flow between May and September will be determined by the final year-type forecast. The average monthly releases into lower Rush Creek for each year-type are listed in Appendix A.

The flows listed are average monthly flows. Because flushing flows of 165 cfs are required every even numbered year, the daily flows in even dry and below normal years would be higher, but the monthly average would still be equal to the flows listed. For above normal years and higher, flows of 165 cfs are exceeded, so no additional flushing flows are necessary.

On about October 1 of each year, the runoff forecast is revisited to determine its accuracy. The October 1 storage in Grant Lake will be higher or lower than predicted, depending on if there was more or less runoff than forecasted. Reservoir outflow between October 1 and April 1 will be fairly constant Grant Lake will be returned to its original 20,000 acre-foot storage level. In dry years, the flow between October and March would range from 30 to 60 cfs, while in the extreme case, the flow during this period would average about 150 cfs. Table A shows the expected accuracy of the runoff forecasts from 1950 to 1990. The table shows the April 1 and May 1 runoff forecasts, and compares them to the final value. Also, the year-type is listed with each forecast.

The release schedule was developed to mimic the natural hydrograph within the bounds of the physical limitations of the system. Grant Lake reservoir will function similar to the Edison reservoirs - that is, to attenuate the high flows and increase the minimum flow. Edison reservoirs give Rush Creek some characteristics of a spring fed system, with Grant Lake spreading out the flow even further. Despite the flow attenuation, however, the releases mimic the shape of the natural hydrograph.

One characteristic absent on Rush Creek is a significant diurnal fluctuation. Unlike Lee Vining Creek, which can undergo major flow fluctuations during a single day, Rush Creek above Grant Lake is remarkably stable. Figures 9 and 10 demonstrate the instantaneous flows during the peak runoff of 1993 for each creek. Lee Vining Creek had diurnal flow fluctuations up to 50 cfs, while Rush Creek was almost constant. It is important to note that Edison's reservoirs were spilling on both creeks when these peak flows were measured. One reason for the lack of a significant diurnal fluctuation on Rush Creek may be because of the large number of upstream lakes, which dampen out rapid flow changes. Along with Edison's reservoirs, June, Gull, and Silver Lakes are upstream of Grant Lake.

Results of Grant Lake Operations Model Simulations

Appendix A demonstrates the results of several sample years based on the assumptions listed above along with the given rule curves for releases into lower Rush Creek. The sample years used the April 1 and May 1 runoff forecasts to determine releases, even if the forecast for these years were inaccurate. The graphs show the flow in Rush Creek above Grant Lake, the releases from Grant Lake into lower Rush Creek, and the storage of Grant Lake for the sample runoff year.

In each of the years simulated using the model, Grant Lake reservoir is kept from spilling. In 1983 and 1967, the two wettest years on Rush Creek, Grant Lake approaches but does not exceed 45,000 acre-feet - about 2,500 below capacity. Even though the inflow to Grant Lake approached 1000 cfs in 1967, Grant Lake could effectively store the water and release it without exceeding a flow of 250 cfs. One of the reasons that Grant Lake spilled so severely in 1967 was that water was diverted from Walker, Parker, and Lee Vining creeks both before and during the time that the reservoir was spilling. With prudent operations and limited diversions into the conduit, Grant Lake can go through another 1967 event without spilling.

A target April 1 elevation of 20,000 acre-feet in Grant Lake seems to work well in both wet and dry years. In wet years, water can be released from the reservoir before the snowmelt peaks, and maximize the storage in the reservoir. In dry years, there is sufficient storage to augment the low flows coming into Grant Lake. There is a potential draw back to storing water in Grant Lake, however. At current Mono Lake elevations, each 4,000 acre-feet of storage in Grant Lake translates to a level in Mono Lake of about 0.1 feet. Grant Lake reservoir, therefore, is capable of storing the equivalent amount of water to affect the level of Mono Lake by about 1.2 feet. If Mono Lake is at a critical level, it may be more desirable to release water to Mono Lake rather than storing it in Grant Lake reservoir.

Summary and Conclusions

Grant Lake reservoir has had several uncontrolled spills in its history. Some of the historic spills could have been avoided, but there was little concern of the downstream effects of reservoir spills while higher reservoir levels were given the priority. Also, there were no channels on lower Walker and Parker creeks, so water not used for irrigation was diverted into Grant Lake.

With the return of instream flows in Lee Vining, Walker, and Parker creeks, and with the concern of the effects of reservoir spills on the stream system, spills from Grant Lake will be avoided when possible. The results of the hydrologic simulations of the Grant Lake Operations Model show the historic spills could be eliminated if the historical hydrography is repeated. Flows in lower Rush Creek can be limited to 250 cfs, with prudent operational management of Grant Lake reservoir.

It is possible that flows higher than historic amounts could occur and force a spill in Grant Lake. Figure 11 shows the frequency of high flow volumes and the recurrence interval of such events. A one in one-hundred year event would equal a total runoff of about 155,000 acre-feet.

The State Water Board may require channel riparian maintenance flows of 300 cfs in lower Rush Creek. If this flow requirement is adopted and the return ditch were capable of releasing 300 cfs, then Grant Lake would even be less likely to spill.

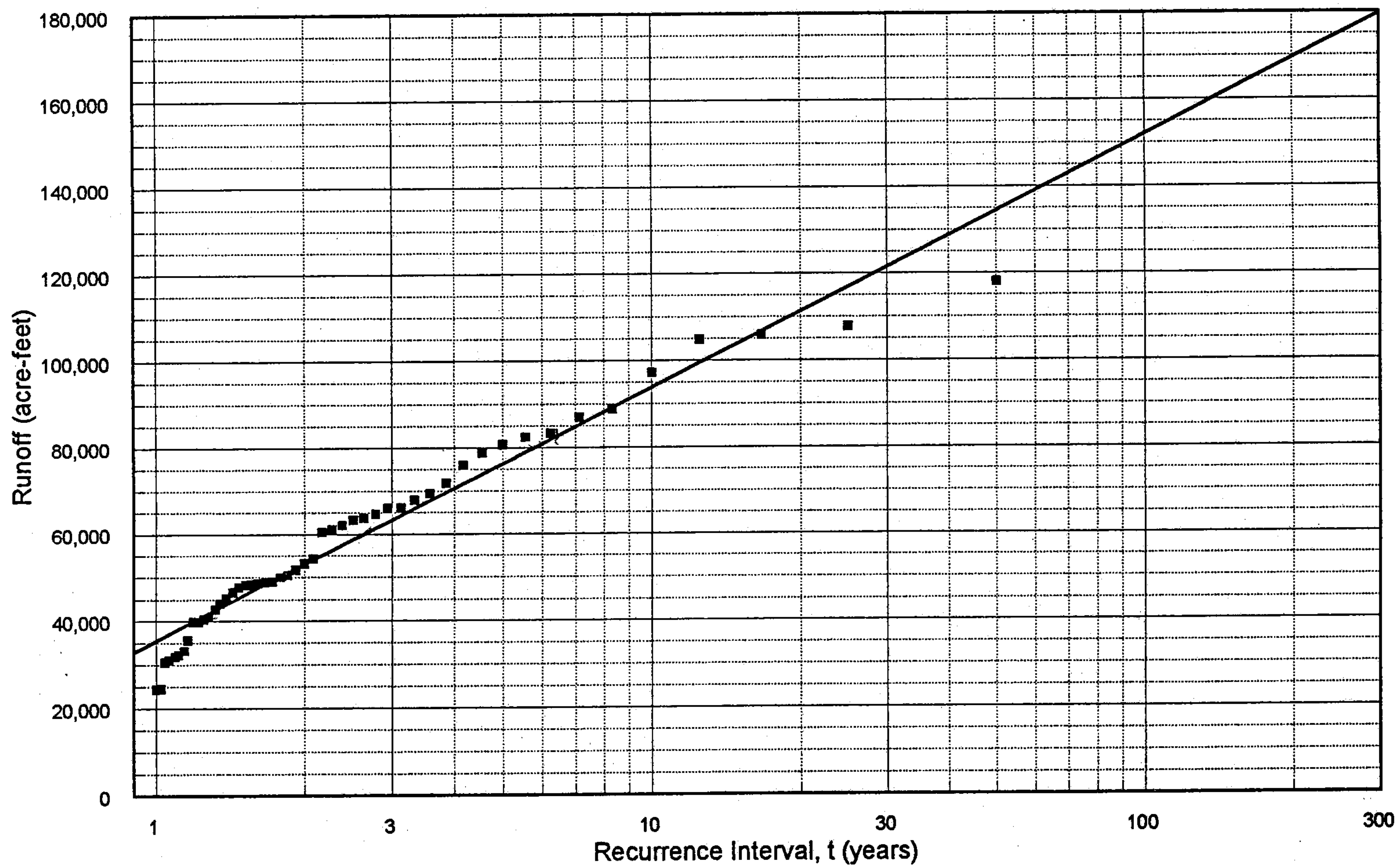
The plan for releasing water from Grant Lake is similar to the natural runoff pattern, although in general, as with any reservoir, the flows are attenuated. The attenuation of flows allows for the minimum fishery requirements to be satisfied more frequently than they would be under natural conditions. For example, natural flows in October average 17 cfs. After Edison's reservoirs affect flow, the average for October is 64 cfs, and below Grant Lake the average would be closer to 80 cfs.

For the most part, flows will remain constant for any given month, except during the period of channel riparian maintenance flows. During this time of increased flow, flow changes will be made on a daily basis, consistent with the ramping requirements. There will be no semi-daily changes in flow, as they are neither consistent with Grant Lake inflow nor practical to implement. Because Walker and Parker creeks will function in a flow through condition, however, there will be diurnal changes in flow in the bottomlands area of Rush Creek.

When the State Water Board's water right decision is adopted, the release schedules will be modified to accommodate the new requirements. It is not anticipated, however, that the changes will have a significant affect on the release schedule outlined in this document. When completed, a revised release schedule will be made available to the Restoration Technical Committee.

RUSH CREEK RUNOFF

(1941-1990)



Equation: Runoff = 35390.5 + 25301(ln(t))
$R^2 = 0.96$

Figure 11

	Apr 1 Runoff Forecast		May 1 Runoff Forecast		Actual Runoff Apr-May		April Forecast Error	May Forecast Error
1950	82.3%	Below-Normal	84.2%	Below-Normal	91.7%	Below-Normal	9.3%	7.5%
1951	94.2%	Below-Normal	96.1%	Below-Normal	91.4%	Below-Normal	-2.7%	-4.7%
1952	152.3%	Wet	151.6%	Wet	143.5%	Wet	-8.8%	-8.1%
1953	78.8%	Below-Normal	80.8%	Below-Normal	78.1%	Below-Normal	-0.7%	-2.7%
1954	86.6%	Below-Normal	83.8%	Below-Normal	68.6%	Dry	-18.0%	-15.2%
1955	69.8%	Dry	72.3%	Below-Normal	81.3%	Below-Normal	11.5%	9.0%
1956	138.8%	Above-Normal	141.4%	Wet	137.5%	Above-Normal	-1.4%	-4.0%
1957	77.8%	Below-Normal	77.8%	Below-Normal	85.6%	Below-Normal	7.8%	7.8%
1958	132.0%	Above-Normal	133.9%	Above-Normal	129.4%	Above-Normal	-2.6%	-4.4%
1959	67.6%	Dry	66.1%	Dry	60.7%	Dry	-6.9%	-5.5%
1960	68.6%	Dry	66.5%	Dry	58.1%	Dry	-10.5%	-8.3%
1961	55.9%	Dry	55.3%	Dry	59.5%	Dry	3.6%	4.2%
1962	113.1%	Above-Normal	110.0%	Above-Normal	108.4%	Above-Normal	-4.7%	-1.6%
1963	96.2%	Below-Normal	103.5%	Above-Normal	112.5%	Above-Normal	16.3%	9.0%
1964	58.6%	Dry	59.0%	Dry	69.5%	Dry	10.8%	10.5%
1965	107.8%	Above-Normal	108.5%	Above-Normal	116.8%	Above-Normal	9.0%	8.2%
1966	84.8%	Below-Normal	83.1%	Below-Normal	77.2%	Below-Normal	-7.6%	-5.9%
1967	133.7%	Above-Normal	141.8%	Wet	162.9%	Wet	29.2%	21.1%
1968	69.7%	Dry	66.7%	Dry	67.5%	Dry	-2.2%	0.8%
1969	175.4%	Wet	174.2%	Wet	174.7%	Wet	-0.7%	0.5%
1970	92.2%	Below-Normal	90.7%	Below-Normal	85.7%	Below-Normal	-6.5%	-5.0%
1971	88.2%	Below-Normal	86.4%	Below-Normal	93.2%	Below-Normal	5.0%	6.8%
1972	72.0%	Below-Normal	73.8%	Below-Normal	74.9%	Below-Normal	2.9%	1.1%
1973	111.0%	Above-Normal	108.2%	Above-Normal	108.8%	Above-Normal	-2.2%	0.6%
1974	113.1%	Above-Normal	113.6%	Above-Normal	108.3%	Above-Normal	-4.8%	-5.4%
1975	97.3%	Below-Normal	100.6%	Above-Normal	98.9%	Below-Normal	1.6%	-1.8%
1976	44.5%	Dry	43.3%	Dry	44.8%	Dry	0.3%	1.5%
1977	35.9%	Dry	32.3%	Dry	42.7%	Dry	6.7%	10.3%
1978	141.6%	Wet	145.8%	Wet	146.6%	Wet	5.0%	0.8%
1979	109.0%	Above-Normal	107.5%	Above-Normal	100.4%	Above-Normal	-8.6%	-7.0%
1980	146.1%	Wet	146.9%	Wet	139.2%	Above-Normal	-6.9%	-7.7%
1981	82.5%	Below-Normal	80.1%	Below-Normal	81.9%	Below-Normal	-0.6%	1.8%
1982	144.9%	Wet	158.4%	Wet	173.8%	Wet	28.9%	15.4%
1983	184.5%	Extreme	186.4%	Extreme	196.1%	Extreme	11.7%	9.8%
1984	118.5%	Above-Normal	119.0%	Above-Normal	121.0%	Above-Normal	2.4%	2.0%
1985	88.8%	Below-Normal	85.9%	Below-Normal	88.3%	Below-Normal	-0.5%	2.5%
1986	155.1%	Wet	153.2%	Wet	139.8%	Above-Normal	-15.3%	-13.4%
1987	57.0%	Dry	54.5%	Dry	55.6%	Dry	-1.4%	1.1%
1988	57.3%	Dry	56.7%	Dry	57.3%	Dry	0.0%	0.6%
1989	80.5%	Below-Normal	79.2%	Below-Normal	73.5%	Below-Normal	-7.0%	-5.8%
1990	55.3%	Dry	54.1%	Dry	49.0%	Dry	-6.3%	-5.1%

Appendix A