PRELIMINARY ALTERNATIVES FOR

GLEN CANYON DAM

ENVIRONMENTAL IMPACT STATEMENT

Prepared by EIS Team

for presentation to

Cooperating Agencies

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Introduction

The EIS Team has formulated 10 alternative operations in 3 categories for Glen Canyon Dam:

- **Mimic Pre-Dam Condition Alternatives**
  - **Run-of-the-River**
  - **Historic Pattern**
- **Steady Flow Alternatives**
  - **Year-Round**
  - **Seasonally-Adjusted**
  - **Existing Monthly Volume**
- **Fluctuating Flow Alternatives**
  - **Low Fluctuations**
  - **Moderate Fluctuations**
  - **High Fluctuations**
  - **No Action**
  - **Maximum Fluctuations**

Table 1 presents a comparison of these alternatives.

The team also investigated several nonoperational elements, consisting of structural and nonstructural measures, which could be added to the alternatives to either mitigate adverse impacts or to enhance resources:

- **Structural Measures**
  - **Sediment Slurry Pipeline**
  - **Pumping River Bottom Sand**
  - **Beach Protection**
  - **Reregulation Dam**
  - **Multiple Intake Structure**
  - **Fish Barriers**
- **Nonstructural Measures**
  - **Power System Adjustments**
  - **Agency Management Plans**
  - **Research and Monitoring Programs**

Table 2 presents these nonoperational elements in greater detail.

Table 3 presents a display of the alternatives and example configuration with the nonoperational elements.

Contents

Table 1--Display of Alternatives

	Alternatives									
	Mimic pre-dam conditions		Steady flow			Fluctuating flows				
Operational elements	Run-of the-river	Historic pattern	Year-round	Seasonally-adjusted	Existing monthly volumes	Low	Moderate	High	No action	Maximum
Minimum flow (ft^3/s)	Outflow - inflow	5,300 Oct 5,500 Nov 4,600 Dec 4,200 Jan 5,000 Feb 6,500 Mar 12,700 Apr 33,200 May 33,200 Jun 14,300 Jul 6,900 Aug 4,700 Sep	Steady	5,000 Oct-Dec 8,000 Jan-Mar 15,000 Apr-Jun 5,000 Jul-Sep	8,000	8,000 Dec-Feb 5,000 Mar-Nov	5,000	5,000	1,000 Labor Day-Easter 3,000 Easter-Labor Day	1,000
Maximum flow (ft^3/s)	Outflow - inflow	NTE 33,200[2] except during flooding	Steady	NTE 33,200[2] except during flooding	NTE 33,200[2] except during flooding	NTE 33,200[2] except during flooding	NTE 33,200[2] except during flooding	NTE 33,200[2] except during flooding	NTE[1] 31,500[2] except during flooding	NTE 33,200[2] except during flooding
Allowable daily change in flow ($ft^3/s/day$)	Outflow - inflow	2,000	2,000	2,000	2,000	+/- 25% of Mean daily flow for the month NTE 7,000	+/- 45% of Mean daily flow for the month NTE 12,000	+/- 75% of Mean daily flow for the month NTE 18,000	30,500 Labor Day-Easter 28,500 Easter-Labor Day	32,200
Allowable ramping rate ($ft^3/s/hour$)	Outflow - inflow	Steady	Steady	Steady	Steady	2,500	4,000	6,000	Control system restriction	Control system restriction
Flood frequency (years)[3]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	1 in 20	[4]

[1] Not to exceed.

[2] Would occur only during extreme runoff years.

[3] A flood is defined as flows greater than powerplant capacity (33,200 ft^3/s).

[4] Flood frequency management measures seem to be important for managing some downstream resources. Such management measures, which are not yet defined, may be considered along with one or more of the alternatives.

Table 2.--Nonoperational elements

Alternative operations have been formulated based on a full range of changes in Glen Canyon Dam operational elements. Some of these alternative operations would have major impacts on various resources if such impacts were unmitigated. A number of nonoperational elements have been identified which, although not constituting a full integrated alternative, can be added to various operational alternatives to either mitigate adverse consequences or to enhance resources. Listed below are some of these nonoperational elements that have been identified in the scoping process and which are still under active study. These elements include both structural and nonstructural measures.

STRUCTURAL ELEMENTS

The scoping process has identified various nonoperational structural measures that would maintain or protect some resources downstream from Glen Canyon Dam. The following structural elements are being investigated as part of the Glen Canyon Dam EIS.

Sediment Slurry Pipeline

- Sediment (mostly sand) would be continually dredged from a delta deposit in Lake Powell or Lake Mead and conveyed to Lees Ferry as a sediment/water slurry mix in a pipeline.

- River flows would transport the sediment downstream from Lees Ferry and sand-sized sediment would deposit in main channel pools.

- Natural floods (or special high releases) would transport sand from the main channel pools to the beaches.

- The slurry pipeline is expected to cost $400,000 per mile for construction and $7 million per year to operate.

Pumping River Bottom Sand

- Beaches would be rebuilt at specific locations by pumping sand from recirculating zones or main channel pools onto the beaches.

- The pumping equipment would be transported by raft.

- A temporary berm would be constructed on the beach to capture the pumped sand and to prevent erosion during the pumping operation.

Table 2.--Nonoperational elements (continued)

- Sand pumping operations could occur as part of a regular program or on a one-time basis, depending on the needs of each alternative.

Beach Protection

- Rock riprap could be placed to protect a beach face from erosion.
- A rock jetty could be constructed to deflect high velocity currents away from a beach and create an eddy on the downstream side of the structure.
- Material from debris fans could be used for construction and planted with native vegetation. All construction would be performed by hand or with small mechanized equipment.

Reregulation Dam

- The dam would be constructed one half mile upstream from Lees Ferry.
- Various dam heights are being investigated that would reregulate the fluctuating releases from Glen Canyon Dam to nearly steady flow. A 19-foot-high dam (19 feet above low water) would reregulate current operations to less than 5,000 cubic feet per second per day (ft^3/s/day) 99 percent of the time. A 14-foot-high dam would reregulate current operations to less than 5,000 ft^3/s/day 87 percent of the time.
- The cost of the reregulation dam is between $40 million and $110 million.

Multilevel Intake Structure

- Water temperature historically varied between 32 °F and 82 °F at Lees Ferry.
- Presently water temperatures at Lees Ferry range between 42 °F and 64 °F with an average of 50 °F.
- The installation of eight multilevel intake structures could increase temperatures 5 °F to 18 °F depending upon the season (54 °F to 69 °F from May to October).
- Eight multilevel structures would cost on the order of $60 million.

Table 2.--Nonoperational elements (continued)

Fish Barriers

- The warming of downstream water temperatures may encourage the undesirable establishment of striped bass and therefore may require a fish barrier (if possible).

- Possible barriers include electric curtains, lights, screens, bubble curtains, louvers, water velocity, rack bars, sill dams, chains, and introduction of chemicals, odors, or sounds to cause a fright reaction.

- Items to consider in determining appropriateness of fish barrier:
  - Will warmer water facilitate striped bass spawning?
  - Has it been verified that the bass have migrated upstream, or have they been artificially transplanted or travelled freely over rapids during the flood years of the early 1980's?
  - Below what point in the river is it acceptable to have the bass?

NONSTRUCTURAL ELEMENTS

Power System Adjustments (See Attachment 1 for supplemental information)

- Alternative generation

- Alternative marketing

- Energy conservation

Agency Management Plans

- Conservation plans for humpback chub

- Trout stocking/breeding policies

Research and Monitoring Programs

Table 3.--Display of alternatives and potential configuration with nonoperational elements[1]

	Alternatives									
	Mimic Pre-Dam Conditions		Steady Flow			Fluctuating Flows				
	Run-Of The-River	Historic Pattern	Year-Round	Seasonally-Adjusted	Existing Monthly Volumes	Low	Moderate	High	No Action	Maximum
OPERATIONAL ELEMENTS										
Minimum flow (ft^3/s)	Outflow - inflow	5,300 Oct 5,500 Nov 4,600 Dec 4,200 Jan 5,000 Feb 6,500 Mar 12,700 Apr 33,200 May 33,200 Jun 14,300 Jul 6,900 Aug 4,700 Sep	Steady	5,000 Oct-Dec 8,000 Jan-Mar 15,000 Apr-Jun 5,000 Jul-Sep	8,000	8,000 Dec-Feb 5,000 Mar-Nov	5,000	5,000	1,000 Labor Day-Easter 3,000 Easter-Labor Day	1,000
Maximum flow (ft^3/s)	Outflow - inflow	NTE 33,200[3] except during flooding	Steady	NTE 33,200[3] except during flooding	NTE 33,200[3] except during flooding	NTE 33,200[3] except during flooding	NTE 33,200[3] except during flooding	NTE 33,200[3] except during flooding	NTE[2] 31,500[3] except during flooding	NTE 33,200[3] except during flooding
Allowable daily change in flow ($ft^3/s/day$)	Outflow - inflow	2,000	2,000	2,000	2,000	+/- 25% of Mean daily flow for the month NTE 7,000	+/- 45% of Mean daily flow for the month NTE 12,000	+/- 75% of Mean daily flow for the month NTE 18,000	30,500 Labor Day-Easter 28,500 Easter-Labor Day	32,200
Allowable ramping rate ($ft^3/s/hour$)	Outflow - inflow	Steady	Steady	Steady	Steady	2,500	4,000	6,000	Control system restriction	Control system restriction
Flood frequency (years)[4]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	1 in 20	[5]
NONOPERATIONAL ELEMENTS										
Sediment slurry pipeline	X	X								
Sand pumping										
Regular program						X	X			
One-time basis	X	X	X	X	X			X		X
Beach protection							X			
Reregulation dam								14-foot-high dam		19-foot-high dam
Multilevel intake structure	X	X				X	X			
Fish barriers	X	X				X	X			
Power system adjustments	X	X	X	X	X	X	X	X		
Agency management plans										
Humpback chub conservation			X			X	X			
Trout stocking/breeding	X	X				X	X	X		X
Research and monitoring	X	X	X	X	X	X	X	X		X

[1] Example configuration of nonoperational elements with alternatives. Other configurations may be formulated depending on the results of studies of the operational and nonoperational elements.

[2] Not to exceed.

[3] Would occur only during extreme runoff years.

[4] A flood is defined as flows greater than powerplant capacity (33,200 ft^3/s).

[5] Flood frequency management measures seem to be important for managing some downstream resources. S...

Elements Common to All Alternatives

The alternatives being assessed as a part of the Glen Canyon Environmental Impact Statement have several elements in common which are not specifically addressed in the discussion of the individual alternatives and which are not expected to change. For example, the relationship between the Bureau of Reclamation and Western Area Power Administration (Western) for the determination of releases from Glen Canyon Dam (see figure on following page) is not anticipated to change in the alternatives. Other elements include inflow forecasting, operational emergencies, humanitarian situations, water releases for special studies and monitoring, dam and powerplant maintenance, and spinning reserves. The following is an overview of these elements.

Inflow Forecasting

Inflow projections are received from the National Weather Service twice a month and are used to project ahead for a 3- to 4-month period. This data comes from a satellite telemetered network of more than 100 data collection points within the Upper Colorado River Basin that gather snow water content, precipitation, temperature, and streamflow information. The water year begins in October, and adjustments are made for anticipated targets such as annual volumes, flood control elevations, etc.. Starting on January 1, forecasts are made for the April through July inflow, the peak run-off period. Due to variability in climatic conditions, modeling, and data uncertainties these early forecasts may contain large errors. The level of uncertainty decreases as the snow accumulation period progresses into the runoff season. As the season progresses modifications in the monthly scheduled releases are made to accommodate changes in the projected runoff.

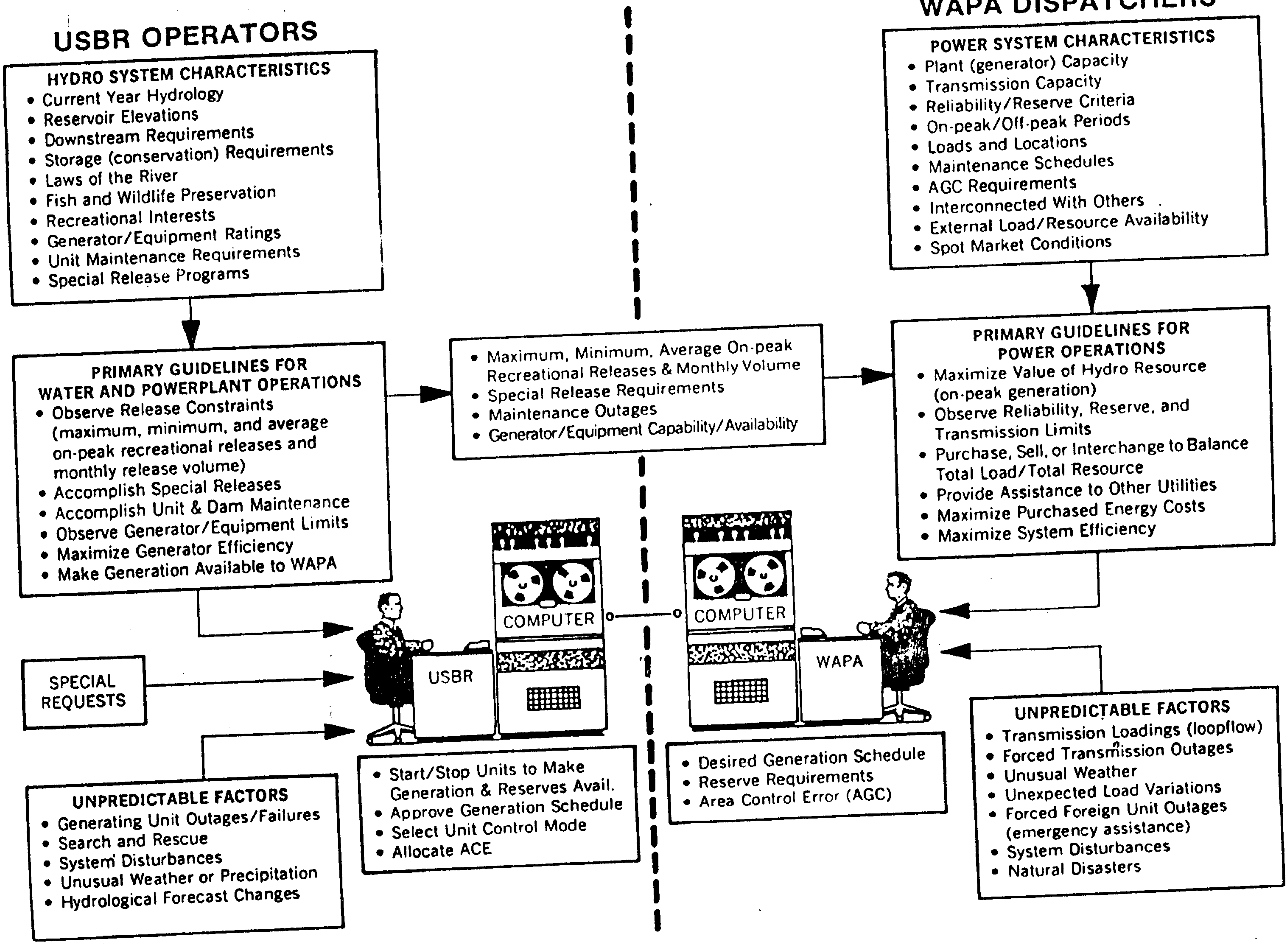
Operational Emergencies

The North American Electrical Reliability Council (NERC) has established guidelines for the emergency operations of interconnected systems. A number of these guidelines apply to the operation of Glen Canyon Dam and may account for operational changes outside of the operations identified in the description of each alternative. These changes in operations are intended to be of short duration and are the result of emergencies at the dam or within the transmission network. NERC provides the following guidelines for system emergencies. Because of the technical nature of the descriptions, only examples are given here.

A. Insufficient Generation Capacity

A control area which has experienced an operating capacity emergency shall promptly balance its generation and interchange schedules to its load, without regard to financial cost, to avoid prolonged use of the assistance provided by interconnection frequency bias. The emergency reserve inherent in frequency deviation is intended to

OPERATIONAL FACTORS CONSIDERED BY:



be used only as a temporary source of emergency energy and is to be promptly restored so that the interconnected systems will be prepared to withstand the next contingency. A control area unable to balance its generation and interchange schedules to its load shall have the responsibility to remove sufficient load to permit correction of its Area Control Error.

A control area anticipating an operating capacity emergency shall bring on all available generation, postpone equipment maintenance, schedule interchange purchases well in advance, and prepare to reduce load.

An example of insufficient generation capacity and the response would be when any of the coal-fired powerplants in Western's load control area is unexpectedly lost. The response being an increase in Colorado River Storage Project (CRSP) generation or imports to cover the change in anticipated generation within the control area.

B. Transmission - Overload, Voltage Control

If a transmission facility becomes overloaded or if voltage levels are outside of established limits and the condition cannot be relieved by normal means such as adjusting generation or interconnection schedules, and if a credible contingency under these conditions would adversely impact the interconnection, appropriate relief measures, including load shedding, shall be implemented promptly to return the transmission facility to within established limits. This action shall be taken by the system, control area, or pool causing the problem if that system or control area can be identified, or by other systems or control areas, as appropriate, if that identification cannot be readily determined.

An example of a response to an overloaded transmission system would be an automatic relay tripping and taking a transmission out of service, such as the Glen Canyon-Flagstaff 345-kilovolt (kV) line. This action causes Glen Canyon powerplant generation to be instantaneously reduced to a predetermined level. This predetermined level depends on the capacity of the line taken out of service.

C. Load Shedding

After taking all other steps, a system or control area whose integrity is in jeopardy due to insufficient generation or transmission capacity shall shed customer load rather than risk an uncontrolled failure of components of the interconnection.

An example requiring the extreme step of load shedding generally occurs when there is an interruption of the transmission capacity between the heavy load areas of Southern California and Arizona and the heavy generation areas of the Pacific Northwest, Colorado, Wyoming and Montana. In this situation, Glen Canyon is isolated with the heavy load areas. The response is for Glen Canyon to swing from existing generation levels to maximum powerplant capacity. Then the automatic relay protection would open the transmission lines to the heavy load area reducing the generation at Glen Canyon.

D. System Restoration

After a system collapse, restoration shall begin when it can proceed in an orderly and secure manner. Systems and control areas shall coordinate their restoration actions. Restoration priority shall be given to the station supply of power plants and the transmission system. Even though the restoration is to be expeditious, system operators shall avoid premature action to prevent a recollapse of the system.

Customer load shall be restored as generation and transmission equipment becomes available, recognizing that load and generation must remain in balance at normal frequency as the system is restored.

E. Emergency Information Exchange

A system control area or pool which is experiencing or anticipating an operating emergency shall communicate its current and future status to neighboring systems, control areas, or pools and throughout the interconnection. Systems able to provide emergency assistance shall make known their capabilities.

F. Special System or Control Area

Because the facilities of each system may be vital to the secure operation of the interconnection, systems and control areas shall make every effort to remain connected to the interconnection. However, if a system or control area determines that it is endangered by remaining interconnected, it may take such action as it deems necessary to protect its system.

If a portion of the interconnection becomes separated from the remainder of the interconnection, abnormal frequency and voltage deviations may occur. To permit resynchronizing, relief measures shall be applied by those separated systems contributing to the frequency and voltage deviations.

An example of when Western may choose to disconnect the Glen Canyon powerplant from the interconnected system is in the case of a search and rescue operation in the canyon because of a need to control the releases.

Although these situations are infrequent they do occur and will require immediate, short term changes in the operation of the dam. In general those changes that are a result of emergencies at Glen Canyon will result in decreases in the flows. Emergencies in the system away for the dam will result in increases in the flows.

Humanitarian Situations

There are occasions when managing agencies and local authorities, such as the police, request that the flows from the dam be reduced so that search and rescue procedures can be conducted or fatalities can be recovered from the river. In these situations the flows will be reduced for an agreed upon period of time. When returning to normal operations, the flows will be brought up quickly to the minimum flow identified in the alternative and then may be increased at the ramping rate identified in the alternative.

Water Releases for Special Studies and Monitoring

All the alternatives assume there will be a need for monitoring the downstream resource to determine if the desired objectives are being achieved. There may be a need to adjust operations outside of the limits identified in each of the alternatives to conduct special studies. The alternatives assume sufficient flexibility to accommodated these short term changes.

Dam and Powerplant Maintenance

Facilities maintenance is scheduled during periods of low power demand, usually spring and fall. Standard maintenance does not typically impact powerplant capacities or monthly water volumes.

Spinning Reserves

Generating capacity that is on-line and in excess of the current load on the system is called spinning reserve. Western, as a control area operator, must provide for an adequate spinning reserve since such reserve is an important factor in the security of the power system.

Mimic Pre-Dam Condition Alternatives

Run-of-the-River (Outflow Equals Inflow)

- **Purpose and Objective**. The Run-of-the-River Alternative was developed in response to comments received during the scoping process that called for a return to pre-dam flows. This alternative would approximate pre-dam high spring flows (which commonly exceeded 100,000 cubic feet per second (ft^3/s) and fall/winter low flows insofar as possible. Spring releases would generally be limited to 45,000 to 50,000 ft^3/s (all turbines and outlet tubes operating) unless the reservoir was full and the spillways were able to operate. In that event, outflow could equal inflows above 50,000 ft^3/s. Extended periods would occur when higher spring inflows could not be passed through the reservoir because of low lake levels. It is important to note, however, that this pattern of clear water releases would not mimic pre-dam conditions in one critical area: sediment.

- **Range of Fluctuating Flows**. Water releases would be passed through the dam as though they were not controlled under this alternative, except when inflows could not be bypassed because of a low water surface elevation in the reservoir. Prior to the dam (1922-1962) median daily flows ranged from a low of about 5,200 ft^3/s in January to a high of about 50,000 ft^3/s in June.

- **Maximum Flow**. The maximum recorded daily pre-dam (1922-1962) flows were about 120,000 ft^3/s in May, June, and July. Flows of 85,000 ft^3/s or greater occurred 90 percent of the time during June. During these 3 months, flows were greater than 45,000 ft^3/s about 90 percent of the time. The maximum flow would be determined by the water to be released in any month. Up to 33,200 ft^3/s could be discharged through the powerplant. Flows greater than this capacity would be discharged through the outlet works first and subsequently through the spillways, as required.

- **Minimum Flow**. The minimum recorded daily pre-dam (1922-1962) flows were about 1,000 ft^3/s mostly in December, January, July, August, and September. For all months combined, daily flows were less than 10,000 ft^3/s about 50 percent of the time and less than 5,000 ft^3/s about 25 percent of the time.

- **Annual Volume**. The pre-dam (1922-1962) median annual flow at the dam site was about 12 million acre-feet. The expected flow under future operations could be slightly less because of increasing upper basin depletions.

- **Monthly Volume**. The pre-dam (1922-1962) median monthly flow at the dam site ranged from about 320,000 acre-feet in January to about 3,100,000 acre-feet in June. The expected flow under future operations could be slightly less because of increasing upper basin depletions.

- **Daily Volume**. The pre-dam (1922-1962) median daily flow at the dam site ranged from about 10,300 acre-feet (5,200 ft^3/s) in January to about 100,000 acre-feet (50,000 ft^3/s) in June. The expected flow under future operations could be slightly less because of increasing upper basin depletions.

- **Forecast Adjustments**. Forecast adjustments would not be applicable to this alternative.

- **Avoidance of Spills**. Essentially all operational flexibility necessary to avoid spills and maintain conservation storage would be eliminated.

- **Ramping Rate (Daily and/or Hourly)**. Ramping rates would not be applicable under this alternative.

- **Power Considerations**. The powerplant would operate as a run-of-the-river plant.

Historic Pattern

- **Purpose and Objective**. The Historic Pattern Alternative was developed in response to comments received during the scoping process that called for a return to pre-dam flow patterns. This alternative would be a refinement of the Run-of-the-River Alternative and would constrain flows to current powerplant operational capacity while maintaining the pattern of a pre-dam hydrograph. Water would be released from the dam in constant-rate monthly patterns generally reflective of pre-dam conditions in order to protect downstream resources from frequent daily fluctuations and destructive high-flow floods.

- **Range of Fluctuating Flows**. Flows would be held steady within each month with this alternative.

- **Maximum Flow**. The maximum flow would be determined by the water to be released in any month. Up to 33,200 ft^3/s could be discharged through the powerplant. Flows greater than this capacity would be discharged through the outlet works first and subsequently through the spillways, as required.

- **Minimum Flow**. The basis for determining the base constant flow for each month is the "median" pre-dam recorded flows at Lees Ferry, limited to the powerplant capacity and prorated downward to achieve the minimum annual release of 8.23 million acre-feet. The minimum flow rates determined using these procedures would be as follows:

Month	Minimum Flow (ft^3/s)	Month	Minimum Flow (ft^3/s)
October	5,300	April	12,700
November	5,500	May	33,200
December	4,600	June	33,200
January	4,200	July	14,300
February	5,000	August	6,900
March	6,500	September	4,700

  Required release volumes greater than the minimums would be distributed equally among all months with remaining "release capacity" less than powerplant capacity.

- **Annual Volume**. The scheduled annual release volume would be determined using existing practices, based on considerations for maintaining conservation storage, avoiding spills, and balancing storage between Lakes Powell and Mead.

- **Monthly Volume**. Monthly volumes would be determined based on distributing water among months in proportions indicated by the minimum release rates.

- **Daily Volume**. Daily volumes would be determined by distributing the monthly volume equally among the days in the month.

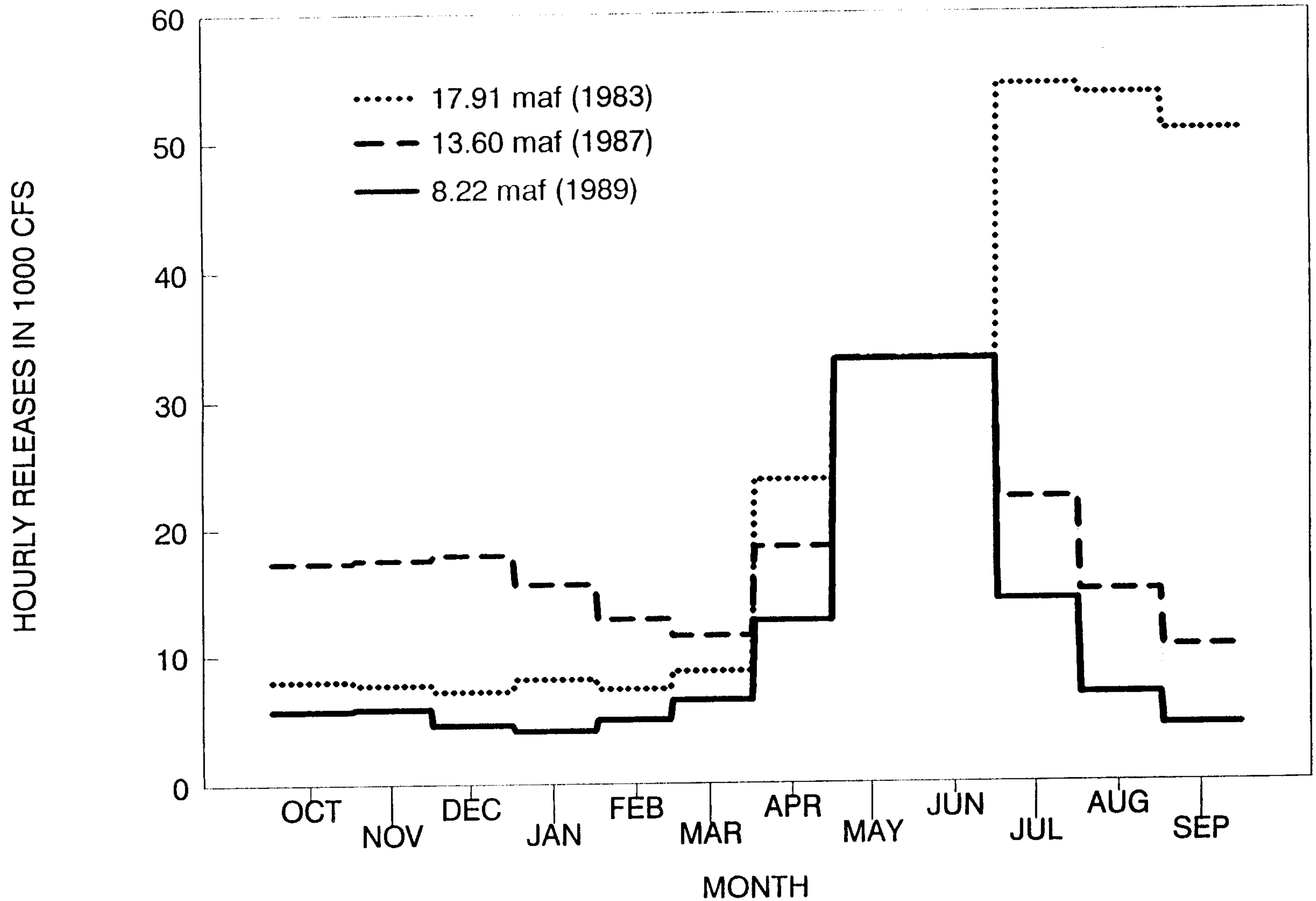
- **Forecast Adjustments**. The volume of water to be released during the remainder of the year would be recomputed monthly based on updated streamflow forecast information (as under existing practices), and the rate of release for remaining months would be adjusted accordingly. The figure on the following page shows estimated release patterns from Glen Canyon Dam for this alternative for three water supply situations (water years 1983, 1987, 1989). The 1989 water year represents a low reservoir pool with a minimum annual release volume. Water year 1983 represents a high reservoir pool with high inflow, a high forecast error, and an increasing forecast over a short period of time. Water year 1987 represents a high reservoir pool with a moderate inflow, a moderate forecast error, and a decreasing forecast. Attachment 2 shows the release patterns for each of these water years as well as for 1980 in response to changes in forecast as well as the release patterns assuming a perfect forecast of reservoir inflow. The year 1980 represents a high reservoir pool with moderate inflow and outflow and a low forecast error.

- **Avoidance of Spills**. Operational flexibility necessary to avoid spills and maintain conservation storage would be reduced to some extent (in years when Lake Powell is expected to fill).

- **Ramping Rate (Daily and/or Hourly)**. The maximum ramping rate in adjusting flows between months would be 2,000 ft^3/s per day.

- **Power Considerations**. Power operations would be driven almost entirely by constant water release requirements, except for electrical system emergencies. Daily variations of ±1,000 $ft^3/s/day$ (approximately 42 megawatt (MW)) would allow some minor flexibility at the dam to be used primarily for regulation. Under some situations, regulation may be moved to another CRSP facility, and this flexibility would be used to better meet on- and off-peak firm load.

Mimic Predam - Historic Pattern



Steady Flow Alternatives

Year-Round

- **Purpose and Objective**. The Year-Round Steady Flow Alternative was developed in response to scoping comments that called for complete elimination of fluctuating flows. This alternative would have the objective of releasing water from Glen Canyon Dam at a year-round steady rate, thus eliminating daily river fluctuations and minimizing peak discharges in order to preserve existing beaches and sediment-dependent resources.

- **Range of Fluctuating Flows**. Flows would be held steady throughout the year with this alternative, subject to forecast adjustments. In the event changes were required between months to respond to forecast changes, flows would remain steady within each month.

- **Maximum Flow**. The maximum flow would be determined by the water to be released in any month. Up to 33,200 ft^3/s could be discharged through the powerplant. Flows greater than this capacity would be discharged through the outlet works first and subsequently through the spillways, as required. Release in excess of 31,500 ft^3/s, the current limitation on releases, has historically (1966-1989) only occurred in the months of May through August. These flows in excess of 31,500 ft^3/s have occurred about 9, 12, 7, and 2 percent of the time in those months.

- **Minimum Flow**. The minimum flow would correspond to the minimum annual release volume of 8.23 million acre-feet, which is about 11,400 ft^3/s.

- **Annual Volume**. The scheduled annual release volume would be determined using existing practices, based on considerations for maintaining conservation storage, avoiding spills, and balancing storage between Lakes Powell and Mead. Releases would be 11,400; 16,600; and 22,100 ft^3/s for annual volumes of 8.23; 12.0; and 16.0 million acre-feet, respectively.

- **Monthly Volume**. The monthly volume would be the annual volume divided by 12, except under circumstances where adjustments would be required in responding to forecast changes.

- **Daily Volume**. The daily volume would be the monthly volume divided by the number of days in the month.

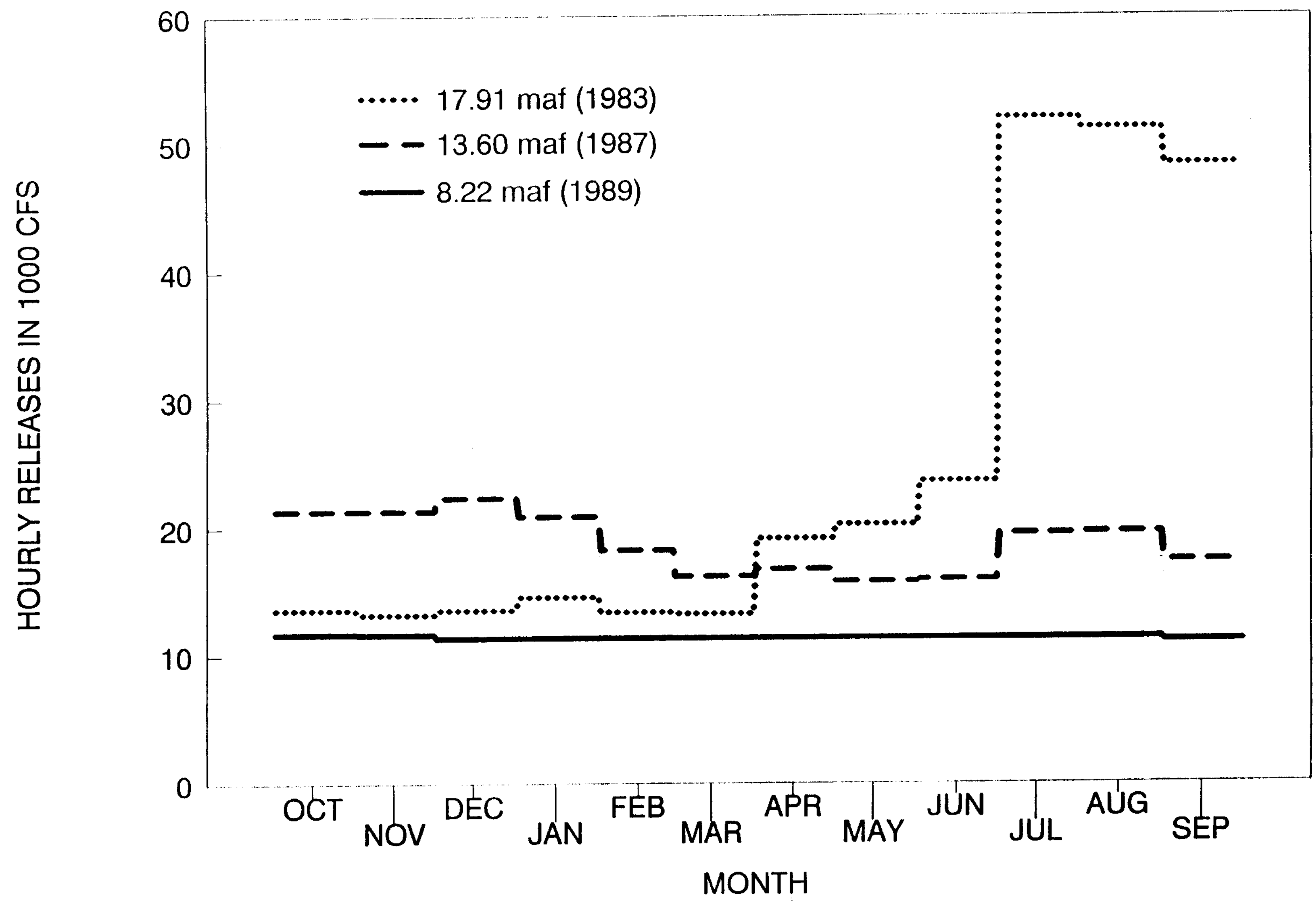
- **Forecast Adjustments**. The volume of water to be released during the remainder of the year would be recomputed monthly based on updated streamflow forecast information (as it is under existing practices), and the constant rate of release would be adjusted accordingly. The ability to maintain a constant rate of release for the entire year would be dependent on the accuracy of streamflow forecasts and the amount of space remaining in Lake Powell. The figure on the following page shows estimated release patterns from Glen Canyon Dam for this alternative under conditions experienced in water years 1983, 1987, 1989. These patterns reflect different conditions of inflow, the reservoir pool, and the forecast error (as described in the Mimic Pre-Dam Condition -- Historic Pattern Alternative.

- **Avoidance of Spills**. Operational flexibility necessary to avoid spills and maintain conservation storage would be reduced to some extent (in years when Lake Powell is expected to fill).

- **Ramping Rate (Daily and/or Hourly)**. The maximum ramping rate in adjusting flows between months because of forecast changes would be 2,000 ft^3/s per day.

- **Power Considerations**. Power operations would be driven almost entirely by constant water release requirements, except for electrical system emergencies. Daily variations of ±1,000 $ft^3/s/day$ (approximately 42 MW) would allow some minor flexibility at the dam to be used primarily for regulation. Under some situations, regulation may be moved to another CRSP facility, and this flexibility would be used to better meet on- and off-peak firm load.

Steady Flow - Year Round



Seasonally-Adjusted

- **Purpose and Objective**. The Seasonally-Adjusted Steady Flow Alternative is a refinement of the Year-Round Steady Flow Alternative and was developed in response to scoping comments that called for a flow regime that would address the varying seasonal needs of downstream resources. This alternative would release water from Glen Canyon Dam at a constant rate within each of four seasons, in order to preserve the altered ecosystem that currently exists downstream of the dam.

- **Seasons**. The seasons would be fall (October through December), winter (January through March), spring (April through June), and summer (July through September).

- **Range of Fluctuating Flows**. Flows would be held steady throughout each season with this alternative, subject to forecast adjustments. In the event changes were required between months to respond to forecast changes, flows would remain steady within each month.

- **Maximum Flow**. The maximum flow would be determined by the water to be released in any month. Up to 33,200 ft^3/s could be discharged through the powerplant. Flows greater than this capacity would be discharged through the outlet works first and subsequently through the spillways, as required. Release in excess of 31,500 ft^3/s, the current limitation on releases, has historically (1966-1989) only occurred in the months of May through August. These flows in excess of 31,500 ft^3/s have occurred about 9, 12, 7, and 2 percent of the time in those months.

- **Minimum Flows**. The constant release for each respective season would be based on minimum flows of 5,000; 8,000; 15,000; and 5,000 ft^3/s. Required release volumes greater than the minimums would be distributed equally among all seasons.

- **Annual Volume**. The scheduled annual release volume would be determined using existing practices, based on considerations for maintaining conservation storage, avoiding spills, and balancing storage between Lakes Powell and Mead.

- **Monthly Volume**. The monthly volume would be the seasonal volume divided by three, except under circumstances where adjustments would be required in response to forecast changes.

- **Daily Volume**. The daily volume would be the monthly volume divided by the number of days in the month.

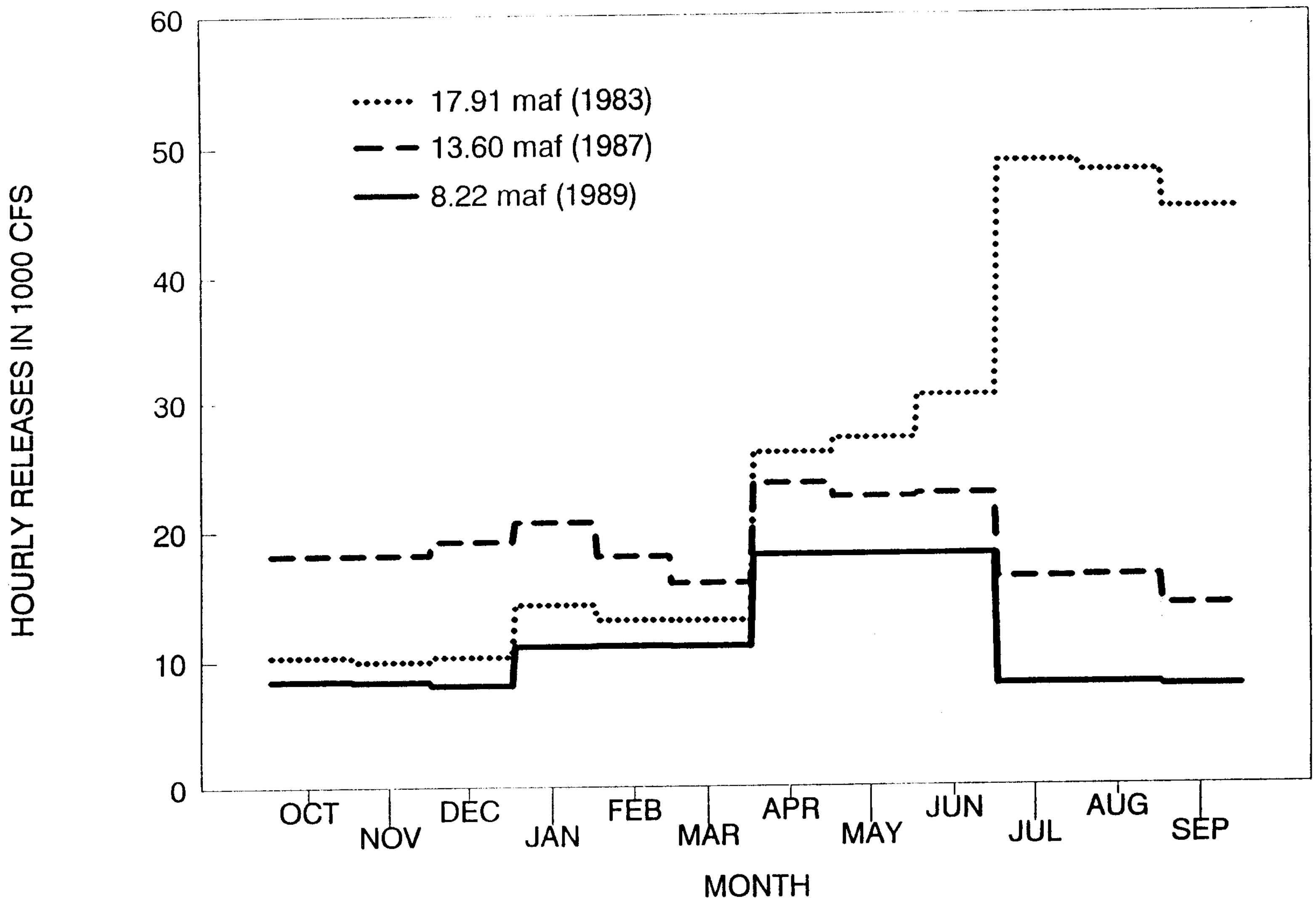
- **Forecast Adjustments**. The volume of water to be released during the remainder of the year would be recomputed monthly based on updated streamflow forecast information (as it is under existing practices), and the rate of release for remaining seasons would be adjusted accordingly. The ability to maintain a constant rate of release for each season would be dependent on the accuracy of the streamflow forecasts. The figure on the following page shows estimated release patterns from Glen Canyon Dam for this alternative under conditions experienced in water years 1983, 1987, 1989. These patterns reflect different conditions of inflow, reservoir pool, and forecast error (as described in the Mimic Pre-Dam Condition -- Historic Pattern Alternative).

- **Avoidance of Spills**. Operational flexibility necessary to avoid spills and maintain conservation storage would be reduced to some extent (in years when Lake Powell is expected to fill).

- **Ramping Rate (Daily and/or Hourly)**. The maximum ramping rate in adjusting flows between months would be 2,000 ft^3/s per day.

- **Power Considerations**. Power operations would be driven almost entirely by constant water release requirements, except for electrical system emergencies. Daily variations of ±1,000 $ft^3/s/day$ (approximately 42 MW) would allow some minor flexibility at the dam to be used primarily for regulation. Under some situations, regulation may be moved to another CRSP facility, and this flexibility would be used to better meet on- and off-peak firm load.

Steady Flow - Seasonally Adjusted



Existing Monthly Volume

- **Purpose and Objective**. The Existing Monthly Volume Steady Flow Alternative was developed in an attempt to integrate the concepts of steady flow and current monthly water delivery schedules. This alternative would release water from Glen Canyon Dam at a constant rate within each month to maintain the operational flexibility necessary to avoid spills and maintain conservation storage while eliminating the possible negative effects of daily fluctuating flows on downstream resources.

- **Range of Fluctuating Flows**. Flows would be held steady throughout each month with this alternative.

- **Maximum Flow**. The maximum flow would be determined by the water to be released in any month. Up to 33,200 ft^3/s could be discharged through the powerplant. Flows greater than this capacity would be discharged through the outlet works first and subsequently through the spillways, as required. Release in excess of 31,500 ft^3/s, the current limitation on releases, has historically (1966-1989) only occurred in the months of May through August. These flows in excess of 31,500 ft^3/s have occurred about 9, 12, 7, and 2 percent of the time in those months.

- **Minimum Flow**. The objective minimum constant rate of flow would be 8,000 ft^3/s, which is equivalent to about 480,000 acre-feet per month. In water-critical years, the monthly volume could be somewhat less, thus necessitating a corresponding drop in the minimum rate of release.

- **Annual and Monthly Volumes**. The scheduled monthly and annual release volumes would be determined using existing practices, based on considerations for maintaining conservation storage, avoiding spills, and balancing storage between Lakes Powell and Mead. Fall and winter monthly release volumes have been close to 500,000 acre-feet about 50 percent of the time for the period 1963 through 1989.

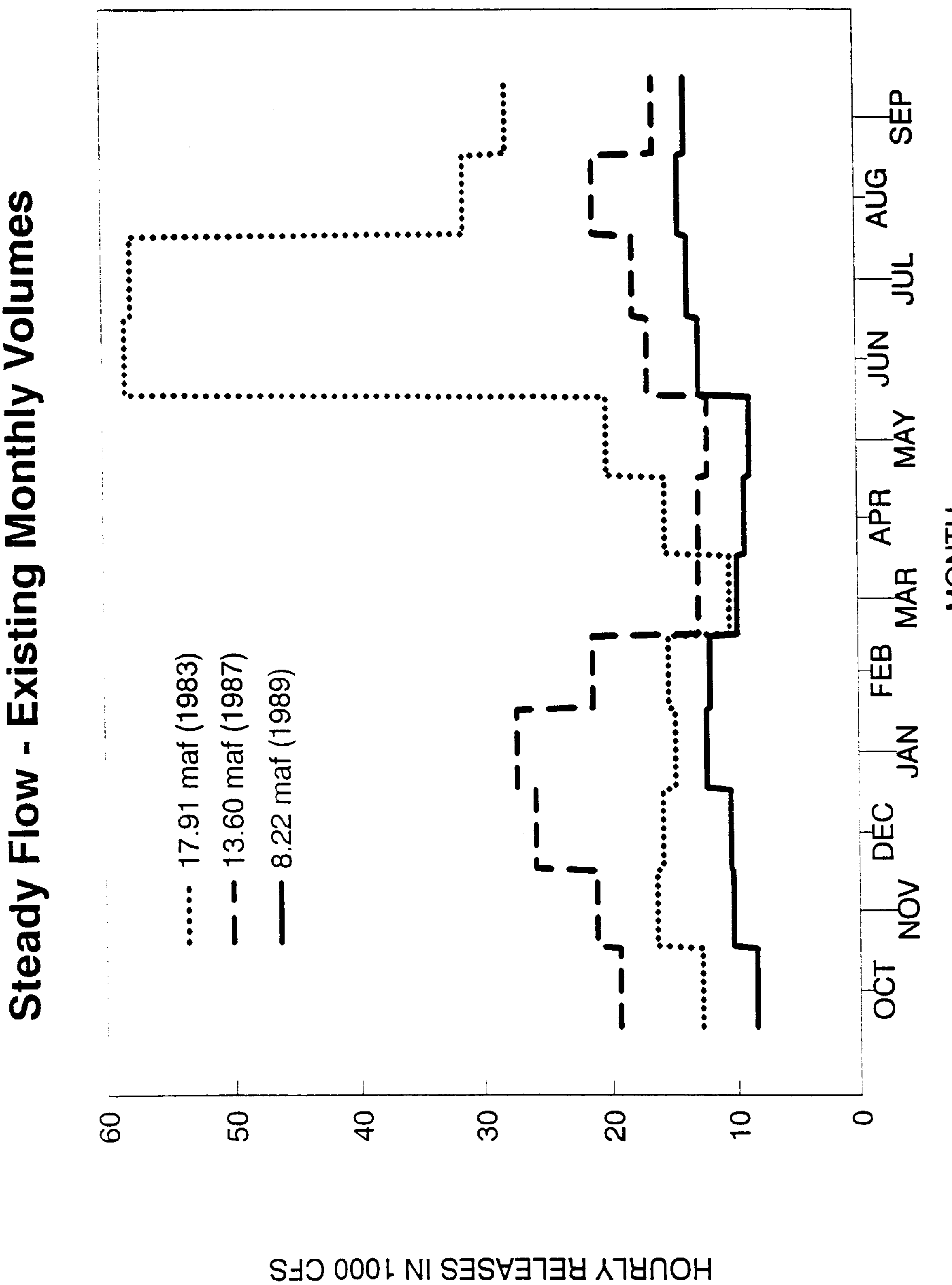
- **Daily Volume**. The daily volume would be the monthly volume divided by the number of days in the month.

- **Forecast Adjustments**. The volume of water to be released during the remainder of the year would be recomputed monthly based on updated streamflow forecast information (as it is under existing practices), and the rate of release for remaining seasons would be adjusted accordingly. The figure on the following page shows estimated release patterns from Glen Canyon Dam for this alternative under conditions experienced in water years 1983, 1987, 1989. These patterns reflect different conditions of inflow, reservoir pool, and forecast error (as described in the Mimic Pre-Dam Condition -- Historic Pattern Alternative).

- **Avoidance of Spills**. Operational flexibility necessary to avoid spills and maintain conservation storage would be the same as current operations.

- **Ramping Rate (Daily and/or Hourly)**. The maximum ramping rate in adjusting flows between months would be 2,000 ft^3/s per day.

- **Power Considerations**. Power operations would be driven almost entirely by constant water release requirements, except for electrical system emergencies. Daily variations of ±1,000 $ft^3/s/day$ (approximately 42 MW) would allow some minor flexibility at the dam to be used primarily for regulation. Under some situations, regulation may be moved to another CRSP facility, and this flexibility would be used to better meet on- and off-peak firm load.


Steady Flow - Existing Monthly Volumes
17.91 maf (1983)
13.60 maf (1987)
8.22 maf (1989)
HOURLY RELEASES IN 1000 CFS
0
10
20
30
40
50
60
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
MONTH

Fluctuating Flow Alternatives

Low Fluctuations

- **Purpose and Objective**. The Low Fluctuation Alternative was developed to permit fluctuating flows well below existing levels. This alternative would release water from Glen Canyon Dam in a manner that would significantly reduce the daily magnitude of fluctuating flows and ramping rates, in order to reduce the possible adverse effects of current powerplant operations on downstream beaches, sediment-dependent resources, and aquatic resources.

- **Range of Fluctuating Flows**. Daily fluctuations would be limited to ±25 percent of the mean monthly flow but not to exceed 7,000 ft^3/s. The allowable daily fluctuations would be about 4,200; 7,000; and 7,000 ft^3/s, corresponding to monthly volumes of 500,000; 1,000,000; and 1,500,000 acre-feet; respectively. The figure and table on the following pages show the limits of fluctuating flow based on the mean daily flow for the month.

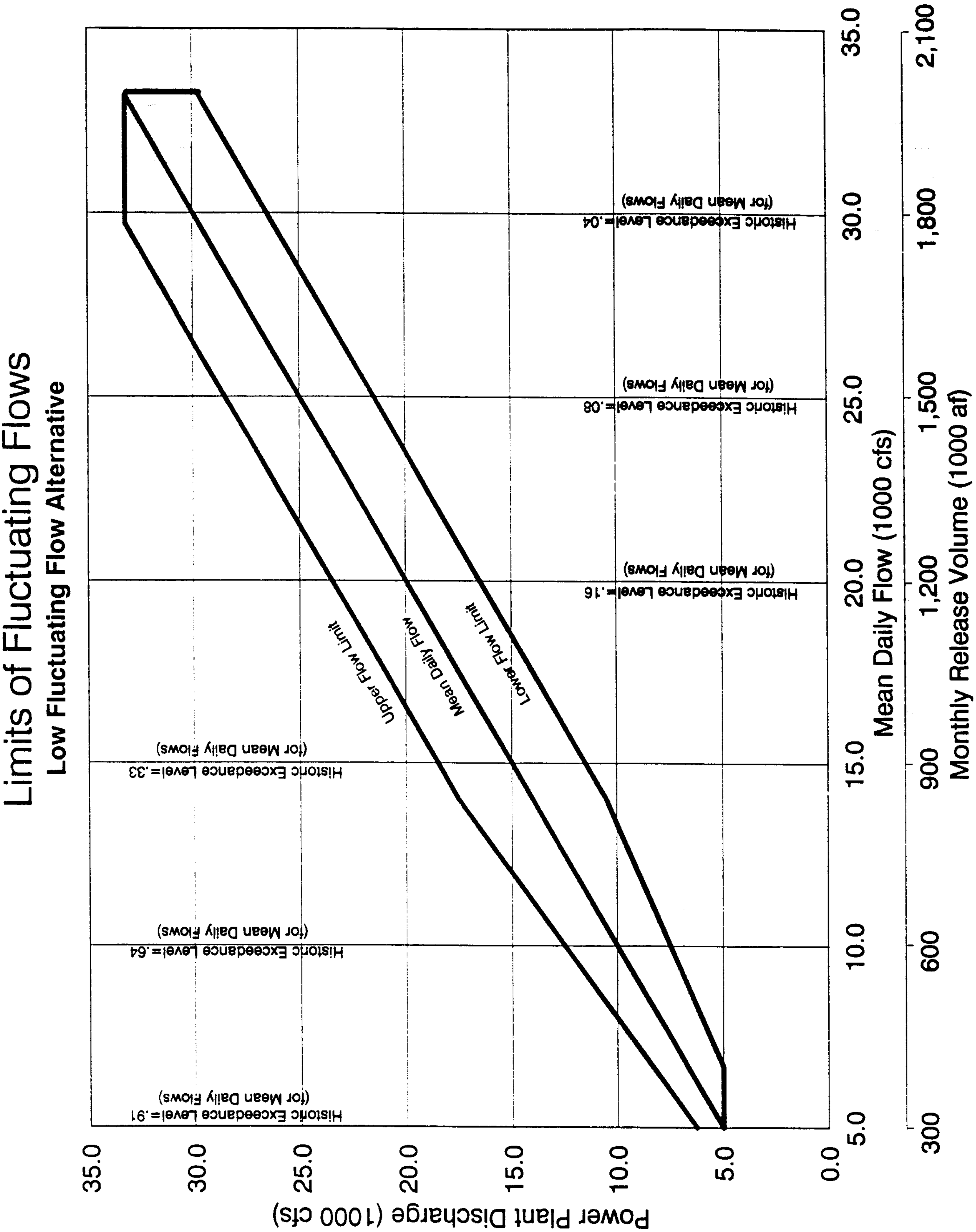
- **Maximum Flow**. The maximum flow would be determined by the water to be released in any month. Up to 33,200 ft^3/s could be discharged through the powerplant. Flows greater than this capacity would be discharged through the outlet works first and subsequently through the spillways, as required. Peak discharges under fluctuating flow would not exceed 33,200 ft^3/s.

- **Minimum Flow**. Minimum flows would be 8,000 ft^3/s from December through February and 5,000 ft^3/s for the remainder of the year.

- **Annual and Monthly Volumes**. The scheduled annual and monthly release volumes would be determined using existing practices, based on considerations for maintaining conservation storage, avoiding spills, and balancing storage between Lakes Powell and Mead.

- **Daily Volumes**. The mean daily release volume would be determined from the mean monthly volume. The actual daily release volume could vary between the limits of fluctuating flow for that month. The daily release pattern could tend to be steady in extreme applications of this alternative (e.g. if the mean daily flow for a given month were 15,000 ft^3/s, the powerplant could be baseloaded on Sunday at 11,500 ft^3/s).

- **Forecast Adjustments**. The volume of water to be released during the remainder of the year would be recomputed monthly based on updated streamflow forecast information (as it is under existing practices), and the rate of release for remaining months would be adjusted accordingly. The estimated mean monthly discharge for this alternative would be the same as shown on the figure for the Steady Flow - Existing Monthly Volumes Alternative for conditions experienced in water years 1983, 1987, and 1989.



Limits of Fluctuating Flows
Low Fluctuating Flow Alternative
Power Plant Discharge (1000 cfs)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Mean Daily Flow (1000 cfs)
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Monthly Release Volume (1000 af)
300
600
900
1,200
1,500
1,800
2,100
Historic Exceedance Level=.91 (for Mean Daily Flows)
Historic Exceedance Level=.64 (for Mean Daily Flows)
Historic Exceedance Level=.33 (for Mean Daily Flows)
Historic Exceedance Level=.16 (for Mean Daily Flows)
Historic Exceedance Level=.08 (for Mean Daily Flows)
Historic Exceedance Level=.04 (for Mean Daily Flows)
Upper Flow Limit
Mean Daily Flow
Lower Flow Limit

Fluctuating flow alternatives

Mean daily flow (ft³/s)	Historical exceedance (percent)	Low (±25%) NTE 7000 ft³/s		Medium (±45%) NTE 12000 ft³/s		High (±75%) NTE 18000 ft³/s	
		Minimum (ft³/s)	Maximum (ft³/s)	Minimum (ft³/s)	Maximum (ft³/s)	Minimum (ft³/s)	Maximum (ft³/s)
5,000.	90.0	5,000.	6,250.	5,000.	7,250.	5,000.	8,750.
7,500.		5,625.	9,375.	5,000.	10,875.	5,000.	13,125.
10,000.		7,500.	12,500.	5,500.	14,500.	5,000.	17,500.
12,500.		9,375.	15,625.	6,875.	18,125.	5,000.	21,500.
13,333.		10,000.	16,666.	7,333.	19,333.	5,000.	22,333.
14,000.	50.0	10,500.	17,500.	8,000.	20,000.	5,000.	23,000.
15,000.		11,500.	18,500.	9,000.	21,000.	6,000.	24,000.
17,500.		14,000.	21,000.	11,500.	23,500.	8,500.	26,500.
20,000.		16,500.	23,500.	14,000.	26,000.	11,000.	29,000.
22,500.		19,000.	26,000.	16,500.	28,500.	13,500.	31,500.
25,000.	10.0	21,500.	28,500.	19,000.	31,000.	16,000.	33,200.
25,700.		22,200.	29,200.	19,700.	31,700.	16,700.	33,200.
27,200.		23,700.	30,700.	21,200.	33,200.	18,200.	33,200.
27,500.		24,000.	31,000.	21,500.	33,200.	18,500.	33,200.
29,700.		26,200.	33,200.	23,700.	33,200.	20,700.	33,200.
30,000.	3.5	26,500.	33,200.	24,000.	33,200.	21,000.	33,200.
31,500.		28,000.	33,200.	25,500.	33,200.	22,500.	33,200.
33,200.		29,700.	33,200.	27,200.	33,200.	24,200.	33,200.

- **Avoidance of Spills**. Operational flexibility necessary to avoid spills and maintain conservation storage would not be affected.

- **Ramping Rate (Daily and/or Hourly)**. The ramping rate would be limited to 2,500 ft^3/s per hour.

- **Power Considerations**. Power operations would be dependent on monthly water release volumes. Generally, power operations would optimize the water allocation to maximize the ability to generate to meet firm load and to allow greater purchases during off-peak periods, given the release restrictions.

  In months with low water releases, off-peak releases would be close to the minimum allowed and peak releases and ramping rates would be close to the maximum allowed.

  In months with moderate releases, a tendency toward greater load following would be noted. Minimum releases would be higher than the required minimums, ramping may be less than the restriction, and peak releases would follow load rather than be held close to the maximum.

  In months with high releases, power operations would approach a high constant level. This operation would be dictated by a need to release a high volume of water during the month, leaving little flexibility to fluctuate during peak and off-peak hours.

Moderate Fluctuations

- **Purpose and Objective**. The Moderate Fluctuation Alternative was developed to permit fluctuating flows below existing levels. This alternative would release water from Glen Canyon Dam in a manner that would reduce the daily magnitude of fluctuating flows and ramping rates, in order to reduce the possible adverse effects of current powerplant operations on downstream beaches, sediment-dependent resources, aquatic resources.

- **Range of Fluctuating Flows**. Daily fluctuations would be limited to ±45 percent of the mean monthly flow but not to exceed 12,000 ft^3/s. The allowable daily fluctuations would be about 7,500; 12,000; and 12,000 ft^3/s, corresponding to monthly volumes of 500,000; 1,000,000; and 1,500,000 acre-feet; respectively. The limits of fluctuating flow, based on the mean daily flow for the month, are shown on the figure on the following page and in the table under the Low Fluctuations Alternative.

- **Maximum Flow**. The maximum flow would be determined by the water to be released in any month. Up to 33,200 ft^3/s could be discharged through the powerplant. Flows greater than this capacity would be discharged through the outlet works first and subsequently through the spillways, as required. Peak discharges under fluctuating flow would not exceed 33,200 ft^3/s.

- **Minimum Flow**. Minimum flows would be 5,000 ft^3/s for all months.

- **Annual and Monthly Volumes**. The scheduled annual and monthly release volumes would be determined using existing practices, based on considerations for maintaining conservation storage, avoiding spills, and balancing storage between Lakes Powell and Mead.

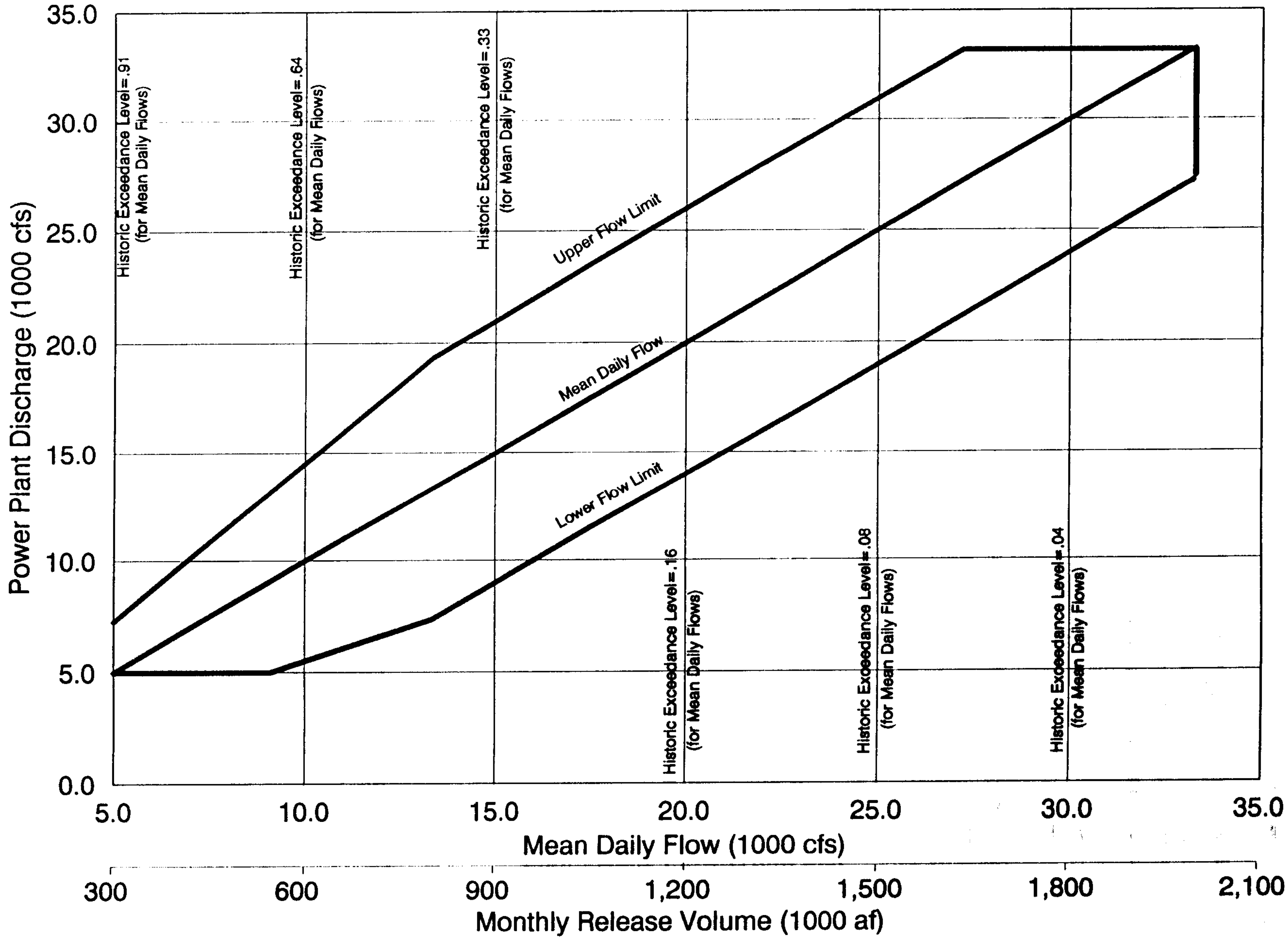
- **Daily Volumes**. The mean daily release volume would be determined from the mean monthly volume. The actual daily release volume could vary between the limits of fluctuating flow for that month. The daily release pattern could tend to be steady in extreme applications of this alternative (e.g. if the mean daily flow for a given month were 15,000 ft^3/s, the powerplant could be baseloaded on Sunday at 9,000 ft^3/s).

- **Forecast Adjustments**. The volume of water to be released during the remainder of the year would be recomputed monthly based on updated streamflow forecast information (as it is under existing practices), and the rate of release for remaining months would be adjusted accordingly. The mean monthly discharge for this alternative would be the same as shown on the figure for the Steady Flow - Existing Monthly Volumes Alternative under conditions experienced in water years 1983, 1987, and 1989.

- **Avoidance of Spills**. Operational flexibility necessary to avoid spills and maintain conservation storage would not be affected.

Limits of Fluctuating Flows

Moderate Fluctuating Flow Alternative



- **Ramping Rate (Daily and/or Hourly)**. The ramping rate would be limited to 4,000 ft^3/s per hour.

- **Power Considerations**. Power operations are dependent on monthly water release volumes. Generally, power operations would optimize the water allocation to maximize the ability to generate to meet firm load and to allow greater purchases during off-peak periods, given the release restrictions.

  In months with low water releases, off-peak releases would be close to the minimum allowed and peak releases and ramping rates would be close to the maximum allowed.

  In months with moderate releases, a tendency toward greater load following would be noted. Minimum releases would be higher than the required minimums, ramping may be less than the restriction, and peak releases would follow load rather than be held close to the maximum.

  In months with high releases, power operations would approach a high constant level. This operation would be dictated by a need to release a high volume of water during the month, leaving little flexibility to fluctuate during peak and off-peak hours.

High Fluctuations

- **Purpose and Objective**. The High Fluctuation Alternative was developed to permit fluctuating flows slightly below existing levels. This alternative would release water from Glen Canyon Dam in a manner that would slightly reduce the daily magnitude of fluctuating flows while retaining most of the current flexibility for peaking power, in order to slightly reduce the possible adverse effects of current powerplant operations on downstream beaches, sediment-dependent resources, and aquatic resources.

- **Range of Fluctuating Flows**. Daily fluctuations would be limited to ±75 percent of the mean daily flow, but not to exceed 18,000 ft^3/s. The mean daily flow could vary from 15 percent less than the mean monthly flow to 15 percent greater. If the mean daily flow were equal to the mean monthly flow (monthly volume distributed equally to each day), the allowable daily fluctuations would be about 12,500; 18,000; and 18,000 ft^3/s, corresponding to monthly volumes of 500,000; 1,000,000; and 1,500,000 acre-feet; respectively. The limits of fluctuating flow, based on the mean daily flow for the month, are shown on the figure on the following page and on the table under the Low Fluctuations Alternative.

- **Maximum Flow**. The maximum flow would be determined by the water to be released in any month. Up to 33,200 ft^3/s could be discharged through the powerplant. Flows greater than this capacity would be discharged through the outlet works first and subsequently through the spillways, as required. Peak discharges under fluctuating flow would not exceed 33,200 ft^3/s.

- **Minimum Flow**. Minimum flows would be 5,000 ft^3/s year-round.

- **Annual and Monthly Volumes**. The scheduled annual and monthly release volumes would be determined using existing practices, based on considerations for maintaining conservation storage, avoiding spills, and balancing storage between Lakes Powell and Mead.

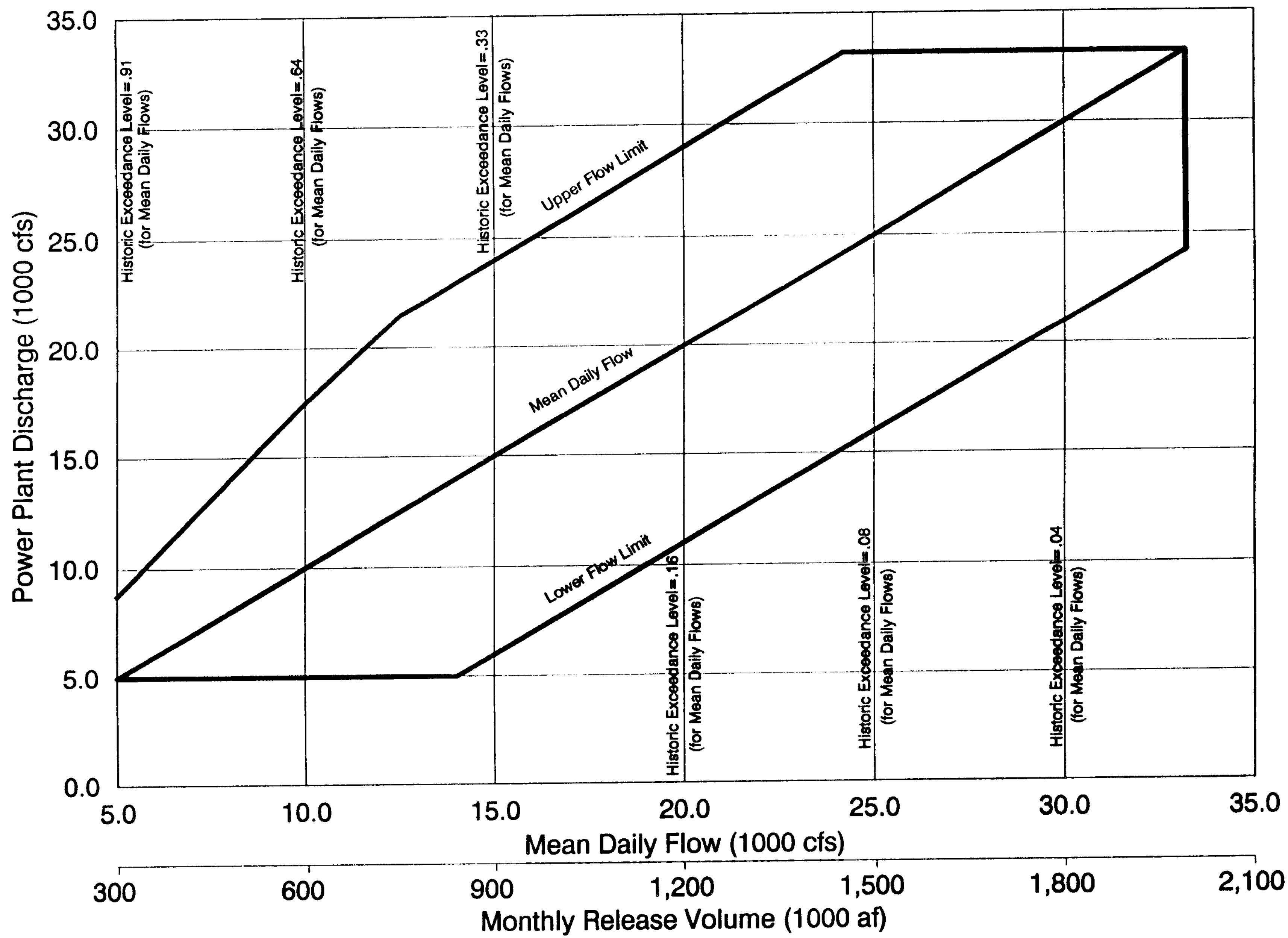
- **Daily Volumes**. The mean daily release volume would be determined from the mean monthly volume. The actual daily flow could vary from 15 percent less than the mean monthly flow to 15 percent greater (e.g., if the mean daily flow for a given month were 15,000 ft^3/s, the powerplant could be baseloaded on Sunday at 5,000 ft^3/s).

- **Forecast Adjustments**. The volume of water to be released during the remainder of the year would be recomputed monthly based on updated streamflow forecast information (as it is under existing practices), and the rate of release for remaining months would be adjusted accordingly. The mean monthly discharge for this alternative would be the same as shown on the figure for the Steady Flow - Existing Monthly Volumes Alternative under conditions experienced in water years 1983, 1987, and 1989.

- **Avoidance of Spills**. Operational flexibility necessary to avoid spills and maintain conservation storage would not be affected.

Limits of Fluctuating Flows

High Fluctuating Flow Alternative



- **Ramping Rate (Daily and/or Hourly).** The ramping rate would be limited to 6,000 ft^3/s per hour.

- **Power Considerations.** Power operations are dependent on monthly water release volumes. Generally, power operations would optimize the water allocation to maximize the ability to generate to meet firm load and to allow greater purchases during off-peak periods, given the release restrictions.

  In months with low water releases, off-peak releases would be close to the minimum allowed and peak releases and ramping rates would be close to the maximum allowed.

  In months with moderate releases, a tendency toward greater load following would be noted. Minimum releases would be higher than the required minimums, ramping may be less than the restriction, and peak releases would follow load rather than be held close to the maximum.

  In months with high releases, power operations would approach a high constant level. This operation would be dictated by a need to release a high volume of water during the month, leaving little flexibility to fluctuate during peak and off-peak hours.

No Action

- **Objective**. Existing operational practices would continue under this alternative.

- **Range of Fluctuating Flows**. The median (equalled or exceeded 50 percent of the time) daily fluctuation in hourly flows for the period 1966 to 1989 ranged from about 11,000 ft^3/s in April to about 16,000 ft^3/s in August. Daily fluctuations greater than 20,000 ft^3/s occurred about 3 percent of the time in April and about 25 percent of the time in August.

- **Maximum Flow**. The maximum flow is determined by the water available in any month. Up to 33,200 ft^3/s is discharged through the powerplant. Flows greater than this capacity are discharged through the outlet works first and subsequently through the spillways, as required. Peak discharges under existing normal operations do not exceed 31,500 ft^3/s. The median (equalled or exceeded 50 percent of the time) maximum hourly flow for the period 1966-1989 ranged from about 17,000 ft^3/s in October to about 25,000 ft^3/s in August. Releases greater than 25,000 ft^3/s occurred about 11 percent of the time in April and about 50 percent of the time in August.

- **Minimum Flow**. Minimum flows allowable have been 1,000 ft^3/s from Labor Day until Easter and 3,000 ft^3/s from Easter until Labor Day (the recreation season). The median (equalled or exceeded 50 percent of the time) minimum hourly flow for the period 1966-1989 ranged from about 3,200 ft^3/s in October to about 6,000 ft^3/s in April. Releases less than 2,000 ft^3/s occurred about 30 percent of the time in October and about 9 percent of the time in April.

- **Annual Volume**. The scheduled annual release volume is determined based on considerations for maintenance of conservation storage, avoidance of spills, and balancing of storage between Lakes Powell and Mead. This volume is a function of the inflow and remaining space in Lake Powell. From 1966 to 1989, releases have ranged from 8.23 million acre-feet to 20.4 million acre-feet (1984). The minimum release of 8.23 million acre-feet has occurred about 50 percent of the time since 1963.

- **Monthly Volume**. The scheduled monthly release volumes are determined based on considerations for maintenance of conservation storage, avoidance of spills, and the value of generated electrical energy. The median (equalled or exceeded 50 percent of the time) monthly release for the period 1963-1989 ranged from about 550,000 acre-feet in February to about 900,000 acre-feet in August.

- **Daily Volume**. The mean daily release volume is determined from the mean monthly volume. The median (equalled or exceeded 50 percent of the time) daily release volume for the period 1963-1989 ranged from about 19,400 acre-feet (9,700 ft^3/s) in March to about 30,000 acre-feet (15,000 ft^3/s) in August.

- **Forecast Adjustments**. Each month the volume of water to be released during the remainder of the year is recomputed based on updated streamflow forecast information, and the required release for the remaining months is adjusted accordingly. The mean monthly discharge for this alternative would be the same as shown on the figure for the Steady Flow - Existing Monthly Volumes Alternative under conditions experienced in water years 1983, 1987, and 1989.

- **Avoidance of Spills**. Monthly and annual release volumes are scheduled to avoid spills and to maintain conservation storage in accordance with the "Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs."

- **Ramping Rate (Daily and/or Hourly)**. Ramping rate restrictions are programmed in the power control system and, depending on area control error, are either 17 MW per minute (approximately 430 cubic feet per second per minute (ft^3/s/minute) or 50 MW per minute (approximately 1,260 ft^3/s/minute). These rates are rarely held over an extended time period, but are equivalent to 25,800 cubic feet per second per hour (ft^3/s/hour) and 75,600 ft^3/s/hour, respectively. Based on the 1980-89 period, ramping rates were below 8,000 ft^3/s/hour 99 percent of the time and below 5,000 ft^3/s 95 percent of the time. The daily ramping rate has historically been less than 8,000 ft^3/s per hour more than 95 percent of the time.

- **Power Considerations**. Glen Canyon power generation is used to meet firm and non-firm load, and to allow off-peak purchases to be made whenever possible. Imposed powerplant capacity is 31,500 ft^3/s.

Maximum Fluctuation

- **Purpose and Objective**. The Maximum Fluctuation Alternative was developed in response to comments received during the scoping process that called for full use of powerplant capacity. This alternative would be similar to existing operations except that allowable peak discharge during fluctuating flows would increase from 31,500 ft^3/s to 33,200 ft^3/s, and allowable minimums would be 1,000 ft^3/s year round.

- **Range of Fluctuating Flows**. Flows would be allowed to fluctuate on a daily basis from a minimum of 1,000 ft^3/s to a maximum of 33,200 ft^3/s.

- **Maximum Flow**. The maximum flow would be determined by the water to be released in any month. Up to 33,200 ft^3/s could be discharged through the powerplant. Flows greater than this capacity would be discharged through the outlet works first and subsequently through the spillways, as required. Peak discharges under fluctuating flow would not exceed 33,200 ft^3/s.

- **Minimum Flow**. Minimum flows would be 1,000 ft^3/s.

- **Annual and Monthly Volumes**. Scheduled annual and monthly release volumes would be determined using existing practices, based on considerations for maintaining conservation storage, avoiding spills, and balancing storage between Lakes Powell and Mead.

- **Daily Volume**. The mean daily release volume would be determined from the mean monthly volume.

- **Forecast Adjustments**. The volume of water to be released during the remainder of the year would be recomputed monthly based on updated streamflow forecast information (as it is under existing practices), and the rate of release for remaining months adjusted accordingly. The mean monthly discharge for this alternative would be the same as shown on the figure for the Steady Flow - Existing Monthly Volumes Alternative under conditions experienced in water years 1983, 1987, and 1989.

- **Avoidance of Spills**. Operational flexibility necessary to avoid spills and maintain conservation storage would not be affected.

- **Ramping Rate (Daily and/or Hourly)**. The ramping rate would not be limited, except by the physical capability of the powerplant.

- **Power Considerations**. This alternative would allow full use of the powerplant uprate. No higher release requirement occurs during the recreation season (Easter through Labor Day). Glen Canyon generation would be used to meet firm and non-firm load, and allow for off-peak purchases of thermal energy. Ramping rate restrictions would be the same as under existing operations, and are not expected to be different than historical rates.

ATTACHMENT 1

SUPPLEMENTAL POWER OPERATION INFORMATION

Elements of Power Mitigation

Power mitigation is a very broad term and is used in this document to define ways to lessen the impact to the power system resulting from possible changes in operations of Glen Canyon Dam. The following is a very general discussion of different types of power mitigation. Specific details will result from further definition of alternatives and through the Power Resources Committee work on alternative impact assessment.

Some types of power mitigation are not obvious and, in fact, may not be a result of power generation. An example would be allowing monthly patterning of water releases from Glen Canyon Dam in order to avoid spills. In moderate or high release years (where a risk of spills exists) water releases are patterned to meet "fill and spill" targets, which tend to coincide with months of high power demand. Higher releases mean greater generation levels and greater ability to meet higher load levels.

A second type of power mitigation would be a strategy to avoid powerplant bypass. Any water that bypasses the powerplant does not generate electricity and, therefore, revenue.

A third type of power mitigation would be the violation of release restrictions in order to respond to power system emergencies. This accommodation would allow Western to claim the full capacity of Glen Canyon Dam (modified to reflect reservoir storage elevations) towards reserve requirements of the Western Systems Coordinating Council and the Inland Power Pool. If the required reserves cannot be claimed, the impact is greater as the reserves must be obtained, probably through purchase.

A final example of power mitigation would be the ability to allow lower volumes of water (even if at a constant release rate) to be released during different days of the week and on holidays. With the ability to release lower volumes of water on days with lower electric loads, less expensive purchases can be made, saving water to be released on days with higher (and generally more expensive purchase price) loads.

Generally, power mitigation is considered in terms of steps to be taken after alternative release patterns are determined. These types of mitigation will depend on two major factors: first, the nature of the operational alternative and the associated loss in generation flexibility; and second, the decisions made by Western with regard to marketing criteria. These factors are examined below.

Depending on the alternative, the hydropower resource at Glen Canyon will be impacted to a greater or lesser extent. A constant flow alternative will convert the existing peaking resource into a base-load resource. Less capacity will be available for marketing from Glen Canyon, but nearly the same amount of energy will be available for sale during the year. The value of the product to be marketed, therefore, will be very different. An alternative which allows full use of the powerplant capacity, but with ramping rate restrictions, may cause the powerplant to become more of an "intermediate" resource. That is, the plant can still fluctuate to meet load, but the resource will not be able to respond as quickly, so another generation resource will need to be utilized in the system to meet instantaneous load changes. The nature of these impacts, and hence the type of mitigation, can be described as occurring "at the plant." Such impacts can be measured directly for each alternative and are essentially the magnitude of the impact.

The second factor is determined by how Western and/or the electric utility system, choose to respond to the changes to power generation represented by each alternative. The impact can either be born entirely by Western, entirely by the customers, or by some combination of the two.

The decision by Western is whether to not change contract commitments, change the contracts some--based on a change in available resources, or change contracts by a total change in marketable resources. The decision determines, to a large part, who bears the brunt of the impact. If firm power commitments are kept as they are now, then Western must find alternative sources to meet the commitments. Based on historical operational philosophies and authorities, this lost resource would be made up by increased purchase. However, other ways to mitigate the impact (and depending somewhat on the alternative and, hence, the magnitude of the impact) might include Western gaining the authority to own and operate fossil-fuel fired generation facilities, construction of additional Federal hydropower units (including pumped storage), increased operational efficiency (transmission system improvements, changing thermal-hydro integration strategies, project use load management, etc.), and reserve sharing among projects. These strategies would involve overcoming various levels of political and legal hurdles. Nonfirm revenues, which in some years are substantial, would also be impacted. The cost of these strategies would be met through the Salt Lake City Area Integrated Projects rate.

At the other extreme, Western could change the firm level of commitment to equal the change in the available power resource. Assuming a reduction in resources, power customers would be forced to make up the lost Federal resource. Customers could replace this resource through increased purchases, operating existing facilities differently, building new facilities, adopting demand-side management strategies, or combinations of the above. Additional financial impacts would occur since the SLCA/IP rate would also need to be increased to offset decreases in the amount of marketable resources. This rate increase would be necessary to ensure the repayment obligations of the Integrated Projects (of which CRSP and Glen Canyon Dam are a part).

At either extreme marketing commitment, the SLCA/IP rate could increase significantly, perhaps to the point of jeopardizing repayment. Another type of mitigation would be to have the project cost allocation changed to reflect changed project purposes, thereby reducing the repayment obligation of power revenues.

SIMULATED POWER OPERATIONS
FLUCTUATING FLOW ALTERNATIVES

			MONTHLY ACRE FOOT RELEASE
LOW FLUCTUATION ALTERNATIVE			
	Fall Season	Dry Hydrology	490,000
		Moderate Hydrology	762,000
		Wet Hydrology (not done)	1,421,000
	Winter Season	Dry Hydrology	696,000
		Moderate Hydrology	1,034,000
		Wet Hydrology (not done)	1,617,000
	Spring Season	Dry Hydrology	553,000
		Moderate Hydrology	770,000
		Wet Hydrology	1,198,000
	Summer Season	Dry Hydrology	717,000
		Moderate Hydrology	1,108,000
		Wet Hydrology (not done)	1,715,000
MODERATE FLUCTUATION ALTERNATIVE			
	Fall Season	Dry Hydrology (not done) Moderate Hydrology Wet Hydrology (not done)	same as above
	Winter Season	Dry Hydrology Moderate Hydrology Wet Hydrology (not done)	same as above
	Spring Season	Dry Hydrology Moderate Hydrology Wet Hydrology	same as above
	Summer Season	Dry Hydrology Moderate Hydrology Wet Hydrology (not done)	same as above
HIGH FLUCTUATION ALTERNATIVE			
	Fall Season	Dry Hydrology (not done) Moderate Hydrology Wet Hydrology (not done)	same as above
	Winter Season	Dry Hydrology Moderate Hydrology Wet Hydrology (not done)	same as above

HIGH FLUCTUATION ALTERNATIVE (con't)

Spring Season	Dry Hydrology Moderate Hydrology Wet Hydrology (not done)	same as above
Summer Season	Dry Hydrology Moderate Hydrology Wet Hydrology (not done)	same as above

MAXIMUM POWERPLANT FLUCTUATION (NOT DONE)

Assumptions

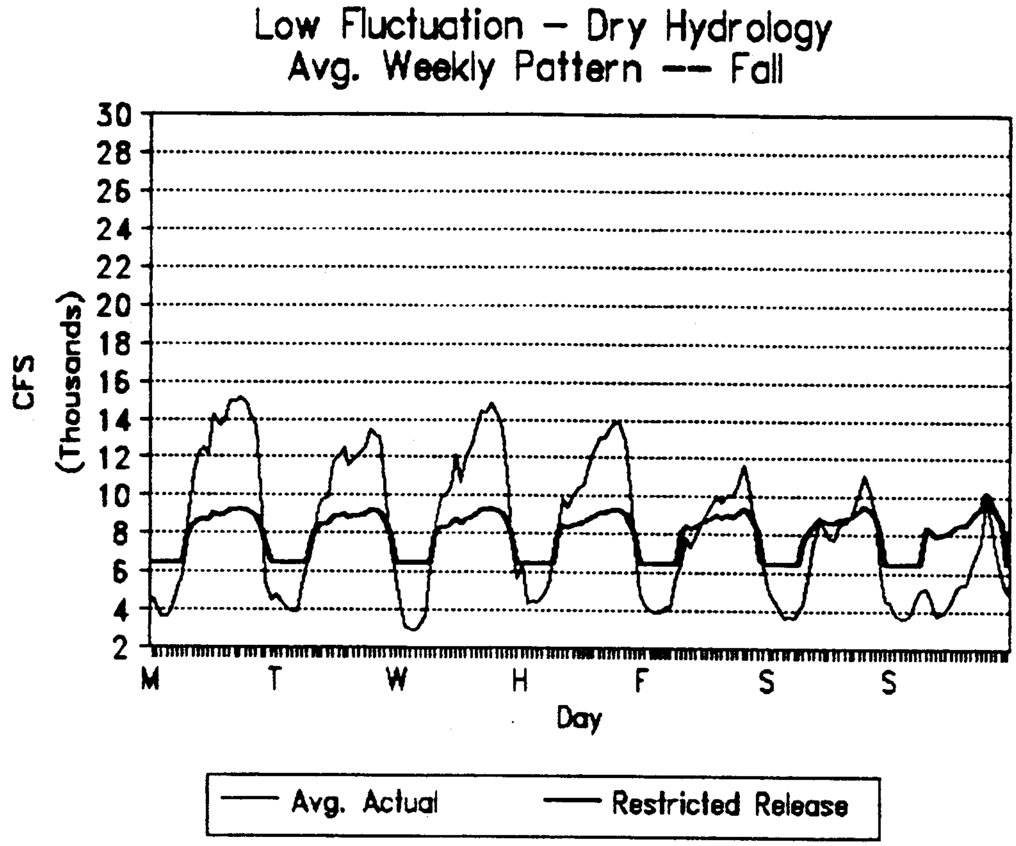
1. These graphs show average actual release patterns (weekly and daily) compared to simulated release patterns given the restrictions of the fluctuating flow alternatives. In order to illustrate how Glen Canyon Dam might operate under these scenarios, graphs were developed for a "dry", "moderate", and "wet" hydrological scenario. This was done for each season, for each alternative. **THESE GRAPHS ARE NOT INTENDED TO SERVE AS A TOOL FOR ESTIMATING IMPACTS TO POWER OPERATIONS.** They are merely an illustration of how Glen Canyon Dam might be operated given each set of restrictions developed by the EIS team.

2. The data are believed to be accurate. However, this is a draft report, and it is possible that some erroneous data points exist.

3. Graphs of the "maximum" fluctuating flow alternative were not prepared largely because these operations would not be significantly different than the "No Action" alternative. The lower minimum release restriction of 1,000 cfs in the recreation season would probably only affect dry (or low water release) summer months. Water release volumes impose their own set of "restrictions" on operations. Therefore, the maximum fluctuating flow alternative would only apply when hydrology allowed.

4. Graphs were prepared only when operations under the restriction were significantly different from actual operations or other alternatives. For example, restricted operations defined by these alternatives in the "wet" or high release months would look similar to actual operations. Because of the need to release a high volume of water, actual powerplant operations on average fluctuate less than lower volume release months, and therefore are typically within the bounds imposed by these alternatives. Also, the only graph prepared for the "Dry Fall" was for the low fluctuating flow alternative. The higher fluctuations allowed under the moderate and high scenarios could not be utilized because of the very low water release. Therefore, the restricted release pattern for all three alternatives in the dry fall season example would look the same.

5. The "No Action" alternative is represented by the actual Glen Canyon generation shown on the graphs for each modified operational alternative for each season and each hydrology.


Low Fluctuation – Dry Hydrology
Avg. Weekly Pattern –– Fall
CFS (Thousands)
30
28
26
24
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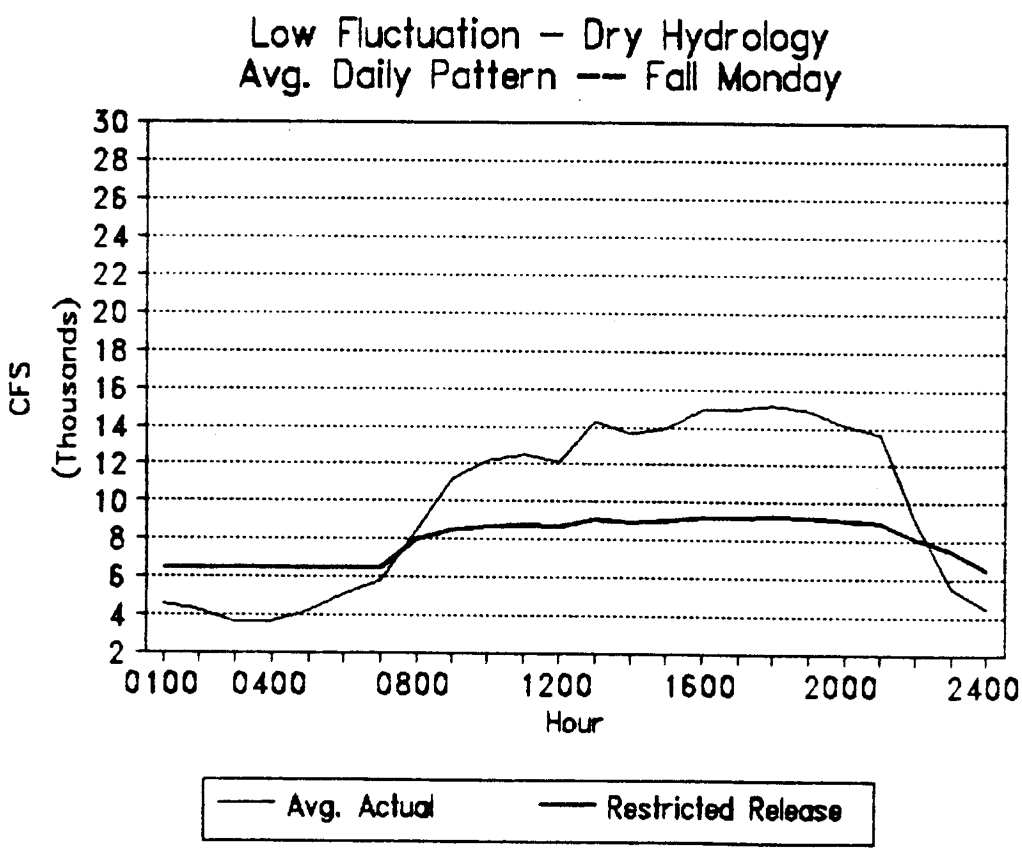
Day
Avg. Actual
Restricted Release


Low Fluctuation – Dry Hydrology
Avg. Daily Pattern –– Fall Monday
CFS (Thousands)
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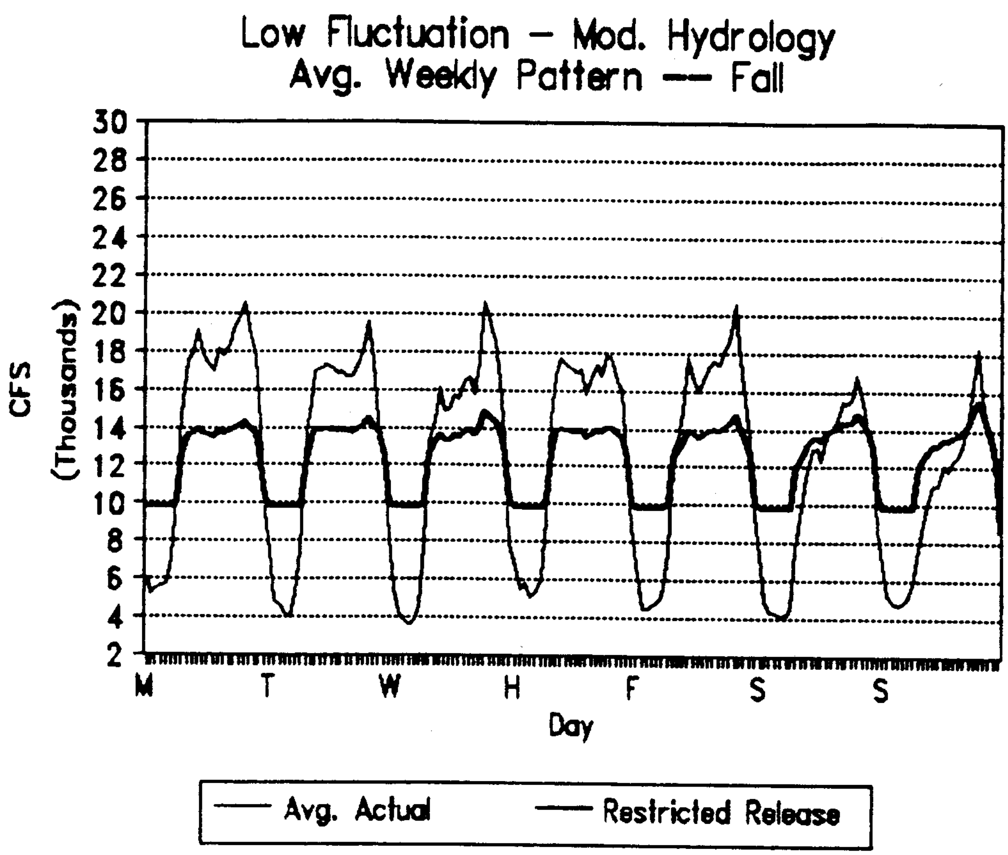
Avg. Actual
Restricted Release


Low Fluctuation – Mod. Hydrology
Avg. Weekly Pattern — Fall
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CFS
(Thousands)
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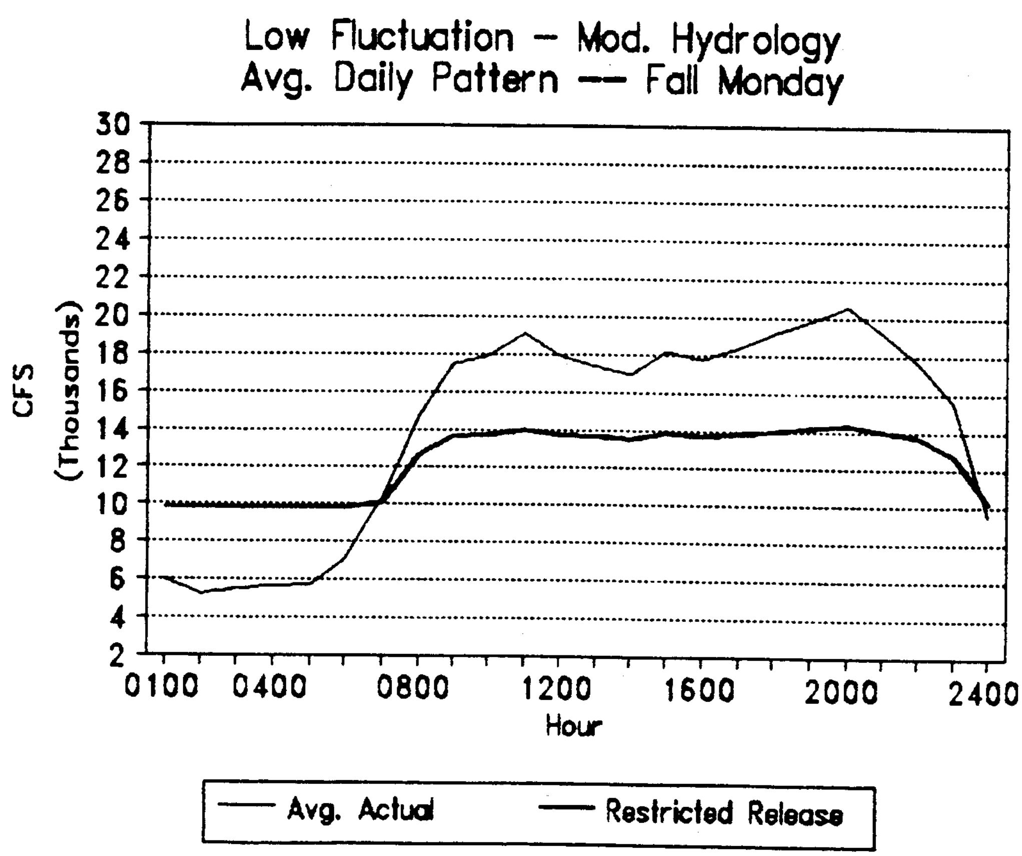
Avg. Actual
Restricted Release


Low Fluctuation – Mod. Hydrology
Avg. Daily Pattern — Fall Monday
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(Thousands)
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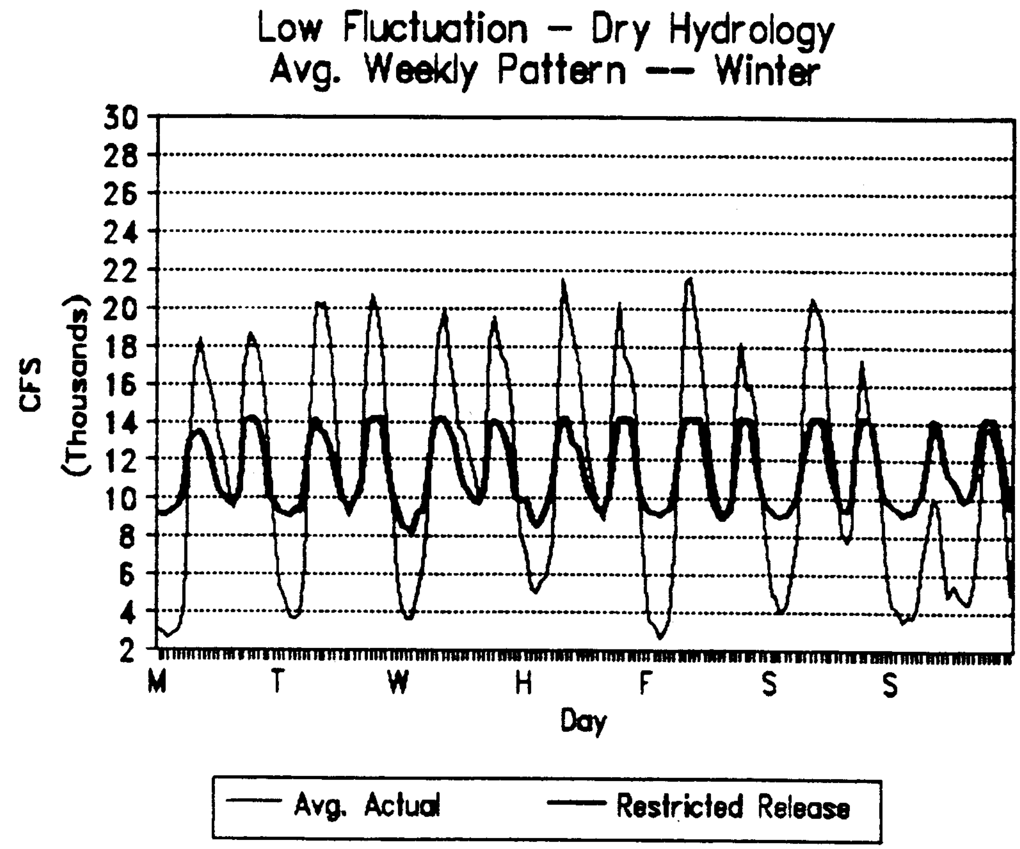
Hour
Avg. Actual
Restricted Release

LOW FLUCTUATION ALTERNATIVE
Fall Season
Wet Hydrology
(This graph was not done)



Low Fluctuation - Dry Hydrology
Avg. Weekly Pattern -- Winter
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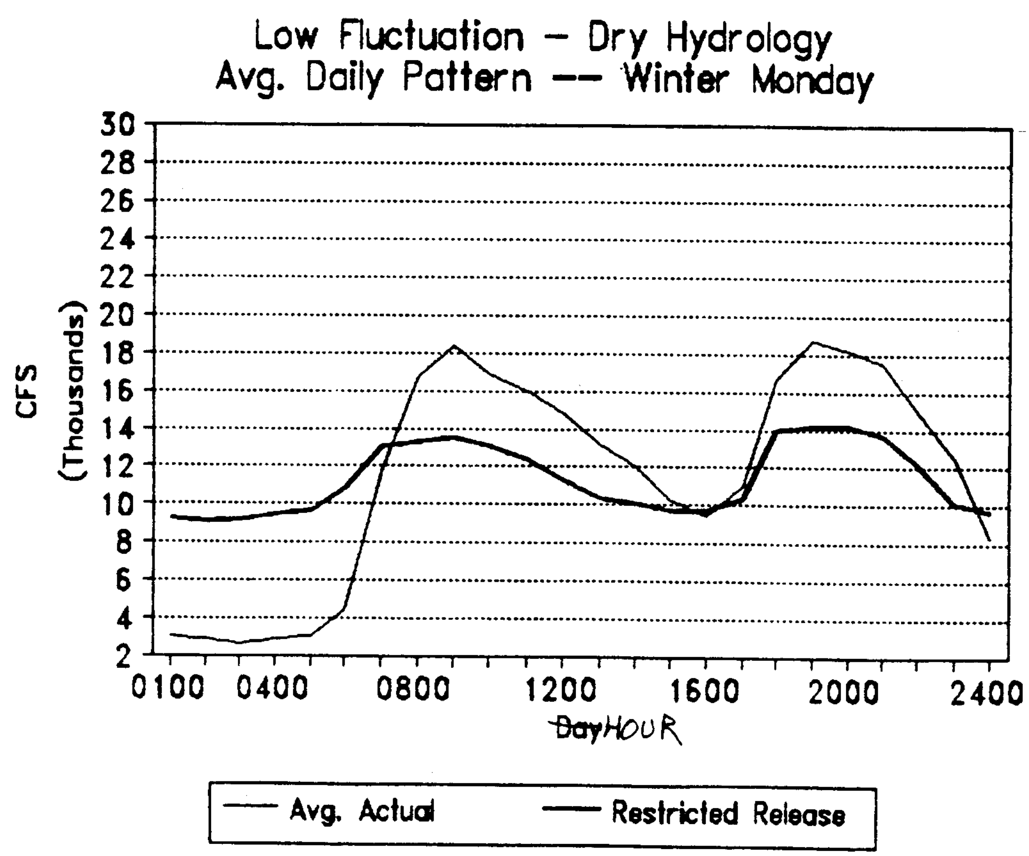
Avg. Actual
Restricted Release



Low Fluctuation - Dry Hydrology
Avg. Daily Pattern -- Winter Monday
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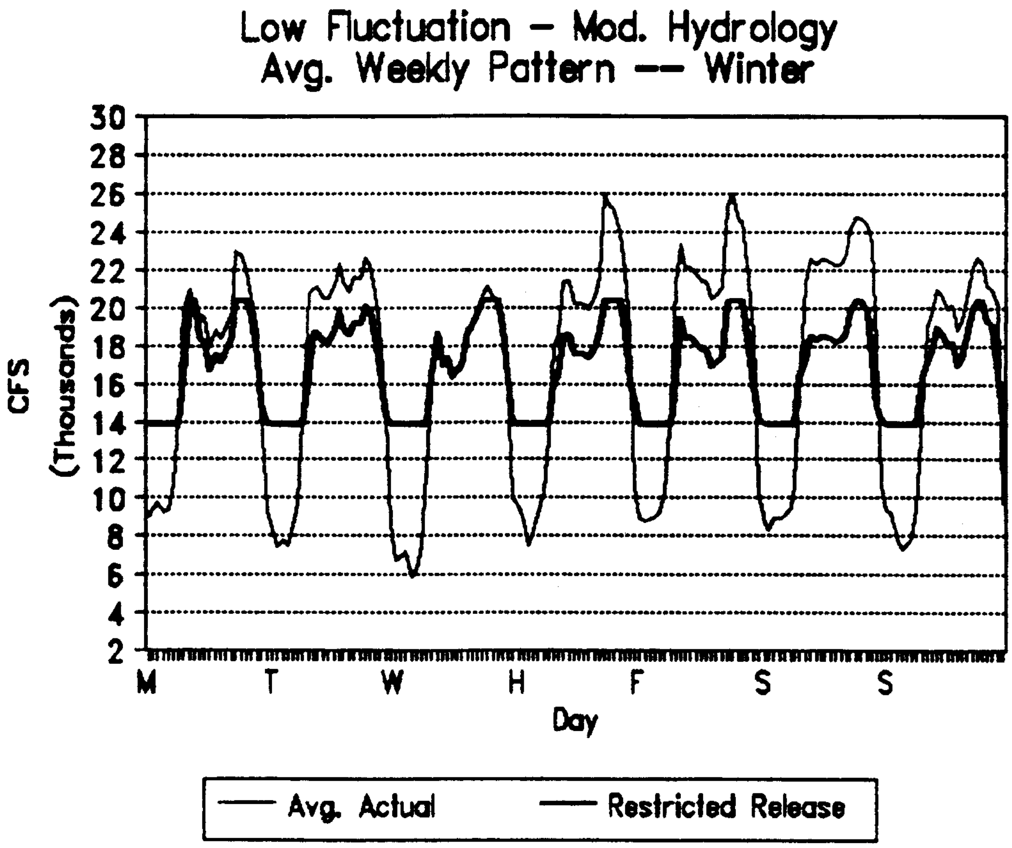
Avg. Actual
Restricted Release


Low Fluctuation – Mod. Hydrology
Avg. Weekly Pattern –– Winter
CFS (Thousands)
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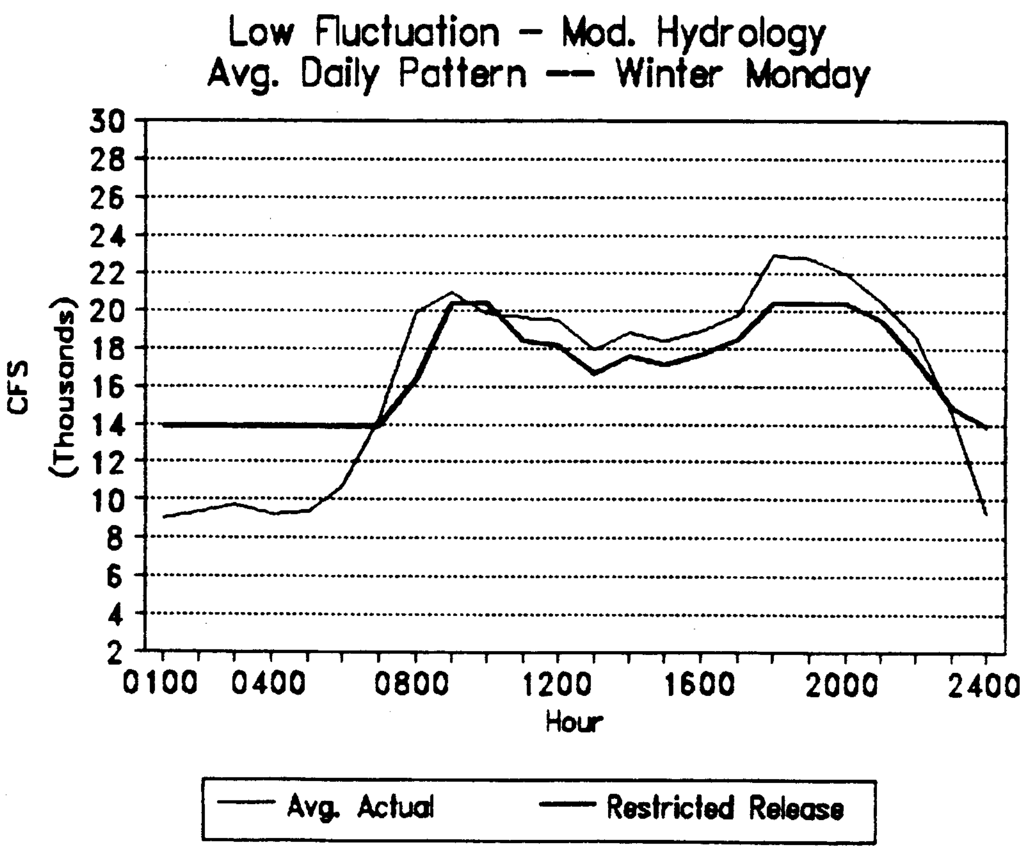
Avg. Actual
Restricted Release


Low Fluctuation – Mod. Hydrology
Avg. Daily Pattern –– Winter Monday
CFS (Thousands)
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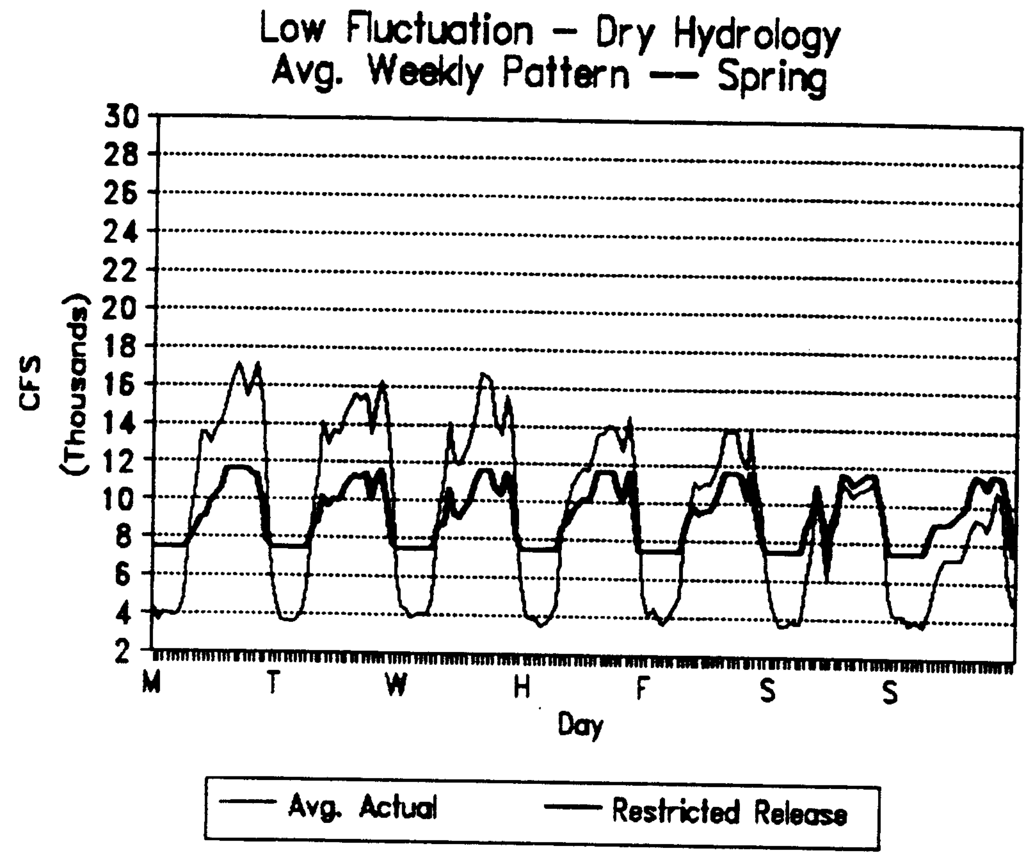
Avg. Actual
Restricted Release

LOW FLUCTUATION ALTERNATIVE
Winter Season
Wet Hydrology
(This graph was not done)


Low Fluctuation – Dry Hydrology
Avg. Weekly Pattern –– Spring
CFS (Thousands)
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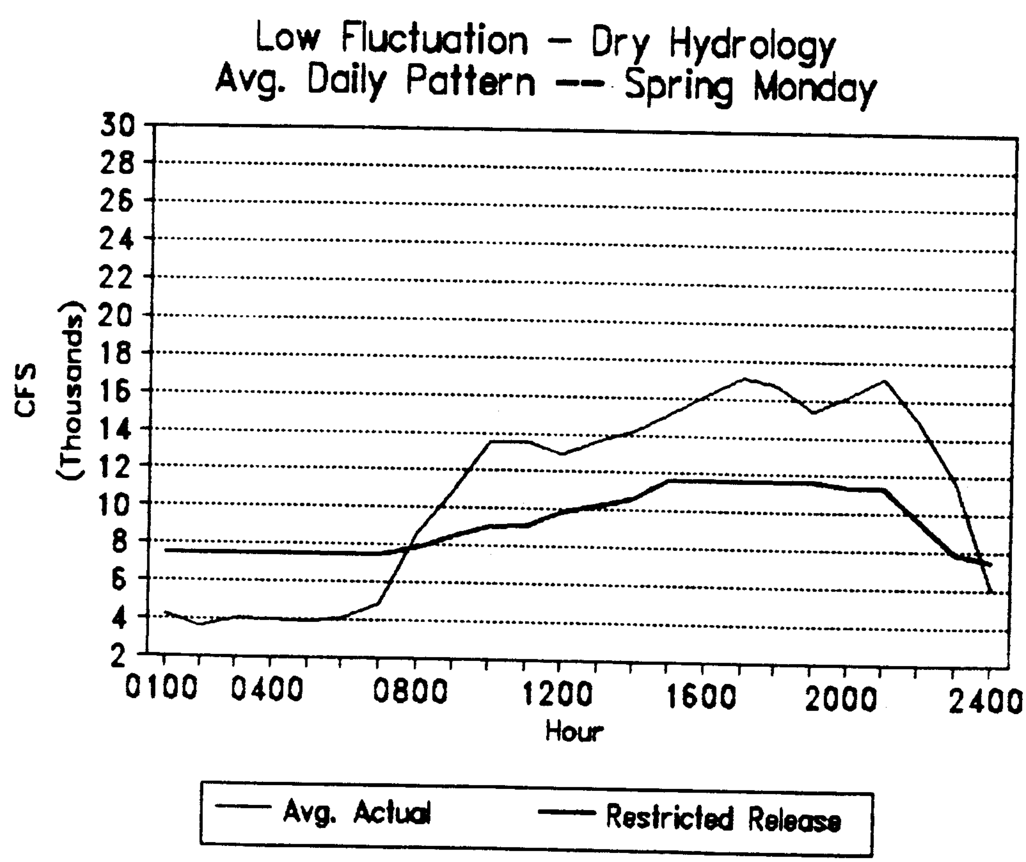
Avg. Actual
Restricted Release


Low Fluctuation – Dry Hydrology
Avg. Daily Pattern –– Spring Monday
CFS (Thousands)
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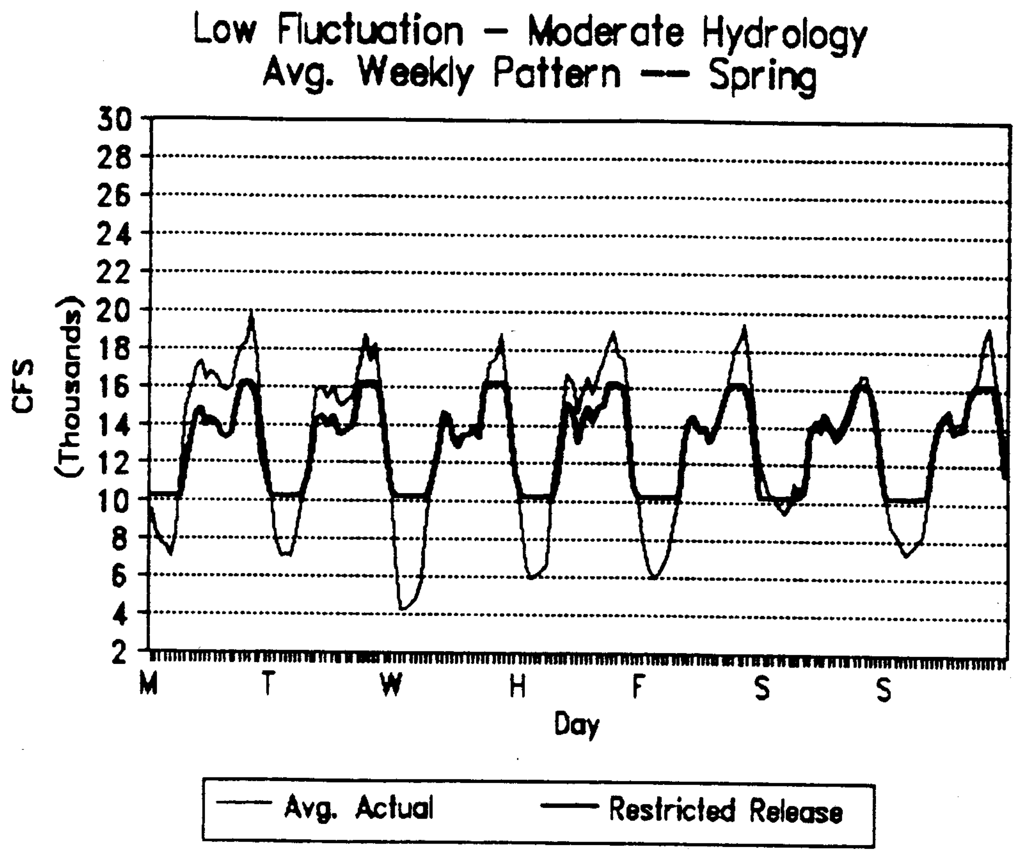
Avg. Actual
Restricted Release


Low Fluctuation – Moderate Hydrology
Avg. Weekly Pattern –– Spring
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CFS
(Thousands)
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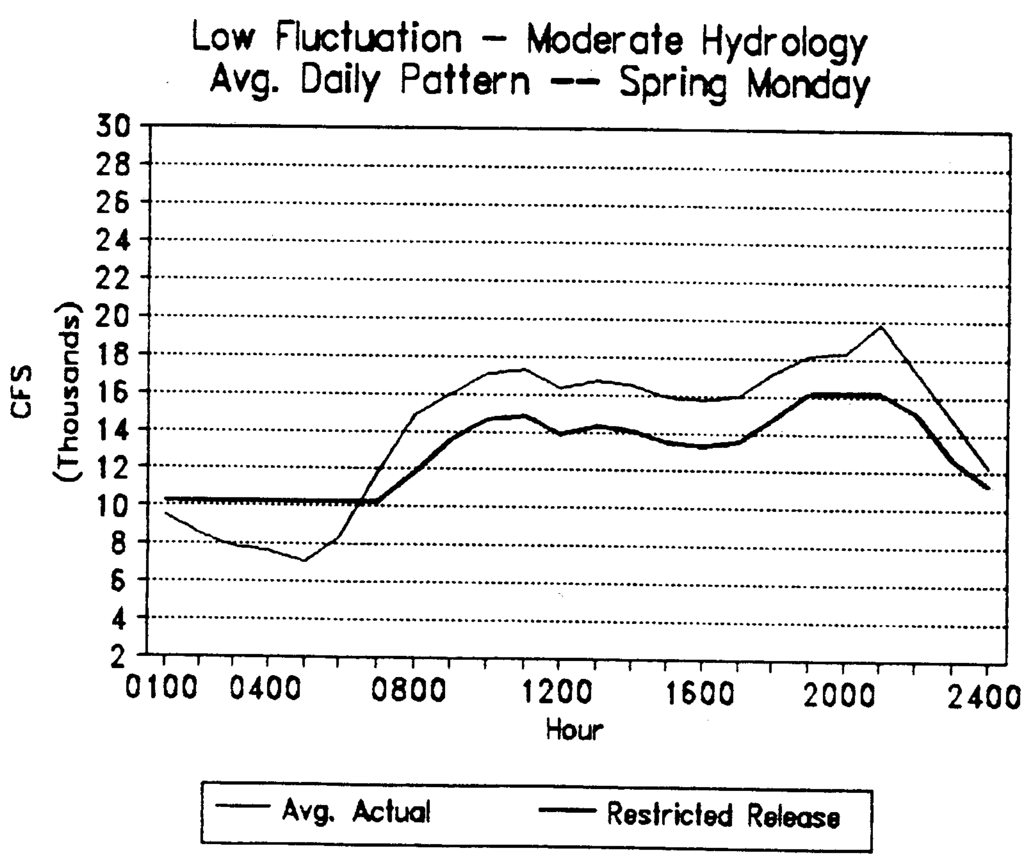
Day
Avg. Actual
Restricted Release


Low Fluctuation – Moderate Hydrology
Avg. Daily Pattern –– Spring Monday
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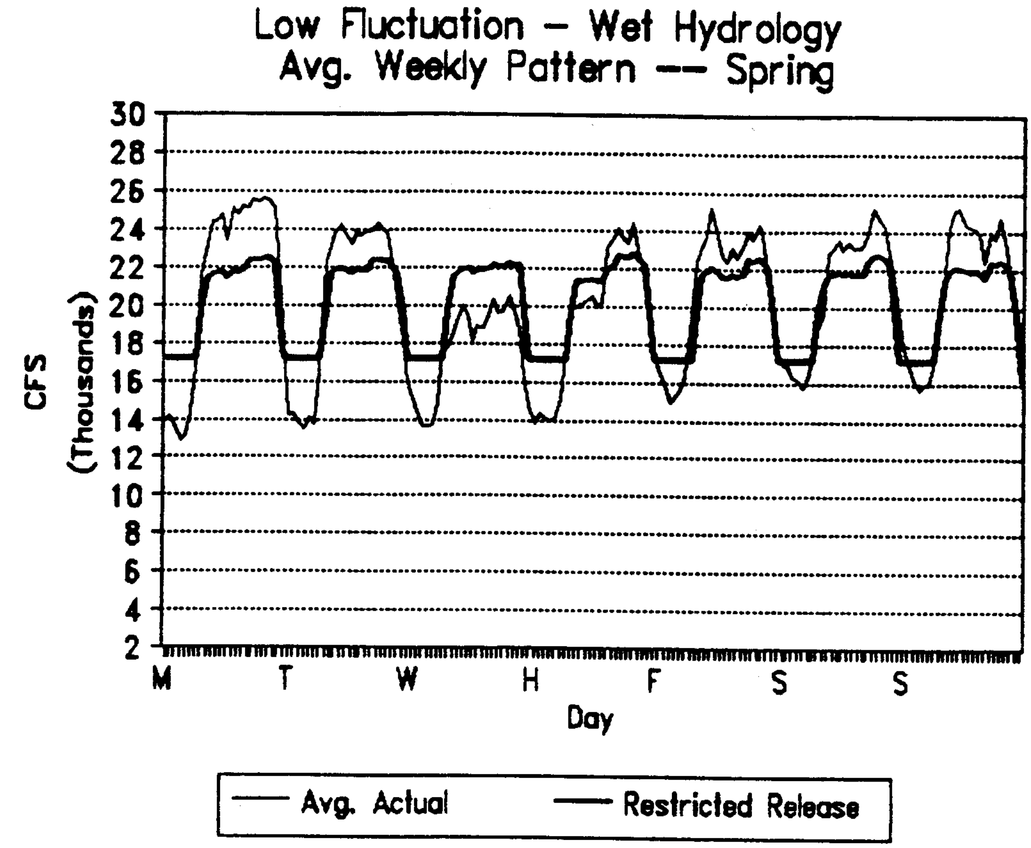
Avg. Actual
Restricted Release


Low Fluctuation – Wet Hydrology
Avg. Weekly Pattern –– Spring
CFS
(Thousands)
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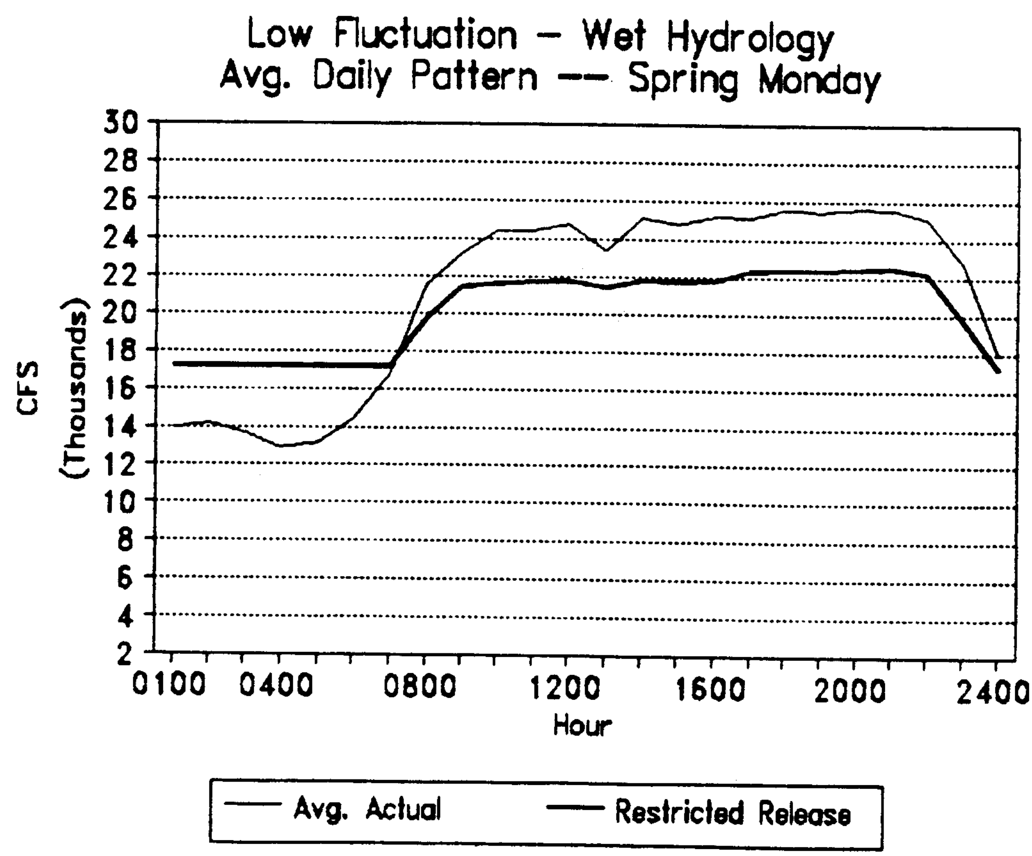
Day
Avg. Actual
Restricted Release


Low Fluctuation – Wet Hydrology
Avg. Daily Pattern –– Spring Monday
CFS
(Thousands)
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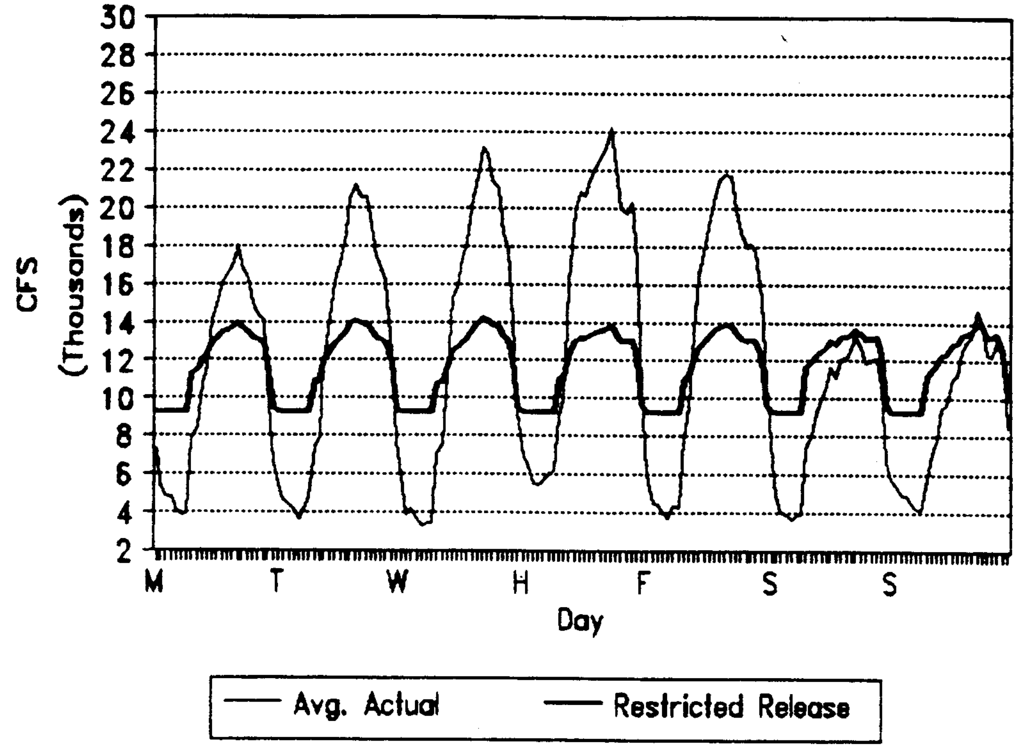
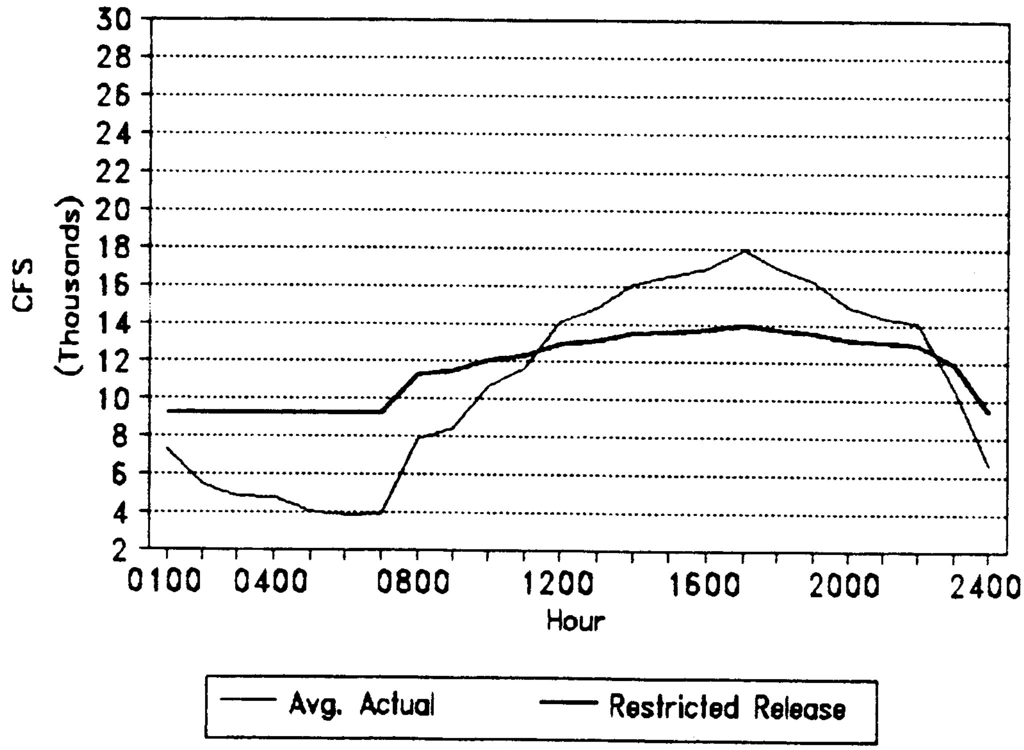
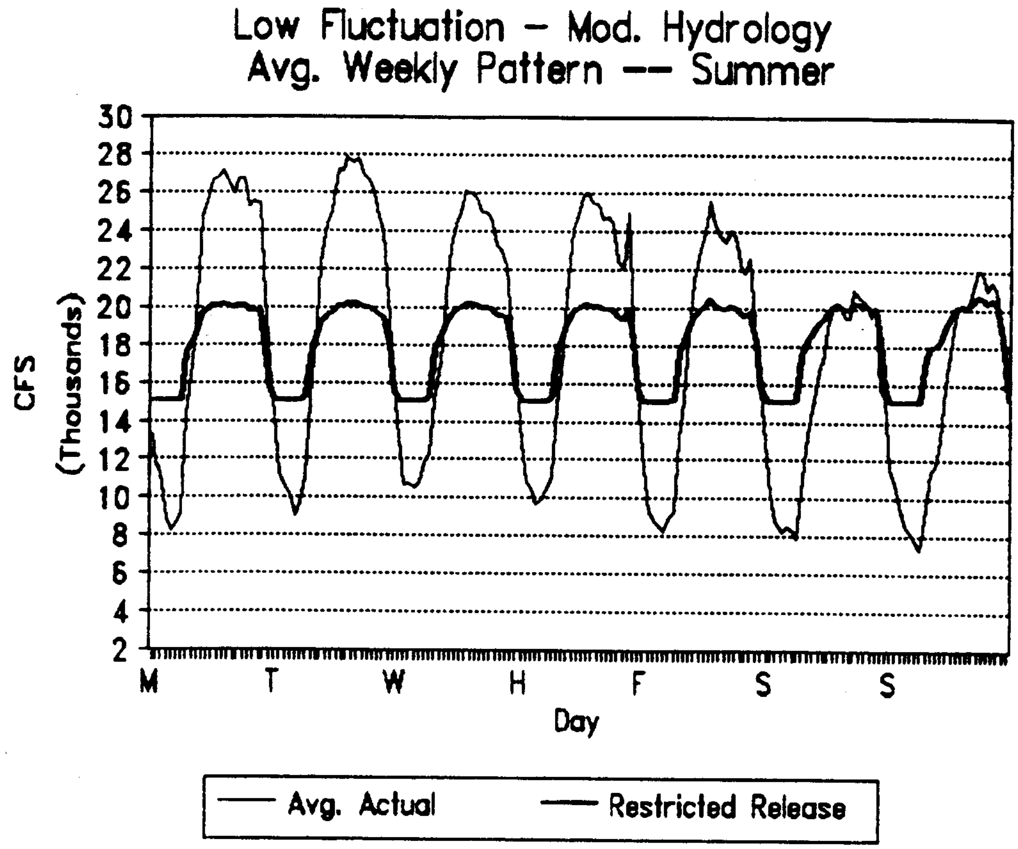
Avg. Actual
Restricted Release

Low Fluctuation – Dry Hydrology
Avg. Weekly Pattern –– Summer



Low Fluctuation – Dry Hydrology
Avg. Daily Pattern –– Summer Monday




Low Fluctuation – Mod. Hydrology
Avg. Weekly Pattern –– Summer
CFS (Thousands)
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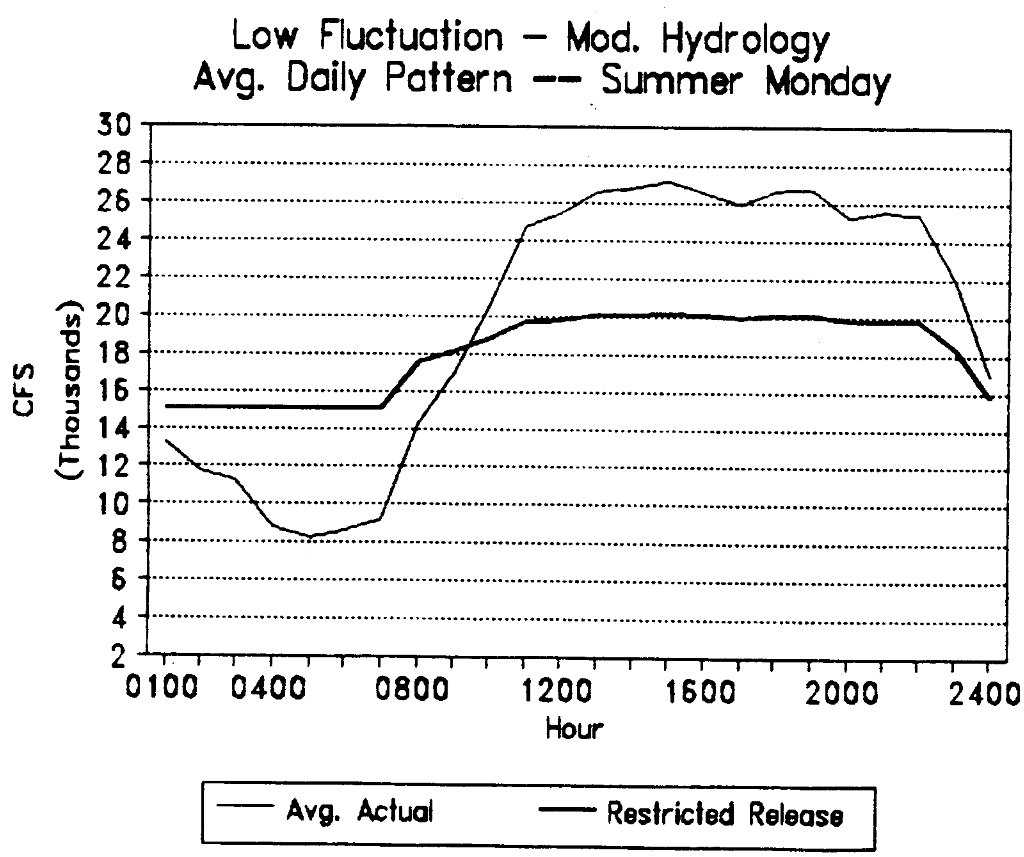
Avg. Actual
Restricted Release


Low Fluctuation – Mod. Hydrology
Avg. Daily Pattern –– Summer Monday
CFS (Thousands)
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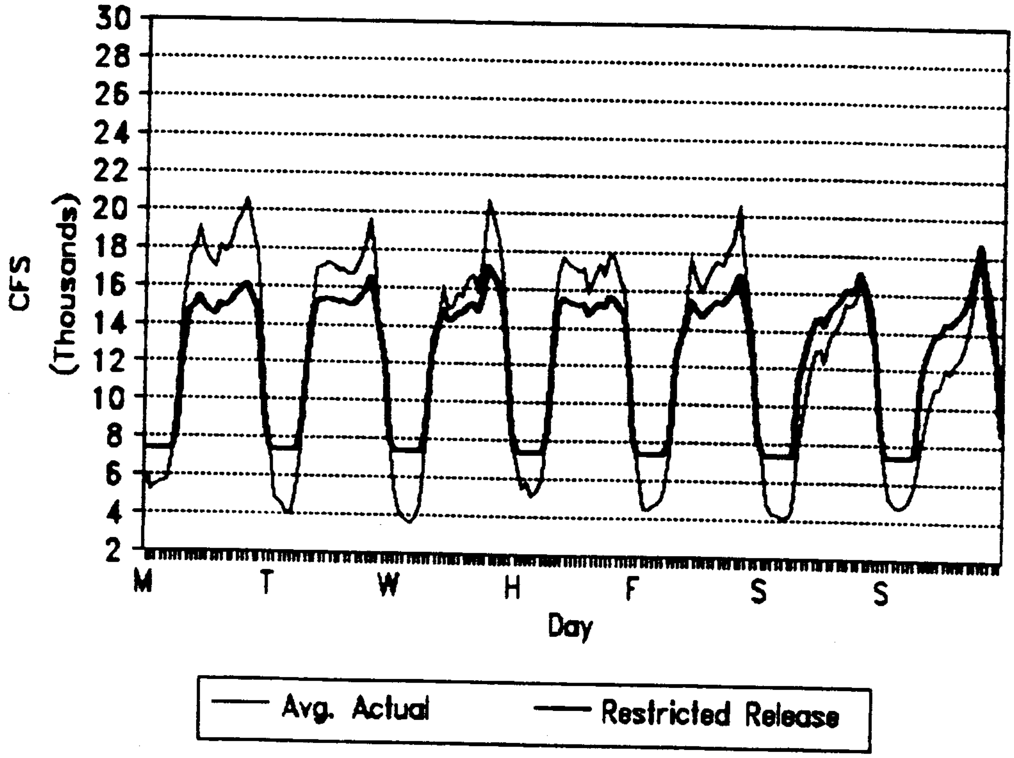
Avg. Actual
Restricted Release

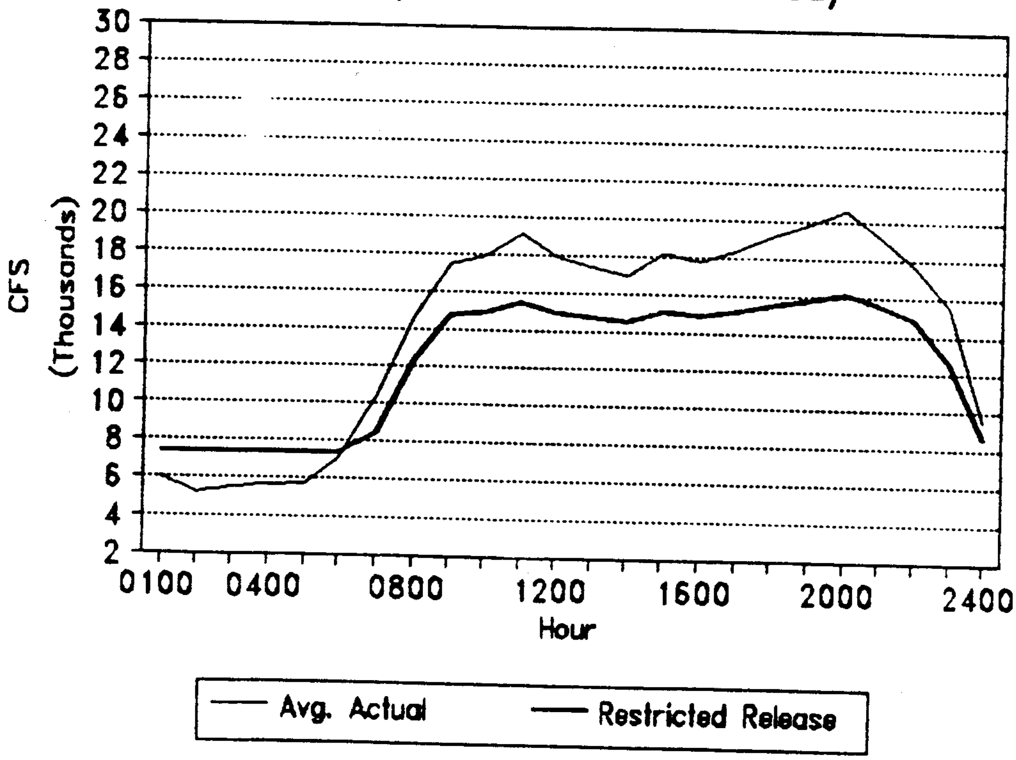
LOW FLUCTUATION ALTERNATIVE
Summer Season
Wet Hydrology
(This graph was not done)

MODERATE FLUCTUATION ALTERNATIVE
Fall Season
Dry Hydrology
(This graph was not done)

Moderate Fluctuation – Mod. Hydrology
Avg. Weekly Pattern –– Fall

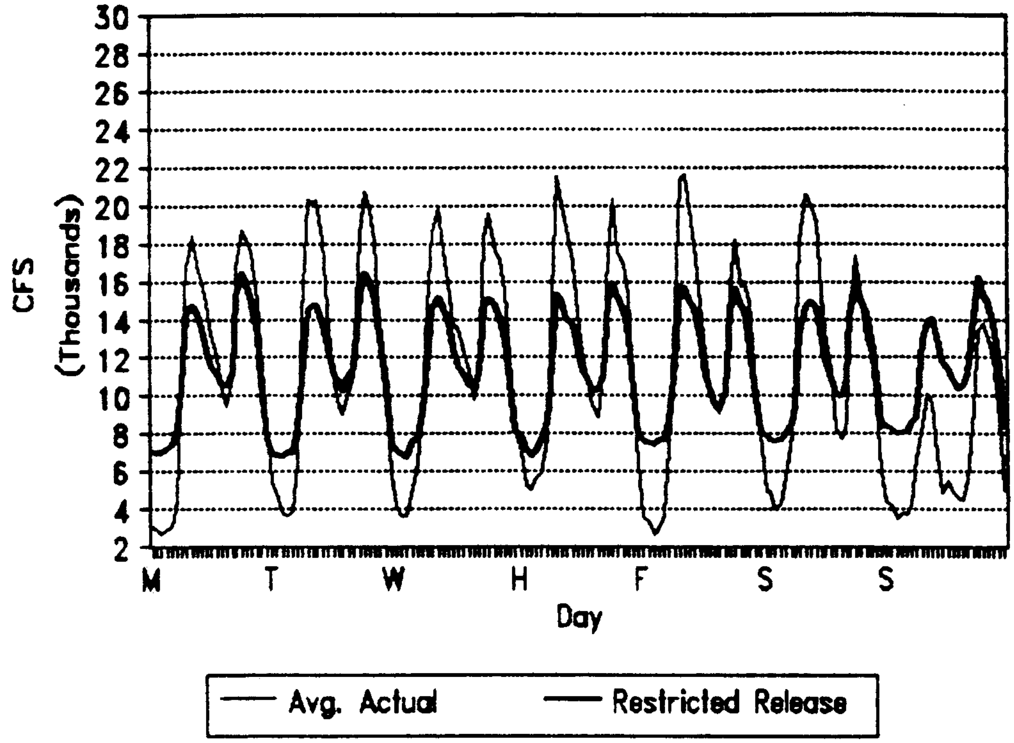


Moderate Fluctuation – Mod. Hydrology
Avg. Daily Pattern –– Fall Monday

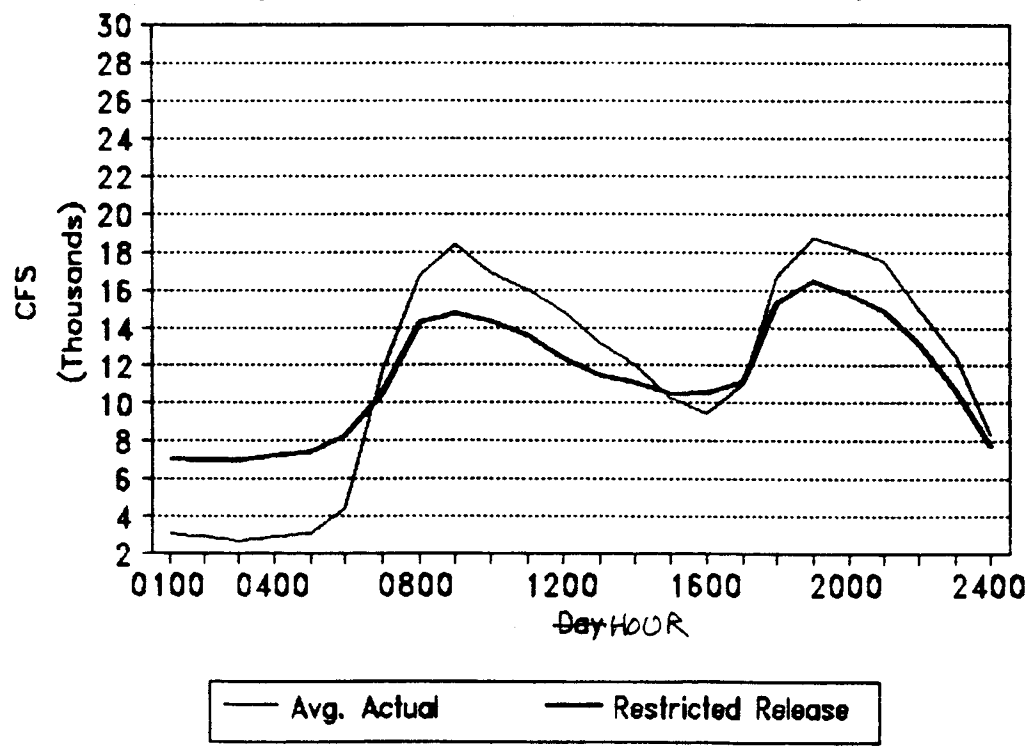


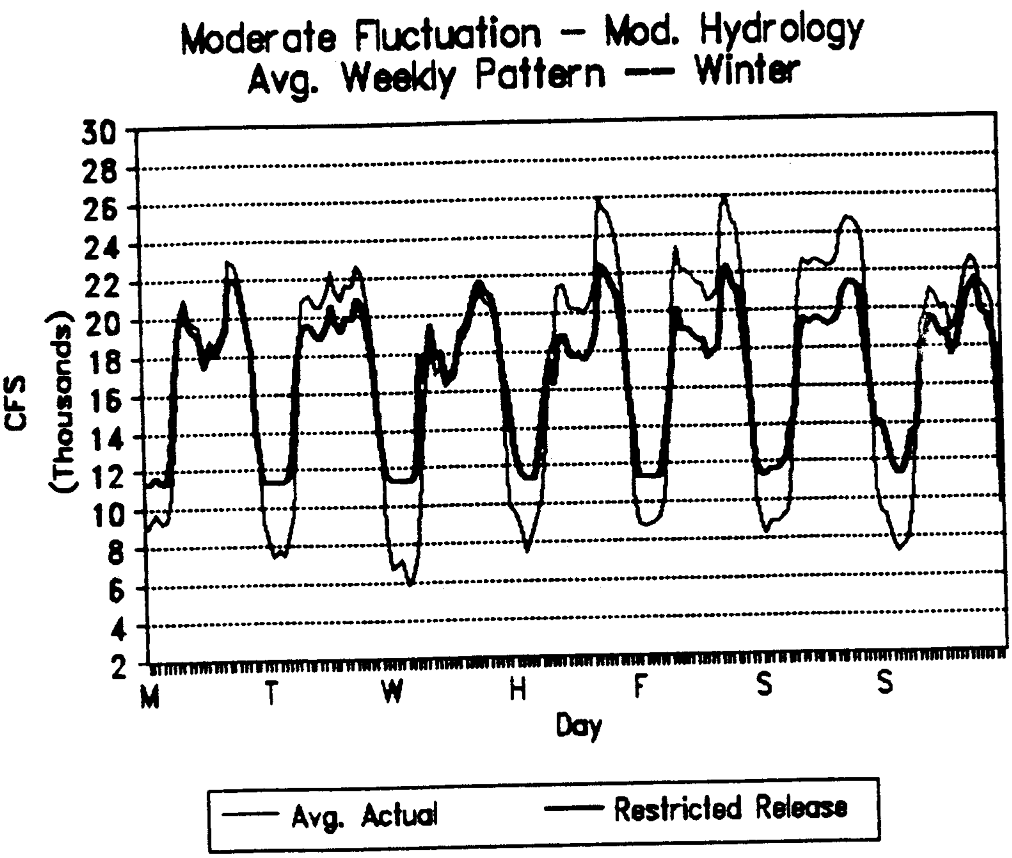
MODERATE FLUCTUATION ALTERNATIVE
Fall Season
Wet Hydrology
(This graph was not done)

Moderate Fluctuation – Dry Hydrology
Avg. Weekly Pattern –– Winter



Moderate Fluctuation – Dry Hydrology
Avg. Daily Pattern –– Winter Monday




Moderate Fluctuation - Mod. Hydrology
Avg. Weekly Pattern -- Winter
CFS
(Thousands)
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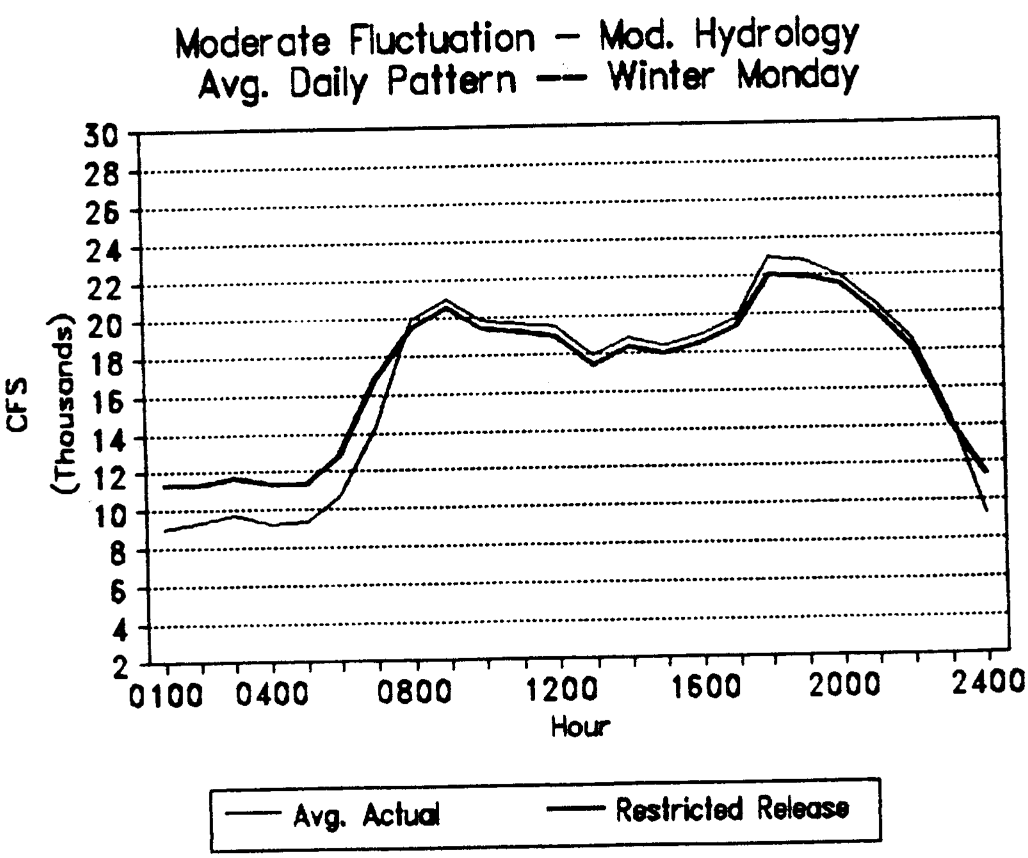
Day
Avg. Actual
Restricted Release


Moderate Fluctuation - Mod. Hydrology
Avg. Daily Pattern -- Winter Monday
CFS
(Thousands)
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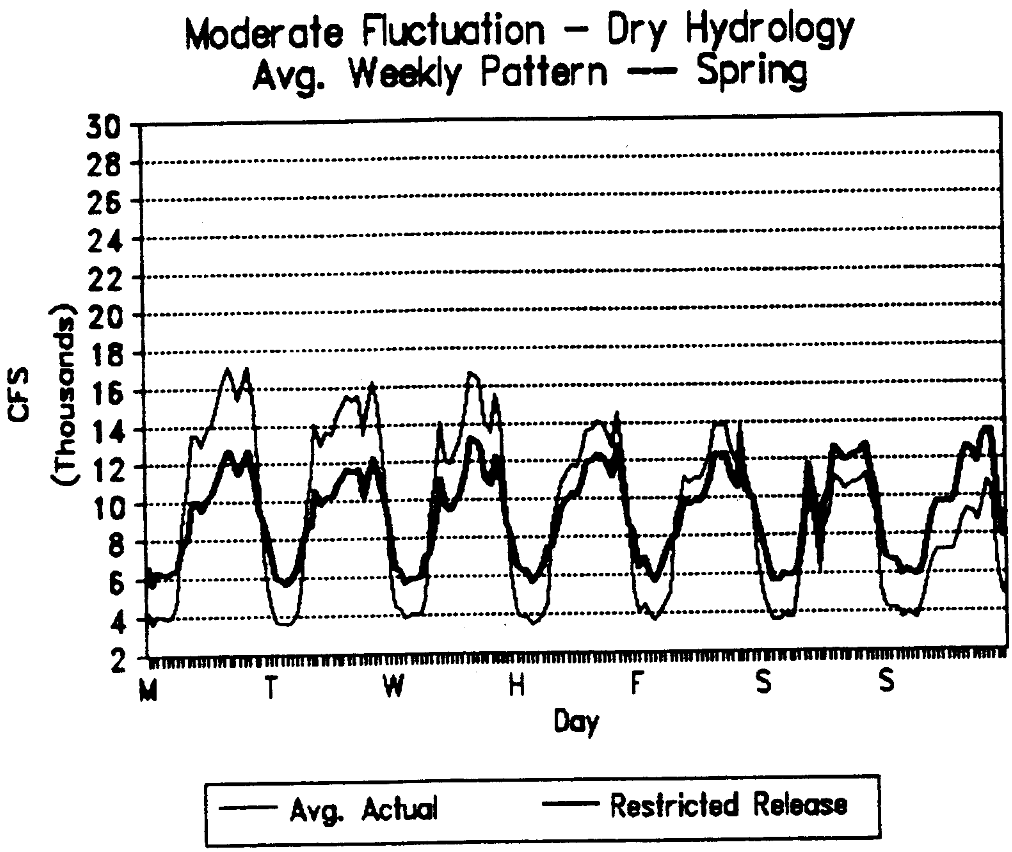
Hour
Avg. Actual
Restricted Release

MODERATE FLUCTUATION ALTERNATIVE
Winter Season
Wet Hydrology
(This graph was not done)



Moderate Fluctuation – Dry Hydrology
Avg. Weekly Pattern –– Spring
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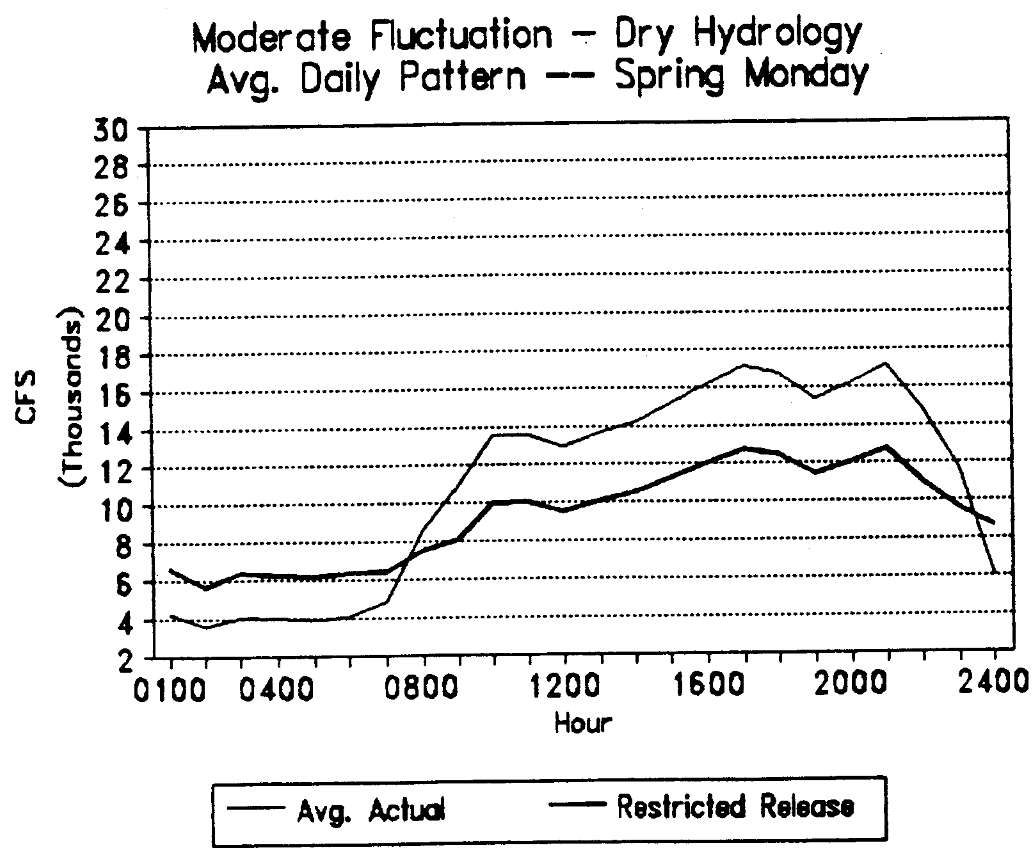
Avg. Actual
Restricted Release



Moderate Fluctuation – Dry Hydrology
Avg. Daily Pattern –– Spring Monday
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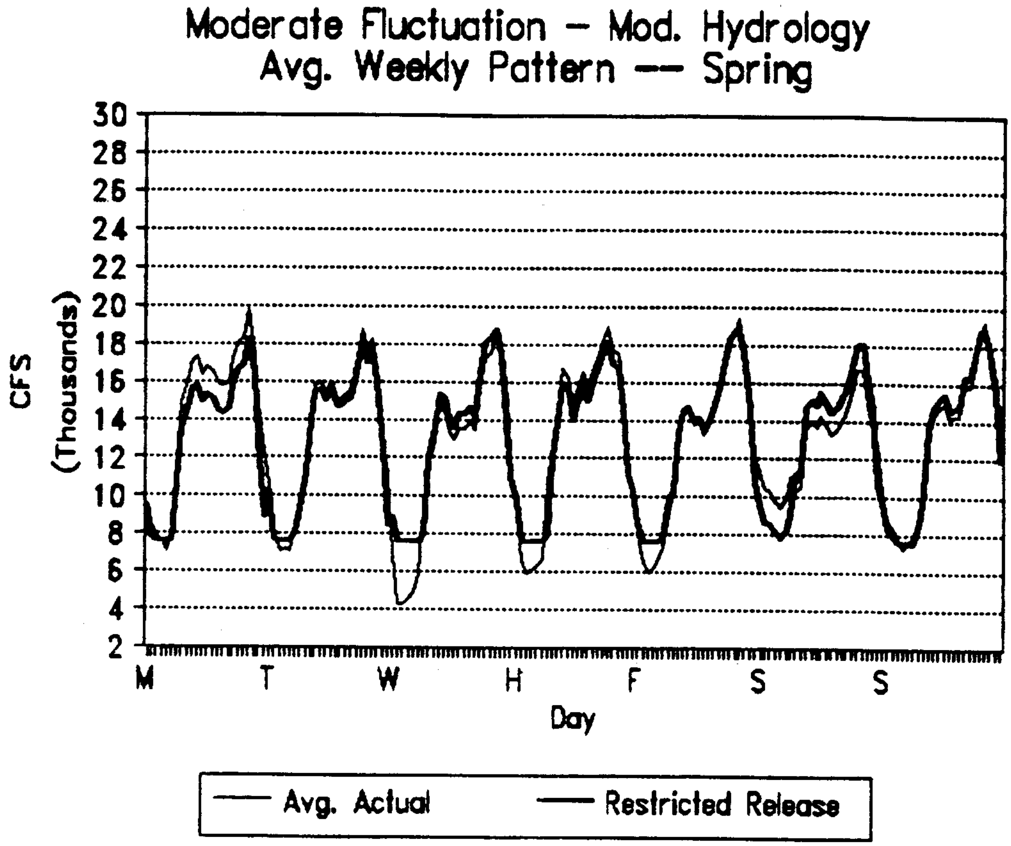
Avg. Actual
Restricted Release



Moderate Fluctuation - Mod. Hydrology
Avg. Weekly Pattern --- Spring
CFS
(Thousands)
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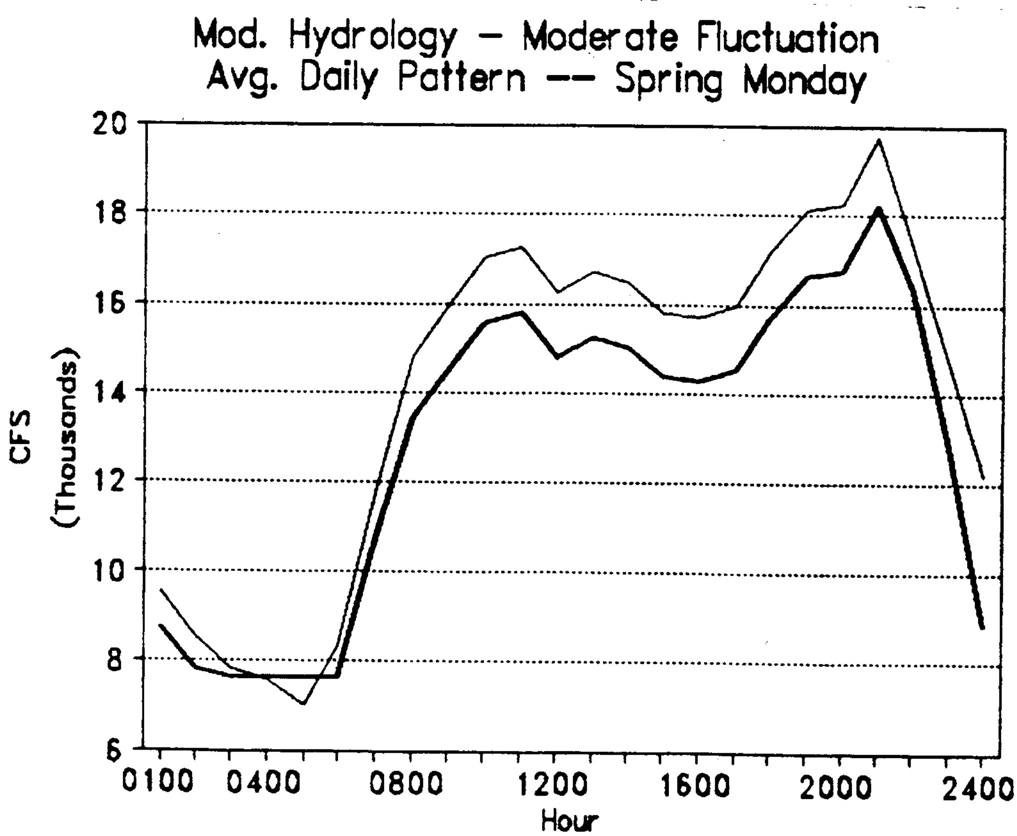
Avg. Actual
Restricted Release



Mod. Hydrology - Moderate Fluctuation
Avg. Daily Pattern --- Spring Monday
CFS
(Thousands)
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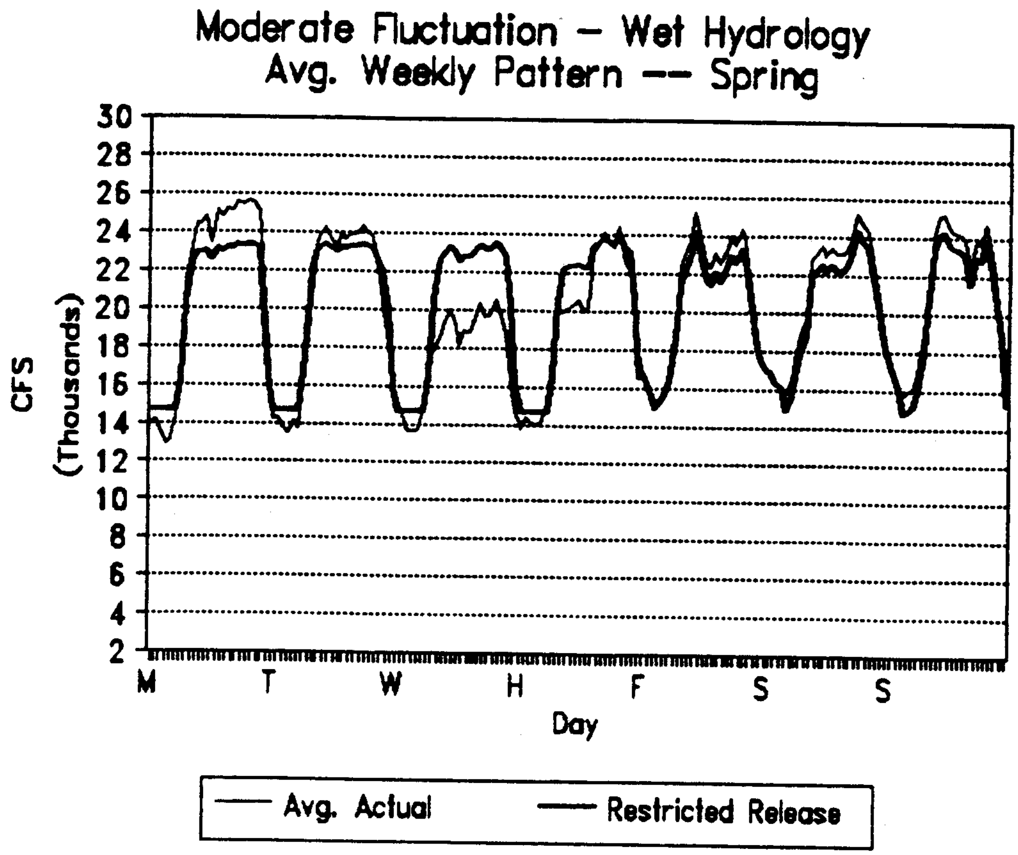
Hour


Moderate Fluctuation – Wet Hydrology
Avg. Weekly Pattern -- Spring
CFS (Thousands)
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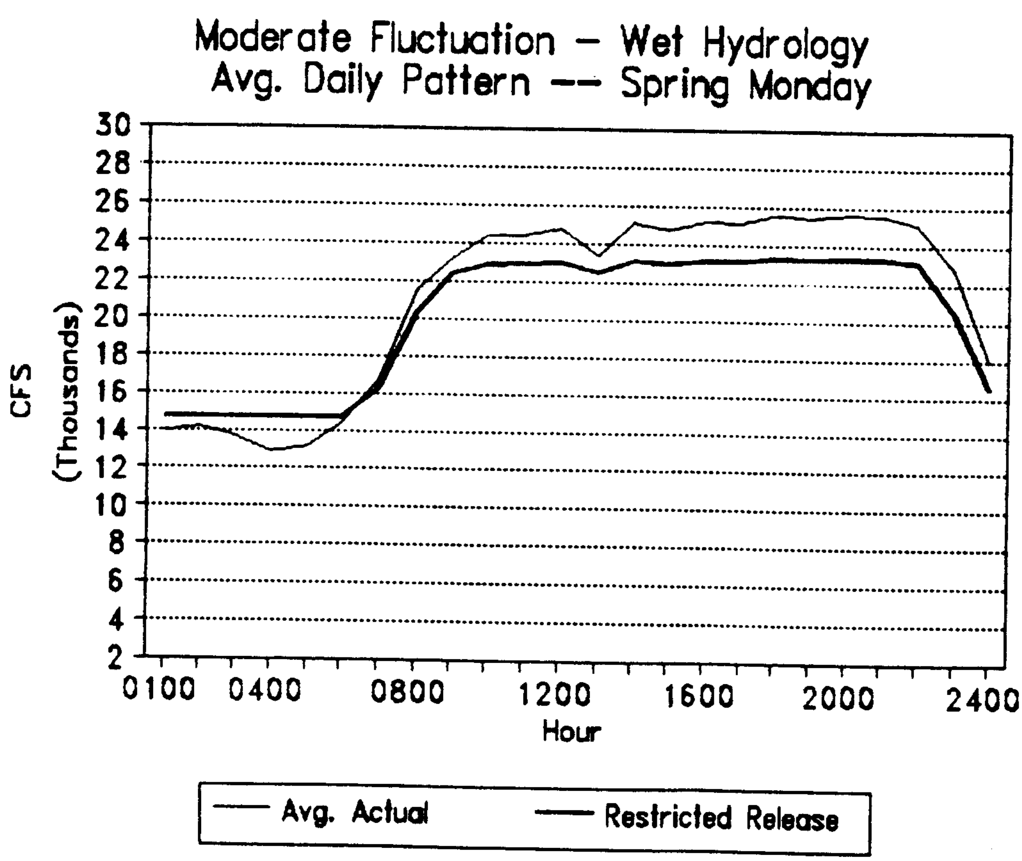
Avg. Actual
Restricted Release


Moderate Fluctuation – Wet Hydrology
Avg. Daily Pattern -- Spring Monday
CFS (Thousands)
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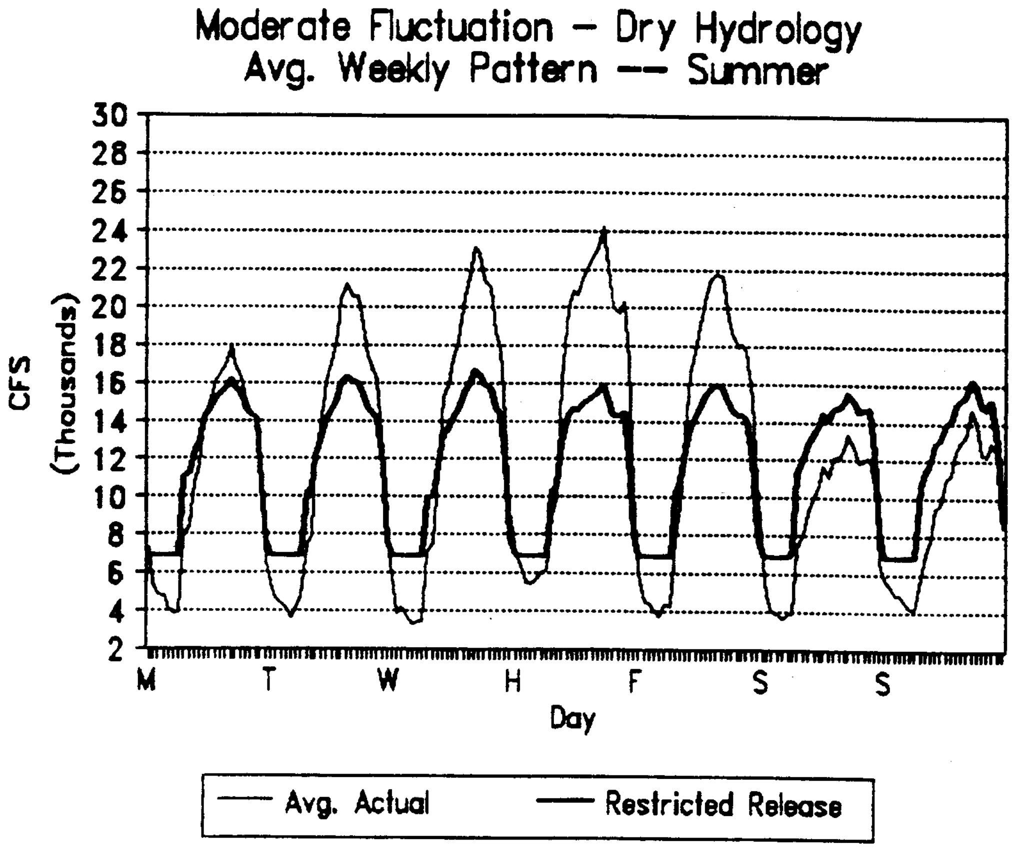
Avg. Actual
Restricted Release



Moderate Fluctuation – Dry Hydrology
Avg. Weekly Pattern –– Summer
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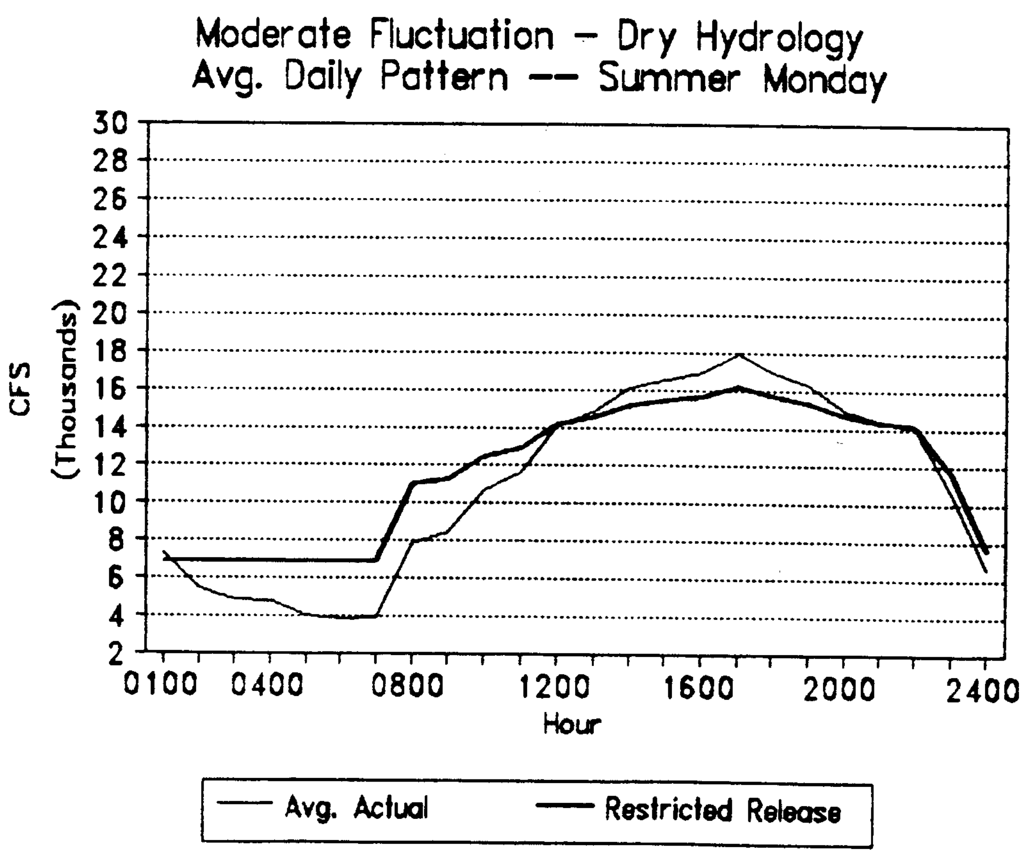
Avg. Actual
Restricted Release



Moderate Fluctuation – Dry Hydrology
Avg. Daily Pattern –– Summer Monday
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CFS
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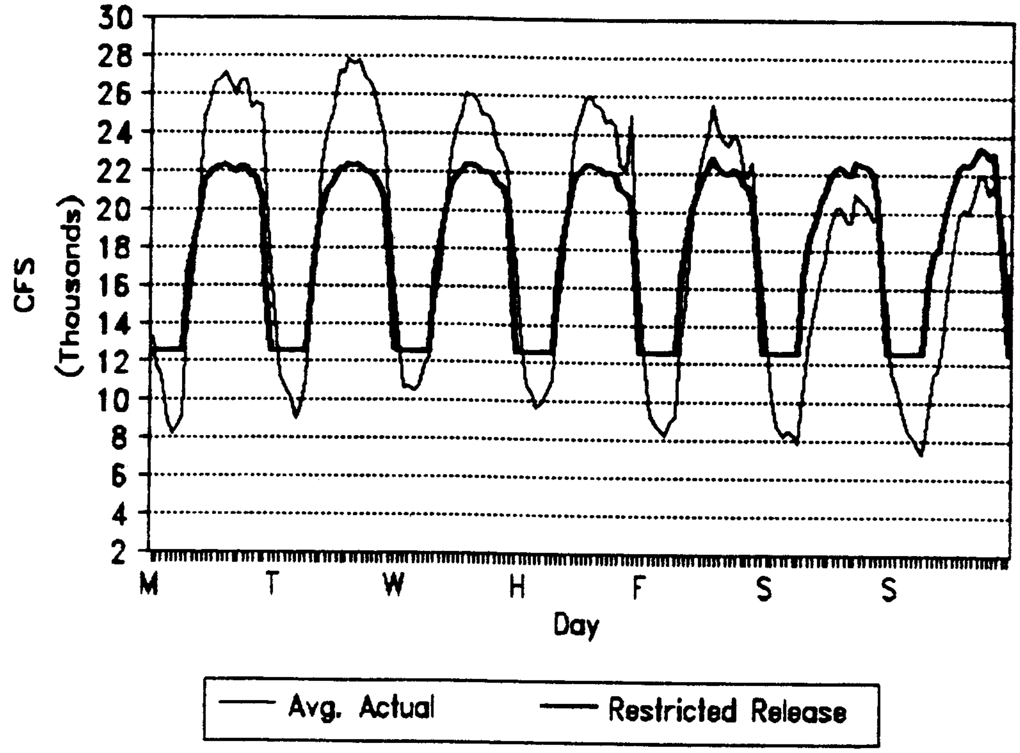
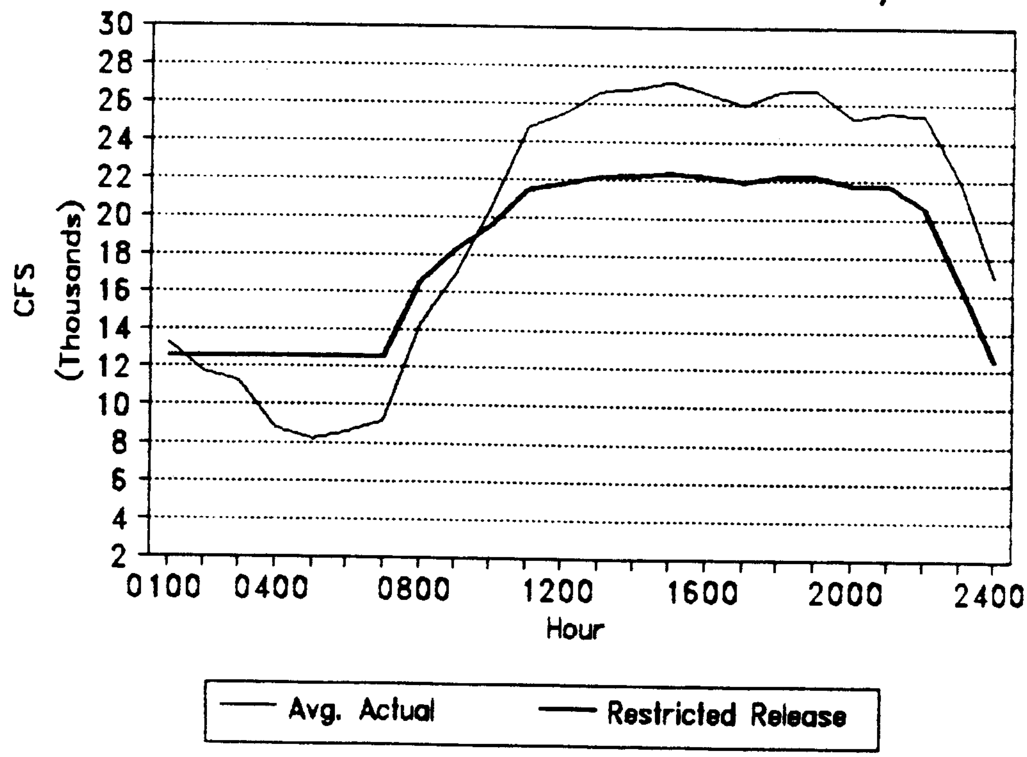
Avg. Actual
Restricted Release

Moderate Fluctuation – Mod. Hydrology
Avg. Weekly Pattern –– Summer

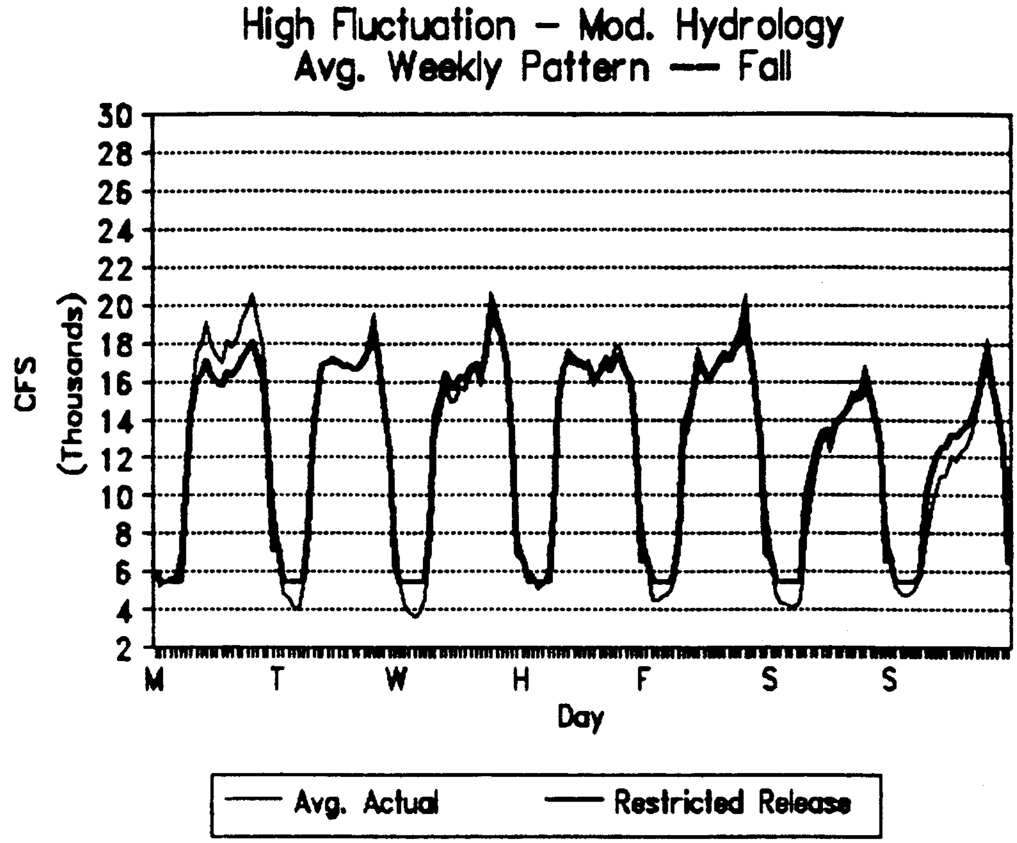


Moderate Fluctuation – Mod. Hydrology
Avg. Daily Pattern –– Summer Monday



MODERATE FLUCTUATION ALTERNATIVE
Summer Season
Wet Hydrology
(This graph was not done)

HIGH FLUCTUATION ALTERNATIVE
Fall Season
Dry Hydrology
(This graph was not done)


High Fluctuation - Mod. Hydrology
Avg. Weekly Pattern — Fall
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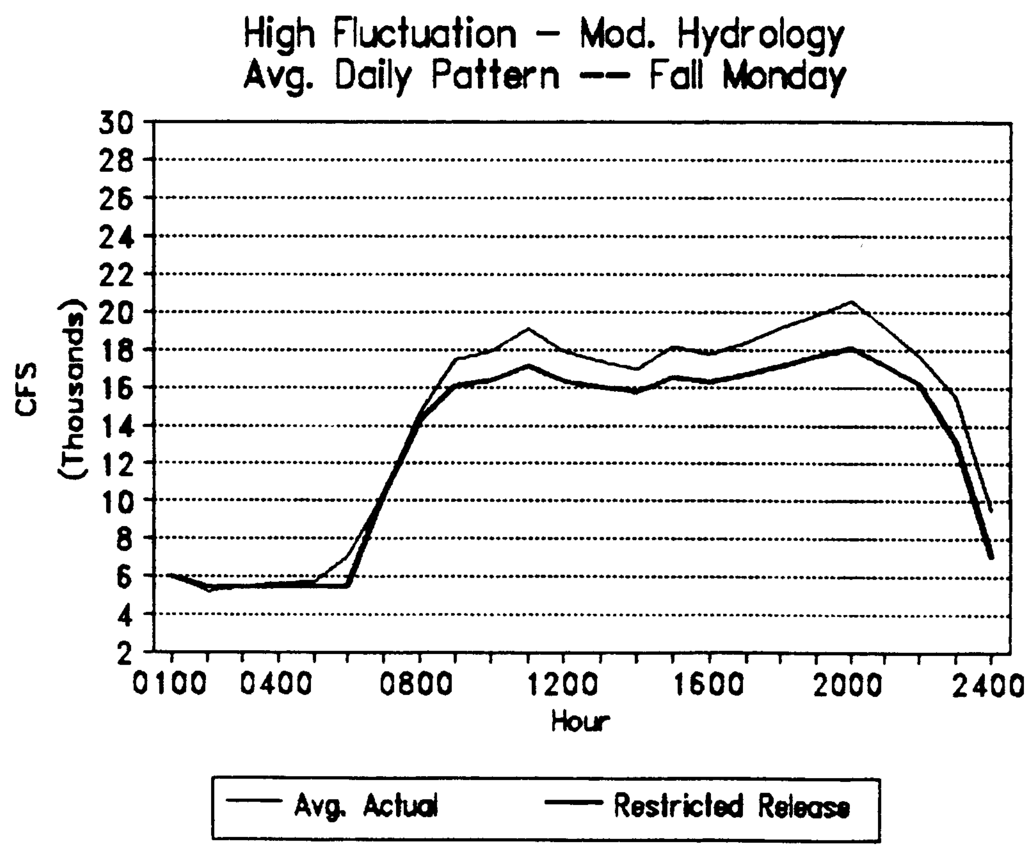
Day
Avg. Actual
Restricted Release


High Fluctuation - Mod. Hydrology
Avg. Daily Pattern — Fall Monday
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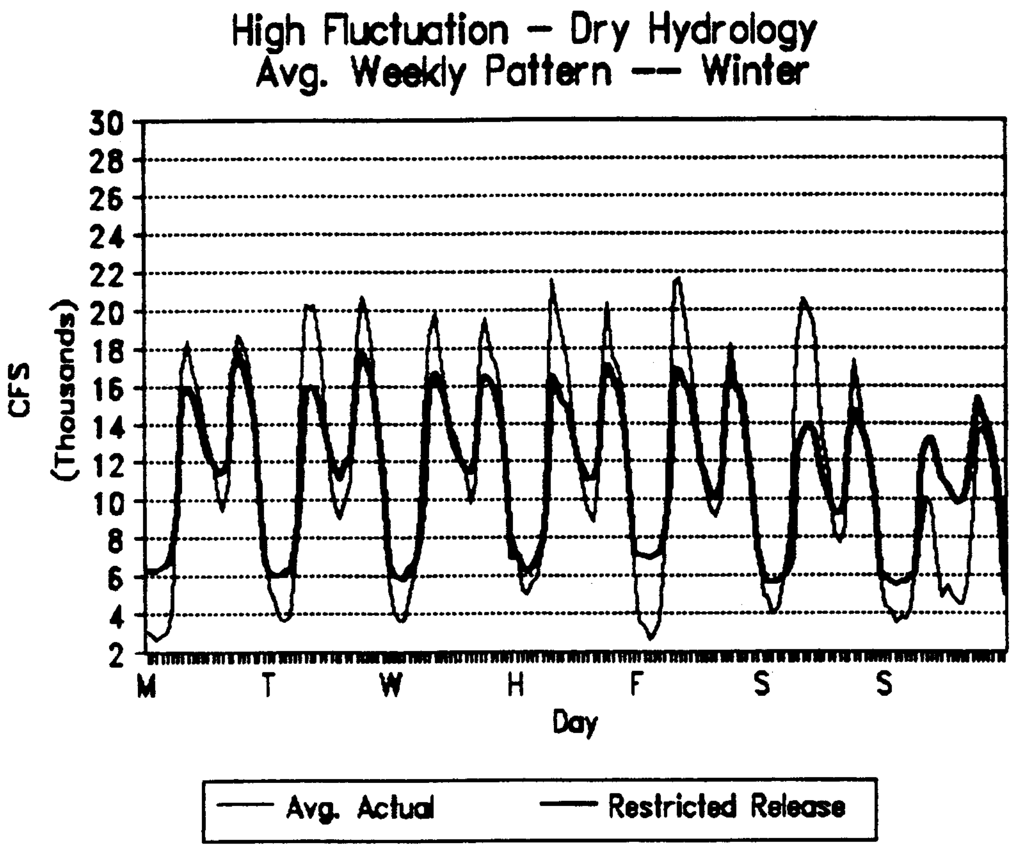
CFS
(Thousands)
0100
0400
0800
1200
1600
2000
2400
Hour
Avg. Actual
Restricted Release

HIGH FLUCTUATION ALTERNATIVE
Fall Season
Wet Hydrology
(This graph was not done)


High Fluctuation – Dry Hydrology
Avg. Weekly Pattern –– Winter
CFS
(Thousands)
30
28
26
24
22
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18
16
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12
10
8
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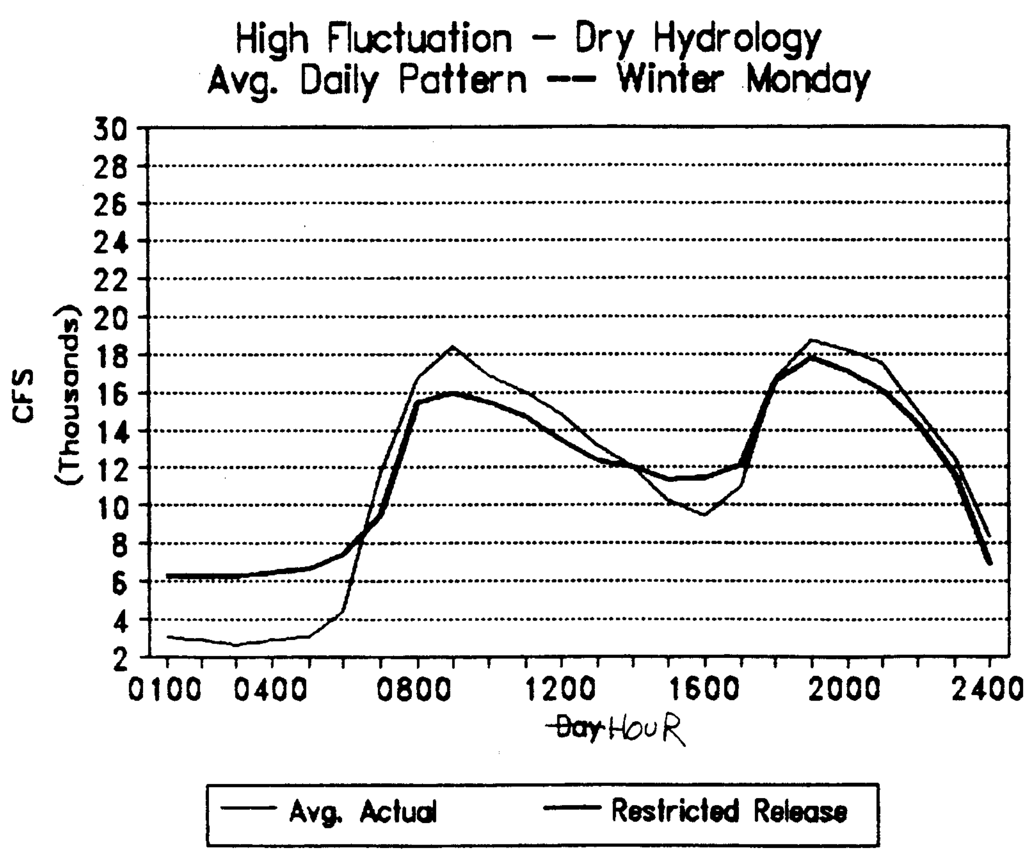
Day
Avg. Actual
Restricted Release


High Fluctuation – Dry Hydrology
Avg. Daily Pattern –– Winter Monday
CFS
(Thousands)
30
28
26
24
22
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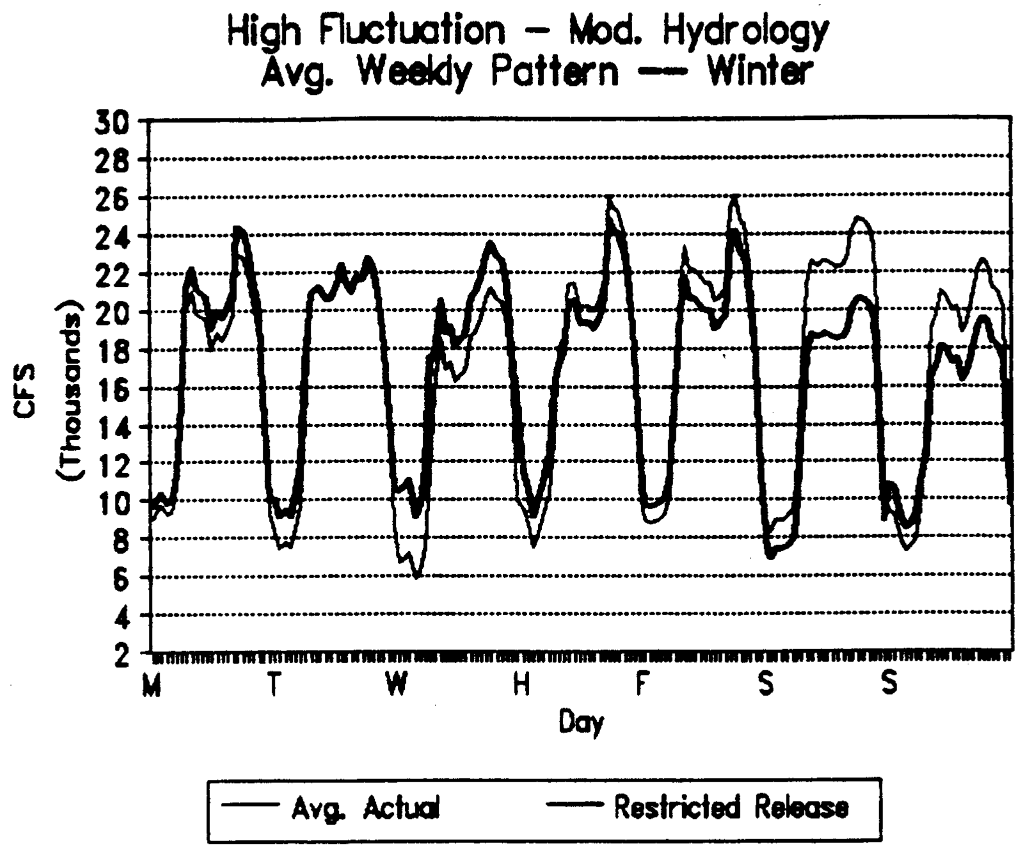
~~Day~~ HOUR
Avg. Actual
Restricted Release


High Fluctuation – Mod. Hydrology
Avg. Weekly Pattern — Winter
CFS
(Thousands)
30
28
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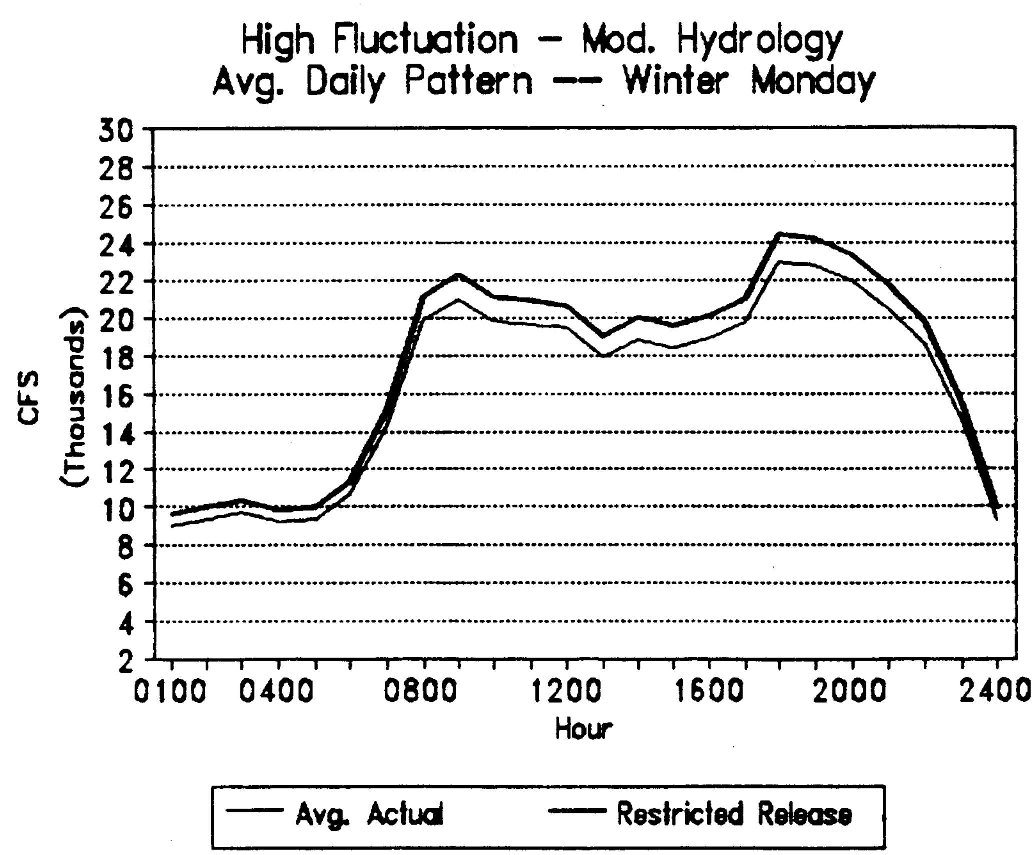
Day
Avg. Actual
Restricted Release


High Fluctuation – Mod. Hydrology
Avg. Daily Pattern — Winter Monday
CFS
(Thousands)
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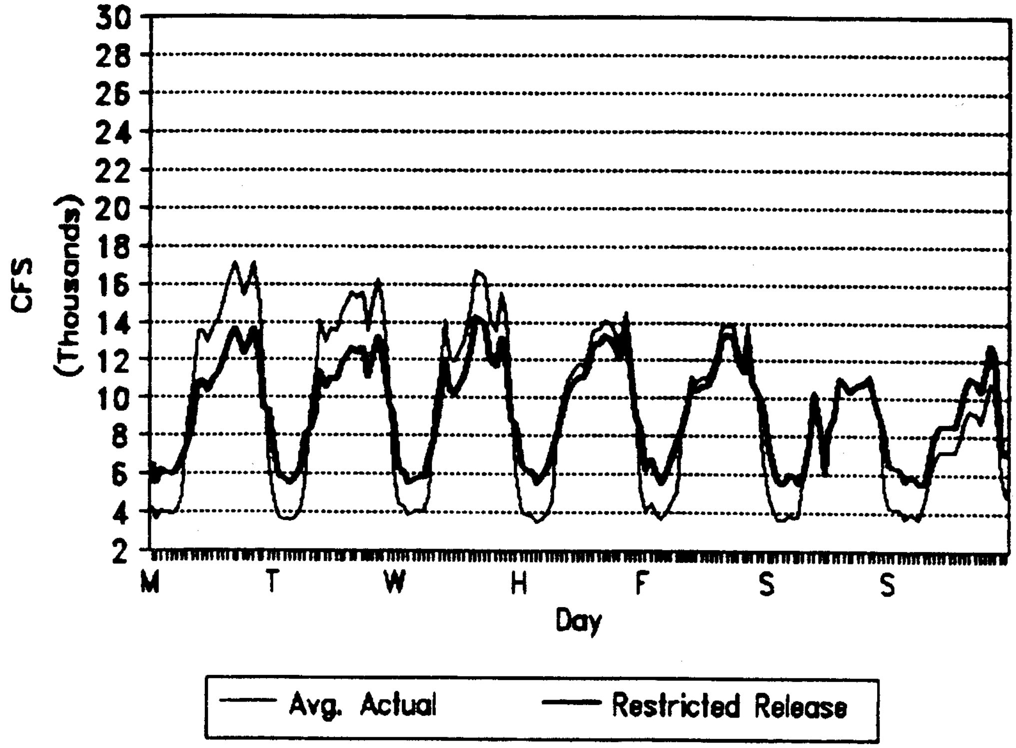
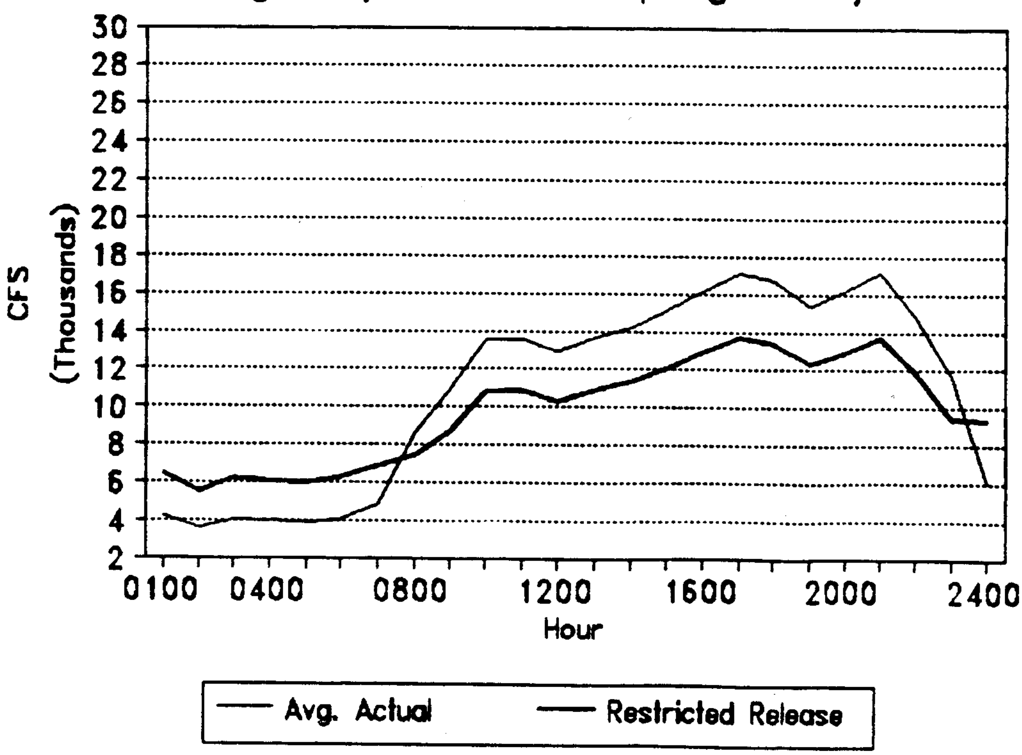
0100
0400
0800
1200
1600
2000
2400
Hour
Avg. Actual
Restricted Release

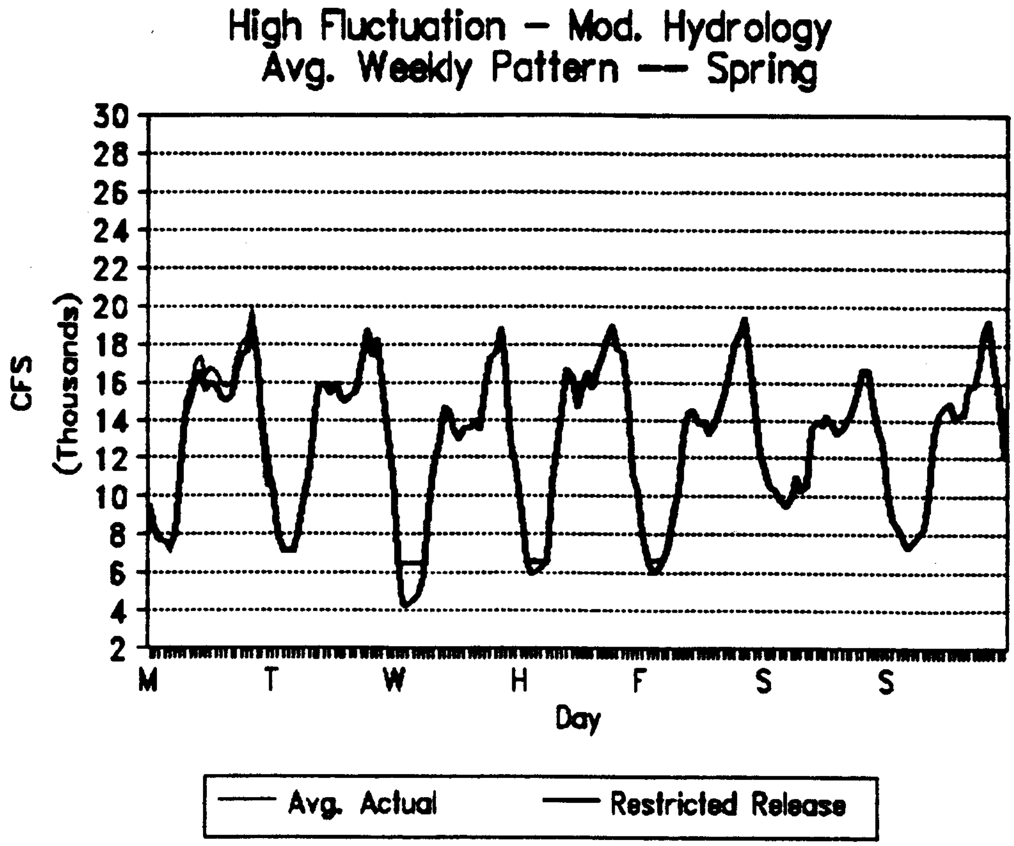
HIGH FLUCTUATION ALTERNATIVE
Winter Season
Wet Hydrology
(This graph was not done)

High Fluctuation – Dry Hydrology
Avg. Weekly Pattern –– Spring



High Fluctuation – Dry Hydrology
Avg. Daily Pattern –– Spring Monday




High Fluctuation – Mod. Hydrology
Avg. Weekly Pattern — Spring
30
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CFS
(Thousands)
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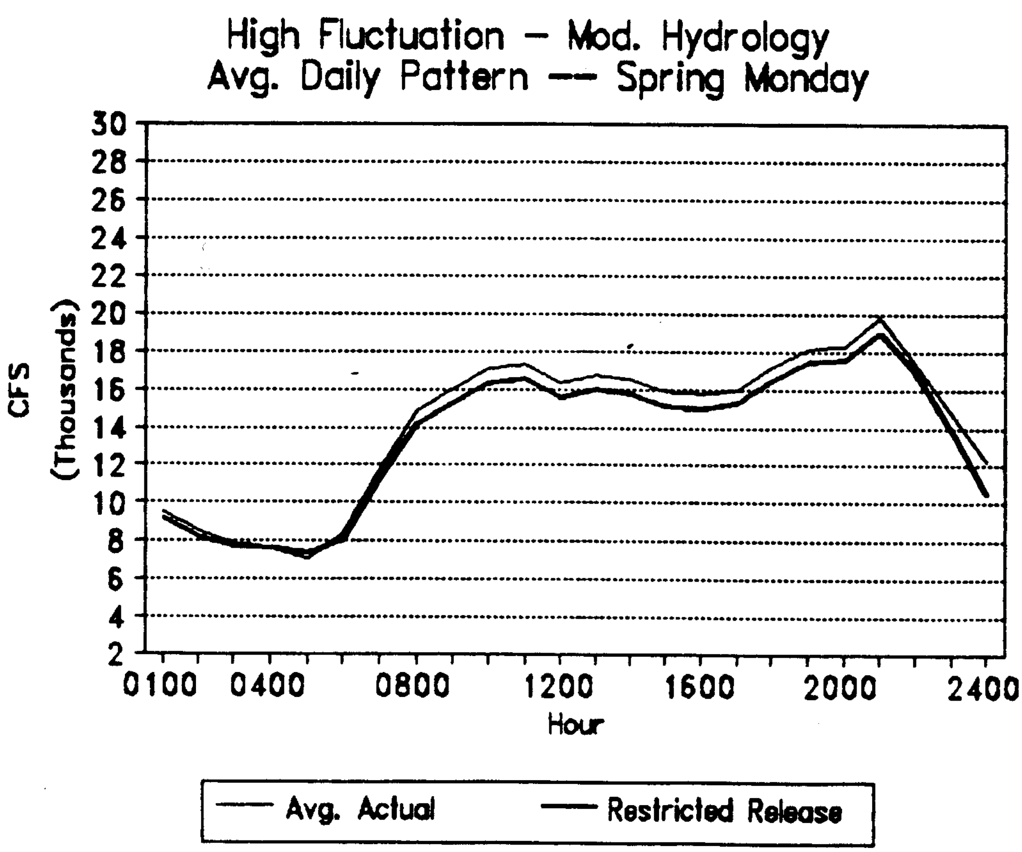
Day
Avg. Actual
Restricted Release


High Fluctuation – Mod. Hydrology
Avg. Daily Pattern — Spring Monday
30
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8
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4
2
CFS
(Thousands)
0100
0400
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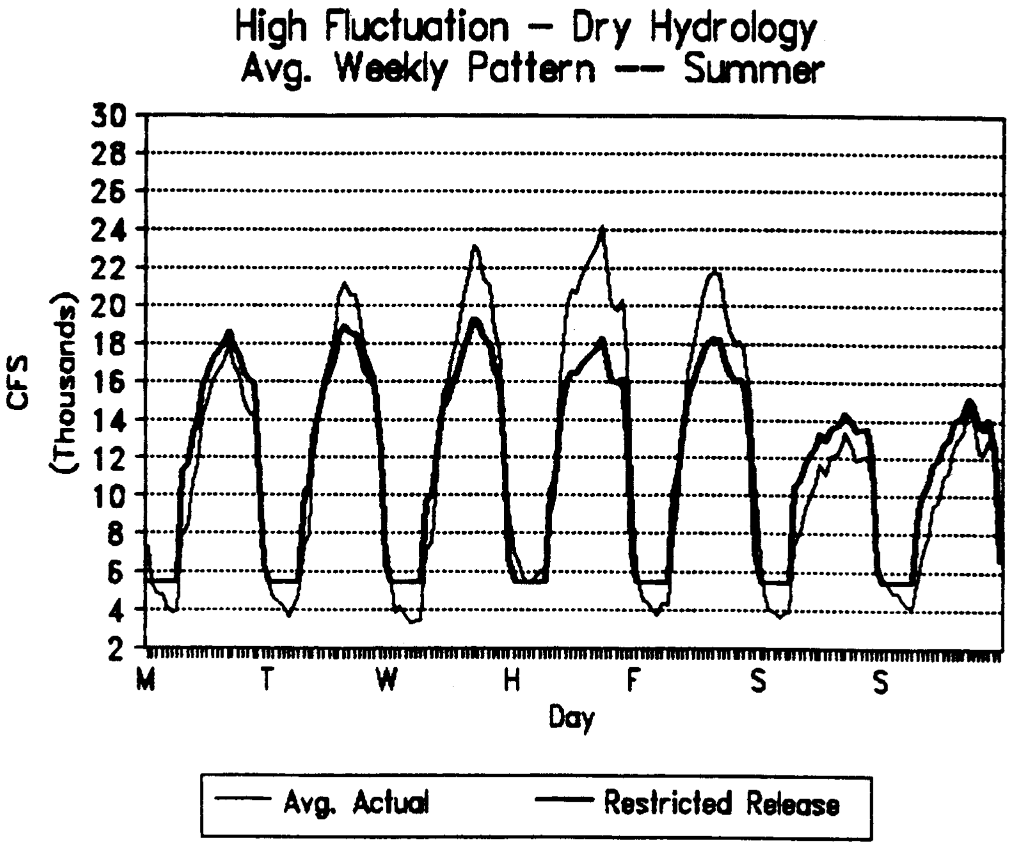
1200
1600
2000
2400
Hour
Avg. Actual
Restricted Release

HIGH FLUCTUATION ALTERNATIVE
Spring Season
Wet Hydrology
(This graph was not done)


High Fluctuation — Dry Hydrology
Avg. Weekly Pattern -- Summer
CFS
(Thousands)
30
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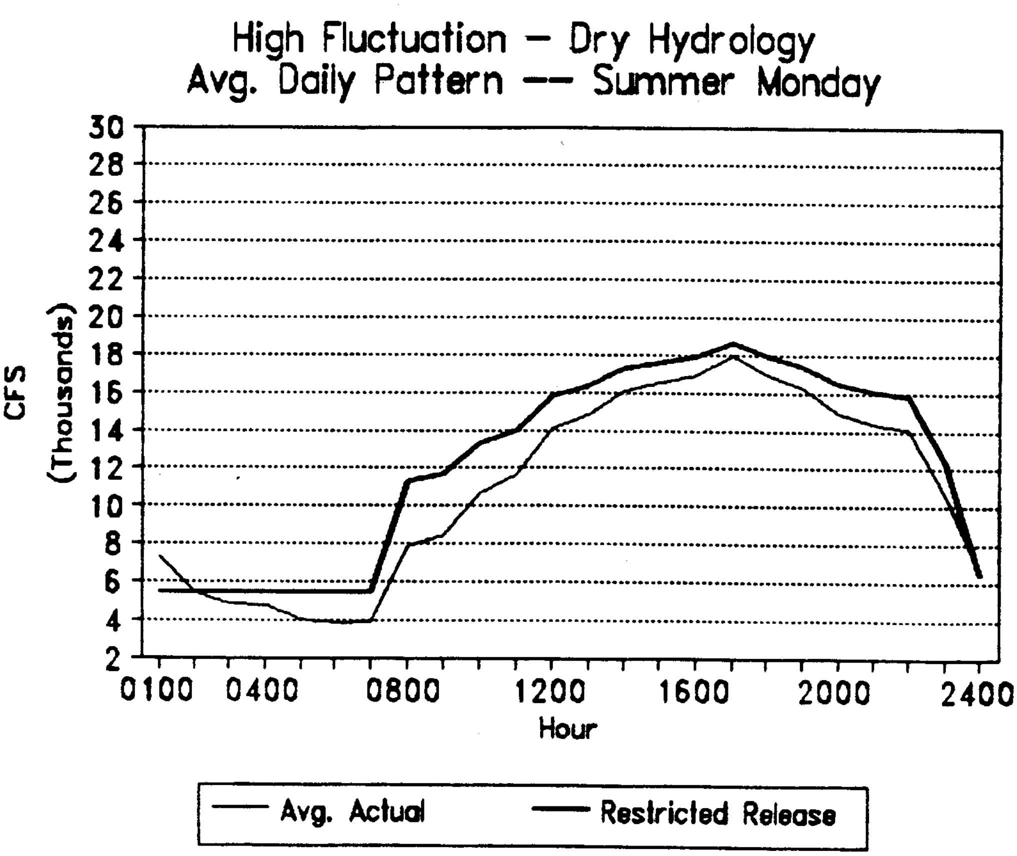
Day
Avg. Actual
Restricted Release


High Fluctuation — Dry Hydrology
Avg. Daily Pattern -- Summer Monday
CFS
(Thousands)
30
28
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24
22
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0400
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1200
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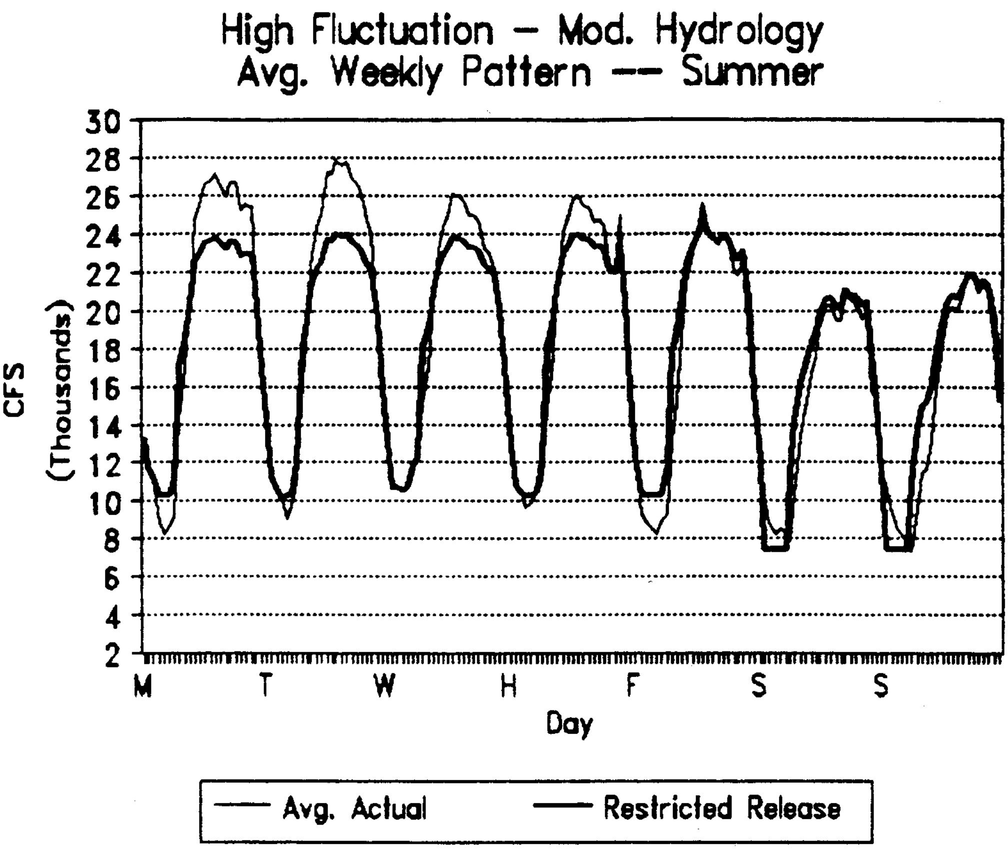
2000
2400
Hour
Avg. Actual
Restricted Release


High Fluctuation – Mod. Hydrology
Avg. Weekly Pattern –– Summer
CFS
(Thousands)
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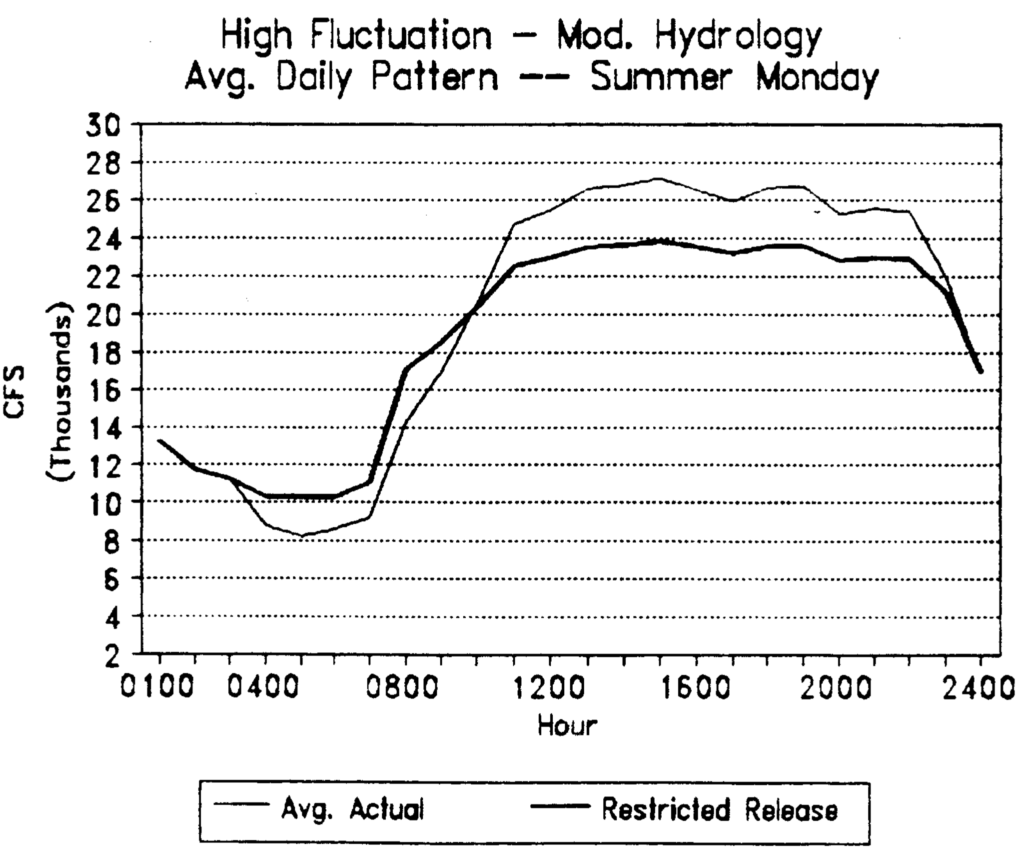
Day
Avg. Actual
Restricted Release


High Fluctuation – Mod. Hydrology
Avg. Daily Pattern –– Summer Monday
CFS
(Thousands)
30
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2
0100
0400
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1200
1600
2000
2400
Hour
Avg. Actual
Restricted Release

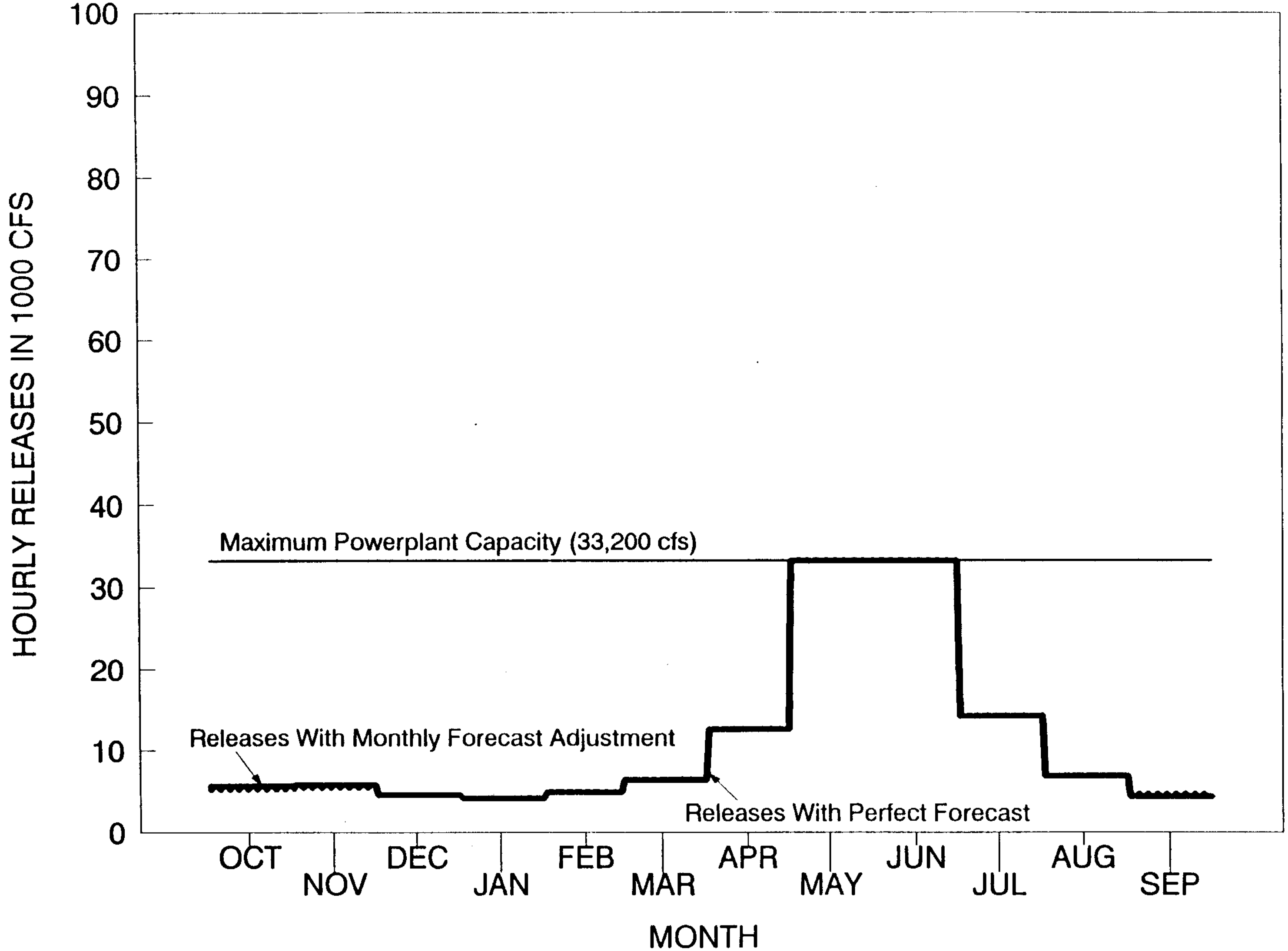
HIGH FLUCTUATION ALTERNATIVE
Summer Season
Wet Hydrology
(This graph was not done)

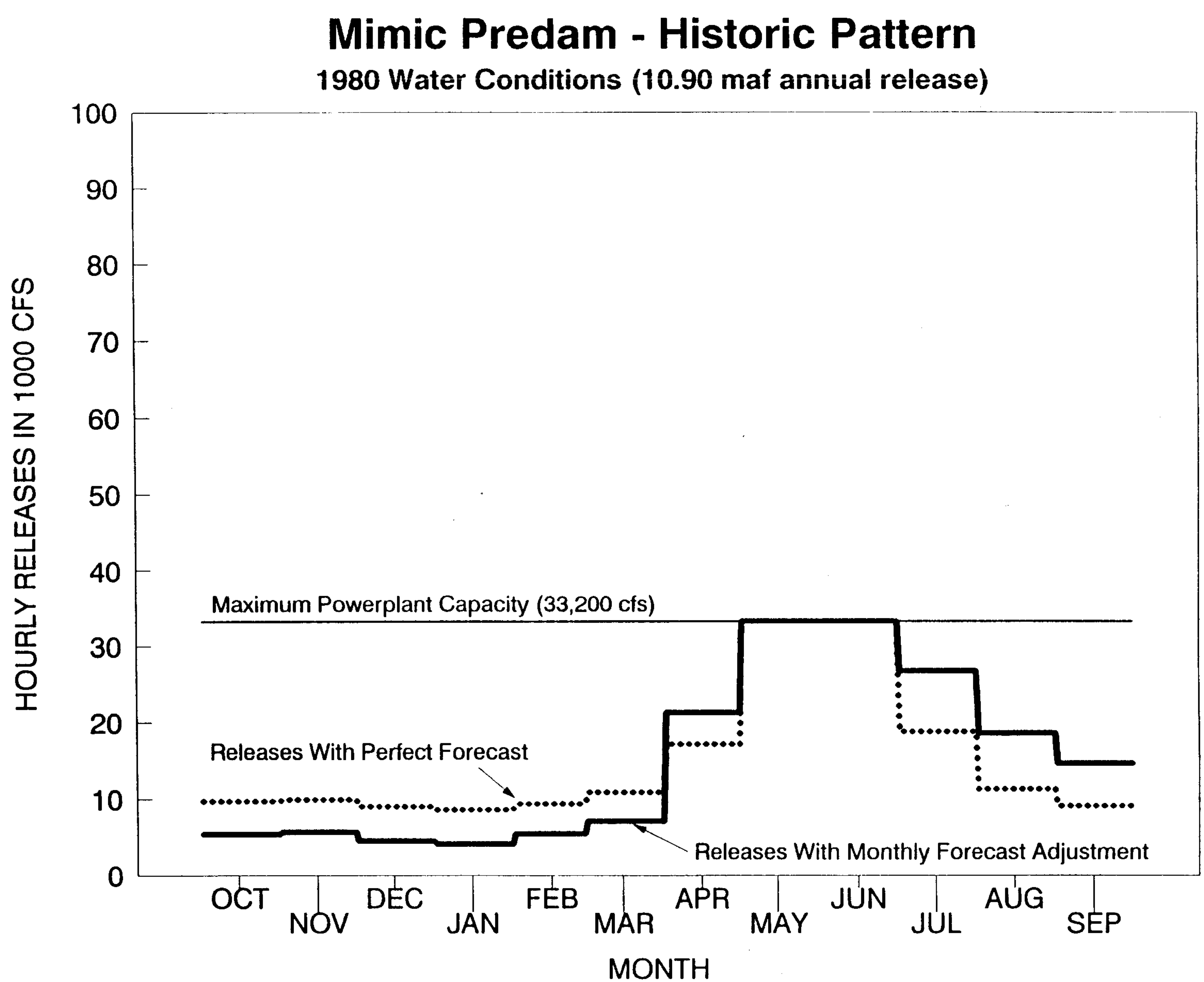
ATTACHMENT 2

SUPPLEMENTAL HYDROLOGIC INFORMATION

Mimic Predam - Historic Pattern

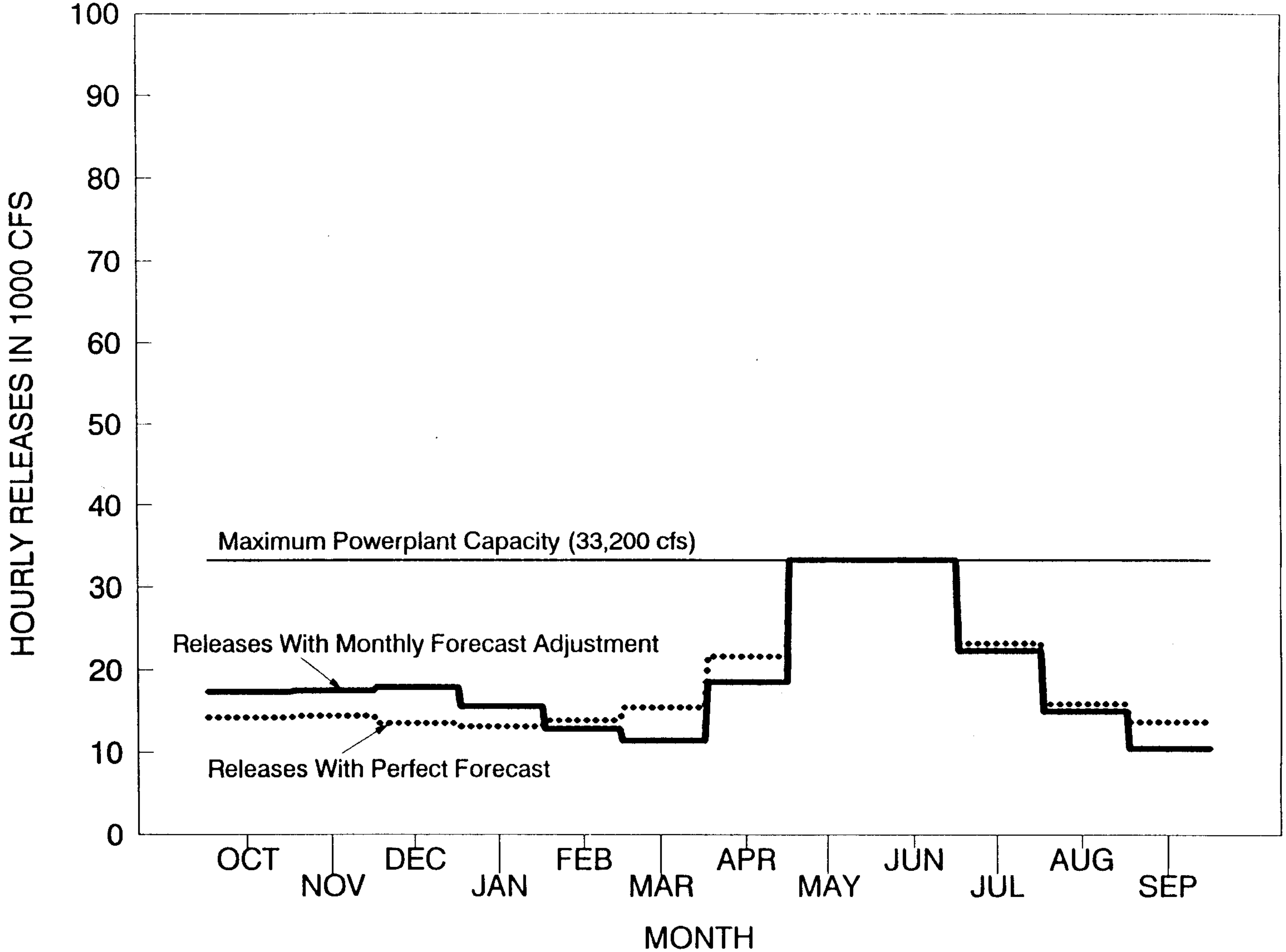
1989 Water Conditions (8.22 maf annual release)




Mimic Predam - Historic Pattern
1980 Water Conditions (10.90 maf annual release)
HOURLY RELEASES IN 1000 CFS
100
90
80
70
60
50
40
30
20
10
0
Maximum Powerplant Capacity (33,200 cfs)
Releases With Perfect Forecast
Releases With Monthly Forecast Adjustment
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
MONTH

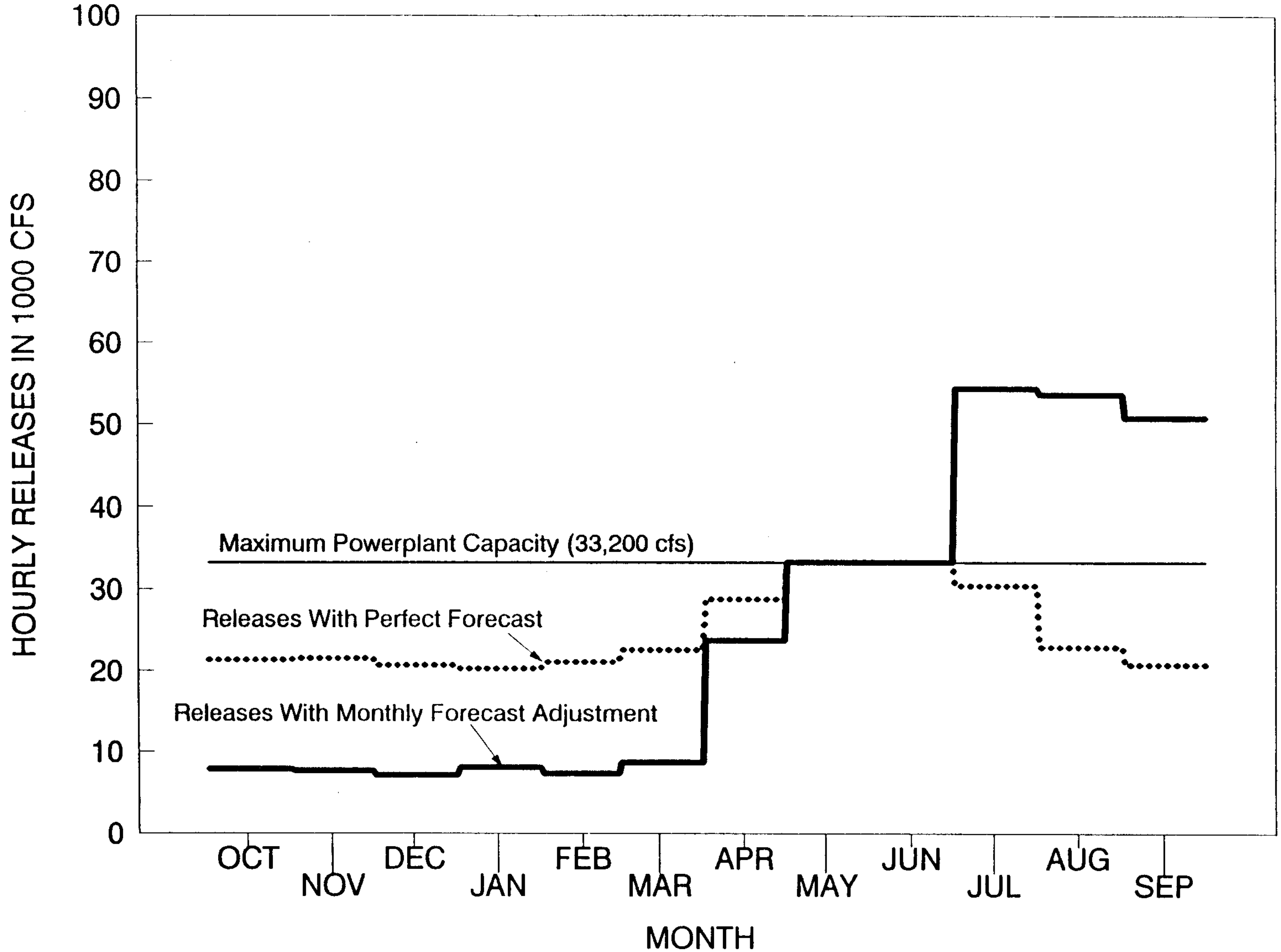
Mimic Predam - Historic Pattern

1987 Water Conditions (13.60 maf annual release)



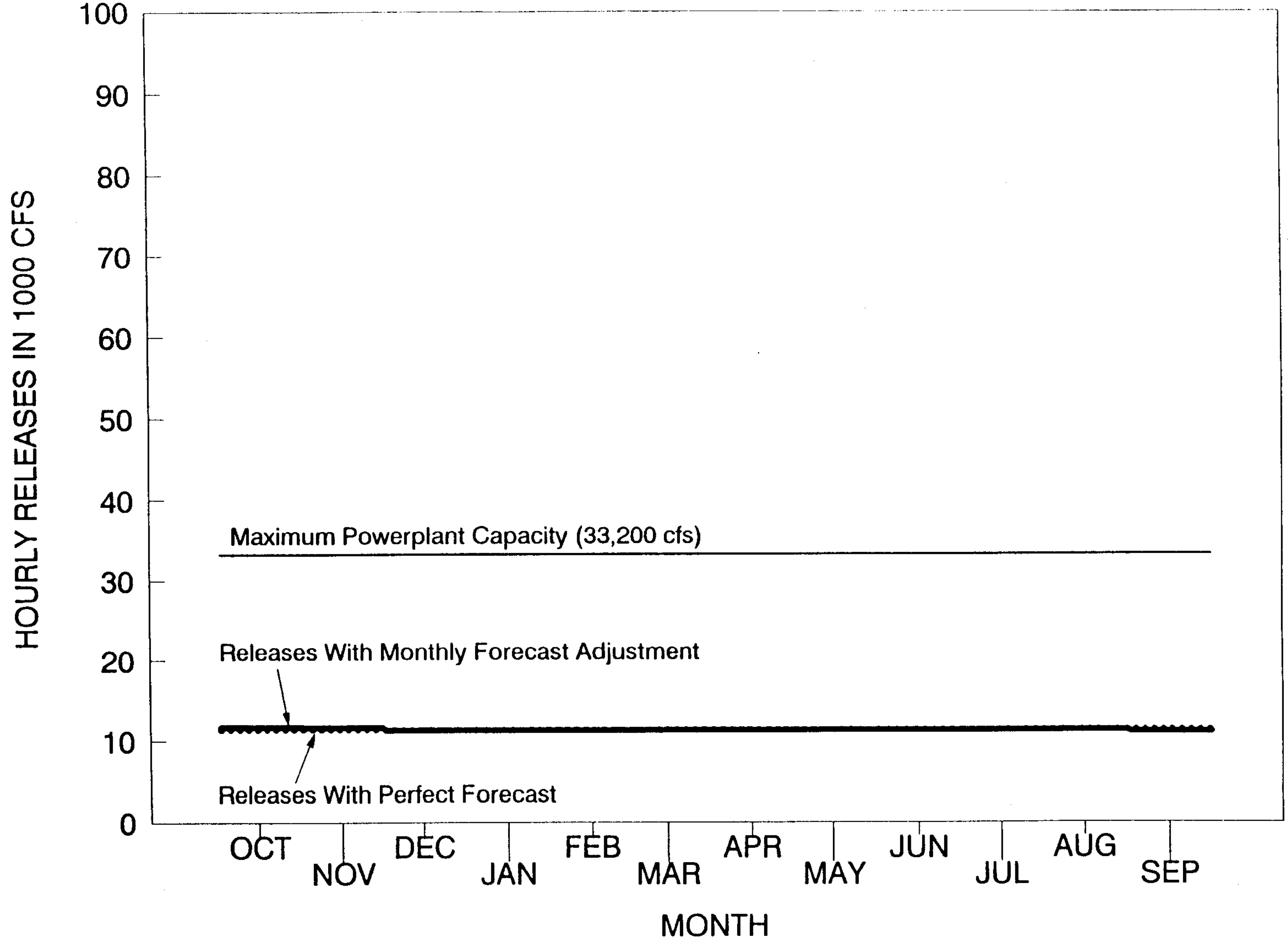
Mimic Predam - Historic Pattern

1983 Water Conditions (17.91 maf annual release)



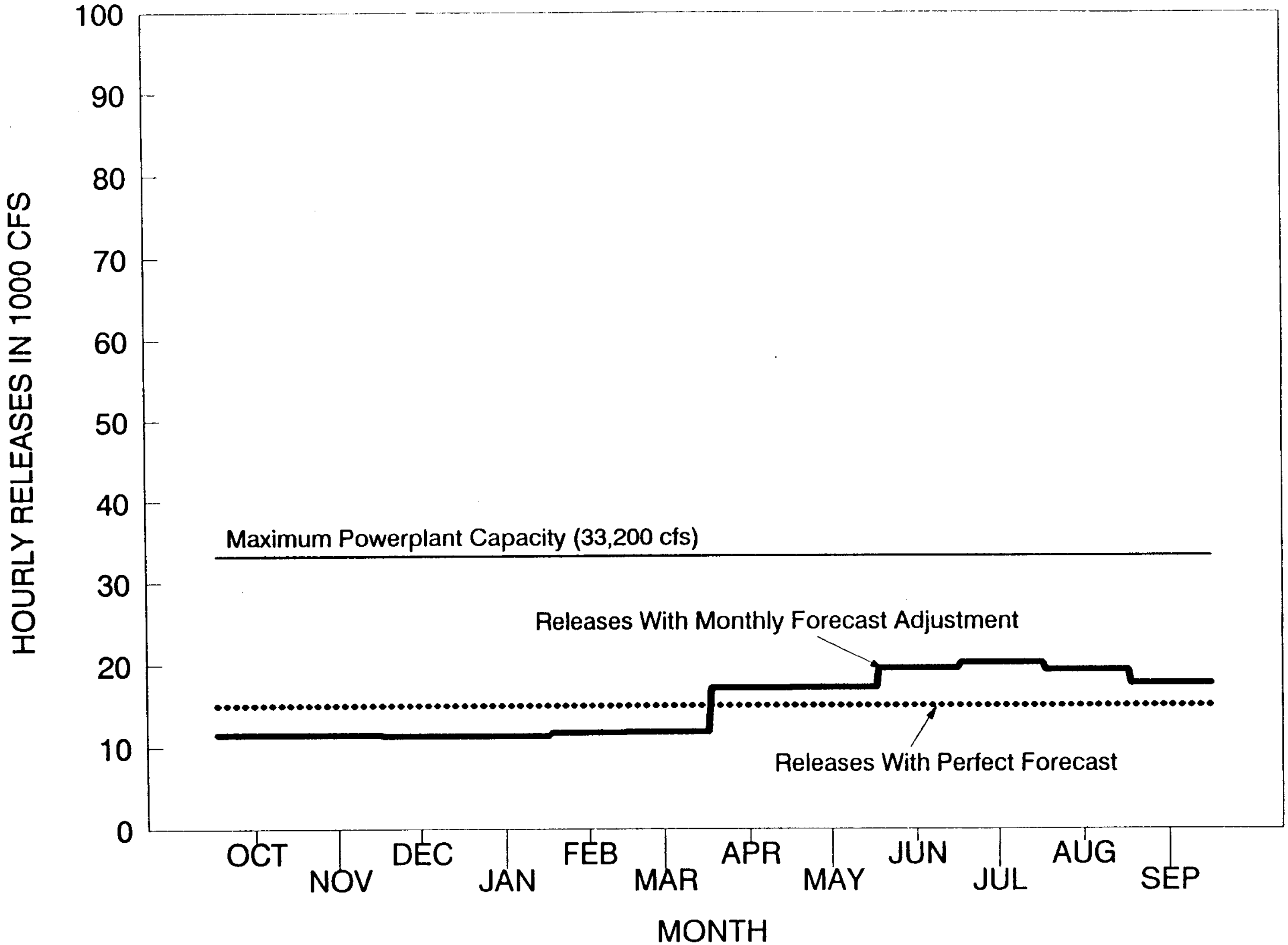
Steady Flow - Year Round

1989 Water Conditions (8.22 maf annual release)



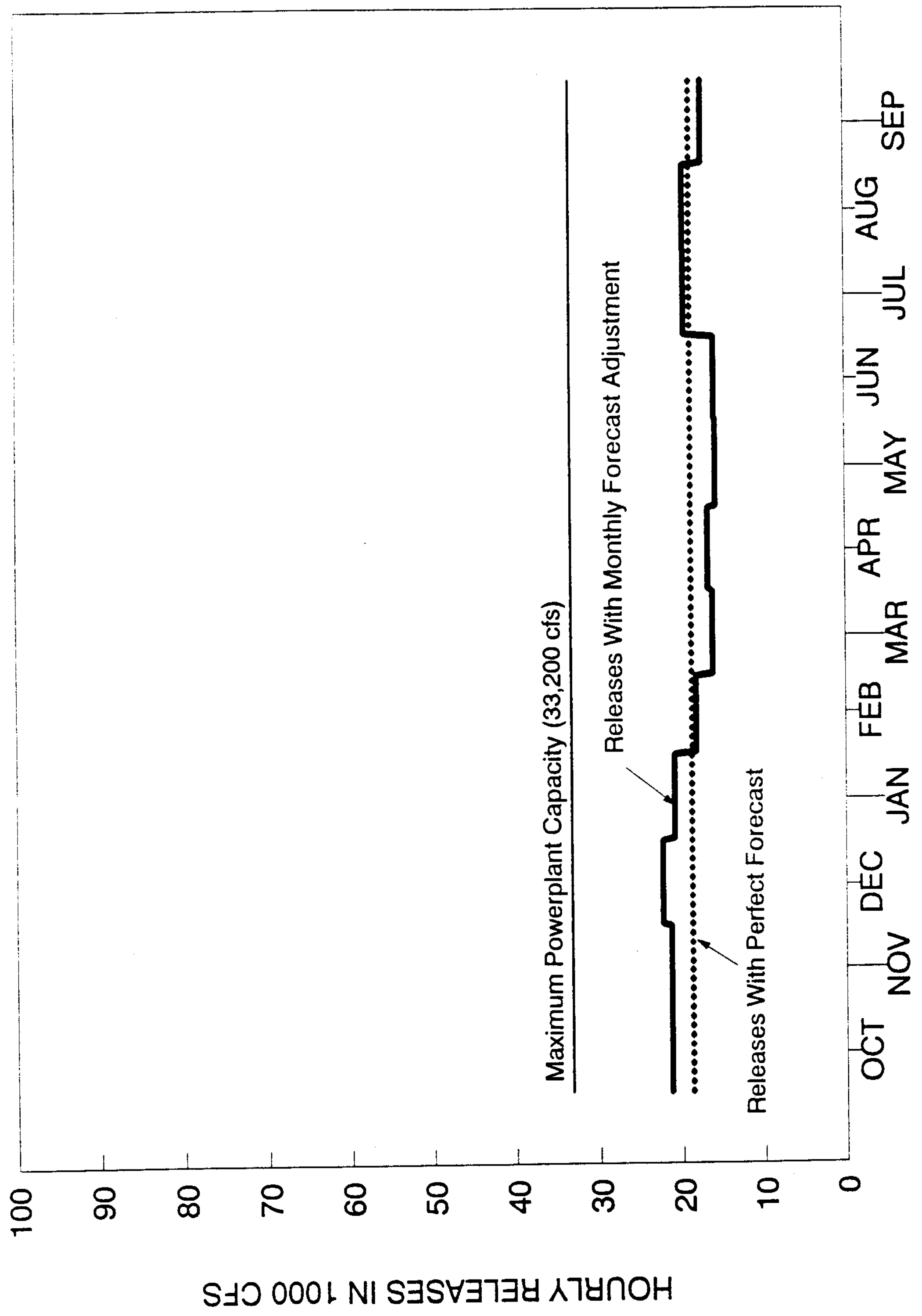
Steady Flow - Year Round

1980 Water Conditions (10.90 maf annual release)



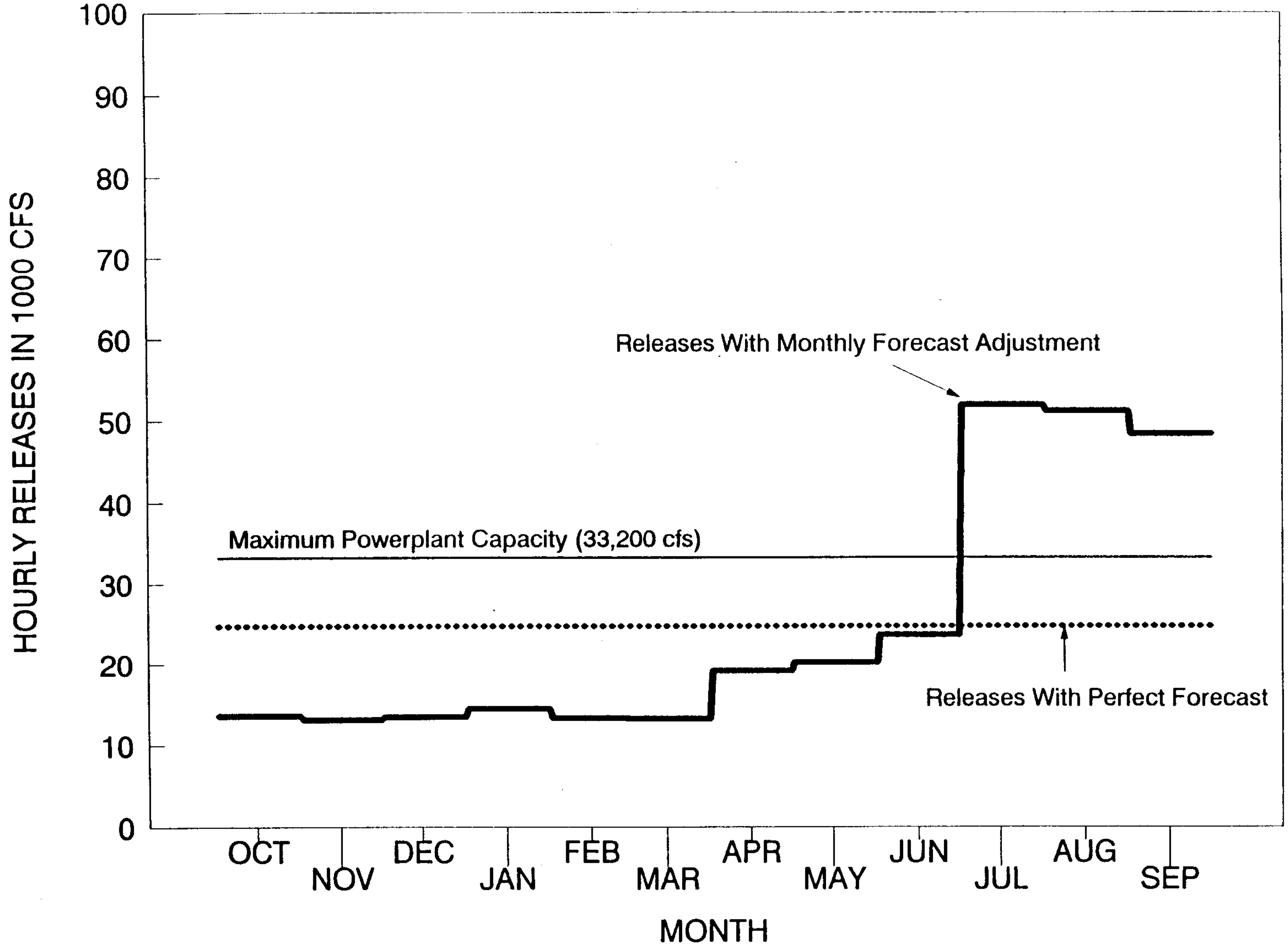
Steady Flow - Year Round

1987 Water Conditions (13.60 maf annual release)



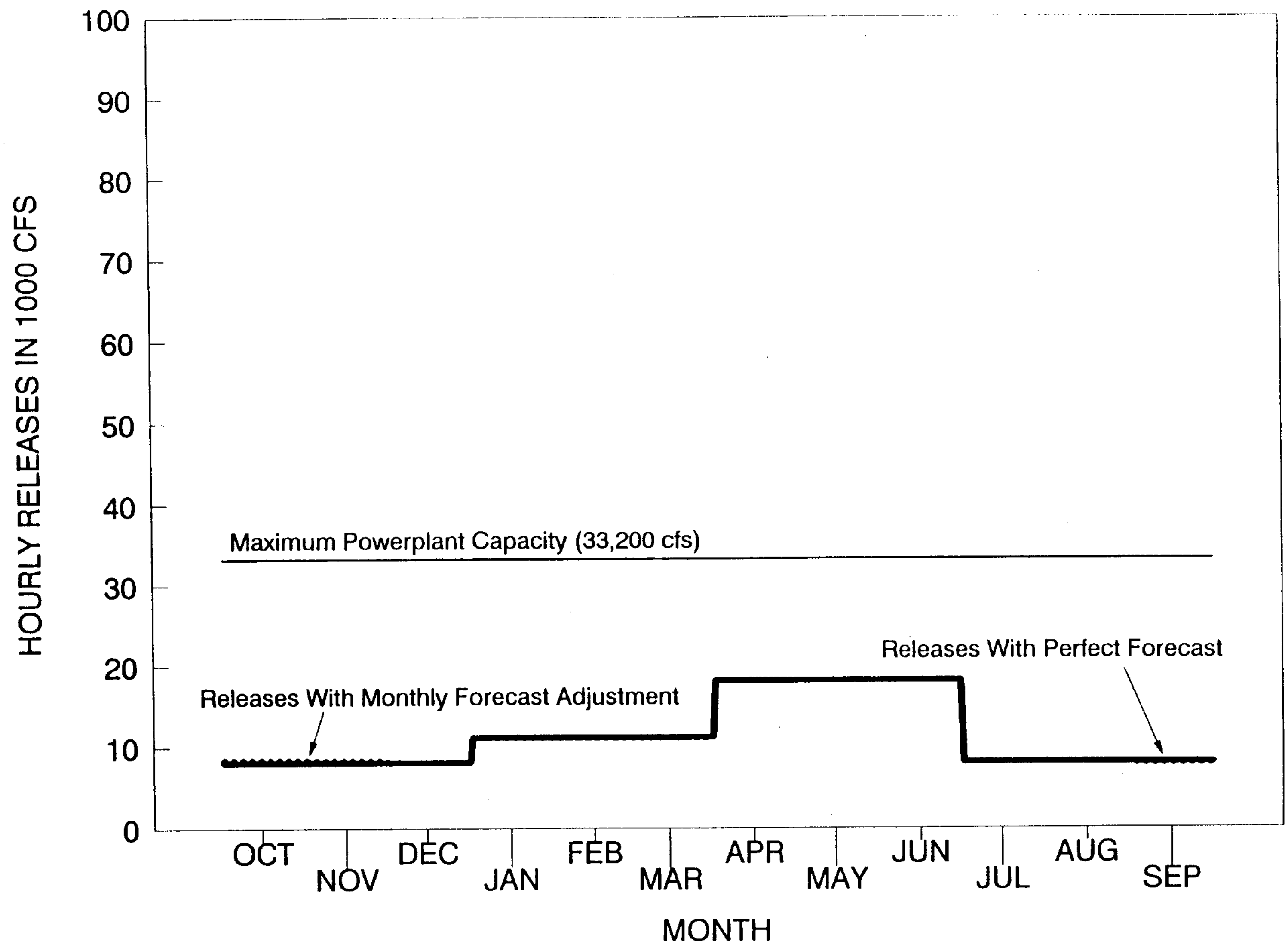
Steady Flow - Year Round

1983 Water Conditions (17.91 maf annual release)



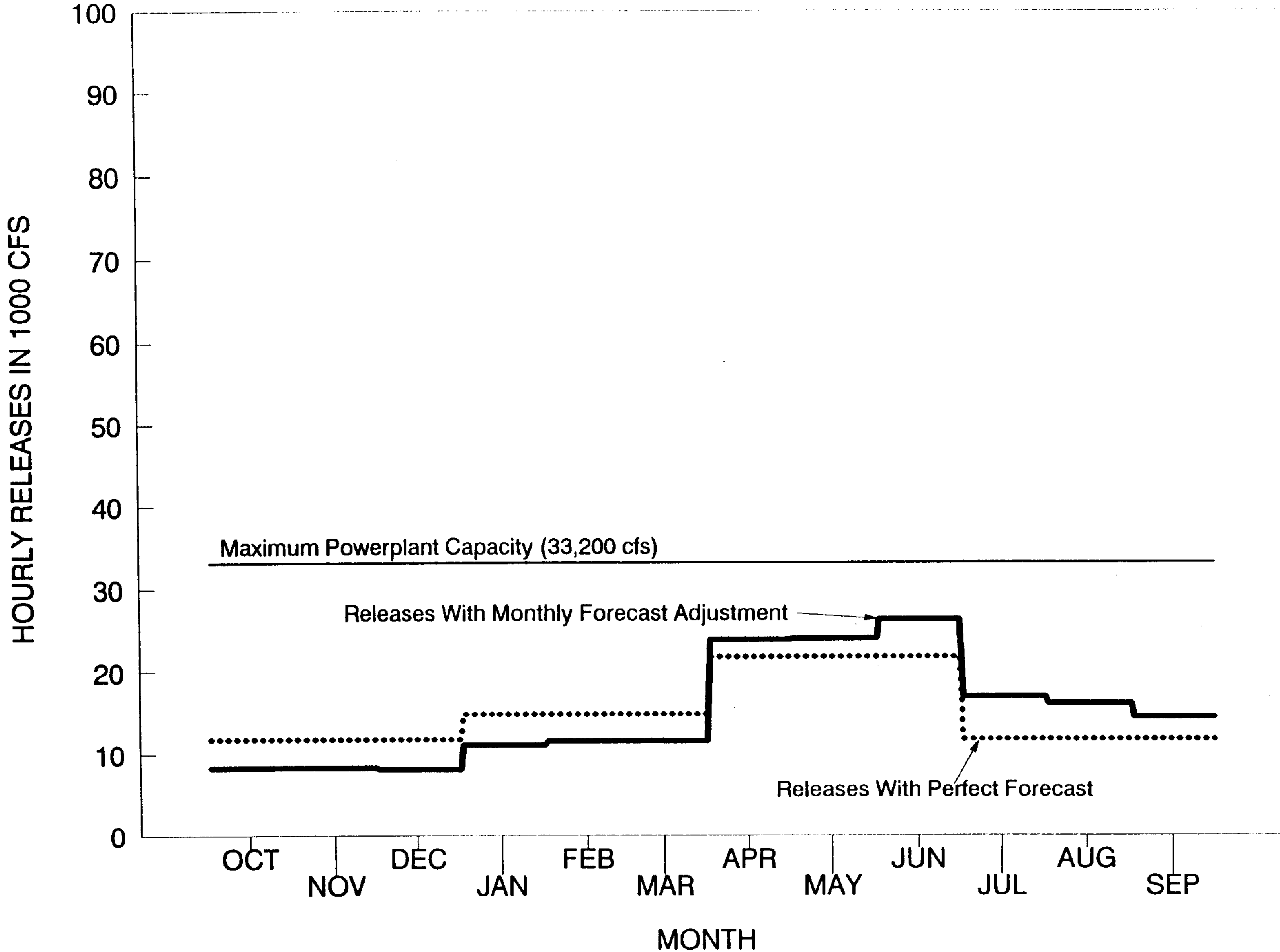
Steady Flow - Seasonally Adjusted

1989 Water Conditions (8.22 maf annual release)



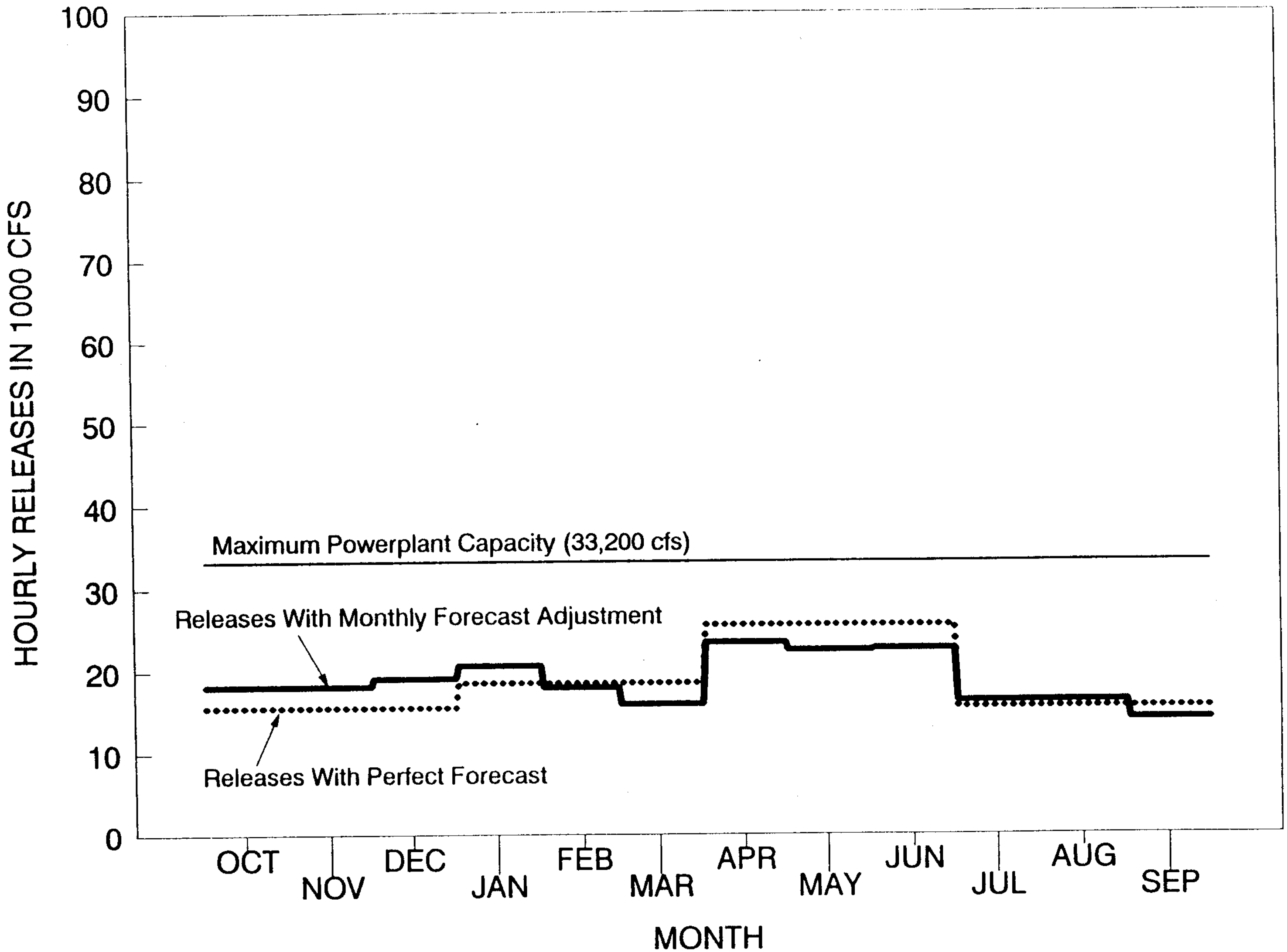
Steady Flow - Seasonally Adjusted

1980 Water Conditions (10.90 maf annual release)



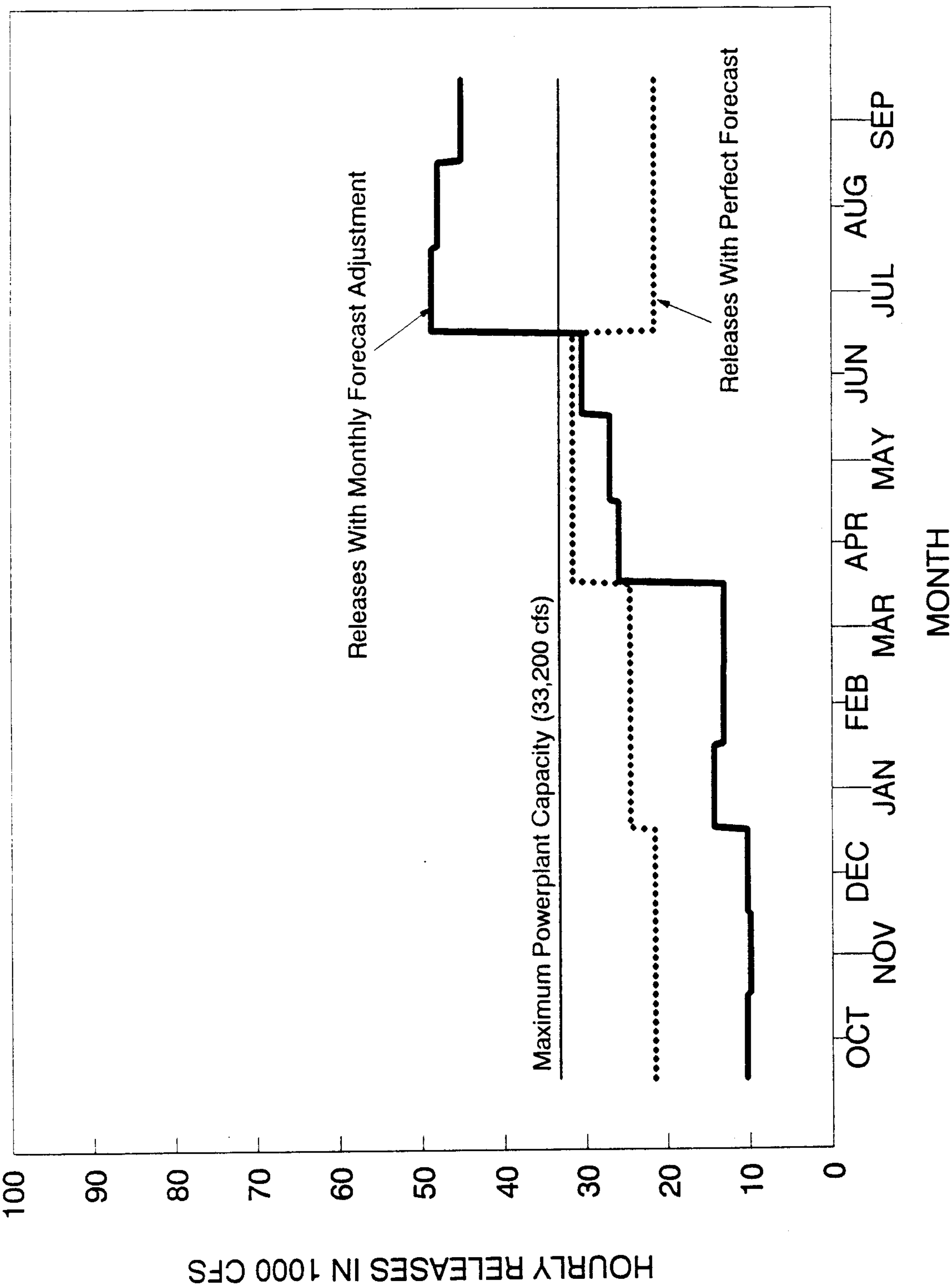
Steady Flow - Seasonally Adjusted

1987 Water Conditions (13.60 maf annual release)



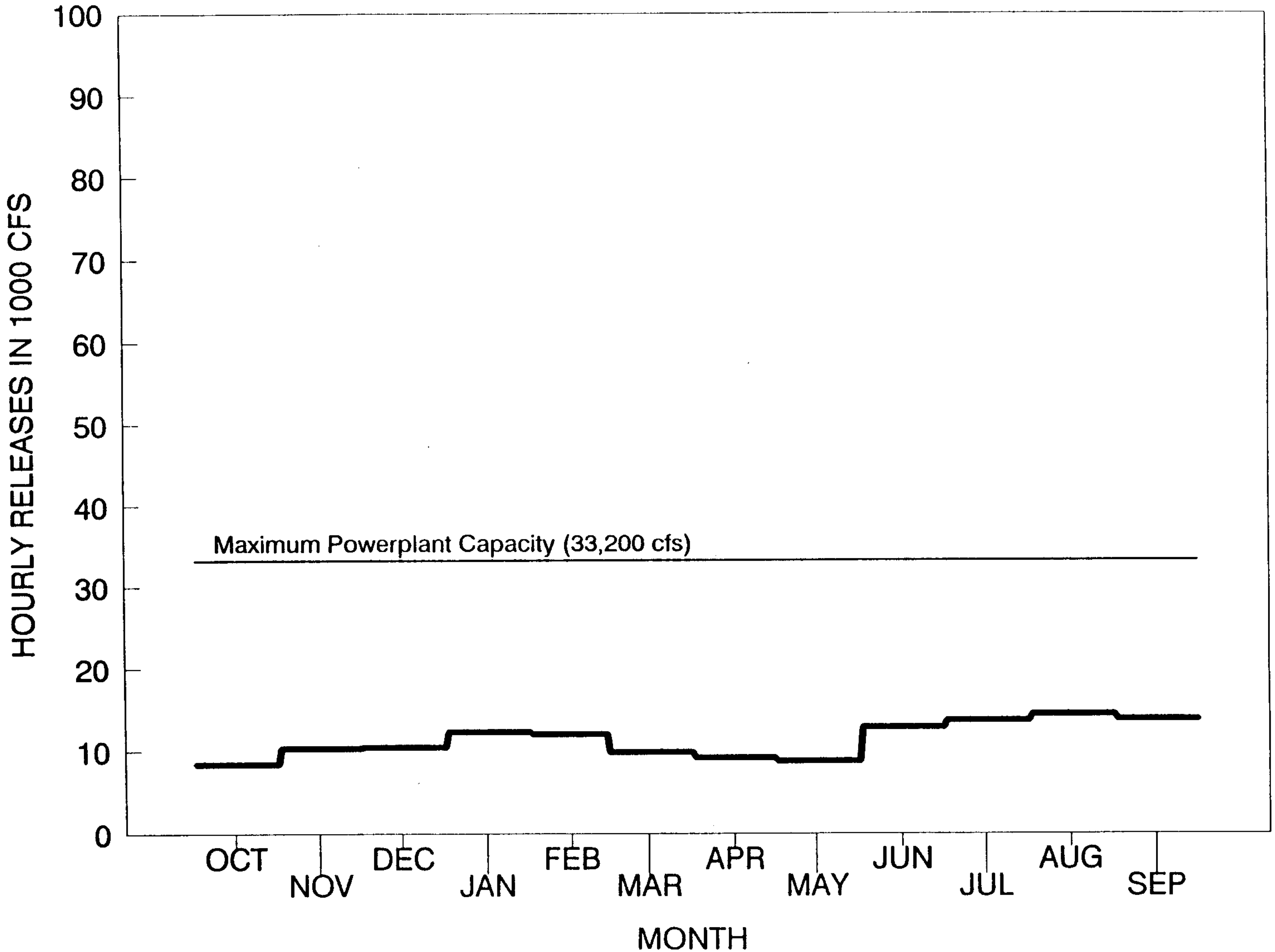
Steady Flow - Seasonally Adjusted

1983 Water Conditions (17.91 maf annual release)



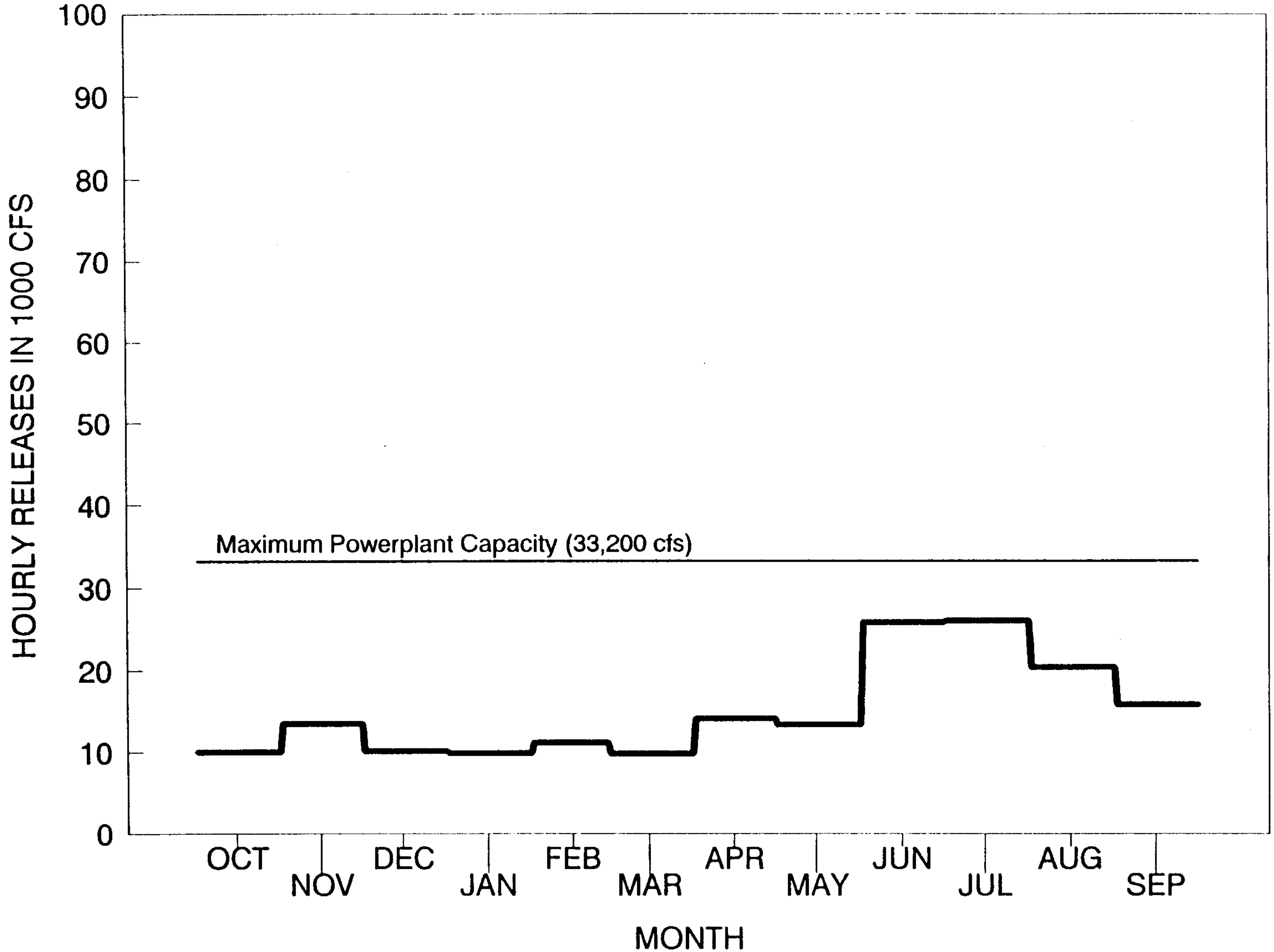
Steady Flow - Existing Monthly Volumes

1989 Water Conditions (8.22 maf annual release)



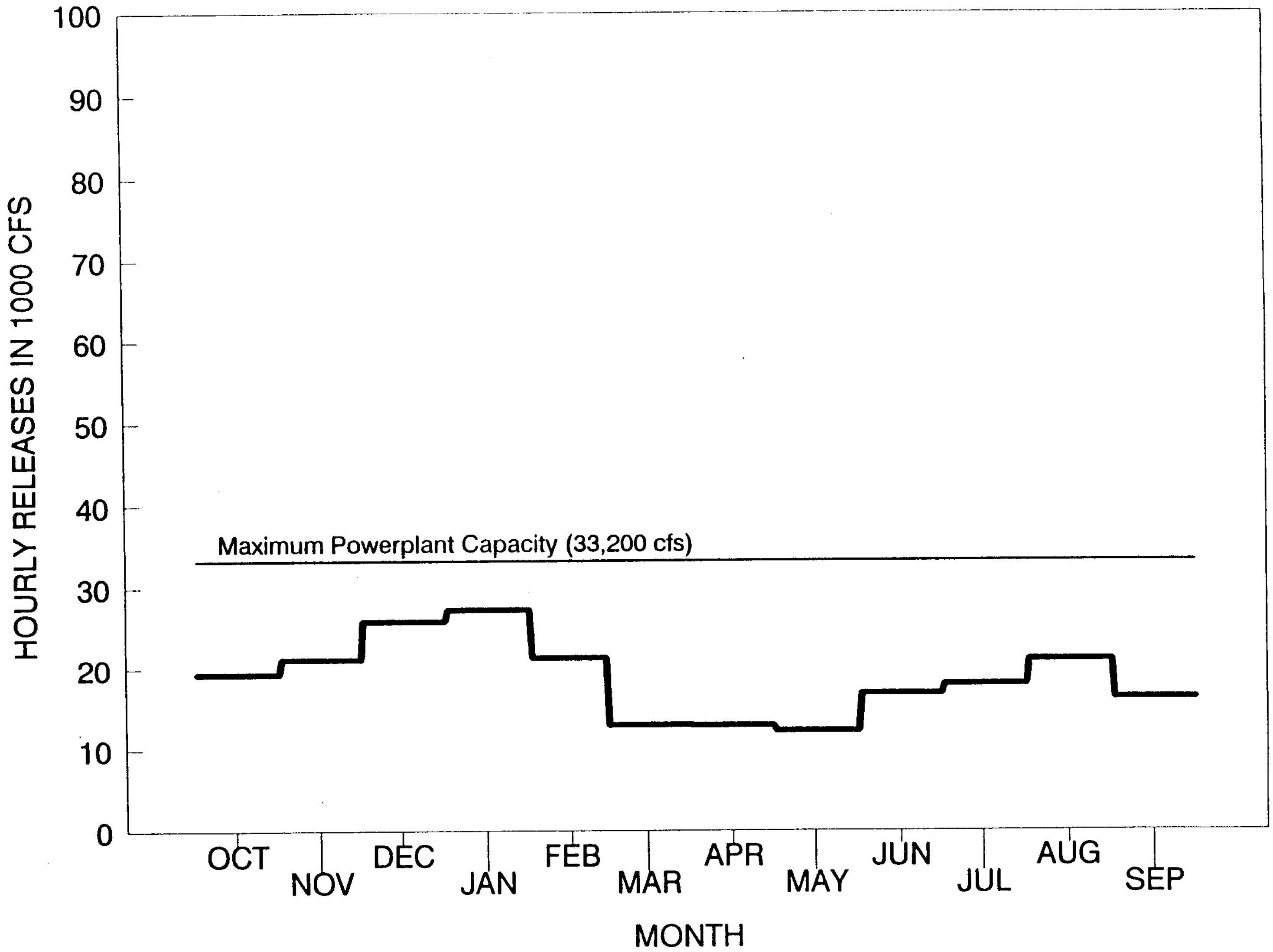
Steady Flow - Existing Monthly Volumes

1980 Water Conditions (10.90 maf annual release)



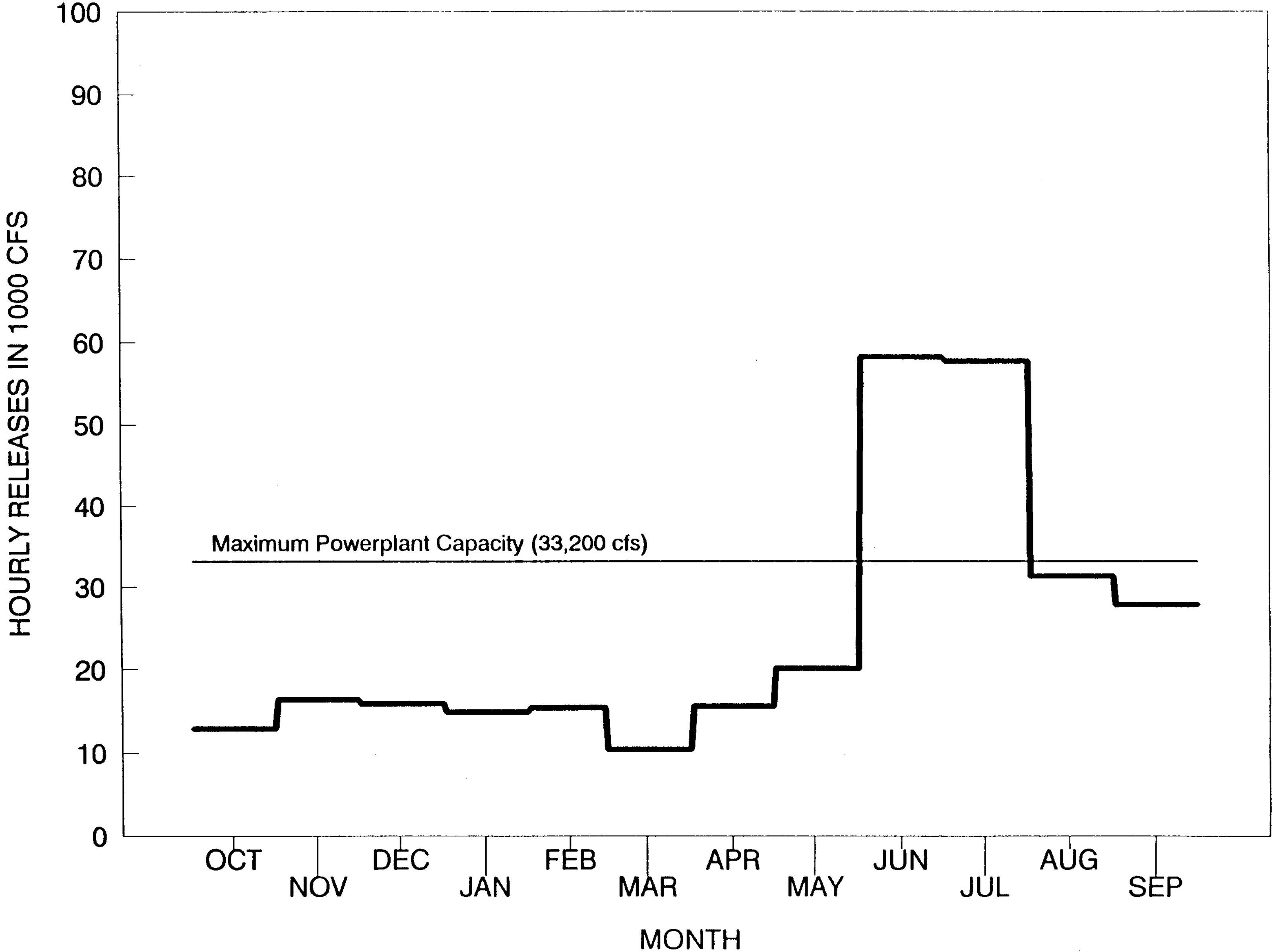
Steady Flow - Existing Monthly Volumes

1987 Water Conditions (13.60 maf annual release)



Steady Flow - Existing Monthly Volumes

1983 Water Conditions (17.91 maf annual release)



Frequencies of Daily Flow Ranges in Percent
Glen Canyon Dam Powerplant

YEAR	0 to 5000	5000 to 10000	10000 to 15000	15000 to 20000	20000 to 25000	25000 to 30000	30000 to 35000
1966	1	49	45	5	0	0	0
1967	8	40	47	5	0	0	0
1968	2	19	55	22	2	0	0
1969	2	19	44	32	3	0	0
1970	2	16	36	40	6	0	0
1971	1	7	32	39	18	3	0
1972	1	12	18	25	37	7	0
1973	6	17	26	24	20	7	0
1974	2	12	29	32	20	5	0
1975	3	12	18	35	28	4	0
1976	0	7	23	36	29	5	0
1977	11	17	24	29	17	2	0
1978	0	13	23	41	21	2	0
1979	5	18	20	30	23	4	0
1980	3	16	38	32	10	1	0
1981	1	21	42	26	10	0	0
1982	0	17	44	33	6	0	0
1983	46	13	19	18	3	1	0
1984	85	12	1	0	2	0	0
1985	33	30	18	13	5	1	0
1986	35	26	22	11	6	0	0
1987	5	16	36	34	9	0	0
1988	1	15	38	34	12	0	0
ALL YEARS	11	18	30	26	12	2	0