FLOW MONITORING AND RESERVOIR WATER LEVEL MEASUREMENT PLAN

BIG CREEK HYDROELECTRIC SYSTEM

MAMMOTH POOL (FERC Project No. 2085)
BIG CREEK NOS. 1 AND 2 (FERC Project No. 2175)
BIG CREEK 2A, 8, AND EASTWOOD (FERC Project No. 67)
BIG CREEK NO. 3 (FERC Project No. 120)

FEBRUARY 2007

SUBMITTED BY
SOUTHERN CALIFORNIA EDISON COMPANY

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1.0 OBJECTIVES

The Flow Monitoring and Reservoir Water Level Measurement Plan (Plan) describes the approach to measurement and documentation of flow conditions in the bypass and augmented stream reaches that will have instream flow requirements specified in the new Federal Energy Regulatory Commission (Commission or FERC) licenses issued to Southern California Edison Company (SCE) for the four Big Creek Alternative Licensing Process (ALP) Projects. It also lays out a process and schedule for the design, permitting and construction of infrastructure changes proposed in the new license and new flow monitoring equipment associated with these infrastructure changes. This Plan also documents the measurement of water surface elevations (water levels) at major Project reservoirs. These Projects include: Mammoth Pool (FERC No. 2085), Big Creek Nos. 1 and 2 (FERC No. 2175), Big Creek Nos. 2A, 8, and Eastwood (FERC No. 67), and Big Creek No. 3 (FERC No. 120).

2.0 INTRODUCTION

This Plan describes how SCE will measure and document flow conditions and reservoir water levels for the four ALP Projects. This Plan describes how instream flow information will be collected and recorded to document compliance with instream flow requirements. This Plan describes the equipment proposed to collect and record flow information and identifies the locations where instream flow measurements will be collected within the Basin. The Plan documents how information on water levels at major ALP Project reservoirs is collected.

The Plan includes the following components:

- Location and Design of Flow Monitoring Equipment
- Instream Flow Monitoring, and Recording of Flow Data
- Operation, Maintenance, and Calibration of Flow Monitoring Equipment
- Schedule for Designing, Permitting and Installing Infrastructure Changes and Associated Flow Monitoring Equipment
- Flow Data Dissemination to Resource Agencies
- Reservoir Water Surface Elevation Measurement

Each of these topics is addressed in the following sections of this Plan.

3.0 LOCATION AND DESIGN OF EXISTING FLOW MONITORING EQUIPMENT

SCE currently operates an extensive network of flow monitoring equipment in the vicinity of the four Big Creek ALP Projects to monitor and record stream flows at various locations. Instream flow is measured at either stream gages or flow release structures.

The types of equipment used to monitor flow at each location may potentially include Acoustic Velocity Meters (AVMs), float level recorders, pressure transducers, bubblers, or other flow measurement equipment, depending on location conditions. There are many factors that will influence the choice of flow measurement equipment selected. Such factors include the specific infrastructure present at the diversion or in the bypass reach, site remoteness, site climatic conditions, visibility of satellites or radio reception, and availability of electricity.

Table 1 identifies the stream bypass or augmented reaches where changes in minimum instream flow are proposed, whether infrastructure changes are proposed, and whether instream flows are currently gaged in those locations. Table 1 also indicates where new instream flow gages are currently proposed and the proposed type of measurement equipment to be installed. SCE will evaluate the choices of flow measurement equipment and will choose the specific equipment that is both practicable for the location and meets the needs of complying with the terms of the FERC license. SCE will obtain the approval of the Chief of the Division of Water Rights prior to installing new equipment.

4.0 INSTREAM FLOW MONITORING, COLLECTING, AND RECORDING OF FLOW DATA

To document compliance with required instream flows, SCE shall monitor flow for the various Project bypass and augmented reaches at the locations identified in Table 1. Table 1 presents the current United States Geological Survey (USGS) gage number for those compliance gages currently in operation. During operation of facilities, SCE will monitor the required 24-hour average and instantaneous (instantaneous floor) instream flows. The instantaneous flow is the flow value used to construct the average daily flow value and will be measured in time increments of at least once every 15-minutes. The 24-hour average flow is the average of the incremental readings from midnight of one day to midnight of the next day. Except for malfunctions or occurrences beyond the control of SCE, 24-hour average, instantaneous flows will be measured at each site during the period the associated diversion point is diverting water. The instream flow requirements allow the Licensee to compensate for an under release, as follows:

- Should the 24-hour average flow as measured, be less than the 24-hour average flow, but more than the Instantaneous Flow (instantaneous floor), Licensee shall begin releasing the equivalent under-released volume of water within seven days of discovery of the under-release. Credit for such releases will not exceed 20% of the instantaneous flow amount, when used to attain the equivalent of the under-released volume.

Therefore, under-releases and volumes released to compensate for under-releases will be documented to demonstrate compliance, as needed, based upon the 15-minute flow recordings which will be available upon request. The 24-hour average flow values will be reported to the USGS on an annual basis. The 15-minute recordings used to construct the 24-hour average flows will be available from SCE upon request. Turn-in and turn-out dates for small diversions also will be available upon request.

5.0 OPERATION, MAINTENANCE, AND CALIBRATION OF FLOW MONITORING EQUIPMENT

The type and frequency of maintenance activity on the flow monitoring equipment, and the methods and frequency used to calibrate the flow measuring devices will depend on the equipment chosen to monitor stream flows and the quality assurance (QA) requirements of USGS. SCE will use the QA requirements outlined in the May 15, 2006 letter from the USGS to FERC cooperators (Attachment A), or such USGS requirements that may supercede these in the future.

As presented in Table 1, the proposed types of equipment used to monitor flow include AVMs and float level recorders (as stated previously, the type of equipment selected may change due to infrastructure limitations that are dependant on the license requirements). SCE has identified the locations and types of equipment to be used for monitoring flow in Table 1. As stated previously, SCE will evaluate the choices of gaging equipment and will choose the equipment that is practical for application and best meets SCE's needs to comply with the conditions of the FERC license. As discussed above, several factors may influence SCE's ability to operate equipment, especially during the winter. Due to low flows and severe winter conditions at elevations over 5,000 feet (ft) in the Project area, it may not be feasible to operate flow-measuring equipment in smaller streams during winter months, when SCE is not diverting flow from those streams.

Calibration of the AVMs will be performed biannually using a portable AVM. Float level recorders or bubblers will include the collection of current meter measurements to verify the rating tables. Float level recorders and bubblers will be checked on a monthly basis by SCE by comparing the inside recorder reading to the outside permanent staff gage reading for any discrepancies. The USGS also conducts biannual inspections to verify the calibration of the rating curves for each of the gaging stations for which it is responsible for reviewing and publishing flow records.

6.0 SCHEDULE FOR INSTALLING FLOW MONITORING EQUIPMENT

A schedule for installing any additional flow monitoring equipment is provided as Table 2 to this Plan. Engineering, design, and construction is scheduled to begin after the new license is final and no longer subject to appeal. This work may differ among the four licenses. Where significant infrastructure modifications are necessary to release the instream flows, SCE has provided a preliminary engineering and construction schedule for infrastructure modifications and gage installation. The

schedule may be updated as evaluation of site conditions, preliminary engineering, and permitting for each site is completed. Licensee will notify the agencies if there are changes to the schedule resulting in a change of one year or more.

7.0 LOCATION, DESIGN AND PERMITTING PROCESS FOR INFRASTRUCTURE CHANGES AND NEW FLOW MONITORING EQUIPMENT

The proposed infrastructure changes necessary for the release of instream flows and gaging are identified in Table 1. The engineering, design, construction, and permitting by resource agencies other than FERC for each location will vary. In some cases, access will need to be provided for construction equipment. It is expected that infrastructure changes at Dam 4, Mammoth Pool Dam, and Dam 6[1] may involve the most extensive engineering and construction work. Site access below Dam 4 and Dam 6 is particularly difficult and access is likely to necessitate additional construction, or, depending upon site-specific conditions, alternative design strategies.

For Ross, Balsam, and Ely creeks, new float type gages shall be installed downstream of these diversions. The design and installation of these gages will likely involve the construction of gaging weirs with associated in-channel construction.

For each site at which infrastructure changes are proposed, preliminary engineering work, including design, likely construction approach, and access needs, will be assessed first. Based on this preliminary work, necessary permits from resource agencies other than FERC to construct the infrastructure changes will be identified. SCE will prepare a description for each infrastructure modification proposal that is identified to need additional permits and consult with the appropriate agencies regarding permits necessary for construction-related activities. Permit applications will be prepared and any necessary site-specific studies will be carried out, while engineering design proceeds. It is anticipated that sites involving instream construction or otherwise affecting the stream channel for access and use of heavy equipment may involve the need for the following permits:

- US Army Corps of Engineers (USACE) 404 Permit (the use of a Nationwide 3 Permit is assumed, and consultation with the U.S. Fish and Wildlife Service (USFWS), if necessary)
- California Department of Fish and Game (CDFG) Streambed Alteration Agreement
- State Water Resources Control Board (State Water Board) 401 Permit or Waiver
- Preparation of U.S. Department of Agriculture-Forest Service (USDA-FS) Biological Evaluation (BE)

[1]The need for infrastructure change at Dam 6 is being evaluated.

The majority of the information needed will be derived from SCE's ALP relicensing studies. The Biological Assessment for the ALP will address threatened and endangered species issues. In some cases, additional site-specific surveys may be needed for special-status plants and animals. The need for site-specific studies will be based on consultation with the agencies.

Where needed, procurement of equipment and support services to implement the infrastructure modifications will take place, when design work is complete. The timing of these activities will vary with location due to potential differences in license issuances, site-specific design issues, permitting, and procurement. In general, SCE will plan to stagger timing of construction to allow for efficient use of personnel and resources.

8.0 RELEASE OF INSTREAM FLOWS

After installation of necessary infrastructure and flow monitoring equipment, SCE will release instream flows in accordance with the terms of the new licenses. As indicated above, compliance with instream flow requirements will be measured at the appropriate gage, as indicated in Table 1. The gages identified for monitoring flow at SCE's small diversions will not be operated when SCE stops diverting at those locations (turn out of diversions). Diversions will be turned out when the natural stream flow upstream of diversions decreases to or below the instream flow required for that stream, or as agreed to in the instream flow schedule.

The instream flow releases may be temporarily modified, if required for safety reasons, by operating emergencies, by actions beyond the control of SCE (including, but not limited to "acts of God" and natural events), or upon agreement between SCE, the USDA-FS, State Water Board, USFWS, and CDFG for short periods.

9.0 FLOW DATA DISSEMINATION TO RESOURCE AGENCIES

SCE will measure and document all instream flow releases in readily accessible formats. Flow data collected by SCE from the stream gages will be reviewed by SCE hydrographers as part of its QA/QC protocol. Upon completion of the QA/QC process, the data will be catalogued and made available to USGS in annual hydrology summary reports. SCE understands that the USGS will then complete their QA/QC review of the data and subsequently publish the data and post it within their electronic database that can be accessed via the Internet. The flow values (generally 15-minute recordings) used to construct the 24-hour average flows will be available to the resource agencies from SCE upon request.

10.0 RESERVOIR WATER SURFACE ELEVATION MEASUREMENT

SCE measures and documents water surface elevations at each major reservoir. Water levels are measured and reported at midnight each day. For each major reservoir included in the ALP, Table 3 presents the location, gage number, and gage type. The datum of each gage is referenced to sea level as determined by SCE.

TABLES

Table 1. Status of Compliance Gages for Streams with Proposed Changes in Minimum Instream Flows.

	Streams with Proposed Changes in Minimum Instream Flow	Streams with Proposed Changes in Infrastructure at Diversion	Current Status of Gaging		Existing Gage Number	Proposed Flow Monitoring		Type of New Gage Proposed	
			Currently Gaged	Not Currently Gaged		Currently Gaged	New Gage Proposed	Acoustic Velocity Meter (AVM)	Float Type
Mammoth Pool (FERC Project No. 2085)									
SJR (Mammoth Pool Dam to Dam 6)	X	X	X		USGS 11234760	X	X	X	
Rock Creek	X	X		X	-		X	X	
Ross Creek	X	X		X	-		X		X
Big Creek Nos. 1 and 2 (FERC Project No. 2175)									
Big Creek (Huntington Lake to Dam 4)	X		X		USGS 11237000	X			
Big Creek (Dam 4 to Dam 5)	X	X		X	-		X	X	
Balsam Creek (Diversion to Big Creek)	X	X		X	-		X		X
Ely Creek	X	X		X	-		X		X
Big Creek 2A, 8, and Eastwood (FERC Project No. 67)									
South Fork SJR	X		X		USGS 11230215	X[1]			
Bear Creek	X		X		USGS 11230530	X		X	
Mono Creek (Downstream of Mono Diversion)	X	X	X		USGS 11231600	X	X[2]	X	
Bolsillo Creek	X		X		USGS 11230670	X			
Camp 62 Creek	X		X		USGS 11230600	X			
Chinquapin Diversion	X[3]		X		USGS 11230560	X			

Table 1. Status of Compliance Gages for Streams with Proposed Changes in Minimum Instream Flows (continued).

	Streams with Proposed Changes in Minimum Instream Flow	Streams with Proposed Changes in Infrastructure at Diversion	Current Status of Gaging		Existing Gage Number	Proposed Flow Monitoring		Type of New Gage Proposed	
			Currently Gaged	Not Currently Gaged		Currently Gaged	New Gage Proposed	Acoustic Velocity Meter (AVM)	Float Type
Big Creek 2A, 8, and Eastwood (FERC Project No. 67) (continued)									
Hooper Creek	X		X		USGS 11230200	X			
Big Creek (Dam 5 to SJR)	X	X	X		USGS 11238500	X	X[4]	X	
Pitman Creek	X		X		USGS 11237700	X			
Balsam Creek (Forebay to Diversion)	X		X		USGS 11238270	X			
North Fork Stevenson Creek	X		X		USGS 11239300	X			
Stevenson Creek	X		X		USGS 11241500	X			
Big Creek No. 3 (FERC Project No. 120)									
SJR (Dam 6 to Redinger)	X	X	X		USGS 11238600	X			
Portal Hydroelectric Project (FERC Project No. 2174)									
Camp 61 Creek (below Portal Forebay)	X	X		X			X	X	

[1]A new gage has been installed and will be calibrated to better characterize high flow events.
[2]A new gage (AVM) will be installed to monitor increased MIFs under the new license.
[3]24-hour average flow remains the same, but instantaneous floor is added.
[4]An AVM will be installed at Dam 5 to monitor MIF releases. The existing downstream gage (USGS No. 11238500) will be operated to monitor higher flow events

Table 2. Preliminary Schedule for Infrastructure Changes Necessitated by New MIF Schedule.

	2008	2009	2010	2011	2012	2013	2014	2015
Mammoth Pool (FERC Project No. 2085)								
SJR (Mammoth Pool Dam to Dam 6)	Preliminary Engineering, Permitting,	Engineering, Ordering Equipment	Begin Construction	X	X	X		
Rock Creek	Preliminary Engineering, Permitting,	Engineering, Ordering Equipment	Begin Construction	X				
Ross Creek	Permitting, Engineering, Ordering Equipment	Begin Construction	X					
Big Creek Nos. 1 and 2 (FERC Project No. 2175)								
Big Creek (Dam 4 to Dam 5)	Preliminary Engineering, Site Evaluation	Permitting, Engineering	Engineering, Ordering Equipment	Begin Construction	X			
Balsam Creek (Diversion to Big Creek)	Preliminary Engineering, Permitting,	Engineering, Ordering Equipment	Begin Construction	X				
Ely Creek	Preliminary Engineering, Permitting,	Engineering, Ordering Equipment	Begin Construction	X				
Big Creek 2A, 8, and Eastwood (FERC Project No. 67)								
Mono Creek (Downstream of Mono Diversion)	Preliminary Engineering, Permitting,	Engineering, Ordering Equipment	Begin Construction	X				

Table 2. Preliminary Schedule for Infrastructure Changes Necessitated by New MIF Schedule (continued).

	2008	2009	2010	2011	2012	2013	2014	2015
Portal Powerhouse (FERC Project No. 2174)								
Camp 61 Creek	Permitting, Engineering, Ordering Equipment	Begin Construction	X					
Big Creek (Dam 5 to SJR)	Preliminary Engineering, Site Evaluation	Permitting, Engineering,	Ordering Equipment	Begin Construction				
Big Creek No. 3 (FERC Project No. 120)								
SJR (Dam 6 to Redinger)[6]	Preliminary Engineering, Site Evaluation	Permitting, Engineering,	Engineering, Ordering Equipment	Begin Construction	X			

[1]Gray shading indicates continuing activities.

[2]X indicates activity likely to continue into the indicated year.

[3]Gray diagonals indicate that some activities may continue into this year, but less likelihood than for solid gray shading.

[4]Some preliminary site and engineering work may take place prior to license issuance.

[5]Years indicated are generally dependent upon license issuance and possible appeals. Delays in license issuance or by appeals may delay indicated schedules by license.

[6]The extent of needed construction will be re-evaluated after site inspection and preliminary engineering. This may alter the construction schedule at this site.

Table 3. Reservoir Water Level Gages at Major Reservoir.

Reservoir	Gage Number	Gage Type
Big Creek Nos. 1 and 2 (FERC Project No. 2175)		
Huntington Lake	USGS No. 11236000	Water-stage recorder
Big Creek 2A, 8, and Eastwood (FERC Project No. 67)		
Florence Lake	USGS No. 11229600	Water-stage recorder
Shaver Lake	USGS No. 11239500	Water-stage recorder
Mammoth Pool (FERC Project No. 2085)		
Mammoth Pool Reservoir	USGS No. 11234700	Water-stage recorder

ATTACHMENT A

MAY 15, 2006 LETTER FROM THE USGS TO FERC COOPERATORS

IN REPLY REFER TO:

United States Department of the Interior

U. S. GEOLOGICAL SURVEY
California Water Science Center
6000 J Street, Placer Hall
California State University
Sacramento, California 95819-6129
Phone: (916) 278-3026 Fax: (916) 278-3045
http://water.wr.usgs.gov

May 15, 2006

To Whom It May Concern:

You are receiving this letter because you furnish surface-water data to the United States Geological Survey (USGS), California Water Science Center (CAWSC), for quality assurance and publication. This letter, together with the attached document entitled "Guidance and Instructions for the Preparation of Data Furnished to the USGS for Review and Publication" and a reference CD, provide the USGS and CAWSC policy and standards for acceptable furnished data.

As part of the internal USGS quality assurance process, streamgaging activities of each USGS Water Science Center are reviewed to ensure uniform quality and adherence to USGS standards. The 2002 review of the CAWSC revealed some deficiencies requiring improvement. The most common problems concerned records furnished to the CAWSC by non-USGS entities. The review concluded that some streamflow records furnished to the CAWSC were not collected or computed to the same standards as normal USGS data or lacked required documentation of the data collection process. USGS policy requires that furnished data be collected and computed to the same standards as data collected by the USGS. Therefore, the CAWSC will be adhering to the guidelines provided in the attachments to this letter as a condition for the acceptance of all furnished data.

In order to allow the time necessary for review (and possible corrections) of furnished data prior to publication, all furnished data must be received by the reviewing USGS field office no later than December 15th for the water year ending September 30th. This deadline will be effective for the 2006 water year ending September 30, 2006.

If you have any questions or problems regarding this letter or USGS standards, please call Denis O'Halloran, FERC Coordinator for the CAWSC, at (916) 278-3168, or send him email at dohall@usgs.gov.

Sincerely,

Michael V. Shulters
Director, California Water Science Center

Enclosures

Guidance and Instructions for the Preparation of Data Furnished to the USGS for Review and Publication

Annual Review of Furnished Records

The annual review by USGS personnel of furnished records is designed to ensure that furnished records are collected in accordance with USGS standards. The review also provides a mechanism for identifying opportunities for improvement. During the review and during visits to streamgaging facilities, USGS personnel will identify areas, if any, that need improvement. Cooperators may consult USGS staff as they endeavor to make these improvements. For records provided to the USGS as a condition of a FERC license, the USGS will report unresolved deficiencies to the FERC for follow-up action.

To allow the time necessary for review (and possible corrections) of furnished data prior to publication, all furnished data must be received by the reviewing USGS field office no later than **December 15th** for the water year ending September 30th. This deadline will be effective for the 2006 water year ending September 30, 2006. Records not received by the due date will not be included in the annual data report for that water year.

Technical References, USGS standards for streamgaging

As an aid to those providing furnished records, the California Water Science Center created the enclosed CD that includes USGS OFR 96-618 (Surface Water Quality Assurance Plan for the California District (now called California Water Science Center)) and several procedural and technical guidelines for non-USGS hydrographers.

USGS Open-File Report (OFR) 96-618, "Surface Water Quality Assurance Plan for the California District of the U.S. Geological Survey,"

(http://ca.water.usgs.gov/archive/reports/ofr96618/)

summarizes and supplements data collection and computation techniques, practices, and policies described in applicable USGS Techniques of Water Resources Investigations (TWRI's), other USGS published documents, and USGS Technical memoranda. Collectively, these documents, each addressing different streamgaging activities, constitute "USGS standards." These references are included on the enclosed CD for your use.

Two interactive courses have also been created and are available on the Internet at the following URLs:

Surface-Water Field Techniques Training Class:
http://wwwrcamnl.wr.usgs.gov/sws/SWTraining/FlashFandR/Index.html

Stage-Discharge Relations – Basic Concepts:
http://wwwrcamnl.wr.usgs.gov/sws/SWTraining/RatingsWeb/Index.html

Many USGS publications are now available on line and can be retrieved at the following URL: http://water.usgs.gov/pubs. A limited number of CD-based classes on wading measurements, cableway measurements, ice measurements, and levels are available. Please contact your local USGS Field office if you are interested in obtaining one of these CDs.

Materials to Be Included for Review of Furnished Record

Materials that should be provided for review are described in OFR 96-618 and include:

- Daily values table for the water year
- Hydrograph of daily discharge values
- List of discharge measurements
- Copies of discharge measurements
- Primary computation sheets (hourly gage-heights, shifts, datum corrections)
- Copy of any graphic record used for computation
- New rating tables and new rating curves
- Station analysis (explaining how and why ratings were changed, shifts, and datum corrections for the current water year)
- A copy of the latest gaging station levels
- Station description, updated annually as necessary, including:
    - The surveyed elevation of at least three reference marks; and,
    - A revised "Quality Assurance" section containing the information described below.

Questions about what should be included in the review package can be directed to the local USGS Field Office or the FERC coordinator.

Development and Maintenance of Discharge Ratings

Collection and computation of high-quality streamflow data require the development and maintenance of discharge ratings, instrument ratings, or both. Developing and maintaining ratings are among the more challenging aspects of streamgaging. For natural channels, stage-discharge relations (rating curves or tables) are usually defined by discharge measurements (using current-meter or hydroacoustic instrumentation) of sufficient number to define the rating over a sufficient range of discharge, along with applicable changes (shifts) to the rating. Measurements generally are made every 4-8 weeks (depending on the site), and may be required more frequently to document significant changes in channel conditions that will affect the rating. Ratings are then adjusted in accordance with the measurement data. If discharge measurements covering the entire range of stage observed during a period of time indicate that the stage-discharge relation is stable, there is little problem in defining the discharge rating for that period.

In WSP-2175, Measurement and Computation of Streamflow, (included on CD), S.E Rantz states: "At a new station many discharge measurements are needed to define the stage-discharge relation throughout the entire range of stage. Periodic measurements are needed

thereafter to either confirm the permanence of the rating or to follow changes (shifts) in the rating. A minimum of 10 discharge measurements per year is recommended, unless it has been demonstrated that the stage-discharge relation is unvarying with time. In that event the frequency of measurements may be reduced. It is of prime importance that the stage-discharge relation be defined for flood conditions and for periods when the rating is subject to shifts as a result of ice formation (see section titled, "Effect of Ice Formation on Discharge Ratings") or as a result of the variable channel and control conditions discussed in the section titled, 'Shifts in the Discharge Rating'. It is essential that the stream-gaging program have sufficient flexibility to provide for the non-routine scheduling of additional measurements of discharge at those times."

The USGS will make two discharge measurements which will serve as check measurements each year. These measurements are **in addition to, and do not substitute for**, measurements to be made by the licensee. These check measurements represent a key part of the quality assurance process. If there are any questions about the number of discharge measurements to be made by the licensee at a particular site, guidance should be obtained from the local USGS field office.

As part of the normal operation and maintenance of a streamgage, a leveling survey is required every 3 years. For sites that have proven to be particularly stable over the years, the interval between leveling surveys can be extended to 5 years after discussion with and approval by the local USGS Field Office Chief. Three Reference Marks (RMs), all staffs, point of zero flow (pzf), and present water surface should be surveyed during the leveling survey. These are minimum quality assurance procedures. Much more may need to be done if unusual events occur.

Ratings Based on Powerplant Records

Discharge ratings developed for well-maintained turbines and penstocks are usually very stable and accurate. However, worn or damaged meters, orifices, valves, and piping or obstructed passages may result in significant rating changes. The planned technique for ensuring the accuracy of turbine and penstocks ratings, and how often the technique is to be, should be described in the "Quality Assurance" section of the station description. Where possible, such ratings should be checked periodically by independent data such as measurements made using current-meters or AVMs (Acoustic Velocity Meters).

Ratings at Sites with Hydraulic Structures and Hydroacoustic Devices

Properly calibrated and maintained weirs, flumes, or gates (hydraulic structures), various hydroacoustic devices including ultrasonic-velocity meters (UVMs), Acoustic Velocity Meters (AVMs), Acoustic Doppler Velocimeters (ADVMs), Acoustic Doppler Current Profilers (ADCPs), and occasionally, dye-dilution techniques, may be used to collect and verify streamflow records. Use of these techniques requires skilled application and periodic verification or recalibration of instruments and ratings. FERC licensees who use hydraulic structures or other technologies often do so to reduce the number of measurements required to maintain the discharge rating, or to overcome physical limitations that make discharge measurements impractical. Plans for using these methods should be discussed with the USGS field office that will review the data, and the methods should be described under the "Quality

Assurance" section of the station description. The methods used to verify streamflow records will vary depending on gaging conditions.

USGS standards require that the typical stage-discharge relation be checked by periodic discharge measurements (made by the licensee) to ensure that the relation still is applicable and to provide for adjustment of the rating as needed. Hydraulic structures are often used to improve rating sensitivity and stability. However, while ratings for hydraulic structures are usually more precise than those for natural streams, they introduce other factors that require additional consideration. Theoretical or manufacturer ratings for hydraulic structures should be checked by a minimum of two discharge measurements made by the licensee each year (one each on the high-and low-ends of the rating) or as needed to define shifting conditions. This minimum number (two) of measurements can only be justified under the ideal conditions for which the structure was designed. The accumulation of debris, aquatic growth on surfaces, degradation or erosion of contact surfaces, changed or unstable approach conditions, expansion and contraction of materials used in the structure, and settling, all can affect the rating and result in inaccurate or biased discharge estimates. These factors necessitate the need for increased monitoring and measurements to verify the applicability of the rating.

Generally, UVM ratings are stable and accurate, but periodically they should be verified by an independent means such as using temporary clamp-on UVM's, current meter measurements, or against independently developed turbine ratings. UVM instrumentation should be monitored for signal strength and inspected for system wear or damage. Plans for quality assuring UVM data should be described in the "Quality Assurance" section of the station description.

Provisions to maintain the applicability of the rating by periodically inspecting and cleaning the structure, repairing and replacing worn or damaged parts, and ensuring correct positioning (through level surveys and adjustment) will be required and should be described in the "Quality Assurance section" of the station description. Changes in stage or hydraulic head following these activities should be recorded and may be used to apply shifts to established ratings.

Other devices or structures in use for measurement of discharge also are subject to change, so any rating developed must be checked periodically just as in the case of a stage-discharge rating. Turbine wear can change head-flow relationships over time. Intake pipes may become coated with mineral deposits, increasing resistance to flow. AVM transducers may fail, resulting in a biased estimate of the velocity profile, and thus, the average velocity. Any of these changes can result in biased discharge estimates.

Station Description

A station description documents the location and describes the characteristics of a streamgaging station. Beginning with records for water year 2000, records furnished to the USGS were required to be accompanied by a station description that explains how the discharge rating for that system was established, the functional limitations of the rating, how the rating is maintained and its applicability assured, and a section on Quality Assurance. Examples of Quality

Assurance write-ups are provided later in this document. A station description generally should follow the examples included in USGS OFR 96-618.

Most or all of the following elements comprise a station description:

- Location
- Drainage Area
- Establishment and History
- Description of the Gage
- Control
- Discharge Measurements
- Point of Zero Flow
- Regulations and Diversions
- Accuracy
- Reference Marks
- Road Log
- Quality Assurance

A description of the rating could be included in the Discharge measurements section or the Quality Assurance section. Items that should be included in describing the rating include:

- date the rating was developed
- the technique that was used to develop it
- the persons, agencies, or contractors who developed it
- the operational range and sensitivity of the rating over that range
- description of planned activities to check the rating or maintain its applicability.

Planned activities to check ratings might include type and number of check measurements anticipated each year, or a plan for explaining the circumstances under which a hydraulic structure or its components will be re-rated, cleaned, repaired, or replaced. If engineered structures, AVMs, power-plant ratings, or other non-standard streamgaging techniques are used, the station description must include a brief discussion of the applicability of the non-standard technique(s) to the computation of streamflow, how the rating for that system was established, its functional limitations, and how the system is maintained.

Examples of Quality Assurance Section of the Station Description

The following are sample write-ups for the Quality assurance section of the Station description.

- Example 1 (Natural Channel): "Quality assurance - Make 8-10 discharge measurements per year, covering the full range of flow. Read all staffs and recorders during each visit and document. Survey levels every 3-5 years. Three RMs, all staffs, point of zero flow (pzf), and present water surface should be surveyed when levels are run. These are minimum quality assurance procedures. Much more may need to be done if unusual events occur."

- Example 2 (Natural Channel); "Monthly measurements will be made throughout the range of flow up to 50,000 cfs. Higher flows would involve heavy debris that would pose

significant hazards to hydrographers. Flows higher than 50,000 cfs, will be rated by rating extension no greater than twice the measured discharge. Flows beyond that range will be rated by indirect methods."

- Example 3 (Artificial Control): "A minimum of two discharge measurements each year (one each on the high-and low-end of the rating) will be made with more measurements made as needed to define shifting conditions. Included in these visits will be checks of control-structure condition. A leveling survey is required every 3-5 years. Three RMs, all staffs, pzf, and present water surface should be surveyed during the leveling survey. These are minimum quality assurance procedures. Much more may need to be done if unusual events occur."

- Example 4 (Weir): "This 20 foot weir was rated by the manufacturer in 1959 based on standard ratings published by King. The rating was checked after installation using discharge measurements. The weir is cleared monthly of debris when the width of the accumulated debris exceeds 5 percent of the length of the weir. The approach section depth to dam height ratio is __ , greatly exceeding the ratio needed to ensure that the approach section velocity (head) is zero. Brass reference markers are surveyed every 3 years and have shown no settlement or shifting. The spring edge of the weir is covered by angle iron that is in good condition and follows the original profile as determined from visual inspections and level checks. Consequently, the original rating can be continued without change. Flows that exceed the rating are determined by indirect methods for dams as described by USGS TWRI..."

- Example 5 (Power Plants): "This power plant rating was confirmed by the salt-dilution method (Gibson methods, pitot tube methods, etc.) in 1940 by the AAA Turbine Company under contract with the BOR. There is no access for current meter measurements due to backwater from the downstream lake. (Other limitations might apply such as irregular channel bottoms that degrade measurement condition such that measurements are considered poor or unusable by the USGS.) The intake pipes are coated with calcium deposits that have greatly increased flow resistance and may have caused the rating to be in error at low heads. A UVM system has been ordered and will be installed in 2002 to replace the old rating for this intake."

- Example 6 (AVM): "This AVM was installed in 1985 by the AAA Streamgagers Company. The system consists of 16 transducers in a 60 inch steel pipe 50 feet downstream of the nearest pipe elbow. The transducer readings are temperature-compensated by a temperature probe installed in the turbine forebay near the intakes. The temperature probes are calibrated twice each year with a scientific grade thermometer. The cross-sectional area of the pipe is clean and no changes in area were observed during inspections when the plant was dewatered in 1998. Transducer signal strength is routinely monitored to detect failed transducers. Two transducers failed this year. These failures were reported to the vender who furnished a revised area-weighted coefficient that was applied to compute the mean velocity from the remaining transducers. The unit is expected to be replaced in 2001".

- Example 7 (AVM): "This AVM was installed in 1990 by Power Omega Corporation. The system consists of 4 transducers in a 36-inch pipe 25 feet downstream of the nearest elbow. The AVM rating is checked twice each year utilizing a strap-on AVM. When the errors exceed 5 percent the unit is serviced or replaced."

- Example 8 (AVM): "This AVM was installed in 1990 by Tiny Drop Power Company. The system consists of 8 transducers in a 36-inch pipe 25 feet downstream of the nearest elbow. The AVM results match power plant rated flows for heads from 15 (minimum operations pool) to 50 feet (spillway crest) as determined by examination of current records on the 15th of each month in 2001. Flows exceeding the AVM rating are determined by indirect methods at a constricted bridge opening 0.5 miles downstream."