Waterway and Wetland Handbook
CHAPTER 130
WATER LEVELS AND FLOW

GUIDANCE PURPOSE AND DISCLAIMER

This document is intended solely as guidance, and does not contain any mandatory requirements except where requirements found in statute or administrative rule apply. This guidance does not establish or affect legal rights or obligations, and is not finally determinative of any of the issues addressed. This guidance cannot be relied upon and does not create any rights enforceable by any party in litigation with the State of Wisconsin or the Department of Natural Resources. Any regulatory decision made by the Department of Natural Resources in any matter addressed by this guidance will be made by applying the governing statutes, common law and administrative rules to the relevant facts.

This file is an electronic version of a chapter of the Waterway and Wetland Handbook. This document was scanned from the master handbook chapter kept at the Bureau of Fisheries and Habitat Protection central office in Madison. All effort was made to ensure this scanned electronic copy is an actual copy of the hardcopy document. Due to the electronic scanning process, there may be rare instances of typographical errors, omissions or improperly formatted pages. Please refer to the master handbook if accurate transcription is required.

PURPOSE

Water level and flow regulation may be required in the interest of safety, to protect life, health and property, or to preserve public rights in navigable waters.

MECHANISM

Department decisions relating to the levels or flow of navigable waters are issued in the form of an order pursuant to ss. 31.02, 31.13, 31.19 and 31.34, Wis. Stats.

HISTORY

Most of the basic language of 31.02(1), (2), (3), and (4) was first adopted by the legislature as Chapter 652, Laws of 1911, the first of the Water Power Laws. The intent of the Water Power Law (in part) was to establish procedures for authorizing the construction, operation, and maintenance of dams, and to delegate authority to carry out those procedures to the Railroad Commission.

Development of the Water Power Law was an iterative procedure. Various dam owners challenged the new law and the Supreme Court ruled it unconstitutional in 1912 (Water Power Cases, 148 Wis. 124). Since the 1911 law was determined to be unconstitutional, it was repealed and a modified version, Chapter 755, Laws of 1913, was adopted. It was this law which required the Railroad Commission to establish gauging stations and maintain flow records. The 1913 law was also considered unconstitutional and it was repealed and replaced by Chapter 380, Laws of 1915. It wasn't until 1917 that the Supreme Court actually declared the 1913 Water Power Law unconstitutional in State Ex Rel. Owen, Attorney General, vs. Wisconsin-Minnesota Light and Power Company,

165 Wis. 430. The 1915 law was determined to be constitutional. Chapter 474, Laws of 1917 amended and renumbered Chapter 69 (Water Power) and Chapter 146 (Mill Dams of the Statutes) to form Chapter 31 of the statutes. Many of the provisions and most of the language of that law remain essentially unchanged today. Chapter 125, Laws of 1949 added the following language to s. 31.02: "and may by order fix a level for any body of navigable water below which the same shall not be lowered except as provided in this chapter."

Prior to enactment of the water power laws, there were no specific water level and flow statutes other than a small provision in the Mill Dam Acts which provided that "The height to which water may be raised . . . shall be liable to be restricted and regulated by the verdict of a jury . . ." Other than that, the legislature sometimes established a maximum height to which dams could hold water.

As a result of the 1913 law, the Railroad Commission entered into an agreement with the United States Geological Survey in November, 1913, whereby the collection of stream flow data should be carried on as a cooperative measure. Under that agreement, the U.S.G.S. had direct charge of the work and the R.R. Commission paid a portion of the annual program cost as well as participating in flow measurements. Basically, the same cooperative agreement exists today; the DNR pays for part of the annual costs, but no longer participates in flow measurements.

Section 31.34, Wis. Stats., was adopted by Chapter 151, Laws of 1933. The primary purpose given was to protect the rights of lower riparian owners to a reasonably adequate natural flow of the stream.

STANDARDS

Statutory Standards

Under s. 31.02(1), Wis. Stats., the department may regulate and control the level and flow of water in all navigable waters. Specifically, the department may erect benchmarks or require the owner of a dam to erect benchmarks in relation to which the impoundment water levels can be determined. The department can establish the maximum level of water to be impounded and the minimum level of water to be maintained by the dam. Finally, the department is specifically authorized to establish a minimum level for any navigable waterway which includes natural lakes and streams. The standards for action under this statute are:

> "The department, in the interest of public rights in navigable waters . . . may regulate and control the level and flow of water in all navigable waters. . .".
>
> The department is responsible for preserving and protecting public rights in navigable waters. Generally, it is in the interest of public rights to:
>
> a. Maintain natural scenic beauty.
>
> b. Protect natural resources such as fish and game habitat.
>
> c. Preserve acceptable conditions for navigation and its incidents.
>
> d. Allow controlled fluctuations in level for resource management.
>
> e. Insure that stream flow is relatively undiminished in quantity or quality.
>
> f. Maintain water quality standards by ordering flow release amounts or scheduling flow releases from dams. Minimum flows (elevations) may also be established on flowing streams to preserve water quality.

"The Department, . . . to promote safety and protect life, health and property may regulate and control the level and flow of water in all navigable waters . . ."

Under this standard, the Department may regulate and control water level and flow to:

a. Minimize damage to property resulting from flowing, erosion or ice action;

b. Prevent failure of a structurally inadequate dam;

c. Assure effective operation of on-site sewage disposal system;

d. Prevent pollution sources from contaminating a lake or impoundment;

e. Assure that a stream has sufficient flow to assimilate waste and maintain water quality standards;

f. Minimize economic losses resulting from too much or too little water;

g. Allow dam maintenance or inspection;

h. Minimize the possibility of exposing potentially contaminated or unsightly bottom materials or creating stagnant water areas or undesirable odors associated with decaying bottom material;

i. Insure that stream flow is relatively undiminished in quantity or quality.

Note that the elements for consideration mentioned above may have application for lakes impoundments, or streams.

Under s. 31.19, Wis. Stats., the department may order either a partial or total drawdown of an impoundment when it determines that it is necessary to prevent impending danger to persons or property.

Section 31.34, Wis. Stats., requires dam owners to pass at least 25% of the natural low flow of the stream on which the dam is being maintained. For administrative purposes, the seven day ten year low flow, $Q_{7\text{-}10}$, has been determined to be equivalent to 25% of the natural low flow. Dam owners who discharge water directly into a lake or reservoir are exempt from this requirement. This requirement may be waived if the department determines that a minimum discharge is not necessary for the protection of fish life.

Administrative Code Standards

Section NR 1.95 establishes the policy that wetlands shall be preserved, protected, and managed to maintain, enhance, and restore their values in the human environment, and that it is in the public interest that Department decisions which lead to alteration of or adverse effects on wetlands are based on this policy. NR 1.95 requires the Department to review proposals with the presumption that wetlands are not to be adversely affected. However, if it is not reasonable to deny a proposal and reasonable alternatives would also adversely impact on wetlands, the Department will require an alternative which has the least adverse wetland impact and the least overall adverse environmental impact to be used in lieu of the original proposal.

NR 102 established water quality standards which are normally considered in evaluation of permit or approval applications. However, s. 144.27, Wis. Stats., exempts Chapter 31 of the statutes from the provisions of subchapter II of Chapter 144 upon which the water quality administrative rules are based. While violation of the

water quality rules can not be used as a basis for permit denial, they can be used to help establish if a proposal meets statutory standards, i.e., in the interest of public rights or to protect life, health and property.

NR 116 establishes administrative standards which must be followed by local units of government. These standards should be reflected as conditions in permits or orders issued under sections 31.02, 31.06, and 31.13, Stats., to require applicants to conform with standards established in NR 116.

Administrative Interpretations

Authority over the levels of Federal Energy Regulatory Commission (FERC) licensed Projects - Bureau of Legal Services Opinion (7-5-78). The FERC has superior jurisdiction over the levels of flowages on federally licensed projects. The Department's role is largely advisory although FERC considers our opinion a major determinant in the establishment of levels for flowages.

PROCESS

Application

Any person may petition or request the Department to investigate and establish water level or flow requirements. Often these requests are in the form of a complaint. There are no application forms so this is generally accomplished by letter. The request should include specifically what is desired in the way of level or flow to enable that the Department to properly evaluate the request.

The Department may, on its own motion, initiate action to regulate levels or flow. Such action might be undertaken, for example, when necessary to protect a landlocked lake from otherwise legal diversion or to protect life, health and property from an unsafe dam. After investigation, the recommendation regarding levels or flow are incorporated into an order by the Department.

Notice Requirements

A public notice for proceedings to establish levels or flow is not required. If the Department wishes to solicit input from the public, it may issue a notice and hold an informational (legislative) as opposed to a contested case hearing. The Division of Natural Resource Public Hearings will not hold a hearing on the establishment of levels or flow requirements since it not a contested case action. A news release should be required so that interested parties will at least be informed of decisions.

Field Investigations

A comprehensive field investigation is crucial to establish acceptable minimum flows or minimum and maximum elevations. Due to the highly variable topography surrounding most lakes, streams and within proposed impoundments, we strongly recommend that surveying instruments be used to pinpoint critical elevations for consideration.

In many cases, insufficient records exist to accurately estimate a lake or stream's normal range of water elevations. In these instances, questioning the long term riparian landowners may provide valuable information regarding historical water levels.

1. To protect public rights, evaluations should consider:

    a. Navigation and its incidents;

b. Scenic beauty;
c. Fish spawning grounds and wildlife habitat; and
d. Wetland areas.

2. To protect life, health and property, evaluations should consider:

a. Existing sewage systems;
b. Pollution sources;
c. Ice and water erosion potential;
d. Flooding potential and easement requirements;
e. Flow requirements to maintain water quality;
f. Off-shore slopes;
g. Dam structural and hydraulic adequacy if levels are raised; and
h. Agricultural or irrigation diversions and other downstream beneficial users of water.

For temporary or seasonal drawdowns many of the same kind of considerations apply but the scope or magnitude of the concerns is usually much less.

Criteria for Establishing Level or Flow Requirements

Establishing level or flow requirements involves a variety of situations. In order to identify appropriate considerations, the various situations are discussed separately.

For gaining consistency and uniformity in discussing water levels, the following definitions are provided:

1. Historic maximum means the highest recorded water level.

2. Historic minimum means the lowest recorded water level.

3. Normal level means the level ordinarily (commonly) held by a dam.

4. Ordered maximum means the highest water level established by department order to be achieved by reasonable operation of a dam.

5. Ordered minimum means the lowest water level or levels established by department order to be achieved by reasonable operation of a dam.

6. The normal operating range means the water level elevations bounded by the ordered maximum and ordered minimum or where levels have not been established it means the typical range of fluctuation.

A. Natural Lakes With No Outlet

A landlocked lake's level depends upon inflow (precipitation, surface runoff, groundwater inflow) and outflow, or water losses, resulting from evaporation, groundwater recharge or physical removal by ditching, irrigating, hauling water for construction, etc. To protect public and riparian rights, it may be necessary to establish a minimum level for the lake below which no water may be removed. However, establishing a minimum level does not guarantee that a lower water level will not occur naturally, but the minimum level will establish an elevation below which the water cannot be lowered artificially.

We must consider several factors to establish an acceptable minimum level including:

1. The Elevation of the Ordinary High Water Mark (OHWM).

   Since upland adjoining a lake is privately owned, we should generally set the minimum level at or below the OHWM.

2. The Minimum Level to Protect Public Rights

   The chosen elevation should protect recreational opportunities and the values associated with fish and game habitat, aquatic and terrestrial vegetation.

3. The Minimum Level to Protect Riparian Rights

   Generally, the level chosen to protect public rights is sufficient to protect riparian rights unless the lake has limited fish, game, vegetative, and recreational values. In such instances, the Department has a duty to establish an elevation that will protect riparian rights; i.e., right of access to the water, right to have water against their land, right to use water for domestic purposes, etc.

4. The Minimum Level to Protect Life, Health and Property (see Discussion under Statutory Standards)

B. Natural Lakes With Outlet Streams

In addition to the inflow and outflow (or losses) described for landlocked lakes, the range of elevations of a lake having an outlet depends largely upon the outlet stream's discharge capacity (a ditch or channel may also allow outflow).

Generally, the Department is requested to establish minimum and maximum elevations in conjunction with an application to construct an outlet control structure (dam, ditch or channel). A person may make the request in an attempt to restore a higher elevation, maintain a given low elevation, prevent a lake from reaching high elevations or establish a new range of elevations. In some instances, control structures have been constructed in the past without any maximum or minimum elevations being established. For such situations, the Department may (1) on its own motion, (2) upon complaint, or (3) upon petition take action under s. 31.02, Stats., to establish elevations for such control structures to maintain.

Whenever possible, water levels must be maintained within the established range. You should recognize that it may not be possible to maintain the minimum level during a low precipitation period or the maximum level during a high precipitation and flooding period.

We should consider the following factors in order to establish acceptable minimum and maximum elevations:

1. The Normal Operating Range of Water Levels

   We should determine the normal operating range of water levels and possible causes for the fluctuation. A lake subject to great fluctuations may be difficult to control without extensively modifying the outlet. Historical information may prove invaluable for hydrological and hydraulic evaluation of a proposal. The Water Regulation Section has some water level information not found in the district or area offices.

   For physical operation, elevations established within the normal operating range may be best. Affected riparians may more readily accept levels established within the normal range. The elevation difference between the established minimum and maximum varies from lake to lake, but proper outlet control design should control the range between the maximum and minimum to allow less fluctuation.

2. The Range of Elevations Necessary to Protect Public Rights (see discussion under statutory standards)

3. The Range of Elevations Necessary to Protect Life, Health and Property (see discussion under statutory standards)

    a. Upstream from control structure

    b. Downstream from control structure

4. The Ordinary High Water Mark (OHWM)

    The OHWM is particularly significant to establish a lake's maximum and minimum elevations since it is the elevation that separates privately owned uplands from state owned lakebeds. The OHWM elevation generally is not the best choice for establishing the maximum level because a natural lake regularly exceeds the OHWM elevation. Since this occurs naturally, there is no liability for any damages to private property. Establishing the maximum elevation above the OHWM constitutes a "taking" of private property. All affected riparians must agree to this "taking" by signing an easement to the dam owner, or the dam owner must purchase the property potentially flooded. To establish levels within a "normal" range, the maximum elevation should probably be slightly below the OHWM.

5. The Outflow Capacity of the Outlet and Control Structure

    As previously mentioned, the rise in water surface elevation which a lake will experience during heavy precipitation depends primarily upon the outlet's outflow capacity. Through hydraulic and hydrological design a dam, ditch or channel can usually achieve a specific lake elevation for any given flood frequency. In the case of a dam, the outlet stream's outflow capacity must be evaluated to help prevent the installation of a dam that is too large or too small. If the objective of dam construction is to increase outflow capacity, the owner may also have to improve the outflow streams capacity by removing heavy vegetation or modifying the channel according to regulatory authority contained in Chapter 30, Wis. Stats.

C. New Dams on Navigable or Nonnavigable Streams

When considering new dams on streams, essentially the same criteria mentioned above applies to determine maximum and minimum levels except that no OHWM or normal range of levels will exist at the water level proposed to be maintained by the dam. The standards contained in Sections 31.05 and 31.06, Wis. Stats., should be applied since they are far more specific than the standards set forth in Section 31.02, Stats.

D. Raising or Enlarging Existing Dams

Aside from questions of structural and hydraulic adequacy of the dam to maintain a higher water level in the impoundment, the assurance that the applicant has acquired 100% of the flowage easements to the new regional flood elevation required by the higher water level is most important. Though section 31.13, Stats., does not require that flowage easements be obtained as a prerequisite to permit issuance, the strong language requiring that we protect property rights has led to that administrative requirement for any applicant not having the power of eminent domain.

This section of the statutes has been used often in the past when the dam owner simply wants to change the established operating levels. This procedure should be considered when increased levels may adversely impact on riparian owners since this section affords them greater protection.

E. Minimum Flow Requirements

In order to meet statutory and/or administrative code standards, we may have to establish minimum flow requirements. The same criteria apply to determine the minimum flow for a dam or to maintain minimum flows in an unaltered stream segment. The minimum flow required should: (1) protect public rights, (2) protect life, health and property, or (3) meet the minimum requirements in Section 31.34, Wis. Stats.

Section 31.34 states that a dam must pass at least 25% of the stream's natural low flow except as otherwise provided by law (Section 31.02), or where the Department determines that no minimum flow is necessary to protect fish. The term "pass" has been interpreted to mean only the flow through the control sections of the dam (gates, spillways, etc.) and not any uncontrolled flow through the dam (leakage, seepage, etc.). If the dam owner wishes us to consider the uncontrolled flow, he should have the burden of proof that the combined controlled and uncontrolled flow meets the required minimum flow. The present staff recommendation is that $Q_{7,10}$ be used as the value for 25% of the natural low flow.

We have established minimum flows (or elevations) in every district resulting from the intensified irrigation program. Therefore, most of our field staff have gained experience in evaluating stream flow requirements. See Chapter 90 of the handbook for additional discussion.

F. Hydrologic and Hydraulic Considerations

Although a separate section of the handbook deals with dams and dam design criteria the following factors relate to establishing and maximum or minimum elevations and/or minimum flows:

1. Design flood frequency and magnitude;
2. Regional flood magnitude;
3. Any additional flood magnitude required for evaluation;
4. Inflow-stage-discharge relationship for flood magnitude of concern without a water level control structure;
5. Inflow-stage-discharge relationships for flood magnitudes of concern with proposed water level control structure; and
6. Minimum flow required to meet statutory or administrative code standards.

G. Temporary Drawdowns Where There Is An Ordered Minimum

Dam owners may occasionally wish to draw the level of their flowage below its ordered minimum elevation. At times, a drawdown may be of an emergency nature such as a potential dam failure. In such instances, a dam owner is required by law (s. 31.18(1), Wis. Stats.) to take action to protect life, health and property. If he lowers the level of his flowage, he is simply meeting his statutory obligations and no drawdown order is required. Before allowing the dam owner to raise the water level to its normal operating range, a repair order may be necessary or maintenance work may have to be performed to correct deficiencies. The dam owner may also desire nonemergency drawdowns for dam inspection purposes or to make dam repairs. In such instances, he should request authority from the Department. Concerns of other riparians should be considered in evaluating the request.

Temporary drawdowns may be desired by property owners for specific reasons such as for dredging projects or to reduce shoreline erosion due to unusual circumstances. Concurrence of the dam owner with the temporary drawdown plan may be required before the Department can issue the drawdown order. If the dam is used for hydro-power and the dam owner is dependent on the power for his livelihood, it may <u>not</u> be appropriate for the Department to issue a drawdown order if he objects.

H. Seasonal Drawdowns

Seasonal drawdowns may be desirable for a variety of reasons, such as to minimize shore damage potential or for fish or game management practices. Again, the dam owner should agree to the seasonal drawdown plan, particularly if the dam is used for hydro power.

I. Drawdowns Where There is NO Ordered Minimum Level

Where there is no ordered minimum level, a dam owner is within his rights to lower the flowage below its normal level, particularly when such drawdowns constitute usual or normal operation.

If complaints and/or a request is made to establish a minimum level, the Department must investigate the situation. A balancing of the dam owner's needs and property owner's concerns is needed to make a determination.

Final Disposition

All Department decisions on levels or flow are issued in the form of an order. In the future, new levels or flow orders pertaining to authorized dams should be issued in the form of an amendment to the initial permit and order authorizing the dam or as an amendment of previously levels orders. By following this procedure, all permanent orders will be located in one file and the problem of having several separate files for the same dam will be eliminated.

Since temporary drawdown orders are one time shots, they may be issued separately. For informational purposes, it is suggested that they be issued under the authorizing docket number, perhaps using a subscript such as "A".

In the case of ordering minimum flows for streams or minimum elevations for natural lakes, the question has been asked, "who do we issue the order to?" These orders are generally issued because someone is conducting an activity which adversely affects the waterway. Although the activity may not be illegal, issuing minimum level or flow orders will serve to control the activity. The order can simply be issued, it is not necessary to issue it to anyone in particular. Copies of the order should be distributed to interested parties and it should be pointed out that causing the orders to be violated is a punishable offense.

Monitoring

Depending upon the scope of Department orders, performance monitoring will provide valuable information regarding the:

a. Sufficiency of minimum flow requirements;
b. Adequacy of control structure design;
c. Effectiveness of Department evaluation;
d. Adequacy of established levels; and
e. Need to issue order modification.

Emergency Procedures

Occasionally problems will develop that may threaten the immediate safety of the structure. In such cases, the downstream area should be assessed to determine probable dangers resulting from the anticipated failure. If human life is threatened, we should take emergency action to draw down the impoundment and begin evacuating the downstream area. In most cases, the sheriff's office is an appropriate contact to aid in an evacuation attempt.

If any emergency threatens the dam, we should order draw down of the impoundment. If the dam's spillway is impaired so that a drawdown cannot be facilitated, the structure should be breached. The owner may make alterations to the structure if an emergency exists without obtaining approval (an order) from the Department.

Education

Educational materials include:

Brochure - "What you need to know about owning a dam."

Handout - "State Dam Regulation Questionnaire."

Enforcement

Section 31.34, Wis. Stats., provides that violation of the section is subject to fines of not less than $50 nor more than $1000. Enforcement pursuant to this section requires local court action.

Sections 31.02, 31.13 and 31.19, Wis. Stats., do not include any enforcement provisions. However, those sections as well as s. 31.34, Wis. Stats., may be enforced through either s. 31.23(2) or s. 31.25, Wis. Stats.

v:\perm\wz91405l.djd

CORRESPONDENCE/ MEMORANDUM **STATE OF WISCONSIN**

Date: July 1, 1986 RESENT 9/25/89 File Ref: 3500

To: District Water Management Coordinators
Water Management Specialists
Program Staff

PUT IN: Chapter 130, Water Regulation Guidebook

From: Scott Hausmann - WZ/6

Subject: Clarification of M.C. 3539.1

Manual Code 3539.1 was revised on December 23, 1985, which omitted language that stated department approval was not required to drawdown dams and impoundments for which no minimum levels have been established. Removal of this language from the Manual Code appeared to imply that department approval is required for all drawdowns regardless if minimum levels are or are not established.

Prior to the December 23, 1985, Manual Code revision, the Manual Code implied explicitly that we did not have regulatory authority over drawdowns if no minimum water levels were established. Because that strict interpretation was not correct, it was deleted during the revision.

The department does have authority, pursuant to sections 31.02 and 31.18, Statutes, to regulate drawdowns, even if no minimum level is established, in the interests of public rights in navigable waters or to promote safety and protect life, health and property...

If no minimum levels are established and there would be no detriment to the public interest, life, health and property, then there should be no reason for requiring department authorization for a drawdown.

SH:DS:el

cc: Robert Roden – WZ

CORRESPONDENCE/ MEMORANDUM **STATE OF WISCONSIN**

Date: November 18, 1988 File Ref: 3500

To: District Directors

Insert: Chapter 130 Water Regulation Handbook

Distribution: Program Staff

From: Scott Hausmann WZ/6

Subject: Levels and Flows of F.E.R.C. Relicensing Projects

One of the items of concern discussed at the recent FERC relicensing meeting of October 13, 1988 in Stevens Point was the need for obtaining and/or maintaining adequate stream flow records for projects coming up for FERC relicensing. To adequately and consistently address this issue Department comments during the stage one consultation should include the following suggested language :

> "In order to protect the public rights in navigable waters and to verify that the hydropower plant is operated in accordance with the operating requirements of the license your draft application should include sufficient information to enable us to determine that adequate measures will be installed and/or maintained to collect data concerning impoundment levels and downstream flow releases. Such measures may include, but are not limited to, installation of staff gauges upstream of the dam to monitor levels, automatic level recorders, continuous or hourly flow releases based on gaging station readings, gate opening readings or downstream staff gauges with an associated stage/discharge curve calibrated at least twice a year. Such levels and flow data shall be provided to the Department annually or at such other intervals as deemed appropriate.

In cases where adherence to license level and flow requirements is highly controversial, may significantly impact the resource, or the past performance of the licensee in complying with the license conditions has been less than acceptable, more specific comments or measures may be more appropriate than the above suggested language.

Requested by: Ken Johnson

Drafted by: John Coke

Reviewed by: Ken Johnson

cc: Bill Clark - NWD
Tom Lovejoy - WD
Bob Martini - NCD
DuWayne Gebken – EA

CORRESPONDENCE/ MEMORANDUM **STATE OF WISCONSIN**

DATE: April 15, 1991 FILE REF: 3500

TO: District Directors

PMMS Response: Insert Chapter 130, Water Regulation Handbook

FROM: Robert Roden - WZ/6

Distribution: WRZ Program Staff

SUBJECT: Minimum Flow Requirements of s. 31.34

We have been asked for an interpretation of the requirement of dam owners to pass "25% of the natural low flow" found in Section 31.34. This response will be limited to just a referral to the administrative interpretation contained on page 6 of Chapter 130 of the Water Regulation Handbook which states that the $Q_{7,10}$ is equivalent to 25% of the natural low flow. This interpretation has been in effect since December 7, 1982 when Chapter 130 of the Handbook was distributed.

This issue was further expanded upon by the previous PMMS Response of December 15, 1983 which is being redistributed as an attachment to this response.

Drafted By: John Coke - WZ
Requested By: John Gozdzialski - NWD
Reviewed By: Scott Hausmann
Larry Larson

CORRESPONDENCE/ MEMORANDUM **STATE OF WISCONSIN**

DATE: December 15, 1983 FILE REF: 3550 (WMC)

PMMS RESPONSE: Put in: Chapter 130 of Water Regulation Handbook

TO: District Directors

FROM: Scott Hausmann

Distribution: All Program Staff

SUBJECT: Minimum Flow for Dams (Sec. 31.34, Stats.)

We have been asked "Can we require a dam owner to pass a minimum flow when the dam discharges directly into a lake, millpond, storage pond or cranberry marsh since those situations are exempt from section 31.34? Can we require a dam owner to pass greater than the $Q_{7\text{-}10}$ flow?"

Although dams that discharge directly into a lake, millpond, storage pond or the cranberry marsh are excluded from the minimum flow requirements of section 31.34, they are subject to our authority under section 31.02. Section 31.02 is a statute which confers broader powers to the department to regulate the flow of water in all navigable waters "in the interest of public rights."

Section 31.02 can be used to require any reasonable minimum flow where it can be shown such a flow is necessary to protect public rights in a waterway (see handbook guidance) regardless of the minimum requirement or exclusions of section 31.34. Section 31.33 also makes section 31.02 applicable to nonnavigable streams.

Reviewed by: Scott Hausmann
Bob Sonntag
Mike Cain

SH:cb
4449K

CORRESPONDENCE/ MEMORANDUM **STATE OF WISCONSIN**

DATE: October 11, 2001 FILE REF: 3600

TO: Regional Directors
Statewide FERC Committee

FROM: Susan Sylvester – AD/5

Distribution: Water Mt. Specialists
Water Mgt. Engineers
Dam Safety/FP/SL Section
River & Regulation Section

Insertion: Ch. 130 Water Reg Guidebook

SUBJECT: Guidance – Defining and Monitoring Run-of-River Operations for State Regulated Dams and Federal Energy Regulation Commission (FERC) Licensed Hydropower Dams

Under Section 31.02, Wis. Stats., the Department may regulate and control the level and flow of water for dams on navigable waters. Pursuant to Section 401 of the Clean Water Act and under Wis. Admin. Code NR 299, Water Quality Certification (WQC) authority the Department may also regulate flows and water levels on FERC licensed hydroelectric dams. Recent court decisions indicate state WQC conditions must be incorporated by FERC as conditions in their (re)licenses.

Unless site-specific analysis shows that an alternate operating regime would not have serious adverse environmental impacts, run-of-river operating mode should be ordered so that dam operations are least disruptive to the normal river flow. The enclosed guidance is provided to assist Department staff, when a decision has been made to require a run-of-river operating mode at a dam, in defining run-of-river performance, compliance standards and monitoring needs.

cc: Al Shea – WT/2
Mike Staggs – FH/3
Mary Ellen Vollbrecht – FH/3
Joanne Juhnke – FH/3

Enclosure: WDNR Run-of-River Guidance (October 11, 2001)

WDNR Run-of-River Guidance*
Defining and Monitoring Run-of-river Operations for State Regulated Dams and Federal Energy Regulation Commission (FERC) Licensed Hydropower Dams
October 11, 2001

Purpose

When Department staff have determined that a run-of-river operating mode should be required at a dam, it is important that all parties clearly understand what is expected. This guidance is provided to help define a performance standard and monitoring needs by which to determine compliance.

Application

The Department has found, in most cases, the public interest is best served when state or FERC licensed dams operate so as not to disrupt the normal river flow. This type of operation, commonly referred to as run-of-river or ROR, assures tailwater reaches below dams are not subjected to unnatural flow variations caused by dam store and release operations(also called pulsing, cycling or peaking). These variations may reflect efforts to meet peak demand for electricity, be a function of equipment with limited flexibility or be the result of an inadequate level of attention given to operation. It has been extensively documented in the scientific literature that run-of-river operations best protect water quality, fish and wildlife habitat, recreation, navigation, aesthetics and control erosion in dam tailwaters.

When recommending ROR operations, it is important to clearly define a compliance standard and specify a monitoring protocol(s) to measure data capable of being used to determine if the performance standard is being met. Failure to have both components in place can lead to disagreements between dam operators, FERC, and the Department, sometimes leading to costly enforcement or legal action. Also, dam operators may acquire and install equipment which may not be capable of operating within or monitoring compliance with ROR requirements.

The ROR definition which follows has been developed by the Department, based on the above factors, in attempt to assure that dam operations best protect public interest values.

ROR Definition

At all times dam owner/licensee shall maintain a discharge from the dam (includes powerhouse, spillway or diversion channel) so that, at any concurrent point in time, flows, as measured downstream, approximate the sum of inflows (main channel and tributaries) to the reservoir. Following this type of operation should also result in minimal fluctuation of the project reservoir.

---

*

Legal Notice: This document is intended solely as guidance and does not contain any mandatory requirements except where requirements found in statute or administrative rule are referenced. This guidance does not establish or affect legal rights or obligations and is not finally determinative of any of the issues addressed. This guidance does not create any rights enforceable by any party in litigation with the State of Wisconsin or the Department of Natural Resources. Any regulatory decisions made by the Department of Natural Resources in any matter addressed by this guidance will be made by applying the governing statutes and the administrative rules to the relevant facts

The Department is aware of alternate definitions of ROR that have historically been used but resulted in problems. One common example is a simple "outflow equals inflow", with no correlation to any measured flow data. In 1995 a FERC hearing examiner found in an enforcement case that such a definition provided insufficient guidance in that it failed to apprise dam operators of what quantity of flow fluctuations would be permissible. A second common example of a problem ROR definition is "reservoir water level fluctuations are limited". This definition attempts to prevent the dam operator from substantially storing within and subsequently releasing water from the reservoir, thus avoiding substantial flow fluctuations in tailwater areas below the dam. Even a few inches of reservoir water level operating range, especially in a large reservoir, can result in significant flow fluctuations in the tailwater. For example, opening a dam gate for a short period may cause only a small change in reservoir level, but can greatly change downstream discharge. Such operations can result in significant adverse environmental and recreational impacts.

ROR Compliance Performance Standard

Run-of-river compliance is determined by comparing inflow with outflow. "Approximate" is used in the above definition to recognize several operational and natural conditions which make it difficult or impossible for inflow upstream to exactly equal outflow downstream of a dam despite an operator's best efforts and installation/use of the most sophisticated equipment. Such constraints can include:

- travel time for flow from when it enters the reservoir to a point in the tailwater.
- unmeasurable inflows to reservoir or tailwater (small tributaries, groundwater discharge, etc.)
- unmeasurable project outflows (evaporation, freezing, groundwater recharge, leakage, etc.)
- basin runoff characteristics (flashiness)
- reservoir or river channel configuration or other site-specific physical features.

Ideally, it would be best to attempt to quantify and factor in these conditions when comparing inflow vs. outflow. Unfortunately, this will not always be possible.

The Department should normally seek, and clearly describe as a permit/FERC license WQC condition, a run-of-river compliance standard where measured outflow from a dam is within ± 10% of measured inflow. This range should assure that outflow reasonably matches inflow, such as would reflect a natural hydrograph, and for which public interest values would be protected as compared to greater, unnatural flow fluctuations. If no significant adverse effects are expected and/or operational limitations warrant, a higher percentage can be negotiated on a site specific basis. For a new dam or when a dam is changing operations to run-of-river, it may be acceptable and appropriate to establish a target compliance standard and monitor performance for an agreed-to and predetermined length of time to determine if the target compliance standard is reasonably achievable or should be changed.

To demonstrate and compare the difference, Appendix 1 contains hydrographs showing dams where run-of-river compliance is and is not being met.

It is important when a new project or change to ROR operation is being proposed or negotiated, that early discussions takes place with potential applicants, FERC licensees' and other parties so there is clarification as to the meaning, compliance and monitoring expectations of run-of-river operations. During early consultation for FERC license applications, the Department should identify the need for run-of-river compliance standard(s) in commenting on applicant's Initial Consultation Package. The test period should be conducted as part of pre-application studies. This will help avoid problems, including possible enforcement or legal battles, after start-up. Experience shows these problems are very difficult, contentious and often expensive (i.e., capital investment, staff time, legal costs, etc.) if not resolved prior to construction and/or start-up. If agreement cannot be reached, the Department should still pursue operating conditions, including run-of-river standards, if necessary to protect the public interest. Such conditions can be incorporated and thoroughly described in Chapter 31

permits/approval or WQC for FERC regulated dams. If the dam operator chooses, they can elect not to construct, or cease to operate the project or seek judicial review of stipulated conditions.

Exceptions

There may be times, such as during drought conditions, when aquatic resources in project tailwaters can best be protected by modifying run-of-river operations. For instance, let's say a sensitive fish spawning area or mussel bed exists below a dam. If project inflows are so low that passing just inflows would not keep these areas inundated, it may be appropriate to augment downstream flow using storage water in the reservoir. To cover such occurrences, it may be appropriate to add a permit/WQC condition that allows temporary exception to run-of-river compliance for fish and wildlife protection or enhancement or to protect public health and safety, but only with concurrence from the Department. It may also be appropriate to consult with other interested parties when considering temporary modifications to run-of-river compliance. For instance, if such modifications may potentially impact federally listed endangered or threatened resources, advance consultation with USFWS should occur.

Monitoring

The compliance standard would be unenforceable if there was not an adequate means of measuring inflow and outflow. Without sound monitoring data, means to identify or quantify if a run-of-river violation is occurring can become contentious, with possible serious impacts to public interest values. If violations occur, are they an isolated incident possibly due to natural causes? Or are they repetitive, intentional or not, and due to dam operator economic or other motives? Monitoring can help identify the cause of problems, and greatly simplify identification of remediation measures needed. Or, if needed, it can provide factual data to use as evidence in enforcement proceedings.

Stream flow (not just water level) should be gauged at all projects where the Department determines the need to protect the downstream reach from artificial flow fluctuations. Gauges should be located, installed, calibrated and operated in accordance with USGS Water Supply Paper 2175, "Measurement and Computation of Streamflow (volumes one and two). Gauges capable of being called up on the Internet should be considered if access to near real-time data by a variety of parties is important. Other techniques are available for immediate access to real-time data and should be considered on a case-by-case basis (e.g. automated phone number which provides instantaneous flow*).* The Department can accept an alternative monitoring plan (i.e., measured or calculated discharges from turbines, spillways, water level gauges, etc.) if the dam operator can demonstrate it will provide data equal to USGS standards and in a format and frequency which will enable the Department to determine run-of-river compliance.

The extent that dam design and operations can cause flow fluctuations should be considered in determining appropriate monitoring requirements:

FERC Dams
Optimally, the Department prefers automated, instantaneous inflow and outflow flow gauges at FERC regulated dams. Hydro dams have controllable gates which can be operated to vary the passage of stream flow and, therefore, disrupt natural flow patterns. With such gauges it will be simple to compare inflow and outflow and see if the compliance standard is being met. Hydro projects should also have staff gauges installed in reservoirs and tailwaters which are clearly marked showing required operating ranges.

State Regulated Dams

State regulated dams should be considered in three categories when determining ROR requirements and monitoring:

A. Dams with automated or manual gates where frequent(daily) flow control adjustments are expected.
B. Dams with manual gates that are utilized infrequently.
C. Dams with only a fixed crest spillway – no flow adjustments possible.

Category C dams need not have an operation plan or monitoring plan. Category A and B dams may need to have an operation plan and monitoring required depending on: 1. Sensitivity of the stream below the dam to impacts from flow fluctuation(length of tailwater affected, species expected, etc.); 2. Downstream water needs(waste assimilation, irrigation, other dams, etc.); or 3. Risk that dam operations will cause flow fluctuations if a plan and monitoring is not required.

When Category A & B dam operations can have serious impacts on environmental, recreational and other public interest values, a detailed run-of-river compliance standard should be established. Where a ROR requirement is specified, Category A dams should be equipped with automated, instantaneous flow monitoring equipment and a flowage staff gauge clearly marked(ie notched) indicating the required operating range(s). Category B dams should include: 1. A log of all operational adjustments; 2. A specific plan for gate operation which deals with issues of frequency, rate, and extent of allowable gate changes; 3. A flowage staff gauge; and 4. A means for the operator to convert flowage stage and gate settings to total stream flow.

For clarity, the table below is provided as a summary of the above two paragraphs <u>for state regulated dams</u>:

	'A' dams	'B' dams	'C' dams
Operations plan needed	Yes	Yes	No
Need ROR compliance standard	Yes	Yes	No
Automated,instantaneous flow gauging	Yes	Yes, if high public interest values are at risk	No
Logs/data which can be used to calculate instantaneous flow	No	Yes, if automated flow gauges not available	No
Staff gauge	Yes	Yes	No

Gauging a stream to determine if a stable flow is being delivered by a dam is considered the responsibility of the party(ies) operating the dam. Cost sharing for stream gauges may be available to units of government from USGS. In some cases, private parties operating a dam have gifted money to DNR, which is then cost shared with USGS to finance a flow gauge. The availability of USGS funds can depend on the need for additional flow gauging in the region beyond the need to document dam operations.

Wherever possible, the compliance monitoring system should be installed and operational one year prior to any significant change in operation. This is especially important for new projects with a single monitoring point(i.e., absent inflow and outflow gauges). Sometimes a trial period is deemed necessary before a final operational definition and compliance monitoring plan can be developed. On FERC licensed dams, this is often used as justification for postponing all progress on these issues until post-licensing. The development of a definition of "run of river" and the associated monitoring plan should not be entirely deferred to after FERC licensing or after Chapter 31 permit issuance for state regulated dams. During stage 2 of hydro (re)licensing consultation or in Chapter 31 permit language it should be clearly understood by all parties, such as in a draft plan/agreement or other written form, which provisions are subject to change during a post-license trial period and which are not. For example, numeric values may be considered negotiable (i.e., +/- XX%) while the underlying concept is not (i.e., limit based on a fraction of the daily average flow). It may take several years to work out the operational issues when a new project is (re)developed. Note that this allowance is primarily in recognition of difficulties in monitoring flow and is not an allowance for existing inadequate equipment or inattentive operation.

Every hydropower project should maintain an hourly log of project operations, which includes headwater elevation, unit generation through each turbine in cubic feet per second, any spillage and tailwater elevation. This data, along with accurate rating curves, would best describe what is happening at the project.

Determination of ROR compliance during winter at FERC or state regulated dams
should recognize that some gauges are susceptible to ice effects and may produce inaccurate flow data. A routine recalibration schedule should be incorporated as a permit/license condition to assure monitoring data is accurate.

Appendix 2 provides examples of acceptable alternative monitoring scenarios with accompanying ROR compliance definitions.

Use and Updating of Guidance

Following the above-described guidelines should be helpful to assure consistent Department application and regulation of run-of-river operations at state regulated and FERC regulated dams. The guidelines could also be useful as a training tool for new staff. Also, this may be a useful document to clarify points of discussion or negotiations with dam operators, FERC staff or other interested parties.

It is intended that this guidance provide as much information to Department staff regarding run-of-river issues as possible. Appendix 3, a technical paper prepared by FERC staff in 1997, provides more background and perspective. Other appendices will be added on a continuing basis in an effort to keep this document updated.

Reviewed/approved by:

Michael Scott, Attorney
Bureau of Legal Services — Date: 10/9/01

Al Shea, Director
Bureau of Watershed Management — Date: 10/30/01

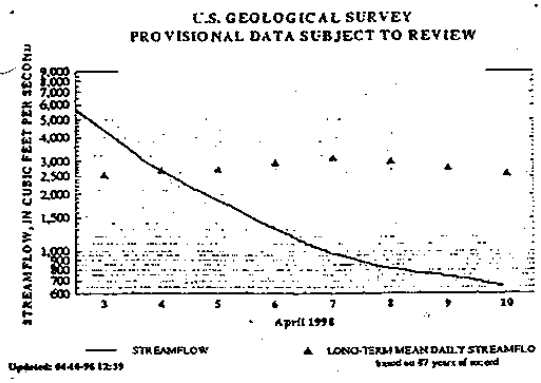
Michael Staggs, Director
Bureau of Fisheries Management and Habitat Protection — Date: 30/X/01

Susan Sylvester, Administrator
Division of Water — Date: 11-01-01

Appendix 1

ACCEPTABLE VS. UNACCEPTABLE RUN-OF-RIVER HYDROGRAPHS

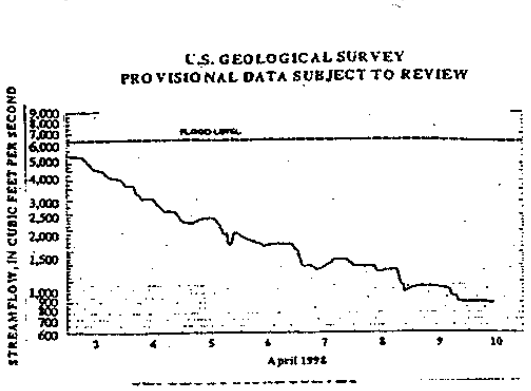
INFLOW



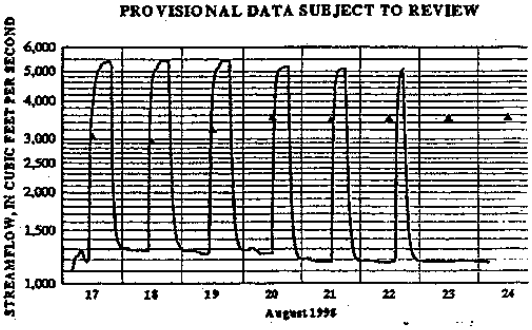
Run of River

(inflow and outflow equal

OUTFLOW



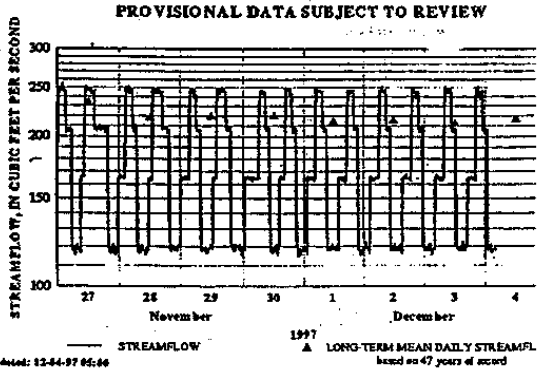
Peaking, intentional store and release



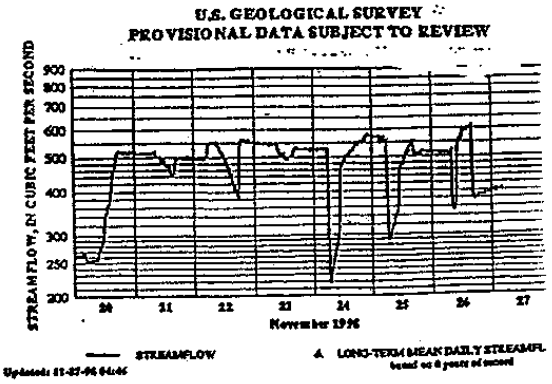
NOT run-of-river

Inflow(as above) stable, outflow with severe fluctuations

Pulsing or Cycling, due to equipment limitations



No intentional peaking or pulsing on a set pattern, haphazard operation



APPENDIX 2

RUN OF RIVER HYDROPOWER OPERATION USING TWO OR MORE FLOW GAUGES

In this scenario total project flow is gauged at or below the dam and inflow is gauged at one or more points entering the flowage. Requirements for this alternative include:

Upstream gauges must be capable of accounting for a specified percentage of inflow under base flow conditions. The adequacy of upstream gauging is a site-specific determination.

Outlet gauging must account for all water passed by the project. This may require multiple gauging points where bypass channels are present. Flow can be determined at a separate gauge (eg USGS style) or summed discharges from project turbines, spillways, gates, leaks etc. Values must be recorded at least once every 15-60 minutes at projects with automated operation. Manually operated projects can record data less frequently if it is demonstrated that all critical flow conditions will be measured. Data capture need not always be automated, but should generally be required at larger and more complicated projects.

Travel time adjustments must be applied during compliance determinations. This is usually a simple matter of graphically comparing the two data sets and applying the necessary time shifts.

Correction factors will probably be necessary to account for un-gauged water. The significance of these factors can be determined through a multi-year initial trial period. Alternatively, they can be estimated on a theoretical basis, such as:

A constant addition for groundwater inflow.

A % adjustment for un-gauged surface water inflow based on watershed area ratios.

A temperature/area weighted adjustment for evaporation losses.

A temperature/area weighted adjustment for losses during ice making.

Compliance definition:

The two flows, as determined above, should agree with each other within a specified percentage. The Department will normally accept +/- 10% as a flow range, but can negotiate a higher percentage range on a site-specific basis.

RUN OF RIVER HYDROPOWER OPERATION USING ONE TAILWATER FLOW GAUGE

There are some circumstances that do not allow for the use of gauges both above and below a project. These instances should be the exception rather than the rule. In this scenario, compliance is determined at or below the dam only. Upstream flow must be natural and not susceptible to influence of other dams. If upstream dams are expected to alter natural flow regimes to the point of complicating compliance determination, then paired gauges above and below the flowage are needed.

Outlet gauging must account for all water passed by the project. This may require multiple gauging points where bypass channels are present. Flow can be determined at a separate gauge (eg USGS style)

or summed discharges from project turbines, spillways, gates, leaks etc. Values must be recorded at least once every 15-60 minutes at projects with automated operation. Manually operated projects can record data less

frequently if it is demonstrated that all critical flow conditions will be measured. Data capture need not always be automated, but should generally be required at larger and more complicated projects.

Compliance definition – Alternative 1
The preferred compliance measure is defined as an acceptable range about the daily average flow expressed as percentage +/-. The Department will always normally +/- 10% range as an acceptable level of gauge performance, but can negotiate a higher percentage on a site-specific basis. This compliance standard is not applied under the following conditions:

- Rainfall events, as demonstrated by an event hydrograph or using records of rainfall in the watershed.
- Freeze/thaw cycles attributable to daily fluctuations in ambient temperature in the presence of snow cover.
- Ice making in the flowage attributable to an incident of very cold weather. (Example - making 1" of ice on a 1000 acre flowage on a cold night will cause 84 cfs of outflow to disappear for 12 hrs.)

All other operational requirements other than the +/-% value (eg. flowage water levels, ramping rates, gate sequencing etc.) would still apply under these circumstances.

Compliance definition – Alternative 2
(This compliance definition should not be used on projects with large reservoirs, where headwater elevation does not fluctuate significantly with changes in unit operation and/or downstream flows. Check should be made to see if unacceptably large downstream flow fluctuations during drought conditions will produce measurable changes in headwater elevation before using this compliance definition. If either of the above situations exists, alternative 1 above should be used).

If the flow in the river is within the hydraulic capacity of the project's turbines and there is no spill, or only a minimum flow is occurring through the spillway, then the project would be deemed in run-of-river compliance when –

- Flows at the downstream gauge are increasing, project generation is increasing, and the headwater elevation is either increasing or constant, or
- Flows at the downstream gauge are decreasing, project generation is decreasing, and the headwater elevation is either decreasing or constant, or
- Flows at the downstream gauge are constant, project generation is constant, and the headwater elevation is constant.

If river flows are higher than the hydraulic capacity of the project's turbines, and spill, above any licensed mandated minimum flows, is occurring, then the project would be deemed in run-of-river compliance when –

- Flows at the downstream gauge are increasing, project generation is constant, spill is increasing and the headwater elevation is either increasing or constant, or
- Flows at the downstream gauge are decreasing, project generation is constant, spill is decreasing and the headwater elevation is either decreasing or constant, or

An allowance for accuracy of monitoring equipment will be made. The Department will assume a 10% accuracy allowance unless a higher value justified on a site-specific basis.

An accuracy allowance for changes in reservoir water level will always be determined on a case-by-case basis.

Compliance definition – alternative 3
If, due to physical characteristics of the watershed, impoundment or basic dam configuration, acceptable flow regulation cannot be achieved through definition 1 or 2, the Department may choose to establish only a minimum

lower flow expressed as a percentage of the daily average flow under specific or all flow conditions. This has the advantage of providing a level of protection from project-induced fluctuation similar to that attained by specifying a flow range without having to make exceptions for runoff events. This alternative should be pursued only if those listed above don't work out.

Run-of-River License Requirements, A Compliance Perspective

Timothy J. Welch and Thomas J. LoVullo [1] [2]

Abstract

Many licenses issued by the Federal Energy Regulatory Commission (FERC) include provisions requiring licensees to operate hydroelectric projects in a run-of-river mode. Since 1988, the Division of Licensing and Compliance has conducted numerous compliance investigations involving deviations from run-of-river requirements. In some instances, FERC imposed civil penalties for run-of-river violations.

Although functional definitions of "run-of-river" vary, many run-of-river license articles include language requiring licensees to operate projects such that: 1) outflow approximates inflow and; 2) reservoir water level fluctuations are minimized. Adherence to run-of-river requirements is expected, although we recognize that project operators often face certain constraints such as project structures, varying inflows, etc., when operating projects in a run-of-river mode. Because these constraints vary greatly from project to project, FERC staff considers run-of-river operations site specific.

We discuss the type of data FERC staff need to accurately monitor compliance with run-of-river requirements. We also discuss factors staff may consider when reviewing compliance with run-of-river requirements.

---

[1] Fishery Biologists, Federal Energy Regulatory Commission, Office of Hydropower Licensing, Division of Licensing and Compliance, 888 First Street, NE, Washington, DC, 20426.

[2] The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Office of Hydropower Licensing or the Federal Energy Regulatory Commission.

Finally, we encourage licensees to work with FERC staff and the resource agencies in determining a framework of operational constraints, given the limitations of the project, best suited for complying with run-of-river requirements.

Introduction

A survey of new hydroelectric licenses and relicenses issued by the Federal Energy Regulatory Commission (FERC) indicates a majority include provisions requiring licensees to operate projects in a run-of-river (ROR) mode, such that project inflows approximate project outflows. In many instances, ROR requirements were recommended by FERC and natural resource agency staff because of the adverse environmental impacts often associated with downstream water level fluctuations from store and release operations. These adverse environmental impacts may include fish strandings, elimination of algae and aquatic macrophytes due to periodic exposure of channel margins, delayed migration of anadromous fish, and dislodging of aquatic insects and fish eggs due to rapid changes in discharge (Rochester et al. 1984).

Hydroelectric projects operated in an ROR mode generally have less adverse environmental impacts on downstream aquatic resources because downstream flow fluctuations are minimized and may emulate the natural hydrograph of the river. In fact, newly imposed FERC ROR operational requirements on store and release facilities may lead to improved downstream environmental conditions. In a study of lake sturgeon, downstream of a recently licensed Michigan project, Auer (1996) found larger total numbers of lake sturgeon and larger spawning females two years after the project ceased store and release operations and began FERC mandated ROR operations. The author concluded that, because consistent ROR water flows from the project maintained downstream water depths suitable for spawning, greater numbers and larger sturgeon had access to new spawning habitats.

Failure to comply with ROR requirements may cause unnecessary downstream flow fluctuations resulting in downstream environmental damage for reasons previously mentioned. For example, periodic dewatering caused by an upstream hydroelectric project operating in violation with its ROR requirements was cited as a contributing factor in the decline in distribution and abundance of a small catfish, the slender madtom, in a Midwestern stream (Lyons, 1996). In one case, as a result of numerous violations of ROR requirements, with the threat of environmental damage, the Commission assessed a civil penalty of $19,000 to

a project in New York State.[3]

In this paper, we discuss how FERC staff views ROR requirements and outline the types of data FERC staff need to accurately monitor compliance with these requirements. We also discuss factors FERC staff may consider when reviewing compliance with ROR requirements.

What is ROR?

The term "run-of-river" is defined by Webster's Third New International Dictionary as, "Operating on the flow of the river without modification of upstream storage." Linsley and Franzini (1979) present a broader definition of ROR by stating, "A run-of-river plant generally has very limited storage capacity and can use water only as it comes. Some run-of-river plants have enough storage (called pondage) to permit storing water during off-peak hours for use during peak hours of the same day."

Despite the varied technical ROR definitions, recently issued FERC licenses with ROR requirements include standard language explicitly defining "run-of-river" by stating, "The licensee shall operate the project in a run-of-river mode... The licensee shall at all times minimize the fluctuation of the reservoir surface elevation by maintaining a discharge from the project so that, at any point in time, flows, as measured immediately downstream from the project tailrace, approximate the sum of inflows to the project reservoir." (FERC 1992). Licenses issued before 1992 often include references to operating the project in an "instantaneous" run-of-river mode. Mandatory terms and conditions specified by resource agencies in hydroelectric exemptions issued by FERC may also include ROR requirements. However, as one would expect, the degree of specificity pertaining to ROR requirements included in project exemptions varies greatly among the resource agencies. Regardless of ROR terminology, FERC staff views ROR as operations consistent with a balanced inflow/outflow relationship and a stable reservoir elevation.

In recent years, when the necessary information was available, some FERC licenses were issued with ROR requirements including numerical bounds allowing minor deviations from predetermined reservoir elevations or minor differences between inflows and outflows. For example, a license issued for a Wisconsin project included a requirement to maintain the project reservoir within ±0.5 foot of a specified elevation to minimize fluctuations. Although the license article allows deviations of that magnitude, it also requires that the licensee

---

[3] 49 FERC ¶ 61,140

attempt to maintain the reservoir elevation within ±0.3 foot of the specified elevation.[4] In addition, a Michigan hydroelectric project included an ROR requirement allowing a ±5% difference between an upstream gage reading, estimating inflows, and turbine outflows.[5] Finally, in an instance where the necessary information was not readily available at the time of licensing, FERC established an interim ±1 foot reservoir fluctuation operational band and required that the licensee consult with the resource agencies and file a reservoir operating plan based on historical streamflow gaging data. Based on the licensee's proposed plan, the license allows FERC to establish a permanent reservoir fluctuation band that minimizes fluctuations.[6]

Constraints Associated with ROR Operations

We recognize there are site-specific constraints that licensees must contend with when operating a hydroelectric project in compliance with ROR requirements. These constraints may necessitate changes in project operations and/or structures to ensure compliance with ROR requirements at all times. Some constraints associated with ROR operations include: 1) project design; 2) operation of upstream projects; and 3) installed equipment.

Some projects with ROR requirements are designed with long bypass reaches and/or large reservoirs. When these projects suddenly and unexpectedly trip off-line, significant decreases in downstream water flows may result as outflows, measured downstream, fall below inflow levels. This phenomena is often a result of a significant time lag from the time generations flows are curtailed to the time reservoir levels rise allowing inflows to spill over the dam, travel down the bypass reach, and restore flows downstream of the powerhouse to levels approximating inflow. To limit the downstream effects of this time lag, licensees may be required to alter project operations to automatically open a gate at the dam powerhouse upon project shutdown to maintain downstream flows at levels approximating inflows.

Operations at upstream projects may significantly affect ROR operations at downstream projects. If an upstream project is allowed to operate in a store and release mode, or if an upstream project deviates from its ROR requirements, downstream projects with ROR requirements may have difficulty operating, such

---

[4] 73 FERC ¶ 61,346.

[5] 68 FERC ¶ 61,074.

[6] 72 FERC ¶ 62,182.

that inflows approximate outflows, as inflows may change often and without warning. The dynamic nature of this arrangement forces downstream operators to continually adjust project operations to adapt to the changing inflows. When several projects located on the same river are involved, downstream flow fluctuations are often amplified downstream of each project. In these instances, FERC staff encourage licensees to establish lines of communication whereby downstream projects are notified of planned or unplanned changes in inflows from upstream projects and project operations are altered accordingly.

Constraints on ROR operations also may be dictated by the type and sensitivity of equipment installed at a hydroelectric project. During low flow periods, we have observed severe downstream flow fluctuations at an ROR project in Pennsylvania caused by turbines with limited flow operating ranges and maximum hydraulic capacities approximating low flow average streamflows. Because of the "flashy" nature of the stream and the small capacity of the reservoir, turbines are constantly tripped on and off by short-term changes in streamflow.

Location and sensitivity of pressure transducers functioning as an electronic "trigger" for generation may affect consistent ROR operations. ROR projects with transducers located in a forebay or power canal isolated from the project reservoir often operate in non-compliance with ROR requirements, as the project responds to changes in forebay elevation rather than changes in reservoir elevations. Projects with transducer sensitivities set too high or too low may also have difficulty with ROR operations. In either case, severe reservoir water level and downstream flow fluctuations may result as project operations do not respond accordingly to changes in inflow.

Data Used to Determine ROR Compliance

When conducting compliance investigations of alleged non-compliance with ROR requirements, FERC staff request that licensee's provide accurate data on project inflows, outflows, reservoir elevation, and power generation. Most licenses with ROR requirements include provisions requiring streamflow gaging plans to ensure that licensees install and operate the gages necessary to provide data on water levels or stage. The plans also require that gaging data be used to develop stage-discharge relationships to estimate streamflows.

Pressure transducers, staff gages, and automatic recorders are gages commonly installed at ROR projects. Pressure transducers installed in reservoirs to control project operations are frequently used to provide data on reservoir elevations. Staff gages installed in reservoirs or upstream and downstream of projects provide data on reservoir elevation or inflows and outflows. Typically,

staff gage data are recorded manually. However, given the dynamic nature of ROR operations, it may be necessary for licensees to read staff gages at regular intervals throughout a 24 hour period to maintain an accurate record of ROR operations. Automatic recorders, on the other hand, connected to a float in a stilling well, a bubbler gage, or a pressure transducer, are capable of providing a continuous record of ROR operations. Whatever type of data are used to monitor ROR operations, FERC often requests that licensees provide evidence of calibration ensuring data are accurate.

ROR Compliance Factors

Since 1988, FERC staff have conducted numerous compliance reviews of projects based on allegations of non-compliance with ROR requirements. Because of the constraints and site-specific nature of ROR operations discussed above, FERC staff must consider a myriad of factors when reviewing a licensee's data documenting compliance with ROR requirements. These factors include: 1) water level or flow fluctuations; 2) project operations; 3) operation of upstream projects; and 4) emergencies. Because these factors combine to portray an accurate picture of ROR operations, FERC staff employ an holistic approach to ROR compliance investigations using all four factors, whenever possible, to determine if reservoir water level fluctuations or downstream flow fluctuations are project induced.

To monitor ROR compliance, using either discrete or continuous data, FERC staff may examine the magnitude of water level fluctuations in the project reservoir. Increases or decreases in reservoir water levels are often indicative of an imbalance in the "outflow approximates inflow" ROR relationship. If ROR requirements include specified limits on reservoir fluctuations, water level readings outside these limits may be considered violations. However, in situations where there are no specified limits on reservoir elevations, FERC staff may make a determination on what constitutes "minimizing reservoir fluctuations," in concert with licensees and resource agencies, based on historical data and local environmental conditions.

However, stable reservoir water levels, even within specified limits, may not be indicative of ROR compliance. Because of a large storage capacity, even minor water level changes in large reservoirs may result in major downstream flow fluctuations. Therefore, to gain insight into ROR compliance, FERC staff examine the magnitude and duration of changes in downstream flows whenever possible. When reviewing continuously recorded streamgaging data, FERC staff looks for dips and spikes in the downstream hydrograph suggesting periods of sudden decreases and increases in downstream flows. When reviewing discrete flow data from staff gages, staff examine the differences between inflow and

outflows. In either case, fluctuating outflows in the presence of stable inflows suggests to FERC staff that the project may not be operating in compliance with ROR requirements.

Before a final determination of compliance with ROR requirements is made, however, FERC staff examine project generation data to determine if the reservoir water level or downstream flow fluctuations, suggested by the licensee's gaging data, were induced by project operations. In cases where reservoir water levels fall below dam crest elevations, operational records are checked to determine if the project generation was responsible for the drawdown. Likewise, when reservoir elevations exceed reasonable levels, operational records are checked to determine if all available turbines were operating and if all gates necessary to pass inflows were open. In situations concerning downstream flow fluctuations, project generation data are checked against downstream flow data to see if the timing of project start-ups and shut-downs match the same general pattern as the dips and spikes in the downstream hydrograph. Finally, in instances where downstream flow data are not available, project generation data may be converted to flow data using turbine rating curves.

In one case, FERC staff, investigating a report of severe downstream flow fluctuations below a Midwestern project, examined U.S. Geological Survey streamflow data from a gage downstream of the project. Figure 1, from October 1996, shows stable flows below the project for one week while the project was off-line. Figure 2, depicting downstream flows from September 1996 during project operations, presents a highly recognizable pattern of dips and spikes, suggesting that project outflows do not equal inflows. Review of project operational records indicated that the project tripped on and off line on a daily basis. Based on this information, FERC staff found the project in non-compliance with its ROR requirements.

As previously discussed, operation of upstream projects often impose constraints on downstream projects required to operate in a ROR mode. Therefore, when FERC staff investigate allegations of flow fluctuations in a river, staff will often review operational records from several projects upstream of the alleged incident to determine which project is the source of the flow fluctuations.

Most license articles include provisions allowing licensees to deviate from ROR operations "if required by operating emergencies beyond the control of the Licensee, and for short periods upon mutual agreement between the Licensee and the (state fish and game agency)." (FERC 1992). Some licenses issued before 1992 include provisions requiring agreements with federal fish and wildlife

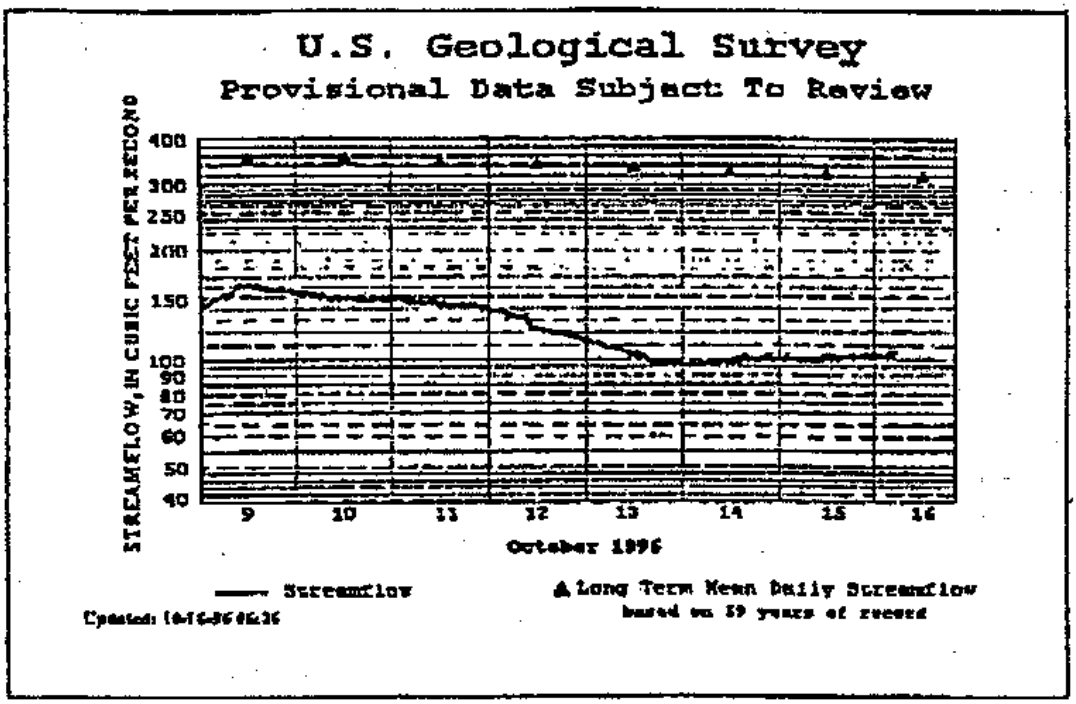


Figure 1. October 1996 flows below a Midwestern project while not operating.

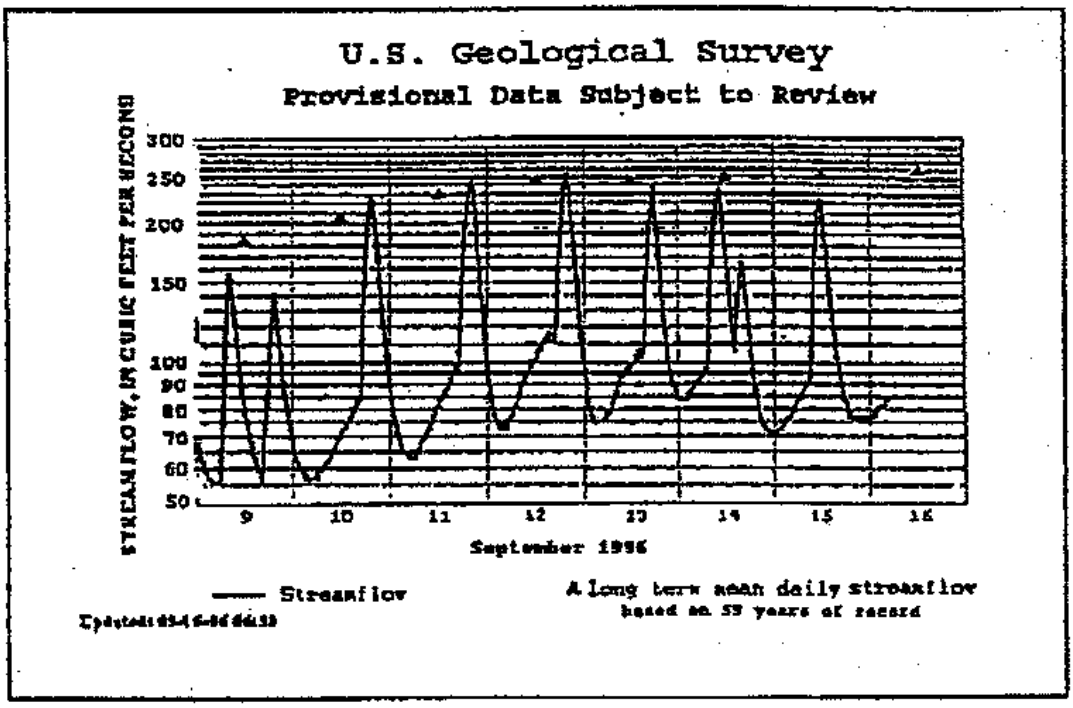


Figure 2. September 1996 flows below the same Midwestern project during project operations.

agencies as well. These provisions are included to allow licensees to lower reservoirs for emergencies such as assisting local law enforcement with searches for drowning victims. This provision also allows licensees to lower reservoirs for maintenance activities with the consent of the state and/or federal fish and wildlife agency. Therefore, when investigating reports of reservoir drawdowns for maintenance purposes, FERC staff requests that licensees provide evidence of consultation with these resource agencies.

Conclusion

Investigations of alleged violations of ROR requirements are often complex and involve examination of several aspects of project operations. After careful consideration of the factors previously discussed, FERC staff may consider reservoir level fluctuations or any imbalance in the inflow/outflow relationship a possible violation of ROR requirements. Operating in a ROR mode should result in a reasonably smooth and uninterrupted flow of water that approximates the natural flow of the river on which the project is located. This requires that licensees install, calibrate, and operate project facilities in a manner that minimizes disturbances and distortions in streamflows.

To ensure compliance with ROR requirements at all times, licensees should continually monitor data on reservoir water level and downstream flow fluctuations and be proactive in adjusting project operations accordingly when these data suggest deviation from ROR requirements. If operational constraints preclude consistent ROR operations, we encourage licensees to confer with resource agencies and FERC staff, and implement operational or structural changes best suited for compliance with ROR requirements.

Literature Cited

Auer, N.A. 1996. Response of spawning sturgeons to change in hydroelectric facility operation. Transactions of the American Fisheries Society 125:66-77.

FERC. 1992. Manual of Standard Special Articles. Office of Hydropower Licensing. Paper No. DPR-4.

Linsley, R.K., and J.B. Franzini. 1979. Water Resources Engineering. McGraw-Hill.

Lyons, J. 1996. Recent decline in the distribution and abundance of slender madtom (*Noturus exilis*) in Wisconsin. Journal of Freshwater Ecology. 11:415-419.

Rochester, H., Jr., T. Lloyd, and M. Farr. 1984. Physical impacts of small-scale hydroelectric facilities and their effects on fish and wildlife. U.S. Fish and Wildlife Service. FWS/OBS-84/19.