

COE's PLAN OF ACTION FOR DISSOLVED GAS MONITORING IN 1999

(Draft/19 January 1999)

INTRODUCTION

This Plan of Action for 1999 summarizes the role and responsibilities of the Corps of Engineers as they relate to dissolved gas monitoring, and identifies channels of communication with other cooperating agencies and interested parties. The Plan summarizes what to measure, how, where, and when to take the measurements and how to analyze and interpret the resulting data. It also provides for periodic review and alteration or redirection of efforts when monitoring results and/or new information from other sources justifies a change. Some information on the complementary activities of other participating agencies is provided at the end of this document.

GENERAL APPROACH

The total dissolved gas (TDG) monitoring program consists of a range of activities designed to provide management information about dissolved gas and spill conditions. These activities include time-series measurements, data analysis, synthesis and interpretation, and calibration of numerical models. Four broad categories of objectives are involved:

- 1) data acquisition, to provide decision-makers with synthesized and relevant information to control dissolved gas supersaturation on a real-time basis,
- 2) real-time monitoring, to ascertain where project release water quality stands relative to existing state dissolved gas standards and federal criteria;
- 3) trend monitoring, to identify long-term changes in basin wide dissolved gas saturation levels resulting from water management decisions; and
- 4) model refinement, to enhance predictive capability of existing models used to evaluate management objectives.

Portland, Seattle and Walla Walla Districts will continue to assume direct responsibilities for TDG monitoring at their respective projects, including data collection, transmission, and analysis and reporting. The Division's Reservoir Control Center (RCC) will coordinate this activity with the Districts and other State and Federal agencies and private parties as needed to insure the information received meet all real-time operational and regulatory requirements. Districts and Division roles and functions are described in more detail in later sections of this document.

The Corps considers TDG monitoring a high priority activity with considerable potential for adversely affecting reservoir operations and ongoing regional efforts to save the salmon. It will make all reasonable efforts toward achieving at least a data quality and reliability level comparable to that provided in 1998.

Furthermore, the Corps believes it is important to maintain a two-way communication between those conducting the monitoring and the users of monitoring information. These interactions give decision-makers and managers an understanding of the limitations of monitoring and, at the same time, provide the technical staff with an understanding of what questions should be answered. Therefore, comments and recommendations received from users were and continue to be very useful in establishing monitoring program priorities and defining areas requiring special attention.

DISTRICTS/DIVISION RESPONSIBILITIES

Portland, Seattle and Walla Walla Districts Functions. Portland, Seattle and Walla Walla Districts will perform all the activities required at their TDG monitoring sites. Data will be collected and transmitted from those sites systematically and without interruption to the Columbia River Operational Hydromet Management System (CROHMS) (or any alternate database as may be specified). Normal monitoring season will be from 1 April through 15 September for all stations except Bonneville and the stations below Bonneville. Because of the Spring Creek hatchery release, monitoring for Bonneville and stations below Bonneville will be from 10 March through 15 September. Winter monitoring, where applicable, will be at least from 15 December through 15 March.

Districts responsibilities include but are not limited the following tasks:

- preparing annual monitoring plan of action and schedule
- procuring data collection/transmission instruments
- preparing and awarding equipment and service contracts
- performing initial instrument installation and testing
- setting up permanent monitoring installations, if requested
- relocating existing stations, if warranted
- collecting and transmitting TDG data to CROHMS
- reviewing data for early detection of instrument malfunction
- making periodic service and maintenance calls once every 2-3 weeks
- providing emergency service calls as needed and/or when so notified
- performing special TDG measurements, if needed
- keeping records of instrument calibration and/or adjustments
- retrieving, servicing, and storing instruments at the end of the season
- making final data correction and posting in separate data base
- performing data analysis to establish/strengthen spill vs. TDG relationship
- preparing an annual activity report

All three Districts will also be responsible for (1) preparing an annual report on instrument performances, and (2) providing the necessary material including test and data analyses, charts, maps, etc. for incorporation in the Corps' Annual TDG Report, which will be finalized by the Division. Additional monitoring at selected locations may be required on an as needed basis and as possible based on available funding. Dissemination of data to outside users will remain a Division responsibility to avoid duplication and uncoordinated service.

Division's Functions. The Division will be responsible for overall coordination of the TDG monitoring program with the Districts, other State and Federal agencies and cooperating parties. The Chief of the Water Quality Section, CENWD-NP-ET-WR, is the designated TDG Division Program Coordinator. He will report through the chain of command through Chief, Reservoir Control Center and Chief, Water Management Division to Director, Engineering & Technical Services Directorate. He will consult as needed with interested staff in Planning Division, Pacific Salmon Coordination Office, Construction-Operations Division, and others.

The Division TDG Program Coordinator will provide overall guidance to his District counterparts to ensure that the monitoring program is carried out in accordance with the plan outlined in this document, including close adherence to a general schedule and operating QA/QC protocols. He will

be the main point of contact for all technical issues related to the TDG monitoring at Corps projects. He will refer problems of common regional interest to relevant forums such as the NMFS's Dissolved Gas Team (DGT) for peer review and open discussion. He will facilitate final decision-making on technical issues based on all relevant input from interested parties.

The Division TDG Program Coordinator will meet with his District counterparts in January to discuss and firm up detailed implementation plan and schedule for the current year. Discussion will cover monitoring sites, equipment, data collection and transmission procedures, service and maintenance, budget, etc. A set of specific performance standards will be jointly prepared as a basis for reviewing and monitoring District performances. A post-season review meeting will be held annually to provide a critique of the operations and identify areas needing changes and/or improvements.

1999 ACTION PLAN

The 1999 Action Plan consists of the usual seven phases observed in previous years, plus winter monitoring. These phases are as follows:

- (1) Program start-up;
- (2) Instrument Installation;
- (3) In-season Monitoring and Problem Fixing;
- (4) Instrument Removal and Storage;
- (5) Winter Monitoring
- (6) Data Compilation, Analysis and Storage;
- (7) Program Evaluation and Report; and
- (8) Special Field Studies

The Plan of Action for all three Districts is essentially the same as in 1998 with the exception of two added sites in the Walla Walla District; the Anatone station (ANQW) and the Pasco (PAQW) station.

Portland and Seattle Districts will continue to use the USGS to do their TDG monitoring. Walla Walla District water quality staff will continue to operate their TDG monitoring system by themselves. In general the 1999 plan is as follows.

Phase 1: Program Start-Up

Responsible parties (See Table 1) will be invited for a coordination meeting some time in January for preliminary discussions on a draft plan of action. This will ensure a good mutual understanding of the most current objectives of the dissolved gas monitoring program, including data to be collected, instrument location, procedures to be used, special requirements, etc. The draft plan will be presented for peer review at a January meeting of the DGT.

All three Districts will ensure that adequate funding is available for 1999 monitoring activities. Portland District, having decided to continue to use the service of the USGS in 1999, will prepare the necessary MIPR's to secure those services and provide for rental and associated maintenance of the USGS's Sutron data collection platforms. Seattle will renew their contractual arrangements as needed for the operation of the Chief Joseph and Libby stations. Walla Walla District will review their equipment inventory and proceed with the necessary orders for new TDG instruments and DCPs, if applicable. Special attention will be paid to the operation of the two new recently installed stations, one near the Columbia and Snake River confluence in Pasco, WA and other at the USGS Anatone gage site on the Snake River approximately 27 miles upstream of the Clearwater River confluence.

All maintenance and service contracts should be completed at least two weeks before the instruments are installed in the field. Where applicable, the Districts will ensure that real estate agreements and right of entry are finalized between the landowners and the Corps. All paper work for outside contracting will be completed no later than 31 January.

To date, Portland District has already initiated the MIPR process and entered in a preliminary agreement with the USGS for conducting the 1999 monitoring activity. Seattle is in the process of reviving similar agreement with Common Sensing Inc. for the Chief Joseph stations. In addition, Seattle District is planning to perform a near-field study below Chief Joseph Dam in conjunction with the Chief Joseph gas abatement study. Walla Walla District had just installed two new TDG monitoring stations. All of their instruments are now Hydrolab instruments, which seemed to have increased overall system reliability and reduced calibration time. Practically all the Walla Walla monitoring tasks will be accomplishment in-house.

It is also understood that the following entities will continue to operate their monitoring instruments in 1999:

- U.S. Bureau of Reclamation, below Hungry Horse, at the International Boundary and above and below Grand Coulee Dam;
- Mid-Columbia PUD's (Douglas, Chelan and Grant Counties), above and below all five PUD dams on the Columbia River; and
- Idaho Power Company, in the Hells Canyon area (as part of its Federal Energy Regulatory Commission's license renewal requirement)

Phase 2: Instrument Installation

Instruments to be installed and their assigned locations are listed in Table 2 and shown in Figure 1. Some of them are already in place for the 1998-1999 winter monitoring. The Corps network will essentially remain the same as in 1998, except for the following. Walla Walla District may install additional sensors to measure temperature in the McNary forebay and the Kalama and Wauna Mills stations in the Portland District may be removed in the Portland District.

Currently the two McNary forebay stations have only one set of sensors each, immersed at the 15-foot depth. Given the potential for higher surface temperatures in portions of this reservoir, which could affect fish movement and survival, a request was been made by regional agencies to add one more sensor at those stations. If this were to occur, the sensors would likely be located directly below the forebay sensors, but submersed at a greater depth than 15 feet (e.g. 50-75 feet). They would be used to define a third point of the water temperature profile between the scroll case and the surface. Walla Walla District is considering these station additions but is still discussing both cost and monitoring configurations. Possibly, some lateral temperature monitoring would be included to best characterize temperature distributions.

The Kalama and Wauna Mills stations have been in operation since 1993 without interruption. They have now gathered six years worth of data for the extreme end of the Columbia River that should be adequate for most baseline physical and biological studies. Furthermore, data collected from these two stations have never been used in operational decision-making. Because of this limited use and the need to cut costs, the Corps plans to seek regional agreement on discontinuing operation at Kalama and Wauna Mills starting as soon as possible. Funds saved from removing these stations may be used for other water quality projects within Portland District. Some possibilities being considered by Portland District include installation of a water quality monitoring station on the opposite bank from the John Day tailwater station; or placement of total dissolved gas sensors below Bonneville

near the Pierce and Ives spawning grounds. Finally, as before, the station below Libby Dam will only be activated if spill for flood control at the project becomes likely.

All instruments are scheduled to have been in place and duly connected to their Sutron or Zeno DCP's no later than 10 March at Bonneville and downstream stations, and no later than 1 April at all other stations. If needed, the station below Libby will be reactivated in May or at least two weeks before the start of flow releases for white sturgeon. Monitoring stations below Bonneville are scheduled to be in place first, prior to the release of Spring Creek Hatchery fish.

Corps stations that remain in service during the 1998-1999 winter will continue their operation with minimum interruption into the spring, following the necessary instrument service and maintenance check-up. These stations include the following: Dworshak tailwater, Lower Granite forebay and tailwater, Ice Harbor forebay and tailwater, McNary forebay (Oregon and Washington sides) and tailwater, Bonneville forebay, and Warrendale. An assessment of monitoring site integrity will be conducted; any damages that may have occurred over the winter will be fixed before proceeding on to calibration and testing. Selected project personnel may be requested to assist on this task as needed.

Phase 3: In-season Monitoring and Problem Fixing

Actual data collection and transmission will start prior to the first Spring Creek Hatchery release, but no later than 15 March for stations below Bonneville, and no later than 1 April for the remainder of the monitoring network. Exact starting dates will be coordinated with the Corps' Reservoir Control Center (CENWD-NP-ET-WR), project biologists and cooperating agencies, based on run-off, spill, and fish migration conditions.

The following data will be collected approximately every hour:

- WC, Water Temperature (°C)
- BH, Barometric Pressure (mm of Hg)
- NT, Total Dissolved Gas Pressure (mm of Hg)

Oxygen pressure and calculated nitrogen pressure parameters are currently collected at Walla Walla stations and at one Seattle District station.

- OP, Dissolved Oxygen Pressure (mm of Hg)
- NP, Nitrogen + Argon Pressure (mm of Hg)

Data will be collected at least hourly and transmitted every four hours. If feasible, the previous 12 hours of data will also be sent to improve the capability of retrieving any data that may have been lost during the preceding transmission. For Portland and Seattle Districts, data transmission will be done via the GOES Satellite, to the Corps' ground-receive station in Portland. After decoding, all data will be stored in the CROHMS database. Per their contract with Portland District, the USGS is planning to have the satellite data going into CROHMS and ADAPS (internal to the USGS) simultaneously to allow for some pre-screening and expeditious posting. The Walla Walla District will transmit their data hourly to CROHMS and the Walla Walla District's Home page on the Internet. Transmission will be through routes other than the GOES satellite.

Given their direct relevance to fish mortality, the first three parameters (WC, BH and NT) will be collected on a first priority basis. At the annual post-season review of the TDG monitoring activities held on October 5, 1998, a suggestion was made to extend high monitoring priority to Dissolved Oxygen in known oxygen-deficient areas. This potential priority change --which will require more

efforts -- will remain open for further regional discussion, if such sites can be clearly identified. Until such time, dissolved oxygen data will be released with an appropriate disclaimer with regard to inherently limited accuracy and reliability.

Given the importance of the Ice Harbor tailwater and McNary forebay data, response time for fixing any instrumentation problems at those sites will be as quick as possible. The fact that Walla Walla District equipment can be interrogated from the District office will help minimize downtime.

Daily reports summarizing TDG and related information will be posted on the Technical Management Team's home page. To the extent feasible, the measured TDG data will be compared with model predicted values so that suspicious values can be flagged and/or discarded before they are released. Data filtering through other methods will also be made. Information provided on the homepage will include the following data:

- Station Identifier
- Date and Time of the Tensionometer Probe Readings
- Water Temperature, °C
- Barometric Pressure, mm of Hg
- TDG Pressure, mm of Hg
- Calculated TDG Saturation Percent (%)
- Project Hourly Spill, Kcfs (QS)
- Project Total Hourly Outflow, Kcfs (QR)
- Number of Spillway Gates Open

Stop settings, if different from the numbers provided in the Fish Passage Plan, will also be given.

Reconciliation between data received via the CBT and those manually recorded on the coding sheets will be made by the Reservoir Control Center staff based on the input from the field, before the data are permanently stored in the Corps' Water Quality Data Base. Additional data posting in the Technical Management Team or Portland, Seattle and Walla Walla Districts' home page will continue.

Instrument reliability and accuracy will be monitored through QA/QC procedures followed in 1998. This is a systematic maintenance and service program implemented at least once every two to three weeks (or more frequently if required by specific site conditions). Every two to three weeks, competent personnel (Contractor or Corps staff) will visit the monitoring sites to check for and, if necessary, fix site problems (probes clogging, leaking membranes, instruments out of calibration, etc.) and recalibrate the faulty instrument(s) using a portable calibration instrument as reference. If data recorded by the fixed sensors are different from those recorded by the portable sensors, appropriate corrections will be made to current as well as past data already stored in CROHMS as soon as possible. Significant and/or unusually large changes will be reported immediately to all customary users, including the Fish Passage Center. Adequate inventory of spare instruments will be maintained to ensure that at least one backup monitor will be made available for deployment as necessary in each Corps District. A malfunctioning instrument will be repaired within 24 to 48 hours, depending on the remoteness of the instrument location and TDG conditions. High priority will be on fixing a faulty instrument when TDG are or expected to be in excess of the current state standards.

Contractor and/or Corps staff will maintain TDG instruments. Instruments needing repairs that are beyond the staff's capability will be shipped to the manufacturer. In-house water quality and information management will do repairs of communication network staff. USGS Stennis Center

(MS) staff will handle Service and repairs of the Sutron DCPs. Service and repairs of the Zeno DCPs will be performed by a contractor.

To better understand the physical process of dissolved gas distribution across the reservoirs and its dissipation along the various pools, selected transects studies will continue to be conducted on an as-time-permits basis. An additional objective for this activity is to be able to define how representative readings from current monitoring sites really are with respect to the entire river reach. Model runs using GASSPILL and other acceptable tools such as a Neural Network model or regression-based equations developed by the Waterway Experimental Station for the Gas Abatement Study will be performed as needed to define the range of expected/acceptable TDG levels under various spill conditions.

Phase 4: Instrument Removal and Storage

Tensionometers will be removed shortly after the end of the monitoring season (15 September) by Corps staff or the USGS, except for those that are slated for continued winter monitoring. Those removed will be serviced by the maintenance and service contractors and stored at a convenient location until the beginning of the next monitoring season. A selected number of tensionometers and spare DCPs will be available for off-season special monitoring activities upon request. Seattle District owns its Sutron DCPs, and maintains and stores them as needed. The District also owns a Coastal Electronics Zeno.

Phase 5: Winter Monitoring

The same few stations that were selected for winter operation in 1998-1999 will be retained for compliance monitoring in the following 1999-2000 winter. These included, at a minimum, stations located at Dworshak tailwater, Lower Granite forebay and tailwater, Ice Harbor forebay and tailwater, McNary forebay (Oregon and Washington) and tailwater, Bonneville forebay, and Warrendale. Implementation details will be worked out as needed, internally and with other participating agencies.

Phase 6: Data Compilation, Analysis and Storage

Time and resource permitting, Corps staff and contractors will fill data gaps, perform statistical analyses, and develop trends and relationships between spill and TDG saturation. Efforts will continue to be expanded on the calibration and application of GASSPILL (Dissolved Gas) and COLTEMP (Water Temperature) models, and finding ways to facilitate and/or improve user access to the TDG and TDG-related database. The GASSPILL model will be periodically modified to incorporate the latest findings brought about by the Gas Abatement Study. Regression-based models assembled by the University of Washington will also be used as appropriate. Data collected at and transmitted from all network stations will be ultimately stored at CENWD-NP-ET-WR, where they can be accessed through a data management system such as HEC-DSS.

Phase 7: Program Evaluation and Summary Report

An annual report will be prepared after the end of the normal (spring and summer) monitoring season to summarize the yearly highlights of the TDG monitoring program. It will include a general program evaluation of the adequacy and timeliness of the information received from the field, and how that information is used to help control TDG supersaturation and high water temperature in the Columbia River basin. Information on the performance of the instruments (including accuracy, precision and bias associated with each parameter) and the nature and extent of instrument failures will be documented. Division staff will prepare the Annual TDG Monitoring Report based on field

input and other material provided by each District. This report will also contain suggestions and recommendations to improve the quality of the data during the FY2000 monitoring program.

Phase 8: Special Field Studies

As provided for in Phase 3, additional monitoring of dissolved gas saturation will be conducted on an as-needed basis. The current plan for additional monitoring includes transect measurements below selected dams to: 1) establish the relationship between various spill amounts and TDG saturation, and 2) plot TDG variations within a given cross-section of the river, especially a cross-section that includes a fixed monitoring station. Special consideration will continue to be made at evaluating improvements (or any other changes) to TDG levels brought about by the new flip-lips at Ice Harbor and John Day Dams. Efforts will also be expanded in learning more about dissolved gas supersaturation dissipation along the fish migration route, possibly using monitoring made from moving fish barges and deployment of self-contained wireless probes. These on-going efforts are expected to continue for several years.

COOPERATION WITH PARTICIPATING AGENCIES

The Bureau of Reclamation, Douglas County PUD, Chelan County PUD, and Grant County PUDs currently monitor for total dissolved gases at their mainstem projects. Until recently, these groups were not directly influenced by the listings of salmon and steelhead under the Endangered Species Act. Nonetheless, they have maintained a cooperative effort with the Corps in collecting and reporting total dissolved gas and related water quality parameters and in making this information available to the Corps for storage in their CROHMS database. Idaho Power Company is believed to have been collecting some TDG information in the Hells Canyon Complex, however, this information has not been as widely disseminated as the data from the rest of the TDG monitoring network. Following are the action plans for the cooperating agencies.

Bureau of Reclamation. Bureau of Reclamation TDG monitoring will continue at International Boundary and the Grand Coulee forebay and tailrace, and the Hungry Horse sites in 1999. Hourly data transmission to CROHMS will continue via the GOES satellite. Modification to the Grand Coulee forebay installation will be made to install the sensors at a fixed depth --15 feet below the minimum operating pool. This installation will provide more representative water quality data for the impounded waters that are released downstream via power intakes or outlets.

Douglas County PUD. 1999 gas monitoring at Wells Dam will include the forebay station and the new tailwater station installed in 1998. Hourly data from both of these stations will be sent to the Corps. The forebay station may be moved to a location where there is better communication access. If this is done, the PUD will perform some transects to see if there are any differences between the two locations.

Chelan County PUD. The physical monitoring of TDG to be conducted in 1999 will be very similar to the monitoring conducted in 1998. Chelan will continue to monitor TDG in the forebay and tailrace of both Rocky Reach and Rock Island Dams. The PUD will continue to use Common Sensing monitors in the forebay and Hydrolab Datasonde 4s in the tailrace. Data will continue to arrive to the Corps hourly, and efforts will be made to repair malfunctioning probes within 48 hours. Monitoring instruments will be calibrated every three to four weeks or as necessary. Chelan will reduce the number of "links" in the data transmission chain to minimize trouble with the transmission flow. Chelan will also continue to conduct weekly transects in the tailraces of both projects to validate the locations of the tailrace monitors and may institute some forebay transects to verify that forebay readings are representative of the conditions in the river at large.

Grant County PUD. TDG will continue to be monitored in the forebays and tailraces of both Wanapum and Priest Rapids Dams. Grant County PUD will purchase state-of-the-art equipment for installation by April 1. Fixed site locations will not be changed and all probes will be calibrated before the season and every three to four weeks following. Hourly data transmission will continue through the GOES satellite. The PUD will also continue weekly cross sectional monitoring at the four fixed monitoring stations in the forebay and tailraces of both projects.

Table 1. List of Contact Persons in 1999

Project	Name	Position	Phone #	E-Mail/ Fax
International Boundary, Grand Coulee	Dave Zimmer	Limnologist /Oversight	(208)378-5088	(208)378-5066
	Jim Doty	/Transmission	(208)378-5272	
	Norbert Cannon	/Oversight	(208) 334-1540	(208) 334-1858
Chief Joseph, Libby	Marian Valentine	Hydraulic Engr. /Oversight	(206) 764-3543	marian.valentine@usace.army.mil
	Ray Strode	Meteo Techn	(206) 764-3529	(206) 764-6678
Wells (Douglas)	Rick Klinge	Biologist /Oversight	(509) 884-7191	(509) 884-0553 rklinge@televar.com
Rocky Reach, Rock Island (Chelan)	Robert MacDonald	Biologist /Oversight	(509) 663-8121	(509) 664-2898 robertm@televar.com
Wanapum, Priest Rapids (Grant)	Chris Carlson	Biologist	(509) 754-3541 x2154	(509) 754-5095
	Dee Chandler	Grant /Transmission	(509) 754-3541	
Dworshak, Low. Granite, Little Goose, Low. Monumental, Ice Harbor, McNary, Pasco, Anatone	Tom Miller	Limnologist /Oversight/ Tech	(509) 527-7279	(509)527-7808 thomas.d.miller@nww01.usace.army.mil
	Gary Slack	Hydro.Tech.	(509) 527-7636 fax(509)527-7808	Gary.m.slack@nww01.usace.army.mil
	Russ Heaton	Hydro. Tech.	(509)527-7282 fax (509)527-7808	Russ.d.heaton@nww01.usace.army.mil
John Day, The Dalles, Bonneville, Warrendale, Skamania, Camas/Washougal, Kalama, Wauna Mills	Jim Britton	Biologist /Oversight	(503) 808-4888	
	Jim Williams	Project. Supt. JDA	(541) 298-7502	
	Darrell Hunt	Ch. Of Ops BON	(541) 374-8338	
	Joe Rinella	USGS	(503) 251-3278	
	Dwight Tanner	USGS	(503) 251 3289	
Division Program Coordination	Bolyvong Tanovan	/Oversight	(503) 808-3938 (503) 808-3932 fax	bolyvong.s.tanovan@usace.army.mil
	Mary Todd Uhlir	Hydro. Tech. /Oversight	(503) 808-3939	mary.t.uhlir@usace.army.mil

Table 2. 1999 Dissolved Gas Monitoring Network

STATION CODE	STATION NAME	OWNERS
CIBW*	US/Can Boundary	USBR
HGHW	Below HGH	USBR
FDRW	GCL Forebay	USBR
GCGW	GCL Tailwater	USBR
LIBM (#)	LIB Tailwater	NWS
CHJ	CHJ Forebay	NWS
CHQW	CHJ Tailwater	NWS
WEL	WEL Forebay	DOUGLAS CO.
WELW	WEL Tailwater	DOUGLAS CO
RRH	RRH Forebay	CHELAN CO.
RRDW	RRH Tailwater	CHELAN CO.
RIS	RIS Forebay	CHELAN CO.
RIGW	RIS Tailwater	CHELAN CO.
WAN	WAN Forebay	GRANT CO.
WANW	WAN Tailwater	GRANT CO.
PRD	PRD Forebay	GRANT CO.
PRXW	PRD Tailwater	GRANT CO.
DWQI*	DWR Tailwater	NWW
PEKI	Peck/Clearwater	NWW
LEWI	Lewiston/Clearwater	NWW
ANQW*	Anatone/Snake	NWW
LWG*	LWG Forebay	NWW
LGNW*	LGNW TW	NWW
LGS	LGS Forebay	NWW
LGSW	LGS Tailwater	NWW
LMN	LMN Forebay	NWW
LMNW	LMN Tailwater	NWW
IHR*	IHR Forebay	NWW
IDSW*	IHR Tailwater	NWW
PAQW"	Columbia above Snake	NWW
MCQW*	MCN FB/Wa	NWW
MCQW-1 (?)	MCN FB1/Wa	NWW
MCQO*	MCN FB/Or	NWW
MCQO-1 (?)	MCN FB1/Or	NWW
MCPW*	MCN Tailwater	NWW
JDA	JDA Forebay	NWP
JHAW	JDA Tailwater	NWP
TDA	TDA Forebay	NWP
TDDO	TDA Tailwater	NWP
BON*	BON Forebay	NWP
WRNO*	Warrendale	NWP
SKAW	Skamania	NWP
CWMW	Camas	NWP

(?) Tentative (#) during spill only (*) winter monitoring station USBR= U.S. Bureau of Reclamation NPP= Portland District
 NPS= Seattle District NPW= Walla Walla District LB=Left bank RB=Right bank MC=mid-channel

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