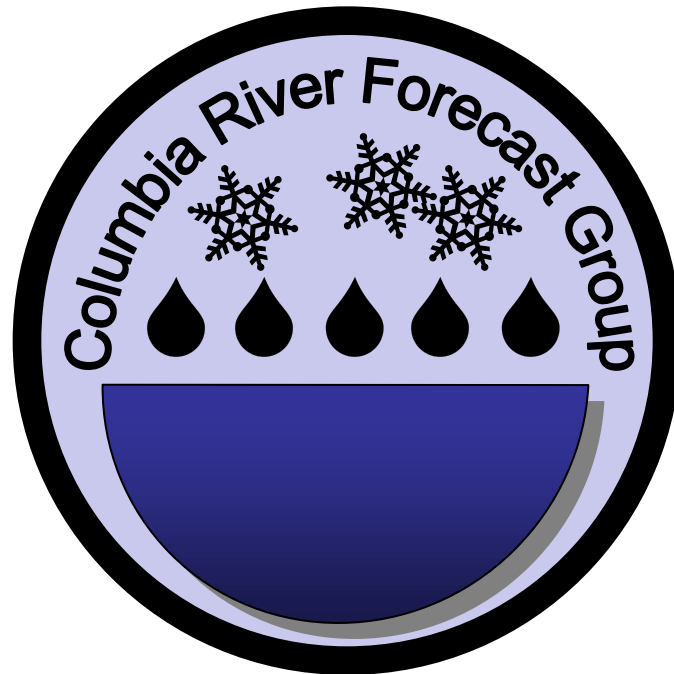


COLUMBIA RIVER FORECAST GROUP

2014
ANNUAL
REPORT



CHAIR: STEPHEN HALL, USACE
VICE-CHAIR: TED DAY, BOR

APRIL 2015

C O L U M B I A R I V E R F O R E C A S T G R O U P
2 0 1 4 A N N U A L R E P O R T

A N N U A L S U M M A R Y

The Columbia River Forecast Group (CRFG) was formed to work to promote and support the advancement of forecasting skill, products, and techniques in the Columbia River Basin for the purpose of improving reservoir operations for the benefit of the region and as prescribed and documented in the Columbia Basin Fish Accords and 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp), Reasonable and Prudent Alternative (#7) as shown below.

RPA Action 7 – Forecasting and Climate Change/Variability: The Action Agencies will hold annual forecast performance reviews looking at in-place tools for seasonal volume forecasts and to report on the effectiveness of experimental or developing/emerging technologies and procedures. As new procedures and techniques become available and are identified to have significant potential to reduce forecast error and improve the reliability of a forecast, the Action Agencies will discuss the implementation possibilities with regional interests. The purpose is to improve upon achieving upper rule curve elevations by reducing forecasts errors and thereby providing for improved spring flows...

The Action Agencies and Fish Accord partners formed the Columbia River Forecast Group (CRFG) to collaboratively implement this RPA action. To address the RPA, the CRFG has provided an open forum for sharing, discussing, evaluating and potentially implementing new forecasting techniques, supporting procedures, and information into the planning and operation of the Columbia River Basin system. The term “forecasting” refers to both water supply forecasting and streamflow forecasting.

In 2014, the following agencies regularly sent representatives or participated via conference call in CRFG meetings:

Bonneville Power Administration (BPA), Portland, OR
US Army Corp of Engineers (USACE, or COE) Divisional Office, Portland, OR
US Army Corp of Engineers District offices in Seattle, WA, and Walla Walla, WA
Bureau of Reclamation (USBR), Boise, ID
Columbia River Inter Tribal Fish Commission (CRITFC), Portland, OR
Natural Resources Conservation Service (NRCS), Portland, OR
NOAA/National Weather Service Northwest River Forecast Center, Portland, OR
NW Power and Conservation Council
BC Hydro (BCH), Burnaby, BC
Idaho Power Company (IPC), Boise, ID

The CRFG met four times in 2014, as required by the Charter:

February 13, 2014
April 22, 2014
September 25, 2014
December 4, 2014

Water supply and forecasting was a “Roller-Coaster-Ride” for the 2014 water year. All across the basin a dry and relatively cold fall settled in. The dry spell lasted through January where nearly all of the CRB’s reservoirs were expecting a well below normal spring runoff. In February and March a couple of large storms brought some much needed precipitation as snow and brought the majority of the CRB to normal seasonal water supply with a 150% of normal precipitation gain during those two months. April was nearly normal across the basin followed by a dry May which caused many forecast predictions to miss though only slightly. The extreme changes in the water supply forecast did however cause some duress in regards to project operations for a lot of the storage projects.

Large contributors to successful operations were frequent ESP updates from BPA and RFC for decision making purposes. In addition, four new snow pillows were added in Canada which should prove useful in the future. BPA will also be looking at experimenting with five climate indices; QBO, EPMP Blocking Index, PMA, PDO, and ENSO. This will be done this winter in the ESP’s, however it will not be done for inventory studies. The RFC is now experimenting with post processing/bias correction tools within CHPS for the next two years.

The “dry-wet” pattern of the year was a great benefit for marketing and fish as explained by Paul of the NOAA-Fisheries. The pattern caused a holdover of water due to the lack of fall and winter precipitation which was then drafted suddenly and was very helpful for the spring salmon release.

In regards to climate change research, some downscaling challenges with MACA were overcome in trying to capture events in the downscaling. BPA, USACE, and USBR have reviewed the data and calibrations are ongoing. In addition, there are more projects up for review by the BPA’s review panel. Here some projects are accepted, others continue to be funded, and approximately 10% are dropped. It was suggested to have a concurrent CRFG meeting with the next review panel.

Efforts are underway to ensure continued operations for the Pacific Northwest in the event of a Cascadia Subduction Earthquake (M-9). Walla Walla District would operate for Seattle and Portland districts. BPA has alternate offices in Vancouver WA and Spokane/Monroe WA. They may have difficulty however transporting Portland staff to Spokane. Additionally, the Corps will have a standing seat at BPA’s Spokane facility. BPA could provide some weather/forecast data in lieu of the local NWS office being down. NWS would transfer operations to their field office in Pendleton OR as a back-up of the Portland WFO. USBR would utilize another area office in the event the Portland office were incapacitated. A 2016 “Cascadia Earthquake” exercise is expected to occur in 2016 with BPA, USACE, USBR, NWS, FEMA, and others. Other potential considerations for the next year include maintaining data transfer between the agencies in case of a cyber attack potentially shutting down the internet.

Due to Ted Day changing positions in the USBR and Eric Rothwell assuming Ted’s role with CRFG, Kyle Dittmer (CRITFC) volunteered to chair for the group in 2015. Eric Rothwell will serve as the vice-chair. Other initiatives include USACE Walla Walla working on a new Ririe inflow forecast. USBR is developing PCA forecast equations using NRCS’s VIPER model. USBR will continue using current techniques while testing the PCA equations in 2015. RMJOC-II will continue to be a constant through 2016. It was suggested to make CRFG a clearing house for ongoing research. Further, updates on research and initiatives for forecasts from NWS RFC would be of benefit.

A P P E N D I X A

Columbia River Forecast Group (CRFG)

CRFG CHARTER

I. Purpose

The Columbia River Forecast Group will work to promote and support the advancement of forecasting skill, products, and techniques in the Columbia River Basin for the purpose of improving reservoir operations for the benefit of the region and as prescribed and documented in the Columbia Basin Fish Accords and 2008 FCRPS Biological Opinion, Reasonable and Prudent Alternative (#7). It will also provide an open forum for sharing, discussing, evaluating and potentially implementing new forecasting techniques, supporting procedures, and information into the planning and operation of the Columbia River Basin system. The term forecasting will refer to both water supply forecasting and streamflow forecasting.

II. Composition

The CRFG will be composed of technical representatives from the AAs, namely the BPA, the USACE, and the USBR, as well as the parties to the Fish Accords. The CRFG will also be open for participation from any representative of a governmental organization, academic institution or invited guests of the CRFG, who are willing to contribute to the effectiveness and success of the group.

The Chair of the CRFG will be a representative from the three AAs or Fish Accord Tribes. The Chair position will rotate annually among these four representative organizations or groups following the Fall Workshop.

III. Meetings_and Workshops

A general business meeting will occur no less than quarterly but more frequently if workload and projects require it. Meetings and workshops will be called at the discretion of the Chair.

In addition to business meetings, there will be an Annual CRFG Meeting in the fall to review the performance of various operational and experimental forecast procedures over the previous water year, to report on any new approved procedures being implemented in the next year, and to plan committee work for the coming year.

IV. Functions

1. Facilitate the sharing of information and research pertinent to the improvement of forecasting for the Columbia River Basin, namely in the areas of water supply forecasting, operational streamflows forecasting, data quality and availability, weather forecasting (as

it pertains to improving water supply and streamflow forecasting), and climate change.

2. Track and review the performance of current forecasting procedures and techniques, as well as sharing, discussing, and investigating the potential of new forecasting techniques and modeling.
3. When promising research or techniques are discovered and introduced for consideration, the CRFG will develop a strategy for either investigating the potential improvement with available technical staff within the CRFG or provide recommendations or proposals to the AAs for possible funding and support for further research and development.
4. The group will participate in the evaluation of proposed new forecast procedures, models, and techniques and provide recommendations on the incorporation of new procedures into the planning and operation of the Columbia River system.
5. Facilitate the sharing of data, where possible, and the monitoring of the data network and systems which enhance and support the forecasting capabilities of the region. When necessary, the group will provide recommendations on improvements and enhancements to the network.
6. When necessary, the group will plan and facilitate workshops with presenters speaking on current research and forecast projects. The group will also have a role in educating users on forecasting products and on specific focus areas, providing the technical expertise and platform for conducting seminars and workshops on various topics pertinent to the group's purpose.

V. Reporting

1. The CRFG will produce minutes of each official meeting for distribution to the group and for the purpose of summarizing the group's activities and achievements at the end of the year.
2. The CRFG will produce an annual summary of the group's activities, achievements, and recommendations no later than 4 months after the end of the water year. This report will be the basis for annual reporting required for the Biological Opinion and Fish Accord records.
3. The organization chairing the CRFG will be responsible for meeting notes and annual reporting at the end of the water year.

Appendix B: Columbia River Forecast Group Agendas and Meeting Minutes

AGENDA

Columbia River Forecasting Group (CRFG)

February 13th, 2014

Meeting time: 9:00-12:00am PST

Teleconference: Phone Number: (877)848-7030
Access code: 3626353
Security Code: 7722
Web Meeting: <https://www.webmeeting.att.com>
Meeting Number: (877)848-7030
Access code: 3626353

Contact Info: Steve Hall (509-527-7550)
Ted Day (208-378-5273)

9:00am Introductions/Roll Call (Steve)

9:15 Approval of December 4th minutes (all)

9:30 2014 Water Supply Forecasts

Corp Seattle:	Libby
BC Hydro:	Canadian Columbia and Kootenai
Reclamation/NRCS:	Hungry Horse and middle/upper Snake
Corp Walla Walla:	Dworshak
NWSRFC:	Grand Coulee, Lower Granite, Dalles

10:30 RMJOC-II Climate Change Research Update (Erik)

10:45 Break

11:00 Libby WSF Update (Kevin/Joel)

11:30 Other items, Next meeting

12:00 Adjourn

MINUTES

Columbia River Forecasting Group (CRFG)

Columbia River Forecast Group Meeting Notes

February 13th, 2014

Teleconference Participants: Kyle Dittmer (CRITFC), Erik Pytlak (BPA), Stephen Hall (USACE), Ted Day (USBR), Toni Turner (USBR), Steve King (NWRFC), Jeremy Giovando (USACE), Kevin Shaffer (USACE), Paul Wagner (NOAA), Margaret Filardo (FPC), Jason Ward (USACE), Oriana Chegwidan (UW), Tim Brewer (Idaho Power), Joanie Salerno (NWRFC), Joel Fenolio (USACE), Rich Vanderzweep (BPA), Adam Gobena (BC Hydro), others?

Meeting Minutes from Dec. 4 2013 not quite ready; request of Dec. 4 speakers to provide any presentations. Will be finalized at next meeting.

Agenda Item: Presentations on February water supply forecasts by forecasters

Ted Day – presented on Hungry Horse (2183 kaf Feb-July, 107%), Snake River at Heise (92%), and Boise River (59%) water supply forecasts. Very low forecasts in much of eastern and central Oregon (20 to 40%) and middle Snake tributaries (50 – 70%), better in the Upper Snake and points further north.

Kevin Shaffer - Libby forecast– April-August 5.2 maf, 88%. Stable forecast so far; neutral QBO not adding or subtracting much from the forecast.

Stephen Hall – Dworshak forecast 2.27 maf, 93%. Expected to dramatically increase given February precip. Snow approaching normal.

Joanie Salerno: near normal along divide, drops as you move west. Dalles downward trend all season, but now an uptick, same with the Snake.

Comment from a participant (Jason?) about concern over effects of QPF on days 4 and 5 and the sensitivity of the forecast.

Hall: Are there limits to how much the forecast can change per day?

King: RFC has looked at it, but daily issuance changes are consistent with bulk changes seen with the former 3 times per month issuance. Storms tend to come in a step-wise pattern; the model is rightfully sensitive, but the QPF forecasts do not always pan out.

Kyle Dittmer – The Dalles: 104 maf (102%) Jan-July. Updatee MEI suggests trend toward El Nino later in season.

Adam Gobena – BC: below normal at the 3 treaty projects. Mica 91% in Dec, 90% in Feb; Arrow 92% in Dec, 89% in Feb; Duncan 92% in Dec, 85% in February. Internal ESP forecasts are consistent with statistical forecasts, except on the Kootaney where Oct precip at 2 stations is driving statistical equation down.

Tim Brewer – Snake at Brownlee: low volumes expected in the lower Snake due to low reservoir carryover going into the season. Optimistic the wetter pattern change will last for awhile.

Erik Pytlak: expressed “relief for now” thanks to pattern change, but could not share internal longer range forecasts due to proprietary nature.

General discussion of outlier events and the impact forecasts (specifically at Libby). Libby PCR forecast with multiple variables – high month of precip in early season forecast (which relies on precip prior to snow accumulation) drove fall forecast too high. Decision was made to decrease precip value to 0.5 std deviations (?) above normal to limit impact. BC Hydro states they did the same.

Pytlak: putting limit makes sense but is there a scientific basis that can be applied? At what point in the fall if you get X precip that soils will saturate and it simply runs off and is lost to the future forecast? There is no easy way to handle different impact potential with each variable, need to understand the physical process that is potentially affected. Suggests we continue to look for “drivers” of the forecast as we move through each year. Also suggests examining ENSO variable to test for limits.

AGENDA ITEM: RMJOC-II

Pytlak: Both projects are “picking up steam”.

UW: 1st tasks nearing completion; handling glacial input very well. Getting good results with a simpler model versus a complex dynamical model. GCM selection moving forward.

PSU: moving a little bit slower. Downscaling data from U of I being re-done to utilize a better method caused delay to later in February, then some catching up to do. Most of PSU work will be post-processing of future work.

Toni Turner: USBR/COE working together to provide the NRNI (no regulation no irrigation) “base case” data sets.

Giovando: compiled data for entire basin, doing QC on it. Additional effort to disaggregate Snake data to daily values will occur. NRNI effort is ahead of schedule.

Pytlak: Action agencies need to get together to specify the list of stations of interest for the researchers. List by March, will share with CRFG.

AGENDA ITEM: Libby Forecast Procedure Update (Shaffer w/ ppt presentation)

Oddities with climate indices spurns the need for an update. QBO example: similar March snow for 2011 vs. 2012, but radical difference of 1.5 maf in the forecast due primarily to QBO and fall precipitation. Also, month to month breakpoints equates to inconsistency moving through season. Variables changing and dropping out as season goes on. Also, training years change with each changed monthly equation.

Goals:

- develop equations that are consistent and use measurable physical processes;
- only use climate variables with fully explained connection to historic hydrology or show no deterioration of forecast skill;
- Eliminate November first of month forecast
- Enhance geographic coverage of snow stations

Training period discussion. Noted shift in hydrology around 1975; snow data limited to back to the 80's, combined with a desire to add Alberta snow sites. Test of different training periods equates to different error bounds. In addition, inclusion of 2012 increases error, suggesting impact from an outlier year.

Period of 1984 – 2013 was chosen. Maximizes use of Alberta sites and excludes changed hydrology prior to 1975, along with minimizing back generation of missing data.

An outlier test was also performed on 2012. Outliers defined as extreme if greater than 3.0 standard residuals (Handbook of Hydrology), and outliers = 1.5 to 3 std residuals, with greater than 3.0 being extreme (Applied Statistics and Probability).

2012 = 3.73 std residuals. Compelling case to exclude; next closest outlier was 1.5 to 2.5 residuals.

Exclusion meant no significant change in median value, but inclusion moves error bounds significantly.

Graph of QBO vs. inflow shows low R squared value of 0.0578. No compelling evidence to keep it in forecast. SOI vs. forecast slightly better at 0.1791; kept in for early season forecast.

Next meeting will be scheduled for April 22.

AGENDA
Columbia River Forecasting Group (CRFG)
April 22nd, 2014

Meeting time: 10:00 am - 2:00 pm PST
Teleconference: Phone Number: (877)848-7030
Access code: 3626353
Security Code: 0422
Web Meeting: <https://www.webmeeting.att.com>
Meeting Number: (877)848-7030
Access code: 3626353

Contact Info: Steve Hall (509-527-7550)
Ted Day (208-378-5273)

10:00am **Introductions/Roll Call** (Steve)

10:15 **Approval Minutes:** December 4th 2013 minutes, and February 13th, 2014 (all)

10:30 **2014 Water Supply Forecasts**
Corp Seattle: Libby
BC Hydro: Canadian Columbia and Kootenai
Reclamation/NRCS: Hungry Horse and middle/upper Snake
Corp Walla Walla: Dworshak
NWSRFC: Grand Coulee, Lower Granite, Dalles
CRITFC: Dalles
Idaho Power Company, Others

11:00 **Idaho Power Company Stream Gaging** (Kresta)

11:10 **NASA Research Grant:** Medium range (30-180 day) forecast improvement (Dr. Demissie WSU)

11:30 **Break/Lunch**

12:15 **RMJOC-II Climate Change Research Update**
GCM Selection (Erik)
UW Research progress (Bart Nijssen)

1:15 **Libby WSF Update** (Kevin/Joel)

1:30 **Draft Annual Report for 2013**

1:45 **Other items:** Set next meeting dates

2:00 **Adjourn**

MINUTES

Columbia River Forecast Group Meeting Notes

April 22, 2014

Participants (in-person and via teleconference): Kyle Dittmer (CRITFC), Erik Pytlak (BPA), Stephen Hall (USACE-Walla Walla), Ted Day (USBR), Eric Rothwell (USBR), Joe Intermill (NWRFC), Adam Price (USACE-Seattle), Paul Wagner (NOAA), Jim Ruff (NWPPC), Jason Ward (USACE), Oriana Chegwidan (UW), Tim Brewer (Idaho Power), Adam Gobena (BC Hydro), Bruce Anderson (NWRFC), Dave Garen (NRCS), Kresta Davis-Butts (Idaho Power), Bob Heineth (CRITFC-retired), Kristian Mickelson (USACE-Seattle), Tracy Schwarz (USACE-Walla Walla), Bart Nijssen (UW), others?

Meeting minutes from February CRFG meeting were finalized, pending comments from Seattle COE pertaining to Libby discussion.

Agenda Item: Presentations on 2014 water supply forecasts by forecasters

Kevin Shaffer - Libby forecast – forecast April through August at 117%. Normal so far in April more or less, so expected similar volume % with May forecast. Heavy precip/snow in March dramatically improved forecast. No big influence from QBO variable.

Jason Ward, comment that Fernie precip variable has not been adding value and having data reliability problems.

Eric Pytlak, comment cautioning about loss of COOP network, look for opportunities to update equations with this in mind, taking advantage of telemetered data. No known effort to fix or replace Fernie data.

Adam Price/Jason Ward: New Libby forecast is running in parallel, in March was well aligned with old technique. But QBO not having influence so impact may be hard to tease out.

Pytlak: QBO does not have a physical connection and he still supports not including it as a candidate variable.

A question was posed on Hungry Horse stations; Day responded with list of precip stations used in forecast and that all are telemetered.

Adam Gobena – Canadian projects – Forecasts are in line with Libby, going up 7 to 8% over the March forecasts for all 3 projects. Mica and Arrow = 97%, Duncan at 93%. These are snow driven forecasts; went from below normal in Feb to near normal now.

Ted Day – Hungry Horse and Snake River @ Heise: Hungry Horse April-July volume forecast of 2436 kaf, 130% of average. Heise forecast Apr-July of 4370, 135% of average. Major turn around mid-winter in the Snake Basin, avoids drought situation.

Dave Garen – presented NRCS forecast map for entire Region

Stephen Hall – Dworshak: forecast of about 3.1 maf, or 128%. Went up about 400 kaf from last forecast; not expected to change much with May issuance. There will be a change of stations used in the May forecast due to low elevation snow sites dropping out.

Bruce Anderson – Lower Granite and The Dalles: LWG similar trend, 115% first of month but dipped to 105% mid-month, now stabilized around 109%. TDA had a 2 month rise, but stable now. (no forecast value/% was noted).

Kyle Dittmer – MEI bouncing near neutral over the winter. April TDA forecast of 103 maf (102%); been fairly consistent in the 101 to 104 maf range. El Nino likely later this year according to Australian Meteorologic website.

Garen: some forecasts are predicting “extreme” El Nino, although NOAA is not.

Kresta Davis-Butts – Brownlee: BRN forecast is below average (no value cited), lots of improvement in the runoff component but low carryover in the upstream Snake Basin will mean more goes into upstream storage.

AGENDA ITEM: Idaho Power Stream Gaging Program

Davis-Butts: Idaho Power stream gaging program began in the late 1990s/early 2000s for FERC compliance needs, and has since morphed into contract stream gaging, support for in-house RFS model, COOP gaging with State of Oregon.

Pytlak: Does Idaho Power do stage measuring?

Davis-Butts: Yes, especially for compliance; USGS is invited along and USGS certifies for quality at end of year to USGS standards.

Pytlak: Idaho Power data may be useful for calibrations for other ongoing modeling.

Davis-Butts: coordinated with USGS and available through USGS; primarily just stage/discharge stations but Idaho Power has some “in-house” weather stations in support of cloud seeding programs.
Pytlak: acknowledged the contribution this program potentially provides.

AGENDA ITEM: RMJOC-II

Pytlak: “Going well” with the “regulation piece” of what to do with RMJOC flows. 2016/2017 timeframe to have climate change flows for doing regulation studies. The data will be publicly available.

Bart Nijssen: “Predicting the Hydrologic Response of the Columbia River System to Climate Change” Principal Investigator is Dennis Lettenmaier (UW). Co-PI’s are Nijssen (UW) and Phil Mote (OSU).

Nijssen gave presentation summing up study and work to date. See powerpoint (availability?)

Ward: Is 8.5 RCP considered the upper bound?

Nissjen: Not necessarily upper bound, more of the “do nothing” scenario.

Garen: Does solar radiation come direct from GCMs or from internal model calculations?

Nissjen: from the latter.

AGENDA ITEM: Libby Forecast Procedure Update (Shaffer)

Still working toward final (see morning discussion).

Graph of QBO vs. inflow shows low R squared value of 0.0578. No compelling evidence to keep it in forecast. SOI vs. forecast slightly better at 0.1791; kept in for early season forecast with overlap in January.

AGENDA ITEM: 2013 Annual Report draft (Pytlak)

Will finalize by email by May 2. Should be very close to final already.

Adjournment

Next meetings will be scheduled for Sept 10 and Nov 18.

AGENDA

Columbia River Forecasting Group (CRFG)

September 25th, 2014

Meeting time: 10:00 am - 2:00 pm PST

Location: Celilo Room (5th floor CRITFC)

Teleconference: Phone Number: (877)848-7030

Access code: 3626353

Security Code: 1111

Web Meeting: <https://www.webmeeting.att.com>

Meeting Number: (877)848-7030

Access code: 3626353

Contact Info: Steve Hall (509-527-7550)

Ted Day (208-378-5273)

10:00am **Introductions/Roll Call** (Steve)

10:15 **Approval Minutes:** February 13th, 2014, April 22nd 2014 (all)

10:30 **Approval of 2013 Minutes and Annual report:** Due to missing changes, we will
reapprove the minutes and the annual report. (All)

10:45 **Portland State RMJOC II Climate Change Research:** Dr. Hamid

11:45 **Break/Lunch**

12:30 **RMJOC-II Climate Change Research Update:** Pytlak

12:45 **Using Climate Change with Water Supply Forecasting:** all

1:15 **Libby Water Supply Forecast Update:** Mickelson

1:30 **COOP and Forecasting:** all

1:55 **Other items:** Set next meeting dates

2:00 **Adjourn**

MINUTES

Columbia River Forecast Group Meeting Notes
September 25, 2014

Participants (in-person): Kyle Dittmer (CRITFC), Erik Pytlak (BPA), Stephen Hall (USACE-Walla Walla), Ted Day (USBR), Joe Intermill (NWRFC), Adam Price (USACE-Seattle), Paul Wagner (NOAA), Jason Ward (USACE), Dave Garen (NRCS), Kresta Davis-Butts (Idaho Power), Bart Nijssen (UW), Hamid Moradkhani (Portland State), Benjamin Beal (USGS), Arun Rana (Portland State), John Risley (USGS-Portland), Cara McCarthy (NRCS), Gus Goodbody (NRCS), Philip Mote (OCCR/OSU), Rashawn Tama (NRCS), David Graves (CRITFC), Laura Gephart (CRITFC), Participants on phone: Paul Pickett (WA Dept. of Ecology), Stephanie Smith (BC Hydro), Kristian Mickelson (USACE-Seattle), Margaret Filardo (Fish Passage Center), Oriana Chegwidan (UW), **others?**

Introductions and Roll Call (Hall)

AGENDA ITEM 1: Approval of Minutes: Feb. 13 and Apr. 22

Corrections were offered on both sets of minutes by Dittmer, Pytlak, Ward. Both sets of minutes were subsequently approved as amended.

AGENDA ITEM 2: Approval of 2013 Minutes and Annual Report

Erik P. explained delay in finalizing annual report due to substantive changes to meeting minutes that were previously not captured. Annual report was subsequently approved as amended. Thanks to Erik for all his work on producing the report, which will be posted on the Salmon Recovery website.

AGENDA ITEM 3: Portland State RMJOC-II Climate Change Research (Dr. Hamid Moradkhani)

Erik P. introduced the topic by giving a quick background on RMJOC -II, and how it follows the basic process of RMJOC- I, but much more expansive based on lessons learned. Dr. Moradkhani gave a detailed presentation on the research work and results (thus far) that PSU has been performing, along with an updated schedule for completing the remaining work. The project has already yielded some results which will benefit climate change research in the region, especially with respect to downscaled data quality control.

AGENDA ITEM 4: RMJOC –II Climate Change Research Update (Pytlak)

Erik started with a discussion/comparison of current GCMs vs. the last set of GCMs. For example, the new GCMs tend to be warmer and slightly wetter for the PNW, but with a slightly larger range in possible future temperatures, and a continued large spread in future basin precipitation. He also shared that both projects are generally on track

Ten PSU and 10 UW GCMs chosen, but some could drop out based on unregulated streamflow routing. BCSD (bias corrected statistical downscaling) is rather close to the old “Delta-Hybrid” downscaling used in the mid 2000s, but generally regard in the scientific community.

PSU not likely to produce a final set of climate change streamflows until October, 2015.

NRNI flows are considered final and are now posted for all to use on the BPA Modified Flows website: <http://www.bpa.gov/power/streamflow/default.aspx>. Erik caution that the NRNI flows should not be used for any other purpose because of how the NRNI was calculated. Modified Flows should generally be used for long range planning purposes.

Moving forward in FY15, BPA/COE/USBR will be working need to put together a new “base case” scenario, using NRNI as the starting point, although BPA will have to subtract irrigation back out for its hydropower base case development. .

Garen: are both PSU and UW using PRMS and VIC for their hydrologic models?

Erik: Yes, but both are using different setups, and developed their own calibrations.

Garen: expressed concern over range of variability due solely from setup variability. Erik replied that the project intent is to capture how much uncertainty is introduced by different model setups.

Ward: climate change driven hydrology changes will inform future changes for forecasting schemes.

Tama: how much influence will RMJOC have over GCM selection?

Erik: None, researches will choose GCMs.

AGENDA ITEM 5: Using Climate Change with Water Supply Forecasting

Steve Hall opened up this top for general discussion, with the basic question of “are we nimble enough as we enter/continue a transitional period of climate change?”

Ward: How does BPA think they are going to adapt their ESP approach to include climate change?

Pytlak: There are different methods we can employ. For example, we can adjust the period of record to reflect later trends, for calibrating on more current period. This is similar to statistical approach with more frequent updated regressions. We do need to study the nexus with rule curves, too. For example, if runoff and refill really does occur earlier with time, will April-August continue to make sense, or will we have to use different period (i.e. March-July). We already do this now at Hungry Horse, which uses a May-Sep forecast period. Perhaps the issue the CRFG should consider going forward is how to make ourselves more resilient to change.

Ward: Is it an option to put in synthetic flows into ESP instead of/in addition to recent historical data?

NRCS: Could not do it for calibration, but could use it for forcing. Garen: time horizons don't match up... climate change is decades time scale, ESP is trying to get at current year.

Wagner: Action agencies can appear to be adverse to change. Need to be careful to not assume you know more than you do, avoid mis-steps going in the wrong directions. Need to operate in a conservative manner and avoid drafting too far ahead in time.

Day: Need to maintain adaptability to match conditions, ie take middle ground and able to react either direction in response to changes.

Hall: When do we start to say what we're observing is outside of the historical forcings? Hall discussed historic floods (late 1800s) that suggest we are still in historical forcings if we had the empirical data to look back far enough.

Pytlak: Unfortunately, we probably won't see a "hockey stick" and have an "ah ha!" moment that climate change is "here." We may only know it has taken hold by looking back. "Changing procedure" may be too strong a term when we are in a gradual change process.

Intermil: Lots of options (for study) now that we have such a richer history of hydrology vs. when most operations criteria were formed.

Tama: Long term shift and higher variability BOTH have distinct impacts and implications.

AGENDA ITEM 6: Libby Water Supply Forecast Update (Kristian Mickelson)

Kristian provided a presentation summarizing the final updated Libby forecast equation, giving background on selection and testing of variables and alternate training periods. One area of discussion was whether or not to include 2012 in the calibration, given that 2012 is (arguably) an outlier year. Decision was made to keep it; inclusion did not change the median forecast results but does affect (by widening them) the error bounds.

Stephanie Smith (BC Hydro): 1972 and 1974 were similar in volume and so 2012 is not considered an outlier.

Kristian: 72 and 74 were unfortunately not in Libby's training period due to lack of snow data.

AGENDA ITEM 7: Other Items

Erik Pytlak had a few "odds and ends":

- No change in ESP for RFC for the upcoming 2015 water year; we will continue to use day 5 (or closest prior) ESP run, using 5 day QPF.
- 2 of the 3 BC snow pillows are in, with the last hopefully still to go in but having weather issues.

Kyle Dittmer shared some news updates:

1) The Special Issue (Oct. 2013), "Climate Change and Indigenous Peoples in the United States", of the journal *Climatic Change* is available online:

<http://link.springer.com/journal/10584/120/3/page/1>

Kyle's article, "Changing Streamflow on Columbia Basin Tribal Lands--Climate Change and Salmon", is free to view. He is also a co-author of another paper (Cozzetto [et.al.](#)) in that same issue, "Climate change impacts on the water resources of American Indians and Alaska Natives in the U.S.".

2) The book version of the Special Issue was just published in May 2014:

<http://www.springer.com/environment/global+change+-+climate+change/book/978-3-319-05265-6>

Kyle is inquiring if Federal agencies can get a price discount on the \$99 book.

3) A delegation of Chinese engineers and water supply managers came to CRITFC for a recent tour. They were especially interested in water resource projects and ways to minimize environmental impacts. The Chinese are actively trying to do environmental clean-up past civil-works projects. The delegation was accompanied by U.S. State Dept. staff and hosted by the World Affairs Council of Oregon (<http://worldoregon.org/international-visitors>). Kyle suggested that if any of your agencies is interested in having future foreign delegation take a tour of your agency facilities/projects, then please contact the World Affairs staff directly. It is a very rewarding experience.

4) The annual Winter Weather Meeting, co-sponsored by the OMSI science center and the Oregon Chapter AMS will be Saturday morning, Oct. 25. Kyle will present his winter weather forecast. The event is free and open to the public. For more info: <http://oregonams.wordpress.com/2014/09/12/2014-winter-weather-conference/>

Adjournment

Next meeting tentatively set for Nov. 18 or 19.

AGENDA

Columbia River Forecasting Group (CRFG)

December 4th, 2014

Meeting time: 9:00 am - 3:00 pm PST

Location: CRITFC, 700 NE Multnomah, Suite 500 (Celilo Room)

Teleconference: Phone Number: (877)848-7030
Access code: 3626353
Security Code: 1111
Web Meeting: <https://www.webmeeting.att.com>
Meeting Number: (877)848-7030
Access code: 3626353

Contact Info: Steve Hall (509-527-7550)
Ted Day (208-378-5273)

9:00am Introductions/Roll Call (Steve)

9:25 Approval Minutes: September 25th, 2014 (all)

9:30 2014 Water Year Forecasts in Review
COE Seattle: Libby
BC Hydro: Canadian Columbia and Kootenai
Reclamation/NRCS: Hungry Horse and middle/upper Snake
COE Walla Walla: Dworshak
Idaho Power: Brownlee
NWRFC: Columbia Basin
BPA: The Dalles
CRITFC: The Dalles
NRCS:
Others?

11:45 Break/Lunch

12:45 RMJOC-II Climate Change Research Update: Pytlak

1:00 COOP and Forecasting: all

2:00 2015 Initiatives and Chair selection: all

2:30 Other items: 2014 report and set next meeting dates

3:00 Adjourn

MINUTES

Columbia River Forecast Group Meeting Notes
December 4, 2014

Participants in person: Steve Hall (USACE-Walla Walla), Jason Ward (USACE-Portland), Joel Fenolio (USACE-Seattle), Erik Pytlak (BPA), Kevin Berghoff (NWS NWRFC), Kyle Dittmer (CRITFC), Paul Wagner (NOAA-Fisheries), Ted Day (USBR), Eric Rothwell (USBR).

Participants by phone: David Benner (FPC)

Introductions and Roll Call (Hall)

Agenda Item 1: Approval of minutes

Joel offered a correction to the Sept. 2014 minutes, and he will send to Ted. Ted will amend the minutes. The minutes were approved as final.

Agenda Item 2: 2014 Water Year Forecast in Review

COE Seattle (Fenolio): Libby

The April to August volume for the Kootenai River was 6.7 KAF, 113% of average. Dry fall and early winter resulted in a full December Flood Risk Management relaxation, but region-wide precipitation from March to April resulted in a 1.3 MAF jump in the forecast. Didn't have any extraneous issues with QBO, unlike in 2012.

BC Hydro: Canadian Columbia and Kootenai
Not in attendance.

Reclamation (Day):

Hungry Horse and middle/upper Snake

Hungry Horse – The water year started off dry, but was near normal from November to January. A wet period followed in February and March experienced 204% of normal. Precipitation returned to average in April, and May was dry. Overall the March precipitation turned the water year, changing the forecast and operations.

Upper Snake – Similar trend in the Upper Snake, the water year precipitation started below average, but February dramatically changed the water supply forecast with wet conditions. The snowpack distribution was atypical, where the eastern/high elevation part of the basin was collecting a lot of snow, potentially affecting performance of forecasts. Precipitation in March resulted in a major jump in the forecast. Drop off in precipitation in May also contributed to an eventual forecast “miss”. Reclamation investigated the forecast miss but could not find an obvious cause for the bias. We assumed the error was largely due to precipitation pattern/timing, snow distribution, and melt. The miss was not inconsistent with other misses in the past, nor was it the largest miss. Typically big years have tended to continue wet with an eventual “under forecast”, but 2014 went the other way. The forecast and carryover dictate the amount of flow augmentation that the Upper Snake is required to rent. The forecast, going from near or below average to much above average, changed the expectations of the Upper Snake flow augmentation. The full 487 KAF was able to be delivered.

Boise/Payette – Similar to the Upper Snake the water year started dry, (Oct-Jan). Then in February the basins received nearly 200% of normal precipitation. March was also above average (165% of normal). Highly variable precipitation was seen: very low and very high months. SW Idaho and SE Oregon basins (Malheur, Owyhee) were very low., Storage did not meet demands and irrigators were curtailed.

COE Walla Walla (Hall): Dworshak

Forecast in comparison with ESP traces, dry fall had the forecast of 85% go to 120% in May, so a ~40% change. Then it went down again after a dry May, resulting in ~110% of normal or a ~3 MAF drop. The change in forecasts presented a very challenge to operations, requiring a large draft that was not possible. Z-score performed less well, with predicted value about 100 KAF higher.

Idaho Power Company: Brownlee

Not in attendance but IPC's Kresta did provide a couple of slides. Showed a lower than normal forecast and over-forecasted in the dry fall. Then the spring forecast performed well. For the mid-January forecast they nailed it.

They included a max case in addition to their expected case. Eric P. found this to be an important data product.

Water Year 2014 Brownlee Reservoir April – July Volume Forecast Summary

October – Following a significantly wet September, the major storage reservoirs above Brownlee were 45% of average for mid-October, with the least percent of average storage in the Upper Snake at 29% (11% of capacity). The volume forecast in October is primarily driven by reservoir carryover, as little is known about the expected winter-time snowpack. Therefore, the October April-July volume forecast for Brownlee was 4.2 MAF or 0.9 MAF below the 1960-2013 median volume.

November-December – November and December winter-time precipitation was significantly below normal within the basin. The weighted average snowpack accumulation above Brownlee at the end of December was 68% of normal. The Brownlee April – July volume forecast remained unchanged at 4.2 MAF as January and February have historically been significant in accumulation of winter-time precipitation.

January – Precipitation into January followed the trend set in December and remained significantly below normal. The weighted average snowpack accumulation above Brownlee at the end of January was 71% of normal. Our physical model (RFS) and internal regression based models indicated Brownlee Reservoir April – July volumes between 2.6 and 3.2 MAF, but the forecast was only reduced from 4.2 MAF to 3.4 MAF. We do this step reduction to minimize the swing that occurs with a physically based model, while still allowing for the impact of the current state of the system, i.e., low snowpack and reservoir carryover.

February – The amount of precipitation in February greatly improved throughout the basin, most notably in the Upper Snake. The Upper Snake February precipitation was approximately 130% of normal for the month, with most snow accumulating at the mid- to high elevations. A small adjustment was made to the Brownlee volume forecast to reflect the improved conditions. The February Brownlee April – July volume forecast was 3.5 MAF.

March – Again, basin conditions improved with a couple of wet storm systems that moved through the area during the month of March. The snow accumulation mostly occurred in the higher elevations which made our regression models produce unreasonably high volume forecasts, and therefore, we relied heavily on the physically based RFS model which better captured the distribution of the snowpack. Again, a small adjustment was made to the Brownlee volume forecast to reflect the improved conditions. The March Brownlee April – July volume forecast was 3.6 MAF.

April – The Brownlee April – July volume forecast remained unchanged from the forecast produced in March.

NWS NWRFC (Berghoff): The Dalles

At the end of WY2013 the precipitation was near normal, then it went very dry in Oct-January basin wide. In November – January Canada was a little wetter, closer to average. We saw a rapid turn around in February and March, with much of the basin in excess of 150% of average. This wet period brought the seasonal water supply back towards normal. Seasonal Jan.-July final at TDA was ~ 106%... ; April-August was 94 MAF or 108%. TDA January forecast (April-Aug.) was for 97% runoff.

BPA (Pytlak): The Dalles

Pytlak presented a similar summary of the precipitation trend, dry fall and early winter transitioning to a wet February and March that helped the water supply rebound. The October to January precipitation for the basin was the driest on record, followed by the wettest February and March on record.

The tropical Pacific Ocean signal was ENSO-Neutral but strong positive QBO going into the season. This year the QBO is strongly negative, with ENSO slightly neutral. Current indications and predictions are for a very weak El Niño.

BPA's monthly forecasts were generally 2-3 MAF higher than the RFC from December-May. Both BPA and RFC caught the rapid volume increase in February and March, which turned out to be fortuitous for marketing and fish. Paul (NOAA-Fisheries) explained that this "dry-wet" pattern meant that more water was stored in the reservoirs, as we were expecting a dry winter. Then all of a sudden a forced release of water for flood control draft meant that the flushing water would benefit early spring salmon migrants. Frequent ESP updates by BPA and the RFC were critical in informing decision making. Frequent snow updating was helpful. Four additional snow-pillows in Canada are now available and operational. Five climate indices: QBO, epmp blocking index, PMA, PDO, ENSO (we use ONI, not MEI because it can sometimes present false positives of El Niño). Will experiment with climate index ESPs this winter, but not for inventory studies.

Now experimenting with post processing/bias correction tool within CHPS. Will be testing this year and next.

CRITFC: The Dalles

MEI and Columbia River – 2015 water supply forecast... The November-December-January moving average now provides the best r-squared values for the MEI averages regressed against TDA historical flows. Pre-season 2015 forecast is 97 MAF (Jan.-July), 95%; 85 MAF (April-Aug.), 97%. Have now added the April-Aug. period which may benefit the COE's operations.

Water supply forecast – using the MEI method, 2014 was best forecast ever. Error was 0.3% (Jan.-July forecast made in Oct. 2013).

NRCS: not in attendance.

Agenda Item 3: RMJOC-II Climate Change Research Update: Pytlak

Overcame some downscaling challenges with MACA to try to capture events in the downscaling. BPA, Corps, and Reclamation have reviewed the data. Calibrations are ongoing.

Projects have to go in front of BPA review panel. About 10% of projects are dropped typically. Funds are either continued, merged, or dropped.

The 2/19 -2/20 RMJOC-II workshop, for broader interest community (states, partners, Canadians, NCAR, etc). We are looking for volunteers to help with invites, etc.... Erik **suggests a concurrent CRFG meeting on 2/18 Wednesday.**

Agenda Item 4: COOP and Forecasting

Continuation of operations (COOP)

COE – in the event of a Cascadia Subduction Earthquake (M=9), Walla Walla District would operate for Seattle and Portland Districts.

BPA - BPA has an operations office in Vancouver, WA and an additional field office in Spokane/Monroe but transport to Spokane of Portland staff could be difficult. Walla Walla Corps and BPA can share data at the Monroe/Spokane location. Corps would have a standing seat at BPA's Spokane facility. BPA could provide some weather/forecast data in the event that the local NWS office is down.

NWS - They have a field office in Pendleton, OR that could serve as a back-up to the Portland WFO. They have ongoing efforts to have a backup location at Tuscaloosa, AL as part of their water forecasting center.

Reclamation – We would use area office if PN office was incapacitated. Data transfer between agencies could be a major concern in the case of a cyber-attack that may shut down the internet.

The Cascadia Earthquake exercise will occur in 2016 – BPA, NWS, Corps, FEMA...

Agenda Item 5: 2015 Initiatives and Chairman Selection:

The chairmanship is a rotating position and 2015 was USBR's responsibility. In light of Ted Day changing positions within the USBR, and Eric Rothwell assuming Ted's role with CRFG, Kyle Dittmer (CRITFC) volunteered to chair the group for 2015; Eric Rothwell will serve as the vice-chair for 2015.

2015 Initiative:

COE Walla Walla is working on a new Ririe inflow forecast.

USBR is developing PCA forecast equations using NRCS's VIPER model. USBR plans on continuing use of their current forecasting techniques while testing the PCA equations in 2015.

Erik said that RMJOC-II will be a consistent thread through 2015 and 2016. Ted suggested that CRFG be a clearing house for ongoing research. Kyle suggested that we invite Dr. Moradkhani from PSU to give presentation on new work projects that he and his graduate students are pursuing.?, Kevin said an update from NWS RFC on initiatives and forecast changes would be good. Other suggestions include Columbia River Treaty modeling and lessons learned from the modelers, how does Corps use ESP traces, issues from the Salmon Managers from FPAC.

BPA is hosting a CHPS users workshop. BC Hydro and others will be there.

Next meeting scheduled for February 18, 2015 at CRITFC

Appendix C: Historical Forecast Results Columbia River Forecast Group 2013

Historic forecast results:

http://www.nwd-wc.usace.army.mil/report/flood_risk

Historical Jan-Jul Results for The Dalles and Lower Granite and Observed KAF:

<http://www.nwrfc.noaa.gov/ws>

1. Use the interactive map at the web address above.
2. Go to the forecasting map for TDA and LWG or the runoff map for Observed results.
3. Click on the dam needed and for TDA and LWG, look up the appropriate archive data. For the observed runoff, click on the dam needed and add up the observed for the months stated in the tables below.

In 2012, the official Water Supply Forecasts used for FCRPS operations for Grand Coulee, Brownlee, Lower Granite, and The Dalles changed to the NWRFC ESP median issued on certain days of the month, and based on different lead times on future precipitation:

2012: 4th working day of the month, 10 days of future precipitation

2013: 5th working day of the month, 3 days of future precipitation

Duncan: (Apr-Aug)

Year	Jan		Feb		Mar		Apr		May		Observed
	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	
2005	2003	<u>109%</u>	2013	<u>110%</u>	1972	<u>108%</u>	1968	<u>107%</u>	1876	<u>102%</u>	1834
2006	1839	<u>87%</u>	1906	<u>90%</u>	1946	<u>92%</u>	1922	<u>91%</u>	1932	<u>91%</u>	2120
2007	2087	<u>88%</u>	2122	<u>90%</u>	2096	<u>88%</u>	2221	<u>94%</u>	2257	<u>95%</u>	2370
2008	2202	<u>113%</u>	2091	<u>107%</u>	2091	<u>107%</u>	2059	<u>105%</u>	1985	<u>101%</u>	1957
2009	2003	<u>123%</u>	1945	<u>120%</u>	1866	<u>115%</u>	1859	<u>114%</u>	1787	<u>110%</u>	1627
2010	2030	<u>125%</u>	1962	<u>121%</u>	1825	<u>113%</u>	1817	<u>112%</u>	1813	<u>112%</u>	1621
2011	1846	<u>82%</u>	1942	<u>86%</u>	1912	<u>85%</u>	1997	<u>89%</u>	2057	<u>91%</u>	2251
2012	1987	<u>77%</u>	2039	<u>79%</u>	2015	<u>78%</u>	2138	<u>83%</u>	2227	<u>87%</u>	2571
2013	2283	<u>105%</u>	2079	<u>96%</u>	1975	<u>91%</u>	2061	<u>95%</u>	2094	<u>96%</u>	2172
2014	1785	<u>86%</u>	1728	<u>83%</u>	1761	<u>85%</u>	1891	<u>91%</u>	1903	<u>91%</u>	2081

Libby: (Apr-Aug)

Year	Jan		Feb		Mar		Apr		May		Observed
	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	
2005	5786	<u>104%</u>	5630	<u>101%</u>	5371	<u>97%</u>	5401	<u>97%</u>	5096	<u>92%</u>	5564
2006	5487	<u>83%</u>	6186	<u>93%</u>	6350	<u>96%</u>	6076	<u>92%</u>	6179	<u>93%</u>	6629
2007	6955	<u>102%</u>	6582	<u>96%</u>	6516	<u>96%</u>	6847	<u>100%</u>	6990	<u>102%</u>	6822
2008	6282	<u>113%</u>	6498	<u>117%</u>	6435	<u>116%</u>	6387	<u>115%</u>	6166	<u>111%</u>	5539
2009	5526	<u>125%</u>	5436	<u>123%</u>	5296	<u>120%</u>	5672	<u>128%</u>	5209	<u>118%</u>	4425
2010	5682	<u>126%</u>	5478	<u>121%</u>	5084	<u>113%</u>	5103	<u>113%</u>	4887	<u>108%</u>	4517
2011	5610	<u>73%</u>	6656	<u>86%</u>	7111	<u>92%</u>	7191	<u>93%</u>	8165	<u>106%</u>	7729
2012	5524	<u>69%</u>	5714	<u>62%</u>	5635	<u>61%</u>	6872	<u>75%</u>	7159	<u>78%</u>	9185
2013	6898	<u>96%</u>	6384	<u>89%</u>	6315	<u>88%</u>	6189	<u>86%</u>	6535	<u>91%</u>	7173
2014	5432	<u>81%</u>	5192	<u>78%</u>	5505	<u>82%</u>	6868	<u>103%</u>	6996	<u>105%</u>	6673

Hungry Horse: (May-Sep)

Year	Jan		Feb		Mar		Apr		May		Observed
	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF
2005	1647	<u>132%</u>	1418	<u>114%</u>	1144	<u>92%</u>	1217	<u>98%</u>	1173	<u>94%</u>	1245
2006	1826	<u>101%</u>	2024	<u>112%</u>	1958	<u>108%</u>	1912	<u>106%</u>	1824	<u>101%</u>	1811
2007	1823	<u>136%</u>	1803	<u>135%</u>	1786	<u>134%</u>	1495	<u>112%</u>	1425	<u>107%</u>	1337
2008	1840	<u>76%</u>	1859	<u>77%</u>	1876	<u>78%</u>	1913	<u>79%</u>	2131	<u>88%</u>	2410
2009	1809	<u>112%</u>	1864	<u>115%</u>	1697	<u>105%</u>	1817	<u>112%</u>	1816	<u>112%</u>	1618
2010	1654	<u>103%</u>	1429	<u>89%</u>	1284	<u>80%</u>	1305	<u>81%</u>	1345	<u>84%</u>	1608
2011	1944	<u>61%</u>	2139	<u>67%</u>	2222	<u>69%</u>	2357	<u>73%</u>	2798	<u>87%</u>	3212
2012	1691	<u>80%</u>	1781	<u>85%</u>	1739	<u>83%</u>	1906	<u>91%</u>	1680	<u>80%</u>	2102
2013	1968	<u>106%</u>	1877	<u>102%</u>	1743	<u>94%</u>	1750	<u>95%</u>	1789	<u>97%</u>	1849
2014	1787	<u>73%</u>	1819	<u>75%</u>	2142	<u>88%</u>	2204	<u>90%</u>	2400	<u>99%</u>	2436

Grand Coulee: (Apr-Aug)

Year	Jan		Feb		Mar		Apr		May		Observed
	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF
2005	54863	<u>112%</u>	53657	<u>110%</u>	45820	<u>94%</u>	47628	<u>98%</u>	47628	<u>98%</u>	48807
2006	55466	<u>91%</u>	58480	<u>96%</u>	57877	<u>95%</u>	57275	<u>94%</u>	58500	<u>96%</u>	61189
2007	60000	<u>105%</u>	61600	<u>107%</u>	61200	<u>107%</u>	61600	<u>107%</u>	61000	<u>106%</u>	57350
2008	59300	<u>99%</u>	59200	<u>99%</u>	61300	<u>103%</u>	61600	<u>103%</u>	60000	<u>100%</u>	59739
2009	55800	<u>116%</u>	54600	<u>113%</u>	53100	<u>110%</u>	55400	<u>115%</u>	54000	<u>112%</u>	48186
2010	54000	<u>113%</u>	49100	<u>103%</u>	45800	<u>96%</u>	44900	<u>94%</u>	45300	<u>95%</u>	47711
2011	56500	<u>75%</u>	61400	<u>82%</u>	62200	<u>83%</u>	64700	<u>86%</u>	70800	<u>94%</u>	75107
2012	44509	<u>56%</u>	56788	<u>71%</u>	60853	<u>76%</u>	68525	<u>86%</u>	72812	<u>91%</u>	79874
2013	58230	<u>89%</u>	54536	<u>84%</u>	54020	<u>83%</u>	55882	<u>86%</u>	57373	<u>88%</u>	65121
2014	54683	<u>87%</u>	48197	<u>77%</u>	57818	<u>92%</u>	60382	<u>96%</u>	64683	<u>103%</u>	62620

Brownlee: (Apr-Jul)

Year	Jan		Feb		Mar		Apr		May		Observed
	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF
2005	3170	<u>88%</u>	2590	<u>72%</u>	1740	<u>48%</u>	2180	<u>60%</u>	2440	<u>68%</u>	3612
2006	6690	<u>75%</u>	8016	<u>89%</u>	6940	<u>77%</u>	8380	<u>93%</u>	9020	<u>101%</u>	8975
2007	5200	<u>185%</u>	3630	<u>129%</u>	3760	<u>134%</u>	3300	<u>118%</u>	3040	<u>108%</u>	2807
2008	4390	<u>101%</u>	5260	<u>120%</u>	5500	<u>126%</u>	5400	<u>124%</u>	4860	<u>111%</u>	4368
2009	4260	<u>76%</u>	4020	<u>72%</u>	3350	<u>60%</u>	4970	<u>89%</u>	5000	<u>90%</u>	5575
2010	3300	<u>72%</u>	3020	<u>66%</u>	2470	<u>54%</u>	2590	<u>56%</u>	2780	<u>61%</u>	4586
2011	7230	<u>69%</u>	6280	<u>60%</u>	5690	<u>54%</u>	7510	<u>71%</u>	9060	<u>86%</u>	10549
2012	4783	<u>86%</u>	4986	<u>90%</u>	5211	<u>94%</u>	6388	<u>115%</u>	6162	<u>111%</u>	5535
2013	4650	<u>178%</u>	4229	<u>162%</u>	3744	<u>144%</u>	3478	<u>133%</u>	2673	<u>102%</u>	2609
2014	3723	<u>108%</u>	3246	<u>94%</u>	3861	<u>112%</u>	3934	<u>114%</u>	3519	<u>102%</u>	3436

Dworshak: (Apr-Jul)

Year	Jan		Feb		Mar		Apr		May		Observed KAF
	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	
2005	1914	<u>116%</u>	1642	<u>100%</u>	1423	<u>87%</u>	1321	<u>80%</u>	1344	<u>82%</u>	1643
2006	2601	<u>97%</u>	2707	<u>101%</u>	2612	<u>98%</u>	2593	<u>97%</u>	2626	<u>98%</u>	2677
2007	2905	<u>161%</u>	2126	<u>118%</u>	2192	<u>122%</u>	1982	<u>110%</u>	1868	<u>104%</u>	1799
2008	2717	<u>79%</u>	2738	<u>80%</u>	2810	<u>82%</u>	3010	<u>88%</u>	3003	<u>87%</u>	3434
2009	3075	<u>121%</u>	2681	<u>106%</u>	2461	<u>97%</u>	2662	<u>105%</u>	2631	<u>104%</u>	2539
2010	2174	<u>114%</u>	1742	<u>91%</u>	1571	<u>82%</u>	1398	<u>73%</u>	1526	<u>80%</u>	1906
2011	3340	<u>83%</u>	3142	<u>78%</u>	3329	<u>82%</u>	3387	<u>84%</u>	3772	<u>93%</u>	4042
2012	2473	<u>74%</u>	2504	<u>75%</u>	2585	<u>77%</u>	2966	<u>89%</u>	3226	<u>97%</u>	3343
2013	2587	<u>123%</u>	2202	<u>105%</u>	2128	<u>101%</u>	2036	<u>97%</u>	2296	<u>109%</u>	2105
2014	2296	<u>78%</u>	2274	<u>77%</u>	2701	<u>92%</u>	3111	<u>106%</u>	3183	<u>108%</u>	2943

Lower Granite: (Jan-Jul)

Year	Jan		Feb		Mar		Apr		May		Observed KAF
	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	
2005	20700	<u>114%</u>	18000	<u>99%</u>	14600	<u>81%</u>	15700	<u>87%</u>	16500	<u>91%</u>	18134
2006	31600	<u>98%</u>	34500	<u>107%</u>	31900	<u>99%</u>	33200	<u>103%</u>	34900	<u>108%</u>	32194
2007	28200	<u>149%</u>	23000	<u>122%</u>	23500	<u>124%</u>	21400	<u>113%</u>	20600	<u>109%</u>	18887
2008	27200	<u>99%</u>	29500	<u>107%</u>	29200	<u>106%</u>	28000	<u>102%</u>	26500	<u>96%</u>	27522
2009	25700	<u>89%</u>	25100	<u>87%</u>	22400	<u>78%</u>	26400	<u>91%</u>	26900	<u>93%</u>	28899
2010	22400	<u>100%</u>	19300	<u>86%</u>	17000	<u>76%</u>	16600	<u>74%</u>	17000	<u>76%</u>	22460
2011	31253	<u>75%</u>	30439	<u>73%</u>	30676	<u>74%</u>	32924	<u>79%</u>	36291	<u>87%</u>	41610
2012	23497	<u>79%</u>	25598	<u>86%</u>	26022	<u>87%</u>	29996	<u>100%</u>	30266	<u>101%</u>	29893
2013	27769	<u>147%</u>	24052	<u>127%</u>	21683	<u>114%</u>	20774	<u>110%</u>	19130	<u>101%</u>	18948
2014	23024	<u>85%</u>	23286	<u>86%</u>	27967	<u>104%</u>	29328	<u>109%</u>	28629	<u>106%</u>	26942

The Dalles: (Jan-Jul)

Year	Jan		Feb		Mar		Apr		May		Observed KAF
	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	
2005	85600	<u>105%</u>	82400	<u>101%</u>	70700	<u>87%</u>	73800	<u>91%</u>	74700	<u>92%</u>	81349
2006	101000	<u>88%</u>	111000	<u>97%</u>	107000	<u>93%</u>	107000	<u>93%</u>	110000	<u>96%</u>	114672
2007	105000	<u>110%</u>	101000	<u>105%</u>	100000	<u>104%</u>	100000	<u>104%</u>	99100	<u>104%</u>	95738
2008	102000	<u>103%</u>	103000	<u>104%</u>	103000	<u>104%</u>	101000	<u>102%</u>	97300	<u>98%</u>	99209
2009	94700	<u>105%</u>	92900	<u>103%</u>	86200	<u>96%</u>	92000	<u>102%</u>	91100	<u>101%</u>	90244
2010	88500	<u>104%</u>	79200	<u>93%</u>	71800	<u>85%</u>	69700	<u>82%</u>	70900	<u>84%</u>	84718
2011	99041	<u>71%</u>	105851	<u>73%</u>	111213	<u>72%</u>	119785	<u>79%</u>	126943	<u>89%</u>	142616
2012	86041	<u>66%</u>	93781	<u>72%</u>	98799	<u>76%</u>	114135	<u>88%</u>	120043	<u>93%</u>	129441
2013	102470	<u>105%</u>	92040	<u>94%</u>	89674	<u>92%</u>	90972	<u>93%</u>	92870	<u>95%</u>	97709
2014	90334	<u>84%</u>	79222	<u>73%</u>	95865	<u>87%</u>	105424	<u>98%</u>	105513	<u>98%</u>	108082

The Dalles: (Apr-Aug)

Year	Jan		Feb		Mar		Apr		May		Observed
	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF	% of OBS	KAF
2005	74300	<u>109%</u>	69200	<u>101%</u>	57200	<u>84%</u>	60800	<u>89%</u>	61900	<u>90%</u>	68452
2006	87500	<u>90%</u>	94300	<u>97%</u>	91200	<u>93%</u>	92700	<u>95%</u>	95600	<u>98%</u>	97541
2007	91300	<u>116%</u>	88200	<u>112%</u>	88300	<u>112%</u>	85200	<u>108%</u>	84200	<u>107%</u>	78939
2008	88200	<u>95%</u>	91800	<u>98%</u>	94300	<u>101%</u>	94700	<u>102%</u>	90900	<u>98%</u>	93198
2009	82100	<u>102%</u>	79700	<u>99%</u>	74800	<u>93%</u>	82400	<u>102%</u>	81400	<u>101%</u>	80771
2010	76700	<u>99%</u>	68500	<u>88%</u>	62100	<u>80%</u>	60900	<u>79%</u>	62200	<u>80%</u>	77410
2011	90600	<u>71%</u>	92500	<u>73%</u>	92300	<u>72%</u>	101000	<u>79%</u>	113000	<u>89%</u>	127378
2012	77041	<u>65%</u>	84454	<u>71%</u>	90604	<u>76%</u>	103726	<u>87%</u>	110762	<u>93%</u>	119127
2013	92030	<u>105%</u>	81863	<u>94%</u>	80372	<u>92%</u>	81811	<u>94%</u>	82502	<u>95%</u>	87052
2014	84888	<u>90%</u>	72458	<u>77%</u>	88832	<u>94%</u>	92057	<u>97%</u>	96741	<u>102%</u>	94548

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<i>revised September 13, 2013</i>			
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