

COLUMBIA RIVER FORECAST GROUP

2013

ANNUAL
REPORT



CHAIR: ERIK PYTLAK, BPA
VICE-CHAIR: STEPHEN HALL, USACE

SEPTEMBER 2014

COLUMBIA RIVER FORECAST GROUP

2013 ANNUAL REPORT

ANNUAL SUMMARY

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 2013, 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
BC Hydro (BCH), Burnaby, BC
Idaho Power Company (IPC), Boise, ID

The CRFG met four times in 2013, as required by the Charter:

January 24, 2013

April 18, 2013
August 1, 2013
December 5, 2013

Most of the CRFG participants had significant budget pressures in 2013 which impacted the ability for some to attend meetings in person. To save on costs and time, the January meeting was held via conference call, with the other three held in person but included a phone bridge. The January and August meetings were held as half-day sessions, while more involved meetings in April and the End-of-Year Review in December were all-day sessions.

Because the CRFG has now been in existence since the 2008 BiOp, the group used 2013 to review all forecast procedures now used in the basin and enhanced since our inception. Several of our forecast techniques and procedures have improved since 2009, while Ensemble Streamflow Predictions (ESPs) grew into wider use and acceptance. Because ESPs can be prepared and issued much more frequently than statistical forecasts (at least as they are currently prepared), decision makers have gained considerable advance notice when antecedent conditions changed rapidly in the basin. The CRFG is still learning how to use these forecasts, though, since they have their own shortcomings (i.e. underdispersion of potential range of outcomes, longer range/lower skill QPF forecasts occasionally caused sharp swings in forecasts).

Several members of the CRFG attended the American Geophysical Union Chapman Hydrologic Conference on July 28-31, 2013, which was held in Portland, OR. The conference focused on the current State-of-the-Science with respect to hydrologic forecasting science. The Conference proceedings are available at:
<http://chapman.agu.org/watermanagement/files/2013/07/Final-Program1.pdf>.

There was one major forecast change recommended by the CRFG early in 2013, and adopted by NWRFC in December, 2013. NWRFC has developed and implemented a 5-day QPF-based ESP volume forecast now that precipitation forecasts out to five days in advance are regularly exhibiting skill over climatology across the Columbia River Basin.

The group also found through its forecast evaluations that statistical water supply forecasts remain powerful tools to guide decision-making at headwater projects, especially when statistical variables used in the equations have solid meteorological backing and reasoning to back their use. CRFG members applied this guiding principle several times as they adjusted equations in 2013. For example, BC Hydro and USACE-Seattle District, with the approval of the Columbia River Treaty Operating Committee (CRTOC), temporarily adjusted equations for the Canadian Treaty projects in 2013 when record rainfall in October, 2012, yielded unreasonable early-season volume forecasts. In 2013 a new Dworshak forecast equation, after two years of science and statistical method feedback from CRFG, was adopted for regular use. Finally, initial discussions began on updating and improving the Libby Water Supply forecast equations – not only to update its predictands, but to account for changes to the observation network, particularly in Canada.

One ongoing challenge reported in previous years and continued in 2013, is the increasing difficulty in maintaining a viable hydrometeorological network. Human cooperative observers continue to retire, while their supporting meteorological agencies (Environment Canada and NOAA/National Weather Service) are unable to find replacements. Meanwhile, routine manual snowpack sampling (e.g., snow courses) is under increasing budgetary pressure, with several eliminated since 2012 just east of the Columbia basin. This has driven an increased need to maintain and expand the automated observing network. To this end, NRCS continues to solicit feedback from the CRFG and other user groups on possible additions to its snow pillow network as snow courses are reduced or eliminated. BPA and BC Hydro began execution of a two-year Memorandum of Agreement to jointly fund the installation of four new snow pillows in the data-sparse Upper Columbia basin, with one new station at Keystone Peak, BC, becoming operational in August, 2013.

Also in 2013, as part of its requirement to consider climate change in its forecast improvements, the CRFG was established as the main technical body to review progress on the RMJOC-II Climate Change research initiative. In August, Erik, on behalf of the RMJOC and its research partners at the University of Washington, Oregon State University, and Portland State University presented the project outline which will begin in 2014 and continue through 2017. The overall objective will be to use the latest data from the Global Climate Models (GCMs), published as part of the Fifth Coupled Model Intercomparison Project (CMIP-5) in summer 2013, and generate a new temperature, precipitation and streamflow dataset for wide community use in future planning activities. Results are expected to be available for use by all CRFG parties by late 2016.

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)

January 24, 2013

Meeting time: 9:00-11:00am PST
Location: Conference Call. (877-848-7030)
Access code: 3626353
Security Code: 7722

Contact Info: Erik Pytlak (503-230-5335)
Steve Hall (509-527-7550)

- 1. Introductions/Roll Call** (Erik)
- 2. Approval of 2011 CRFG Annual Report** (all)
- 3. Status of 2012 Annual Report** (Kyle)
- 4. 2010-2013 BiOp Comprehensive Evaluation/2014-2018 Implementation Plan** (Erik)
 - a. Actions CRFG will commit to in the next BiOp (All, will be an ongoing discussion)
- 5. 2013 CRFG project proposal: Compilation of water supply forecast verification efforts**
- 6. News items:**
 - a. AGU Chapman Conference, tentatively **July 28-31** (Steve K., Andy W.)
 - b. NRCS Snow Course curtailments in MT (Rashawn)
 - c. BCHydro Climate Change Study (Adam)
 - d. New 30-year averages implementation (Steve K., Ted)
 - e. NWRFC Routine 3-Day QPF ESP Forecast Posting (Steve K.)
 - f. BCHydro-BPA snow pillows
- 7. Forecast Round Robin:**
 - a. NWS, NRCS, USACE districts (Seattle/Walla Walla), USBR, BCH, CRITFC

Next meetings

April 18, 9:00am-Noon PDT (web conference?)

MINUTES

Columbia River Forecasting Group (CRFG)

January 24, 2013

CRFG meeting 24Jan2013

Participants: Tim Brewer and Pam Pace - Idaho Power Company, Paul Wagner – NOAA Fisheries, Ted Day – Bureau of Reclamation, Stephen Hall – USACE Walla Walla District, Jason Ward – USACE Northwester Division, Erik Pytlak – BPA, Kyle Dittmer – CRITFC

Agenda Item #3- Kyle Dittmer- CRITFC 2012 Report has a short turnaround this year, so a draft will be ready soon.

Item #4: Implementation Plan for the ESA plan Action Agencies – USACE, BPA, BOR

Item #5: Projecting what the CRFG is going to be doing for 2014-2018. Mid-month conversation: when the WSF is lower we don't adjust until the end of month. When it's higher, we can recalculate and adjust to draft deeper. Consider presenting an evaluation WSF results for each location. ESP at BPA vs RFC Several years (as far back as we go) of forecast effectiveness perhaps present in late July (Chapman conference).

April 18th 9AM next meeting. In person if we have forecast evaluation info.

Item #6: News Items

a) July 28-31 Chapman AGU conference (looking for a venue) Tour of Bonneville Dam

b) Montana is the only state planning snow course cutbacks in FY13

<http://www.mt.nrcs.usda.gov/news/releases/snowcourses1-18-2013.html>

There was some discussion about precipitation patterns and snow course replacement. Cost of snow courses is increasing with fewer in the future. The Corp and Reclamation may need to redevelop forecast equations with and without snow course data to determine their forecast value and consider converting to SNOTEL if it is needed.

c) Similar conclusion to the RMJOC effort and good comparison of results, using it in the CRT CC team effort

d) New averages. There is a disconnect when comparing current reports (i.e. 80% of average to 85% of average) as some agencies are a little later than others in converting to the new NWRFC 30-year volume averages. NRCS is using median and new period, as is BPA.

e) NWS was occasionally having problems posting 0 and 3 day QPF ESPs in Fall 2012. NWRFC has since begun to post both regularly.

f) Snow pillow siting discussions continue in BC. An archaeological study may be required by BC Hydro on two sites. Costs have also gone up, but are still within reason and are supportable by BPA. However, five sites may be reduced to three or four. Snow pillow installation is still moving forward, though, on a 50/50 cost share basis with BC Hydro.

Item #7: Round Robin:

There has been a drop in WSFs across the basin after starting off quite high in October when it was particularly wet. NRCS says that early season storms primed the basin. Dry in Eastern OR and the Snake, but still if we get normal spring the system should be OK. Although October was an anomalously wet month, Rashawn cautions against removing that information from the statistical forecasts because fall precip can be a good predictor of the seasonal runoff in the long term. BC Hydro and The Corp are not considering ignoring the October precipitation, but may cap it at about ½ of a standard deviation above the mean so that the forecasts are not unreasonably high going into the winter, especially as drier conditions have developed. The influence of October precipitation diminishes over time. At Dworshak, PCA of 2.026 Zscore = 2.266 Zscore closer to other forecasts. HGH WSF- Ted Day- PCA higher than MLR (116% of new avg 107 of old average) higher than RFC forecast. CRITFC- TDA 88 MAF April-Aug Idaho Power- Cloud seeding in the Payette and some in the Upper Snake. Storms have been too warm for the seeding to be very effective this fall. However, more suitable storms are coming soon. They use SNOTEL data close by and longer term hydrologic models to evaluate effectiveness.

April 18th 9AM next meeting. (In person or on a call)

AGENDA
Columbia River Forecasting Group (CRFG)
April 18, 2013

Meeting time: 8:30am-2:30pm PDT
Location: CRITFC Celilo Room
729 NE Oregon St.
Portland, OR 97232
Conference Call #: (503) 326-7668

Contact Info: Erik Pytlak (503-230-5335)
Steve Hall (509-527-7550)

8:30-8:45 **Introductions/Roll Call** (Erik) (8:30-8:45)

8:45-9:00 **Approval of 2012 CRFG Annual Report** (all)

9:00-9:15 **News Items/Updates**
i. AGU Chapman Conference, **July 28-31** (abstracts due April 18)
ii. BCHydro-BPA snow pillows

2013 CRFG project: Compilation of water supply forecast validations

9:15-9:30 USACE Seattle (statistical, Libby)
9:30-9:45 USACE Walla Walla (statistical PCA and Z-score, Dworshak)

9:45-10:00 Break

10:00-10:15 USBR Boise (statistical, Hungry Horse)
10:15-10:45 NRCS (statistical, Columbia)
10:45-11:15 USACE Walla Walla (Statistical, PCA and new method, Brownlee)
Note: CRFG is being asked to comment on the proposed, new water supply forecasting method for Brownlee

11:15-11:30 Discussion on methods presented so far

11:30-12:30 Lunch (on your own)

12:30-1:00 BC Hydro (statistical, Canadian Columbia)
1:00-1:15 NWRFC (ESP, much of the basin)
1:15-1:30 BPA (ESP, much of the basin)
1:30-1:45 CRITFC (statistical, The Dalles)

1:45-2:00 Optional break

2:00-2:30 Discussion of methods presented

Next meeting
August 2, 9:00am-Noon PDT (in person, at the end of the Chapman Conference)

MINUTES

Columbia River Forecasting Group (CRFG)

April 18, 2013

Attendees: Erik Pytlak and Rick van der Zweep (BPA); Ted Day (Reclamation); Kresta Davis-Butts (Idaho Power); Kyle Dittmer (CRITFC); Kevin Shaffer (USACE Seattle); Tracy Schwarz (USACE Walla Walla); Jason Ward (USACE Portland Division); Steve King (NWRFC); Rashawn Tama (NRCS); Adam Gobena (BCHydro via conference call).

2012 CRFG Annual Report:

The report was approved by unanimous consent. Action Item: Erik will ensure the report is posted on the salmonrecovery.org website (action complete).

News Items/Old Business:

AGU Chapman Hydrologic Conference: The group discussed CRFG conference support, which was proposed at the January meeting. Erik joined the local planning committee in February to represent CRFG. Erik also submitted an abstract on behalf of CRFG on our 2013 validation project. Most federal agencies have since been placed under travel freezes and conference participation bans due to sequestration budget cuts, including USACE, NRCS, Reclamation, and NWS. In response, the group discussed other options, including holding its own mini-conference in 2014, or having Erik as CRFG Chair present a poster at AMS or AGU annual meetings. Action Item: Erik will keep the board informed as the Chapman conference planning moves forward.

New Snow Pillow Installations in BC: Erik reported that BPA and BC Hydro have signed a MOA to install one new snow pillow in the Upper Columbia River this summer (near Keystone Mountain, BC), with three additional pillows in 2014. The original plan was to install five, but several beneficial sites were ruled out because of avalanche hazards, national park restrictions, and/or cultural resource protection concerns.

CRITFC Climate Change Paper: Kyle reported that his climate change research paper was about to be published after clearing peer review and several years of work.

Future Meeting Locations Moving: Kyle reported that CRITFC offices were moving two blocks away to the 700 Building this summer. However they will have meeting space there, which will enable CRFG to continue meeting there. Erik reported that BPA is about to open a new Rates Hearing Room in the same building that NRCS is located, which will also have freer public access.

2013 CRFG Project: Compilation of Water Supply Forecast Validations

The rest of the meeting was devoted to sharing current water supply forecast methods and tools in use across the basin. Erik opened the session by sharing CRFG's chartered mission: to promote and support the advancement of forecasting skill, products and techniques with the intent to improve long range volume forecasts to optimize operations and facilitate endangered species restoration. The question is whether we've done that in the course of five years, and where we go from here.

Libby, USACE Seattle (Kevin):

Principal Component Analysis (PCA), which is a statistical technique, is employed. It was updated in 2010, and includes precipitation, snow-water equivalent (SWE), and three climate indices (Southern Oscillation Index, Quasi-Biennial Oscillation and Pacific North American Index), with the weights increasingly tilted toward SWE as the season progresses. The equation uses a few snow pillows in basins that drain toward Alberta (away from the Columbia Basin), but were judged to be representative of snow conditions on BC side of the border. However in 2012-13, Libby, like the BC Hydro equations, needed to be temporarily modified as record October rainfall in the basin skewed the forecast much higher than what could reasonably occur. USACE Seattle will be looking into the advantages and disadvantages of using climatic indices, the possibility of removing or replacing inconsistent precipitation stations, and developing a permanent fix on handling outlier fall precipitation which is a key indicator for fall soil moisture and can in turn impact runoff potential in the spring.

Dworshak, USACE Walla Walla (Tracy):

PCA is also employed for this basin. It was last updated in 2005, but SOI was recalibrated since inception. They have proposed an update to the PCA, which was initially reviewed by CRFG in 2012, and is now in final review by the Columbia River Hydromet Committee for use in the 2014 water supply season. It, too, uses SWE, precipitation, and early in the season, a climate index (SOI) as its independent variables. They have also proposed a Z-score method for water supply forecasting. However it is only proposed for comparisons or deviations.

Hungry Horse, Reclamation (Ted)/Upper Snake Irrigation Projects, Reclamation and USACE-WallaWalla (Ted and Tracy)

Reclamation has traditionally relied on Multiple-linear Regression (MLR) as its primary forecast technique for roughly 35 different forecast locations for its PN Region projects. The MLR equations typically include variables for: antecedent runoff (surrogate for soil moisture); fall and winter precipitation (valley locations); April 1 snowpack; and spring precipitation. These forecasts are primarily used for flood control and irrigation supply, but also for ESA related operations in a few locations. Reclamation is also now producing PCA forecast at each forecast point, using the same candidate variables as MLR, to provide further guidance and verification. These PCA forecasts are still considered experimental with more work planned in the future. No climate indices are currently included. MLR is used at Hungry Horse, with guidance from the PCA forecast, as it has been for many years with some minor tweaks as SNOTELs were added or removed from the network.

For many Reclamation projects above Brownlee in the Snake Basin, Reclamation generally uses MLR forecasts, but the PCA forecasts are used to verify, modify, or even replace the MLR results. Other agency forecasts are also examined in the verification process, and may be adopted if the results look more reasonable. Reclamation and the USACE coordinate forecasts at four Section 7 flood control projects above Brownlee (Boise, Little Wood, Ririe, and Palisades). The USACE generally uses Single Linear Regression (SLR) forecasts using only Snow-Water Equivalent. Other agency forecasts (NWRFC, NRCS) are typically considered in the coordination process. These coordinated forecasts are used internally to set flood control requirements, and while not published publicly they are made available to interested parties. Reclamation has interest in looking at Z-score and other potential methods in the future particularly at their top 6-10 projects.

Brownlee, USACE Portland Division (Walla Walla, Tracy):

Since 2012 when NWRFC discontinued statistical water supply forecasts, the median of the latest Ensemble Streamflow Prediction (ESP) set has been used for flood control decision-making. However, USACE Portland Division has encouraged Walla Walla district to investigate a possible return to a statistical method. One challenge is that unlike most projects, Brownlee operations depend primarily on upstream regulated flows. USACE Walla Walla has tested many potential regressors in a Z-score method, and upstream storage content appears to have a strong correlation. The group then offered some suggestions, as requested by USACE, on the forecast technique they're developing. They will also take written comments from the group through mid-May. Work is ongoing.

Brownlee, Idaho Power (Kresta):

In addition to close monitoring of NWRFC ESP forecasts, Idaho Power generates an internal single-trace long range forecast, with two additional traces bounding the upper and lower range of possible outcomes using internally-provided long range weather forecasts. By using both techniques, they have been generally satisfied with their forecasts, although they are investigating ESP development and usage.

The Dalles, CRITFC (Kyle):

CRITFC uses a regression forecast using the Multivariate ENSO Index (MEI) as its single dependent variable. MEI incorporates six other ENSO-related indices (<http://www.esrl.noaa.gov/psd/enso/mei/>). The CRITFC regression forecast is quite stable over the course of the water year unless the MEI changes drastically (which is rare in the winter). However, the model's correlation coefficient is low (R² around 0.3), and it does not update/adjust using observed data or snow that has already fallen.

Canadian Projects, BC Hydro (Adam):

For internal decision-making, BC Hydro has moved mostly to Ensemble Streamflow Prediction, which is a probabilistic forecast derived from historic streamflow scenarios which are adjusted based on current snowpack conditions and future weather forecasts. Their operational ESP forecast set uses short-range weather forecast and climatology to inform the traces generated in the UBC watershed model. The forecast system can generate additional ESP traces using synthetic weather sequences, but that capability is primarily used for risk of spill studies at large reservoirs. Like the US groups that regularly use ESP, they notice some underdispersion of the probability distributions. BC Hydro also uses PCA statistical forecasts, last updated in 2007, for Treaty coordination, as agreed upon by the Columbia River Treaty Hydromet Committee (CRTHC). Similar to the situation encountered at Libby in fall, 2012, BC Hydro coordinated with CRTHC a one-time change to its statistical equations this past year due to unusually heavy October rainfall which is a key, early-season proxy for fall soil conditions. They, like USACE Seattle, are investigating a more permanent solution.

Columbia Basin, NWRFC (Steve):

Since 2012, NWRFC exclusively uses ESP for water supply forecasting, with the 55 traces (1948-2003) calibrated in the Sacramento Soil Moisture Accounting (SAC-SMA) hydrologic model. Since inception, NWRFC has been making steady improvements to the ESPs as they gain experience, and has expanded its product suite to include sets of ESPs: using just climatology, using 3 days of deterministic precipitation forecasts, and using 10 days of precipitation forecasts. Unlike statistical water supply forecasts that can only be updated once or twice a month, ESPs can be updated daily, which NWRFC has been generally doing this water year. The frequent updates allow ESP to catch rapid volume changes quickly, but at the expense of greater forecast volatility. ESP is also flexible in using either climatology, or future precipitation out a number of days, to inform the forecast traces. The frequent, evolutionary nature of ESP development makes it difficult to compare how forecasts are “verifying” from year-to-year. However, they have noticed a general tendency for statistical forecasts to do better early in the fall, with ESP gradually improving and eventually doing better than statistical forecasts by spring. One also has to keep in mind that “verification” of ESP forecasts (which uses metrics like ranked probability skill score) is different than verification of statistical techniques, which generally uses Standard Error (SE) or Root Mean Square Error (RMSE) as a key metric. This makes comparison between the two methods somewhat problematic. NWRFC, too, has noticed a problem with underdispersion of the model and note that internal model errors (e.g. snow and soil moisture states) are not fully represented in the forecast.

Columbia Basin, BPA (Rick):

BPA has been using ESP since 2004, but with numerous changes and improvements over that time. Because BPA runs a nearly identical forecasting platform, model, and calibrations as NWRFC, the issues they experience are similar to NWRFC's. The one difference with BPAs methodology is that they can vary how far out in time precipitation forecasts should be incorporated into the ESP traces before trending to climatology, based on forecaster confidence. For example in high confidence medium range weather situations, they may use precipitation as far as 7 or 8 days out, while in low confidence situations they may only use one or two days and defer to climatology for the rest. BPA also notices underdispersion in its ESP set.

General Discussion:

The group discussed the relative strengths and weaknesses of each approach being used, along with some ideas on moving forward. There is general agreement that while ESP is rapidly emerging as a “method of choice” for water supply forecasting, statistical methods are still reliable in most situations, and most of our system operation rules were developed with statistical water supply uncertainty in mind. NWRFC and BPA reported that they are conducting initial scoping on expanding their ESP set to 65 traces to help with underdispersion, but that the issue won't be fully resolved until multiple trace or ensemble weather forecasts are incorporated into ESPs. There was also some discussion in NWRFC perhaps moving from 3 days of QPF to 5 in one of their ESP “flavors.” Finally, the group discussed the importance of evaluating both statistical and ESP-based water supply forecasts with the scientifically correct metrics for each.

At the close of the meeting, the group briefly discussed collating the presentations into a single presentation for the Chapman Conference. Action Item: Erik will begin drafting a presentation for the Chapman conference, and circulate to the co-authors in late June.

AGENDA
Columbia River Forecasting Group (CRFG)
August 1, 2013

Meeting time: 9:00-11:00am PST
Location: CRITFC Headquarters
700 Multnomah St., Ste. 1200
Portland, OR 97232

Conference Call. (877-848-7030)
Access code: 3626353
Security Code: 7722

Contact Info: Erik Pytlak (503-230-5335)
Steve Hall (509-527-7550)

- 8. Introductions/Roll Call** (Erik)
- 9. Approval of January 18 and April 18, 2013 minutes** (all)
- 10. 2014-2018 Implementation Plan** (Erik)
- 11. 2013 CRFG project: Compilation of water supply forecast verification efforts**
 - a. Chapman Conference Discussion (Kresta, Pam, Adam, Rick, Jason, Erik)
 - b. Libby Water Supply Forecast Update (Kevin)
 - c. Next steps for CRFG
- 12. News items:**
 - a. RMJOC-II Climate Change Research Effort (2014-2016)
- 13. Forecast Round Robin:**
 - a. NWS, NRCS, USACE districts (Seattle/Walla Walla), USBR, NWRFC, BCH, CRITFC.

Next meetings
November 14, 9:00am-3:00pm (Annual Review)

MINUTES

Columbia River Forecasting Group (CRFG)

August 1, 2013

Participants: Kyle Dittmer CRITFC, Erik Pytlak. BPA, Ted Day BOR, Steve Hall USACE-NWW, Kevin Shaffer USACE-NWS, Adam Gobena BC Hydro, Jason Ward USACE-NWD, Cara McCarthy NRCS, Rick van der Zweep BPA, Pam Pace IPC, Kresta Davis-Butts IPC, Phone: Tim Bureauer IPC, Tracy Schwartz.

Item 1 - Introduction

Item 2 - Review Meeting Minutes: January 18th meeting minutes – waiting for draft from Steve Hall. Steve committed to sending a draft to Erik as soon as possible. April 18th meeting minutes amended and approved.

Item 3 - BiOp Implementation Plan for 2014 to 2018 – The current BiOp contains language under RPA #7 addressing water supply forecast improvement and is the basis for the CRFG charter and presence. Action Agencies (COE, BPA, and BOR) are drafting language for the new BiOp starting in 2014. Proposed language was distributed by Erik P. and includes more of a focus on Climate Change. It also contains language about related issues including non-stationary of data. All participants should review the proposed language and provide comments to Erik no later than August 15th.

The discussion on the BiOp language led to a discussion about NWS-RFC (NWS) participation in CRFG and their critical role in generating the water supply forecast for the Columbia River at the The Dalles. Several commented that The Dalles forecast is central to all the Columbia River Power System operations including the operations of all the treaty dams. CRFG will request a detailed presentation of the performance of the NWS The Dalles forecast at the fall forecast review meeting. NWS has been more active in their participation in CRFG, and the group discussed the central role that NWS plays and considered asking NWS if they would be willing to be part of the lead agency group. However it was pointed out that the CRFG is a mandate under the Columbia River Power System BiOp, therefore the lead agency group will remain the Action Agencies (COE, USBR, and BPA) and CRITFC.

Item 4a – Review of the Water Supply Forecast Verification efforts and Chapman Conference Report. Everyone expressed kudos to Erik for his work on the CRFG presentation on Water Supply Forecast Verification for the Chapman Conference. Unfortunately most federal staff were not allowed to attend the conference due to travel and conference restrictions. Feedback from Idaho Power Company (Pam Pace and Kresta Davis-Butts), BC Hydro (Adam Gobena), USACE (Jason Ward) and BPA (Erik Pytlak) was provided to the group. The general feeling was the conference was very good with a lot of very interesting presentations, however more focus on applied forecasting research and presentations would be even better.

The following is a summary of the feedback...

Idaho Power Company – very interesting success story regarding forecast skill optimization. Need to bridge gap between theory and operation. Take home – IPC will be looking into hiring graduate students to help bridge that gap.

BC Hydro – Very good presentation about the insurance industries use of forecasting to offset risk including an example in Peru where Banks change the crop protection interest rates based on the probability of an El Niño (charging 10% versus 22% interest rate). Discussed the difference between research and operations, for example one presenter was spending days and even weeks on a single forecast point. In contrast, BC Hydro must forecast more than 20 points in less than 1.5 hours each day. There are also significant issues with the current scaling techniques used in climate forecasting that need additional research and improvement.

USACE – Interested in the work that Dr. Hamid Moradkhani is planning in the next year on improving downscaling of the GCMs and the granularity that results and its impact on other applications. Jason gave a presentation on the criticality of defensibility in our forecast due to legal, policy and other ramifications from our forecasts.

BPA – Erik was surprised at the lack of research and presentation regarding statistical forecasting versus ESP based forecasting. There is a real need to explore blending forecasting techniques, improve the ability to quantify and communicate uncertainty in the forecast. One interesting suggestion was to evaluate forecast performance based on the decision resulting from the forecast rather than observed results (such as flood control and refill decisions versus observed runoff volume). Also recommend looking at the accumulative result instead of or along with accuracy of a forecast. A disappointment from the conference was a lack of any discussion on the quality and availability of data – as these are limiting conditions in forecast improvement in a lot of Columbia River sub-basins.

Item 4b – Libby Water Supply Forecast update – Kevin Shaffer gave a short update on Corp Seattle District efforts to improve their water supply forecast for Libby Dam. The last couple years have demonstrated some problems with their current Principle Components Regression forecast. The issues appear to be the result of a narrow focus on generating a forecast with a low standard error without also having a focus on maximum errors and other error terms. The new forecast will improve the number and type of predictor variables, variable continuity from month to month, and include a clear connection to physical process. Kevin asked for input into the climatic indices used in the new forecast. Several suggestions were given including using analysis to guide the selection of a climatic index, limiting the use of the climatic variable to early season forecasts, use a multi-month moving average, etc. The BiOp recommends but does not mandate using climatic index in water supply forecasts. Kevin will keep CRFG updated on the forecast development as it proceeds.

Item 5 – RMJOC Climate Change Project 2 (RMJOC—II) will begin in October 2013 and continue through 2016. BPA is the principal cost-share funding agency. The University of Washington and Portland State University will analyze, downscale, and hydrologically route IPCC-5 Global Climate Model data for the Columbia Basin. The new scope of work includes glacier modeling, and a greater emphasis on statistical analysis. The duration of the effort is three years with potentially more than 50 data sets. The resulting data will be a significant improvement over the currently available RMJOC data. Erik Pytlak is the overall project lead with Toni Turner the Reclamation lead, and Peter Brooks serving as the Corp lead

Kyle Dittmer has an article in the journal *Climatic Change* scheduled to be published in September.

Ron Abramovich is concerned about the number and location of Snow-Courses being discontinued in Idaho due to lack of funding.

Annual Forecast Review Meeting is scheduled for November 14th, 2013.

AGENDA
Columbia River Forecasting Group (CRFG)
December 5, 2013

Meeting time: 9:00-11:00am PST
Location: CRITFC Headquarters Celilo Room
700 Multnomah St., Ste. 1200
Portland, OR 97232

Conference Call. (877-848-7030)
Access code: 3626353
Security Code: 7722

Web Conference Call Instructions:

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

Meeting Number(s): (877)848-7030 or (404)443-2170

ACCESS CODE: 3626353

* The first time you use the Web Meeting Service, you will need to download the client software. Web Meeting HELP & Software Downloads can be found at:

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

Contact Info: Erik Pytlak (503-230-5335)
Steve Hall (509-527-7550)

8:30am **Introductions/Roll Call (Erik)**

8:45 **Approval of August 1 minutes (all)**

9:00 **2013 Water Year Forecasts in Review**

Corp Seattle: Libby
BC Hydro: Canadian Columbia and Kootenai
Reclamation/NRCS: Hungry Horse and middle/upper Snake
Corp Walla Walla: Dworshak

10:00 **Break**

10:15 **2013 Water Year Forecasts in Review (con't)**

Idaho Power: Brownlee
NWRFC: Columbia Basin
BPA: The Dalles
CRITFC: The Dalles
Others?

11:15 **Overall findings/lessons learned from 2013**

11:30 **Lunch**

12:30 **2014 Water Year Prep**

Corp Seattle: Proposed Libby Forecast Change
NWRFC: Discussion on 5-day QPF ESP
Corp, Reclamation, CRITFC: Initial forecasts for WY2014

1:30 **Break**

1:45 **RMJOC-II Climate Change Research Kickoff**

BPA: 2014-2017 Research Plan
Corp: NRNI development (to be used for both for bias correction and new/updated base case)
CRITFC: Dittmer, et al. climate change research summary
All: Discussion and next steps (this will be a recurring CRFG agenda item in 2014)

3:30 Adjourn

Next meeting: February, 2014

MINUTES

Columbia River Forecasting Group (CRFG)

December 5, 2013

Participants: Kyle D, Erik P., Stephen H., Ted D., Steve K., Kevin S., Kresta D., Jason W., Harold O., Tim B., Rick V., Dave B., Dave G., Rashon T., Joe Intermill, O. Chegwiddden, B. Nijssen

Meeting Minutes – August 2013 meeting notes – a few minor corrections were discussed which will be made to the final minutes. Motion made and sustained to approve minutes as corrected. Presentations on this year's water supply forecast performance by forecasters.

Ted Day – presented on Hungry Horse, Snake River at Heise and Boise River water supply forecasts. The forecast for Hungry Horse performed well, due to very stable weather patterns. On the other hand, the Heise and Boise forecasts both performed poorly due to very inconsistent precipitation patterns.

Kevin Shaffer - Libby forecast review: Overall, the forecast performed well for the year. Again June the rain event was outside the normal forecast expectations with 3-day precipitation totals ranging between 1 inch and over 4 inches at some locations in the basin. This raised the question if the June precipitation observed the last three years is indicating a changing trend in weather patterns. The group discussed high late season precipitation and concluded that it is very common for late season high precipitation to occur in the Columbia Basin, but it is still very difficult to accurately predict where the heavy precipitation will fall. This is a known issue that needs to be considered during operations in May and June. Kevin also discussed the October 2012 extremely wet outlier that resulted in a Deviation Request to limit the impact of the very large October precipitation. The Columbia River Hydromet Committee approved an adjustment to use using a 1.5 x Standard Deviation to limit fall precipitation effect on the water supply forecast.

Stephen Hall – Dworshak water supply forecast performance in 2013 was very good, again due to very consistent weather patterns, similar to Hungry Horse forecast. Over all the forecast was for an 80% of average runoff. Z-score water supply forecast performance was also shown. It was very similar to the Principle Components Forecast performance, with very little difference in the forecasts.

Steve King – presented on the ESP forecasts for all other locations in the Columbia Basin including the Dalles, Lower Granite and other locations. Steve gave a good comparison between ESP forecasts using the 10 day, 5 day, and 3 day deterministic weather forecast before using climatology. BPA indicated they generally use the 5-day ESP traces, but will vary if forecast confidence is unusually high or low.

Idaho Power Company – discussed some of their Brownlee Reservoir inflow forecasts. Soil moisture is a big driver of their forecasts due the extensive amount of irrigation in the Upper and Middle Snake above Brownlee. They use a multi-model approach with expected state, low case, high case and other weather/use levels to generate a number of forecasts.

Kyle Dittmer - CRITFC's 2013-2014 winter forecast calls for near normal temperature and near normal precipitation, with below normal precipitation early winter then above normal late winter and early spring. The MEI-based forecast for the Columbia River at The Dalles calls for 105 MAF (using the AUG-SEP-OCT index) or 104% during January-July.

Libby Water Supply Forecast Update short presentation – Kevin led a short discussion on the Libby Water Supply Forecast update and some of the primary forecasting issues that they were dealing with. Topics included looking at other ways to evaluate forecast errors besides using the CVSE, and clarifying that the RPA only states that they need to try to reduce errors in general, not specific types of errors. He also shared that things like maintaining a good distribution of stations, using reliable stations, considering the potential for high absolute errors, and standardizing the forecast training period are all important but may raise standard errors. They also discussed the challenges of using climatic indices and fall precipitation, particularly late in the forecasting period. Finally, he asked the group about eliminating outlier years from equation training, and whether the group wanted to weigh in on criteria for what makes an outlier. Seattle District will present the proposed forecast equations in the February meeting.

The River Forecast Center discussed plans for ESP forecasts moving forward. They will keep the 10-day and 0-day traces. They are seeking input on the preference of the group between also generating a 3-day or 5-day trace, however due to limited resources they cannot produce both. In the future they will be moving to a short-term ensemble (expect to see more in the next 6 to 18 months). The group discussed the benefits of a 3-day versus 5-day ESP ensemble, but in general supported the chance to a 5-day QPF.

RMJOC-2 Climate Change – Erik presented an update on the River Management Joint Operating Committee (RMJOC)-2 Climate Change effort. The International Panel on Climate Change (IPCC 5) has produced a new set of Global Climate Models. BPA and several co-funders have contracted with UW and OSU to select multiple Global Circulation Models (GCMs) and run a large number of scenarios using the new GCMs coupled with advanced downscaling techniques and several different hydrologic models to produce climate change flow data sets. The overall intent of the project is to provide an update set of streamflow scenarios using the new, slightly warmer GCM forcings, but also to better quantify the uncertainties introduced by different downscaling and hydrologic modeling methods. This new research effort will also explicitly account for glacial melting in the upper Columbia Basin, which was only indirectly handled in the RMJOC-I effort.

Erik also shared plans to develop the No Regulation-No Irrigation (NRNI) dataset, which will remove the irrigation effects from the 2010 Modified Flows dataset and serve as the baseline for the Principal Investigators to use for bias correction and post processing. The NRNI dataset will also be used for the new “base case” for future streamflow scenario comparison, and to test and improve BPA, Corps, and Reclamation hydroregulation models before the new streamflow scenarios are ready in late 2015 (for Portland State’s part of the project) and late 2016 (for the University of Washington-Oregon State part of the project). The Corps and Reclamation expect this dataset to be ready by late February or early March for RMJOC review, and for on-time submittal to the PIs by April 1, 2014.

As the project proceeds, the CRFG will be the public forum for the RMJOC technical teams, and research Principal Investigators, to share their ongoing progress, exchange information of how hydroregulation studies will be produced, and the answer questions from the regional research, operations, and fish management communities. The project will continue through 2017.

Early season runoff forecasts:

Libby – 5.5 MAF, leading to full relaxation of winter flood control space requirement.

Dworshak – 2.7 MAF forecast.

Kyle Dittmer – Columbia at The Dalles forecast for 105 MAF, 104% of normal.

Next meeting will be scheduled for the 2nd or 4th weeks of February.

Appendix C: Historical Forecast Results Columbia River Forecast Group 2013

Historic forecast results:

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

Observed KAF = from runoff processor

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
	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

Libby: (Apr-Aug)

Year	Jan		Feb		Mar		Apr		May		Observed KAF
	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

Hungry Horse: (May-Sep)

Year	Jan		Feb		Mar		Apr		May		Observed
	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

Grand Coulee: (Apr-Aug)

Year	Jan		Feb		Mar		Apr		May		Observed
	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

Brownlee: (Apr-Jul)

Year	Jan		Feb		Mar		Apr		May		Observed
	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

Dworshak: (Apr-Jul)

Year	Jan		Feb		Mar		Apr		May		Observed KAF
	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

Lower Granite: (Jan-Jul)

Year	Jan		Feb		Mar		Apr		May		Observed KAF
	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

The Dalles: (Jan-Jul)

Year	Jan		Feb		Mar		Apr		May		Observed KAF
	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

The Dalles: (Apr-Aug)

Year	Jan		Feb		Mar		Apr		May		Observed KAF
	KAF	% of OBS									
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

CRFG Mailing List December, 2013

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