

*COLUMBIA RIVER FORECAST GROUP*

2011  
ANNUAL  
REPORT



CHAIRMAN: TED DAY, USBR  
VICE-CHAIR: KYLE DITTMER, CRITFC

OCTOBER 2012

# COLUMBIA RIVER FORECAST GROUP

## 2011 ANNUAL REPORT

### 2011 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.

The CRFG developed a charter and organizational structure in 2009 as well as organizing expectations and a strategy for the group. Under the terms of the charter, the CRFG is also 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 CRFG conducted six business and/or workshop meetings in 2011: January 18 (conference call), February 25, April 14, August 3, October 13 (conference call), and November 15 (annual workshop). Each meeting provided a forum to review the current runoff forecasts (or to review their performance), discuss topics of common interest, and to hear speakers on various topics related to water supply forecasting. Meetings were attended by numerous agencies including the Natural Resources Conservation Service (NRCS), Northwest River Forecast Center (NWRFC), National Oceanic and Atmospheric Administration (NOAA) Fisheries, Columbia River Inter-Tribal Fish Commission (CRITFC), Bonneville Power Administration (BPA), Corps

of Engineers (COE), Bureau of Reclamation (USBR), Northwest Power and Conservation Council (NPCC), and the Fish Passage Center (FPC).

Topics and discussion covered a wide range of interests, and included:

- Dissemination and discussion of current forecasts (winter/spring meetings), with focus on forecast discrepancies and challenges.
- Formulation of potential CRFG activities and work elements.
- Review of NRCS Daily Guidance forecast product.
- Summaries of snow and precipitation patterns.
- Implementation of the updated 30-year averages data set (1981-2010) and relative changes from the 1971-2000 data set.
- Future direction of NWRFC forecast products.
- SNOTEL network update.
- Implementation protocol for new RFC forecasts in 2012, where official operating forecasts that set flood control will be the ESP forecast closest to and prior to the 4<sup>th</sup> working day of each month.
- Review of presentations given at the October 2011 climate workshop sponsored by BC Hydro and others in Vancouver, British Columbia.
- Review of anomalous runoff and 2011 operations in the Upper Snake basin.
- The 2011 wrap-up and review of runoff forecasts, comparison of results, discussion of challenges, and lessons learned.

Various guest speakers were invited to give presentations at the CRFG meetings, which were very well received and appreciated by the group. These included the following:

- ❖ Toni Turner, USBR, presenting on the results from assessing reservoir operations in the Yakima, Deschutes, and Snake River sub-basins using future climate change supply projections. These results will be input to the River Management Joint Operating Committee (RMJOC) climate change and reservoir systems analysis.
- ❖ Karl Tarbet, USBR, gave a demonstration of the Pisces statistical analysis tool. Pisces is a desktop application designed to organize, graph, and analyze natural resource data that varies with time: gauge height, river flow, water temperature, etc. Pisces also provides convenient access to time series model results and allows users to easily compare many different scenarios or alternatives.

- ❖ Dr. Hamid Moradkhani, Portland State University, provided an overview on a wide range of climate and water resources based research that PSU has been involved with over the last few years, with an emphasis on new statistical methods.
- ❖ Chris Lynch, USBR, gave a presentation titled “Understanding the Yakima Basin”, identifying how forecasts are used in short term operations to long term planning, including calculation of the Total Water Supply Available (the basis of how water is shared in the basin), fishery flows, balancing power and fish and flood control, and other operational constraints.
- ❖ Rashawn Tama, NRCS, presented “How Much Do We Trust our Models? Memes in Streamflow Forecast Adjustment.” Memes - how is a “way of thinking”, shortcuts, or philosophy passed on as professional judgment to the next hydrologist (or next generation), and do they bias a forecast? Professional judgment: (1) Will an adjustment improve or weaken the forecast?; (2) What memes should a hydrologist use?

CRFG work accomplishments and ongoing studies in 2011 included the following:

- Review of BPA and BC Hydro initiative to install new SNOTEL stations and collect more real-time (daily) snow data in data-sparse areas of the Canadian Upper Columbia basin. In March, 2012, BPA and BC Hydro signed a new Memorandum of Agreement to install five new, real-time snow pillow sensors. The five sites were chosen based on the 2011 BPA study which was reviewed by the CRFG. When all five sensors are installed by late 2013, CRFG expects the additional data will give us a better sense of snow pack changes in this critical part of the basin, particularly when rapid changes occur between monthly site surveys.
- The Corps of Engineers Walla Walla District’s (NWW) proposed Dworshak runoff volume forecast was redeveloped in 2011 and provided to the CRFG for review and comment. In response to those comments revisions to the forecast were made. The NWW proposed forecast is now a combination of two Z-Score regression forecasts. The first is a 3-parameter Z-Score regression (SOI, precipitation, SWE beginning on 1-Jan) for the time period of 1-November through 1-June. The second is a SWE only forecast from 1-Jan through 1-June. Both utilized consistent variables for the 1-January through 1-June periods to the extent of reliable snow measurements above zero. The SWE only Z-Score regression is recommended to be used typically after 1-May when the snowpack has peaked and "turned over" into recession. The current PC Regression has similar forecast statistics. However, the Z-Score procedure is more adaptable to the present conditions forecasting process utilized by the Corps for the Snake River Basin reservoirs. The NWW proposed procedure was under internal COE review at the end of 2011.
- Finalized the CRFG 2010 Annual Report on the group’s activities that includes an appendix that will track WSF performance each year. The 2011 Annual Report will be finalized in 2012.

### Action Items for CRFG 2011

Meeting	Item	Final Status	Complete
From 2009	Mid-Month Forecasts	Decision was to table this exercise until the new ResSim model is complete and then run simulations to determine the impacts of using a mid month forecast on final water availability.	Preliminary results completed. More detailed analysis tabled until ResSim model is ready.
March 2010	Should NRCS be involved in the comparison with NWS and the USACE to see whose procedures are most accurate?	Tabled for now due to lack of defined need and lack of dedicated funding/staff time.	Tabled
May 2010	NWS and discussion of impacts of 10-day forecast on ESP process.	Discuss with the NWS about using less than the 10 day deterministic forecast as part of the ESP process. Would a 3 day or 5 day be better and then shift to ESP traces instead of 10 days out?	Complete
January 2011	Review of forecast procedures and accuracy	Various forecasts were presented and discussed at January and March meetings, and results reviewed at November meeting.	Complete
February 2011	Pursue more active involvement of the NWRFC	Regular attendance by representative of NWRFC, with presentations on current methodologies, forecasts, upcoming changes.	Complete
February 2011	30-Year Averages data set	Comparison of results with implementation of new 30 year average period (1981-2010)	Complete
February 2011	30-Year Averages data set	Determine process and timetable for new 30 year averages; what if any role CRFG will have.	Ongoing discussion, to be completed in 2012
February 2011	2010 Annual Report	Annual report for 2010 was reviewed and report was finalized in August 2011.	Complete
Jan/Feb 2011	Dworshak forecast procedure(s)	CRFG asked to review proposed changes to Dworshak inflow volume forecast	Complete

## A P P E N D I X A

### Columbia River Forecast Group (CRFG)

The following pages document the CRFG Charter approved on July 21, 2009.

#### 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.

## **A P P E N D I X B**

### **Columbia River Forecast Group**

Meeting notes. The following meetings took place for the CRFG. Meeting notes are attached where available:

- 18 January 2011 (conference call)
- 25 February 2011
- 14 April 2011
- 3 August 2011
- 13 October 2011 (conference call)
- 15 November 2011 (Annual Review)

**Date: January 18, 2011, 13:00 – 15:00 PST (Draft Agenda)**

**Location: Via Conference Call, (303) 445-3911 (FTS); 800-822-7681 (non-FTS)  
Password: 5171**

**Contact: Ted Day (208) 378-5273 Office**

1. Introductions - Ted Day (13:00 – 13:10)
2. Review/Discussion of Jan. 1 forecasts, by agency. Data trends; forecast ‘drivers’; sensitivity to future conditions; confidence intervals; etc.  
COE: Steve Hall – DWR  
Kristian Mickelson – LIB  
Randy Wortman – TDA?  
USBR: Ted Day – HGH & Upper Snake  
NRCS: To be determined  
  
CRIFTC: Kyle Dittmer  
Others?  
(13:10 – 13:40)
3. Update on Dworshak mid-month forecasting test – Steve Hall (13:40 –13:45)
4. Update and discussion of climactic conditions and available 1 to 3 month forecasts (tentative, will need to find willing subject matter expert). (13:45 – 13:55)
4. Topics for Future meetings (some of these are left from last agenda as ‘placeholders’). (13:55 – 14:30)
  - Review/discussion of CRFG formation document (Appx E of Fish Accords)
  - Informal update on ensemble forecast system and forecast verification system design: 15 min.
  - NWS Analyses on NW Service ESP traces and the affect that the 10 day deterministic forecasts has on them vs the 3 and 5 day forecast-Harold Opitz
  - PSU Research Water Resource Mgt., Hydro Forecasts, and Climate Change – Dr. Hamid Moradkhani from Kyle Dittmer This could be a Webinar in November or December 2010.
  - Final Report on NW Service adding Pillows at existing snow course sites in BC
  - Below are suggestions for additional topics covered by the Annual Report:
    - List of key forecasting-related accomplishments by group members; here, I would limited the definition of accomplishments to project work. Is there anything for 2010 Report?
    - Technical publications by group members
5. Meeting Adjourned. (14:30)

**Columbia River Forecasting Group  
Meeting (Teleconference) of January 18, 2011**

Meeting Minutes (DRAFT) – by Ted Day (2011 Chair)

Attendance list: Ted Day (USBR), Randy Wortman (USACE NWD), Steve Hall (USACE Walla Walla), Kristian Mickelson (USACE Seattle), Cara McCarthy (BPA), Erik Pytlak (BPA), Rashawn Tama (NRCS), Jolyne Lea (NRCS), Jim Ruff (NWPPC), Dave Benner (FPC), Margaret Filardo (FPC), Kyle Dittmer (CRITFC), Paul Wagner (NOAA Fisheries)

1. Representatives from agencies provided their January 1, 2011 water supply forecasts:
  - a. Steve Hall: Jan 1 forecast for Dworshak Apr-Jul inflow came in at 3340 kaf (125% of the 1929-1999 average.) They also produced an MLR forecast of about 95% of average. The 125% forecast was driven largely by the Sept SOI index (largest on record) and Nov/Dec precip at Headquarters. These two factors will decrease as we move through the season. Current operations are not particularly sensitive to the Jan 1 forecast; Feb 1 forecast could have more implications. In regards to the high water event over MLK weekend, loss of SWE was noted below 4500 feet, with increases above that.
  - b. Kristian Mickelson: Jan 1 forecast for Libby was 5610 kaf, 96% of the 1975-2009 average (89% of 1929-1999). The forecast is being held down because of the low snowpack in the Canadian headwaters, which has seen improvement so far in January.
  - c. Ted Day: Jan 1 forecast for Hungry Horse (Jan-Jul) was 106% (MLR). The PCA forecast was consistent at 110%. Snowpack has dramatically improved during January, and the MLR midmonth forecast has increased to 118% (guidance only.) This 12% increase closely matches the snowpack % increase, which went from 114% to 125%. Ted suggested it may have value to track change in snow % versus change in forecast at other locations as an additional tool for mid-month guidance; this is essentially what the NRCS daily automated SNOTEL forecasts provide.

Other USBR forecasts:

Boise 112% (snow has since dropped about 13%)

Payette 106% (5% drop in snow since Jan 1)

Upper Snake at Heise 111% (5% drop in snow)

Yakima 96% (7% drop in snow)

- d. Rashawn Tama: Followed up on Ted's mention of NRCS daily forecasts using SNOTEL data. They are "guidance" only, run automatically, and can potentially contain data errors prior to QC'ing. The Flathead at Polson daily forecast confirms the significant increase due to recent snow. Expect decreases with each day it does not snow. These can be developed for other basins; one is currently being tested for SF Flathead.

- e. Randy Wortman: reported the NWRFC forecast value at The Dalles of 97% of average for most of the different forecast periods. The ESP forecasts come out a few % lower.
  - f. Kyle Dittmer: his MEI forecast for 2011 at The Dalles is 102% of average. He has suspended his “correction-curve” forecast procedures for the time being but it may be a subject of further review in the future for him.
2. Steve Hall provided brief update on Dworshak mid month forecast evaluation. Analysis is still being reviewed in-house, but a report will be available sometime in near future. Current work has focused on development of the forecasts; future work to model the results and examine operational sensitivity is not scheduled at this point but will likely be part of a broader flood control review study.
3. Ted Day, 2011 Chair, reiterated the need and responsibility of the CRFG members, and in particular the signatories to the Fish Accords, to submit agenda items for consideration at future meetings, and for developing a work plan for 2011. Ted had provided a text version of Appendix E of the Accords, which created the CRFG and provides the intent and direction for the group. Please review; CRFG activities should be consistent with this document. With that in mind, Ted asked the group to begin brainstorming/submitting ideas and topics for future meetings. The following items were mentioned:
  - a. Follow-up presentation by Phil Butcher (BPA) to give update on study to co-fund new Canadian SNOTEL sites. Number to add? Locations? Study is nearing completion and may be ready for presentation in February.
  - b. Continue to pursue a presentation from Dr. Hamid Moradkhani, PSU research on water resources management, forecasts, and climate change. Kyle Dittmer will contact to determine his availability.
  - c. Pursue more active involvement of the NWRFC; possible presentation(s) on current methodologies, ESP updating procedures, any upcoming changes, etc. Basic question: is there anything the CRFG would like to see or learn from the RFC?
  - d. (Rashawn Tama): Hungry Horse: operational daily water supply guidance forecast with historic (~20 yrs) reconstructions.
  - e. (Rashawn Tama): The right tools for the job: a review of Columbia Basin water management objectives and open discussion of what tools (i.e. forecast products) would help managers respond to increasingly complex reservoir (and system) operations.
  - f. (Rashawn Tama): The Dalles: the role of TDA seasonal volume forecast in managing the Columbia River System; NRCS daily water supply guidance forecast with historic (~20 yrs) reconstructions; open discussion about whether a focused effort needs to be put forth to review (and potentially redevelop) operational forecasting for TDA.
  - g. (Cara McCarthy): Examination of the various forecasts and forecast products. What forecasts are used? Where? How? Why?

- h. (Jolyne Lea): CRFG role in new 30-year averages data set. What role should we have?
  - i. (Kyle Dittmer): New work from CIG and others (Fitzgerald, Burgess, Lee) on optimizing flood control rule curves w/ ENSO years. Presentation from author?
  - j. Various climate change/climate variability research work is being conducted that may be appropriate for presentation, particularly how it will impact future forecasting abilities. Several agency efforts are underway that could be candidates. Need to scope for possible topic.
4. It was decided to schedule a face-to-face meeting in February; the tentative date will be Feb. 24. CRFG members are tasked to continue submitting and refining agenda items for this meeting. Development of a 2011 work plan will be one of the key goals of the Feb meeting.

**Date: February 25, 2011, 08:30 – 13:30 PST (Draft Agenda)**

**Location: Columbia River Inter-Tribal Fish Commission, Celilo Room (basement conference room), 729 NE Oregon St, Suite 200**

**Contact: Ted Day (208) 378-5273 Office**

1. Introductions - Ted Day (08:30 - 08:40)
2. Review/Discussion of Feb. 1 forecasts, by agency. (08:40 – 09:00)
  - COE: Steve Hall/Kristian Mickelson/Joel Fenolio
  - USBR: Ted Day
  - NRCS: Rashawn Tama/Jolyne Lea
  - CRIFTC: Kyle Dittmer
  - Others?
3. Results from assessing reservoir operations in the Yakima, Deschutes, and Snake River subbasins using future climate change supply projections (input to RMJOC climate change and reservoir systems analysis) – Levi Brekke and Toni Turner, USBR (09:00 – 09:45)
  
- <<<BREAK>>> (09:45 – 10:00)
  
4. Pisces statistical analysis tool. Pisces is a desktop application that graphs and analyzes time series data. Pisces is designed to organize, graph, and analyze natural resource data that varies with time: gauge height, river flow, water temperature, etc. Pisces provides convenient access to time series model results and the ability to easily compare many different scenarios or alternatives. It has a scenario selector unique to Pisces that converts massive amounts of output data into a summary form for each time series by scenario/alternative – Karl Tarbet, USBR (10:00 – 10:45)
  
5. NRCS Daily Guidance Models, background and current status – Rashawn Tama, NRCS (10:45 – 11:15)
  
- <<<LUNCH>>> (11:15 – 12:00)
  
6. Discussion of 2011 Dworshak runoff forecasts. Focus is on discrepancies between forecasts, issues/concerns involved, and the potential implications to operations. Followed by CRFG discussion and potential formulation of a work plan – Steve Hall/Randy Wortman/Bill Proctor, COE (12:00 – 12:30)
  
7. Other business: 2011 work plan; future agenda items; finalization of 2010 Annual Report; scheduling of next meeting, etc – All (12:30 – 13:30)
  
8. Meeting Adjourned (13:30)

**Date: April 14, 2011, 08:30 – 11:30 PST (Final Agenda)**

**Location: Columbia River Inter-Tribal Fish Commission, Celilo Room (basement conference room), 729 NE Oregon St, Suite 200.**

**Call in Number: 1-213-342-3000, Access Code 1550046**

**Contact: Ted Day (208) 378-5273 Office**

1. Introductions - Ted Day (08:30 - 08:40)
2. Summary of March precip and snow patterns – Rashawn Tama, NRCS with input from others. (8:40 – 8:55)

3. Review/Discussion of April 1 forecasts, by agency. (08:55 – 09:30)

COE: Steve Hall/Kristian Mickelson/Joel Fenolio  
USBR: Ted Day  
RFC: (invited)  
NRCS: Rashawn Tama/Jolyne Lea  
CRITFC: Kyle Dittmer

Included in this discussion are the implications that the current weather forecasts/patterns may have on future forecasts, as a 'heads up' for operational impacts.

4. Presentation on PNW Runoff Forecast research –Dr. Hamid Moradkhani, Portland State University (09:30 – 10:15)

<<<BREAK>>> (10:15 – 10:30)

5. Comparison of results with implementation of new 30 year average period (1981-2010). Each presenter in item 3 should be prepared to show results for various data of interest. For example: April-July average volume, or precip, or snow, etc for the pertinent forecast locations. (10:30 – 10:45)

6. Other business: 2011 work plan; future agenda items; discussion of proper roll and vision for CRFG activities, finalization of 2010 Annual Report; scheduling of next meeting, etc – All (10:45 – 11:30)

7. Meeting Adjourned (11:30)

**Date: Aug 3, 2011, 1:00 pm – 4:00 pm PDT (Final Agenda)**

**Location: Columbia River Inter-Tribal Fish Commission, Celilo Room (basement conference room), 729 NE Oregon St, Suite 200.**

**Call in Number: 1-503-326-7668 (there is no passcode required)**

**Contact: Ted Day (208) 378-5273 Office**

1. Introductions - Ted Day (1:00 – 1:05)
2. Brief synopsis/roundtable discussion of forecast performance and challenges in 2011

(1:05 – 1:25)

COE: Steve Hall/Kristian Mickelson/Joel Fenolio  
USBR: Ted Day  
RFC: Steve King  
NRCS: Rashawn Tama/Jolyne Lea  
CRITFC: Kyle Dittmer

- While too early to review in detail, we should start focusing on any lessons learned; unique challenges; identify gaps in data and/or knowledge; any special techniques utilized; forecast modifications, etc. This will lead to a more robust review in the fall meeting.
3. Update on BPA Canadian Snotel initiative, and other Snotel network discussion – Erik Pytlak/Rashawn Tama/others?

(1:25 – 1:45)

4. Update/discussion of mid-month forecast initiative – Ted Day and Steve Hall (others?)

(1:45 – 2:00)

5. Future Direction of NWRFC Forecast Products – Steve King (2:00 – 2:30)

<<<< BREAK >>>> (2:30 – 2:40)

6. Discussion of a work element to do a systematic evaluation and comparison of the various forecast procedures – Dave Garen/Randy Wortman/All CRFG members (2:40 – 3:45)

Be prepared to discuss potential scope of work: need, potential approaches, expected outcomes, data requirements, identify prospective technical staff, timetable, work products, ability to provide staff time, agency funding, etc

7. Other business: future agenda items; discussion of proper roll and vision for CRFG activities, finalization of 2010 Annual Report; scheduling of next meeting, etc – All

(3:45 – 4:00)

8. Closing comments and adjournment (4:00)

**Columbia River Forecast Group – Summer Meeting, CRITFC, Portland, Oregon, 3 Aug 2011**

*Introductions:*

Chairman Ted Day welcomed everyone. The 16 attendees introduced themselves.

*Preliminary Forecast Performance and Challenges in 2011:*

USBR (Ted Day, Boise)...Record snow for spring was unusual. Hungry Horse had the largest snowpack, ever. Grand Coulee had the deepest draft, since 1999). The Yakima basin WSF was 122% or the 4<sup>th</sup> highest ever. McKay inflows (Umatilla basin) were highest on record. This was the first time, in many years (since when?), that all the eastern Oregon reservoirs filled.

NWS-NWRFC (Steve King, Portland)...There was an over-emphasis on very dry antecedent conditions (summer 2010) as we moved into WY 2011. He compared the regulation-based forecasts vs. the ESP-based forecast points.

NRCS (Rashawn Tama, Portland)...The season was noted for cool, wet, snowy weather. The SWE increased during spring! Many SWE April 1<sup>st</sup> volume forecast values exceeded the 90%, 95% confidence levels.

NOAA-Fisheries (Paul Wagner, Portland)...There was some TDG (Total Dissolved Gas) problems with the fish (mostly the mid-Columbia), fall-back incidents, but really good fish passage this spring. The migration was fast and sustained. Run is still strong. The adults were late in returning upriver. The outgoing sub-yearlings were delayed, too.

BPA (Eric Pytlak, Portland)...There were no load or resource issues across the western power grid. Good news. However, because of high water, BPA needed to invoke environmental-driven re-dispatch due to over-generation. BPA's forecast challenge, like everyone else, was spent most of spring catching up with the ever-increasing snow pack accumulation and late runoff.

FPC (Margaret Filardo, Portland)...There were much debris that clogged the dam intake orifices this spring. The spill operations were very good, except for Chief Joseph Dam.

CRITFC (Kyle Dittmer, Portland)...The MEI forecast method, for the Columbia at The Dalles, produced forecasts of 130 MaF (pre-season) to 130-137 MaF (in-season), Jan.-July. The forecast error was -4% this year.

*Update on Canadian SNOTEL Initiative, Erik Pytlak (BPA Weather Office, Portland):*

The goal is to collect more real-time (daily) snow data in data sparse area of the Canadian Upper Columbia. Five new sites have been identified in the Mica/Arrow drainages, at 1650-2010 m elevations. Installation occurs in August 2012. Sites become operational in October 2012. BPA and BC Hydro are cost-sharing. There are existing snow-course sites in the area with records going back to 20 years. BPA-BCH have 15 additional sites on a "wish list", should more funding become available.

*SNOTEL Network Update*, Rashawn Tama (NRCS Water and Climate Center, Portland):

More SNOTEL sites have been added, during 2006-2011: nine in Washington Cascades, two in Idaho, two in western Montana, two in the south Oregon Cascades, one in the Upper Snake. Eric noted that NWS “Coop” sites are getting harder to replace, as observers age, die off, or move. Ted suggested that a “Thank You” letter be sent to each NWS-WFO for the Coop data.

*Update/Discussion on Mid-month Forecast Initiative*, Ted Day (USBR, Boise):

Hind-casts of Hungry Horse and Dworshak have been conducted. Steve Hall (COE) previously reported his results: 75% of the time the trend was “right” for a mid-month forecast for Dworshak. The COE is working on a new RES-SIM model to be operational soon. Randy W. said that the model uses monthly precipitation, not daily, so a disaggregation is needed.

*Future Direction of NWRFC Forecast Products*, Steve King (NWS-NWRFC, Portland):

The “Legacy” WSF (i.e., regression-based) will be replaced by the SWS- Statistical Water Supply (i.e., principal component based) and ESP (weekly) products. In 2012, ESP becomes the official product, but without formal coordination. Legacy WSF will serve as a backup, but unpublished. SWS will replace the Legacy WSF in 2013, but unpublished. The ESP product incorporates a 10-day deterministic forecast with future weather forcings derived from climatology. The NWRFC is putting 100% of its effort into CHPS (Community Hydrologic Prediction System) and intends to reduce duplication of effort among forecast agencies. Implications – ESP is not coordinated. Because ESP is issued weekly, there will be no more Final/“Early-Bird”/Midmonth forecasts. The WSF network locations may change (some sites dropped?). The status of the Westwide (WSF) Publication (produced by the SLC RFC) is unclear. ESP enhancements include a suite of forecasts with different forcings (e.g., -0, 3, 10-day QPF), climate change signals, and new ways to reflect forecast model uncertainties.

Jolyne said that the NRCS has policy coordination issues with the NWRFC plans. There is a MOA on joint coordinated forecasts in place since the early 1970s.

*Evaluation & Comparison of Forecast Procedures*, Randy Wortman (COE-Portland, Portland):

He shared a handout about a proposed process. Need to form a small team to assess forecast verification. David Garen said that a verification report was published in 1995. What are good verification metrics? Top study basins – Dworshak, Hungry Horse, and Libby. Randy W. and David G. will serve as co-Leads.

*Fall Meeting*, Ted Day (USBR, Boise):

Issues – forecast performance, WY 2012 pre-season outlooks. A proposed date of Nov. 9, Wednesday, seemed to be agreeable. Lastly, Ted presented a “Certificate of Appreciation” to Bob Heinth, CRITFC’s Hydro Program Coordinator, in recognition on his efforts to promote forecast issues, on behalf of the CRFG. Bob retires in October.

Note-taker: Kyle Dittmer, Columbia River Inter-Tribal Fish Commission, Portland, Oregon

**Date: October 13, 2011, 1:00 pm – 3:00 pm PDT (Draft Agenda)**

**Call in Number: 1-303-445-3940 (non-FTS 888-808-5102), Access Code 6525**

**Contact: Ted Day (208) 378-5273 Office**

Topics to be discussed (more can be added per suggestions)

1. Introductions - Ted Day
2. Forecast review/comparison work item for Dworshak (or Libby?) and Hungry Horse (discussed at previous meetings). Where are we going with this? Will NRCS and COE take the lead? What are the data needs? What are expectations for final product? [Day, Garen, Wortman, others?]
3. New Dworshak forecast. Summary of project, status of review, decision path forward and timetable. Please note the attached review comments from Randy Wortman (Review Comments\_rtw) in response to CRFG request for review. You should have received the NRCS comments earlier, but they are attached here as well (Review Comments\_NWCC). [Tracy Schwarz, others?]
4. Implementation of new RFC “official” ESP forecasts for 2012. [Erik Pytlak, others]
5. CSTAR funding of Dr. Hamid Moradkhani, Portland State University, forecast research: Towards Objective Multi-Modeling for Multi-Institutional Seasonal Water Supply Forecasting. (see attached pdf)
6. Annual Fall Workshop in mid November. Discuss direction and format, potential topics, location and time.
7. Other business

**Date: November 15, 2011, 8:30 am – 2:30 pm PDT (Draft Agenda)**

**Location: Columbia River Inter-Tribal Fish Commission, Celilo Room (basement conference room), 729 NE Oregon St, Suite 200.**

**Call in Number: (503) 326-7668 (no access code required)**

**Contact: Ted Day (208) 378-5273**

1. Introductions - Ted Day (08:30 - 08:40)
2. Review/Discussion of 2011 forecast procedures and performance, by agency. (approximately 15 minutes each, more if needed) (08:40 – 09:45)

COE: Steve Hall/Kristian Mickelson/Joel Fenolio  
USBR: Ted Day  
RFC: (not able to attend)  
NRCS: Rashawn Tama/Dave Garren  
CRITFC: Kyle Dittmer

Included in this discussion are any 'lessons learned' in 2011.

3. Comparing NWS ESP and NRCS statistical models in the Upper Colorado River Basin (Angus Goodbody – NRCS Portland) (09:45 – 10:15)

<<<BREAK>>> (10:15 – 10:30)

4. Understanding the Yakima Basin: How forecasts are used in short term operations to long term planning, including calculation of TWSA (total water supply available), fishery flows, balancing power and fish and flood control, and other operational constraints.

(10:30 – 11:30)

<<<LUNCH>>> (11:30 – 12:15)

5. Presentation given at fall 2011 climate conference in BC and summation of conference (Rashawn Tama – NRCS Portland) (12:15 – 12:40)

6. 2011 Upper Snake operations: A quick review of record setting conditions and response. (Ted Day – USBR Boise) (12:40 – 1:10)

7. Status update on new DWR forecast, and any other forecasting issues for 2012 (COE along with others) (01:10 – 1:30)

8. Other business: 2012 work plan; future agenda items; discussion of proper roll and vision for CRFG activities, 2011 Annual Report, etc – All (1:30 – 2:15)

9. New Chairman – CRITFC (2:15 – 2:30)  
Schedule for meetings in 2012 New Chairman

10. Meeting Adjourned (2:30)

## **Columbia River Forecast Group–Autumn Meeting, CRITFC, Portland, Oregon, 15 Nov 2011**

### *Introductions:*

Chairman Ted Day welcomed everyone at 8:30 am. The 13 attendees introduced themselves.

### *Review & Discussion of 2011 Forecast Procedures and Performance:*

USBR (Ted Day, Boise)...The greatest challenges were the very late season snow accumulation and hard to predict (and often changing) melt pattern. However, there were no major problems.

NOAA-Fisheries (Paul Wagner, Portland)...There were TDG (Total Dissolved Gas) problems, 140% with the fish at the mid-Columbia dams, and LGS powerhouse (also 140% TDG), but the resident time for those fish was short. Good runoff and migration conditions occurred for fish.

COE (Steve Hall, Walla Walla)...The Dworshak forecasts were 3755-4050 KAF, April-July. Conditions started dry but quickly turned in March and more than 50% of the snow accumulation occurred after April 1<sup>st</sup>. Challenge: the largest SOI on record, which drove the forecast and hard to believe, at the same time). It worked best to look at multiple forecasts.

COE (Kristian Mickelson, Seattle)...The Libby forecasts were 5775 KAF (Nov.), 5610 KAF (Jan.), 7111 KAF (March), and 8165 KAF (June), April-Aug. The observed was 7800 KAF. The ESP was consistently low early in the season.

NWS-NWRFC (???, Portland)...There was no representation present.

NRCS (Rashawn Tama, Portland)...The season started low then quickly climbed, in some cases to record levels (how many records?).

CRITFC (Kyle Dittmer, Portland)...The MEI forecast method, for the Columbia River at The Dalles, produced forecasts of 130 MAF (Oct. 2010, best pre-season,  $\pm 10\%$ ) to 137 MAF (Jan. 2011, best in-season,  $\pm 4\%$ ), Jan.-July. Seasonal forecast was spot-on: near normal temperature (slightly warm early, slight cool late), above normal precipitation 118% vs. 127% (observed). Five of the six Portland snow events verified. The new 2012 pre-season forecast, using the MEI method and 26 analog years, calls for 116 MAF (109%),  $\pm 76$  MAF, for the Columbia at The Dalles, three snow events in Portland, and a winter similar to 2010-2011.

### *Status Update on new Dworshak Forecast, Tracy Schwarz (COE, Walla Walla):*

Procedure was updated March 2011. Concerned was aired over early-season rain and SOI impacts on the forecast. Focus was on SWE stations, Z-Score forecasting, and PCA (Principal Components Forecasting). The CRFG was given the opportunity for review in September 2011. The COE (Portland), NRCS, BPA, and FPC submitted review comments. It was found that adding precipitation alone degraded the forecast. Forecast factors include SOI (Aug.-Sept.), precipitation, and SWE. The Square-Root Transform showed only minor improvement, so was dropped from the procedure. The new procedure was sent to the Columbia River Treaty Operating Committee's Hydromet Subcommittee for review. Hope to be operational by March.

### *Understanding the Yakima Basin, Chris Lynch (USBR, Yakima):*

Quick facts: annual runoff 3.2 MAF, reservoirs hold 1 MAF, and irrigation deliveries 2.2 MAF to 500,000 acres of cropland. Water is also reserved for fish – Chinook, steelhead, sockeye, coho, and bull-trout. With only 8-inches per year precipitation, the Yakima basin is highly dependent on

snow pack accumulation and runoff. Authorization – treaty trust/tribes (e.g., fish), ESA, fish & wildlife, flood control, recreation, and power. Agriculture benefit is \$1.2 billion. There are 68 hydromet stations. Flow forecasts are reviewed from the NWS and COE-Seattle. Water Supply Forecasts are examined from USBR-Boise, NRCS, and NWS-NWRFC. Long-range trends use ENSO and PDO indices. Irrigation flows occur in September, during fish spawning, but then drop after the harvest, which hurts incubation of the redds (i.e., fish egg nest). A new operation, “Flip-Flop”, lowers outflows from Cle Elem dam and raises flows from Rimrock (500 cfs to 2500 cfs) during autumn to smooth out flow fluctuations, increase fish habitat, and provide consistent (and higher) protection of redds. New operational curves (since 2002) gives guidance on the amount of water need to fill the reservoirs (pre-season plus in-season), based on November storage levels and the Nov.-June precipitation and runoff need to fill. This method is conditioned by ENSO years. Carryover storage water for fish is now recognized as important. This method helps operators anticipate flow cuts.

*How much Do We Trust our Models? Memes in Streamflow Forecast Adjustment*, Rashawn Tama (USDA-NRCS, Portland).

Memes - how is a “way of thinking”, shortcuts, or philosophy passed on as professional judgment to the next hydrologist (or next generation)? Common memes – more sophisticated model gives better results, adjust model to long-range weather outlook, more data stations will give better statistical performance, over-predict on low years, under-predict on high years, adjust model based on field observations, seasonal volume closely matches basin-wide snow-pack (% average), early seasonal model should not deviate significantly from average. Professional judgment: (1) Will an adjustment improve or weaken the forecast?, (2) What memes should a hydrologist use? Case study: 40 forecast locations, areas include Upper Deschutes River (OR), Jefferson River (southwest MT), and Gunnison River (CO). Results: Jefferson, 1998 El Nino, 110-160% observed, 80-90% forecast. Gunnison, 1995 ENSO Neutral, 160-190% observed, 80-110% forecast (very wet spring). Deschutes, 1993, 70-160% observed, 80-190% forecast. MAE calculated 1993-2010 early-season forecast added value and did improve some forecasts. Be aware of all the memes in your forecast process.

*2011 Upper Snake Operations...Review of Record-Setting Conditions*, Ted Day (USBR, Boise):

All reservoirs were full. Early season saw many storms, then quiet and dry by early-to-mid winter, then a blast of several snow events in March onward. The May 1<sup>st</sup> SWE was 160% for Lewis Lake Divide (7850 feet). May-June: medium-sized runoff spikes (could have been much higher). Milner flows were 10-20 kcfs from May-June. Severe flooding didn’t occur due to slow snowmelt. The June-July runoff was 185%, a new record (?). Lessons learned: be flexible during in-season operations and be ready for any condition.

*Other Business*, Ted Day (USBR, Boise):

The 2012 Work Plan – review past agendas for ideas, field trip late spring, advocate for advancing new forecast ideas and skills, and educate on new methods. The 2011 Annual Report – Ted will assemble, Kyle will assist. Ted ceremoniously handed the “gavel” over to Kyle, as the new 2012 chairman. Erik Pytlak, BPA, will now be the Vice-Chairman.

*New Chairman*, Kyle Dittmer (CRITFC, Portland):

Kyle will poll members to see what dates will work good for our Winter Quarter meeting. We are more than welcome to meet at CRITFC. Meeting was adjourned at 2:30 pm.

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Attendance:

Benner, David – FPC

Day, Ted – USBR (Boise)

Dittmer, Kyle – CRITFC  
Hall, Steve – COE (Walla Walla)  
Low, Patti – COE (NW Division)  
Lynch, Chris – USBR (Yakima)  
Malmgren, Ron – COE (NW Division)  
Mickelson, Kristian – COE (Seattle)  
Rodgers, Kasi – COE (NW Division)  
Tama, Rashawn – NRCS  
Vander Zweep, Rick – BPA  
Wagner, Paul – NOAA Fisheries  
Wortman, Randy – COE (Portland)

Absent:  
BC Hydro  
NPCC  
NWS/NWRFC

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Note-taker: Kyle Dittmer, Columbia River Inter-Tribal Fish Commission, Portland, Oregon

## Appendix C Historical forecast results

### Columbia River Forecast Group 2011

Historic forecast results:

Period Forecasts for different months = from <http://www.nwd-wc.usace.army.mil/report/colriverflood.htm>

Observed KAF = from runoff processor

#### 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

#### 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

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

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

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

Dworshak: (Apr-Jul)

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

Lower Granite: (Jan-Jul)

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

The Dalles: (Jan-Jul)

Year	Jan		Feb		Mar		Apr		May		Observed
	KAF	% of OBS	KAF								
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>69%</u>	105851	<u>74%</u>	111213	<u>78%</u>	119785	<u>84%</u>	126943	<u>89%</u>	142616

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