8.0 Limitations and Data Gaps

8.1 Data Gaps

8.1.1 Crop and Irrigation Extent Estimates

The estimation of crop and irrigation extent in the 2011 Forecast has several assumptions which could impact the results.

For the Canadian portion of the Columbia River Basin, WSU did not simulate crops and the modeling relied on the coarser land cover parameterization utilized by the hydrology model, VIC. For the United States portion of the Columbia River Basin, crop and irrigation extent data utilized a combination of the WSDA and USDA cropland data layers. The inconsistency in the naming of crop categories between these two datasets could result in an overestimation of crop extent in certain areas for some crops.

Irrigation extent information was available in the WSDA cropland layer dataset only for Washington State. . Outside of Washington, the modeling based irrigation extent on the type of crop grown from the USDA dataset. For example, crops that are usually irrigated were assumed to be always irrigated in the biophysical models, and vice versa. Pasture extent was not captured by the WSDA cropland layer dataset. Therefore, pasture extent from the USDA cropland layer was used, with the assumption that if more than half of the non pasture cropland in a grid cell was irrigated, than the pasture in that grid cell was also irrigated. This assumption could result in an over or underestimation of pasture extent in different areas.

8.1.2 National Agricultural Statistics Service Statistics for Crop Production Calibration

NASS crop yield statistics were used to calibrate crop production in the United States portion of the Columbia River Basin. These data were not available for all the modeled crops. In some cases, they were available only at a state level of aggregation. Data at a finer resolution (county level) would improve crop production estimates.

8.1.3 Water Rights Data

Water rights data for Washington State were primarily from Ecology's Water Rights Tracking System (WRTS). The data in WRTS were linked to geographic information in Ecology's Geographic Water Information System (GWIS). GWIS associated water rights records in WRTS with points of diversion, and with geographic locations for places of use represented by polygons in a geographic information system. While it was not always possible to identify the parcel of land being irrigated by the water right, GWIS did make it possible to identify with some approximation, at least down to the section, the general location where a water right applied. The extent to which this could be done also depended on the quality of the data in WRTS. Much of the data in WRTS was incomplete, often due to underlying uncertainty in the water rights records and/or lack of information submitted by water users. For example, many records did not include an annual use amount, while another significant group contained neither an annual use amount, nor the number of acres irrigated.

There was significantly more uncertainty associated with claims, and this contributed to uncertainty in calculating the amount of allocated water. The majority of the water right claims have not been confirmed through court adjudications. Some claims seemed to have been entered more than once (whether by the water user, or through data entry errors), while other claims seemed to have dates that were inconsistent with existing water rights law. For the Yakima Basin, the adjudication process is in the final completion stage. Having provisional data from the adjudication created relatively more certainty associated with the data in this watershed than in others. However, since the major claimants have yet to be mapped, they could not geographically be located using GWIS data. .

8.1.4 Interruptible Water Rights

Some water rights are curtailed when specified low flow conditions are not met. Curtailment data could be used to determine 1) which users would potentially have their water use interrupted in the future and 2) the frequency of curtailment.

8.1.5 Water Rights Subject to Low Flows Defined in Washington Administrative Code

The most tractable case of curtailment was with water rights that are subject to low flow provisions defined in WAC. However, even in this case, underlying issues presented challenges for the WSU analysis. For example, it was difficult to tell when these water rights were actually historically curtailed. Lists of curtailable water rights were separate from WRTS, and did not include specific identification of the gage against which users are regulated (though in some cases this could be logically determined). In addition, interviews with Ecology staff indicated that there are some valid regulatory practices that occur within the framework of the Water Code that are different than the regulation described in Washington Administrative Codes (WAC). For example, interviews indicated that, since at least 2000 (and likely significantly before that), the Methow River has been regulated based on the flow at the Pateros gaging station (located several miles upriver from Pateros). This is done because one regulatory gauging station on the Chewuch River washed out after the Instream Flow Rule was adopted, and another regulatory gauging station near Winthrop on the Methow River was moved by the USGS. The USGS has also relocated a gage on the upper Methow River farther upstream than it was a few years ago (Susan Burgdorff-Beery, Ecology, personal communication).

To test the quality of the water rights modeling, it would have been useful to have reliable information about the frequency of historical curtailment. While it was possible to match historical data to the low flows described in WAC (and there was a list from 1992-2004 of the dates on which low flow orders were sent indicating that water rights holders *might* be asked to curtail water use), comprehensive historical information indicating when water users were asked to stop using water by Ecology was unavailable.

8.1.6 Water Rights Subject to Surface Water Source Limitations (SWSLs)

Other water rights have been issued subject to administrative limitations known as surface water source limitations (SWSLs). A list of water rights subject to SWSLs in Ecology's Central Region (including WRIAs 30-31, 37-40, and 45-50, most of WRIAs 44 and 51, and parts of WRIAs 29, 42, 52, 53 and 60) was unavailable. There were lists of water rights subject to SWSL in Ecology's Eastern Region t (including all of WRIAs 32-36, 41, 43, 54-59, and 61-62, most of WRIAs 42 52, 53, 60, and parts of WRIA 51). However, after several interviews, it seemed that many of these water rights were not regulated in practice.

In addition, determining the flows that each water right was subject to would have required looking up the individual water rights documents in Ecology's Water Resources Explorer (http://www.ecy.wa.gov/programs/wr/info/webmap.html). It was decided not to do this because of time and budget constraints and uncertainty on how the data would be used for modeling purposes.

8.1.7 Curtailment of Junior Water Rights Holders in Favor of Senior Water Right Holders

There are watersheds where junior water rights holders have been curtailed with some frequency to ensure that senior water rights holders can exercise their water rights, including Walla Walla, Alkali Squilchuck/Stemilt Squilchuck, Kettle, and adjudicated portions of Methow and Okanogan (Darrell Monroe and Lynn Maser, Ecology, personal communication).

A lack of information about the water rights subject to this type of curtailment and the relationships between them made it impossible to model this. In addition, interviews indicated that the system was complicated. For example, in the Walla Walla, surface water rights have been adjudicated Water rights were grouped into 20-30 classes by priority dates, with Class 1 having the oldest date. Records indicating when Ecology required classes in different portions of the watershed to stop using water were unavailable. Each tributary is managed separately, as curtailment depends on the class status of water rights holders in each reach (Darrell Monroe, Ecology, personal communication).

Within the Yakima River Basin, different classes of water users have also been regulated to ensure that the needs are met for senior water rights holders. Because of the current adjudication data regarding when junior classes of water rights holders have been managed in favor of senior water rights holders was not further investigated.

8.1.8 Identifying Interruptible Grid Cells in VIC-CropSyst

To capture information related to who is curtailed, the WSU modeling effort used the list of interruptible water right holders maintained by the Washington Department of Ecology, and matched it up with the information describing where the water rights could be used in the WRTS/GWIS database to generate a list of grid cells which are interruptible (see Figure 29 in

Chapter 3, Methodology, for definition of a VIC-CropSyst grid cell). However, more than half of these grid cells did not have irrigated crops and hence there was no demand to curtail. Also, the interruptible list was incomplete for this Forecast in that SWSL water right holders in parts of eastern Washington have yet to be incorporated into the list.

In the Yakima River Basin, which follows a system of pro-rationing of water, spatially disaggregated information about the location of the major pro-ratable water rights holders was not available. Hence the 2011 WSU modeling effort assumed that all grid cells in the Yakima River Basin had pro-ratable and non-proratable water rights holders and the water deficit was distributed across all grid cells. This would result in an overestimation of deficit in grid cells that in reality have no proratable water right holders and an underestimation in others. Overall for the Yakima River Basin, the differences should average out.

There was also a lack of spatial information on the locations of supplemental groundwater right holders, and their supplemental water right amounts. These supplemental water rights can be used by the water right holders in the event that their surface water rights are curtailed. Not including this information leads to an overestimation of curtailment amounts.

8.1.9 Sources of Withdrawal and Conveyance Loss Estimates

Spatially disaggregated information related to sources of withdrawal was not available and the WSU modeling assumed that 20% of the total irrigation demand was met by groundwater sources The only exceptions were 1) the Odessa groundwater management subarea where all of the grid cells outside of the area catered to by surface water canals were assumed to use groundwater sources, and 2) the Yakima River Basin where 10% of the irrigation demand was assumed to be met with groundwater sources. (These assumptions were based on data available in Lane 2009 and Vaccaro et al. 2006, as further described in Chapter 3, Methodology). The Department of Ecology water rights database has some information on groundwater and surface water sources of withdrawal that could be used. However, to facilitate this, a process of completing and cleaning the database would need to be undertaken first.

The biophysical framework did not model a system of canals and associated losses and conveyance loss values had to be assumed. The process WSU followed in estimated conveyance losses is explained in Section 3.4.8.4 of Chapter 3, Methodology.

8.2 Modeling Framework Limitations

8.2.1 VIC-CropSyst Limitations

The hydrology model in VIC-CropSyst is a land surface hydrology model and lacks dynamic deep groundwater modeling. The 2011 Forecast only modeled subsurface hydrologic processes to approximately 10 ft below the surface and did not simulate a groundwater table. This feature is important in areas that have a strong aquifer presence or strong surface water-groundwater interactions. Groundwater modeling would help in the understanding of how groundwater withdrawals could help meet demands.

CropSyst can simulate multiple management options including crop rotation, cultivar selection, irrigation, nitrogen fertilization, tillage operations, and residue management. However, the implementation of VIC-CropSyst used for the 2011 Forecast had a simplified version of CropSyst that focuses solely on water use and crop productivity. In simulating cropping systems, WSU did not model crop rotations either within a year or for multiple-year rotations. For the historical simulations, cropping patterns in Washington were based on year 2008 information. Similarly, future cropping patterns were determined using the 2008 WSDA data as the baseline case. Other management options were also not considered. Irrigation demand for non-cash crops, such as mustard cover crops, was not modeled.

VIC utilizes coarse data on soils. This is not desirable for modeling crops because the CropSyst model is relatively more sensitive to soil parameters. To address this, the current implementation had CropSyst using soil parameters from a separate source. Efforts are underway to improve the soil data for the VIC-CropSyst model.

Communication of soil water content between VIC and CropSyst was undertaken one time at the beginning of the simulation for each crop being simulated. This was due to computational inconsistencies between soil layers of VIC and the CropSyst model. WSU is in the process of revising this structure so that the models are more closely coupled.

In the implementation used for the 2011 Forecast, the coupled VIC-Cropsyst model was not calibrated as a single unit. Parameter estimates from the individual calibration of VIC and CropSyst separately were used. Improvements to model performance could be expected by calibrating the coupled VIC-CropSyst as a single unit.

VIC is a "macroscale" hydrology model. This means it is best suited to model the hydrologic response of very large river basins and is limited in capturing all the processes in a small watershed scale. Therefore, caution should be exercised in interpreting results at a small watershed scale.

VIC is designed to solve the water balance equations as well as the energy balance equations, in determining the hydrologic response. However, solving both the water and energy balance equations is computationally expensive. Due to computational resource restrictions, modeling ran VIC (as well as VIC-CropSyst) in a "water balance" mode, where the surface temperature is set to air temperature and not iteratively solved for.

8.2.2 Municipal Demand Estimates

There were five significant assumptions made in estimating current and future demands, each of which caused a limitation in the analysis. First, the analysis assumed that Washington OFM's future population estimates were distributed uniformly across counties and distributed to WRIAs by area. In fact, future populations are often located near existing urban centers rather than scattered throughout the watershed. In the future, the Forecast should examine population patterns and growth and apply growth projections accordingly.

Second, consumptive use estimates were based on the differences between water diversions and waste water treatment plant flows. Leaky pipes, private wells with public sewers, separate irrigation systems, and a mismatch in some areas between water diversion service areas and wastewater treatment service areas, etc. all contribute to uncertainties in the consumptive use estimates. According to the literature, there is currently no adequate means of addressing this limitation.

Third, future use estimates assumed no improvement in existing infrastructure or conservation efforts. Many municipalities have leaks in their infrastructure that could be repaired thereby reducing water demand. It is difficult to determine which of these repairs will be made because of tight budgets and which of the aging pipelines will develop new leaks in the future. However, in general, the assumption made could be expected to be conservative.

Fourth, rural wells were assumed to be shallow and connected to surface water supply. The number of domestic wells drives the magnitude of the limitation caused by the fourth assumption. Without conducting a complete subsurface investigation of shallow groundwater in each WRIA, it would be impossible to get a reliable estimate of surface water impact. This would be cost prohibitive. Therefore, assuming that wells take water from nearby streams in the months of use was a simplifying and needed decision.

Last, per capita urban and rural water use was assumed to be the same, as there was little available information comparing urban and rural water usage for eastern Washington. While municipalities are monitored for water diversion, rural users are largely free of reporting requirements. Individual landscapes vary considerably and no single model would likely capture each circumstance perfectly. Monitoring rural domestic water use would be hugely expensive and unpopular, and future estimates will therefore likely continue to have this assumption built in.

8.2.3 Hydropower Demand Estimates

Power demand estimates were based on projections conducted by NWPPC and individual PUDs in Washington State. While the best available estimates were provided, there are three issues worth discussing that could affect future demand (and which were generally not factored into these projections):

- Potential impact of Columbia River Treaty negotiations.
- Implementation of the 2010 BiOp.
- Integration of renewable energy.

The 2011 Forecast assumes historic operation will continue at least into the 2030s. However, any one of these three issues could dramatically shift hydropower needs and supplies, as further discussed in Chapter 5, Tier I Results.

8.2.4 Integrated Biophysical Modeling Limitations

The surface water availability estimates used to calculate the amount of curtailment or deficit irrigation required were based on the first set of VIC-CropSyst runs in which full irrigation was applied to the crops. These runs assumed that all crop irrigation requirements were met. Generally speaking, curtailment at an upstream location will affect instream flows and surface water availability downstream. Ideally, the model should be run iteratively until an equilibrium is reached between surface water availability and curtailment amount. Due to computing resource restrictions, these iterative runs were not performed for this Forecast.

The model assumed that reservoir operation rules in the future would be the same as the historical operation rules. However, the rules may evolve in the future to adjust to changing climate as well as changing hydropower, instream and other demands. Ideally, a set of reservoir operations rules optimized for future conditions should be used.

The modeling of the process of curtailment has some limitations that can impact the results. These limitations affect correctly capturing who is curtailed, when they are curtailed, as well as how much they are curtailed. Section 8.1.4.4 described the data gaps which affect correctly capturing "who to curtail?" and "how much to curtail". The limitations related to "when to curtail?" are related to the fact that curtailment decisions are in reality made at a weekly time step whereas the WSU model was configured to run at a monthly time step. The future 2030s scenario assumed, for the Odessa area, that ground water sources for irrigation were unavailable. Hence the model did not fulfill any irrigation requirements of the crops. However, the model retained the original irrigated crop mix. In reality, the crop mix in the Odessa area could be expected to change to some form of dryland agriculture (eg. dryland wheat).

8.2.5 Biophysical Model Evaluation

In Ecology's Central Region, an estimated 92% of water users along the Columbia River mainstem had meters installed as of 2011 (Dan Haller, Ecology, personal communication). While the largest water users had been reporting for several years, older data were of mixed quality. Ecology's Central and Eastern Regions continue to work with users to improve the percentage reporting and quality of data.

Due to a lack of extensive metered data for actual withdrawal estimates, the modeled demand estimates have not been extensively evaluated. The WSU team had three years of withdrawal data from Banks Lake (which supplies the Columbia Basin Project area) and found that the modeled "top of crop" irrigation demand model estimates for the area (which do not include conveyance losses) were within 15% of the withdrawal data from Banks Lake.

8.2.6 Economic Modeling and Biophysical/Economic Integration

Many of the agricultural commodities modeled in this study were described as having regional markets. A commodity has a regional market when price variations across regions and the regional price is a function of regional production. A limitation of the 2011 Forecast was to model Washington as the entire region when the region more realistically should include surrounding states that grow similar crops including Oregon, Montana, Idaho, and California. Importantly, there is a significant amount of production transported between the states to regional processing facilities. As a result, production trends in neighboring states can affect Washington production based on price effects. These interactions were not modeled in this study.

This Forecast also did not account for the availability of land for agriculture that is not currently used for agriculture. There are some isolated areas of Washington such as Chelan County where there is little additional land available for agriculture. In the aggregate this is a relatively unimportant.

This Forecast did not model the impact of technological change on productivity growth nor did it consider the long-run impacts of water curtailment on cropping patterns. Including these aspects would require recalibrating the crop growth model for a large number of crops which was not feasible for this study.

Modeling of on-farm management decisions was limited in this Forecast. This includes all the tradeoffs that agricultural producers make in terms of inputs of fertilizer, labor, irrigation, etc. and cropping decisions in response to changes in prices and growing conditions in order to maintain profitability. This study did prioritize deficit irrigation across crops in response to water curtailments in accordance with economic theory, as further described in Chapter 3, Methodology.