Assessment of Columbia River Flood Stage at Portland, OR in a Future Climate

Proposal submitted to Oregon Solutions by

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and

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Problem Statement and Background

The Multnomah County Drainage District (MCDD) is in the process of accrediting levees that it manages in the North Portland peninsula to protect lands from flood stage on the Columbia and Willamette Rivers. These levees surround PEN1 and PEN2 and span the southern shore of the Columbia River between Smith and Bybee Lakes and the Sandy River, approximately river miles 106 to 108. MCDD has taken a pro-active approach to the accreditation process for these levees, and has requested assistance in determining design criteria that incorporate the effects of a changing climate on the river hydrographs upstream of Portland and on sea level downstream at the mouth of the Columbia River (MCR). The US Geological Survey (USGS) and US Army Corps of Engineers (USACE) propose to provide this assistance in the form of hydraulic model simulations of the lower Columbia River (LCR) that incorporate the best available knowledge regarding peak flows in the Columbia and Willamette Rivers in a future climate, and projected sea level change (SLC) at the MCR, both of which affect river stage at Portland.

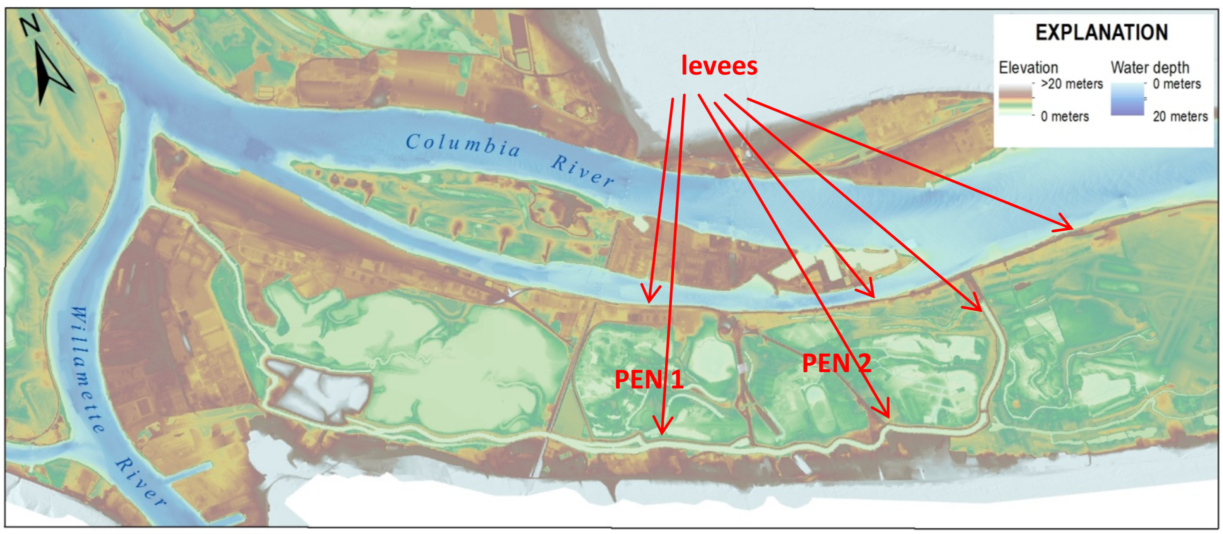

Figure 1. Composite image of LiDAR and river bathymetry showing the study area at the confluence of the Columbia and Willamette Rivers.

Peak flow statistics derived from the current period of record at The Dalles (the nearest upstream streamflow gage on the Columbia) or the Willamette gage at Portland or Oregon City (the nearest upstream gages on the Willamette) is not adequate for this study because the frequency distribution of streamflows is expected to be different in future decades than it has been during the period of record. Climate change projections predict that, in general, river basins of the Pacific Northwest will experience a decline in spring snowpack and reduced snowfall to annual precipitation ratios, earlier snowmelt, and earlier peaking hydrographs. This is particularly true of those basins (like many in the Cascade Range) that are currently classified as mixed-rain-and-snow type (Hamlet et al. 2014). Some basins may experience higher peaks as well. The Willamette River basin and other sub-basins of the Columbia River are expected to share these trends.

Climate change projections are based on the output of planetary scale atmospheric models called general circulation models (GCMs), and assumptions made about the rate of increase of the greenhouse gases that warm the earth's surface. Many institutions and government agencies around the world run their own unique GCM, and many of these have formed a collaborative arrangement in order to develop standardized approaches to simulating future climate scenarios. The umbrella term for the collaborative arrangement is the Coupled Model Intercomparison Project (CMIP) under the World Climate Research Programme. CMIP products inform the assessments of the Intergovernmental Panel on Climate Change (IPCC). The IPCC fifth assessment is in progress, and the experimental design that the GCMs will use to inform that assessment is CMIP-5. However, because it takes many years between the development of the experimental protocol and the availability of products useful to regional studies, we propose to use CMIP-3 products in this study.

The Climate Impacts Group (CIG) at the University of Washington has made available downscaled versions of the climate forcing functions and streamflow output of the CMIP-3 experiments. “Downscaled” means that the data from the GCMs, which has a resolution of perhaps 50 km, has been refined either statistically or with regional-scale models to provide information at the scale useful to regional studies ($1/16^{the}$ degree or about square 6 km grid resolution). The CIG used these downscaled data to provide forcing functions for a hydrologic model (the Variable Infiltration Capacity, or VIC model; Liang 1994) that converts meteorological variables such as precipitation, soil moisture, and air temperature into daily values of streamflow. The hydrologic model simulations cover 3 time periods of 30 years: 2020s (between 2010 and 2039), 2040s (between 2030 and 2059) and 2080s (2070 to 2099). Each simulation is further identified by the assumption regarding the greenhouse gas emissions scenario that went into the GCMs. For example, the A1B scenario is one in which it is assumed that the world experiences rapid economic growth and future energy sources are assumed to be balanced between fossil intensive and non-fossil sources. The B1 scenario is one in which it is assumed that the world experiences the same rapid economic growth as in A1B, but with far more reliance on clean and resource-efficient technologies. The A1B scenario is therefore a more extreme scenario of future emissions than the B1 scenario.

An example is useful to understand these products. Figure 2 shows the monthly mean hydrograph (expressed as inches of runoff plus base flow over the entire contributing basin) of the Willamette River at Portland, and the Columbia River at Bonneville, respectively, based on the historical record (in blue) and on 10 GCMs (shown as a pink range, with the average shown as a red line). Results from the two emissions scenarios A1B and B1 are shown. It is apparent in figure 2 that most GCMs predict higher runoff in the late winter months as captured at the Willamette River at Portland, particularly for the A1B scenario. It can be seen in figure 2 that most GCMs predict higher and slightly earlier runoff in the spring in the Columbia River at Bonneville, for both emissions scenarios. Higher monthly runoff translates to higher peak flows on event time scales, and higher peak flows associated with given recurrence intervals, which is the basis for the interest in incorporating climate change into design criteria for flood-protection levees in Portland. The daily streamflows on which these monthly mean hydrographs are based are referred to as “naturalized,” that is to say unregulated, flows.

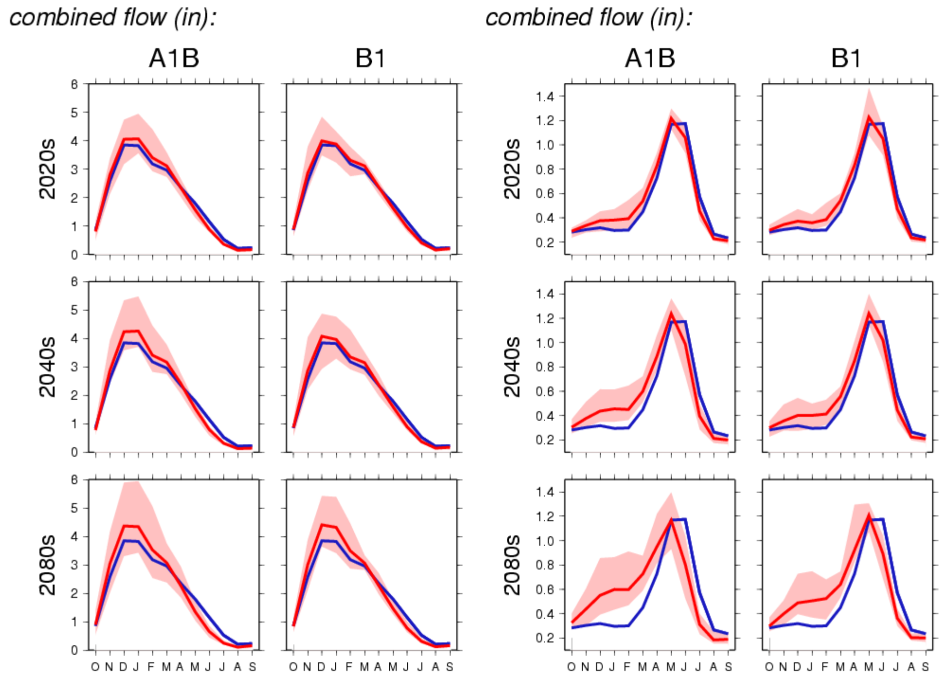

Figure 2. Monthly mean hydrographs (not adjusted for bias) for the Willamette River at Portland (left) and the Columbia River at Bonneville (right). Blue lines show the average historical values (1916-2006). A1B and B1 refer to emissions scenarios. Pink bands show the range of climate change scenarios from 10 (for A1B) or 9 (for B1) GCMs. Dark red lines are the average of the climate change scenarios. These figures were downloaded from the CIG website: http://warm.atmos.washington.edu/2860/products/sites/.

The hydrographs shown in figure 2 are based on unregulated flows (no dams) because the hydrologic model (VIC) that generated them incorporates the physics and chemistry of precipitation, infiltration, snowmelt, runoff and baseflow, but not the effects of man-made restrictions on streamflow. In order to incorporate the effects of the dams in the Columbia River system, the streamflows developed by the CIG (daily values) are used as inflows to the reservoirs, and the operating rules of the Army Corps of Engineers and Bonneville Power Authority are applied with the use of the USACE Reservoir System Simulation model developed by the Hydrologic Engineering Center (ResSim). In practice, there is an additional step, in which the VIC streamflows determined from the downscaled climate data need to be further bias-corrected by a comparison with measured data at a specific location before using them as input to ResSim. The USACE is currently in the process of putting the bias-corrected CMIP-3 streamflows developed by the CIG for the 2040s through a next-generation version of ResSim. This produces a daily hydrograph of regulated flows, based on future climate scenarios as modified by passage through the reservoirs in the basin, under the assumption that the reservoirs are operated under present-day, or known future, rules, at selected gage sites throughout the Columbia River basin. To supply boundary conditions for model scenarios, the sites of interest are the Columbia River at Bonneville and the Willamette River below Willamette Falls. These daily streamflows are the regulated upstream flows referred to in task 3 below.

River stage in the Columbia at Portland is influenced by Pacific Ocean tides, and any study of worst-case scenario flooding in Portland has to take this into account. Tides have strong natural cycles at monthly time scales. High stage events in Portland that take place over days and weeks will be influenced by how the timing of the event interacts with astronomically driven tidal cycles. In addition, strong winds associated with weather systems over the coastal ocean can push water toward shore, causing high water. Superimposed on each of these is the effect of climate change, which is expected to cause a rise in mean sea level over time. The projected rise in sea level depends on the assumptions made regarding the rate of warming of the earth and associated melt of land ice sheets, and therefore will be represented by a range of values in the model simulations. The total influence of the Pacific Ocean on river stage in Portland is dependent on the combination of all three of these.

Methods

We propose to use two existing 2-dimensional hydraulic models of the LCR to simulate stage in the river reach of interest (Columbia RM 106 to 108), and compare the output of the two models as an additional constraint on the precision of the results. Starting with existing models is a big advantage, because the model domain already extends out to the ocean, facilitating the inclusion of the tidal effect and sea level change at the ocean boundary into the analysis. Comparison of these two models is instructive because, while each solves the same underlying equations governing fluid flow, there are interesting differences between them. Perhaps the most important difference is the underlying grid used to apply the numerical methods. Delft3D employs a static curvilinear grid, whereas AdH employs an unstructured grid that adapts to the flow conditions as the simulation progresses.

The first model is a Delft3D model of the LCR that was originally developed by the USGS in collaboration with the US Army Corps of Engineers (USACE) to inform sediment management at the mouth of the river (Elias and Gelfenbaum, 2009). Delft3D is an open-source code developed by Deltares in the Netherlands, with a long record of documented applications to many river and estuarine systems around the world. The second is the USACE Adaptive Hydraulics (AdH) model of the LCR. The USACE used the AdH model to estimate sea level change (Pevey, Savant, Moritz, Childs, 2012) in accordance with USACE guidance on incorporating sea-level change considerations into infrastructure planning (Circular EC-1165-2-211). Both models require boundary conditions at Bonneville on the Columbia, at Willamette Falls on the Willamette, and at the Pacific Ocean boundary.

Task 1. Model Development: Because the study team is starting with existing models, little hydrodynamic model development is required. However, because the emphasis of the application of the Delft3D model has been on sediment transport and deposition at the mouth of the estuary, the model grid was not originally developed with the great detail in the Portland area that is required to address the question of water levels on the Portland levees. Therefore, included among the tasks of this study is the enhancement of the model grid to incorporate the fine detail required in the Portland area utilizing existing LiDAR and bathymetric data, and subsequent re-calibration of the model. The U.S. Army Corps of Engineers (USACE) acquired topographic LiDAR data for the Columbia River, including complete coverage of the floodplains and surge plains from December 2009 through February 2010 (data were collected by Watershed Sciences, Inc.). Comprehensive multibeam bathymetric data were collected by David Evans and Associates for NOAA (Columbia RM 30 to 110) as part of the agency's updates to existing nautical charts. Both of these data sources produced 0.5-meter-resolution gridded data sets. A merged digital terrain model of the area of interest including the land topography and river channel bathymetry, based on best available data with 1-m horizontal resolution was developed by the ORWSC (fig. 1).

Task 2. Development of Boundary Conditions to Represent Future Climate Conditions: The development of boundary conditions in the form of hydrographs at the upstream boundary and tidal elevations at the ocean boundary that are appropriate to address the question being posed is a critical part of this study.

Task 2.1. Daily Hydrographs at the upstream boundaries (Columbia at Bonneville and Willamette at Willamette Falls).

Inflow boundaries for the first hydraulic model simulations (see Task 3 below) will use observed flows utilizing USGS streamflow gages 14207740 Willamette River Above Falls at Oregon City, OR and 14128870 Columbia River below Bonneville Dam, OR. The 1 and 0.2 annual exceedance probability flood hydrographs would be used as inflow boundaries for these first model runs.

For the future projection time frame of the 2040s, this study builds on work already done by USACE to support Columbia River Treaty (CRT) deliberations for the upstream hydrographs. For the time frame of the 2080s, however, the study cannot rely on work already done. Several time-consuming steps need to be repeated, in particular the bias-correction of the naturalized flows from the VIC model, the routing of the bias-corrected flows with the ResSim model, and the smoothing of the output from the ResSim model. Therefore, the development of upstream boundary conditions for the 2040s is relatively straightforward; the development of upstream boundary conditions for the 2080s requires substantially more effort.

The CRT Climate Change Workgroup focused on two “bookend” scenarios from the 2040s CIG dataset (2030-2059), which represented the most reasonable range of possible climate change outcomes in the Basin using CMIP-3 products. These were:

1. LW/D: A Less Warming/Driest scenario. This scenario derived from the ECHO_G GCM (Legutke and Voss, 1999), assuming a modest carbon dioxide emission scenario (scenario B1). This scenario resulted in an average annual temperature increase of 1.8°C in the Columbia basin, and an aggregated precipitation decrease of 7.9 percent, compared to the 1971-2000 average temperature and precipitation.
2. MW/W: A More Warming/Wettest scenario. This scenario derived from the MIROC 3.2 Global Climate Model (ref), assuming an aggressive carbon dioxide emission scenario (scenario A1B). This scenario resulted in an average annual temperature increase of 2.8°C in the Columbia basin, and an aggregated precipitation increase of 14.2 percent, compared to the 1971-2000 averages.

Because the focus of this study is on high flows and possible “worst-case” scenarios, the LW/D scenario is of limited interest, and it is proposed to use the unregulated, bias-corrected streamflows that the CRT workgroup developed based on simulations of the MIROC 3.2 GCM for the 2040s, under the A1B emissions scenario. These streamflows will be routed through an updated version of the ResSim model of the Columbia River basin. The updated ResSim will include updated year round water management rule sets for flood, power and biological operations. This will provide 30 years of streamflow data at our sites of interest; we propose to extract the year representing the 99^{th} percentile peak flow (evaluated individually for the Columbia and the Willamette) from those years for running the hydrodynamic models.

In order to look at projections for the 2080s, the work done by the CRT workgroup must be repeated for the 2080s simulations from the same GCM and emissions scenario. This includes bias-correcting the MIROC unregulated flows at many sites throughout the Columbia basin, and routing them through the updated ResSim model. While the methodology has largely been worked out, this still represents a substantial effort.

Task 2.2. Tidal elevations at the mouth of the Columbia River- Pacific Ocean boundary. As with streamflows, the projections of SLC depend on the assumptions made about greenhouse gas emissions in the future and the rate of warming of the climate. We propose to follow the projections provided by NOAA (Parris et al. 2012) as modified by USACE guidance. The range of NOAA projections can be summarized as follows:

1. A "lowest" scenario. SLC is extrapolated from the historical rate derived from tide gages. At the MCR, this projection is slightly negative because the land surface elevation at the MCR has been rising very slowly over the historical record.
2. An "intermediate-low" scenario. SLC is projected to be 0.5 m (1.6 ft) by 2100. The projections are based on climate models using the B1 emissions scenarios (a more moderate scenario). This scenario focuses its projection primarily on thermal expansion of the oceans.
3. An "intermediate-high" scenario. SLC is projected to be 1.2 m (3.9 ft) by 2100. The projections are based on statistical relations between observed global sea level change, air temperature, and ice sheet loss. This scenario focuses its projection on a limited loss of ice sheets.
4. A "highest" scenario. SLC is projected to be 2.0 m (6.6 ft) by 2100. SLC is based on thermal expansion of the oceans, and a calculation of maximum possible glacier and ice sheet loss by the end of the century.

Because the focus of this study is on possible "worst-case" scenarios, the "lowest" scenario is not of interest. The USACE guidance uses a modification of NOAA projections, applied to specific coastal locations. We propose to use the USACE "intermediate" and "high" scenario to bookend our projections (fig. 3). SLC is not linear through time; therefore, the consideration of a projection applicable to the 2040s and 2080s will be interpolated appropriately. Note that it is relatively straightforward to project SLC to the 2080s or even to 2100 for that matter, in comparison to the level of effort required to get the future climate upstream hydrograph for the 2080s.

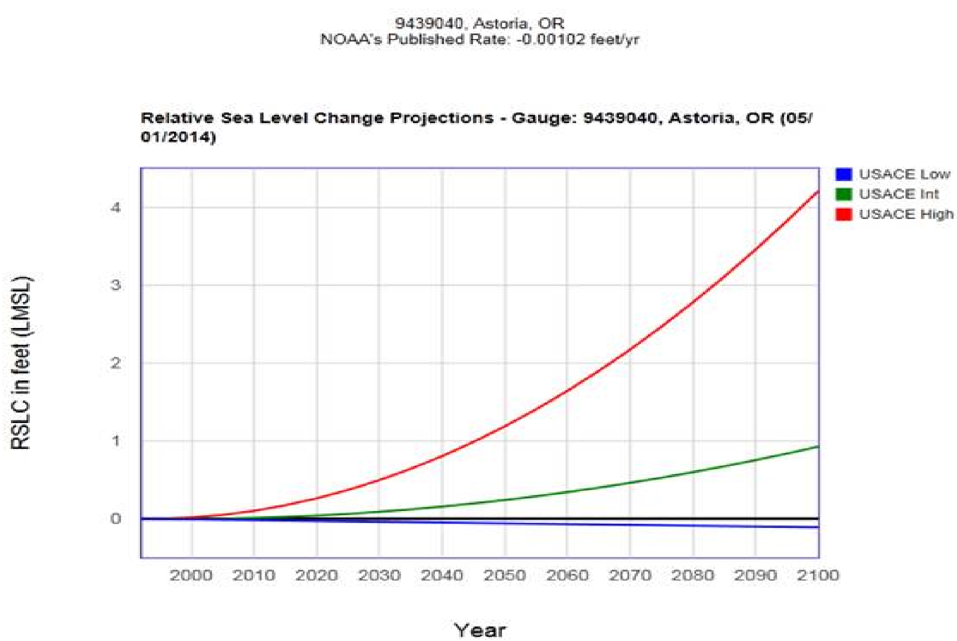

Figure 3. Range of SLC projections at the MCR (Astoria gage), as defined by USACE. This figure was obtained from the USACE sea level change calculator, found at: http://www.corpsclimate.us/ccaceslcurves.cfm

Task 3. Hydraulic Model Simulations. It has been noted that there is a relatively straightforward method for projecting SLC at the ocean boundary into the future as far as 2100, and that obtaining an upstream hydrograph for the 2040s (2030 and 2059) is possible in a short time frame, whereas obtaining an upstream hydrograph for the 2080s, while possible, will take significantly longer. In order to provide useful, citable results within the time frame required by MCDD and other stakeholders, we propose a 3-phased approach. By doing the work in phases we will be able to assess the sensitivity of peak flood stage in Portland to SLC at the MCR through 2100, relative to future climate changes to the hydrographs upstream, through the 2040s, within about a year.

Task 3.1. Run both models with historical flows (HF) and SLC; compare to HF and historical sea level (HSL), and to the extent possible, observations. Upstream boundary conditions will be based on events from hydrographs observed at USGS streamflow gages on the Columbia River at Bonneville (site 14207740) and on the Willamette at Oregon City (site 14128870). The boundary condition at the MCR will be based on observations at the Astoria gage, in combination with the “intermediate-high” and “highest” SLC projections for the 2040s (SLC-2040). This provides a baseline for the relative effects of SLC in combination with high flows under current conditions, for comparison to the simulations in the remaining tasks.

Task 3.2. Run both models with future-climate regulated flows from the 2040s and SLC. Upstream boundary conditions will be based on projected flows from a future climate, utilizing the work done by the CRT workgroup to determine regulated flows in the 2040s timeframe (FF-2040). The boundary condition at the MCR will be based on high tides in combination with the “intermediate-high” and “highest” SLC projections for the 2040s (SLC-2040), the 2080s (SLC-2080), and 2100 (SLC-2100).

Task 3.3. Run both models with future-climate regulated flows from the 2040s and SLC. Upstream boundary conditions will be based on projected flows from a future climate, after going through the steps described in Task 2.1 for determining regulated flows in the 2080s timeframe (FF-2080). The boundary condition at the MCR will be based on high tides in combination with the “intermediate-high” and “highest” SLC projections for the 2080s (SLC-2080), and 2100 (SLC-2100). If it is determined in Tasks 3.1 and 3.2 that SLC is the dominant factor determining how peak flood stage in Portland will change beyond the 2040s, then Task 3.3 can be optional.

The common simulations to be run with the hydraulic models are summarized in the following table:

	MCR boundary condition determined by:	Upstream boundaries in the Columbia and Willamette Rivers determined by:
Task 3.1	HSL SLC-2040	HF HF
Task 3.2	SLC-2040 SLC-2080 SLC-2100	FF-2040 FF-2040 FF-2040
Task 3.3	SLC-2080 SLC-2100	FF-2080 FF-2080

Timelines and Deliverables

We provide two timelines, for two different options that the TAC can consider. In Option 2040s the future climate upstream hydrographs on the Columbia and Willamette will be based on the 2040s time frame, but SLC out to 2100 is considered (tasks 3.1 and 3.2 above). In Option 2080s, the future climate upstream hydrographs will be developed for the 2080s, and SLC through 2100 is considered (Task 3.3).

The timeline is structured to provide a joint report product that presents results based on the 2040s within about a year (a draft by the end of FY16, published report early in FY17). A short public-friendly fact-sheet product based on the longer report will also be published in early FY17. A joint report with task 3.3 results would come in late FY2017. The results of Delft3D and AdH model simulations, specifically the river stage at requested levee locations, will be provided in electronic form. The work group will provide quarterly updates to the TAC. Fiscal years are based on federal fiscal years (October 1 to September 30).

Timeline: Option 2040s	**FY2016**				**FY2017**			
Task 1. Model Development	x							
Task 2. Boundary Conditions	x	x						
Task 3. Model Simulations		x	x					
Task 4. Analysis			x	x	x			
Task 5. Reporting				x	x			

Timeline: Option 2080s	**FY2016**				**FY2017**			
Task 1. Model Development	x							
Task 2. Boundary Conditions	x	x	x	x				
Task 3. Model Simulations		x	x	x	x			
Task 4. Analysis			x	x	x	x	x	
Task 5. Reporting				x	x	x	x	x

Budget

We provide two budget scenarios, one in which only the 2040s time frame is considered for the future climate hydrographs at the upstream boundaries on the Columbia and Willamette Rivers (Option 2040s), and one in which the 2080s timeframe is considered in addition to the 2040s (Option 2080s). In both cases the budget reflects three funding sources: Oregon Solutions, USGS cost share with Oregon Solutions, and USACE Planning Assistance to State (PAS) Agreement. The USGS budget options provided in the table reflect the percentage of costs which show that the local sponsor will provide 65% of the funds and USGS will provide 35%.

Total Cost and Funding Sources

OPTION	TOTAL	Oregon Solutions	USGS (cost share)	USACE PAS (cost share)
2040s	$235,930	$101,130	$54,450	$80,350
2080s	$315,040	$135,950	$73,200	$103,430

Attachment 1 provides the USACE budget for Option 2040s and Option 2080s. The funding source for this effort is provided in a Planning Assistance to States Agreement. The local sponsor will match the cost of USACE tasks by submitting work in kind contributions as stated in the current agreement.

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Pevey, K., Savant G., Moritz H., Childs E. Lower Columbia River Adaptive Hydraulics (adH) Model: Development, Water Surfaces Elevation Validation and Sea Level Rise Analysis. Army Corps of Engineers, Northwest Division, Portland, OR.

US Army Corps of Engineers Columbia River Treaty Review Studies Technical Work Group. 2014. Columbia River Treaty 2014/2024 Review Program Climate Change Appendix Entity Review Draft. Army Corps of Engineers, Northwest Division, Portland, OR.

Attachment 1: USACE Budget for Option 2040s and Option 2080s

PAS PEN1&PEN2 MCDD Climate Change Study

BASELINE SCOPE OF WORK

PROJECT AND PRODUCT TITLE:			P2 #	DATE:
PAS PEN1&PEN2 MCDD Climate Change Study				**10-Jul-15**
TECHNICAL LEAD	OFFICE:	PROJECT MANAGER	OFFICE	
Keith Duffy /Rod Mortiz	**CENWP-EC-HY**	**Beth McDowell**	**CENWP-EC-HY**	

A separate scope , jointly developed by the USACE and USGS is attached to this budget.

In summary, the Corps shall particpate in a joint project with USGS to perform a Climate Change Analysis of Columbia River in the vicinity Multnomah County Diking District (MCDD) PEN21 &PEN2 levees, for Oregon Solutions, with the prime faciliating agent being MCDD.

The Corps work will include:

1) Refinement of it's existing AdH model of the Lower Columbia River, from the Mouth of the Columbia River (MCR) to the end of the tidal influnce, Columbia River at Bonneville Dam (CRM145.2) and the Oregon City (the Falls) on the Willamette River.
2) Development of inflow boundaries at Bonneville and the the Falls on the Willamette,. These will consist of:
   1) Observed historic flows (PH1)
   2) 2040's daily, MIROC, A1B flows. (PH2)
   3) 2080's daily, MIROC, A1B flows (PH3 otional)
3) The Corps shall run the AdH model to determine hydraulic profiles at Pen1 and Pen2 (PH1 thru PH3).
4) The Corps shall compare the modeling resutlts to model runs perfromed by USGS, Delt3d (PH1 thru PH3).

The work was broken into 3 phases.

Phase 1:*Run both models with historical flows (HF) and SLC; compare to HF and historical sea level (HSL), and to the extent possible, observations*. Upstream boundary conditions will be based on events from hydrographs observed at USGS streamflow gages on the Columbia River at Bonneville (site 14207740) and on the Willamette at Oregon City (site 14128870). The boundary condition at the MCR will be based on observations at the Astoria gage, in combination with the “intermediate-high” and “highest” SLC projections for the 2040s (SLC-2040). This provides a baseline for the relative effects of SLC in combination with high flows under current conditions, for comparison to the simulations in the remaining tasks.

Phase 2: Run both models with future-climate regulated flows from the 2040s and SLC. Upstream boundary conditions will be based on projected flows from a future climate, utilizing the work done by the CRT workgroup to determine regulated flows in the 2040s timeframe (FF-2040). The boundary condition at the MCR will be based on high tides in combination with the “intermediate-high” and “highest” SLC projections for the 2040s (SLC-2040), the 2080s (SLC-2080), and 2100 (SLC-2100).

Phase 3. Run both models with future-climate regulated flows from the 2040s and SLC. Upstream boundary conditions will be based on projected flows from a future climate, after going through the steps described in Task 2.1 for determining regulated flows in the 2080s timeframe (FF-2080). The boundary condition at the MCR will be based on high tides in combination with the “intermediate-high” and “highest” SLC projections for the 2080s (SLC-2080), and 2100 (SLC-2100). If it is determined in Tasks 3.1 and 3.2 that SLC is the dominant factor determining how peak flood stage in Portland will change beyond the 2040s, then Task 3.3 can be optional.

The work is proposed as two option packages to Oregon Solutions.

In option 2040’s the future climate upstream hydrographs on the Columbia and Willamette will be based on the 2040s time frame, but SLC out to 2100 is considered.

In option 2080’s, the future climate upstream hydrographs will be developed for the 2080s, and SLC through 2100 is considered.

The timeline is structured to provide a joint report product that presents results based on the 2040s within about a year (a draft by the end of FY16, published report early in FY17). A short public-friendly fact-sheet product based on the longer report will also be published in early FY17. A joint report with task 3.3 results would come in late FY2017. It is anticipated that computer run data from this study will be available as well. However, the specific computer models such as AdH and HEC-ReSim may not be made available at time of study completion. The work group will provide quarterly updates to the TAC. Fiscal years are based on federal fiscal years (October 1 to September 30).

The total Costs for the Options are:

Option 2040s:	$80,350
Option 2080s:	$103,430

The Corps shall perform Option 2040s by end of FY2016.
The Corps shall perform Option 2080s by the Q1 of FY2017.

BUDGET SUMMARY SHEET (Option 2040's: Phase 1 thru Phase 2)

PROJECT AND PRODUCT TITLE:
PAS PEN1&PEN2 MCDD Climate Change Study

P2 #

TECHNICAL LEAD	**OFFICE:**	**PROJECT MANAGER:**	**OFFICE:**
Keith Duffy and Rod Moritz	CENWP-EC-HY	Beth McDowell, PM	CENWP-EC-HY

EC MANAC

ORGANIZATION NAME	OFFICE SYMBOL	ORG CODE	Task 1: Model Development	Task 2: Development of Boundary Conditions	Task 3: Hydraulic Model Simulations	Task 4: Coordination	Task 5: Closeout	TOTAL
LABOR								
Design Branch	CENWP-EC-D	G2L1D00	$0	$0	$0	$0	$0	$0
Civil & Environ Dsn	CENWP-EC-DC	G2L1DC0	$0	$0	$0	$0	$0	$0
Hydraul. & Hydrol. Branch	CENWP-EC-H	G2L1M00	$317	$964	$1,242	$487	$27	$3,036
Hydrology and River Engine	CENWP-EC-HY	G2L1MH0	$6,336	$19,272	$24,834	$9,742	$532	$60,716
Const Svcs, Cost Engr & Sp	CENWP-EC-CC	G2L1C00 (Const/Cost/Sp	$0	$0	$0	$0	$0	$0
Tech Resources Branch	CENWP-EC-T	G2L1T00	$0	$0	$0	$0	$0	$0
GIS & Mapping	CENWP-EC-TG	G2L1TG0 (GIS)	$0	$0	$3,000	$0	$0	$3,000
SUBTOTAL EC IN-HOUSE LABOR COSTS			$6,653	$20,236	$29,075	$10,229	$559	$66,751
GOVT ORDERS & CONTRACTS								
SUBTOTAL MIPR & CONTRACT COSTS MANAGED BY EC			$0	$0	$0		$0	$0
OTHER COSTS								
Resident Office Vehicle		GSAVEH	$0	$0	$0		$0	$0
GSA Vehicle		SHOP/FACIL	$0	$0	$0		$0	$0
Travel		TRAVEL	$0	$0	$0		$0	$0
Printing		PRINTING	$0	$0	$0		$0	$0
CADD/ETDS		OTHFACSVCS	$200	$607	$872		N/A	$1,679
Budget Unit	CENWP-EC-TB	G2L1TB0	$133	$405	$582		N/A	$1,119
SUBTOTAL OTHER COSTS MANAGED BY EC			$333	$1,012	$1,454		$0	$2,798
PRODUCT SUBTOTAL COSTS MANAGED BY EC			$6,985	$21,247	$30,529	$10,229	$559	$69,550

COSTS MANAGED BY OTHERS

ORGANIZATION NAME	OFFICE SYMBOL	ORG CODE	Task 1	Task 2	Task 3	Task 4	Task 5	TOTAL
LABOR								
Programs and Project Branch	CENWP-PM-P	G2H4R00						$0
Project Manager Unit	CENWP-PM-PM	G2H4RP0						$0
Project Controls Unit	CENWP-PM-PC	G2H4RC0						$0
Programs Management Sectio	CENWP-PM-PD	G2H4RR0						$0
Planning Branch	CENWP-PM-F	G2H4P00						$0
Planning Managers	CENWP-PM-FP	G2H4PP0						$0
Economics Section	CENWP-PM-FE	G2H4P00						$0
Environmental Resources Brar	CENWP-PM-E	G2H4E00						$0
Contracting Division	CECT-NWP	G2P0000						$0
Hydro Electric Design Center	CENWP-HDC	G220000						$0
Real Estate Division	CENWP-RE	G2N0000						$0
Operating Project	TBD	TBD						$0
								$0
SUBTOTAL NON-EC IN-HOUSE LABOR COSTS			$0	$0	$0		$0	$0
GOVT ORDERS & CONTRACTS								
								$0
								$0
								$0
SUBTOTAL MIPR & CONTRACT COSTS NOT MANAGED BY EC			$0	$0	$0		$0	$0
OTHER COSTS								
Resident Office Vehicle		GSAVEH						$0
GSA Vehicle		SHOP/FACIL	$320					$320
Travel		TRAVEL						$0
Printing		PRINTING	$0					$0
SUBTOTAL OTHER COSTS NOT MANAGED BY EC			$320	$0	$0		$0	$320
PRODUCT SUBTOTAL NOT MANAGED BY EC			$320	$0	$0		$0	$320
TOTAL			$7,305	$21,247	$30,529	$10,229	$559	$69,870
Contingency (determined by PM w/input from TL) % =		15.00%	$1,096	$3,187	$4,579	$1,534	$84	$10,480
PROJECT TOTAL COST			$8,401	$24,434	$35,108	$11,763	$643	**$80,350**

TO BE COMPLETED BY P2 CONTROLLER AFTER SSB APPROVAL:

	Task 1: Model Development	Task 2: Development of Boundary Conditions	Task 3: Hydraulic Model Simulations	Task 4: Coordination	Task 5: Closeout	
Work Item						
P2 Activity No.						
P2 Project Controller Initials After Inputting into P2						

NOTES: Supporting Documentation can be found in the project directory
Budget estimates are not required from Office of Counsel, Public Affairs, and Native American Coordinator offices.
*S&A is managed by the PM & the Resident Office, not the EC TL.

TASK/BUDGET WORKSHEET

PROJECT/PRODUCT	PAS PEN1&PEN2 MCDD Climate Change Study	DATE	15-Jul-15
	Option 2040's: Phase 1 thru Phase 2	OFFICE SYMBOL	EC-HD/HY
OFFICE	CENWP-EC-HD and HY		
PREPARED BY	Keith Duffy and Rod Moritz	FOR	Beth McDowell, PM

In "option 2040's" the future climate upstream hydrographs on the Columbia and Willamette will be based on the 2040s time frame, but SLC out to 2100 is considered (Phases 1 and 2). In "option 2080's", the future climate upstream hydrographs will be developed for the 2080s, and SLC through 2100 is considered (Phase 3).

	LABOR HOURS														
	ENGR	ENGR	ENGR	ENGR	TECH	SECR									
Product Work Tasks	Moritz	Duffy	Thrush	GS-9	GS-9	GS-5									
Task 1: Model Development															
Modifiy AdH model for optimal results at RM 106-108.															
Grid modifications	20														
Recalibration of updated model	20														
Task 1: Model Development Total	**40**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Task 2: Development of Boundary Conditions															
2.1 Develop daily inflows for AdH model runs															
Process USGS flows at BON and WIL (Low flows 5%) (PH1)	2	16													
Process USGS flows at BON and WIL (High flows 95%) (PH1)	2	16													
Process MIROC 2040's flows (PH2)	4	4													
Setup CRT Columbia Basin ReSim Model (MIROC inflows)		20													
Run MIROC flows through the CRT ReSim WAT model		20													
Post process ResSim Miroc Results for AdH/Delft3		20													
2.2 Develop MCR Stage boundary															
Phase1: Develop the MCR boundary. No extreme surge.	16	4													
Phase 2: Develop MCR boundary for future CC, with surge	24	4													
Task 2: Development of Boundary Conditions Total	**48**	**104**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Task 3: Hydraulic Model Simulations															
Phase 1 Runs															
Phase 1 Obs High Flow 1 (~1%) run (prepare and run)	12														
Phase 1 Obs High Flow 1 (~0.2%) run (prepare and run)	12														
Determine model sensetivities (Tidal or Terrestrial driven)	8														
Develop Model Comparison Metrics (magnitude and timing)	8														
Compare model runs (AdH and Delft3)	24														
Phas2 Runs															
Phase 2 CC (2040's MIROC) Flow run	16														
Compare model runs (AdH and Delft3)	12														
Prepare Reports															
Prepare Intermediate Report	24	24	2												
Prepare Final Report including response to Intermediate Report Comme	12	12	2												
Task 3: Hydraulic Model Simulations Total	**128**	**36**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Task 4: Coordination															
TAC Meetings (once a month)	14	14													
General Coordination (10% of total above)	22	14	0	0	0	0	0	0	0	0	0	0	0	0	0
Task 4: Coordination Total	**36**	**28**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Task 5: Closeout		2		2	2										
Task 5: Closeout TOTAL	**0**	**2**	**0**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Rates were last updated Mar 2013

BUDGET WORKSHEET

			Task 1: Model Development			Development of Boundary Cor			sk 3: Hydraulic Model Simulatio			Task 4: Coordination			Task 5: Closeout		
LABOR			Hrly			Hrly			Hrly			Hrly			Hrly		
POSITION		GRADE	Rate	HRS	$ EST	Rate	HRS	$ EST	Rate	HRS	$ EST	Rate	HRS	$ EST	Rate	HRS	$ EST
SUPV		Thrush	$118.00	5	$576	$118.00	15	$1,752	$118.00	19	$2,258	$118.00	8	$886	$118.00	0	$48
ENGR		Moritz	$144.00	40	$5,760	$144.00	48	$6,912	$144.00	128	$18,432	$144.00	36	$5,184	$144.00	0	$0
ENGR		Duffy	$102.00	0	$0	$102.00	104	$10,608	$102.00	36	$3,672	$102.00	36	$3,672	$102.00	2	$204
ENGR		Thrush	$118.00	0	$0	$118.00	0	$0	$118.00	4	$472	$118.00	0	$0	$118.00	0	$0
ENGR		GS-9	$70.00	0	$0	$70.00	0	$0	$70.00	0	$0	$70.00	0	$0	$70.00	2	$140
TECH		GS-9	$70.00	0	$0	$70.00	0	$0	$70.00	0	$0	$70.00	0	$0	$70.00	2	$140
SECR		GS-5	$46.00	0	$0	$46.00	0	$0	$46.00	0	$0	$46.00	0	$0	$46.00	0	$0
TOTAL LABOR Costs					**$6,336**			**$19,272**			**$24,834**			**$9,742**			**$532**
CONTRACTS & GOVT ORDERS (list)																	
		TOTAL BUDGET			**$6,336**			**$19,272**			**$24,834**			**$9,742**			**$532**

BUDGET SUMMARY SHEET (Option 2: Phase 1 thru Phase 3)

PROJECT AND PRODUCT TITLE: PAS PEN1&PEN2 MCDD Climate Change Study | **P2 #**

TECHNICAL LEAD: Keith Duffy and Rod Moritz | **OFFICE:** CENWP-EC-HY | **PROJECT MANAGER:** Beth McDowell, PM | **OFFICE:** CENWP-EC-HY

EC MANAC

ORGANIZATION NAME	OFFICE SYMBOL	ORG CODE	Task 1: Model Developme nt	Task 2: Development of Boundary Conditions	Task 3: Hydraulic Model Simulations	Task 4: Coordinatio n	Task 5: Closeout	TOTAL
LABOR								
Design Branch	CENWP-EC-D	G2L1D00	$0	$0	$0	$0	$0	$0
Civil & Environ Dsn	CENWP-EC-DC	G2L1DC0	$0	$0	$0	$0	$0	$0
Hydraul. & Hydrol. Branch	CENWP-EC-H	G2L1M00	$317	$1,637	$1,463	$503	$27	$3,947
Hydrology and River Engine	CENWP-EC-HY	G2L1MH0	$6,336	$32,736	$29,269	$10,058	$532	$78,932
Const Svcs, Cost Engr & Sp	CENWP-EC-CC	G2L1C00 (Const/Cost/Sp	$0	$0	$0	$0	$0	$0
Tech Resources Branch	CENWP-EC-T	G2L1T00	$0	$0	$0	$0	$0	$0
GIS & Mapping	CENWP-EC-TG	G2L1TG0 (GIS)	$0	$0	$3,000	$0	$0	$3,000
SUBTOTAL EC IN-HOUSE LABOR COSTS			$6,653	$34,373	$33,732	$10,561	$559	$85,878
GOVT ORDERS & CONTRACTS								
SUBTOTAL MIPR & CONTRACT COSTS MANAGED BY EC			$0	$0	$0		$0	$0
OTHER COSTS								
Resident Office Vehicle		GSAVEH	$0	$0	$0		$0	$0
GSA Vehicle		SHOP/FACIL	$0	$0	$0		$0	$0
Travel		TRAVEL	$0	$0	$0		$0	$0
Printing		PRINTING	$0	$0	$0		$0	$0
CADD/ETDS		OTHFACSVCS	$200	$1,031	$1,012		N/A	$2,243
Budget Unit	CENWP-EC-TB	G2L1TB0	$133	$687	$675		N/A	$1,495
SUBTOTAL OTHER COSTS MANAGED BY EC			$333	$1,719	$1,687		$0	$3,738
PRODUCT SUBTOTAL COSTS MANAGED BY EC			$6,985	$36,091	$35,419	$10,561	$559	$89,616
COSTS MANAGED BY OTHERS								
LABOR								
Programs and Project Branch	CENWP-PM-P	G2H4R00						$0
Project Manager Unit	CENWP-PM-PM	G2H4RP0						$0
Project Controls Unit	CENWP-PM-PC	G2H4RC0						$0
Programs Management Sectio	CENWP-PM-PD	G2H4RR0						$0
Planning Branch	CENWP-PM-F	G2H4P00						$0
Planning Managers	CENWP-PM-FP	G2H4PP0						$0
Economics Section	CENWP-PM-FE	G2H4P00						$0
Environmental Resources Bra	CENWP-PM-E	G2H4E00						$0
Contracting Division	CECT-NWP	G2P0000						$0
Hydro Electric Design Center	CENWP-HDC	G220000						$0
Real Estate Division	CENWP-RE	G2N0000						$0
Operating Project	TBD	TBD						$0
								$0
SUBTOTAL NON-EC IN-HOUSE LABOR COSTS			$0	$0	$0		$0	$0
GOVT ORDERS & CONTRACTS								
								$0
								$0
								$0
SUBTOTAL MIPR & CONTRACT COSTS NOT MANAGED BY EC			$0	$0	$0		$0	$0
OTHER COSTS								
Resident Office Vehicle		GSAVEH						$0
GSA Vehicle		SHOP/FACIL	$320					$320
Travel		TRAVEL						$0
Printing		PRINTING	$0					$0
SUBTOTAL OTHER COSTS NOT MANAGED BY EC			$320	$0	$0		$0	$320
PRODUCT SUBTOTAL NOT MANAGED BY EC			$320	$0	$0		$0	$320
TOTAL			$7,305	$36,091	$35,419	$10,561	$559	$89,936
Contingency (determined by PM w/input from TL) % =		15.00%	$1,096	$5,414	$5,313	$1,584	$84	$13,490
PROJECT TOTAL COST			$8,401	$41,505	$40,732	$12,146	$643	$103,426

TO BE COMPLETED BY P2 CONTROLLER AFTER SSB APPROVAL:

	Task 1: Model Developme nt	Task 2: Development of Boundary Conditions	Task 3: Hydraulic Model Simulations	Task 4: Coordinatio n	Task 5: Closeout
Work Item					
P2 Activity No.					
P2 Project Controller Initials After Inputting into P2					

NOTES: Supporting Documentation can be found in the project directory
Budget estimates are not required from Office of Counsel, Public Affairs, and Native American Coordinator offices.
*S&A is managed by the PM & the Resident Office, not the EC TL.

TASK/BUDGET WORKSHEET

DATE **15-Jul-15**

PROJECT/PRODUCT PAS PEN1&PEN2 MCDD Climate Change Study
Option 2080's: Phase 1 thru Phase 3

OFFICE CENWP-EC-HD and HY

PREPARED BY Keith Duffy and Rod Moritz **FOR** Beth McDowell, PM

OFFICE SYMBOL **EC-HD/HY**

In "option 2040's" the future climate upstream hydrographs on the Columbia and Willamette will be based on the 2040s time frame, but SLC out to 2100 is considered (Phases 1 and 2). In "option 2080's", the future climate upstream hydrographs will be developed for the 2080s, and SLC through 2100 is considered (Phase 3).

Product Work Tasks	LABOR HOURS ENGR Moritz	ENGR Duffy	ENGR Thrush	ENGR GS-9	TECH GS-9	SECR GS-5									
Task 1: Model Development															
Modifiy AdH model for optimal results at RM 106-108.															
Grid modifications	20														
Recalibration of updated model	20														
Task 1: Model Development Total	**40**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Task 2: Development of Boundary Conditions															
2.1 Develop daily inflows for AdH model runs															
Process USGS flows at BON and WIL (Low flows 5%) (PH1)	2	16													
Process USGS flows at BON and WIL (High flows 95%) (PH1)	2	16													
Process MIROC 2040's flows (PH2)	4	4													
Bias Correct MIROC A1B 2080 Flows with USGS (PH3)		80													
Post Process 2080's flows for use in ResSiim (PH3)		40													
Setup CRT Columbia Basin ReSim Model (MIROC inflows)		20													
Run MIROC flows through the CRT ReSim WAT model		20													
Post process ResSim Miroc Results for AdH/Delft3		20													
2.2 Develop MCR Stage boundary															
Phase1: Develop the MCR boundary. No extreme surge.	16	4													
Phase 2: Develop MCR boundary for future CC, with surge	24	4													
Task 2: Development of Boundary Conditions Total	**48**	**224**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Task 3: Hydraulic Model Simulations															
Phase 1 Runs															
Phase 1 Obs High Flow 1 (~1%) run (prepare and run)	12														
Phase 1 Obs High Flow 1 (~0.2%) run (prepare and run)	12														
Determine model sensetivities (Tidal or Terrestrial driven)	8														
Develop Model Comparison Metrics (magnitude and timing)	8														
Compare model runs (AdH and Delft3)	24														
Phas2 Runs															
Phase 2 CC (2040's MIROC) Flow run	16														
Compare model runs (AdH and Delft3)	12														
Phase 3 (Optional if SLC is the dominant driver)															
Phase 3 CC (MIROC) Flow run	16														
Compare model runs (AdH and Delft3)	12														
Prepare Reports															
Prepare Intermediate Report	24	24	2												
Prepare Final Report including response to Intermediate Report Comm	12	12	2												
Task 3: Hydraulic Model Simulations Total	**156**	**36**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Task 4: Coordination															
TAC Meetings (once a month)	14	14													
General Coordination (10% of total above)	24	26	0	0	0	0	0	0	0	0	0	0	0	0	0
Task 4: Coordination Total	**38**	**40**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Task 5: Closeout		2		2	2										
Task 5: Closeout TOTAL	**0**	**2**	**0**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Rates were last updated Mar 2013

BUDGET WORKSHEET

LABOR		Task 1: Model Development			Development of Boundary Cor			sk 3: Hydraulic Model Simulatio			Task 4: Coordination			Task 5: Closeout		
POSITION	GRADE	Hrly Rate	HRS	$ EST	Hrly Rate	HRS	$ EST	Hrly Rate	HRS	$ EST	Hrly Rate	HRS	$ EST	Hrly Rate	HRS	$ EST
SUPV	Thrush	$118.00	5	$576	$118.00	25	$2,976	$118.00	23	$2,661	$118.00	8	$914	$118.00	0	$48
ENGR	Moritz	$144.00	40	$5,760	$144.00	48	$6,912	$144.00	156	$22,464	$144.00	38	$5,472	$144.00	0	$0
ENGR	Duffy	$102.00	0	$0	$102.00	224	$22,848	$102.00	36	$3,672	$102.00	36	$3,672	$102.00	2	$204
ENGR	Thrush	$118.00	0	$0	$118.00	0	$0	$118.00	4	$472	$118.00	0	$0	$118.00	0	$0
ENGR	GS-9	$70.00	0	$0	$70.00	0	$0	$70.00	0	$0	$70.00	0	$0	$70.00	2	$140
TECH	GS-9	$70.00	0	$0	$70.00	0	$0	$70.00	0	$0	$70.00	0	$0	$70.00	2	$140
SECR	GS-5	$46.00	0	$0	$46.00	0	$0	$46.00	0	$0	$46.00	0	$0	$46.00	0	$0
TOTAL LABOR Costs				**$6,336**			**$32,736**			**$29,269**			**$10,058**			**$532**
CONTRACTS & GOVT ORDERS (list)																
	TOTAL BUDGET			**$6,336**			**$32,736**			**$29,269**			**$10,058**			**$532**

Attachment 2: USGS Budget for Option 2040s and Option 2080s

Attachment 2: USGS BUDGET TABLES

Table 1. Personnel Requirements

TASK	Personnel Requirements (days)	
	Option 2040s	Option 2080s
Model Development	20	20
Preparation of Boundary Conditions	20	40
Run Model Simulations	40	55
Analysis	45	50
Reporting and Communication	40	60
TOTAL	165	225

Table 2. Budget Details

EXPENSE	Option 2040s	Option 2080s
Salary and Benefits	$84,716	$112,476
Publication	$5,134	$8,343
Facilities and Overhead	$65,731	$88,332
TOTAL	$155,582	$209,151
USGS Cost Share (35%)	$54,454	$73,203
Oregon Solutions (65%)	$101,128	$135,948