The Chehalis River flood of December 3-4, 2007

Summary. The damaging flood of December 3-4 on the Chehalis River resulted from exceptionally heavy rainfall that was confined to the vicinity of the Willapa Hills, as evident from rainfall records and from the USGS analysis of flows at Doty. Rainfall in the rest of the basin and in surrounding areas was heavy but in most cases ranked only in the top 10 events of the instrumental record.

1. Precipitation from rain gauges

Networks of weather observations are maintained by the National Weather Service (COOP), USDA Forest Service (RAWS), USDA Natural Resources Conservation Service (SNOTEL), US Geological Survey (USGS), and Weyerhaeuser Corporation. In addition, some citizen weather observers make their observations available via the internet. This wide array of networks enables us to better quantify the rainfall during this event, but only the long (>30 years) records allow us to put this event into longer-term context -- and that excludes all networks but the COOP network.

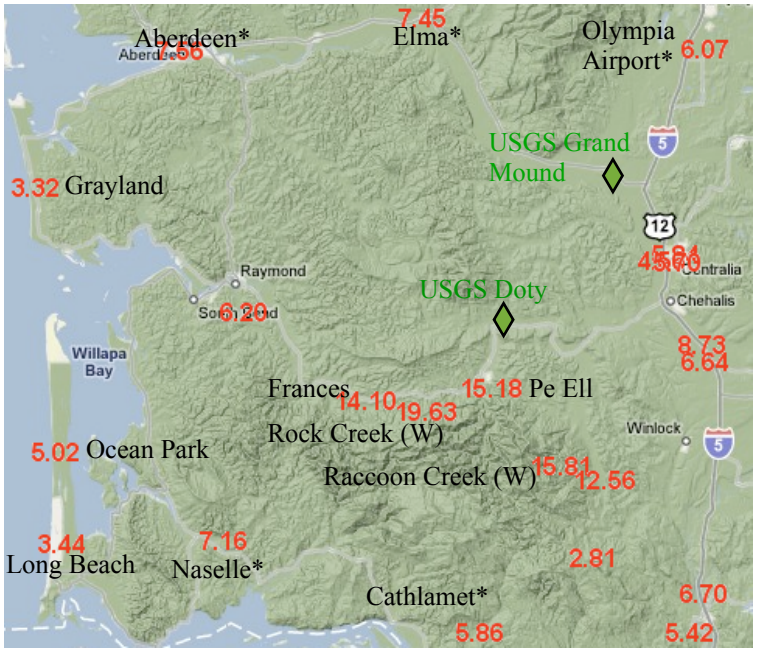
Figure 1 summarizes rainfall totals from the Willapa Hills for the four-day period December 1-4. Slight differences may result because the time of observation varies from network to network. The totals range from 2.81" for the RAWS station, a total that we view with some suspicion (RAWS is intended primarily for summer observations to monitor forest fire risk and winter measurements are often missing), and 5.84" for the COOP station at Cathlamet, to 15.81" and 19.63" for the two Weyerhaeuser gauges. By contrast, all of the surrounding stations had totals less than 8", and most had totals less than 6.5".

The heaviest rain fell on December 3, with totals in the Willapa Hills of more than 11" at the two Weyerhaueser gauges (Figure 2). Surrounding stations reported only 1-4".

2. Precipitation from other sources

WSR-88D weather radars located at Portland and Camano Island (North Puget Sound) provide estimates of precipitation by measuring the reflectivity of falling rain or frozen precipitation. Figure 3 shows the total precipitation estimated for Dec 1-4 from the Camano Island radar (top) and the Portland radar (bottom). In some places the beam is blocked by hills and mountains, and furthermore because the beams angle slightly upward, the altitude at which the radar estimates the quantity of falling precipitation is quite different across the map (see for example Westrick et al. 1999). Nonetheless, the radar totals of 4-7" along the I-5 corridor are roughly as observed, and the Portland radar suggests an enhancement of precipitation (8-14") in the Willapa Hills.

Figure 1. December 1-4 total rainfall. Stations with * have daily data back to at least 1948, and Weyerhaeuser gauges are marked (W).



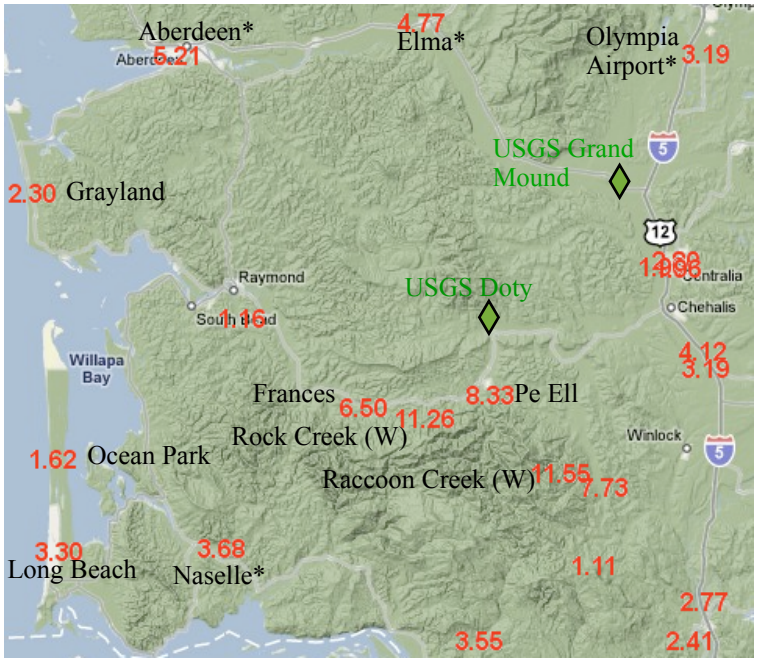


Figure 2. Precipitation on December 3.

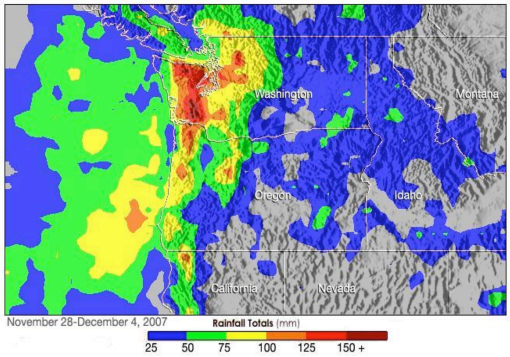


Figure 4. Estimated precipitation totals from the TRMM-based, near-real time Multi-satellite Precipitation Analysis (MPA) at the NASA Goddard Space Flight Center, for the period from 28 November to 4 December 2007.

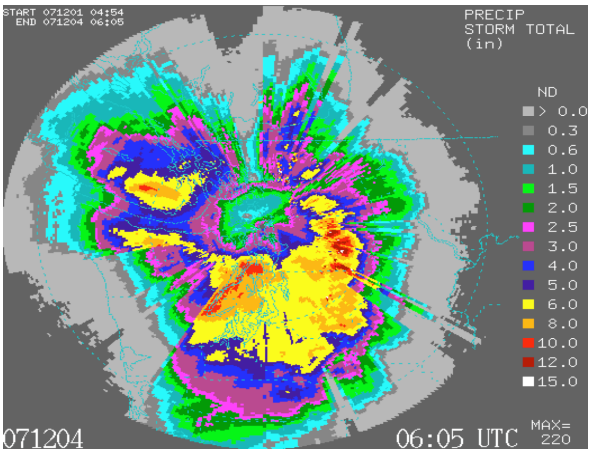
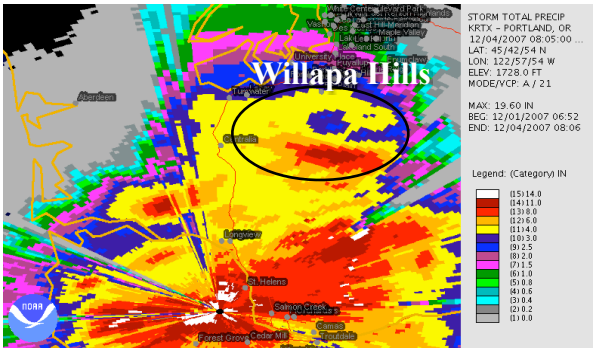


Figure 3. Radar estimates of rainfall from (top) Camano Island and (bottom) Portland, for 1-4 December.



3. Precipitation measurements in context

As Table 1 below indicates, the rainfall on December 3 at stations with long records in and near the Chehalis River Basin ranked among the top 10 or so ever observed, except at Cathlamet. Only at Elma and Aberdeen did this event rank in the top 5, however. Previous 1-day and 2-day record events occurred on a number of different dates, with November 2006 predominating. For the stations with long enough and complete enough records to calculate return periods, we find 10-year return values of 2-day precipitation (last column, using log-Pearson 3 fits to annual maxima) of about 3".

The "pineapple express" meteorological conditions of December 3 2007 are familiar to Northwest residents. Another recent pineapple express was the storm of November 6 2006, which set records at Longview, Cathlamet, and Centralia (see table) and caused severe damage to Mt Rainier National Park. During this event, Weyerhaeuser's gauges at Rock Creek and Raccoon Creek recorded 4.54" and 5.97" respectively. This is less than the 1-day total at Cathlamet during that event and approximately 10% and 50% respectively more than observed at Longview. The 2-day totals at Rock Creek and Raccoon Creek for 6-7 November 2007 were 6.61" and 7.74", roughly the same as at Longview and actually less than at Cathlamet. This comparison emphasizes how unusual the December 3, 2007 storm was in concentrating so much more precipitation on the Willapa Hills (2-3 times as much) than in surrounding areas.

Table I. Rainfall for Dec 2-3 2007

			Top 2 Years				2-Day Return	
Station	Dec. 2	Dec. 3 (rank)	1-Day Max.		2-day Max.		1948-1976	1977-2006
Centralia	2.10	2.80 (10)	4.13 (1/1990)	3.96 (11/1990)	6.09 (11/1986)	5.65 (11/2006)	2.84	3.93
Longview	1.04	2.83 (8)	4.04 (11/2006)	3.95 (11/1962)	7.00 (11/2006)	6.20 (2/1986)	2.70	3.59
Naselle 2ENE	2.30	3.68 (105)	8.10 (3/1950)	6.45 (3/1997)	9.17 (11/2001)	9.00 (11/1986)	N/A	N/A
Cathlamet 6NE	1.45	3.55 (26)	6.50 (12/1977)	6.35 (11/2006)	11.95 (11/2006)	9.36 (02/1996)	N/A	N/A
Elma	1.91	4.77 (1)	4.52 (11/2001)	4.33 (10/2003)	7.07 (11/2006)	6.80 (12/1994)	3.16	3.69
Aberdeen	0.97	5.21 (4)	7.03 (11/1990)	5.46 (12/1977)	9.45 (11/1990)	9.30 (11/2006)	5.10	7.29

Previous flood events on the Chehalis River included November 1990 and February 1996. The figures below show how the cumulative precipitation at Centralia and Frances (no data for 1990) compared in those cases. At Centralia, although the peak 1-day rainfall occurred in 1990, the 5-day total was greater in 1996 than in either 2007 or 1990. At Frances, the totals in the 12/2007 event far exceeded the 2/1996 total.

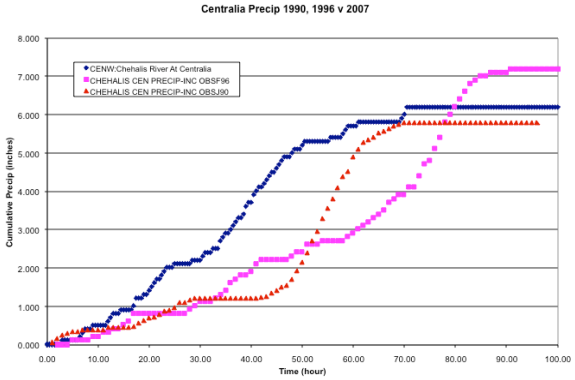


Figure 5. Centralia hourly precipitation plot comparing the recent December flood event to the event of 1/1990 and 2/1996. From USGS.

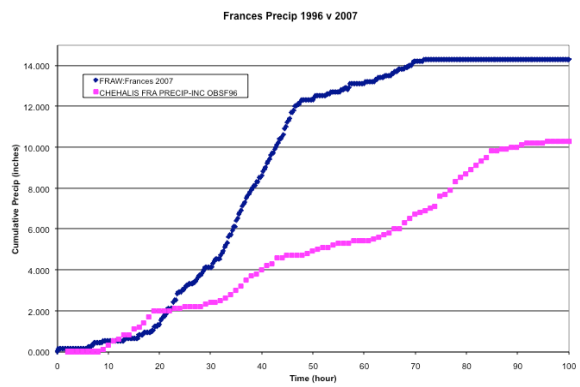


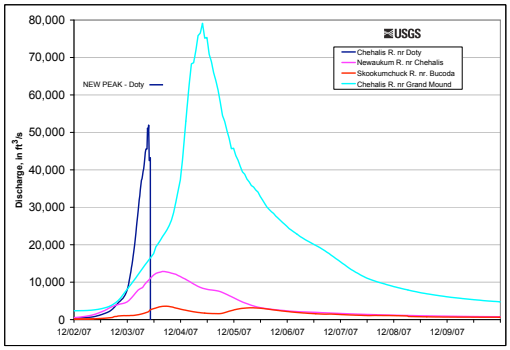
Figure 6. Frances hourly precipitation plot comparing the recent December flood event to the event of 2/1996. From USGS.

4. Streamflow records

The USGS analyzed gauge flows on the Chehalis River at Doty and Grand Mound (see labels on Figures 1-2); the Doty record clearly shows that the exceptionally heavy rainfall was confined to the Willapa Hills. The streamflow at Doty appears to have more than doubled its previous record flow in February 1996 (Figure 7).

During the flood on December 3, the Doty gauge reported a peak flow of 51,100 cubic feet per second (cfs) before floodwaters swamped the instruments and destroyed equipment at the site, far in excess of the

28,900 cfs peak flow during the February 1996 flood. USGS scientists surveyed the site afterwards and determined that the peak streamflow was 63,100 cfs. Down river at Grand Mound, the peak instantaneous flow was only slightly higher than in the 1996 flood, and the daily average flow was actually lower in the December 2007 event than in the February 1996 event.



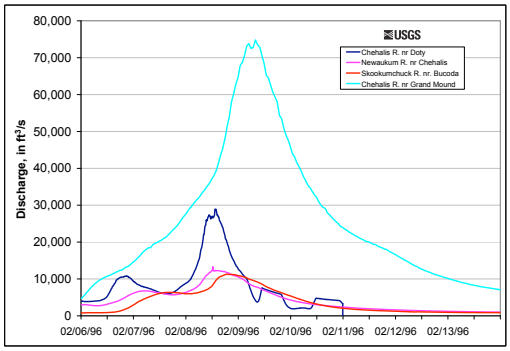


Figure 7. Streamflow records on four gauges in the Chehalis River Basin for the February 1996 flood (top) and the December 2007 flood (bottom). Note that flows at Doty were more than double the 1996 peak whereas the flows at Grand Mound were only slightly higher. The gauge at Doty failed during the flood, and the peak flow at Doty was determined by a post-flood survey.

A final note: A common way to refer to the severity of an event is in terms of its return period, as in, "this was a 100-year storm". Few people who use such terms understand how return periods are derived: by fitting a curve to a frequency distribution of the data and then looking at the tail of the fitted curve and often extrapolating it. Almost by definition, deriving a return period in excess of the length of the record requires extrapolating the fitted curve, resulting in large uncertainties, whereas for return periods near the length of the record the uncertainties are lower. For example, the 100-year return period for 1-day precipitation at Centralia is about 4.4", slightly exceeding the all-time record (see the table above) for this record. The shape of the fitted curve, and assumptions about relationships between precipitation in valleys and precipitation in nearby hills, strongly affect the derived return period, and this event shows that scientists do not understand these relationships well enough to decide on the basis of available evidence that this was a 500-year event.

Office of Washington State Climatologist
Box 354235
University of Washington

Prepared by Philip Mote, Josiah Mault, Valerie Duliere, UW. Thanks to Maryanne Reiter, Weyerhaeuser, for sharing data, and to USGS for Figures 5-7. Questions about this report can be directed to the Office of Washington State Climatologist, **climate@atmos.washington.edu**