

Lester Olson
Dale Rancour, P.E.
Department of Roads and Transportation Services
2404 Heritage Ct SW
Olympia, Washington 98502

Re: Sunrise Beach Road Landslide and Hunter Point Road and Landslide Data Report

Dear Les and Dale,

A magnitude 5.0 (M5.0) earthquake occurred near Satsop, Washington on June 10th 2001. This was the second event in four months to fall into the category of “Additional Reading Cycles” (Section 5.1.3 of the Long Term Instrument Monitoring Plan). As a result an additional reading cycle was conducted on Monday, June 18, 2001, to determine if the June 10th M5.0 earthquake produced any further earthquake-related deflections. As you recall, the M6.8 earthquake on February 28, 2001 produced minor deflections (< 0.15 in.) in all of the monitored inclinometers at Sunrise Beach Road and Hunter Point Road.

The intent of this report is also to present a summary of findings to date as defined by section 4.3 of the Long Term Instrument Monitoring Plan. It summarizes results from all reading cycles conducted since monitoring began in December 2000, including the three supplemental earthquake reading sets. Plots of the data, where applicable, are provided in Appendix A and B of this report.

INCLINOMETER RESULTS

The results of the May 16th reading cycle indicated that no movement occurred at the site between March 1, 2001 and May 16, 2001. In addition, a comparison of data collected May 16th and June 10th indicate that no further deflections occurred as a result of the most recent earthquake. The deflection plots for all three roadway inclinometers at Sunrise Beach indicate that the minor deflections observed after the February 28th earthquake have ceased and the June 10th event produced no further increases in total deflections.

Total deflections observed in the Sunrise Beach inclinometers are summarized in Table 1 below.

Table 1: Sunrise Beach Road Inclinometer Deflection Summary Table

Instrument ID	Initialization Date	Total Deflection Since Initialization Date	Deflection Depth	Comments
B-1	2/27/2001	0.12 inches (2 zones)	18' & 65'	Feb 28 th quake
B-2	11/13/2000	0.05 inches (1 zone)	35'	Feb 28 th quake
B-3	11/13/2000	0.02, 0.09, 0.13 inches (3 zones)	52', 35' & 20'	Feb 28 th quake
B-4	3/07/2001	Not determined	N.A.	N.A.

The direction of deflection is reported by the A axis of the inclinometers at this site. The resultant direction of the A and B axes are not calculated for the table above because the B axis deflection is essentially zero in these instruments, indicating the direction of displacement is almost entirely in the A axis direction. Refer to section 3.1.1 of the Long Term Instrument Monitoring Plan for more details on direction of displacement.

The observed deflections indicate movement toward Eld Inlet (East) and downslope. The displacement appears to correspond to landslide failure zones identified in 1999. These failure zones resulted in the initial 1999 landslide that caused damage to several homes and reconstruction of Sunrise Beach Road.

Inclinometer B-4 was added to the reading cycle after the February 28th earthquake to provide a downslope observation point and help correlate with the roadway borings. A zone of displacement has not been determined in this inclinometer as of the June 18th reading. B-4 will be permanently added to the reading and reporting cycles. The deflection plots of B-1, B-2, and B-3, and B-4 are attached in Appendix A, "Inclinometer Deflection Plots" of this report. Locations of the inclinometers are shown on the Instrument and Site Plan (Fig. 2).

In addition to the three inclinometers at Sunrise Beach Road, the Hunter Point Road Landslide plot of Inclinometer SI-9 is included. The Hunter Point Road plot indicated that minor deflections occurred as a result of the February 28th earthquake at depth 42.0' as reported in the March 8, 2001 memo. The amount of deflection observed as a result of the earthquake was less than 0.05 inches. No new deflections have been observed as a result of the June 10, 2001 earthquake. Note the plot scale presented is +/- 0.25 inches rather than the +/- 0.5 inches used for the Sunrise Beach data plots. This is to allow for better visual resolution of the deflection zone at 42.0 feet. The "wavy" nature of the B-axis plot is typical for the presentation scale and great depth of the inclinometer; it does not represent deflection.

PIEZOMETER and PRECIPITATION RESULTS

Ground water levels have remained lower than the previous years throughout the Sunrise Beach Road site. Automated piezometers were installed in January 2001 to allow continuous data collection between manual readings. There are two automated piezometers recording hourly ground water levels along Sunrise Beach Road. They are located at Automated Station #1 (DM-3p) and Automated Station #2 (B-2p). Both sites monitor deep ground water levels. The ground water levels appear to be greatly affected by tidal action as evidenced by the sinuous pattern of the data plots. Ground water level changes by as much as 10 feet are observed in the data as a result of the local tidal effect. These tidal effects are visible in the data plots as spikes in the graphs.

In addition to the two automated piezometers, there are 10 manually recorded deep and shallow piezometers located throughout the site (see Fig 2). In general, all groundwater levels have remained at or below the historical high levels reported in 1999 and 2000 by others. Trend lines indicating overall lowering of the ground water are visible in the graphs of the data attached in Appendix B "Piezometer and Precipitation Data".

A precipitation gage was installed at Station #2 in February 2000. The precipitation gage is attached to the same datalogger as the automated piezometer B-2. It monitors and records precipitation at the site to correlate precipitation with ground water levels. A total of 10 inches of precipitation was recorded from January 30, 2001 to June 18, 2001; approximately 50 percent below average. The maximum-recorded rainfall event for this period occurred between February 17th and 18th totaling 1.4 inches of precipitation. Other events occurred February 29th through March 1st (1.2 inches), April 16th through April 18th (1.17 inches) and June 10th and 11th (1.1 inches). A plot of the rainfall data is presented in Appendix B.

The piezometer P-9, located approximately 50 feet south of the current Hunter Point Road Landslide headscarp, revealed a locally high ground water level present in the plateau south of the scarp. The present ground water elevation is approximately equivalent to the elevation of the rotated scarp block at elevation 151.7'; seeps are present at the base of the scarp. The ground water level has remained relatively constant during the monitoring period between December 2000 and June 2001.

HORIZONTAL DRAIN OUTFALL RESULTS

The horizontal drains installed as part of the roadway reconstruction drainage plan have been visually monitored and manually sampled since December 2000. There are seven drain outfalls along the beach bulkhead (Beach Outfalls 1-7 on the Instrument and Site Plan). Each drain outfall is directed into a manifold surrounded by a rock-filled gabion basket on the beach. Five of the seven beach outfalls (outfalls 1-4 and 6) direct ground water from within the hillside below Sunrise Beach Road to the beach. A sixth drain outfall (Beach Outfall 5) directs combined surface runoff and ground water down the slope from five horizontal drain arrays installed upslope and west of Sunrise Beach Road. The water is directed from the southern and northern arrays, into collection basins, and

pipd to the beach where it is observed and manually sampled. The seventh Beach Outfall (Outfall 7) intercepts and directs ground water from a trench drain beneath Sunrise Beach Road to the bulkhead outfall pipe in the northern portion of the slide.

No ground water discharge was observed from Outfalls 1-4 during the December 2000 through June 2001 monitoring period. Beach Outfall 5 consistently produced 0.25 to 0.5 gallons per minute (GPM) throughout the entire monitoring period. Ground water discharge from Beach Outfalls 6 and 7 was observed only from April 2001 through June 2001 at a rate of < 0.25 GPM. Table 2 below summarizes the measured discharge rates of the Beach Outfalls.

Table 2: Beach Outfall Discharge Rates

Outfall Designation	Measurement Period	Measured Discharge (GPM)
Beach Outfalls 1-4	Dec. 2000 to June 18, 2001	No Ground Water Discharge Observed
Beach Outfall 5	Dec. 2000 to June 18, 2001	0.25 (Dec.' 00 – Mar. '01) to 0.5 (Apr. '01 – Jun. '01)
Beach Outfall 6-7	Dec. 2000 to June 2001	No Ground Water Discharge (Dec. '00 – Mar. '01): <0.25 (Apr. '01 – Jun.' 01)

The observations suggest that the zones targeted for ground water removal downslope of Sunrise Beach Road did not recharge sufficiently over the dry winter to reach a flow threshold. Ground water levels remained below the elevation of the slotted drainpipes in the lower portion of the slide mass below the road (Beach Outfalls 1-4). This likely indicates that the ground water level did not intercept the drainpipes below the road. The minimal discharge volumes observed in Beach Outfalls 5, 6 and 7 indicate that overall

ground water levels upslope of the roadway also remain low. The ground water level upslope of Sunrise Beach Road, however, has been periodically high enough to intercept the upper drain systems. These very low-flow or no-flow conditions observed at the site indicate a general lowering in ground water levels over the past year, probably as a result of the abnormally dry winter.

Because the lack of data gathered during the monitoring period due to such dry conditions, plots of the outfall discharges are not presented as an attachment to this report as they represent extended periods of zero discharge.

Observations made of the wire-mesh Gabion baskets along the beach indicate they are continuing to settle, though no serious deformation has yet occurred.

SUMMARY of RESULTS

- Inclinator data and plots from May and June 2001 reading cycles indicate no further land mass movement has occurred in the vicinity of the instruments at Sunrise Beach and Hunter Point Road. The deflections observed after the February 28th earthquake appear to have ceased. The June 10th 2001 earthquake does not appear to have induced any further movement in either of the landslides. These observations indicate a stable condition near the instruments is again present at both sites. Table 1 summarizes deflections at Sunrise Beach measured to date.
- Ground water levels remained low during the monitoring period between December 2000 and June 2001 at the Sunrise Beach Road Landslide. They were observed to be at or lower than levels reported in previous years. Trends in the data indicate ground water levels are continuing to drop and will likely do so over

the summer. The lack of the typical precipitation patterns of the previous winter are the likely cause of the lowering ground water trends; in fact, precipitation amounts are approximately 50 percent less than normal and almost 90 percent lower than the previous year.

- Ground water levels at the Hunter Point Road Landslide have remained essentially static throughout the same monitoring period at approximately 16 feet below ground surface (El. 152').
- No increases or decreases in ground water elevations were observed as a result of the February 28th or June 10th earthquakes.
- Horizontal drain discharge rates have remained very low throughout the monitoring period from December 2000 through June 2001. Many of the drains (outfalls 1-4) had no ground water discharge throughout the period of observation. In the Beach Outfalls where ground water discharge was observed (outfalls 5,6 and 7), rates remained below 0.5 gallons per minute. The low discharge volumes indicate low ground water levels are present upslope of Sunrise Beach Road. This is consistent with data collected from the roadway piezometers.

If you have any questions or comments please call 754 4681 (7606).

Sincerely,

Mark P. Biever; Geologist
Senior Engineering Technician
Storm and Surface Water Utility