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LONG TERM INSTRUMENT MONITORING PLAN FOR SUNRISE BEACH ROAD AND HUNTER POINT ROAD LANDSLIDES THURSTON COUNTY, WASHINGTON

GUIDELINES FOR A TWENTY-YEAR SUBSURFACE CONDITION MONITORING PROGRAM

Prepared for Thurston County Roads and Transportation Services
By
Thurston County Water and Waste Management – Storm and Surface Water Utility

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LONG TERM INSTRUMENT MONITORING PLAN
SIGNATURE AND ACCEPTANCE PAGE

Mark P. Biever, Geologist
Storm and Surface Water Utility
Plan Author

Mark Cook, P.E.
Storm and Surface Water Utility
Program Manager

Gordie Kelsey, P.E.
Roads and Transportation Services

Lester Olson
Roads and Transportation Services
Department Director

Upon final acceptance of the Long Term Instrument Monitoring Plan by the signators indicated above, the Plan shall take effect.

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1.0 INTRODUCTION

In response to two damaging landslides in 1999, Thurston County contracted two geotechnical studies imparted by the slides. The landslides occurred in the communities of Sunrise Beach Road and Hunter Point Road and damaged numerous homes and significant portions of roadways in two communities requiring significant reconstruction costs and lead to the condemnation of several homes. During the reconstruction several instruments were installed to monitor the landslide, construction activity, and long-term, post-construction performance of the rebuilt roadway segments. This Long Term Instrument Monitoring Plan (LTIMP) outlines the goals, guidelines and procedures for long term performance monitoring of the projects, alerts the public to potential safety risks associated with potential reactivation of the landslides, and evaluates the long term (20-year) performance of the reconstructed roadway sections and the landslide masses. Two different approaches to monitoring and reconstructing the damaged roadways were accomplished for the two affective communities. Because of the different instrument types, design and construction approaches, and dynamics of each site, Sunrise Beach Road and Hunter Point Road landslides are dealt with separately in many cases throughout this Long Term Instrument Monitoring Plan.

2.0 BACKGROUND

In January and February of 1999, the culmination of three years of above average annual rainfall resulted in numerous landslides throughout the Puget Sound. Two large residential landslides occurred in the neighborhoods of Sunrise Beach Road Road, located on the western bluffs of Eld Inlet and /Hunter Point, a community located on the shore of Squaxin Passage near Steamboat Island in Thurston County. Both of the residential slides resulted in significant property damage to homes and roadway infrastructures.

Sunrise Beach Road Landslide

In February 1999, Shannon and Wilson, Inc., was selected as the geotechnical consultant to monitor and design remedial measures for roadway reconstruction by Thurston County Roads and Transportation Services. The Consultants were contracted to identify locations of failure planes, rates of movement, and groundwater conditions. They also helped recommend methods of design, hillside stabilization and reconstruction of the damaged roadway in their Phase 2

Geotechnical Report. The reconstruction of the roadway and attempts to lower groundwater levels consisted of removing the damaged portions of the road, installing trench drains beneath the grade and installation of horizontal drain arrays into the hillside. Collector points that concentrate outflow from the trench and horizontal drains terminate near the beach bulkhead and upslope along the roadway. Construction of the roadway and hillside drainage regime was completed in February 2000. The construction was funded by a 20 year Roadway Improvement District (RID), with fund sharing based on square footage of affected properties. After the construction was completed in 2000, four inclinometers and five piezometers remained to serve as long-term performance and early detection monitoring instruments. The instruments will be used to establish long-term creep and settlement rates within the landslide mass and monitor groundwater conditions to help evaluate the effectiveness of the horizontal drain arrays in lowering and maintaining groundwater levels. The combined array of instruments will constitute the performance and early warning monitoring system for the reconstructed roadway should ground movements again threaten the area. Locations of the instruments are presented on Figure 2.

Hunter Point Road Landslide

Near the same time of the damaging Sunrise Beach Road Slide, a major landslide also occurred within the Carlyon Beach community on Hunter Point. GeoEngineers Inc, was contracted to evaluate the landslide and provide technical assistance to Thurston County in two Geotechnical reports, Phase I and Phase II. Movement of the slide continued between the two phases of the reports as measured by inclinometers installed as part of the Phase I study. The conclusion was that the current slide was a reactivated portion of an older slide. Dozens of homes have been damaged and several local access roadways have also been severely damaged by the landslide restricting access to many portions of the community. As of May 1999, a total of 37 residences have been damaged or destroyed. Because of the severity of the damage caused by the landslide in this neighborhood, several homes were condemned by the County for public safety. Several inclinometers and piezometers were installed during the initial geotechnical investigations to monitor the slide. Some of the remaining instruments will be incorporated into the LTIMP. Locations of the instruments are presented on Figure 4.

2.1 PURPOSE

The purpose of the Long Term Instrument Monitoring Plan for the two slide areas is three fold. In discussions with Thurston County Roads and Transportation personnel responsible for the twenty year long term performance monitoring of the two sites, three main goals for the long term monitoring of instrumentation installed in the sites have been identified. Specifically, the goals are:

- Ensure Public Safety by monitoring the reconstructed roadway section at Sunrise Beach Road and surrounding slopes for long-term stability and to monitor roadway surface and subsurface conditions.

- Evaluate General Design Performance of the installed horizontal drains, structural fill, roadway section, trench drains, and other mitigation devices.

- Early Warning Indicator of potential reactivation of the landslides within and adjacent to the reconstructed roadway segments.

The goals of the monitoring plans outlined above will determine the methods of monitoring and format of the data presentation, and appropriate response to the information provided by the instruments.

The primary purpose of this plan is to monitor, evaluate, and report conditions where the selected instruments to be read are located and should not be misconstrued as a global landslide stability study or an early warning indicator for large portions of the landslides at Sunrise Beach Road or Hunter Point Road, nor should the data be construed as performance indicators of areas outside of the reconstruction or engineered zones.

The Hunter Point Road evaluation has been identified and limited to the monitoring of one inclinometer and one piezometer located approximately 200 feet upslope of the active scarp area along Hunter Point Road. The limited number of instruments involved in the long term monitoring of this location (a total of two) will preclude the monitoring results obtained from Hunter Point Road from pertaining to global stability interpretations within the Carlyon Beach neighborhood downslope.

3.0 INSTRUMENTATION AND DATA COLLECTION OVERVIEW

The instruments installed for the Long Term Monitoring Program consist of inclinometers, piezometers and horizontal drain outflows installed before and after construction of the roadway sections. The horizontal drain outflows will be used as monitoring devices to rate the performance and production of the installed drains. In many cases, the instruments were installed in the roadway segment after reconstruction was complete. A few of the instruments that will be monitored remain from the initial landslide monitoring and geotechnical studies that began in March 1999. These instruments will help evaluate long-term trends in slope movement and groundwater draw down related to the horizontal drains installed in the Sunrise Beach Road reconstruction and stabilization. Four inclinometers are intact at Sunrise Beach Road and one at Hunter Point Road (five total). These five instruments will be incorporated into the LTIMP, where applicable, to evaluate general conditions of the landslides. They will provide a historical record spanning the initial landslide investigation and roadway reconstruction. In general, however, the data collected from the instruments will represent potential deflections taking place in the roadway beginning in August 2000. Historical initial data values disclosing information about the landslide itself will be evaluated and may be used as the initial reference marker for the outlying instruments. New initial values will be obtained for the inclinometers recently installed in the roadway after reconstruction. The piezometers and survey point information gathered at the onset of the projects will be collected from the earlier geotechnical investigations and incorporated into a database. Methods of data calculation, presentation and reporting are discussed in Section 4. Numerous survey points were established during the initial landslide activity, however, their continued usefulness in determining slope movement is in question because of regrading activity.

Attachment 1, "Instrument Detail Summary" is a summary table that provides the instrument details for Sunrise Beach Road and Hunter Point Road. The table lists the instruments that will be included in the LTIMP as well as the instruments that will be abandoned.

3.1 INSTRUMENT DESCRIPTIONS

The instruments being monitored are installed within the landslide masses to precisely monitor lateral slope deflection and elevation changes, groundwater conditions, and groundwater outflow rates over time. Each instrument is constructed with steel monuments anchored in concrete at the surface to secure the instruments from vandalism damage. Instruments located within the roadway are secured with steel flush-to-grade monuments to permit traffic to pass over the instruments without causing damage to the casings. The instrument types present at the monitoring sites are described in the following sections.

3.1.1- Inclinometers

Each inclinometer installation consists of 2.75 inch OD Slope Indicator™ axial-grooved casing designed to measure deflection of the casing based on an initial reading value obtained the first time the instrument casing is profiled. All subsequent readings are compared to the initial reading values for displacement calculations. Four grooves are cut into the inside of the casing running the axial length of each segment and are oriented orthogonally (90° offset). The segments are fitted together to reach the desired depth of the boring. Readings are taken by inserting a biaxial accelerometer probe (also manufactured by Slope Indicator Company of Redmond, Washington) attached to a power supply and sensor support cable into the casing. The support cable is demarcated in two-foot increments to accurately situate the probe within the casing. The probe is equipped with wheels, which fit into the grooves inside of the casing. The grooves guide the probe within the casing as readings are taken. The precision of the readings is dependent on the condition of the guide grooves and the location of the probe within the casing. Other instrument probes which monitor spiral deflection (twisting) of the casing are also used to measure inclinometers but only for error correction purposes. This type of probe is not used to monitor Sunrise or Hunter Point Road slides. The inclinometers installed at these locations are read using an English-unit probe read at two-foot intervals.

The biaxial sensors mounted within the probe measure offset angles of the casing over a two-foot interval between the top and bottom set of wheel axels. There are two sets of biaxial accelerometer sensors orthogonally mounted within the probe to profile the axial casing grooves. All four sensors simultaneously record each direction of angular offset in the casing. The four casing grooves are positioned and labeled A+ and A- and B+ and B- axes. The A Axes are positioned at 0 and 180 degrees and are designated by the direction of slope movement. The A+ axis groove is the most important because it is positioned in the boring to monitor movement in the most probable direction of deflection, typically parallel to the slope and probable direction of landslide movement. The B axes grooves are located within the casing at 90 and 270 degrees. The B axes record deflections that may be occurring within the casing perpendicular to the A axes (this is a common dynamic condition within landslides). The A and B axes are then resolved to calculate total displacement within the casing at each two-foot interval. The angle of offset for each interval is calculated and summed into inches of deflection from the *initial reading* by the readout box attached to the sensor cable at the surface and the presentation software used to prepare data reports.

<u>3.1.2 Piezometers</u>

The piezometers installed at Sunrise Beach Road and Hunter Point Road consist of open standpipes of 1-inch and 2-inch outside diameter PVC casing installed to the desired depth to be monitored. The piezometers casings are slotted near the bottom to allow groundwater inside the casing to be measured. The outside of the casing is backfilled with clean sand around the slotted section to permit groundwater to enter the piezometer. Bentonite or cement grout is placed around the casing, above the slotted sand section, to seal off the instrument to the ground surface. This prevents surface water from percolating along the piezometer casing, possibly cross-contaminating the groundwater being monitored. The groundwater is measured within the casing using a sounding device that is manually lowered inside the casing. A probe is attached to the end of a incrementally-marked power cable which closes an electrical contact when it reaches water causing a light and buzzer to activate, thus indicating the distance below the surface that groundwater was encountered in the casing. The value is recorded manually.

Another type of piezometer that is typically employed is known as a vibrating wire (VW) pressure transducer. The VW pressure transducers measure groundwater pressure by measuring the relationship of pressure acting on a thin pretensioned, chromium steel wire enclosed in a stainless steel housing. The frequency of the pretensioned wire changes with the amount of pressure applied to one end of the wire in relation to the other end which is welded to the piezometer housing. The change in the frequency of the wire is inversely proportional to the pressure applied (some models vary in the frequency output in that the frequency is directly proportional to the applied pressure). A voltage is applied to a coil surrounding the wire which induces a "plucking" of the wire. The plucking, in turn, induces a current from the wire to the coil and returns a voltage signal in the frequency of the vibrating wire. Since the frequency changes with pressure, it can be calculated and converted into head above the transducer. By subtracting the values from previous values, changes in groundwater depth above the transducers can be calculated. The advantages to this type of piezometer are that they can be automated, they are very accurate (accuracy better than 0.01 feet depending on model) and stable, and provide long term (>10 years) monitoring life. In addition, the piezometers are typically installed and backfilled to the surface. The borehole is permanently sealed around the signal wire so that later abandonment is not required. There is currently one vibrating wire piezometer transducer installed at Sunrise Beach Road Road; none were installed at Hunter Point Road. A second transducer is planned for the future at Sunrise Beach Road for the purposes of automation.

Automated vibrating wire piezometers can utilize dataloggers to take readings without having to manually lower the probe or record readings. The automated datalogger/piezometer systems allow for a more accurate data collection method because a much more complete data record is obtained by using automation. Details on this method of data collection are presented in Section 6.0 "Recommendations."

3.1.3 Horizontal Drain Outflows

Ten Horizontal Drain Outflow pipes collect and discharge groundwater intercepted by trench and horizontal drain arrays installed into the hillside and below the roadway at Sunrise Beach Road. The outflow pipes direct groundwater to the surface and route it to the beach through a series of pipes. The outflow pipes can be measured manually by sampling the water flowing from the points where they discharge to the surface. The measurement is a good indicator of groundwater and drain conditions.

The horizontal drains are a series of 1 to 2-inch diameter pipes drilled into the slope at an angle slightly above horizontal, typically 3 to 8 degrees. The pipes vary in length and are slotted near the end to allow groundwater within the slope to enter the pipes and drain at the slope face onto an erosion control pad. A series of the horizontal drain pipes are terminated to a main collection pipe to coalesce the drain flow. The Horizontal drains installed at Sunrise Beach Road are terminated into collection pipes which outfall to the Puget Sound. Horizontal drains were not used as slope dewatering methods at Hunter Point Road.

The horizontal drain outflows are collected and routed beneath the roadway via eight-inch plastic pipes. The outflow is directed into two main collection pipes, one for the southern portion of the slide and another for the northern portion of the slide. The main collection pipes combine the surface stormwater runoff from the street along with the trench drain and horizontal drain runoff. The combined runoff is subsequently piped approximately 200 feet downslope to Puget Sound. The southern and northern systems are separated with the southern system draining three horizontal drain arrays and the northern system draining two horizontal arrays. Several horizontal drains are also present along the slope below the roadway but do not contribute to the main collection shafts; rather, they discharge directly to the beach.

3.1.4 Surveying

Any surveys conducted for purposes of verifying slope movement or identifying features related to landslide movement will be surveyed utilizing the following guidelines and references until such time that new bench marks are established within the State of Washington.

The survey point data will be collected using either the Global Positioning System (GPS) or a traditional ground survey triangulation loop to the nearest 0.01 feet. The historical readings taken by Consultants in the past phases of work have consisted of GPS data. In either case, the readings taken indicate cumulative changes in Northing, Easting and Elevation as referenced to the initial survey taken in March 1999 based on NGVD-29 datum for vertical reference and NAD83 for horizontal data. The survey data, weather GPS or traditional, will be collected by a professional surveyor licensed in the State of Washington and will continue to conform to the initial reference data.

3.2 ACCESS AND ABANDONMENT

Access to the instruments is provided along easements within the county roadways or easements obtained from property owners prior to installation of the instruments. Instruments that do not have access easements will not be included in the Long Term Instrument Monitoring Plan. Certain instruments will also be eliminated from the monitoring plan because of their limited usefulness in the long term monitoring goals set forth. The instruments selected for abandonment will be filled with a bentonite and concrete mix consistent with Washington State Department of Ecology monitoring well abandonment guidelines (WAC 173-160-450 and 173-160-460). A well driller licensed in the State of Washington will accomplish the abandonment process for each of the selected instruments. The cost of abandonment for each instrument should be estimated at $500.00 to $750.00 for budgeting purposes. A list of instruments selected for abandonment is included in Attachment 1.

3.3 MAINTENANCE

The inclinometers and piezometers should require minimal or no maintenance over the course of the Long Term Instrument Monitoring Plan other than the usual care to prevent contamination or foreign objects form entering the casings. This can be done by always securing the monument lids using the bolts provided when readings are completed. These instruments do not typically require silt removal common to the horizontal drains because groundwater does not rapidly flow into the casing bringing silt with it as is the case with the horizontal drains.

The horizontal drains may require periodic cleaning depending on silt infiltration rates. These rates will be determined over the course of the monitoring. Typically, the horizontal drains should be cleaned every two to three years. The cleaning of each drain is accomplished by using a pressure washer with a rotating head. The assembly is gently advanced the entire length of each horizontal drain to lift silt or debris from the pipes. The task of cleaning the horizontal drain pipes can be accomplished by a local pipe-cleaning contractor.

The gabion baskets located at the outfalls along the beach will require periodic inspection and maintenance to assure they have not been damaged by changing conditions along the surf line. The wire mesh baskets should be inspected for distortion of the wire mesh, tension between the outflow pipes and the gabions, and potential harm to sea life such as animals being trapped by the wire mesh. The general condition of the wire mesh should also be observed to warn of potential corrosion from seawater.

4.0 DATA COLLECTION, PRESENTATION AND PROCESSING

Data collected from the instruments identified in the Long Term Instrument Monitoring Plan will be archived after each reading cycle. The data will be stored in a secure location and backed up periodically electronically and in hard copy to prevent loss of information. When readings are obtained during a monitoring cycle, the data should be downloaded and processed within one week of completion of the reading cycle. The processing and interpretation of the data should be accomplished by personnel trained in the various field and office techniques. It is recommended that in addition to training one primary field and office person, two backup people should be trained to take readings and process data for final reporting. The data collection, presentation, and interpretation procedures for each type of instrument described in Section 3 are outlined in the following sections.

4.1 DATA COLLECTION AND PROCESSING PROCEDURES

Data is collected from the instruments on a periodic schedule outlined in later sections of the monitoring plan. The manner in which the data is collected is dependent on the type of instrument being monitored. Each of the instrument types present in the field will be discussed individually and guidelines for data collection will be presented for each type. Data collection in the field must be correctly done to avoid incomplete or inaccurate readings. Data calculation and presentation should be managed using a spreadsheet or database to construct tables and prepare graphs. All data plots, charts, or tables should clearly identify the site name, instrument designation, and data subject being presented.

4.1.1 Inclinometers - Reading Procedures

Inclinometers are the primary instruments used for detecting lateral movement of the casing being profiled. The inclinometers installed at the two sites are read by manually lowering the sensor probe into the casing. Accurate collection of the inclinometer data is essential because of the sensitivity of the instrument. When taking readings using a Standard English probe, such as the one used at Sunrise and Hunter Point Road, the detection capability of the instrument is on the order of one thousandth of an inch resolution. Because of this, the way in which each casing is profiled must be nearly identical for each reading cycle. As discussed previously, the displacement data is calculated from an initial reading value called the "initial reading value". As a result, the probe must be placed at the same 2-foot increment within the casing each time the reading is recorded. Placement of the probe of more than 1/4 inch from the initial reading location will result in erroneous displacement readings. The readings are taken in two directions by rotating the probe 180 degrees. There are two sets of sensors that record data orthogonally to each other so rotating the probe and taking two readings provides checksum readings in four directions. This is done to obtain a statistical representation of the data gathered and to provide a statistical "check" (referred to as checksum) of the data. The "check" offers a way to verify data or discover errors in the field to indicate if the reading needs to be retaken before returning to the office. Specific instructions on taking inclinometer readings will not be discussed in detail in this Monitoring Plan document and should be taught to individuals who will be collecting field data by a qualified, trained individual.

Always use great care when operating the equipment because of its highly sensitive nature. Do not drop the probe or sound the bottom of the casing with the probe. The probe will slowly lose calibration over time but dropping it will accelerate this process and require factory recalibration. Recalibration of the probe should be performed by the manufacturer about once every two years depending on level of use.

The data gathered from the inclinometers is stored within an electronic processing device called the Slope Indicator Datamate™. The Datamate™ is a portable readout device that stores and calculates filed data. The Datamate™ is attached to the sensor probe via a graduated cable. The cable is marked in two-foot intervals to correspond with the reading intervals of the casing. The Datamate™ provides power to the probe as well as takes and stores the readings. When the data is collected and returned to the office for processing, the Datamate™ is attached to a PC via an interface cable and data is downloaded. Specific training on the downloading procedures from the Datamate™ to the PC will be conducted for the individuals selected to perform the process.

4.1.2 Inclinometer Data Processing and Presentation

The Datamate™ data is then processed and plotted using Slope Indicator's DMM™ and Digipro™ for Windows™. All inclinometer data will be calculated and reported in English units using Slope Indicator's software at a scale that brackets the data appropriately. All graphs and data will display the project title indicating monitoring location and boring identification indicated to clearly identify the site the data is representing. Graphs should be reported in Depth in Feet along the Y-axis, and Inches of displacement along the X-axis. Five-foot intervals will be displayed on the Y-axis. The Y-axis will display data from 0 (ground level) to five feet below the deepest reading depth. Resolution of the X-axis should be +/- 0.50 inches with 0.10-inch increments marked on the axis. The resolution of the X-axis may vary due to the magnitude of deflection and should be adjusted accordingly as necessary. Both the A and B axes will be displayed on one sheet in the manner described. Time/ Displacement plots may be displayed to substitute the B axis if a noticeable amount of movement is discovered at a distinct zone in the profile.

4.1.3 Piezometers– Reading Procedures

Piezometer data is manually collected from the open standpipe piezometers by lowering the sounding device until a buzzer indicating a closed contact is made with the water in the piezometer casing. A light may also illuminate depending on the type of sounding device that is used. The sounding device cable should be marked along its entire length in intervals of feet. The sounding device cable location should be recorded to the nearest 0.01 feet below ground surface when the buzzer and or light indicates that the water level has been reached in the casing. The data is entered into a spreadsheet to be calculated and presented graphically. The graphs indicate the groundwater elevation on the date the reading was made.

Contamination from iron reducing bacteria is a problem in Western Washington. To prevent the spread of the contamination by the bacteria, the sounding device probe should be cleaned with bleach water and dried before moving to a new location to take a reading.

Vibrating wire piezometers installed at Sunrise Beach Road are read using an electronic readout device. The device is attached to the transducer signal cables at the ground surface where the reading is taken by the device. Exact methods and settings for the devices differ by model and transducer type. There is one Slope Indicator™ vibrating wire pressure transducer installed at Sunrise Beach Road.

4.1.4 Horizontal Drain Outfalls – Reading Procedures

The horizontal Drain Outfall data is collected at the three main collector pipes that gather the cumulative discharge from five individual horizontal drain arrays. The outfalls are measured manually by a time/volume method. A bucket of known volume is placed beneath the outfall pipe and the time it takes to fill the bucket to a known volume along with date is recorded. The main drain outfalls are located beneath the roadway approximately twenty feet below the surface. There are two locations where the outfalls will be accessed using manholes in the roadway. The southern manhole is used to access the outfalls collecting water from three horizontal drain arrays located in the southern extent of the slide. The northern manhole provides access to two horizontal drain arrays located at the northern extent of the reconstructed roadway. A bucket tethered to a rope will be used to collect water flowing from the pipes over a known period of time. The outfalls will be monitored more frequently during the wet seasons as outlined in Section 5.

The gabion baskets constructed on the beach where the combined horizontal drain outflow pipes terminate should be evaluated during each reading cycle as discussed in Section 3.3. Comments regarding these issues should be noted in the summary and letter memorandums during data reporting.

4.1.5 Piezometer and Horizontal Drain Outfall Data - Processing and Presentation

Data collected from the Piezometers should be processed using a spreadsheet program (preferably Microsoft Excel or equivalent) to create tabular and graphic data representations of the field data. The spreadsheets will be used to calculate and present the data in English units to the nearest 0.01 feet. The Y-axis should represent groundwater elevation or depth of groundwater below the surface. The X-axis should represent the date the readings were recorded. The tabular data should contain the date the readings were recorded, the value recorded and the change from the previous reading. Each spreadsheet and associated graph will display the project title indicating monitoring location and boring identification indicated to clearly identify the site the data is representing.

Data obtained from the Horizontal Drain Outfalls should be processed in English units and presented in Gallons per Minute of flow on the date the reading was obtained. The data should be presented in tabular format and should contain the date the readings were recorded, the value recorded to the nearest 0.10-gallon and the change from the previous reading. Presentation of the data in graphic form is not necessary but may be included for visual comparison of the values over time. Graphic data, if included, will contain a plot of Gallons per minute on the Y-axis and Reading Date on the X-axis. Each spreadsheet and associated graph will display the project title indicating monitoring location and boring identification shown clearly identifying the site the data is representing. Appropriate scales to clearly display the data will be chosen.

4.2 HISTORICAL DATA

The Consultants contracted to evaluate the landslides may have a useful record of historical data for some of the inclinometers to be monitored long term. This data will be compiled and added to the historical record where possible. The inclinometers to be monitored at Sunrise Beach Road were all installed after roadway construction was completed, therefore historical initial values and readings prior to August 2000 will not be incorporated into the long term monitoring data. The inclinometer installation at Hunter Point Road may include the historical initial reading but may require a new initial reading due to recent grade changes made to the roadway.

Historical Piezometer and Horizontal Drain Outflow Data are available from the Consultants throughout the history of both projects. This data is useful for providing an ongoing record and to evaluate groundwater conditions and surface displacements and will be incorporated into the long term. The historical Horizontal Drain data will be useful in evaluating the effect the drains may have had on local groundwater levels in the areas they were installed. Long-term effects of the drains on the local area may be observed by comparing the historical groundwater data prior to installation of the drains. This data will be compared to groundwater levels measured during construction and post construction over the duration of the long term monitoring.

4.3 DATA REPORTS

Comprehensive reporting of the calculated data from all of the instruments at both sites should be compiled into a report that presents the results of the field data **once per year.** One report for Sunrise Beach Road and another report for Hunter Point Road should be prepared and presented separately. During the first two years of the Long Term Monitoring Program, however, the results of the monitoring should be reported twice per year for Sunrise Beach Road because of the recommended reading interval presented in Section 5. The reports should contain the calculated data, plots and tables of the data, and a summary letter memorandum. Interpretation of the data and any comments on general site conditions and recommendations should be presented in the letter memorandum. The contents and frequency of the reports should increase if there are indications of movement, severe weather events, and seismic events or as directed by the responsible engineer.

Brief summary memorandums should be presented for the sites after each reading. The memorandums should indicate that the site was read and processed and no change was observed. Plots and charts of the data are not necessary for the brief memorandums unless conditions warrant.

4.4 DATABASE CONTSRUCTION

In addition to comprehensive annual data report generation, an electronic database will be created to store all information gathered from the field. The database will be separated into two subdirectories, one for Sunrise Beach Road, the other for Hunter Point Road data. The directories will be structured so that data from the inclinometers, piezometers and horizontal drains, and reports is separated into subdirectories. The subdirectories will be named to clearly identify which data is contained within them. The database will contain all graphs, plots and calculated data generated during the course of the monitoring. All data reports and memorandums will be stored in the database also. The database will be stored in a secure location in at least two locations, one on a network that is electronically backed up periodically, the other on a separate disk. Duplicates of the database will be kept up to date so that data gaps and lags will not occur.

5.0 LONG TERM MONITORING APPROACH

The Long Term Instrument Monitoring Plan should be established to meet the goals set forth in Section 2. In an effort to meet the goals of the Plan, a phased approach to field monitoring should be adopted. The phased approach typically consists of limiting the long term monitoring to a specified time period. The recommend time period for this monitoring Plan is 20 years to facilitate the duration of the RID. The twenty-year monitoring period should be evaluated for amendments to the plan every five years for Sunrise Beach Road. This time period limitation is based on the premise that the structural integrity of the reconstructed and engineered portions of the landslides, as well as normal seasonal groundwater conditions within the observation areas should be adequately determined within five years. Continued monitoring beyond five years and up to 20 years should be based on data collected during the initial five-year period. The level of monitoring after the initial five years, and up to 20 years should be based on observations made within the first five-year monitoring period. Readings performed after the first five-year period has been completed should reflect general trends to be expected throughout the remainder of the twenty years. Additional readings and reports should be considered, however, during very high seasonal precipitation years or in the event of close-proximity seismic activity.

5.1 RECOMMENDED MONITORING INTERVALS

The monitoring plan has been established to provide guidelines for monitoring intervals based on current understanding of the two sites. The guidelines are intended for review after five years to make amendments to the LTIMP as necessary. The 20-year length of the monitoring plan is longer than is typically established to monitor performance of landslides and it is anticipated that some instruments will not survive the entire length of the program. Because of this, the five-year evaluation periods are strongly recommended to evaluate the instruments' performance as well as the overall performance of the landslides. The first five years will involve an intensive, phased approach to establish creep rates, determine groundwater and recharge relationships, and to establish monitoring guidelines that will adapt to the entire length of the program. As a result, the first five years will contain variable reading frequencies that will lessen with time. The phased approach is not necessarily appropriate for Hunter Point Road, therefore, a different flat reading interval is proposed for that location as described in Section 5.1.2. The recommended reading intervals pertain to all of the instruments contained within each site unless otherwise specified. Reading intervals for both sites should be closely tied with rainfall local data, especially during the winter and spring months. A rainfall gage will be necessary to closely monitor precipitation at the sites. A proposed rain gage installation is outlined in Section 6.

5.1.1 Sunrise Beach Road

A five year phased approach should consisting of three monitoring intervals is recommended for the first five years of the LTIMP at Sunrise Beach Road. The intervals described below pertain only to the first five years of the LTIMP for Sunrise Beach Road. Recommendations for the remaining fifteen years (2006 through 2020) follow the first five-year intensive observation period.

Phase 1 - 1st and 2nd Years

Beginning in 2000 and ending in December 2002, field instrument readings of the inclinometers, piezometers and horizontal drain outfalls should be **one reading cycle per month**. This interval should be adjusted as necessary depending on weather conditions. The intervals should be increased to bi-monthly during February, March and April or when precipitation is above the monthly average. Any indication of landslide reactivation or abnormal roadway settlement would result in an immediate reading cycle being conducted.

Phase 2 – 3rd and 4th Years

The second and third year years of the Long Term Instrument Monitoring Plan will represent the mid point of first five-year observation period. At this stage in the monitoring enough data will have been gathered to begin to evaluate the performance of the reconstruction, groundwater behavior with respect to the horizontal drains, and general slope stability near the project sites. Siltation rates of the horizontal drains will also be established by this phase. The intervals that the instruments are read should be decreased to four per year during this phase of monitoring. **One reading cycle per quarter** (four per year) is an appropriate interval for the inclinometers, piezometers and horizontal drain outfalls. Phase 2 of the Long Term Instrument Monitoring Plan reading intervals should be increased if signs of movement are observed, or, if a base rate of creep movement identified and established in the Phase 1 (if any has been observed) increases.

Phase 3 – 5th Year

In the fifth year of monitoring, the reading intervals of the field instruments should be further scaled back to **two readings per year** for the inclinometers, piezometers, and horizontal drain outflows. Well-established creep rates (if observed) or settlement should be identified in this phase and overall performance of the reconstruction and general landslide and groundwater conditions should be evident. At the end of Phase 3 consideration of amendments to later phases of monitoring should be assessed based on findings of the fifth year plan.

2006 through 2020 Reading Intervals

After the first five years is completed, an evaluation of the data gathered from the three phases should be performed and a second five-year evaluation period should begin in 2005 after reviews for amendments to the LTIMP are made. The second five-year cycle should be a flat rate cycle of **one reading per year** unless otherwise warranted by weather (high-intensity rainfall), seismic activity, or unusually high groundwater. The second five year cycle would end in 2010 with an evaluation of the data and recommendations for amendments to the next two five year reading cycles. It is assumed at this point in time that the flat rate of one reading cycle per year will be sufficient for the final ten years of the LTIMP. The final cycle would conclude in December 2020.

5.1.2 Hunter Point Road

The Hunter Point Road site upslope of the Carlyon Beach community will be dependent on the inclinometer and piezometer. Because of the nature of the slide and the community that was affected, a monitoring interval of the existing instruments should be read a flat rate of one reading per year for five years. Because of the differing nature of the Hunter Point Road Slide and they quantity and type of instruments installed and available for monitoring it is recommended that a **flat rate of one reading per year** be maintained throughout the twenty-year observation for this site.. During the first year, however, two readings, an initial in August 2000 and a subsequent reading in December 2000, should be conducted to establish a baseline. Modifications to the flat rate should be made if the conditions described in Section 5.1.3 occur. The twenty year monitoring period would end in December 2020 and would be evaluated every five years for amendments to the LTIMP that reflect observations made during each five year period.

Most of the initial instruments have been damaged or destroyed after installation and would need to be replaced prior to creating a comprehensive reading agenda for the entire slide mass.

5.1.3 Additional Reading Cycles

Severe conditions including major storm events equal to, or greater than the Thurston County 25 year, 24-hour storm event (5.10 inches of rain in a 24 hour period) should be recorded by accomplishing a reading cycle of all instruments at Sunrise Beach Road. Near-proximity (10 miles) seismic events of magnitude greater than M3.5 may also require additional reading cycles. These events may occur at any time during the 20-year LTIMP resulting in additional readings and reports.

The intensity of the rainfall will be monitored by the rain gage proposed to monitor local conditions for the sites. A new rain gage is proposed because local rainfall data is not currently avalible and reading frequencies will depend on information provided by the new gage. Section 6 of the LTIMP provides additional details on the proposed addition of the precipitation gage.

5.2 SLOPE FAILURE INDICATORS

In the event a failure of the slope is detected in the course of monitoring, certain procedures should be followed based on the severity of the failure. Several indicators can be used as guidelines to help determine the level of response. The following indicators can be used as guidelines to the severity of a possible slope failure and how to proceed with a response. Movement may be very localized and show up in only one instrument or may be widespread and be observed in a wide spectrum of instruments. In general, the more widespread the indicators, the higher the threat level, though localized failures may be severe and cause damage also. The following paragraphs describe possible landslide movement indicators.

1. Minor Slope Movement Indicators

Described as: Discrete deflection indicated at a discrete zone in one or more inclinometers. The deflection may be gradual over a period of time (creep movement) or episodic. The subsurface movement may or may not be correlated with other inclinometers. Groundwater levels may or may not be elevated. The movement should be less than 0.25 inches between any given monitoring cycles to be considered minor.

In the event of minor movement, the coarse of action would be to increase the monitoring frequency to approximately twice the current frequency, especially in the instruments detecting the movement. Watch closely for deflection trends in the inclinometers.

2. Moderate Slope Movement Indicators

Described as: Discrete or massive movement detected at one or several zones within one or more inclinometers. The magnitude of movement for a moderate indicator would be on the order of 0.50 inches or more. Minor surface cracks may appear on the asphalt or downwarping of the road surface may be barely noticeable. Minor offsets in pavement striping may also be observed. Typically one or more of the inclinometers will indicate movement at the surface and below ground. Groundwater levels may be higher than historically normal for the date of the reading. Settlement of the inclinometer casings may be observed as a “bowing” or warping of the casing profile. Horizontal drain outflow levels may be higher than normal.

Actions to take in the event of a moderate movement indicator are: 1. Increase the monitoring frequency to twice the current frequency or greater. If the indications of moderate movement are observed in Phase 2 or 3 of the plan, reading frequencies should be increased to once per month until it is clear that the event has subsided. 2. Notify County personnel trained in landslide interpretation and modeling. 3. Print out plots and tables of each reading cycle for a historical record of the event. A brief memo should accompany the plots for documentation of the event.

3. Severe or Catastrophic Slope Movement Indicators

Described as: Massive deflection in several instrument types. Indicators of this type of movement will be obvious. They include large, discrete deflections of 1.0 inches or greater in the inclinometer profile, abnormally high groundwater levels observed in the piezometers, abnormally high or extremely low (indicating the drains have pinched off) horizontal drain outflows. The deflections will likely be seen as expressions in the roadway surface such as vertical or horizontal cracks in the pavement, fog line or centerline deflections. Nearby structures such as homes, trees or power lines my lean or deform and subsurface utilities may snap cutting service. Sounds of cracking wood and crumbling soil can sometimes be heard. Survey points should be established to monitor surface deformation. Groundwater may breech the surface and cause debris flows. At this point, residents will likely notice surface deflections in structures and will likely call for assistance. Severe or catastrophic movement may be associated with extreme weather or seismic events.

Procedures for this type of movement should include very close monitoring of the instruments under direction of a Geologist or Engineer. Road closures or evacuations may be needed and local residents should be notified as the situation warrants. Data gathered during such an event should be processed and printed immediately to document the event. A formal report of the event(s) should be prepared after the event is ceased.

Though catastrophic events are rare, they do occur. Both Sunrise Beach Road and Hunter Point Road landslides are examples of a Severe and Catastrophic event resulting in the loss of private and public property.

6.0 RECOMMENDATIONS

Based on the reading frequency of the Sunrise Beach Road landslide, valuable groundwater data may be missed which would allow for an accurate development of a flow rate through the site. The rate can be determined by monitoring and recording rainfall and associated piezometric levels within the ground. An accurate method for monitoring would be to install an automated rain gaging and ground water monitoring station. The automated system would monitor precipitation and a minimum of two piezometers. The piezometers to be monitored would consist of using two existing installations and equipping them with vibrating wire pressure transducers or down-hole, self-contained dataloggers with pressure transducers. The vibrating wire pressure transducers would be connected to one or more dataloggers to monitor fluctuations in groundwater levels. The connections should be made by saw cutting the asphalt and installing 1-inch minimum outside diameter PVC conduit from the instrument location to the datalogger location when determined. The asphalt removed during the installation of the conduit will be replaced. Signal cables will be pulled from the transducer locations to the datalogger location. The conduit should be equipped with a nylon pull string inside to allow the signal cable to be pulled inside of the conduit to the datalogger location. The self-contained dataloggers do not require saw cutting of the pavement because the entire apparatus, including the datalogger module, is inserted down hole and connected to the surface by a signal and support cable by which the instrument is downloaded. These dataloggers should be considered for more remote installations.

The data gathered from the instruments would be correlated with rainfall data also collected from one of the dataloggers attached to a rain gage. The combined data will be used to develop an accurate model of the recharge/flow relationship of the groundwater in the hillside at Sunrise Beach Road. The system can be programmed to take readings at intervals that would detect rapid rises or drops in groundwater levels in response to recharge conditions. Data that would be otherwise missed by manual data collection methods would be collected and could be downloaded from the datalogger providing a very accurate representation of groundwater conditions. County personnel do not have to be present for the system operation cutting back on field costs. This recommended automated monitoring method would greatly help in evaluating the performance of the horizontal drains over time. The system would also help in developing groundwater models that may be useful in predicting potential failure events. The approximate cost of such a system would be $6,000.00 for monitoring equipment. The cost of the system includes all hardware and datalogger programming. Installation of the system would be charged at an hourly rate for labor.

Additional monitoring cycles of the Hunter Point Road landslide would rely heavily on the data gathered from the precipitation gage to determine frequency adjustments in the flat rate readings. Additional readings would be based heavily on data gathered from the rain gage site. The rain gage can be installed at either location; however, the Hunter Point Road location possesses conditions that may be more favorable to the installation of the gage at that site.

7.0 FINANCIAL IMPACT

The financial implications of establishing and following the Guidelines set forth in this Long Term Instrument Monitoring Plan are outlined in the following sections. The estimated cost of implementing the plan over the entire twenty year period is based on factors including the number of readings made, frequency and extent of report preparation, and readings made above and beyond those outlined in the Plan based on emergency need. Inclusion of the recommended instrumentation from the Recommendations Section is also factored into the estimated costs presented below. Estimated 5 % inflation per year is also added into the long term projected cost. Because of the long duration of the twenty-year plan, revisions to the financial impact should be made in combination with revisions to frequency of readings. **Revisions to the financial impact should be made every five years.**

1. Plan Development – Initial cost to develop The Long Term Instrument Monitoring Plan is a one-time event. Future amendments and additions to the plan may increase costs in the future. The estimated cost to develop this plan will be approximately $4,000 dollars from Plan inception to final draft and acceptance by the Thurston County Roads and Transportation Department.

2. Phase 1 (2 years duration) – The first phase of the reading for Sunrise Beach Road and the first yearly reading and reporting cycle for Hunter Point Road (one reading per month) is the most intensive and will require a higher rate of funding. The estimated cost of implementing and completing Phase 1 is expected to be approximately $10,000.00 over two years ($5,000.00/year).

3. Phase 2 (2 years duration) – The middle phase of the proposed LTIMP is expected cost substantially less than Phase 1. The Phase 2 costs are estimated at $6,000.00 over two years ($3,000.00/year). The reading frequency is one cycle per quarter (four per year- eight total).

4. Phase 3 (1 year duration) – The final phase of the first five years of the proposed LTIMP is estimated to cost less than $3,000.00 because fewer readings are expected. This number may, however be higher than Phase 2 depending on the findings of the earlier phases and adjustments that may be made accordingly. The reading frequency is one cycle per year (one reading cycle at the beginning of the year and a final reading cycle at the close of the final year- two cycles total). Software upgrades and programming adjustments will likely be necessary at the end of this phase and are estimated at $3,000.00.

5. Yearly database generation and upkeep and equipment and software upgrades for the first five-year period are estimated at $8,000.00 ($1,600/year).

6. The Addition of the recommended rainfall and groundwater monitoring station presented Section 6 should remain fixed at $6,000.00 plus labor unless expanded capabilities are requested. This includes the dataloggers, gages, security, and datalogger programming. The equipment would be installed at the initiation of the plan in 2000.

7. 2006 through 2020 – Amendments to the financial impact of the LTIMP will more accurately define actual costs of the remaining fifteen years of the program. It is recommended that the costs be reevaluated after each five-year period to help budget the following five-year period. Costs for monitoring

after 2005 are not included because they are subject to the five-year review and evaluation and would not be accurate at this time.

The total estimated financial impact of the first five-year observation period of the LTIMP should therefore be approximately $34,000.00 ($6,800.00/year average) from plan inception to completion of the first five-year evaluation period in December 2005. These costs assume many factors throughout the first five years of the LTIMP, the most substantial being the number of unscheduled reading and reporting cycles that may become necessary due to unforeseen circumstances. It can be assumed that each subsequent reading and reporting cycle performed outside of the Plan outline can be estimated at an additional $2,000.00 per incident.

A cost for the entire twenty-year LTIMP based on information and assumptions made at its inception will be evaluated every five years. Projections of the actual cost of the entire twenty-year plan at this point would result in unreliable figures. The evaluations and revisions made every five years should take into account the reduction of planned reading cycles in the future. The cost presented herein includes inflation, administration, training, software and hardware upgrades, and additional reading cycles.

Replacement costs for instruments are not included in this section. If the instruments are replaced during the course of the plan, the costs will include a drilling subcontractor and materials. The cost of replacement of an inclinometer or piezometer in 2000 is approximately $5,000.00 per installation.

8.0 PLAN IMPLEMENTATION

Upon acceptance of the LTIMP by the Roads and Transportation Services Department and other Thurston County agencies, this plan will take effect and the guidelines and procedures contained herein will be adopted.

9.0 PLAN CLOSURE

A closure plan should be formally developed at the end of the fifteen-year period in 2015 and prior to the final five-year segment of the plan.

At the termination of the LTIMP in 2020, the instruments should be abandoned as recommended in Section 3.2. The abandonment of the remaining instruments will finalize the Plan by securing the instruments from future contamination. The abandonment of the instruments should be conducted simultaneously to avoid any installations from being missed. The abandonment at this time should include all instruments replaced or remaining at the end of the LTIMP.

A final report summarizing the twenty-year LTIMP should be drafted for closure of the Plan and should include overall observations made during the lifetime of the monitoring program. The final report should include comments on the entire plan and make recommendations for future plans. The plots and charts created over the lifetime of the LTIMP should not be included in the final report due to the amount of data anticipated.

10.0 LIMITATIONS

Limitations of the Long Term Instrument Monitoring Plan include type and use of the data collected from the field. Although one of the goals stated in this plan is to "Ensure Public Safety by monitoring the reconstructed roadway sections and surrounding slopes for long term stability and to monitor roadway surface conditions" the instruments installed at the sites may not be adequate to predict the potential magnitude of ground failures. The instrumentation installed at the sites is not intended to monitor specifically for global landslide conditions and potential global danger to the public. Instead, data can be interpreted from the available instruments and warnings to the public can be made based on the conditions the instruments are designed to monitor near the roadway. A more systematic instrument network should be employed to monitor the landslides for early warning indicators. Obvious signs of potential catastrophic or severe ground movement should be verified and interpreted by qualified Engineers or Geologists prior to decisions regarding public safety. Potential litigation regarding extrapolation of the data beyond the monitoring locations in and around Sunrise Beach Road and Hunter Point Road is high.

The twenty-year duration of the LTIMP is not typical of most landslide monitoring plans. The design life of most instrument monitoring systems is eight years, though ten is common. Over the twenty-year span of monitoring, it is not unreasonable to assume that a majority of the instruments will malfunction or be destroyed by unforeseen events. The LTIMP will become much less reliable as time proceeds and the recommended amendments to the plan every five years should reflect losses of instruments and increase the plan's overall effectiveness.

This plan was written with the intent to be a framework that can be adapted to meet long term monitoring needs for future sites.

Attachment 1 – Table of Instrument Details

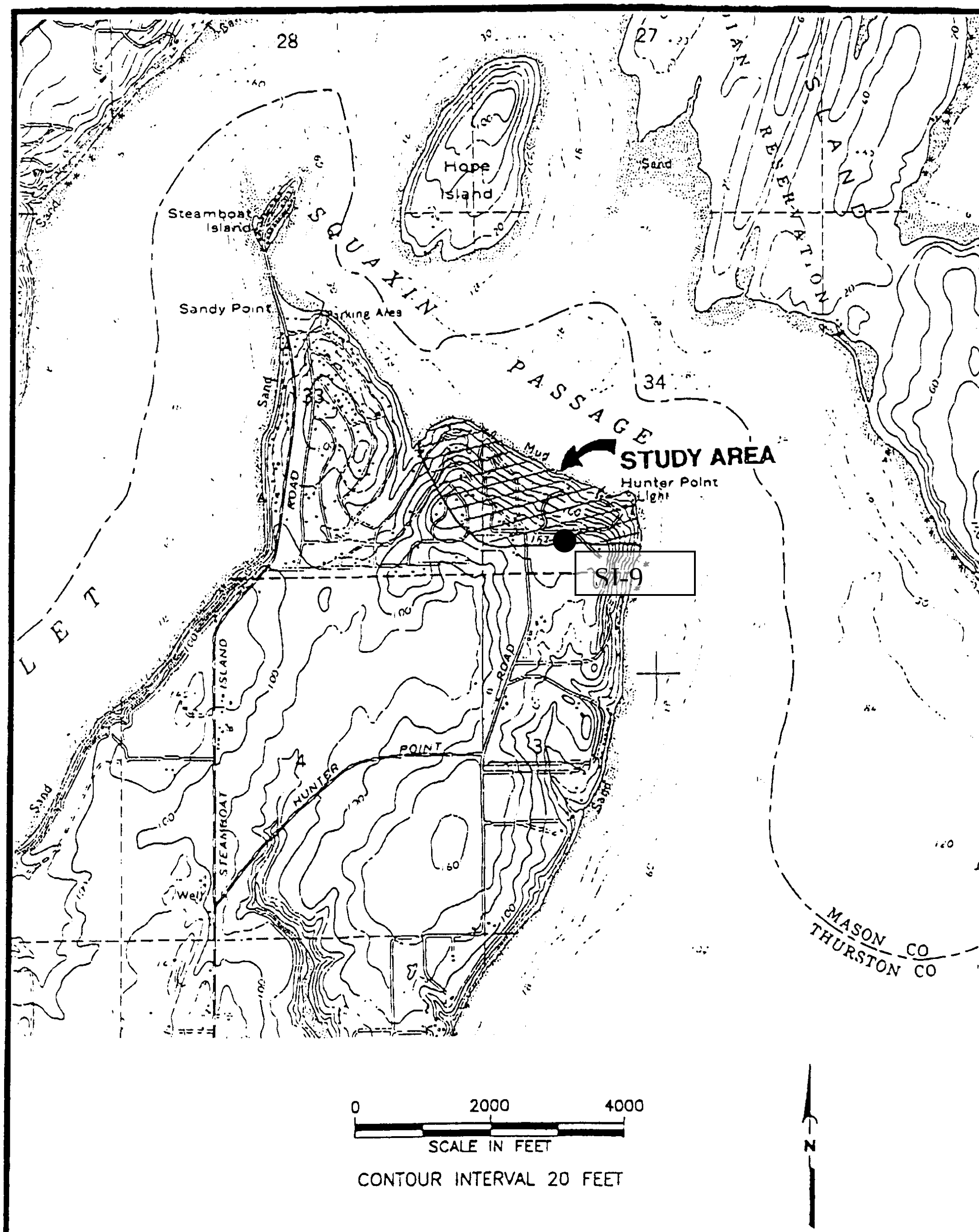
Attachment 1- Instrument Detail Summary

Location	Instrument ID	Instrument Type	Casing Depth	Comments
Sunrise Beach	B-101	1" piezometer	30.0'	Active
Sunrise Beach	B-102	1" piezometer	30.0'	Active
Sunrise Beach	B-103	1" piezometer	20.0'	Active
Sunrise Beach	B-104	1" piezometer	35.0'	Active
Sunrise Beach	B-105	1" piezometer	25.0'	Active
Sunrise Beach	B-106	1" piezometer	25.0'	Active
Sunrise Beach	B-107	1" piezometer	25.0'	Active
Sunrise Beach	SM-1	1" piezometer	34.5'	Active
Sunrise Beach	SM-2	1" piezometer	27.5	Active
Sunrise Beach	DM-1	1" piezometer	115.0'	Active
Sunrise Beach	DM-2	1" piezometer	98.0'	Active
Sunrise Beach	DM-3	1" piezometer	110.0'	Active (Add/Automate VW piezometer)
Sunrise Beach	SI-1	Inclinometer	116.0'	Active
Sunrise Beach	B-2	Inclinometer/VW piezometer	110.0'	Active (Redrilled 6-2000) (Automate VW piezometer)
Sunrise Beach	SI-3	Inclinometer	120.0'	Active
Sunrise Beach	SI-4	Inclinometer	86.0'	Active
Sunrise Beach	HD-1	Horizontal Drain Outfall		Monitor Array 1,2 Drains (Southern Arrays)
Sunrise Beach	HD-2	Horizontal Drain Outfall		Monitor Array 3,4 Drains (Southern Arrays)
Sunrise Beach	HD-3	Horizontal Drain Outfall		Monitor Array 5 Drains (Northern Arrays)
Sunrise Beach	B-4/SI-4	Inclinometer /Piezometer		ABANDON
Sunrise Beach	B-108	1" piezometer		ABANDON
Location	**Instrument ID**	**Instrument Type**	**Casing Depth**	**Comments**
Hunter Point Road	SI-9	Inclinometer		Active
Hunter Point Road	P-9	1" piezometer		Active (Possible automation)

The table above provides details about the instruments included in the Long Term Instrument Monitoring Plan (LTIMP). The instruments included in the table will be monitored throughout the life of the Plan. The two instruments denoted for abandonment at Sunrise Beach should be filled as recommended in Section 3.2 "Abandonment" of the LTIMP.

Inclinometer B-2 at Sunrise Beach was redrilled in June 2000 by Shannon & Wilson Incorporated. The boring was redrilled to 110 feet and an inclinometer casing was installed to 94 feet deep. A Slope Indicator Vibrating Wire pressure transducer was installed concurrently with the inclinometer casing. This vibrating wire pressure transducer is located in a dip at the northern portion of the drainage system and is planned for future automation with a datalogger. A second automated VW transducer is planed for the southern drainage system at DM-3.

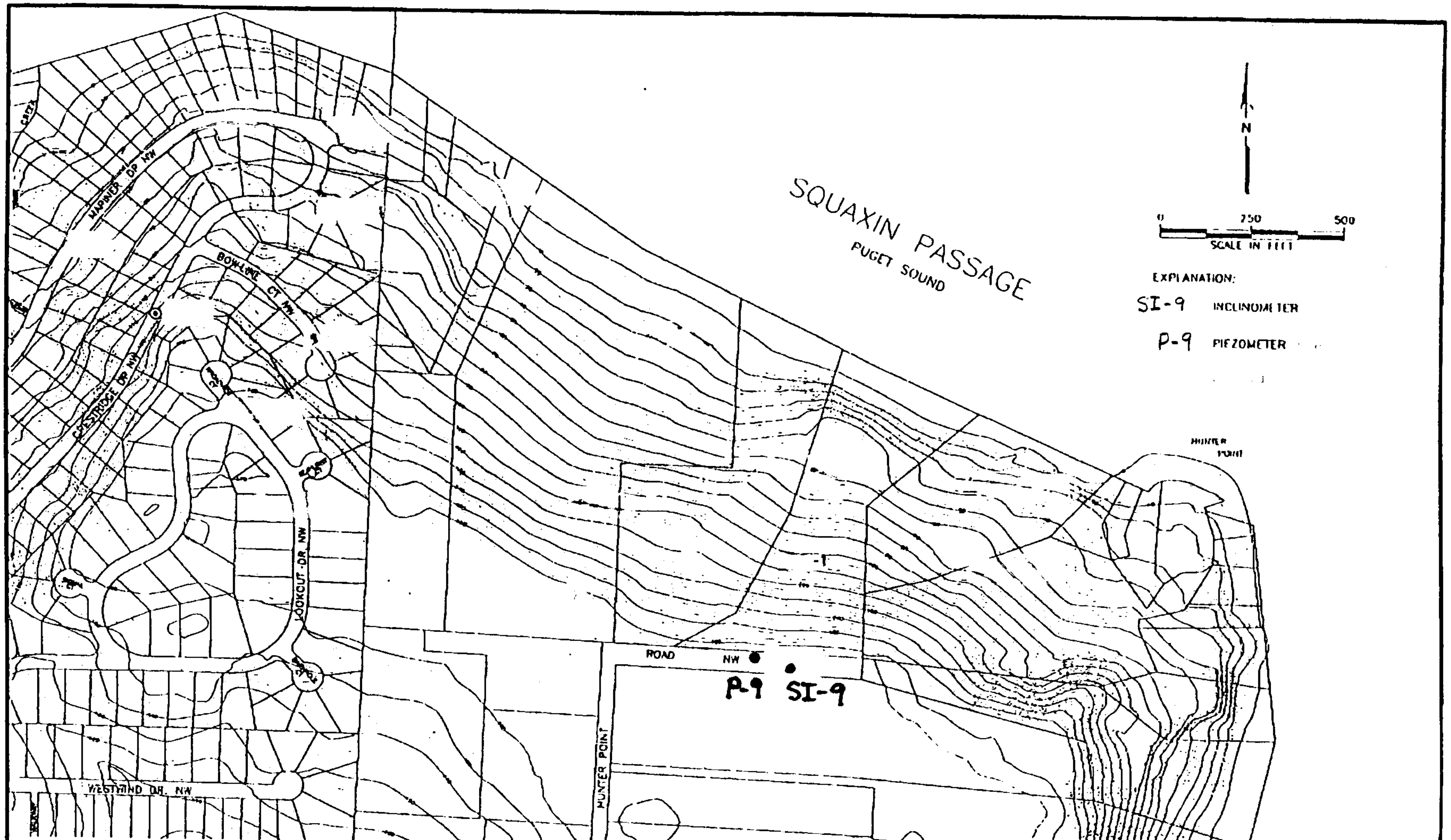
Piezometer P-9 located at Hunter Point Road is a possible candidate for future automation in association with an automated rain gage.



Reference: USGS 7.5' topographic quadrangle map "Squaxin Island, Wash." photorevised 1968.

GeoEngineers	VICINITY MAP Hunter Point Road
	FIGURE 3

BEB:JLD 7318-001-00 03/16/99

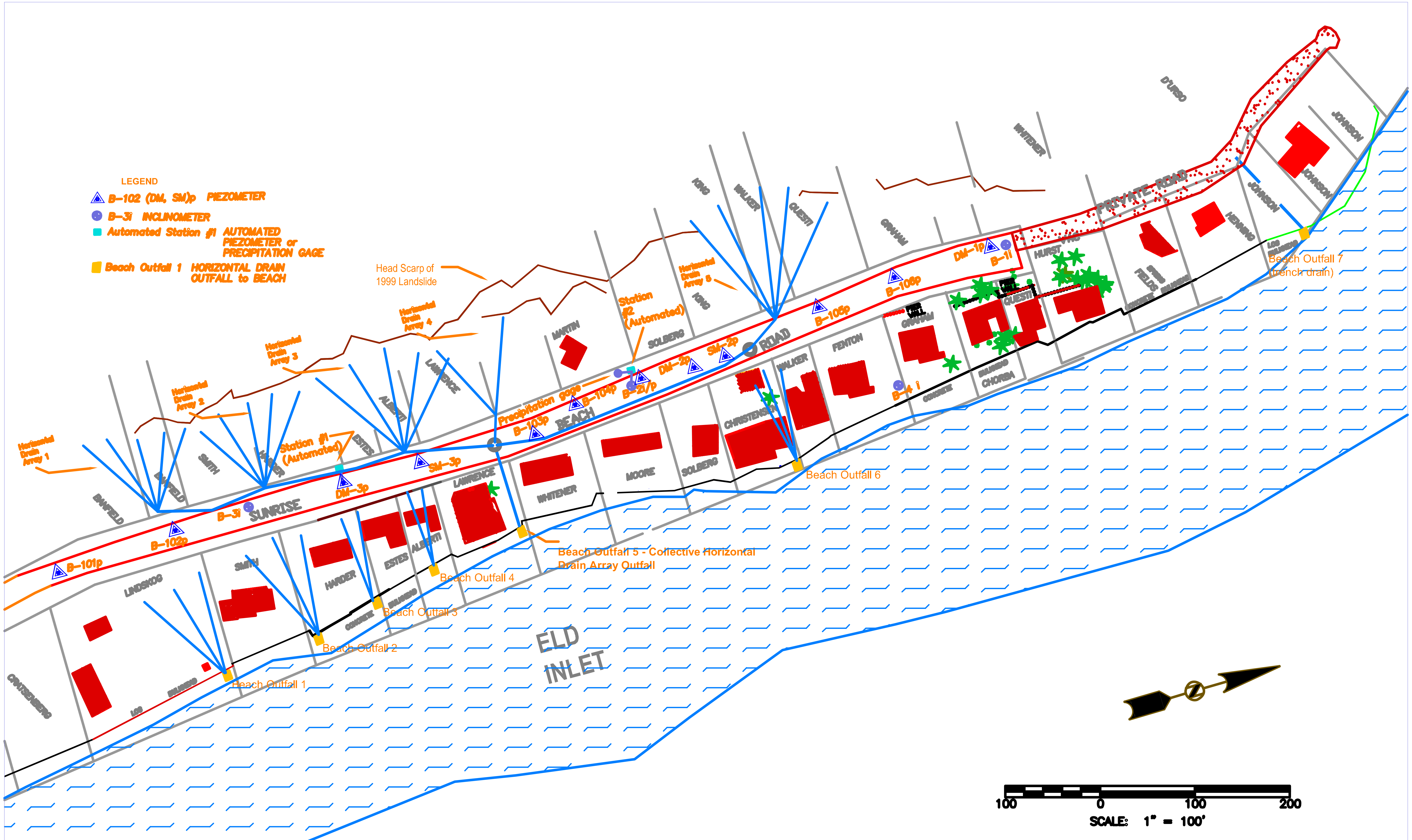


Note: The locations of all features shown are approximate.
Reference: Drawings provided by Thurston GeoData Center, March 1999

GeoEngineers

Hunter Point Road Boring Locations

Figure 4



THURSTON COUNTY
DEPARTMENT OF WATER AND WASTE MANAGEMENT
921 LAKERIDGE DRIVE SW
BUILDING 4, ROOM 100
OLYMPIA, WA 98502
PHONE (360) 754-4681 FAX (360) 754-4682

Designed By:
Drafted By:
Checked By:
Scale:
Contract No.:
Project No.:

Revisions	Date
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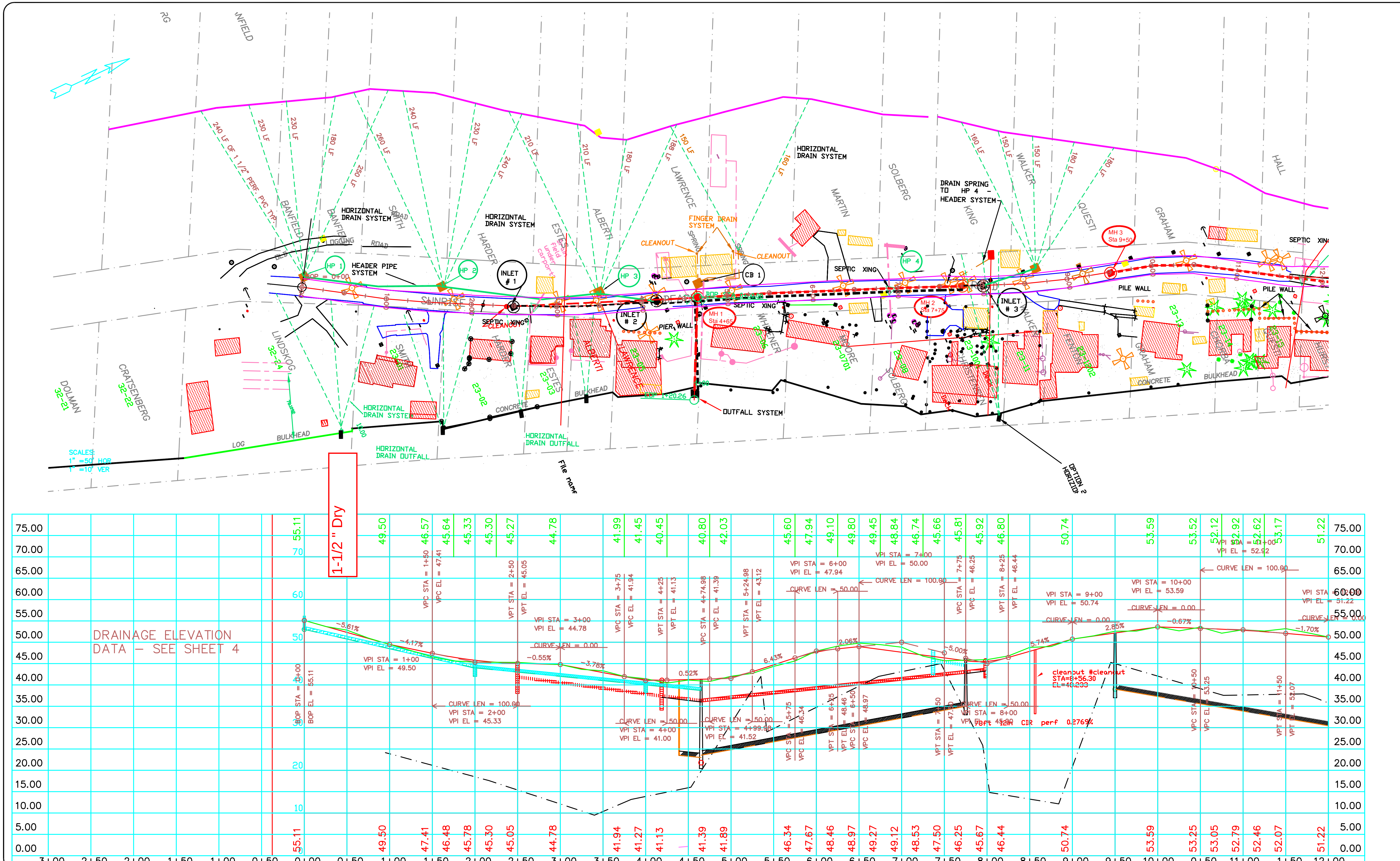
Sunrise Beach Road Landslide

Instrument and Site Plan

Inclinometer, Piezometer and Horizontal Drain Locations

Sheet # of Figure 2



THURSTON COUNTY ROADS & TRANSP. SERVICES
DESIGN/CONSTRUCTION DIVISION
2404-A HERITAGE CT SW
OLYMPIA, WA 98502 (360) 754-4580

DESIGN ENGINEER

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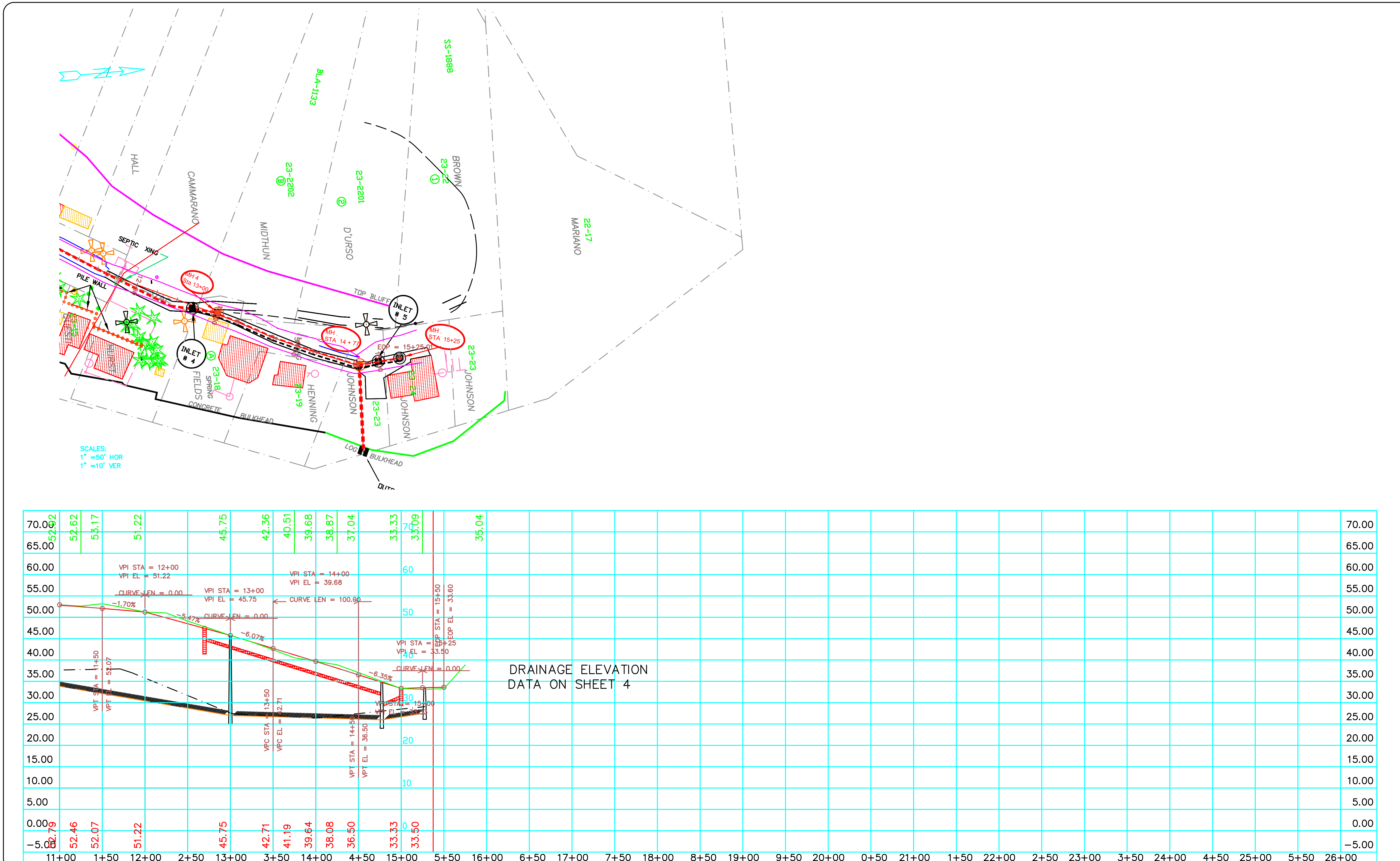
Revisions	Date

PLAN AND PROFILE

C.R.P. No. 77040 F.A. No. ______

SUNRISE BEACH ROAD NW LANDSLIDE MITIGATION



THURSTON COUNTY ROADS & TRANSP. SERVICES
DESIGN/CONSTRUCTION DIVISION
2404-A HERITAGE CT SW
OLYMPIA, WA 98502 (360) 754-4580

DESIGN ENGINEER

Designed: DP, DR
Drafted: DP
Checked: DP, DR
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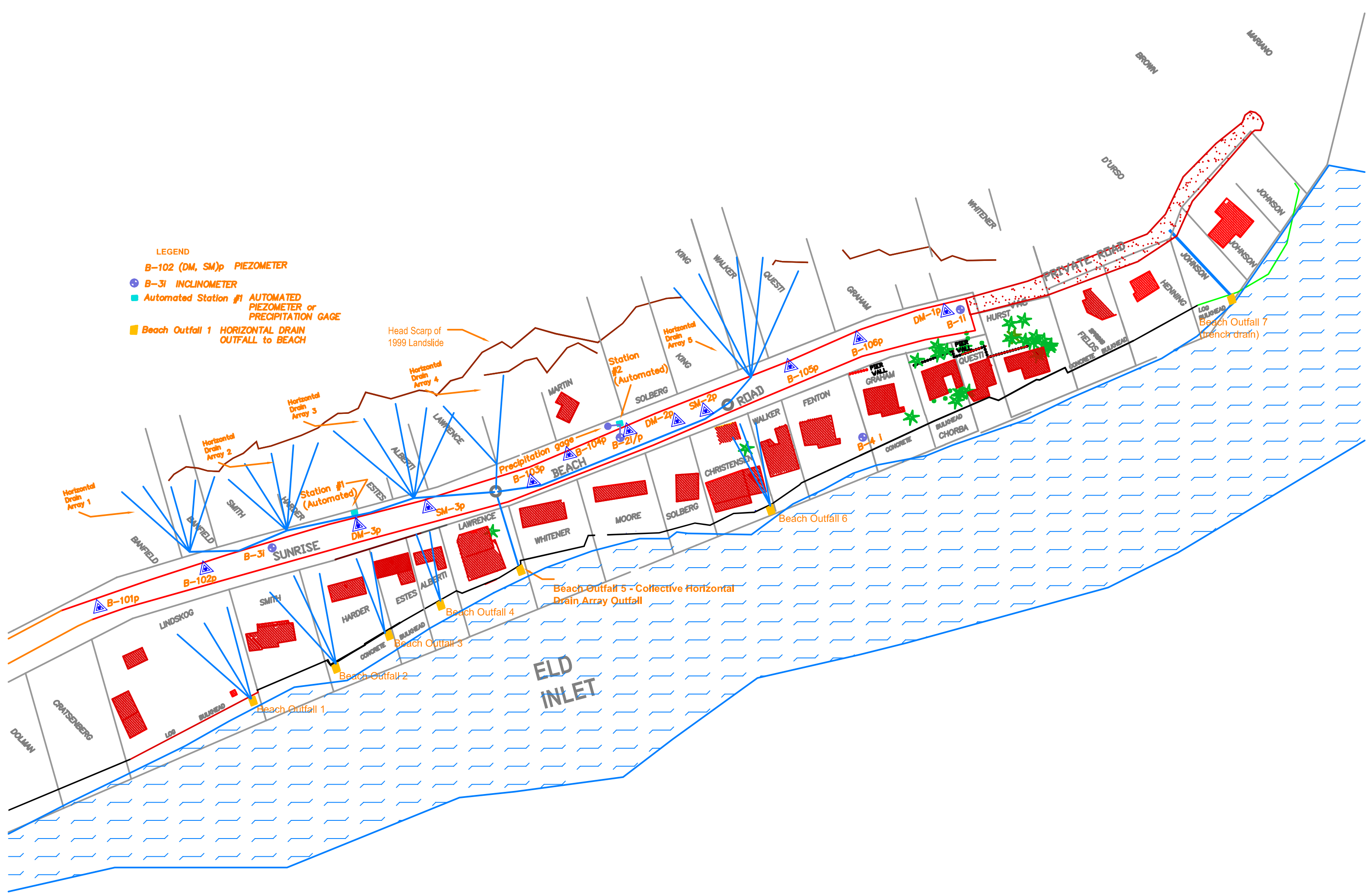
Revisions	Date

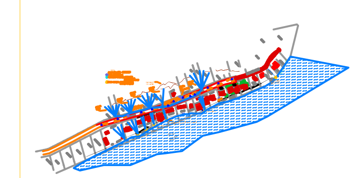
PLAN AND PROFILE

C.R.P. No. 77040 F.A. No. ______

SUNRISE BEACH ROAD NW
LANDSLIDE MITIGATION

Sheet 3 of 12





THURSTON COUNTY

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BOARD BRIEFING AND WORK SESSION

DEPARTMENT OF WATER AND WASTE MANAGEMENT

DIVISION: Storm and Surface Water Program

DATE: September 12, 2000

ITEM: Discussion of Roads and Transportation Services Long Term Instrument Monitoring Plan for Sunrise Beach Road and Hunter Point Road landslides.

RESPONSIBLE STAFF: L. Olson, M. Cook

PURPOSE OF THIS BRIEFING: Staff will apprise the Board of County Commissioners on a Long Term Monitoring Plan developed for the Roads and Transportation Services Department to observe and monitor potential continued landslide activity along Sunrise Beach Road and Hunter Point Road.

BACKGROUND INFORMATION AND OTHER REFERENCES: Two Geotechnical consultants were retained by Thurston County to investigate the Sunrise Beach Road and Hunter Point Road landslides to monitor conditions for the Roads and Transportation Services Department and develop potential mitigation strategies. The findings of the geotechnical consultant investigations are presented in the following reports. County staff created a Long Term Instrument Monitoring Plan (LTIMP) in 2000 to establish monitoring intervals, reading procedures, and data presentation protocols for continued monitoring of selected portions of the slides. The LTIMP is currently being reviewed in draft form.

- Shannon and Wilson Inc. Phase I and II Geotechnical Reports (Sunrise Beach Road Slide, 1999)
- GeoEngineers Inc. Phase I and II Geotechnical Reports (Hunter Point Road Slide, 1999)

- Thurston County Long Term Instrument Monitoring Plan (Sunrise Beach Road and Hunter Point Road Slides, 2000)

Essential products are:

- Final draft of the Long Term Instrument Monitoring Plan
- Monitoring reports for each site documenting observations from the field instruments.

DISCUSSION: During the winter seasons of 1996-97 and 1998-99, above average rainfall was recorded throughout western Washington and Oregon resulting in several major landslides. Dozens of landslides occurred throughout the Puget Sound region that resulted in millions of dollars in property damage and the loss of several lives throughout the region.

In Thurston County, landslides damaged or threatened several communities and roadways around the county. Two damaging landslides occurred in the communities along Sunrise Beach Road and Hunter Point Road in the Carlyon Beach community. The two landslides caused extensive damage to homes and roads in the communities. As a result of the slides, two initial phase I studies were conducted by two geotechnical consultants under contract with Thurston County. The studies were conducted to identify characteristics of the landslides by installing geotechnical instrumentation to monitor the magnitude and extent of the slides. A second phase of geotechnical investigations was undertaken by the consultants to provide recommendations on drainage and stabilization methods and to provide further monitoring of the two landslides.

The Roads and Transportation Services Department began periodically monitoring the instruments installed by the consultants at both landslide locations in 1999 after the contracts with the consultants had ended. Construction of recommended drainage mitigation techniques along Sunrise Beach Road had been completed at the end of the consultant contracts and Roads and Transportation Services staff was interested in evaluating the condition of the newly installed road stabilization techniques along Sunrise Beach Road.

In addition to evaluating the newly installed roadway repairs, both of the geotechnical consultants reported that continued movement within the slide masses is likely in the future and recommended monitoring of the slides. To address this, staff created a twenty-year, Long Term Instrument Monitoring Plan utilizing the existing instruments.

The monitoring will consist of electronic measurement of slope inclinometers to determine rates, direction and depth of movement, groundwater level monitoring using piezometers, and manual measurement of groundwater discharge in areas along Sunrise Beach Road where horizontal drains were installed to lower groundwater levels in the hillside. Three new automated instruments will be added to the existing instrument array to expand the data gathering capability of the sites. The existing instruments are concentrated within and adjacent to Sunrise Beach Road and Hunter Point Road. This results in a limited ability to project conditions within either of the slides much beyond the roadways. The implication of this concentration of instruments is that the information obtained from them cannot be reliably applied to the entire slide masses. This fact is recognized in the limitations of the instruments as early warning indicators in the Long Term Instrument Monitoring Plan.

FINANCIAL IMPACTS: The estimated cost of the first five-year portion of the twenty-year plan is $34,000. The cost will be paid by Roads and Transportation Services. Amendments to the cost of the remaining fifteen years of the plan will be evaluated and projected every five years thereafter.

CRITICAL CONSIDERATIONS:

1. Long term monitoring of the landslides is critical to evaluate subsurface conditions within portions of the slide masses. The existing instrumentation installed by previous geotechnical consultants was designed to provide limited capabilities for detecting reactivation of portions of the landslides. Any public notification of movement detected within the roadway instruments should be carefully evaluated.

2. The Long Term Instrument Monitoring Plan outlines procedures for monitoring the Sunrise Beach and Hunter Point Road Landslides and provides guidance to County staff in evaluating the data gathered during the twenty-year duration of instrument monitoring.

3. The LTIMP provides guidelines for identifying signs that property or safety may be at risk. The plan is not intended as an early warning guide for local residents to safeguard against injury and property loss.

STAFF RECOMMENDATIONS:

1. Adopt the Long Term Instrument Monitoring Plan for evaluating and documenting field conditions at the sites.

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TODAY'S RESULT/FUTURE ACTION:

ADDENDUM TO THE LONG TERM INSTRUMENT MONITORING PLAN

Section 4.1.4 – Horizontal Drain Outfalls – Reading Procedures

Replace sentence: " There are two locations where the outfalls will be accessed using manholes in the roadway."

With the sentence: "Due to the depth and angle at which the pipes enter the base of the manholes it is not possible to access them from the surface."

Replace sentence: " A bucket tethered to a rope will be used to collect water flowing from the pipes over a known period of time."

With the sentence: "Discharge will be observed and measured at the beach bulkhead outfall and the contributing components of surface runoff and horizontal drain discharge will be estimated based on visual observations."