GEOTECHNICAL INVESTIGATION & REPORT

WASHOUGAL RIVER ROAD
FANNING HILL SLIDE AT MP 13, CRP 1006.2 - PHASE I
SKAMANIA COUNTY, WASHINGTON

Submitted To:

Skamania County Public Works Department, County Annex
170 NW Vancouver Avenue
Stevenson, Washington 98648

Submitted By:

AGRA Earth & Environmental, Inc.
7477 S. W. Tech Center Drive
Portland, Oregon 97223-8025

9-61M-10402-0

March 2000

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March 6, 2000
9-61M-10402-0

Mr. Gary Turner, PE
Project Engineer
Skamania County Public Works Department, County Annex
170 NW Vancouver Avenue
Stevenson, Washington 98648

Dear Mr. Turner:

RE: GEOTECHNICAL INVESTIGATION & REPORT
WASHOUGAL RIVER ROAD
FANNING HILL SLIDE AT MP 13, CRP 1006.2 - PHASE I
SKAMANIA COUNTY, WASHINGTON

In accordance with your authorization, AGRA Earth & Environmental, Inc. has completed our preliminary geotechnical study for the Washougal River Road, Fanning Hill Landslide at MP 13 in Skamania County, Washington. We have identified a slide surface at a depth of ± 70 feet below the road level at the west end of the project. Based on our discussions with you on February 04, 2000, conceptual surface and sub surface drainage treatments are discussed in this report. A conceptual cost estimate is also prepared for the drainage alternate.

This report also includes recommendations for additional geotechnical and civil work to design the recommended slope stabilization measure(s). An expanded continuing monitoring program through at least one full season is also recommended.

We appreciate the opportunity to assist you on this project. If you have questions regarding this report, or require additional information, please feel free to contact either of the undersigned at (503) 639-3400.

Sincerely,

AGRA Earth & Environmental, Inc.

Rajiv Ali, P.E.
Project Geotechnical Engineer

Frederick G. Thrall, PhD, PE
Principal Geotechnical Engineer

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1.0 PROJECT BACKGROUND

The segment of the Washougal River Road addressed in this study is located immediately east of MP 13 as shown in Figure 1. Since the 1970 realignment, approximately 1300 lineal feet of Washougal River Road, east of mile post 13 has experienced repeated failures due to an active landslide. Repeated pavement resurfacing and patching has been done to correct the cracks in the pavement where the road crosses the left and right flanks of the slide area. As indicated in our scope of work for this project, we proposed to complete this work in two phases: i) Phase I would preliminarily identify the landslide conditions determined from data taken over the winter of 1999-2000 and present conceptual options for fixing the landslide; ii) Phase II would be the development of a mitigation option for treating the landslide condition identified in Phase I. This document presents the results of our Phase I studies.

Two reports completed in areas adjacent to the project site were identified: i) Northwest Testing laboratories, 1971 includes a boring log of the subsurface located within the eastern portion of the subject slide area. The boring logs are described as having an upper unit, 26 to 30 feet thick, consisting of slope wash containing angular rock fragments and boulders in a soft red or yellow clay matrix. Underlaying the upper unit is a weathered basalt, 4 to 8 feet thick, following by fractured, blue-grey basalt; and ii) Kent Associates, 1981 presents general regional geologic information in support of geothermal studies. This information is incorporated into our discussion regarding regional geology.

2.0 SCOPE OF WORK

AGRA Earth & Environmental, Inc. has prepared this report for Washougal River Road - Fanning Hill Landside at MP 13 for Skamania County, Washington. The scope of work includes the following:

- Development of three survey cross-sections and one analytical section
- Preliminary surface drainage design
- Literature review
- Geologic mapping
- Field investigation and geotechnical instrumentation installation
- Inclinometer and piezometer monitoring
- Laboratory testing
- Environmental research
- Engineering analysis
- Draft engineering report
- Development of Phase II scope and estimated fees

3.0 FIELD EXPLORATION

The field exploration program for this project consisted of drilling three subsurface borings, installation and monitoring of geotechnical instrumentation.

3.1 SUBSURFACE EXPLORATION

Three borings were advanced from December 13 to 20, 1999, using mud rotary and rock coring drilling techniques. Temporary casings were advanced during the drilling to prevent soil caving. The Boring locations are shown on Figure 2. Boring B-1, B-2 and B-3 were advanced to 31.5, 86.5 and 41.0 feet below existing ground surface (bgs) respectively. The Boring locations were estimated by a representative of AGRA from previously established engineering survey stationing marks. Boring locations shown on Figure 2 should be considered approximate. Boring logs are provided in Appendix A of this report.

Soil samples were collected at select intervals in each boring for visual classification and geotechnical laboratory testing. HQ size rock cores were recovered from the rock formation encountered. Figures A1 through A5 shows photographs of the rock cores collected.

3.2 GEOTECHNICAL INSTRUMENTATION

All three borings were completed as inclinometers. 2.5 inch I.D. slope inclinometer casings were installed in all of the borings to monitor the slope movement. Boring B-1 was also completed as a standpipe piezometer. Two vibrating wire piezometer were installed, one in boring B-2 and one in boring B-3. Details of these installations are shown in the boring logs in Appendix A.

4.0 LANDSLIDE CONDITIONS

4.1 GEOLOGIC RECONNAISSANCE AND REGIONAL GEOLOGY

Regional Geology. Regional geology in the site vicinity is primarily volcanic in origin and the units have been combined into the Western Cascade Group (Hammond, 1980). The geologic stratigraphy is described as a complex set of Oligocene age volcanic units that include calkalkaline andesite, dacite-rhyodacite, lava flows, pyroclastic flows, mudflows and volcaniclastic deposits. Regional correlation of units is complex. However, the stratigraphy resembles the Ohanapecosh Formation based on visual descriptions. The lower stratigraphic units show low grade regional metamorphism by hydrothermal alteration (Kent Associates, 1981). The Western Cascade Group is gently folded with one anticline and several synclines that plunge to the southeast. One of the synclines is mapped east of the project site.

The MP 13 landslide site and surrounding area is mapped as Qls, landslide terrain in the Geologic literature (Figure 3). As shown, the road cuts across the southern edge of a large landslide that covers a majority of T2N, R5E, Section 27. The active portion of the MP 13 landslide which has a significant effect on the road is limited to the extreme southwest lobe of a much larger ancient landslide (Figure 4).

Activity of the massive landslide was confirmed by our reconnaissance of the roadway slide and surrounding area. The topography of the site vicinity is characteristic of landslide terrain and is generally described as hummocky and irregular with steep slopes followed by flat benches. A majority of the mature conifer trees are "back-tilted" indicating downslope movement and rotation.

The slopes in and around Camp Melacoma, located north of the project site, range from 20 to 25 degrees dipping to the south and are followed by nearly horizontal benches with abundant springs observed near the base of the slopes.

Geologic Reconnaissance. Results of our geologic reconnaissance of the immediate area of the roadway is recorded on Figure 5. Site topography was estimated based on the results of the survey cross section transects. Visible surface features were noted, including some of the drainage ways, cracks and outcrops. A transect of the slope located northwest of the borings indicate that the surficial geology consists of unconsolidated landslide deposits overlying a dense, light gray, highly weathered cobble conglomerate consisting of layered basalt clasts in a clayey silt matrix. Underlying the conglomerate is a thick unit of weathered basalt that extends along the slide scarp and below the contact between the scarp and the top of the slide surface.

Many of the mature trees located on the top of the benched areas are "back-tilted" to the north. The topography south of the road is hummocky and irregular with blocky basalt outcropping near mid-slope and continuing at relatively shallow depths down to the river. A prominent "toe" feature forms a steep bank on the north side of the river. Several tension cracks were observed in the asphalt road pavement and shoulder aggregate. The location and orientation of the cracks indicate the formation of multiple scarps and corresponds with breaks in topography that indicate continued displacement over time. It appears that the limits of the very active landslide area affecting the roadway can be shown as indicated on Figure 5.

A major inflow area is located on the extreme northwest corner of the active area. This inflow has been identified as a potential major contributor to the overall stability of the local landslide. Observations made after the major storm event in late November, 1999 and later during lesser events indicated that this inflow creates a pond which appears to eventually soak into the landslide mass through the exposed cracks and fissures. The majority of landslide activity appears to be focused in the area as indicated (Figure 5) by the larger crack offsets located just to the south of the inflow area and the existence of springs emerging near the river level just down slope. We addressed treatment of the drainage in this area in our memorandum and accompanying drawing dated December 21, 1999. The memorandum presents a treatment method for this specific drainage area and indicates that it is "imperative" that surface water infiltration in the landslide mass be minimized.

4.2 SUBSURFACE CONDITIONS

Based on subsurface cores encountered in the borings for this project, the subsurface geology consists of 15 to 23 feet of unconsolidated sediments consisting of clayey silt, sand and gravel. Some shallow granular fill was encountered in borings B-2 and B-3 near the road. Underlying the sediments is strong, slightly weathered, highly fractured and jointed, gray basalt that is approximately 33 feet thick. The base of the basalt is highly weathered to decomposed and is approximately 9 feet thick (Figure 6).

Underlying the basalt are a series of four volcanic interflow deposits that includes debris flow, volcanic breccia, hydrothermally altered flow breccia and volcanic tuff. These are depicted on

Figure 5 as one deposit. The sequence is approximately 9 to 10 feet thick and contains abundant volcanic rock fragments and pumice. A contact was observed in boring B2 below the volcanic breccia that appears to contain a large amount of charcoal as determined by visual observation. The organics are incorporated into a debris flow that may indicate a possible buried soil zone. The layers below consist of a fine-grained flow breccia and a volcanic tuff that show hydrothermal alteration as indicated by the presence of abundant chlorite and epidote. The abrupt change to hydrothermal alteration characteristics indicates an unconformity that may be the result of a slide surface.

The failure plane is assumed to be near the charcoal layer as indicated by the slope inclinometer data and the low percent recovery of the core sample. This same deposit was found exposed near the edge of the River as indicated in Figure 6. The upper basalt is thought to be moving as a transnational block, or blocks, with a small rotational component as indicated by the "back-tilted" trees.

4.3 GROUNDWATER

Groundwater was encountered at a depth of 52 and 22 feet bgs in borings B2 and B3 at the time of exploration. Subsequent measurements in the piezometers are summarized in Table I below:

Table I
Measured Ground Water Levels

Boring Number & Depth	B2 - 50 feet		B2 - 72 feet		B2 - 22 feet	
Date	Depth (feet)	Elevation (feet)	Depth (feet)	Elevation (feet)	Depth (feet)	Elevation (feet)
December 24, 1999	49.5	523.5	57.5	515.5	21.7	554.3
January 04, 2000	49.9	523.1	57.4	515.6	21.9	554.1
January 13, 2000	50.3	522.7	56.5	516.5	22.3	553.7

Groundwater was measured at a depth of approximately ± 57 and ± 22 feet in borings B-2 and B-3 respectively. This corresponds to an approximate elevation of ± 515 and ± 554 feet. The groundwater appears to be approximately 15 to 20 feet above the failure surface. Springs were observed at the river level as indicated in Figure 5, during our geologic reconnaissance. The groundwater data shows gradually receding levels. However, during this time period, movements on the order of 0.5 inches were measured in B-2.

4.4 LANDSLIDE MOVEMENT

The three inclinometer readings were initialized on December 24, 1999 and subsequent readings were recorded on January 04 and 13, 2000. The A and B axis deflections for the three inclinometers are shown in Figures A6 through A8. A study of this data indicates no movement in inclinometer B1 which shows that this installation is not deep enough to record movement.

Inclinometer B2 shows a distinctive movement at a depth of 69 to 70 feet below the existing ground surface. Inclinometer B3 shows a slight backtilting at a depth of 22 feet that may be due to the vertical downward movement of a graben at this location. Based on the inclinometer data, the depth of movement is approximately 70 feet below the road surface. Figure 6 shows our interpreted subsurface section and failure surface.

5.0 LABORATORY TESTING

Laboratory tests were performed in accordance with accepted test methods of the American Society for Testing and Materials (ASTM). Selected samples were tested for their moisture content. Moisture contents of soils samples are indicated in the boring logs.

6.0 ENGINEERING ANALYSIS

6.1 DISCUSSION

Review of Figure 6 indicates that the top of the basalt in B-3 and the top of the basalt in the exposed scarp are offset by ± 120 vertical feet. This indicates that major significant movements are possible and continued movements similar to those observed in the past are likely without treatment. The area of very active movement, as defined by the tension cracks, is a very active slide within a larger active landslide. Typically, these massive landslides can be segmented into "lobes" of movement with each lobe exhibiting various levels of activity. Defining the lobes, and relative activity of the larger landslide is a substantial undertaking and is not within the scope of this study. The future behavior of the massive landslide therefore remains unpredictable. We may expect that this very large landslide may reactivate at any time, probably in response to unusually wet conditions. Any movements of the massive landslide will exert forces and involve large tracks of land far larger and deeper than anything the County may attempt to stabilize.

We therefore recommend that the County specifically focus on stabilizing the more manageable area defined within the limits shown on Figure 5. The underlying issue is that anything that the County constructs at this location is subject to sudden destruction by the much larger landslide. We therefore also recommend that the County limit the costs of the installation with the understanding that periodic rebuilding may be required.

6.2 SUBSURFACE MODEL - SECTION AA'

A conceptual model was developed for slope stability analysis along Section AA'. The model is limited to within the limits of the very active landslide between the scarp just upslope of the road to the river. Figure 6 shows the subsurface profile along this section. This model was developed based on the borings, geologic reconnaissance and a review of literature for the project site. The failure surface is interpreted to be near the charcoal layer (as indicated in the summary logs and by the slope inclinometer movements) extending to the river. The low ground or depression near the scarp is interpreted to be a graben. ?

Groundwater was measured at approximately 15 to 20 feet above the lower basalt layer. Springs were observed in the vicinity of the river along this section during our geologic reconnaissance. We understand that under the existing conditions, the groundwater may rise rapidly from the input of surface water flowing onto the landslide and ponding in the low area adjacent to the scarp. The groundwater levels shown on the map indicate the "steady state" or slowly receding levels as of January 4 - 13, 2000. We noted that 0.5 inches of movement were recorded during the receding levels, indicating a factor of safety less than one, even during lower ground water levels than might be expected during a storm event.

6.3 BACK ANALYSIS

A back analysis was conducted along Section AA' using Computer program X-Stabl V5.2. The slope model described in Section 6.2 along with the measured ground water levels was used for this analysis. Back analysis is conducted by setting cohesion intercept at zero and calculating the effective stress angle of internal friction for incipient failure conditions (FOS = 1.0). The angle of internal friction (ϕ') was estimated to vary between 9.5 and 10 degrees for incipient failure conditions. This value of ϕ' was used in our subsequent analysis to evaluate the drainage measures.

6.4 FOS IMPROVEMENT

A stability analysis was conducted for Section AA' for various lowered water levels using the strength parameters developed in Section 6.2. The stability analysis was conducted using computer program X-Stabl V5.2. The results of our stability analysis are summarized below:

Table 2
Factor of Safety Under Various Ground Water Level Scenarios

Groundwater Conditions	Spencer's Method		Generalized Limit Equilibrium Method	
	Φ = 9.5 Deg	Φ = 10 Deg	Φ = 9.5 Deg	Φ = 10 Deg
Measured Water Level	0.989	1.026	0.981	1.018
Lowered by 5 feet	1.051	1.090	1.043	1.082
Lowered by 10 feet	1.095	1.135	1.087	1.127
Lowered by 15 feet	1.130	1.178	1.121	1.170

Based on the results of this analysis, it appears that a reduction in water level by 15 feet will increase the factor of safety on the order of 10 to 15 percent.

7.0 REMEDIAL MEASURES

The above indicated findings were presented to the county on February 04, 2000. Based on our discussions with the County staff. We concluded that, given the regional condition of the much larger landslide impinging on any treatment, the ground conditions and relative FOS improvements which can be realized by removing water from the slope, the most practical and cost effective remedial measure appears to be drainage improvements. The drainage improvements under consideration include immediate rerouting of the major inflow area per the plans already submitted to the County, further surface regrading and rerouting of surface water flows away from the very active slide area, and potential installation of subsurface horizontal drains. Thus options of toe buttresses, retaining walls, etc., were only briefly considered in our discussions and are therefore not further discussed in this report.

The mutually agreed approach would be to complete surface drainage improvements this summer, install further subsurface borings and monitoring instrumentation to cover the east portion of the landslide, and monitor the improvements over the next one to two wet seasons. Considerations would then be given to installing the subsurface drains based on the success of the surface drainage measures.

We have completed an initial assessment of the permitting requirements involved in pursuing the above described landslide treatment. We understand that there is an argument for some relief from the permitting agencies given that the County is contemplating improving the stability of the slope which, in turn, will reduce the input of sediment into the river. We also understand that the requirements of these permits may have a significant impact on the design approach and final design details for the project. A brief synopsis of possible permitting scenarios are as follows:

> *404 of the Clean Water Act* - Because of the quantity of water in the project area and the saturated nature of the soils, it is unlikely that all proposed activities will be able to avoid impacts to jurisdictional waters (which includes wetlands, drainages, intermittent streams, etc.). If impacts can be kept down, which seems reasonable, then the permitting should go fairly easy (Nationwide process). However, the dispersed nature of the impacts will create challenges for keeping the permitting cost effective.
>
> *401 of Clean Water Act* - Many of the Nationwide permits have been pre-approved for § 401 water quality certification. Because of this there is a good chance that it will be possible to avoid § 401 for the Washougal River road project. If it is not possible to avoid, the biggest impact will likely be the time certification adds to the process.
>
> *Shoreline Management Act* - The Shoreline Management Act can be avoided by ensuring that no activity occurs within 200 feet of the Washougal River. There appears to be some flexibility with respect to where the drainage mechanisms outfall. Accordingly, it may be possible to finagle the design in such a way that it avoids triggering Shoreline requirements.
>
> *State Environmental Policy Act* - There is little chance of avoiding the need for preparation of SEPA document. However, the proposed project should have little affect on most of the elements that are considered during the process, which will ease the documentation burden somewhat.
>
> *Endangered Species Act § 7 consultation* - If the project results in an impact to wetlands or other jurisdictional waters, then it will be necessary to comply with § 7 consultation requirements. However, needing to comply with § 7 is not all-bad. Projects that receive concurrence from NMFS and/or USFWS do not need to worry about § 9 and § 4(d) prescriptions. This removes substantial potential liability concerns.

Endangered Species Act §§ 9 and 4(d) - These sections are only relevant if the project does not involve federal permitting. However, if there is no federal nexus, then these will be relevant.

Hydraulic Project Approval - If the efforts to remove groundwater from the area of the slide are successful, then they will also result in a release of additional water into the Washougal and/or one of its tributaries. This release of additional water will trigger the need for an HPA. If it is possible to release the water in a manner that avoids impacts to habitat values, then the process should not be overly difficult.

Further detailed discussions of the permitting issues are included in Appendix C.

7.1 SURFACE DRAINAGE

A conceptual surface drainage plan for the major inflow area was developed by Entranco and is shown in Appendix D. The proposed improvements are intended to produce immediate results in reducing the activity of the subject landslide. Presently, large amounts of water are ponding near the base of the scarp at the west margin of the active landslide. Our observations indicate that this water infiltrates directly into the slide mass. Immediate removal of the "pond" condition will reduce the amount of water entering into the slide thus reducing the activity in this area of the slope.

The proposed approach includes an open ditch draining into existing culverts at the road. The improvements can be built by Skamania County maintenance personnel or by a grading and drainage contractor. The catchment and ditch is designed to trap sediment and provide storage during a large storm event. We anticipate that the water quantities would overflow in the existing 18-inch culvert at the road. We have therefore included provisions for diverting excess flows into the other existing culverts which cross the road.

Plans are to further incorporate the ditch construction into the final surface drainage network sized to handle the design storm and provide a low flow pipe and outlet and accompanying improvements to the outlet culvert(s) which cross the road. We have included a scope and costs for AGRA/Entranco to complete a comprehensive design for the site drainage. The major components of that design are:

- Prepare topographic survey for the approximately 21 acres site
- Prepare AutoCAD basemap for the site
- Further identify drainage problem areas and develop preliminary grading and drainage solutions
- Prepare design memorandum and present to the County
- Select final design approach and finalize grading plans and details
- Complete environmental documentation and permitting.

A draft of the detailed scope and estimated fees for the drainage design and environmental permitting are included in Appendix E. The final scope will require discussions between the County and AGRA Earth & Environmental prior to finalization.

It is imperative that surface water infiltration into the landslide mass be minimized. Excess water in the slide mass increases its weight and the water pressures driving the movement. Draining the high flows through the ditch will immediately improve the stability of the slope (our slope stability analysis will demonstrate this effect). Eventual further removal of the low flows will help complete the stabilization process.

7.2 GEOTECHNICAL MONITORING

AGRA has included a Phase II scope of work to fill in our knowledge of the eastern portion of the slide area with borings and inclinometers and continue to monitor the landslide over the 2000 – 2001 wet seasons. The results of the borings and monitoring will be used to evaluate the effectiveness of the surface grading and drainage improvements and provide design information for eventually installing horizontal drains. The major components of the geotechnical monitoring include:

- Refine the geologic reconnaissance using the topographic map developed by Entranco.
- Installation of Borings and field instrumentation
- Monitoring of the instruments over a period of one wet season
- Analysis of the effectiveness of the surface water drainage
- Optional design of horizontal drains

A draft of the detailed scope and estimated fees for the geotechnical monitoring are included in Appendix E. The final scope will require discussions between the County and AGRA Earth & Environmental prior to finalization.

7.3 HORIZONTAL DRAINS

If the groundwater cannot be adequately lowered by surface drainage, horizontal drains can be used to further lower the water table. A horizontal drain is a small diameter (3- to 6- inch hole) drilled at a 5 to 10 percent grade and fitted with a 1.5- to 2.5- inch diameter perforated pipe wrapped in filter fabric. The first five feet of the pipe next to the outlet should not be slotted to prevent invasion of vegetation and other subsequent obstructions. The length of sub-surface drainage pipes for this project would be on the order of 400 to 500 feet. One to two layers of this system may be required. Horizontal spacing for the pipes would be on the order of 20 to 50 feet. A maintenance access road should also be provided for the future maintenance of the drainage system.

Based on preliminary analysis, approximately 10,000 to 15,000 linear feet of drain would be required for this project. These drains are generally installed for a cost of $12.00 to $15.00 per foot. Thus the drainage system for this project could be completed for an estimated cost of $120,000 to $225,000 would be required for the installation of subsurface drainage system.

Incidental costs for the construction of access roads, repaving the road are not included in this estimate.

8.0 LIMITATIONS

This report has been prepared for Skamania County, and their agents, for specific application to this project in accordance with generally accepted geotechnical engineering practice. This report may not contain sufficient information for purposes of other parties or other uses.

The geotechnical recommendations provided in this report are based on site conditions as they are described herein, and on information gathered during our field exploration, office review, and on information provided by the client's representatives. If there is a substantial lapse of time between our geotechnical exploration and the start of work at this site, or if conditions have changed, or if the project details have been significantly modified from that described herein, we recommend that we be requested to review this report to reevaluate our conclusions and recommendations.

Subsurface conditions encountered in soil borings were interpreted based on subsurface exploration as well as a review of existing in-house and published soil and geologic literature for the project site vicinity. The soil boring logs depict subsurface conditions only for the specific boring locations at the time of exploration. Subsurface conditions and water levels at other locations may differ from those where sampling was performed. The passage of time may also result in changes in the conditions interpreted to exist at the locations where sampling was performed during this investigation.

The information provided in this report is preliminary and is for the purposes of conceptual design only. Additional study is suggested in Appendix E and should be completed before the design of this project is completed.

If you have any questions or desire further information, please feel free to contact the undersigned at (503) 639-3400.

AGRA Earth & Environmental, Inc.

Rajiv Ali, P.E.
Project Geotechnical Engineer

Rick Thrall, P.E.
Principal Geotechnical Engineer

FREDERICK G. THRALL
23278
EXPIRES 10/09/00

REFERENCES

Geomatrix Consultants, 1995, Seismic Design Mapping State of Oregon, Oregon Department of Transportation, scale 1:250,000.

Hammond, Paul E., 1980, Reconnaissance Geologic Map and Cross Sections of Southern Washington Cascade Range Latitude 4530'-4715' N., Longitude 12045'-12222.5' W.

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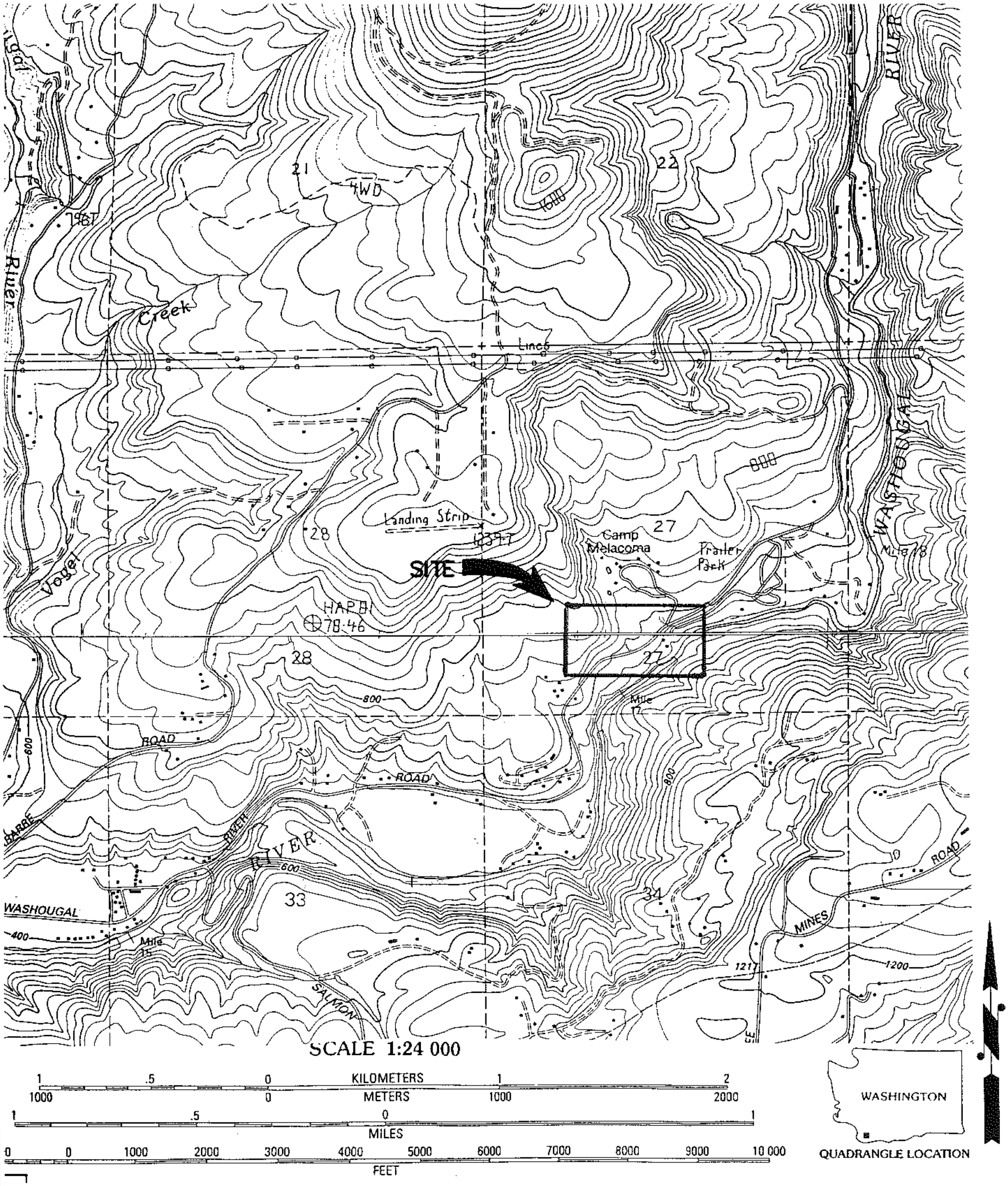


FIGURE 1

AGRA
ENGINEERING GLOBAL SOLUTIONS
7477 S.W. Tech Center Drive
Portland, OR, U.S.A. 97223-8025

W.O. 9-61M-10402-0
DESIGN RA
DRAWN DRF
DATE JAN. 2000
SCALE NTS

WASHOUGHAL RIVER ROAD MP13
SKAMANIA COUNTY, WASHINGTON

SITE LOCATION MAP

AGRA EARTH & ENVIRONMENTAL, INC. DRAWING NO. \PROJECTS\21\10402\SITELOC.DWG

APPENDIX A

Field Data

PROJECT: Washougal River Road MP 13 **PAGE 1 OF 2**

Boring Number: B- 1

Boring Method: Mud Rotary/HQ Coring
Borehole Diameter: 5.0 inch
Ground Surface Elevation: 607 feet

DEPTH (FEET) — SOIL DESCRIPTION

0 — Soft, wet, brown clayey SILT with trace gravel and roots (topsoil).

Medium dense, brown, moist to wet, sandy GRAVEL with trace clay (landslide debris).

5

10

SPT refusal at 15 feet. Switched to HQ coring.

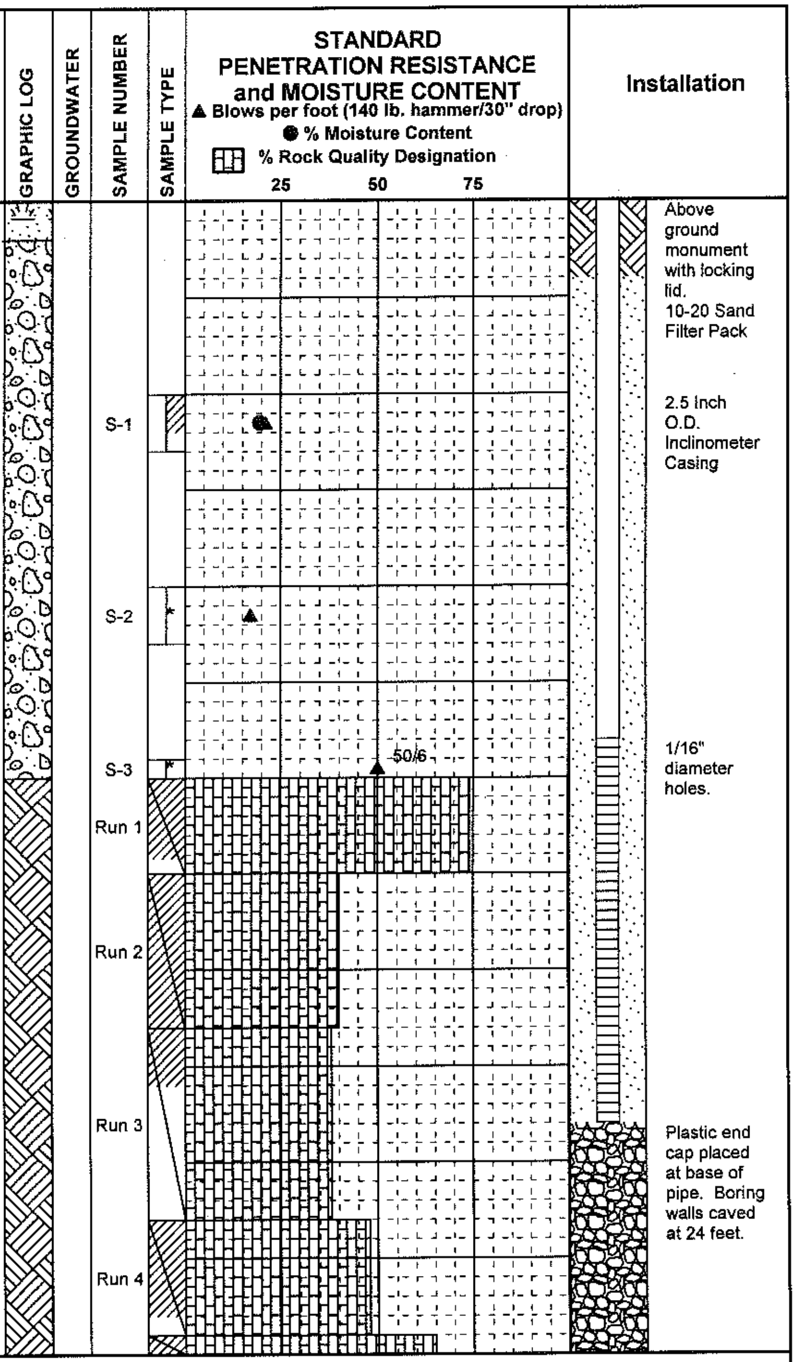
15 — Strong to very strong (R5-R5) BASALT, gray, slightly weathered, closely jointed. Joints are predominantly planer, smooth, and open with red and black iron staining, clay infilling, or epidote mineralization.

20

Sample lost at 23 - 26.5 feet. Hole caved at 24 feet.

25

30



LEGEND

2.0" O.D. split spoon sampler	Percent Recovery
HQ Diamond Core Barrel Sampler	* No Recovery

AGRA Project Number: 9-61M-10402-0

Washougal River Road MP 13
Skamania County, Washington

AGRA Earth & Environmental
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GOODBOR WASHUGAL.GPJ GOODBOR.GDT 3/6/00

Drilling Started: 12/20/99 **Drilling Completed:** 12/20/99 **Logged By:** C. Clough **Boring Number:** B- 1

Boring Number: B- 1

Boring Method: Mud Rotary/HQ Coring
Borehole Diameter: 5.0 inch
Ground Surface Elevation: 607 feet

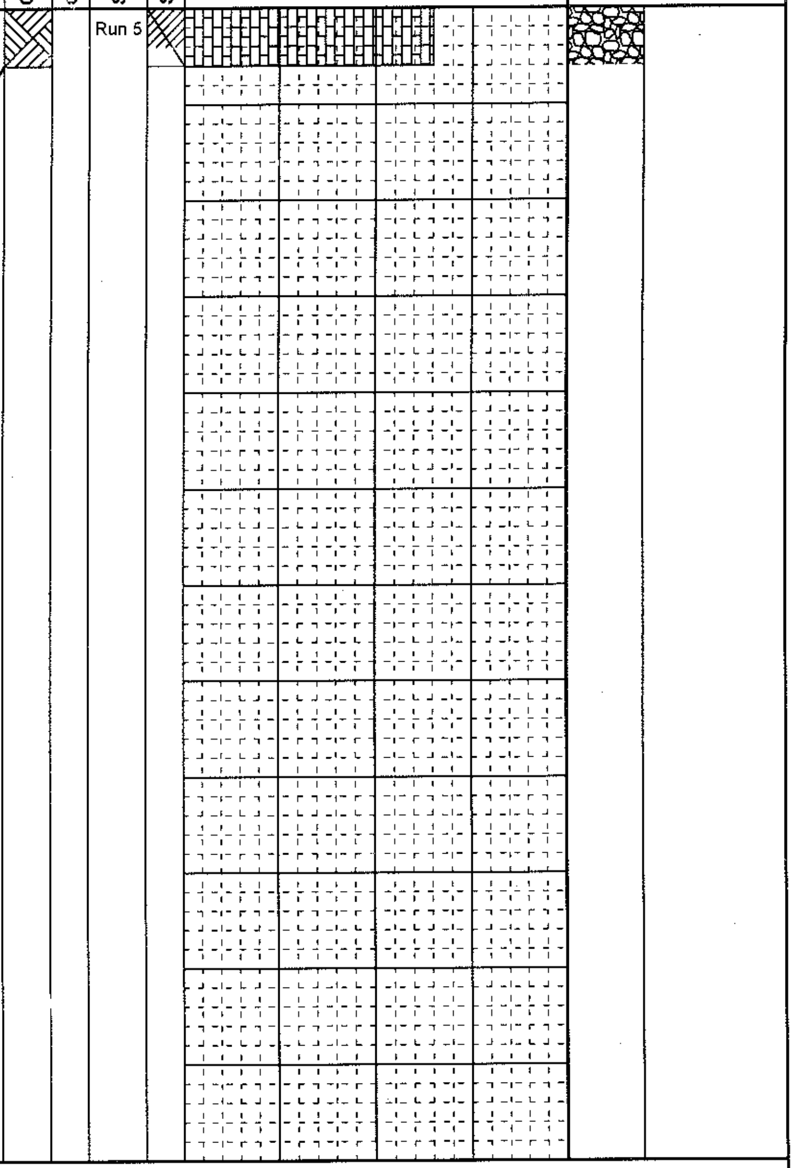
DEPTH (FEET) | SOIL DESCRIPTION | GRAPHIC LOG | GROUNDWATER | SAMPLE NUMBER | SAMPLE TYPE | STANDARD PENETRATION RESISTANCE and MOISTURE CONTENT | Installation

▲ Blows per foot (140 lb. hammer/30" drop)
● % Moisture Content
▦ % Rock Quality Designation

30 — Strong to very strong (R5-R5) BASALT, gray, slightly weathered, closely jointed. Joints are predominantly planer, smooth, and open with red and black iron staining, clay infilling, or epidote mineralization.

Boring terminated at 31.5 feet below ground surface. Slope indicator pipe installed from 0 to 26.5 feet below ground surface on 12/20/99.

Groundwater was not observed.



35 — 40 — 45 — 50 — 55 — 60

LEGEND

2.0" O.D. split spoon sampler
HQ Diamond Core Barrel Sampler
Percent Recovery
* No Recovery

AGRA Project Number: 9-61M-10402-0

Washougal River Road MP 13
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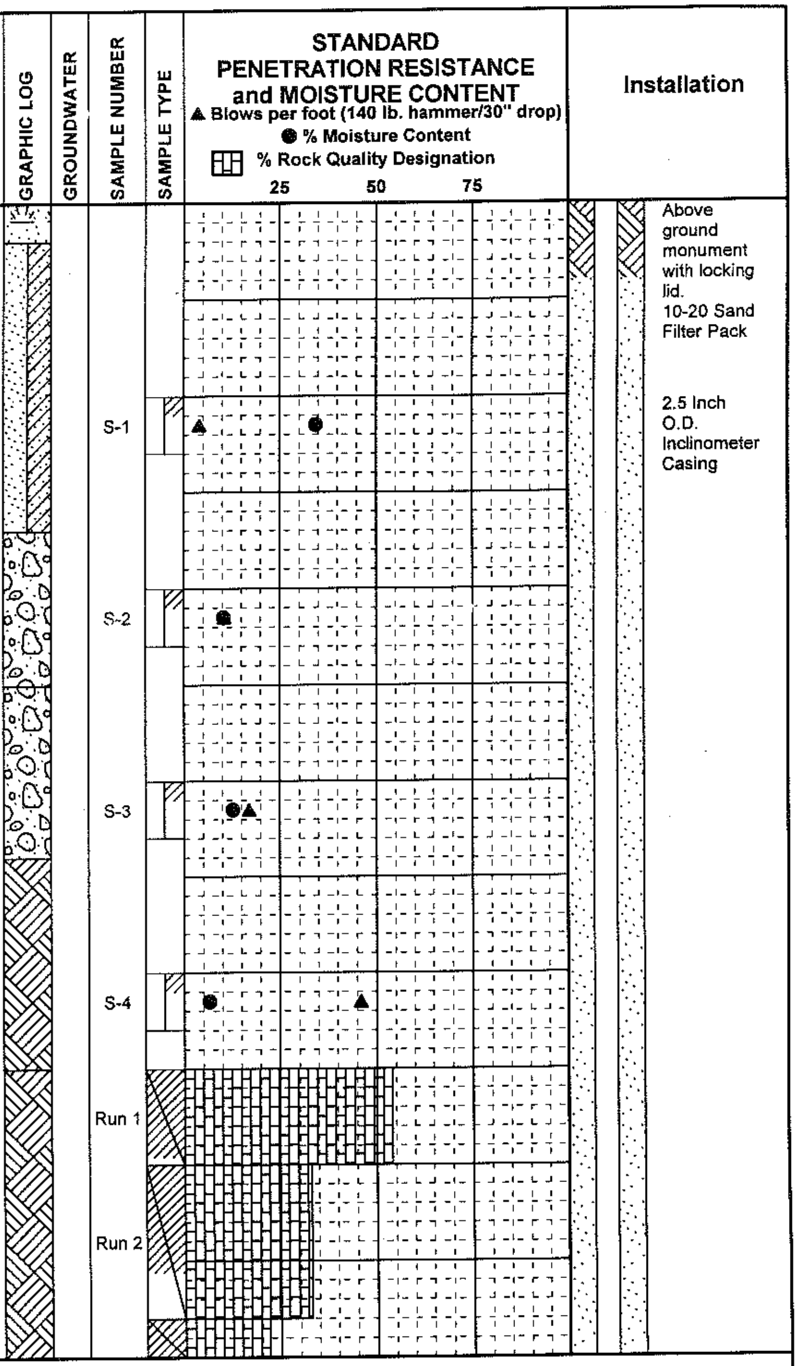
Drilling Started: 12/20/99 **Drilling Completed:** 12/20/99 **Logged By:** C. Clough **Boring Number:** B- 1

PROJECT: Washougal River Road MP 13

Boring Number: B- 2

Boring Method: Mud Rotary/HQ Coring
Borehole Diameter: 5.0 inch
Ground Surface Elevation: 610 feet

DEPTH (FEET)	SOIL DESCRIPTION
0	Loose, wet, brown, clayey SAND with roots (topsoil).
	Loose, moist, brown, coarse SAND with clay (old road fill).
5	
	Loss of circulation at 8 feet.
	Loose, moist, brown sandy GRAVEL (landslide debris).
10	
	Loose, moist, dark gray to brown SAND and angular basalt GRAVEL.
15	
	Medium strong (R3) BASALT, dark gray, slightly weathered, fractured.
20	
	Very slow drilling. Switched to HQ coring.
	Medium strong to very strong (R3-R5) BASALT, gray, slightly weathered, closely to very closely jointed. Joints are predominantly planer, smooth, and open with epidote mineralization or red and black iron staining.
25	
30	



LEGEND

I 2.0" O.D. split spoon sampler	⫽ Percent Recovery
⧅ HQ Diamond Core Barrel Sampler	* No Recovery
	▼ WD Groundwater level at time of drilling

AGRA Project Number: 9-61M-10402-0

Washougal River Road MP 13
Skamania County, Washington

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS
7477 SW Tech Center Drive
Portland, Oregon 97223
Phone: (503)639-3400 Fax: (503)620-7892

Drilling Started: 12/15/99 **Drilling Completed:** 12/15/99 **Logged By:** C. Clough **Boring Number:** B- 2

Boring Number: B- 2

Boring Method: Mud Rotary/HQ Coring
Borehole Diameter: 5.0 inch
Ground Surface Elevation: 610 feet

DEPTH (FEET)

SOIL DESCRIPTION

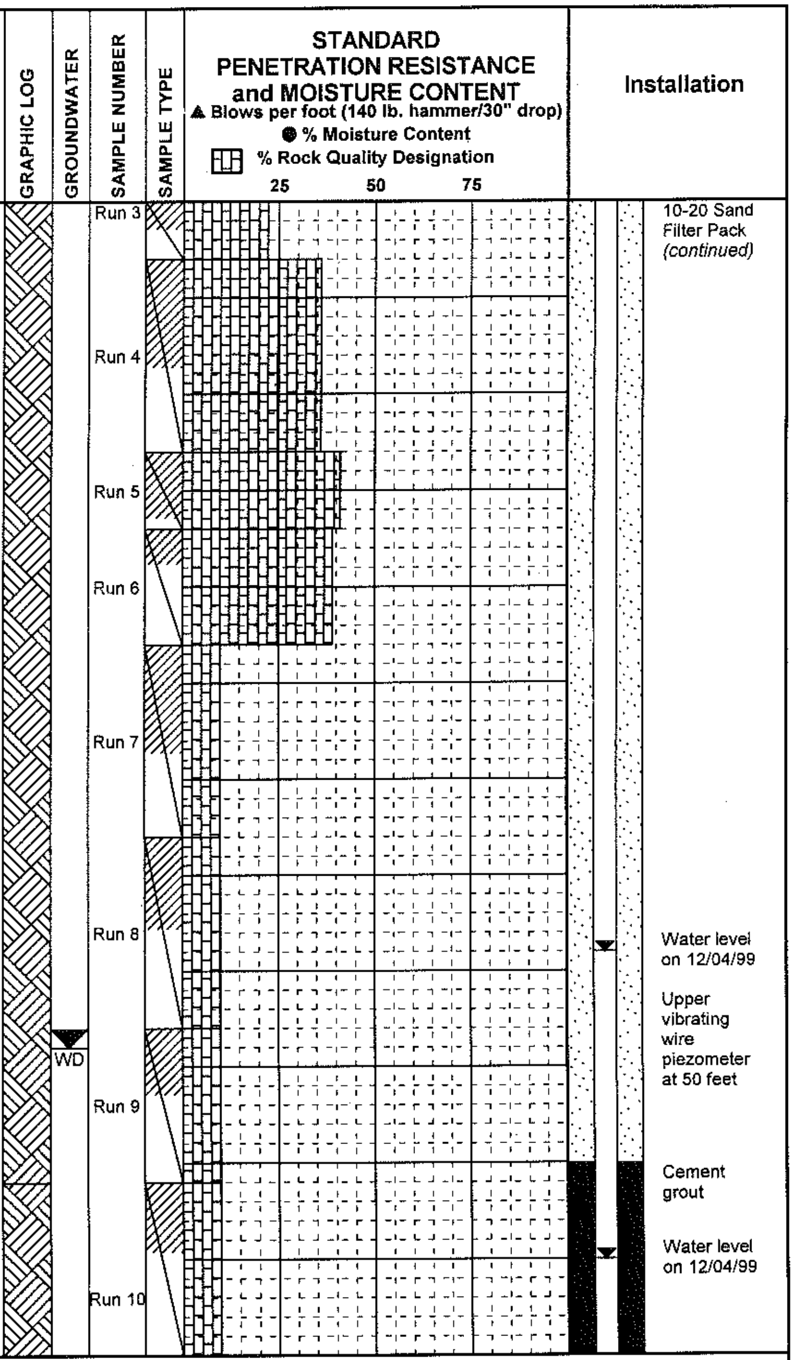
Medium strong to very strong (R3-R5) BASALT, gray, slightly weathered, closely to very closely jointed. Joints are predominantly planer, smooth, and open with epidote mineralization or red and black iron staining. *(continued)*

Trace native pyrrhotite on joint surfaces at 30 feet.

Basalt becomes very closely jointed at 41 feet

Groundwater observed at 52 feet.

Extremely weak (RO) BASALT, reddish brown, highly weathered to decomposed, and very closely jointed. Joints are predominantly planer, rough, and open. (Decomposed basalt).



LEGEND

I	2.0" O.D. split spoon sampler
⧅	HQ Diamond Core Barrel Sampler
▨	Percent Recovery
*	No Recovery
▼ WD	Groundwater level at time of drilling

AGRA Project Number: 9-61M-10402-0

Washougal River Road MP 13
Skamania County, Washington

AGRA Earth & Environmental
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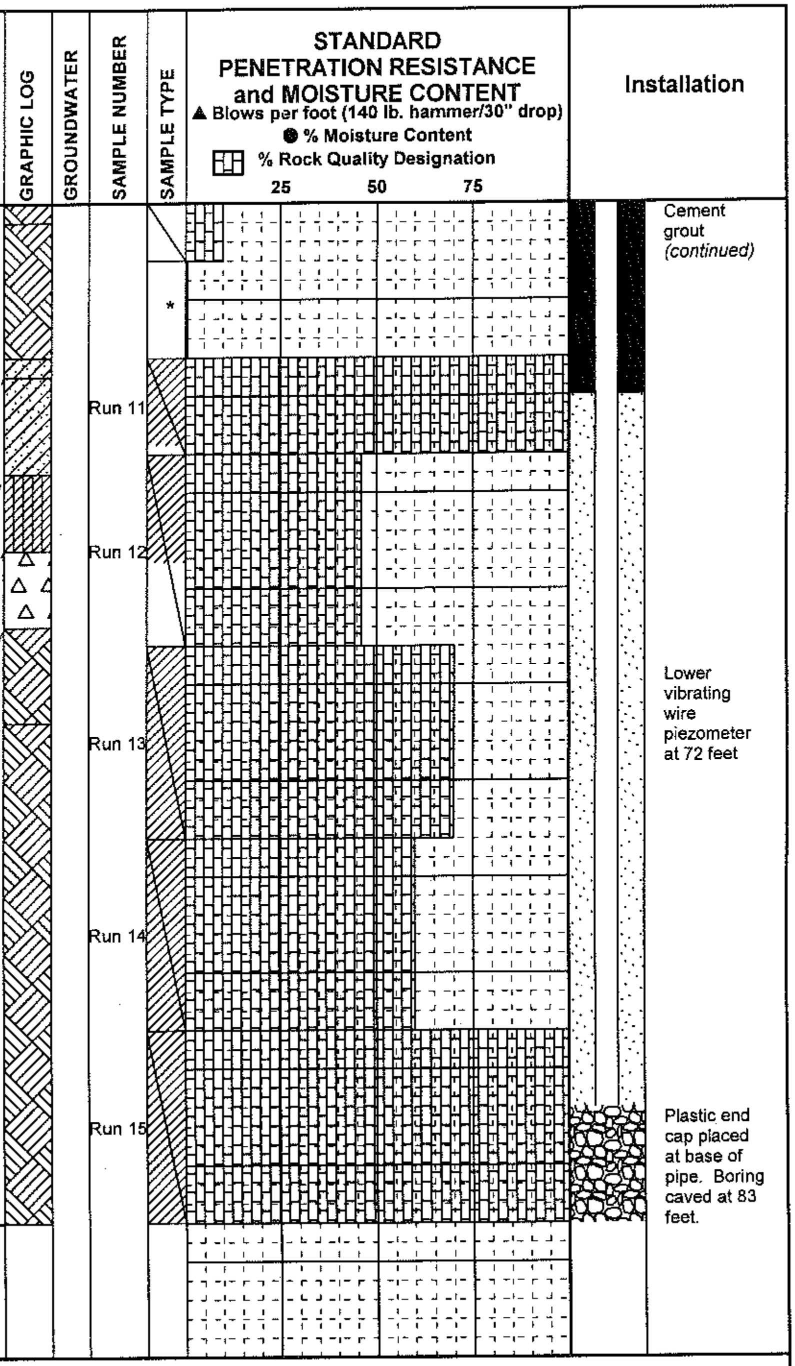
7477 SW Tech Center Drive
Portland, Oregon 97223
Phone: (503)639-3400 Fax: (503)620-7892

Boring Number: B- 2

Boring Method: Mud Rotary/HQ Coring
Borehole Diameter: 5.0 inch
Ground Surface Elevation: 610 feet

DEPTH (FEET)	SOIL DESCRIPTION
60	Extremely weak (RO) BASALT, dark gray to reddish brown, mottled. Highly weathered basalt fragments in a sandy clay matrix. (Decomposed basalt).
	Very dense, moist, gray to brown, clayey SAND with trace gravel. Blocky structure with volcanic and sedimentary clasts with weak to moderate cementation. (Volcanic debris flow).
65	Very dense, damp, reddish brown, clayey SAND with trace gravel. Blocky structure with moderate to strong cementation. Contains coarse sand to fine gravel, subangular to subrounded, and moderately to well-graded. Has "baked" appearance.
	Dense, damp, black, silty CLAY, moderately cemented, high charcoal content. Landslide slip contact between a depth of 69 to 70 feet below ground surface
70	Weak (R2) VOLCANIC BRECCIA, green to reddish brown, very thinly bedded fine sand and clay with flow banding. Hydrothermally altered with abundant chlorite. Slickensides observed at 70 feet. (Altered flow breccia).
	Weak to medium strong (R2-R3) VOLCANIC TUFF, green, thin bedded, coarse to fine sand and silt. Hydrothermally altered with abundant chlorite.
75	Strong to very strong (R4-R5) BASALT, green, slightly weathered, highly vesicular and closely jointed. Vesicles are partially filled with chlorite. Joints and fractures are predominantly planer and rough. Hydrothermally altered with abundant chlorite and epidote, Trace native pyrrhotite on joints and fractures.
80	Some fractures are healed with calcite and silica mineral infilling. (Vesicular basalt). Grades to gray vesicular basalt with trace to some vesicle infilling at base of boring.
85	
	Boring terminated at 86.5 feet below ground surface. Slope indicator pipe installed from 0 to 83 feet below ground surface on 12/15/99.
90	



LEGEND

- 2.0" O.D. split spoon sampler
- HQ Diamond Core Barrel Sampler
- Percent Recovery
- * No Recovery
- ▼ WD Groundwater level at time of drilling

AGRA Project Number: 9-61M-10402-0

Washougal River Road MP 13
Skamania County, Washington

AGRA Earth & Environmental
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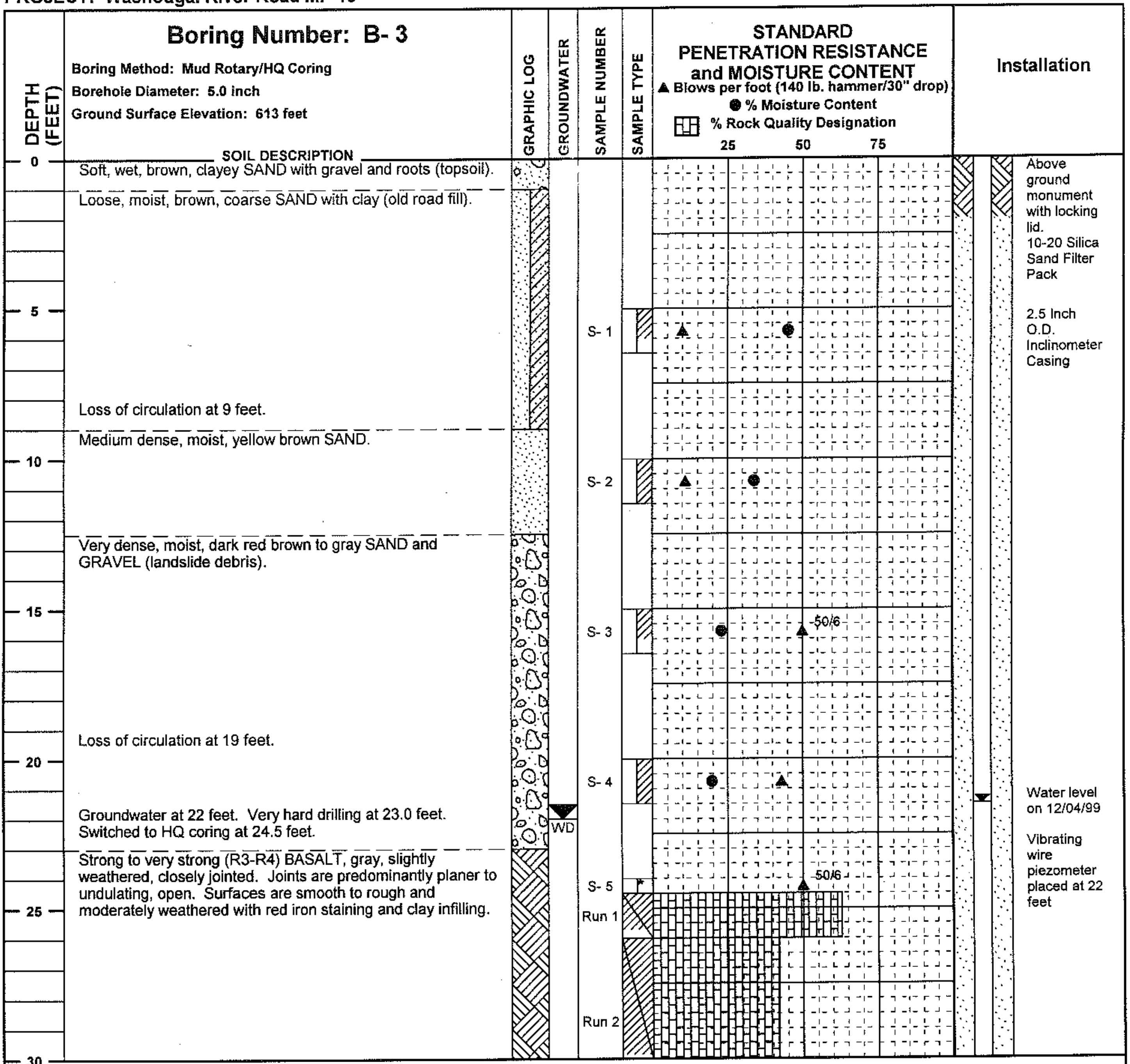
Portland, Oregon 97223
Phone: (503)639-3400 Fax: (503)620-7892

Drilling Started: 12/15/99 **Drilling Completed:** 12/15/99 **Logged By:** C. Clough **Boring Number:** B- 2

PROJECT: Washougal River Road MP 13 **PAGE 1 OF 2**

Boring Number: B- 3

Boring Method: Mud Rotary/HQ Coring
Borehole Diameter: 5.0 inch
Ground Surface Elevation: 613 feet



Soft, wet, brown, clayey SAND with gravel and roots (topsoil).

Loose, moist, brown, coarse SAND with clay (old road fill).

Loss of circulation at 9 feet.

Medium dense, moist, yellow brown SAND.

Very dense, moist, dark red brown to gray SAND and GRAVEL (landslide debris).

Loss of circulation at 19 feet.

Groundwater at 22 feet. Very hard drilling at 23.0 feet. Switched to HQ coring at 24.5 feet.

Strong to very strong (R3-R4) BASALT, gray, slightly weathered, closely jointed. Joints are predominantly planer to undulating, open. Surfaces are smooth to rough and moderately weathered with red iron staining and clay infilling.

Above ground monument with locking lid.

10-20 Silica Sand Filter Pack

2.5 Inch O.D. Inclinometer Casing

Water level on 12/04/99

Vibrating wire piezometer placed at 22 feet

LEGEND

I 2.0" O.D. split spoon sampler

▨ HQ Diamond Core Barrel Sampler

▨ Percent Recovery

* No Recovery

▼ WD Groundwater level at time of drilling

AGRA Project Number: 9-61M-10402-0

Washougal River Road MP 13
Skamania County, Washington

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

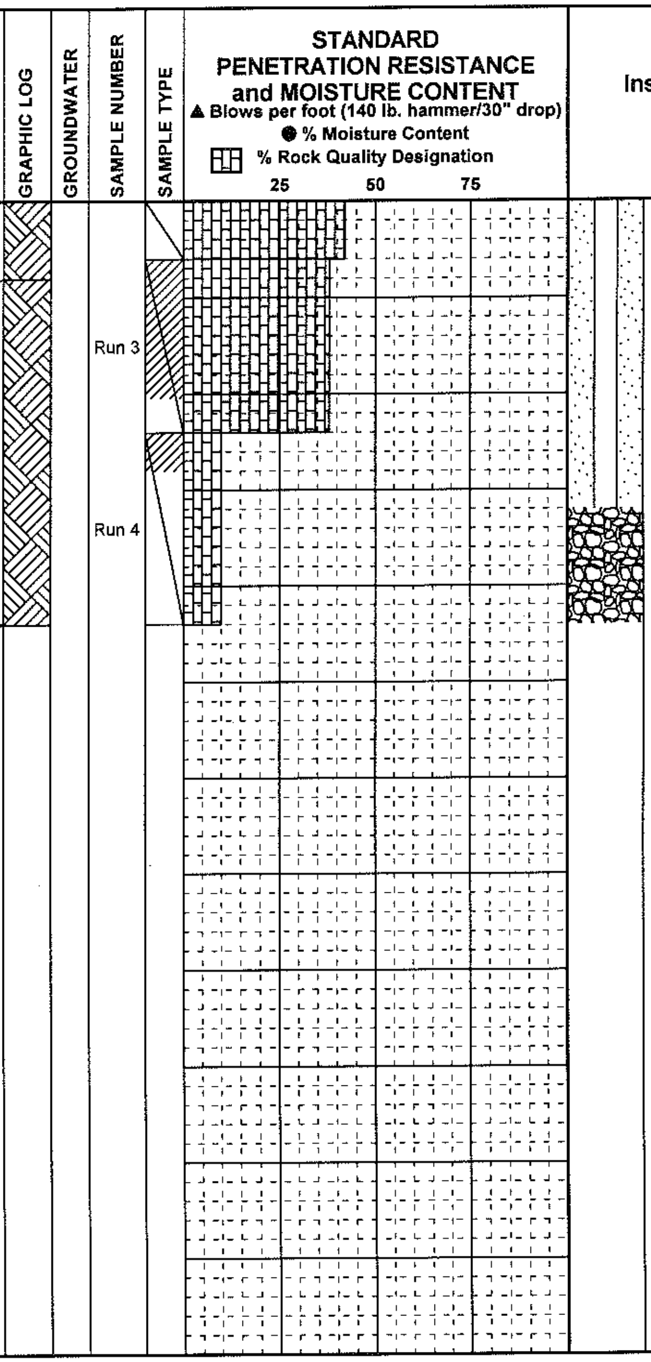
7477 SW Tech Center Drive
Portland, Oregon 97223
Phone: (503)639-3400 Fax: (503)620-7892

Drilling Started: 12/13/99 **Drilling Completed: 12/14/99** **Logged By: C. Clough** **Boring Number: B- 3**

Boring Number: B- 3

Boring Method: Mud Rotary/HQ Coring
Borehole Diameter: 5.0 inch
Ground Surface Elevation: 613 feet

DEPTH (FEET)	SOIL DESCRIPTION
30	Strong to very strong (R3-R4) BASALT, gray, slightly weathered, closely jointed. Joints are predominantly planer to undulating, open. Surfaces are smooth to rough and moderately weathered with red iron staining and clay infilling.
	Extremely weak (RO) BASALT, red brown, highly weathered, and closely fractured. Rock fabric is iron-stained and minerals are highly altered. (Decomposed Basalt)
35	
40	
	Boring terminated at 41 feet below ground surface. Slope indicator pipe installed from 0 to 38 feet below ground surface on 12/14/99.
45	
50	
55	
60	



Installation

10-20 Silica Sand Filter Pack *(continued)*

Plastic end cap placed at base of pipe. Boring caved at 38 feet.

LEGEND

2.0" O.D. split spoon sampler

HQ Diamond Core Barrel Sampler

Percent Recovery

* No Recovery

Groundwater level WD at time of drilling

AGRA Project Number: 9-61M-10402-0

Washougal River Road MP 13
Skamania County, Washington

AGRA Earth & Environmental
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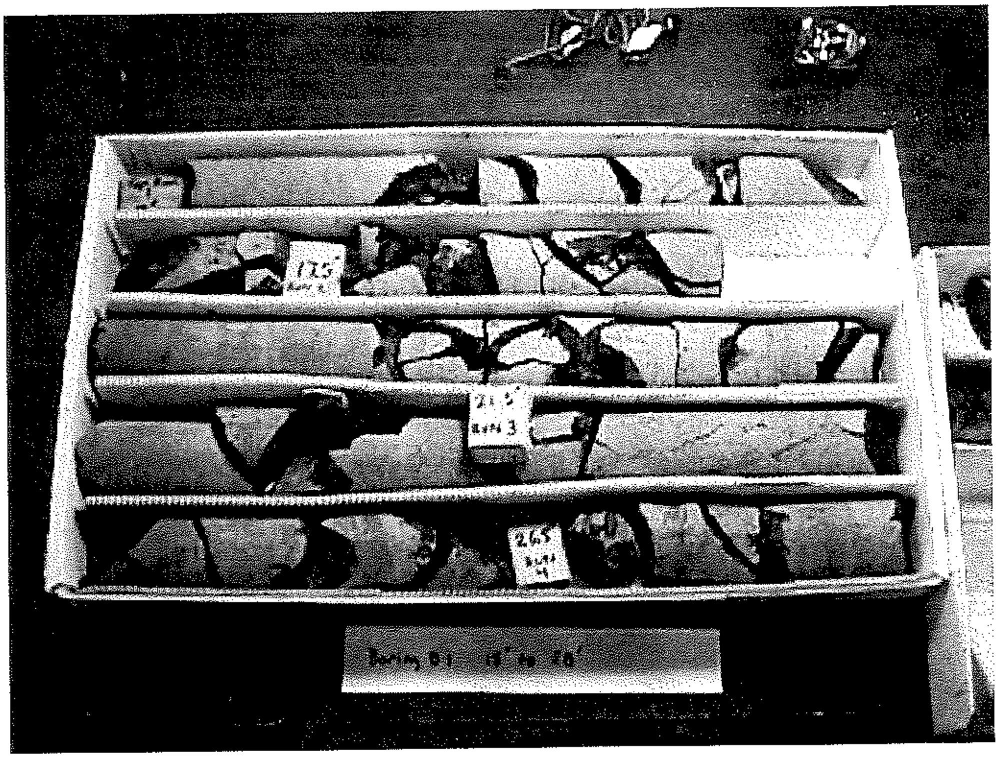
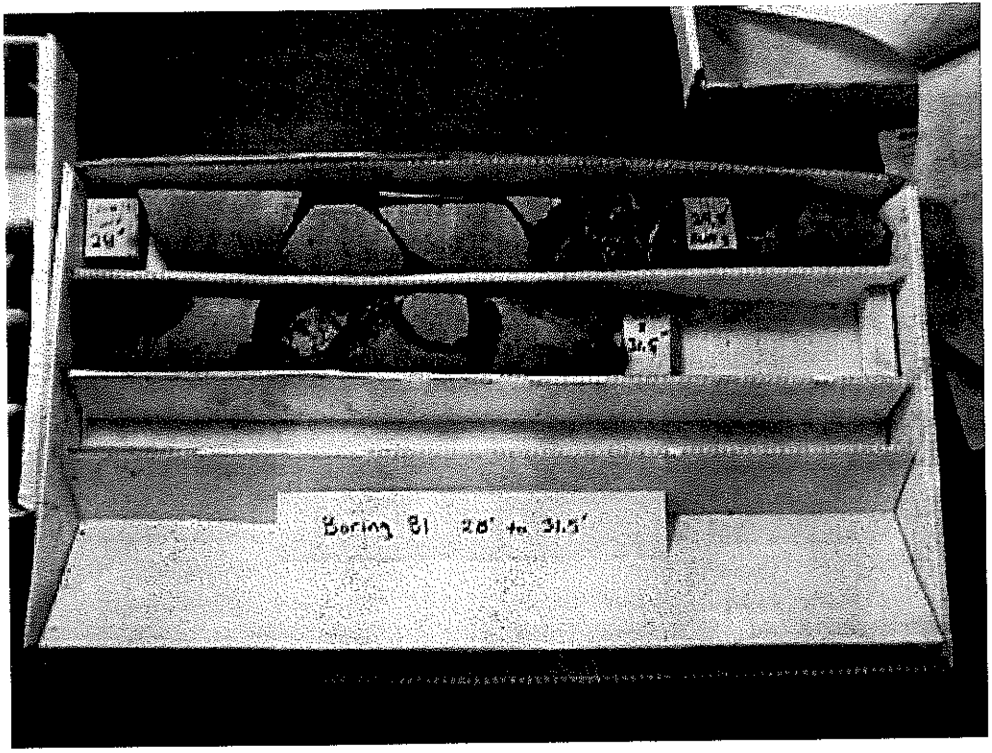
7477 SW Tech Center Drive
Portland, Oregon 97223
Phone: (503)639-3400 Fax: (503)620-7892

Drilling Started: 12/13/99 **Drilling Completed:** 12/14/99 **Logged By:** C. Clough **Boring Number:** B- 3



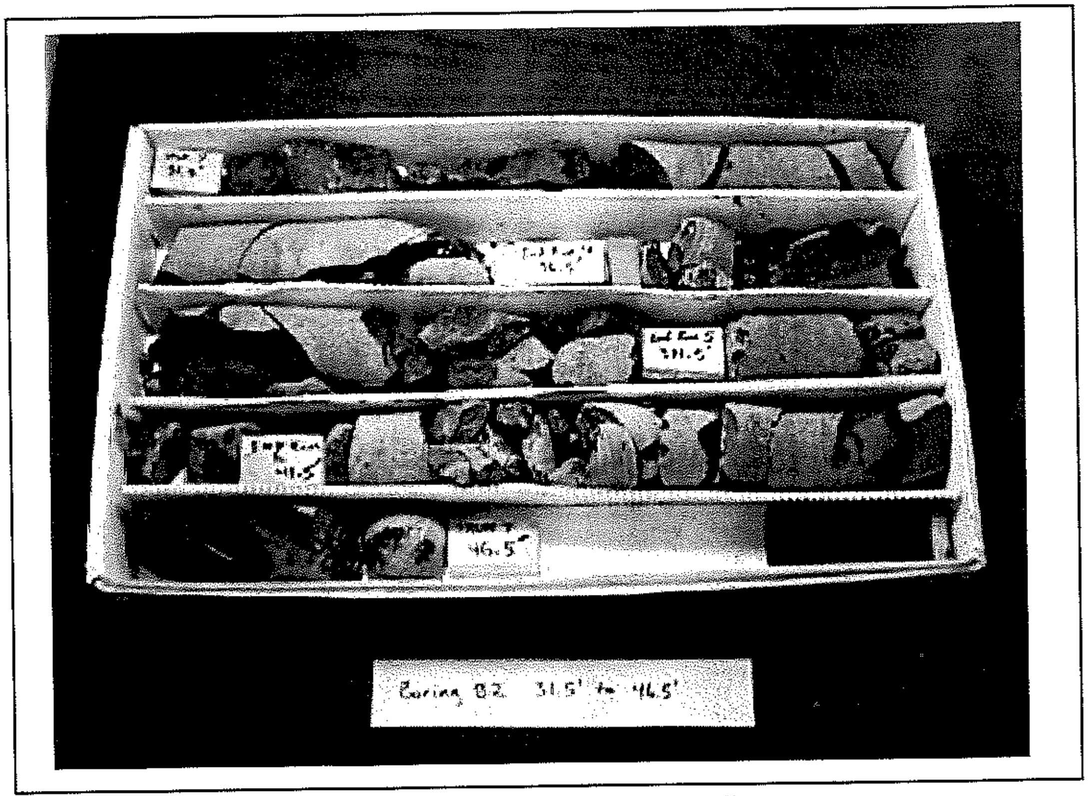
B1- Rock cores from 15' - 28'.



B1- Rock cores from 28' - 31.5'.

AGRA Earth & Environmental ENGINEERING GLOBAL SOLUTIONS 7477 SW Tech Center Drive Portland, Oregon 97223	Photograph Log Project 9-61M-10402-0 January 2000	Figure A1 Landslide Investigation Washoughal River Road MP13 Skamania County, WA

B2 - Rock cores from 22.5' - 31.5'.



B2- Rock cores from 31.5' - 46.5'.

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Photograph Log
Project 9-61M-10402-0
January 2000

Figure A2
Landslide Investigation
Washoughal River Road MP13
Skamania County, WA

B2 - Rock cores from 46.5' - 66.5'.

B2- Rock cores from 66.5' - 76.5'.

AGRA Earth & Environmental ENGINEERING GLOBAL SOLUTIONS 7477 SW Tech Center Drive Portland, Oregon 97223	Photograph Log Project 9-61M-10402-0 January 2000	Figure A3 Landslide Investigation Washoughal River Road MP13 Skamania County, WA

B2 - Rock cores from 76.5' - 83.5'.

B2- Rock cores from 83.5' - 86.5'.

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Portland, Oregon 97223

Photograph Log
Project 9-61M-10402-0
January 2000

Figure A4
Landslide Investigation
Washoughal River Road MP13
Skamania County, WA

B3 - Rock cores from 24.5' - 41'.

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Portland, Oregon 97223

Photograph Log
Project 9-61M-10402-0
January 2000

Figure A5
Landslide Investigation
Washoughal River Road MP13
Skamania County, WA

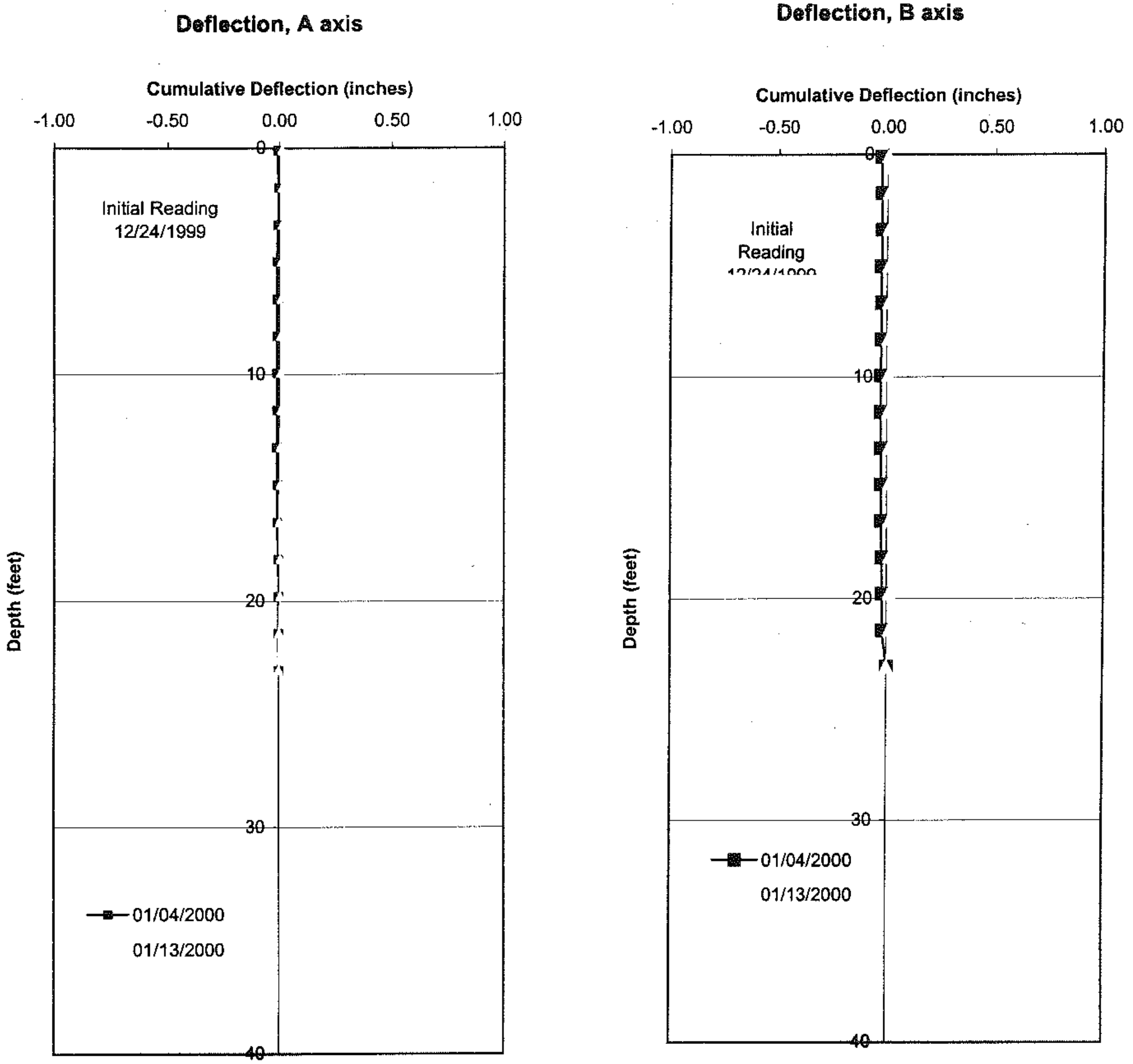

FIGURE A6

AGRA

ENGINEERING GLOBAL SOLUTIONS

7477 S.W. Tech Center Drive
Portland, OR, U.S.A. 97223–8025

W.O. 9–61M–10402–0
DESIGN RA
DRAWN DRF
DATE JAN. 2000
SCALE NTS

WASHOUGHAL RIVER ROAD MP13
SKAMANIA COUNTY, WASHINGTON

B-1 - INCLINOMETER DATA

AGRA EARTH & ENVIRONMENTAL, INC. DRAWING NO. \PROJECTS\21\10402\A6.DWG

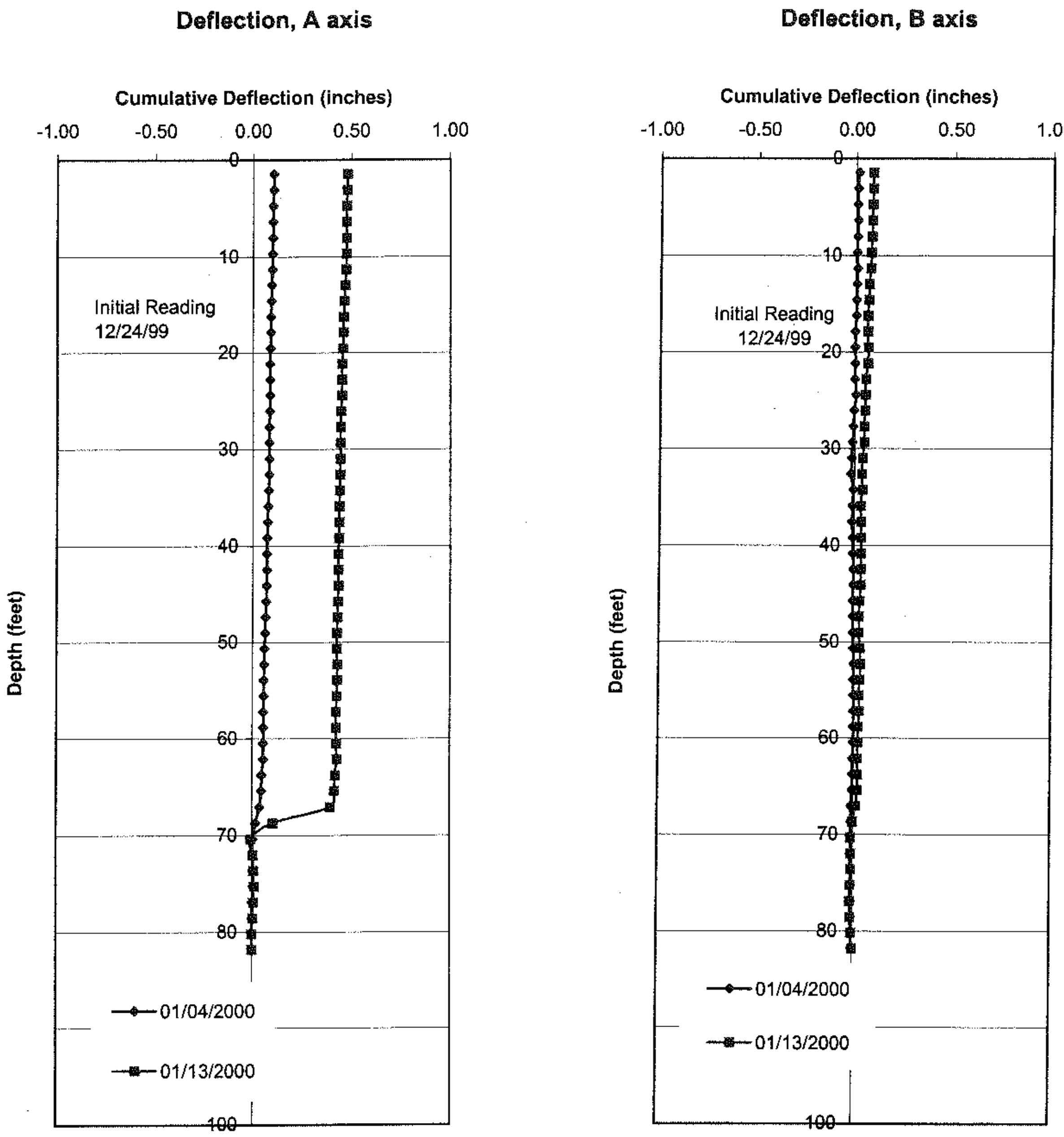

FIGURE A7

AGRA
ENGINEERING GLOBAL SOLUTIONS
7477 S.W. Tech Center Drive
Portland, OR, U.S.A. 97223-8025

W.O.	9-61M-10402-0
DESIGN	RA
DRAWN	DRF
DATE	JAN. 2000
SCALE	NTS

WASHOUGHAL RIVER ROAD MP13
SKAMANIA COUNTY, WASHINGTON

B-2 - INCLINOMETER DATA

AGRA EARTH & ENVIRONMENTAL, INC. DRAWING NO. \PROJECTS\21\10402\A7.DWG

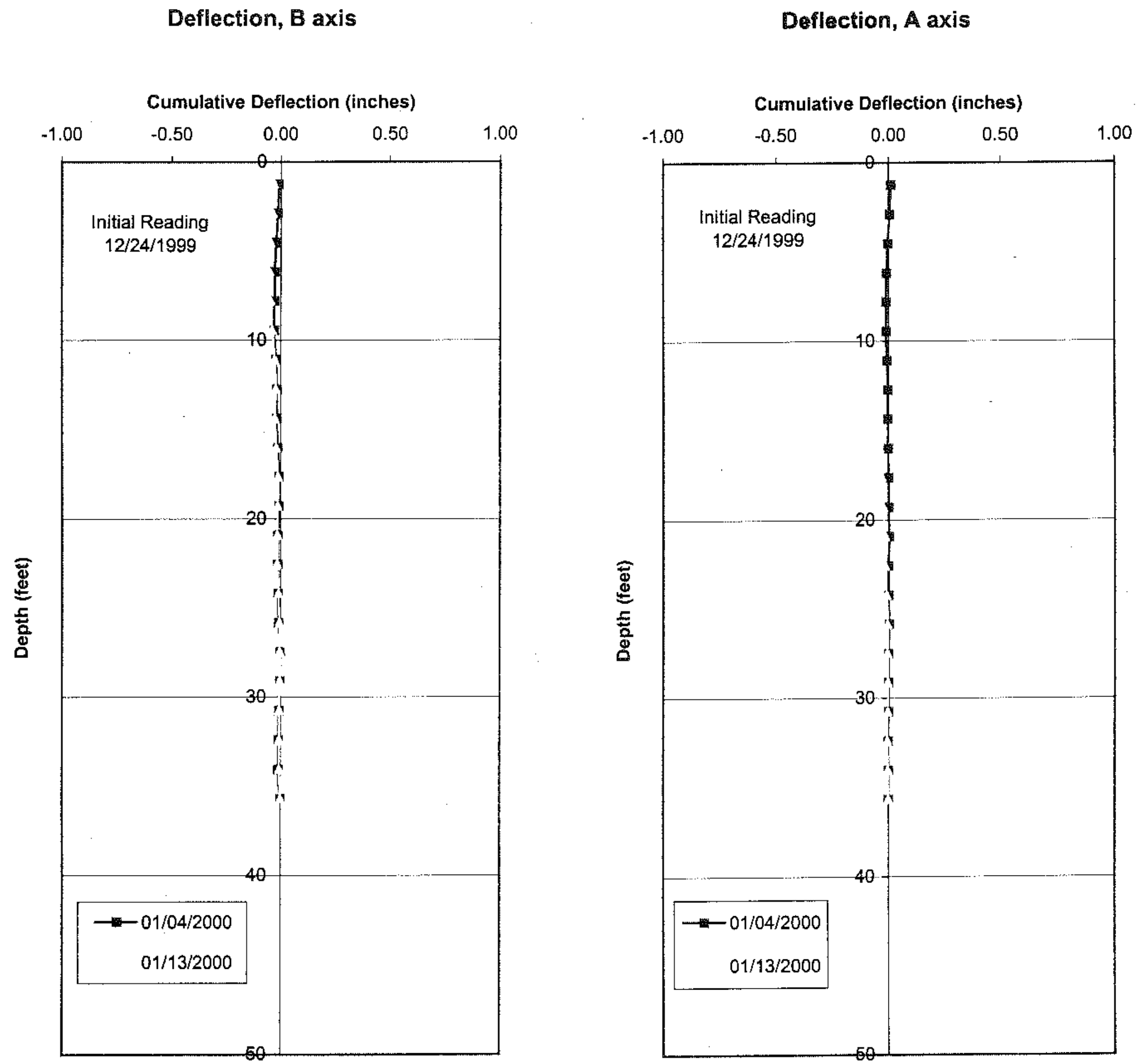

FIGURE A8

AGRA

ENGINEERING GLOBAL SOLUTIONS

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W.O. 9-61M-10402-0
DESIGN RA
DRAWN DRF
DATE JAN. 2000
SCALE NTS

WASHOUGHAL RIVER ROAD MP13
SKAMANIA COUNTY, WASHINGTON

B-3 - INCLINOMETER DATA

AGRA EARTH & ENVIRONMENTAL, INC. DRAWING NO. \PROJECTS\21\10402\A8.DWG

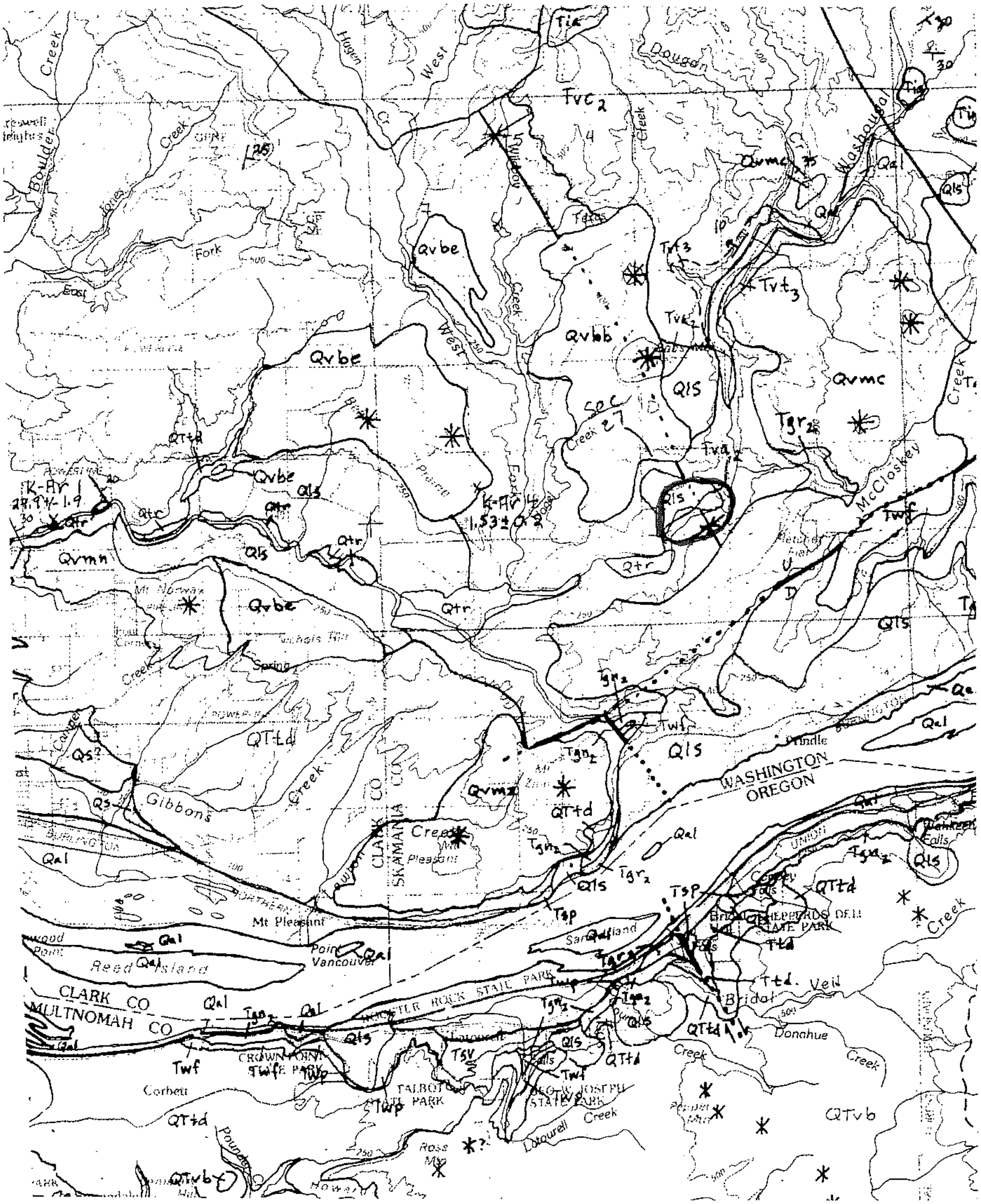


FIGURE 3

AGRA
ENGINEERING GLOBAL SOLUTIONS
7477 S.W. Tech Center Drive
Portland, OR, U.S.A. 97223-8025

W.O. 9-61M-10402-0
DESIGN RA
DRAWN DRF
DATE MAR. 2000
SCALE NTS

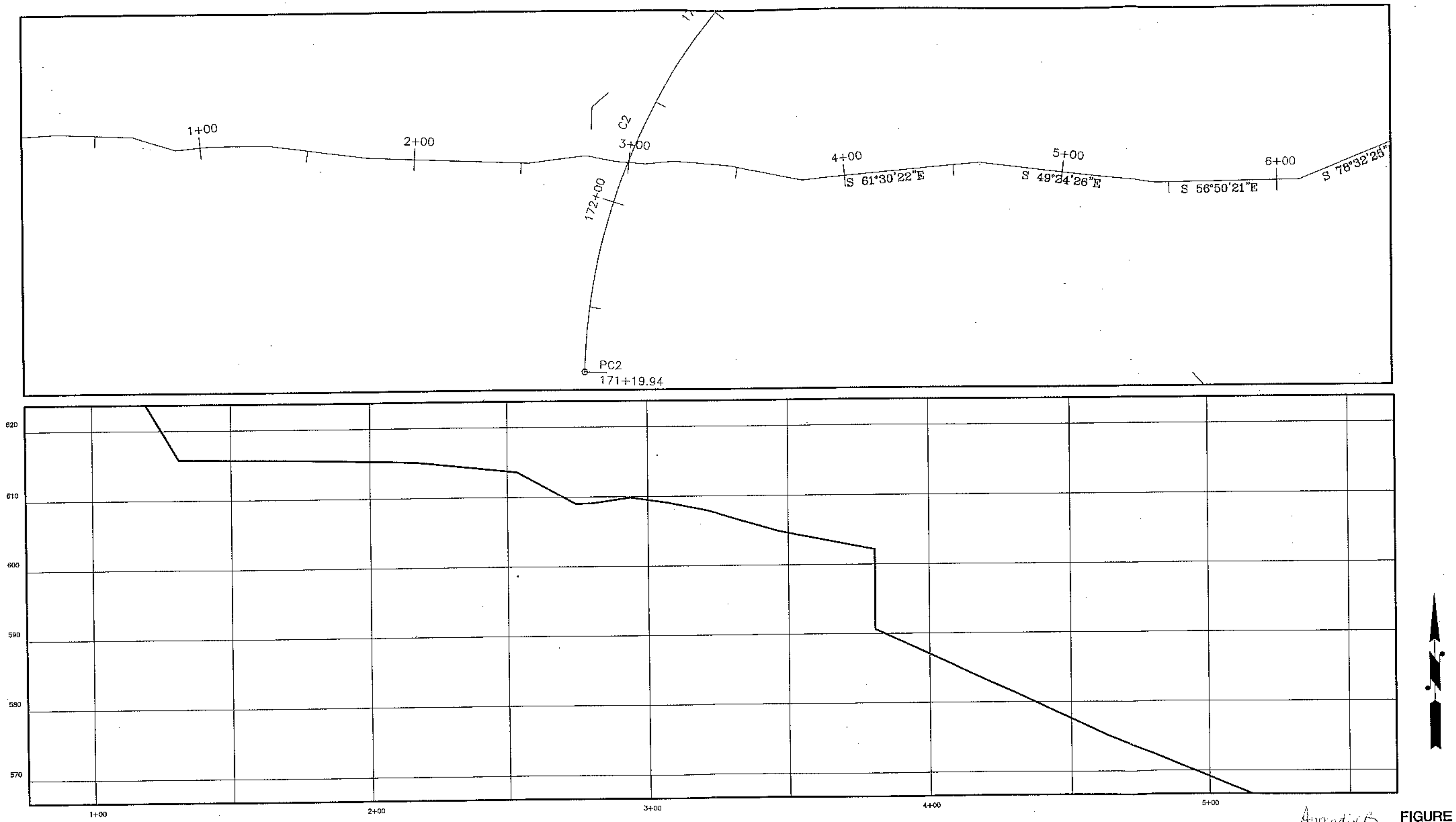
WASHOUGHAL RIVER ROAD MP13
SKAMANIA COUNTY, WASHINGTON

REGIONAL GEOLOGY MAP

AGRA EARTH & ENVIRONMENTAL, INC. DRAWING NO. K:\10000\10400\10402\DWG\FIG3.DWG

APPENDIX B

Traverse Sections



Appendix B

FIGURE B1

SOURCE: ENTRANCO, ENTITLED "WASHOUGAL RIVER ROAD – STORM IMPROVEMENTS",
JOB NUMBER: 99197–20, FILE NAME: pr001.

AGRA
ENGINEERING GLOBAL SOLUTIONS

7477 S.W. Tech Center Drive
Portland, OR, U.S.A. 97223–8025

W.O. 9–61M–10402–0
DESIGN RA
DRAWN DRF
DATE FEB. 2000
SCALE AS SHOWN ABOVE

WASHOUGAL RIVER ROAD MP13
SKAMANIA COUNTY, WASHINGTON

PLAN AND PROFILE - SECTION A-A'

AGRA EARTH & ENVIRONMENTAL, INC. DRAWING NO. K:10000\10400\10402\SWG\pr001–AGRA7.DWG

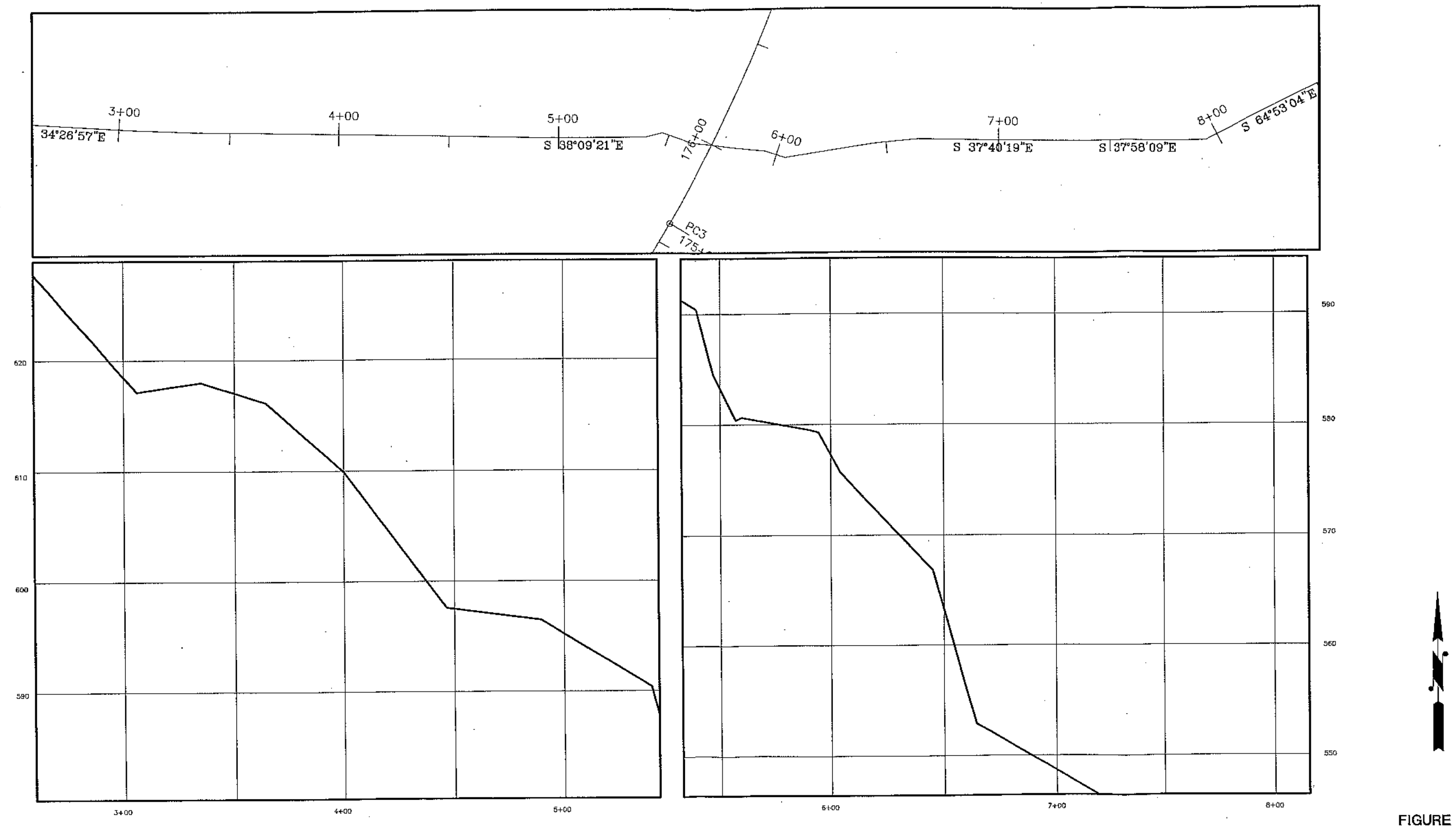


FIGURE B2

AGRA
ENGINEERING GLOBAL SOLUTIONS
7477 S.W. Tech Center Drive
Portland, OR, U.S.A. 97223-8025

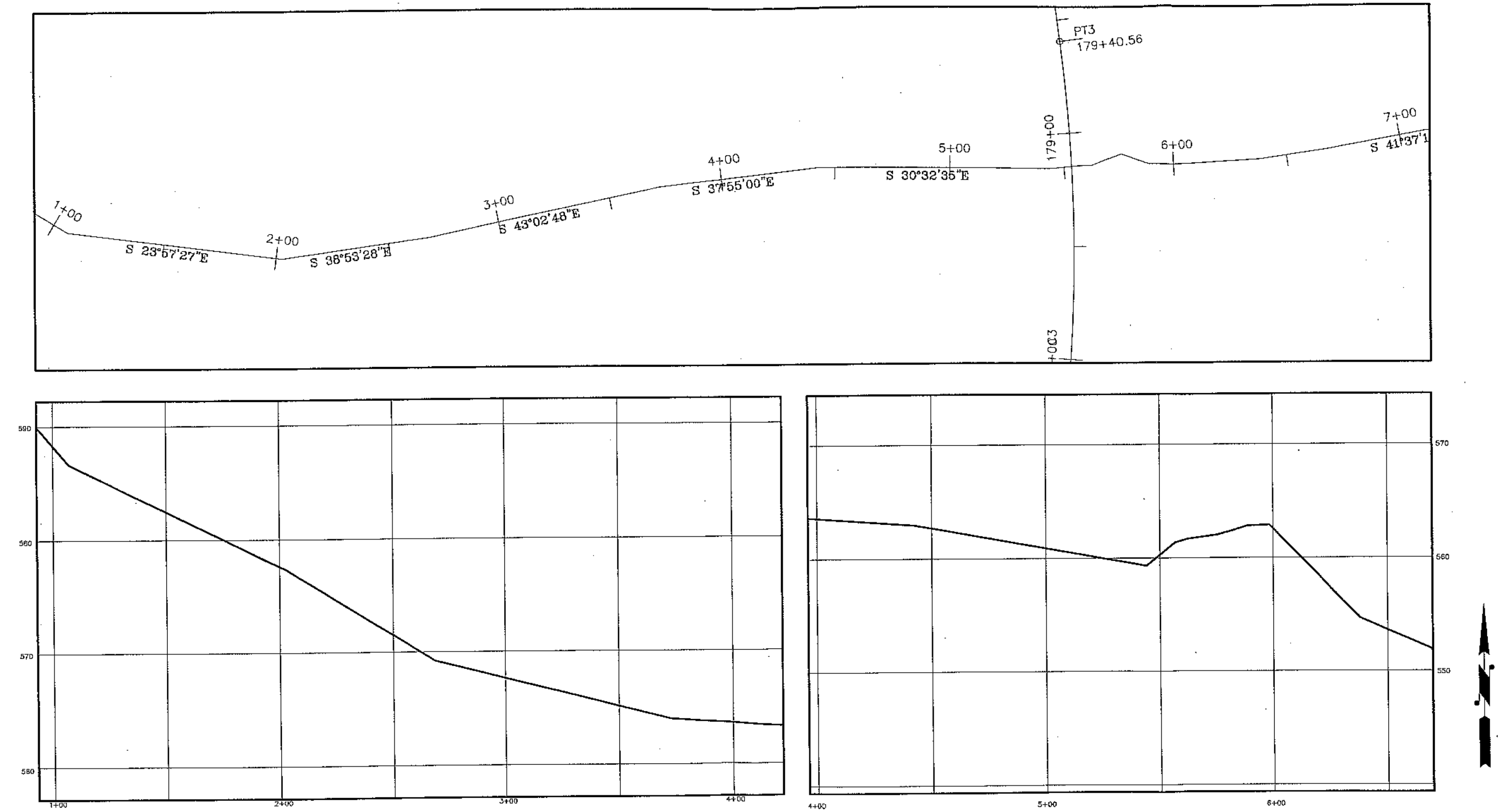
W.O. 9-61M-10402-0
DESIGN RA
DRAWN DRF
DATE FEB. 2000
SCALE AS SHOWN ABOVE

WASHOUGAL RIVER ROAD MP13
SKAMANIA COUNTY, WASHINGTON

PLAN AND PROFILE - SECTION B-B'

SOURCE: ENTRANCO, ENTITLED "WASHOUGAL RIVER ROAD - STORM IMPROVEMENTS",
JOB NUMBER: 99197-20, FILE NAME: pr002.

AGRA EARTH & ENVIRONMENTAL, INC. DRAWING NO. K:\10000\10400\10402\DWG\pr002-AGRA.DWG



SOURCE: ENTRANCO, ENTITLED "WASHOUGAL RIVER ROAD – STORM IMPROVEMENTS",
JOB NUMBER: 99197–20, FILE NAME: pr003.

FIGURE B3

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W.O. 9–61M–10402–0
DESIGN RA
DRAWN DRF
DATE FEB. 2000
SCALE AS SHOWN ABOVE

WASHOUGAL RIVER ROAD MP13
SKAMANIA COUNTY, WASHINGTON

PLAN AND PROFILE – SECTION C-C'

AGRA EARTH & ENVIRONMENTAL, INC. DRAWING NO. K:\10000\10400\10402\DWG\pr0003–AGRA.DWG

APPENDIX C

Permitting Summary Sheet

Regulation	Protected Resource	How Regulation Functions	Timing (in days)	Difficulty	Expense
§ 404 of CWA	Waters of the United States	Permits are required from the Army Corps of Engineers for any removal of soil from or fill of material into protected "waters of the U.S.", which includes wetlands, intermittent streams, seeps, etc.	NW: 45 - 60 Ind.: 60 - 120	Potentially time consuming, can cause need for small design adjustments, but seldom stops projects	$5,000 to $25,000*
§ 401 of CWA	Water Quality	Before the Corps or EPA can issue any CWA permit, the state (DOE) must certify that the activity being permitted will not affect state water quality standards.	30 to 60**	Certification seldom stops projects, but can slow them down and may lead to changes in erosion control measures	$0 to $2,000 (depends on agency concern or need to provide info.)
SMA	Streams & Riparian Areas	Activities taking place within riparian areas of streams (200 feet) with a mean annual flow greater than 20 cfs must ensure that they comply with County set policies regarding the use of these areas.	120 to 150	Seldom changes project drastically, but time consuming and laborious	$5,000 to $10,000***
SEPA	Human & Natural Environment	SEPA is designed to act as a decision making tool by requiring agency decision-makers to consider the affects of the project on all aspects of the human and natural environment.	60 to 90	Process oriented, seldom changes projects, but can be laborious	$2,500 to 5,000
ESA § 7	Threatened & Endangered Species	Federally funded or permitted projects must consult with NMFS and USFWS to determine whether the proposed activity will adversely affect listed species. Consultation performed through preparation of a BA, which is sent to agencies. If process successfully completed, then §§ 9 and 4(d) do not apply.	30 to 270****	Difficult and time consuming - frequently leads to design modifications	$ 4,000 to $10,000 per species (economy of scale for numerous species)
ESA §§ 9 and 4(d)	Threatened & Endangered Species	If there is no federal funding or permitting, then projects must ensure that they will not result in the potential "take" of a listed species. If a take will occur, then a permit must be obtained pursuant to § 10	15 to 270*****	Substantial liability uncertainty unless HCP is prepared - however HCP is time consuming, expensive and should be avoided	$500 to $2,000 (does not consider potential cost of HCP)
HPA	Waters of the State	The HPA mandates that proposed activities taking place within the bed and banks or affecting the flow of waters of the state must be reviewed and approved by the WDFW. The Act is designed to protect habitat values.	30 to 60	Can lead to small design compromises but is typically dealt with expediently with little fuss	$1,500 to $3,000

* Typical expenses include: delineation of the impact areas; locating mitigation site (if on-site mitigation not possible); permit application preparation; delineation of mitigation area (if off-site); permit preparation; mitigation design and plan preparation; pre-submittal agency coordination; and responding to public and agency concerns. Typical costs not included in potential expense projection are survey, mitigation construction, and mitigation monitoring and maintenance. The expense associated with § 404 permitting will range drastically depending on the size and nature of the area to be delineated, the extent of the impacts, and whether the permit is a Nationwide or Individual.

** § 401 certification is not entirely concurrent with the § 404 process - the time period will not start to run until part way through the § 404 review.

*** Potential expense projection includes cost of a cultural resource survey, which will typically be a required component. However, potential cost could be substantially increased if the project area is large or if there is a need to go beyond a pre-determination report.

**** Timing depends on whether analysis of project results in initial "no effect" determination and if not, then whether there is a determination of "adverse affect", which will require formal consultation.

***** Low end of timing estimate represents design review/"take" evaluation. Upper end of time estimate is for preparation of a Habitat Conservation Plan (HCP) pursuant to § 10 requirements.

APPENDIX D

Surface Drainage Detail

AGRA
ENGINEERING GLOBAL SOLUTIONS

AGRA Earth & Environmental, Inc.
7477 SW Tech Center Drive
Portland, Oregon, 97223-8025
Tel (503) 639-3400
Fax (503) 620-7892
Web www.agra.com

MEMORANDUM

DATE: December 21, 1999 **FILE NO.:** 9-61M-10402-0

TO: Mr. Gary Turner, Project Engineer, Skamania County

FROM: Rick Thrall

SUBJECT: Draft Memorandum, Washougal River Road MP-13, Drainage Improvements

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This memorandum accompanies the drainage plan drawing. entitled "Washougal River Road, Storm Improvements, Plan and Profile". The proposed improvements are intended to produce immediate results in reducing the activity of the subject landslide. Presently, large amounts of water are ponding near the base of the scarp at the west margin of the active landslide. Our observations indicate that this water infiltrates directly into the slide mass. Immediate removal of the "pond" condition will reduce the amount of water entering into the slide thus reducing the activity in this area of the slope.

The proposed approach includes an open ditch draining into existing culverts at the road. The improvements are intended to be built by Skamania County maintenance personnel. The catchment and ditch is designed to trap sediment and provide storage during a large storm event. We anticipate that the water quantities would overflow the existing 18-inch culvert at the road. We have therefore included provisions for diverting excess flows into the other existing culverts which cross the road.

Plans are to further incorporate the ditch construction into the final surface drainage network sized to handle the design storm and provide a low flow pipe and outlet and accompanying improvements to the outlet culvert(s) which cross the road.

It is imperative that surface water infiltration into the landslide mass be minimized. Excess water in the slide mass increases its weight and the water pressures driving the movement. Draining the high flows through the ditch will immediately improve the stability of the slope (our slope stability analysis will demonstrate this effect). Eventual further removal of the low flows will help complete the stabilization process.

C:\WINDOWS\TEMP\drainage.wpd

APPENDIX E

Draft Phase II

Scope of Work

Cost Estimate

Draft Phase II Scope of Services
Washougal River Road Slide Repair
Skamania County, Washington

1.1 Site Investigation and Data Collection:

a. Perform up to two (2) site visits to review existing site conditions.

1.2 Survey and Terrain Modeling:

a. Topographic Survey
   - Topographic survey area delineated by AGRA totaling up to 21 acres. Survey will include research and setting control points as needed for project.

b. Mapping
   - Prepare base map in AutoCAD for up to 21 acre site. Potential drainage problems and ponding will be identified and mapped with a 2' contour interval. Steep terrain areas will be mapped at a 5' terrain interval.

1.3 Geotechnical Investigation

1.3.1 Geologic Field Reconnaissance

Additional geologic field mapping to include areas to the north of the immediate slide will be prepared. Also, the subsurface features will be plotted on a topographic map of the area based on an survey. Field reconnaissance would include mapping streams, rock outcrops, erosion features and other manifestations of slide on the surface.

1.3.2 Field Exploration

Four additional borings will be advanced. Three of these borings would be used to develop another cross-section along Section CC'. The fourth borings will be advanced along the river on section AA'. Also, boring B3 will be deepened to intercept the interpreted failure plane along Section AA'. Inclinometer and piezometers will be installed in all of these borings. Some road building and a track-mounted drill-rig will be required for advancing these borings.

1.3.3 Monitoring

The geotechnical instruments will be monitored at least four times during the next year after installation. The appropriate monitoring times will be summer, beginning of winter, mid winter and end of winter. This monitoring program will provide us with data to evaluate the effectiveness of the surface drainage system.

1.3.4 Analysis and Design

Slope stability analysis along Section AA' and Section CC' will be conducted with this additional data. Our earlier slope model along AA' will be refined based on the results of these additional borings. Effectiveness of the surface drainage system will be evaluated at this stage.

The design of sub surface drainage system i.e. the location, length and the spacing will be completed at this stage with coordination with the civil design.

1.4 Conceptual Design and Documentation:

a. Identify potential drainage problem areas. Develop conceptual grading and drainage solution for project site (21 acres) and up to two culvert crossings. Prepare conceptual culvert crossing repair with revised roadway profile each side of culvert. No horizontal realignment will be designed. Vertical profile will be designed to repair areas of roadway settlement at up to two culvert crossings.

b. Prepare a design memorandum documenting the development of these concepts including design criteria, and environmental permitting requirements.

c. Meet with AGRA to provide information for their preparation of the conceptual design documentation.

1.5 Final Drainage Design and Documentation:

a. Coordinate with AGRA to develop final grading plans and drainage details. Drainage details shall include drainage swale typical sections and slope stabilization.

b. Prepare final culvert crossing design for two crossings and revised roadway profiles.

c. Prepare construction cost estimate and contract special provisions.

d. Coordinate with AGRA on subsurface drainage design. Subsurface drainage design details are not included in this scope and will be provided by AGRA.

e. Construction inspection or administration is not included in this budget.

1.6 Environmental Documentation and Permitting:

a. Site Natural Resource Evaluation

- Delineation of wetlands and jurisdictional waters
- Determination of presence of listed species and designated critical habitat
- Evaluation and identification of potential mitigation locations

b. Permit Application Preparation

- § 404 of Clean Water Act
- § 401 of Clean Water Act
- Shoreline Management Act
- State Environmental Policy Act
- Endangered Species Act § 7
- Endangered Species Act §§ 9 and 4(d) (if needed)
- Hydraulic Project Approval

c. Mitigation Design

d. Agency Consultation

1.7 Meeting with County

Two coordination meetings will be held with the County during the course of this project. One additional meeting will be held after the completion of the design phase to present the final design to the County.

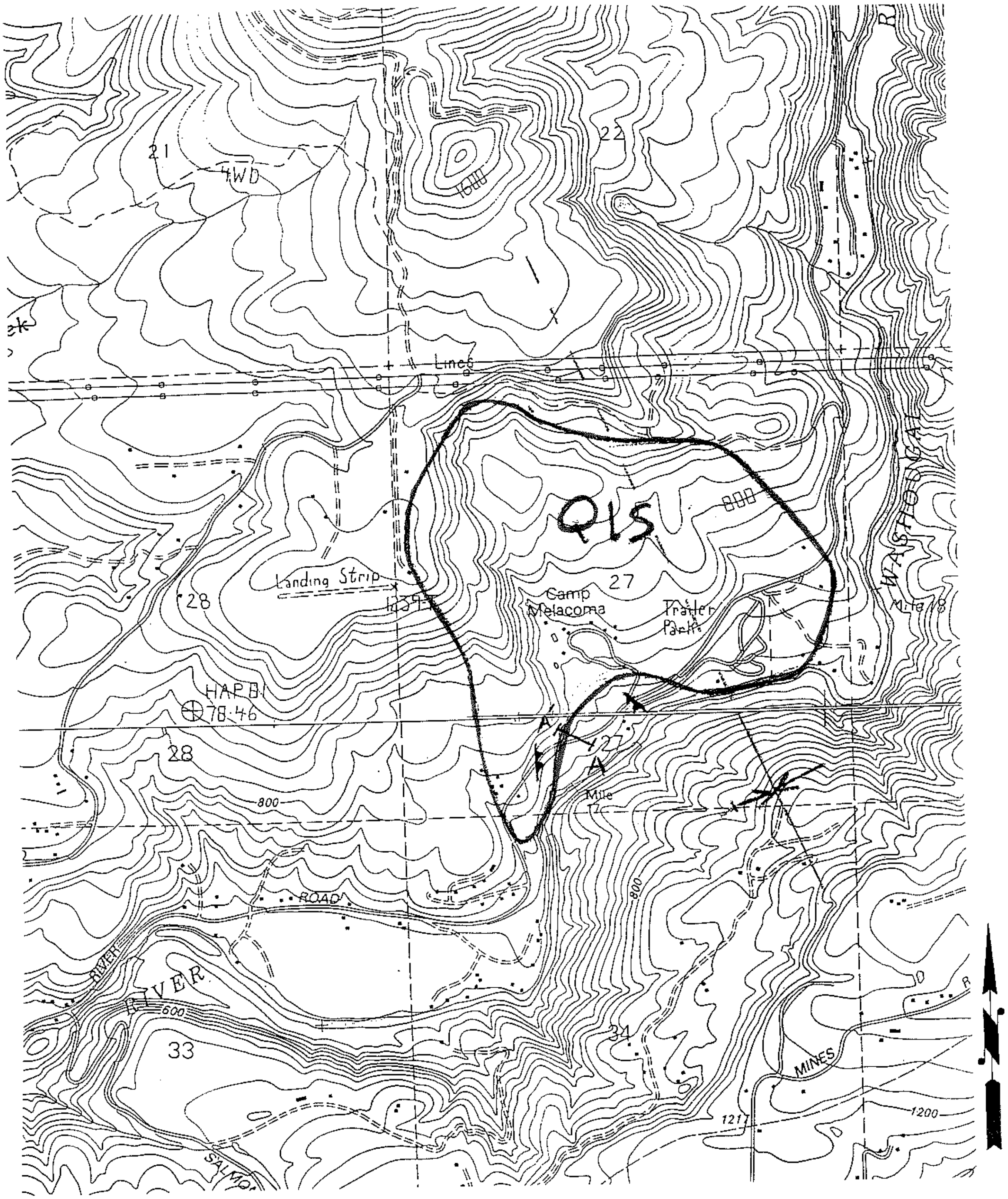

FIGURE 4

AGRA
ENGINEERING GLOBAL SOLUTIONS
7477 S.W. Tech Center Drive
Portland, OR, U.S.A. 97223-8025

W.O. 9-61M-10402-0
DESIGN RA
DRAWN DRF
DATE MAR. 2000
SCALE NTS

WASHOUGHAL RIVER ROAD MP13
SKAMANIA COUNTY, WASHINGTON

LANDSLIDE LOCATION MAP

AGRA EARTH & ENVIRONMENTAL, INC. DRAWING NO. K:\10000\10400\10402\DWG\FIG4.DWG