Pacific Geotechnical
Geotechnical Engineering and Engineering Geology
with a Focus on Sustainability

MEMORANDUM

Date: April 6, 2011

To: Kate Holleran, METRO
600 NE Grand Avenue
Portland, Oregon 97232-2736

From: Tim Blackwood, PE, GE, CEG

Regarding: Additional Geotechnical Evaluation
Chehalem Ridge Property
Project No. 1344-002-00

REGISTERED PROFESSIONAL ENGINEER 52838 OREGON JAN. 12, 1999 TIMOTHY W. BLACKWOOD
EXPIRES 12/31/2011

INTRODUCTION

This memorandum provides the findings and recommendations of our additional geotechnical evaluation of a portion of the Chehalem Ridge Natural Area in Washington County, Oregon that has been affected by ground movement in the past (the site). The location of the site is shown on Figure 1. We performed a preliminary geotechnical evaluation of the site which we summarized in a memorandum dated July 26, 2010. As noted in that memorandum, the site is an active portion of a larger landslide, which is likely a natural feature. Although natural, it can be adversely affected by anthropogenic activities, including roadway construction and drainage. We discussed options for METRO's consideration related to the project site. Based on the options, METRO requested that we complete an evaluation of the road drainage improvement option.

Our scope of additional work was described in our Personal Services Agreement with METRO, authorized on January 26, 2011 and included the following tasks:

- Conducting a site visit to evaluate existing road drainage features and identify potential locations outside of the landslide area to reroute stormwater.
- Completing detailed field reconnaissance in the potential outfall areas. Evaluating the stability of these areas and the potential for increased water to destabilize them.
- Measuring approximate relative road elevations to evaluate road grades for drainage improvements.
- Evaluating the affect(s) of rerouting the water to other locations, in particular, whether such measures are likely to improve site stability or risk creating other unstable areas.
- Providing recommendations for improvements to the road drainage system.

Our evaluation and recommendations are provided in the following sections. Information in our previous memorandum is not repeated here, but provides background to the discussions in this memorandum.

SITE CONDITIONS

Our initial site visit was conducted on June 11, 2010. As described in our subsequent July 2010 memorandum, an existing, unsurfaced logging road leads to the subject landslide, crosses above it, and continues east across site slopes. A culvert was apparently present near the head of the landslide and which was removed prior to our visit, leaving a swale through the road prism for water to drain. The subject landslide reportedly occurred in 1996, based on a report by AKS Forestry which was prepared for the previous landowner at that time. Based on the initial site visit and description in the 1996 report, the landslide did not appear to have significantly changed since 1996. The landslide appeared similar to the report description and physical features during our visit suggested the landslide occurred within the last 10 to 15 years. A house was present below the toe of the landslide, but the house did not appear to be affected by landsliding. We also observed additional landsliding below the house at the time of our June visit.

We conducted an additional site visit on March 3, 2011, which included a visual reconnaissance of the logging road, the subject landslide, the slopes around the road, and off-site areas on adjacent properties. We understand that no significant activity or alteration to the site has occurred since our initial site visit, except a new landslide adjacent to a barn, described later in this report. Our observations are documented below, with locations of significant features shown on Figure 2.

- The unsurfaced logging road leading to the area appeared unchanged from our previous visit. Due to recent heavy rain fall, we were able to better evaluate the surface drainage of the road to the landslide area. We observed that surface water on the road east and west of the major stream drainage which is present at the west edge of the subject landslide ("Main Stream" on Figure 2) varies significantly. These features are shown on Figure 2 and drainage of these road segments are described separately below.

    - "West Road Segment" – The road extending about 400 feet from the "Main Stream" to a natural drainage divide ("West Road Drainage Divide") was very wet during our visit. We observed surface water runoff and spring seepage flowing in the road ditch and across the road surface. Much of this water drained into the Main Stream, but some seeped over the outside edge of the road onto the lower slopes.

    - "East Road Segment" – From the Main Stream east to the subject landslide, we did not observe water in the ditch or on the road. Additionally, the road showed no signs of past surface water flow. For example, we observed leaves in the ditch, which would have been removed by water if water had flowed in the ditch. The swale created when the old culvert was removed from above the head of the landslide was free of water, and there were no indications of recent water flow, such as surface erosion or channeling. Even during the very high precipitation this year, it does not appear water flowed in the ditch or on the road surface.

- The Main Drainage (Figure 2) flows through a steep drainage that appears generally stable in its existing condition, although stream-adjacent slopes are subject to localized failures.

- The "Active Landslide" (Figure 2) appeared similar to as observed during our June 2010 site visit and as described in our July 2010 memorandum.

- The "Lower Landslide" (Figure 2) was noted during our June 2010 reconnaissance and appeared similar to as observed at that time.

- The "Existing House" below the landslide appeared similar to as we observed and described in our July 2010 memorandum.

- We observed an active rotational failure near a pole barn southeast of the existing house (noted as "Cut-bank Failure" on Figure 2). The west end of this landslide is consistent with a reported ground crack that affected the driveway and was noted in our July 2010 memorandum. This active landslide has occurred since our June 2010 visit. We observed as much as 3 to 4 feet of vertical displacement on the backscarp of this slide, as well as several feet of lateral movement at the toe. Our observations suggest that this slide is related to the failure of the cut-bank on the uphill side of the pole barn which was made for construction of the pole barn. We did not observe evidence that suggests that this feature is related to larger, deep-seated slope movement that might extend onto METRO property, but it could be related to it.

- A significant "Seep" (Figure 2) was noted to the southeast of the subject site. The slope near the Seep was otherwise regular and planar, and the surrounding conifer trees were generally straight. However, the ground surface was extremely soft, saturated, and the water volume was sufficient to form a stream that flowed from the seep past the home southeast of the project site.

- We did not observe other indications of landsliding at the site or nearby areas we traversed.

DISCUSSION

Based on our observations, the Eastern and Western Road Segments have very different affects on the surface and shallow subsurface hydrology at the site. The Western Road Segment does not direct water to the Subject Landslide but to the Main Stream drainage just west of it. However, it is intercepting and redirecting significant surface and shallow groundwater during normal winter rainfall events. The water mostly flows down the road and into the Main Stream. Some saturates the road prism and possibly the stream crossing fill. The stream channel below the road is steep and the slopes appear marginally stable. Increased stream flow could cause increased erosion and shallow sliding adjacent to the stream. The slopes below the road and continuing to the stream, however, did not exhibit sliding, and the evergreen trees were generally straight. However, the slopes are steep for this area and saturation of the slopes could lead to landsliding.

The East Road Segment topographically drains to the Active Landslide, capturing most water from the drainage basin between the "Center Drainage Divide" and "East Drainage Divide" (Figure 2) (e.g. from the Main Stream to the swale formed by the Removed Culvert). The captured water is then delivered to the head of the Active Landslide at the Removed Culvert. This is more water than naturally would drain to this area and at a higher rate than would be natural. Such occurrences could exacerbate the instability of the Active Landslide. However, although the road topographically drains to the Active Landslide, it appears to intercept and/or redirect only minimal, if any, surface and shallow ground water. As previously noted, despite recent heavy rainfall, there was no water present in any of the drainage facilities and no evidence there has been any through this winter. During extreme rain-on-snow or rainfall events, this segment may intercept and/or redirect more water to some extent, but it is unlikely that it is a large volume.

Slopes below the West Road Segment include or are adjacent to the Active Landslide, so are expected to be too unstable to direct water onto. Therefore, if drainage improvements were to be made to the West Road Segment, water would need to be taken to the Main Stream drainage and/or east of the East Drainage Divide (Figure 2). Slopes within the Main Stream drainage are marginally stable, as noted earlier, so additional water flow could have adverse affects on the stream-adjacent slopes. Water delivered east of the East Drainage Divide could be routed to surface drainage facilities at either Option 1 or Option 2 locations shown on Figure 2. Slopes below these areas did not exhibit signs of active or recent sliding locally. Conifer trees were sparse on these slopes but straight where present. The Seep is present near the Option 2 site and soils were locally saturated near it. These slopes appear to be the most stable of those in the area, but still may be adversely affected by increased water.

CONCLUSIONS

Based on our observations and discussion above, the West Road Segment and East Road Segment have different risks. Each is discussed separately below.

The West Road Segment does not drain to the Active Landslide, so does not adversely affect it. However, the road significantly changes the hydrology in this area and future landsliding may occur from the uncontrolled and unnatural drainage condition that is now present. Options to address this risk from the West Road Segment are summarized in Table 1 below.

Table 1. Summary of Mitigation Options, West Road Segment

OPTION	NEGATIVE	POSITIVE
No Action	• Potential water impoundment along road and ditch, soil saturation, possible erosion. • Possibility of fill saturation and failure. • Potential erosion through road surface, saturation of slope below, and incision failure of slope.	• Inexpensive. • Allows continued access east of landing.
Surface Drainage Improvements	• Intermediate cost. • Continuing potential for roadcut and ditch impounding water. • May increase risk of erosion downslope of bar outfall. • Will require on-site monitoring during construction. • Will require some long-term maintenance.	• Reduces potential soil erosion. • Less expensive than full regrading. • Continuing but limited access east of landing.
Road Removal	• Highest cost. • Temporary disturbance • Limits access • Need to address seep and drain to surface.	• Limited future maintenance. • Removes potential for roadcut/ditch impounding water flow. • Removes potential fill failure. • Significantly reduces potential for slope failure. • Returns area closest to natural conditions.

The East Road Segment topographically drains to an area that would increase landsliding of the Active Landslide. If significant water flow were to be captured by the road, it could have adverse affects on the Active Landslide. Options to address the road drainage were considered and are summarized in Table 2 below.

Table 2. Summary of Mitigation Options, East Road Segment

OPTION	NEGATIVE	POSITIVE
No Action	• Continued, although low, potential for water impoundment along road and ditch. • Continued potential to direct water flow to existing landslide in high precipitation/rain-on-snow events.	• Inexpensive. • Continuing access to slope area east of landing.
Road Removal	• Temporary disturbance. • Eliminates access east of main stream. • Low decrease in risk.	• Moderate cost. • Removes potential for roadcut/ditch impounding water flow, although potential is lower here than west segment. • Removes undocumented roadfill soil prism. • Returns area closest to natural conditions.
Surface Drainage Improvements	• Highest cost. • Disturbance of existing slopes and vegetation. • Continuing risk of roadcut impounding water. • May increase risk of erosion/landslides downslope below outfalls, including nearby off-site properties. • Will require construction monitoring to locate, ensure construction to plan. • Will require long-term maintenance to ensure proper functioning. • Low decrease in risk.	• Slows and/or diverts water flow, reduces potential for soil saturation and erosion. • Continued access east of main stream. • Provides positive control of water flow.

RECOMMENDATIONS

WEST ROAD SEGMENT

We do not have a strong opinion of the option METRO should select for the West Road Segment. We do not see a significant safety or property damage risk from this segment. However, landslide risk is increased beyond natural conditions by the present condition. If landsliding were to occur, it would most likely affect local vegetation and also increase stream turbidity. If METRO wishes to address this condition, either Surface Drainage Improvements or Road Removal should be selected which is most consistent with cost and access goals for the property. Road removal measures would be as described as per the East Road Segment below and per the typical section included as Figure 3. In addition, any visible seeps should be addressed with subdrains (Figure 4) that consist of 4-inch diameter perforated pipe surrounded by a minimum of one cubic foot of drain rock per lineal foot. The drain rock should be wrapped with a drainage geotextile (i.e. filter fabric).

If Surface Drainage Improvements are made, they should consist of the following:

1. Water bars should be constructed at the approximate spacing/locations shown on Figure 2 and per the detail shown on Figure 4.

2. The existing culvert should be removed and the slopes in the area of the stream restored to their natural conditions.

3. The affected area should be replanted with native vegetation consistent with METRO's access objectives.

4. Temporary erosion control measures should be put into place until vegetation is reestablished, such as straw mulch, silt fences and other measures and as per jurisdictional requirements.

In addition to the above work, waterbars require future monitoring and potential future maintenance. For example, high flows off the road can lead to erosion below the outfall which may require some outfall protection. This should be taken into account in selection of a preferred option.

EAST ROAD SEGMENT

Although the East Road Segment topographically drains to the Active Landslide, it does not appear that significant water is captured by the existing road. If drainage improvements were to be made, they would require relatively significant grading to the locations shown on Figure 2. It appears that little water would be routed to these areas, and if it were, there is some risk that new landslides could be caused by the new water inputs. Due to these factors, we do not recommend Drainage Improvements as noted in Table 2. Due to the potential for routing water during extreme events, however, we recommend Road Removal for this segment per Table 2. Road Removal would restore surface drainage to its natural condition so there is not an increase in surface water inputs above natural conditions. This does not increase the stability of the slopes, but ensures it is not decreased by anthropogenic conditions. Road removal should include the entire East Road Segment and consist of the following elements:

1. The road should be regraded to approximate natural grades present before the logging road was constructed.

2. Reconstruction should consist of benching into the uphill cut slope; stripping organics from the downhill side of the slope; pulling fill from the downhill side of the road; and then placing and compacting the fill on the road prism and against the cut side. Strippings can be placed as a thin layer over the regraded surface. A typical schematic section is attached to this memorandum as Figure 3.

3. The affected area should be replanted with native vegetation.

4. Temporary erosion control measures should be put into place until vegetation is reestablished, such as straw mulch, silt fences and other measures and as per jurisdictional requirements.

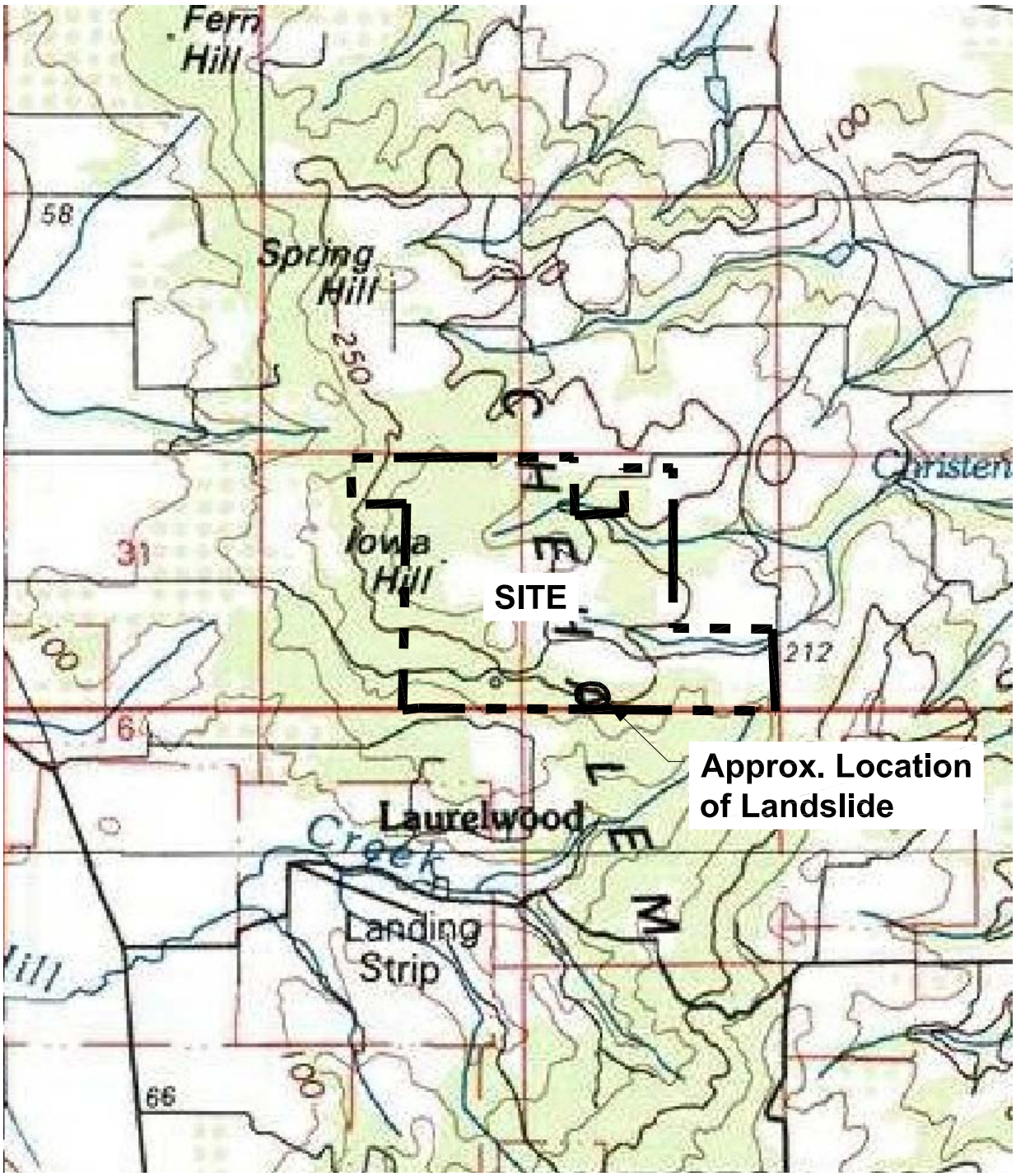
We can be contacted to further discuss any of the above recommendations with METRO.

LIMITATIONS

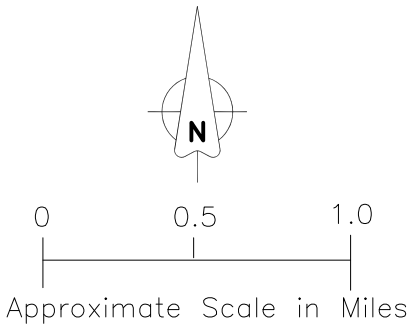
We have prepared this memorandum for the exclusive use of METRO and their authorized agents for evaluating potential mitigation options at the subject site. Our work was completed in general accordance with our services agreement. Our memorandum is intended to evaluate these specific geotechnical conditions and options as they relate to the subject site only. However, all development on slopes involves risks, only part of which can be mitigated through qualified geotechnical evaluation, engineering and construction practices. Favorable performance of structures in the near term does not imply a certainty of long-term performance, especially under conditions of adverse weather or seismic activity.

Our opinions are based solely on evaluation of existing information and our observations of site conditions at the time of our site visit. Subsurface explorations would be necessary to increase our confidence in actual site conditions and interpretation, and we can provide such services if requested. Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty, expressed or implied, should be understood.

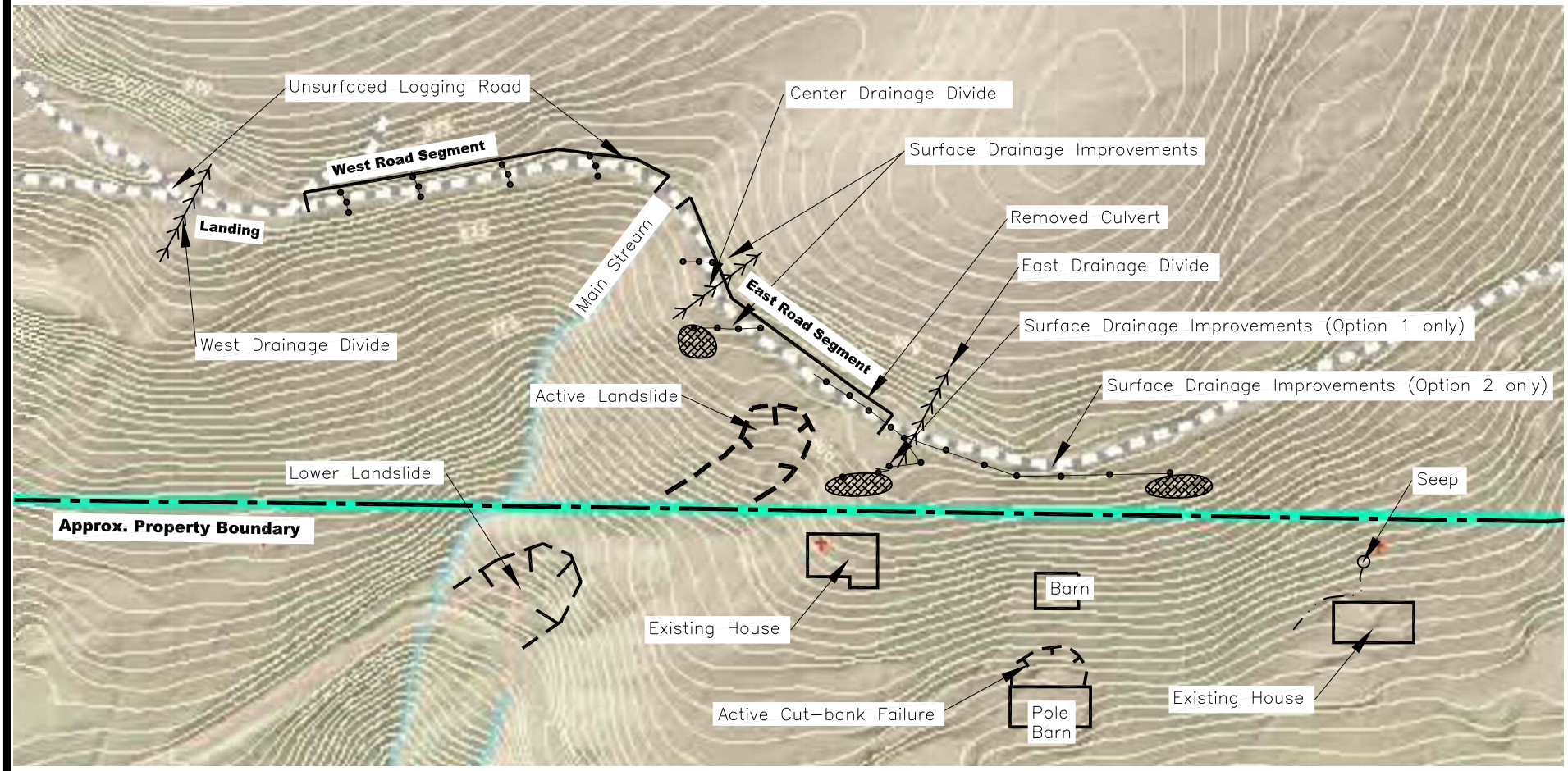
Document ID: 1344-002-01Memo2_04_06_11.docx



Base map created using National Geographic TOPO mapping application
Locations are approximate



DWG NAME:	Vicinity Map		
DESCRIPTION:	Chehalem Ridge Natural Area Washington County, Oregon		
JOB NO.:	1344-002-01	DATE:	4/6/11
FILE NAME:	134400201F1 Vicinity Map.dwg	FIGURE	1



Legend

Approximate location/extent of observed landslide

Approximate location of possible waterbars/rock-lined ditches

Approximate location of possible water dispersal areas

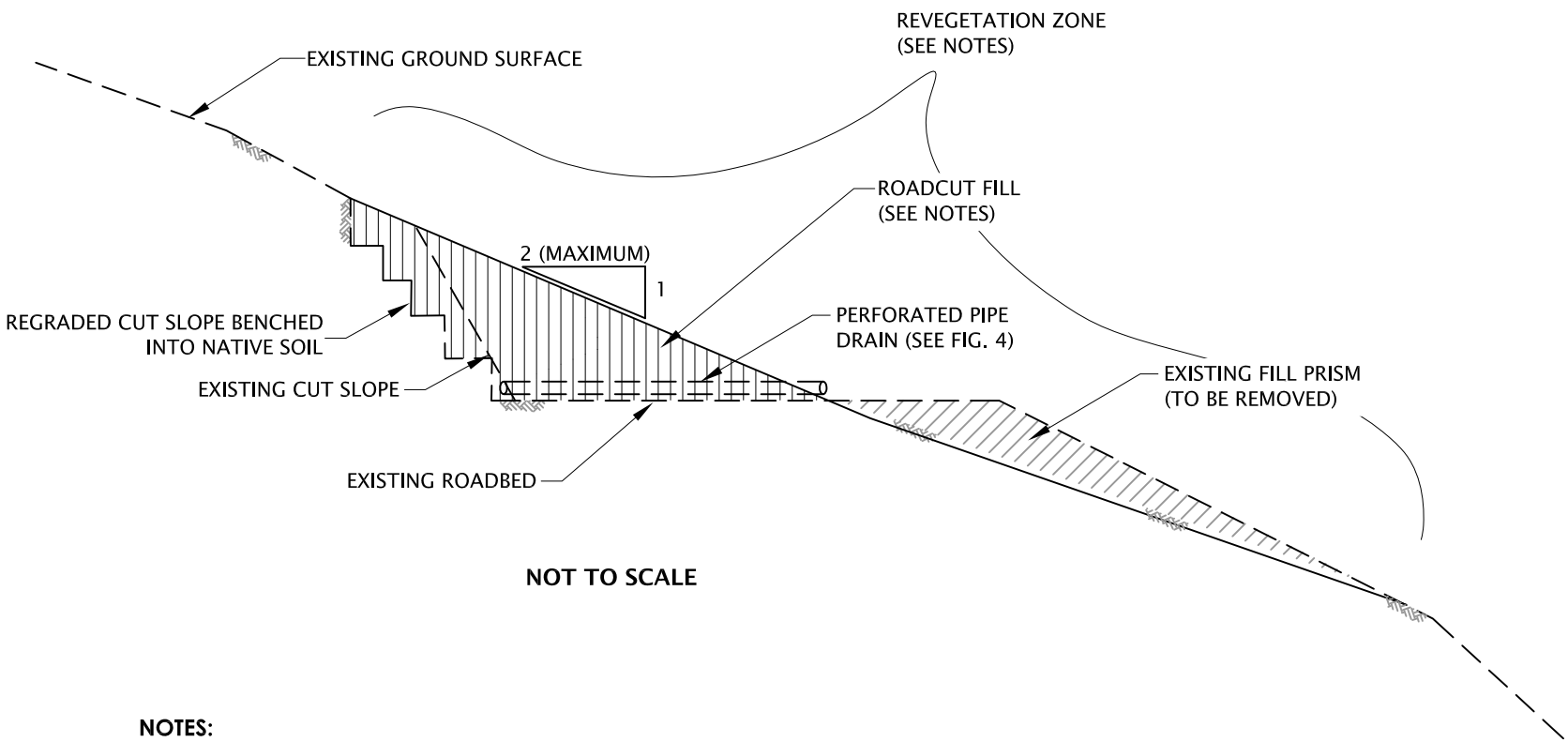
N

200 0 200

APPROXIMATE SCALE IN FEET

Base map adapted from "smChehalemLIDARHillshade.pdf"", prepared by METRO, undated. Original scale 1" = 666.7'. Field observations and potential drainage improvements from site sketch prepared by Pacific Geotechnical staff; all locations approximate.

DWG NAME:	Site Map		
DESCRIPTION:	Chehalem Ridge Natural Area Washington County, Oregon		
JOB NO.:	1344-002-01	DATE:	4/6/11
FILE NAME:	134400201F2 Siteplan.dwg	FIGURE	2



NOT TO SCALE

NOTES:

1. SUBGRADE SHOULD BE STRIPPED OF VEGETATION AND TOPSOIL, AND EVALUATED BY GEOTECHNICAL ENGINEER PRIOR TO ROADCUT FILL PLACEMENT.

2. FILL SHOULD CONSIST OF ON-SITE MINERAL SOIL (FREE OF ORGANIC MATERIALS) OR IMPORTED BORROW IN CONFORMANCE WITH OSSC 00330.12 - BORROW MATERIAL.

3. SOIL FILL SHOULD BE MOISTURE CONDITIONED, PLACED IN THIN LEVEL LIFTS, AND COMPACTED BY TRACKING WITH EQUIPMENT OR SHEEPSFOOT ROLLER. TRANSITION ALL GRADES TO NATIVE ADJACENT SLOPES WITHOUT ABRUPT CHANGES, AND ENSURE SURFACE DRAINAGE MATCHES PRE-ROAD CONDITIONS.

4. AREA OF REGRADING TO BE REVEGETATED WITH SUITABLE NATIVE PLANTS AND PROTECTED FROM EROSION (HYDROSEEDED, JUTE MAT, ETC.)

5. SPRINGS OR SEEPAGE TO BE ADDRESSED AS PER FIGURE 4.

DWG NAME: Schematic Road Removal Diagram	
DESCRIPTION: Chehalem Ridge Natural Area Washington County, Oregon	
JOB NO.: 1344-002-01	DATE: 4/6/11
FILE NAME: 134400201F3 Section.dwg	FIGURE 3

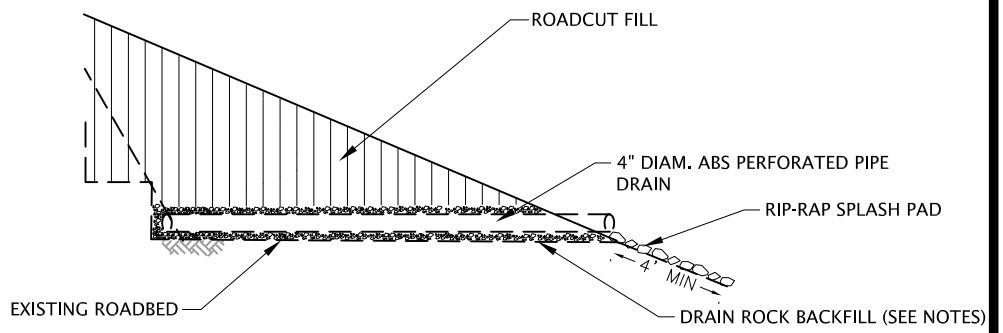
?

WATERBAR DETAIL

NOTES:

1. THE WATERBAR CROSS-DITCH IS CUT INTO THE ROAD BED FROM CUT BANK OR DITCH LINE COMPLETELY ACROSS ROAD SURFACE, EXTENDING BEYOND THE SHOULDER OF THE ROAD.
2. PHYSICAL BLOCKAGE OF THE DITCHLINE DOWN GRADE FROM THE WATERBAR CROSS-DITCH IS REQUIRED TO DEFLECT WATER FLOW INTO THE CROSS-DITCH.
3. THE CROSS-DITCH SHOULD BE PLACED AT A MINIMUM SKEW OF 30 DEGREES TO THE DITCHLINE - GREATER ON STEEP ROAD GRADIENTS.
4. THE EXCAVATED MATERIAL IS SPREAD ON THE DOWNHILL GRADE OF THE ROAD CREATING A BERM.
5. WATER SHOULD ALWAYS BE DISPERSED ONTO A STABLE NATIVE SLOPE WITH VEGETATION OR RIP-RAP PROTECTION.
6. THE WATERBAR BERM SHOULD DIP TO ALLOW VEHICLES CROSS-OVER WITHOUT DESTROYING THE DITCH.
7. THE WATERBAR CROSS-DITCH WHOULD BE CUT TO THE DEPTH OF THE DITCHLINE TO PREVENT WATER PONDING AND TO ENSURE DRAINAGE FROM THE DITCHLINE.

SUBDRAIN DETAIL



NOT TO SCALE

NOTES:

1. PIPE INLET TO BE PLACED AT DOWNSLOPE COLLECTION POINT OF SEEPS. LOCATIONS OF PIPES TO BE FIELD DETERMINED BY GEOTECHNICAL ENGINEER.
2. ONE CUBIC FOOT OF DRAIN ROCK BACKFILL PER LINEAL FOOT TO FULLY ENVELOPE PIPE. DRAIN ROCK TO CONSIST OF 4" WASHED ROCK MEETING OSSC 00360.11 - GRANULAR DRAINAGE BLANKET.
3. DRAIN ROCK TO BE FULLY ENVELOPED BY FILTER FABRIC MEETING OSSC 02320 - DRAINAGE GEOTEXTILE.
4. OUTFALL OF PIPE SHOULD DRAIN ON TO NATIVE SLOPE SURFACE WITH MINIMUM 12-INCH THICK CRUSHED ROCK SPLASH PAD. DRAIN ROCK MATERIALS MAY BE USED FOR SPLASH PAD.

DWG NAME:	Details		
DESCRIPTION:	Chehalem Ridge Natural Area Washington County, Oregon		
JOB NO.:	1344-002-01	DATE:	4/6/11
FILE NAME:	134400201F4 Details.dwg	FIGURE	4