Province of British Columbia

Ministry of Environment and Parks
WATER MANAGEMENT BRANCH

MEMORANDUM

C. Bull Copy

To: Don Dobson, Head
Engineering
Penticton Sub-Regional Office

Date: April 12, 1988

Our File: 82E12 #31

403502
Trout Creek

Re: Trout Creek Landslide

Further to your request of February 1987, please find attached a preliminary groundwater assessment of the Trout Creek Landslide as prepared by our staff.

There is not enough information about the hydrogeology beneath the slide area for the design of remedial measures at this time. Initial test drilling to obtain sub-surface hydrogeological data is recommended as a first step in gaining greater overall understanding of the slide before any remedial measures can be planned.

In addition, a geotechnical appraisal of the slide should also be done so that any hydrogeological investigation is integrated within the overall stability study of the slide. A copy of this report is being forwarded to Peter Woods, Head, Special Projects Section.

If you have any further questions, please do not hesitate to call me at 387-1115 in Victoria.

A. P. Kohut

A. P. Kohut
Acting Head
Groundwater Section
Water Management Branch
387-9464

MW/sz
Enclosure
AES:W2396

cc: Peter Woods, Head
Special Projects Section

Province of British Columbia

Ministry of Environment and Parks
WATER MANAGEMENT BRANCH

MEMORANDUM

To: A.P. Kohut
Senior Geological Engineer
Groundwater Section

Date: April 9, 1988

Our File: 82E/12 #31

Re: Trout Creek Landslide

INTRODUCTION

As requested by D. Dobson, Engineering Section Head, Penticton Regional Office, a preliminary assessment of the groundwater conditions in the area of the above has been completed. The slide is situated along the north bank of Trout Creek in the Trout Creek Canyon, 3 miles south of Summerland and has been moving continuously for about the last 60 years (Fig. 1). Besides threatening residential and agricultural development in the terrace area back of the slide (Paradise Flats), the slide is continually sloughing and moving material into Trout Creek and is contributing to the creek's silt load.

The Regional Office's main concern is primarily with the heavy silt load in the creek because it kills aquatic life (fish food), "chokes" the fish and silts up gravel spawning beds for the kokanee (pers comm. C.J. Bull, 1987) The creek must be silt-free from fall to spring if it is to benefit kokanee (assuming that water quantity and quality conditions outside of the slide during that period are also adequate to sustain the kokanee). The true worth of Trout Creek from kokanee is estimated at $3,000,000 (Bull, 1987). These considerations affect the planning of any remedial measures to stabilize the slide for Fisheries' benefit.

Numerous preliminary studies have been done on the slide. Much of this memorandum is based on a review of these previous studies, especially work by Riglin (1977) as well as from interpretation of air photos covering different periods and field visits by Groundwater Section staff in June, 1987. This memorandum outlines the physical and hydrogeological conditions at the slide and recommends further investigative work to determine stratigraphic and hydrogeologic factors of the slide in greater detail so that appropriate and effective remedial measures can be planned.

apk

SLIDE DESCRIPTION

The slide has developed along the edge of a sandy terrace above Trout Creek. From the ground (and from air photos) the slide is obvious and well defined (Photo 1 and 2). The bounding failure surface is evident along the back and side scarps and is exposed along the toe, 150 feet above the creek. Within the slide the land surface is stepped in appearance and has an overall slope of about 22%.

Three main slide blocks - the upper, middle, and lower blocks - occupy most of the slide (Figs. 2 and 3). Failure surfaces separate these main blocks as a result of differential movement. Numerous other failure surfaces exist within the main blocks themselves especially in the middle and lower blocks as a result of differential movements within the blocks. The appearance and geometry of the slide indicate that differential slumping and backward rotation has occured and that the blocks have also moved laterally downhill.

Overall, the slide measures a maximum 1,400 feet in length from head to toe and maximum 1,400 feet from side to side (Fig. 2). However, the slide volume is unknown because the bounding failure surface beneath the slide is unknown.

LOCAL GEOLOGY

Terraced glaciofluvial sand and gravel deposits line the lower reaches of Trout Creek, including the slide area. Presence of the glaciofluvial deposits as far up the creek as the slide area suggests that the water level of Okanagan Lake was probably about 200 feet higher during the ice age than today. These deposits were probably formed during the last ice age where Trout Creek emptied into Okanagan Valley (Nasmith, 1962).

Geologically, the slide area is situated along the southern boundary of the Summerland Basin, an assemblage of Tertiary volcanic rocks (Church, 1980). Pre-Tertiary granitic basement rocks bound the Summerland Basin to the west and south (Figure 1). The southern part of the Summerland Basin is truncated by the Summerland Fault which is believed to run subparallel to the lower reaches of Trout Creek and near the slide area (Figure 1).

Much of the slide involves the unit of glaciofluvial sand and gravel which is saturated at its bottom section (Figs. 2 and 3). The overall thickness and saturated thickness of this unit beneath the slide is unknown. Beneath this sand and gravel unit is a thinner assemblage of till, clay, and silt and weak bedrock comprised of light-grey volcanic sandstone, claystone, and coal. This weak bedrock may be part of the Tertiary volcanics mapped by Church (1980). This assemblage is exposed only in the lower block along the toe and is broken up, sheared, and repeatedly upthrusted (Photo 3). Along the toe, the failure surface occurs within this weak assemblage and above competent orange and green granitic bedrock (probably the Pre-Tertiary basement rocks) which forms the Canyon Wall (Photo 4). The slide doesn't appear to involve the granitic rock, but only the materials overlying it.

Field inspection and limited drill log information from Golder Associates Ltd. (1979) indicate that the whole section of unconsolidated sediments and weak Tertiary bedrock is thicker at the slide than in the adjacient areas; the competent Pre-Tertiary bedrock appears to be located higher on either side of the slide than at the slide. In fact, the weak Tertiary bedrock appears to exist only locally at the slide. This suggests that the slide occurs within a Tertiary buried valley feature which intersects Trout Creek Canyon.

SPRING DISCHARGE AND GROUNDWATER FLOW

Much of the lower block appears saturated. Upper springs occur along the head of the lower block and the spring water either collects in hollows further down the lower block and then resurfaces at the toe as lower springs or incises a steep channel in the slide material (Figs 2 and 3). On reaching the toe of the slide the water flows over the granitic bedrock lip and then down to Trout Creek. Spring water continually erodes and moves the slide material to the toe where it sloughs bit by bit onto the talus slopes below. Spring flow over the lower part of the slide and down the loose, steep talus becomes silt laden as it reaches Trout Creek (Photos 4&5)Total discharge in June, 1987 is estimated at a few hundred gpm. Nowhere else along the Canyon Wall is groundwater discharge as obvious as at the slide.

The groundwater feeding the springs likely originates from the terrace area behind the slide and flows through the sand and gravel aquifer unit and maybe also through the underlying weak Tertiary assemblage as well. This is inferred from:

1. inspection of topography - the slide lies directly downhill from the terrace area

2. prescence of nitrates in the spring water (Riglin, 1977) suggests that the water likely originates from agricultural areas (the most immediate is the terrace area)

3. peak spring discharge correlates with irrigation patterns in the terrace area (Riglin, 1977).

No springs are apparent in the Pre-Tertiary granitic rock.

SLIDE MOVEMENTS

Removal of slide material at the toe by spring discharge removes the buttress support for the slide and allows the lower block to move continuously as a waterlogged mass downhill probably along the surface of the Pre-Tertiary granitic rock. Downhill movement of the lower block reduces support for the middle block causing it to move and so on as failure gradually and continuously reaches back up the slide. Previous ground measurements by Riglin (1977) and Madsen (1974) and from inspection of air photos covering different years show that, in general, recent movements increase from the upper block (about 1 foot/year) downhill to the lower block (up to 35 feet/year) and from the sides to the centre of the slide (Figs. 2 and 3). Within a year the rate of movement seems to coincide with the rate of spring discharge, occurring greatest in late fall (Riglin, 1977).

Rate of movement over the years is uncertain because no long-term data are available. However, the slide is believed to have initiated in the period 1914 to 1917, about 10 years after irrigation water was first introduced onto the terrace area. Mathews (1975) inferred that over half of the total slide movement occurred during the initial failure. Apparently the slide has been moving continuously at a steady rate eversince.

In recent years, much of the overburden cover on the upper block was stripped away and part of the block was mined for gravel (photo 1). This would tend to enhance infiltration of any precipitation and irrigation runoff into the upper block which would promote greater slide movement.

TALUS SLOPES

Steep talus cones have formed below the lip of the slide down to the bank of Trout Creek as a result of accumulation of sloughed material from the lower block (Photo 2). The slope ravels constantly trying to adjust its slope angle. Material is continually being added to the talus slopes from the top and removed from the bottom by Trout Creek. This erosion at the bottom apparently also contributes to the creek silt load especially during freshet. In June 1987, however, it was apparent that spring flow was bringing more silt into the creek than that caused by erosion of the talus slopes (Photo 5). Movement of the talus slope has not been well studied.

DISCUSSION

Evidently local geology and groundwater conditions greatly influence the slide stability which in turn affects the siltation of Trout Creek. The thick overburden section at the slide acts as a basin or channel for groundwater flow and the occurrence of the till, clay, and weak Tertiary volcanic sandstone, claystone, and coal render the slope susceptible to failure. Although groundwater discharge was likely present even before the initial slide formation (some springs had always been present along the Canyon Wall), history suggests that increased irrigation on the terrace probably triggered the slide by increasing recharge into the groundwater system and raising the groundwater level thereby decreasing the effective shear strength of the ground thus leading to failure. Factors such as topography, spring water chemistry, irrigation, and spring discharge patterns suggest that recharge for the springs is perpetuating instability and comes from the terrace area, where irrigation is occurring. Spring runoff is eroding the lower portion of the slide and the talus slopes bringing significant amounts of silt to Trout Creek. Controlling groundwater flow and protecting the talus slopes against erosion by Trout Creek on a year-round basis are potential measures which would likely stabilize slide movement and minimize the siltation problem for Fisheries' benefit. Remedial measures for slide stabilization may involve for example (refer also to Fig. 4):

A. dewatering wells on the terrace back of the slide to lower the groundwater level by intercepting the flow before it reaches the slide

B. horizontal drains along the lower block to dewater the toe and lower section of the slide

C. an interceptor ditch along the toe to collect spring runoff after it comes out of the slope and to protect the toe from erosion as recommended by Smythe (1975).

The water collected would have to be piped away from the slide. The rate of movement at the toe suggests that an interceptor ditch however would need frequent maintenance and may even be destroyed within a year. Furthermore, an interceptor ditch in this case would simply collect spring discharge and would not dewater the slide.

Horizontal drains may work provided that a drilling rig can be brought into the lower section of the slide and the holes can penetrate far enough into the slope to effectively intersect the sand and gravel unit beneath the slide to lower the groundwater level. Maintenance and possible replacement for the horizontal drains may also be required.

On the other hand dewatering wells in the upland terrace above the slide could remain as permanent installations, largely unaffected by slide movements.

At the present, there is insufficient understanding of the local stratigraphy, structure (including the failure surfaces), hydrology (water levels, hydraulic conductivities, storativities, flow), and geotechnical aspects (soil strength, resistance along the failure surfaces, rates of movement) of the slide to recommend the most cost-effective measures:

1. would dewatering wells be effective for example in intercepting groundwater flow before it reaches the slide? How many wells would be required, where, what size, how deep, the pumping rates, costs of construction and pump installations, etc.

2. would horizontal drains at the toe be effective? how far into the slide can horizontal drains be constructed (will depend on local geology and access), will they be relatively maintenance-free etc.

The significance of the talus slopes on siltation of Trout Creek has not been well documented. More information such as the nature and rates of movement, timing, and degree of talus slope erosion is needed to decide what appropriate protective measures should be taken such as rip rapping, building protective walls, planting vegetation, etc.

Under present conditions, not only will siltation of Trout Creek from spring discharge and erosion at the slide continue but the slide would continue moving, failing progressively further back onto the terrace area.

RECOMMENDATIONS

The following initial steps are recommended in gathering necessary site specific information on the slide to help plan appropriate stabilization measures:

1. drill up to five testwells to determine water levels, hydraulic gradients, groundwater flow, hydraulic conductivities and storativities of the slide materials. The testwells should be located along the slide cross-section where accessible and along the area back of the slide. The testwells should be drilled through the sand and gravel unit and underlying till-clay-weak Tertiary bedrock assemblage to the surface of the granitic bedrock. The testwells should be drilled by the cabletool method with continuous tube sampling and completed with screens and pump tested to determine aquifer characteristics. Cost of five 8-inch, 200-foot deep testwells would cost up to roughly $110,000 excluding engineering supervisory costs (Appendix I).
   After well completion and testing, the wells should be fitted with automatic water level recorders to monitor fluctuation of the water level in the slide area.

2. document irrigation practices in the terrace area and, if possible, check for any leakages in the irrigation pipeline system.

3. in conjunction with the above steps, a comprehensive geotechnical appraisal of the slide should be undertaken so that any hydrogeologic work undertaken is integrated within an overall study of the slide complex.

Once subsurface information, groundwater conditions, and slide movements are better understood, the most appropriate remedial measure, if any, can then be designed. Monitoring of slide movements, groundwater levels, and water quality at Trout Creek after implementation of remedial measures would be imperative to assess the actual effectiveness of any remedial program.

REFERENCES

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Mike Wei

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387-9463

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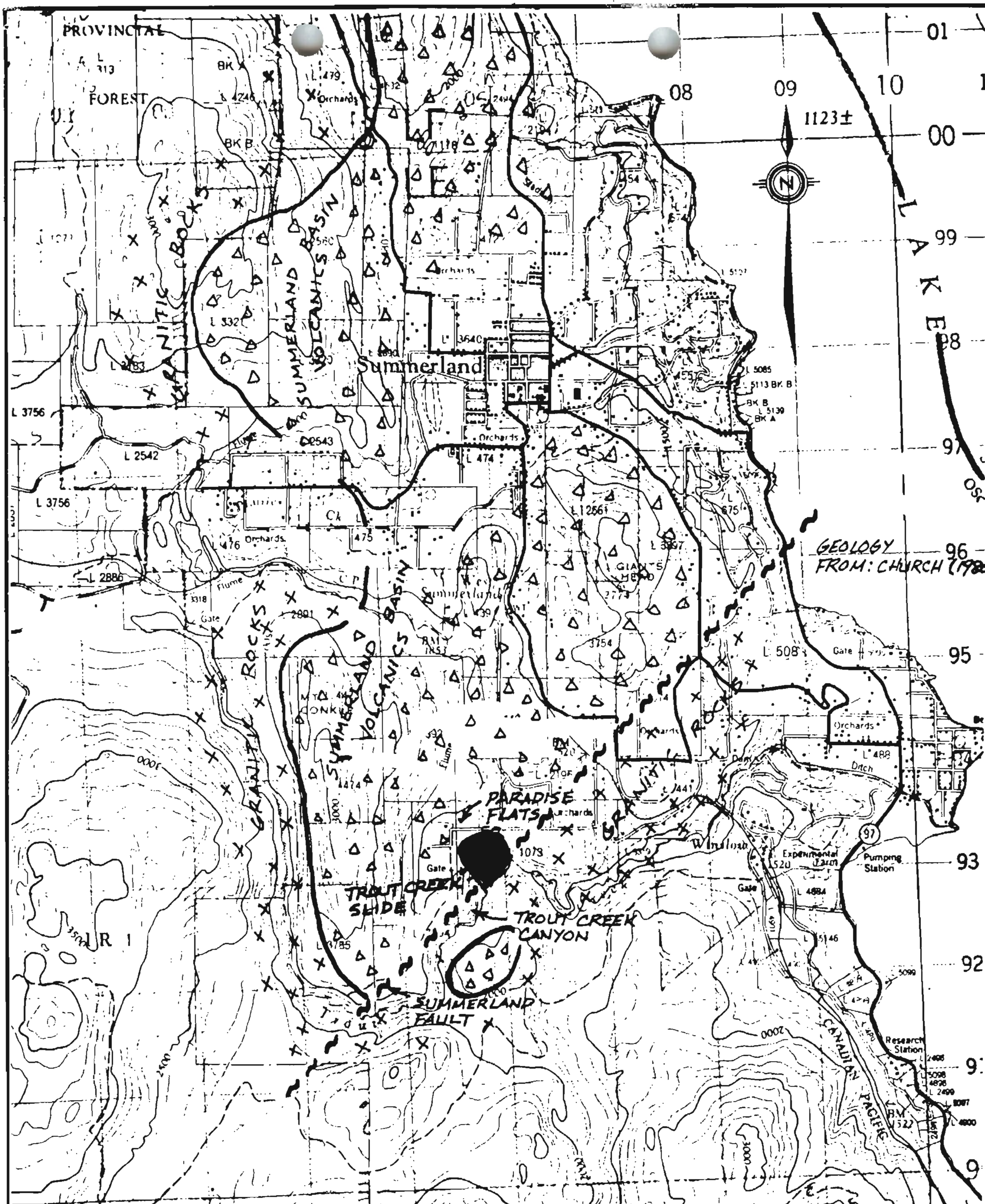
AES:W2396



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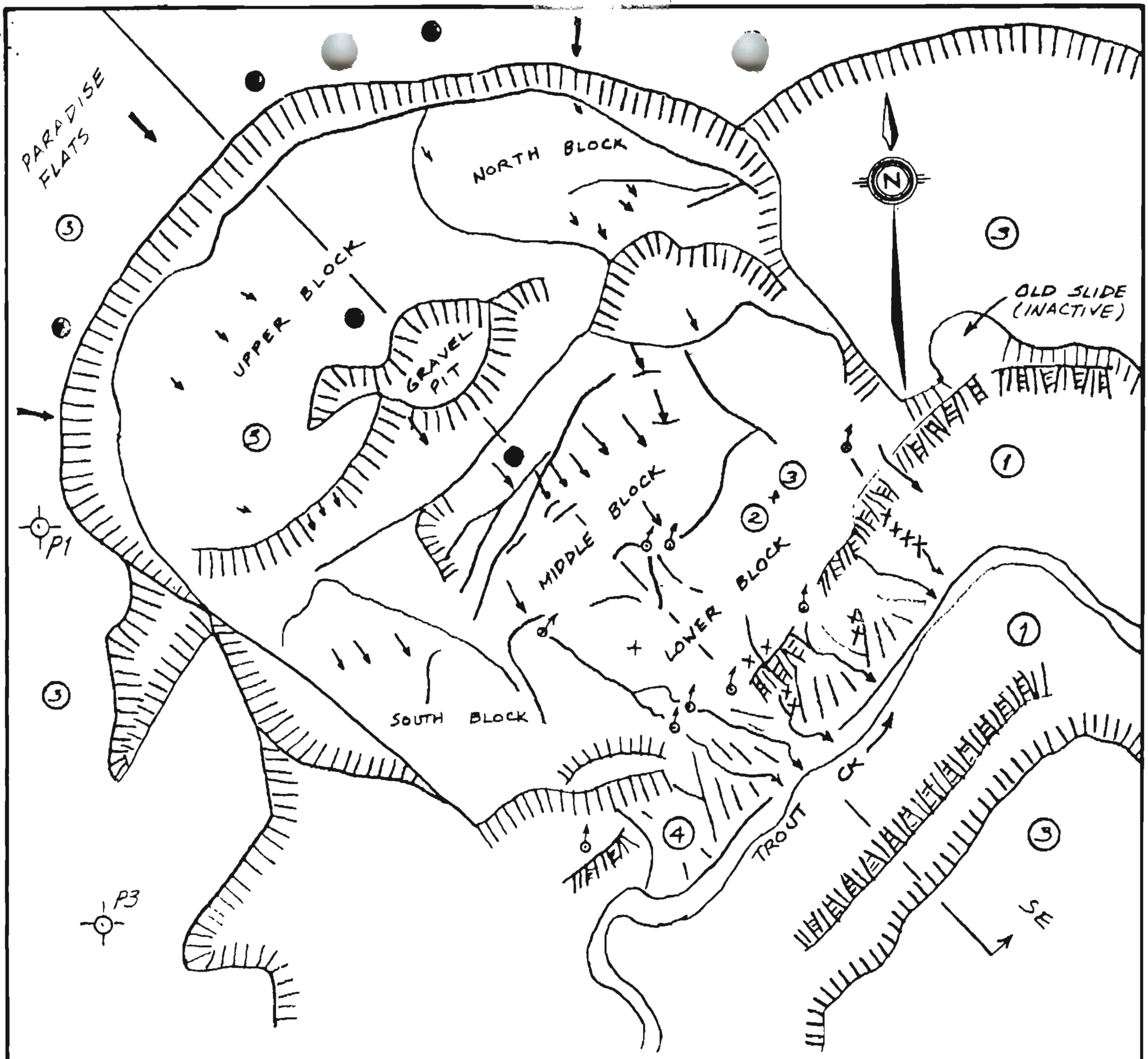
LOCATION PLAN,
TROUT CK. SLIDE.

SCALE: VERT. N/A HOR 1:50,000	DATE 25/2/87	M. WEI ENGINEER FILE No. 82E/12 DWG No. FIGURE 1

VAN CAL 15712



NOTE: FROM GOLDERS (1979), RIGLIN (1977), AIR PHOTO, & FIELD STUDY

LEGEND

- ④ – TALUS
- ③ – SAND & GRAVEL, PERMEABLE
- ② – TILL, SILT, & CLAY
  WEAK TERTIARY VOLC. S.S., CLAYSTONE, & COAL
- ① – PRE-TERTIARY BEDROCK INCL. GRANITIC ROCKS
- ——— GEOL. BOUND. INCL. FAILURE SURFACES
- TTTTTT SCARP
- – BEDROCK CONTACT
- × – BEDROCK OUTCROP
- → – SLIDE MOVEMENT (INFERRED)
- – SPRING
- – EXISTING GOLDERS ASSOC. PIEZOMETER
- ● – PROPOSED TESTWELL
- – GROUNDWATER FLOW DIRECTION (INFERRED)
- – STREAMFLOW

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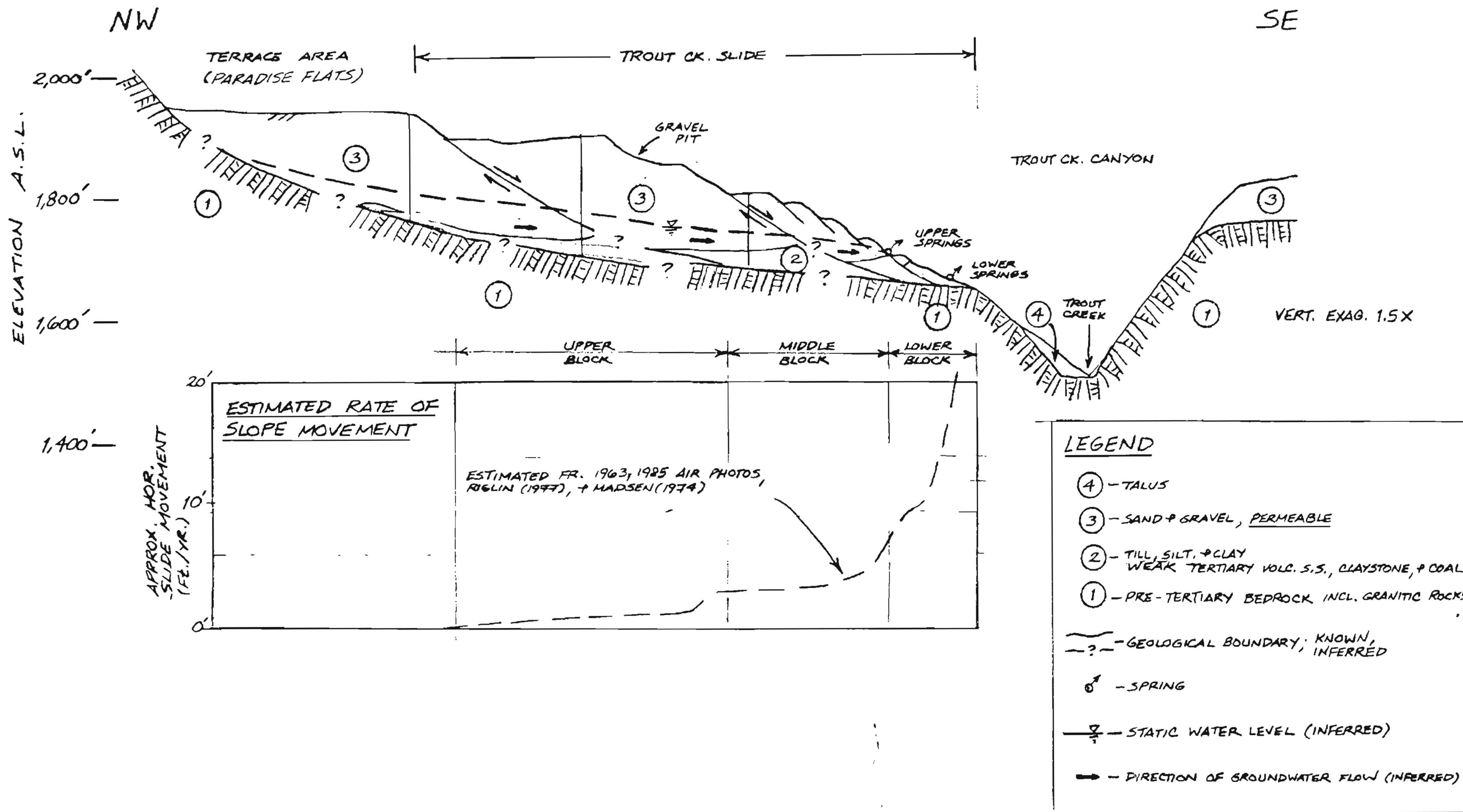
~~TO ACCOMPANY REPORT ON~~

SCHEMATIC MAP, TROUT CK. SLIDE

SCALE VERT N/A HOR 1" = 300'	DATE 14/12/87	M. WEI ENGINEER FILE No. 82E/12 DWG No. FIGURE 2

VAN CAL 15712



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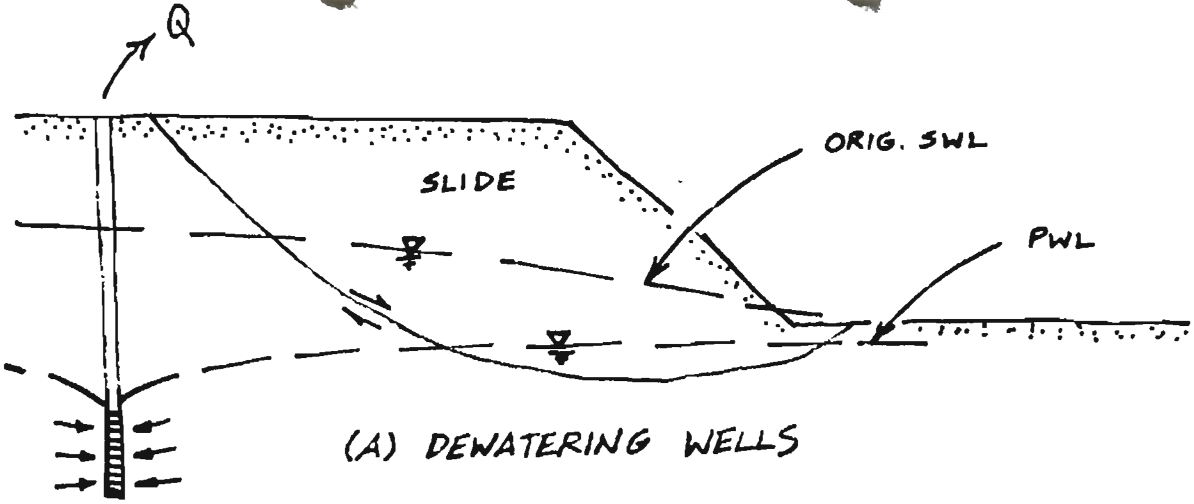
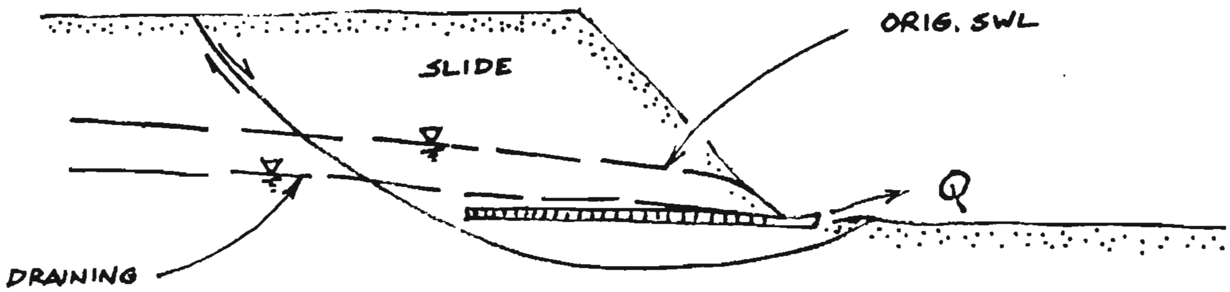
~~TO ACCOMPANY REPORT ON~~

SCHEMATIC CROSS-SECTION ALONG TROUT CK. SLIDE

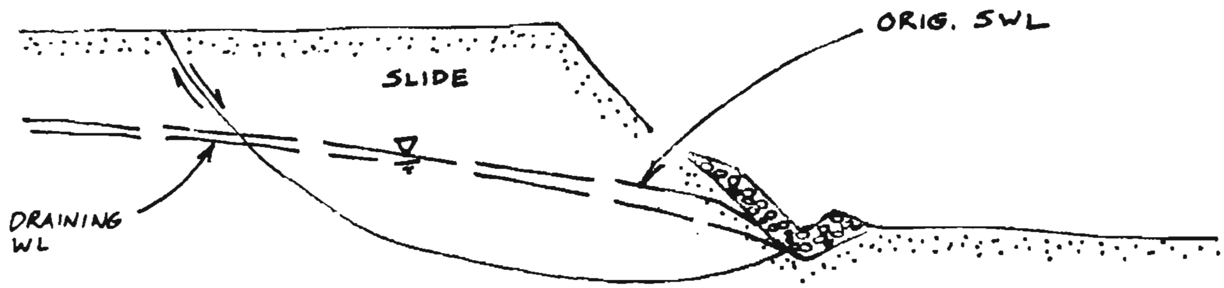
SCALE: VERT. 1" = 200' HOR. 1" = 300'	DATE 14/12/87
M. WEI ENGINEER	
FILE No. 82E/12	DWG No. FIGURE 3



(A) DEWATERING WELLS



(B) HORIZONTAL DRAINS



(C) INTERCEPTOR DITCH

EXAMPLES OF REMEDIAL MEASURES
TROUT CK. SLIDE

Province of British Columbia Ministry of Environment WATER MANAGEMENT BRANCH	TO ACCOMPANY REPORT ON
SCALE: VERT N/A HOR N/A — DATE 2/9/87	M. WEI ENGINEER FILE No 82E/12 DWG No. FIGURE 4

VAN CAL 15712


PARADISE FLATS.
NORTH BLOCK
UPPER BLOCK
GRAVEL PIT
OLD SLIDE
MIDDLE BLOCK
LOWER BLOCK
SOUTH BLOCK
TROUT CK.
BEDROCK SURFACE
SCALE 1" = 300'

PHOTO 1

SOUTH

NORTH

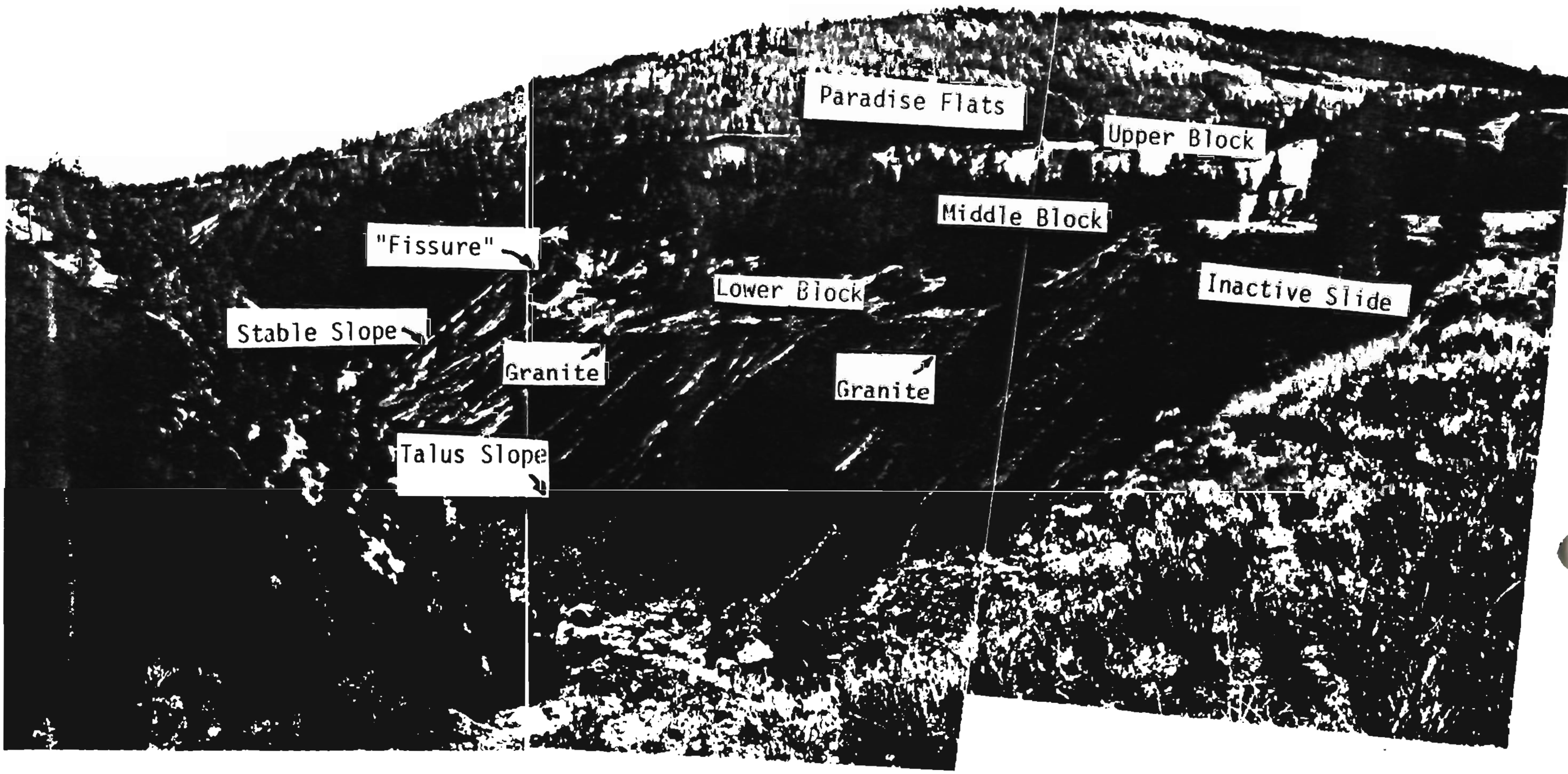


PHOTO 2. VIEW OF TROUT CK. LANDSLIDE. JUNE 1987.

PHOTO 3. UPTHRUSTED + BROKEN UP WEAKLY CONSOLIDATED VOLCANIC SANDSTONE + SILTSTONE.

PHOTO 4. LIP OF SLIDE RESTING ON GRANITIC BEDROCK.

PHOTO 5. SILT-LADEN SPRING DISCHARGE ENTERING TROUT CK.

DATE OF PHOTOS: JUNE, 1987.

APPENDIX 1

- Preliminary Cost Estimate, Testwell Drilling Program, Trout Creek Slide, Summerland, B.C. *

ITEM	AMOUNT	COST
Mobilization and demobilization	1	$ 2,000
Move between sites and set up	4	$ 600
Install 10"Ø surface casing to 15 feet	75'	$ 3,375
8"Ø Drive shoe	5	$ 1,200
8"Ø overlap casing	75'	$ 1,500
8"Ø cased drilling and sampling	925'	$ 37,000
Hourly work	200 hrs.	$ 20,000
Screens and fittings	4	$ 15,000
Standby	40 hrs.	$ 2,000
Mobilization and demobilization of test pump	1	$ 2,000
Install and remove test pump	5	$ 2,500
Pumping test	120 hrs.	$ 9,000
		$ 96,175
	+15% contingencies	$ 14,426
		$110,600

*Excluding engineering supervisory and administrative costs