

GEORES No!  
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523-89-00

**Report to**  
**Proctor & Redfern Limited**  
**on Rock Mass Conditions at Chabanel Twp.**  
**Highway 101, Wawa, Ontario**

November 7, 1997

## Executive Summary

This report describes the rock mass conditions visible in three exposed rock cuts alongside Highway 101 about 10 kilometres east of Wawa, Ontario. The sites were identified by Ministry of Transportation, Ontario staff as potentially hazardous. Ontario Ministry of Labour personnel undertook preliminary assessments in 1992 and concluded that the cuts contained rock hazard; this was confirmed by Franklin Geotechnical Limited during a 1994 field study.

The sites were inspected by the writer on Thursday, October 16th 1997. Rock mass conditions were evaluated and an assessment was made as to the potential remedial works which might alleviate the rock hazard. Of the three sites, identified in previous studies by the letters "P", "Q" and "R", it has been proposed that realignment of the highway away from the rock hazard should be carried out at P and that mitigating measures be employed at Q and R.

Minor scaling and ditch excavation are suggested for Site Q. The proposed measures suggested by Franklin Geotechnical Limited for Site R will be adequate for short-term stabilization but, in the long-term, highway realignment will be required. This report contains not only commentary regarding the mitigation of rock hazard at Q and R, but discusses rock engineering issues which may be considered if a larger rock excavation were taken at Site R.

# 1 Introduction

The work which is described in this report was carried out at the request of Proctor & Redfern Limited (P&R), Sudbury, Ontario. Conversations between P&R and the writer on October 15th, 1997 confirmed the scope of work for the project, part of Ministry of Transportation, Ontario's (MTO's) WP 523-89-00, located on Highway 101 from 8.1 km west of Hwy 547 (at Fire Sand Creek Culvert), westerly 10.4 km to Wawa.

In this stretch of rural collector undivided highway, three specific rock cuts had been previously identified as posing a hazard to the travelling public due to marginally unstable rock mass conditions. An initial appraisal was carried out by Ontario Ministry of Labour (MOL) Geotechnical Engineer, Mr. Bob Barclay, P.Eng. on October 21st, 1992 and reported in an internal memorandum dated October 23rd, 1992. Franklin Geotechnical Limited (FGL) was commissioned to carry out a Hazard Rock Evaluation on Highways 17 and 101, including these three sites, under MTO WP 7830-94-01 and reported in FGL report G762.1, dated 24th August, 1994.

In the MTO Preliminary Design Report, GWP 523-89-00, dated September, 1996, commentary provided by District Engineering Supervisor, G.L. Gardiner notes the 1974 installation of wire mesh rockfall protection at the Site R, and mentions the requirement for review and improvements if needed. Further, in the Summary of the Design and Cost Estimates for Twp. of McMurray, Stations 16+456 to 17+374 (in the vicinity of Site P, 16+760 to 16+945) realignment and rock scaling are recommended to bring the horizontal and vertical curves up to a 90km/h design speed. For Site Q, the recommendation was to trim and scale selected loose rock from the face and cleanout existing ditch, while for Site R, the recommendations were to trim and scale selected loose rock from the face, shotcrete existing rock face, and cleanout existing ditch.

The approved Design Criteria presented by MTO in a three page document, dated February 1997, comments on the modifications to the pavement width, shoulder width and rounding for the proposed RCU 80 standards, as well as giving the following in the scope of work relating to rock engineering:

- Treat hazard rock face locations in conjunction with consultant report G762.1, as required.

P&R gave instructions that centreline realignment at Site P meant that detailed recommendations to treat rock hazard would not be required, but that Sites Q and R would need specific recommendations for mitigation of the rock hazard.

## 1.1 Scope of report

This report discusses the rock mass conditions as exposed in the existing rock cuts at the project sites assuming the highway to be running in a west to east sense,

and in natural outcrops examined to the west and east of these sites as observed by the writer on October 16th, 1997. It comments on the engineering character of the ground as interpreted from the rock mass descriptions, and describes the different scenarios which may be considered for reducing the rock hazard, including relevant portions of the Ontario Provincial Standard Specification for this type of work. The report ends with concluding statements.

## 2 Rock Mass Conditions

In order to efficiently excavate a rock mass using drill and blast techniques, concise knowledge of the engineering geological character of the ground is crucial. The behaviour of a rock mass during excavation is controlled to a large extent by its block size, block shape and block condition, and the manner in which an excavation is carried out: particularly drill hole diameter, drill hole pattern, explosive charge weight per delay, delay sequencing and overall powder factor or weight of explosive per unit volume of rock mass affected. The weathering and alteration of a rock mass in the years after excavation are also related to block size, block shape and rock surface condition.

A complete rock mass description would normally include comments on *weathering, structure, colour, grain size, rock material strength* and *rock name* for the rock material, together with notes on *discontinuity sets* and *discontinuity condition* for the important natural features such as joints or other discontinuities which break up the rock material into a rock mass. These descriptive indices have become incorporated into standard engineering practice which is utilized throughout the world.

### 2.1 Descriptions from site visit

For descriptive purposes, Highway 101 is assumed to run from Wawa in the west towards the east. Thus Site P is to the south of the highway alignment and Wawa Lake lies to the north of Site P. Site Q is also to the south of the highway alignment on a right hand curve climbing uphill. Site R is to the north of the highway alignment close to the crest of a hill, with a smaller rock excavated face to the south; ie the highway is in a through cut at this location. The sites were located using the survey stations painted on the highway surface with reference to station numbers given in the FGL report G762.1.

During the site investigation, the complete exposure of all three rock cut faces was inspected from highway level, and for Site Q from the slope itself. Natural exposures of similar rock types were also evaluated to the west and east of the subject cut faces.



## 2.2 Site P

This site, mostly on a tangent alignment of the highway on a downhill grade heading east, Figure 1 in Appendix 1, was constructed using some form of controlled blasting using vertically oriented drill holes, Figure 2. The face was estimated by FGL to be in the 8–14 metre range, although the MTO drawings show a rock cut up to 18 metres high. Without the aid of detailed surveying, the face was estimated to be 15–16 metres high at the crest. Many of the original blast hole traces are visible in this south excavated face, attesting to the competence of the rock mass in general, Figure 3. There are, however, some noticeable zones of more highly fractured, or in some cases faulted, rock where freeze-thaw action is likely to generate fragments of rock which are prone to ravelling, Figure 4.

The realignment of the highway at Site P will certainly give a long term solution to rock hazard, provided that the final design has a well-developed ditch. Realignment towards the north may not require the placement of fill in Wawa Lake if bedrock conditions continue to the shoreline as anticipated, Figure 5. Further east, the lake shore is shallow and fill may be required, Figure 6.

## 2.3 Site Q

The exposed rock mass in this vicinity is immediately adjacent to the eastbound lane of Highway 108 with limited ditch allowance. The road is on a right hand curve eastbound. Figure 7 is looking west and shows a knob of rock which is close to the travelled portion of the road and may impair visibility. Further, the loose condition of the rock mass in certain segments may lead to rock fall activity which could impinge upon the travelled portion of the road. The cut face is approximately 9 metres high up to a local maximum of almost 12 metres, and about 90 metres long.

The rock mass, as observed, may be described as slightly weathered; tabular and blocky; dark greenish grey; fine to medium grained; medium strong; metavolcanic rock material. Some shearing and faulting is visible which locally gives a highly fractured rock mass. There are two steeply dipping joints sets that are highly persistent, widely spaced, with very narrow apertures close to the exposed surface probably reducing to tight apertures at depths of 3 metres or so, clean to iron stained, planar, and rough. There are other randomly oriented joints which dip in the 45 to 60° range. The rock mass has medium-sized, tabular shaped blocks with fair surface condition. There is a strong toppling potential for the larger blocks at this site, shown in Figures 8 and 9.

There was no evidence of old drill holes in the eastern cut face excavation. The rock face was made up of blocks of rock bounded by a combination of natural discontinuities and blasted rock surfaces. The current rock hazard is believed to a product of a fair quality rock mass and poor controlled blasting practices combined with severe winter conditions and multiple freeze-thaw events every fall and spring.

### 2.3.1 Site Q — Remediation

The rock mass requires local scaling, see Figure 8, and would be accessible from highway level with a long reach hoe-ram. The scaled rock will probably be contained in the existing ditch. The segment identified by FGL, and marked on the rock face, extends from approximately Ch. 21+650 to 21+680, some 30 metres. To the west and east of these limits the rock face decreases in height or is set back from the roadway, Figure 10.

Since part of the work at Site Q also requires trimming of the ditch line and removal of about 7.5 cu m of rock at the western end of the site at ditch level, Figure 7, hoe-ram work at the highway level could proceed in advance of scaling. It is estimated that the complete work at this site could be carried out in two days, including moving equipment in and out from the main construction area.

## 2.4 Site R

The exposed rock mass in this vicinity is immediately adjacent to the westbound lane of Highway 101 with very limited ditch allowance, Figures 11, 12 and 13. The road is on a slight right hand curve eastbound close to the crest of the hill, but the proximity of the rock face to the travelled portion of the road is unlikely to impair visibility. The loose condition of the rock mass in certain segments may lead to rock fall activity which could impinge upon the travelled portion of the road, Figure 14, even though part of the highway shoulder is protected by the installation of restraining mesh hung over part of the slope from 21+196 to 22+037.

The cut face is approximately 8 metres high with a natural slope of the same order of magnitude up to the tree line. It is believed that the slope continues to climb beyond the tree line. The segment identified by FGL, and marked on the rock face, extends from approximately Ch. 21+955 to 22+055, some 100 metres. To the west and east of these limits the rock face decreases in height and is set back from the roadway.

The rock mass description given for Site Q applies here, with more pronounced zones of locally weakened material and a far larger excavated rock face. It is apparent that this excavated face has been the source of annual rock fall events. The slope has received remediation previously and is liable to require considerable maintenance unless a long-term stabilization program is undertaken.

### 2.4.1 Site R — Short-Term Remediation

The FGL locations RA through RG were identified and the commentary provided by FGL in their 1994 study was reviewed for conformance with existing conditions. It is believed that the design provided by FGL<sup>1</sup> is adequate to provide short- to

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<sup>1</sup>FGL report G762.1, dated 24th August, 1994: Main Text, Section 5 - Highway 101, Faces P-R, pages 5 to 8; Appendix A - Detailed Observations of Rock Stability, pages 10 to 12; Appendix B - Rock Face Photographs, pages B18 to B23; Appendix D - Preliminary Cost Estimates, last page

medium-term solutions to rock hazard at Site R. The suggested combination of manual scaling, hoe-ram scaling, trim blasting and shotcreting will ensure a degree of stability for the next few years. The details of the FGL design are included as Appendix 2 to this report. Long-term remediation for Site R is considered below.

### 3 Engineering Character of the Rock Mass

The following paragraphs give the writer's interpretation of the engineering character of the rock mass based on personal observations, using standard engineering geological descriptions published by the Geological Society in 1970<sup>2</sup> which were later incorporated into the International Society of Rock Mechanics' *Suggested Methods for Rock Characterization, Testing and Monitoring* in 1981.

Discolouration and iron staining on major discontinuity surfaces, in addition to mineral alteration, indicates slight weathering of the rock material and thus a reduction in rock material strength from its initial fresh condition. The shear and fault zones as well as steeper dipping fracture zones are more highly weathered and represent isolated panels of weaker rock mass than the bulk of the cut. Rock blocks are tabular or irregularly shaped in the 60 to 200 and 200 to 600 mm size range. Most of the mineral grains are just visible to the naked eye. They are dark greenish grey and black in colour giving a dark (greenish) grey appearance to the rock mass. Hand held specimens of rock may be indented to about 5 mm with the firm blow of a geological pick yielding a uniaxial compressive strength in the 25–50 MPa range. The rock material is a metamorphosed volcanic rock.

Natural fractures, which occur in at least two steeply dipping sets, are spaced in the 200–600 mm range giving natural blocks that are tabular in shape. The steeply dipping fractures are planar in shape with a surface that feels like rough concrete. The space between natural discontinuity surfaces is commonly less than 0.6 mm although where strongly affected by blasting and subsequent weathering the aperture may be in the order of a few millimetres.

The rock mass would be considered to be of "fair quality" with small to medium sized (60–600mm)<sup>3</sup> blocks in the main body of the rock mass. With this rock mass it could be interpreted that drilling and blasting could be carried out without much difficulty.

### 4 Site R — Long-Term Remediation

The long-term solution for the cut at Site R would be to realign the highway to the south away from the rock mass. This opinion is based on the height of the excavated face; the size, shape and disposition of the ditch; the fair quality rock mass and local variations in quality; and the erodibility of certain horizons within

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<sup>2</sup> *The logging of rock cores for engineering purposes*, The Quarterly Journal of Engineering Geology, Vol. 3, No. 1, December 1970, pages 1–24

the rock mass. Such an excavation would require removal of the smaller rock cut to the south of the highway and filling a small corner of Mud Lake just to the east of the site. This option would likely be the most suitable engineering solution. By providing adequate ditch allowance in width and depth, and by scaling the existing face thoroughly, any future rock fall events, even after years of weathering, would be restrained from reaching the travelled portion of the road. The costs of removing the smaller rock mass to the south and filling the corner of Mud Lake would probably be less than providing the same level of long-term security without increasing the ditch effectiveness.

Complete stabilization of the rock mass at Site R would require: either that all loose and potentially loose rock were removed from the cut face, or held in place so not to be able to move; or that there were sufficient catchment for rock fall material that the slope itself could be ignored. Of course, some combination of the two could also be considered.

If it were required that this current programme of rock hazard treatment<sup>3</sup> be considered a long-term solution to the potential rock hazard, then the amount of shotcreting recommended by FGL would have to be increased, rock bolting would be required after shotcrete placement, and drainage of the shotcrete would have to be fully designed rather than just by drilling weep-holes after placement. In the long-term, however, some degree of ditch enlargement would also be required, and this would be effected most easily by removing rock from the south side of the road and realigning the highway.

#### 4.1 Bulk Rock Excavation at Site R

Other than the FGL proposals for hazard control on this project, four other scenarios are briefly addressed in this section of the report:

- place a guiderail between the north rock face and the highway after scaling the rock cut — zero rock excavation;
- excavate the rock either side to accommodate a 'standard cross section' with an adequate ditch — maximum excavation of 1 to 2 m;
- excavate the south rock to MTO's 'clear zone' requirements for a design speed of 100 km/hr — maximum excavation of about 4 to 5 m; and
- excavate the rock to sight distance requirements for a design speed of 100 km/hr — maximum excavation of approximately 8 m.

For the first option – scaling the rock and installing a guiderail between the north rock face and the travelled portion of the roadway – there appears to be

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<sup>3</sup>The MTO Design Criteria, GWP 523-89-00, page 2 of 3, Scope of Work states "Treat hazard rock face locations in conjunction with consultant report G762.1, as required", but there is no comment as to the design life of the hazard rock treatment.



insufficient space available to create a large enough catchment area to safely protect the travelling public. A solid guiderail would be required to prevent falling rock from spilling onto the paved roadway and considerable effort would be required in order to remove the guiderail, clean out the ditch area and replace the guiderail during regular and routine maintenance. It is understood that one of the main concerns of MTO is to reduce maintenance requirements rather than increase them. There is also the potential for the failure of a large volume of material which may not be contained by the minimal ditch width available, unless a significantly high guiderail were installed (such as with lock blocks).

The second option – excavating sufficient rock by local trim blasting on the south side to create a minimally adequate ditch – suffers from all of the concerns mentioned in the previous paragraph. Additionally, local blasting of small knobs of rock may, indeed, worsen the current stability situation by allowing blast gases to penetrate in behind the intended final line. Again, maintenance would be required to keep the ditch clean and prevent rock fall material from spilling onto the highway.

The third option – excavating up to 5m of the existing rock face to meet clear zone requirements for a 100km/hr design speed – starts to be acceptable from a rock engineering standpoint. If there were a guaranteed width of 5m throughout, and the crest of the slope at the 5m setback were uniformly accessible, then such an excavation would be appropriate. However, based on the results of the field inspection, when it was seen that the existing rock face is irregular in both cross- and long-section with amplitudes in excess of 1.5 metres, it appears to be less feasible. Since the rock mass is highly irregular, it would have to be assumed that a significant amount of the drilling would have to be undertaken by hand. This has a number of drawbacks: firstly, the costs would be increased due to the labour-intensive nature of the work; secondly, the control on the orientation of the drill holes would be difficult to regulate; so thirdly, the outcome would likely be a rock face as ragged as the existing one, with little guarantee of improved stability. It is quite likely that this option would generate an expensive project with little guarantee of success.

The fourth option – removal of around 8 m of the rock mass to meet sight distance requirements for a 100km/hr design – is the preferred scenario from a rock engineering perspective. This would allow well-controlled drilling along the final line to be carried out using a hydraulic tank drill (or equivalent). Creation of an access road across the crest of the slope would probably be required, and this would likely be set back far enough from the existing slope crest as to be reasonably straightforward. This would permit the realignment of the highway as well as the creation of proper ditches on both sides of the highway.

The rock to be removed at the site<sup>4</sup> would be an unconfined slab up to about 7 metres high, possibly up to 8 metres thick, and about a hundred metres long. It would be preferable to distribute the designed explosive charge over more drill holes than would be common for, say, a confined trench excavation. This would commonly

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<sup>4</sup>Appendix 3 contains selected paragraphs from the Ontario Provincial Standard Specification, OPSS 206, dealing with rock face and rock mass excavations

be achieved by decreasing the blast hole drilling pattern and hole diameter and increasing the number of holes. The overall drilling cost may be slightly higher, but this is not necessarily the case since the drill hole diameter is reduced, so the drilling time per hole is also reduced (the volume of rock to be removed per hole is lower).

The blast hole drilling pattern suggested would incorporate a controlled final line (pre-shear or pre-spilt) with vertically drilled holes, approximately 50 mm in diameter and spaced 750 mm apart, marking the southern limit of drilling and blasting. A buffer row would be offset about 1 metre from the final line with about a 2-metre hole spacing. The first production row would be stepped out about 2 metres, while the final production row would be stepped out a further 2 metres. All production holes would have a 2-metre hole spacing and the burden on the final row should be at least 2 metres. The production holes would have to be about 75–100 mm in diameter. The rows mentioned above would be aligned west-east, or parallel to the road alignment.

Blasts would be taken with individual holes from these rows tied in together to form lines perpendicular to blast hole rows which would be fired in Vee-cuts either to the west (or east). Under this arrangement, there is a free face to the west (or east) and also to the north (adjacent to the eastbound lane of the highway). It seems likely that this combination of blast hole layout and natural rock mass condition would produce good fragmentation and a stable rear face.

It is the experience of many workers that if the burden (the distance from a blast hole to the closest free face) is only in the order of a few metres, then pre-split blasting is rarely effective. Indeed, in order for pre-split blasting to work well, the burden has to be sufficient to prevent any rock movement at all. The mild explosive energy is intended to do no more than create an instantaneous tensile wave front which creates a single crack running the complete length of the final line. The dominant fragmentation effect is due to rapidly expanding gases, and the presence of a fracture along the final line allows the gases from production blasting to vent to atmosphere, thus protecting the rock behind the final line from being damaged.

The pre-split line could be fired in a single delay creating a stable back wall to blast to in the buffer and production rows. The pre-split line would be drilled only to the design grade, ie without any sub-grade drilling, and lightly loaded with de-coupled, well-distributed charges. The buffer row can be drilled with sub-grade (probably up to 1m deeper than the pre-split line if needed) and toe loaded for ditch shatter if required. The buffer and production holes should be drilled off in a single bench. The final wall should be scaled thoroughly (preferably manually) before the rock work is completed.

## 5 Conclusions

Three excavated rock cuts along Highway 101 were inspected. At Site P a decision has already been made to realign the highway away from the hazard. It appears

that the bench to the north of the highway at this location, adjact to the shoreline of Wawa Lake, is in bedrock rather than rock fill. If the highway grade is not plaaned on being at a higher elevation, it may not be necessary to add fill to the lake.

Site Q is a minor hazard which, on its own, would not merit a detailed rock hazard assessment. As part of other work in the vicinity, however, it probably deserves about two days work of scaling and ditch excavation.

Site R is arguably the most unstable site of the three. The vertical and horizontal alignment gives reduced vizibility in a narrow through cut with about 20 metres of exposed rock to the north. The stabilization measures recommended by FGL are considered adequate for short-term hazard control. In the long-term, however, realignment of the highway is suggested with rock removal from the smaller cut to the south of Site R.

Respectfully submitted,

for David F. Wood Consulting Ltd.  
David F. Wood, P.Eng., President



**Appendix 1**  
**Photographs of Rock Excavation**  
**at Sites P, Q and R**



Figure 1: Overview of Site P from PA, 16+760. Note wet face PE-PF

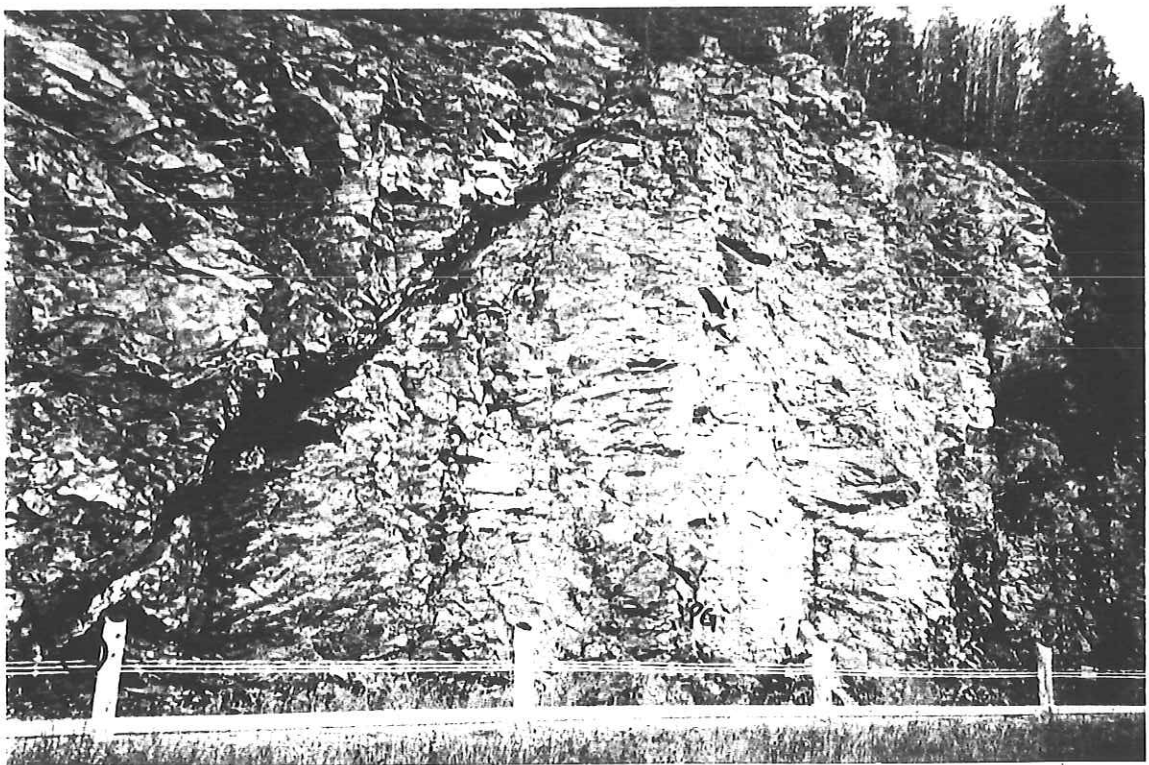


Figure 2: Site P, PF-PH, 16+840-16+875. Note FGL mark PH at left

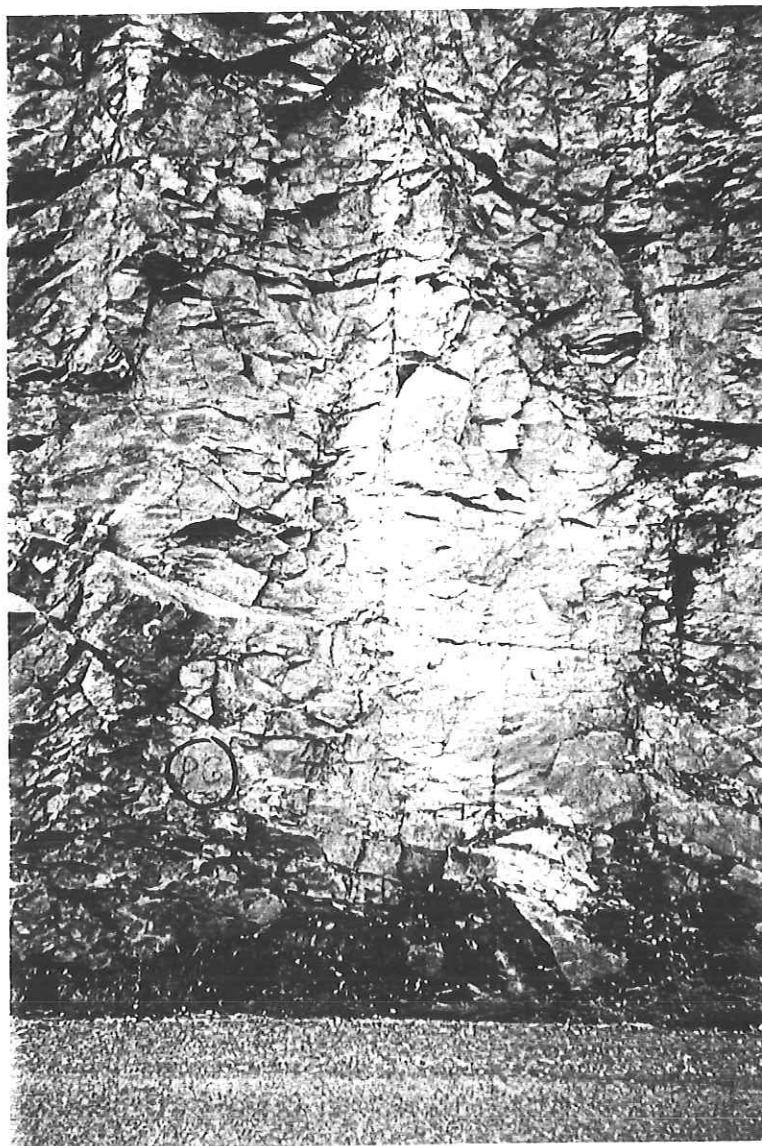


Figure 3: Close-up of PG showing drill hole half barrels, minor loose in ditch



Figure 4: Rock mass above PJ, 16+910, showing blocky ground

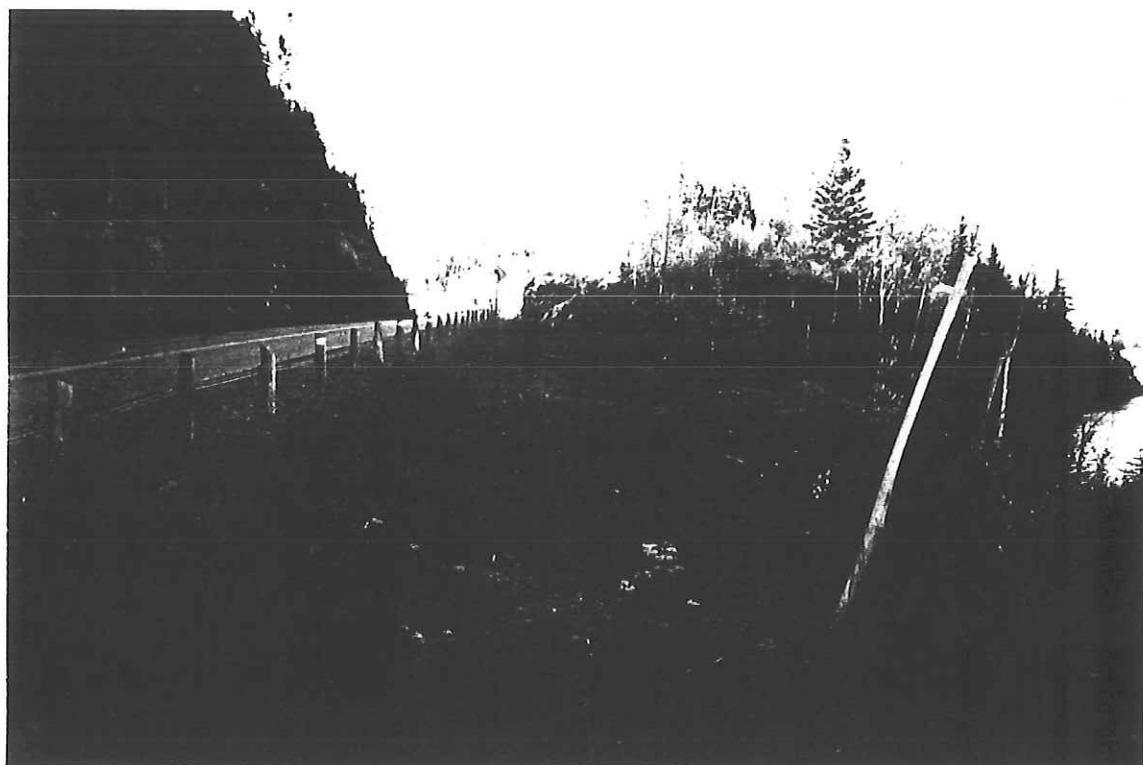


Figure 5: Bench to north of highway opposite 16+900, founded on bedrock

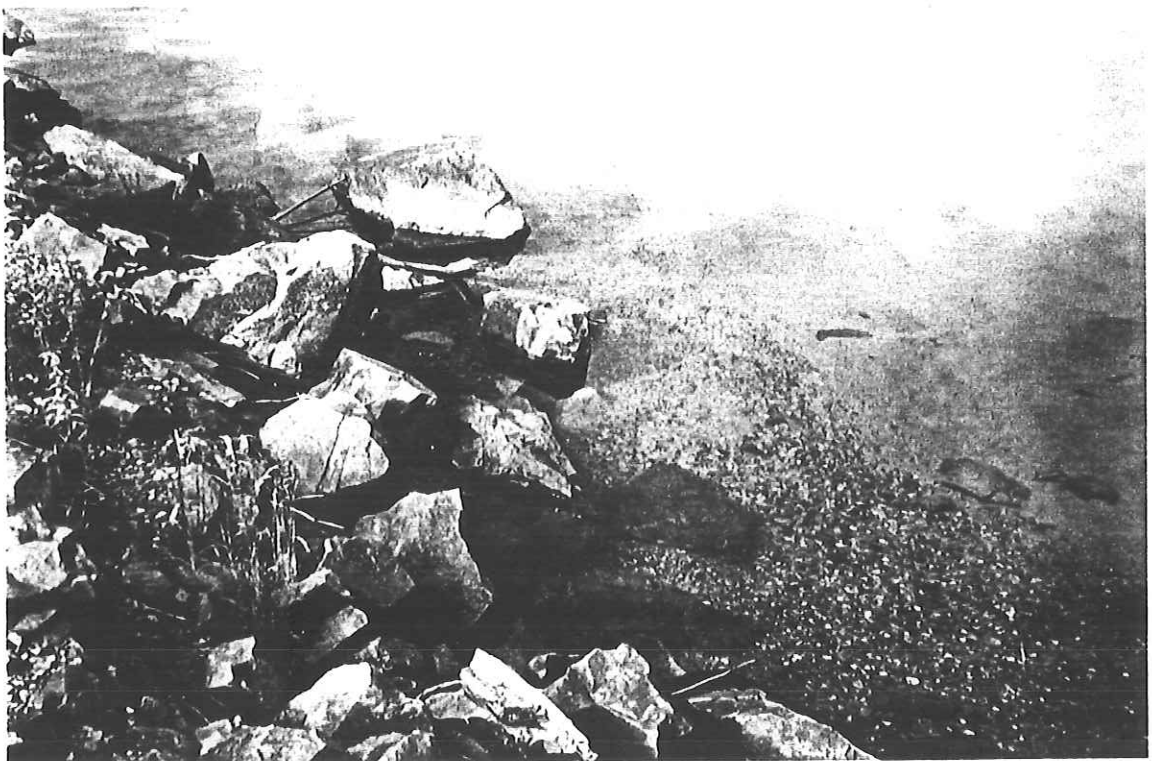


Figure 6: Shoreline of Wawa Lake opposite 17+050 in shallow water



Figure 7: Site Q, lower slope and ditch, showing poor visiblity at 21+650



Figure 8: Site Q, crest at QA above 21+665, showing toppling



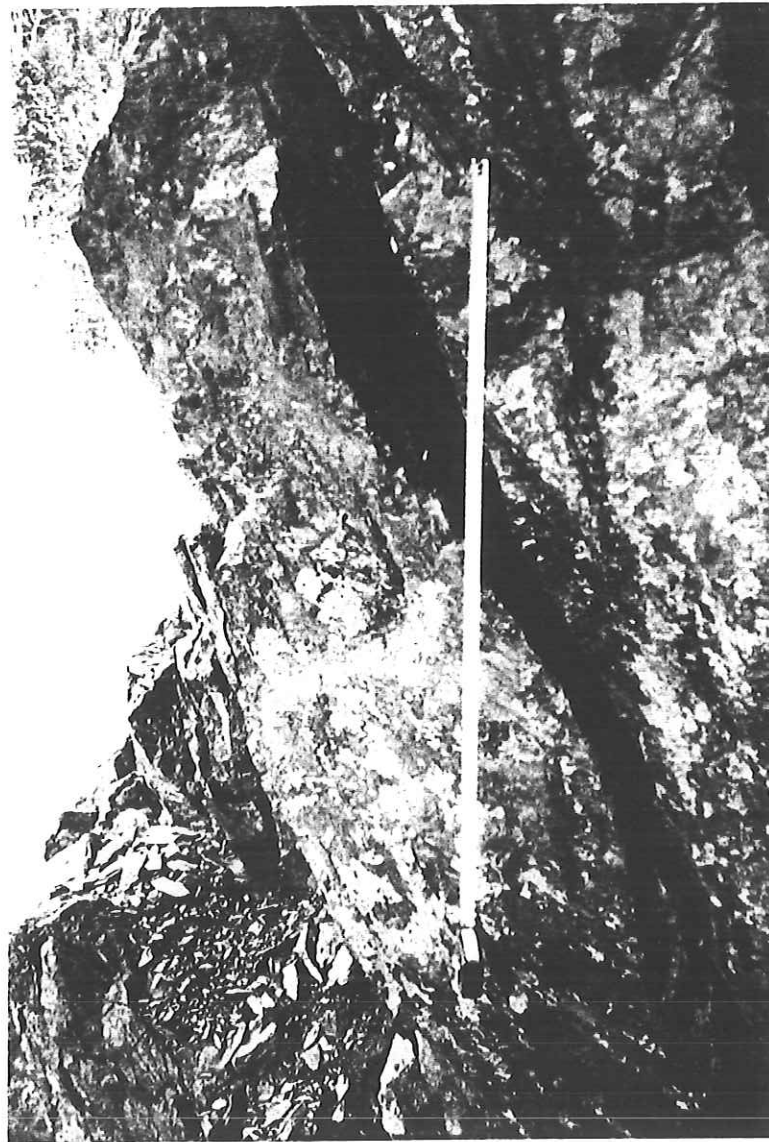


Figure 9: Close-up of crest at QA showing toppling. Machine scale



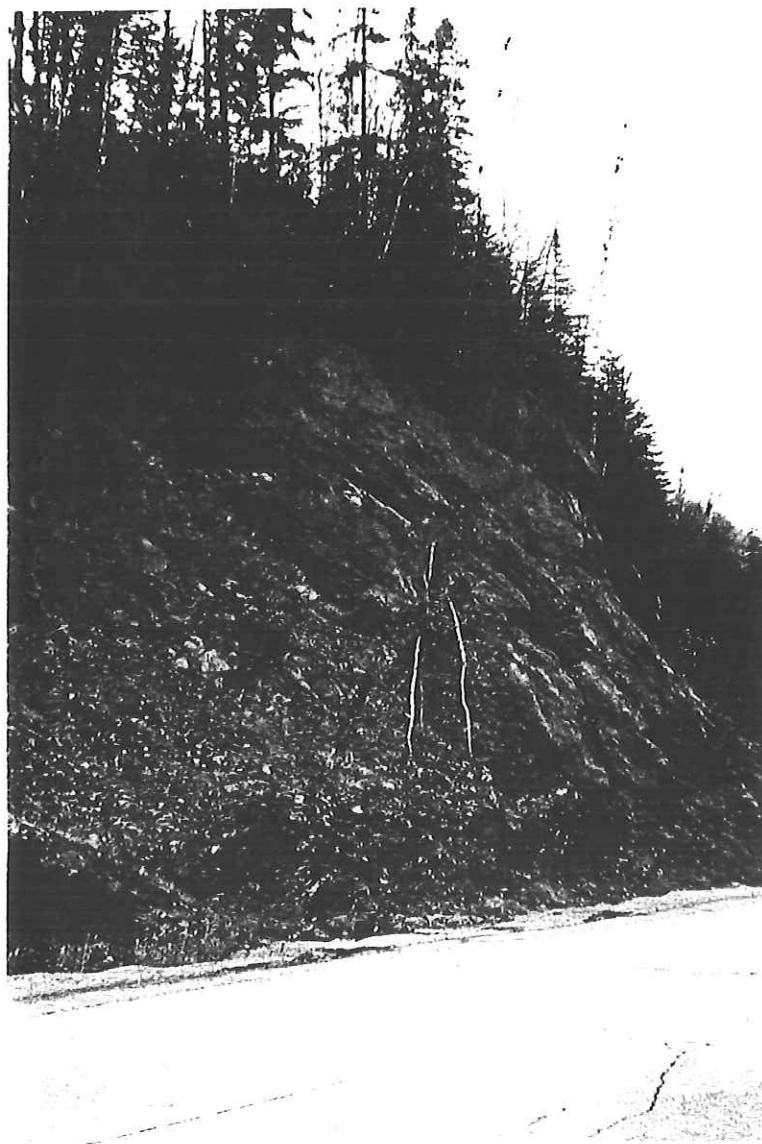


Figure 10: Site Q showing QB from 21+700, toppling rock at top right



Figure 11: Approach to Site R (left side) at 21+800 looking east



Figure 12: Approach to Site R (left side) at 21+900. Note limited ditch



Figure 13: Site R, centreline at 22+000, mesh from 21+196 to 22+037. Note rock in ditch



Figure 14: Close-up of impact mark near centreline at 22+000

**Appendix 2**  
**Copies of FGL Stabilization Design**  
**for Site R**

**Location QB (21+680) - Figure B18**

Top right of QB about 6 m above road, overhanging block on shaly joint becoming loosened by ice jacking. Probably low risk but as well to remove this by long reach hoe-ram or by local hand wedging when the work team are in the area. Trim and remove about 3 m<sup>3</sup> in 0.3 m<sup>3</sup> pieces. Top left of QB various small to medium sized blocks to be scaled by hand or by hoe-ram. Uphill of QB the height of cut is only 2 to 3 m above road with a gentle slope back through the trees. Some small rock fragments may be rolling through the trees. Enlarged ditch would take care of this.

**FACE R****SUMMARY FOR ROCK FACE R**

Metavolcanic rock with irregular jointing in some places dipping towards highway, very closely jointed and microfissured in places. Face extends from about 21+945 to 22+060.

**Hazard:**

The mesh is controlling small rockfalls although some fragments are reaching the pavement, because of minimal ditch, about 1.5 m wide x 0.5 m deep.

Presently moderate but increasing hazard of large rockfalls sufficient to block highway. The microfissured rock is loosening each year as a result of frost and ice action. Serious undermining hazard at RC and RE will get worse unless the rock is protected against further deterioration.

**Treatment:**

Alternative 1: Light hoe-ram scaling and shotcreting to preserve microfissured rock locally, followed by road realignment when convenient.

Alternative 2: Realign highway by up to 7 m to provide an adequate shoulder and rock catch ditch.

**Location RA (21+955) - Figures B19, B20, B22**

Minor loose rock total volume about 6 m<sup>3</sup> in pieces up to 0.8 m<sup>3</sup> from about 4 m above road, and some large blocks of similar total volume about 10 m above road near base of tree line. Require selected manual or machine scaling. Might be difficult to remove with scaling bar; better with hoe-ram if reach available, or with wedging.

**Location RB (21+975) - Figures B19, B20, B21, B22**

From 4 m to 10 m above road, about 50 m<sup>3</sup> of loose rock with open joints within a zone about 4 m long, 6 m high and 1.8 m thick. Sound and scale by hoe-ram working from side. Manual scaling probably difficult and slow.

**Location RC (21+990) - Figures B21, B22**

Substantial unstable mass at base of tree line about 12 to 15 m above road just to left of mesh, precariously resting on steeply dipping joint face. Volume about 100 m<sup>3</sup> (8 m long, 5 m high and 2.5 m thick). Would cover road with debris if it came down. Might remove by trim blasting but difficult access for drilling. Would require crew working for about 1 week with plugger drills and wedges and/or explosives.

Immediately above RC is a vertical slab of potentially loose rock extending from 1 m above road to about 8 m above road. Volume about 40 m<sup>3</sup> (3 to 4 m long, 7 m high and 1.5 m thick). Can be scaled by hoe-ram but only after removing upper loose rock.

**Location RD (22+005) - Figures B21, B22**

About 8 to 10 m above roadway at top of shelf along a line of green bushes, and above this at base of tree line near the slope crest, about five to ten medium to large blocks, up to 1.5 m<sup>3</sup>, might be trapped by mesh if they fall.

**Location RE (22+010) - Figures B21, B22**

About 1 m<sup>3</sup> of very loose rock blocks about 3 m above road, very precarious and easily scaled by hand. These blocks may support a 10 m<sup>3</sup> block above, so scale either from the top down, or from side using hoe-ram. If overhang remains in place, repair undercut with remotely applied shotcrete.

Midway between RE and RF at chainage 22+025, a triangular block beneath the mesh measuring about 8 m long, 5 m high, and 2 m thick is very loose, backed by a wet joint. Will progressively loosen by ice wedging. Stabilize with shotcrete.

**Location RF (22+045) - Figure B23**

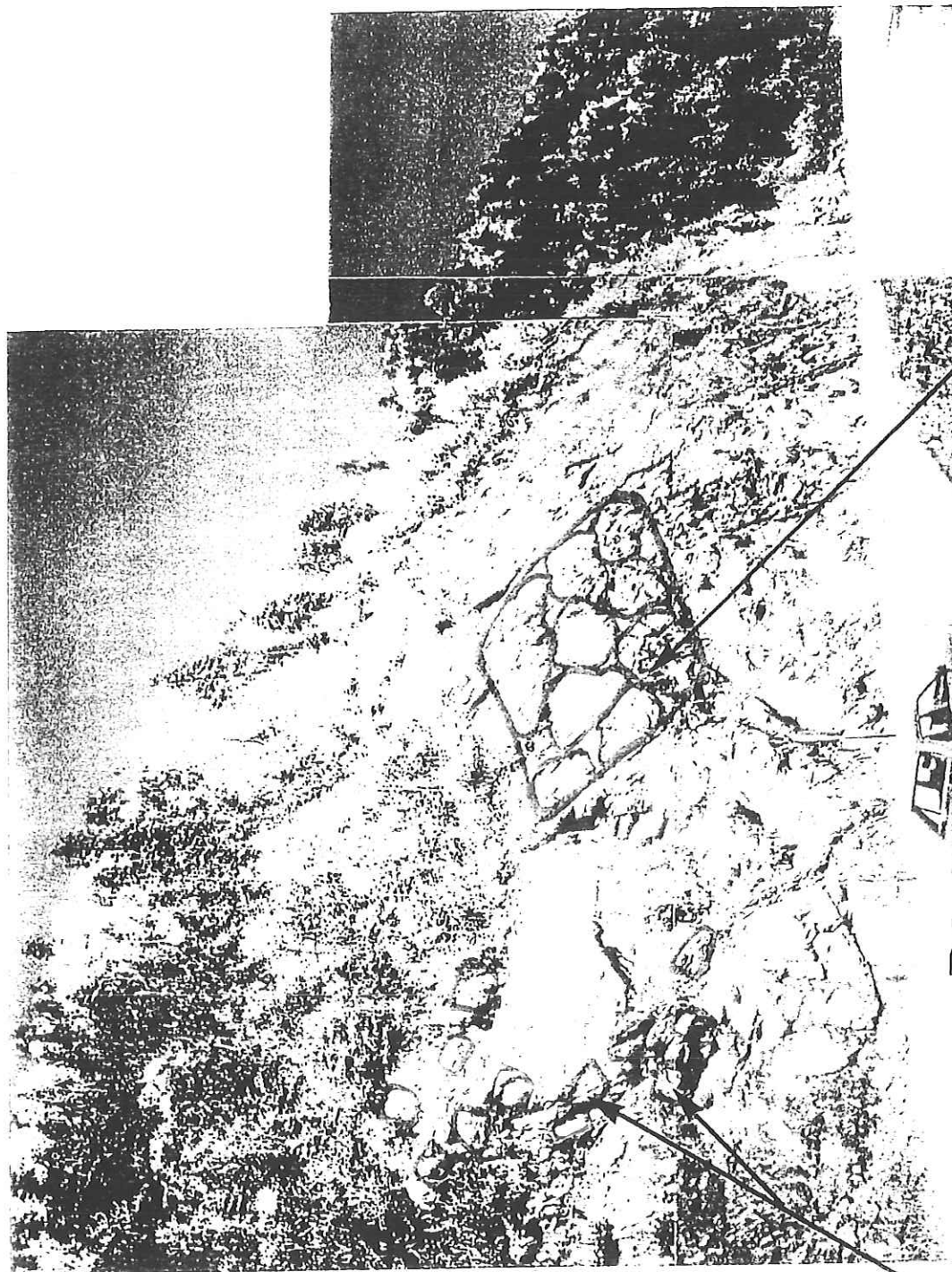
Slabby rock about 6 to 8 m above road, about 10 m either side of RF, may be keyed in but extensively cracked. Sound and scale by hoe-ram. About 12 m<sup>3</sup> of loose rock to be removed including slabby block from top of shear about 10 m above road.

Between Locations RF & RG a large triangular wedge of material has computed safety factor of 0.91 to 1.71 depending on assumptions. The left-hand side appears resting securely on a plane striking nearly perpendicular to the highway. The large mass is unlikely to slide, but because of microfissuring, will deteriorate over several years. Cable anchoring unsafe because of risk of disintegration during drilling. Scale only smaller loose blocks. Consider shotcrete stabilization for prolonged durability here and elsewhere.

**Location RG (22+055) - Figure B23**

No further hazard east of here. The rock cuts further from Wawa opposite Mud Lake represent no hazard because all rock will be caught in the ditch.





trim with hoe-ram

RB

RA

light manual or hoe-ram scaling

	NAME	DATE
Drawn By	DJE	JUN94
Checked By	JAF	JUN94
Revisions		



franklin geotechnical engineering

PROJECT: G762.1

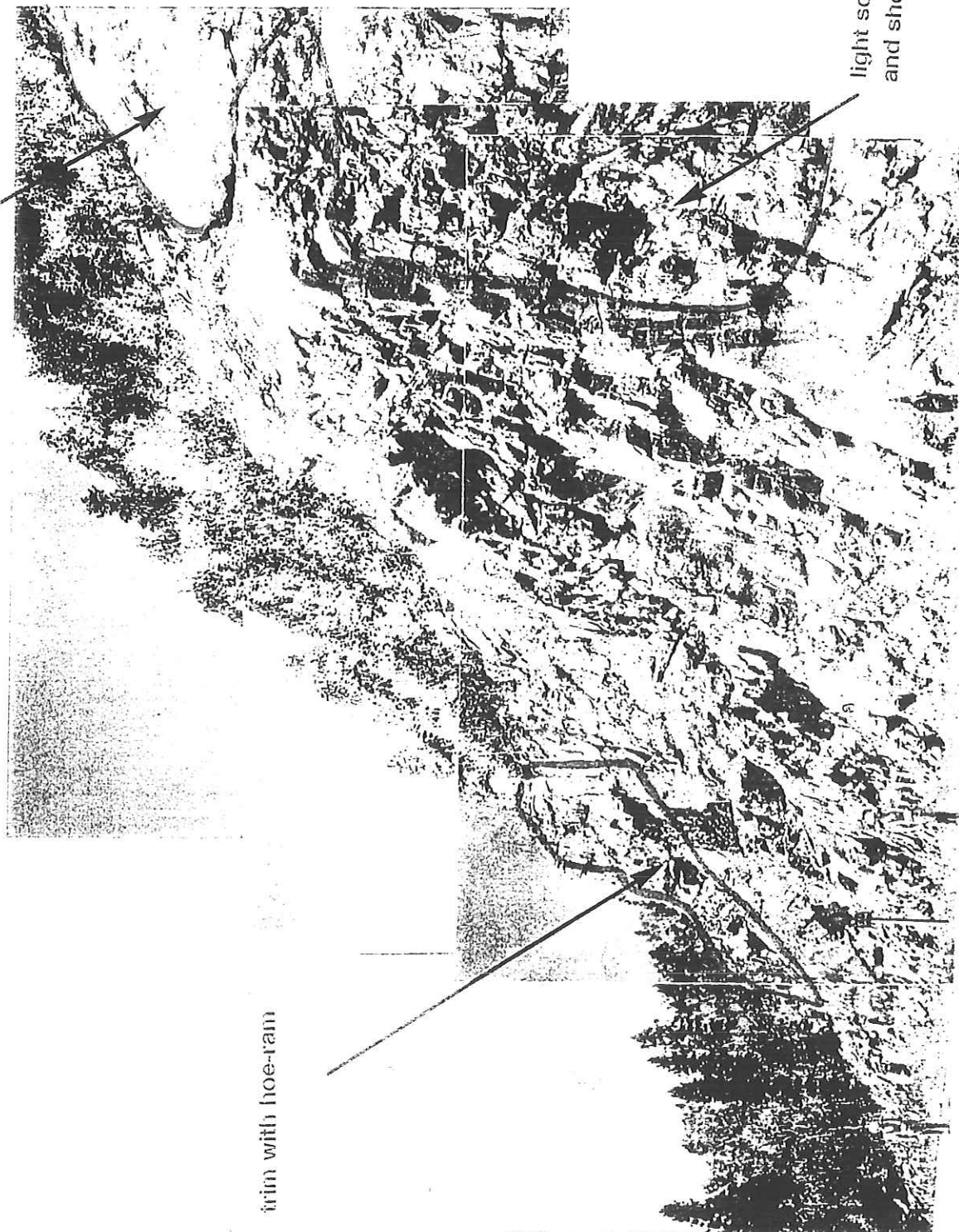
FIGURE: B19



underpin block with shotcrete

light scaling  
and shotcrete

trim with hoe-ram



RA RB

	NAME	DATE
Drawn By	DJE	JUN94
Checked By	JAF	JUN94
Revisions		



franklin geotechnical engineering

PROJECT: G762.1

FIGURE: B20

contained by mesh

underpin block with shotcrete

light scaling  
and shotcrete

light scaling and shotcrete

RE

RD

RC

RB

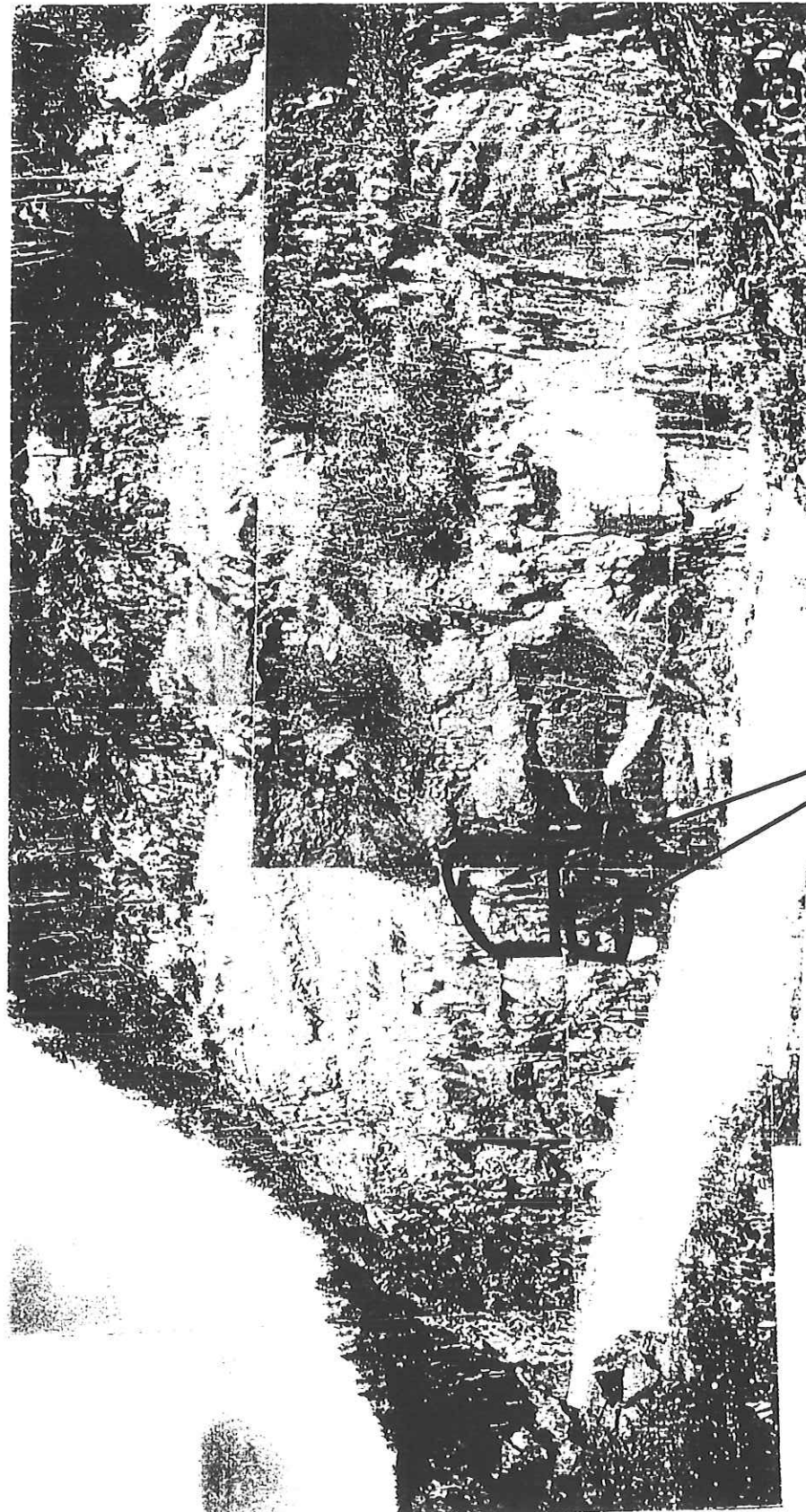
	NAME	DATE
Drawn By	DJE	JUN94
Checked By	JAF	JUN94
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FIGURE: B21



light scaling and shotcrete

RA RB RC RD RE

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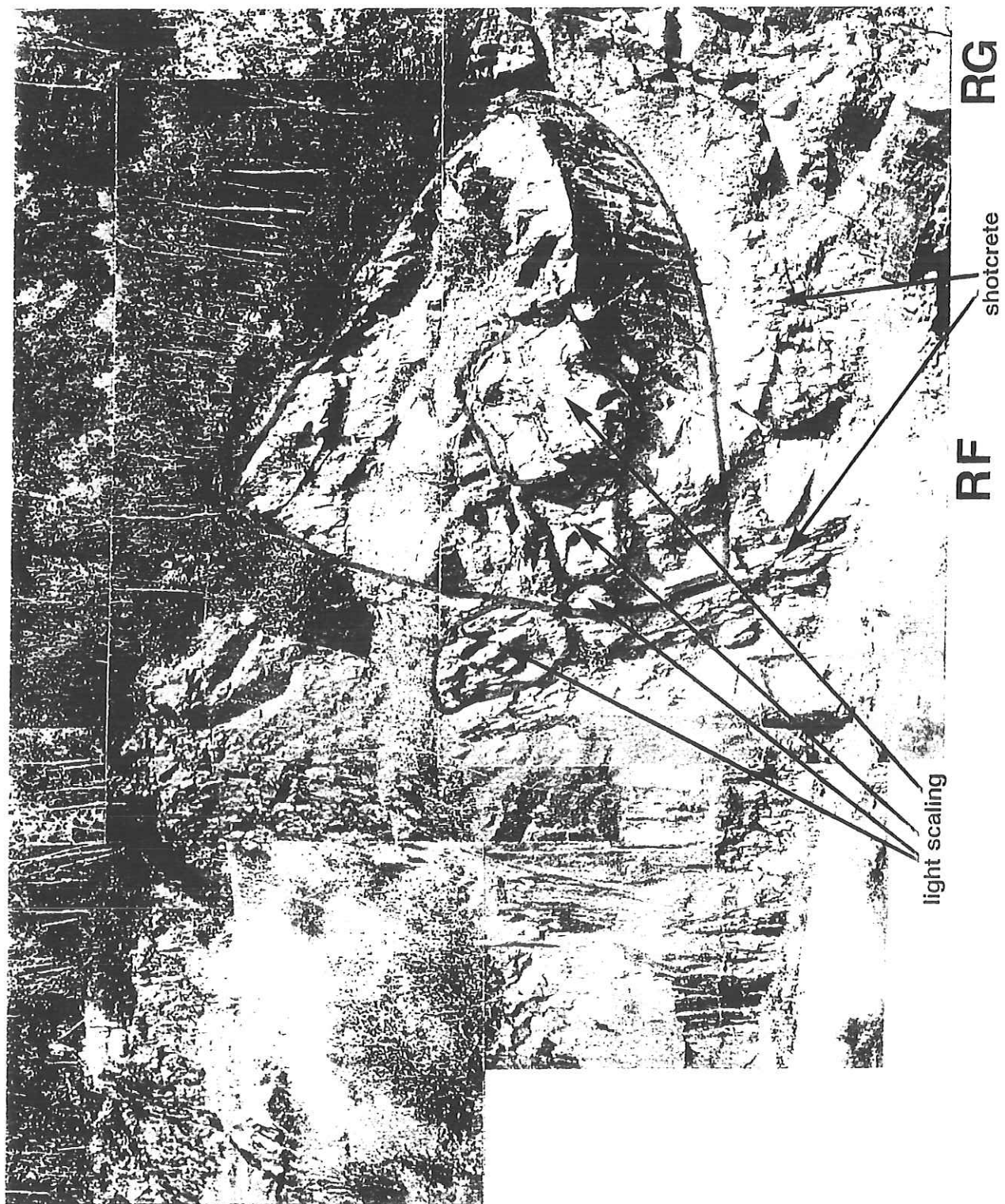


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FIGURE: B22





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**Appendix 3**  
**Excerpts from Ontario Provincial**  
**Standard Specification, OPSS 206**

## Ontario Provincial Standard Specification

The Ontario Provincial Standard Specification OPSS 206, metric version, dated April 1990 and titled "Construction Specification of Grading" provides an excellent starting point for the successful excavation of a rock face to MTO standards. The following subsections have been selectively transcribed from OPSS 206 with minor editorial modifications made for clarity. Items shown in italics are further defined below.

### Description from OPSS 206.07.06, Rock Face

"The work to be done under the item *Rock Face* shall include: drilling and blasting using one or more of the *wall control blasting* techniques to produce the rock face where required in the Contract; scaling; removing all *overbreak* and scaled rock; and incorporating removed rock into embankments, unless otherwise specified in the Contract. A trial section to determine optimum explosive loads and drill and blast patterns for different rock conditions shall be used.

Holes for wall control blasting shall be a maximum diameter of 100 mm and shall be located accurately and consistently along the excavation limits.

The spacing of the wall control blasting holes shall be decided by the Contractor, but shall not exceed 0.75 m centre to centre. The spacing shall be adjusted where necessary to ensure a uniform shear face between holes.

The Contractor shall accurately position and load the adjacent line of production holes, located inside the controlled blasting limits, in such a manner as to produce the required rock face by wall control blasting. The first line of production holes, located inside cut limits, shall be drilled such that no portion of the hole is within 0.75 m of the line of the wall control blasting holes."

### Definitions from OPSS 206.03

"Rock Face: means the vertical face between the top of the rock surface after removal of overburden and the designated rock ditch grade line.

Overbreak: means the portion of any rock or broken rock which is excavated, displaced, or loosened outside and beyond the designated excavation limit(s), regardless of whether it has been excavated, displaced or loosened due to the inherent nature of the rock formation or due to any other cause.

Wall Control Blasting: means blasting using one of the techniques of either *cushion blasting*, *pre-shearing*, *smooth wall blasting*, or *line drilling*. Wall control blasting is to produce a maintenance free rock face with a minimum of blast induced fractures; generally characterized by noticeable drill hole traces over the majority of the rock face.

Cushion Blasting: means a wall control blasting technique involving the placing of a single row of closely spaced holes along the excavation limit(s), loading them with light, well distributed charges, completely stemmed, and firing them simultaneously to remove the rock left in place after blasting inside the cut limit(s).

Pre-Shearing: means a wall control blasting technique involving the placing of a single row of closely spaced holes, placed along the excavation limit(s), lightly loading and firing them simultaneously before and independently of the main excavation blast. Pre-shearing is sometimes referred to as pre-splitting.

Smooth Wall Blasting: means a wall control blasting technique involving the placing of a single row of closely spaced holes along the excavation limit(s), lightly loading and firing them along with but moments in advance of the main excavation blast.

Line Drilling: means a wall control blasting technique involving the placing of a single row of very closely spaced unloaded holes along the excavation limit(s)."