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PRELIMINARY REPORT ON

SERIES II

5

**RELIEF WELLS / RECHARGE WELLS  
PROPOSED HIGHWAY 416  
LYNWOOD SUBDIVISION AREA  
NEPEAN, ONTARIO**

Submitted to:

Ministry of Transportation, Ontario  
Foundation Design Section  
1201 Wilson Avenue  
Central Building, Room 315  
Downsview, Ontario  
M3M 1J8

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October, 1993

931-1113

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October 6, 1993

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1201 Wilson Avenue  
Central Building, Room 315  
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Attention: Mr. M. S. Devata, P. Eng.

**RE: PRELIMINARY REPORT  
RELIEF WELLS / RECHARGE WELLS  
PROPOSED HIGHWAY 416  
LYNWOOD SUBDIVISION AREA  
NEPEAN, ONTARIO**

Dear Sirs:

Highway 416 will pass under the CNR railway line and will be in cut adjacent to the Lynwood Village subdivision. The cut will be up to about 10 meters in depth. Boreholes put down by us at the locations shown on Figure 5, attached, indicate that much of the soil in the cut area will be sands and sands and gravels below the groundwater level. Groundwater lowering will be required during construction to effect the cut and a permanent groundwater lowering system will be required to maintain the cut slopes and the pavement structure.

From borings put down in the Lynwood Village subdivision it is known that the sand deposit underlies the surface clay deposit to about 150 to 200 meters west of Cedarview Road. Beyond that point the clay is underlain directly by the glacial till.

## GROUNDWATER AND SETTLEMENT MONITORING

The clay in the Lynwood Village subdivision is a compressible soil especially when loads exceed the past preconsolidation load of the clay. As groundwater lowering increases the loading on the soil, we intend to limit the groundwater lowering in the subdivision area to keep the loading well below the past preconsolidation load on the clay.

A monitoring system was set up in the pre-construction period to determine the normal variation in the groundwater level below the subdivision area throughout the year, and in particular the dry summer period of July and August. The monitoring was begun in 1992 but the results of that summer were not very significant as the weather was wet and relatively cool. The summer of 1993 was somewhat drier and warmer but it was not considered a drought period. There were no reported incidents of foundation settlement of houses in subdivision areas in the summer of 1993.

The plots of the groundwater variation below the Lynwood Village subdivision and within the clay, sand and glacial till strata are shown on Figures B, C and D, attached. The groundwater levels started at a high elevation this spring after a heavy snowmelt and decreased by about one meter by the end of the summer. This groundwater monitoring will be continued up to construction, during construction and to the end of the summer period after the construction has been completed.

A precise level loop has been set up in the Lynwood Village subdivision area and settlement points have been installed on selected homes. The precise levelling of these homes is being carried out prior to construction to determine the normal variation in the house elevations due to seasonal variation.

## RELIEF WELLS

The Contractor will effect the temporary groundwater lowering in the highway cut area by deep wells or by wellpoints, or by a combination of these two systems. The permanent groundwater lowering will be effected by relief wells in the sands and sands and gravels and also in the bedrock, at and immediately south of the railway underpass. The approximate

area where we expect the sand and bedrock relief wells to be installed is shown on Figure 5. A typical detail of a relief well in sand is shown on Figure 6.

### RECHARGE WELLS

Based on the lateral extent and the thickness of the sands below the Lynwood Village subdivision, a proposed layout for the recharge wells has been determined and is shown on Figure A. The wells are on about 50 to 80 meter spacing throughout the area considered for potential recharge. The wells have been located near the street line where they can be readily accessed by service vehicles and by tanker truck. The wells could be located in ditch lines to be less conspicuous and to not interfere with the front lawns of homeowners. The well locations could be altered somewhat from the locations shown on Figure A to be near watermains.

A typical detail for the recharge well has not been developed yet though it is considered that it would be similar to the relief well (Figure 6), except there would be no connection to a discharge pipe. Water injected under pressure into the recharge well would discharge into the sand and sand and gravel deposit.

The recharge wells would be activated when the groundwater level reaches one meter below the lowest levels measured in the preconstruction monitoring program. The recharge wells would be initially fed from a tanker truck and a record would be kept of the inflow (take) on each well. Wells that experienced little or no inflow over a period of time would be abandoned and, if necessary, replaced with new recharge wells.

Following the construction period and the installation of a permanent groundwater lowering system, the inflow (take) in the whole system would be analyzed. If the period per year that recharge was required was several months and the involvement by tanker trucks was large, consideration would then be given to hooking up to the watermains. A float arrangement would be required which would activate the recharge well when the water level dropped below a set point. The details of the connection into the watermains would be arrived at in conjunction with Ottawa-Carleton Region personnel.

We trust that this report contains sufficient information for your present purposes. Should you have any questions concerning this report, please contact us.

Yours truly

**GOLDER ASSOCIATES LTD.**

A handwritten signature in black ink, appearing to read 'F. J. Heffernan', written in a cursive style.

F. J. Heffernan, P. Eng.  
Principal

FJH/jm

Attachments:      Lists of Abbreviations and Symbols  
                         Figures 5 and 6  
                         Figures A, B, C and D

## LIST OF ABBREVIATIONS

The abbreviation commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

### I. SAMPLE TYPES

*AS* auger sample  
*CS* chunk sample  
*DO* drive open  
*DS* Denison type sample  
*FS* foil sample  
*RC* rock core  
*ST* slotted tube  
*TO* thin-walled, open  
*TP* thin-walled, piston  
*WS* wash sample

### II. PENETRATION RESISTANCES

#### Dynamic Penetration Resistance:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 0.3 m (12 in.).

#### Standard Penetration Resistance, *N*:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 0.3 m (12 in.).

*WH* sampler advanced by static weight—weight, hammer

*PH* sampler advanced by pressure—pressure, hydraulic

*PM* sampler advanced by pressure—pressure, manual

### III. SOIL DESCRIPTION

(a) <i>Cohesionless Soils</i>	' <i>N</i> ' <u>Blows/0.30m</u> <u>or Blows/ft.</u>
Relative Density	
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

#### (b) *Cohesive Soils*

Consistency	<u>kPa</u>	' <i>Cu</i> ' <u>psf.</u>
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1000
Stiff	50 to 100	1000 to 2000
Very stiff	100 to 200	2000 to 4000
Hard	over 200	over 4000

### IV. SOIL TESTS

*C* consolidation test  
*H* hydrometer analysis  
*M* sieve analysis  
*MH* combined analysis, sieve and hydrometer<sup>1</sup>  
*Q* undrained triaxial<sup>2</sup>  
*R* consolidated undrained triaxial<sup>2</sup>  
*S* drained triaxial  
*U* unconfined compression  
*V* field vane test

#### NOTES:

<sup>1</sup>Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.

<sup>2</sup>Undrained triaxial tests in which pore pressures are measured are shown as  $\bar{Q}$  or  $\bar{R}$ .

## LIST OF SYMBOLS

### I. GENERAL

$\tau$	= 3.1416
$e$	= base of natural logarithms 2.7183
$\log_e a$ or $\ln a$	natural logarithm of $a$
$\log_{10} a$ or $\log a$	logarithm of $a$ to base 10
$t$	time
$g$	acceleration due to gravity
$V$	volume
$W$	weight
$M$	moment
$F$	factor of safety

### II. STRESS AND STRAIN

$u$	pore pressure
$\sigma$	normal stress
$\sigma'$	normal effective stress ( $\bar{\sigma}$ is also used)
$\tau$	shear stress
$\epsilon$	linear strain
$\epsilon_{xy}$	shear strain
$\nu$	Poisson's ratio ( $\mu$ is also used)
$E$	modulus of linear deformation (Young's modulus)
$G$	modulus of shear deformation
$K$	modulus of compressibility
$\eta$	coefficient of viscosity

### III. SOIL PROPERTIES

#### (a) Unit weight

$\gamma$	unit weight of soil (bulk density)
$\gamma_s$	unit weight of solid particles
$\gamma_w$	unit weight of water
$\gamma_d$	unit dry weight of soil (dry density)
$\gamma'$	unit weight of submerged soil
$G_s$	specific gravity of solid particles $G_s = \gamma_s / \gamma_w$
$e$	void ratio
$n$	porosity
$w$	water content
$S_r$	degree of saturation

#### (b) Consistency

$w_L$	liquid limit
$w_P$	plastic limit
$I_P$	plasticity index
$w_S$	shrinkage limit
$I_L$	liquidity index = $(w - w_P) / I_P$
$I_C$	consistency index = $(w_L - w) / I_P$
$e_{max}$	void ratio in loosest state
$e_{min}$	void ratio in densest state
$D_r$	relative density = $(e_{max} - e) / (e_{max} - e_{min})$

#### (c) Permeability

$h$	hydraulic head or potential
$q$	rate of discharge
$v$	velocity of flow
$i$	hydraulic gradient
$k$	coefficient of permeability
$j$	seepage force per unit volume

#### (d) Consolidation (one-dimensional)

$m_v$	coefficient of volume change = $-\Delta e / (1+e) \Delta \sigma'$
$C_c$	compression index = $-\Delta e / \Delta \log_{10} \sigma'$
$c_c$	coefficient of consolidation
$T_v$	time factor = $c_v t / d^2$ ( $d$ , drainage path)
$U$	degree of consolidation

#### (e) Shear strength

$\tau_f$	shear strength
$c'$	effective cohesion
$\phi'$	effective angle of shearing resistance, or friction
$c_u$	apparent cohesion*
$\phi_u$	apparent angle of shearing resistance, or friction
$\mu$	coefficient of friction
$S_i$	sensitivity

$\left. \begin{array}{l} \text{in terms of effective stress} \\ \tau_f = c' + \sigma' \tan \phi' \end{array} \right\}$

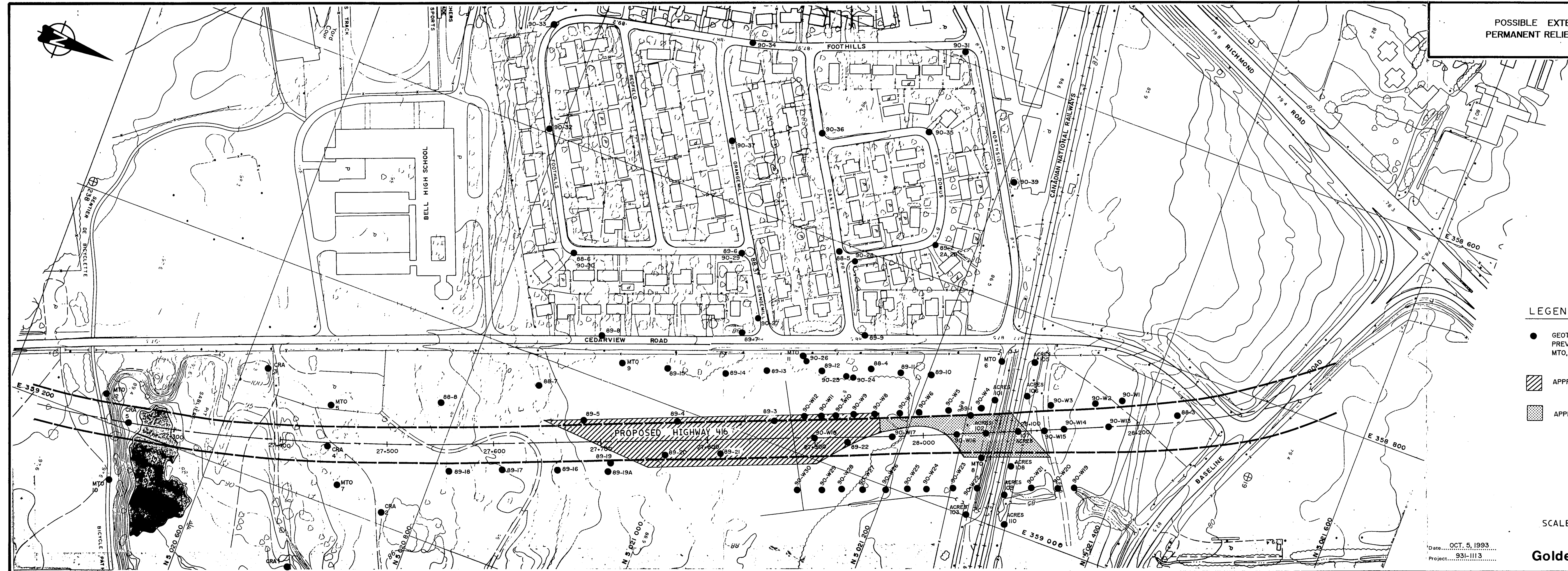
$\left. \begin{array}{l} \text{in terms of total stress} \\ \tau_f = c_u + \sigma \tan \phi_u \end{array} \right\}$

\*For the case of a saturated cohesive soil,  $\phi_u = 0$  and the strength  $\tau_f = c_u$  is taken as half the undrained compressive strength.

strength  $\tau_f = c_u$  is taken

POSSIBLE EXTENT OF  
PERMANENT RELIEF WELLS

FIGURE 5  
WP 146-74-00-3



- LEGEND
- GEOTECHNICAL BOREHOLE OR PROBEHOLE LOCATION, PREVIOUS INVESTIGATIONS BY GOLDER ASSOCIATES, MTO, ACRES INTERNATIONAL, AND CONESTOGA ROVERS.
  - ▨ APPROXIMATE AREA OF SAND RELIEF WELLS
  - ▤ APPROXIMATE AREA OF BEDROCK RELIEF WELLS

SCALE 1 : 2,000

Date OCT. 5, 1993  
Project 931-1113

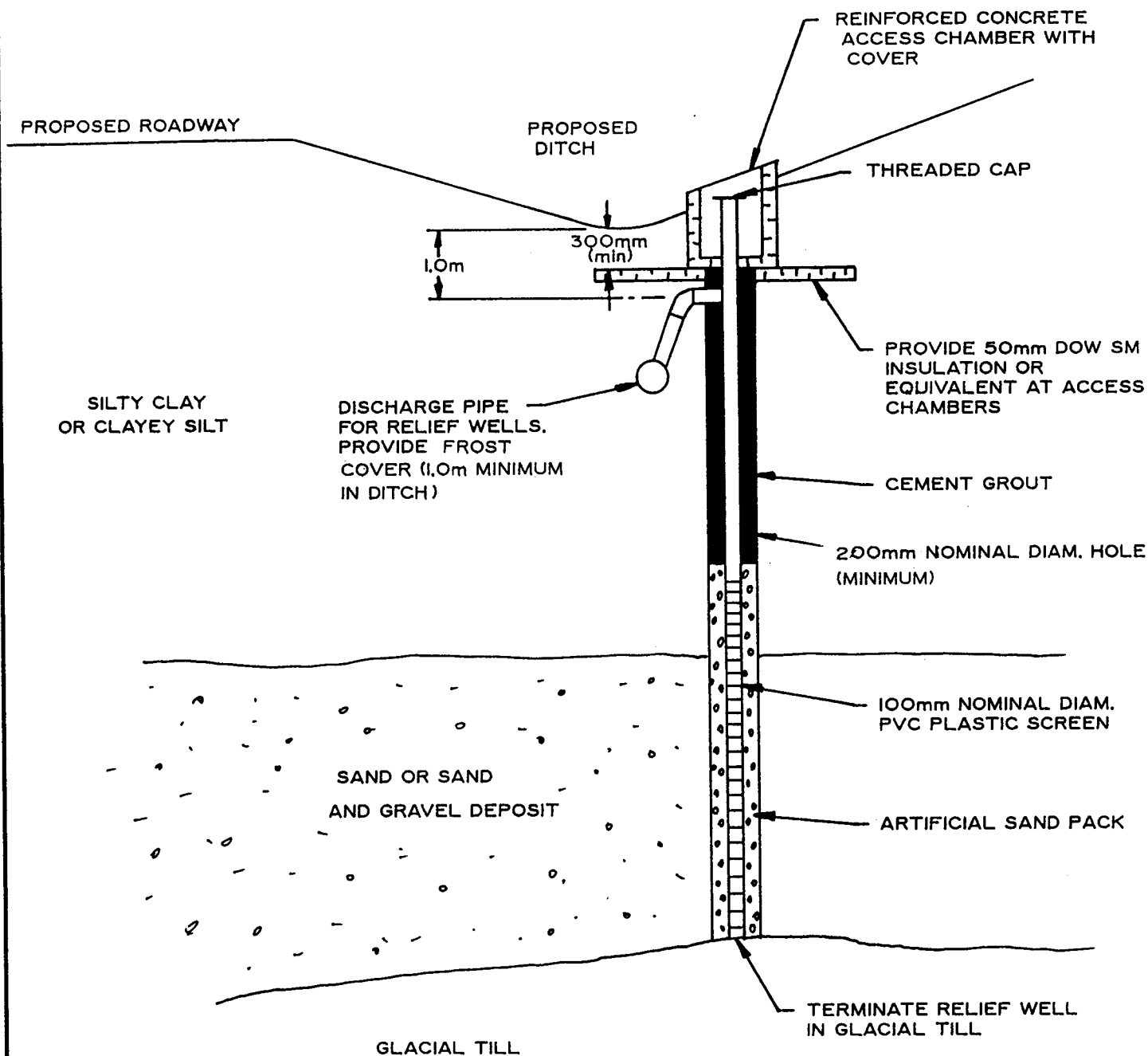
Golder Associates

Drawn MHW, JC  
Chkd F.J.H.



# TYPICAL PRESSURE RELIEF WELL DETAIL — SAND —

FIGURE 6  
WP 146-74-00-3



NOT TO SCALE

**SPECIAL NOTE**  
THIS DRAWING IS TO BE READ IN CONJUNCTION  
WITH ACCOMPANYING REPORT

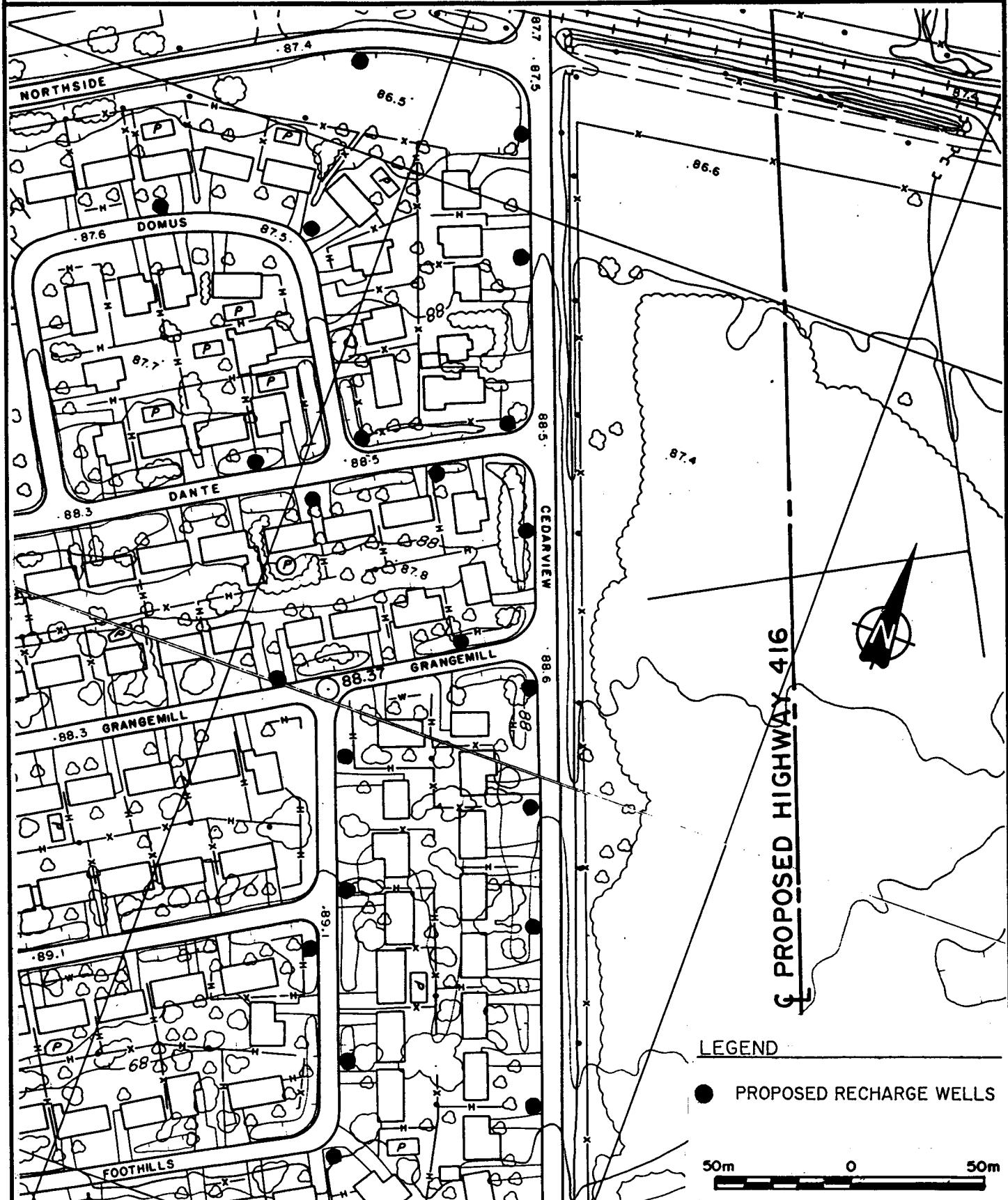
Date OCT. 4, 1990  
Project 901-2115

**Golder Associates**

Drawn S.L.  
Chkd. *ae*

# LOCATION OF PROPOSED RECHARGE WELLS TO LIMIT DRAWDOWN

FIGURE A



Date OCT. 1993

Project 93I-1113

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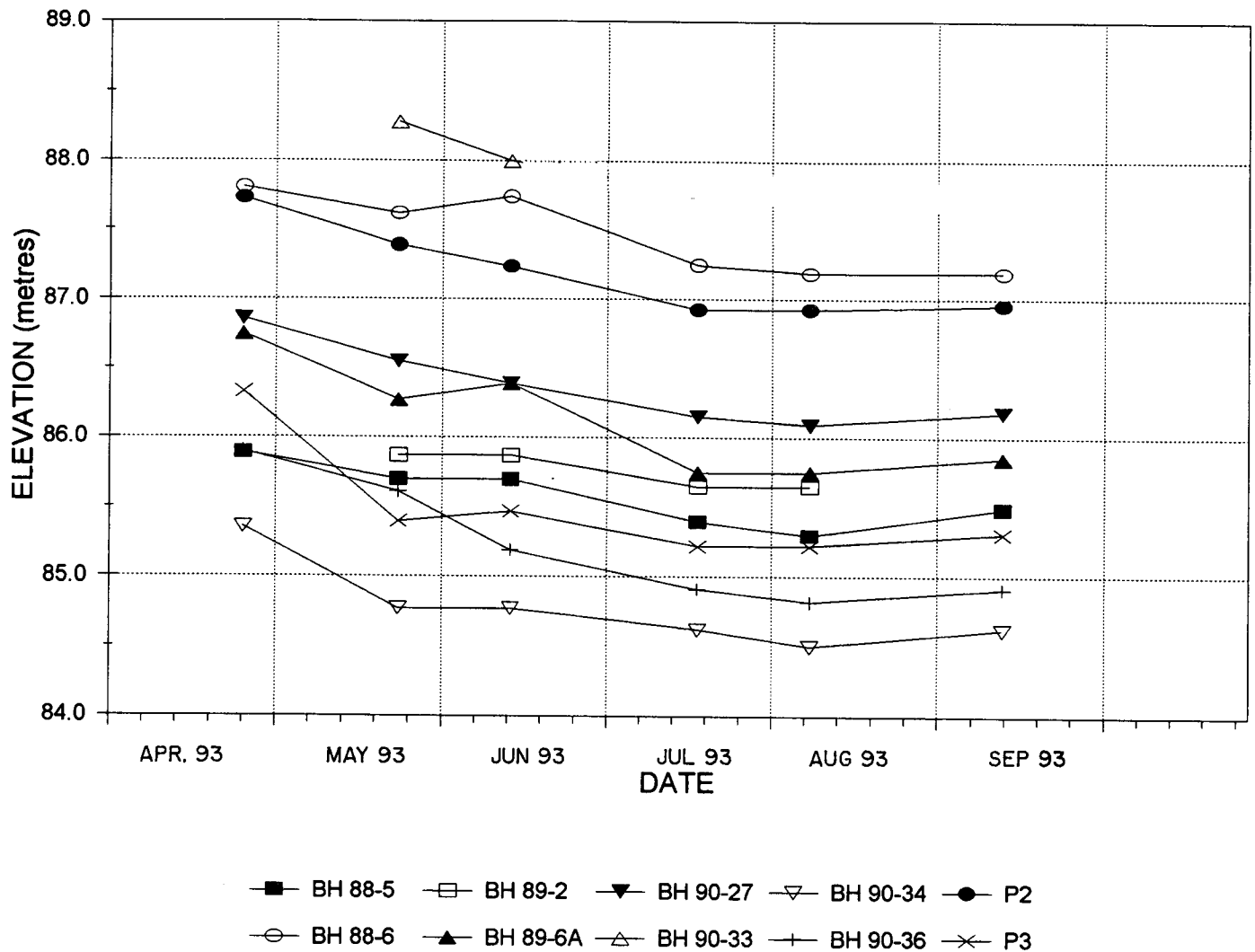
Drawn MHW/KD

Chkd. F.J.N.

# GROUNDWATER LEVEL DATA

## APRIL TO SEPTEMBER 1993 (SILTY CLAY)

FIGURE B



Date OCT. 5, 1993  
Project 93I-1113

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Drawn SL  
Chkd. F.J.H.

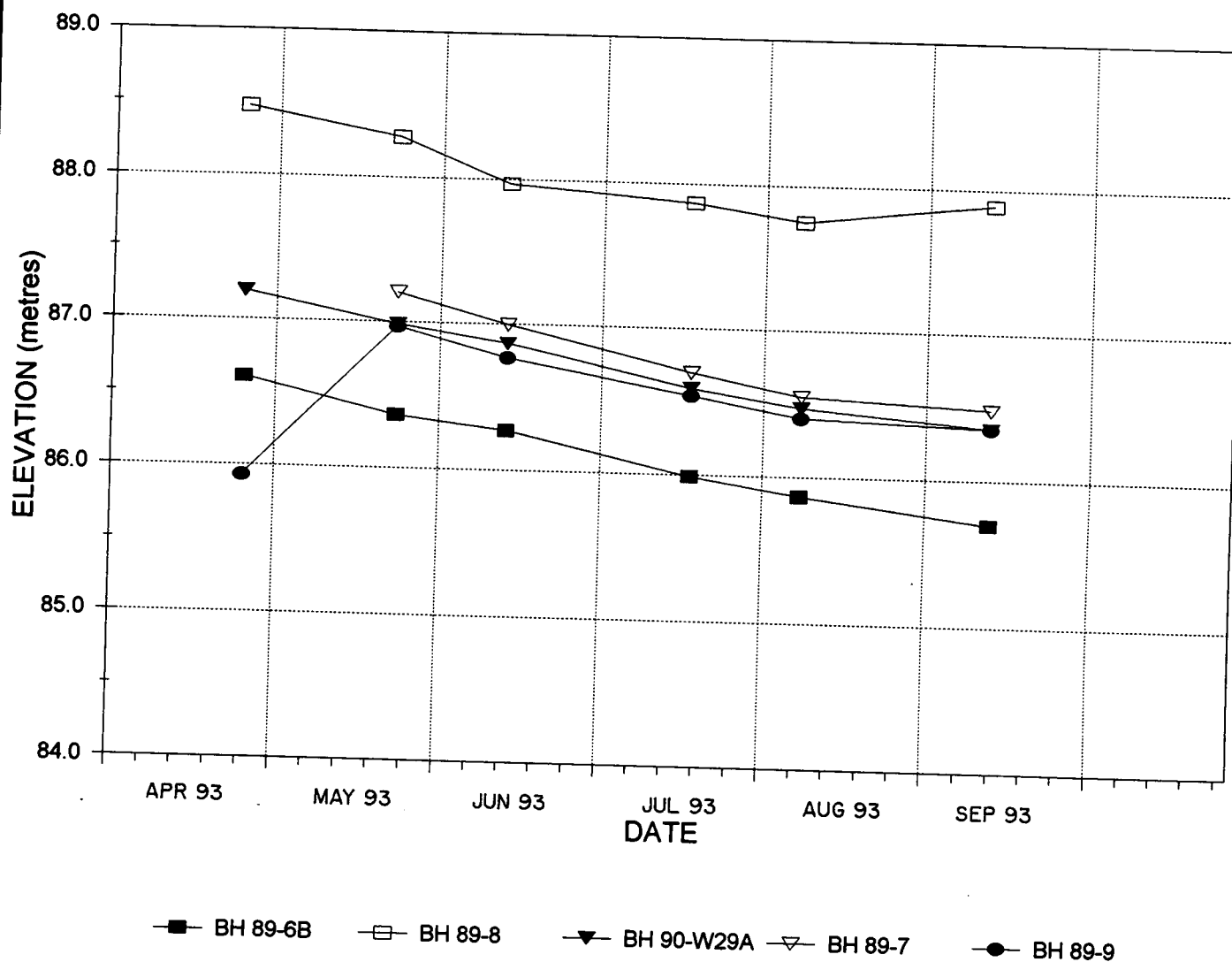
FORM PRODUCED JUNE 1986

Form GA-D-4 (imperial)

# GROUNDWATER LEVEL DATA

APRIL TO SEPTEMBER 1993 (SAND)

FIGURE C



Date OCT. 5, 1993  
Project 93I-1113

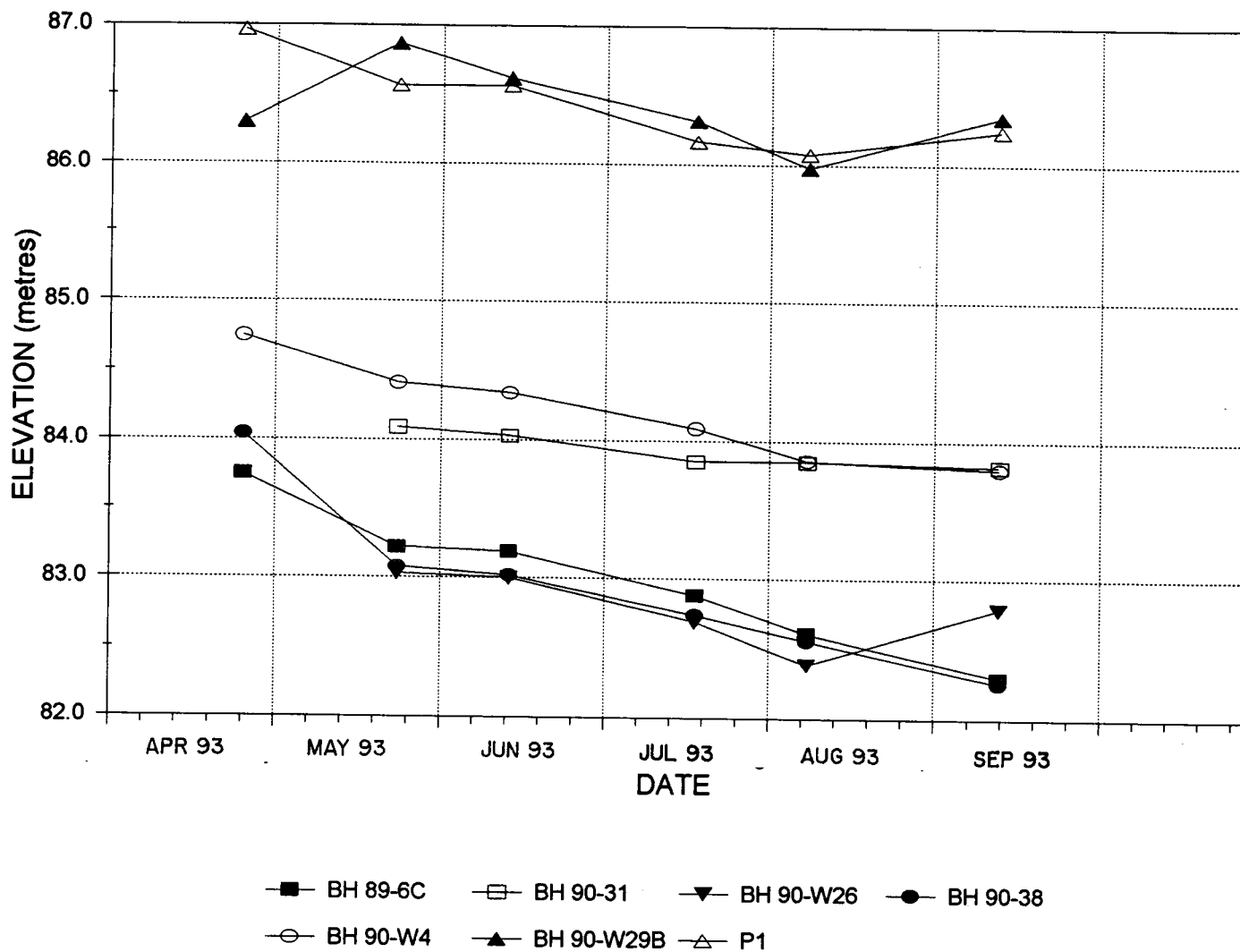
**Golder Associates**

Drawn SL  
Chkd. R.J.W.

# GROUNDWATER LEVEL DATA

APRIL TO SEPTEMBER 1993 (GLACIAL TILL AND BEDROCK)

FIGURE D



Date OCT. 5, 1993  
Project 93-1113

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Drawn SL  
Chkd. F.J.H.