



# URKKADA

Comprehensive Geotechnical Engineering Services

GEOCRES No  
31F-115-1



## **Report 8**

### **Falsework Foundation Design**

#### **Regional Road 22**

**MTO 2001-0002**

**Grading, Drainage, Granular Base, Hot Paving, and Two Structures at**

**HWY 417 – From Regional Road 29 (Formerly) HWY 15 and**

**HWY 17 Intersection, Easterly 4.7 km to Regional Road 22**

**ONTARIO**

Our File No. 0203CS250

August 7, 2002

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**Urkkada Technology Ltd.**

1010 Polytek Street, Unit 6

Ottawa, Ontario, K1J 9H8

Tel. (613) 748-3232; Fax (613) 748-7402

<info@urkkada.com>

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**Urkkada Pacific Ltd.**

20800 Westminister Hwy, Suite 1318

Richmond, British Columbia, V6V 2W3

Tel. (604) 244-0505; Fax (604) 244-5955



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HWY 417 – From Regional Road 29 (Formerly) HWY 15 and  
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ONTARIO**

Prepared for

**R.W. Tomlinson Limited**

**4497 Power Road,  
Ottawa, Ontario  
K1G 3N4**

Your Job No. 2002-060

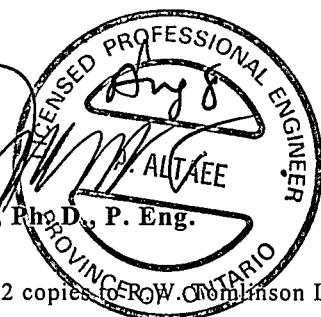
Your Order No. 2002-060-16

Our File No. 0203CS250

August 7, 2002

Prepared by:

Ameir Altaee, Ph.D., P. Eng.



Thomas Walsh, M.A.Sc.

Distribution: 2 copies to R.W. Tomlinson Limited  
3 copies to M.T.O.  
1 copy to Urkkada project files



# URKKADA

Comprehensive Geotechnical Engineering Services

## Report 8

### Falsework Foundation Design

### Regional Road 22

MTO 2001-0002

#### 1. Introduction

Urkkada Technology Ltd. has been retained by R.W. Tomlinson Limited, Mr. Richard Irving, P.Eng., to prepare this falsework foundation design report and to provide details of soil preloading and field instrumentations associated with the falsework system as per the project specifications of MTO 2001-0002. This report is prepared in conformity with OPSS 919 dated July 1995.

#### 2. Scope of Work

The scope of work is outlined in the project specifications as follows.

- ☐ Prepare a falsework foundation design report
- ☐ Develop and implement a settlement monitoring programme
- ☐ Detail the procedures and the monitoring requirements of preloading, unloading and reloading of an area within the falsework zone to confirm the settlement characteristics of the subsurface soils under cycles of loading and unloading

#### 3. Performance Requirement

The project specifications establish the following performance requirement.

*"The settlement of the falsework between the time of the initial set of the concrete and the completion of the longitudinal prestressing of the structure shall not exceed 12 mm."*

#### 4. Available Information

The analysis and design computations of this report are based on the following.

- ☐ Contract Specifications and Drawings, MTO Contract No. 2001-0002.
- ☐ Foundation Investigation and Design, Highway 417 underpass Bridge at Region of Ottawa-Carleton Road 22, District 9, West Carleton W.P. 128-92-00 and 451-90-06. Report by Golder Associates Ltd., dated January 2001.
- ☐ Shoring Layout to Bridge Deck, HWY 417 – Regional Rd. 22, Drawing Number TOP 6797-01 dated July 17, 2002, by Aluma Systems Canada Inc.
- ☐ E-mail message of Aluma Systems Canada Inc. dated July 12, 2002, providing the following loading of falsework support system.

*“The maximum expected leg load will be about 15,300 lb. This will be on a 6'x5' grid. The maximum expected load on a sill will be about 3,600 lb/ft near the piers, but the legs near the piers will be spaced at about 4' c/c, again using 6' wide frames”*

- ☐ The following construction time schedule of falsework support system, bridge deck construction, and stressing of tendon as provided by Dufferin Construction Company on August 6, 2002.

<i>Formwork, rebar placement, ducts placement, etc.,</i>	<i>56 Calendar days</i>
<i>Concrete pouring,</i>	<i>10 Calendar days</i>
<i>Concrete curing,</i>	<i>14 Calendar days</i>
<i>Tendon stressing,</i>	<i>7 Calendar days</i>

#### 5. Foundation Design

##### 5.1 General

In conformity with OPSS 919, the foundation design presented herein addresses the following two items

- a. the soil bearing capacity
- b. site preparation details

To ensure compliance with the project specifications performance requirement mentioned in Section 3 above, detailed settlement analyses are carried out. The analyses consider three levels of preloading and address the soils response during the following three time periods.

- ☐ Preloading of the soil supporting the falsework
- ☐ Unloading and reloading of a selected area within the falsework zone
- ☐ Post reloading

Finally, conventional slope stability analyses are performed to ensure no slope instability exists during the preloading and unloading periods.

## 5.2 Design Parameters

### 5.2.1 Geotechnical

Input soil parameters for the present analyses including strength, compressibility, void ratio, unit weight, and hydraulic conductivity are based on the Golder Associates Ltd. report listed in Section 4 above. The boundaries defining the soil layers, location of the ground water table, and the bedrock elevation within the falsework zone are based on Boreholes 22-2, 22-3, and 22-4 of the above mentioned report.

### 5.2.2 Loading

The following loading values are used based on the information provided by Aluma System Canada Inc.

- ☐ Maximum axial leg load 67 kN
- ☐ Equivalent uniformly distributed load 25 kPa

### 5.2.3 Time Schedule

The following time table of the relevant activities is used in the analyses.

<u>Duration</u>	<u>Activity</u>	<u>Cumulative Days</u> <u>Wks</u>	
Twelve months	Preloading		1
7 days	Removal of preload and site preparation	7	
56 days	Formwork, rebar placement, ducts placement, etc.	63	9
10 days	Concrete pouring	73	10 3/4
14 days	Concrete curing	87	12 3/4
7 days	Tendons stressing	94	13

## 5.3 Bearing Capacity

A construction grade spruce sill plate size 4"x12" is available to Dufferin Construction Company. Using the dimensions of the sill plate and the loading values provided by Aluma System Canada Inc., contact stress of 150 kPa is calculated at the top of the granular pad. At the natural ground surface, below a 0.5 m thick granular pad, the contact stress is calculated to be 55 kPa. These contact stress values are low and acceptable.

## 5.4 Site Preparation Details

No site preparation is necessary to start the installation of the instruments (detailed in the following), and to subsequently place the preload of the soils within the falsework zone.

The following should be observed to ensure a satisfactory performance.

- ❑ Prior to the installation of the falsework support system, place a 14 m wide granular pad to support the sill plates. The top of the pad is at Elevation +101.00 m and it extends between Station 9+984.96 and Station 10+055.06.
- ❑ Place 4" x 12" sill plates in the pattern indicated in Drawing Number TOP 6797-01 dated July 17, 2002, by Aluma Systems Canada Inc.
- ❑ Extend the sill plates a distance of at least 0.3 m past the centerline of the two end rows of legs placed at the offset lines 5.932 m Right and 5.932 m left.
- ❑ Do not block access to instruments placed and identified within the falsework zone.

## 5.5 Settlement Analysis

### 5.5.1 Method of Analysis

Finite element analysis using the Advanced Geotechnical Analysis Code (AGAC) is used to simulate the loading-unloading-reloading of the foundation soils. The analysis is non-linear, elasto-plastic, and time dependent. That is, the preloading-unloading-reloading was simulated in a continuous manner using the design time schedule mentioned in Section 5.3. All analyses are plane-strain cases. The method of analysis used in this report was applied in the design of the approach embankments at HWY 416 and County Road 19 overpass, MTO 96-59.

### 5.5.2 Geometry and Finite Element Mesh

A transverse section across the preload is selected for the analysis. The finite element mesh used is shown in Fig. FW1. The boundary conditions are as follows.

- ❑ Boundary AD is the existing ground surface before the start of placing the preload. Water flow as well as vertical and lateral displacements are allowed along this boundary.
- ❑ Boundary AB represents the center line of the preload. Lateral displacement and water flow are restricted along this boundary but vertical movements are permitted.
- ❑ Boundary CD is a side boundary placed far enough away where water flow and movements will not occur.
- ❑ Boundary BC is the lower boundary and it represents the bedrock surface. Water flow and movements are prevented along this boundary.

### 5.5.3 Cases Analyzed

Three finite element analysis cases, Cases 1, 2, and 3, are performed. The analyses employ the finite element mesh shown in Fig. FW1 and use the same soil parameters and loading time history. Different levels of preload were used for the three analysis cases. Case 1 uses preloading to Elevation +102.75 m, Case 2 uses a preloading to Elevation +104.00 m, and Case 3 uses a preloading to Elevation 104.5 m. Case 1 corresponds to the specified preloading in the Contract Drawings, Sheet 27. Cases 2 and 3 employ larger than the specified preloading. The width of the top of the preload embankment in the three analyses is 16 m and the sides slope at 2 horizontal to 1 vertical as shown in Fig. FW2. The preload material is granular material.

### 5.5.4 Analysis Results

The output of the finite element analyses consists of settlement, vertical and horizontal displacements, vertical and horizontal stresses, vertical and horizontal strains, and excess pore water pressure. All these quantities are output for each time step of the analysis throughout the finite element mesh. The only relevant quantity for the purpose of this report is the maximum settlement at the ground surface during the performance requirement duration presented in Section 3 above; that is "*...the time of the initial set of the concrete and the completion of the longitudinal prestressing of the structure ...*"

Figure FW3 presents the vertical movement at the ground surface (settlement or heave) verses time along the centerline of the preload for the three cases analyzed. Settlement corresponds to positive vertical movement, and heave corresponds to negative vertical movement. Time zero in Figure FW3 is the start of the preload removal. Movement at time zero is taken as reference and is plotted as zero.

The performance requirement time period, according to the design construction time schedule used in the analyses (as given in Section 4.3), corresponds to the period from the start of week 9 through the end of week 13.5. As shown in Fig. FW3, the three cases analyzed show the same trend of movement versus time. The trend is characterized by an initial heave followed by settlement with elapsed time. The larger the preload, the larger the heave, followed by a smaller rate of settlement with time. Furthermore, the rate of settlement with time is constant from week 5 on for each of the three cases. Because the analysis is time dependant, it correctly shows that heave continues for some time beyond the completion of the preload removal.

The computed settlement within the performance time period is 25 mm, 14 mm, and 11 mm for Cases 1, 2, and 3, respectively. This means, in order to comply with the performance requirement (limiting the settlement to a maximum of 12 mm), it is necessary to preload to Elevation +104.5 m. Furthermore, the preload should extend from Station 9+984.96 to Station 10+055.06.

To investigate the effect of preloading period, Case 1, preload to Elevation +102.75, was run again using a 24-month preloading period instead of the 12 months period used earlier. All other soil and analysis parameters were kept unchanged. The computed settlement of the renewed analysis is still larger than 12 mm.

Based on the analysis results, Case 3, Preloading to Elevation +104.5 m, is considered the design case. Further, a parametric study using the design case with different time histories, indicates that the **computed settlement during the performance compliance period:**

- ❑ Is not influenced when the preload removal period was extended from one to two weeks or shortened from one week to one day only
- ❑ Is not influenced when the time period to erect the formwork, rebar placement, duct placement, and other activities prior to concrete pouring is extended to 12 weeks or shortened to 4 weeks
- ❑ Is reduced when the concrete pouring, curing, and tendon stressing period is shortened
- ❑ **Exceeds the 12 mm** specified as the upper limit for performance compliance, when the concrete pouring, curing, and tendon stressing period takes more than 5 weeks to complete.

## 5.6 Conventional Slope Stability Analysis

Two slope stability analyses are performed; one when the preload is at full height and the other when the unloading of a limited area is complete (see details later on). The computations are performed by means of the computer program XSTABL Version 5-1996. The analyses indicated that the lowest factor of safety was about 1.7.

## 6. Unloading Reloading

This section describes the unloading and reloading procedures to confirm the settlement characteristics of the subsurface soils as computed in Section 6 above. The unloading and reloading follows in principal the project specifications. However, the process is to be completed in a shorter than the specified time period.

- ❑ Stage 1: Ten months after placement of the preload, unload one of the two areas identified in Fig. FW4a depending on the performance of the instruments within the two alternative areas. The details of the unloaded zone are shown Fig. FW4b. The removal of the preload material should be made in 4 lifts of about equal thickness and it should allow for an at least two-hour break between the lifts for data collection from all instruments within the falsework area and also to perform necessary work to ensure access to the instruments for subsequent data collection.
- ❑ Stage 2: After one week from the start of unloading, place back a 1.5 m thick layer as shown in Figs. FW5a and FW5b. Placement of the 1.5 m thick layer should be made in two lifts of approximately the same thickness. An at least two-hour break between the two lifts should be allowed similar to that of Stage 1 above.
- ❑ Stage 3: Data collection continues for at least four weeks after the completion of placing the 1.5 m thick layer.
- ❑ Assess the collected data from all instruments and restore the preloading if necessary. The assessment process could involve additional finite element analysis to incorporate the as-build preloading, unloading, and reloading time schedule.

## 7. Settlement and Pore Water Pressure Monitoring Programme

### 7.1 General

Vibrating wire piezometers will be used to monitor the development and dissipation of pore water pressure during the preloading, unloading and reloading, and after the unloading reloading periods. To monitor the development of settlement with time, vibrating wire settlement cells, settlement plates, and magnetic settlement profilers will be installed at selected locations and elevations.

The instruments will be clustered in two main locations, one near each of the abutments. In addition two additional settlement plates will be placed closer to the pier location.

In total, six vibrating wire piezometers, two vibrating wire settlement cells, six settlement plates, and two magnetic settlement profilers will be installed and monitored.

### 7.2 Instrumentations

#### 7.2.1 Type of Instruments

##### 7.2.1.1 Vibrating Wire Piezometers

Roctest Ltd PW Series Vibrating Wire Piezometers are selected. The part numbers of the relevant items are as follows.

IR 301900021025	PWP V.W. Piezometer, 1.75 bar - Roctest
IR 301900021050	PWP V.W. Piezometer, 3.5 bar - Roctest
57711600	Terminal Box – Slope Indicator
57710900	Data Mate MP with Manager Software, Slope Indicator

##### 7.2.1.2 Vibrating Wire Settlement Cells

Slope Indicator Company Inc., VW Settlement Cells are selected. The Vibrating Wire Settlement Cells are identical to Contract Item 64, Specification Section 2, Pages 150 through 154, and Construction Drawings, Sheet 31, as detailed in Appendix I. The part number of the relevant items are as follows.

52612020	VW Settlement Cell, 3.5 bar with vented reservoir.
52630512	Settlement Plate
51416950m	Tubing for VW Settlement Cell, liquid-filled
50613524m	Signal Cable, PU Jacket
57711600	Terminal Box
51419500	Vented reservoir
51407301	Quick-Connect Plug
SPECIAL	Enclosure for Vented Reservoir
6010105	Barometric Compensation Kit

### 7.2.1.3 Settlement Plates

Steel settlement plates measuring 0.5m x 0.5m with 25 mm steel pipe and a 50 mm friction reducing sleeve are selected. The Settlement Plates are Identical to Contract Item 62, Specification Section 2, Pages 144 and 145, and Construction Drawings, Sheet 31, as detailed in Appendix I.

### 7.2.1.4 Settlement Profiler

RST Instruments Ltd. Reed Switch Settlement System is selected. The part numbers of the relevant items are as follows.

Model 4001 RS0002	Reed Switch Readout
176-SS3201	1.5" I.D. Corrugated Pipe
176-SS3220	Target Magnet for 1.5" I.D. Corrugated Pipe
176-SS3210	End Cap Weight for 1.5" I.D. Corrugated Pipe
176-SSRS00D1	Settlement Datum Target

Installation of all instruments is per the details enclosed in Appendix I.

## 7.2.2 Instruments Location

The locations and elevations of the geotechnical instruments within the falsework area are presented in Fig. FW6 and Tables FW1 through FW4.

## 7.2.3 Instruments Installation Reports

### 7.2.3.1 General

Reporting of the installation of the geotechnical instruments will be in accordance with the project specifications and as follows.

### 7.2.3.2 Vibrating Wire Piezometers

The report of each Vibrating Wire Piezometer installation will include the following.

- Instrument ID No.
- Instrument location
- Elevation of VW sensor
- Stratigraphic log of the subsurface conditions (soil profile in a boring log)
- Date of installation and readings since installation
- Embedment length and stick-up length of pipe.
- Installation and backfilling notes
- Model, make, and serial numbers of VW sensor, readout unit, and signal cable
- Calibration details of VW sensor
- Manufacturer's Serial No. and calibration information

#### 7.2.3.3 Vibrating Wire Settlement Cells

The report of each Vibrating Wire Settlement Cell installation will include the following.

- Instrument ID No.
- Instrument location
- Elevation of cell and reservoir
- Calibration details for cell and transducer
- Date of installation and readings since installation
- Installation and backfilling notes
- Description of settlement cell, reservoir, tubing, cables, and liquid in tubes
- Manufacturer's Serial No. and calibration information

#### 7.2.3.4 Settlement Plates

The report of each Settlement Plate installation will include the following.

- Instrument ID No.
- Instrument location
- Description of settlement rods, sleeve, corrugated metal pipe, and plate
- Elevation of plate and rod
- Distance between base of plate and top of rod
- Date of installation and datum readings
- Embedment length and stick-up length of pipe.
- Installation and backfilling notes

#### 7.2.3.5 Settlement Profiler

- Instrument ID No.
- Instrument location
- Elevation of Profiler tip
- Elevation of magnetic rings
- Stratigraphic log of the subsurface conditions (soil profile in a boring log)
- Date of installation and readings since installation
- Installation and backfilling notes
- Model, make, and serial numbers of Settlement Profiler and readout unit
- Manufacturer's Serial No. and other information

### **7.3 Data Collection Schedule**

The schedule of data collection from all the instruments is provided in Table FW5.

## **8. Falsework Foundation Certificate**

As per OPSS 919, prior to placing of concrete, the falsework foundation will be inspected. A signed and sealed compliance Certificate will be issued following the inspection if the work is in conformity with this foundation design report.

## **9. Closing Remarks**

- ❑ The process of preloading unloading and reloading causes a significant change in the pore water pressure regime within a large soil mass within the underpass area. Large residual excess pore water pressure could remain in the soil for long time after the completion of the bridge construction. We recommend that an assessment of the effects of these residual pore water pressure on the serviceability of the HWY417 pavements be carried out.
- ❑ This falsework foundation design report is limited in addressing the items listed in the scope of work. The report does not address the impact that the preloading of the falsework zone might have on any of the components of both approach embankments.
- ❑ This falsework foundation design does not suggest any changes to the specified construction sequence during the various stages of all components of the approach embankments and the foundations of the pier and the two abutments.

**Table FW-1: Locations and Elevations**

**Vibrating Wire Piezometers, Falsework Foundation, Regional Road 22**

Instrument ID	Monitoring Station No.	at	Instrument Location			
			Station	Offset	Tip Elevation (m)	
VWPFW1	22-FW1	9+ 998.0	9+ 998.399	0.5 (Rt)	84.00	North Embankment
VWPFW2			9+ 998.399	0.5 (Rt)	91.00	
VWPFW3			9+ 998.399	0.5 (Lt)	94.00	
VWPFW4	22-FW2	10+ 042.0	10+ 041.616	0.5 (Rt)	84.00	South Embankment
VWPFW5			10+ 041.616	0.5 (Rt)	91.00	
VWPFW6			10+ 041.616	0.5 (Lt)	94.00	

Grading, Drainage, Granular Base, Hot Paving, and Two Structures  
At HWY 417 - From Regional Road 29 (Formerly) HWY 15 and  
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**Table FW-2: Locations of  
Vibrating Wire Settlement Cells, Falsework Foundation, Regional Road 22**

Instrument ID	Monitoring Station No.	at	Instrument Location		
			Station	Offset	
VWSCFW1	22-FW1	9+ 998.0	9+ 998.399	1.5 (Lt)	North Embankment
VWSCFW2	22-FW2	10+ 042.0	10+ 041.616	1.5 (Lt)	South Embankment

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**Table FW-3: Locations of  
Settlement Plates, Falsework Foundation, Regional Road 22**

Instrument ID	Monitoring Station No.	at	Instrument Location		
			Station	Offset	
SPFW1	22-FW1	9+ 998.0	9+ 996.570	0	North Embankment
SPFW2			10+ 000.228	0	
SPFW3			10+ 013.031	0	
SPFW4	22-FW2	10+ 042.0	10+ 026.984	0	South Embankment
SPFW5			10+ 039.787	0	
SPFW6			10+ 043.445	0	

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**Table FW-4: Locations and Elevations**

**Magnetic Settlement Profile, Falsework Foundation, Regional Road 22**

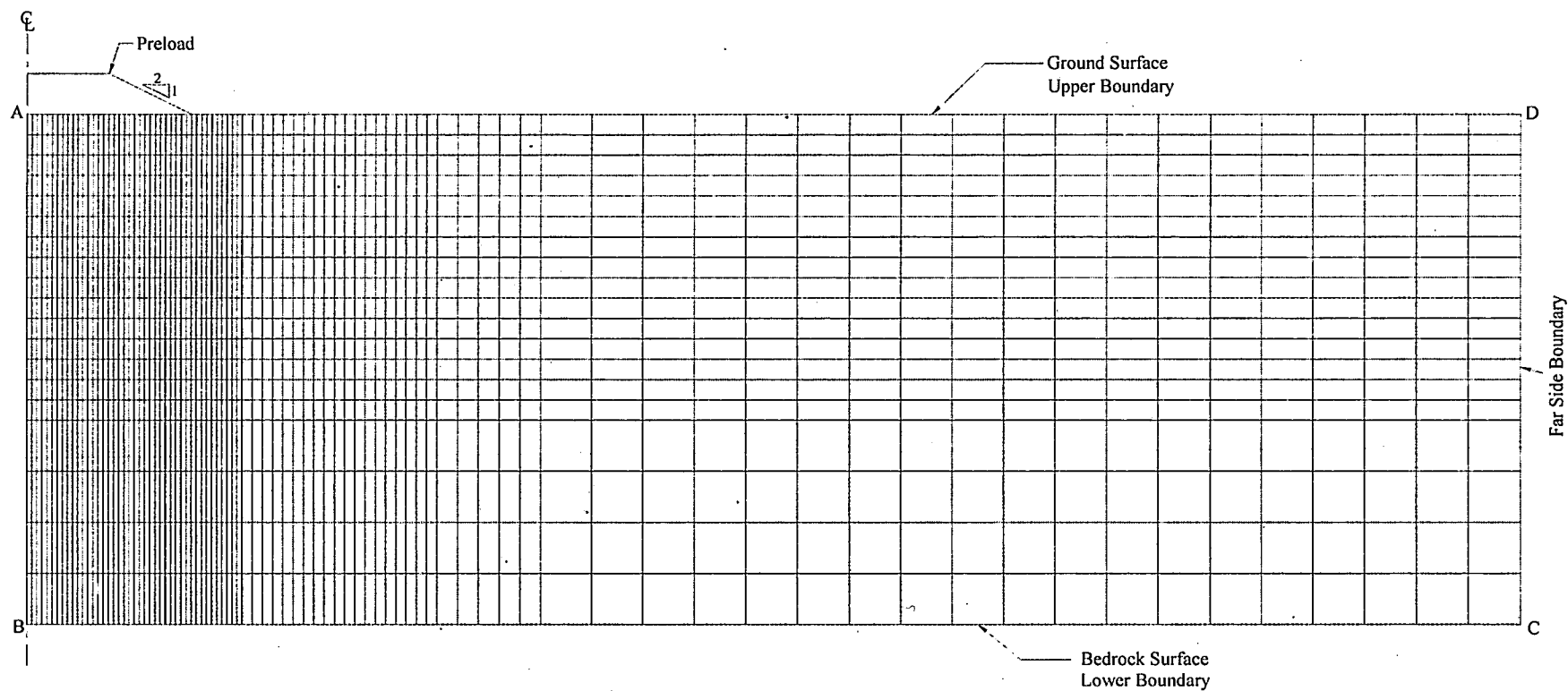
Instrument ID	Monitoring Station No.	at	Instrument Location			
			Station	Offset	Tip Elevation (m)	
MPFW1	22-FW1	9+ 998.0	9+ 998.399	1.5 (Rt)	84.00	North Embankment
MPFW2	22-FW2	10+ 042.0	10+ 041.616	1.5 (Rt)	84.00	South Embankment

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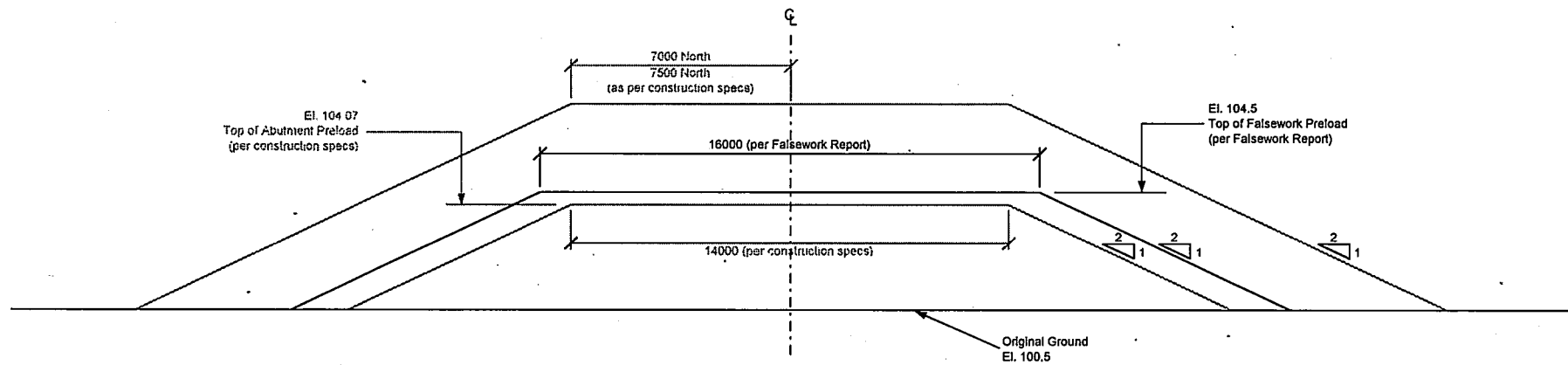
**Table FW5: Schedule of Geotechnical Instrument Data Collection**

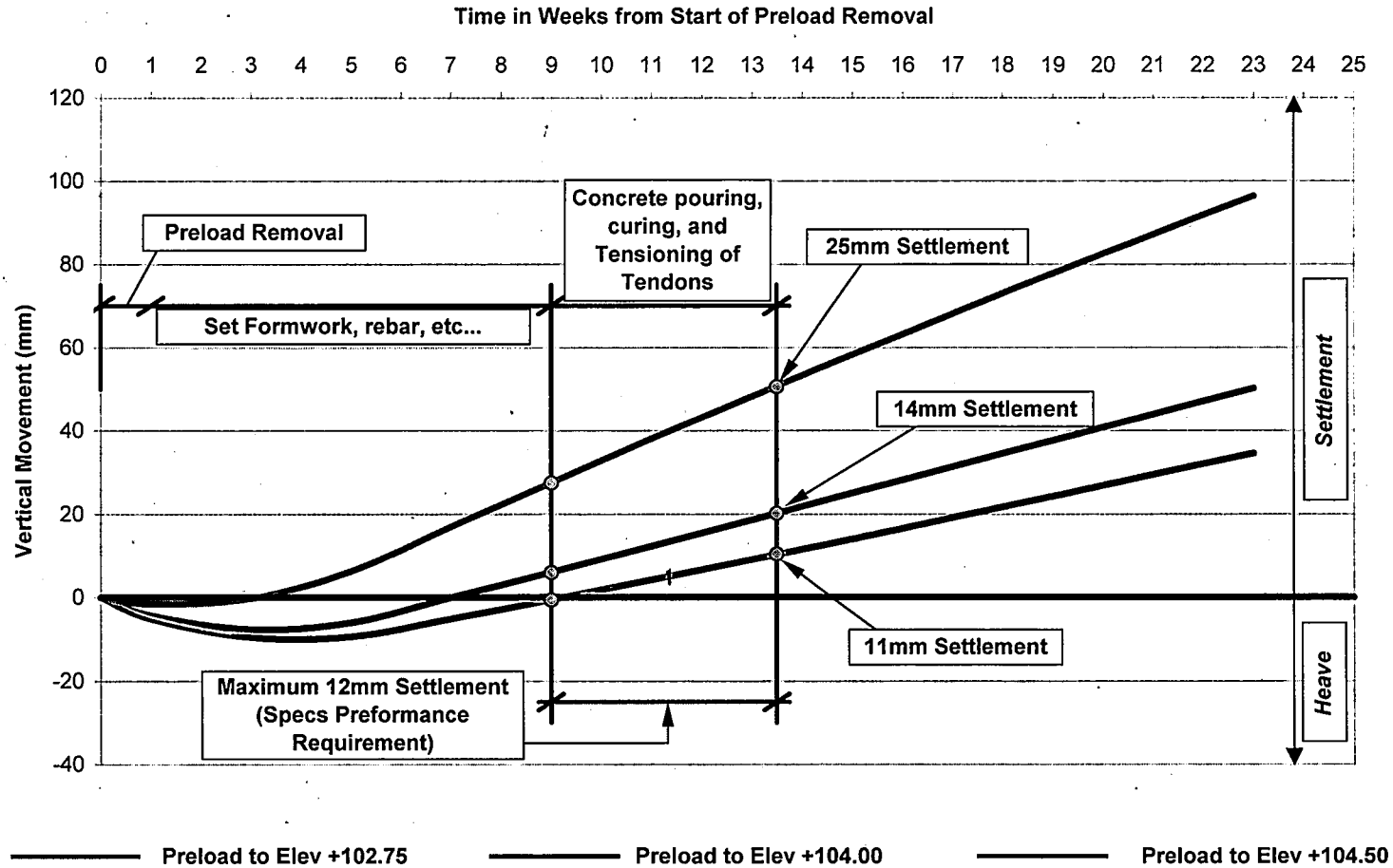
Sequence	Construction Activity	Vibrating Wire Piezometer	Vibrating Wire Settlement Cell	Settlement Plate	Magnetic Settlement Profile
1	Prior to Installation of Instrument	1 Reading	1 Reading	N/A	N/A
2	After Installation of Instrument but Prior to Preloading	3 Readings	2 Readings	1 Survey	2 Readings
3	During Preloading Period	1 Reading Every 2 Weeks			
4	Unloading-Reloading Stage 1	4 Readings Once After Each Lift			
	Unloading-Reloading Stage 2	2 Readings Once After Each Lift			
	Unloading-Reloading Stage 3	Twice a Week for an at Least 4 Week Period			
5	Continuation of Preloading (if necessary)	1 Reading per Week			
6	Construction of Bridge	1 Reading per Week			



**Figure FW1: Finite Element Mesh, Falsework Foundation, Regional Road 22**

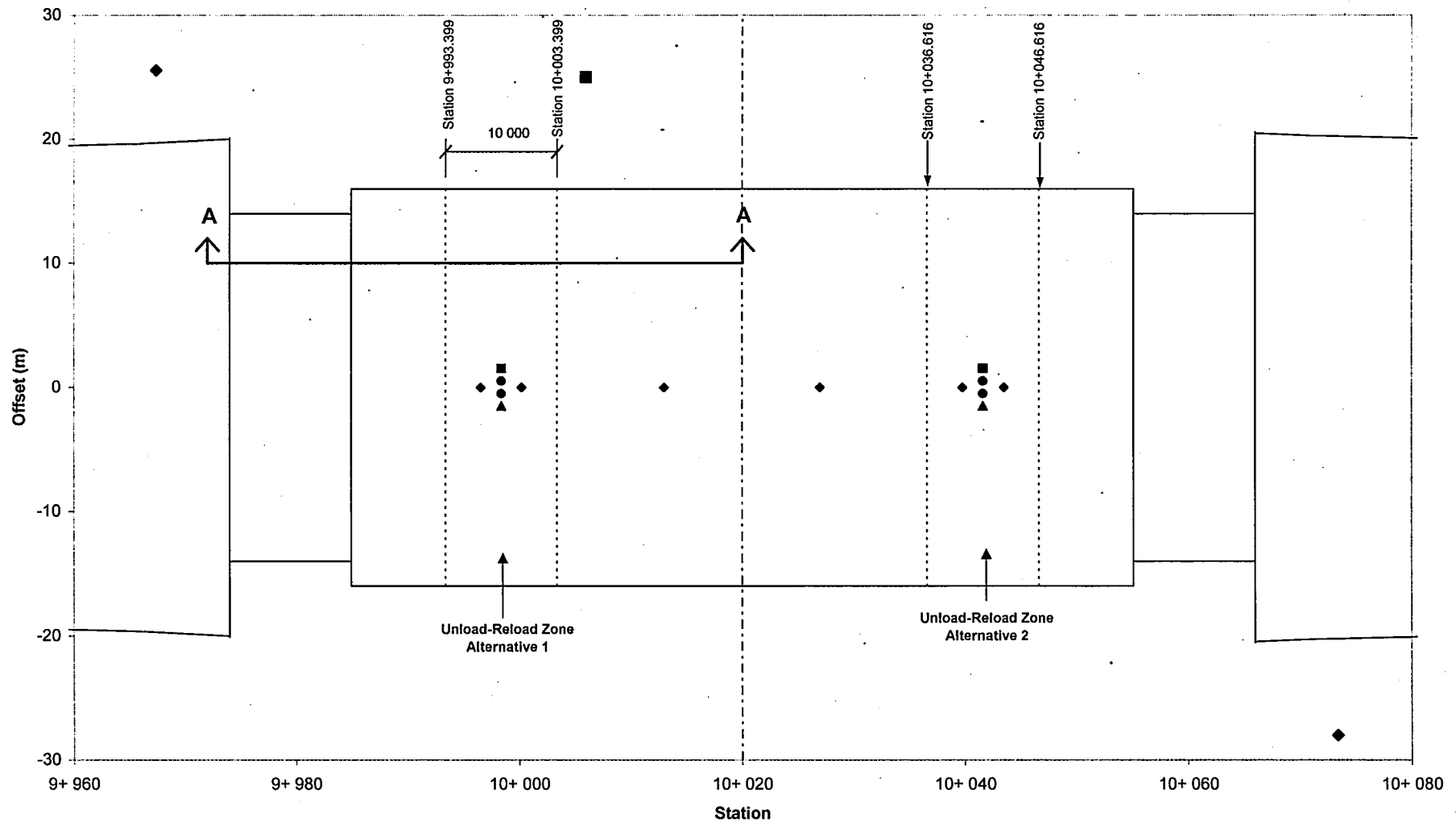
Figure FW2: Typical Preload Section, Falsework Foundation, Regional Road 22





**Figure FW3: Vertical Movement vs Time, Falsework Foundation, Regional Road 22**

Figure FW4a: Layout of Stage 1 Unloading-Reloading, Falsework Foundation, Regional Road 22



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Figure FW4b: Section AA, Traverse Section of Stage 1 Unloading-Reloading  
Falsework Foundation, Regional Road 22

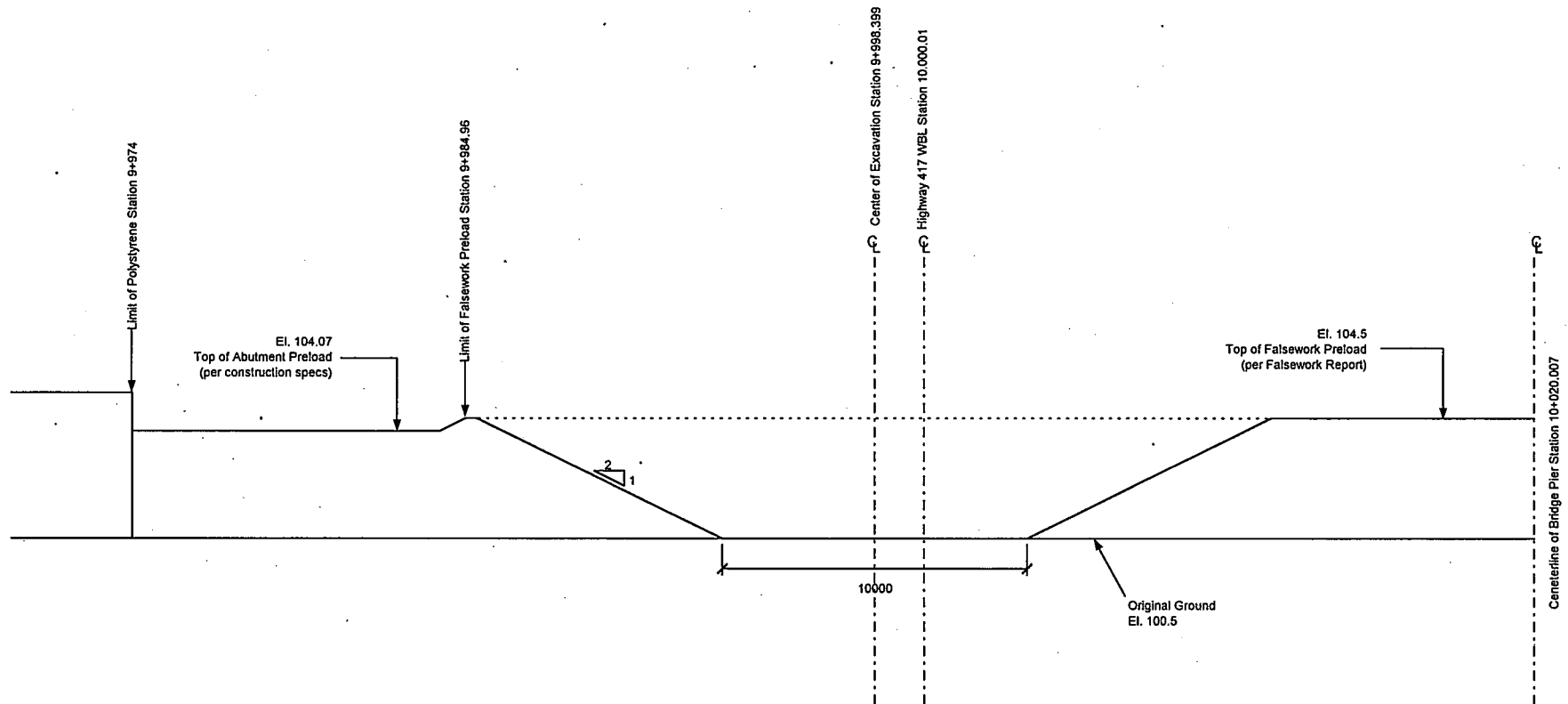
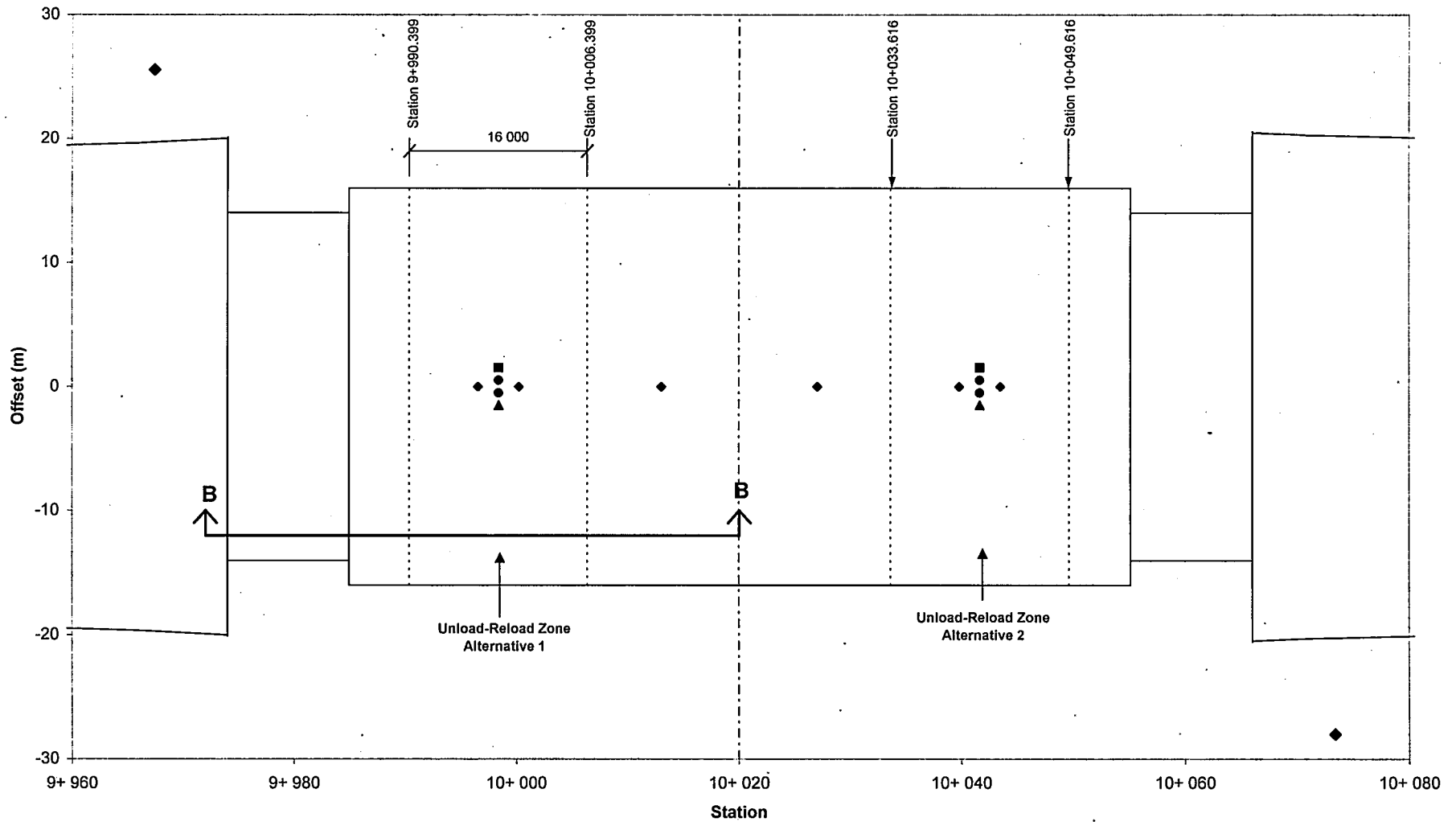


Figure FW5a: Layout of Stage 2 Unloading-Reloading, Falsework Foundation, Regional Road 22



**Figure FW5b: Section AA, Traverse Section of Stage 2 Unloading-Reloading  
Falsework Foundation, Regional Road 22**

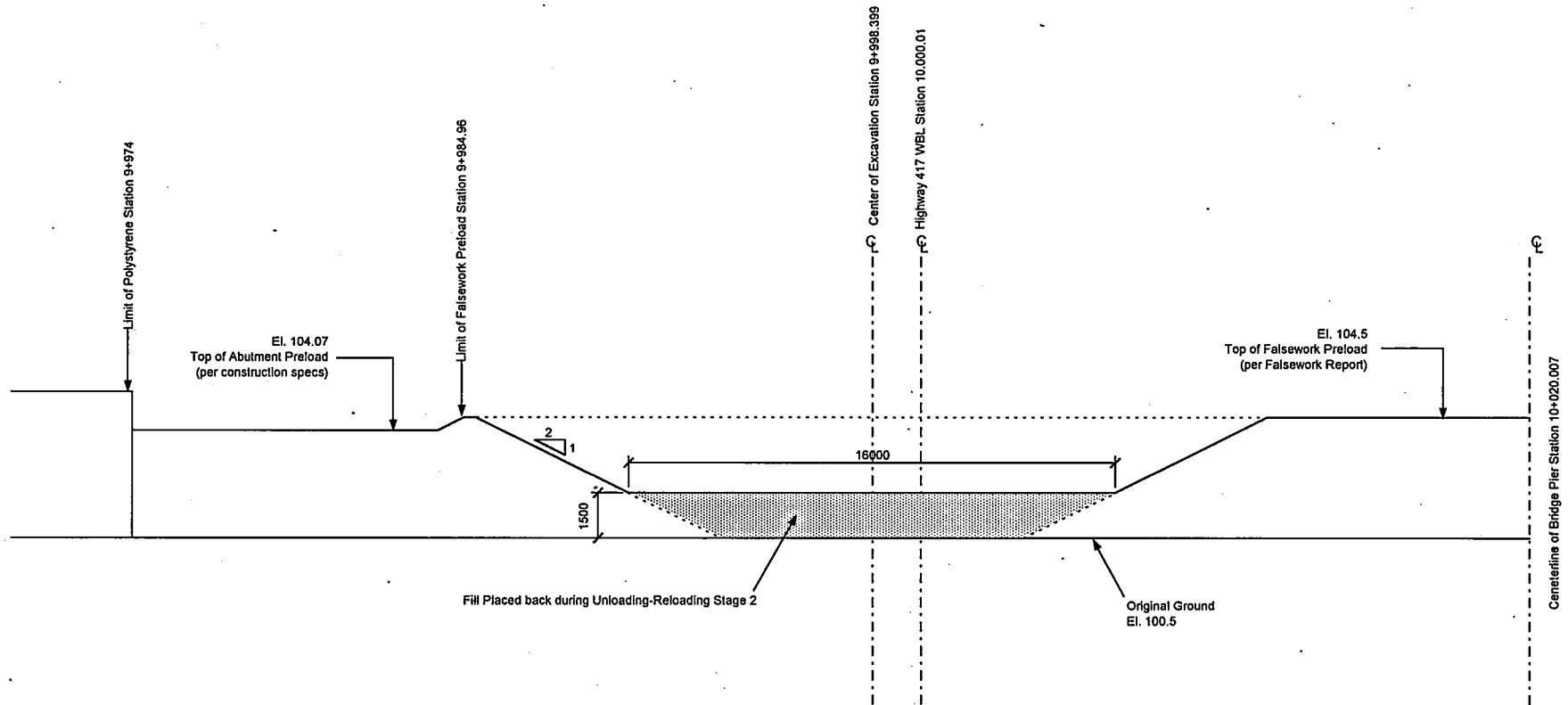
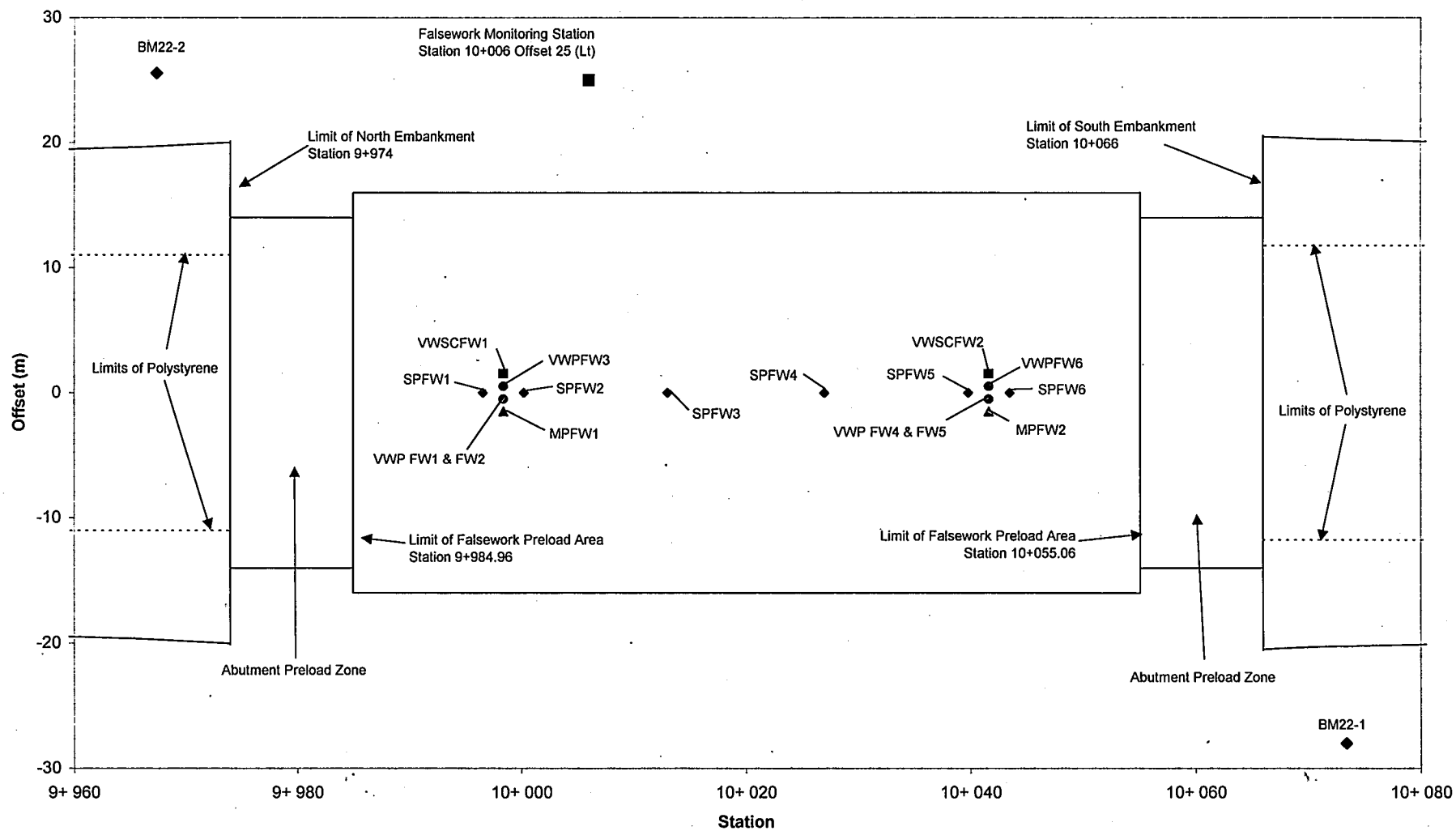


Figure FW6: Instrumentation Layout, Falsework Foundation, Regional Road 22

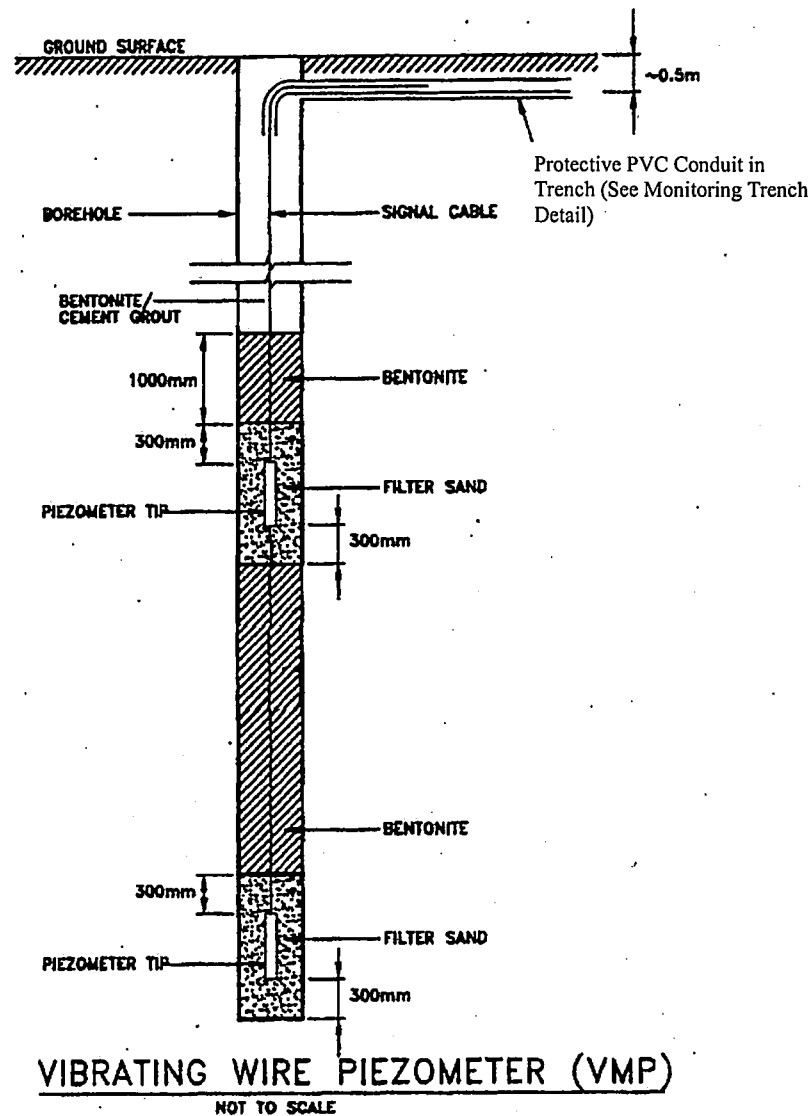


# **APPENDIX I**

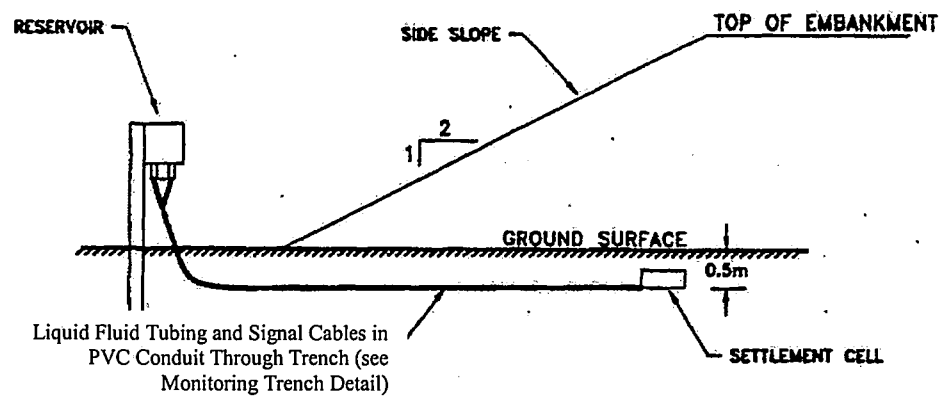
## **Typical Details**

### **for the Installation of**

### **Geotechnical Instruments**

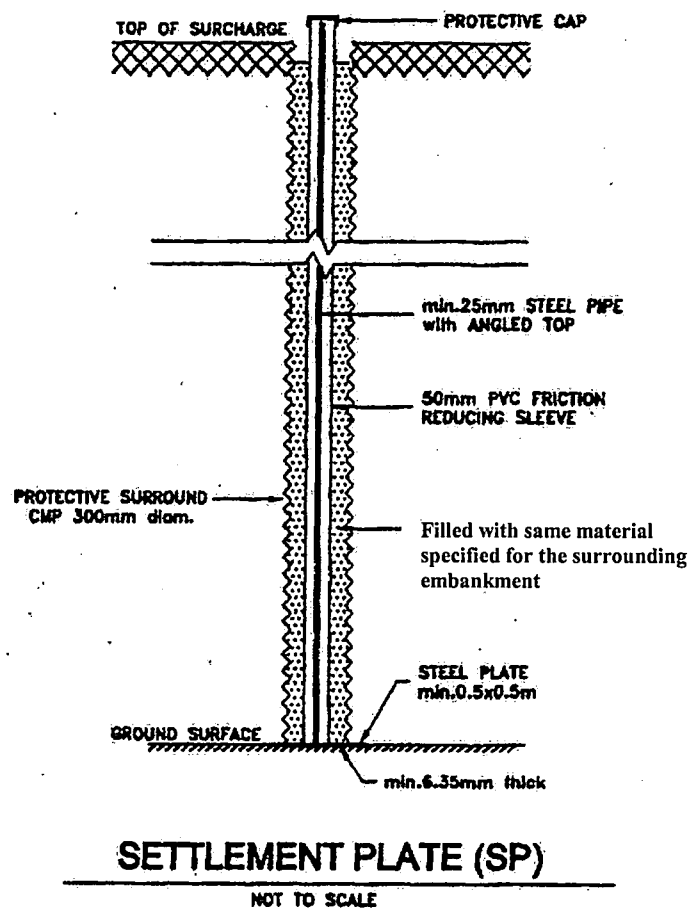


Copied from the Contract Drawing Sheet 31 and Modified to show optional second Piezometer

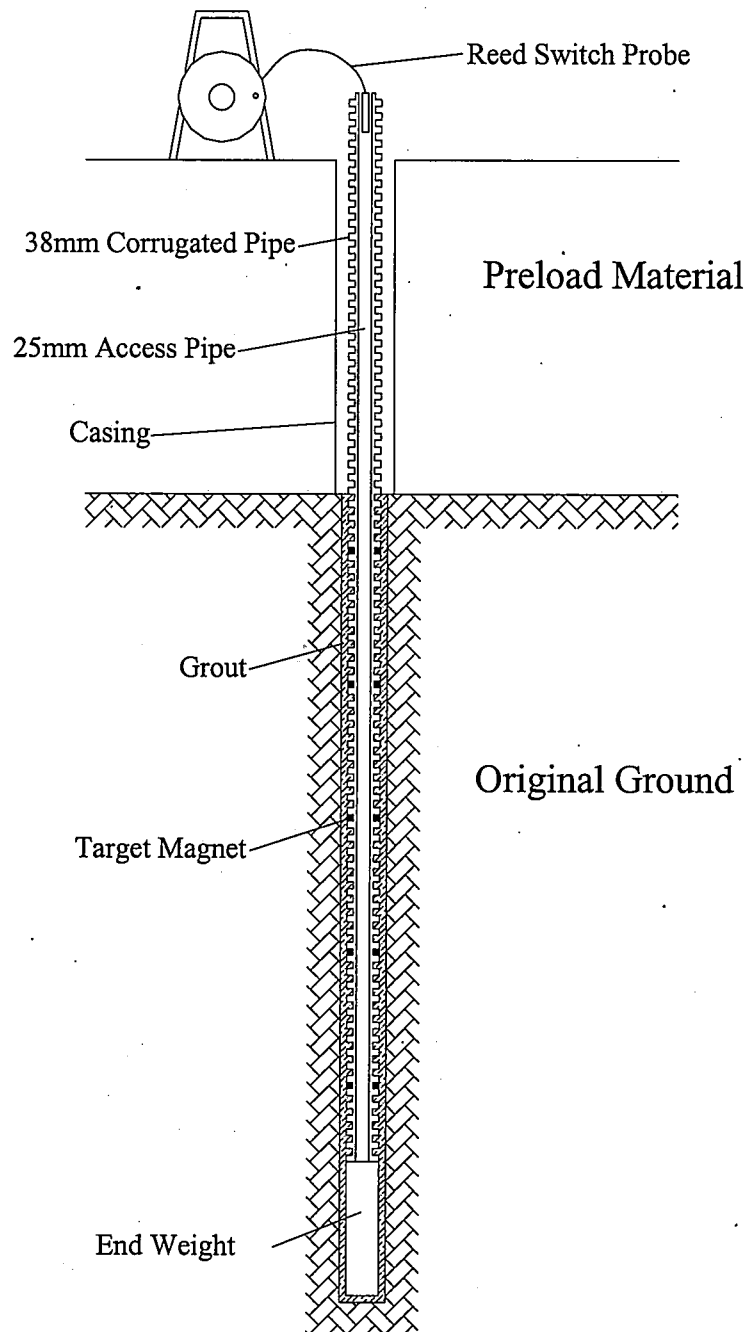


**VIBRATING WIRE SETTLEMENT CELL  
WITH VENTED RESERVOIR (SC)**

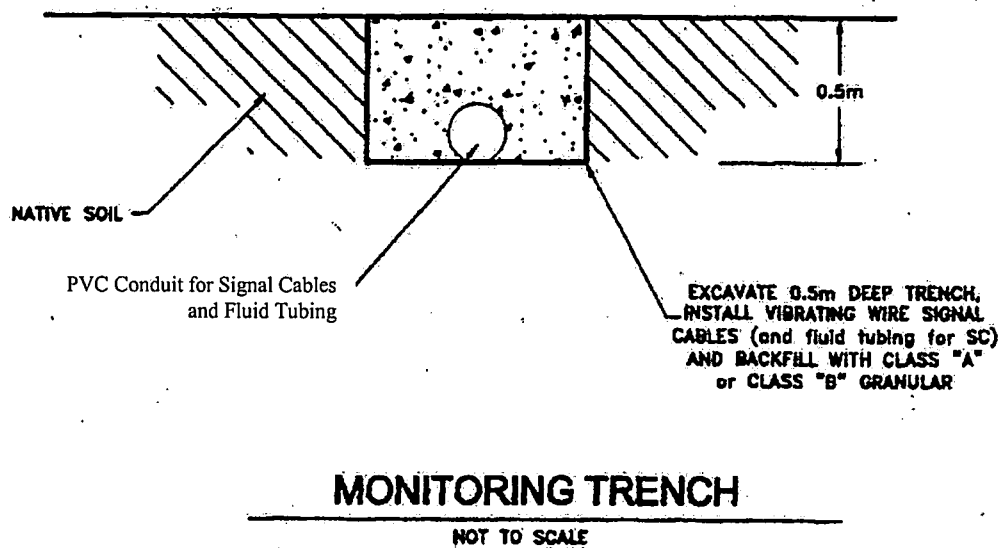
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Copied from the Contract Drawing Sheet 31



Reed Switch Settlement Profile System



Copied from the Contract Drawing Sheet 31