CONSULTING EARTH SCIENTISTS

SUBSURFACE LANDFILL GAS MONITORING PLAN:
MANGROVE MOUNTAIN LANDFILL
HALLARDS ROAD, CENTRAL MANGROVE, NSW.

PREPARED FOR VERDE TERRA PTY LTD
REPORT ID: CES110703-VDT-FE
Revision No: B

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Revision Register

Revision Number	Revision Date	CES Document Reference	Description
0.1	06/10/2011	CES110703-VDT-87-D	Draft report for CES review
1	11/11/2011	CES110703-VDT-87-F	Final issue to client
A	03/08/2015	CES110703-VDT-BO	Revised following issue of LEMP2014
B	16/06/2015	CES110703-VDT-FE	Revised following Amendment to LEMP2014 following EPA comments of Dec 2015

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1 INTRODUCTION

Consulting Earth Scientists Pty Ltd (CES) have been commissioned by Verde Terra Pty Ltd (Verde Terra, the client) to provide a Subsurface Gas Monitoring Plan for Mangrove Mountain Landfill, located at Hallards Road, Central Mangrove NSW (herein referred to as the site). The site occupies part of Lot 582, DP1123656 and is located within the north western corner of the Lot. This Subsurface Gas Monitoring Plan forms a sub-plan under the Landfill Environmental Management Plan 2014 (LEMP 2014).

2 OBJECTIVES AND SCOPE

The objectives of the Subsurface Gas Monitoring Plan include the following:

- Provide Verde Terra with a subsurface gas monitoring program to implement at the site in accordance with Benchmark Technique 15 and 16 of the Environmental Guidelines: *Solid Waste Landfills* (NSW EPA, 1996). The purpose of a subsurface gas monitoring network at the site is to detect, prevent and remediate any subsurface gas migration from the landfill.

The scope of the Subsurface Gas Monitoring Plan includes the following:

- Assess the suitability of monitoring wells currently located at the site for subsurface gas monitoring;
- Develop a subsurface gas monitoring program; and
- Provide Verde Terra with a Subsurface Gas Monitoring Plan for the site.

3 ASSESSMENT AND JUSTIFICATION FOR SUBSURFACE GAS MONITORING WELLS PROPOSED

It is proposed to monitor twelve subsurface gas monitoring wells at the site, six existing monitoring wells (2AS, 2AD, 3AS, 3AD, 6AS, 6AD) and three groups of two nested wells to be installed as described below:

- VDTBH1 (2 nested wells);
- VDTBH2 (2 nested wells) that will replace 7AS and 7AD; and
- VDTBH3 (2 nested wells) that will replace 8AS and 8AD.

The existing monitoring wells have been installed as nested groups of two monitoring wells (suffix AS denotes the shallow well, while suffix AD denotes the deeper well) at three locations at the site. The new nested wells (VDTBH1, VDTBH2 and VDTBH3) will be installed to assess the landfill gas presence along the southern site boundary.

A summary of monitoring wells which were assessed is provided in Tables 1a and 1b, while proposed monitoring well locations are provided in Figure 2 of the Quality Assurance/Quality Control (QA/QC) Plan: Environmental Monitoring Programme (QA/QC Plan) (CES Document referenced: CES110703-VT-QAQC-CC dated 30 May 2016). Table 1 also provides the current CES well identifications in relation to the well identifications given at the time of well installation. Well installation logs have been provided in Appendix 1.

Benchmark Technique 15 of the Environmental Guidelines: *Solid Waste Landfills* (NSW EPA, 1996) outlines the requirements for the installation of subsurface gas monitoring wells including the following:

'Monitoring wells should be installed around the perimeter of the site, at a depth equal to the minimum groundwater level, the greatest depth of refuse, or 10 meters below underground utilities or manholes within 50 metres of the landfill.

…If distinct lithological units that could act as a conduit for landfill gas were identified…then a separate well for each lithological unit should be installed'.

The six monitoring wells currently installed at the site were assessed against the above installation requirements provided in the guidelines (NSW EPA, 1996). The findings of the assessment of the monitoring wells include the following:

- Three monitoring wells 2AS3AD and 6AD are installed at depths (Relative Levels RL used), which met or exceeded the greatest depth of refuse at the site. The greatest depth

of refuse was calculated as approximately 295 RL, including the depths of new cells W, X, Y and Z which have been proposed at the site.

- Three monitoring wells 2AS, 3AS and 6AS have screened intervals at depths which are screened within the overlying natural soils at the site. (1.2m to 6.8m Below Ground Level (m BGL)). LEMP 2014 states that natural soils at the site were encountered at depths ranging from 0.3m to 3.4 m BGL. From this information, CES assess that these wells remain suitable for providing subsurface gas samples representative of landfill gas which may be transported through soils at the site.

- CES assess that the monitoring wells currently installed at the site have been installed at intervals sufficiently small to detect potential offsite migration of subsurface gas.

- The monitoring wells have been installed and constructed in accordance with Benchmark Technique 15 (NSW EPA, 1996). The well installation logs for each well illustrate individual slotted screen sections, with bentonite seals above each monitoring zone. Monitoring zones were backfilled with sand, which CES consider to be adequate to facilitate the movement of gas.

From the information provided in the above assessment, CES advise that the six monitoring wells currently installed at the site (2AS, 2AD, 3AS, 3AD, 6AS and6AD) in conjunction with the six additional monitoring wells (VDTBH1, VDTBH2 and VDTBH3) will be suitable for the purpose of monitoring subsurface landfill gas migration at the site.

As describe above, three groups of two nested wells (one shallow well, one deep well) will be installed at the positions proposed in Figure 2 of the QA/QC Plan at locations VDTBH1, VDTBH2 and VDTBH3 along the southern site boundary.

Shallow wells will be installed at depths (Relative Levels RL used) which met or exceeded the greatest depth of refuse at the site as shown in Figure 4 of the Leachate Management Plan 2014 (LMP 2014) prepared for the site.

4 SUBSURFACE GAS MONITORING PROGRAM

The Subsurface Landfill Gas Monitoring Program for the site is outlined below.

4.1 SUBSURFACE GAS MONITORING LOCATIONS

Subsurface gas monitoring will be undertaken at the following subsurface gas monitoring wells at the site:

Table 1: Summary of Existing Subsurface Gas Monitoring Locations						
CES Well ID	**Well Installation ID[1]**	**Easting**	**Northing**	**Bore depth (m)**	**Screened interval (m)**	**Standing Water Level (m BTOC)**
2AS	MMBH4	336417.3	6315590.20	6.8	1.2-6.8	4.55
2AD				15.4	12.6-15.4	6.06
3AS	MMBH5	335958.2	6315520.4	6.8	1.2-6.8	Well dry
3AD				38.06	35.2-.38.06	36.90
6AS	MMBH1	336193.7	6315637.8	7.2	1.2-7.2	Well dry
6AD				23.7	20.9-23.7	19.15

1. Well Installation ID refers to the well ID at the time of well installation

m BTOC: metres Below Top of Casing

Table 1b: Summary of Subsurface Gas Monitoring Locations (To Be Installed)				
Well ID[1]	**Bore depth (m)**	**Approx. SWL[2] (m BTOC)**	**Screened interval (m)**	**Location Description[4]**
VDT BH1(S)	To be installed	To be installed	To be installed	South-western portion of the landfill
VDT BH1(D)	To be installed	To be installed	To be installed	South-western portion of the landfill
VDT BH2(S)	To be installed	To be installed	To be installed	Southern portion of the landfill facing 7AS and 7AD
VDT BH2(D)	To be installed	To be installed	To be installed	Southern portion of the landfill facing 7AS and 7AD
VDT BH3(S)	To be installed	To be installed	To be installed	Southern portion of the landfill facing 8AS and 8AD
VDT BH3(D)	To be installed	To be installed	To be installed	Southern portion of the landfill facing 8AS and 8AD

Table 1b: Summary of Subsurface Gas Monitoring Locations (To Be Installed)				
Well ID[1]	**Bore depth (m)**	**Approx. SWL[2] (m BTOC)**	**Screened interval (m)**	**Location Description[4]**
VDT BH4 (S)	To be installed	To be installed	To be installed	South-eastern portion of the landfill in the golf course
VDT BH4(D)	To be installed	To be installed	To be installed	South-eastern portion of the landfill in the golf course
VDT BH5(S)	To be installed	To be installed	To be installed	North-eastern portion of the landfill in the golf course
VDT BH5(D)	To be installed	To be installed	To be installed	North-eastern portion of the landfill in the golf course

4.2 FREQUENCY OF MONITORING

In accordance with Benchmark Technique 16 (NSW EPA, 1996), subsurface gas monitoring at the site will be undertaken on a quarterly basis. Quarterly monitoring of subsurface gas will be conducted in conjunction with quarterly groundwater, and surface gas monitoring events at the site. The current quarterly monitoring program at the site is as follows:

- 1st Quarter – February
- 2nd Quarter – May
- 3rd Quarter – August
- 4th Quarter – November

4.3 ASSESSMENT CRITERIA

For gas monitoring in sub-surface gas wells, where the specified aim is to demonstrate that gas is not migrating off site, the EPA NSW (1996) guidelines state that:

"Detection above 1.25% methane (v/v) will require notification to the EPA within 24 hours, and an increase in the frequency of monitoring. . . .

The tabulated results of all monitoring are to be submitted as part of an annual report, unless subsurface methane is detected above 1.25% (v/v), in which case more frequent reporting will be required by the EPA."

4.4 SUBSURFACE GAS MONITORING METHODOLOGY

4.4.1 Subsurface Gas Field Data Sheet

The following information will be recorded on the subsurface gas field data sheet for each subsurface gas monitoring location at the time of monitoring.

- Project information including client, CES project ID, project, location, sampler, project manager, well ID and monitoring date and time;
- Well status information including the general condition of the well and surrounds and gas information including ambient air pressures, length and volumes of air columns, formation pressure, venting information and flow rates; and
- Monitoring details including volumes purged, maximum negative pressure applied to the well, recovery times and landfill gas monitoring results (CH_4, CO_2, O_2 and general comments. H_2S is able to be monitored if necessary).

Additional notes are to be recorded on additional sheets of A4 size paper or on the back of the Field Data Sheets. Separate sheets are to be attached to the Field Data Sheet at the conclusion of field work. Comments on the Field Data Sheet will refer to the attached sheets as appropriate.

Field Data Sheets are to be completed using permanent blue or black ink.

Subsurface landfill gas monitoring will be undertaken at specified landfill gas monitoring well locations at the site (Table 1).

Gas monitoring wells should be fitted with caps designed to fit directly into inlet hoses for monitoring instruments. The use of such caps minimises the potential for gas loss during sampling.

Monitoring will be undertaken in accordance with Benchmark Technique 16 (NSW EPA, 1996), using procedures developed by CES based on techniques for soil-gas studies and landfill

subsurface and surface gas surveys. The procedure for monitoring landfill gas wells involves the following stages:

- Initial measurements and observations;
- Purge well by the application of a negative pressure (if required); and
- Gas measurements in the well.

4.4.2 Initial Measurements and Observations

The procedure for initial measurements and observations upon arrival at a monitoring well is detailed in CES Quality Work Procedure F023 and outlined below:

1. The condition of the well is inspected and any observations noted;
2. The volume of the void in the monitoring well is estimated;
3. The gas pressure build up (pressure in well before venting) is measured using a pressure gauge. Three gauges with specific pressure ratings are available (2kPa (lowest pressure), 10 kPa and 100 kPa (highest pressure));
4. The well is then opened to the atmosphere (vented) and the response noted: i.e. no response; brief initial pulse (typically 1-2 s); long pulse (>5 s); or continuous emission;
5. After the initial vent the gas pressure is measured using the pressure gauges as outlined in Step 3;
6. If the gas from the well continuously vented when exposed to atmospheric pressure the flow rate is measured using a flow meter. Two flow meters with specific flow ratings are available (440 L hr^{-1} (lowest rate) and 3000 L hr^{-1} (highest rate));
7. The initial gas concentrations in the well are measured by connecting the Landfill Gas Analyser (LGA) to the well gas cap;
8. If the well initially exhibited a brief or long pulse, the gas pressure is measured again in accordance with Step 3; and
9. If the gas from the well continuously vented when exposed to atmospheric pressure, every 2 to 5 minutes the flow rate is measured using the flow meter and after the flow rate has been measured the gas concentrations are measured using the LGA until the flow rate and concentrations stabilise to a variation of +/-10 %.

All initial measurements and observations are recorded on the subsurface gas monitoring field data sheets.

4.4.3 Purging Well

A specialised compressor unit has been developed for purging the air column of the monitoring well. Gauges fitted to the unit allow the following information to be gathered:

- Measurement of initial negative pressure applied to the well;
- Measurement of the time for the well to return to atmospheric pressure after negative pressure has been applied (recovery time); and
- Measurement of the volume of gas purged from the well.

Operating instructions for purging of gas from wells are detailed in CES Quality Work Procedure F013 and described below:

1. Attach the inlet hose using the “Quicklock” fitting to the gas cap on top of the monitoring well. Make sure the pump line control valve is closed;
2. Turn on the pump and allow negative pressure to develop in the tank. Pump the tank down to the desired negative volume and pressure (tank gauge). Note that the pump is not operated during sampling. That is, the pump is operated to create a negative pressure in the tank, which is then applied to the well;
3. Switch the pump off;
4. Open the line control valve and note the initial negative pressure applied to the well (small gauge);
5. Record the time required for the well pressure to return to atmospheric pressure as indicated on the tank gauge (recovery time);
6. When the well has recovered to atmospheric pressure (a zero reading on the tank gauge), disconnect the inlet hose, connect a calibrated LGA with a “Quicklock” fitting to the gas cap and measure landfill gas concentrations; and
7. Repeat the purging and measurement process until gas concentrations stabilise to within +/-10% or three well volumes have been purged.

At the conclusion of sampling from each monitoring well, gas in the tank should be replaced with atmospheric air. This is done by disconnecting the unit from the well, creating full negative pressure and then opening the line control valve to allow ambient air to enter the tank. If the inlet

hose is fitted with a Quicklock fitting, it will be necessary to attach a male fitting (eg. spare well cap) to allow air to enter the tank.

The following points should be noted:

- Recovery times of greater than 10 minutes should be considered to be suspect as the effect of sample train leakages is increased with long recovery times. If recovery times of greater than 10 minutes occur, the operator should conclude that the formation has a low permeability to gas, record the final negative pressure (small gauge) and volume removed from the well and take no further action;
- Start the purging process with the same initial tank pressure and volume (to the limit of the pump). This causes equal disturbance with respect to the applied pressure change and volume displacement during each purge event;
- Be sure to watch the transparent sample line when applying negative pressure and shut off immediately at the first sign of water entering the line. If water enters the tank, vent the negative pressure to restore atmospheric pressure, remove the bung from the end of the tank and empty. Replace the bung. If water is drawn from the well, record the final negative pressure (small gauge) and volume remove from the well and take no further action; and
- Before each use, check the sampling train for leaks. This is done by creating negative pressure in the tank, opening the line control valve (with “Quicklock” fitting at end) and monitoring tank pressure. A leak is present in the sample train if pressure increases in the tank.

Well purging and sampling information will be recorded within the respective fields detailed on the gas monitoring field data sheet.

4.5 REPORTING

CES will provide Verde Terra with a quarterly subsurface gas report for each quarterly monitoring round. The report will provide Verde Terra with quarterly subsurface gas results in tabulated form, a brief discussion of subsurface gas results, field data sheets and time series plots for subsurface gas results from each monitoring well.

CES will also provide Verde Terra with subsurface gas results for the reporting year in an annual report, alongside results from groundwater, surface gas and wet weather environmental monitoring undertaken during the monitoring year.

Should the subsurface gas monitoring wells be added to the licence, subsurface gas tabulated results are required to be reported to the NSW Environment Protection Authority in the following manner:

- In accordance with NSW EPA (1996) Guidelines, methane concentrations exceeding the NSW EPA (1996) threshold of 1.25 % methane *(v/v)* for subsurface gas must be reported to the NSW EPA within 24 hours of monitoring; and

- Subsurface gas monitoring results will be required to be reported to the NSW EPA annually in a licence specific annual return document provided and required by the NSW EPA.

5 REFERENCES

Environmental Protection Authority NSW, 1996: *Environmental Guidelines, Solid Waste Landfills*, EPA 95/85, January 1996.

Consulting Earth Scientists, 2016: *Quality Assurance/Quality Control (QA/QC) Plan: Environmental Monitoring Programme (CES Document referenced: CES110703-VT-QAQC-CC dated 30 May 2016).*

Consulting Earth Scientists, 2016: *Leachate Management Plan 2014 (CES Document reference: CES110703-VDT-FB dated 14 June 2016)*

Consulting Earth Scientists, 2014: *CES Quality Work Procedures F013 Surface and Subsurface Gas Monitoring at Landfill Facilities*, February 2014.

Appendix 1:

Well Installation Logs – Existing Subsurface Gas Monitoring Wells

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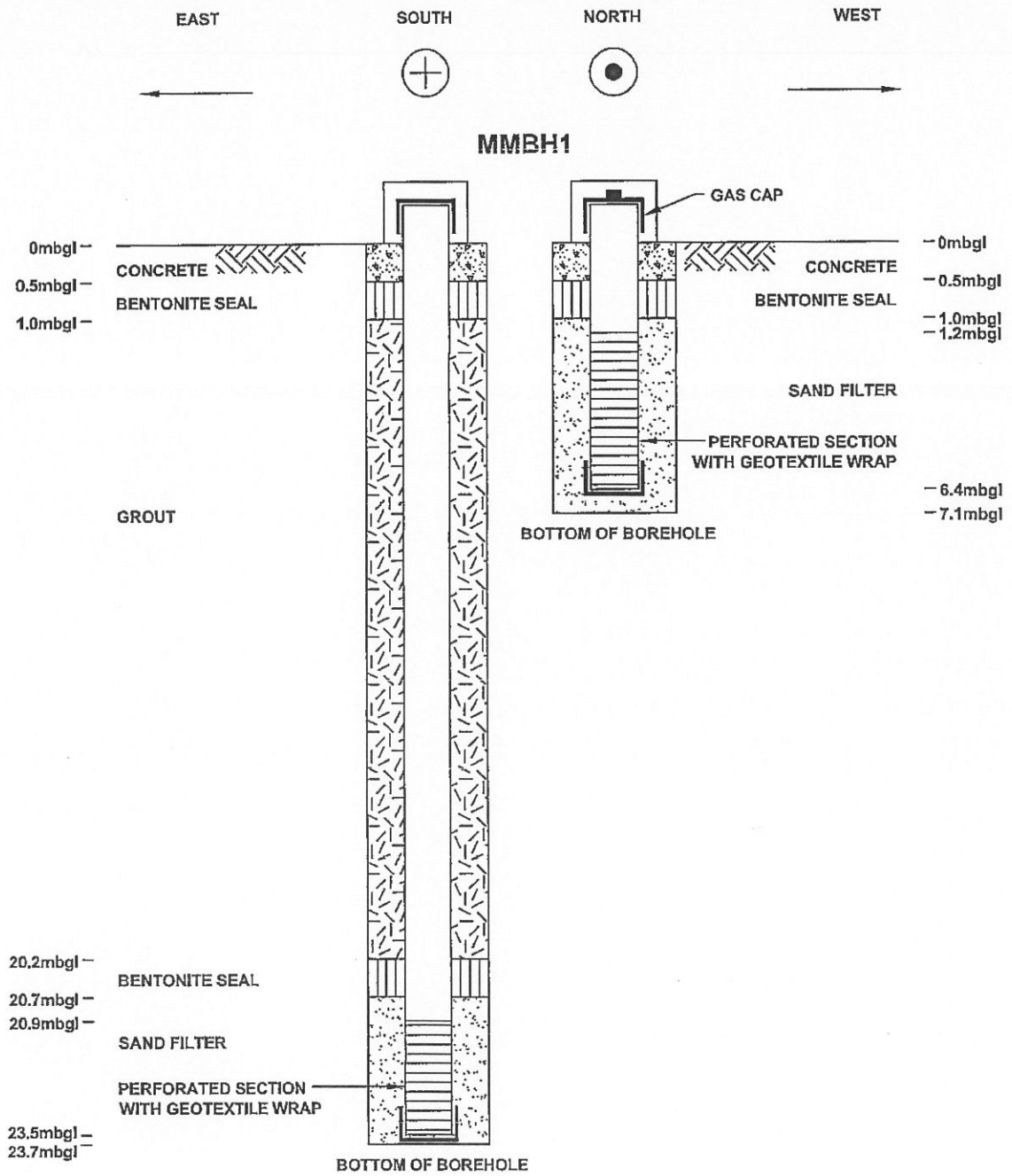
Well Installation Logs – Existing Subsurface Gas Monitoring Wells



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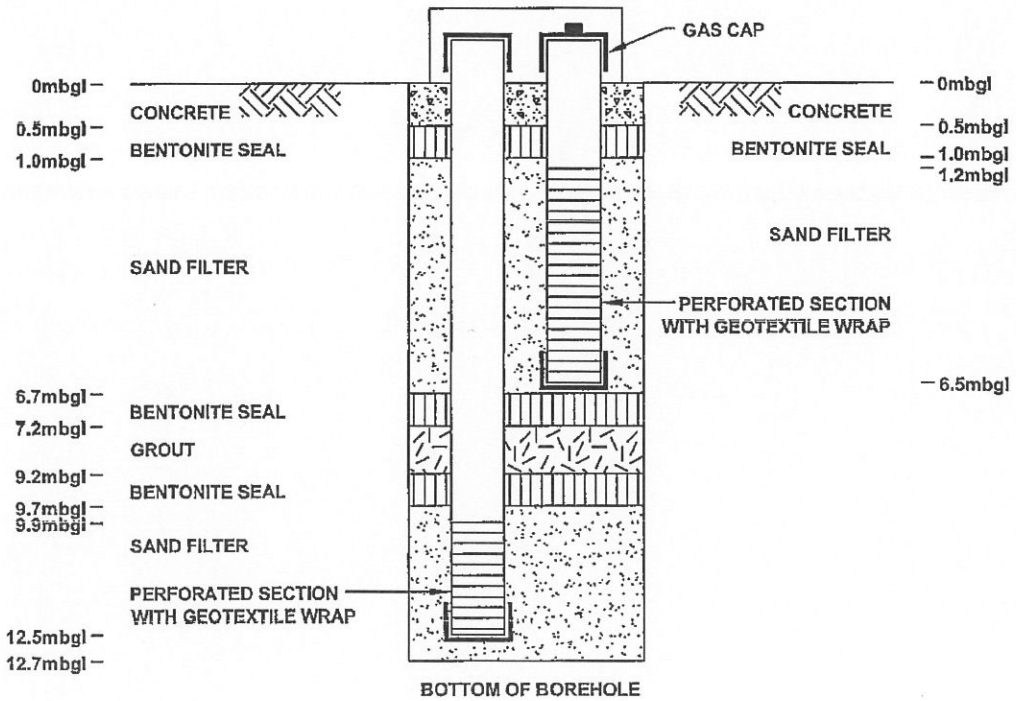
date	7/04/09			
scale	NTS		title: PIEZOMETER INSTALLATION PLAN - MMBH1	
original size	A4		project no: GEOTKARI02200AB	figure no: FIGURE 3.1

MMBH2



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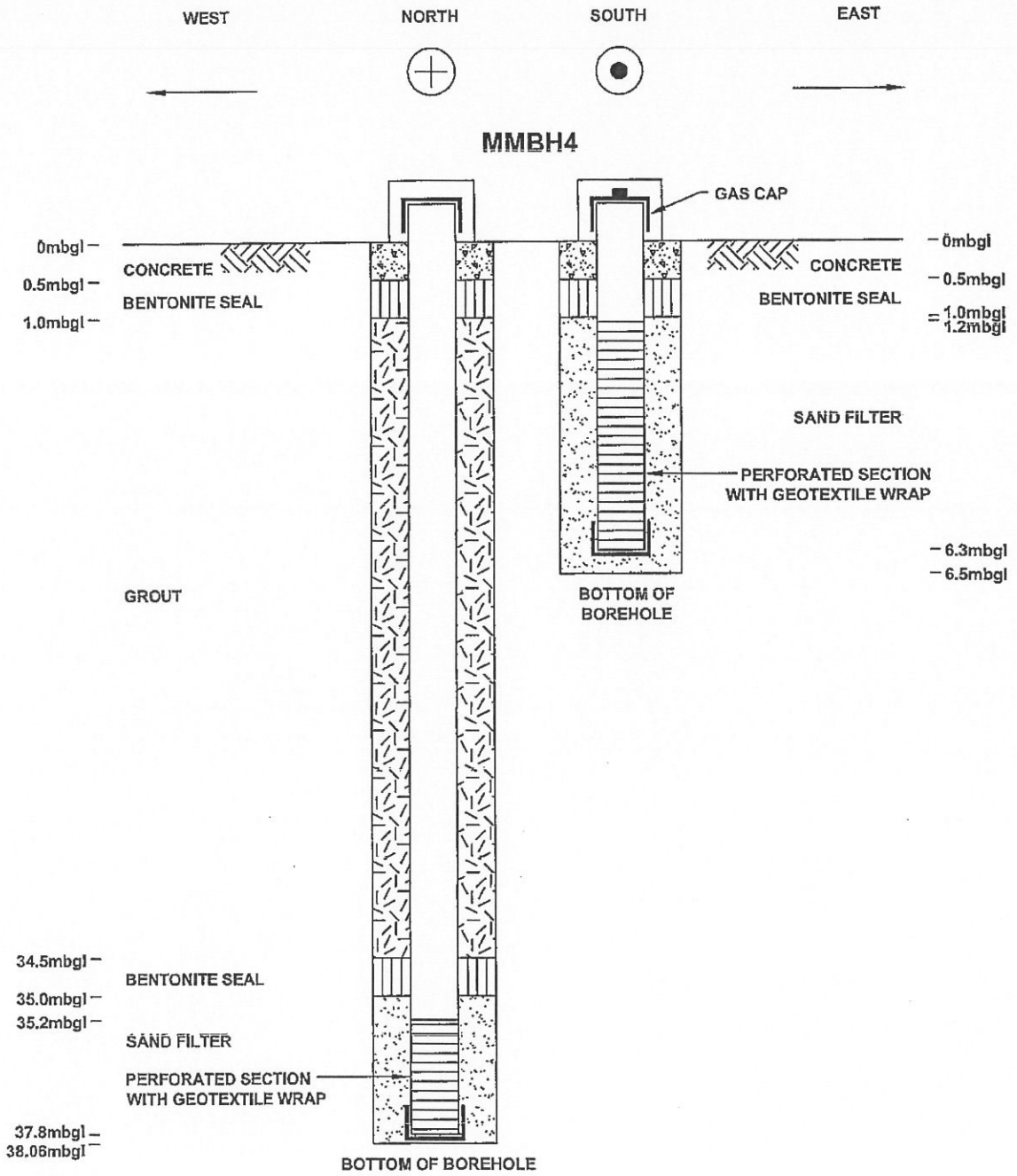

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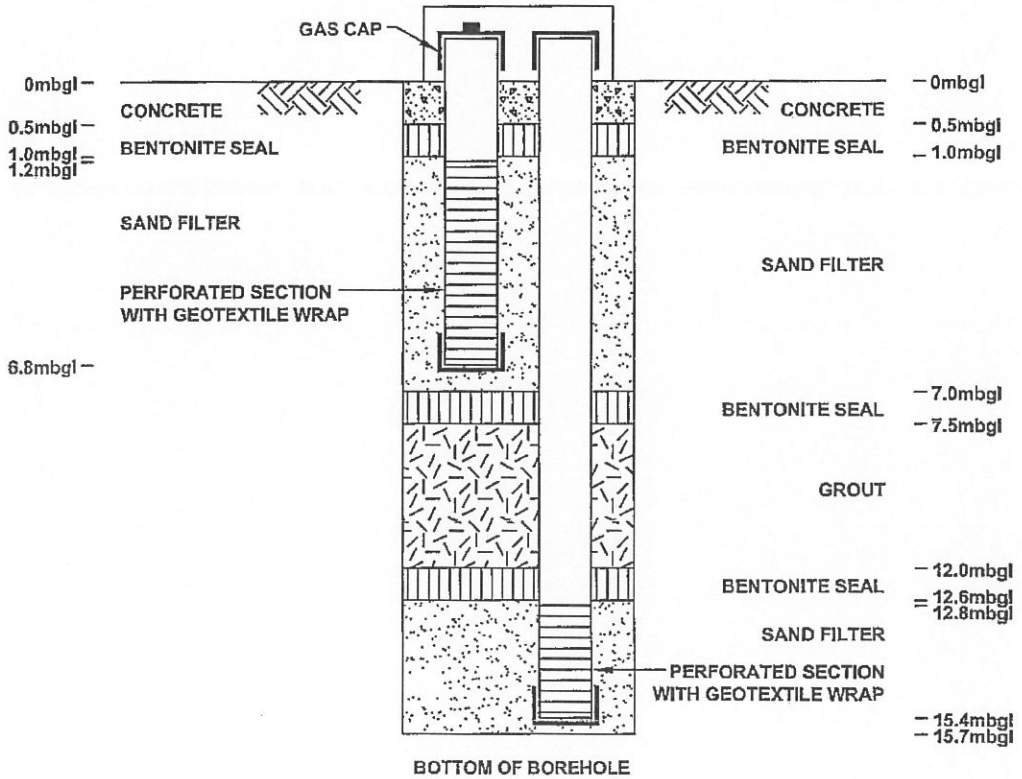
MMBH4



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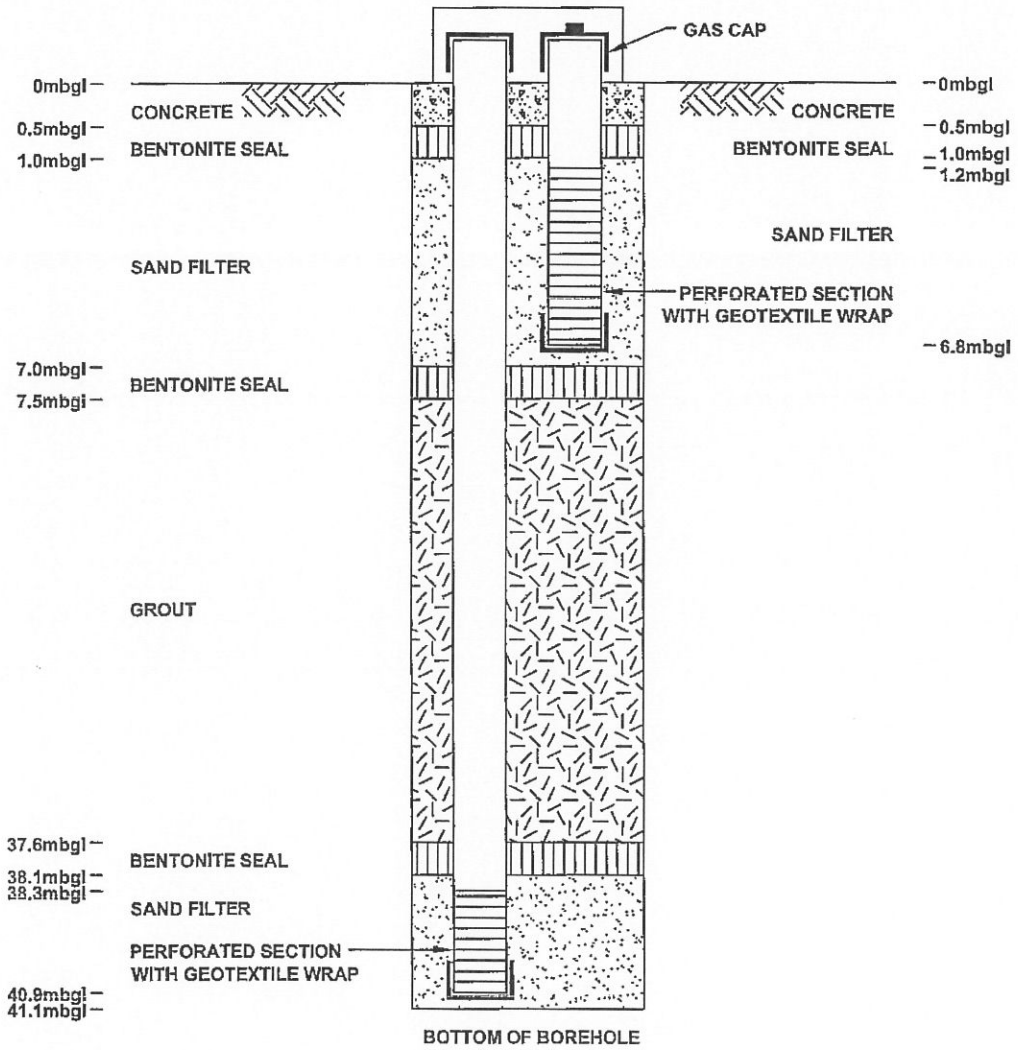
MMBH5



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