QL40-SGR2G-CeBr3

Adelaide calibration pits

27.06.2022

1. Introduction

ALT (Advanced Logic Technology) recently developed a new spectral gamma ray tool - the QL40-SGR2G-CeBr3

- implementing a Cerium Bromide scintillation crystal for use in high radiation environments such as uranium deposits. The main applications targeted by this tool are mineral composition/identification and ore grade analyses.

As part of the validation process, the tool was deployed in the Adelaide calibration pits with the assistance of our technical partner **Geosensor Wireline.** The calibration site is managed by the Australian Department for Water, Land & Biodiversity Conservation (DWLBC). The Adelaide pits offer reference calibration models for many wireline service companies in Australia.

The aim of these measurements was to validate the radioisotope concentrations and borehole corrections computed by the Full Spectrum Analysis (FSA) algorithm[1] implemented in the tool, and to compare them with the Adelaide reference models.

This report summarises the spectral gamma results acquired with the QL40-SGR2G-CeBr3 spectral gamma tool in this specific context.

2. Tool specifications

Tool

Diameter :	40 mm (1.6")
Length :	1.01 m (39.4")
Measurement point :	0.25 m (9.9") from bottom QL (Quick Link) joint
Weight :	6 kg (13 lbs.)
Max. Temp :	70 °C (158 °F)
Max. Pressure :	200 bar (2900 psi)

Sensor

CeBr3 scintillation crystal :	2048 channels gamma ray energy spectrum
Dimensions :	20.0 x 96.0 mm (0.79 x 3.78 in)
Spectral resolution @ Cs :	6.2 %
Dead time:	0.8 µs

[1] The Full Spectrum Analysis algorithm is developed by Medusa Systems B.V. in the Netherlands

3. Mnemonics

Below is a list of mnemonics used in the report:

- **RHOB :** density (ρ)
- **PHI :** porosity (ϕ)
- **dw :** dry weight
- **%U3O8 dw :** dry weight concentration in % of U3O8
- **%U3O8 dw stdev :** standard deviation of %U3O8 dw
- **dw conc :** dry weight concentration
- **dw conc stdev :** standard deviation of dry weight concentration

4. Concentrations - Unit conversions

For direct comparison with the calibration models the measured radioisotope concentrations are converted to potassium, thorium and uranium oxides (K2O, Th2O, U3O8). Corrections to dry weight concentrations are also applied when bulk density and porosity are available.

- Unit conversions

Nuclide	Bq/Kg to % or ppm	Bq/Kg to % or ppm oxides
40-K	1 Bq/kg = 1/316 %	1 Bq/kg = 1/262 % K2O
238-U	1 Bq/kg = 1/12.3 ppm	1 Bq/kg = 1/10.4 ppm U3O8
232-Th	1Bq/kg = 1/4.1 ppm	1Bq/kg = 1/3.55 ppm ThO2

- Conversion to dry weight concentrations

$$A_{dw} = \frac{A_{bulk} \times \rho_{bulk}}{\rho_{bulk} - \phi \times \rho_{fluid}}$$

5. Results

Refer to section 9 for the description and schematic of the calibration pit models.

Results are summarised in tables. Cells filled in grey colour refer to the nominal concentration values. Cells filled in black colour refer to the measured concentrations.

Nominal value
Measured value

5.1. Uranium pits: AM1-AM2-AM3

	AM1	AM2	AM3
RHOB	2.2	2.2	2.2
PHI	0.11	0.11	0.11
%U3O8 dw	0.21	0.983	0.051
%U3O8 dw	0.22	0.982	0.051
%U3O8 dw stdev	0.01	0.02	0.004

Comments :

- AM1, AM2, AM3 pits have one depth section enriched in uranium oxides.
- Nominal concentrations in AM1, AM2, AM3 are updated according to : "Reassessment of the grades of the Adelaide model logging pits" by Bruce Dickson.
- Measurements were recorded in time mode (1 second sampling over a 400 second period).
- Dry weight concentrations are based on estimated density (RHOB) and porosity (PHI) values.
- The measured concentrations are within the nominal values.

5.2. K-U-Th pits : AM5-AM6

	AM5		
	K [%]	U3O8 [%]	ThO2 [%]
RHOB	2	2	2
PHI	11	11	11
dw conc	1.31	0.17	0.22
dw conc	20.15	0.19	0.24
dw conc stdev	15.34	0.01	0.02

Comments – AM5 :

- AM5 pit has one ore section enriched with a mixture of K, U, Th oxides.
- Measurements were made in time mode (1 second sampling over a 400 second period).
- Dry weight concentrations are based on estimated density (RHOB) and porosity (PHI) values.
- The measured U and Th concentrations are within the nominal values.
- The measured K concentration is abnormally high. The measurement of K concentration is not reliable in a high U-Th ore grade. It can be explained by the difference in nuclear activity of the radioisotopes involved in the measurement process. K produces fewer gamma particles per decay than U or Th (by a factor 20). The activity of K is thus much harder to determine in a spectrum dominated by U radiations. For example, in a situation where K and U have the same concentration (in Bq/kg), most of the spectrum is produced by U activity. Uncertainty in K is much higher than uncertainty in U in this context.

	AM6		
	K [%]	U3O8 [ppm]	ThO2 [%]
RHOB	2.16	2.23	1.99
PHI	14.9	13	22.7
dw conc	4.52	32	66-70.3
dw conc	3.61	32	71
dw conc stdev	1.63	10.2	19.9

Comments – AM6 :

- AM6 pit is crossing 3 separate intervals respectively enriched with a single radioisotope. The U and Th intervals are characterised by a low concentration.
- Measurements were recorded in dynamic mode with a 5cm vertical sampling rate and a constant logging speed of 1m/min.
- Dry weight concentrations are based on true density (RHOB) and porosity (PHI) values.
- The measured U, Th concentrations are within the nominal values.
- The dynamic mode used for the record is probably responsible for the higher standard deviation values. The accumulated time for defining the spectrum is only 3 seconds in this instance.
- The measured K concentration is less accurate and underestimated.

5.3. Uranium pits with different hole sizes : AM7

AM7					
Borehole diameter	**108mm**	**BQ 60mm**	**HQ 76mm**	**NQ 96mm**	**PQ 123mm**
%U3O8 dw	0.18	0.18	0.18	0.18	0.18
%eU3O8 dw	0.21	-	0.21	-	0.21
%eU3O8 dw stdev	0.01	-	0.01	-	0.01

Comments – AM7 :

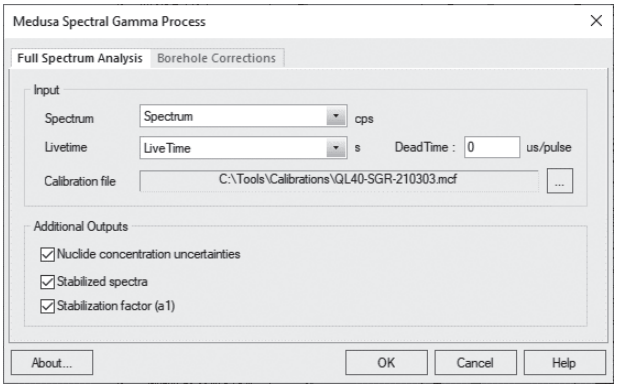
- AM7 calibration model includes 5 boreholes of different diameters. Each borehole is enriched with the same uranium oxide concentration.
- It is a good model for checking the effectiveness of borehole corrections computed by the Medusa Full Spectrum Analysis process.
- Measurements were recorded in time mode (1 second sampling over a 400 second period).
- The measured U concentrations do not vary with the hole sizes.
- The measured U concentrations are slightly higher compared to the nominal values.

6. Conclusion

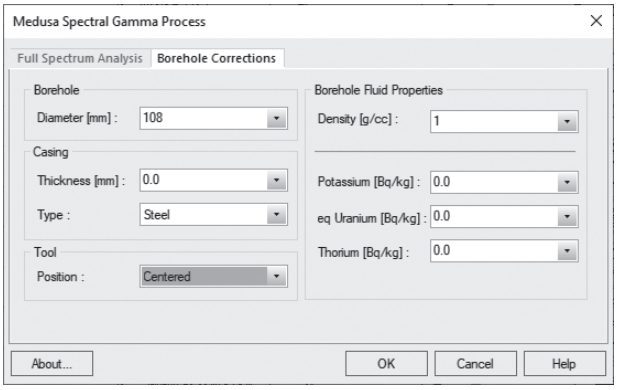
For calibration models enriched in uranium oxides (AM1- AM2 – AM3), the measured U concentrations are within the nominal values.
For calibration model AM5 enriched with a mixture of K, U, Th - the measurement of U and Th concentrations are reliable but the measurement of K concentration is not due to the difference in nuclear activity of the radioisotopes involved in the measurement process.
For calibration model AM6, characterised by 3 separate intervals enriched with a single radioisotope, the measured U and Th concentrations are within the nominal values. The measured K concentration is slightly underestimated.
Finally, in calibration model AM7, the measured U concentrations do not vary with the hole sizes confirming that borehole corrections applied by the Medusa algorithm works as expected.

7. Annex1 -Process settings

• Full spectrum analysis settings



• Borehole corrections



8. Annex 2 - Data acquisition settings

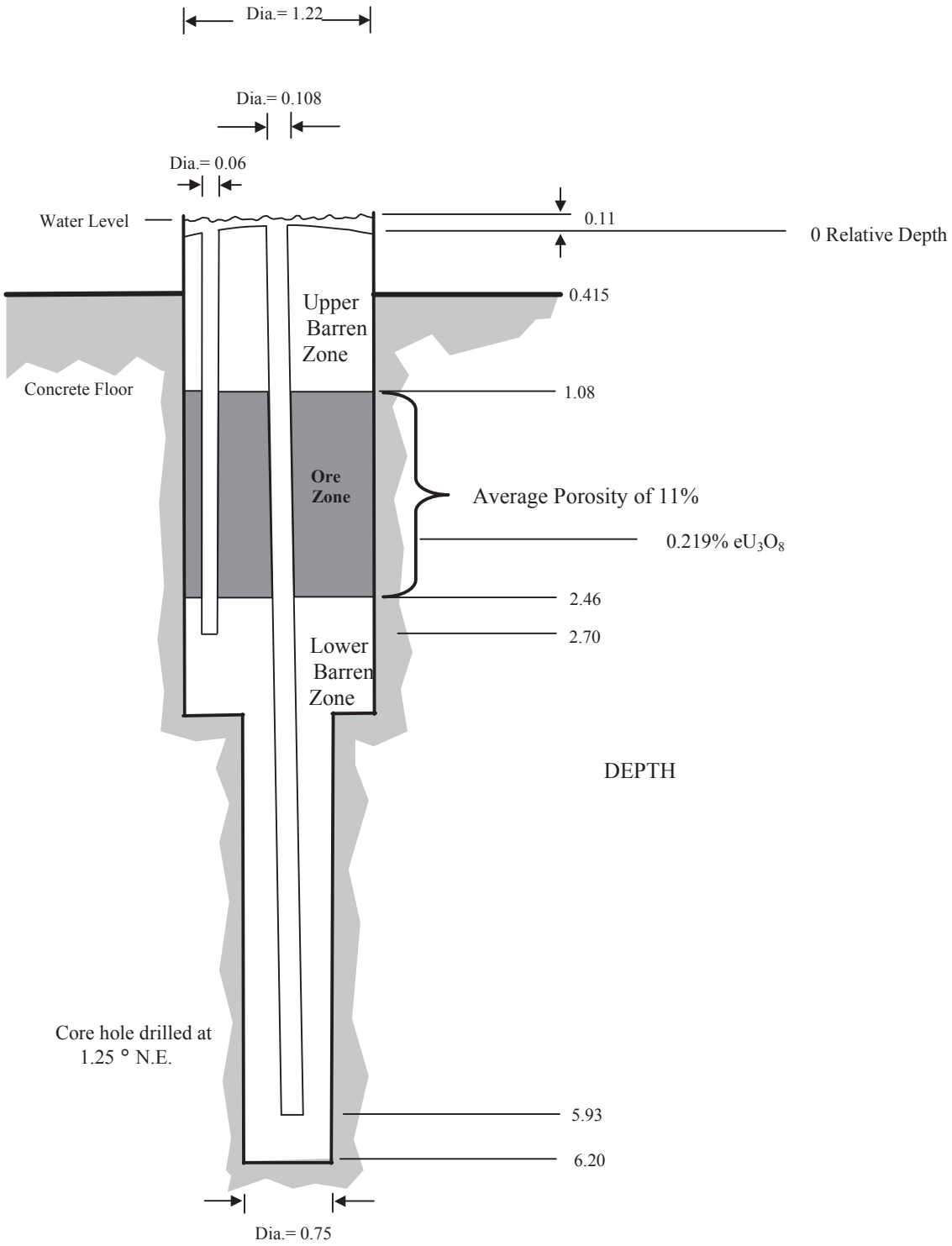
Pit	Logging speed m/min	Depth sampling m	Time sampling s	Depth interval m	Total time s
AM1	-	-	1	-	400
AM2	-	-	1	-	400
AM3	-	-	1	-	400
AM5	-	-	1	-	400
AM6	1	0.05	3	1	60
AM7	-	-	1	-	400

• Tool was run centralised in the boreholes.

9. Annex 3 – Adelaide Calibration Models

• Refer to pdf documents.

AM1



WATER MUST NOT BE PUMPED FROM PIT WITHOUT PERMISSION

ALL MEASUREMENTS ARE IN METRES.

DO NOT SCALE

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Department of Water, Land and Biodiversity Conservation

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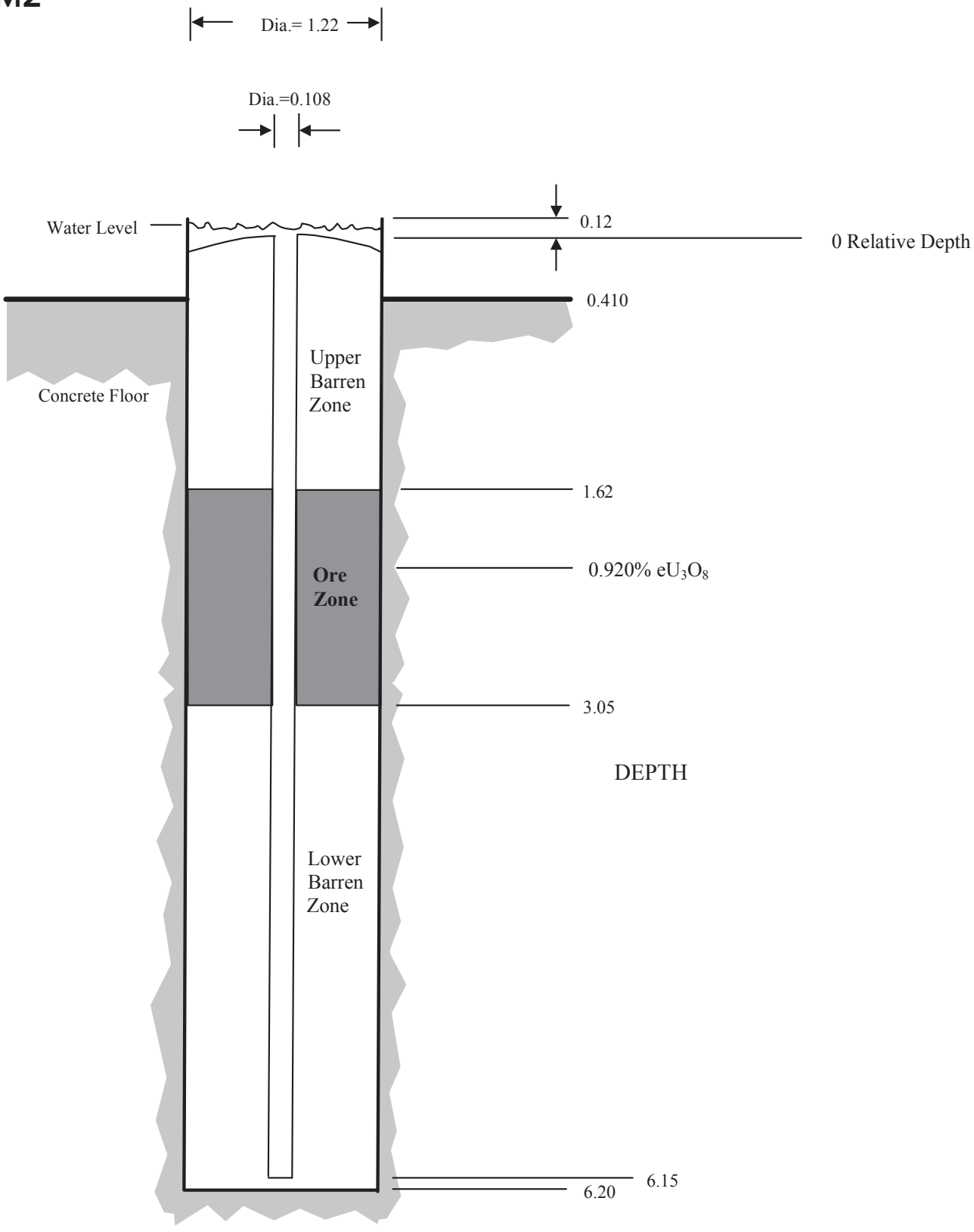
Adelaide Calibration Models - AM1
0.21% eU_3O_8 (% dry weight)
vertical Section

Sheet 1 of 1	Version 2.1	24/10/2005	Drawn by: DAC

AM2



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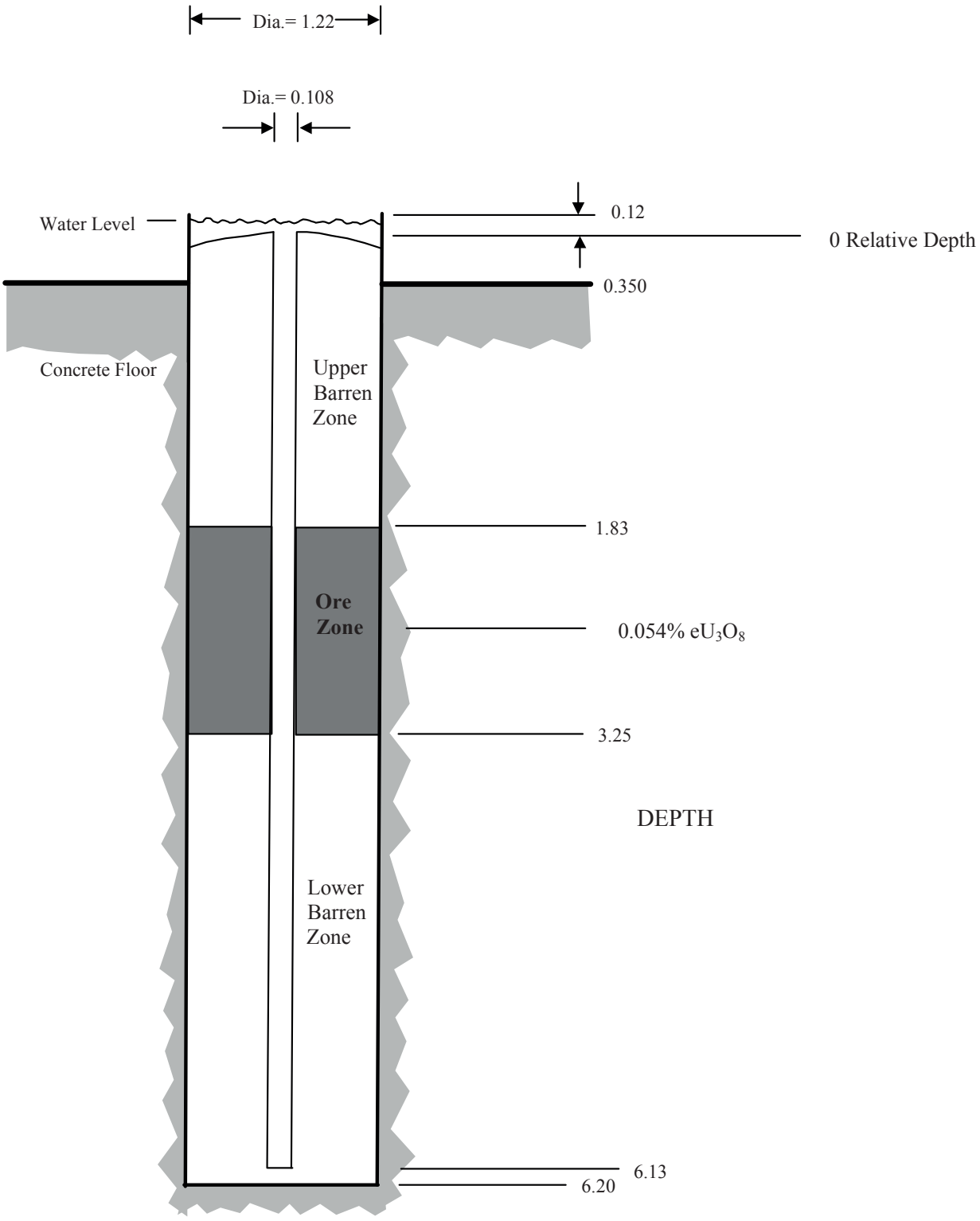
Adelaide Calibration Models – AM2
0.92% eU_3O_8 (%dry weight)
vertical Section

Sheet 1 of 1	Version 2.1	02/12/2005	Drawn by: DAC

AM3



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Adelaide Calibration Models – AM3
0.054% eU_3O_8 (%dry weight)
vertical Section

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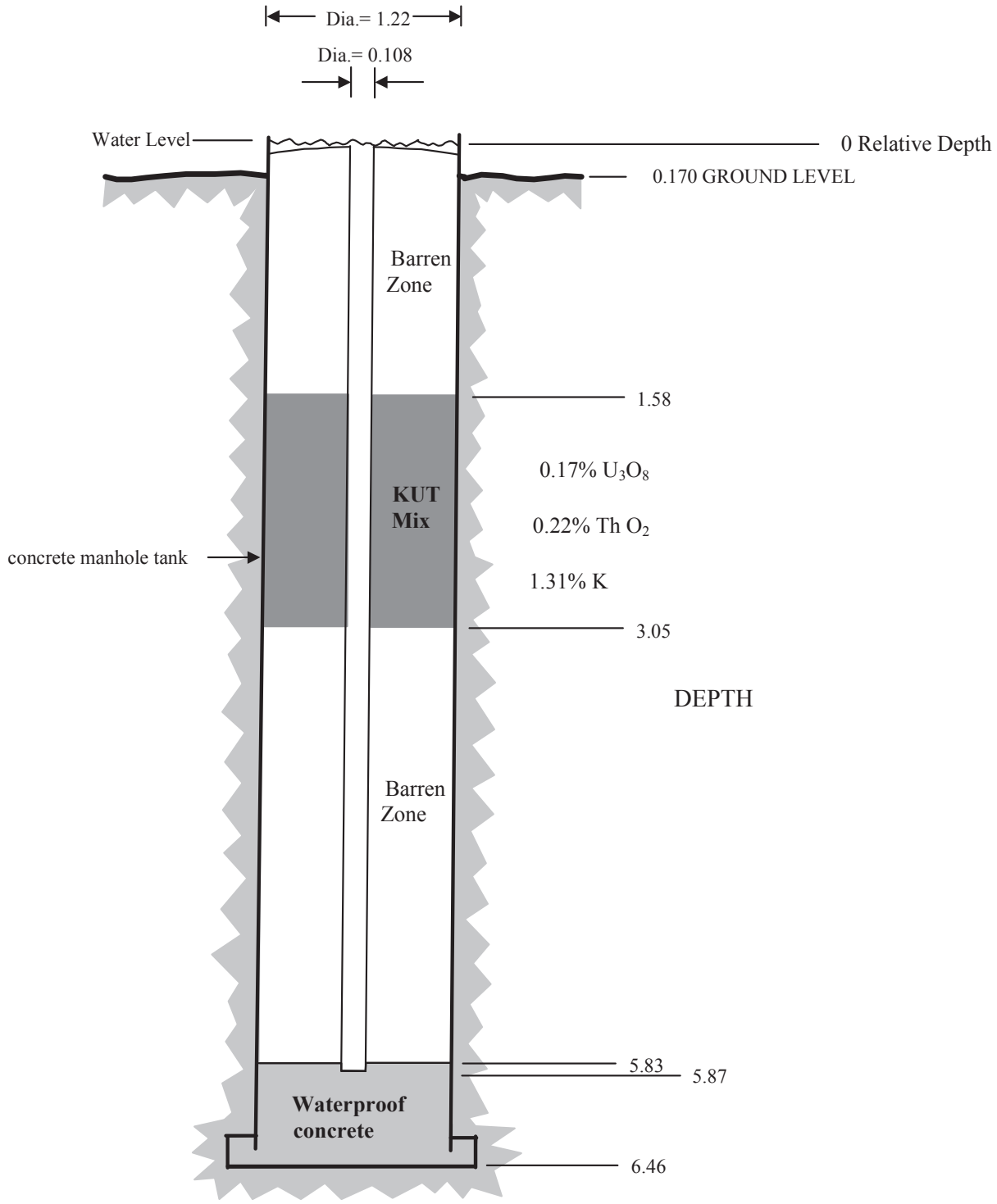
AM5



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Adelaide Calibration Models – AM5
K.U.T.
Vertical Section

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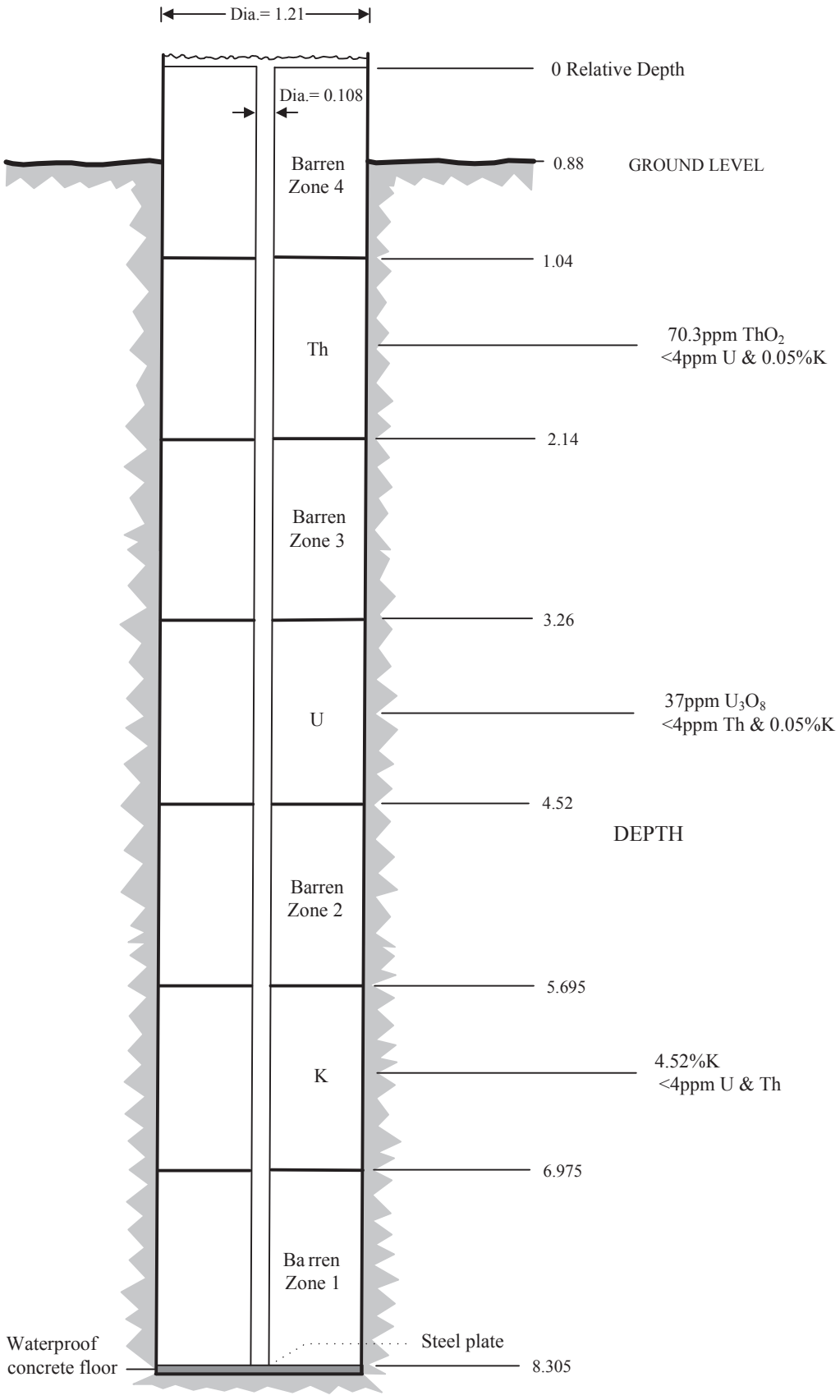
AM6



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Adelaide Calibration Models – AM6
Low Level K.U.Th.
Vertical Section

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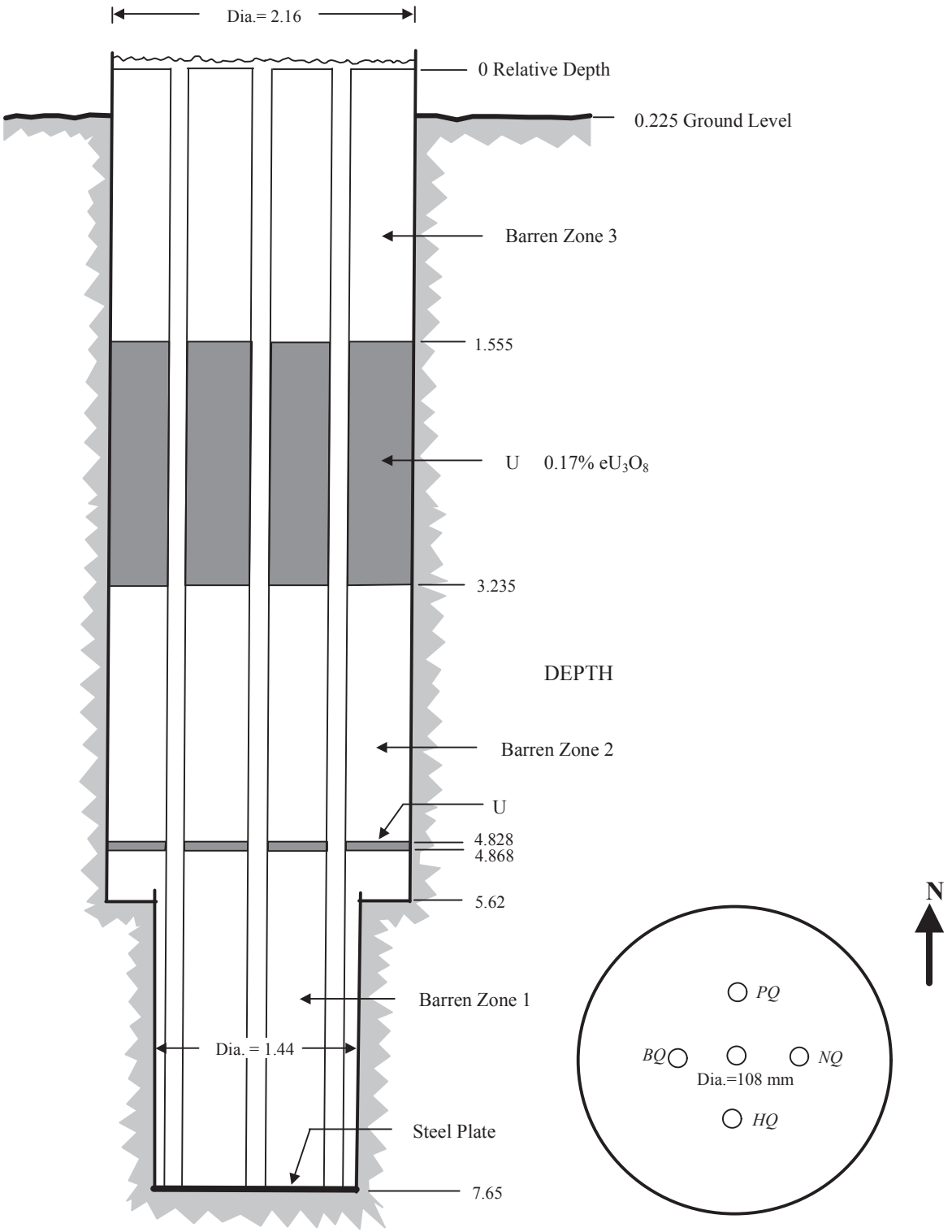
AM7



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Adelaide Calibration Models – AM7
U Hole Size
Plan & Vertical Section

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