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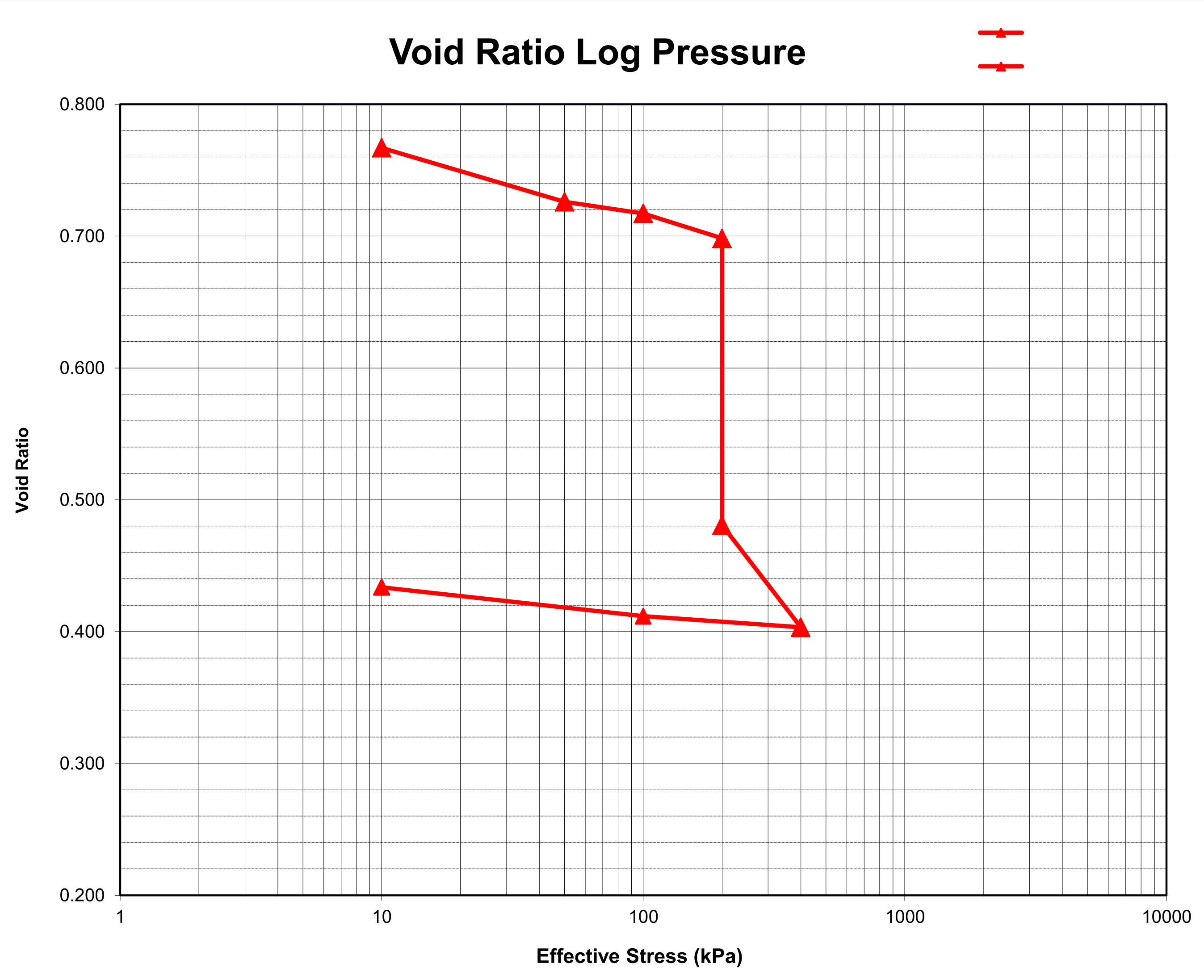
Consolidation Tests

Project:	SPITZ LAND		
Project No.:	2014-B-985	Sample No.:	985-14
Borehole No:	TP 39	Depth:	1.1
Date Receivec	03/06/2014	Date Tested:	20/06/2014

Test 1

Effect. Stress (kPa)	10	50	100	200	200	400	100	10			
Strain (%)	0.04	2.35	2.85	3.93	16.24	20.61	20.14	18.90			
Mv (1/MPa)		0.5790	0.1005	0.1073		0.2187	0.0157	0.1382			
Void Ratio	0.7671	0.7261	0.7172	0.6983	0.4806	0.4033	0.4117	0.4337			

Test 2



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Consolidation Tests

Project:	SPITZ LAND		Test 1
Project No.:	2014-B-985	Sample No.:	985-16
Borehole No:	TP 41	Depth:	1.0
Date Received:	03/06/2014	Date Tested:	20/06/2014
Remarks:	An undisturbed sample soaked @ 200kPa. Collapse Potential: 16.3%		

Machine No.	1	Ring No.	12	Height (mm)	19.4	Diameter (mm)	76.1

Masses for Water Content Determination (g)

Wet Sample and Ring		Dry Sample and Ring	Ring Only	Water Content	
Before Test	After Test			Before Test	After Test
221.8	227.9	208.3	86.55	11.1%	16.1%

Estimated Particle Specific Gravity	2.65

Initial Parameters

Void Ratio	0.9206	Degree of Saturation (%)	31.9	Dry Density (Kg/m3)	1380

Effect. Stress (kPa)		10	50	100	200	200	400	100	10	0	0	0
Dial Correction (u)		0	39	65	96	96	137	123	65	0	0	0
HH:MM:SS	√Minutes	Dial Readings in Microns								Initial Dial Reading		13454
00:00:00	0.00	13454										
03:00:00	13.42	13449										
17:00:00	31.94								9013			
20:00:00	34.64			12882								
22:00:00	36.33						8811					
23:00:00	37.15					9657						
24:00:00	37.95				12826							
74:00:00	66.63		12913									
97:00:00	76.29							8873				
End of Primary Cons		13449	12913	12882	12826	9657	8811	8873	9013			
Number of Readings:		2	1	1	1	1	1	1	1	0	0	0

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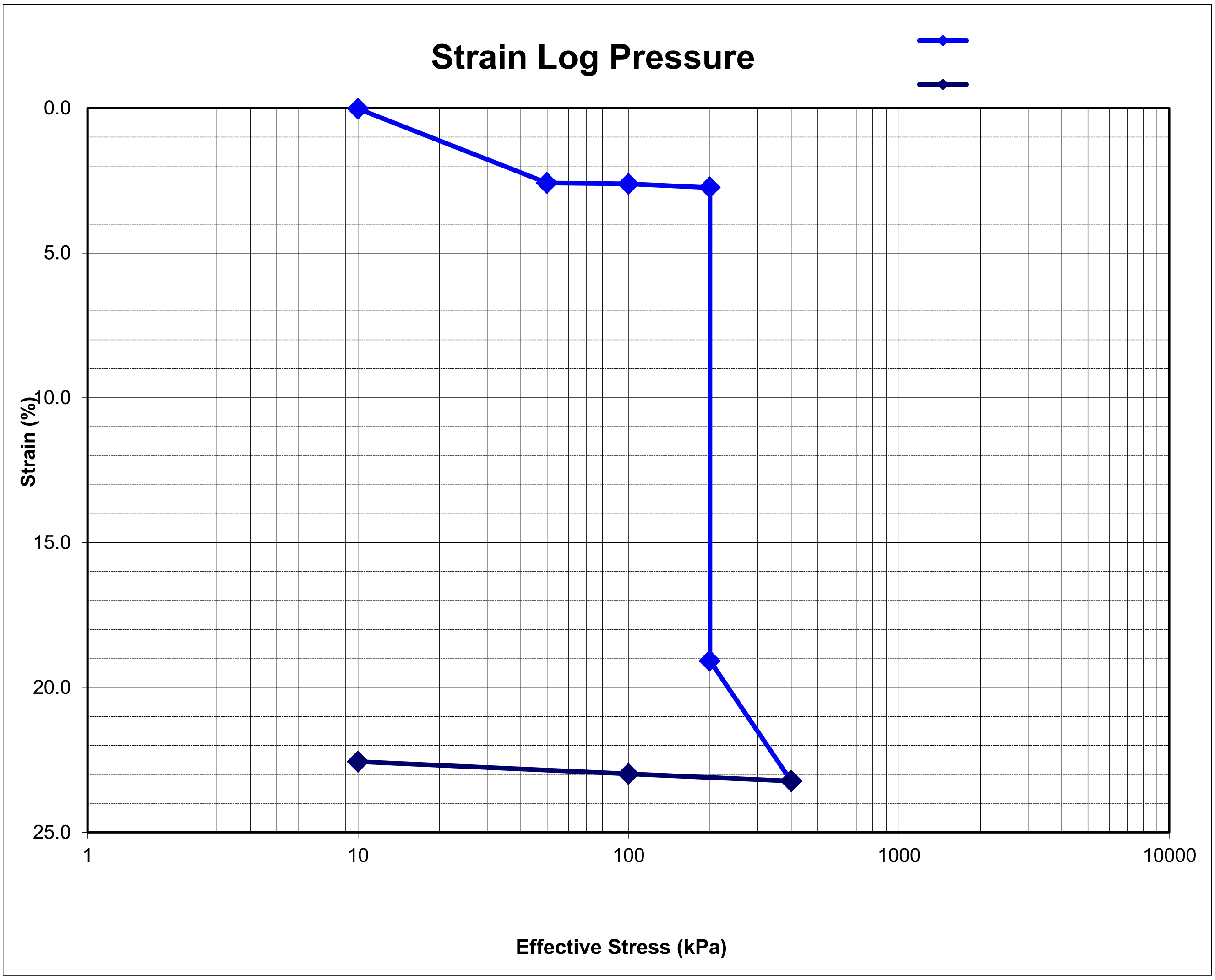
Consolidation Tests

Project:	SPITZ LAND		
Project No.:	2014-B-985	Sample No.:	985-16
Borehole No:	TP 41	Depth:	1.0
Date Received:	03/06/2014	Date Tested:	20/06/2014

Test 1

Effect.Stress (kPa)	10	50	100	200	200	400	100	10			
Strain (%)	0.03	2.59	2.61	2.74	19.08	23.23	22.98	22.56			
Mv (1/MPa)		0.6405	0.0052	0.0129		0.2075	0.0082	0.0470			
Void Ratio	0.9201	0.8709	0.8704	0.8679	0.5542	0.4745	0.4793	0.4874			

Test 2



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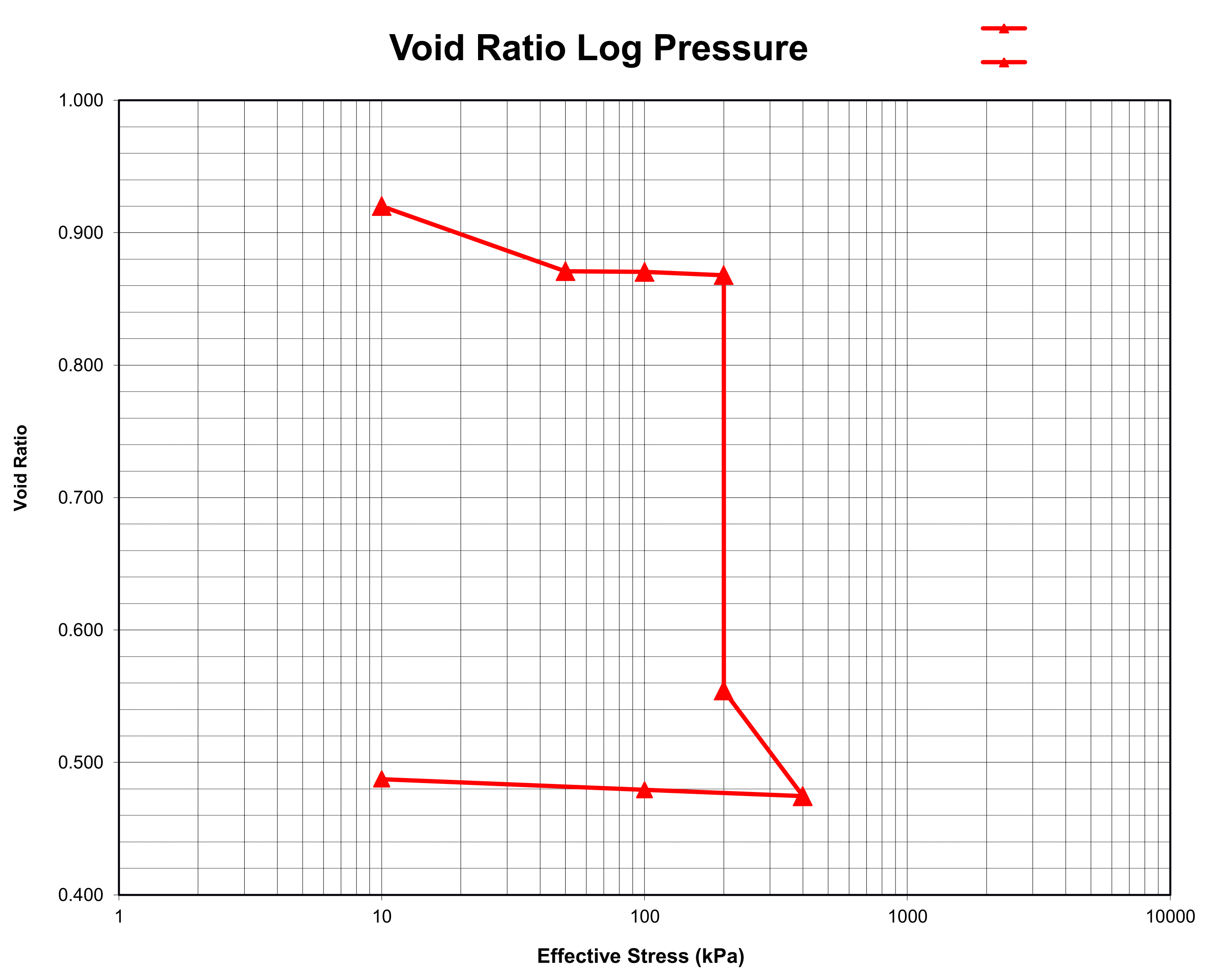
Consolidation Tests

Project:	SPITZ LAND		
Project No.:	2014-B-985	Sample No.:	985-16
Borehole No:	TP 41	Depth:	1.0
Date Receivec	03/06/2014	Date Tested:	20/06/2014

Test 1

Effect. Stress (kPa)	10	50	100	200	200	400	100	10			
Strain (%)	0.03	2.59	2.61	2.74	19.08	23.23	22.98	22.56			
Mv (1/MPa)		0.6405	0.0052	0.0129		0.2075	0.0082	0.0470			
Void Ratio	0.9201	0.8709	0.8704	0.8679	0.5542	0.4745	0.4793	0.4874			

Test 2



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Consolidation Tests

Project:	SPITZ LAND		Test 1
Project No.:	2014-B-985	Sample No.:	985-2
Borehole No:	TP 7	Depth:	1.0
Date Received:	03/06/2014	Date Tested:	20/06/2014
Remarks:	An undisturbed sample soaked @ 200kPa. Collapse Potential: 10.4%		

Machine No.	13	Ring No.	H	Height (mm)	19.15	Diameter (mm)	69.35

Masses for Water Content Determination (g)

Wet Sample and Ring		Dry Sample and Ring	Ring Only	Water Content	
Before Test	After Test			Before Test	After Test
203.0	213.8	196.9	81.86	5.3%	14.7%

Estimated Particle Specific Gravity	2.65

Initial Parameters

Void Ratio	0.6663	Degree of Saturation (%)	21.1	Dry Density (Kg/m3)	1590

Effect. Stress (kPa)		10	52	102	202	202	402	102	10	0	0	0
Dial Correction (u)		0	16	29	47	47	67	29	10	0	0	0
HH:MM:SS	√Minutes	Dial Readings in Microns								Initial Dial Reading		13713
00:00:00	0.00	13713										
03:00:00	13.42	13682										
18:00:00	32.86							10711				
20:00:00	34.64				13190							
22:00:00	36.33			13363					10885			
26:00:00	39.50					11202						
74:00:00	66.63		13390									
97:00:00	76.29						10622					
End of Primary Cons		13682	13390	13363	13190	11202	10622	10711	10885			
Number of Readings:		2	1	1	1	1	1	1	1	0	0	0

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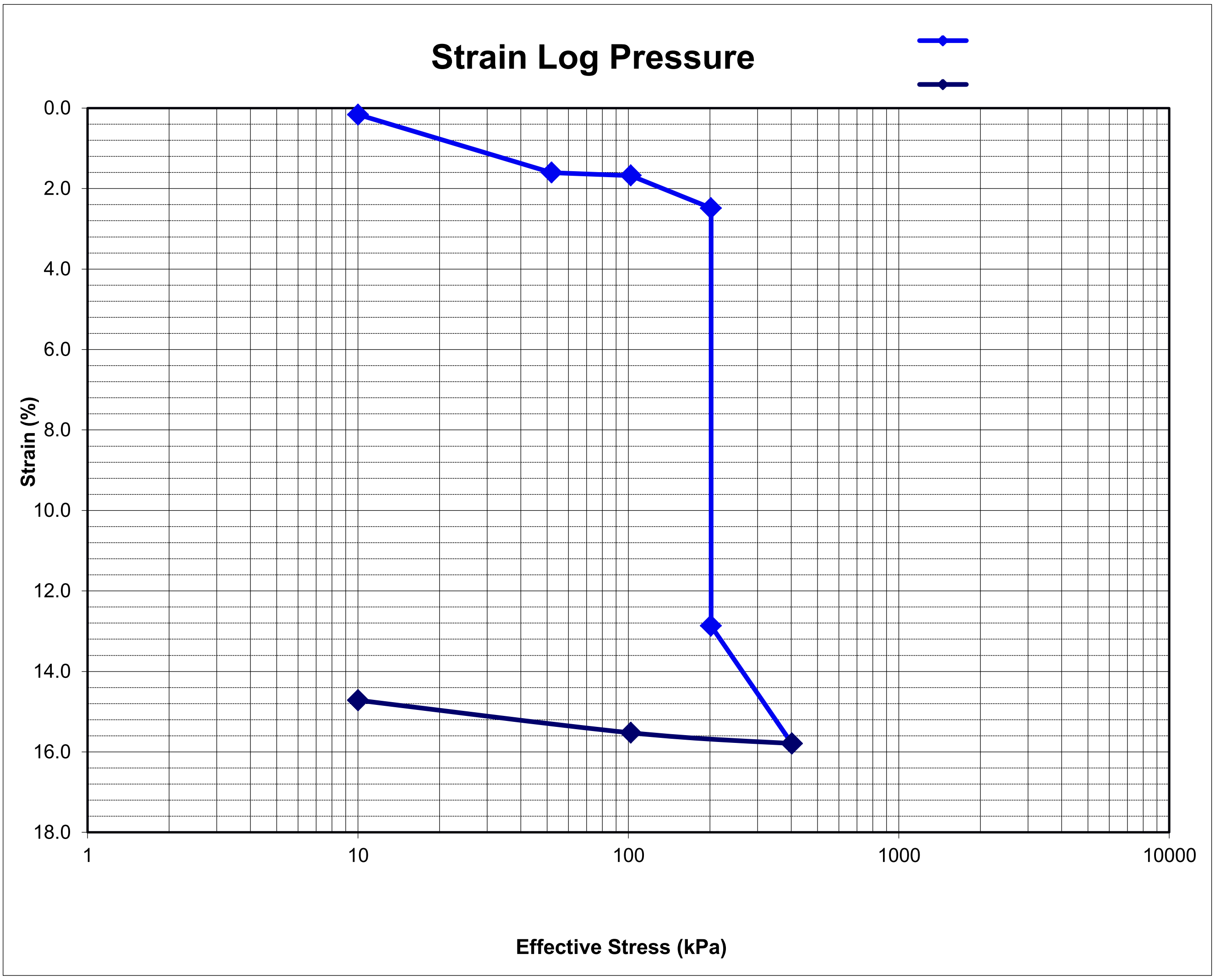
Consolidation Tests

Project:	SPITZ LAND		
Project No.:	2014-B-985	Sample No.:	985-2
Borehole No:	TP 7	Depth:	1.0
Date Received:	03/06/2014	Date Tested:	20/06/2014

Test 1

Effect.Stress (kPa)	10	52	102	202	202	402	102	10			
Strain (%)	0.16	1.60	1.68	2.49	12.87	15.79	15.52	14.72			
Mv (1/MPa)		0.3432	0.0146	0.0809		0.1462	0.0089	0.0880			
Void Ratio	0.6636	0.6396	0.6384	0.6249	0.4519	0.4032	0.4076	0.4211			

Test 2



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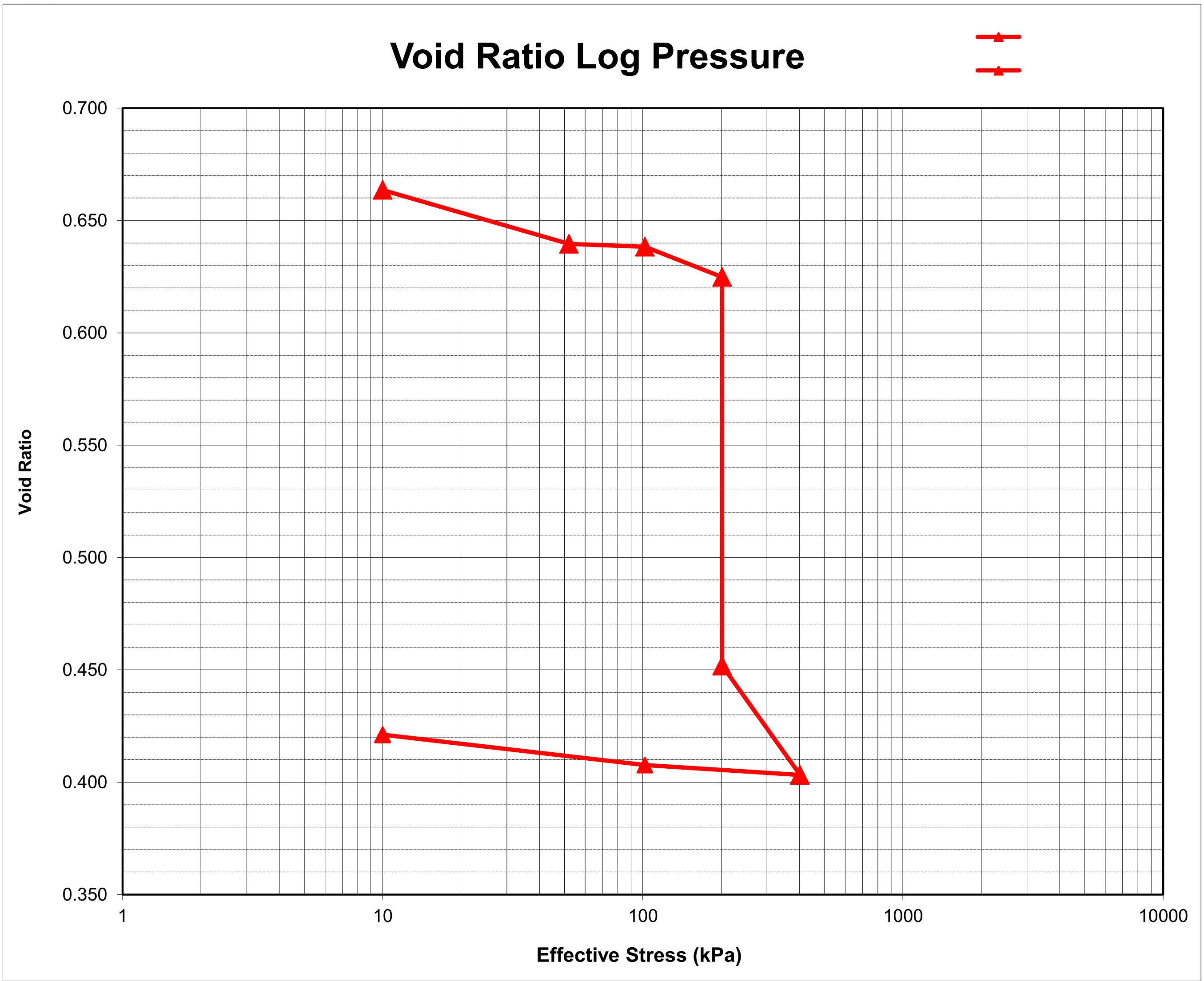
Consolidation Tests

Project:	SPITZ LAND		
Project No.:	2014-B-985	Sample No.:	985-2
Borehole No:	TP 7	Depth:	1.0
Date Receivec	03/06/2014	Date Tested:	20/06/2014

Test 1

Effect. Stress (kPa)	10	52	102	202	202	402	102	10			
Strain (%)	0.16	1.60	1.68	2.49	12.87	15.79	15.52	14.72			
Mv (1/MPa)		0.3432	0.0146	0.0809		0.1462	0.0089	0.0880			
Void Ratio	0.6636	0.6396	0.6384	0.6249	0.4519	0.4032	0.4076	0.4211			

Test 2



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Consolidation Tests

Project:	SPITZ LAND		Test 1
Project No.:	2014-B-985	Sample No.:	985-4
Borehole No:	TP 14	Depth:	1.1
Date Received:	03/06/2014	Date Tested:	20/06/2014
Remarks:	An undisturbed sample soaked @ 200kPa. Collapse Potential: 14.4%		

Machine No.	14	Ring No.	AR	Height (mm)	18.8	Diameter (mm)	69.1

Masses for Water Content Determination (g)

Wet Sample and Ring		Dry Sample	Ring	Water Content	
Before Test	After Test	and Ring	Only	Before Test	After Test
193.3	199.0	183.5	79.13	9.4%	14.9%

Estimated Particle Specific Gravity	2.65

Initial Parameters

Void Ratio	0.7901	Degree of Saturation (%)	31.5	Dry Density (Kg/m3)	1480

Effect. Stress (kPa)		10	52	102	202	202	402	102	10	0	0	0
Dial Correction (u)		0	16	29	47	47	67	29	10	0	0	0
HH:MM:SS	√Minutes	Dial Readings in Microns								Initial Dial Reading		13581
00:00:00	0.00	13581										
03:00:00	13.42	13567										
18:00:00	32.86							9677	9846			
20:00:00	34.64				13073							
22:00:00	36.33			13125								
24:00:00	37.95					10359						
76:00:00	67.53		13159									
97:00:00	76.29						9586					
End of Primary Cons		13567	13159	13125	13073	10359	9586	9677	9846			
Number of Readings:		2	1	1	1	1	1	1	1	0	0	0

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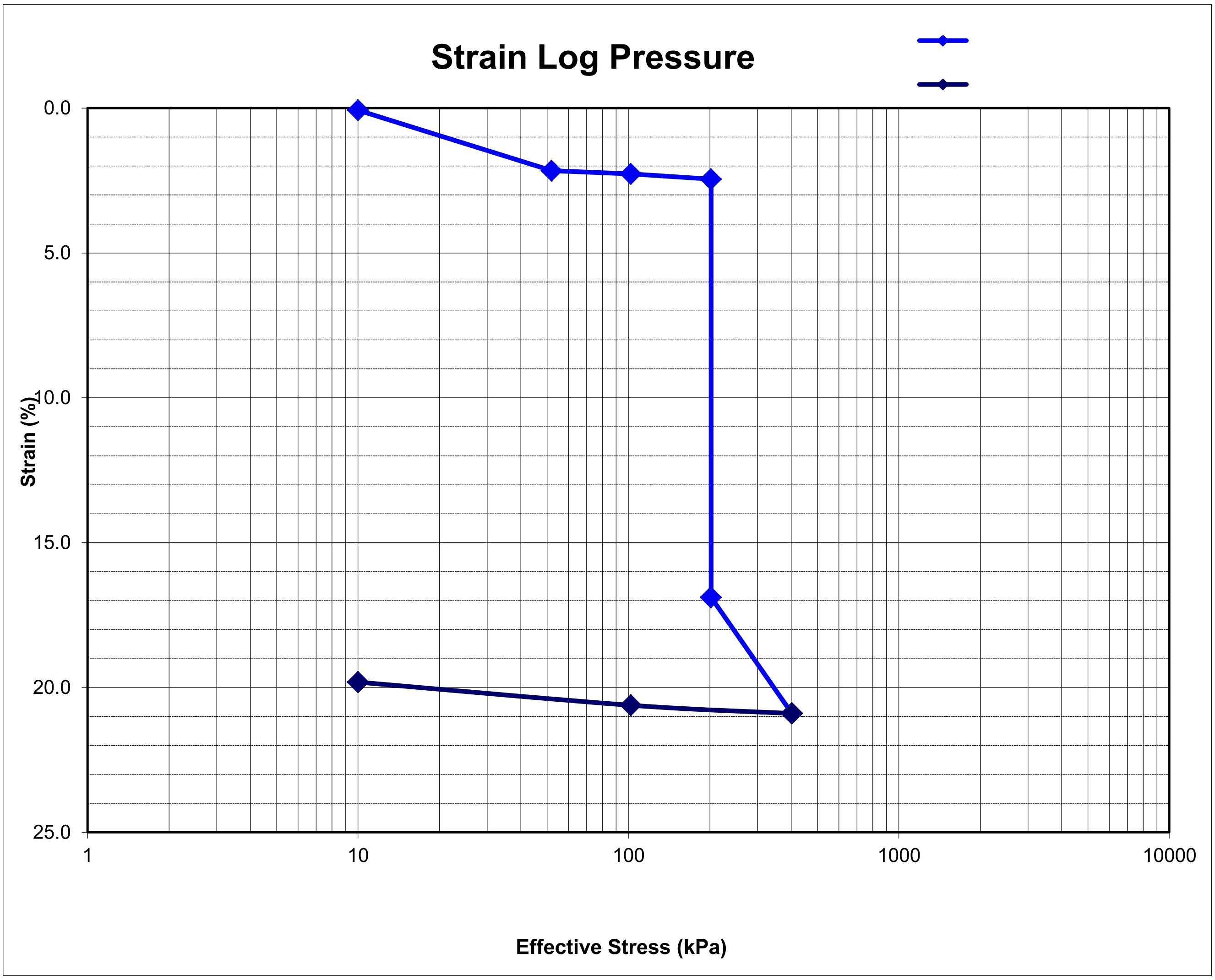
Consolidation Tests

Project:	SPITZ LAND		
Project No.:	2014-B-985	Sample No.:	985-4
Borehole No:	TP 14	Depth:	1.1
Date Received:	03/06/2014	Date Tested:	20/06/2014

Test 1

Effect.Stress (kPa)	10	52	102	202	202	402	102	10			
Strain (%)	0.07	2.16	2.27	2.45	16.89	20.89	20.61	19.81			
Mv (1/MPa)		0.4965	0.0223	0.0181		0.2003	0.0094	0.0867			
Void Ratio	0.7888	0.7514	0.7494	0.7462	0.4878	0.4161	0.4211	0.4354			

Test 2



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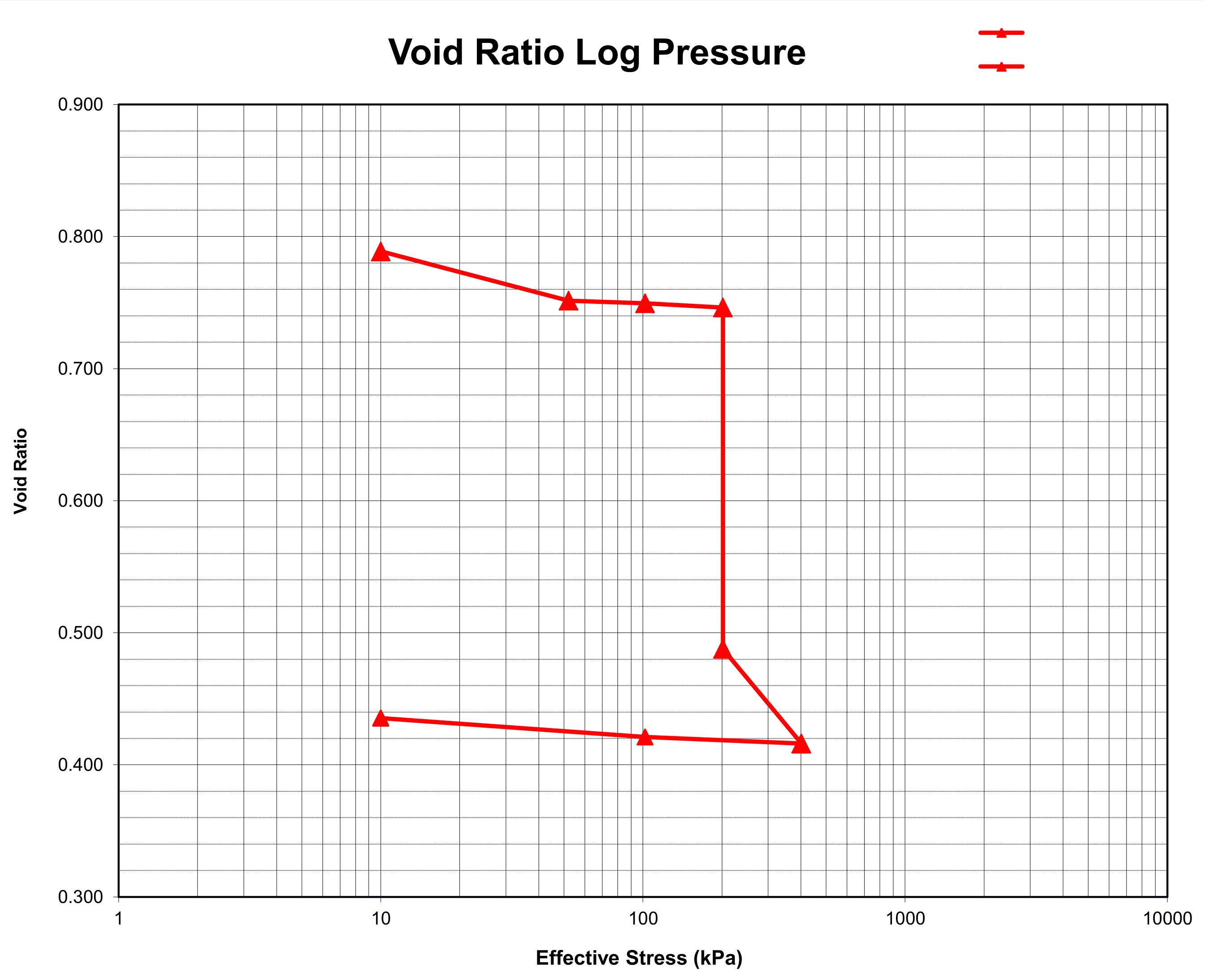
Consolidation Tests

Project:	SPITZ LAND		
Project No.:	2014-B-985	Sample No.:	985-4
Borehole No:	TP 14	Depth:	1.1
Date Receivec	03/06/2014	Date Tested:	20/06/2014

Test 1

Effect. Stress (kPa)	10	52	102	202	202	402	102	10			
Strain (%)	0.07	2.16	2.27	2.45	16.89	20.89	20.61	19.81			
Mv (1/MPa)		0.4965	0.0223	0.0181		0.2003	0.0094	0.0867			
Void Ratio	0.7888	0.7514	0.7494	0.7462	0.4878	0.4161	0.4211	0.4354			

Test 2



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Consolidation Tests

Project:	SPITZ LAND							Test 1
Project No.:	2014-B-985			Sample No.:	985-9			
Borehole No:	TP 28			Depth:	1.0			
Date Received:	03/06/2014			Date Tested:	24/06/2014			
Remarks:	An undisturbed sample soaked @ 200kPa. Collapse Potential: 5.09%							
Machine No.	17	Ring No.	BR	Height (mm)	18.3	Diameter (mm)	69.1	

Masses for Water Content Determination (g)

Wet Sample and Ring		Dry Sample	Ring	Water Content	
Before Test	After Test	and Ring	Only	Before Test	After Test
208.5	210.1	192.1	80.81	14.7%	16.2%

Estimated Particle Specific Gravity	2.65

Initial Parameters

Void Ratio	0.6341	Degree of Saturation (%)	61.6	Dry Density (Kg/m3)	1622

Effect. Stress (kPa)		10	51	100	198	198	398	100	10	0	0	0
Dial Correction (u)		0	16	29	47	47	67	39	10	0	0	0
HH:MM:SS	√Minutes	Dial Readings in Microns									Initial Dial Reading	13841
00:00:00	0.00	13841										
16:00:00	30.98	13771										
18:00:00	32.86			13115					11877			
20:00:00	34.64				13076							
22:00:00	36.33						11240					
24:00:00	37.95							11306				
96:00:00	75.89		13146									
98:00:00	76.68					12145						
End of Primary Cons		13771	13146	13115	13076	12145	11240	11306	11877			
Number of Readings:		2	1	1	1	1	1	1	1	0	0	0

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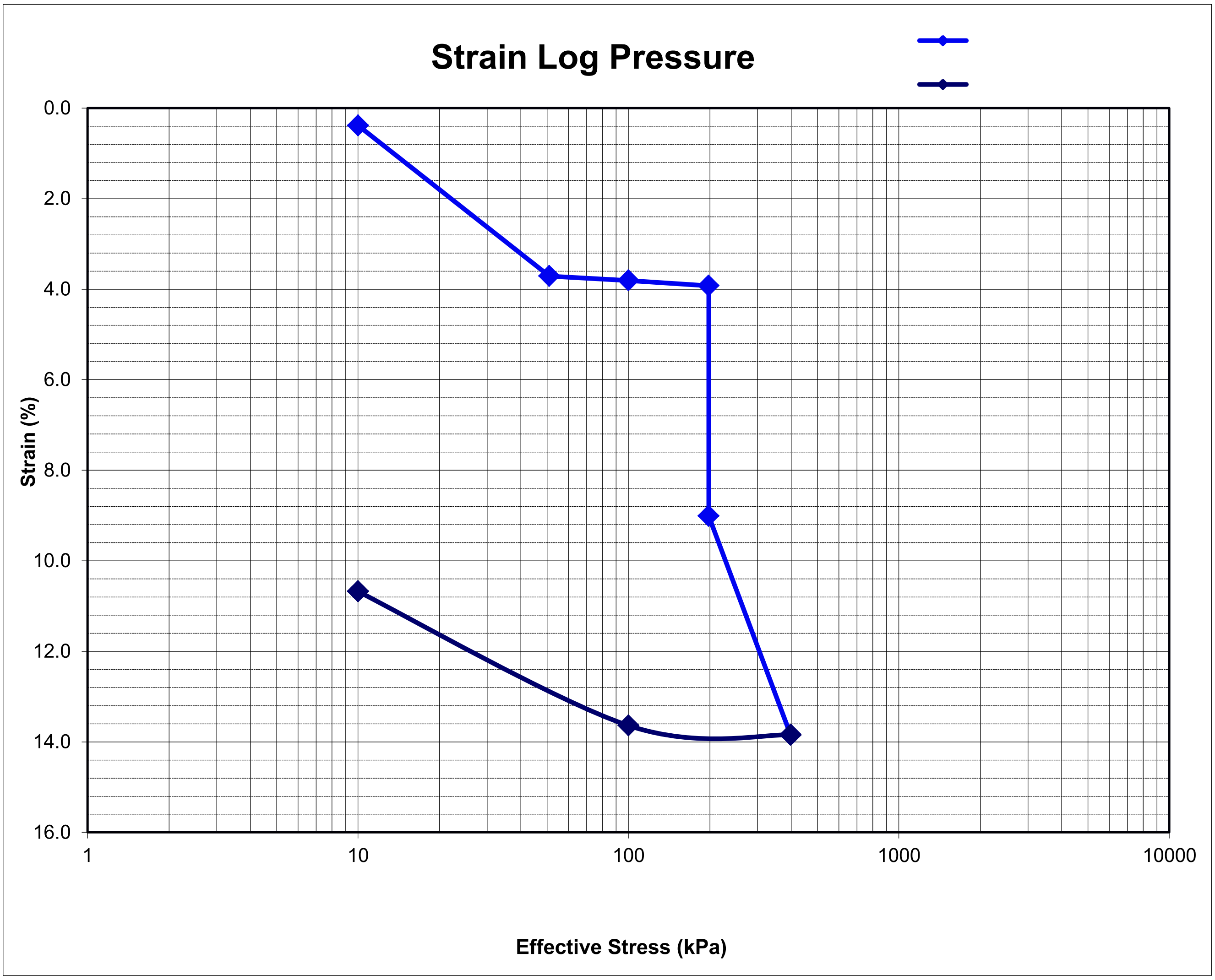
Consolidation Tests

Project:	SPITZ LAND		
Project No.:	2014-B-985	Sample No.:	985-9
Borehole No:	TP 28	Depth:	1.0
Date Received:	03/06/2014	Date Tested:	24/06/2014

Test 1

Effect.Stress (kPa)	10	51	100	198	198	398	100	10			
Strain (%)	0.38	3.71	3.81	3.92	9.01	13.85	13.64	10.68			
Mv (1/MPa)		0.8117	0.0201	0.0117		0.2418	0.0070	0.3291			
Void Ratio	0.6279	0.5735	0.5719	0.57	0.4869	0.4079	0.4112	0.4596			

Test 2



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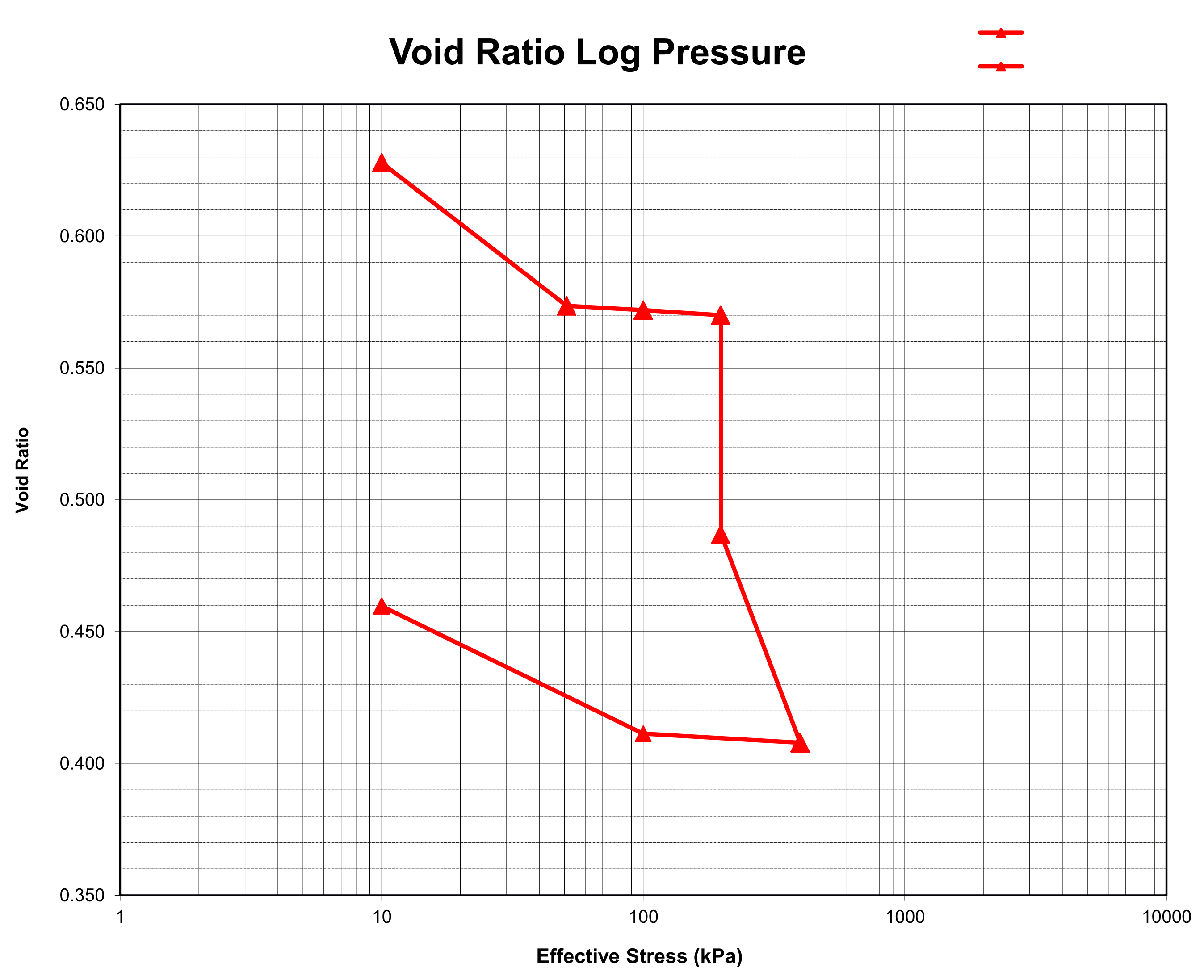
Consolidation Tests

Project:	SPITZ LAND		
Project No.:	2014-B-985	Sample No.:	985-9
Borehole No:	TP 28	Depth:	1.0
Date Receivec	03/06/2014	Date Tested:	24/06/2014

Test 1

Effect. Stress (kPa)	10	51	100	198	198	398	100	10			
Strain (%)	0.38	3.71	3.81	3.92	9.01	13.85	13.64	10.68			
Mv (1/MPa)		0.8117	0.0201	0.0117		0.2418	0.0070	0.3291			
Void Ratio	0.6279	0.5735	0.5719	0.57	0.4869	0.4079	0.4112	0.4596			

Test 2



RONEY HOFFMANN CONSULTANTS CC
WATER AND WASTE WATER PROCESS CONSULTANTS

141 Cresswell Road Silverton P.O. Box 11864 Queenswood 0121 Tel: (012) 804 8363 Fax: (012) 804 2212 Cell: 083 273 8638 E-mail: roney@tiscali.co.za

CLIENT	CIVILAB
SAMPLE IDENTIFICATION	SPITZ LAND
DATE RECEIVED	12 JUNE 2014
ORDER NO.	11997
RHC REF. NO.	PM 2014-6/12c

pH, CONDUCTIVITY (EC) AND RESISTIVITY (R)

SAMPLE	pH	EC CONDUCTIVITY, mS/m	EC CONDUCTIVITY, mS/cm	R RESISTIVITY, Ohm/cm
TP 7 @ 1.80 m	5.1	3.6	0.04	27778
TP 14 @ 1.10 m	6.3	14.6	0.15	6849
TP 15 @ 1.50 m	5.3	13.7	0.14	7299
TP 19 @ 0.20 - 0.60 m	4.0	42	0.42	2381
TP 22 @ 2.50 m	5.8	3.7	0.04	27027
TP 30 @ 0.40 - 1.60 m	5.0	7.0	0.07	14286
TP 33 @ 1.20 m	5.3	5.7	0.06	17544
TP 39 @ 1.10 m	5.2	7.3	0.07	13699
TP 44 @ 1.00 m	5.0	6.6	0.07	15152
TP 47 @ 0.50 - 1.00 m	6.0	5.6	0.06	17857

After the sample were dried and c rushed there was not enough sample to do corrosivity but only the pH and conductivity.

WE NEED AT LEAST ONE KG OF CRUSHED, DRY AND SIEVED UP TO TWO MM TO DO CORROSIVITY!

INTERPRETATION OF TEST RESULTS
(WATER/SOIL EXTRACT, 2:1)

pH	DEGREE OF ACIDITY	RESISTIVITY (R) Ohm/cm	DEGREE OF CORROSIVITY
<4	Extremely acidic		
4 - 5.4	Strongly acidic		
5.5 - 6.4	Moderately acidic	0 - 2 000	Extremely corrosive
6.5 - 7.0	Slightly acidic	2 000 - 4 000	Very corrosive
7.1 - 7.4	Slightly alkaline	4 000 - 5 000	Corrosive
7.5 - 8.4	Moderately alkaline	5 000 - 10 000	Mildly corrosive
>8.4	Strongly alkaline	>10 000	Not generally corrosive

NOTE : THE INTERPRETATIONS ARE FOR WATER SAMPLES AND THE INTERPRETATION OF THE ACIDITY AND CORROSIVITY VALUES DO NOT NECESSARY CORRELATE FOR THE WATER EXTRACTS OF SOIL SAMPLES

____

PW DE BEER

2 JULY 2014

APPENDIX C

GEOTECHNICAL CLASSIFICATION FOR URBAN DEVELOPMENT (SANS 634:2012)

CONSTRAINT	Most Favourable (1)	Intermediate (2)	Least favourable (3)
A Collapsible Soil	Any collapsible horizon or consecutive horizons totalling a depth of less than 750mm in thickness*	Any collapsible horizon or consecutive horizons with a depth of more than 750mm in thickness	A "least favourable" situation for this constraint does not occur
B Seepage	Permanent or perched water table more than 1,5m below ground surface	Permanent or perched water table less than 1,5m below ground surface	Swamps and marshes
C Active Soil	Low soil-heave potential predicted*	Moderate soil heave potential anticipated	High soil heave potential anticipated
D Highly compressible soil	Low soil compressibility expected *	Moderate soil compressibility anticipated	High soil compressibility anticipated
E Erodability of soil	Low	Intermediate	High
F Difficulty of excavation to 1,5m depth	Scattered or occasional boulders less than 10% of the total volume*	Rock or hardpan pedocretes between 10 and 40% of the total volume	Rock or hardpan pedocretes more than 40% of the total volume
G Undermined ground	Undermining at a depth greater than 200m below surface (except where total extraction mining has not occurred)	Old undermined areas to a depth of 200m below surface where stope closure has ceased	Mining within less than 200m of surface or where total extraction mining has taken place
H Stability(dolomite land)	Possibly unstable. Areas of dolomite overlain by Karoo rocks or intruded by sills. Areas of Black Reef rocks. Anticipated inherent hazard class 1 (see SANS 1936-2)	Potentially characterised by instability. Anticipated inherent hazard classes 2 to 5 (see SANS 1936-2)	Known sinkholes and dolines. Anticipated inherent hazard classes 6 to 8 (see SANS 1936-2)
I Steep slopes	Between 2 and 6 degrees (all regions)	Slopes between 6 and 18 degrees and less than 2 degrees (Natal and Western Cape). Slopes between 6 and 12 degrees and less than 2 degrees (all other regions)	More than 18 degrees (Natal and Western Cape) More than 12 degrees (all other regions)
J Areas of unstable natural slopes	Low risk	Intermediate risk	High risk (especially in areas subject to seismic activity)
K Areas subject to seismic activity	10% probability of an event less than 100 cm/s^2 within 50 years	Mining-induced seismic activity more than 100 cm/s^2	Natural seismic activity more than 100 cm/s^2
L Areas subject to flooding	A "most favourable" situation for this constraint does not occur	Areas adjacent to a known drainage channel or floodplain with slope less than 1%	Areas within a known drainage channel or floodplain.

*These areas are designated as 1A, 1C, 1D or 1F where localised occurrence of the constraint may arise.

APPENDIX D

RESIDENTIAL SITE CLASS DESIGNATIONS NHBRC Home Building Manual, Revision 1, February 1999

RESIDENTIAL SITE CLASS DESIGNATIONS

TYPICAL FOUNDING MATERIAL	CHARACTER OF FOUNDING MATERIAL	EXPECTED RANGE OF TOTAL SOIL MOVEMENTS (mm)	ASSUMED DIFFERENTIAL MOVEMENT (% OF TOTAL)	SITE CLASS
Rock (excluding mudrocks which may exhibit swelling to some depth)	STABLE	NEGLIGIBLE	-	R
Fine grained soils with moderate to very high plasticity (clays silts and sandy clays)	EXPANSIVE SOILS	<7,5 7,5 - 15 15 - 30 >30	50% 50% 50% 50%	H H1 H2 H3
Silty sand, sands, sandy and gravely soils	COMPRESSIBLE AND POTENTIALLY COLLAPSIBLE SOILS	<5 5 - 10 >10	75% 75% 75%	C C1 C2
Fine grained soils, (clayey silts and clayey sands of low plasticity), sands, sandy and gravely soils	COMPRESSIBLE SOIL	<10 10 - 20 >20	50% 50% 50%	S S1 S2
Contaminated soils Controlled fill Dolomitic areas Landslip Land fill Marshy areas Mine waste fill Mining subsidence Reclaimed areas Very soft silt/silty clays Uncontrolled fill	VARIABLE	VARIABLE		P

Notes :

1. The classifications, C, H, R and S are not intended for dolomitic areas sites unless specific investigations are carried out to access the stability (risk of sinkholes and doline formation) of the dolomites. Where the risk is found to be acceptable, the site shall be designated as class P (dolomitic areas).

2. Site classes are based on the assumption that differential movements, experienced by single-storey residential buildings, expressed as percentage of the total soil movements are approximately equal to 50% for soils that exhibit expansive or compressive characteristics and 75% for soils that exhibit both compressible and collapse characteristics. Where this assumption is incorrect or inappropriate, the soil movements must be adjusted so that the resultant differential movement implied by the table is equal to that which is expected in the field.

3. In some instances, it may be more appropriate to use a composite description to describe a site more fully, e.g. C1/H2 or S1 and/or H2. Composite Site Classes may lead to higher differential movements and result in design solutions appropriate to a higher range of differential movement, e.g. a Class R/S1 may be described as a Class S2 site. Alternatively, a further site investigation may be necessary as the final design solution may depend of the location of the building on a particular site.

4. Where it is not possible to provide a single site designation and a composite designation is inappropriate, sites may be given multiple descriptions to indicate the range of possible conditions, e.g. H-H1-H2 OR C1-C2.

5. Soft silts and clays usually exhibit high consolidation and low bearing characteristics. Structures founded on these horizons may experience high settlements and such sites should be designated as Class S1 or S2, as relevant and appropriate.

6. Sites containing contaminated soils include those associated with reclaimed mine land, land down of mine tailings and old land fills.

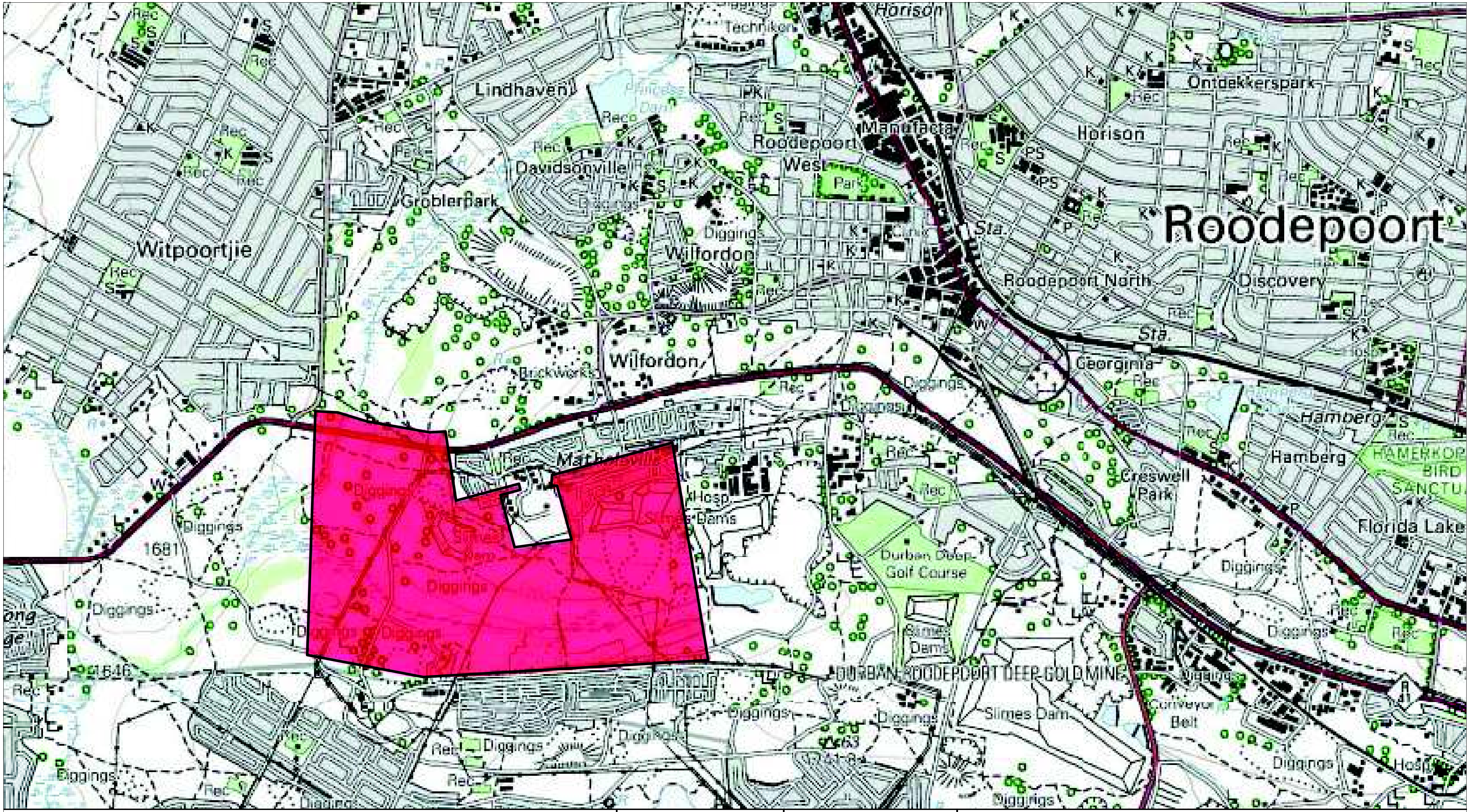
7. Where a site is designated as Class P, full particulars relating to the founding conditions on the site must be provided.

8. Where sites are designated as being Class P, the reason for such classification shall be placed in brackets immediately after the suffix, i.e. P (contaminated soils). Under certain circumstances, composite descriptions may be more appropriate, e.g. P (dolomitic areas) - C1.

9. Certain fills may contain contaminants which present a health risk. The nature of such fills should be evaluated and should be clearly demarcated as such.

APPENDIX E

DRAWINGS



LEGEND

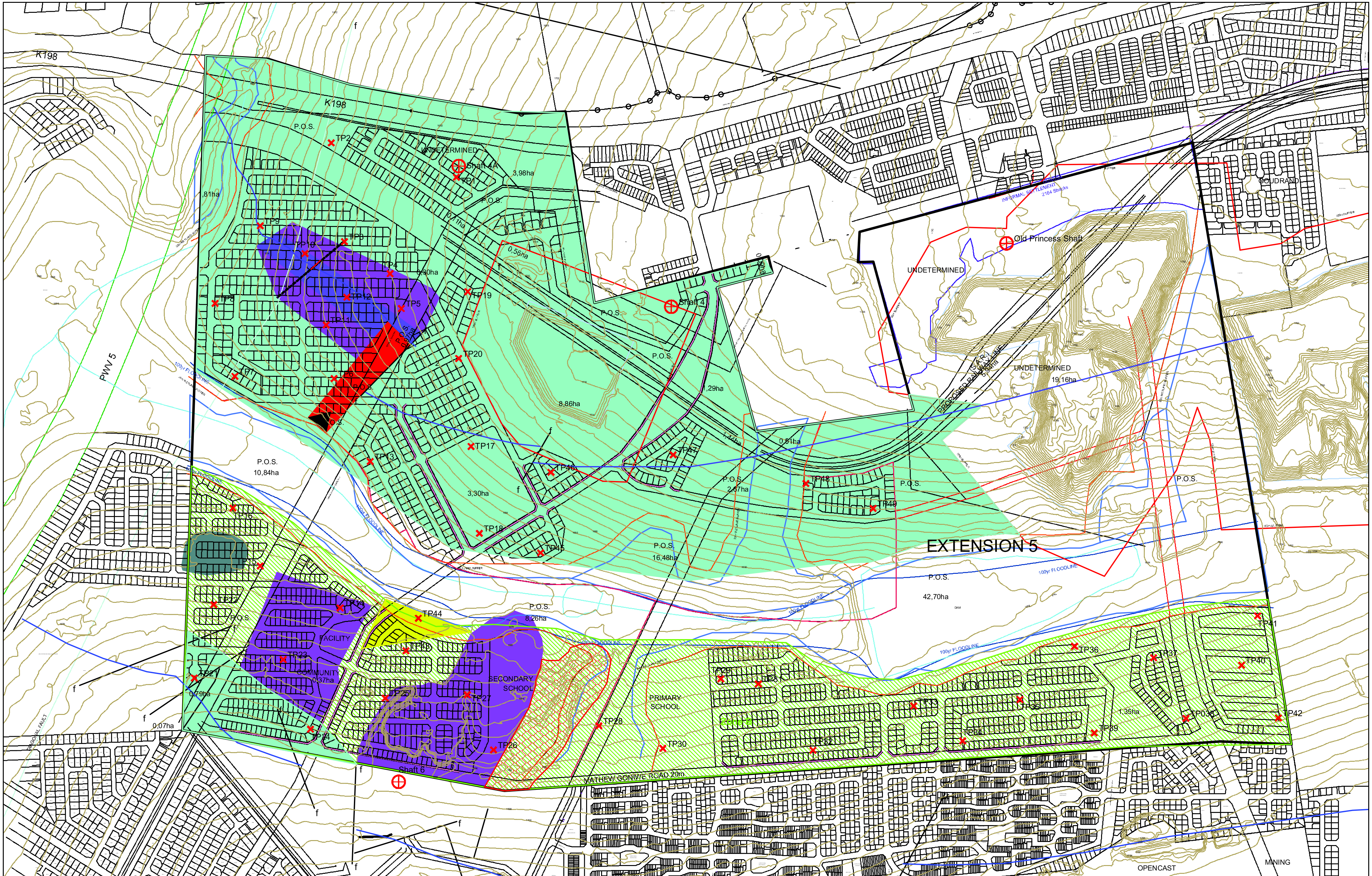
Site

Scale 1:30000

0 0.15 0.6 0.9 1.2 1.5 km

N

CLIENT		PROJECT
LIVING AFRICA DEVELOPMENTS (PTY) LTD	Bear GeoConsultants	SPITZ LAND
		LOCALITY PLAN
		DWG No. J13-131/1/1



LEGEND

Geotechnical		Undermining	
Test Pits	Disturbed ground	Bird Reef	Adit
Zone A	Terrace	Kimberley Reef	Trench
Zone B	Tailings	Outcrop Zone	Possible Mining
Ash dump		Adit Zone	Shafts

Scale 1:5000

0 75 150 300 450 600 750 m

Map Datum: WGS84 Lo27

CLIENT: LIVING AFRICA DEVELOPMENTS (PTY) LTD

PROJECT: SPITZ LAND

GEOTECHNICAL PLAN

DWG No. J13-131/1/2

Appendix C3

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Council for Geoscience
Applied Geoscience Solutions

Enquiries: Dr S Diop
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Date: 07 November 2016

Dear Sir / Madam,

TECHNICAL REVIEW OF REPORT J13-131/2

Report on the Undermining Study for the Proposed Township of Spitzland

Reviewer: Dr S. Diop

Summary

An investigation of the potential impact of undermining on the proposed township of Spitzland has been completed. The township is to be developed for residential purposes. The study has involved retrieval of undermining plans and the drilling of nineteen boreholes.
Two zones relating to undermining have been identified which will allow safe and economical development of the area. This report details the work done and gives recommendations concerning the limits within which development may take place.

Reviewer comments

Living Africa Developments (Pty) Ltd has requested Bear GeoConsultants (Pty) Ltd to carry out a study of the potential impact of undermining on the proposed township of Spitzland. In support of this application, a geotechnical report has been prepared by Bear GeoConsultants (Pty) Ltd (Report on the Undermining Study for the Proposed Township of Spitzland, Report J13-131/2, dated October 2014). The review

The report accompanying contains suggested levels of investigation and analysis to determine the potential impact of undermining on the proposed township.
The investigation carried out by Bear GeoConsultants (Pty) Ltd included analysis of previous works, ground penetrating radar (GPR) survey and the drilling of 19 percussion boreholes.

The work program also included an assessment of the undermined ground following the methodology proposed by Stacey and Bakker (1992). This is considered an appropriate level of investigation to characterise the site for the potential impact of undermining on the proposed township.

The report notes that no mining of the Bird Reef took place except for limited “open cast” mining in a narrow band along the outcrop and this appears to have been limited to 3,0 m depth. We consider that this is reasonable, although the geophysical survey pointed out the presence of a large number of point features across the site potentially indicating the presence of a number of old mine workings at very shallow depth.

The report further states that the bulk of the site falls into the Deep Zone, although a small section could be considered as Outcrop Zone as defined by Stacey and Bakker (1992). For the former, there are no restrictions on development due to the fact that the undermining is deeper than 200 m depth or no undermining has taken place. For the latter, no development should take place in this zone and it should be reserved for open parkland. This zone encompasses those areas in which there is some potential for sinkholes to develop and includes the shafts on this site as well as the area above and around the Mona Liza Adit.

This assessment is largely consistent with the Central Rand Land Hazard Categories map prepared by Barker (Banzi Geotechnics cc, 2010). Figure 1 shows that most of the site has negligible risk of structurally damaging surface movement, although pockets to the central north-western and south-western sections of the site are recorded as potential zones of incipient instability. The central north-western pocket corresponds to what this report refers to as Outcrop Zone.

In addition, since the original work of Stacey and Bakker was completed in1992, new legislation has been promulgated. This legislation relates to health and safety in mines and their impact on the surface (Inset below). In essence no surface development may occur without a risk assessment by a competent person or the Chief Inspector of Mines (Section 17(7) (a & b). Consequently the Hazard Mapping is useful in guiding planning as to what areas fall within the requirements of the Act and to some extent what levels of intensity of investigation may be required.

INSET:

Mine Health and Safety Act and Regulations: (Act 29 of 1996)
SECTION 17: SAFETY PRECAUTIONS

Responsibilities regarding safety precautions

17(7) No person may erect or construct any buildings, roads, railways, or any structure ***within a horizontal distance of 100 metres from the workings of a mine***, or such lesser distance and at such positions and subject to such restrictions and conditions, determined by -
- (a) risk assessment or
- (b) the Chief Inspector of Mines.

17(8) The person(s) responsible for activities in terms of regulations 17(6)(a) and 17(7)(a) must-
- (a) in the case of an employer, provide the Chief Inspector of Mines with the distance and accompanying restrictions and conditions for comment, prior to commencement of such activity;
- (b) in the case of other persons, provide the Chief Inspector of Mines with the distance and accompanying restrictions and conditions for approval, prior to commencement of such activity.

Reviewer recommendations

Several recommendations are made at the end of the report, some of which are the precautionary measures to be adhered to on this site with regard to any development. This is very important especially in undermined areas where not much accurate information is readily available.

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In addition, given the safety precautions mentioned in Section 17(7) of the Inset above, it might be more prudent to increase the buffer zones for both the suspected adit and all identified shafts

Special attention should also be given to the south-western section of the site where zones of incipient instability have been previously recorded (Figure 1).

References

- Stacey, T.R. and Bakker, D. The erection or construction of buildings and other structures on undermined ground. Proceedings, COMA: Symposium on Construction Over Mined Areas, Pretoria, South Africa, May 1992, pp 282 to 288.
- Banzi Geotechnics cc: Witwatersrand Gold Mining Surface Settlement Risk Assessment and Hazard Analysis 2010 update, Job 148-01-2009-CGS, December 2010.

Limitation

These comments have been prepared solely for the benefit of Mr J. Thomas, Director of Living Africa Developments (Pty) Ltd. The comments in it are limited to the purpose stated in this report. No liability is accepted by the Council for Geoscience in respect of its use by any other person, and any other person who relies upon any matter contained in this report does so entirely at their own risk.

Yours faithfully

____

Dr S. Diop (Ph.D., Pr. Nat. Sci.)
Chief Scientist: Engineering Geoscience Unit
Council for Geoscience

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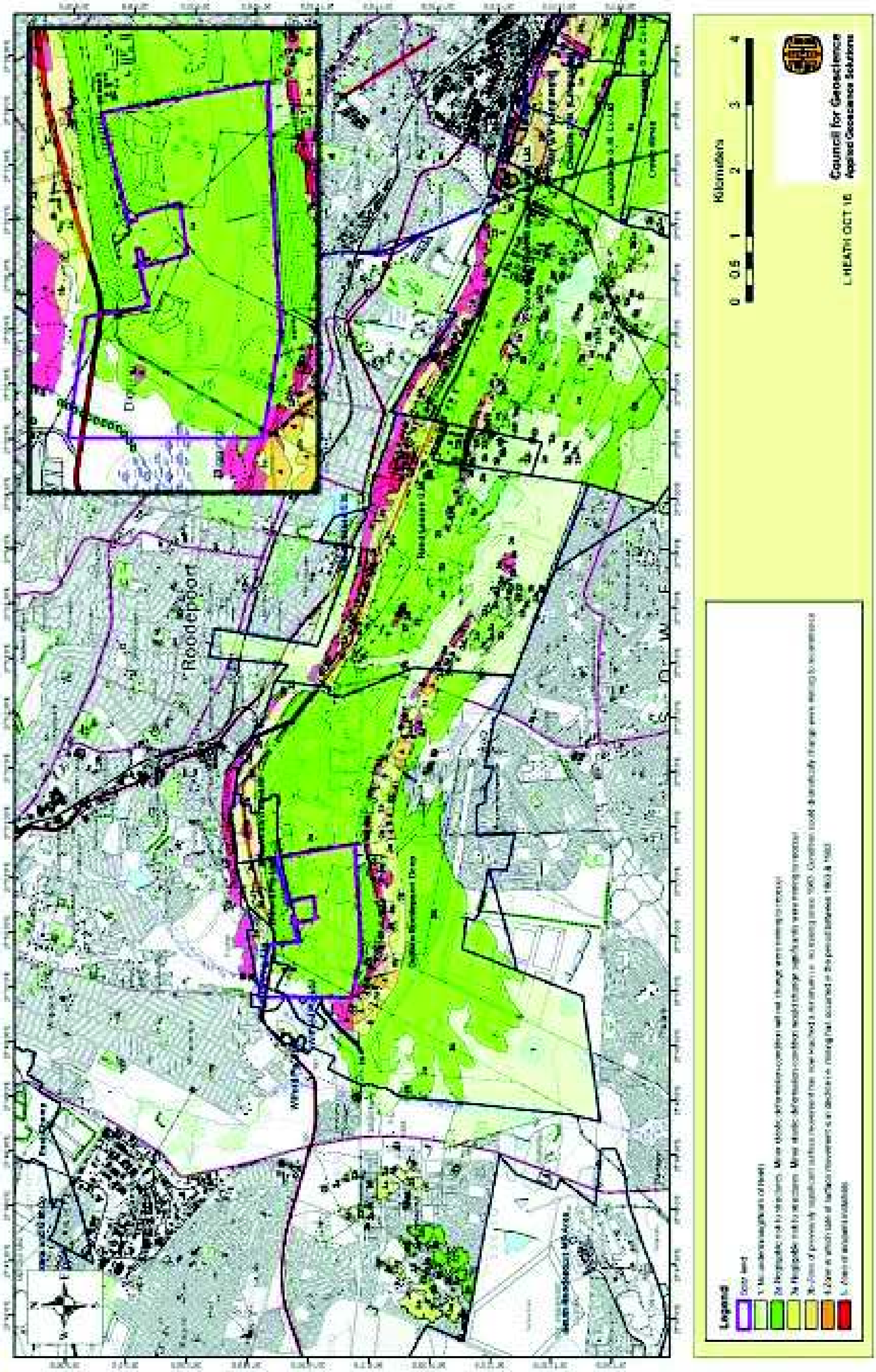
Figure 1: Central Rand Land Hazard Categories



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Appendix D

SPITZLAND

SAFETY ASSESSMENT REPORT (Rev 0)

30 September 2013

Contact Details

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1. BACKGROUND

Naturally occurring radionuclides are present in many natural resources. Elevated concentrations of these radionuclides are often found in certain geological materials, namely igneous rocks and ores. Human activities that exploit these resources may lead to enhanced concentrations of radionuclides (often referred to as technologically enhanced naturally occurring radioactive material (TE-NORM)) and (or) enhanced potential for exposure to NORM (Naturally Occurring Radioactive Materials) in products, by-products, residues and wastes.

NORM comprises radionuclides associated with the ^{238}U and ^{232}Th decay chains as well as ^{40}K. These radionuclides are very long lived and have some progeny that are long lived, such as ^{226}Ra. The distribution of radionuclides in the geosphere depends on the distribution of the geological media from which they are derived and the processes which concentrate them at a specific location in specific media [9].

Gold deposits on the Witwatersrand basin co-occur with pyrite (Fe_2S) and uranium, as well as a number of other metals, metalloids and NORM. With the curtailing of mining activities and the opening up of mining land previously covered by MRDs (Mine residue deposit) through reprocessing, there is an ever-increasing demand from developers and the SA Government to put this land to use, especially for residential purposes [9].

In South Africa the risks and impacts of gold mining on the Witwatersrand Basin may include, *inter alia,* contamination and alteration of surface watercourses through tailings spillages, surface instability through seismicity and sinkholes, TSF failure, contaminated decant from underground workings, and dust as well as noise, vibration, radioactivity from naturally occurring radioactive materials (NORMs), soil and ground water contamination, air pollution, land degradation and loss of productivity, bioaccumulation of metals and NORMs, loss of biodiversity, impairment of ecosystem services, contributions to ozone depletion, contributions to global warming, and human health impacts. [10]

Radiological field survey was conducted on the Spitzland site (*Figure 1*) with the view of making an application to the National Nuclear Regulator (NNR) for the clearance of this site for housing and a community development project.

The South African scope of regulatory control with respect to Radioactive Material is entrenched in Government Notice No. R28755 (dated 28 April 2006), which makes reference to the level below which a nuclear authorization is not necessary. This level is specified as 500 Bq (per nuclide)/kg for naturally occurring radioactive nuclides. The National Nuclear Regulator (NNR) is the regulatory authority responsible for the implementation of the notice R28755.

Figure 1 - Extent of the Spitzland site

2. PURPOSE

The purpose of this report is to provide a Radiological Hazard Assessment of the above-mentioned site and to ascertain if the specific activity levels on this site are below or above the set regulatory limits. The survey was conducted to validate the radiation levels on the site against the regulatory standard of 500 Bq (per nuclide)/kg.

3. METHOD OF ASSESSMENT

- The survey was conducted by the Radiation Protection Monitor, assisted by a Radiation Protection Specialist using NNR approved instrumentation.
- The methods used in the site gamma survey to assess the radioactivity content entails gamma assaying of the surface with an RS-230 spectrometer. The RS-230 was used at a height of 1m above the soil surface. Calibration factors from pads of material containing known amounts of Uranium, Thorium and Potassium (K-40) are used to infer Uranium and thorium content from the measured gamma counts. *Figure 2* and *Figure 3* provide the results of the calibration which was conducted in February

2013.

- The survey was conducted to determine the possible radiation hazard and to classify the area in correspondence to the hazard. The survey grid of less than 10x10 m was adopted in all the accessible sections of the site.

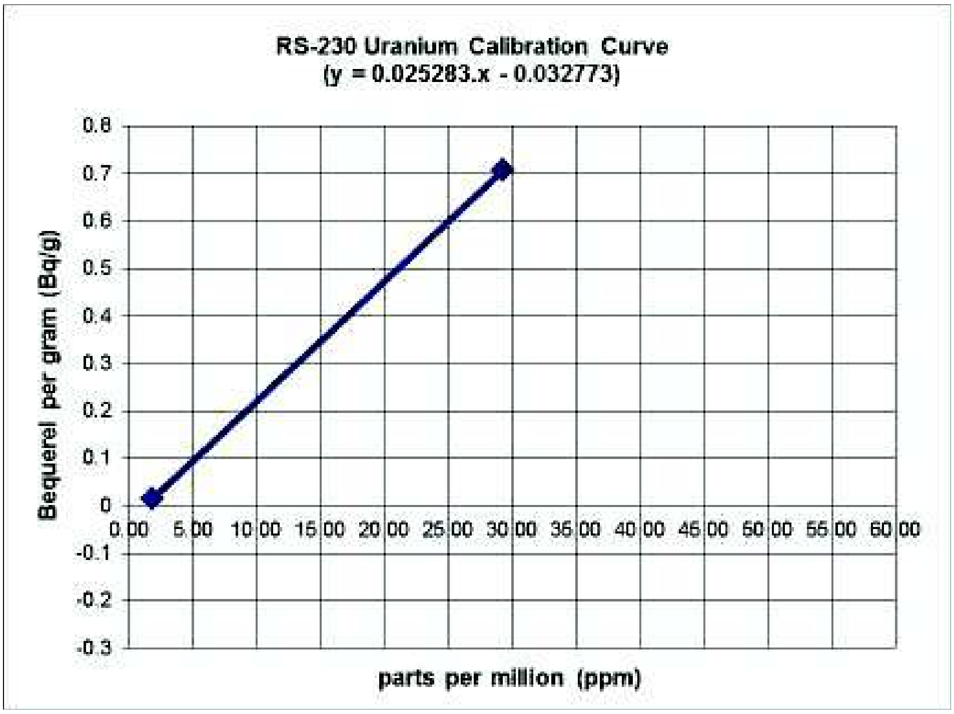

Figure 2 – Uranium calibration curve

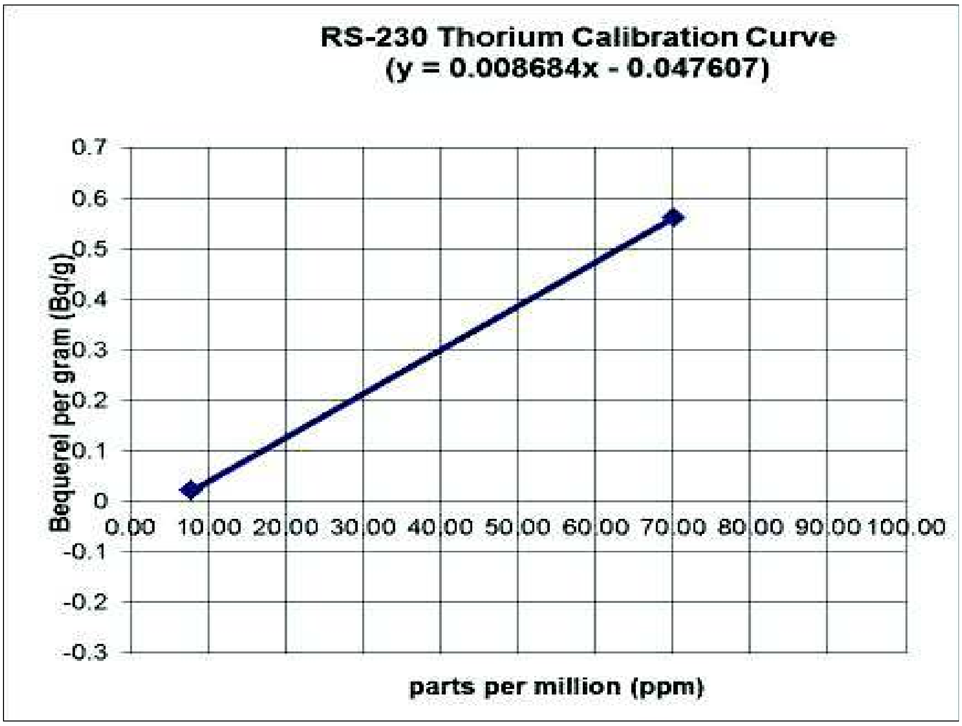

Figure 3 – Thorium calibration curve

4. SUMMARY OF THE RESULTS

A total of 6586 readings were obtained in parts per million and the instrument calibration factors as indicated in Figure 2 and Figure 3 were used to convert the results into Bq/g. Table 1 below presents a summary of the results whilst Appendix 1 contains the full results.

Table 1 - Summary of the Spitzland site

	U Activity (Bq/g)	Th Activity (Bq/g)	^{40}K (%)	Dose Rate (uSv/hr)
Average	0.047	-0.009	0.255	0.040
Maximum	0.210	0.077	1.30	0.091
90th Percentile	0.086	0.007	0.500	0.053

Of the 6586 readings, 0% (0 readings) is above the 500 Bq/Kg limit with the highest Uranium activity recorded on the entire site being 210 Bq/Kg whilst the average for the site was 47 Bq/Kg and the 90th percentile being 86 Bq/Kg. The activity map for the site is presented in Figure 4 whilst the uranium activity distribution is presented in Figure 5. However, it should be noted that the three Mine residue deposits were neither surveyed nor sampled.

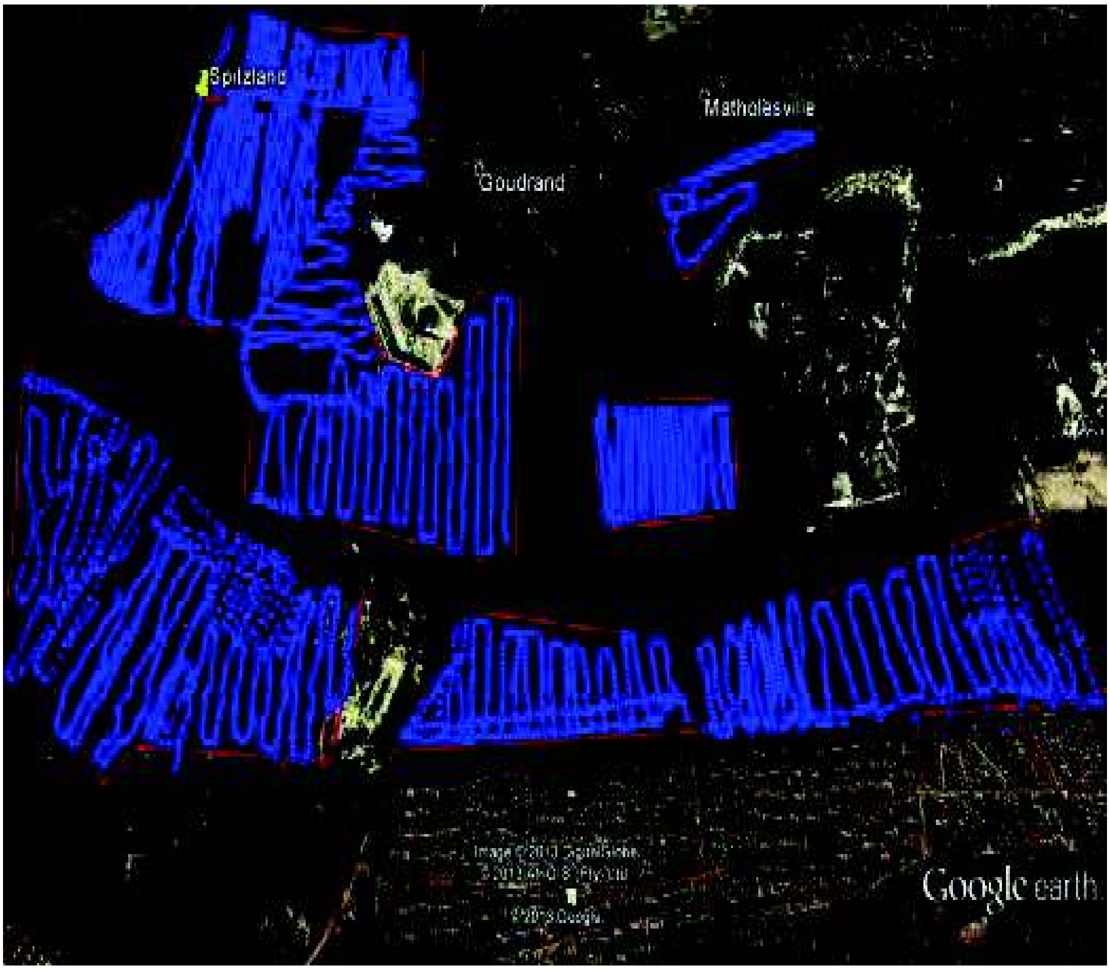

Figure 4 - Activity Map for the Spitzland Site (●- < 0.4 Bq/g)

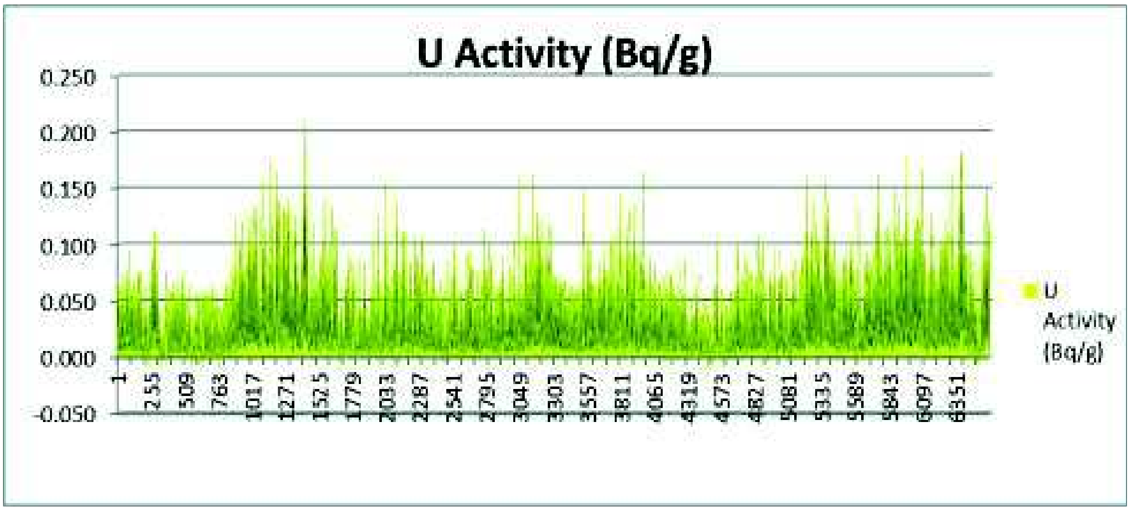

Figure 5 – Uranium Activity (Bq/g) Distribution for the Spitzland Site

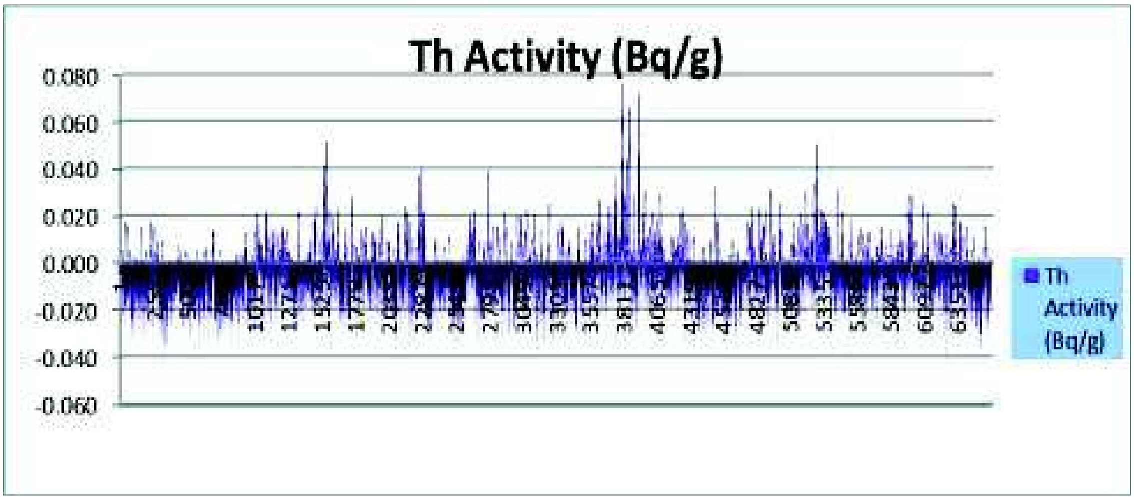

Figure 6 – Thorium Activity (Bq/g) Distribution for the Spitzland Site

5. LAND USE DEVELOPMENT

An exposure pathway describes the course a hazardous substance takes through the environment from a source of contamination to a human or ecological receptor. Modeling the transport of a contaminant via an exposure pathway means defining:

a) the nature, extent and location of the contaminant source or sources,
b) actual or potential mechanisms of release, migration, and fate in the environment,
c) a medium or media through which the contaminant is transported or in which the contaminant remains,
d) points of possible receptor contact with the contaminated medium, and
e) an exposure route (e.g., ingestion) or routes at the point of contact.

The primary objective of an exposure pathway analysis is to identify all significant exposure pathways and to provide quantitative estimates of contaminant concentrations in all affected media for all likely exposure routes.

One or several exposure pathways may exist for any given source of contamination, and the presence or absence of an exposure pathway is highly dependent upon several site-specific conditions, including current and future land use, hydrogeology, and local population density and location among others.

Human health risk assessment combines information from the exposure pathways analysis—on contaminated media concentrations and exposure pathways—with exposure factors to estimate contaminant intakes and risks to individuals and populations. Exposure factors include:

1. intake rates for specific exposure routes (e.g., inhalation) or for specific exposure pathways (e.g., ingestion of drinking water),
2. exposure rates (i.e., exposure times, frequencies and duration), and
3. modifying factors (e.g., shielding factors for external exposure).

Exposure scenarios are combinations of exposure pathways and exposure assumptions that are used to evaluate site risks under different land-use classifications. Each scenario describes actual or potential contaminant releases, migration pathways, contaminated media, exposure point concentrations, and receptor characteristics for a specific land use and its assumed set of site conditions. The purpose of these scenarios is to ensure that every reasonable exposure pathway and assumption is considered and that all individual exposures and risks are assessed consistently and comprehensively.

The future land use of the surveyed area has been defined as residential development. Residential development is meant to include development where members of the public will be exposed 24 hours per day and 365 days per year, thus it should be assumed that all building users are exposed for periods of 8760 hours/annum. However, 5700 hours per annum and 3100 hours/year will be assumed for outdoor and indoor occupancy factors [LG-1032] respectively. Furthermore, due to gamma shielding, the indoor dose will be calculated at 60% of the outdoor doserate [LG-1032].

5.1 External Exposure

The following formula can be used to calculate the outdoor external dose from external exposure to soil contaminated to various extents for the uranium series:

$$D_{ext\text{-}out} = T*SA*DC_{ext}$$

Where:

$D_{ext\text{-}out}$ = Outdoor external dose (Sv/yr)

T = Exposure time (5700 hours/annum were assumed for outdoors)

SA = Specific activity for Uranium (Bq/g)

DC_{ext} = External dose coefficient for uranium in surface soil (Sv.h^{-1}/Bq.g^{-1})

Table 2 presents a summary of the external dose results using the maximum uranium activity values (excluding the tailings dams activity) for the Spitzland site. It should be noted that the Dose Coefficients used in the calculation is for Exposure to Soil Contaminated to a Depth of 5 cm.

Table 2 - Summary of maximum external dose results for Spitzland

Radionuclide	Average (Bq/g)	90th Percentile (Bq/g)	Maximum (Bq/g)
U-238	0.047	0.086	0.210
Th-232	0	0.007	0.077

	Radionuclide	Exposure Time (hr/yr)	Activity Concentration (Bq/Kg)	DCF** (Sv/hr)/(Bq/kg)	Dose µSv/yr	Total Dose µSv/yr
External (Outdoors)	U-238	5700	210	3.1E-15	3.8E-03	0.010
	Th-232	5700	77	1.4E-14	6.0E-03	
External (Indoors)	U-238	3100	210	3.1E-15	2.0E-03	0.005
	Th-232	3100	77	1.4E-14	3.2E-03	
					Total (µSv/yr)	0.015

5.2 Internal Exposure

As shown in

Figure 7, depending on the prevailing atmospheric conditions, the contaminants on the soil may be re-suspended into the air and through the process of re-suspension, airborne contaminants can thus be redistributed. Exposure to the soil concentration also contributes to an external gamma radiation dose.

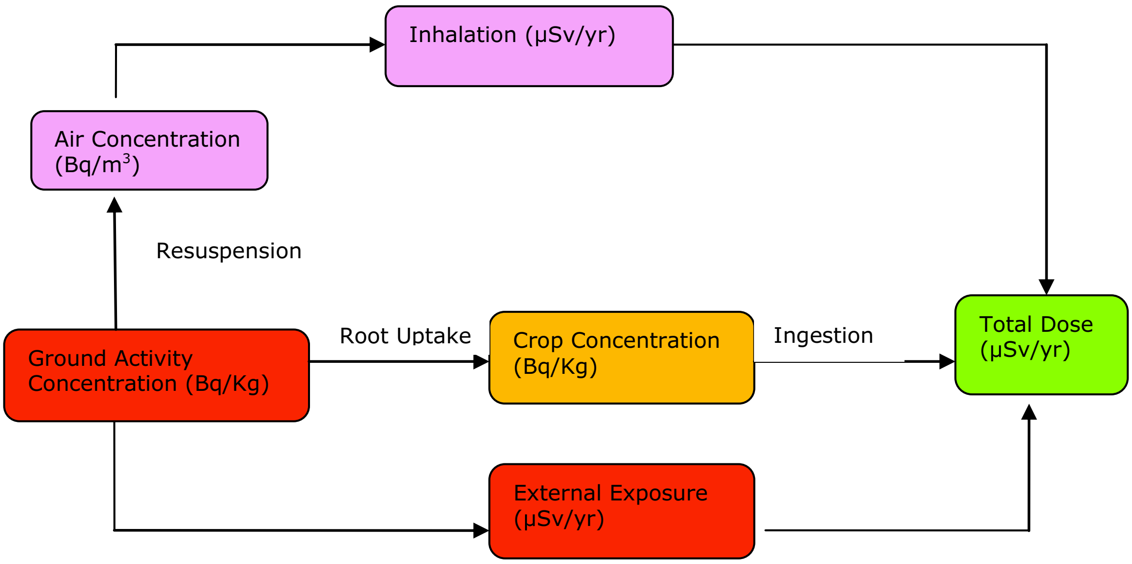

Figure 7 – *Schematic diagram for the residential scenario*

To calculate the inhalation dose that members of the public will be exposed to from airborne LLRD concentrations, it is necessary to make certain human behaviour assumptions:

a) An exposure period of 5700 $h.a^{-1}$ to be spent outdoors at the site in the contaminated air.
b) Human ingestion of the soil is minimal compared to the other exposure pathways and thus not considered.
c) A value of 0.01 was chosen as the dilution factor of the dust to take into account the fact that only a part of the soil or dirt will consist of radioactive material [8].

The mathematical expression to calculate the LLRD inhalation dose is given by:

$$D_{ILLRD} = Conc_{soil} * DL * DCF_{inh} * ET_{LLRD} * BR * DF \quad \textbf{(1)}$$

Where

D_{ILLRD} = Inhalation dose from airborne dust concentration (Sv/yr)
$Conc_{soil}$ = Radionuclide concentration in the soil ($Bq.g^{-1}$)
DL = Dust Loading (g/m^3)
DCF_{inh} = Dose Coefficient for inhalation (Sv/Bq)
ET_{LLRD} = Exposure period to LLRD ($h.yr^{-1}$)
BR = Breathing rate ($m^3\,h^{-1}$)
DF = Dilution Factor

The Radionuclide concentration in airborne dust ($Bq.m^{-3}$) can be calculated from the product of the Activity concentration of the soil (Bq/g) and the dust loading (g/m^3). A dust loading of 1 mg/m^3 is assumed.

Since an exposure period of 5700 hours per year and the dilution factor of 0.01 is assumed, equation (1) can be written as for each age group:

$$D_{ILLRD} = Conc_{soil} * 1\ mg/m^3 * DCF_{inh} * BR * 5700\ h/yr * 0.01 \quad \textbf{(2)}$$

OR

$$D_{ILLRD} = 0.057\ gh.m^{-3}yr^{-1} * Conc_{soil} * DCF_{inh} * BR \quad \textbf{(3)}$$

The transfer of contaminants to crops can occur through root uptake of contaminants in the soil, followed by internal redistribution of radionuclides within the plant. Human ingestion of contaminated crops, soil or the inhalation of airborne LLα will result in an internal human dose. Processes that may lead to the reduction of radionuclide concentrations in vegetation include radioactive decay, growth dilution, wash-off of externally deposited radionuclides, leaching and soil fixation.

The mathematical expression to calculate the ingestion dose from eating secondary crops (e.g. fruit, cereals, leafy or root vegetables) grown on the contaminated soil is given by:

$D_{ing} = Conc_{soil} * DCF_{ing} * CF_{crops} * CR$

Where
D_{ing} = Ingestion dose from eating leafy or root vegetables (Sv/yr)
$Conc_{soil}$ = Radionuclide concentration in the soil (Bq/Kg)
DCF_{ing} = Dose conversion factor for ingestion (Sv/Bq)
CF_{crops} = Concentration factor from soil to crop (-)
CR = Annual consumption rate (Kg/yr)

Table 3 presents the annual consumption rates for the various age groups as indicated in LG-1032 while Table 4 presents the ingestion dose conversion factors ($Sv.Bq^{-1}$) used in this report. Scaling factors (as a percentage of adult consumption value) of 60 and 40 were applied to the 10 and 1 year age groups [LG-1032] and included in Table 3. Table 5 provide the breathing rates used in the calculation of the exposure from the atmospheric pathway.

Table 3 – Annual Consumption rates (Kg/yr)

	Age Dependent Ingestion Rates ($Kg.a^{-1}$)		
	1 Year	**10 Years**	**Adults**
Root Crop *	68	102	170
Leafy Vegetable **	22	33	55

* - Values from LG-1032
** - Values determined from NUREG/CR-5512

Table 4 - Dose conversion factors ($Sv.Bq^{-1}$) for various radionuclides.

Isotope	Ingestion Dose Coefficient ($Sv\ Bq^{-1}$) for the various age groups		
	Infant	Child	Adults
^{232}Th	4.50E-07	2.90E-07	2.30E-07
^{228}Ra	5.70E-06	3.90E-06	6.90E-07
^{228}Th	3.70E-07	1.50E-07	7.20E-08
^{224}Ra	6.60E-07	2.60E-07	6.50E-08
^{238}U	1.20E-07	6.80E-08	4.50E-08
^{230}Th	4.10E-07	2.40E-07	2.10E-07
^{226}Ra	9.60E-07	8.00E-07	2.80E-07