Appendix D. Project Specific Geotechnical Investigation Factual Report

1. Introduction

Jacobs Group Australia (Jacobs) has completed the geotechnical investigation for the detailed business case of the Stage 2 Haughton Pipeline Project. This report contains the findings of the geotechnical testing undertaken along the proposed pipeline alignment and associated infrastructure.

The Haughton Pipeline Project was recommended by the Townsville Water Security Task Force in order to increase water security in Townsville to support the current population and facilitate future growth of the region. The recommendations consisted of two stages. The first stage was the construction of a new pipeline between the Haughton balancing storage / pump station and Ross River Dam to replace the ageing supply pipeline. The second stage was to extend the pipeline to the Burdekin River as an option to increase future water security under predicted demand scenarios.

The Queensland government agreed to commit $225 million to implement the recommendations made by the Townsville Water Security Task Force. The Townsville City Council used the funds to commence work on Stage 1 of the pipeline. Construction of this stage is currently underway.

It was identified by the taskforce that the second stage of the pipeline can be built now or in the future. However, it was found that a saving of $55 million in capital costs could be made if construction of both stages of the pipeline are undertaken concurrently.

This detailed business case undertaken by Jacobs focuses on investigating the technical and economic feasibility and desirability of constructing both stages of the pipeline concurrently under various configurations, or later.

This report will provide factual geotechnical information obtained from the geotechnical investigations undertaken for the detailed business case of the Stage 2 Haughton Pipeline Project. The data gathered for this site-specific investigation campaign has been used in the interpretation of ground conditions and related design of ground engineering aspects of the proposed works.

2. Fieldwork

2.1 Overview

Fieldwork was undertaken between 2 May 2019 and 15 May 2019. The proposed original investigation comprised thirty-two (32) test pits and twelve (12) boreholes. However, due to complications with obtaining access to SunWater owned property (at the northern end of the Stage 2 alignment) and time constraints, the investigation was reduced to twenty-six (26) test pits (including Dynamic Cone Penetrometer (DCP) tests) and nine (9) boreholes. A summary of the investigations undertaken is provided in Table 1 and the test locations are shown in Figure 1.

Prior to any intrusive investigations, test locations were checked against plans obtained through Dial Before You Dig (DBYD) searches online. Service locating using a subcontracted service locator or via potholing was not undertaken as the DBYD searches did not reveal any services in the extent of the investigation.

The investigation was undertaken in the full-time presence of two geotechnical engineers from Jacobs who were responsible for directing the borehole drilling, test pitting, DCP testing, collecting samples for testing, logging and photographing test pit excavations. Test locations were located and recorded using a hand-held GPS with an anticipated accuracy of +/- 5m. Surface RL's were estimated based on LiDAR surveys obtained from the Department of Natural Resources, Mines and Energy dated 2009 and 2011.

Photographs taken during the investigation are presented in Appendix A. Engineering logs of the boreholes and test pits are presented in Appendix B. DCP test results are presented in Appendix C.

Table 1 - Summary of test locations

Test Location	Date Commenced	Date Completed	GPS Co-ordinates (MGA94 Zone 55K)		RL (m AHD)	Test location Depth (in m BGS)	Reason for Termination	Corresponding DCP Test Depth (m)
			Easting (m)	Northing (m)				
JBH1	3/05/2019	3/05/2019	522734	7796602	37.86	19.58	Target depth	-
JBH2	7/05/2019	7/05/2019	522765	7796545	37.7	9.75	Target depth	-
JBH3	8/05/2019	8/05/2019	522814	7796451	37.86	18.41	Target depth	-
JBH4	9/05/2019	9/05/2019	512265	7803040	34.11	9.95	Target depth	-
JBH5	9/05/2019	9/05/2019	511518	7804152	34.41	9.76	Target depth	-
JBH6	10/05/2019	10/05/2019	510896	7807858	31.60	9.60	Target depth	-
JBH7	11/05/2019	11/05/2019	509906	7809257	33.39	9.75	Target depth	-
JBH8	11/05/2019	11/05/2019	510259	7811103	28.59	10.95	Target depth	-
JBH9	15/05/2019	15/05/2019	509031	7817337	28.18	9.95	Target depth	-
JTP1	2/05/2019	2/05/2019	522781	7796526	37.38	3.40	Refusal	2.10
JTP2	2/05/2019	2/05/2019	522816	7796168	41.58	2.40	Refusal	1.17
JTP3	7/05/2019	7/05/2019	522235	7796529	38.38	2.80	Refusal	0.58
JTP4	3/05/2019	3/05/2019	521965	7797058	37.45	3.50	Machine Limit	3.475
JTP5	7/05/2019	7/05/2019	521834	7797366	38.88	3.60	Machine Limit	4.00
JTP6	3/05/2019	3/05/2019	521250	7798266	36.72	2.00	Refusal	0.59

Test Location	Date Commenced	Date Completed	GPS Co-ordinates (MGA94 Zone 55K)		RL (m AHD)	Test location Depth (in m BGS)	Reason for Termination	Corresponding DCP Test Depth (m)
			Easting (m)	Northing (m)				
JTP7	3/05/2019	3/05/2019	520973	7798703	36.04	3.50	Machine Limit	3.69
JTP8	3/05/2019	3/05/2019	520582	7799239	35.90	3.50	Machine Limit	0.76
JTP9	3/05/2019	3/05/2019	520277	7799718	35.79	1.10	Refusal	0.27
JTP10	2/05/2019	2/05/2019	519470	7800260	35.75	1.40	Refusal	1.11
JTP11	2/05/2019	2/05/2019	518841	7801109	35.62	3.20	Refusal	1.395
JTP12	7/05/2019	7/05/2019	518115	7801316	35.01	1.30	Refusal	1.05
JTP13	7/05/2019	7/05/2019	517621	7801412	36.13	0.95	Refusal	0.9
JTP14	8/05/2019	8/05/2019	515032	7801363	35.68	1.30	Refusal	0.58
JTP15	8/05/2019	8/05/2019	514577	7801397	35.39	1.75	Refusal	0.6
JTP16	8/05/2019	8/05/2019	513823	7801830	35.56	1.40	Refusal	0.5
JTP17	8/05/2019	8/05/2019	512551	7802854	33.87	3.40	Machine Limit	1.4
JTP18	8/05/2019	8/05/2019	511286	7804595	33.76	1.40	Refusal	1.065
JTP19	9/05/2019	9/05/2019	511112	7805040	34.02	1.00	Refusal	0.495
JTP20	9/05/2019	9/05/2019	511390	7806475	39.37	1.60	Refusal	1.3
JTP21	9/05/2019	9/05/2019	510282	7808472	32.81	2.20	Refusal	1.7
JTP22	9/05/2019	9/05/2019	510062	7810514	29.71	2.20	Refusal	1.0
JTP23	10/05/2019	10/05/2019	509646	7812609	30.15	3.40	Machine Limit	1.8
JTP24	10/05/2019	10/05/2019	509339	7814165	30.60	3.10	Refusal	1.9
JTP25	10/05/2019	10/05/2019	509087	7815882	29.95	3.50	Machine Limit	3.2
JTP26	10/05/2019	10/05/2019	508429	7818500	29.10	3.40	Machine Limit	2.9

Notes: Position recorded using handheld GPS with anticipated accuracy of ±5m (UTM Zone 55K). Surface reduced levels based on LiDAR surveys obtained from the Department of Natural Resources, Mines and Energy from 2009 and 2011.

2.2 Test Pits

Test pits were excavated using a John Deere 3155KK backhoe equipped with an extendable arm and a 600mm digging bucket fitted with teeth attachments at twenty-six (26) locations. Disturbed samples were collected from all distinctive soil layers identified within the full depth of each test pit.

Hand penetrometer testing was undertaken on fine grained soil on test pit walls to a depth of 1m and on clumps of relatively undisturbed cohesive soil obtained from the backhoe bucket until the termination depth of each excavation.

Each test pit was supplemented with a Dynamic Cone Penetrometer (DCP) test performed directly adjacent to the test pit. The results of DCP testing were recorded as blows per 100mm of penetration and was generally

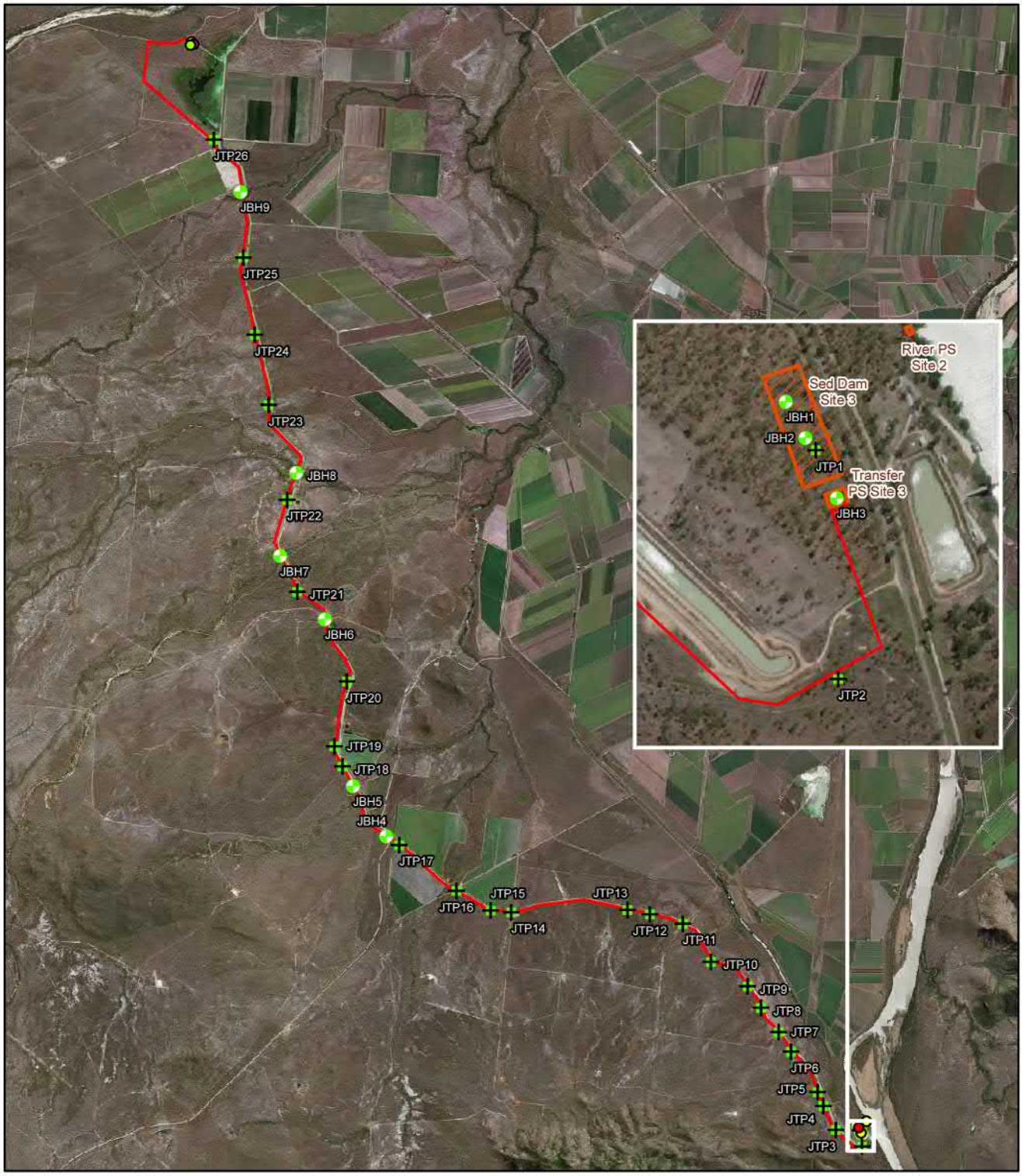
terminated when blow counts exceeded three consecutive blow counts of 15 or greater, or a single blow count of 20.

Groundwater levels were recorded where encountered during the investigation. Test pits were excavated to varying depths depending on the conditions encountered as described in Table 1. Engineering logs of the test pits are presented in Appendix B. DCP test results are presented in Appendix C.

2.3 Boreholes

Boreholes were drilled using a truck mounted geotechnical drilling rig using solid flight auger and rotary wash boring techniques at nine (9) locations shown in Figure 1. Auger drilling was utilised in the first instance generally in the upper 3m with wash boring methods being utilised thereafter. SPT's were generally undertaken at 1.0m intervals typically starting at 0.5m below the ground level. Samples recovered from the split spoon sampler were logged, bagged and sealed for potential further laboratory testing. Acid sulfate soil (ASS) samples were also generally collected at 0m (surface), 0.25m, 0.5m, 1.00m, and at every SPT test in the top 6.5m. Engineering logs of boreholes are presented in Appendix B.

Figure 1. Geotechnical Investigation Overview



LEGEND

Pipeline Infrastructure

- Haughton Balancing Storage
- Pump Station
- Haughton Surge Tank
- Sediment Dam Site
- Proposed Pipeline

Geotechnical Locations Completed

- Test Pit
- Borehole

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Source: Jacobs: Pipeline locations, Geotechnical locations (2019), ESRI: Imagery (2016)

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3. Laboratory Testing

3.1 Geotechnical Classification and Emerson Class Testing

Geotechnical Classification testing was undertaken in accordance with Australian Standards in the NATA accredited testing laboratory operated by Construction Sciences in Townsvillle. Results of moisture content, Atterberg limits, particle size distribution (grading) and Emerson Class Number testing are summarised in Table 2.

Table 2 – Summary of Laboratory Test Results

Test Location	Depth (m)	MC (%)	Atterberg Limits				Grading Standard			Emerson Class Number	Material Classification
			LL (%)	PL (%)	PI	LS (%)	Fines (%)	Sand (%)	Gravel (%)		
JBH1	0.50 – 0.95	-	-	-	-	-	-	-	-	2	Silty CLAY
JBH1	1.50 – 1.95	13.2	33	15	18	9	72	28	0	2	CLAY
JBH2	1.50 - 1.95	6.8	-	-	-	-	72	28	0	2	CLAY
JBH3	1.50 – 1.95	12.0	-	-	-	-	72	28	0	2	CLAY
	3.50 – 3.95	11.2	-	-	-	-	67	33	0	-	Sandy CLAY
	6.50 – 6.95	10.2	-	-	-	-	66	34	0	-	Sandy CLAY
JBH4	1.50 – 1.95	12.2	-	-	-	-	47	50	3	2	Sandy CLAY
	5.50 – 5.95	16.8	-	-	-	-	38	61	1	-	Sandy CLAY
JBH5	7.50 – 7.95	14.3	-	-	-	-	19	68	13	2	CLAYEY SAND
JBH6	1.50 – 1.95	12.3	36	15	21	9	50	50	0	-	Sandy CLAY
JBH7	1.50 – 1.92	13.4	-	-	-	-	38	59	3	2	Sandy CLAY
	4.50 - 4.95	14.2	-	-	-	-	27	73	0	2	CLAYEY SAND
JBH8	1.55 – 1.95	-	-	-	-	-	43	57	0	-	Sandy CLAY
	3.50 – 3.56	-	-	-	-	-	14	74	12	-	CLAYEY SAND
JBH9	0.50 – 0.95	10.4	-	-	-	-	52	45	3	2	Sandy CLAY
	3.50 – 3.95	17.8	-	-	-	-	64	35	1	2	Sandy CLAY
JTP1	0.80 - 1.00	9.7	25	16	9	6	55	45	0	2	Sandy CLAY
	3.10 – 3.20	7.8	27	17	10	7	61	39	0	5	Sandy CLAY
JTP2	0.60 - 0.70	14.4	54	23	31	18	67	13	20	5	CLAY
JTP3	0.50 – 0.70	-	-	-	-	-	-	-	-	2	Sandy CLAY
	2.30 – 2.40	10.3	50	17	33	16	77	22	1	2	CLAY
JTP4	2.80 – 2.90	13.2	37	15	22	8	66	24	10	2	CLAY
JTP5	0.50 – 0.60	12.0	27	20	7	4	-	-	-	5	CLAY
JTP6	0.50 – 0.60	7.5	-	-	-	-	62	32	6	5	Sandy CLAY
JTP7	1.90 – 2.00	17.1	88	19	69	17	72	24	4	2	CLAY
JTP8	2.50 - 2.60	8.4	47	30	17	10.5	11	57	32	3	Gravelly SAND
JTP9	0.40 – 0.50	5.5	18	15	3	2	-	-	-	3	SLIT
JTP11	0.60 – 0.80	13.6	26	13	13	9	52	46	2	5	Sandy CLAY

Test Location	Depth (m)	MC (%)	Atterberg Limits				Grading Standard			Emerson Class Number	Material Classification
			LL (%)	PL (%)	PI	LS (%)	Fines (%)	Sand (%)	Gravel (%)		
JTP14	0.9 – 1.00	11.4	28	13	15	11.5	40	55	2	3	Sandy CLAY
JTP16	0.40 - 0.50	13.7	21	13	8	7	35	63	2	5	Sandy CLAY
JTP17	0.60 -0.70	21.8	-	-	-	-	76	23	1	5	CLAY
	2.60 – 2.70	10.1	30	16	14	10.5	28	67	5	6	CLAYEY SAND
JTP18	0.40 -0.50	1.6	-	-	-	-	26	73	1	3	CLAYEY SAND
	0.80 -0.90	7.6	-	-	-	-	26	25	49	-	CLAYEY GRAVEL
JTP19	0.80 - 0.90	8.0	23	11	12	8	44	52	4	2	Sandy CLAY
JTP20	1.30 – 1.40	8.0	-	-	-	-	17	62	21	-	CLAYEY SAND
JTP21	0.30 – 0.40	15.0	22	17	5	3.5	49	51	0	5	Sandy CLAY
	2.10 – 2.20	10.3	20	12	8	6	23	61	16	2	CLAYEY SAND
JTP23	0.50 – 0.60	9.9	34	16	18	12.5	61	36	3	2	Sandy CLAY
	2.80 – 2.90	2.3	-	-	-	-	10	85	5	2	SAND
JTP24	2.60 - 2.70	14.9	49	16	33	16	68	30	2	2	CLAY
JTP25	1.20 –1.30	13.2	42	21	21	15	62	35	3	2	Sandy CLAY
	2.70 – 2.80	13.9	41	18	23	14.5	69	29	2	2	CLAY
JTP26	0.30 -0.40	18.0	24	12	12	8	64	34	2	3	Sandy CLAY

Notes: MC = field moisture content, LL = liquid limit, PL = plastic limit, PI = plasticity index, LS = linear shrinkage, Fines = particles less than 75μm , Sand = particles between 75μm and 2.36mm, Gravel = particles greater than 2.36mm, MDD = Maximum Dry Density, OMC = Optimum Moisture Content, DD = Dry Density, CBR soaked for 4 days.

3.2 Particle Size Distribution (PSD)

Particle size distribution were undertaken on representative material samples. The test results are summarised in Table 3 and graphically illustrated in Figures 2,3,4 and 5. Laboratory test results are included in Appendix D.

Table 3 – Summary of Particle Size Test Results.

Test Location	Depth (m)	Fines (%) (<0.075mm)	Coarse (%)		Material Classification
			Sand (0.075mm – 2.36mm)	Gravel (2.36mm – 63mm)	
JBH1	1.50 – 1.95	72	28	0	CLAY
JBH2	1.5 0- 1.95	72	28	0	CLAY
JBH3	1.50 – 1.95	72	28	0	CLAY
	3.50 – 3.95	67	33	0	Sandy CLAY
	6.50 – 6.95	66	34	0	Sandy CLAY
JBH4	1.50 – 1.95	47	50	3	Sandy CLAY

Test Location	Depth (m)	Fines (%) (<0.075mm)	Coarse (%)		Material Classification
			Sand (0.075mm – 2.36mm)	Gravel (2.36mm – 63mm)	
	5.50 – 5.95	38	61	1	Sandy CLAY
JBH5	7.50 – 7.95	19	68	13	CLAYEY SAND
JBH6	1.50 – 1.95	50	50	0	Sandy CLAY
JBH7	1.50 – 1.92	38	59	3	Sandy CLAY
	4.50 – 4.95	27	73	0	CLAYEY SAND
JBH8	1.55 –1.95	43	57	0	Sandy CLAY
	3.50 – 3.56	14	74	12	CLAYEY SAND
JBH9	0.50 – 0.95	52	45	3	Sandy CLAY
	3.50 – 3.95	64	35	1	Sandy CLAY
JTP1	0.80 -1.00	55	45	0	Sandy CLAY
	3.10 – 3.20	61	39	0	Sandy CLAY
JTP2	0.60 - 0.70	67	13	20	CLAY
JTP3	2.30 – 2.40	77	22	1	CLAY
JTP4	2.80 – 2.90	66	24	10	CLAY
JTP6	0.50 – 0.60	62	32	6	Sandy CLAY
JTP7	1.90 – 2.00	72	24	4	CLAY
JTP8	2.50 - 2.60	11	57	32	Gravelly SAND
JTP11	0.60 – 0.80	52	46	2	Sandy CLAY
JTP14	0.90 – 1.00	40	55	5	Sandy CLAY
JTP16	0.40 - 0.50	35	63	2	Sandy CLAY
JTP17	0.60 - 0.70	76	23	1	CLAY
	2.60 – 2.70	28	67	5	CLAYEY SAND
JTP18	0.40 - 0.50	26	73	1	CLAYEY SAND
	0.80 - 0.90	26	25	49	CLAYEY GRAVEL
JTP19	0.80 - 0.90	44	52	4	Sandy CLAY
JTP20	1.30 – 1.40	17	62	21	CLAYEY SAND
JTP21	0.30 – 0.40	49	51	0	Sandy CLAY
JTP21	2.10 – 2.20	23	61	16	CLAYEY SAND
JTP23	0.50 – 0.60	61	36	3	Sandy CLAY
	2.80 – 2.90	10	85	5	SAND
JTP24	2.60 - 2.70	68	30	2	CLAY
JTP25	1.20 –1.30	62	35	3	Sandy CLAY
	2.70 – 2.80	69	29	2	CLAY
JTP26	0.30 - 0.40	64	34	2	Sandy CLAY

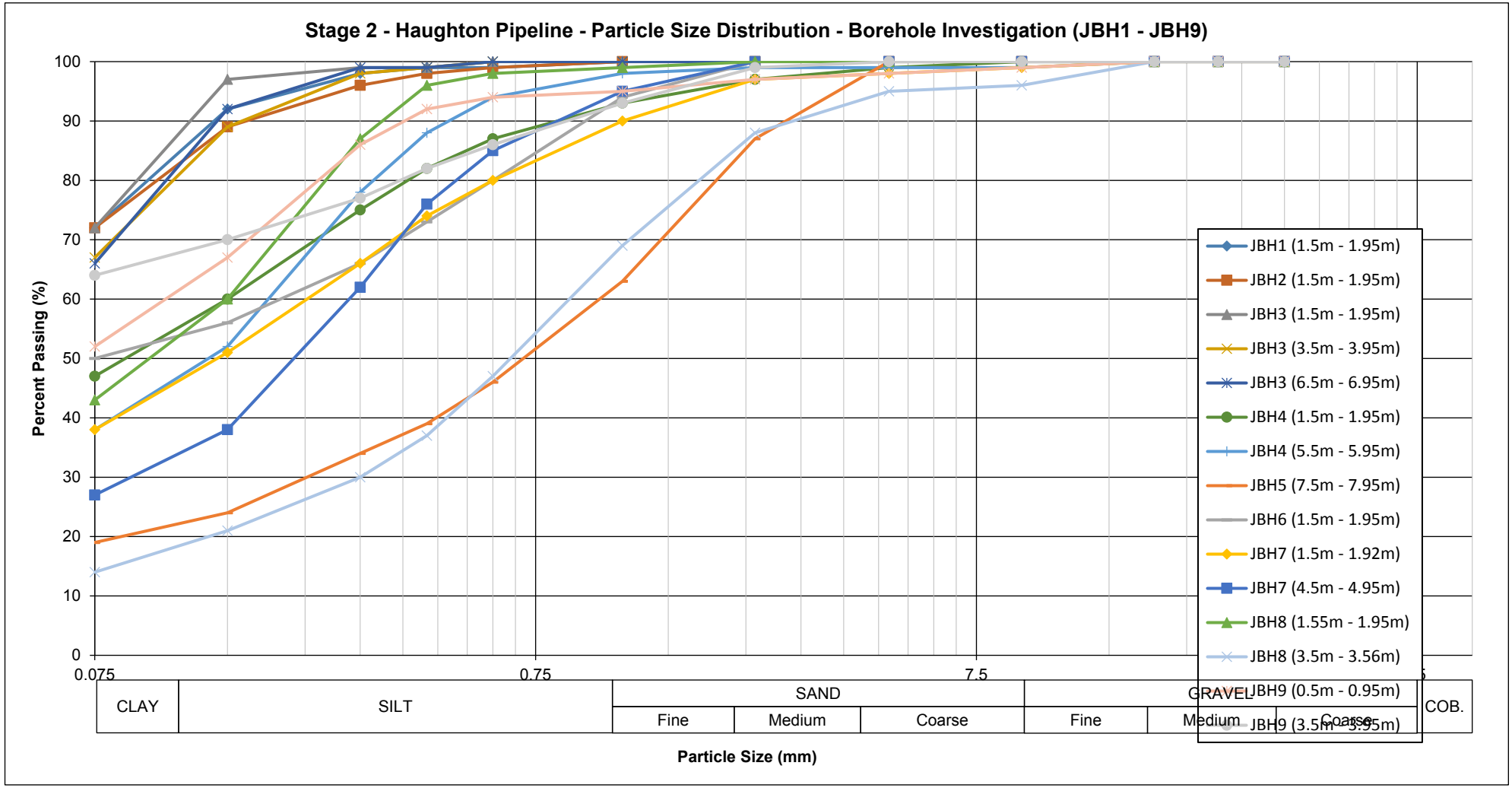


Figure 2. Particle Size Distribution Plot – Borehole Investigation (JBH1 – JBH9).

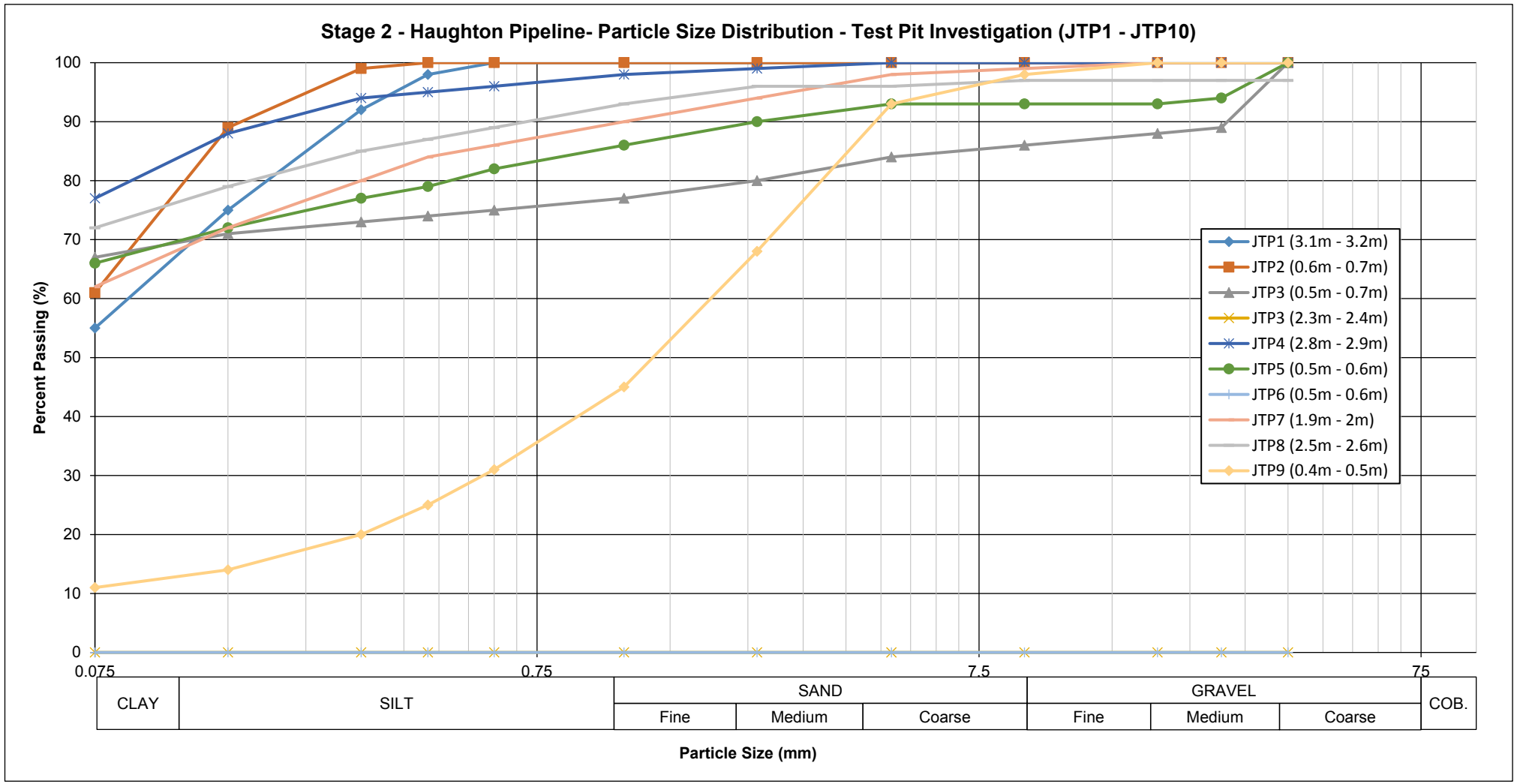


Figure 3. Particle Size Distribution Plot – Test Pit Investigation (JTP1 – JTP10).

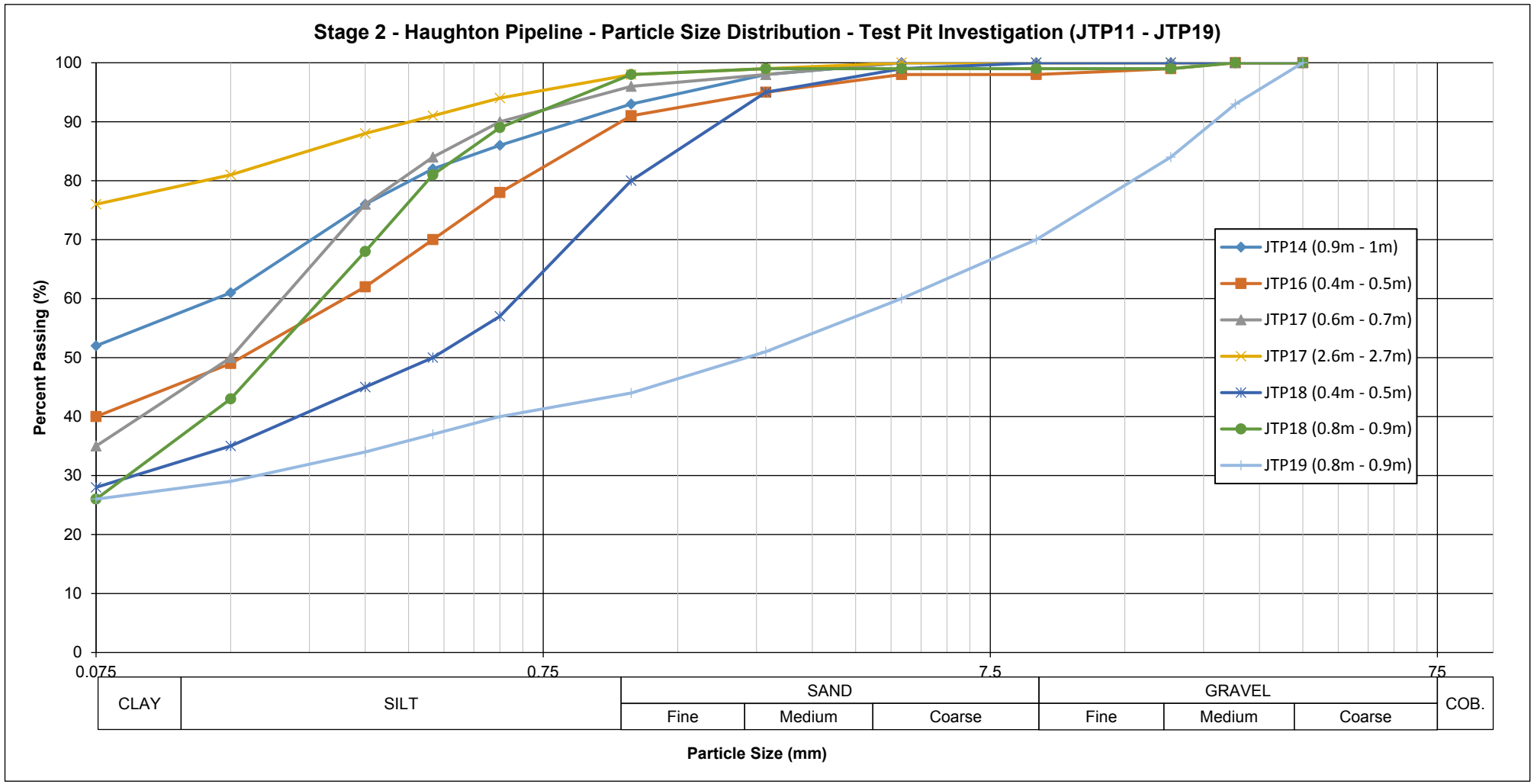


Figure 4. Particle Size Distribution Plot – Test Pit Investigation (JTP11 – JTP19).

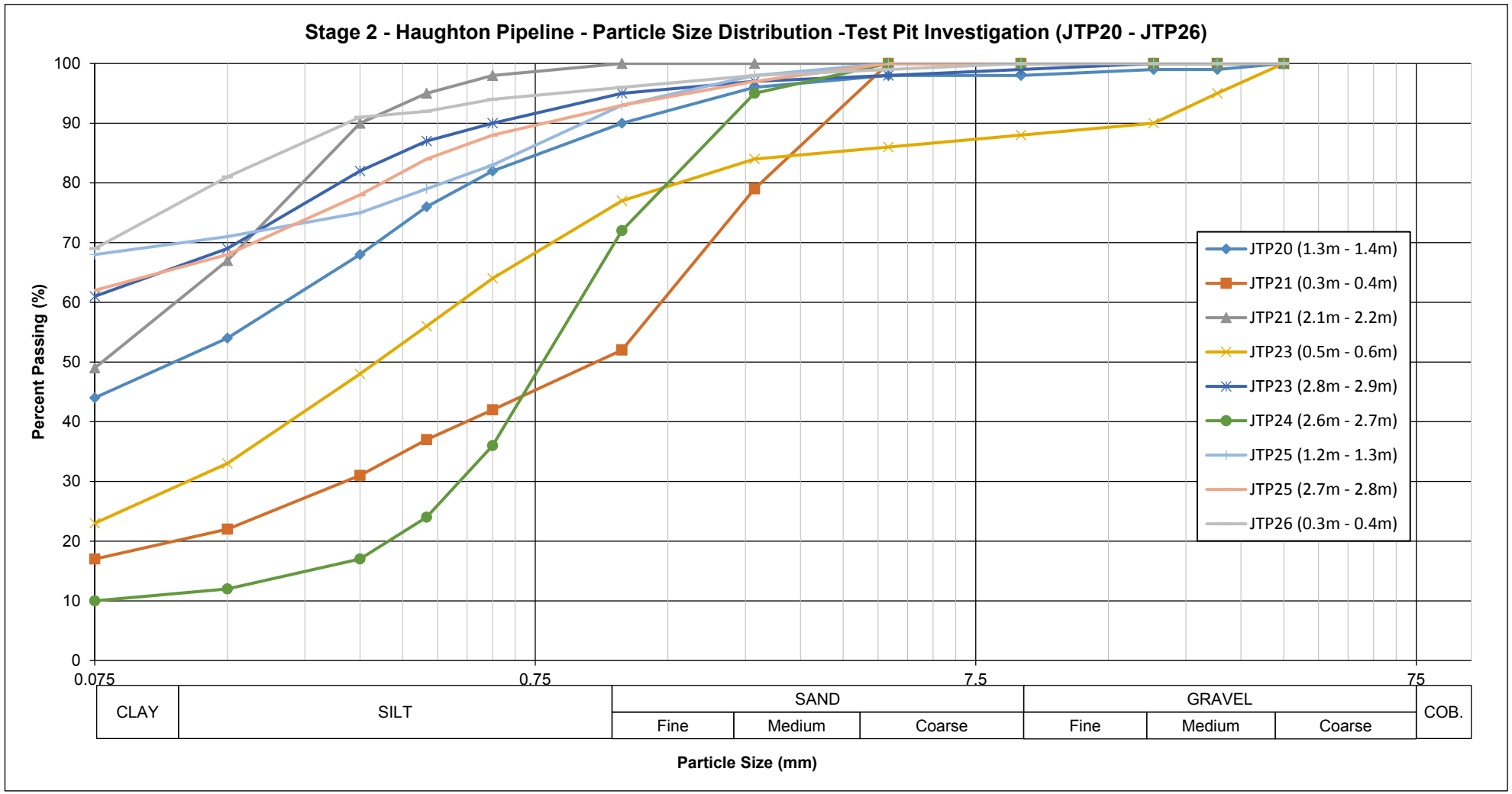


Figure 5. Particle Size Distribution – Test Pit Investigation (JTP20 – JTP26).

3.3 Atterberg Limits

Atterberg limit testing was undertaken on representative material samples from the test pits and the borehole. The test results are summarised in Table 4 and graphically illustrated in Figures 6, 7, 8 and 9. Laboratory test results are included in Appendix D.

Table 4 – Summary of Atterberg Limit Test Results.

Test Location	Depth (m)	Moisture Content (%)	Atterberg Limits				Material Classification
			Liquid Limit (%)	Plastic Limit (%)	Plastic Index (%)	Linear Shrinkage (%)	
JBH1	1.50 – 1.95	13.2	33	15	18	9	CLAY
JBH6	1.50 – 1.95	12.3	36	15	21	9	Sandy CLAY
JTP1	0.80 -1.00	9.7	25	16	9	6	Sandy CLAY
	3.10 – 3.20	7.8	27	17	10	7	Sandy CLAY
JTP2	0.60 – 0.70	14.4	54	23	31	18	CLAY
JTP3	2.30– 2.40	10.3	50	17	33	16	CLAY
JTP4	2.80 – 2.90	13.2	37	15	22	8	CLAY
JTP5	0.50 – 0.60	12	27	20	7	4	CLAY
JTP7	1.90 – 2.00	17.1	88	19	69	17	CLAY
JTP8	2.50 - 2.60	8.4	47	13	15	10.5	Gravelly SAND
JTP9	0.40 – 0.50	5.5	18	15	3	2	SLIT
JTP11	0.60 – 0.80	13.6	26	13	13	9	Sandy CLAY
JTP14	0.90 – 1.00	11.4	28	13	15	11.5	Sandy CLAY
JTP16	0.40 – 0.50	13.7	21	13	8	7	Sandy CLAY
JTP17	2.60 – 2.70	10.1	30	16	14	10.5	CLAYEY SAND
JTP19	0.80 – 0.90	8	23	11	12	8	Sandy CLAY
JTP21	0.30 – 0.40	15	22	17	5	3.5	Sandy CLAY
	2.10 – 2.20	10.3	20	12	8	6	CLAYEY SAND
JTP23	0.50 – 0.60	9.9	34	16	18	12.5	Sandy CLAY
JTP24	2.60 – 2.70	14.9	49	16	33	16	CLAY
JTP25	1.20 – 1.30	13.2	42	21	21	15	Sandy CLAY
	2.70 – 2.80	13.9	41	18	23	14.5	CLAY
JTP26	0.30 – 0.40	18	24	12	12	8	Sandy CLAY

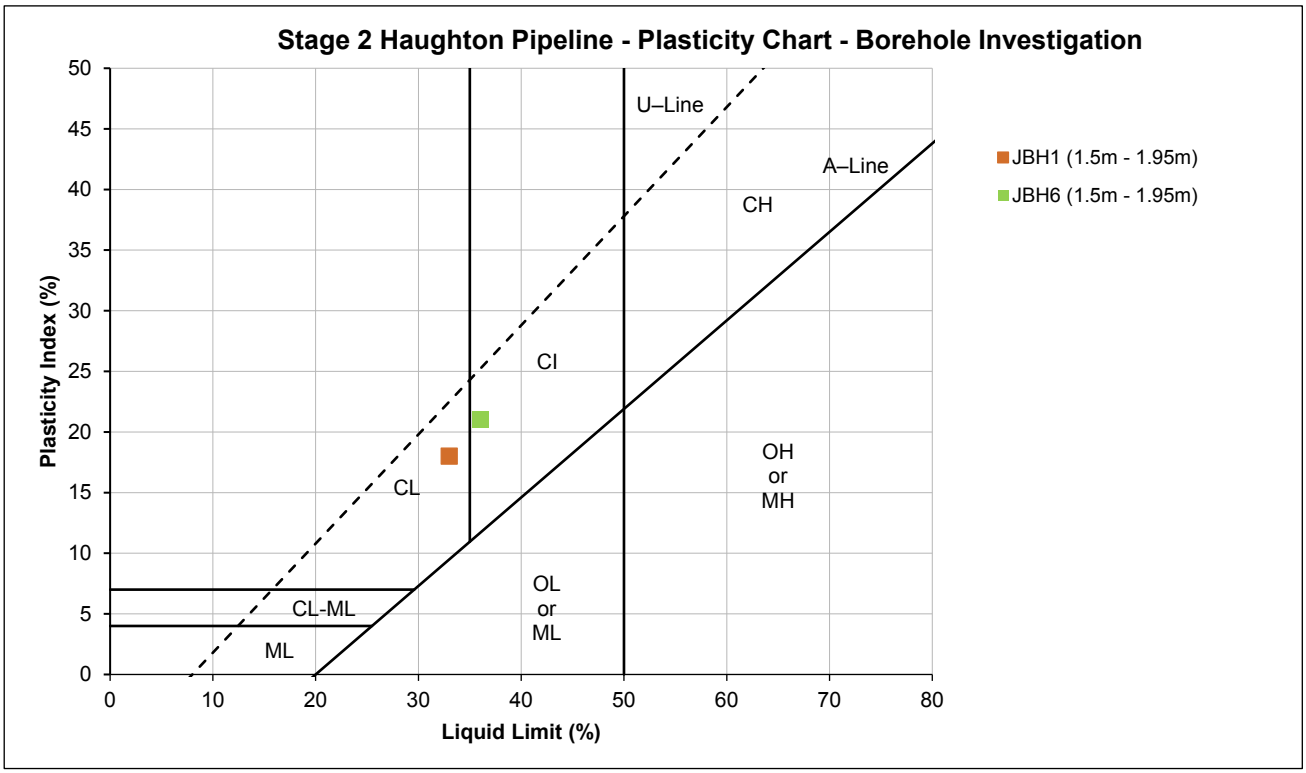


Figure 6. Atterberg Limit Test Results – Borehole Investigation.

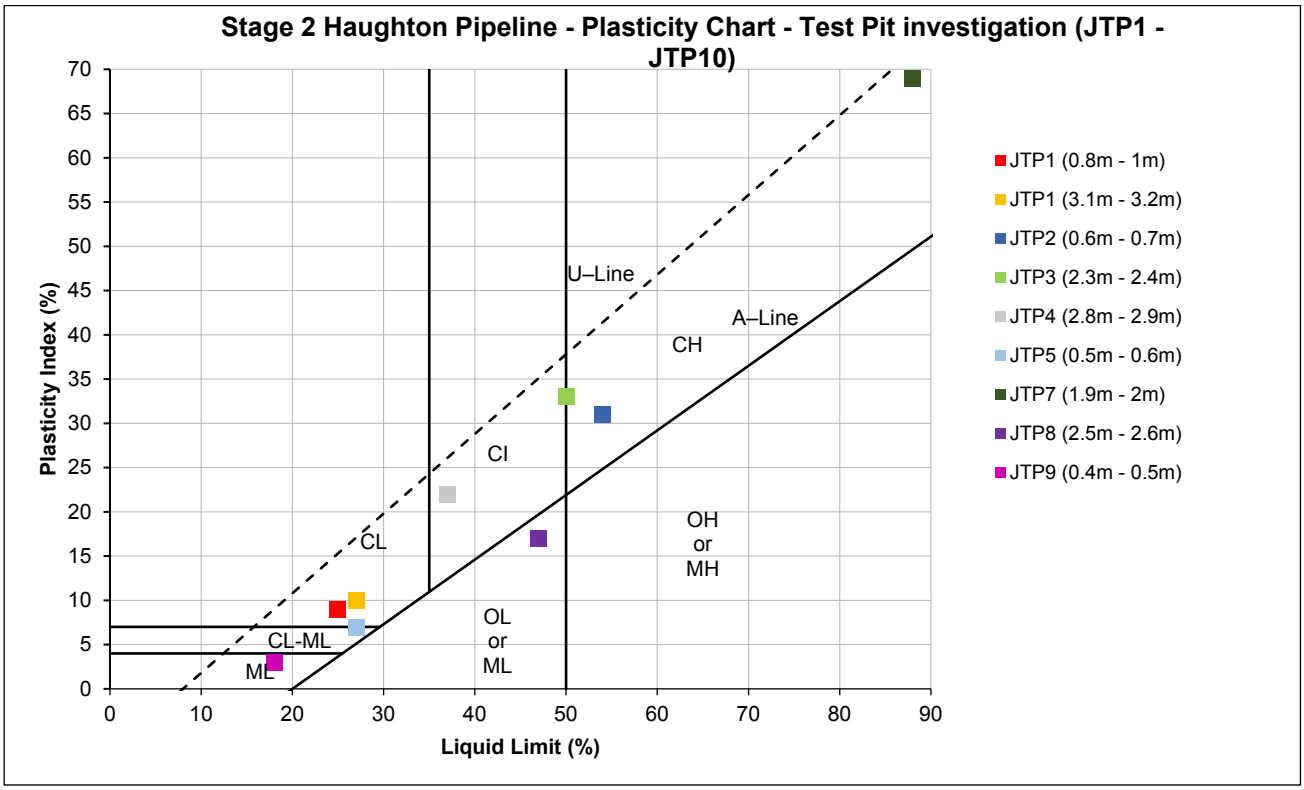


Figure 7. Atterberg Limit Test Results – Test Pit Investigation (JTP1 – JTP10).

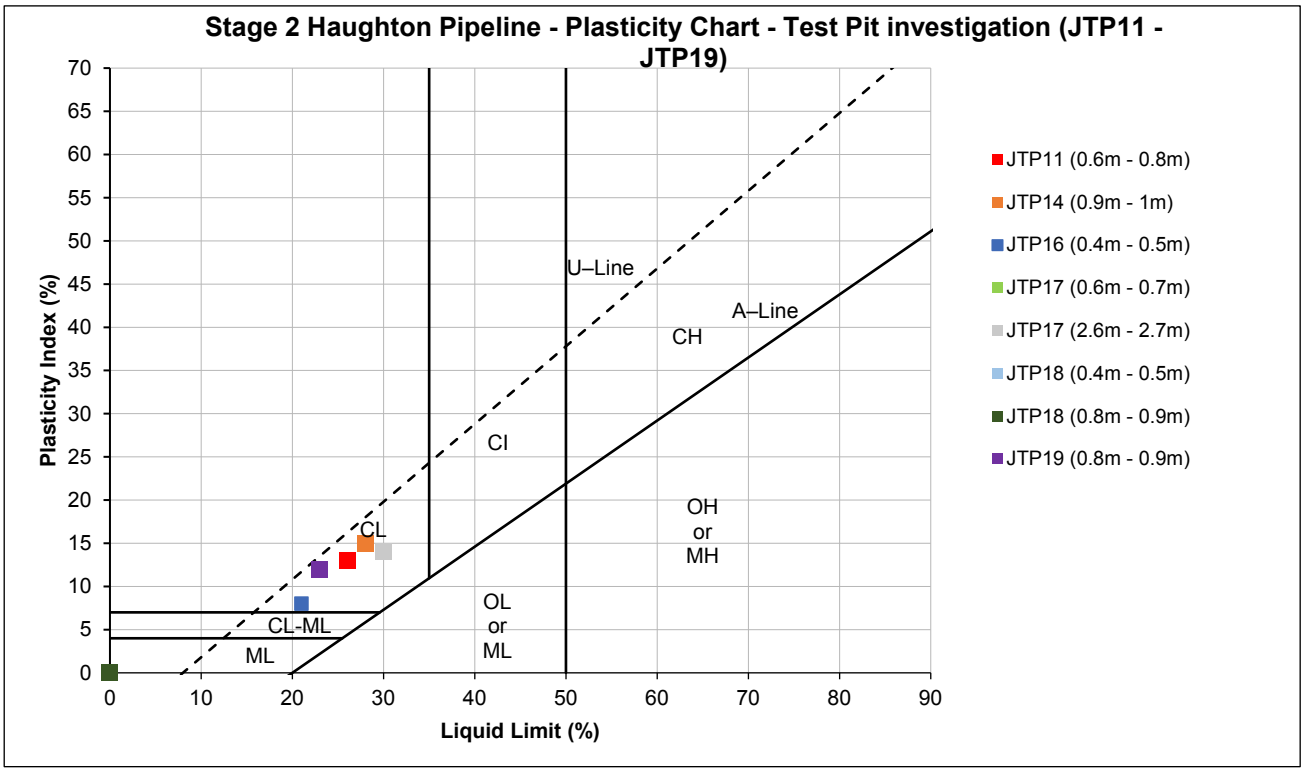


Figure 8. Atterberg Limit Test Results – Test Pit Investigation (JTP11 – JTP19).

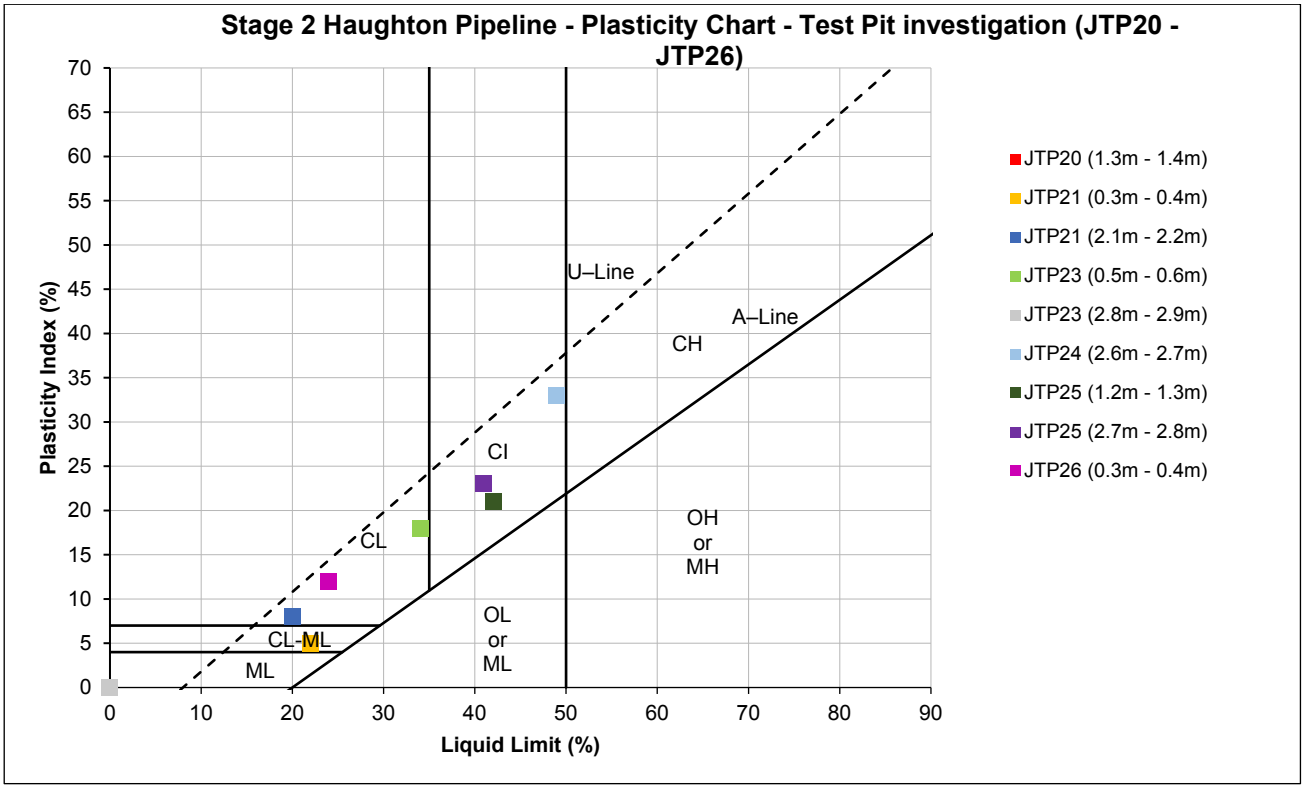


Figure 9. Atterberg Limit Test Results – Test Pit Investigation (JTP20 – JTP26).

3.4 Acid Sulphate Soil Testing

Samples for Acid Sulphate Soil (ASS) testing were stored on ice in the field and frozen for at least 24 hours then freighted to ALS in Brisbane for NATA accredited testing. Screening tests were undertaken on all samples collected in the field. Subsequently, more rigorous chromium suite testing was undertaken on selected samples which showed the strongest indications of being ASS.

The laboratory test certificates for screening results and chromium suite tests are presented in Appendix D. A summary of the screening results is shown in Table 5 and the Chromium suite results are summarised in Table 6.

Table 5 - Summary of ASS Screening Results.

Location	Depth (m)	pH_f	pH_{fox}	Reaction Rate	Selected for Chromium Testing?
JBH3	0.00	6.2	3.9	2	Yes
	0.25	6.8	5.0	2	Yes
	0.50	7.0	5.1	2	No
	1.00	7.6	5.5	2	No
	1.50	7.3	6.3	2	No
	2.50	7.2	6.1	2	No
	3.50	7.8	7.2	4	No
	4.50	8.0	7.3	4	No
	5.50	8.1	7.4	4	No
	6.50	8.0	7.3	4	No
JBH4	0.00	5.5	2.6	3	Yes
	0.25	6.7	3.7	4	No
	0.50	7.7	5.6	4	Yes
	1.00	9.2	8.5	4	No
	1.50	9.0	8.3	4	No
	2.50	9.0	8.5	4	No
	5.50	8.8	5.9	2	Yes
	6.50	9.2	6.7	3	No
JBH5	0.00	6.8	3.3	3	No
	0.25	6.6	4.4	4	Yes
	0.50	6.5	4.3	4	No
	1.00	7.0	5.0	2	Yes
	1.50	6.5	5.0	2	No
	2.50	7.4	5.8	2	No
JBH6	0.00	7.0	4.1	3	Yes
	0.25	6.5	4.0	2	Yes
	0.50	6.4	4.4	2	No
	1.00	7.9	5.2	2	Yes
	1.50	8.1	5.5	2	No
	2.50	7.9	5.6	2	Yes
JBH7	0.00	6.4	3.0	3	Yes
	0.25	6.4	3.7	3	Yes

Location	Depth (m)	pH_f	pH_{fox}	Reaction Rate	Selected for Chromium Testing?
	0.50	7.3	5.3	2	No
	1.00	8.1	6.0	2	No
	1.50	9.0	5.8	2	Yes
	2.50	8.9	6.4	2	No
	3.50	8.6	7.8	3	No
	4.50	8.7	5.7	2	Yes
	5.50	8.6	5.7	2	No
	6.50	8.8	5.9	2	No
JBH8	0.00	7.0	4.3	2	Yes
	0.25	7.9	5.9	2	No
	0.50	8.0	5.7	2	No
	1.50	7.4	5.6	2	No
	2.50	7.7	5.5	2	Yes
	3.50	7.9	7.4	4	No
	4.50	8.6	5.7	2	Yes
	5.50	8.8	5.9	2	No
	6.50	6.9	5.6	2	No
JBH9	0.00	6.1	4.9	1	Yes
	0.25	6.3	5.3	4	Yes
	0.50	6.8	5.5	4	No
	0.75	9.0	8.4	4	No
	1.00	8.8	8.1	4	No
	1.50	9.1	8.5	4	No
	2.50	9.1	8.6	4	No
	3.50	8.5	5.8	2	No
	4.50	8.8	8.7	4	No
	5.50	8.3	5.6	2	Yes

Table 6. Summary of Chromium Suite Test Results for ASS.

Location	Depth (m)	CRS (mole H^+/t)	Liming Rate Excluding ANC (kg CaCO3/t)	Net Acidity excluding ANC (mole H^+/t)	ANC Fineness Factor	Net Acidity (mole H^+ / t)	TAA (mole H^+ / t)	Liming Rate (kg $CaCO_3$/t)	pH_{KCL}	Material Classification
JBH3	0.00	<10	<1	<10	1.5	<10	<2	<1	5.7	Silty CLAY
	0.25	<10	<1	<10	1.5	<10	<2	<1	6.0	Silty CLAY
JBH4	0.00	<10	2	20	1.5	20	20	2	4.6	Silty CLAY
	0.50	<10	<1	<10	1.5	<10	2	<1	5.7	CLAY

Location	Depth (m)	CRS (mole H^+/t)	Liming Rate Excluding ANC (kg CaCO3/t)	Net Acidity excluding ANC (mole H^+/t)	ANC Fineness Factor	Net Acidity (mole H^+ / t)	TAA (mole H^+ / t)	Liming Rate (kg $CaCO_3$/t)	pH_{KCL}	Material Classification
	5.50	<10	<1	<10	1.5	<10	<2	<1	6.4	Sandy CLAY
JBH5	0.25	<10	<1	<10	1.5	<10	<2	<1	6.1	Sandy CLAY
	1.00	<10	<1	<10	1.5	<10	5	<1	5.2	Silty CLAY
JBH6	0.00	<10	<1	<10	1.5	<10	<2	<1	5.6	CLAYEY SAND
	0.25	<10	<1	<10	1.5	<10	<2	<1	5.8	SAND
	1.00	<10	<1	<10	1.5	<10	<2	<1	6.0	SAND
	2.50	<10	<1	<10	1.5	<10	3	<1	5.4	Sandy CLAY
JBH7	0.00	<10	<1	<10	1.5	<10	3	<1	5.5	Sandy SILT
	0.25	<10	<1	<10	1.5	<10	2	<1	5.6	Silty CLAY
	1.50	<10	<1	<10	1.5	<10	<2	<1	6.4	CLAYEY SAND
	4.50	<10	<1	<10	1.5	<10	<2	<1	6.1	CLAYEY SAND
JBH8	0.00	<10	<1	<10	1.5	<10	<2	<1	5.4	Sandy SILT
	2.50	<10	<1	<10	1.5	<10	<2	<1	5.5	Silty CLAY
	4.50	<10	<1	<10	1.5	<10	<2	<1	6.2	Sandy CLAY
JBH9	0.00	<10	<1	<10	1.5	<10	2	<1	5.8	CLAY
	0.25	<10	<1	<10	1.5	<10	<2	<1	5.3	CLAY
	5.50	<10	<1	<10	1.5	<10	<2	<1	6.1	Sandy CLAY
Notes: TAA = Titratable Actual Acidity, CRS = Chromium Reducible Sulphur, ANC = Acid Neutralising Capacity										

3.5 Soil Aggressivity Testing

Samples selected for aggressivity testing were sent to ALS in Brisbane. The result of aggressivity testing are summarised in Table 7 and the test certificates are included in Appendix D.

Table 7 - Summary of Soil Aggressivity Testing.

Location	Depth (m)	MC (%)	pH	Soluble Sulphate SO_4^{2-} (mg/kg)	Chloride (mg/kg)	Material Classification
JBH3	1.50 – 1.95	11.4	7.2	<10	40	Silty CLAY
	3.50 – 3.95	10.5	7.8	<10	<10	Sandy CLAY
	6.50 – 6.95	9.6	8.6	<10	<10	Sandy CLAY
JBH4	1.50 – 1.95	11.4	9.1	20	410	CLAY
	5.50 - 5.95	11.1	9.1	50	380	Sandy CLAY
JBH5	1.50 – 1.92	7.6	7.1	<10	200	Silty CLAY
JBH6	1.50 – 1.95	11.1	8.6	10	210	SAND
JBH7	1.50 – 1.92	10.3	9.1	<10	<10	CLAYEY SAND

Location	Depth (m)	MC (%)	pH	Soluble Sulphate SO_4^{2-} (mg/kg)	Chloride (mg/kg)	Material Classification
	3.50 – 3.59	15.9	8.6	<10	20	CLAYEY SAND
	4.50 – 4.95	11.0	8.9	<10	20	CLAYEY SAND
JBH8	0.65 – 0.95	5.1	6.4	<10	310	Silty CLAY
	3.50 – 3.56	11.3	7.6	<10	10	Clayey SAND
JBH9	0.50 - 0.95	19.3	8.4	<10	50	CLAY
	3.50 - 3.95	10.1	9.0	<10	300	Sandy CLAY
JTP1	3.10 – 3.20	7.3	7.4	<10	<10	Sandy CLAY
JTP2	0.60 -0.70	15.2	6.9	<10	20	CLAY
	1.70 -1.80	7.8	9.0	<10	40	CLAYEY GRAVEL
JTP3	0.50 – 0.70	9.5	8.1	40	150	Sandy CLAY
	2.30 – 2.40	9.4	9.9	<10	180	CLAY
JTP4	2.80 – 2.90	12.3	9.6	60	260	CLAY
JTP5	0.50 – 0.60	11.4	7.6	<10	<10	CLAY
JTP6	0.50 – 0.60	7.3	9.4	100	530	Sandy CLAY
	1.70 – 1.80	6.5	9.4	30	400	Sandy CLAY
JTP7	1.90 – 2.00	21.2	9.3	200	1170	CLAY
JTP8	2.50 - 2.60	8.0	8.9	30	740	GRAVELLY SAND
JTP9	0.40 – 0.50	4.9	7.4	110	560	SILT
JTP11	0.60 - 0.80	12.9	8.0	20	<10	Sandy CLAY
JTP14	0.90 – 1.00	11.8	7.8	50	130	CLAYEY SAND
JTP16	0.40 – 0.50	21.6	5.7	20	<10	Silty CLAY
JTP17	0.60 – 0.70	25.5	6.5	310	300	CLAY
	2.60 – 2.70	8.7	8.7	<10	120	CLAYEY SAND
JTP19	0.80 – 0.90	6.7	5.6	40	220	Silty CLAY
JTP21	0.30 – 0.40	14.0	5.9	10	<10	Sandy CLAY
	2.10 – 2.20	10.3	8.7	<10	20	CLAYEY SAND
JTP23	0.50 - 0.60	10.6	9.1	50	710	Sandy CLAY
JTP24	2.60 -2.70	13.9	8.6	<10	320	CLAY
JTP25	1.20 – 1.30	10.0	9.7	110	780	Sandy CLAY
JTP25	2.70 – 2.80	12.2	9.0	60	770	CLAY
JTP26	0.30 – 0.40	14.9	6.4	10	<10	Sandy CLAY
Note: MC = Moisture Content (as measured during chemical testing).						

3.6 Exchangeable Cation Testing

Samples selected for Exchangeable cation testing were sent to ALS in Brisbane. The results of testing are summarised in Table 8 and the test certificates are included in Appendix D.

Table 8 - Summary of Exchangeable Cation Testing.

Location	Depth (m)	Exchangeable Calcium (meq/100g)	Exchangeable Magnesium (meq/100g)	Exchangeable Potassium (meq/100g)	Exchangeable Sodium (meq/100g)	Cation Exchange Capacity (meq/100g)	Exchangeable Sodium Percent (%)	Calcium/ Magnesium Ratio	Electrical Conductivity (µS/cm)	Material Classification
JBH1	0.50 – 0.95	6.4	3.5	0.3	0.2	10.4	1.6	1.8	21.0	Silty CLAY
	1.50 – 1.95	7.4	3.4	0.4	0.2	11.3	2.2	2.2	17.0	Silty CLAY
JBH2	1.50 – 1.95	6.0	3.6	0.3	0.5	10.5	5.0	1.7	40.0	Silty CLAY
JBH3	1.50 -1.95	6.7	4.1	0.3	0.2	11.3	1.8	1.6	23.0	Silty CLAY
JBH7	1.50 – 1.92	4.2	1.6	<0.2	1.6	7.5	21.8	2.6	31.0	Sandy CLAY
JBH9	0.50 - 0.95	3.0	3.1	<0.2	2.5	8.7	29.1	1.0	-	CLAY
	3.50 – 3.95	1.4	2.6	<0.2	3.8	8.1	46.4	0.6	-	Sandy CLAY
JTP1	0.80 – 1.00	6.1	2.0	0.2	<0.2	8.3	<0.2	3.1	9.0	Sandy CLAY
	3.10 – 3.20	6.9	2.8	0.5	<0.2	10.2	<0.2	2.5	5.3	Sandy CLAY
JTP2	0.60 – 0.70	5.4	4.6	<0.1	1.8	12.0	15.4	1.2	14.0	CLAY
JTP3	0.50 – 0.70	2.2	0.7	<0.2	3.0	5.8	51.1	3.2	141.0	Sandy CLAY
	2.30 -2.40	5.4	2.4	<0.2	10.2	18.0	56.7	2.3	364.0	CLAY
JTP4	2.80 – 2.90	4.0	2.7	<0.2	12.0	18.6	64.2	1.5	415.0	CLAY
JTP5	0.50 – 0.60	6.4	1.0	<0.2	<0.2	7.6	<0.2	6.2	8.0	CLAY
JTP7	1.90 - 2.00	3.5	0.3	19.2	25.1	76.7	0.6	11.3	670.0	CLAY
JTP8	2.50 – 2.60	4.6	5.0	<0.2	21.6	31.2	69.2	0.9	440.0	Gravelly SAND
JTP9	0.40 – 0.50	1.3	1.2	<0.2	2.5	5.0	49.7	1.1	415.0	SILT
JTP11	0.60 – 0.80	5.9	3.4	<0.2	0.7	10.0	6.9	1.7	40.0	Sandy CLAY
JTP14	0.90 – 1.00	0.6	2.2	<0.2	2.6	5.4	47.7	0.3	110.0	Sandy CLAY
JTP16	0.40 – 0.50	2.1	3.3	<0.1	0.4	6.7	6.4	0.6	14.0	Silty CLAY
JTP17	0.60 – 0.70	12.7	8.7	0.2	2.4	24.2	10.1	1.4	41.8	CLAY
JTP18	0.40 – 0.50	0.8	0.4	0.3	<0.1	1.7	1.3	2.0	15.0	CLAYEY SAND
JTP19	0.80 – 0.90	1.1	1.9	<0.1	0.9	5.2	37.8	0.6	169.0	Silty CLAY
JTP20	0.50 – 0.60	3.5	2.9	0.1	0.1	6.8	1.6	1.2	21.3	CLAYEY SAND
JTP21	2.10 – 2.20	2.5	2.1	<0.2	1.7	6.2	27.0	1.2	27.0	CLAYEY SAND
JTP23	0.50 – 0.60	3.6	5.0	<0.2	5.7	14.3	40.0	0.7	580.0	Sandy CLAY
	2.80 – 2.90	0.7	0.6	<0.2	1.2	2.4	48.0	1.3	92.0	SAND
JTP24	2.60 – 2.70	11.2	6.8	0.3	4.4	22.8	19.6	1.6	223.0	CLAY
JTP25	1.20 – 1.30	4.1	7.3	<0.2	9.4	20.9	44.8	0.6	640.0	Sandy CLAY
	2.70 – 2.80	3.5	6.2	<0.2	7.4	17.2	43.0	0.6	520.0	CLAY
JTP26	0.30 - 0.40	3.4	2.6	<0.1	0.7	6.8	9.9	1.3	14.0	Sandy CLAY

4. Site Conditions

4.1 Geological Setting and Local Geology

Figure 10 depicts the local geology of the area encompassing the proposed alignment of the Haughton Pipeline – Stage 2 extracted from published 1: 250,000 geological map of Ayr (sheet no. SF5511).

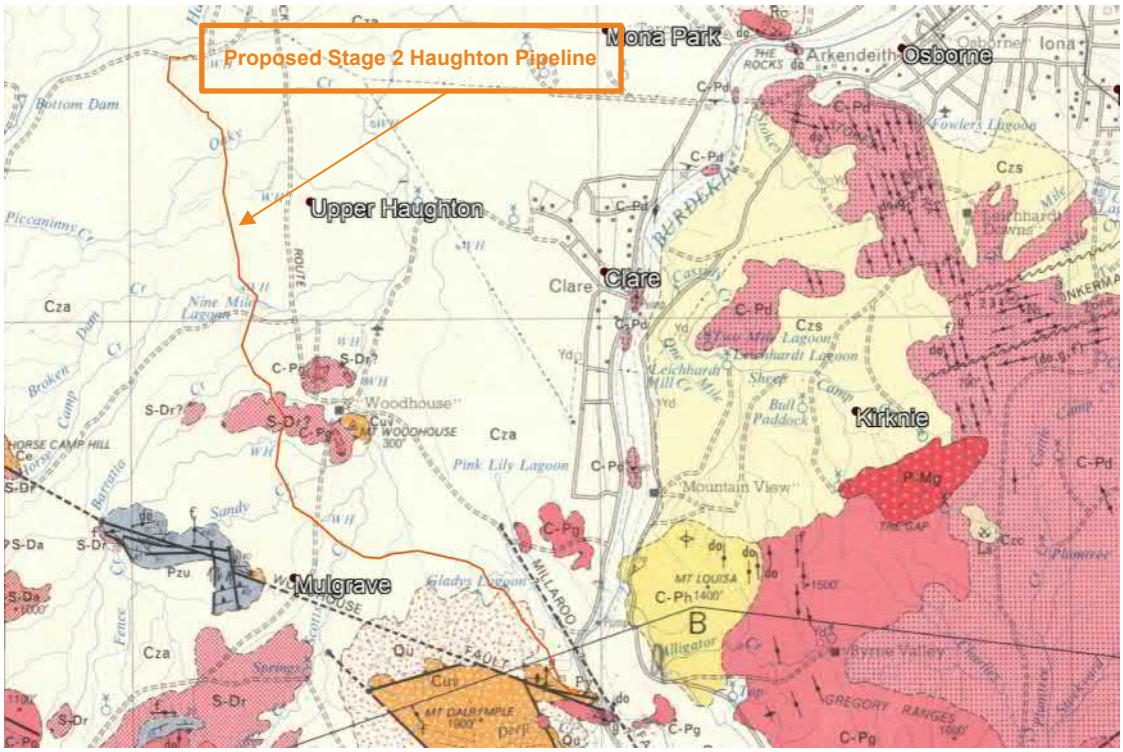


Figure 10. Site Geology.

The site is predominantly underlain by alluvial and deltaic deposits (Cza). Localised deeply weathered hornblende-biotite granodiorite, minor adamellite, quartz diorite, diorite and alkali granite (S-Dr) are present in an area at approximately the midpoint of the pipeline alignment. The area towards the southern end of the proposed pipeline alignment are underlain by flow-banded rhyolite and massive welded tuff, andesite and andesitic tuff (Cuv) and outwash and talus (Qu) deposits. Table 9 provides a summary of the geological units found in this region.

Table 9 – Summary of Site Geological Units

Symbol	Age	Description
Qu	Cainozoic	Sand, sandy soil.
Cza	Cainozoic	Alluvial and deltaic deposits.
Cuv	Palaeozoic	Flow-banded rhyolite and massive welded tuff; andesite and andesitic tuff.
S-Dr	Palaeozoic	Deeply weathered hornblende-biotite granodiorite; minor adamellite, quartz diorite, diorite, alkali granite.

4.2 Surface Conditions

The area surrounding the proposed pipeline alignment was predominantly farm lands used for cattle grazing, cane farming and melon growing. The terrain surrounding the area is mostly flat with a localised mountain (Mount Dalrymple) situated to the west from the southern end of the alignment. JTP2 was situated close to the foot of Mount Dalrymple. Majority of the area surrounding the extent of the pipeline alignment was predominantly vegetated with dense long grass, shrubs and trees. Localised marsh areas are situated adjacent to JBH3, JTP11, JTP14 and JTP22. It was noted that localised in some areas where the surface soils are marshy along the existing Haughton Channel are likely to have resulted by overflowing from the drains immediately adjacent to the channel.

4.3 Subsurface Conditions

Subsurface conditions are presented in the engineering logs in Appendix B. In summary, based on the test pits and boreholes the subsurface profile across the site extent can be described as follows;

Areas adjacent to JTP1 and JBH1 to JBH3

- TOPSOIL approximately to 0.3m depth comprising predominantly firm, low plasticity Sandy CLAY and Silty CLAY; underlain by
- ALLUVIUM comprising predominantly firm to hard, low to high plasticity CLAY, Sandy CLAY and Silty CLAY and loose to medium dense to very dense CLAYEY SAND; underlain by
- RESIDUAL SOIL comprising predominantly hard, low to high plasticity CLAY, Sandy CLAY and Gravelly CLAY and dense to very dense Clayey SAND (except at JTP1); underlain by
- EXTREMELY WEATHERED (XW) material in the form of dense to very dense CLAYEY SAND and CLAYEY GRAVEL and hard, medium to high plasticity Gravelly CLAY (except at JTP1).

Areas adjacent to JTP2 to JTP10

- TOPSOIL approximately to 0.4m depth comprising predominantly firm to very stiff, low to medium plasticity CLAY and Sandy CLAY and loose to medium dense CLAYEY SAND; underlain by
- RESIDUAL SOIL comprising predominantly very stiff to hard, low to medium plasticity CLAY and Sandy CLAY and dense to very dense CLAYEY SAND (Except at JTP2); underlain by
- EXTREMELY WEATHERED (XW) material in the form of very stiff to hard, low to medium plasticity CLAY, Sandy CLAY and Gravelly CLAY and dense to very dense CLAYEY SAND.

Moderately to highly weathered rock was encountered below the residual soil within JTP9 and JTP10.

Areas adjacent to JTP11 to JTP19 (Including JBH4 and JBH5)

- TOPSOIL approximately to 0.35m depth comprising predominantly firm to very stiff, low to high plasticity CLAY and Sandy CLAY and loose SILTY SAND and CLAYEY SAND; underlain by
- ALLUVIUM comprising predominantly firm to hard, low to high plasticity CLAY, Sandy CLAY and Silty CLAY and loose to very dense CLAYEY SAND, SILTY SAND; underlain by
- RESIDUAL SOIL comprising predominantly stiff to hard, low to high plasticity CLAY, Sandy CLAY and Silty CLAY and very dense CLAYEY SAND; underlain by
- EXTREMELY WEATHERED (XW) material in the form of hard, low to medium plasticity Sandy CLAY and dense to very dense CLAYEY SAND.

Areas adjacent to JTP20 to JTP26 (Including JBH6 to JBH9)

- TOPSOIL approximately to 0.35m depth comprising predominantly firm to very stiff, low to high plasticity CLAY, Sandy CLAY and Sandy SILT and loose SILTY SAND and CLAYEY SAND; underlain by
- ALLUVIUM comprising predominantly firm to hard, low to medium plasticity CLAY, Sandy CLAY and loose to very dense SAND, CLAYEY SAND; underlain by
- RESIDUAL SOIL comprising predominantly hard, low to high plasticity CLAY and Sandy CLAY and very dense CLAYEY GRAVEL and CLAYEY SAND.

WEATHERED ROCK in the form of slightly to moderately weathered, medium to high strength granodiorite (only within JTP19 and JTP20).

4.4 Groundwater

Groundwater was only encountered at JTP20 at a depth at 1.5 from the surface. It should be noted that groundwater can vary seasonally and due to other factors.

Appendix A. Site Photographs

Photograph 1 - JBH1.

Photograph 2 - JBH1.

JACOBS	Client	Department of Infrastructure, Regional Development and Cities
	Project Title	Stage 2 – Haughton Pipeline Project
	Project No.	IH175200

Photograph 3 - JBH1 SPT Sample from 0.5 - 0.95m.

Photograph 4 - JBH1 SPT Sample from 1.5 - 1.95m.

Photograph 5 - JBH1 SPT Sample from 2.5 - 2.95m.

Photograph 6 - JBH1 SPT Sample from 3.5 - 3.95m.

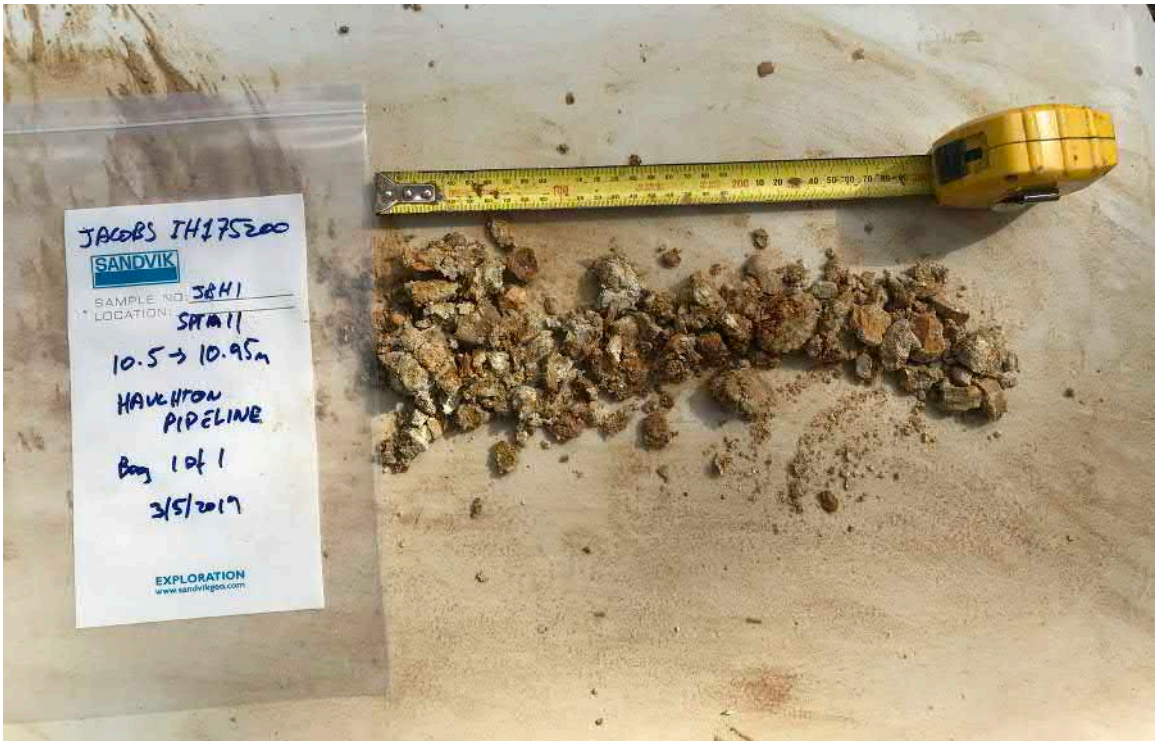
Photograph 7 - JBH1 SPT Sample from 4.5 - 4.95m.

Photograph 8 - JBH1 SPT Sample from 7.5 - 7.95m.

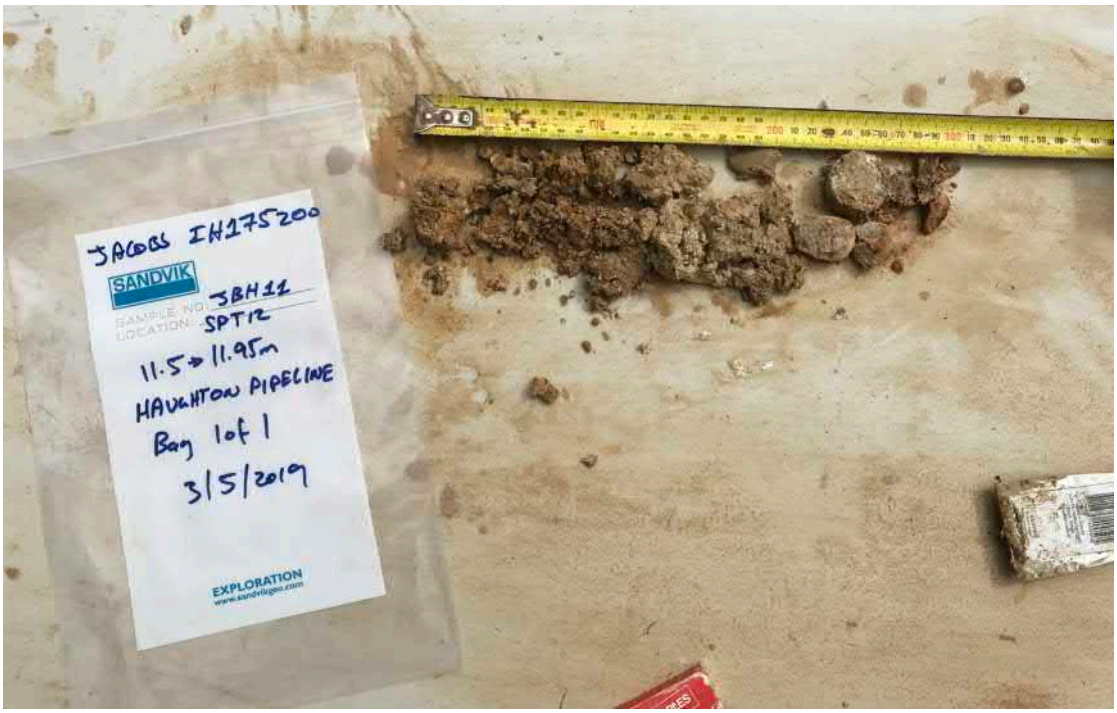
JACOBS	Client	Department of Infrastructure, Regional Development and Cities
	Project Title	Stage 2 – Haughton Pipeline Project
	Project No.	IH175200

Photograph 9 - JBH1 SPT Sample from 8.5 - 8.95m.

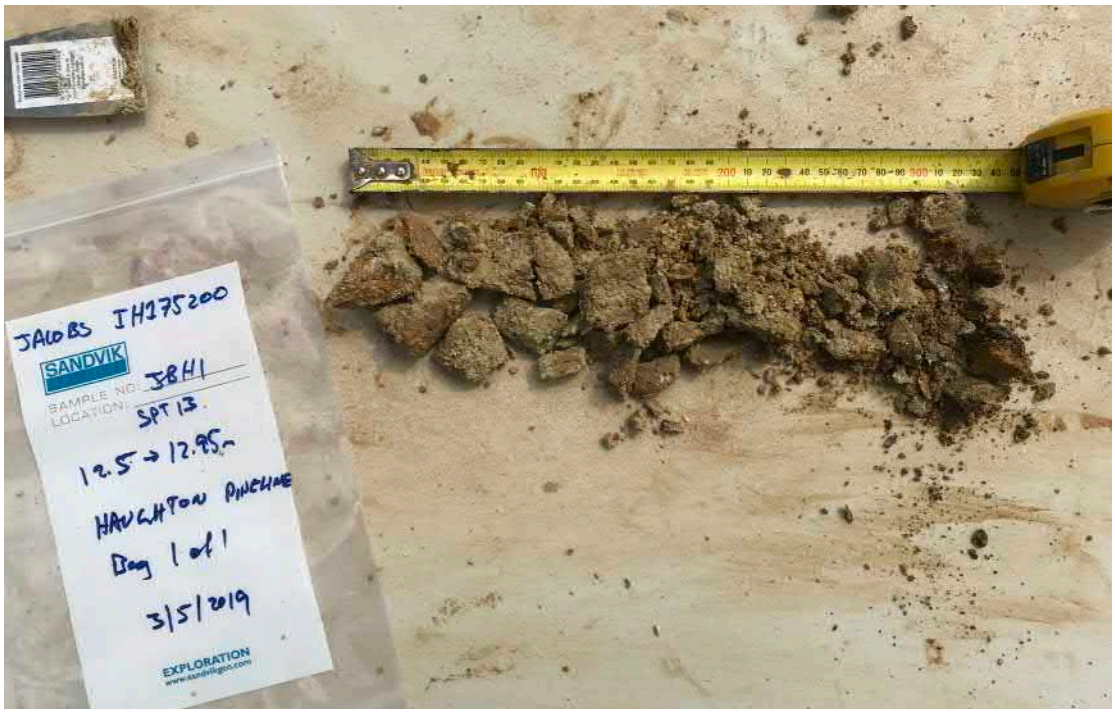
Photograph 9 - JBH1 Sample from 9.5 - 9.95m.



Photograph 10 - JBH1 SPT Sample from 10.5 - 10.95m.

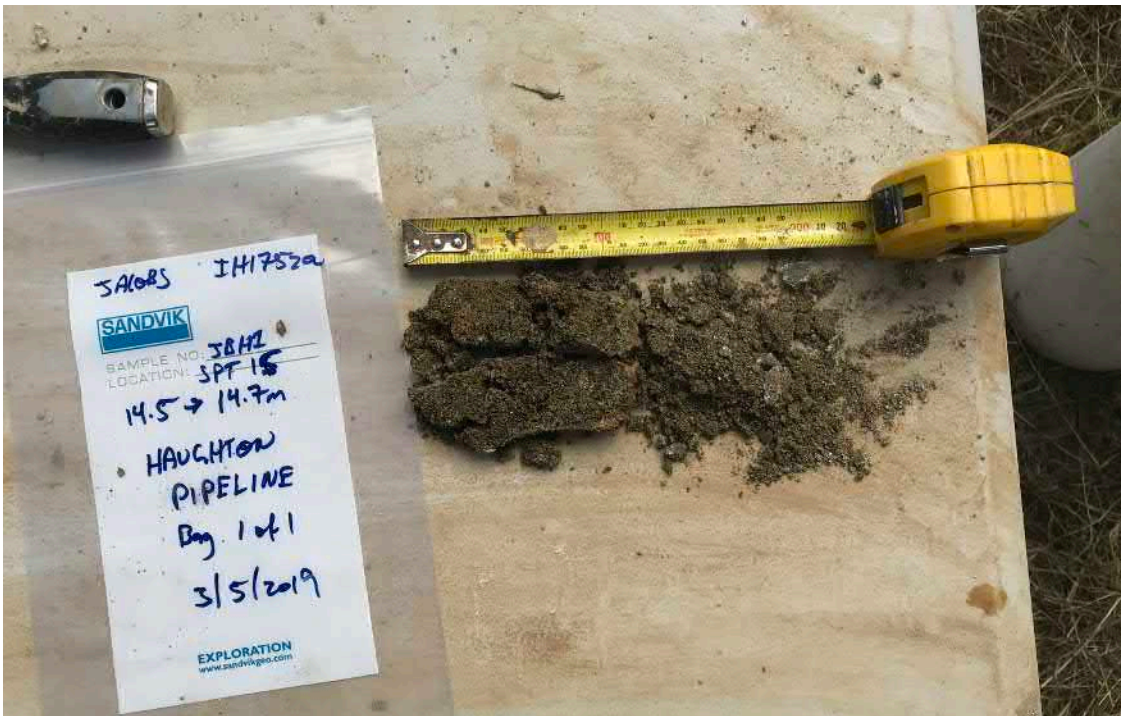


Photograph 11 - SPT JBH1 Sample from 11.5 - 11.95m.



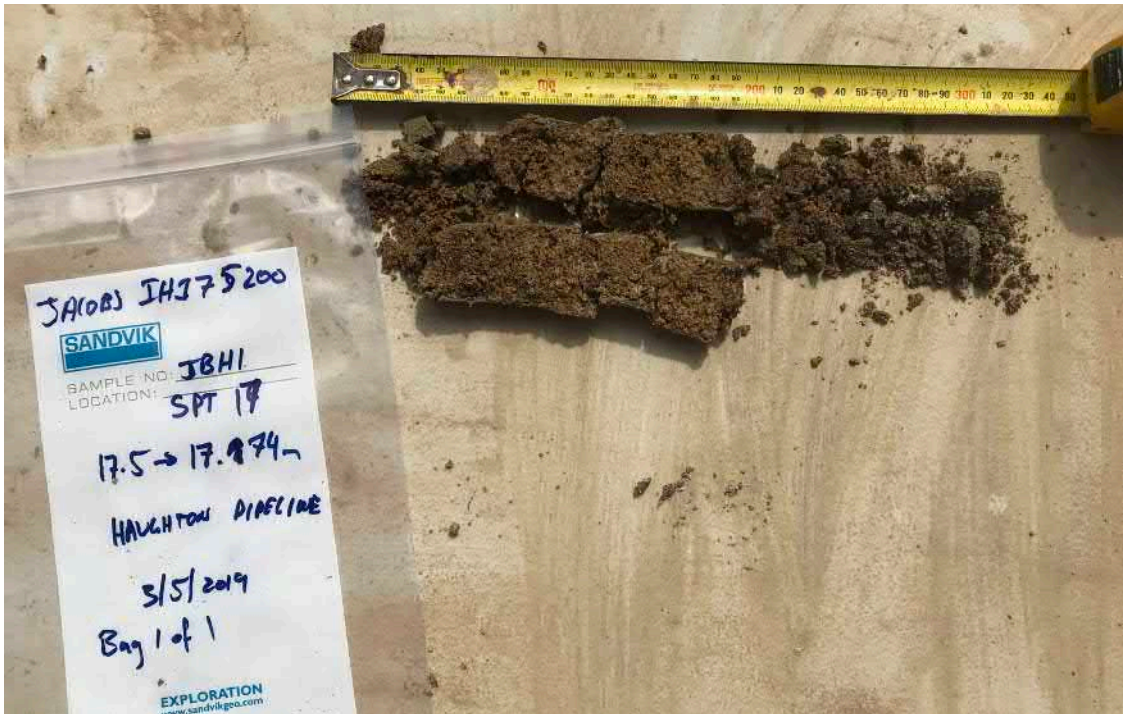
Photograph 12 JBH1 - SPT Sample from 12.5 - 12.95m.

Photograph 13 JBH1 SPT Sample from 13.5 - 13.95m



Photograph 14 - JBH1 SPT Sample from 14.5 - 14.7m.

Photograph 15 - BH1 SPT Sample from 15.5 - 15.85m.



Photograph 16 - JBH1 SPT Sample from 17.5 - 17.74m

Photograph 17 - JBH1 SPT Sample from 19.5 - 19m.

JACOBS	Client	Department of Infrastructure, Regional Development and Cities
	Project Title	Stage 2 – Haughton Pipeline Project
	Project No.	IH175200

Photograph 18 - JBH2.

Photograph 19. - JBH2

Photograph 20 - JBH2 SPT Sample from 0.5 - 0.95m.

Photograph 22 - JBH2 SPT Sample from 1.5 - 1.95m.

Photograph 23 - JBH2 SPT Sample from 2.5 - 2.95m.

Photograph 24 - JBH2 SPT Sample from 3.5 - 3.95m.

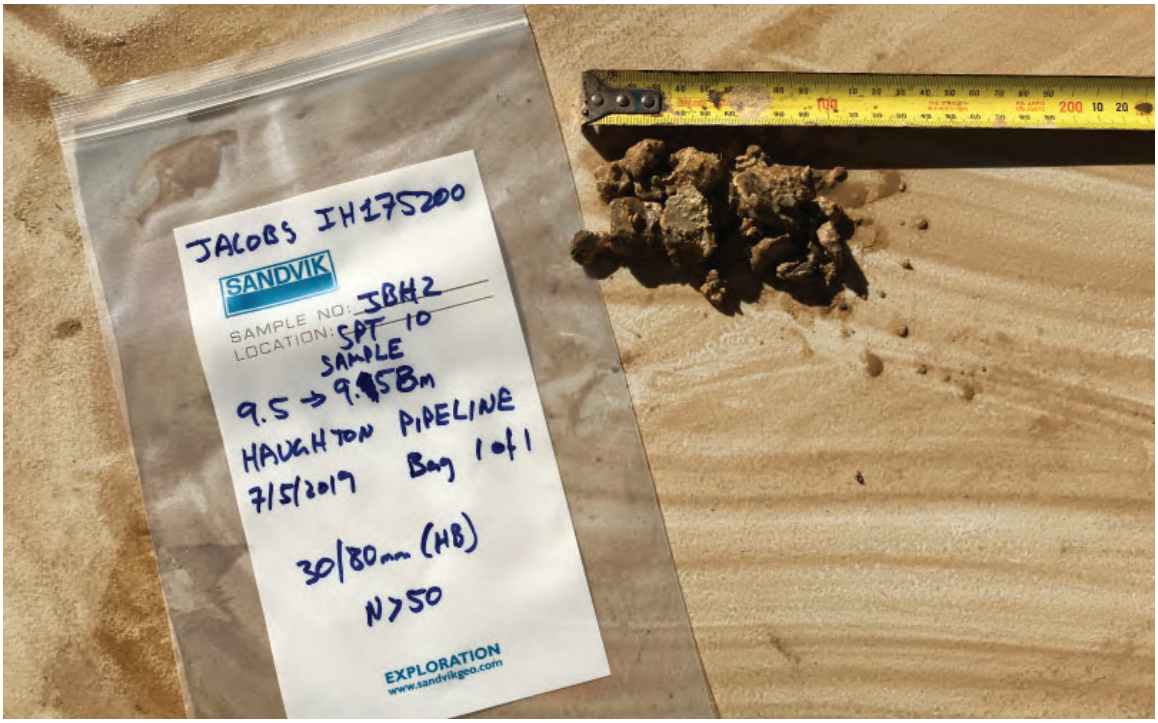
Photograph 25 - JBH2 SPT Sample from 4.5 - 4.95m.

Photograph 26 - JBH2 SPT Sample from 5.5 - 5.95m.

Photograph 27 - JBH2 SPT Sample from 6.5 - 6.95m.

Photograph 28 - JBH2 SPT Sample from 7.5 - 7.95m.

Photograph 29 - JBH2 SPT Sample from 8.5 - 8.95m.



Photograph 30 - JBH2 SPT Sample from 9.5 - 9.95m.

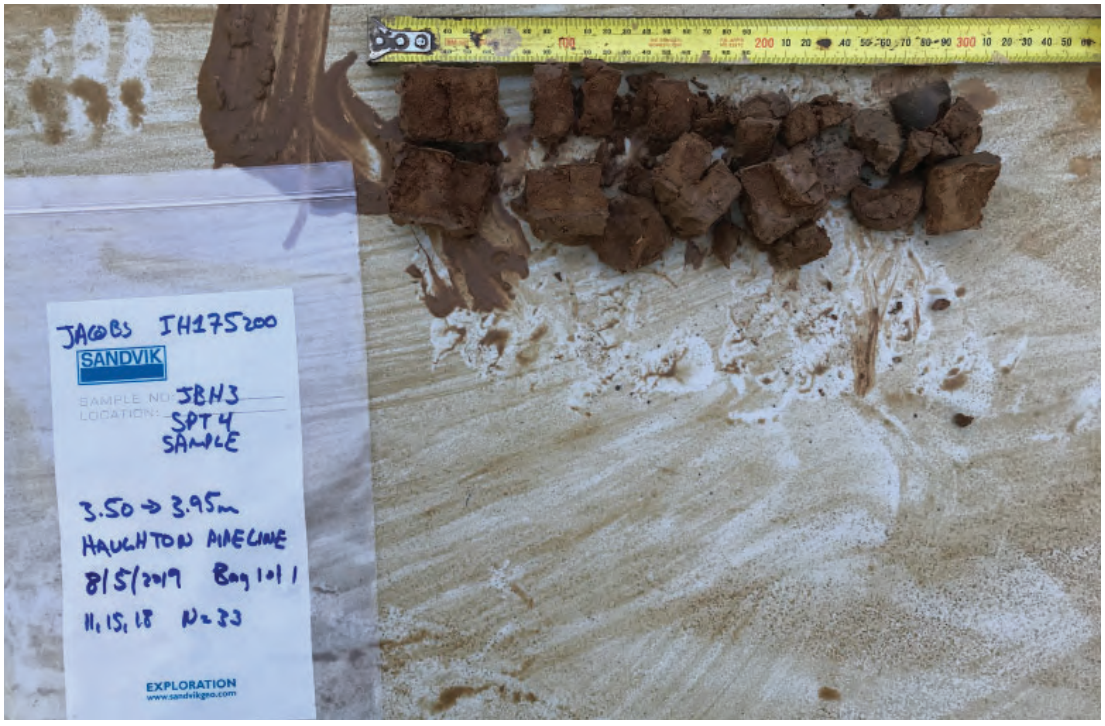
Photograph 31 - JBH3.

Photograph 32 - JBH3.

Photograph 33 - JBH3 SPT Sample from 0.5 - 0.95m.

Photograph 34 - JBH3 SPT Sample from 1.5 - 1.95m.

Photograph 35 - JBH3 SPT Sample from 2.5 - 2.95m.



Photograph 36 - JBH2 SPT Sample from 3.5 - 3.95m.

Photograph 37 - JBH3 SPT Sample from 4.5 - 4.95m.

Photograph 38 - JBH3 SPT Sample from 5.5 - 5.95m.

Photograph 39 - JBH3 SPT Sample from 6.5 - 6.95m.

Photograph 40 - JBH3 SPT Sample from 7.5 - 7.95m.

Photograph 41 - JBH3 SPT Sample from 8.5 - 8.95m.

Photograph 42 - JBH3 SPT Sample from 9.5 - 9.95m.

Photograph 43 - JBH3 SPT Sample from 10.5 - 10.95m.

Photograph 44 - JBH3 SPT Sample from 11.5 - 11.95m.

Photograph 45 - JBH3 SPT Sample from 12.5 - 12.95m.

Photograph 46 - JBH3 SPT Sample from 13.5 - 13.95m.

Photograph 47 - JBH3 SPT Sample from 14.5 - 14.85m.

Photograph 48 - JBH3 SPT Sample from 15.5 - 15.67m.

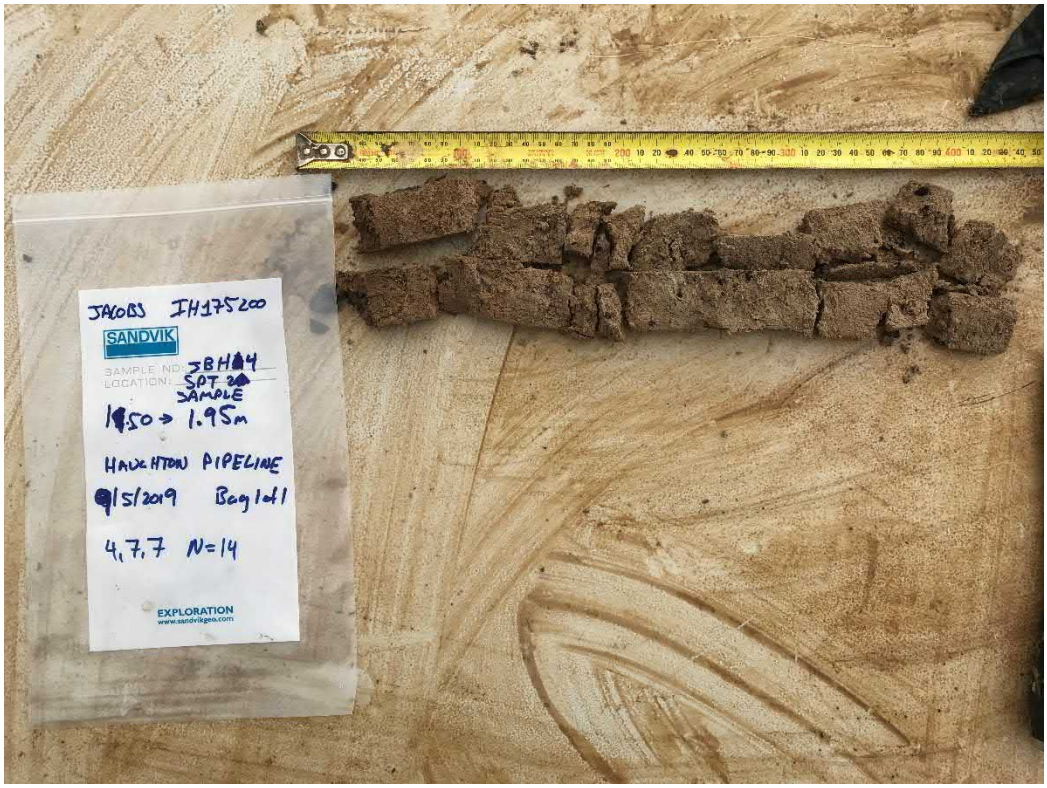
Photograph 49 - JBH3 SPT Sample from 16.5 - 16.58m.

Photograph 50 - JBH3 SPT Sample from 17.5 - 17.57m.

Photograph 52 – JBH4.

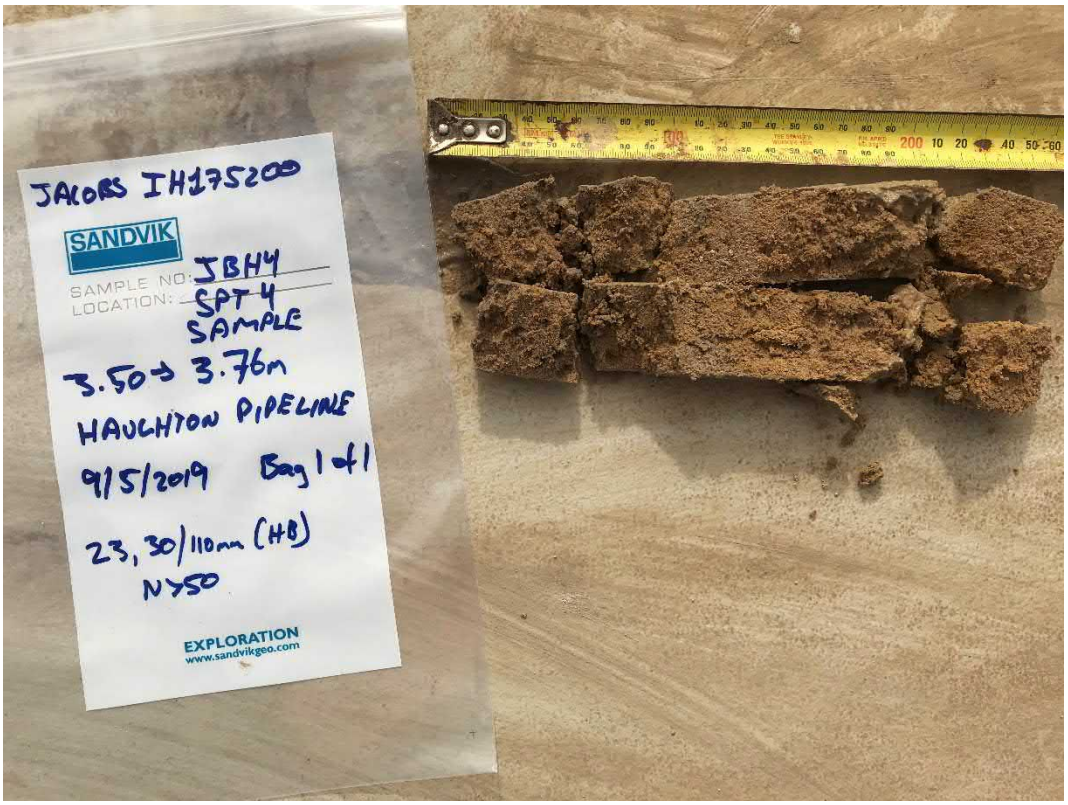
Photograph 53 – JBH4

Photograph 54 – JBH4 SPT Sample from 0.5 - 0.95m.



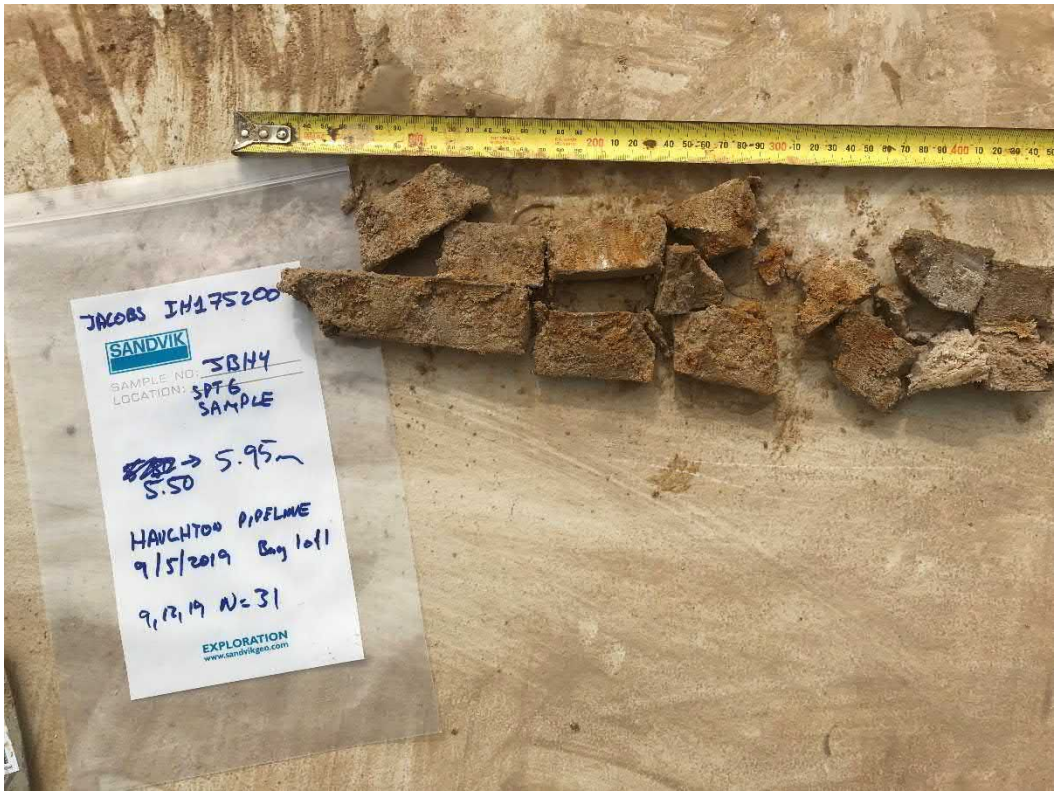
Photograph 55 – JBH4 SPT Sample from 1.5 - 1.95m.

Photograph 56 – JBH4 SPT Sample from 2.5 - 2.95m.

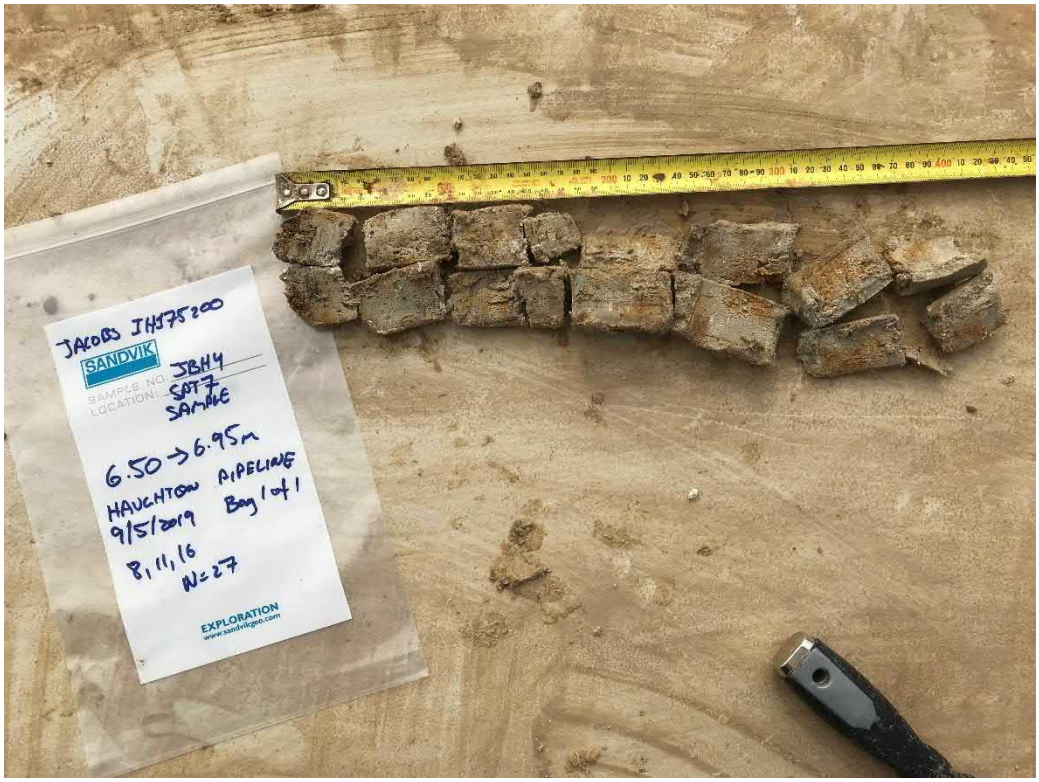


Photograph 57 – JBH4 SPT Sample from 3.5 - 3.76m.

Photograph 58 – JBH4 SPT Sample from 4.5 - 4.95m.

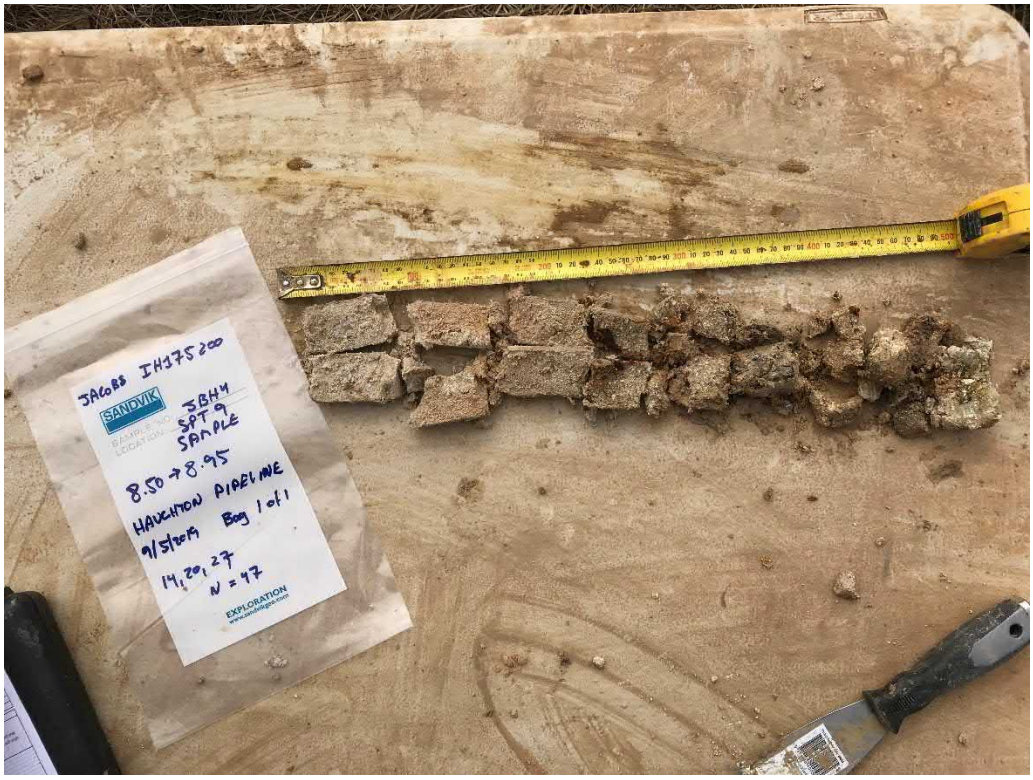


Photograph 59 – JBH4 SPT Sample from 5.5 - 5.95m.



Photograph 60 – JBH4 SPT Sample from 6.5 - 6.95m.

Photograph 61 – JBH4 SPT Sample from 7.5 - 7.95m.

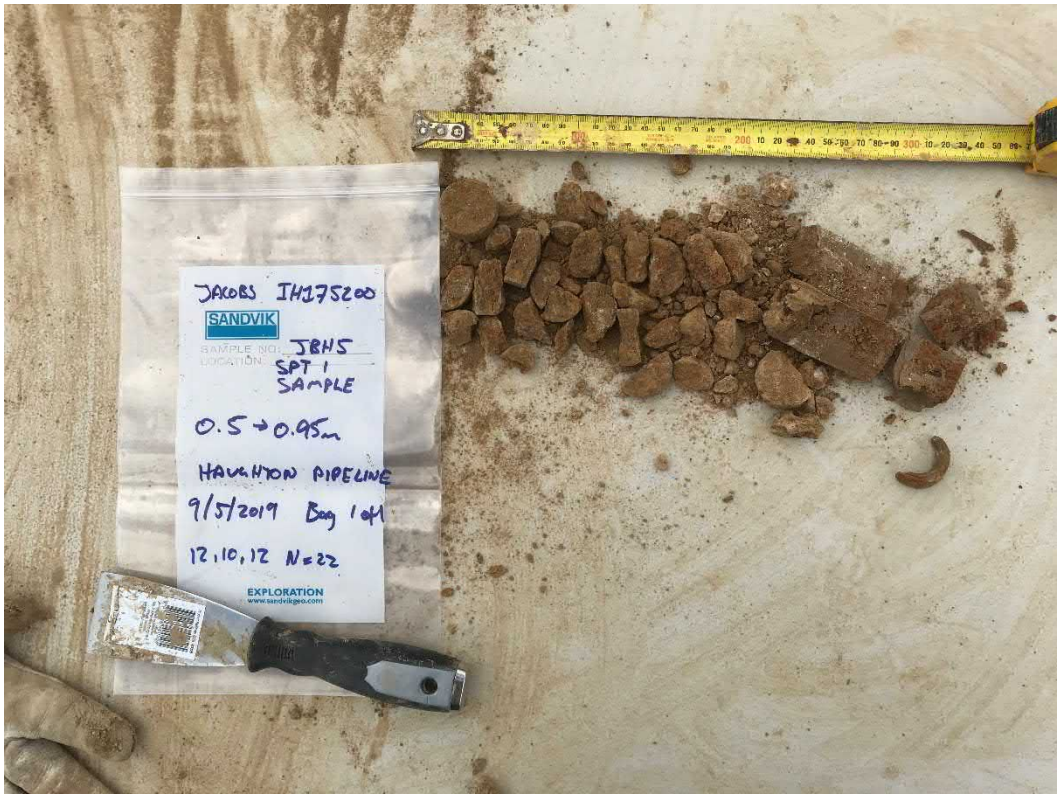


Photograph 62 – JBH4 SPT Sample from 8.5 - 8.95m.

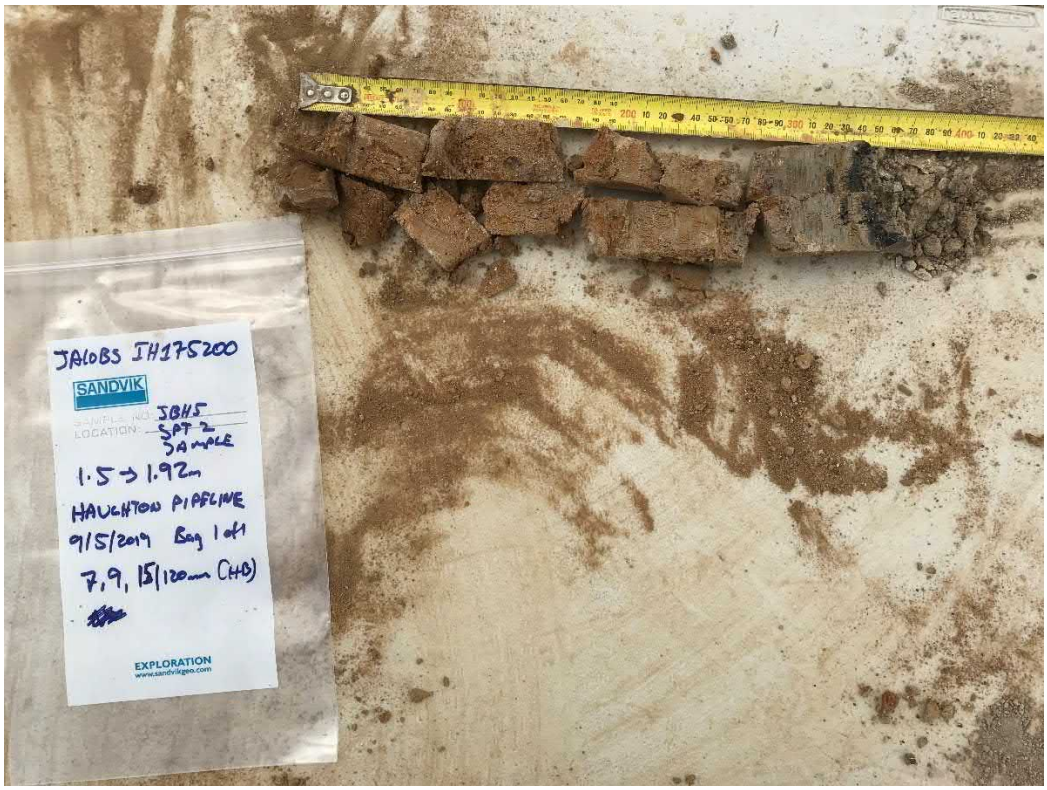
Photograph 63 – JBH4 SPT Sample from 9.5 -9.95m.

Photograph 64 – JBH5.

Photograph 65 – JBH5.



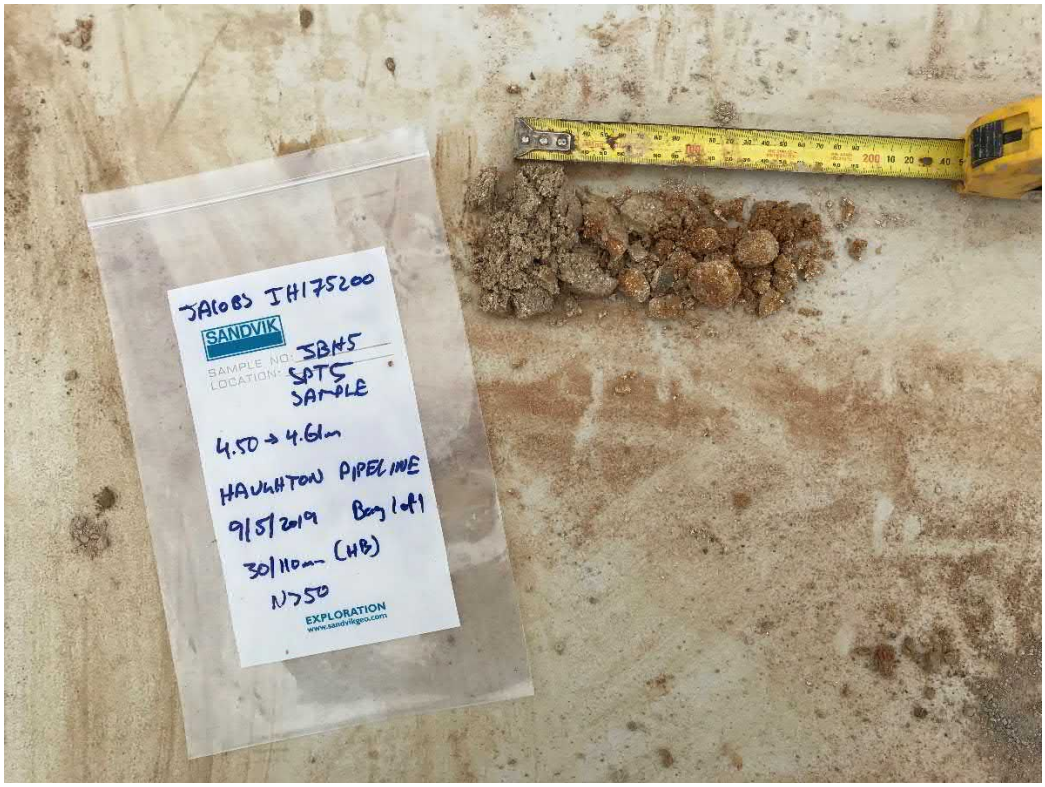
Photograph 66 – JBH5 SPT Sample from 0.5 -0.95m.



Photograph 67 – JBH5 SPT Sample from 1.5 -1.92m.

Photograph 68 – JBH5 SPT Sample from 2.5 -2.95m.

Photograph 69 – JBH5 SPT Sample from 3.5 -3.54m.



Photograph 70 – JBH5 SPT Sample from 4.5 - 4.61m.