Appendix G

Paste Backfill Characterization Testwork – Golder Phase I & II

Evaluation of ARD Potential of Backfill

Golder Paste Technology Ltd.

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REPORT ON

POGO PROJECT, ALASKA

PHASE 1 LABORATORY ANALYSIS OF HYDRAULIC CONDUCTIVITY OF BLENDED FLOTATION:LEACHATE TAILINGS IN PASTE BACKFILL

Submitted to:

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1.0 PHASE I OVERVIEW

Golder Paste Technology Ltd. (PasteTec) was requested by Teck Corporation (Teck) to conduct a two-phase study on the use of blended cemented paste using flotation and CN residue (leachate) tailings from their Pogo Project in Alaska, USA. Phase I was to determine the effect of blending on the unconfined compressive strength (UCS) and on hydraulic conductivity; Phase II was to determine the permeability and degree of leaching from blended paste fill under simulated flooded mine conditions.

Two sample groups were evaluated as a part of the PasteTec study. The first samples consisted of 100% flotation tailings and the second of an 80%:20% (flotation:leachate) blend. Both sample groups were amended with 5% (by weight) ordinary Portland cement (OPC) and mixed to 7-inch-slump paste consistency and poured into standard-size concrete cylinders for testing. Following curing for 28 days, hydraulic conductivity tests were carried out on the samples at confining pressures of 50, 100 and 200kPa in an effort to simulate post-mining backfill conditions. Limited flotation and leachate tailings volumes were available for this test work, a situation which prompted the use of 2-inch (diameter) by 4-inch (height) cylinders as opposed to the more conventional 4-inch by 8-inch cylinders used in typical tests on concrete.

The results presented in this report are the remaining deliverables from the Phase I testing program.

1.1 Hydraulic Conductivity Test Methodology

Constant-head hydraulic conductivity tests were conducted using a flexible-wall permeameter in accordance with the ASTM D5084-90 standards using test cylinders of 2-inch (approx. 50 mm) diameter. The samples were back-pressure saturated until a saturation B-value of at least 0.96 was obtained. The hydraulic conductivity tests were then carried out using a nominal hydraulic gradient 20 and consolidation pressures of 50 kPa, 100 kPa and 200 kPa. The permeant used in these tests was de-aired tap water.

1.2 Review of Hydraulic Conductivity Data for Paste Samples

The testing was carried out on two different sample types. The first set (Pogo 1, 2 and 3) consisted of cement-amended flotation tailings; the second set (Pogo 3, 4 and 5) consisted of blends of 80% flotation tailings and 20% CN residue (leachate). Both sample sets were prepared with 5% (by dry unit weight) OPC binder.

Hydraulic conductivity testing was carried out in Golder Associates' Mississauga, Ontario soils laboratory. For each of the two sample types, a total of three tests were carried out that included confining pressures of 50, 100 and 200 kPa. A complete data history was compiled for each sample tested and the results tabulated to allow for calculation of hydraulic conductivity. The final results of the tests are summarized below for reference.

Sample Number	Sample Type	Confining Stress (kPa)	Hydraulic Conductivity (cm/s)
Pogo 1	Float	50	7.95×10^{-7}
Pogo 2	Float	100	5.0×10^{-8}
Pogo 3	Float	200	7.67×10^{-7}
Pogo 4	Blend	50	4.34×10^{-7}
Pogo 5	Blend	100	8.77×10^{-8}
Pogo 6	Blend	200	3.14×10^{-7}

The results for the 50 and 100 kPa confining pressures (for both sample sets) show a typical pattern of decreased hydraulic conductivity with increasing confining stress. This decrease (between one half and one order of magnitude) is the result of the physical confinement of the sample and has been observed routinely in concrete testing. Since the tests were carried out on relatively small samples, the results indicate a trend that would be attributed to material rather than mass behavior since the effect of small discontinuities in the fill mass cannot be simulated with small samples. The results, therefore, should be interpreted as being representative (although not necessarily statistically valid due to small number of samples tested) of an upper bound of performance. Careful judgment should be exercised when applying the laboratory-measured values as input parameters for larger-scale geohydrologic modeling purposes.

The consistent increase in hydraulic conductivity that was recorded for the 200 kPa confining stress conditions may be due to the onset of failure in the samples that could be manifested by a breakdown in the crystalline (cement) bonds and the possible development of micro-fractures. These features may provide preferential pathways for flow and thus greatly influence the flow measurements used to derive hydraulic conductivity. Since the samples are relatively small, the effective influence of these features may have an exaggerated impact on the derived values for flow through the sample. However, there is some evidence to suggest (based on cursory review of the strength testing data) that as the confining pressures approach the 200 kPa level, the onset of failure is probable. This tends to validate the consistent increase in hydraulic conductivity observed in the laboratory. With only minor exceptions, the test data appear to be very consistent and the test methodology is within accepted standards.

We trust the above is of interest and useful to the Teck Corporation and should you require clarification on any of the points or have any further questions, please do not hesitate to contact the undersigned.

Yours very truly,

GOLDER PASTE TECHNOLOGY LTD.

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Golder Associates PasteTec

REPORT ON

POGO PROJECT, ALASKA

PHASE 1 LABORATORY INVESTIGATION TO DETERMINE THE EFFECT OF BLENDING OF FLOTATION AND LEACHATE TAILINGS ON PASTE BACKFILL STRENGTH

Submitted to:

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1.0 INTRODUCTION

Golder Paste Technology Ltd. (PasteTec) was requested by Teck Corporation (Teck) to conduct a two-phase study on the use of blended cemented paste using flotation and CN residue (leachate) tailings from their Pogo Project in Alaska, USA. Phase I was to determine the effect of blending on the unconfined compressive strength (UCS); Phase II was to determine the permeability and degree of leaching from blended paste fill under simulated flooded mine conditions. The analysis of achievable strengths will allow determination of the ordinary Portland cement (OPC) binder content required for the free-standing height and for considerations of the liquefaction potential of paste backfill using from 0% to 100% leachate tailings in the paste recipe. This testing compliments the prior investigation to determine the strength of paste using 100% flotation tailings samples (Ref. #991-9905, April 1999). Tech will determine the cost-effective nature of this disposal versus surface disposal once the data has been made available.

Preliminary results of the permeability are included in this report. Additional Phase II results and report will be made available upon completion of testing.

2.0 MATERIALS TESTING

2.1 Size Analysis

The flotation and leachate tailings were sized using a Model 2010 Galai particle size analyser at the CANMET laboratories in Sudbury, Ontario.

Figure 1 shows the results and clearly indicates that both samples have sufficient fines to form a paste. The floatation tailings can be classified as medium sized tailings and the leachate as fine tailings when compared to other mineral tailings with the flotation and leachate tailings having 47 wt% and 71 wt% passing 20 μm, respectively. The general rule of thumb for precious and base metals tailings to make a satisfactory paste is to have approximately 15 – 20 wt% passing 20 μm, variations due to particle size distribution, chemical composition and particle shape.

2.2 Strength Testing

Samples of paste were mixed with OPC in order to evaluate the strength gain possible for a given percentage by weight of binder. Three binder mixes were prepared which contained 2%, 5% and 8% binder by total dry weight for 7" slump. Note that there were sufficient quantities of flotation tailings to conduct the ASTM standard 12" slump test; however, there was a limited quantity of the leachate tailings that did not permit the standard 12" slump test. As a result, slump values for the samples with leachate tailings were estimated by correlating the viscocities of the leachate and flotation tailings with the flotation samples at 7" slump.

Due to the small quantity of material available, strength testing was primarily done in 2-inch diameter x 4-inch high cylinders. PasteTec normally does all strength testing in 4-inch x 8-inch cylinders and it was agreed with Teck that the increased confidence associated with the larger cylinders was important. A total of nine large 4-inch diameter x 8-inch high cylinders were prepared with 100% flotation tailings material as a check on the strength gain recorded in the scaled down cylinders.

The testing program consisted of five paste designs at varying binder contents over the probable range of mixtures for delivery underground. A summary of the testing program as carried out is provided below.

Phase I UCS Testing Program

Underground Paste Disposal – 7 in. Slump and 28-Day Cure						
Cyl. Size (in.)	**OPC Content**	**Mix % Flot/Leach**	**Curing Conditions**	**# of cylinders**	**Cured**	**Tested**
2" x 4"	2 wt%	100/0	23°C	3 (small)	Dec. 30th	Jan. 13th
2" x 4"	5 wt%	100/0	23°C	3 (small)	Dec. 31st	Jan. 14th
2" x 4"	8 wt%	100/0	23°C	3 (small)	Dec. 31st	Jan. 14th
80 / 20 Blend Flotation: Leachate						
2" x 4"	2 wt%	80/20	23°C	3 (small)	Jan. 6th	Jan. 20th
2" x 4"	5 wt%	80/20	23°C	3 (small)	Jan. 6th	Jan. 20th
2" x 4"	8 wt%	80/20	23°C	3 (small)	Jan. 6th	Jan. 20th
60 / 40 Blend Flotation: Leachate						
2" x 4"	2 wt%	60/40	23°C	3(small)	Jan. 7th	Jan. 21th
2" x 4"	5 wt%	60/40	23°C	3 (small)	Jan. 7th	Jan. 21th
2" x 4"	8 wt%	60/40	23°C	3 (small)	Jan. 7th	Jan. 21th
40 / 60 Blend Flotation: Leachate						
2" x 4"	2 wt%	40/60	23°C	3 (small)	Jan. 7th	Jan. 21th
2" x 4"	5 wt%	40/60	23°C	3 (small)	Jan. 7th	Jan. 21th
2" x 4"	8 wt%	40/60	23°C	3 (small)	Jan. 7th	Jan. 21th
0 / 100 Blend Flotation: Leachate						
2" x 4"	2 wt%	0/100	23°C	3 (small)	Jan. 3rd	Jan. 17th
2" x 4"	5 wt%	0/100	23°C	3 (small)	Jan. 4th	Jan. 18th
2" x 4"	8 wt%	0/100	23°C	3 (small)	Jan. 17th	Jan. 28th
4" x 8" Cylinders 100% Flotation						
4" x 8"	2 wt%	100/0	23°C	3(large)	Dec. 30th	Jan. 13th
4" x 8"	5 wt%	100/0	23°C	3(large)	Dec. 31st	Jan. 14th
4" x 8"	8 wt%	100/0	23°C	3(large)	Dec. 31st	Jan. 14th

The results of this testing program are presented in Table 1 and are summarised below as well as in Figures 2 through 4. The results achieved are consistent with the earlier report (Ref. #991-9905). The smaller samples do not typically generate consistent strength results as can be expected from the larger samples.

2.3 Unconfined Compressive Strength Comparison with Previous Testing

The following table is used to compare current and previous test results; Figure 2 illustrates the UCS versus wt% OPC binder for the data presented below. As with the previous set of test results, strengths are low but not necessarily anomalous given the relatively high fines content of the paste.

Testing Result -Unconfined Compressive Strengths (PSI) @ Estimated 7" Slump

Tailings	Blend Flotation: Leach	OPC Wt%	2" x 4" Cylinders 7-day Strength	2" x 4" Cylinders 28-day Strength	4" x 8" Cylinders 28-day Est. Strength	Comments
Pogo Apr. 1999	100 / 0	1	4	7		19 psi @ 28-day
		2	7	16		frozen for 1st 7 days
		3	17	25	17	*(Float Tails only)*
Pogo Jan. 2000	100 / 0	2		14	10	
		5		46	32	
		8		74	64	
	80 / 20	2		6	4	
		5		35	26	
		8		79	60	
	60 / 40	2		3	2	
		5		25	19	
		8		84	63	
	40 / 60	2		3	2	
		5		18	13	
		8		78	59	
	0 / 100	2		2	2	
		5		10	8	
		8		49	37	

The test data indicate that strength results are approximately 22% higher using the smaller 2-inch x 4-inch cylinders when compared to the larger 4-inch x 8-inch cylinders as shown in Figure 3. From Figure 4, it can also be seen that the reduction in strength is consistent with the increasing proportion of leachate tailings in the blend throughout the range of binder addition. Data for the 8 wt% cement binder with 100 / 0 flotation:leachate samples is not consistent with expected values and cannot be explained without further testing.

3.0 SUMMARY AND RECOMMENDATIONS

3.1 Summary

Results of the testing were consistent with previous values for the Pogo Project and with similar tailings paste. Increasing the proportion of finer leachate tailings in the paste typically decreases the unconfined compressive strength of tailings paste fill as a result of the greater water bearing capacity (hence higher moisture content), and the increased surface area of the finer (leachate) tailings. The result is a greater requirement wt% of binder to first encapsulate the particles, and subsequently bind the particles together, within an over saturated environment. It can be seen that at above 5 wt% cement addition there is a significant increase in the strength that can be explained by the complete encapsulation requiring approximately 5 wt% binder, and any additional binder filling the voids between particles and creating the particle-particle interaction that significantly influences strength.

For the Pogo Project, the data indicates that cemented blended paste consisting of leachate proportion greater than 60 / 40 flotation:leachate could be subject to potential liquefaction in the 7-day period with OPC up to 5 wt%, which is based on production experience in bulk mining applications with a minimum recommended 10 psi @ 7 days. Addition of OPC beyond this range does provide early strengths required to stabilise the fill mass, but does so at a greatly increasing cost to the operation. Indications are that backfilling mining blocks with less than the above 5 wt% OPC may require appropriate engineered and constructed bulkheads unless the area to be backfilled is effectively isolated from other areas to which failure may pose any unacceptable risks.

It is expected that the proposed bench and fill and cut and fill mining methods to be employed at the Pogo Project will have free-standing heights of 30 feet or less, and a worst case scenario of 65 feet. The 28-day strengths required for this application, as shown in the following, are in the 16 psi to 32 psi (worst case) and can be achieved with blended tailings although further testing is imperative to establish greater confidence in predicting achievable strengths (i.e., 1 – 7-day strengths required to prevent liquefaction). Risks associated with lower strength backfill must be assessed as part of the mining plan. The significant cost reductions via reduction in the percentage of binder are a major benefit, versus failure by liquefaction or poor bulk strength, which may impact rock mass stabilisation.

3.2 Disposal of Leachate Tailings

The addition of leachate tailings into the paste fill system would reduce the amount of leachate tailings reporting to surface tailings area. This must be reconciled with the reduction in strength, potential of liquefaction, increased cement consumption and an increase of flotation tailings reporting to the tailings area. The table below is reproduced from the previous report (Ref. #991-9905) for comparison.

The safe disposal of leachate tailings in the bench and fill and the cut and fill methods for this application when considering liquefaction is largely dependent on the location of the stope to be filled relative to other mining activities and associated risks. The short and long-term stability of the backfill must be taken into consideration when assessing the potential ramifications of fill failure by liquefaction. Through re-scheduling of mining blocks within the local area that may influence cemented paste fill stability, a location specific paste recipe may be applied to maximise underground leachate tailings disposal and minimise risk, surface disposal of leachate tailings and cement consumption with a positive impact on costs. An assessment of each individual workplace may be necessary to make full use of the opportunity presented.

Back fill strengths required for mining at the Pogo Project

Mining Method	Height (feet)	Length (feet)	Depth (feet)	Minimum Strength	Bulkhead Pressure
Bench and Fill 1rys	30	150	40	16 psi	25 psi
Bench and Fill (worst case)	65	150	40	32 psi	54 psi
Bench and Fill 2rys	30	150	30	16 psi	25 psi
Cut and Fill	Free-standing heights small, high strength required for working floor, i.e., top 3-5 ft of fill should be 100 psi strength after 7 days*				

Above calculations assume 112 lbs/ft^3 density fill (1.8t/m^3). * Assumes a mining cycle requiring re-entry within 7 days.

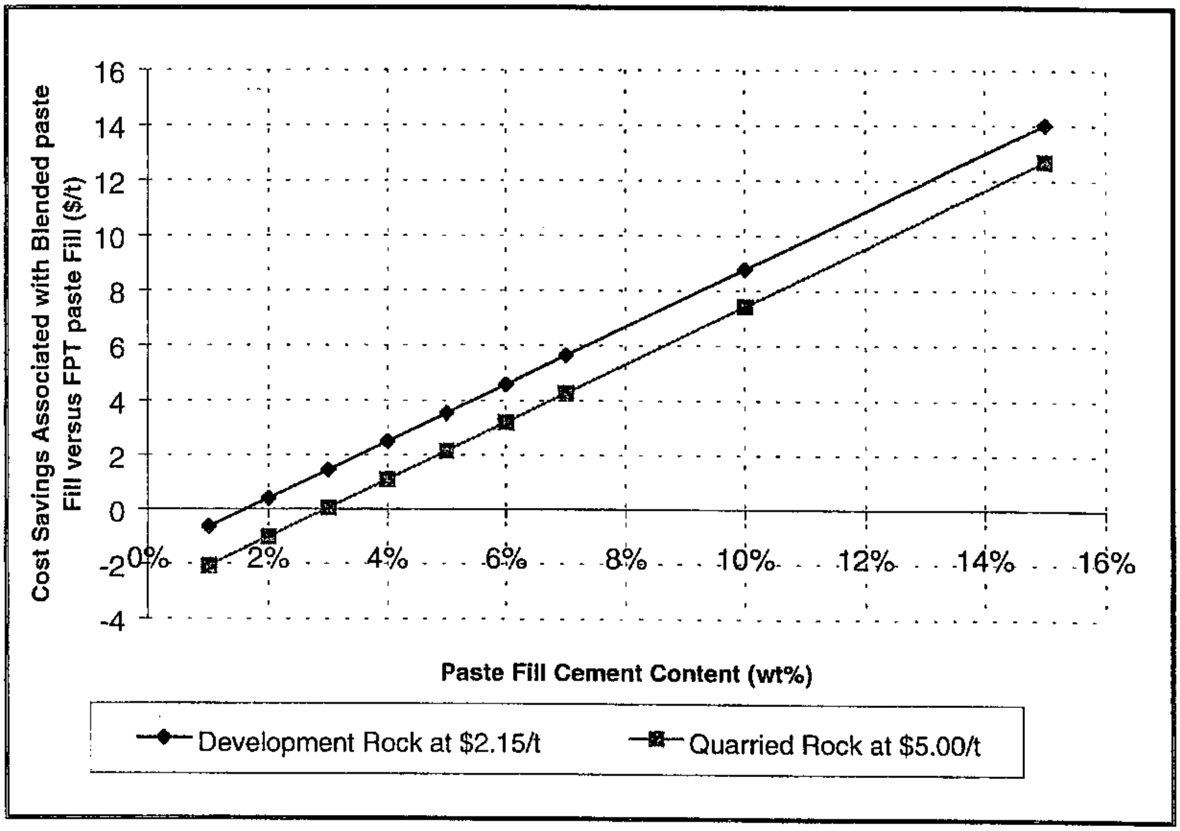
Depending upon mining configurations, it may be cost effective to completely fill secondary stopes with *uncemented leachate tailings*. Engineered design of proper bulkheads is required to withstand potential head of up to 54 psi. The bulkhead pressure as shown is ***prior to applying a factor of safety*** and assumes the specific gravity of the paste fill in place is 1.90. Ground water and permeability of a non-cemented backfill must be investigated to understand future implications.

3.3 Alternatives to High Cement Requirements

Further cost reductions of OPC binder and overall backfill program may be realised by the addition of sand or aggregate into the paste recipe. PasteTec has conducted similar studies and has designed paste plants to deal with low strengths or high cement costs by adding products to enhance the particle size distribution. Sources include quarrying of alluvial type deposits or crushing of waste rock.

Test data from a mine with similar tailings (Mine A) is shown in Figure 5 which illustrates the strength gain at 7 days and 5 wt% OPC binder with increasing proportion of crushed waste rock, while Figure 6 illustrates a 50/50 blend full tailings: waste rock. Test work consisted of 1, 3, 7 and 28 days cures with between 30 wt% and 70 wt% crushed rock mixed with full plant tailings to produce a wider gradation of particle sizes and a decrease in the voids between particles (porosity). The full plant tailings at 7" slump had a pulp density of 77 wt% solids, compared to the blended tailings/crushed rock paste having a pulp density of between 81 wt% and 85.5 wt% solids with 30 to 70 wt% crushed rock, respectively. The flotation tailings from the Pogo Project with a 7" slump had a solids content of 72.3 wt%.

MINE A: Full Plant Tailings Paste vs. 50/50 Blend Paste: Comparable Strength (Cement $US200/t rock $2.15/t and $5.00/t)



As these are site-specific costs with site-specific materials and material properties, care must be taken when attempting to make comparisons. The effects of increasing the proportion of coarse products must be carefully investigated due to high wear associated with larger particle sizes and the greater potential for plugging when greater than 60% solids by weight.

In the example of Mine A, the most cost effective approach was to backfill using 50/50 crushed rock:tailings blend where cement requirements are above 3 wt% and cement at $120/ton. When compared to $200/ton for cement as above, it is most cost effective at slightly more than 1.5 wt% cement. The opportunity to use aggregates and tailings blend may allow for a greater proportion of the leachate tailings to report to underground thus minimising surface disposal.

The same can apply for the cut and fill floors that require a higher strength layer to allow machine access to mine the next lift and minimise ore losses. Based on the strength results to date and our experience with similar tailings an estimated cement content of 8-12 wt% will be required without blending crushed rock or similar materials. The higher end of this range is more likely if the mining cycle were only 7 days.

3.4 Recommendations

Future testing should include additional strength testing of 4-inch x 8-inch cylinders over the 1, 3, 7 and 28 day cure with 2, 5, and 8 wt% OPC content with blended tailings to increase the confidence of the achievable strengths with cement content. The use of either waste rock or alluvial material for blending with the tailings will certainly improve the strength considerably. Assuming such material to be available on site, laboratory strength testing of blended paste should be done. The cost for provision of such material may be offset by a significant reduction in cement consumption.

Potentially, isolated secondary or tertiary mining areas may be backfilled with uncemented leachate tailings once due consideration is given for assessing the need for bulkheads, possible influence on mining activities and long-term ground water movement.

Testing of partially classified tailings should also be done to quantify the strength improvements possible. Manufacturers can conduct testing of low slump (<7") paste backfill with the addition of additives at no cost to Teck, assuming sufficient tailings are available.

Alternative binders such as flyash and slag could be investigated but given the mineralogical make up of the tailings (i.e., low iron content in the case of slag), we do not expect any strength improvements over Portland cement. If there are such binders available at a greatly reduced cost compared to Portland cement, then savings may be possible.

The following table lists approximate amounts of materials required if Teck Corporation were prepared to continue to test the effects of blending tailings and aggregates on potential strengths.

List of Materials for Possible Future Test Program

Weight Percent Binder			OPC Wt%	Cure Days	No of Samples	Samples of each Mix	Total No of Samples
Flotation	Leachate	Aggregate					
Test for Short Term Strengths Required to Prevent Liquefaction – No Aggregate							
80	20	0	2, 5, 8	3, 7	6	3	18
60	40	0	2, 5, 8	3, 7	6	3	18
40	60	0	2, 5, 8	3, 7	6	3	18
0	100	0	2, 5, 8	3, 7	6	3	18
Test for Strengths – Blended Tailings + 50 wt% Aggregate							
20	30	40	2, 5, 8	7, 28	6	3	18
10	40	40	2, 5, 8	7, 28	6	3	18
0	50	40	2, 5, 8	7, 28	6	3	18
Test for Strengths – Blended Tailings + 50 wt% Aggregate							
40	20	60	2, 5, 8	7, 28	6	3	18
20	40	60	2, 5, 8	7, 28	6	3	18
0	70	60	2, 5, 8	7, 28	6	3	18
Total No. of Cylinders							**180**
Total Weight of Products 375 lbs. 725 lbs. 475 lbs. 180 lbs.							**1720**

We trust the above is of interest and useful to the Teck Corporation and should you require clarification in any of the points or have any further questions, please do not hesitate to contact the undersigned.

GOLDER PASTE TECHNOLOGY LTD.

Frank Palkovits, P.Eng.
Senior Project Engineer

David A. Landriault, P.Eng.
President

FP/DAL:lb

Table 1
Unconfined Compressive Strength Test Results
Teck Project

Date Sample Prepared: Dec. 30, 1999
Binder Type: 100%OPC Type 10
Sample Type: 100% Flotation Tailings

Cylinder No.	Binder Content (wt%)	Curing Time (Days)	Slump of Paste (in)	Weight (kg)	Diameter (m)	Length (m)	Density (kg/m3)	Load (kN)	Strength MPa	Strength (psi)
Large Cylinders (4" x 8")										
1	2	28	7	2.97	0.102	0.204	1783	0.57	0.07	10
2	2	28	7	2.97	0.102	0.204	1783	0.56	0.07	10
3	2	28	7	2.97	0.102	0.204	1783	0.60	0.07	11
								Average	**0.07**	**10**
Small Cylinders (2" x 4")										
1	2	28	7	0.4260	0.051	0.112	1863	0.18	0.09	13
2	2	28	7	0.4300	0.051	0.113	1864	0.26	0.13	18
3	2	28	7	0.4250	0.051	0.112	1858	0.16	0.08	11
								Average	**0.10**	**14**

Date Sample Prepared: Dec. 31, 1999
Binder Type: 100%OPC Type 10
Sample Type: 100% Flotation Tailings

Cylinder No.	Binder Content (wt%)	Curing Time (Days)	Slump of Paste (in)	Weight (kg)	Diameter (m)	Length (m)	Density (kg/m3)	Load (kN)	Strength MPa	Strength (psi)
Large Cylinders (4" x 8")										
1	5	28	7	2.98	0.102	0.204	1789	1.85	0.23	33
2	5	28	7	2.99	0.102	0.203	1803	1.83	0.22	32
3	5	28	7	2.99	0.102	0.204	1795	1.80	0.22	32
								Average	**0.22**	**32**
Small Cylinders (2" x 4")										
1	5	28	7	0.4280	0.051	0.111	1888	0.66	0.32	47
2	5	28	7	0.4250	0.051	0.111	1875	0.63	0.31	45
3	5	28	7	0.4280	0.051	0.111	1888	0.65	0.32	46
								Average	**0.32**	**46**

Table 1 (con't)

Date Sample Prepared: Dec. 31, 1999
Binder Type: 100%OPC Type 10
Sample Type: 100% Flotation Tailings

Cylinder No.	Binder Content (wt%)	Curing Time (Days)	Slump of Paste (in)	Weight (kg)	Diameter (m)	Length (m)	Density (kg/m3)	Load (kN)	Strength MPa	Strength (psi)
Large Cylinders (4" x 8")										
1	8	28	7	2.98	0.102	0.204	1789	3.58	0.44	64
2	8	28	7	2.99	0.102	0.204	1795	3.72	0.46	66
3	8	28	7	2.97	0.102	0.203	1791	3.63	0.44	64
								Average	**0.45**	**65**
Small Cylinders (2" x 4")										
1	8	28	7	0.4240	0.051	0.111	1871	1.06	0.52	75
2	8	28	7	0.4210	0.051	0.110	1874	1.04	0.51	74
3	8	28	7	0.4250	0.051	0.112	1858	1.03	0.50	73
								Average	**0.51**	**74**

Table 1 (con't)

Date Sample Prepared: Jan.10, 2000
Binder Type: 100%OPC Type 10
Sample Type: 100% Leach Tailings

Cylinder No.	Binder Content (wt%)	Curing Time (Days)	Slump of Paste (in)	Weight (kg)	Diameter (m)	Length (m)	Density (kg/m3)	Load (kN)	Strength	
									MPa	(psi)
1	2	28	7	0.3845	0.051	0.110	1712	0.03	0.01	2
2	2	28	7	0.3818	0.051	0.109	1716	0.03	0.01	2
3	2	28	7	0.3856	0.051	0.110	1717	0.03	0.01	2
								Average	**0.01**	**2**

Date Sample Prepared: Jan.11, 2000
Binder Type: 100%OPC Type 10
Sample Type: 100% Leach Tailings

Cylinder No.	Binder Content (wt%)	Curing Time (Days)	Slump of Paste (in)	Weight (kg)	Diameter (m)	Length (m)	Density (kg/m3)	Load (kN)	Strength	
									MPa	(psi)
1	5	28	7	0.3854	0.051	0.109	1732	0.15	0.07	11
2	5	28	7	0.3917	0.051	0.111	1728	0.15	0.07	11
3	5	28	7	0.3843	0.051	0.110	1711	0.14	0.07	10
								Average	**0.07**	**10**

Date Sample Prepared: Jan.24, 2000
Binder Type: 100%OPC Type 10
Sample Type: 100% Leach Tailings

Cylinder No.	Binder Content (wt%)	Curing Time (Days)	Slump of Paste (in)	Weight (kg)	Diameter (m)	Length (m)	Density (kg/m3)	Load (kN)	Strength	
									MPa	(psi)
1	8	28	7	0.3820	0.051	0.108	1732	0.70	0.34	50
2	8	28	7	0.3867	0.051	0.110	1722	0.70	0.34	50
3	8	28	7	0.3700	0.051	0.105	1726	0.69	0.34	49
								Average	**0.34**	**49**

Table 1 (con't)

Date Sample Prepared: Jan.13, 2000
Binder Type: 100%OPC Type 10
Sample Type: 80% Flotation Tails / 20% Leach Tails

Cylinder No.	Binder Content (wt%)	Curing Time (Days)	Slump of Paste (in)	Weight (kg)	Diameter (m)	Length (m)	Density (kg/m3)	Load (kN)	Strength MPa	Strength (psi)
1	2	28	7	0.4077	0.051	0.108	1849	0.07	0.03	5
2	2	28	7	0.3969	0.051	0.107	1817	0.09	0.04	6
3	2	28	7	0.4011	0.051	0.106	1853	0.08	0.04	6
								Average	**0.04**	**6**

Date Sample Prepared: Jan.13, 2000
Binder Type: 100%OPC Type 10
Sample Type: 80% Flotation Tails / 20% Leach Tails

Cylinder No.	Binder Content (wt%)	Curing Time (Days)	Slump of Paste (in)	Weight (kg)	Diameter (m)	Length (m)	Density (kg/m3)	Load (kN)	Strength MPa	Strength (psi)
1	5	28	7	0.4140	0.051	0.109	1860	0.47	0.23	33
2	5	28	7	0.4147	0.051	0.109	1863	0.55	0.27	39
3	5	28	7	0.4149	0.051	0.110	1847	0.47	0.23	33
								Average	**0.24**	**35**

Date Sample Prepared: Jan.13, 2000
Binder Type: 100%OPC Type 10
Sample Type: 80% Flotation Tails / 20% Leach Tails

Cylinder No.	Binder Content (wt%)	Curing Time (Days)	Slump of Paste (in)	Weight (kg)	Diameter (m)	Length (m)	Density (kg/m3)	Load (kN)	Strength MPa	Strength (psi)
1	8	28	7	0.4207	0.051	0.111	1856	1.01	0.49	72
2	8	28	7	0.4180	0.051	0.110	1861	1.14	0.56	81
3	8	28	7	0.4215	0.051	0.111	1860	1.18	0.58	84
								Average	**0.54**	**79**

Table 1 (con't)

Date Sample Prepared: Jan.14, 2000
Binder Type: 100%OPC Type 10
Sample Type: 60% Flotation Tails / 40% Leach Tails

Cylinder No.	Binder Content (wt%)	Curing Time (Days)	Slump of Paste (in)	Weight (kg)	Diameter (m)	Length (m)	Density (kg/m3)	Load (kN)	Strength MPa	Strength (psi)
1	2	28	7	0.4002	0.051	0.110	1782	0.05	0.02	4
2	2	28	7	0.3772	0.051	0.102	1811	0.04	0.02	3
3	2	28	7	0.4000	0.051	0.110	1781	0.04	0.02	3
								Average	**0.02**	**3**

Date Sample Prepared: Jan.14, 2000
Binder Type: 100%OPC Type 10
Sample Type: 60% Flotation Tails / 40% Leach Tails

Cylinder No.	Binder Content (wt%)	Curing Time (Days)	Slump of Paste (in)	Weight (kg)	Diameter (m)	Length (m)	Density (kg/m3)	Load (kN)	Strength MPa	Strength (psi)
1	5	28	7	0.4184	0.051	0.113	1813	0.39	0.19	28
2	5	28	7	0.4092	0.051	0.110	1822	0.35	0.17	25
3	5	28	7	0.4209	0.051	0.113	1824	0.33	0.16	23
								Average	**0.17**	**25**

Date Sample Prepared: Jan.14, 2000
Binder Type: 100%OPC Type 10
Sample Type: 60% Flotation Tails / 40% Leach Tails

Cylinder No.	Binder Content (wt%)	Curing Time (Days)	Slump of Paste (in)	Weight (kg)	Diameter (m)	Length (m)	Density (kg/m3)	Load (kN)	Strength MPa	Strength (psi)
1	8	28	7	0.4211	0.051	0.114	1809	1.09	0.53	77
2	8	28	7	0.4253	0.051	0.114	1827	1.25	0.61	89
3	8	28	7	0.4213	0.051	0.114	1810	1.20	0.59	85
								Average	**0.58**	**84**

Table 1 (con't)

Date Sample Prepared: Jan.14, 2000
Binder Type: 100%OPC Type 10
Sample Type: 40% Flotation Tails / 60% Leach Tails

Cylinder No.	Binder Content (wt%)	Curing Time (Days)	Slump of Paste (in)	Weight (kg)	Diameter (m)	Length (m)	Density (kg/m3)	Load (kN)	Strength MPa	Strength (psi)
1	2	28	7	0.4191	0.051	0.113	1816	0.04	0.02	3
2	2	28	7	0.4194	0.051	0.114	1802	0.04	0.02	3
3	2	28	7	0.4192	0.051	0.113	1817	0.04	0.02	3
								Average	**0.02**	**3**

Date Sample Prepared: Jan.14, 2000
Binder Type: 100%OPC Type 10
Sample Type: 40% Flotation Tails / 60% Leach Tails

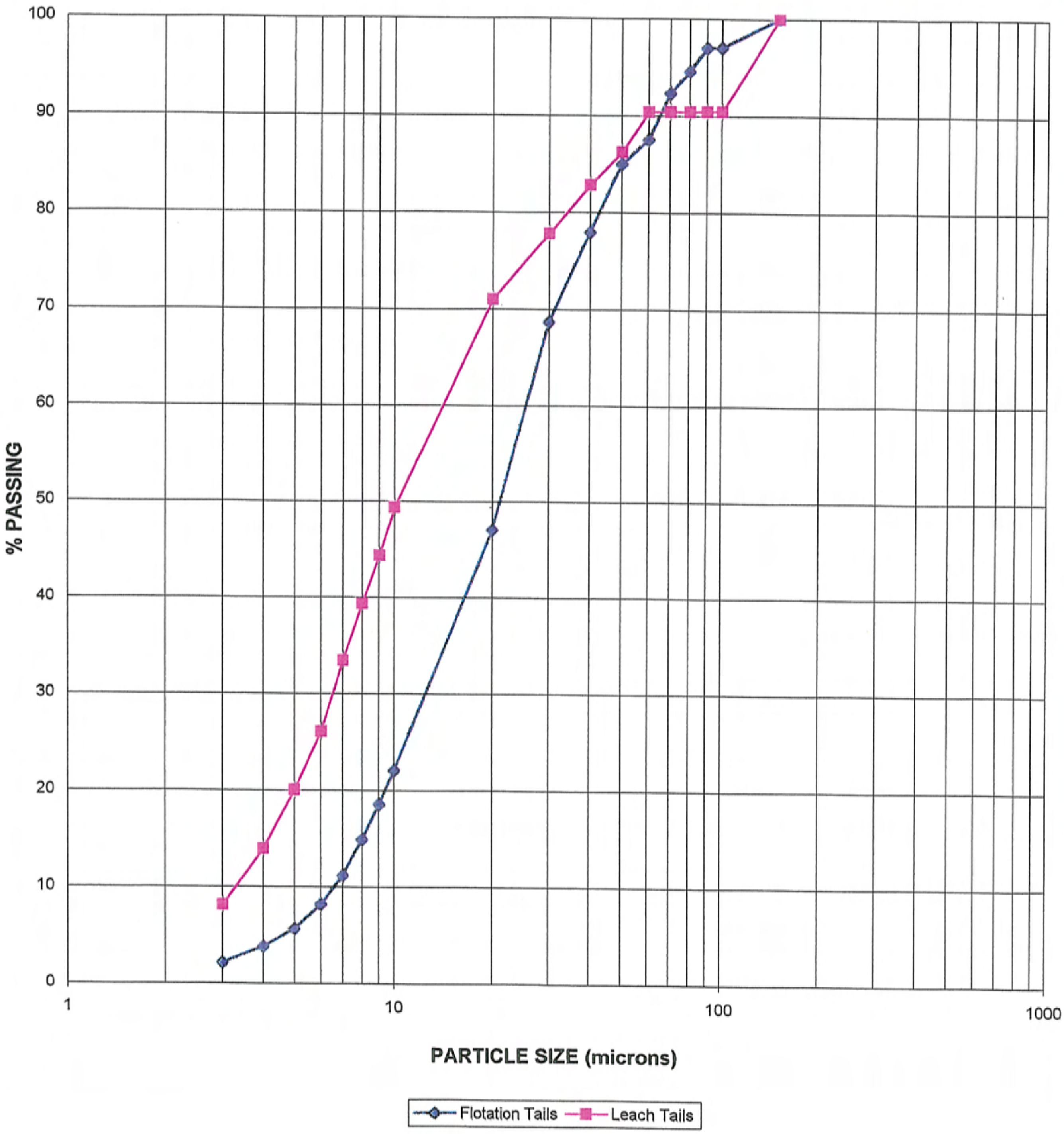
Cylinder No.	Binder Content (wt%)	Curing Time (Days)	Slump of Paste (in)	Weight (kg)	Diameter (m)	Length (m)	Density (kg/m3)	Load (kN)	Strength MPa	Strength (psi)
1	5	28	7	0.4175	0.051	0.115	1778	0.24	0.12	17
2	5	28	7	0.4061	0.051	0.111	1792	0.26	0.13	18
3	5	28	7	0.4160	0.051	0.115	1772	0.27	0.13	19
								Average	**0.13**	**18**

Date Sample Prepared: Jan.14, 2000
Binder Type: 100%OPC Type 10
Sample Type: 40% Flotation Tails / 60% Leach Tails

Cylinder No.	Binder Content (wt%)	Curing Time (Days)	Slump of Paste (in)	Weight (kg)	Diameter (m)	Length (m)	Density (kg/m3)	Load (kN)	Strength MPa	Strength (psi)
1	8	28	7	0.4157	0.051	0.114	1786	1.23	0.60	87
2	8	28	7	0.4186	0.051	0.115	1783	1.02	0.50	72
3	8	28	7	0.4197	0.051	0.115	1787	1.06	0.52	75
								Average	**0.54**	**78**

PARTICLE SIZE DISTRIBUTION OF TECK PROJECT TAILINGS

FIGURE 1

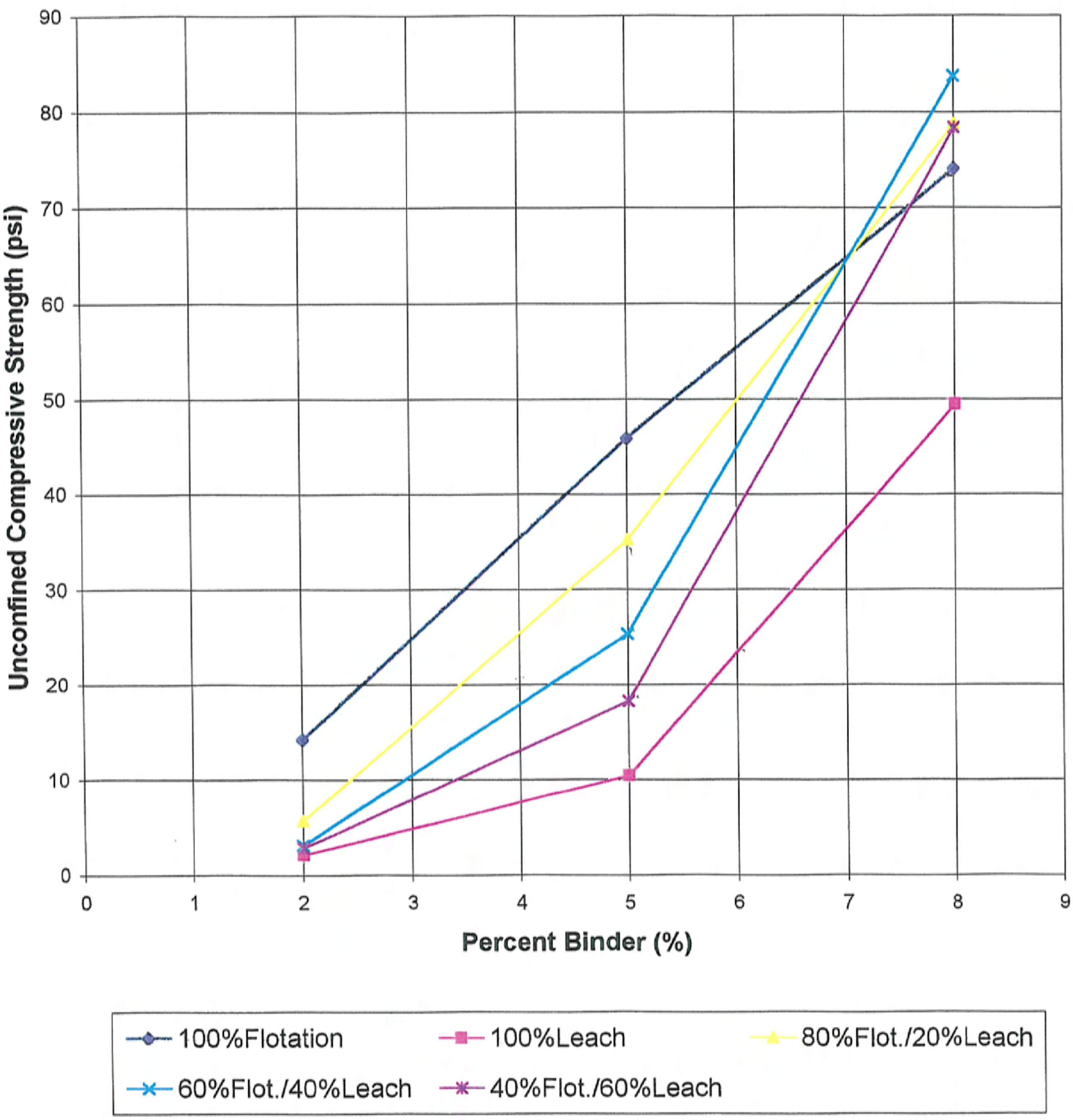


Date: January, 2000

Project: 991-9950

Golder Paste Technology Ltd.

28 DAY COMPRESSIVE STRENGTH TEST RESULTS 7 INCH SLUMP - 100% OPC TECK CORPORATION	FIGURE 2

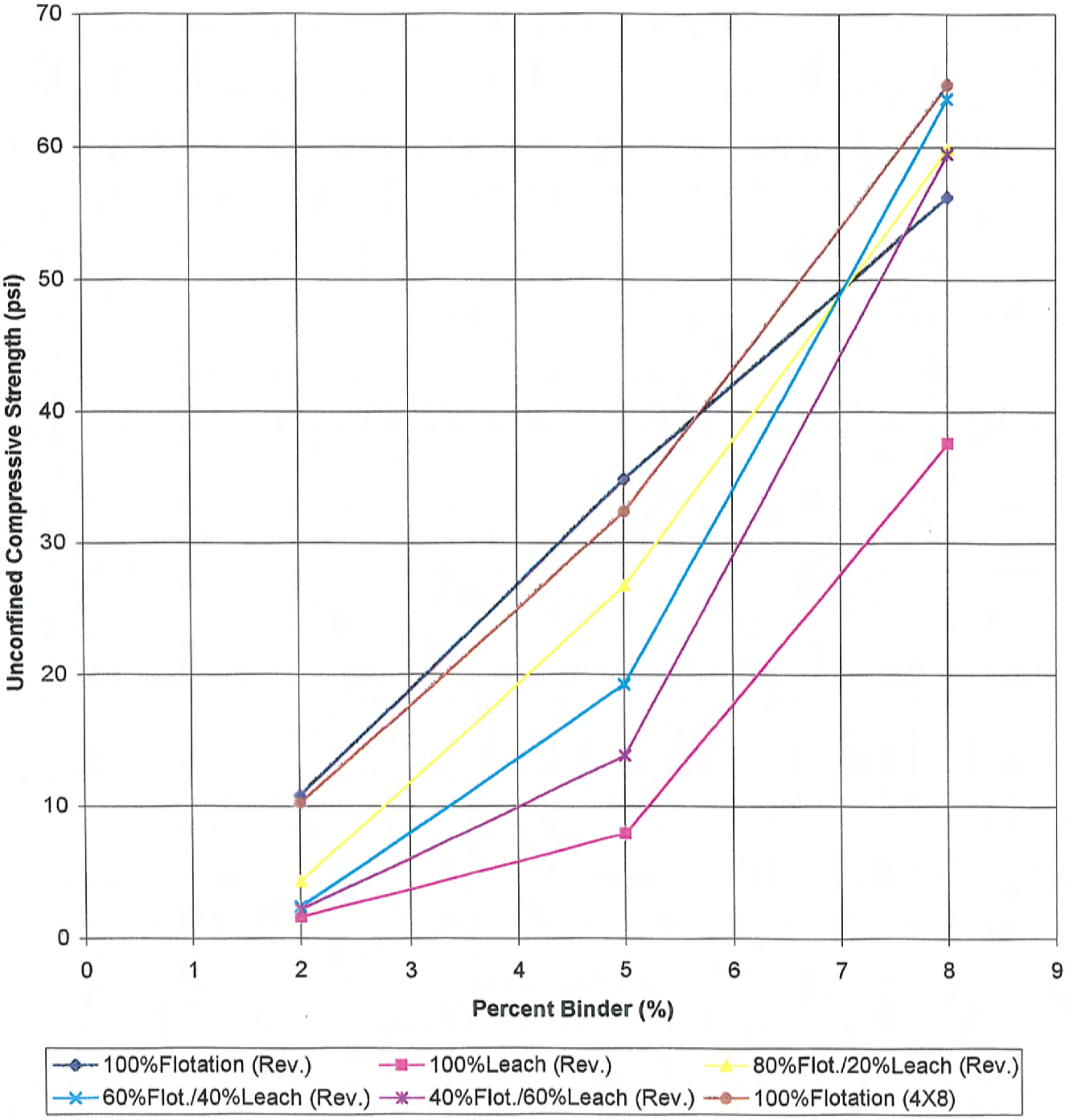


Date: January, 2000
Project: 991-9950

Golder Paste Technology Ltd.

28 DAY COMPRESSIVE STRENGTH TEST RESULTS
7 INCH SLUMP - 100% OPC
ADJUSTED STRENGTHS TO 4" X 8" CYLINDERS

FIGURE 3

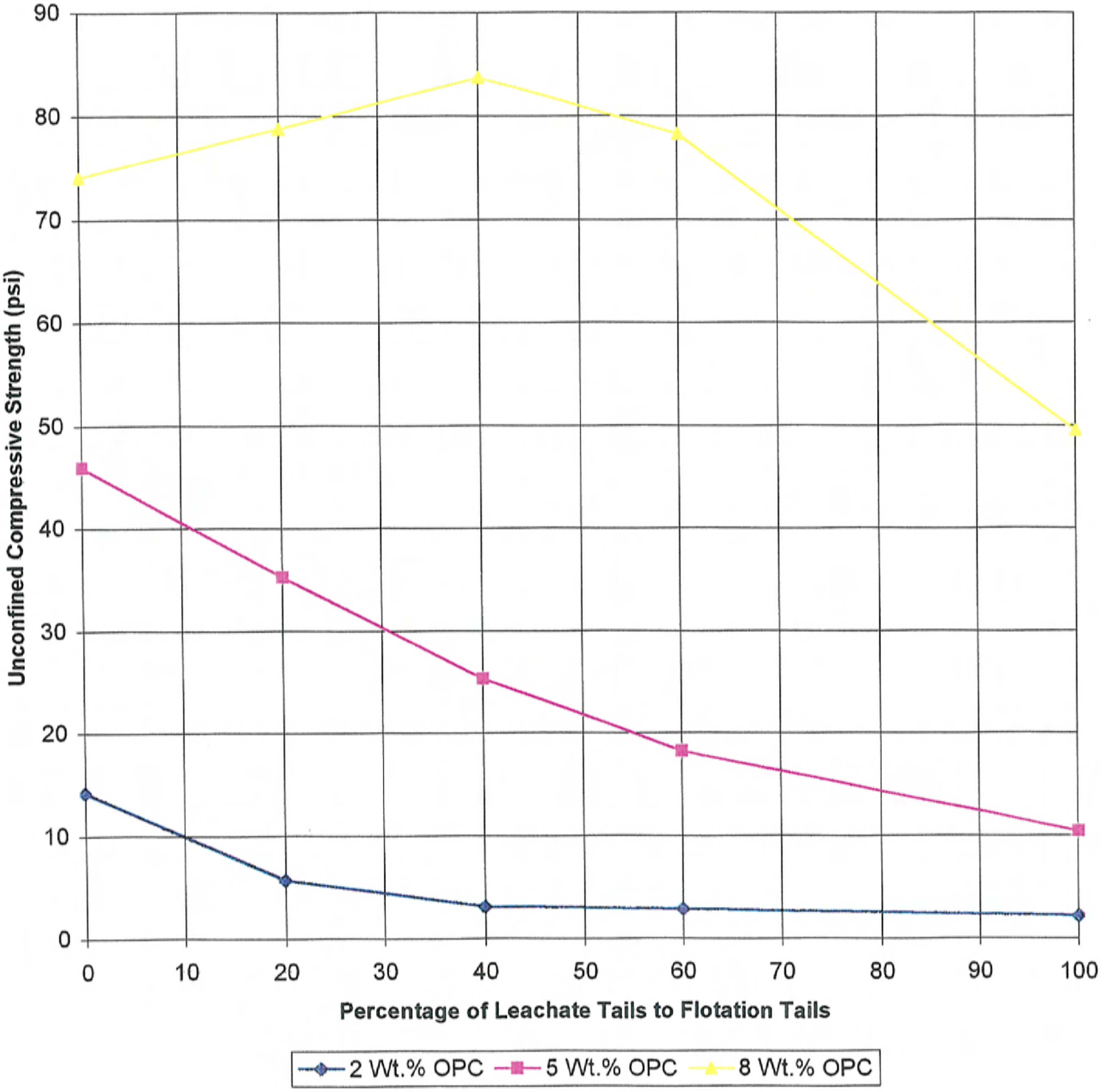


Date: January, 2000
Project: 991-9950

Golder Paste Technology Ltd.

28 DAY COMPRESSIVE STRENGTH TEST RESULTS
PERCENTAGE OF LEACH TAILS VS. UCS
TECK CORPORATION

FIGURE 4

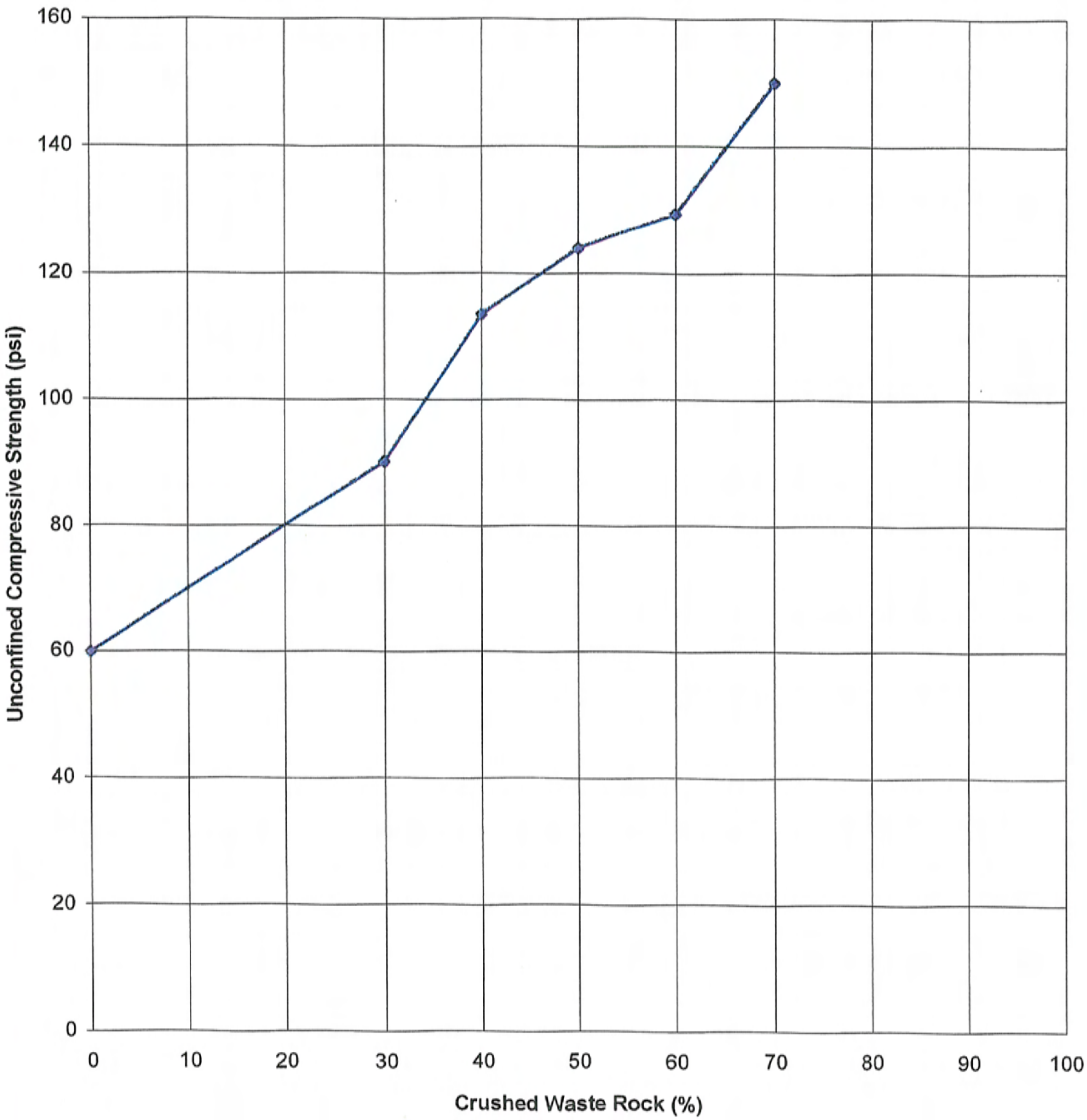


Date: January, 2000
Project: 991-9950

Golder Paste Technology Ltd.

7 DAY, 5 WT% COMPRESSIVE STRENGTH TEST RESULTS
COMPRESSIVE STRENGTH VS.PERCENT WASTE ROCK
MINE 'A'

FIGURE 5

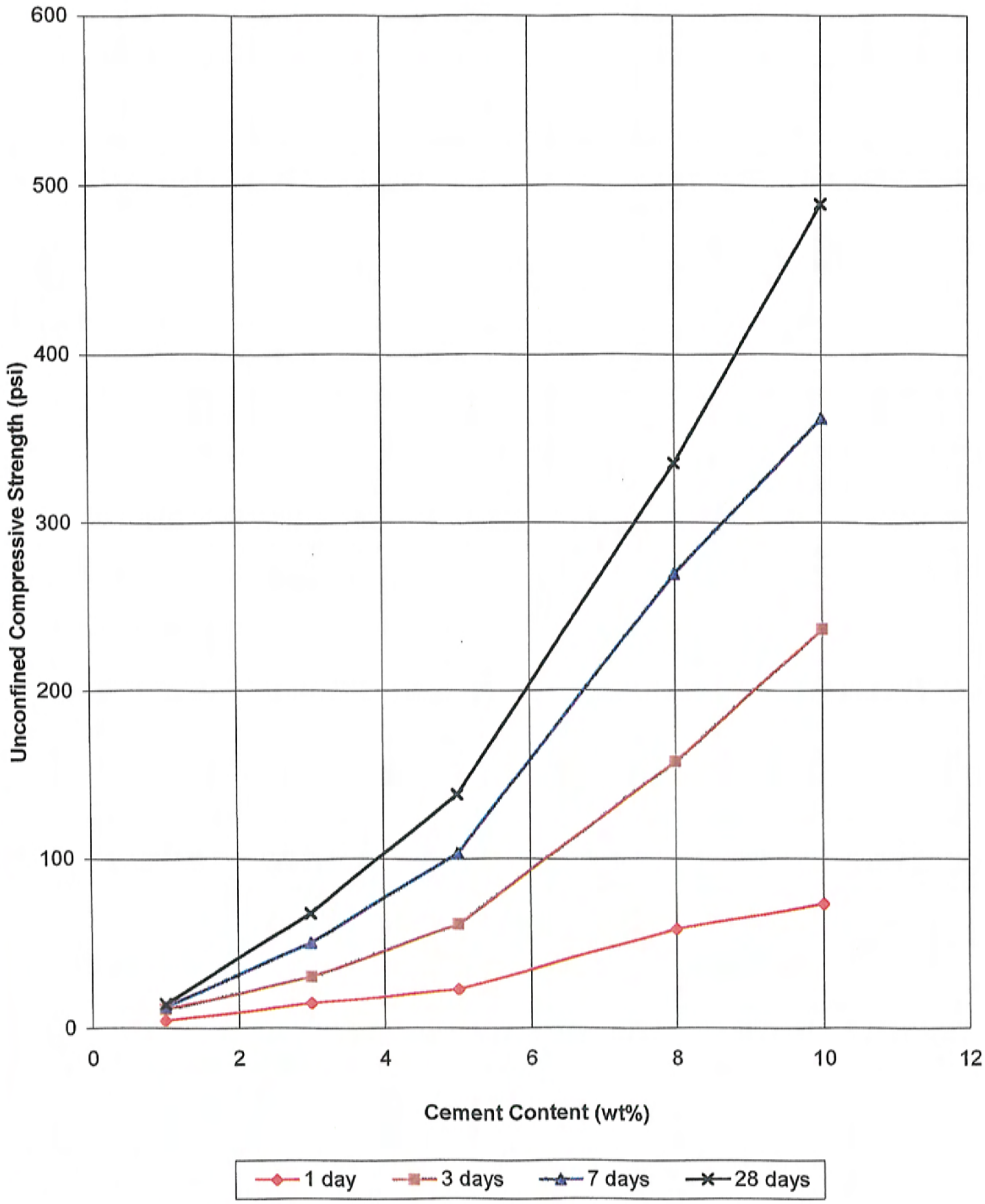


Date: January, 2000

Project: 991-9950

Golder Paste Technology Ltd.

COMPRESSIVE STRENGTH TEST RESULTS 50% FPT / 50% - 100% OPC 7" SLUMP, MINE 'A'	FIGURE 6



Date: January, 2000

Project: 991-9950

Golder Paste Technology Ltd.

APPENDIX A

PHASE I PERMEABILITY RESULTS

HYDRAULIC CONDUCTIVITY TEST

BOREHOLE NUMBER:		PROJECT NUMBER:	991-9950
SAMPLE NUMBER:	Tech-Strength-Pogo 1	PROJECT TITLE:	
SAMPLE DEPTH, m:		DATE STARTED:	February 1, 2000
		DATE COMPLETED:	February 10, 2000

SPECIMEN PROPERTIES AND DIMENSIONS

INITIAL VALUES		AFTER CONSOLIDATION TO 50 kPa		AFTER TEST	
LENGTH (cm):	10.18	LENGTH (cm):	10.16	TOTAL MASS,final(g):	401.16
DIAMETER (cm):	5.22	AREA (cm^2):	21.34	DRY MASS,final(g):	285.93
AREA (cm^2):	21.40	VOLUME (cc)	216.91	WATER CONTENT, (%):	40.30
VOLUME (cc)	217.89	TOTAL MASS (g):	395.99	UNIT WEIGHT (kN/m^3):	18.13
TOTAL MASS (g):	390.87	DRY MASS (g):	285.93	DRY UNIT WEIGHT (kN/m^3):	12.92
DRY MASS (g):	285.93	VOLUME WATER (cc):	110.05	VOLUME SOLIDS (cc):	105.90
WATER CONTENT, (%):	36.70	WATER CONTENT, (%):	38.49	VOLUME VOIDS (cc):	111.01
UNIT WEIGHT (kN/m^3):	17.59	UNIT WEIGHT (kN/m^3):	17.90	VOID RATIO:	1.048
DRY UNIT WEIGHT (kN/m^3):	12.86	DRY UNIT WEIGHT (kN/m^3):	12.92	SATURATION (%):	103.8
SPECIFIC GRAVITY (assumed)	2.70	VOLUME SOLIDS (cc):	105.90		
VOLUME SOLIDS (cc):	105.90	VOLUME VOIDS (cc):	111.01		
VOLUME VOIDS (cc):	111.99	VOID RATIO:	1.048		
VOID RATIO:	1.057				
SATURATION (%):	93.7				

BOUNDARY CONDITIONS IMPOSED ON SPECIMEN

SATURATION STAGE		CONSOLIDATION STAGE		HYDRAULIC CONDUCTIVITY TESTING	
CELL PRESSURE (kPa):	280.0	CELL PRESSURE (kPa):	325.0	CELL PRESSURE (kPa):	345.0
BACK PRESSURE (kPa):	275.0	BACK PRESSURE (kPa):	275.0	HEAD PRESSURE (kPa):	295.0
SATURATION DURATION (min):	4380.0	CONSOL. PRESSURE (kPa):	50.0	BACK PRESSURE (kPa):	275.0
VOLUME OF WATER (cc):	6.1	VOLUME CHANGE (cc):	0.98	EFFECTIVE PRESSURE,TOP (kPa):	50.0
B-VALUE:	0.97			EFFECTIVE PRESSURE,BTM. (kPa):	70.0
WATER CONTENT, (%):	38.83			EFFECTIVE HEAD PRESSURE (kPa):	20.0
				HYDRAULIC GRADIENT:	20.1

Note. For graphical presentation of data - see attached figure.

HYDRAULIC CONDUCTIVITY CALCULATION SUMMARY

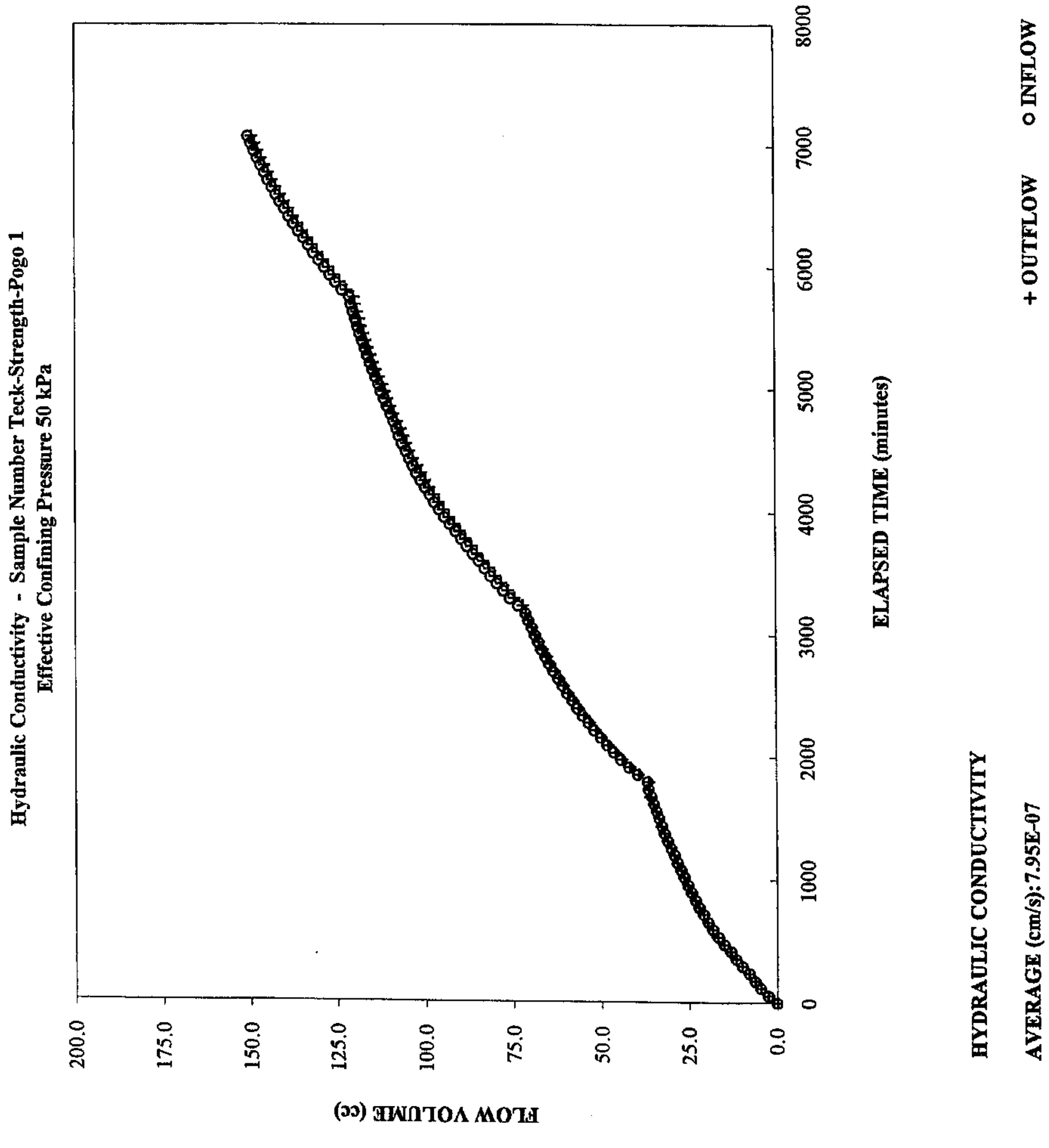
TOTAL ELAPSED TEST TIME (min):	7080.00	STEADY-STATE INFLOW (Q)(cm^3/s):	3.42E-04
ELAPSED TIME TO ACHIEVE STEADY-STATE FLOW (min):	1020.00	STEADY-STATE OUTFLOW (Q)(cm^3/s):	3.39E-04
DURATION OF STEADY-STATE FLOW (min):	6060.00	HYDRAULIC GRADIENT:	20.08
TOTAL INFLOW VOLUME UNDER STEADY-STATE (cc):	124.32	AREA (cm^2):	21.34
TOTAL OUTFLOW VOLUME UNDER STEADY STATE (cc):	123.20		

HYDRAULIC CONDUCTIVITY		
	:INFLOW (cm/s):	7.98E-07
	:OUTFLOW (cm/s):	7.91E-07
	:AVERAGE (cm/s):	7.95E-07

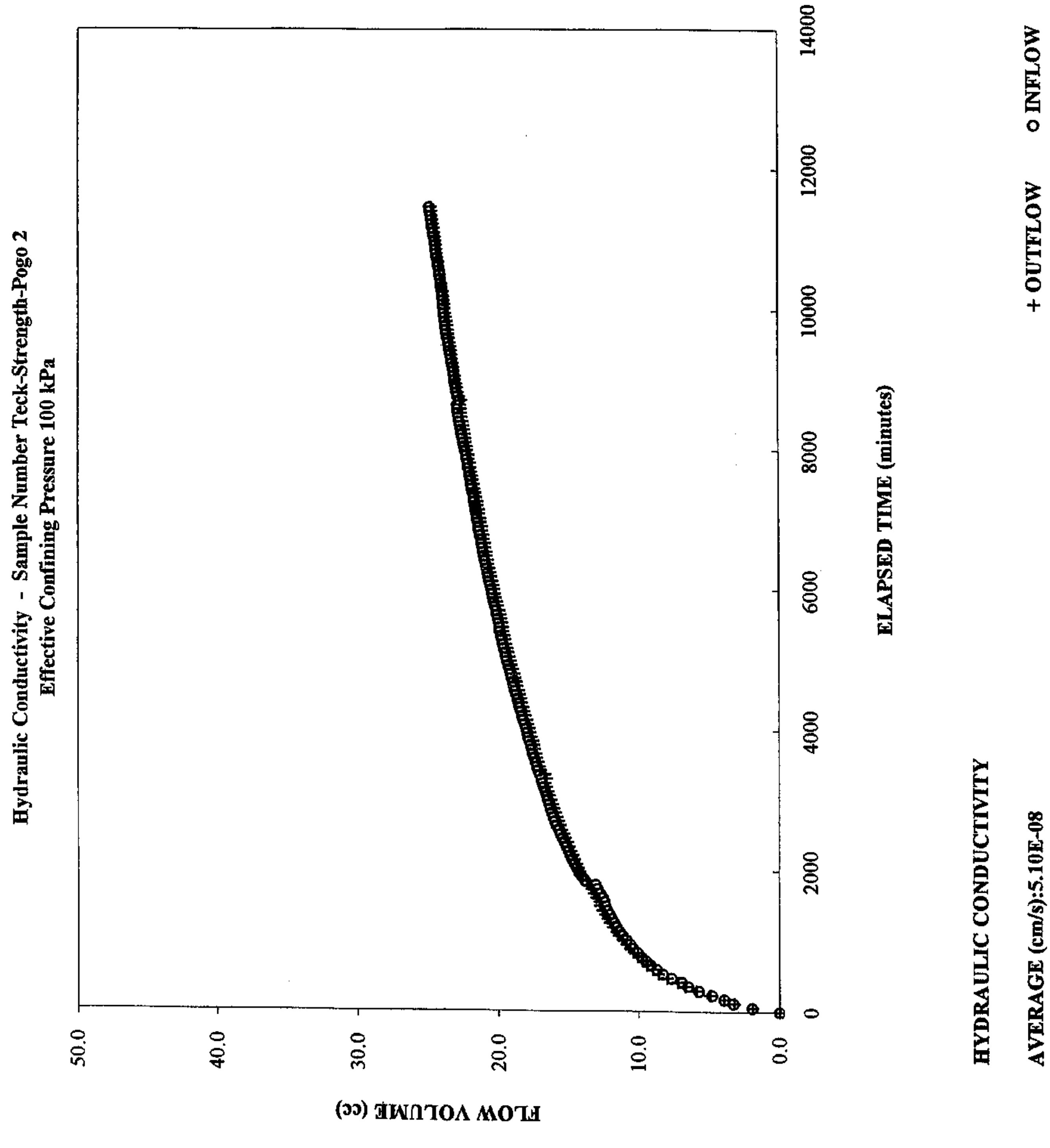
NOTES:

1. Membrane sealed onto sample with vacuum grease.
2. Steady-State inflow and outflow values represent slopes of best fit lines through data points shown on attached Volume - Time Curves.
3. Saturation of sample carried out in increments of 70 kPa up to maximum pressures required to induce saturation B-value of at least 0.96.
4. Test carried out at room temperature using deaired tap water as permeant fluid.

HYDRAULIC CONDUCTIVITY TEST	FIGURE



HYDRAULIC CONDUCTIVITY TEST	FIGURE



HYDRAULIC CONDUCTIVITY TEST

BOREHOLE NUMBER:		PROJECT NUMBER:	991-9950
SAMPLE NUMBER:	Tech-Strength-Pogo 3	PROJECT TITLE:	
SAMPLE DEPTH, m:		DATE STARTED:	February 1, 2000
		DATE COMPLETED:	February 10, 2000

SPECIMEN PROPERTIES AND DIMENSIONS

INITIAL VALUES		AFTER CONSOLIDATION TO 200 kPa		AFTER TEST	
LENGTH (cm):	9.40	LENGTH (cm):	9.33	TOTAL MASS,final(g):	360.10
DIAMETER (cm):	5.23	AREA (cm^2):	21.17	DRY MASS,final(g):	258.88
AREA (cm^2):	21.49	VOLUME (cc)	197.46	WATER CONTENT, (%):	39.10
VOLUME (cc)	201.97	TOTAL MASS (g):	359.11	UNIT WEIGHT (kN/m^3):	17.88
TOTAL MASS (g):	359.33	DRY MASS (g):	258.88	DRY UNIT WEIGHT (kN/m^3):	12.85
DRY MASS (g):	258.88	VOLUME WATER (cc):	100.23	VOLUME SOLIDS (cc):	95.88
WATER CONTENT, (%):	38.80	WATER CONTENT, (%):	38.72	VOLUME VOIDS (cc):	101.58
UNIT WEIGHT (kN/m^3):	17.44	UNIT WEIGHT (kN/m^3):	17.83	VOID RATIO:	1.059
DRY UNIT WEIGHT (kN/m^3):	12.57	DRY UNIT WEIGHT (kN/m^3):	12.85	SATURATION (%):	99.6
SPECIFIC GRAVITY (assumed)	2.70	VOLUME SOLIDS (cc):	95.88		
VOLUME SOLIDS (cc):	95.88	VOLUME VOIDS (cc):	101.58		
VOLUME VOIDS (cc):	106.08	VOID RATIO:	1.059		
VOID RATIO:	1.106				
SATURATION (%):	94.7				

BOUNDARY CONDITIONS IMPOSED ON SPECIMEN

SATURATION STAGE		CONSOLIDATION STAGE		HYDRAULIC CONDUCTIVITY TESTING	
CELL PRESSURE (kPa):	210.0	CELL PRESSURE (kPa):	405.0	CELL PRESSURE (kPa):	423.0
BACK PRESSURE (kPa):	205.0	BACK PRESSURE (kPa):	205.0	HEAD PRESSURE (kPa):	223.0
SATURATION DURATION (min):	4200.0	CONSOL. PRESSURE (kPa):	200.0	BACK PRESSURE (kPa):	205.0
VOLUME OF WATER (cc):	4.3	VOLUME CHANGE (cc):	4.50	EFFECTIVE PRESSURE,TOP (kPa):	200.0
B-VALUE:	0.99			EFFECTIVE PRESSURE,BTM. (kPa):	218.0
WATER CONTENT, (%):	40.46			EFFECTIVE HEAD PRESSURE (kPa):	18.0
				HYDRAULIC GRADIENT:	19.7

Note. For graphical presentation of data - see attached figure.

HYDRAULIC CONDUCTIVITY CALCULATION SUMMARY

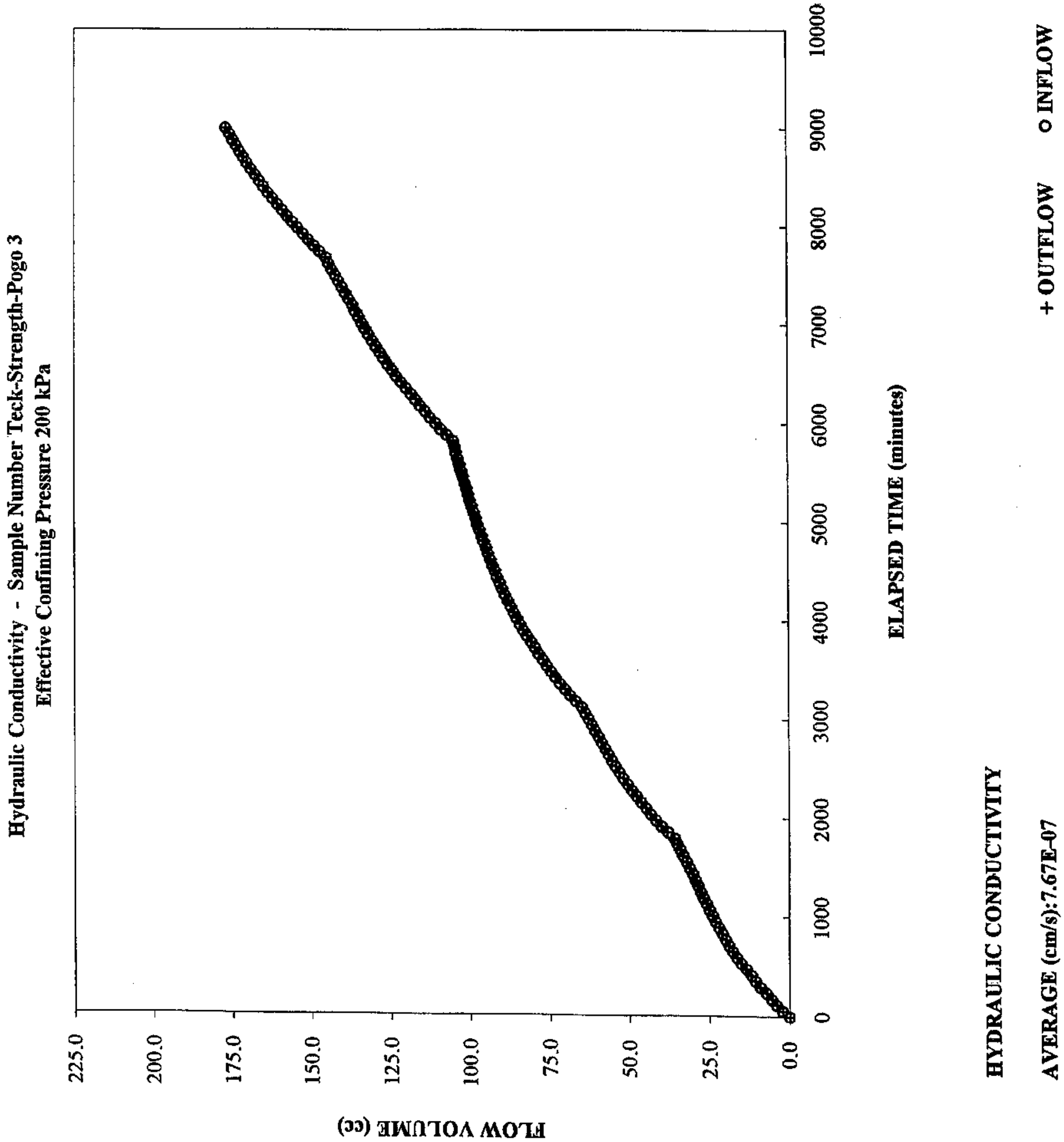
TOTAL ELAPSED TEST TIME (min):	9000.00	STEADY-STATE INFLOW (Q)(cm^3/s):	3.20E-04
ELAPSED TIME TO ACHIEVE STEADY-STATE FLOW (min):	1020.00	STEADY-STATE OUTFLOW (Q)(cm^3/s):	3.19E-04
DURATION OF STEADY-STATE FLOW (min):	7980.00	HYDRAULIC GRADIENT:	19.68
TOTAL INFLOW VOLUME UNDER STEADY-STATE (cc):	153.00	AREA (cm^2):	21.17
TOTAL OUTFLOW VOLUME UNDER STEADY STATE (cc):	152.88		

HYDRAULIC CONDUCTIVITY		
	:INFLOW (cm/s):	7.67E-07
	:OUTFLOW (cm/s):	7.66E-07
	:AVERAGE (cm/s):	7.67E-07

NOTES:

1. Membrane sealed onto sample with vacuum grease.
2. Steady-State inflow and outflow values represent slopes of best fit lines through data points shown on attached Volume - Time Curves.
3. Saturation of sample carried out in increments of 70 kPa up to maximum pressures required to induce saturation B-value of at least 0.96.
4. Test carried out at room temperature using deaired tap water as permeant fluid.

HYDRAULIC CONDUCTIVITY TEST | **FIGURE**



HYDRAULIC CONDUCTIVITY TEST

BOREHOLE NUMBER:		PROJECT NUMBER:	991-9950
SAMPLE NUMBER:	Tech-Strength-Pogo 4	PROJECT TITLE:	
SAMPLE DEPTH, m:		DATE STARTED:	February 11, 2000
		DATE COMPLETED:	February 21, 2000

SPECIMEN PROPERTIES AND DIMENSIONS

INITIAL VALUES		AFTER CONSOLIDATION TO 50 kPa		AFTER TEST	
LENGTH (cm):	9.22	LENGTH (cm):	9.16	TOTAL MASS,final(g):	350.22
DIAMETER (cm):	5.21	AREA (cm^2):	21.05	DRY MASS,final(g):	242.02
AREA (cm^2):	21.32	VOLUME (cc)	192.88	WATER CONTENT, (%):	44.70
VOLUME (cc)	196.59	TOTAL MASS (g):	346.62	UNIT WEIGHT (kN/m^3):	17.80
TOTAL MASS (g):	348.03	DRY MASS (g):	242.02	DRY UNIT WEIGHT (kN/m^3):	12.30
DRY MASS (g):	242.02	VOLUME WATER (cc):	104.59	VOLUME SOLIDS (cc):	89.64
WATER CONTENT, (%):	43.80	WATER CONTENT, (%):	43.22	VOLUME VOIDS (cc):	103.25
UNIT WEIGHT (kN/m^3):	17.36	UNIT WEIGHT (kN/m^3):	17.62	VOID RATIO:	1.152
DRY UNIT WEIGHT (kN/m^3):	12.07	DRY UNIT WEIGHT (kN/m^3):	12.30	SATURATION (%):	104.8
SPECIFIC GRAVITY (assumed)	2.70	VOLUME SOLIDS (cc):	89.64		
VOLUME SOLIDS (cc):	89.64	VOLUME VOIDS (cc):	103.25		
VOLUME VOIDS (cc):	106.95	VOID RATIO:	1.152		
VOID RATIO:	1.193				
SATURATION (%):	99.1				

BOUNDARY CONDITIONS IMPOSED ON SPECIMEN

SATURATION STAGE		CONSOLIDATION STAGE		HYDRAULIC CONDUCTIVITY TESTING	
CELL PRESSURE (kPa):	280.0	CELL PRESSURE (kPa):	325.0	CELL PRESSURE (kPa):	343.0
BACK PRESSURE (kPa):	275.0	BACK PRESSURE (kPa):	275.0	HEAD PRESSURE (kPa):	293.0
SATURATION DURATION (min):	5,460.0	CONSOL. PRESSURE (kPa):	50.0	BACK PRESSURE (kPa):	275.0
VOLUME OF WATER (cc):	2.3	VOLUME CHANGE (cc):	3.70	EFFECTIVE PRESSURE,TOP (kPa):	68.0
B-VALUE:	0.99			EFFECTIVE PRESSURE,BTM. (kPa):	50.0
WATER CONTENT, (%):	44.75			EFFECTIVE HEAD PRESSURE (kPa):	18.0
				HYDRAULIC GRADIENT:	20.0

Note. For graphical presentation of data - see attached figure.

HYDRAULIC CONDUCTIVITY CALCULATION SUMMARY

TOTAL ELAPSED TEST TIME (min):	3,180.00	STEADY-STATE INFLOW (Q)(cm^3/s):	1.81E-04
ELAPSED TIME TO ACHIEVE STEADY-STATE FLOW (min):	0.00	STEADY-STATE OUTFLOW (Q)(cm^3/s):	1.84E-04
DURATION OF STEADY-STATE FLOW (min):	3,180.00	HYDRAULIC GRADIENT:	20.05
TOTAL INFLOW VOLUME UNDER STEADY-STATE (cc):	34.56	AREA (cm^2):	21.05
TOTAL OUTFLOW VOLUME UNDER STEADY STATE (cc):	35.05		

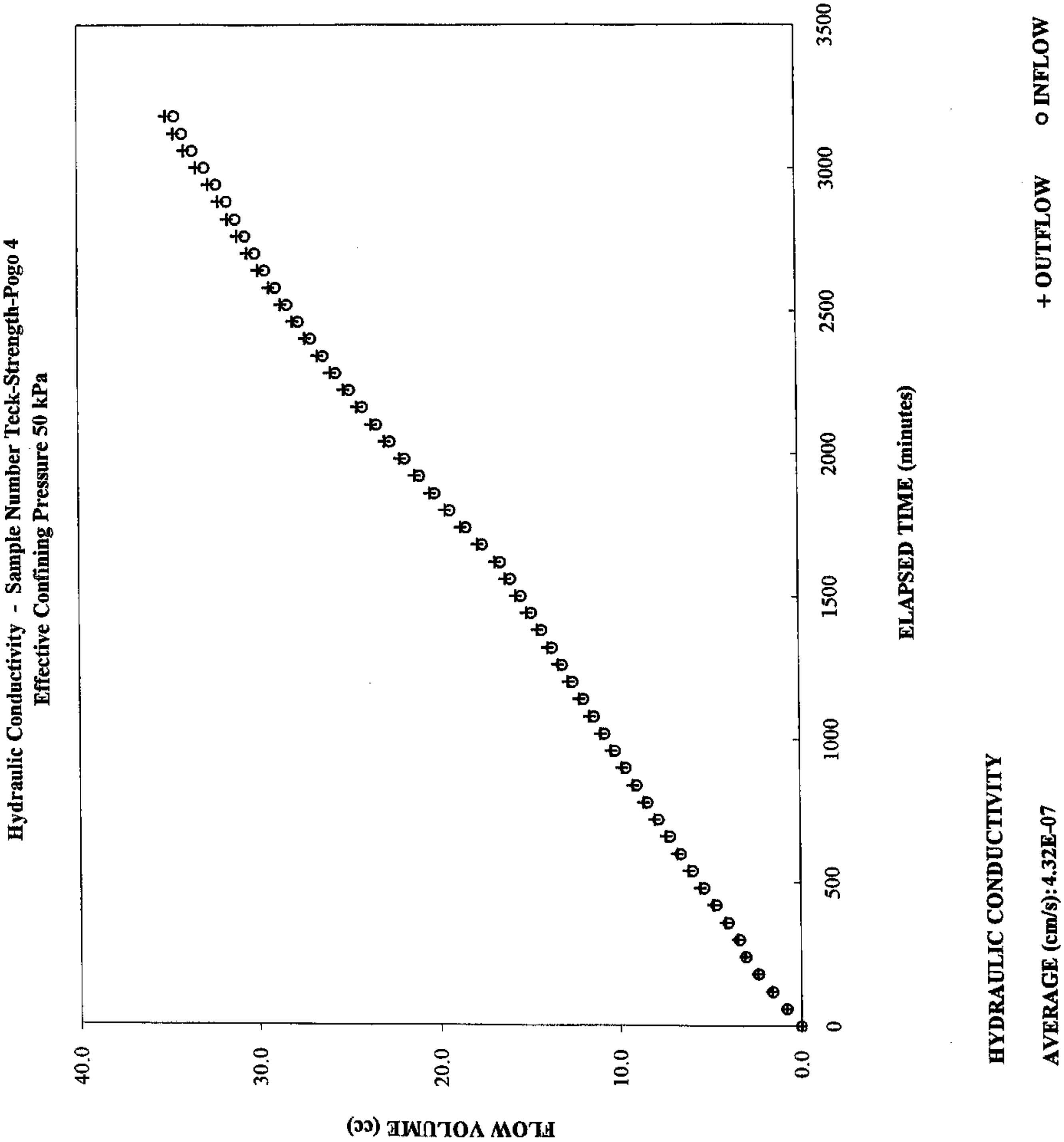
HYDRAULIC CONDUCTIVITY

:INFLOW (cm/s):	4.29E-07
;OUTFLOW (cm/s):	4.35E-07
:AVERAGE (cm/s):	4.32E-07

NOTES:

1. Membrane sealed onto sample with vacuum grease.
2. Steady-State inflow and outflow values represent slopes of best fit lines through data points shown on attached Volume - Time Curves.
3. Saturation of sample carried out in increments of 70 kPa up to maximum pressures required to induce saturation B-value of at least 0.96.
4. Test carried out at room temperature using deaired tap water as permeant fluid.

HYDRAULIC CONDUCTIVITY TEST	FIGURE



HYDRAULIC CONDUCTIVITY TEST

BOREHOLE NUMBER:		PROJECT NUMBER:	991-9950
SAMPLE NUMBER:	Tech-Strength-Pogo 5	PROJECT TITLE:	
SAMPLE DEPTH, m:		DATE STARTED:	February 11, 2000
		DATE COMPLETED:	February 21, 2000

SPECIMEN PROPERTIES AND DIMENSIONS

INITIAL VALUES		AFTER CONSOLIDATION TO 100 kPa		AFTER TEST	
LENGTH (cm):	8.99	LENGTH (cm):	8.81	TOTAL MASS,final(g):	343.79
DIAMETER (cm):	5.20	AREA (cm^2):	20.38	DRY MASS,final(g):	237.06
AREA (cm^2):	21.24	VOLUME (cc)	179.33	WATER CONTENT, (%):	45.03
VOLUME (cc)	190.95	TOTAL MASS (g):	330.49	UNIT WEIGHT (kN/m^3):	18.79
TOTAL MASS (g):	341.36	DRY MASS (g):	237.06	DRY UNIT WEIGHT (kN/m^3):	12.96
DRY MASS (g):	237.06	VOLUME WATER (cc):	93.44	VOLUME SOLIDS (cc):	87.80
WATER CONTENT, (%):	44.00	WATER CONTENT, (%):	39.42	VOLUME VOIDS (cc):	91.53
UNIT WEIGHT (kN/m^3):	17.53	UNIT WEIGHT (kN/m^3):	18.07	VOID RATIO:	1.042
DRY UNIT WEIGHT (kN/m^3):	12.17	DRY UNIT WEIGHT (kN/m^3):	12.96	SATURATION (%):	116.6
SPECIFIC GRAVITY (assumed)	2.70	VOLUME SOLIDS (cc):	87.80		
VOLUME SOLIDS (cc):	87.80	VOLUME VOIDS (cc):	91.53		
VOLUME VOIDS (cc):	103.15	VOID RATIO:	1.042		
VOID RATIO:	1.175				
SATURATION (%):	101.1				

BOUNDARY CONDITIONS IMPOSED ON SPECIMEN

SATURATION STAGE		CONSOLIDATION STAGE		HYDRAULIC CONDUCTIVITY TESTING	
CELL PRESSURE (kPa):	140.0	CELL PRESSURE (kPa):	235.0	CELL PRESSURE (kPa):	252.0
BACK PRESSURE (kPa):	135.0	BACK PRESSURE (kPa):	135.0	HEAD PRESSURE (kPa):	152.0
SATURATION DURATION (min):	1,380.0	CONSOL. PRESSURE (kPa):	100.0	BACK PRESSURE (kPa):	135.0
VOLUME OF WATER (cc):	0.8	VOLUME CHANGE (cc):	11.62	EFFECTIVE PRESSURE,TOP (kPa):	117.0
B-VALUE:	0.99			EFFECTIVE PRESSURE,BTM. (kPa):	100.0
WATER CONTENT, (%):	44.32			EFFECTIVE HEAD PRESSURE (kPa):	17.0
				HYDRAULIC GRADIENT:	19.7

Note. For graphical presentation of data - see attached figure.

HYDRAULIC CONDUCTIVITY CALCULATION SUMMARY

TOTAL ELAPSED TEST TIME (min):	10,980.00	STEADY-STATE INFLOW (Q)(cm^3/s):	3.31E-05
ELAPSED TIME TO ACHIEVE STEADY-STATE FLOW (min):	1,020.00	STEADY-STATE OUTFLOW (Q)(cm^3/s):	3.73E-05
DURATION OF STEADY-STATE FLOW (min):	9,960.00	HYDRAULIC GRADIENT:	19.69
TOTAL INFLOW VOLUME UNDER STEADY-STATE (cc):	19.80	AREA (cm^2):	20.38
TOTAL OUTFLOW VOLUME UNDER STEADY STATE (cc):	22.27		

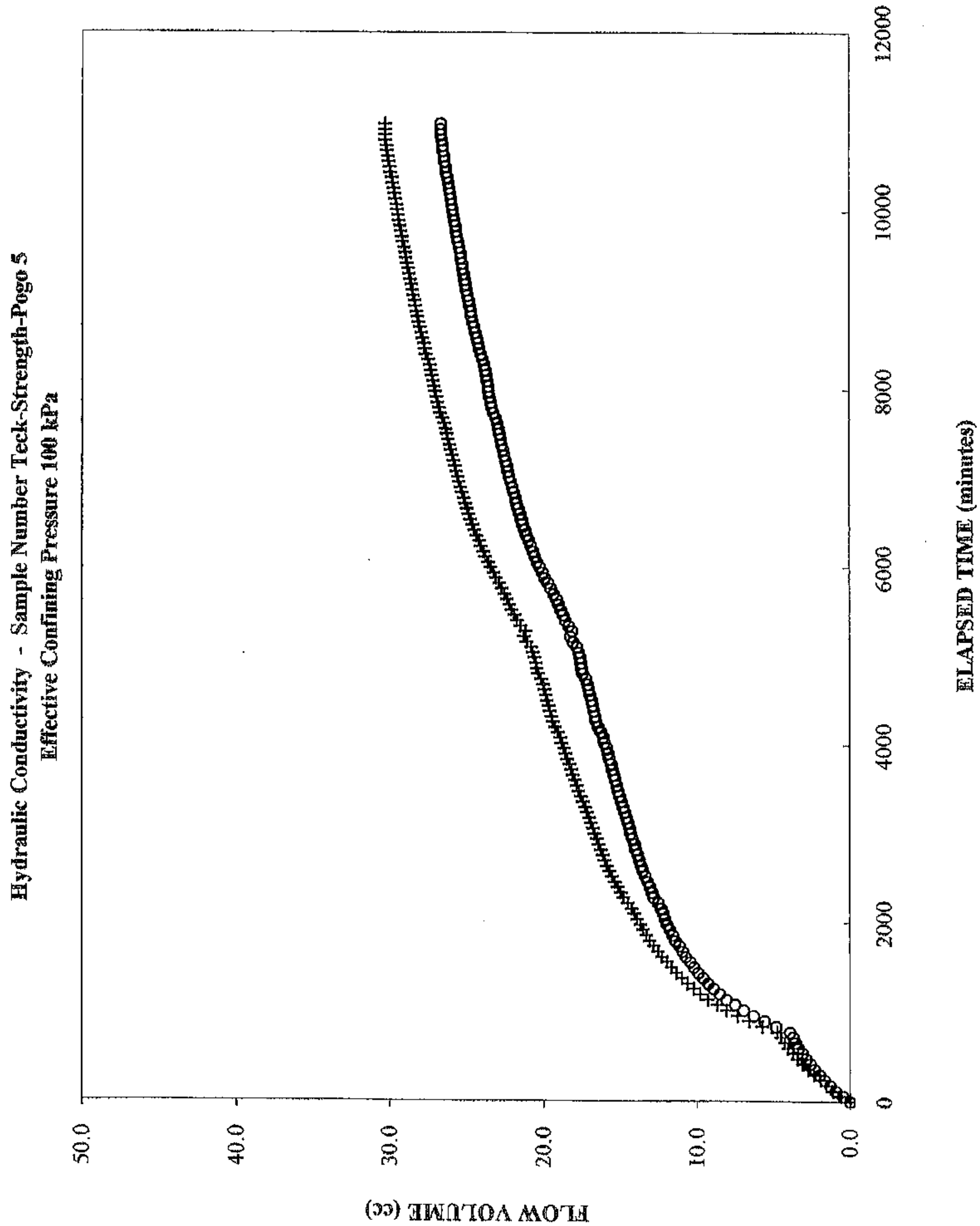
HYDRAULIC CONDUCTIVITY

:INFLOW	(cm/s):	**8.25E-08**
:OUTFLOW	(cm/s):	**9.29E-08**
:AVERAGE	(cm/s):	**8.77E-08**

NOTES:

1. Membrane sealed onto sample with vacuum grease.
2. Steady-State inflow and outflow values represent slopes of best fit lines through data points shown on attached Volume - Time Curves.
3. Saturation of sample carried out in increments of 70 kPa up to maximum pressures required to induce saturation B-value of at least 0.96.
4. Test carried out at room temperature using deaired tap water as permeant fluid.

HYDRAULIC CONDUCTIVITY TEST	FIGURE



+ OUTFLOW o INFLOW

HYDRAULIC CONDUCTIVITY

AVERAGE (cm/s): 8.77E-08

HYDRAULIC CONDUCTIVITY TEST

BOREHOLE NUMBER:		PROJECT NUMBER:	991-9950
SAMPLE NUMBER:	Tech-Strength-Pogo 6	PROJECT TITLE:	
SAMPLE DEPTH, m:		DATE STARTED:	February 11, 2000
		DATE COMPLETED:	February 21, 2000

SPECIMEN PROPERTIES AND DIMENSIONS

INITIAL VALUES		AFTER CONSOLIDATION TO 200 kPa		AFTER TEST	
LENGTH (cm):	9.34	LENGTH (cm):	9.30	TOTAL MASS,final(g):	355.14
DIAMETER (cm):	5.20	AREA (cm^2):	21.04	DRY MASS,final(g):	247.61
AREA (cm^2):	21.24	VOLUME (cc)	195.56	WATER CONTENT, (%):	43.43
VOLUME (cc)	198.38	TOTAL MASS (g):	354.33	UNIT WEIGHT (kN/m^3):	17.80
TOTAL MASS (g):	354.33	DRY MASS (g):	247.61	DRY UNIT WEIGHT (kN/m^3):	12.41
DRY MASS (g):	247.61	VOLUME WATER (cc):	106.72	VOLUME SOLIDS (cc):	91.71
WATER CONTENT, (%):	43.10	WATER CONTENT, (%):	43.10	VOLUME VOIDS (cc):	103.85
UNIT WEIGHT (kN/m^3):	17.51	UNIT WEIGHT (kN/m^3):	17.76	VOID RATIO:	1.132
DRY UNIT WEIGHT (kN/m^3):	12.24	DRY UNIT WEIGHT (kN/m^3):	12.41	SATURATION (%):	103.5
SPECIFIC GRAVITY (assumed)	2.70	VOLUME SOLIDS (cc):	91.71		
VOLUME SOLIDS (cc):	91.71	VOLUME VOIDS (cc):	103.85		
VOLUME VOIDS (cc):	106.67	VOID RATIO:	1.132		
VOID RATIO:	1.163				
SATURATION (%):	100.0				

BOUNDARY CONDITIONS IMPOSED ON SPECIMEN

SATURATION STAGE		CONSOLIDATION STAGE		HYDRAULIC CONDUCTIVITY TESTING	
CELL PRESSURE (kPa):	280.0	CELL PRESSURE (kPa):	475.0	CELL PRESSURE (kPa):	493.0
BACK PRESSURE (kPa):	275.0	BACK PRESSURE (kPa):	275.0	HEAD PRESSURE (kPa):	293.0
SATURATION DURATION (min):	5,460.0	CONSOL. PRESSURE (kPa):	200.0	BACK PRESSURE (kPa):	275.0
VOLUME OF WATER (cc):	2.8	VOLUME CHANGE (cc):	2.82	EFFECTIVE PRESSURE,TOP (kPa):	218.0
B-VALUE:	0.97			EFFECTIVE PRESSURE,BTM. (kPa):	200.0
WATER CONTENT, (%):	44.24			EFFECTIVE HEAD PRESSURE (kPa):	18.0
				HYDRAULIC GRADIENT:	19.8

Note. For graphical presentation of data - see attached figure.

HYDRAULIC CONDUCTIVITY CALCULATION SUMMARY

TOTAL ELAPSED TEST TIME (min):	6,660.00	STEADY-STATE INFLOW (Q)(cm^3/s):	1.30E-04
ELAPSED TIME TO ACHIEVE STEADY-STATE FLOW (min):	0.00	STEADY-STATE OUTFLOW (Q)(cm^3/s):	1.31E-04
DURATION OF STEADY-STATE FLOW (min):	6,660.00	HYDRAULIC GRADIENT:	19.76
TOTAL INFLOW VOLUME UNDER STEADY-STATE (cc):	51.90	AREA (cm^2):	21.04
TOTAL OUTFLOW VOLUME UNDER STEADY STATE (cc):	52.46		

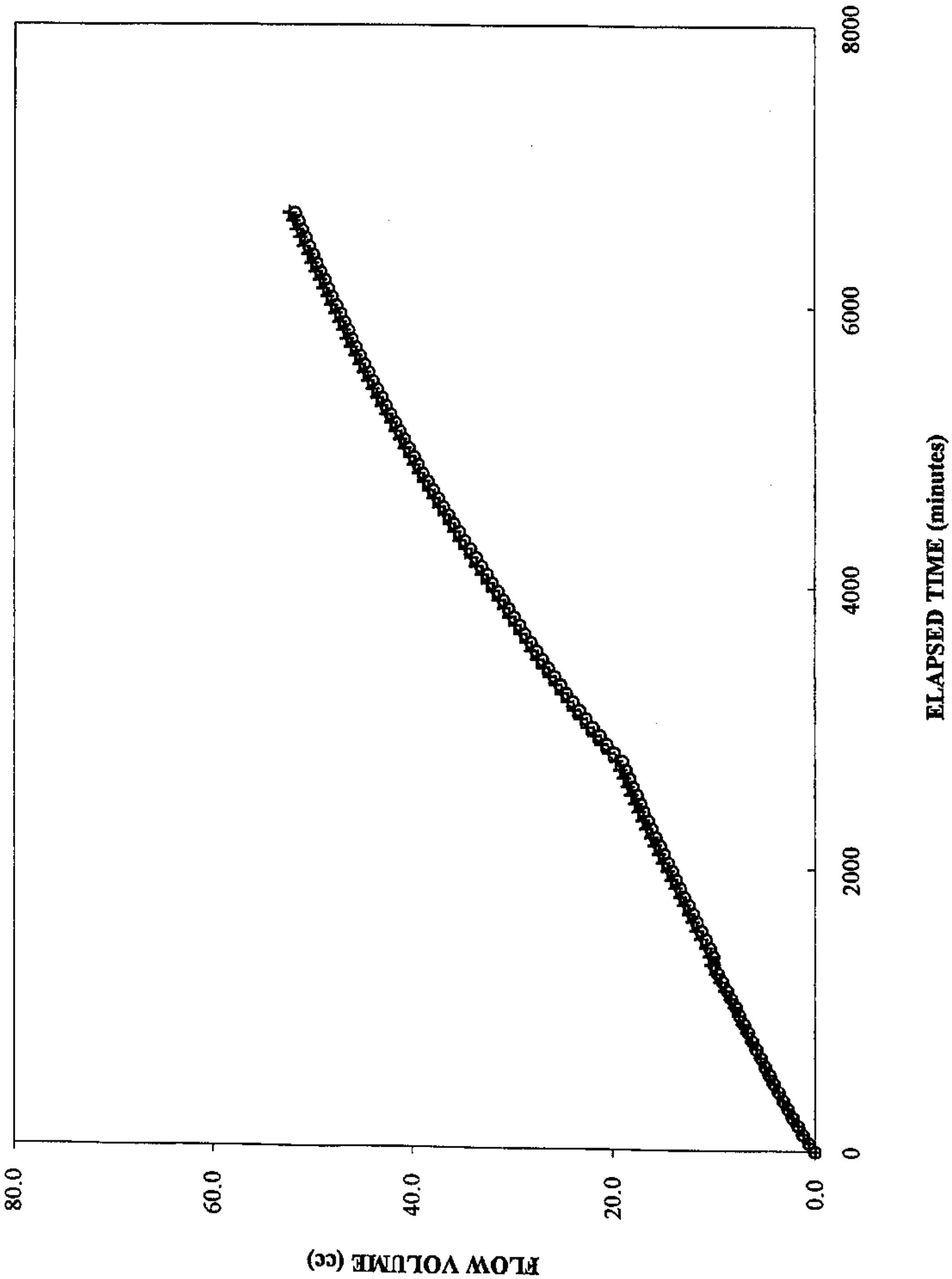
HYDRAULIC CONDUCTIVITY		
	:INFLOW (cm/s):	3.12E-07
	:OUTFLOW (cm/s):	3.16E-07
	:AVERAGE (cm/s):	3.14E-07

NOTES:

1. Membrane sealed onto sample with vacuum grease.
2. Steady-State inflow and outflow values represent slopes of best fit lines through data points shown on attached Volume - Time Curves.
3. Saturation of sample carried out in increments of 70 kPa up to maximum pressures required to induce saturation B-value of at least 0.96.
4. Test carried out at room temperature using deaired tap water as permeant fluid.

HYDRAULIC CONDUCTIVITY TEST | **FIGURE**

Hydraulic Conductivity - Sample Number Teck-Strength-Pogo 6
Effective Confining Pressure 200 kPa



+ OUTFLOW   o INFLOW

HYDRAULIC CONDUCTIVITY

AVERAGE (cm/s): 3.14E-07

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MEMORANDUM

DATE: January 2, 2002

TO: Karl Hanneman, Teck Pogo
Rick Zimmer, TeckCominco

FROM: Stephen Day, SRK

PROJECT: 1CT002.00

RE: EVALUATION OF POGO PROJECT PASTE BACKFILL ACID GENERATION POTENTIAL

INTRODUCTION

Following mining of each block of the Liese Veins, the void will be completely filled to the back with cemented mixed flotation and CIP tailings (Figure 1). The planned ratio of flotation to CIP tailings is 80:20, with 2% cement. This memorandum presents an evaluation of the oxidation rate and acid generation potential for the backfill and an evaluation of the resulting effects on water quality at closure.

AVAILABLE DATA

Three ore composites (Composite 3, Composite 4 and Pilot Plant Composite) were processed in 1998, 1999 and 2001 (respectively) to evaluate recovery of gold. Flotation tailings from Composite 3, 4 and Pilot Plant flotation tailings were tested in humidity cells. Selected triplicates and a refrigerated test were also run (Table 1). CIP tailings from Composite 4 were tested in a humidity cell (Cell 26). The Composite 4 CIP tailings sample and flotation tailings produced by blending the four "F" numbered samples (Table 1) were combined in various proportions and cemented to simulate different backfill composites (Table 1). Further details of testing procedures are provided in SRK (2001)[1]. At the time the composites were prepared a final design composition for backfill had not been selected, therefore, a range of mixtures was prepared.

Cemented flotation tailings samples were also tested due to earlier consideration of drystack construction methods (Table 1). These samples are not directly relevant to the proposed backfill approach but the results are useful as an indicator of the effect of cement on acid neutralization potential (see below).

ACID GENERATION CRITERION

Results from humidity cells were used to develop a material-specific NP/AP acid generation criterion for the cemented flotation and CIP tailings mixtures. The details of this method were described previously by SRK (1999)[2]. In summary, the rate of sulfate release is used to indicate sulfide oxidation, and the rates of calcium and magnesium are used to indicate leaching of carbonate minerals in response to acid generation. These calculations indicate that backfill with NP/AP less than between 1.1 and 1.4 could theoretically generate acid. Humidity cells tend to over state the dissolution of carbonate minerals due to the high flushing rates used during the procedure. An NP/AP<1.4 was selected to indicate potentially acid generating backfill because it is the highest ratio measured. This also allows for uncertainty in the mineral form and availability of NP.

EFFECT OF CEMENT

Comparison of identical samples with varying mixtures of cement shows the effect of cement addition on neutralization potential. These samples are:

- Flotation Tailings – Cells 12, 14, 15 and 18; and
- Composite 4 CIP Tailings – Cells 26 and 33.
- Blended Tailings – Cells 36 and 37.

The flotation tailings samples indicated that NP increased by 8, 11 and 3 kg $CaCO_3$/t for each 1% increase in cement content (average of 7.3 kg $CaCO_3$/t per 1% of cement). The CIP tailings showed an increase of 43 kg $CaCO_3$/t when 10% cement was added (corresponding to an increase of 4.3 kg$CaCO_3$/t per 1% of cement). The blended tailings showed an increase of 20 kg $CaCO_3$/t when cement content increased from 2 to 5% (ie 6.7 kg $CaCO_3$/t per 1% of cement). These increases are also reflected as increases in carbonate content due to the conversion of lime to calcium carbonate by reaction with atmospheric CO_2 during mixing and curing. The effect of cement varies from 4.3 to 7.3 kg $CaCO_3$/t per 1% of cement approximately as a function of the absolute amount of cement (ie the NP value of cement decreases as the amount of cement increases). The average is 6 kg $CaCO_3$/t per 1% of cement. A similar calculation for carbonate NP indicates an increase of 5 kg $CaCO_3$/t per 1% of cement.

As expected, cement addition has no detectable effect on sulfur concentrations.

POTENTIAL FOR ACID GENERATION IN TAILINGS MIXTURES

Table 2 shows the calculated compositions of 80:20 (flotation:CIP tailings) backfill mixtures with 0 and 2% cement for Composite 4 and the Pilot Plant samples. The composition of Composite 3 CIP tailings was not determined hence the calculation was not completed for Composite 3.

For Composite 4, the 80:20 mixture was calculated to contain 1.1% sulfur as sulfide. Without cement, the calculated NP was 28 kg $CaCO_3$/t, and the resulting NP/AP would be 0.7. When cement is added, the NP increased to 40 kg $CaCO_3$/t resulting in NP/AP of 1.2. Cell 36 contains this mixture. The measured NP/AP of 1.5 was higher than the 1.2 predicted by calculation probably because cement has greater NP value at lower cement addition rates.

For the Pilot Plant sample, the 80:20 mixture was calculated to contain 1.7% sulfur as sulfide due to the 8.2% sulfur in the CIP tailings. The corresponding NP was 26 kg $CaCO_3$/t, and the NP/AP was 0.5. The addition of 2% cement increased the NP/AP to 0.7.

These calculations indicate that the NP/AP of 80:20 mixtures with 2% cement are likely to have an NP/AP of less 1.5. Based on the criterion for acid generation of NP/AP<1.4, the mixtures are expected to vary from non-potentially acid generating to potentially acid generating, depending primarily on the sulfur concentration of the CIP tailings component. No evidence of acid generation has been observed in any humidity cells containing flotation and CIP tailings mixtures. Cell 36 has been operating since March 2000 (ie., 20 months).

The following section considers the potential effects of sulfide oxidation and acid generation in backfill.

EFFECT OF ACID GENERATION IN BACKFILL

Configuration of Backfill Placement

Placement of backfill will result in the majority of backfill surfaces being sealed by rock walls (Figure 1). Temporary (less than two months) exposures of backfill will occur during mining until the next lift of backfill is placed. However, the need for access to the stopes dictates that the final backfill surface will be exposed to atmospheric conditions until the mine is flooded at closure. The following modes of oxidation of the backfill have been considered:

1. Oxidation of backfill surfaces sealed against rock masses.

2. Oxidation of temporary backfill faces exposed briefly (less than two months) to oxidation during mining.
3. Oxidation of final backfill surfaces exposed to the atmosphere in the stope access ramps prior to final flooding of the mine.

The following sections discuss the potential for oxidation by any of these processes to become a significant source of acidity in the workings once the mine is flooded at closure (ie by flushing of acidic salts accumulated prior to flooding).

Oxidation of Backfill Surfaces Against Rock Masses

Once the backfill is sealed by the surrounding rock, potential for oxidation is primarily controlled by the availability of dissolved oxygen contained in percolating groundwater.

The flow rate of water into the backfill was estimated based on the measured permeability of the backfill (average 1.8×10^{-6} cm/s for cemented 20:80 backfill, Mine Systems Design Inc., 2001)[3], and the assumption that the backfill is 100% saturated. If the backfill is less saturated, the flow rate would decrease. Assuming the most conservative hydraulic gradient of 1 m/m, the flow over a 1 m^2 area is therefore 1.8×10^{-6} cm/s. This is equivalent to 0.56 m/year, or 1.8 ft/year. ABC(2000)[4] assumed a backfill infiltration rate of 0.18 to 0.75 ft/year, therefore the permeability yields a greater flow, which is conservative when considering oxygen supply.

Assuming that the water is at 5°C, the DO concentration is 12.75 mg/L. The above flow rate of 0.56 m/year yields an oxygen supply of 7.2 g O_2/m^2/year, or 0.23 moles O_2/m^2/year

The conventional pyrite oxidation reaction assumes each mole of sulfur requires 1.875 moles of O_2. Therefore, the above oxygen supply can oxidize 0.12 moles of S/m^2/year, or 3.9 g of S/m^2/year.

To evaluate the effect of this oxygen supply rate, the depth of a depleted weathering rind after one year was estimated. This assumes that all the oxygen is consumed by sulfide minerals at the surface of the backfill.

If 0.12 moles of S/m^2/year is produced, and it is assumed that each mole of sulfur requires 1.4 moles of neutralization potential (NP) (SRK 2001), the mass of NP required is 0.17 moles of $CaCO_3/m^2$/year. Based on a typical contained NP of 47 kg $CaCO_3$/t, this is equivalent to 3.6×10^{-4} tonnes/year of backfill. Using a bulk density of 1.88 t/m^3, and solids of 72.4% (MSDI, 2001), the rate of oxidation rind growth is 0.3 mm/a.

This calculated rate should be considered a maximum value because groundwater monitoring in the vicinity of the ore body indicates that groundwater tends to be reduced (Eh<0 mV) and strongly alkaline. The median alkalinity of all site waters is 185 mg $CaCO_3$/L, and near the ore body alkalinity is greater than 200 mg$CaCO_3$/L. At 0.56 m/year, 185 mg $CaCO_3$/L delivers 1.0 moles $CaCO_3/m^2$/year. This significantly exceeds the acidity produced by sulfur oxidation and indicates that growth of an acidic rind is not likely to occur.

At closure, backfill surfaces in contact with rock are not expected to be acidic due to the oxygen-limited conditions in the backfill, and the anticipated low oxidation potential and elevated alkalinity in groundwater.

Effects of Temporary Exposure

Following placement of backfill, the outside surfaces of the backfill will be exposed to oxidation initially at atmospheric conditions. Teck Pogo Inc has indicated that these surfaces will be exposed for approximately two months during normal operations. Cell 36 indicates that these surfaces will not be significantly depleted of NP during this time.

Effect of Exposure of Final Backfill Faces

A small area of the final backfill in each stope that is adjacent to the access ramps to the stope will be exposed from placement to final flooding. For the oldest stopes, this potentially represents 11 years exposure time, plus the time taken to flood. This effect was considered in three parts. First, the rate of NP-depleted rind growth caused by exposure to fully oxygenated conditions was estimated by assuming that oxygen supply to the backfill surface and sub-surface is not limited, and then the rate of acid salt accumulation in the NP-depleted rind was estimated. Finally, the rate of acid salt accumulation over the life of the mine was calculated and compared to the alkalinity in water used to flood the mine.

Rate of Rind Growth

The rate of rind growth was estimated using the following assumptions:

- Maximum average rate of sulfide oxidation observed in 80:20 (flotation to CIP tailings) mix in humidity cells under non-acidic conditions – 105 mg/kg/week
- Exposed backfill area in humidity cells – 0.0322 m^2

- Temperature in stopes of 4°C. Using the Arrhenius equation, this produces a temperature correction of 4.15
- Neutralization Potential (NP) of 47 kg $CaCO_3$/t in backfill.
- Critical NP/AP Ratio – 1.4
- Backfill bulk density of 1.85 t/m^3

Calculation steps are described below.

1. Temperature adjustment of oxidation rates

   105/4.15 = 25.3 mg/kg/week.

2. Conversion of mass based rate to exposed area based rate

   25.3/0.0322 = 786 mgSO_4/m^2/week

   This calculation is conservative. The exposed area is based on the diameter of the test cell. The actual area exposed to oxidation is expected to be larger because the backfill samples crack during drying and are disturbed during the leaching cycle. This allows for possible cracking in the exposed backfill which would increase the surface area exposed to atmospheric conditions.

3. NP requirement on an area basis

   786 x (100/96) x 1.4 = 1146 mg $CaCO_3$/m^2/week

   This assumes conservatively that all oxygen is consumed by available sulfide grains near the surface.

4. Mass of backfill completely depleted of NP

   $1146 \times 10^{-6}/47 = 2.44 \times 10^{-5}$ tonnes/m^2/week

5. Volume of backfill depleted

   $2.44 \times 10^{-5}/1.85 = 1.32 \times 10^{-5}$ m^3/m^2/week

6. Rate of rind growth

$1.32 \times 10^{-5} \times 10^{3}/1 = 0.0132$ mm/week = 0.7 mm/year

This estimated rate of rind growth is conservative due to the use of the lowest exposed area to calculate the area based oxidation rate, and the assumption that oxygen supply to the backfill is not limited. In practice, supply of oxygen below the surface of the backfill will occur by diffusion, which will be limited by the particle size, connection of pore and degree of saturation.

Rate of Acid Salt Accumulation

The additional data requirement to estimate this rate is the rate of oxidation under acidic conditions. No samples of simulated backfill have generated acid. However, recent tests on pure CIP tailings have generated acid (pH<3). These test materials contained significant amounts of gypsum that occurred as a by-product of operating the pilot plant at an elevated pH, and as a result, leaching of sulfate cannot be used to indicate the expected rate of sulfide oxidation. At these low pHs, iron release can be used as an alternative indicator.

The highest average iron release rate for a pure CIP tailings humidity cell is 228 mgFe/kg/week. The rate of acid generation in the oxidized rind was estimated as follows:

1. Conversion to 80:20 backfill mix

   228/5 = 45.6 mgFe/kg/week

2. Temperature adjustment of oxidation rates

   45.6/4.15 = 11.0 mgFe/kg/week

3. Equivalent acid generation rate

   11.0 x (100/58.85) x 2 = 39.3 $mgCaCO_3$/kg/week = 2048 $mgCaCO_3$/kg/year

4. Acid generated in each rind each year

   $2.44 \times 10^{-5} \times 10^{3} \times 52.1 \times 2048 = 2603$ mg $CaCO_3/m^2$/year

During each year n, the number of year-rinds of acidity accumulated is n(n-1)/2. In year 3, the number is 3. That is, one rind has been acidic for two years, and a new rind has started oxidizing in Year 3. The total acidity accumulated after n years is:

2603 x n(n-1)/2 $mgCaCO_3/m^2$/year

This rate is conservative. It incorporates the assumptions in rind development, including that oxygen can penetrate the backfill without limit. It is also assumed that high oxidation rates under acidic conditions will be sustained indefinitely. At these rates, 1% sulfur is exhausted in less than two decades, implying that oxidation rates will in reality tend to decrease significantly in the long term.

Comparison of Stored Acid and Available Alkalinity in Groundwater

The inputs used for this calculation are:

- Exposed backfill face in a single stope - 60 ft x 20 ft
- Number of stopes – 110
- Mine life - 11 years
- Approx number of new stopes per year – 10
- Open void space in mine – equivalent to 1.4 million tons of development workings
- In situ density of pre-development rock – 2.65 t/m^3
- Calculated void volume – 5.3×10^5 m^3
- Time to fast flood - 2 years
- Fast-flood with groundwater from MW98-005 - average alkalinity 40 $mgCaCO_3/L$.

The acid stored in each exposed backfill face (111 m^2) was calculated using the above equation relating exposure time to acid generation. For example, the oldest backfill faces will have 78 rind-years multiplied by 10 stopes of accumulated acidity in an 8 mm rind. The total acidity stored in all faces over the mine life, plus the two additional years taken to flood the mine at closure is 1.1 tonnes $CaCO_3$. In contrast, the water used to flood the mine will contain 21 tonnes $CaCO_3$.

While it cannot be assumed that all the alkalinity in mine flood water will be available to neutralize the acidity in the stopes, the order-of-magnitude difference between these amounts indicates that acidity in the backfill is very unlikely to cause acidification of groundwater in the workings. Also, acidity will be released from oxidized rinds slowly over time.

IMPLICATION TO GROUNDWATER CHEMISTRY

These conservative calculations indicate that groundwater in the flooded mine is not expected to be acidic. The vast majority of backfill will remain encapsulated and unoxidized. The exposed surfaces in contact with rock or void spaces do not represent significant sources of acidity. This assumption was inherent in the mine water chemistry and attenuation calculations of ABC (2000), and is confirmed to be reasonable.

Once the backfill is flooded, oxidation will be reduced to a very low rate due to limited oxygen supply.

UNCERTAINTIES

The above calculations used conservative assumptions wherever possible. This is consistent with the reasonable worst case (RWC) approaches used previously. The principle uncertainties are the oxidation rate under acidic conditions and the hydrology of the mine at closure. The oxidation rate was assumed to be steady at peak rates when in fact it will decrease over time.

Stephen Day, M.Sc.
Principal Geochemist

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REFERENCES

[1] SRK Consulting 2001. Third Progress Report on Kinetic Geochemical Tests, Pogo Project. February 2001.
[2] SRK Consulting 1999. Progress Report on Kinetic Geochemical Tests, Pogo Project. July 1999
[3] Mine Systems Design Inc. 2001. Pogo Permeability Tests. Internal memo to R. Zimmer. October 26, 2001.
[4] Adrian Brown Consulting, 2000. Post Minig Groundwater Chemistry Pogo Mine Alaska. Report prepared for Teck Corporation. October 31, 2000.

TABLE 1
Summary of Sample Characteristics

Flotation Tailings Samples

Cell	Sample ID	Start Date	Mineralogy			Float	CIP	Cement	Paste pH	S	S-SO4	S-S2-	TIC	TIC	AP	NP	NNP	NP/AP	As
			Py	Aspy	Carb	%	%	%	%	%	%		C %	kg $CaCO_3$/t					ppm
Composite 3																			
Cell 12, Col 5*	F48	21-Jan-99	Tr	Tr	1.2	100	0	0	8.3	0.08	-	0.08	0.3	25	3	30	28	12.0	628
Cell 13, Col 4	F48	21-Jan-99	Tr	Tr	1.2	100	0	0	8.3	0.08	-	0.08	0.3	25	3	30	28	12.0	628
Cell 20, Col 6	F48	18-Mar-99	Tr	Tr	1.2	100	0	0	8.3	0.08	-	0.08	0.3	25	3	30	28	12.0	628
Cell 21, Col 7	F48	18-Mar-99	Tr	Tr	1.2	100	0	0	8.3	0.08	-	0.08	0.3	25	3	30	28	12.0	628
Average									8.3	0.08	-	0.08	0.30	25.00	3	30	27.50	12.00	628
Composite 4																			
Cell 27, Col 8	F95	14-Jun-99	-	-	-	100	0	0	7.9	0.06	0.01	0.05	0.4	29	2	24	22	12.8	540
Cell 28	F96	14-Jun-99	<0.1	<0.1	2.5	100	0	0	7.9	0.12	0.02	0.10	0.3	25	4	25	21	6.7	770
Cell 29	F97	14-Jun-99	-	-	-	100	0	0	8.0	0.18	0.02	0.16	0.3	25	6	25	19	4.4	1200
Cell 30	F98	14-Jun-99	-	-	-	100	0	0	8.0	0.36	0.02	0.34	0.3	25	11	25	14	2.2	3600
Cell 31	F98	14-Jun-99	-	-	-	100	0	0	8.0	0.36	0.02	0.34	0.3	25	11	25	14	2.2	3600
Cell 32	F98	14-Jun-99	-	-	-	100	0	0	8.0	0.36	0.02	0.34	0.3	25	11	25	14	2.2	3600
Average									8.0	0.18	0.02	0.16	0.31	26	6	25	19	4.4	1528
Pilot Plant																			
Cell 50, Col 13	102A	2-Nov-00	Tr	Tr	1.5	100	0	0	8.1	0.09	<0.01	0.09	0.4	36	3	24	21	8.5	342
Cell 51, Col 14	102B	2-Nov-00	Tr	Tr	1.5	100	0	0	8.1	0.13	<0.01	0.13	0.4	36	4	23	19	5.7	348
Cell 52, Col 15	105A	2-Nov-00	Tr	Tr	1.5	100	0	0	8.3	0.06	<0.01	0.06	0.3	27	2	23	21	12.3	332
Cell 53, Col 16	105B	2-Nov-00	Tr	Tr	1.5	100	0	0	8.2	0.07	<0.01	0.07	0.4	32	3	22	20	10.1	336
Average									8.2	0.09	<0.01	0.09	0.4	33	3	23	20	9.1	340

CIP Tailings

Cell	Sample ID	Start Date	Mineralogy			Float	CIP	Cement	Paste pH	S	S-SO4	S-S2-	TIC	TIC	AP	NP	NNP	NP/AP	As
			Py	Aspy	Carb	%	%	%		%	%	%	CO2%	kg $CaCO_3$/t					ppm
Composite 4																			
Cell 26	0:100:0	19-Apr-99	-	-	-	0	100	0	9.1	4.85	0.04	4.81	0.55	13	150	40	-111.6	0.3	30000
Pilot Plant																			
Cell 54, Col 18	PPCN1 - 250A	5-Feb-01	20	0.8	0.8	0	100	0	8.5	9.22	2.05	7.17	1	23	224	27	-197.06	0.12	12800
Cell 55, Col 17	PPCN1 - 250B	5-Feb-01	20	0.8	0.8	0	100	0	8.2	9.38	2.22	7.14	1.2	27	223	24	-199.13	0.11	12500
Cell 56, Col 19	PPCN2 - 253A	5-Feb-01	20	0.8	0.8	0	100	0	8.0	11.3	1.7	9.60	1.2	27	300	21	-279.00	0.07	15900
Cell 57, Col 20	PPCN2 - 253B	5-Feb-01	20	0.8	0.8	0	100	0	8.1	11.4	1.75	9.65	1.2	27	302	21	-280.56	0.07	15900
Cell 58, Col 21	PPCN3 - 256A	5-Feb-01	20	0.8	0.8	0	100	0	8.1	10.3	1.83	8.47	1.4	32	265	22	-242.69	0.08	17900
Cell 59, Col 22	PPCN3 - 256B	5-Feb-01	20	0.8	0.8	0	100	0	8.1	10.4	1.83	8.57	1.2	27	268	23	-244.81	0.09	17700
Cell 60, Col 23	PPCN4 - 259A	5-Feb-01	20	1.5	0.8	0	100	0	8.7	8.74	1.06	7.68	2.8	64	240	81	-159.00	0.34	18200
Cell 61, Col 24	PPCN4 - 259B	5-Feb-01	20	1.5	0.8	0	100	0	8.7	8.67	1.1	7.57	1.6	36	237	80	-156.56	0.34	18600
Average									8.3	9.92	1.6925	8.2313	1.45	33	257.2	37.375	-219.85	0.151547	16188

Mixed CIP/Flotation Tailings

Cell	Sample ID	Start Date	Mineralogy			Float	CIP	Cement	Paste pH	S	S-SO4	S-S2-	TIC	TIC	AP	NP	NNP	NP/AP	As
			Py	Aspy	Carb	%	%	%		%	%	%	CO2%	kg $CaCO_3$/t					ppm
Composite 4																			
Cell 33	0:100:10	23-Mar-00	-	-	-	0	100	10	9.5	4.41	0.33	4.08	2.6	59	128	83	-54.8	0.7	29300
Cell 35	50:50:5	23-Mar-00	-	-	-	50	50	5	9.0	2.43	0.30	2.13	2.40	55	67	67	-8.9	1.0	16400
Cell 36	80:20:2	23-Mar-00	-	-	-	80	20	2	8.6	1.09	0.11	0.98	1.60	36	31	47	12.9	1.5	7740
Cell 37	80:20:5	23-Mar-00	-	-	-	80	20	5	9.3	1.07	0.19	0.88	2.40	55	28	67	33.6	2.4	7080
Cell 38	80:20:5	23-Mar-00	-	-	-	80	20	5	9.3	1.07	0.19	0.88	2.40	55	28	67	33.6	2.4	7080
Cell 39	80:20:5	23-Mar-00	-	-	-	80	20	5	9.3	1.07	0.19	0.88	2.40	55	28	67	33.6	2.4	7080

Cemented Flotation Tailings

Cell	Sample ID	Start Date				Float	CIP	Cement	Paste pH	S	S-SO4	S-S2-	TIC	TIC	AP	NP	NNP	NP/AP	As
			Py	Aspy	Carb	%	%	%		%	%	%	C%	kg $CaCO_3$/t					ppm
Composite 3																			
Cell 14	F48	22-Mar-99	-	-	-	100	0	1	9.6	0.09	0.03	-	0.40	33	1.9	38	35.2	20	584
Cell 15	F48	22-Mar-99	-	-	-	100	0	2	9.9	0.08	0.04	-	0.50	42	1.3	49	46.5	39	616
Cell 18	F48	15-Mar-99	-	-	-	100	0	3	11.1	0.10	0.06	-	0.45	38	1.3	52	48.9	42	590
Composite 4																			
Cell 34		23-Mar-00	-	-	-	100	0	5	9.8	0.13	0.12	-	2.00	167	0.3	68	63.9	218	586

Notes
1. Bold border indicates triplicate tests
2. "-" indicates test not performed

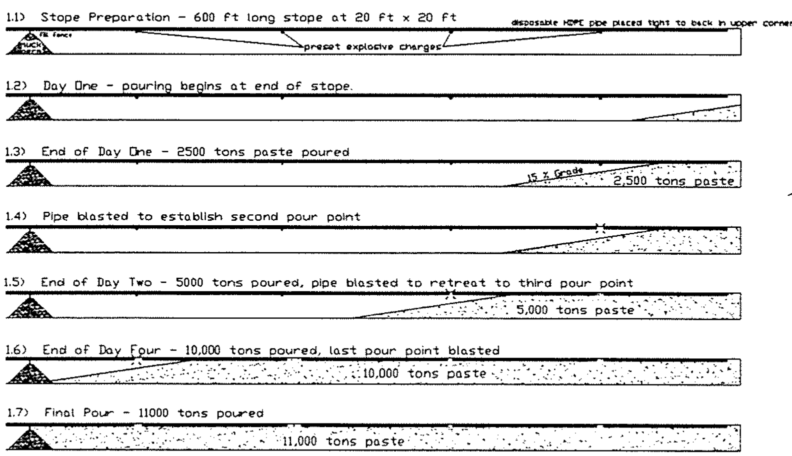
TABLE 2
Comparison of Tailings Mixture Characteristics

	Float	CIP	Cement	S	S-SO4	S-S2-	TIC	AP	NP	NNP	NP/AP	As
	%	%	%	%	%	%	kg $CaCO_3$/t					ppm
Composite 4												
Average Flotation Tailings	100	0	0	0.2	0.0	0.2	26	6	25	19	4.4	1528
CIP Tailings	0	100	0	4.9	0.0	4.8	13	150	40	-112	0.3	30000
Calculated 80:20 Mix with no cement	80	20	0	1.1	0.0	1.1	23	35	28	-7	0.7	7222
Calculated 80:20 Mix with 2% cement	80	20	2	1.1	0.0	1.1	33	33	40	7	1.2	7078
Actual 80:20 Mix with 2% cement	80	20	2	1.1	0.1	1.0	36	31	47	13	1.5	7740
Pilot Plant												
Average Flotation	100	0	0	0.1	0.0	0.1	33	3	23	20	9.1	340
CIP	0	100	0	9.9	1.7	8.2	33	257	37	-220	0.2	16188
Calculated 80:20 Mix with no cement	80	20	0	2.1	0.3	1.7	33	54	26	-28	0.5	3509
Calculated 80:20 Mix with 2% cement	80	20	2	2.0	0.3	1.7	43	53	38	-14	0.7	3439

Notes:

1. Cement calculations assume that each 1% of cement adds 6.1 kg CaCO3/t NP.

FIGURE 1: FILL SEQUENCE OF TYPICAL STOPE



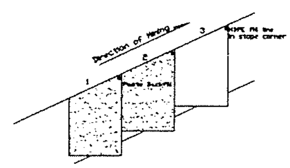


FIGURE 2: CROSS SECTION