Deloitte & Touche

Anvil Range Mining Complex: Results from Trial Covers at Rose Creek Tailings Impoundment

2005/06 Task 22b

Prepared for:

DELOITTE & TOUCHE INC.

on behalf of the

FARO MINE CLOSURE PLANNING OFFICE

Prepared by:

SRK Consulting
Engineers and Scientists

Project Reference Number:
SRK 1CD003.075

July 2006

Anvil Range Mining Complex: Results from Trial Covers at Rose Creek Tailings Impoundment

2005/06 Task 22b

Deloitte & Touche Inc.

On behalf of

Faro Mine Closure Planning Office

SRK Consulting (Canada) Inc.
Suite 800, 1066 West Hastings Street
Vancouver, B.C. V6E 3X2

Tel: 604.681.4196 Fax: 604.687.5532
E-mail: vancouver@srk.com Web site: www.srk.com

SRK Project Number 1CD003.075

July 2006

Author
Maritz Rykaart, Ph.D., P.Eng.

Reviewed by
Cam Scott, P.Eng

Executive Summary

Title:	Anvil Range Mining Complex: Results from Trial Covers at Rose Creek Tailings Impoundment – 2005/06 Task 22b.
Consultant:	SRK Consulting (Canada) Inc.
Status:	Final. Approved by Faro Mine Closure Planning Office (FMCPO).
Date:	July 2006.
Size:	25 Pages of text (including cover, introductory and reference list); 12 Pages of Figures (including one flysheet), 8 Appendices containing 61 pages (including 1 non-standard 11 x 17 page).
Digital File:	PDF format; 9.7 MB.

Objectives and Primary Findings:

This report summarizes the design, construction, and subsequent monitoring observations during 2004 and 2005 for the two trial covers on the Rose Creek tailings impoundment. These observations provide engineering data that is essential to the development and optimization of the design of a cover for the Rose Creek tailings complex.

The trial cover has demonstrated that construction of a cover on soft saturated tailings, using conventional road dump trucks and a D8 dozer, is possible if construction is completed in the winter when the tailings is frozen.

The two seasons of consolidation settlement data recorded total settlement for the two trial covers of 63 and 141 mm (about 8% and 18% respectively of the 80 cm cover thickness). The trial cover placed on a geosynthetic filter cloth settled the least. The consolidation settlement rate appears to be rapid, with primary consolidation occurring within weeks or months, whilst secondary consolidation is complete in under a year.

Physical inspection confirmed that, to date, there is no evidence that fines migration (i.e. tailings) up into the cover material is taking place. Case studies where fines migration has occurred, suggest that this process may take many years to develop so it is premature to say with certainty, that fines migration will not occur.

Future Work Recommendations:

It is recommended that monitoring of the trial covers be continued, and that by the end of the summer season in 2008 or 2009, trench excavations be made in each trial cover to evaluate whether fines migration has taken place.

Table of Contents

List of Tables

List of Figures

List of Appendices

1 Introduction and Scope of Report

1.1 General

Deloitte & Touche Inc. (D&T) was appointed Interim Receiver of the property, assets and undertaking of Anvil Range Mining Corporation (ARMC), and its subsidiaries, Anvil Range Properties Inc., (collectively "Anvil") pursuant to an Order of Mr. Justice Blair of the Ontario Court (General Division) dated April 12, 1998. SRK Consulting (Canada) Inc. (SRK) has been retained by D&T, on behalf of the Faro Mine Closure Planning Office (FMCPO) to assist in the development of a Final Closure and Reclamation Plan (the "Plan") for the Anvil Range Mining Complex. Based on current expectations, this Plan will be submitted to the relevant regulating authorities by late 2006. Engineering studies are being undertaken in the interim to provide the necessary scientific background information required to characterize and estimate costs for various closure methods that may be used in the Plan.

This report documents the results of trial covers over tailings in 2004/05 under Task 16b (SRK proposal included as Appendix A), identified as "Monitor Tailings Cover Trial Areas", and in 2005/06, identified as Task 22b, "Monitoring of Trial Covers at the Rose Creek Tailings Impoundment". The initial trial cover installation and the acquisition of some monitoring data occurred in 2004, culminating with a report under Task 16b in November 2004 (SRK 2006). Acquisition of monitoring data continued in 2005, providing a significantly better understanding of cover performance than was possible when the 2004/05 Task 16b report was written. Therefore, the 2004/05 Task 16b report was updated and is issued under 2005/06 Task 22b as this current final document. This report supersedes the 2004/05 Task 16b report.

1.2 Background of the Project

Lead-zinc tailings from the ARMC in the Yukon, were deposited hydraulically in the Rose Creek tailings complex, which consist of a series of dams within the Rose Creek valley. The complex has a surface area of approximately 196 ha, and as a result of deposition behind a series of dams, the surface is not a single continuum. Overall, there is an elevation change of about 50 m from the toe of the final dam (Cross Valley Dam) to the tailings at the back of the Original Impoundment, over a horizontal distance of about 3,700 m.

Tailings deposition strategies changed over the life of the mine, resulting in fairly random tailings gradations from coarse beach areas which are readily accessible (trafficable) to slimes areas which are currently not trafficable ("trafficability" in this context relates to the ability to use equipment directly on the tailings surface for investigation or construction purposes; naturally "trafficability" will vary depending on the size and type of equipment under consideration, phreatic levels and the time of year). Currently, there are also large sections of the tailings covered by permanent and/or seasonal water, which denotes a high phreatic level.

Three alternate closure strategies are being considered for the Rose Creek tailings complex; (a) complete relocation to the Faro pit, (b) relocation of approximately half of the tailings (measured by surface area) to the Faro pit and covering the remainder in-situ, and (c) covering of the in-situ tailings. The tailings relocation options are being evaluated as a separate task, and do not form part of the scope of work presented in this report.

SRK completed a preliminary cover assessment study (SRK 2004) that discussed what could be achieved by covering the Rose Creek tailings impoundment with a cover consisting of locally available soils and/or benign waste rock. A workshop was held in February 2004, in Vancouver, at which the results of the preliminary cover assessment were discussed, together with the results of site wide engineering studies completed in 2003 as part of the final reclamation planning. It was concluded that if the Rose Creek tailings were to be covered in-situ, the cover should be a “terrestrial” cover. The conceptual design for this cover presented at the workshop was a layer of “run-of-mine” benign waste rock (such as the calc-silicate from the Faro pit). It was envisioned that the thickness of this cover be limited to the minimum that could practically be placed.

The function of the “terrestrial” cover would be threefold: (a) prevent wind erosion; (b) limit access to exposed tailings by human and animal contact, and; (c) prevent vegetation from establishing directly on the tailings. Limiting infiltration and shedding of runoff were considered unimportant, and limiting oxygen ingress was considered unnecessary. The design life of the cover has not been determined; however, it is generally understood that the cover would have to continue to maintain its functionality in perpetuity, and that in order to achieve that, monitoring and maintenance of the cover would be required in perpetuity.

Subsequent to the February 2004 workshop, but after the construction of the trial covers, information become available suggesting the amount of infiltration that will ultimately flow through the Rose Creek tailings may have to be reduced as far as practical through the use of a cover. Therefore, the requirement to construct covers that fulfill the function of reducing infiltration and/or shedding runoff may have to be reconsidered. Cover design concepts are still under discussion, but the most recent studies suggest that a typical tailings cover for this site might consist of 0.5 m of waste rock overlain by 1.5 m of lightly compacted till. The till surface would likely be seeded and fertilized.

Actual construction of any type of cover at this site, poses significant constructability challenges, including:

- trafficability of the tailings; and
- settlement of the final cover (both consolidation and thaw settlement).

In addition to these constructability issues, there are also some long-term sustainability issues, including:

- increased geochemical load, albeit very small, as a result of the release of pore water during consolidation-induced settlement;
- potential for tailings fines to locally migrate upwards through the cover and appear as “boils” (both under normal conditions, freeze-thaw cycles and as a result of infrequent but potentially severe seismic action);

- potential for cover failure as a result of tailings liquefaction triggered by infrequent but potentially severe seismic action;
- phytotoxicity in vegetation that does establish on the cover; and
- physical changes in the cover properties over time.

It was agreed at the February 2004 workshop, and during subsequent discussions between D&T and SRK, that trial covers would be constructed on the Rose Creek tailings impoundment to obtain site specific data regarding some of these constructability and sustainability issues. These trial covers were constructed in April 2004, and monitoring data for these trial covers was collected during the snow free seasons of 2004 and 2005 (i.e. between April and September each year).

1.3 Scope of Work

This report summarizes the design, construction, and subsequent monitoring observations during the 2004 and 2005 summer seasons, for the two trial covers on the Rose Creek tailings impoundment. These observations provide engineering data that is essential to the development and optimization of the design of a cover for the Rose Creek tailings complex.

This report is only intended to document the factual and anecdotal trial cover monitoring results and observations, and in no way constitutes or promotes the final cover design for the Rose Creek tailings complex.

1.4 Methods

Two trial covers, each measuring approximately 80 cm thick and 625 m^2 in size, were constructed between April 8 and 17, 2004. Construction was carried out by a local contractor, Tim Moon Construction, assisted by ARMC personnel and equipment. Gerry Ferris, P.Eng., a Geotechnical Engineer from BGC Engineering Inc. (BGC) provided full-time on-site engineering support on behalf of SRK, who designed the trial covers. An “as-built” report on the trial covers was submitted to D&T and SRK on June 11, 2004 (BGC 2004a).

Following construction, BGC trained ARMC personnel to conduct monthly surveys of 70 points on the two trial covers, such that progressive settlement could be evaluated. Regular (ranging between monthly and bi-weekly) survey results were faxed or e-mailed to SRK between May and September of 2004 and 2005. No data from October to April was collected due to the presence of snow on the trial covers.

The trial covers were visually inspected seven times by various SRK personnel (John Chapman, P.Eng., Dylan McGregor, GIT, and Maritz Rykaart, P.Eng.) between April and September 2004, as well as twice more in June and September 2005. The purpose of these inspections was to observe and document any physical changes in the trial covers. In September 2004, three test pits were excavated on each trial cover to determine whether tailings fines were migrating up through the tailings. A similar test pit program was also carried out in September 2005. Both test pit programs were supervised by Maritz Rykaart.

2 Design and Construction of Trial Covers

2.1 General

The as-built report for the trial covers (BGC 2004a) contains complete details of their design and construction, important aspects of which are reiterated here to facilitate the reader's understanding of the subsequent observations.

2.2 Design

The trial covers were designed to specifically evaluate the following:

- The magnitude of consolidation settlement of the cover after placement.
- If, and to what extent tailings would migrate upwards through the cover.
- If placement of a geotextile would be beneficial to alleviate the problem of potential tailings migration.

Given the objectives of the trial covers, a decision was made to construct them with calc-silicate waste rock (due to its durability and favourable geochemical properties). Particle size distribution data for the calc-silicate waste rock was based on visual inspection, though no samples were collected for analysis during cover construction. The waste rock varied in size from boulders larger than 200 cm in diameter to silt and clay-sized particles (fines). The bulk of the material would be classified as well graded, silty to clayey gravel (GM-GC, based on the Unified Soil Classification System), with boulders less than 60 cm in diameter. Occasionally, pockets of the material were encountered with little or no fines. Based on these properties, it was reasoned that the practical minimum cover thickness using this material would be between 60 cm and 100 cm. The target design thickness for the trial cover areas was set at 80 cm, with a 10 cm tolerance on either side. The as-built survey confirmed that, for the most part, the trial covers were constructed to this specification (BGC 2004a).

The trial covers were supposed to allow for representative evaluation of consolidation settlement potential of the cover and underlying tailings material, and therefore had to be of sufficiently large scale. To achieve this, the design trial cover dimensions called for base dimensions of about 30 x 30 m and crest dimensions of 25 x 25 m. The as-built trial cover dimensions are presented in Table 1. Figures 1 and 2 illustrate the trial cover location, and Figure 3 presents the general layout of the two trial covers.

The location of the trial covers was specifically selected to coincide with soft, saturated slimes, in an area with a shallow water table, since these conditions are expected to represent significant potential for settlement and upwards migration of tailings through the cover. The selected site (Figure 1) appeared to have these characteristics based on cone penetration test (CPT) data (Golder 2004). Figure 4 is a reproduction of the tailings profile in the immediate vicinity of the trial covers, as per the seismic cone penetration test (SCPT) SCPT-03-32 completed by Golder (2004). Subsequent visual inspection, difficult trafficability during construction, and the sinking of an excavator adjacent to the trial covers in June 2004, confirms that the site is probably representative of the tailings properties that may cause settlement and fines migration problems at the Rose Creek tailings impoundment.

Table 1: As-Built Trial Cover (Test Pad) Dimensions

Test Pad	Geotextile Separation	Base Dimensions (m)	Top Dimensions (m)	Volume of Material in Pad (m^3) Based on Survey
East Pad	No	30.0 x 26.0	24.0 x 24.0	615
West Pad	Yes	32.0 x 31.0	27.5 x 27.5	695

One of the concerns related to cover construction was the possibility of fines migrating through the cover due to capillary action associated with the shallow water table within the tailings, or as a result of trapped pore pressure during seismic loading. This physical migration of fines can be prevented by placing an appropriately designed filter between the tailings surface and the cover, and the simplest form of such a filter is a non-woven geotextile. Subsequently, one of the test pads was constructed directly onto the tailings surface (East Pad), and the second pad was constructed on top of a non-woven geotextile (West Pad).

The specified geotextile was Armtec 350, which has an apparent opening size (AOS) of 0.15 mm. There was insufficient quantity of this material on site, and a small portion of the pad was underlain by Armtec 250, with an AOS of 0.18 mm (detail provided in BGC 2004a). The purpose of the geotextile is to provide separation between the tailings and the waste rock cover. Based on the most conservative empirical method described in Koerner (1986), assuming the tailings can be classified as silty sand (SM) with a d_{50} of 0.15 mm and a coefficient of uniformity of 12.4, the geotextile should have an AOS of 0.22 mm or smaller. Both geotextiles used are within the desired specification.

2.3 Construction

A significant concern associated with construction of covers on the Rose Creek tailings is trafficability. Large sections of the Rose Creek tailings impoundment contain fine tailings and slimes, with high moisture content and a shallow water table. It is therefore not possible to use conventional construction equipment directly on these tailings under unfrozen conditions. Placement of a cover onto unfrozen tailings would require that the cover material be placed from the perimeter of the impoundment using an end-dumping methodology from the edge of the working platform. This method of cover material placement has three potential drawbacks; (a) since the cover material is essentially a working platform, substantial mixing of the tailings and cover material may occur, which could lead to larger cover volumes being required; (b) access routes based on the use of fill thicknesses significantly greater than 80 cm will be required for vehicle access, which would lead to larger cover volumes and possibly geotextiles or geogrids being required; and, (c) a bow wave of tailings can develop in front of the working platform, which would again result in more cover material being required, as well as potential re-grading of the surface.

The cold winter climate at ARMC offers an opportunity to circumvent the trafficability problem. During winter, the tailings surface becomes completely frozen, and can generally support large construction equipment. Under these conditions, the cover material can be placed optimally with good control over the volume of material that would be required. Therefore, a cover placed in winter has the potential to eliminate trafficability concerns, provided the tailings are frozen, as the cover is placed. Unfortunately, actual trial cover construction was carried out during a relatively warm spell, late in the winter season, specifically mid April 2004 when the maximum daily ambient air temperatures for the period were between -1°C and 8°C, and the minimum ambient night-time temperatures were between -4°C and -14°C.

The tailings in the trial cover area were frozen prior to construction, to a depth of at least 60 cm as confirmed by driving steel bars into the surface. Throughout daily construction, the upper surface of the tailings thawed, leading to the development of ruts in the surface. These ruts averaged between 10 and 50 mm deep at the East Pad and up to 100 mm deep at the West Pad. The West Pad area was generally less trafficable than the East Pad as a result of the tailings surface thawing. In some areas, it appeared that trucks had caused localized settlement of more than 200 mm, but upon closer inspection it was clear that those areas were snow-filled depressions in the tailings surface that had been created when the snow was cleared prior to the start of construction. The as-built report (BGC 2004a) provides a complete photographic log illustrating these conditions.

Pad construction was intended to mimic, to the extent practical, full-scale construction conditions, including the use of large construction equipment (e.g. CAT 777 haul trucks and D9 to D11 dozers). This was however not practical for such a small trial cover, and standard tandem axle road dump trucks and a D8 dozer were used to construct the trial covers. This difference in construction equipment should not impact cover performance assuming the full scale closure cover is placed on frozen tailings. However, based on the surface thawing that was observed during placement of the trial covers, it was probably beneficial to have lighter equipment for their construction.

2.4 Settlement Monitoring

Formal monitoring of the trial covers was based primarily on consolidation settlement (thaw settlement could be a factor if the trial covers are on frozen tailings; however, available drill hole data suggest that this is not the case). Settlement survey control was set up in two ways; (a) primary survey beacons monitoring the base (foundation) settlement of the trial covers, and (b) secondary survey beacons monitoring the surface settlement of the trial covers. Details of these beacons are described in the as-built report (BGC 2004a).

Three primary survey beacons were installed in each trial cover, as indicated on Figure 3. The objective of these beacons was to measure the trial cover foundation settlement. The secondary survey beacons consisted of 16 boulders placed in a fixed grid pattern on each trial cover surface to monitor the trial cover surface settlement. As a backup, in case the boulders became unstable, a conventional survey pin (30 cm long) was also installed immediately adjacent to each boulder. The pins were labelled with a “Y” prefix to the station number, and the rocks were labelled with an “R” prefix.

It was assumed that the actual cover material would not undergo any discernable settlement, and therefore all measured settlement refers to settlement of the underlying tailings. A significant difference between the primary and secondary survey beacons would provide an indication if this assumption is not valid.

A permanent benchmark (Y6600) was established at the time of the as-built survey (due south of the trial covers, on the Rose Creek Diversion embankment), and all settlement surveys were referenced from this benchmark.

3 Post Construction Monitoring

3.1 Surveying

The as-built survey for the trial covers was carried out by Yukon Engineering Services (YES) from Whitehorse, YK. ARMC staff carried out regular settlement surveys using a "dumpy" level. Levelling was done from a fixed benchmark (Y6600) installed by YES (see Figure 1). The levelling data was reduced to actual elevations by ARMC staff and faxed or e-mailed to SRK. Table 2 summarizes details of the settlement surveys, and Appendix B contains complete data tables for all the surveys.

Table 2: Details of the Settlement Surveys

Date	Surveyed By	Comments
April 20, 2004	Yukon Engineering Services	As-built survey
May 28, 2004	C. McKinnon & R. Meiers	
June 16, 2004	C. McKinnon & R. Meiers	Rock beacons 6587 and 6596 were wobbly
July 16, 2004	C. McKinnon & R. Meiers	Beacons 6566, 6574 and 6578 were disturbed
August 20, 2004	C. McKinnon & R. Meiers	
September 23, 2004	C. McKinnon & R. Meiers	Last survey for 2004; Pin 6585 was disturbed by backhoe
October 22, 2004	No survey	Pads covered in snow
May 12, 2005	C. McKinnon & R. Meiers	
June 14, 2005	C. McKinnon, M. Sevenhuysen & M. Brewer	Primary survey beacon TP1-2 pushed over about 45^{o}
June 28, 2005	M. Sevenhuysen & M. Brewer	
July 12, 2005	M. Sevenhuysen & M. Brewer	
July 26, 2005	M. Sevenhuysen & M. Brewer	
August 9, 2005	M. Sevenhuysen & M. Brewer	
August 23, 2005	M. Sevenhuysen & M. Brewer	
September 15, 2005	C. McKinnon & M. Brewer	Last survey for 2005

On June 17, 2004, ARMC was excavating a test pit approximately 10 m west of the West Pad using the ARMC CAT 235 tracked excavator. The excavator got stuck during this excavation and the ARMC D9 Dozer had to be used on the West Pad to facilitate recovery of the excavator. Upon recovery, the excavator crawled across the trial cover, resulting in disturbance to the south-east corner of the trial cover, as well as to secondary survey beacons 6566, 6574 and, possibly, 6578. The damage on the trial cover is presented schematically on Figure 5.

During test-pitting carried out on the test pads on September 23, 2004, care was taken not to disturb the survey beacons, however, secondary beacon Y6585 (the 30 cm pin) on the East Pad was found to be covered in dirt after the pit was backfilled. The pin was carefully cleared by hand, but some disturbance did occur, and was so noted.

During the June 2005 site visit it was noted that primary survey beacon TP1-2 was leaning at an angle of about 45^{o}. The beacon was not damaged and significant settlement did not occur that would account for such deformation, suggesting that the beacon must have been pushed over manually. Site staff are however unaware of any activity on the trial cover that could have resulted in this damage, and therefore the reason for the movement remains undetermined.

3.2 Visual Inspections

Visual inspections of the trial covers were carried out five times between April and September 2004, and twice in 2005. The details of these inspections are listed in Table 3.

Table 3: Details of the Visual Inspections conducted on the Trial Cover Areas

Date	Inspected By	Comments
April 28, 2004	John Chapman	No notable elements of concern
June 7, 2004	Dylan MacGregor	Slight surface cracking evident on both trial covers
June 24, 2004	Dylan MacGregor & John Chapman	Damage on West Pad as a result of the retrieval of an excavator stuck in the tailings
August 29, 2004	Maritz Rykaart	Abundant surface cracking on East pad; Minor surface cracking on West Pad
September 27, 2004	Maritz Rykaart	Basically unchanged from August 2004 inspection; Test pits excavated
June 12, 2005	Maritz Rykaart	Basically unchanged from September 2004, except for the leaning primary survey beacon TP1-2; No surficial cracks observed
September 21, 2005	Maritz Rykaart	Test pits excavated; Basically unchanged from the June 2004 inspection

With the exception of the damage sustained to the West Pad as a result of the excavator extraction incident, the only noticeable feature during the 2004 inspections was surface cracking. A schematic of the extent of the cracks as observed during the August 29, 2004 site inspection is presented in Figure 6. Appendix D contains photos of these features taken during the inspection. The surface cracks are randomly spaced across the pad surface, and vary in width from a few millimetres to more than 2 cm and are approximately 10 cm deep (as probed from the surface). Surface cracks were first observed during the June 7, 2004 site inspection, and although a schematic similar to Figure 6 was not developed at the time, the inspector’s field notes and photos (Appendix C) suggest that cracking was less severe and slightly more common on the West Pad than on the East Pad. This trend was reversed during the August 2004 inspection, with significantly more cracks observed on the East Pad.

Surface cracking was not observed during any of the 2005 inspections. In fact, the only notable observation throughout the 2005 monitoring season was the significant amount of standing (ponded) water that remained within 20 m of the toe of the northern slope of the trial covers for the most of the summer monitoring period. This information was provided by the ARMC staff that carried out the monthly surveys.

3.3 Test Pits

Three shallow tests pits were excavated into each of the trial covers on September 27, 2004, and another three test pits in each trial cover on September 21, 2005. The test pits were excavated with a rubber-tired Case 580 Super-M backhoe belonging to ARMC. The backhoe was equipped with a 60 cm wide sand bucket. Photographs of the test pits are included in Appendices E and F and the logs are summarized in Tables 4 and 5. The approximate test pit locations are presented in Figure 3.

Table 4: Summary of September 2004 Test Pit Results

Test Pit	Pit Profile	Comments
East Pad: TP-TTC-04-01	0 to 80 cm – calc-silicate waste rock cover material	Undulating mixed zone dominated by presence of angular boulders. Nature of mixing suggests it probably started during construction. Beyond mixed zone there are no signs of tailings migrating upwards. Boulders up to 50 cm in diameter present in cover matrix. Cover material is very moist to wet and test pit side slopes have low strength – progressively failing with time. Cover material consistency is loose. There is no apparent variance in moisture with depth in the cover material. Tailings are very moist to wet, but firm, and unfrozen.
	80 to 100 cm – undulating mixed zone of calc-silicate waste rock cover material and tailings	
	100 cm onwards – undisturbed tailings	
East Pad: TP-TTC-04-02	0 to 100 cm – calc-silicate waste rock cover material	
	100 to 120 cm – undulating mixed zone of calc-silicate waste rock cover material and tailings	
	120 cm onwards – undisturbed tailings	
East Pad: TP-TTC-04-03	0 to 70 cm – calc-silicate waste rock cover material	
	70 to 90 cm – undulating mixed zone of calc-silicate waste rock cover material and tailings	
	90 cm onwards – undisturbed tailings	
West Pad: TP-TTC-04-04	0 to 75 cm – calc-silicate waste rock cover material	Undulated surface at geotextile contact, dominated by original tailings surface. Limited signs of boulders penetrating beyond original tailings profile. Tailings and cover moisture and consistency similar to East Pad test pits. No signs of tailings migrating through geotextile.
	75 - 80 cm – minor undulations in geotextile surface	
	80 cm onwards – undisturbed tailings	
West Pad: TP-TTC-04-05	0 to 70 cm – calc-silicate waste rock cover material	
	70 to 90 cm – minor undulations in geotextile surface	
	90 cm onwards – undisturbed tailings	
West Pad: TP-TTC-04-06	0 to 75 cm – calc-silicate waste rock cover material	
	75 to 80 cm – minor undulations in geotextile surface	
	80 cm onwards – undisturbed tailings	

Table 5: Summary of September 2005 Test Pit Results

Test Pit	Pit Profile	Comments
East Pad: TP-TTC-05-01	0 to 75 cm – calc-silicate waste rock cover material	Undulating mixed zone dominated by presence of angular boulders. Beyond mixed zone there are no signs of tailings migrating upwards. Boulders up to 50 cm in diameter present in cover matrix. Cover material is very moist and test pit side slopes have little strength – progressively failing with time. Cover material consistency is loose. There is no apparent variance in moisture with depth in the cover material. Tailings are very moist to wet, but firm, and unfrozen.
	75 to 95 cm – undulating mixed zone of calc-silicate waste rock cover material and tailings	
	95 cm onwards – undisturbed tailings	
East Pad: TP-TTC-05-02	0 to 80 cm – calc-silicate waste rock cover material	
	80 to 100 cm – undulating mixed zone of calc-silicate waste rock cover material and tailings	
	100 cm onwards – undisturbed tailings	
East Pad: TP-TTC-05-03	0 to 80 cm – calc-silicate waste rock cover material	
	80 to 95 cm – undulating mixed zone of calc-silicate waste rock cover material and tailings	
	95 cm onwards – undisturbed tailings	
West Pad: TP-TTC-05-04	0 to 80 cm – calc-silicate waste rock cover material	Undulated surface at geotextile contact, dominated by original tailings surface. Limited signs of boulders penetrating beyond original tailings profile. Tailings and cover moisture and consistency similar to East Pad test pits. No signs of tailings migrating through geotextile.
	80 - 90 cm – minor undulations in geotextile surface	
	90 cm onwards – undisturbed tailings	
West Pad: TP-TTC-05-05	0 to 70 cm – calc-silicate waste rock cover material	
	85 to 95 cm – minor undulations in geotextile surface	
	95 cm onwards – undisturbed tailings	
West Pad: TP-TTC-05-06	0 to 80 cm – calc-silicate waste rock cover material	
	80 to 90 cm – minor undulations in geotextile surface	
	90 cm onwards – undisturbed tailings	

Excavation of the test pits confirmed that, on average, the cover was within the specified thickness of 70 to 90 cm, as measured from the surface to the point where mixing of tailings and cover material starts to take place. There is a distinct undulating zone of mixed tailings and cover material at the base of the East Pad. This undulating mixed zone is approximately 20 cm thick on average; however, some large boulders were depressed up to 40 cm deep into the tailings. The undulating mixed zone appears to be driven by large boulders, as opposed to a complete homogenous settlement and blending of the two materials. Beyond this undulating mixed zone, which is mechanically induced during construction, there is no evidence of upwards tailings migration.

The test pits on the West Pad were excavated only to the geotextile, and each pit was targeted to intercept a section where the geotextile overlapped. In general the interface between the cover and tailings was significantly less undulating than for the East Pad, averaging around 5 cm, with localized areas reaching 10 cm. In all cases, there was no sign of tailings migration through the textile, and in fact in the overlapped sections, the upper surface of the bottom geotextile was completely clean. In the first test pit of each of the 2004 and 2005 excavations, the geotextile was inadvertently ripped during excavation, which allowed a comparison of the upper and lower surface of the geotextile as further evidence of this observation. The targeted geotextile overlap was reached in two of the test pits, and there was no sign of the overlap being reduced through differential settlement. The geotextile was generally completely flat, mimicking the underlying tailings surface. However, in one pit some irregularities were observed, which appear to be a result of rutting created by the dump truck backing up over the geotextile during construction (BGC 2004a). There was, however, no sign of tears or punctures in the geotextile in any of the test pits.

There was no discernable difference between the moisture regimes in the test pits. Both the tailings, which can be classified as predominantly a silty sand (SM), and the cover material, which can be classified as well graded silty gravel (GM), were “very moist” to “wet” and unfrozen. The moisture distribution in the cover was consistent throughout the profile. The geotextile was damp but no moisture could be expressed by wringing it.

4 Discussion of Results

4.1 Settlement

Regular surveys (between every two to four weeks) were completed on the primary and secondary survey beacons on each test pad. Figures 7 and 8 present the raw settlement data for these surveys. There is no logical physical explanation for the sudden increase in settlement and subsequent "rise" of the test pads indicated by the July 16, 2004 survey data. It is reasonable to assume that a survey error has resulted in the anomalous data. Therefore this dataset has been excluded from the final settlement analysis presented in this report.

On each test pad 16 survey points were set out in a pre-determined grid pattern, as illustrated in Figure 3. After excluding the July 16, 2004 data set, as well as specific data points which are not representative due to disturbance by the excavator recovery on June 17, 2004, as well as the unexplained lean of primary survey beacon TP1-2 in June 2005, the survey data was reduced following a consistent format. All data are presented in a normalized fashion, i.e. the as-built survey data is the reference data set against which all settlement is measured. Initially these survey points were supposed to consist of boulders only. However, when the as-built survey was completed, a standard survey pin was installed adjacent to each boulder, in case a boulder moves as a result of physical disturbance. All surveys subsequently included data for both the 16 boulders and the 16 survey pins on each pad. These two data sets on each test pad are thus essentially duplicates of the same data. The average pad surface settlement was calculated separately for the boulder data and the survey pin data, and then the average of these two datasets was calculated to determine the overall surface settlement for each pad as illustrated in Figure 9.

Considering the survey equipment, the experience of the operators and the monitoring technique, it is reasonable to assume that the surveys are accurate to ± 10 mm, as indicated by the error bars in the figures. The apparent anomalous "rise-and-fall" of the surface between survey intervals, as depicted in Figures 9 and 10, is probably within the inherent accuracy of the monitoring methodology, and does not necessarily infer any unusual movement within or beneath the trial covers.

The trial covers foundation settlement, as presented by the three primary survey beacons installed in each trial cover are presented in Figure 10, and again the apparent anomalous "rise-and-fall" data is probably most likely a reflection of the inherent degree of accuracy of the monitoring technique.

Figure 11 presents the overall settlement for both the East and West Pads. This data was reduced by averaging the settlement from the three primary survey beacons in each test pad, and then calculating the overall average between the average surface settlement presented in Figure 9 and the primary survey beacon average (Figure 10). Overall settlement for the East Pad, which has no geotextile, was approximately 141 mm compared to approximately 63 mm for the West Pad, which is underlain by geotextile. This equates to about 18 and 8% total settlement respectively, as expressed in terms of the design cover thickness of 80 cm.

The shape of the settlement curves suggest most settlement occurred early in the summer of 2004 as the tailings profile thawed out, and by late summer, the settlement rate slowed. There has been very little measurable settlement in 2005, which is consistent with observations at the end of the 2004 monitoring season. This trend is reasonable, indicating primary consolidation of the underlying tailings taking about four months, followed by the onset of secondary consolidation. At this stage it is not clear how much additional settlement will occur beyond the 2005 season. However, considering the small change in 2005, it is likely that the trial covers are close to complete settlement.

The differences in overall settlement and settlement rate between the East and West Pads were not expected. The single layer of geotextile, should theoretically not impact the settlement to any degree; however, the observed data shows a distinct difference in settlement. Several factors may be influencing the results. It is possible that the geotextile has clogged with fine tailings, slowing the rate of consolidation, and therefore, the rate of settlement. In this case, the same total settlement should be observed in the longer term. Another possibility is that since the geotextile is acting as a physical separation between the tailings and waste rock, the cover is “floating” on the tailings as opposed to actually penetrating and creating an undulated mixed zone. The fact that the undulated zone in the West Pad is markedly smaller than for the East Pad supports this idea. Finally, it is possible that some of the settlement observed in the East Pad may have been thaw settlement; however, the available drill hole data does not support this.

Appendices G and H, respectively, contain more information about the physical properties of the tailings beneath the covers as well as a theoretical assessment of the settlement of the trial covers.

4.2 Migration of Fines

4.2.1 Actual

Physical inspection of each cover by test pitting indicated there is an undulating mixed zone approximately 20 cm thick at the base of the East Pad where tailings and the waste rock have been mixed. It is not clear whether this zone formed during construction, or after construction as the tailings thawed. During construction, the tailings surface thawed, but rutting was reported to be 2 to 5 cm at most, suggesting that significant embedding and mixing of material during construction was minimal. However, this can not be definitively stated since no assessment of embedment was done after dumping took place and the pads were flattened with the dozer.

Irrespective of when this mixing occurred, inspection of the test pits at the East Pad shows no indication of tailings migration upwards in any of the three test pits. There was also no sign of tailings migrating through the geotextile, or between seam overlaps in the West Pad.

4.2.2 Theoretical

A number of physical processes take place when a cover material is placed directly onto an unfrozen tailings surface. Firstly, the fine tailings attempt to enter the voids of the waste rock, and secondly the waste rock actually penetrates the fine tailings surface. Both these processes take place simultaneously and result in a layer of mixed tailings at the interface of the two materials (as observed in the East Pad).

In addition, the fine tailings sometimes continue to migrate up through the cover material, in a process similar to capillary water moving up through void spaces in a soil in the vadose zone. The process of physical fines migration is not well understood, and therefore there are no tools to predict what the likely potential would be for it to occur, or even what the likely triggers are. In one documented case study (Beaverlodge Project, SK), fine tailings migrated through the 0.3 m thick waste rock cover, and appeared as boils (SRK 1995). In this case, the cause of the tailings boils was piezometric levels that spiked upwards each spring in response to seasonal thawing.

At the Discovery Mine, NT, small tailings and silt boils appeared on the cover surface one year after construction, and over time increased in size and number. The 0.6 m cover comprises 0.3 m of clayey silt placed directly on the tailings surface, with a 0.3 m protective layer of crushed rock. BGC (2004b) speculate that these boils are consistent with frost boil formation.

The Arctic Gold and Silver Mine, YT tailings were covered with a 30 cm layer of clayey silt, overlain by 50 cm of sand/gravel. This cover has performed satisfactorily since 1999, with no evidence of tailings “boils”.

Geotextiles are routinely used to separate fine and coarse materials in filter applications, and provided the geotextile meets appropriate filter criteria, it can prevent this “pumping” of tailings solids from occurring.

5 Conclusions and Recommendations

5.1 Cover Integrity

5.1.1 Consolidation Settlement

Construction of a cover on the tailings surface will result in consolidation settlement. Because of the variable tailings properties, drainage conditions, and thicknesses, the amount of settlement will vary over the tailings surface. This differential settlement, could be a problem with respect to cover performance, if the cover function requires that there be no differential settlement (e.g. if runoff shedding is required). It is therefore important to determine the possible range of potential settlements that could occur on the Rose Creek tailings impoundment, such that appropriate mitigation measures can be included in the final cover design.

Based on the two seasons of field settlement data (summer 2004 and 2005) for the Rose Creek tailings trial covers, the total measured settlement was between 63 and 141mm. It is also important to note that the consolidation rate for the Rose Creek tailing appears to be rapid. The field data suggest that primary consolidation occurs within weeks or months, whilst secondary consolidation is essentially complete in less than a year.

SRK conducted a first order theoretical assessment of possible consolidation settlement based on different cover thicknesses, using the results of the trial cover settlement results. This assessment is documented in Appendix H. Site specific tailings property data used in this assessment is presented in Appendix G.

5.1.2 Thaw Settlement

Various drilling programs within the Rose Creek tailings impoundment have proven that the tailings are not frozen, except for some intermittent, randomly spaced layers. The presence of excess ice in the tailings mass could result in another form of differential settlement, which will only occur if and when this ice thaws. The infrequent and small amount of frozen tailings observed in the Rose Creek tailings suggests that this form of differential settlement, if it occurs at all, is likely to be limited and much localized. Specific allowances for this settlement in the cover design are therefore not recommended; however, the design should recognize that some localized cover repair, such as minor surface level adjustments by grading, may be required over time.

5.1.3 Migration of Fines

There have been a number of case studies where the fine underlying tailings have migrated up through the cover and emerged on the surface in the form of boils (not associated with seismic activity). The exact physical processes that lead to this happening are not completely understood, and therefore a conclusive statement on whether this will occur for any given cover design cannot readily be made. It can however be prevented by including an appropriate filter zone between the tailings and the cover material. If there is not a suitable natural filter material readily available, a geotextile can fulfill this function. This however adds substantially to the overall cost of any cover system, and therefore site specific trials are warranted.

Based on the two field seasons of monitoring of the Rose Creek tailings trial covers, there is no evidence that fines migration is taking place. Furthermore, SRK is not aware of any case studies where covers about 1 m thick have experienced fines migration to surface. It is however difficult to say with certainty, that fines migration will never occur in the future.

5.1.4 Other Factors

There are numerous other factors that could affect cover integrity; however, they were not the focus of the trial covers. It is however important to recognize that depending on what the final cover functionality is going to be, that these other factors be given due consideration, i.e.:

- Changes in cover material physical and hydraulic properties as a result of being subjected to wet/dry and freeze/thaw cycles.
- Over the long-term vegetation may establish on the cover which may cause roots to penetrate the tailings.
- Weathering of the cover material may impact the erosion resistance of the cover.

5.2 Cover Constructability

5.2.1 Trafficability on Rose Creek Tailings Impoundment

Based on the detailed tailings characterization carried out by Golder (2004), they concluded that constructability of a cover over the entire tailings area may be an issue. Generally, the tailings have a variable thickness upper crust of drier, slightly stronger tailings which are underlain by very soft and weak tailings. Construction equipment operating on the tailings surface, when it is not frozen, to place a cover may or may not be supported by this upper tailings zone. Anecdotal information from site staff regarding past experiences with the use of heavy equipment on the tailings, such as drill rigs, dozers and excavators, support this observation in most areas, except the beach zones of the Original Impoundment.

During the long, cold winters, the tailings surface does however freeze to a sufficient depth that this same equipment can travel across the tailings surface without problems. However, as observed during the construction of the cover trials, this frost layer can rapidly decrease during a warm spell.

Another potential trafficability concern is that even if the tailings at first support traffic, repeated traffic passes have the tendency to increase the pore pressure in finer tailings zones with depth and, if not dissipated, could cause unfrozen tailings to break through at surface, which could lead to trafficability problems.

5.2.2 Methods to Improve Tailings Strength (Trafficability)

A common and simple method used to overcome the problems with placing a dry cover on weak compressible tailings is to place a geosynthetic tensile reinforcement element (geogrid or geotextile) directly onto the tailings. In addition, there are several other measures that have successfully been used at other sites to increase the shear strength of the tailings prior to and during cover placement, i.e.:

- The tailings can be dewatered, allowing air-drying to occur. The effectiveness and time to achieve the desired strength obviously depend on the site specific climate and subsurface drainage conditions. The conditions at the Rose Creek tailings complex is such that air-drying would likely take a long time and require construction of appropriate water management systems, making it a potentially unfeasible option.

- Direct re-vegetation of the tailings would increase the depth to which the tailings can be dewatered. This alternative is, however, not an option for this site, both from a closure objective and a practical perspective.

- High permeability drainage elements, such as band or wick drains can be used to reduce the effective drainage path length, significantly accelerating the consolidation process. The practicality of this has not been assessed for this site.

- As discussed before, winter construction on frozen tailings effectively alleviates trafficability concerns, and presents definite possibilities at this site. There are however some practical limitations, such as placement of a frozen till cover during the winter.

5.3 Recommendations for Further Study

Construction and monitoring of the Rose Creek tailings trial covers has yielded valuable information with regard to tailings trafficability, total consolidation settlement potential and the likelihood of fines migration. SRK recommends that the following actions be undertaken to further enhance the database of information:

- Restart bi-weekly (once every two weeks) settlement monitoring on the trial covers between May and September for at least one more season, and then re-evaluate whether further monitoring would be useful.

- In September 2007 or 2008, excavate two large scale test trenches in each of the trial covers to completely inspect the mixed zone of tailings over an extended area. In the West Pad, after inspection of the geotextile, continue the pit into the tailings. Collect tailings and cover material samples from both trial covers for detailed geotechnical and geochemical characterization, such that the process of fines migration and mixing can be better understood.

- After completion of the test trenches, consider obtaining subsurface tailings core samples for geotechnical testing beneath each trial cover. This data would allow for better calibration of consolidation settlement data with conventional consolidation theory assessment.

This report, **"Anvil Range Mining Complex: Results from Trial Covers at Rose Creek Tailings Impoundment – 2005/06 Task 22b"**, has been prepared by SRK Consulting (Canada) Inc.

Maritz Rykaart, Ph.D., P.Eng.
Principal Consultant

Reviewed by

Cam Scott, P.Eng.
Principal Consultant

6 References

BGC Engineering Inc. (2004a). Tailings Test Cover Construction As Built Report, Faro Mine, YT. Final Report submitted to Deloitte & Touche Inc. and SRK Consulting, Authored by G. Ferris. June 2004, 10 Pages plus appendices.

BGC Engineering Inc. (2004b). Annual Geotechnical Inspection Discovery Mine, NT. Consultants report submitted to the Department of Indian and Northern Affairs Canada Contaminated Sites, Project No. 0131-015-02, March 30.

Golder Associates Ltd. (2004). Rose creek tailings Impoundment Site Characterization and Seismic Stability Assessment Report, Anvil Range Mining Complex, Yukon. Consultants Report submitted to SRK Consulting Inc., Report No. 03-1413-080, Edited by John Cunning and Mike Jefferies, June 30.

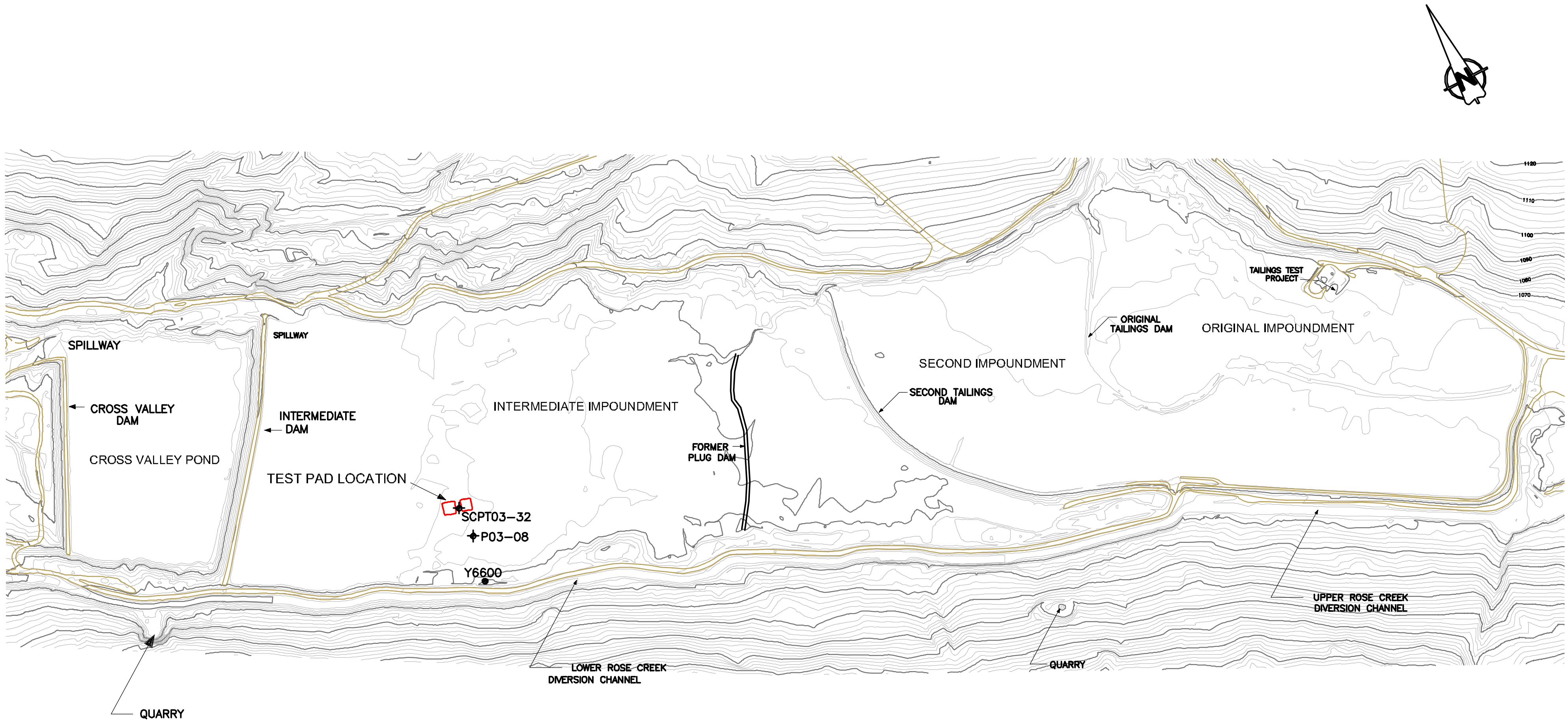
Koerner, R.M. (1986). Designing With Geosynthetics. Prentice-Hall, Englewood Cliffs, NJ 07632, 424 Pages.

SRK Consulting (Canada) Inc. (1995). Report on Proposed Remedial Measures to Counter Sand "Boils" Adjacent to Fookes Lake. Project Number C101101, Beaverlodge Project, Saskatchewan. Consultants Report to Cameco Corporation, September.

SRK Consulting (Canada) Inc. (2004). Waste Rock Pile and Tailings Covers for the Anvil Range Mining Complex, Projects 16(a) & 18(b), Faro, Yukon, Canada. DRAFT Report submitted to Deloitte & Touche Inc., on behalf of the Faro Mine Closure Planning Office, February 2004. *NOTE: This report was never finalized due to concerns about numerical modeling results, and is not available for distribution as a reference document.*

SRK Consulting (Canada) Inc. (2006). Monitor Trial Covers at Rose Creek Tailings Impoundment: 2004/05 Task 16b. Report submitted to Deloitte & Touche Inc., on behalf of the Faro Mine Closure Planning Office, March 2006.

Figures



Date of Photography: 2003/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856
CONTOUR INTERVAL = 2m

0 100 200 300 400 Metres

SRK Consulting
Engineers and Scientists

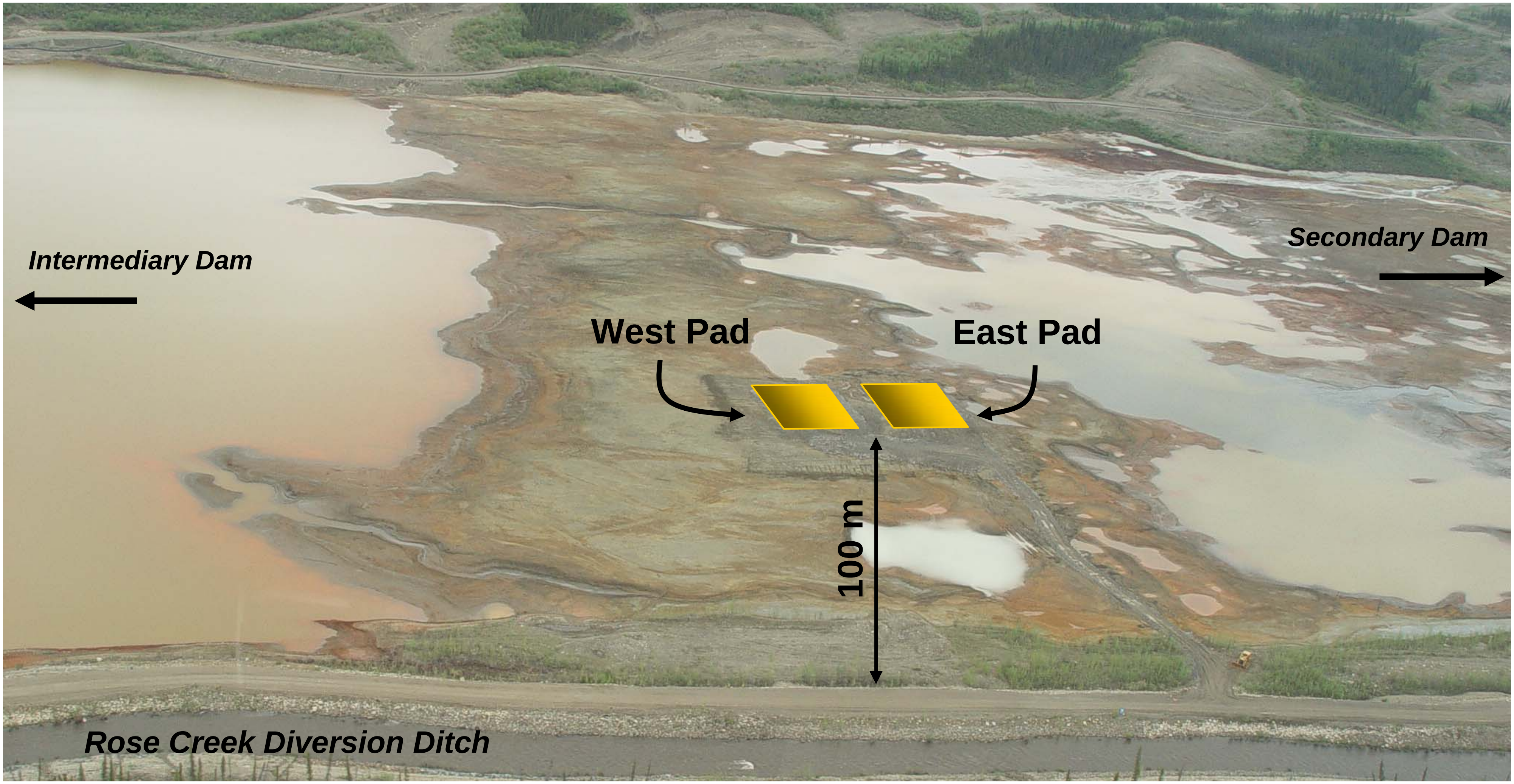
Deloitte & Touche

Anvil Range Mining Complex
Monitor Trial at Rose Creek Tailings Impoundment

Location Plan for Trial Covers

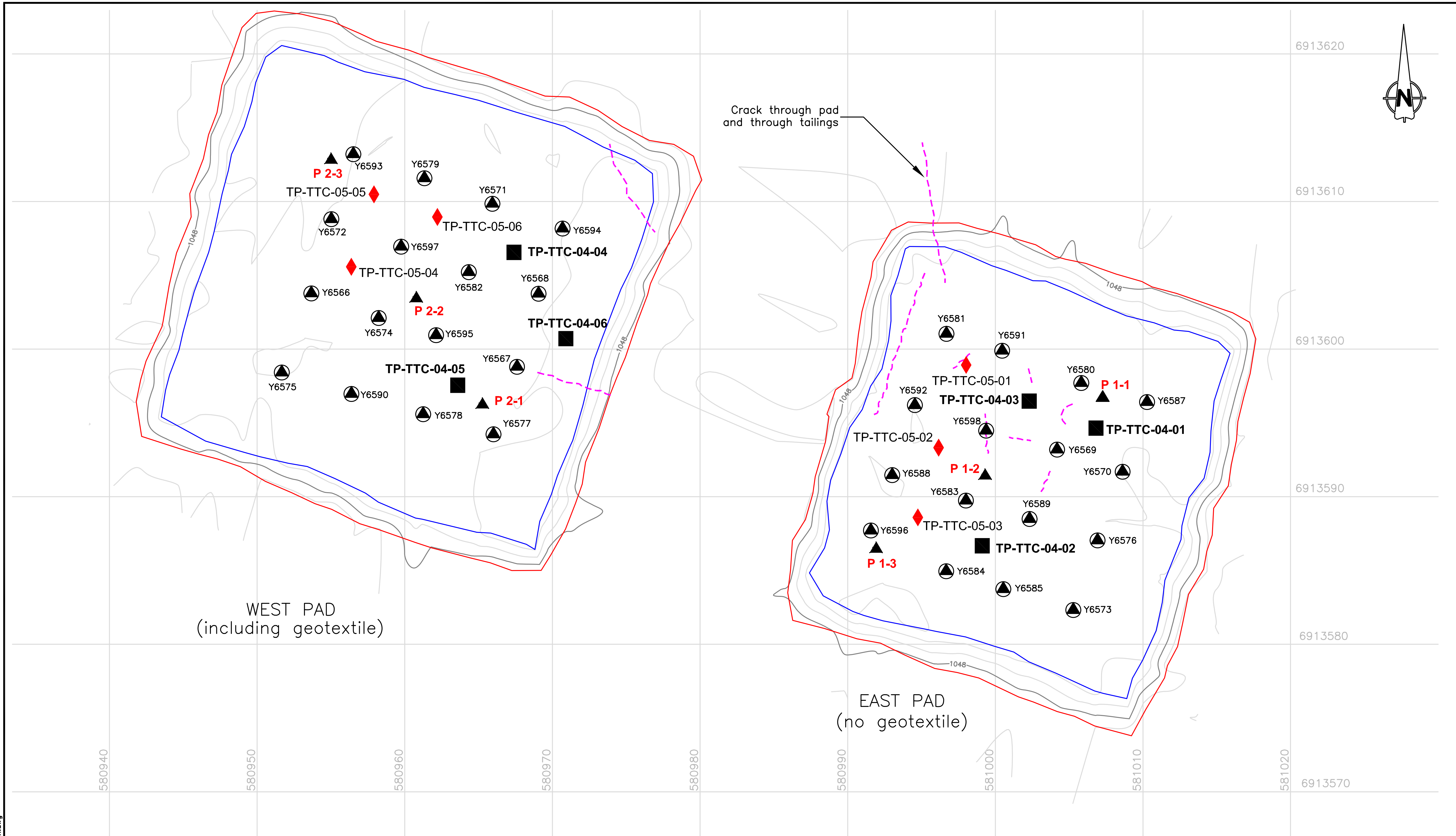
PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.075	July 2006	EMR	1

Dwg Ref: Tailings-Isopachs2006.dwg



SRK Consulting Engineers and Scientists	Anvil Range Mining Complex Monitor Trial at Rose Creek Tailings Impoundment			
Deloitte & Touche	Oblique View Looking Across the Trial Covers towards the North			
	PROJECT: 1CD003.75	DATE: July 2006	APPROVED: EMR	FIGURE: 2

File Ref: Figure 2-17_Rose Creek Trial Covers.ppt



0 2 4 6 8 10 Metres

SCALE

LEGEND

- ▲ PRIMARY SURVEY BEACONS
- ◬ SECONDARY SURVEY BEACONS
- ■ SEPT. 27, 2004 TEST PIT LOCATION
- ♦ SEPT. 21, 2005 TEST PIT LOCATION

Dwg Ref: Tailings Test Pads pm.dwg

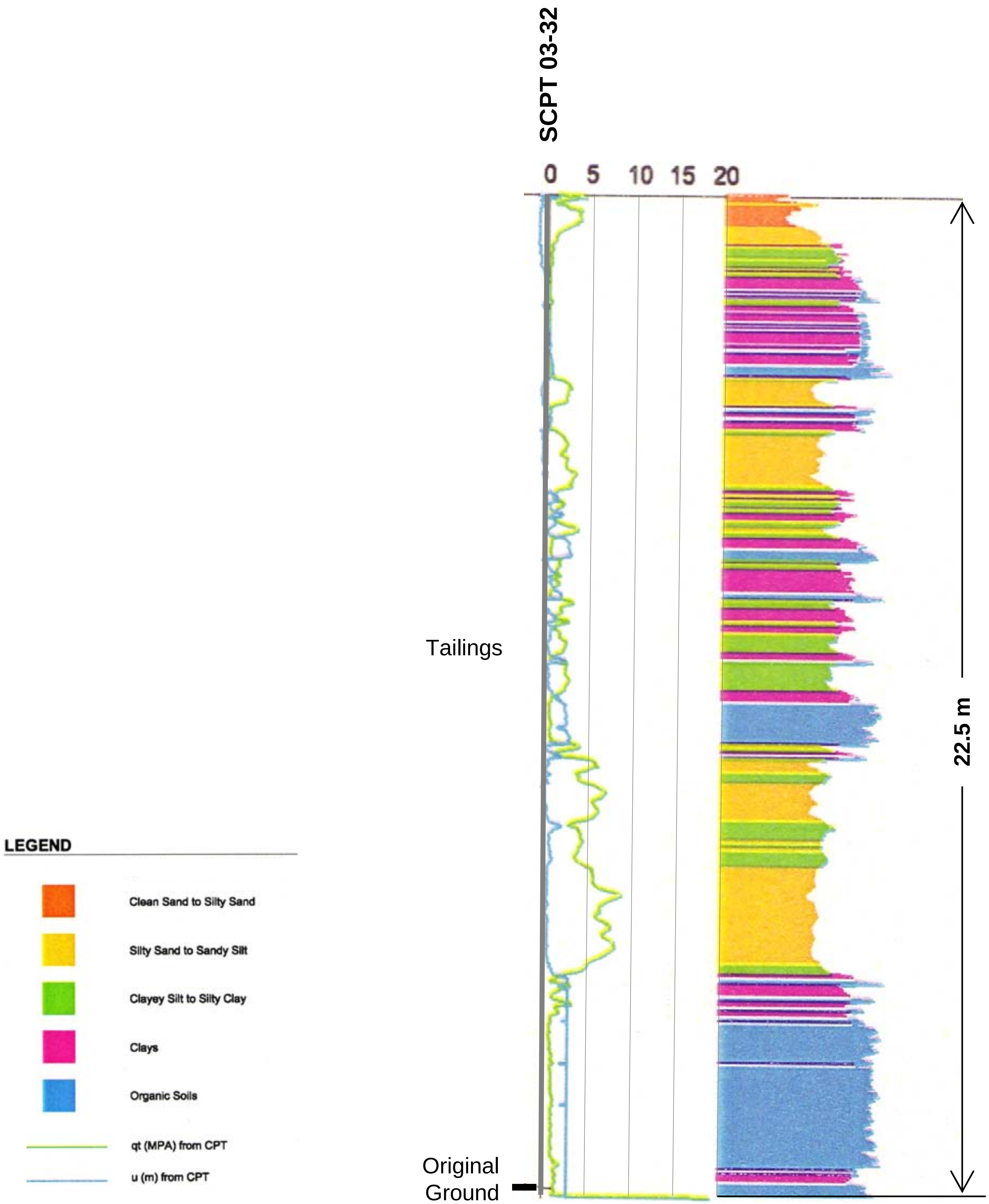
SRK Consulting
Engineers and Scientists

Deloitte & Touche

Anvil Range Mining Complex
Monitor Trial at Rose Creek Tailings Impoundment

General Layout of Trial Covers

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.075	July 2006	EMR	3



Source: Golder Associates (June 2004)

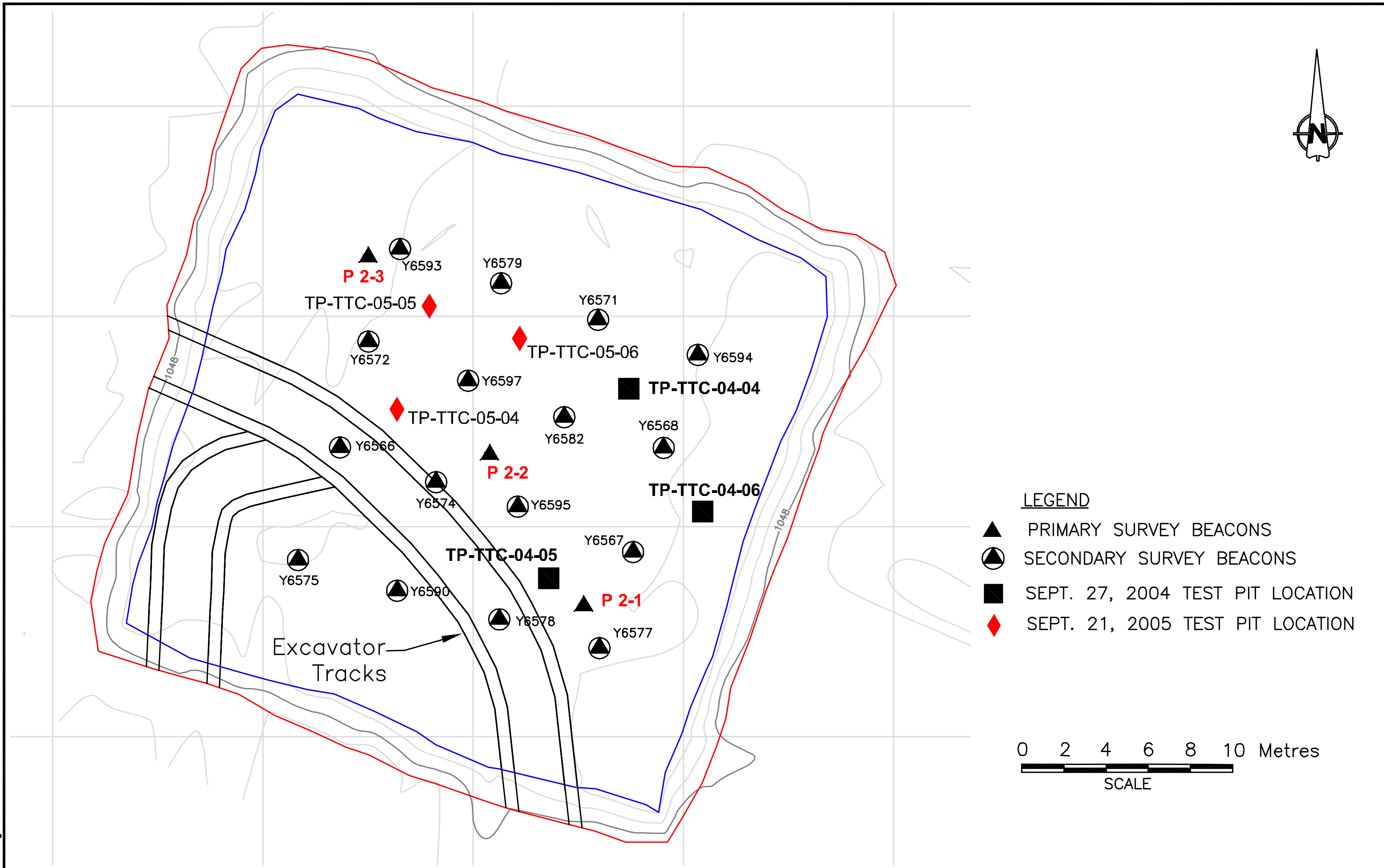
SRK Consulting
Engineers and Scientists

Deloitte & Touche

Anvil Range Mining Complex
Monitor Trial at Rose Creek Tailings Impoundment

Tailings Profile in the Immediate Vicinity of the Trial Covers

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.075	July 2006	EMR	4



SRK Consulting
Engineers and Scientists

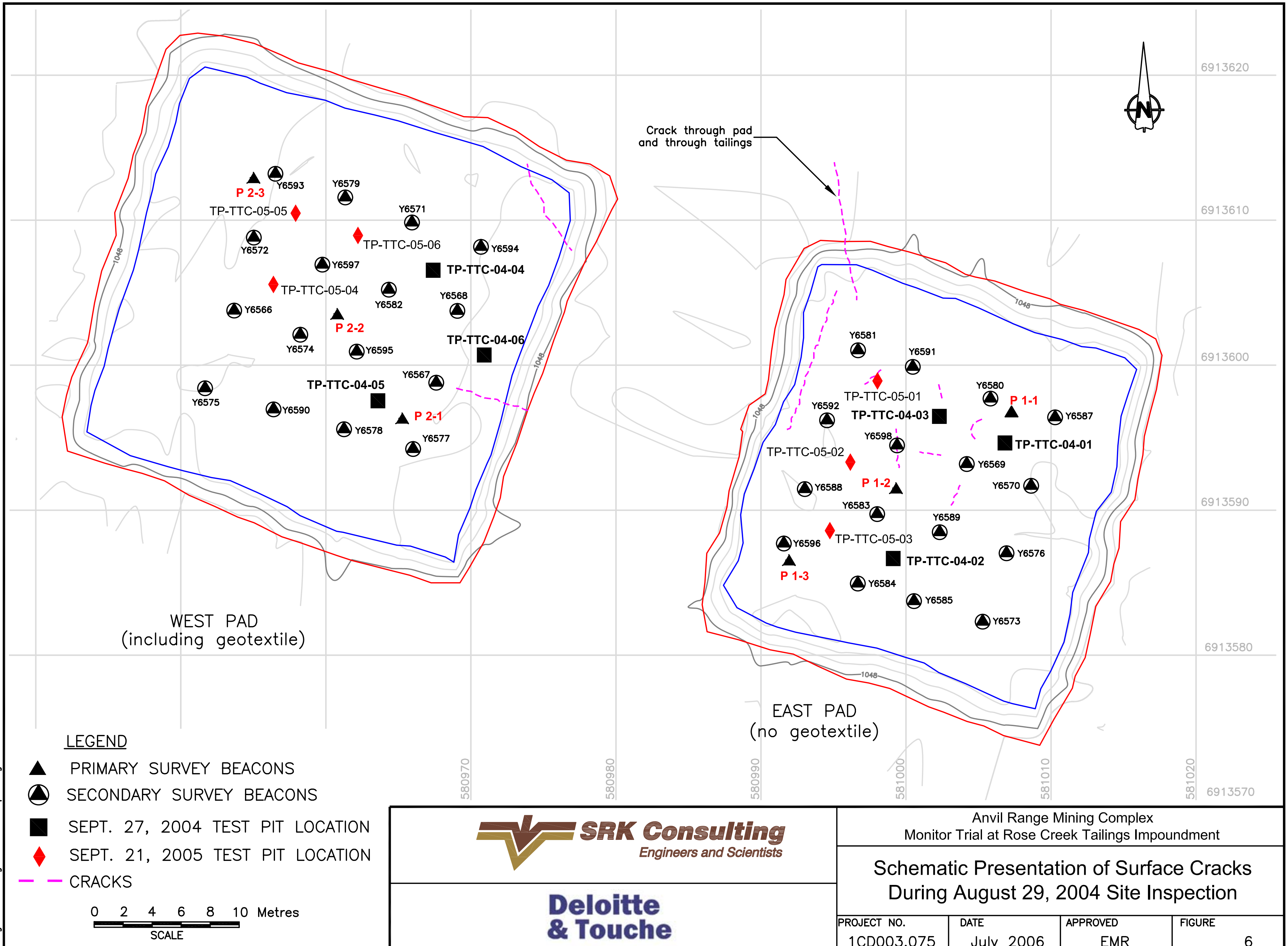
Deloitte & Touche

Anvil Range Mining Complex
Monitor Trial at Rose Creek Tailings Impoundment

Schematic Presentation of Damage to West Pad on June 17, 2004

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.075	July 2006	EMR	5

Dwg Ref: Tailings Test Pads prn.dwg



Dwg Ref: Tailings Test Pads pm.dwg

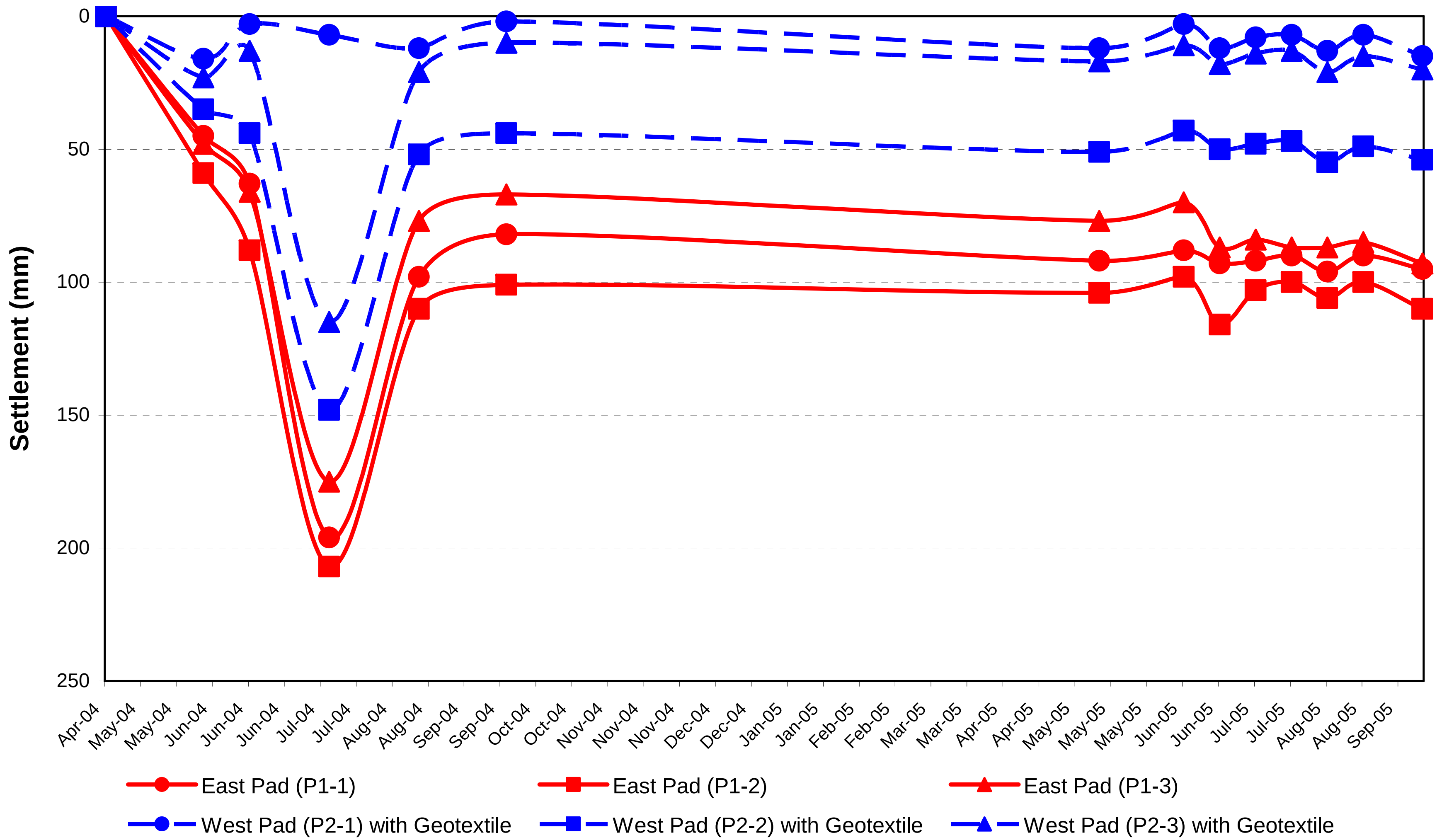
SRK Consulting
Engineers and Scientists

Deloitte & Touche

Anvil Range Mining Complex
Monitor Trial at Rose Creek Tailings Impoundment

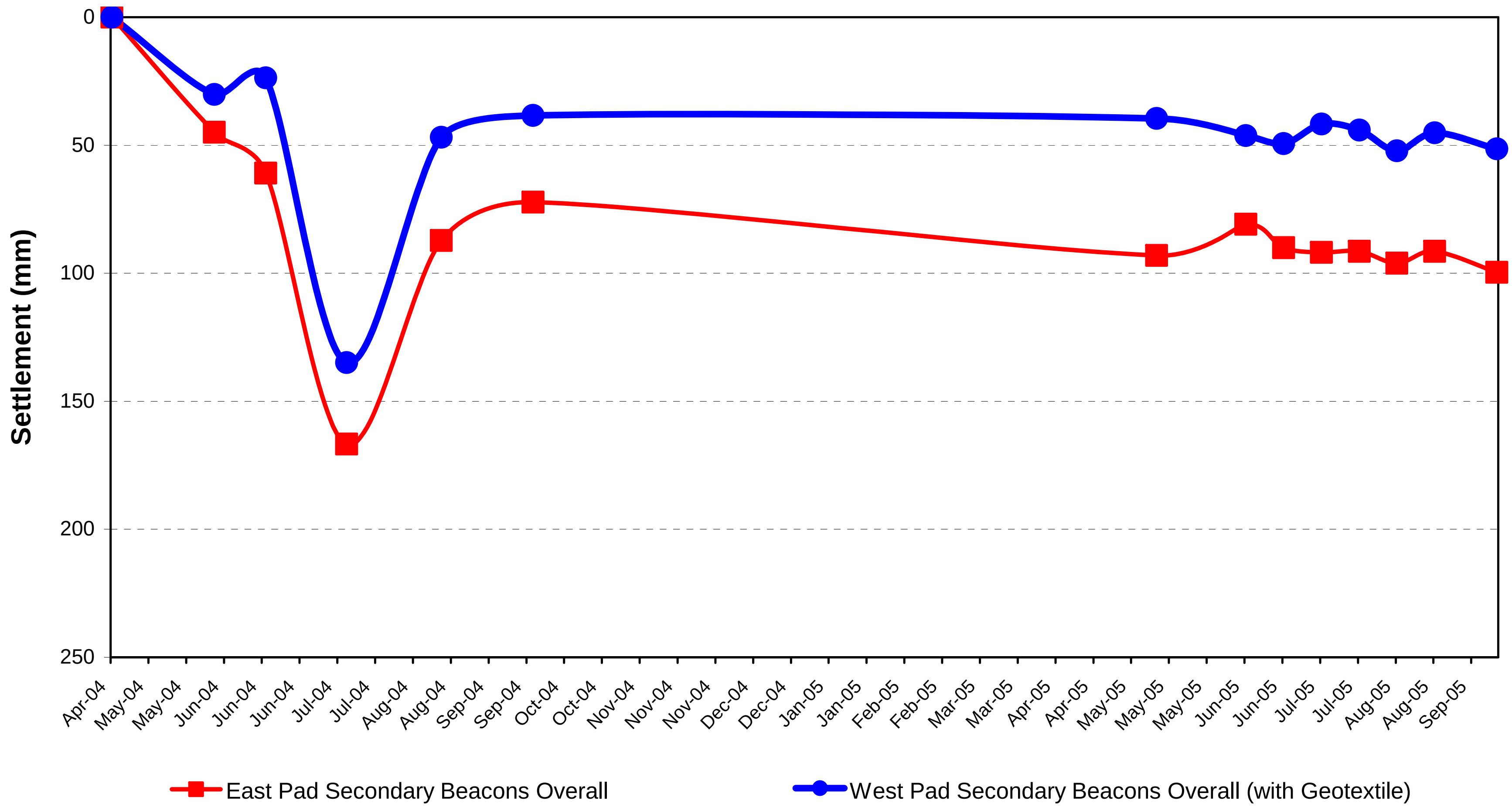
Schematic Presentation of Surface Cracks
During August 29, 2004 Site Inspection

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.075	July 2006	EMR	6



	Anvil Range Mining Complex Monitor Trial at Rose Creek Tailings Impoundment			
SRK Consulting Engineers and Scientists	Raw Settlement Data for Primary Survey Beacons			
Deloitte & Touche	PROJECT: 1CD003.075	DATE: July 2006	APPROVED: EMR	FIGURE: 7

File Ref: Figure 7 to 11_Rose Creek Trial Covers_20060720.ppt



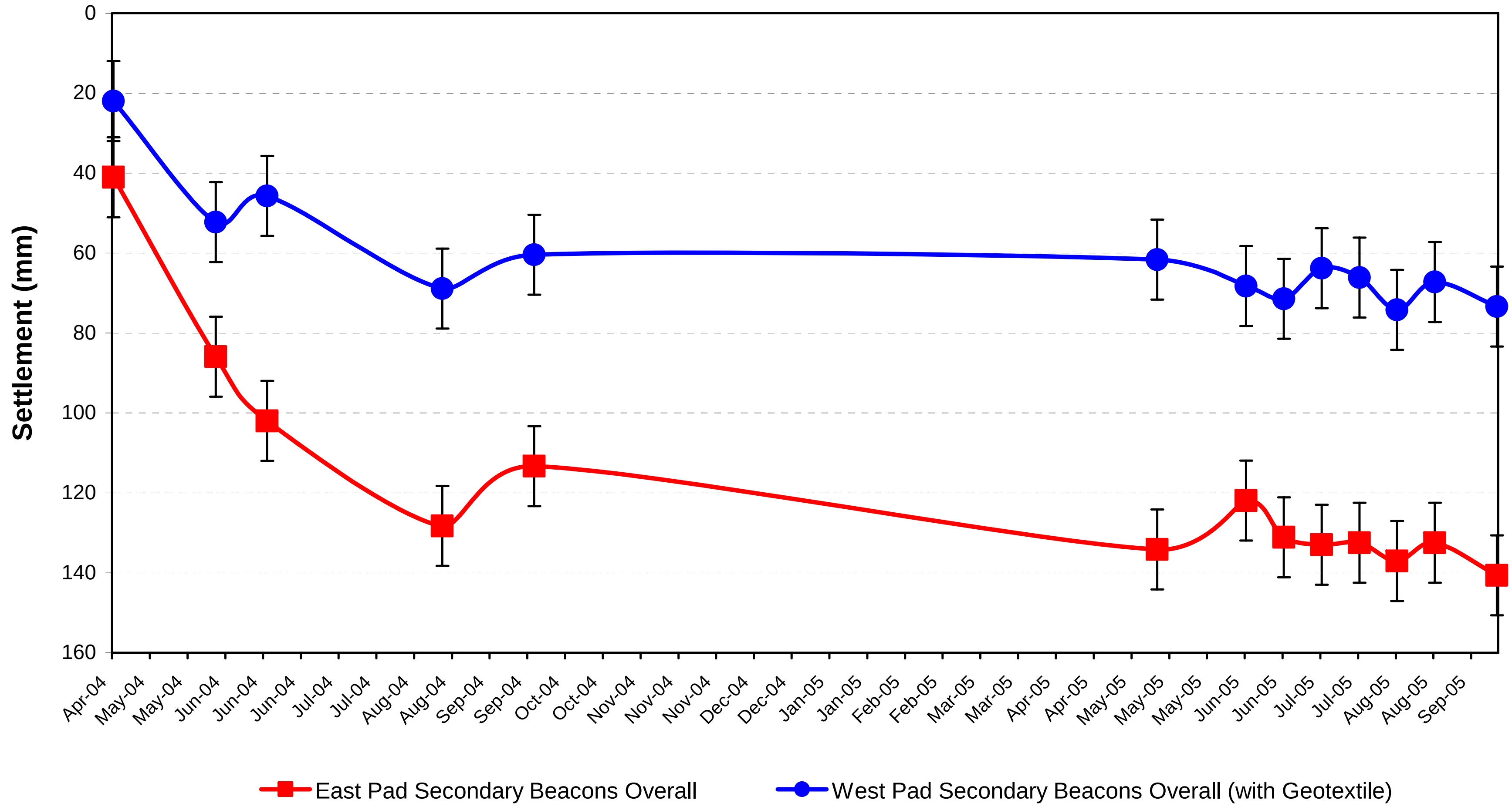
SRK Consulting
Engineers and Scientists

Deloitte & Touche

Anvil Range Mining Complex
Monitor Trial at Rose Creek Tailings Impoundment

Raw Average Settlement Data for Secondary Survey Beacons

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.075	July 2006	EMR	8



SRK Consulting
Engineers and Scientists

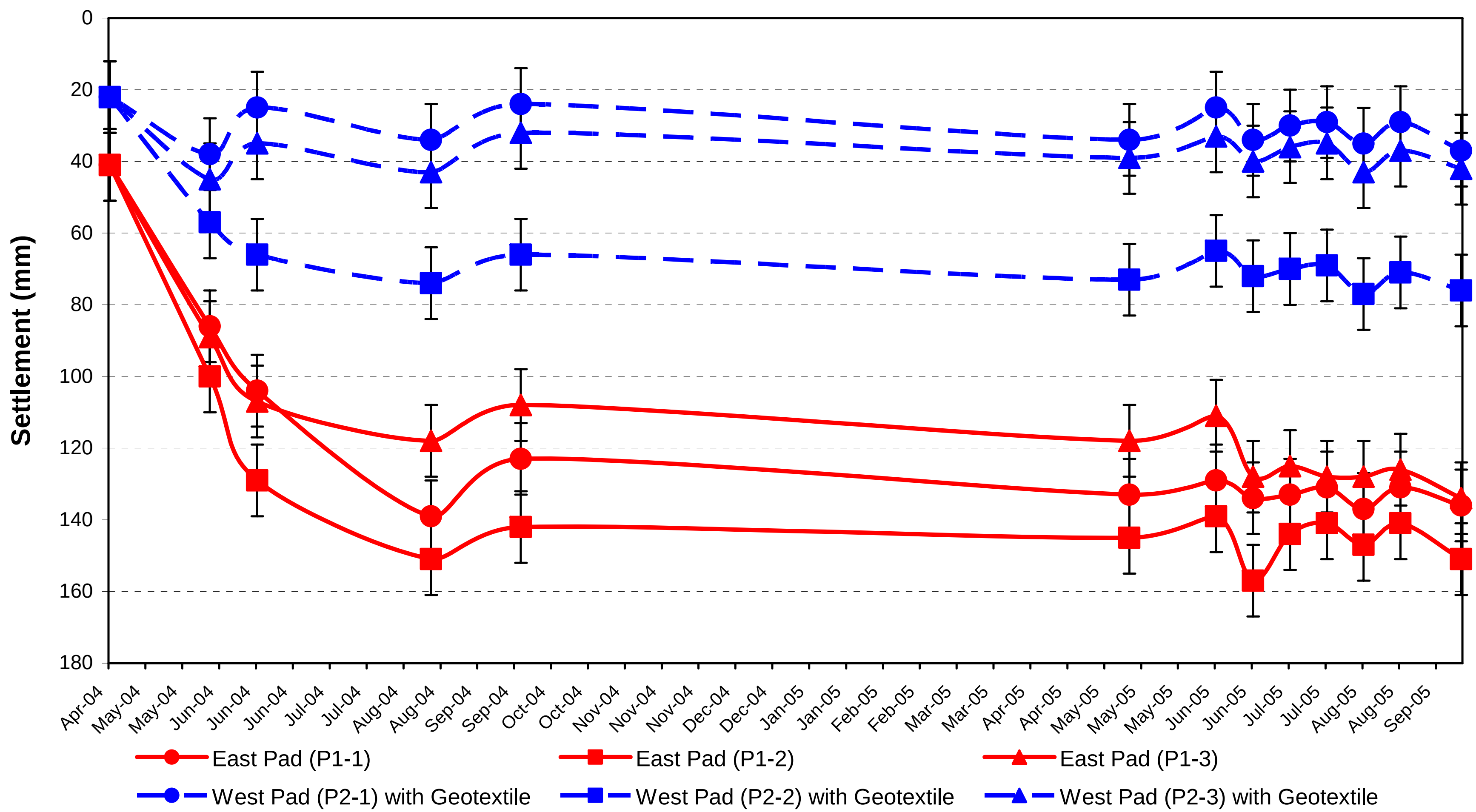
Deloitte & Touche

Anvil Range Mining Complex
Monitor Trial at Rose Creek Tailings Impoundment

Normalized Corrected Average Settlement Data for Secondary Survey Beacons

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.075	July 2006	EMR	9

File Ref: Figure 7 to 11_Rose Creek Trial Covers_20060720.ppt



SRK Consulting
Engineers and Scientists

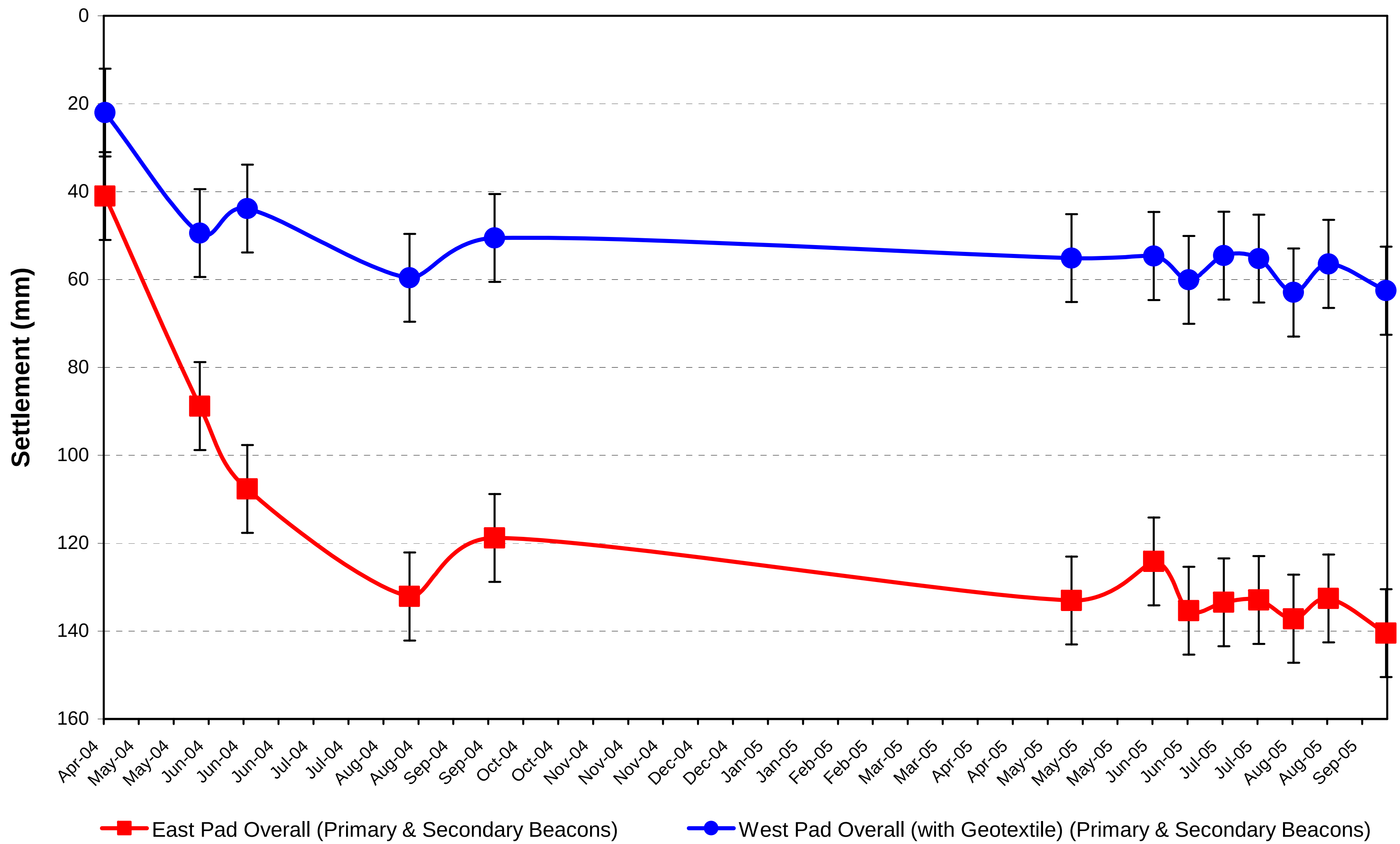
Deloitte & Touche

Anvil Range Mining Complex
Monitor Trial at Rose Creek Tailings Impoundment

Normalized Corrected Settlement Data for Primary Survey Beacons

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.075	July 2006	EMR	10

File Ref: Figure 7 to 11_Rose Creek Trial Covers_20060720.ppt



SRK Consulting Engineers and Scientists	Anvil Range Mining Complex Monitor Trial at Rose Creek Tailings Impoundment		
Deloitte & Touche	Normalized Corrected Overall Average Test Pad Settlement		
PROJECT: 1CD003.075	DATE: July 2006	APPROVED: EMR	FIGURE: 11

File Ref: Figure 7 to 11_Rose Creek Trial Covers_20060720.ppt

Appendix A

SRK Scope of Work for Project (Task) 16(b), dated July 16, 2004

Steffen, Robertson and Kirsten (Canada) Inc.
Suite 800 – 1066 West Hastings Street
Vancouver, B.C. V6E 3X2
Canada

vancouver@srk.com
www.srk.com

Tel: **604.681.4196**
Fax: **604.687.5532**

Memorandum

To:	Valerie Chort	**Date:**	July 16, 2004
cc:	Daryl Hockley	**From:**	Maritz Rykaart/Cam Scott
Subject:	Scope of Work for Project 16(b) – Monitor Tailings Cover Trial Areas	**Project #:**	1CD003.26

1 Status of Tailings Test Cover

The construction of any form of cover over the ARMC tailings poses significant constructability challenges (Golder Associates, 2004; SRK, 2004). Two test covers were subsequently constructed in April 2004 (BGC, 2004) to specifically evaluate the following issues associated with the placing of a cover on the tailings:

- The magnitude of settlement of the cover,
- If, and to what extent tailings migrate upwards through the cover as time progresses, and
- If placement of a geotextile would be beneficial to alleviate the problem of potential tailings migration.

Construction on the test covers was undertaken between April 8 and April 16, 2004 and the final as-built survey of the test cover surface was measured on April 20, 2004.

2 Format of this Scope of Work

This scope of work is intended to illustrate how the post-construction monitoring of the test cover will be carried out. The individual tasks listed are the proposed work packages that each has specific interim deliverables that could be tracked for progress. Each task item includes a description of the proposed work and the deliverables.

3 Task 010 – Project Management

This task will involve the day-to-day management of the project, including communication with the client.

4 Task 070 – Surveying

The test pad surface will be surveyed once a month until freeze-up occurs, probably late October 2004. The survey will entail taking readings at 76 specified stations on the two pads, as measured from a dedicated control point. The settlement of the test covers will be based on the relative variances at these points. The survey can be performed by Deloitte and Touche (DT) staff. Upon completion of the monthly survey, the results will be sent to SRK for analysis. SRK will produce short memo style reports to document the findings of each survey.

If there are any signs of substantial movement, the survey frequency may be increased to bi-weekly, or even weekly to track the progress.

5 Task 080 – Site Inspection

In late August 2004, a geotechnical engineer will inspect the test covers and excavate test pits into them to evaluate how much, if any, tailings has migrated up into the cover. Preferably, the test pits will be dug using the tracked excavator; however, if site access is a problem, the pits will have to be dug by hand. It is expected that at least three pits on each cover would be required.

6 Task 130 – Phase 2 Cover Report

The findings of the test cover trial will be analysed and documented in the phase 2 cover report (which will be part of the Project 14a report). This report will also make recommendations for cover designs on the tailings based on the findings.

7 References

SRK Consulting (Canada) Inc. (2004). Waste Rock Pile and Tailings Covers for the Anvil Range Mining Complex Projects 16(a) and 18(b), Faro, Yukon, Canada. Draft report to Deloitte & Touché Inc., February 2004.

BGC Consulting (2004). Tailings Test Cover Construction As-Built Report. DRAFT report to SRK Consulting, May 18, 2004.

Golder Associates (2004). Rose Creek Tailings Impoundment Geotechnical Issues Related to Cover Viability. Technical Memorandum to SRK Consulting, March 25, 2004, 2 pages.

Appendix B
Survey Settlement Data for 2004

Settlement Monitoring (Raw Survey Data): Trial Covers at Rose Creek Tailings Impoundment

Monitoring Point #	Elevation of MP (m)	Elevation of MP (m)	Elevation of MP (m)	Elevation of MP (m)	Elevation of MP (m)	Elevation of MP (m)	Elevation of MP (m)	Elevation of MP (m)	Elevation of MP (m)	Elevation of MP (m)	Elevation of MP (m)	Elevation of MP (m)	Elevation of MP (m)	Elevation of MP (m)
	Y = Pin, Secondary Beacon; R = Rock, Secondary Beacon; P = Pipe, Primary Beacon													
Y6604	1048.033	1048.025												
Y6573	1048.538	1048.507	1048.509	1048.476	1048.497	1048.484	1048.482	1048.475	1048.477	1048.478	1048.474	1048.478	1048.470	1048.381
R6573	1048.719	1048.687	1048.689	1048.657	1048.671	1048.646	1048.644	1048.639	1048.641	1048.643	1048.639	1048.643	1048.639	1048.564
Y6576	1048.454	1048.410	1048.388	1048.317	1048.331	1048.327	1048.330	1048.323	1048.325	1048.326	1048.322	1048.325	1048.320	1048.217
R6576	1048.633	1048.593	1048.563	1048.497	1048.510	1048.501	1048.502	1048.495	1048.497	1048.500	1048.496	1048.498	1048.490	1048.401
Y6570	1048.378	1048.335	1048.337	1048.317	1048.331	1048.326	1048.331	1048.324	1048.326	1048.324	1048.322	1048.326	1048.319	1048.226
R6570	1048.532	1048.485	1048.479	1048.468	1048.481	1048.466	1048.469	1048.463	1048.466	1048.467	1048.462	1048.466	1048.460	1048.376
Y6587	1048.463	1048.415	1048.379	1048.327	1048.343	1048.331	1048.333	1048.325	1048.330	1048.331	1048.327	1048.331	1048.322	1048.246
R6587	1048.618	1048.573	1048.539	1048.487	1048.503	1048.496	1048.497	1048.492	1048.494	1048.495	1048.490	1048.495	1048.488	1048.396
East Pad (P1-1)	1049.113	1049.068	1049.050	1049.015	1049.031	1049.021	1049.025	1049.020	1049.021	1049.023	1049.017	1049.023	1049.018	1048.917
Y6580	1048.411	1048.345	1048.311	1048.285	1048.301	1048.290	1048.294	1048.286	1048.292	1048.292	1048.287	1048.292	1048.285	1048.187
R6580	1048.627	1048.545	1048.512	1048.485	1048.494	1048.483	1048.487	1048.481	1048.483	1048.484	1048.481	1048.484	1048.478	1048.391
Y6603	1048.111	1047.893												
Y6569	1048.460	1048.405	1048.377	1048.352	1048.365	1048.306	1048.309	1048.301	1048.304	1048.305	1048.302	1048.305	1048.300	1048.258
R6569	1048.688	1048.632	1048.591	1048.507	1048.581	1048.556	1048.563	1048.556	1048.558	1048.559	1048.554	1048.558	1048.550	1048.476
Y6589	1048.473	1048.425	1048.421	1048.409	1048.421	1048.416	1048.412	1048.405	1048.409	1048.408	1048.403	1048.409	1048.400	1048.316
R6589	1048.711	1048.664	1048.655	1048.637	1048.651	1048.557	1048.568	1048.558	1048.561	1048.562	1048.558	1048.565	1048.552	1048.544
Y6585	1048.442	1048.413	1048.417	1048.408	1048.421	1048.381	1048.384	1048.377	1048.380	1048.382	1048.377	1048.382	1048.372	1048.315
R6585	1048.639	1048.605	1048.609	1048.597	1048.611	1048.596	1048.602	1048.595	1048.598	1048.598	1048.593	1048.599	1048.590	1048.504
Y6584	1048.562	1048.536	1048.547	1048.537	1048.551	1048.516	1048.518	1048.510	1048.514	1048.514	1048.506	1048.514	1048.505	1048.441
R6584	1048.847	1048.830	1048.830	1048.822	1048.831	1048.818	1048.824	1048.818	1048.820	1048.823	1048.816	1048.821	1048.810	1048.826
Y6583	1048.523	1048.445	1048.409	1048.397	1048.403	1048.345	1048.351	1048.343	1048.347	1048.346	1048.342	1048.347	1048.340	1048.300
R6583	1048.741	1048.667	1048.634	1048.618	1048.631	1048.596	1048.603	1048.595	1048.597	1048.600	1048.593	1048.598	1048.590	1048.626
East Pad (P1-2)	1049.172	1049.113	1049.084	1049.062	1049.071	1049.068	1049.074	1049.056	1049.069	1049.072	1049.066	1049.072	1049.062	1048.965
Y6598	1048.471	1048.417	1048.391	1048.367	1048.381	1048.366	1048.367	1048.362	1048.366	1048.365	1048.359	1048.364	1048.355	1048.276
R6598	1048.665	1048.615	1048.597	1048.555	1048.563	1048.546	1048.552	1048.706	1048.547	1048.550	1048.541	1048.546	1048.540	1048.458
Y6591	1048.421	1048.375	1048.340	1048.315	1048.331	1048.316	1048.321	1048.317	1048.319	1048.318	1048.315	1048.319	1048.310	1048.318
R6591	1048.685	1048.633	1048.594	1048.557	1048.568	1048.556	1048.564	1048.555	1048.560	1048.559	1048.554	1048.560	1048.550	1048.464
Y6581	1048.464	1048.425	1048.411	1048.395	1048.406	1048.396	1048.401	1048.393	1048.396	1048.397	1048.392	1048.397	1048.387	1048.296
R6581	1048.703	1048.655	1048.633	1048.616	1048.631	1048.619	1048.624	1048.617	1048.620	1048.621	1048.617	1048.621	1048.610	1048.621
Y6592	1048.480	1048.430	1048.399	1048.384	1048.391	1048.346	1048.409	1048.384	1048.387	1048.387	1048.382	1048.387	1048.380	1048.286
R6592	1048.665	1048.613	1048.579	1048.557	1048.571	1048.556	1048.592	1048.557	1048.560	1048.559	1048.558	1048.561	1048.550	1048.465
Y6588	1048.348	1048.334	1048.349	1048.337	1048.351	1048.345	1048.390	1048.343	1048.348	1048.348	1048.342	1048.348	1048.340	1048.244
R6588	1048.623	1048.605	1048.610	1048.599	1048.613	1048.602	1048.646	1048.598	1048.603	1048.602	1048.600	1048.603	1048.592	1048.506
Y6596	1048.535	1048.505	1048.510	1048.497	1048.510	1048.504	1048.557	1048.500	1048.504	1048.501	1048.498	1048.502	1048.495	1048.404
R6596	1048.698	1048.655	1048.657	1048.645	1048.660	1048.648	1048.701	1048.641	1048.646	1048.645	1048.641	1048.645	1048.640	1048.551
East Pad (P1-3)	1049.403	1049.355	1049.337	1049.326	1049.336	1049.326	1049.333	1049.316	1049.319	1049.316	1049.316	1049.318	1049.310	1049.228
Y6577	1048.400	1048.378	1048.387	1048.377	1048.404	1048.376	1048.382	1048.374	1048.381	1048.380	1048.374	1048.380	1048.370	1048.283
R6577	1048.543	1048.519	1048.533	1048.521	1048.528	1048.516	1048.522	1048.515	1048.519	1048.521	1048.513	1048.519	1048.512	1048.526
West Pad (P2-1) with Geotextile	1049.133	1049.117	1049.130	1049.121	1049.131	1049.121	1049.130	1049.121	1049.125	1049.126	1049.120	1049.126	1049.118	1049.126
Y6567	1048.344	1048.305	1048.300	1048.289	1048.301	1048.288	1048.290	1048.284	1048.291	1048.291	1048.284	1048.289	1048.282	1048.196
R6567	1048.617	1048.573	1048.569	1048.559	1048.567	1048.539	1048.542	1048.537	1048.540	1048.542	1048.532	1048.540	1048.532	1048.464
Y6568	1048.361	1048.337	1048.349	1048.341	1048.349	1048.334	1048.337	1048.332	1048.335	1048.336	1048.330	1048.335	1048.328	1048.244
R6568	1048.579	1048.555	1048.559	1048.548	1048.559	1048.546	1048.551	1048.546	1048.549	1048.550	1048.543	1048.549	1048.541	1048.456
Y6594	1048.320	1048.275	1048.268	1048.254	1048.263	1048.251	1048.253	1048.250	1048.254	1048.253	1048.247	1048.250	1048.240	1048.161
R6594	1048.461	1048.414	1048.405	1048.394	1048.401	1048.377	1048.392	1048.386	1048.391	1048.391	1048.384	1048.389	1048.381	1048.299
Y6601	1048.211													
Y6571	1048.279	1048.230	1048.232	1048.222	1048.231	1048.226	1048.229	1048.224	1048.228	1048.228	1048.221	1048.226	1048.218	1048.126
R6571	1048.428	1048.375	1048.387	1048.375	1048.383	1048.376	1048.382	1048.375	1048.379	1048.378	1048.371	1048.378	1048.370	1048.278
Y6582	1048.274	1048.255	1048.267	1048.259	1048.266	1048.361	1048.265	1048.257	1048.264	1048.264	1048.257	1048.263	1048.251	1048.164
R6582	1048.460	1048.433	1048.439	1048.432	1048.441	1048.413	1048.423	1048.417	1048.417	1048.420	1048.410	1048.420	1048.407	1048.336
Y6595	1048.321	1048.272	1048.271	1048.259	1048.268	1048.364	1048.273	1048.264	1048.268	1048.267	1048.261	1048.267	1048.255	1048.165
R6595	1048.573	1048.525	1048.518	1048.507	1048.517	1048.510	1048.520	1048.509	1048.614	1048.514	1048.506	1048.514	1048.505	1048.414
Y6578	1048.323	1048.292	1048.306	1048.302	1048.309	1048.301	1048.291	1048.300	1048.304	1048.305	1048.308	1048.304	1048.315	1048.208
R6578	1048.474	1048.440	1048.452	1048.338	1048.349	1048.339	1048.324	1048.338	1048.345	1048.349	1048.340	1048.348	1048.332	1048.244
Y6590	1048.265	1048.243	1048.254	1048.239	1048.241	1048.239	1048.213	1048.237	1048.243	1048.243	1048.234	1048.242	1048.231	1048.149
R6590	1048.444	1048.423	1048.432	1048.422	1048.427	1048.418	1048.397	1048.424	1048.424	1048.428	1048.418	1048.427	1048.412	1048.328
Y6574	1048.205	1048.179	1048.185	1048.111	1048.119	1048.116	1048.106	1048.115	1048.120	1048.121	1048.113	1048.120	1048.110	1048.016
R6574	1048.435	1048.410	1048.417	1048.117	1048.124	1048.118	1048.114	1048.121	1048.123	1048.125	1048.109	1048.117	1048.118	1048.022
West Pad (P2-2) with Geotextile	1049.062	1049.027	1049.018	1049.010	1049.018	1049.011	1049.019	1049.012	1049.014	1049.015	1049.007	1049.013	1049.008	1048.914
Y6597	1048.228	1048.206	1048.218	1048.207	1048.216	1048.209	1048.221	1048.208	1048.213	1048.215	1048.204	1048.213	1048.204	1048.116
R6597	1048.514	1048.493	1048.501	1048.493	1048.501	1048.491	1048.495	1048.489	1048.494	1048.496	1048.485	1048.495	1048.483	1048.398
Y6579	1048.272	1048.245	1048.254	1048.242	1048.251	1048.241	1048.246	1048.240	1048.244	1048.244	1048.238	1048.244	1048.234	1048.147
R6579	1048.467	1048.448	1048.460	1048.447	1048.455	1048.444	1048.452	1048.444	1048.449	1048.450	1048.443	1048.448	1048.437	1048.356
Y6593	1048.383	1048.345	1048.357	1048.344	1048.356	1048.348	1048.357	1048.347	1048.354	1048.353	1048.346	1048.353	1048.340	1048.251
R6593	1048.626	1048.593	1048.604	1048.590	1048.603	1048.592	1048.599	1048.591	1048.595	1048.595	1048.588	1048.595	1048.582	1048.496
West Pad (P2-3) with Geotextile	1049.073	1049.050	1049.060	1049.052	1049.063	1049.056	1049.062	1049.055	1049.059	1049.060	1049.052	1049.058	1049.053	1048.958
Y6602	1047.922													
Y6572	1048.353	1048.334	1048.349	1048.337	1048.345	1048.336	1048.348	1048.338	1048.342	1048.342	1048.332	1048.346	1048.332	1048.242
R6572	1048.630	1048.595	1048.601	1048.589	1048.599	1048.591	1048.598	1048.587	1048.596	1048.595	1048.584	1048.594	1048.585	1048.496
Y6566	1048.270	1048.247	1048.249	1048.266	1048.261	1048.358	1048.263	1048.257	1048.260	1048.262	1048.251	1048.260	1048.252	1048.171
R6566	1048.481	1048.453	1048.451	1048.474	1048.481	1048.470	1048.477	1048.470	1048.476	1048.476	1048.467	1048.476	1048.566	1048.376
Y6575	1048.128	1048.114	1048.129	1048.117	1048.123	1048.118	1048.124	1048.117	1048.121	1048.122	1048.114	1048.122	1048.109	1048.124
R6575	1048.362	1048.346	1048.357	1048.347	1048.353	1048.346	1048.353	1048.345	1048.350	1048.351	1048.342	1048.350	1048.341	1048.252
Date of reading	20-Apr-04	28-May-04	15-Jun-04	20-Aug-04	23-Sep-04	12-May-05	14-Jun-05	28-Jun-05	12-Jul-05	26-Jul-05	9-Aug-05	23-Aug-05	15-Sep-05	16-Jul-04
Reading #	0**	1	2	4	5	6	7	8	9	10	11	12	13	3
Data Corrections	None	None	None	None	None	P1-2 post knocked over - data corrected by 40 cm	P1-2 post knocked over - data corrected by 40 cm	P1-2 post knocked over - data corrected by 40 cm	P1-2 post knocked over - data corrected by 40 cm	P1-2 post knocked over - data corrected by 40 cm	P1-2 post knocked over - data corrected by 40 cm	P1-2 post knocked over - data corrected by 40 cm	P1-2 post knocked over - data corrected by 40 cm	This dataset was eliminated

Note: Only **reduced elevations** need to be entered in to this spreadsheet.

Red boxes in SP Elevations indicate negative settlement since last consecutive reading.

Appendix C

SRK Record of June 2004 Site Inspection, dated July 19, 2004

SRK Consulting (Canada) Inc.
Suite 800 – 1066 West Hastings Street
Vancouver, B.C. V6E 3X2
Canada

vancouver@srk.com
www.srk.com

Tel: 604.681.4196
Fax: 604.687.5532

Memo

To:	Maritz Rykaart, SRK	**Date:**	July 19, 2004
cc:		**From:**	Dylan MacGregor
Subject:	Faro Tailings Cover Trials- Record of June 2004 Inspections	**Project #:**	1CD003.26

During June 2004, Dylan MacGregor (GIT) of SRK Consulting conducted two inspections of the two tailings test covers recently constructed as part of the cover trials program. The following summarizes the observations of the two inspections.

1 Inspection 1

Inspection of the two tailings test covers was first conducted on June 7, 2004. Weather at the time of inspection was partially overcast, calm, and dry. No significant precipitation had been observed during site work by the inspector at the Anvil Range Mining Complex during the preceding 10 days.

1.1 East Test Cover

The east test cover was found to be generally in good condition. Minor undulation was noted in the pad surface- it is unknown whether this is a remnant of construction, or is a post-construction feature related to differential settlement. No ponded water or evidence of previously ponded water was observed. Minor surface cracking was noted along the eastern edge of the test cover (Figure 1). Orange marker stones appeared to be undisturbed. Two of the three vertical orange-painted steel columns appeared undisturbed; the southwestern-most column was leaning slightly to one side (Figure 2). This may have resulted from a lack of care during installation/ post-installation construction rather than differential settlement or heaving. Figures 3 through 8 show the general condition of the east test cover on June 7, 2004.

1.2 West Test Cover

The west test cover was found to be in generally good condition. The underlying filter fabric was exposed along the eastern edge. Minor cracking was noted along the eastern edge of the pad, as well as on the interior of the pad within the limits of the orange marker stones (Figure 9 and 10). The marker stones themselves appeared undisturbed. There was no evidence of ponded water, although the surface of the west test cover contained more obvious depressions than the east test cover. All three vertical orange painted steel columns were leaning slightly (Figure 11). Figures 12 through 20 show the general condition of the west test cover on June 7, 2004.

2 Inspection 2

The tailings test covers were inspected again on June 24, 2004. During the week prior to the investigation, an excavator had gotten stuck in the tailings immediately adjacent to the west tailings test cover. During efforts to extricate the mired machine, the west test cover experienced damage to its western edge from the extraction efforts. The tailings immediately adjacent to the west test cover were significantly disturbed as a result of these efforts. Following extraction, the excavator appeared to have climbed up onto the surface of the west test cover, and then crossed the southwest corner of the test pad. A number of the orange marker stones were disturbed as a result of this process, and the surface and southern edge of the west test cover were also disturbed.

The east test cover appeared to have been undisturbed as a result of this event. Conditions were as observed on June 7, 2004.

Figures 21 through 31 show the general condition of the west tailings test cover on June 24, 2004, following disturbance.

Figure 1. East test cover: Small cracks along eastern edge.

Figure 2. East test cover: Southwest steel column leaning to the southeast.

Figure 3. East test cover: Eastern edge, showing NE surface and marker stones.

Figure 4. East test cover: Eastern edge, showing SW surface and marker stones.

Figure 5. East test cover: Eastern edge, showing slightly undulating surface.

Figure 6. East test cover: Eastern edge, showing equipment access point and steel columns.

Figure 7. East test cover: Eastern edge, showing minor cracking.

Figure 8. East test cover: Looking SW at steel columns.

Figure 9. East test cover: Western edge, showing NW surface, steel columns, and marker stones.

Figure 10. West test cover: Eastern edge, showing NE surface and marker stones.

Figure 11. West test cover: Southeastern corner, showing SW surface, marker stones and steel columns.

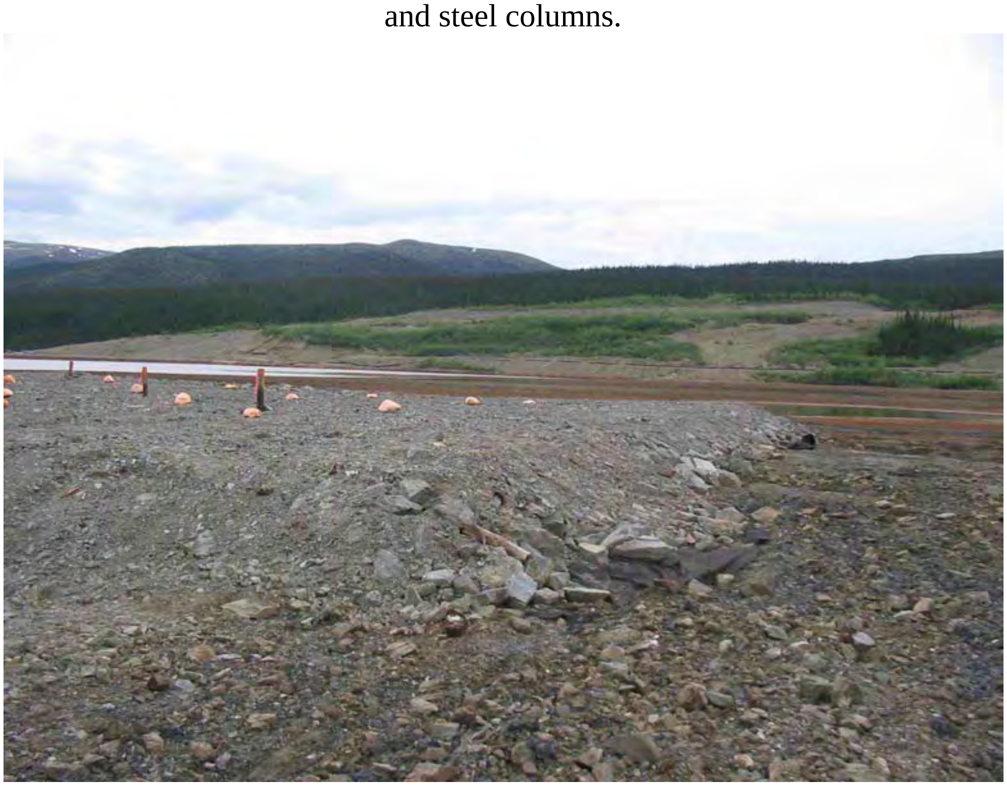


Figure 12. West test cover: Eastern edge, showing NE surface and marker stones.

Figure 13. West test cover: Southern edge, showing SW surface and marker stones.

Figure 14. West test cover: Minor cracking along eastern edge.

Figure 15. West test cover: Minor cracking near center of cover.

Figure 16. West test cover: Looking southeast at traffic surface of test cover.

Figure 17. West test cover: Southern edge, from center of cover, showing minor equipment tracks.

Figure 18. West test cover: Eastern edge from SE corner, showing regular profile.

Figure 19. West test cover: Looking NW from SE corner at vertical steel columns.

Figure 20. West test cover: Looking west from SE corner across surface of test cover.

Figure 21. West test cover: Damage to surface of cover by equipment. Note disturbed marker stone in center.

Figure 22. West test cover: Southern edge, showing equipment egress point.

Figure 23. West test cover: Southern edge, showing damage from equipment.

Figure 24. West test cover: Comparison of damaged SW and pristine NE portions of test cover.

Figure 25. West test cover: Eastern edge, showing undisturbed NE surface and marker stones.

Figure 26. West test cover: Western edge and adjacent disturbed tailings.

Figure 27. West test cover: Looking NE from SW corner, showing surface damage from equipment.

Figure 28. Location where excavator was stuck, adjacent to west test cover.

Figure 29. Looking from tailings at western edge of west test cover.

Figure 30. West test cover: Western edge, showing damage from equipment.

Figure 31. Western edge of west test cover showing equipment tracks in tailings and damage done to edge of cover by equipment.

Appendix D

Photos taken during August 29, 2004 Site Inspection

Photo 1: View of tailings trial cover areas from the Rose Creek diversion. The West Pad (including geotextile) is to the left and the East Pad is to the right.

Photo 2: North-east view across the West Pad (including geotextile) surface. Note the dozer tracks leading onto the pad as a result of the excavator retrieval on June 17, 2004.

Photo 3: Looking north towards the East Pad. Note the standing water in the background.

Photo 4: Panoramic view of the West Pad (including geotextile) from the south-west. Note the permanent pond in the background and the damage caused by the dozer in the foreground.

Photo 5: Panoramic of the East Pad from the south. Note the presence of standing water behind the pad. This water is not dammed up against the pad.

Photo 6: Looking north-east along the primary survey beacons of the East Pad.

Photo 7: Close-up view of a crack on the corner of the East Pad. Note the crack continues from the tailings and on through the pad.

Photo 8: Close-up view of a crack on the surface of the East Pad. The crack is curved and measures approximately 5 m long, 10 to 20 mm wide and 10 to 100 mm deep.

Appendix E
Photos taken during September 27, 2004 Test Pit Excavation

Photo 1: TP-TTC-04-01 Profile of test pit showing the undulated interface between tailings and cover material where mixing has occurred.

Photo 2: TP-TTC-04-01 Base of test pit excavation into tailings.

Photo 3: TP-TTC-04-01 View of complete test pit showing the range amount of fines present in the cover material.

Photo 4: TP-TTC-04-01 View of complete test pit showing range in grain size from fines to boulders measuring 50 cm in diameter.

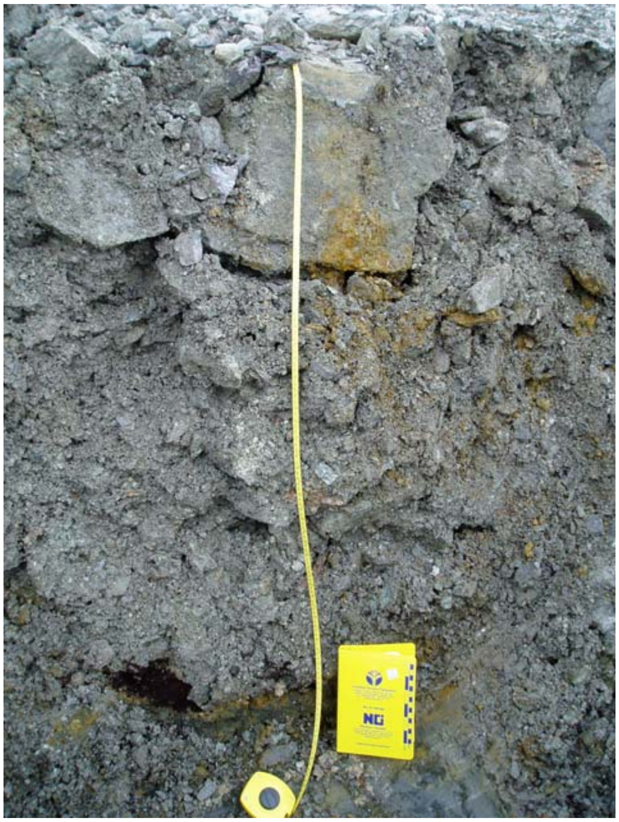


Photo 5: TP-TTC-04-02 Profile of test pit showing undulating bottom mixed zone.

Photo 6: TP-TTC-04-02 Profile of test pit showing range of article sizes in cover material.

Photo 7: TP-TTC-04-02 Overall view of test pit showing range in grain size distribution of cover material.

Photo 8: TP-TTC-04-02 Note the slope angle of the test pit walls. The material is very wet and the walls continuously caved in.

Photo 9: TP-TTC-04-03 Mixed zone of cover material and tailings of approximately 20 cm. The mixing appears to be dominated by larger boulders.

Photo 10: TP-TTC-04-03 Profile showing the range of particle sizes in the cover material.

Photo 11: TP-TTC-04-04 Minor undulating surface at contact between cover material and tailings.

Photo 12: TP-TTC-04-04 The tailings has not migrated through the geotextile. Although both the tailings and the cover material were very wet, the geotextile was relatively dry.

Photo 13: TP-TTC-04-04 The bottom of the geotextile is stained with tailings. It is possible that tailings is clogging the geotextile and subsequently slowing down the consolation time.

Photo 14: TP-TTC-04-04 Complete view of test pit showing the gradation of the cover material.

Photo 15: TP-TTC-04-05 Overlap section of the textile showing no signs of moving apart as a result of differential settlement. Also, no tailings are oozing through the seam opening.

Photo 16: TP-TTC-04-05 Complete view of test pit showing gradation of the cover material.

Photo 17: TP-TTC-04-06 Geotextile overlap showing no signs of tailings moving through the geotextile. The folds in the geotextile is as a result of rutting during construction caused by the trucks passing over the geotextile

Photo 18: TP-TTC-04-06 Complete view of test pit showing range in gradation of cover material.

Appendix F
Photos taken during September 21, 2005 Test Pit Excavation

Photo 1: Case 580 Super-M backhoe used for test pit excavations.

Photo 2: TP-TTC-05-01 Base of test pit excavation showing the interface between the tailings and waste rock cover. Note layer of oxidized tailings.

Photo 3: TP-TTC-05-01 Smaller scale view of the transition zone between tailings and the waste rock cover.

Photo 4: TP-TTC-05-01 View of complete test pit showing range in grain size from fines to boulders measuring 50 cm in diameter.

Photo 5: TP-TTC-05-02 Profile of test pit showing range of particle sizes in cover material.

Photo 6: TP-TTC-05-02 View of the interface between the tailings and the waste rock cover.

Photo 7: TP-TTC-05-03 profile of the test pit showing the interface between the tailings and the waste rock cover.

Photo 8: TP-TTC-05-03 View of complete test pit showing range in grain size from fines to boulders measuring 50 cm in diameter.

Photo 9: TP-TTC-05-03 Profile showing the range of particle sizes in the cover material.

Photo 10: TP-TTC-05-04 Contact between cover material and tailings.

Photo 11: TP-TTC-05-04 The tailings has not migrated through the geotextile.

Photo 12: TP-TTC-05-05 The tailings has not migrated through the geotextile.

Photo 13: TP-TTC-05-05 Complete view of test pit showing the gradation of the cover material.

Photo 14: TP-TTC-05-06 The tailings has not migrated through the geotextile.

Photo 15: TP-TTC-05-06 Complete view of test pit showing gradation of the cover material.

Appendix G
Technical Memorandum re: Tailings Properties

SRK Consulting (Canada) Inc.
Suite 800 – 1066 West Hastings Street
Vancouver, B.C. V6E 3X2
Canada

vancouver@srk.com
www.srk.com

Tel: 604.681.4196
Fax: 604.687.5532

Memo

To:	Valerie Chort	**Date:**	July 20, 2006
cc:	Daryl Hockley	**From:**	Maritz Rykaart/Cam Scott
Subject:	Results from Trial Covers at Rose Creek Tailings Impoundment: 2005/06 Task 22b – Tailings Properties	**Project #:**	1CD003.058

No site specific tailings characterization was carried out prior to construction of the trial covers. Relevant data is however available from two drill holes located in the immediate vicinity of the trial covers (Figure 1). The first is drill hole P03-08 completed by Gartner Lee Ltd. using a sonic rig in 2003 (SRK 2004b). The second is a seismic cone penetration test (SCPT03-32) carried out by Golder Associates Ltd., in 2003 (Golder 2004). In addition, SRK collected a surface tailings sample from the original impoundment in 2003, which was subjected to a full suite of geotechnical laboratory testing (SRK 2004a). Details of the samples, associated geotechnical laboratory testing and primary results for the Rose Creek tailings are summarized in Tables 1, 2 and 3.

Table 1: Summary of Geotechnical Laboratory Testing Completed on Rose Creek Tailings

Sample Details	Sample Name/Number						
	FT-1	FT-2	CT-1	CT-2	Sample A	Sample B	SRK-03-C07
Sample Origin	Gartner Lee Ltd. 2003 sonic drilling program; Closest hole to trial cover is P03-08						SRK surface grab sample
Sample Composition	Duplicate tests on composite “fine” tailings sample from 10 samples from 5 drill holes (includes 1 sample from P03-08)		Duplicate tests on composite “coarse” tailings sample from 6 samples from 2 drill holes (does not include P03-08)		Composite test from 10 “fine” samples from 4 holes (includes 3 samples from P03-08)	Composite test from 6 “coarse” samples from 2 holes (does not include P03-08)	“coarse” beach tailings from original impound-ment
Testing Laboratory	EBA Engineering, Yellowknife, NT				Golder Associates, Burnaby, BC		MDH Engineering, Saskatoon, SK

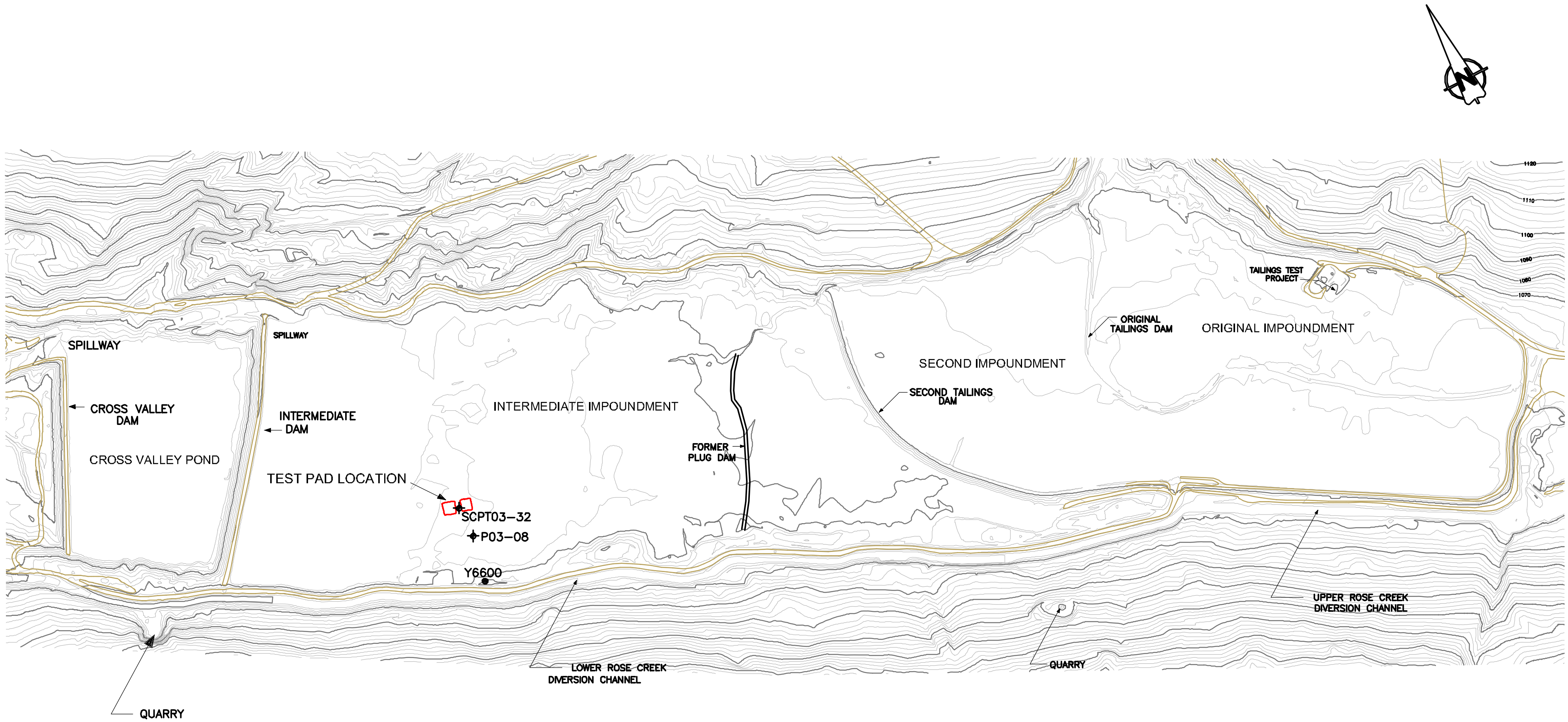
Table 2: Summary of Actual Geotechnical Laboratory Tests Performed on the Samples Listed in Table 1

Laboratory Test	Sample Name/Number						
	FT-1	FT-2	CT-1	CT-2	Sample A	Sample B	SRK-03-C07
Sieve	✓	✓	✓	✓	✓	✓	✓
Hydrometer	✓	✓	✓				✓
Atterberg Limits							✓
Specific Gravity	✓	✓	✓	✓	✓	✓	✓
Consolidation	✓	✓					✓
Hydraulic Conductivity							✓
Soil Water Characteristics							✓
Triaxial Shear					✓	✓	
Column Sedimentation	✓	✓					

Table 3: Summary of Geotechnical Laboratory Testing Results

Sample	% Fines (< 75 μm)	Specific Gravity	Void Ratio		Dry Density [kg/m^3]		Coef. of Consolidation [m^2/yr]	Hydraulic Conductivity [cm/sec]
			Max	Min	Min	Max		
FT-1	73.0	4.30	0.79	1.32	1,852	2,309	39.10	3.01 E-6
FT-2	70.0	4.01	0.91	1.52	1,594	2,015	35.48	4.95 E-6
CT-1	22.0	3.72	-	-	-	-	-	-
CT-2	44.0	4.17	-	-	-	-	-	-
Sample A	66.2	3.97	0.84	2.02	-	-	-	-
Sample B	30.1	4.48	0.56	0.99	-	-	-	-
SRK-03-C07	30.0	3.46	0.32	0.44	-	2,391	21.05	1.16 E-5
Average[1]	**-**	**4.11**	**0.77**	**1.46**	**1,723**	**2,162**	**37.29**	**4.0 E-6**

1. The average excludes sample SRK-03-C07, since it is not located near the trial covers.



Date of Photography: 2003/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856
CONTOUR INTERVAL = 2m

0 100 200 300 400 Metres

Dwg Ref: Tailings-Isopachs2006.dwg

SRK Consulting
Engineers and Scientists

Deloitte & Touche

Anvil Range Mining Complex
Monitor Trial at Rose Creek Tailings Impoundment

Location Plan for Trial Covers

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.075	July 2006	EMR	1

Appendix H
Technical Memorandum re: Theoretical Consolidation Settlement Assessment

SRK Consulting (Canada) Inc.
Suite 800 – 1066 West Hastings Street
Vancouver, B.C. V6E 3X2
Canada

vancouver@srk.com
www.srk.com

Tel: 604.681.4196
Fax: 604.687.5532

Memo

To:	Valerie Chort	**Date:**	July 20, 2006
cc:	Daryl Hockley	**From:**	Maritz Rykaart/Cam Scott
Subject:	Results from Trial Covers at Rose Creek Tailings Impoundment: 2005/06 Task 22b – Theoretical Settlement Assessment	**Project #:**	1CD003.058

Over time, the tailings will undergo settlement due to consolidation under their own weight. Incremental settlement will occur if a cover is placed on the tailings surface. Using basic Terzaghi, one-dimensional, double-drained consolidation and settlement theory (Holtz and Kovacs 1981), the theoretical estimated range of settlements associated with the Rose Creek tailings can be calculated to be between 23 and 233 mm, as presented in Table 1.

These calculations, applying equations (1), (2) (3) and (4), present a possible range of settlements based on the range of geotechnical properties for the Rose Creek tailings listed in Appendix G. In all calculations, the tailings are assumed to be saturated, i.e. water table is at the surface. Case #1 in Table 1, presents the most likely conditions at the test pad location, based on the actual observed settlement for the East Pad of about 141 mm. Similarly, Case #2 presents the most likely conditions at the West Pad location considering the actual observed total settlement of 63 mm.

$$S_c = \frac{C_c}{1+e_o} H_o \log \frac{\sigma'_{vo} + \left(\sigma'_p - \sigma'_{vo}\right)}{\sigma'_{vo}} \qquad (1)$$

$$\sigma'_{vo} = \frac{H_o}{2}\left(\rho_s - \rho_w\right) \qquad (2)$$

$$\rho_s = \rho_w \left(\frac{G_s + e_o}{1+e_o}\right) \qquad (3)$$

$$\Delta\sigma_v = \left(\sigma'_p - \sigma'_{vo}\right) = H_c \gamma_c \qquad (4)$$

Where
S_c = consolidation settlement (m),
e_o = initial void ratio,
C_c = compression index,
H_o = original thickness of soil layer (m),
σ_{vo}' = effective vertical overburden stress (kPa),
σ_p = pre-consolidation stress (kPa),
ρ_s = density of saturated tailings (kg/m^3),
ρ_w = density of water (kg/m^3),
G_s = specific gravity of tailings solids,
H_c = cover thickness (m), and
γ_c = cover material unit weight (kN/m^3).

Table 1: Theoretical range of settlement for trial covers

Description	Case #1	Case #2	Case #3[6]	Case #4[6]	Case #5[6]	Case #6[6]	Case #7[6]	Case #8[6]
Tailings thickness[1], H_o(m)	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5
Tailings specific gravity[2, 3], G_s	4.108	4.108	3.720	4.108	4.108	4.108	4.108	4.108
Tailings compression index[4], C_c	0.304	0.135	0.304	0.500	0.05	0.304	0.304	0.304
Tailings initial void ratio[2, 3], e_o	1.461	1.461	1.461	1.461	1.461	0.990	1.461	1.461
Cover thickness[5], H_c (m)	0.8	0.8	0.8	0.8	0.8	0.8	1.0	0.8
Cover material unit weight[2, 3], γ_c (kN/m^3)	21.62	21.62	21.62	21.62	21.62	21.62	21.62	23.09
Predicted Settlement, S_c (mm)	**141.2**	**62.8**	**160.2**	**232.5**	**23.2**	**142.9**	**174.2**	**150.4**

1. The tailings thickness is based on drill hole information from Golder (2004).
2. Values for these properties are based on the data listed in Table 8.
3. Only the range of data that would result in greater settlement is presented, i.e. "worst" case scenarios.
4. The tailings compression index value of 0.304 and 0.135 is the value required to achieve the field measured settlement the East and West Pad respectively. The range evaluated is from weak, compressible tailings as reported by Robertson and Wels (source unknown).
5. The design and as-built thickness of the cover was 0.8 m ± 0.1 m.
6. The underlined value indicated the specific value changed from the Case #1 base value.

A non-woven geotextile may act as a filter when placed between tailings and a cover material. However, the geotextile will not change the total settlement (Koerner 1981) exclusive of any "mixing" of waste rock and tailings as the tailings thaw. Therefore, these theoretical settlement calculations are expected to apply to both trial covers.

Table 2 lists another series of theoretical settlement calculations, but evaluates how increasing cover thickness will impact on the predicted settlement. Arguably, the worst case tailings properties with respect to ensuring maximum settlement have been selected, but it does demonstrate that as the cover thickness increases from about 1 m to 3 m, for a 30 m thick tailings profile (which is probably the maximum encountered in the Rose Creek tailings impoundment), the settlement increases from about 356 mm to 970 mm.

Table 2: Theoretical upper bound range of settlement assuming variable cover thickness

Description	Case #9	Case #10	Case #11	Case #12	Case #13
Tailings thickness, Ho(m)	5	10	30	30	30
Tailings specific gravity, Gs	3.720	3.720	3.720	3.720	3.720
Tailings compression index, Cc	0.500	0.500	0.500	0.500	0.500
Tailings initial void ratio, eo	0.990	0.990	0.990	0.990	0.990
Cover thickness, Hc (m)	1.0	1.0	1.0	2.0	3.0
Cover material unit weight, γc (kN/m3)	23.09	23.09	23.09	23.09	23.09
Predicted Settlement (mm)	**286.1**	**323.2**	**356.1**	**677.2**	**969.7**

The total settlement rate can also be predicted using basic one-dimensional consolidation theory. Figure 1 illustrates the predicted settlement rate for the two trial covers, as compared to the actual measured settlement values (assuming double-drained consolidation with linear dissipation of excess pore-pressure). In Figure 1, the total settlement as measured was kept constant and the coefficient of consolidation was varied to produce a "best-fit" curve. For both trial covers, the corresponding coefficient of consolidation was 280 m^2/year, as compared to the laboratory measured value for the fine tailings listed in Appendix G of about 37.3 m^2/year. This suggests that actual settlement is occurring much more rapidly than predicted by laboratory data.

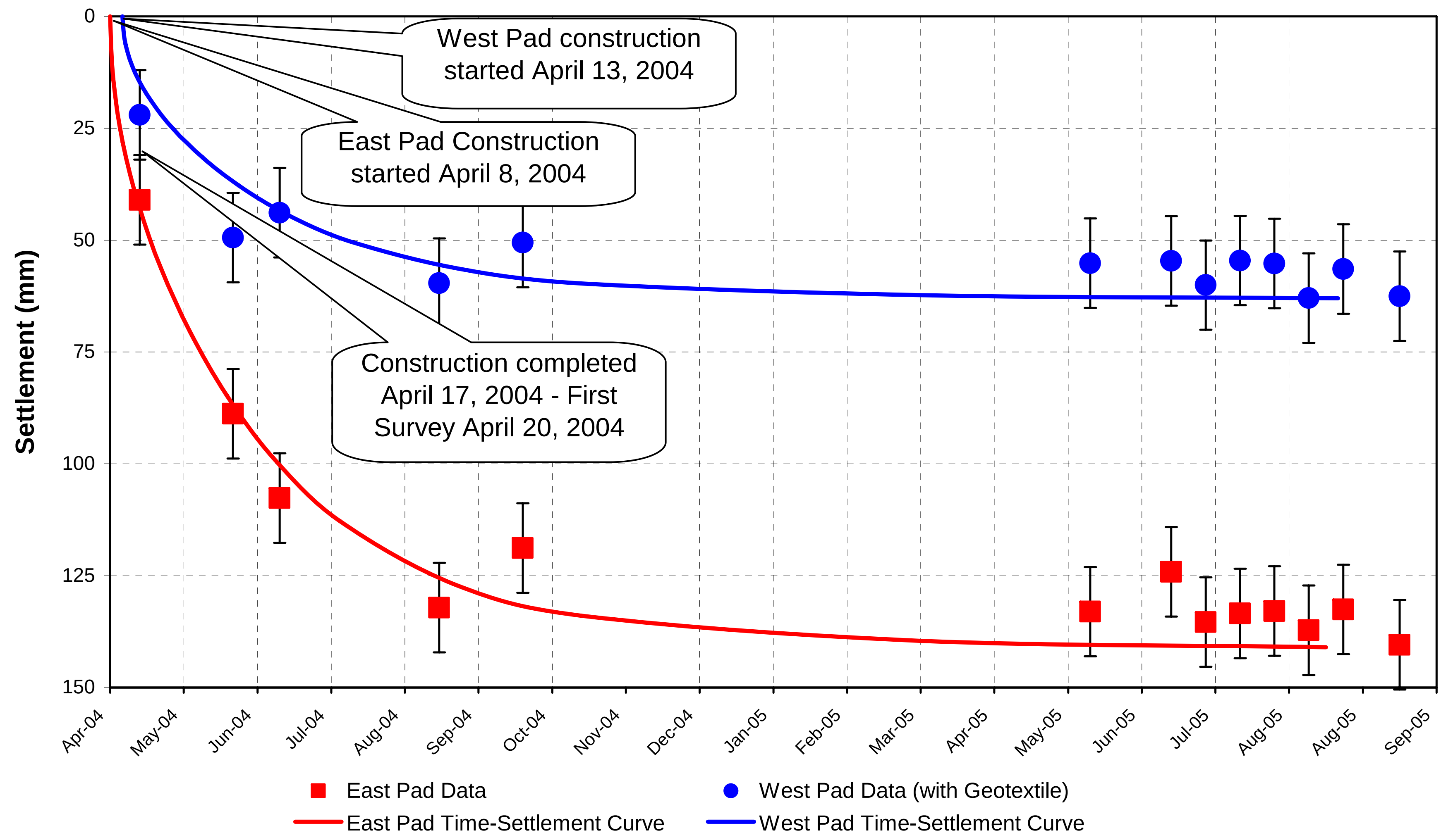
Figures 2, 3 and 4 present the time-rate settlement curves for the final trial covers using a fixed coefficient of consolidation value of 37.3 m^2/year. In all these figures, the total settlement was varied to produce a "best-fit" curve for the 2004 data (Figure 2), the 2005 data (Figure 3), and the overall "best-fit" curve for all the measured data (Figure 4), irrespective of the period or trial cover selection. This information is also summarized in Table 3. The fact that the overall best-fit time-rate curve for all the data conforms best to the East Pad data, confirms that in the very long-term the presence of the geotextile is not likely to make a difference with respect to overall settlement.

Table 3: Predicted overall settlement assuming a constant coefficient of consolidation of 37.3 m^2/year

Condition	Predicted Overall Settlement [mm]
East Pad – 2004 data	350
East Pad – 2005 data	195
West Pad – 2004 data	185
West Pad – 2005 data	85
Overall (2004 and 2005 data for both trial covers)	195

Based on the data in Table 3, the total settlement for the trial covers could be between 85 and 350 mm. These values are certainly within the range of observed actual settlements of between 63 and 141 mm. However, for these settlements the corresponding time to achieve 50% consolidation is about 244 days, whilst full consolidation will take almost 10 years. This does not appear reasonable given the rapid consolidation observed in the trial covers. Based on the actual settlement data, assuming a coefficient of consolidation of 280 m^2/year, 50% consolidation would occur in about 33 days, and 100% consolidation would take less than a year. This is consistent with the site observations.

Clearly there is a discrepancy between the actual settlement data and the predicted settlement when the measured geotechnical properties for the tailings in the vicinity of the trial covers are applied to the simple one-dimensional double drained consolidation model. There are, however, many factors that would account for such changes, including; non-homogeneity of the tailings, anisotropy of the tailings permeability, variable drainage conditions, and the presence of ice to name some of the most likely ones. Although there are more complex numerical techniques to predict total settlement and time-rate settlement values (Holtz and Kovacs 1981), the range of possible settlement is clearly small enough that the use of these complex methods is not warranted.



SRK Consulting
Engineers and Scientists

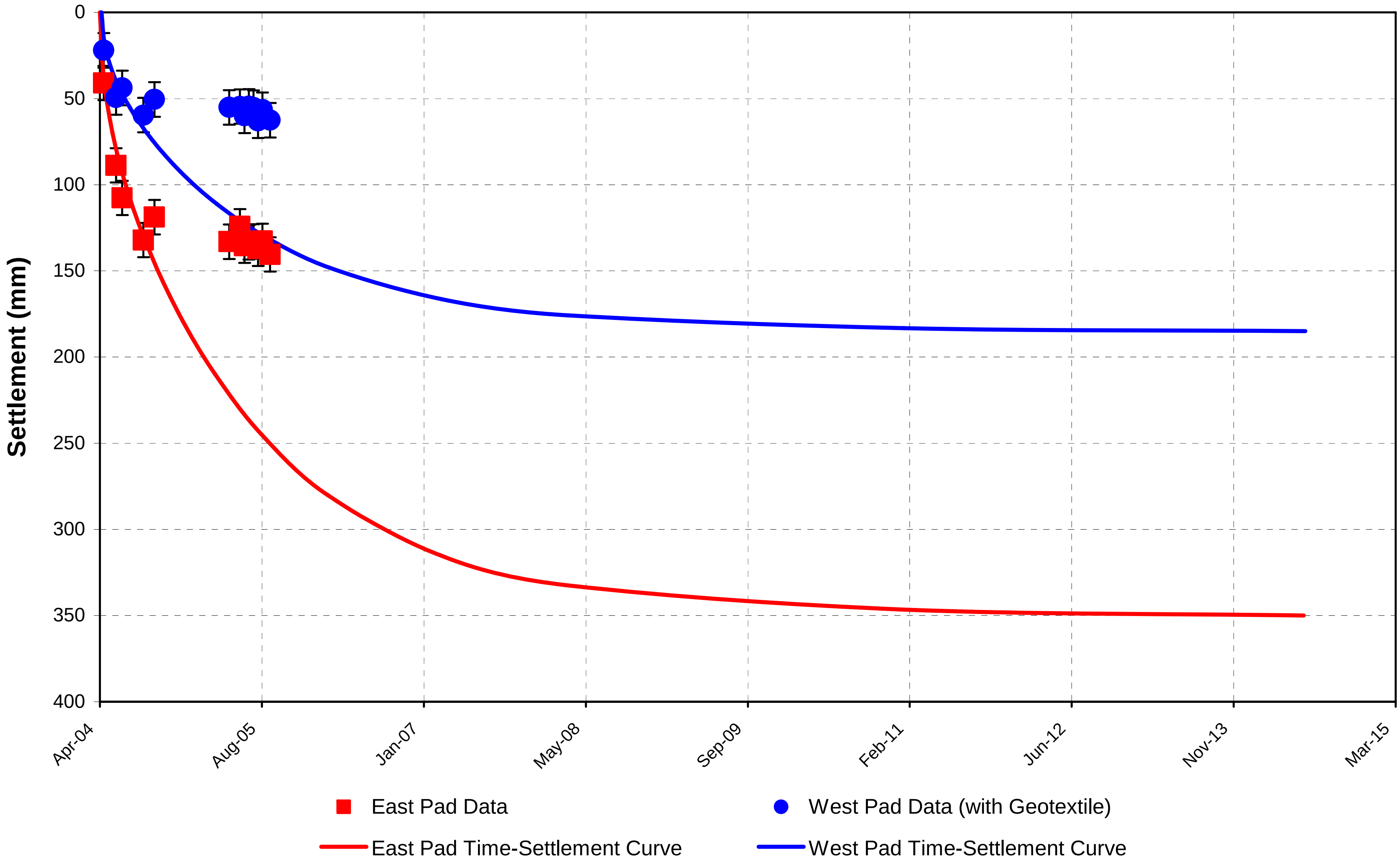
Deloitte & Touche

Anvil Range Mining Complex
Monitor Trial at Rose Creek Tailings Impoundment

Best-fit time-rate settlement curve using fixed total settlement values measured for the cover trials (C_v = 280 m^2/year)

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.075	July 2006	EMR	1

File Ref: App H_Fig 1 to 4_20060720.ppt



SRK Consulting
Engineers and Scientists

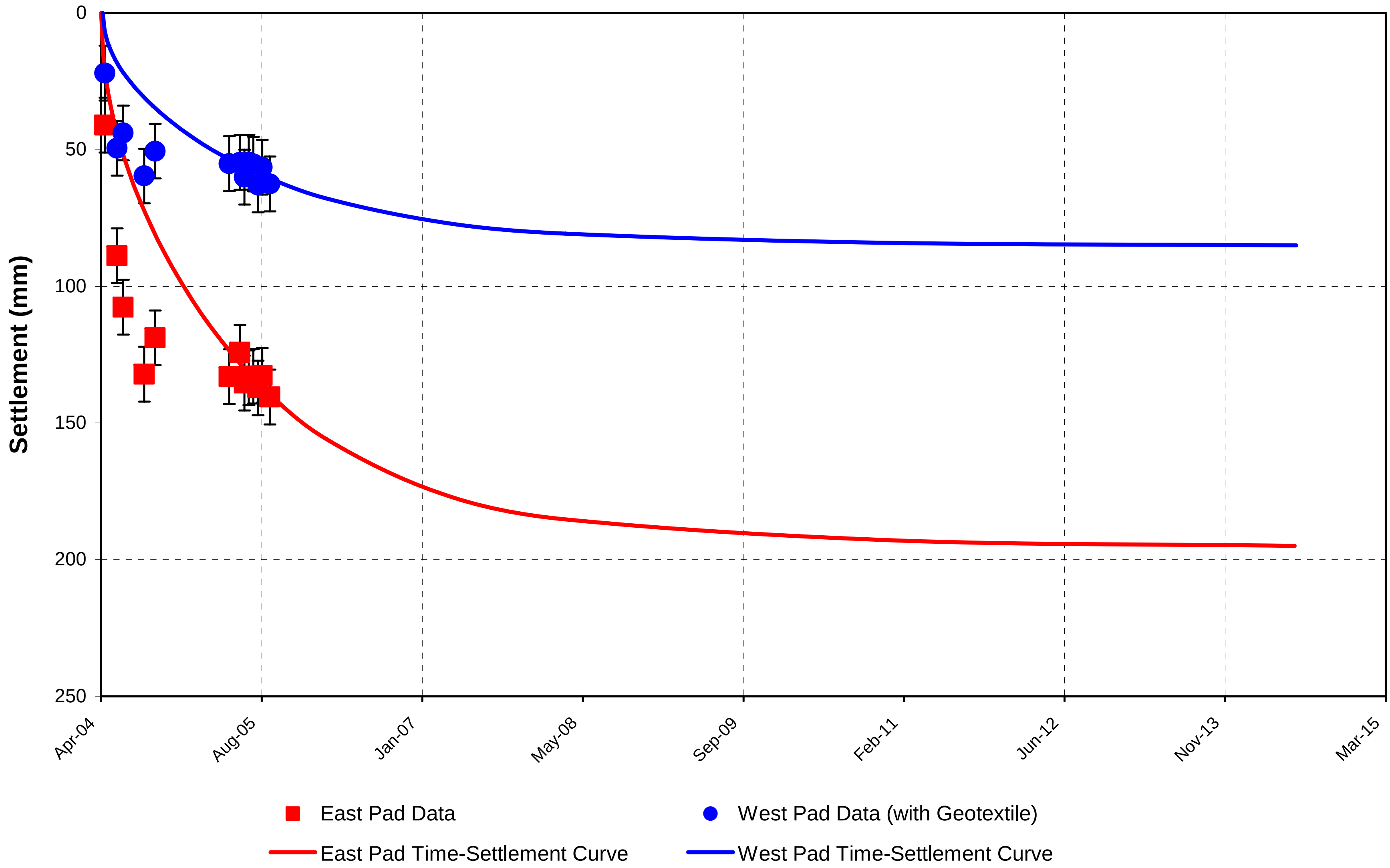
Deloitte & Touche

Anvil Range Mining Complex
Monitor Trial at Rose Creek Tailings Impoundment

Best-fit time-rate settlement curve for 2004 data using fixed laboratory determined C_v value

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.075	July 2006	EMR	2

File Ref: App H_Fig 1 to 4_20060720.ppt



SRK Consulting
Engineers and Scientists

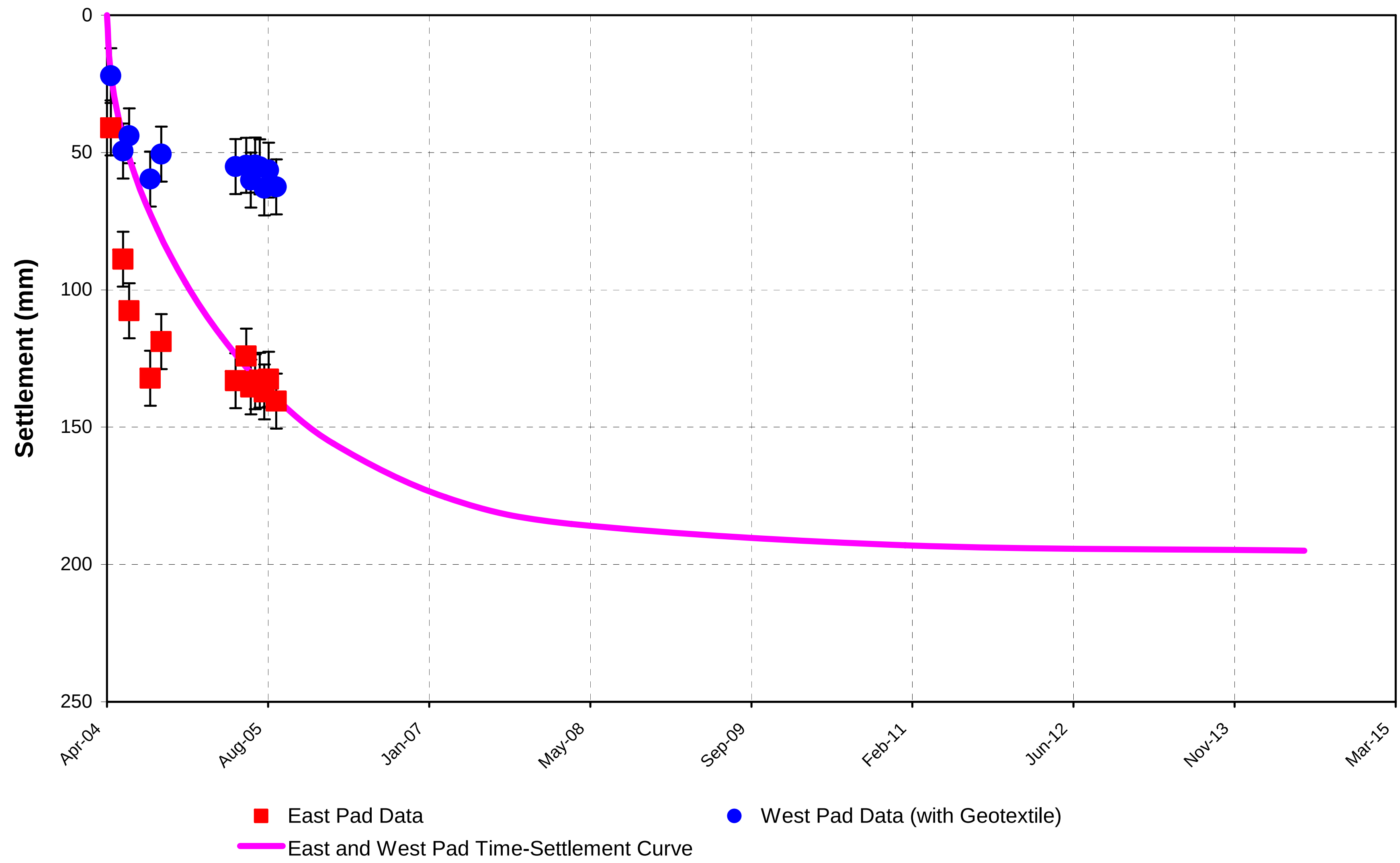
Deloitte & Touche

Anvil Range Mining Complex
Monitor Trial at Rose Creek Tailings Impoundment

Best-fit time-rate settlement curve for 2005 data using fixed laboratory determined C_v value

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.075	July 2006	EMR	3

File Ref: App H_Fig 1 to 4_20060720.ppt



SRK Consulting
Engineers and Scientists

Deloitte & Touche

Anvil Range Mining Complex
Monitor Trial at Rose Creek Tailings Impoundment

Best-fit time-rate settlement curve for all data using fixed laboratory determined C_v value

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.075	July 2006	EMR	4

File Ref: App H_Fig 1 to 4_20060720.ppt