January 23, 2007

Deloitte & Touche Inc.
79 Wellington Street West, Suite 1900
PO Box 29 TD Centre
Toronto, Ontario
M5K 1B9

Mr. Doug Sedgwick

Dear Mr. Sedgwick:

Anvil Range Mining Complex, Yukon
Rose Creek Tailings Impoundment
Seismic Stability of Cross Valley Dam – 1 in 500 Year Earthquake

Enclosed is our report on the seismic stability of the Cross Valley Dam for a 1 in 500 year earthquake. Because this earthquake loading does not liquefy the foundation soils of the dam, it was not necessary to carry out flow slide analyses or failure probability analyses as set out in our proposal. As requested in your request for proposal, this favourable evaluation only applies during the temporary period of closure design and construction. The requirement to improve or decommission the dam in the long term is unchanged.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Bryan D. Watts, P. Eng.
Senior Geotechnical Engineer

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EXECUTIVE SUMMARY

This report is an evaluation of the seismic stability of the Cross Valley Dam for earthquake ground motions at a return period of 1 in 500 years. This work follows our June (KC, 2006) report which showed the dam in its present configuration would not be stable if subjected to MCE motions. Seismic evaluation of the Cross Valley Dam for earthquakes at this higher return period of 1 in 500 was done because the future of the dam within the overall closure scheme is not known at this time. The Regulator has dictated as part of the permitting process that all structures such as this must survive the 1 in 500 year motions during this temporary closure design and construction period which could last 15 to 20 years.

Our evaluation showed that the dam in its present configuration can survive earthquake motions at the 1 in 500 year level, so it meets the temporary safety levels set by the Regulator. However, the eventual long term outcome for the dam is not changed by this study. The dam foundation must be improved or the dam decommissioned during the temporary closure design and construction period.

To undertake this study, we again relied on the seismic work by Atkinson (2004) which identified the nearby Tintina Fault (roughly along the Pelly River) as the dominant source of future damaging earthquakes in this area. Although the Atkinson work provided all of the information necessary to conduct MCE liquefaction evaluations, it did not provide similar information at the 1 in 500 year level because this was not part of that study. Accordingly, we had to run parallel seismic hazard evaluations to provide input earthquake time histories for ground shaking analyses using PROSHAKE.

We used the ground information from our previous work to conduct the liquefaction analyses. We did not undertake any new field or laboratory investigations for this assignment.

The liquefaction evaluation followed the traditional Seed approach where ground shaking results from PROSHAKE, i.e. cyclic stress ratios, are compared to cyclic resistance ratios from field penetration values. This work predicted that the 1 in 500 year earthquake, a M5.8 producing 0.11 g at the Cross Valley Dam, would not liquefy the foundation soils. This result means that seismic displacements for a 1 in 500 year earthquake will be small and the dam is safe, provided that freeboard is more than 1.5 m.

Irrespective of the results of this study, it is always prudent to reduce the consequences of failure of a high hazard dam, such as this, if that is possible within the operational constraints. In this case, the downstream hazard can be reduced by operating the polishing pond at the lowest level possible consistent with other constraints such as the extent of the upstream riprap. Any permanent lowering would require spillway and siphon modifications, together with due consideration of the downstream stability of the Intermediate Dam.

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1. INTRODUCTION

1.1 General

This report evaluates whether the Cross Valley Dam in its present configuration can withstand shaking from an earthquake with a return period of 1 in 500 years without failure. By failure, we mean breach and sudden loss of the reservoir, the polishing pond, which currently inundates the downstream toe of the Intermediate Dam. This evaluation follows our earlier report of June 2006 which showed that the dam will fail if shaken by the largest of earthquakes possible for this site, the Maximum Considered Earthquake (MCE).

We understand that options for closure of the entire mine site include decommissioning of the Cross Valley Dam. Final decisions on site closure configuration have not yet been made so improvements to the Cross Valley Dam to withstand the MCE may be premature at this juncture. Deloitte and Touche had asked us to consider the appropriate safety level for a temporary condition which could last up to 15 to 20 years. There is no code based or good practice based decision guidance for such a case. Certainly, if the Cross Valley Dam were to be built now for an anticipated life of 15 to 20 years, the MCE recommendations in our June 2006 report would apply, but improvements to existing structures are usually planned within the context of available or practical resources.

Subsequent to the letter requesting this work, we learned from Deloitte and Touche that the Regulator has issued a permit that requires that the facilities be able to withstand the 1 in 500 year earthquake during the closure design and construction period. On this basis, we have proceeded to make this evaluation without further consideration of safety levels or return periods.

1.2 Work Scope

The liquefaction potential of the foundation soils beneath the Cross Valley Dam for 1 in 500 motions was determined using the same methodology as for the MCE motions in our June 2006 report. We used the Atkinson (2004) earthquake time histories derived from the Uniform Hazard Response Spectra (UHRS) at the MCE as input to PROSHAKE (site response analysis program) which yielded the level of ground shaking beneath the dam. This ground shaking or cyclic stress ratio was then compared to the cyclic resistance of the soil to determine whether if the ground would liquefy.

The Atkinson (2004) report gives a UHRS at the 1 in 500 motions but does not provide matching time histories because that was not part of that assignment. Those time histories had to be generated within the context of this assignment for use in the PROSHAKE analysis. The same dynamic properties of soils were taken from the previous work. Also, the same penetration resistance values were used; no new field data was obtained and no new laboratory testing was done.

It was found that the soil did not liquefy under the 1 in 500 year motions. This meant that flow slide analyses did not have to be done as per our proposal. Also, there was no need to do further work to determine the probability of liquefaction as per our proposal.

The following sections outline the methodology, assumptions, and results used to determine the liquefaction potential of the foundation soils at 1 in 500 ground motions.

2. EARTHQUAKE CRITERIA FOR SEISMIC STABILITY ASSESSMENT

Based on the seismic hazard analyses conducted by Atkinson (2004) for the project site, the median value of peak ground horizontal acceleration (PGA) for 500 year return period earthquake is 0.11 g. Figure 1 shows the corresponding Uniform Hazard Response

Spectra (UHRS) with 5% damping provided by Atkinson (2004). The PGA and the UHRS are for NEHRP Site C conditions, which is defined as very dense or soft rock having a shear wave velocity between 360 m/s and 760 m/s.

The median[1] UHRS, instead of the mean, was used to derive the earthquake time histories for the PROSHAKE analysis. For our previous MCE evaluation, the earthquake time histories fell between the median and mean URHS. Adopting the more conservative approach for MCE is justifiable when assessing the safety of a high hazard structure which must withstand all earthquake motions possible for the area. In this case where we are trying to test against a specific return period, using the median value does not introduce any bias.

3. SEISMIC HAZARD ANALYSES AND DESIGN EARTHQUAKE PARAMETERS

3.1 General

Seismic hazard and de-aggregation analyses were carried out to determine the magnitude and distance for a 500 year return period earthquake to select appropriate earthquake time histories with the same characteristics. Subsequent sections deal with the following:

- A review of the probabilistic seismic hazard analyses conducted by Atkinson (2004) for Faro as a first step in definition of the 500 year PGA and the UHRS.
- Augmentation of the Atkinson work using Ez-Frisk (Risk Engineering, 1997) to define the design earthquake magnitude and distance parameters.
- Deterministic seismic hazard calculation to check the design earthquake parameters derived from probabilistic seismic analyses.

[1] 50% of values are less and more than the median. The mean is the average value. Because many ground parameters have a lognormal distribution, the mean is usually greater than the median.

3.2 Probabilistic Seismic Hazard Analyses by Atkinson (2004)

Atkinson (2004) performed a seismic hazard assessment for Faro using the modified Geological Survey of Canada (GSC) seismogenic source zone model, namely the H and R models, which formed the basis for the 2005 National Building Code of Canada (2005 NBCC). Figure 2 shows the seismicity surrounding Faro and the GSC's SYT (H Model's South Yukon Territory Zone) and SOY (R Model's Southern Yukon) source zones. Atkinson (2004) noted that there is a linear band of seismicity running southeast to northwest through the Faro site as shown in Figure 2 which coincides with the Tintina Trench Fault system. There is seismological evidence that the Tintina Fault system is more active than the surrounding areas, so Atkinson modified the GSC's model to incorporate the higher seismicity of Tintina Fault system.

Atkinson (2004) incorporated the possibility of discrete Tintina seismicity using a logic tree approach where alternative seismic models were assigned likelihood weightings. Figure 3 shows a portion of the logic tree used by Atkinson (2004). The possibility that the Tintina fault system was either an areal or line sources was included in the logic tree as were three alternative orientations of the fault (vertical, dipping 45^{o} east and 45^{o} west). Table 1 lists the alternative models used by Atkinson (2004).

Table 1 Model Zones and Weights Used by Atkinson (2004)

Model Zone		Areal/Line Source	Assigned Weight
GSC's SYT		Areal	0.33
Tintina Fault System		Areal	0.34
Tintina Fault	Dipping at 45^{o} East	Line	0.33
	Vertical	Line	0.33
	Dipping at 45^{o} West	Line	0.33

The epistemic uncertainties such as the uncertainties in the maximum magnitude, M_{max}, activity rate, N_o, beta, β and the scatter in the attenuation, were also considered in Atkinson (2004) using logic tree approach. The extended logic tree used by Atkinson (2004) is shown in Figure 4. Atkinson (2004) used the computer program FRISK88 (Risk Engineering, Inc.) to compute the extended logic tree shown in Figure 4. Mean, median (50^{th} percentile), 84^{th} percentile and 16^{th} percentile UHRS for 10,000 year return period and median (50^{th} percentile) values corresponding to 500 year return period were reported by Atkinson (2004).

The Atkinson work is the definitive seismic study for the site but does not provide all the information necessary to conduct liquefaction potential evaluations so more seismic work was necessary.

3.3 Probabilistic Seismic Hazard and Deaggregation Analyses

To select earthquake time histories for PROSHAKE analyses at 1 in 500, the dominant magnitude and epicentral distance need to be determined. This was done with "de-aggregation[2]" analyses using Ez-Frisk. However, Ez-Frisk cannot handle the epistemic uncertainty so the logic tree such as the one shown in Figure 4 cannot readily be incorporated into an Ez-Frisk analysis.

In a deaggregation analysis, only one of the several alternative models shown in Figure 4 and a single set of parameters for variables such as the maximum magnitude, M_{max}, activity rate, N_o, beta, β and the scatter in the attenuation can be used with Ez-Frisk. Thus, separate seismic hazard and deaggregation analyses were conducted using Ez-Frisk for each of the alternative models shown in Figure 4 for the Tintina Fault System, together with the "best estimate" parameters for other variables. Table 2 summarizes the

[2] De-aggregation is a computational process whereby the earthquake magnitudes and distances contributing to a specific return period at a subject site are output.

list of analyses and the resulting PGA. The mean magnitude and distance resulting from the corresponding deaggregation analyses are also listed in Table 2.

Table 2 Summary of PGA and Mean Magnitude and Distances from Ez-Frisk Analyses

Case	Alternative Models	Source Type	PGA (g)	Mean Magnitude	Mean Distance (km)
1	GSC's SYT	Area	0.058	5.6	58
2	Tintina Fault System	Area	0.124	5.6	26
3	Tintina Fault- Dipping at 45^o East	Line	0.179	5.9	16
4	Tintina Fault-Vertical	Line	0.156	5.9	21
5	Tintina Fault- Dipping at 45^o West	Line	0.136	6.0	27

Figure 5 shows the UHRS for Cases 1 to 5 listed in Table 2. For comparison, the median UHRS for 500 year earthquake by Atkinson (2004) is also shown in Figure 5. Case 3 where the fault was assumed as dipping to the east towards Faro, resulted in the highest PGA (0.18 g) whereas Case 2, in which the fault system was treated as areal zone, resulted in a PGA of 0.12 g. As expected, the GSC's H model zone SYT resulted in PGA of 0.06 g only. The weighted average of the PGA using the weights listed in Table 1 for the five alternative models results in 0.11 g, which is the same as the median PGA reported by Atkinson (2004) based on the FRISK88 analyses. The weighted spectral accelerations from Ez-Frisk analyses at other periods are also close to the median spectral accelerations reported by Atkinson (2004).

Table 3 Seismic Design Parameters for 500 Year Earthquake

Parameter	Value
Peak Ground Acceleration, PGA	0.11 g
Earthquake Magnitude	M5.8
Distance	15-30 km

Figure 6 shows the deaggregation plots for Cases 1 to 5. It is evident that the earthquakes occurring at the Tintina fault system are the dominant source of earthquake hazard for Faro. The deaggregation analyses for Cases 2 to 5, which considered different scenarios for Tintina fault system, shows that, for 500 year return period, the range of mean magnitude and mean distances fall within a narrow range of M5.6 to M6.0 and 16 km to 27 km, respectively. Thus, for 500 year return period, the design earthquake parameters listed in Table 3 were selected, which were used to select the time histories for site response analyses.

Based on the design parameters derived from the probabilistic analyses above, we have calculated deterministically the PGA and UHRS for the scenario earthquake. The attenuation equation by Boore et al. (1997, 2005) was used in the calculation, which is an updated version of the attenuation equation used by GSC in the development of seismic hazard maps for 2005NBCC and Atkinson (2004). The magnitude of the scenario earthquake was taken as M5.8 and the analyses were conducted for 16 km and 27 km distances. Figure 7 shows the results from the deterministic analyses and, for comparison, the median UHRS from the probabilistic analyses is also shown in Figure 7. As evident from Figure 7, the UHRS based on the probabilistic analyses are bounded by the deterministic spectra for the M5.8 earthquake at the two distances (16 km and 27 km).

4. EARTHQUAKE INPUT MOTIONS

Six new time histories were selected and modified to match the 500 year median probabilistic UHRS provided by Atkinson (2004). For the selection of reference time histories, spectral matching and the generation of time histories, the guidelines recommended by Bolt (1996) and Stewart et al. (2001) were generally followed.

4.1 Reference Earthquake Time Histories

Six reference time histories were selected from four earthquakes. The original records of the time histories were obtained from the US based COSMOS (Consortium of Organizations for Strong Motion Observation Systems) data base. Table 4 lists the parameters for the six reference time histories. The magnitude, distance and recorded PGA are within the acceptable range except for the magnitude of San Fernando and Imperial Valley earthquakes that are slightly higher. The site conditions of the stations listed in Table 4 are either rock or weathered rock.

Table 4 Reference Earthquake Time Histories Parameters

Earthquake	Date	Magnitude	Distance[a] (km)	Station and Component	Recorded PGA (g)
Whittier Narrows	1987-10-01	M_w6.1	22	Mt. Wilson, 0 deg	0.12
Whittier Narrows	1987-10-01	M_w6.1	22	Griffiths Park Obs., 270 deg	0.14
Morgan Hill	1984-04-24	M_w6.1	13	Gilroy#1, 320 deg	0.10
San Fernando	1971-02-09	M_w6.6	26	Griffiths Park Obs., 270 deg	0.17
San Fernando	1971-02-09	M_w6.6	24	Lake Hughes#4, 201 deg	0.15
Imperial Valley	1979-10-15	M_L6.6	22	Superstition Mtn., 45 deg	0.11

[a]Closest distance to fault

4.2 Spectral Matching

The response spectrum matching was carried out in the time domain using the computer program RSPMATCH (Abrahamson, 1992). Figures 8 to 13 show the modified acceleration time histories and the corresponding spectra for the six time histories listed in Table 4. For comparison, the target spectra for the 500 year earthquake and the spectra of the unmodified records are also shown. Note that the spectra of the unmodified records were simply scaled to PGA of 0.11 g. Note that Atkinson (2004) provided the target spectra up to a period of 2 seconds only. The target spectrum was extended to 4 seconds by assuming the spectral ordinates beyond 2 seconds were inversely proportional to the period.

Figures 14 and 15 summarize the acceleration time histories and the corresponding spectra, respectively, for all six modified records. Figure 15 also shows the Husid plots for all six modified records. The Husid plots indicate that the effective duration of the modified records are greater than about 9 seconds, which is adequate for an M5.8 earthquake.

5. DAM CONFIGURATION AND FOUNDATION CONDITIONS

The Cross Valley Dam was constructed as part of the Down Valley Project in the early 1980s to retain a tailings water polishing pond downstream of the Intermediate Dam. Figure 16 shows the design section of the dam. Figure 17 shows the foundation stratigraphy along the downstream toe. It also shows profiles of measured Becker Penetration Test blow counts (BPT) and the corrected Standard or Large Penetration Test blow counts (SPT/LPT) from 2005 site investigation by KC. A detail description of the dam and foundation conditions is given in KC (2006).

The dam fill was compacted, so it will not liquefy even during a major earthquake, irrespective of seismic intensity. Therefore, this seismic stability evaluation, similar to the MCE study, concentrates on the liquefaction triggering potential of the foundation soils only under a 500 year earthquake.

6. GROUND RESPONSE ANALYSES

Similar to the MCE study, one dimensional total stress site response analyses were carried out at three locations (BPT05-03, BPT05-04 and BPT05-05) shown in Figure 18 for conditions with the dam (i.e. through the dam crest) and without the dam (i.e. through the dam toe). The computer program PROSHAKE (Edupro Civil Systems, 2005) was used in the analyses. The soil models and soil properties used in the PROSHAKE analyses are same as those used in the MCE study presented in KC (2006).

The six modified earthquake records listed in Table 4 and shown in Figure 14 were used as input motions in the site response analyses. The peak acceleration of these records is 0.11 g. These records were applied as "outcrop" motions at the base of the soil models in the PROSHAKE analyses.

Figures 19 and 20 shows the peak acceleration and the earthquake induced cyclic stress ratio (CSR) profiles, respectively, at the toe of the dam from PROSHAKE analyses at BPT05-03, BPT05-04 and BPT05-05. The peak accelerations at the surface are generally amplified at all three locations. However, the amplification at BPT04-03, where no silt was present, is higher than those at BPT 05-04 and BPT05-05. The presence of silt at BPT05-04 and BPT05-05 apparently reduced the amount of amplification. The earthquake induced CSRs also show similar trend.

Figures 21 and 22 shows the peak acceleration and the earthquake induced cyclic stress ratio (CSR) profiles, respectively, from PROSHAKE analyses below the crest of the dam at the same three locations. Note that each of these three profiles uses the ground conditions at the respective Becker holes but corrected for the weight of the dam fill. Compared to the response near the toe, at all three locations, the peak accelerations and CSRs are lower.

7. LIQUEFACTION EVALUATION

7.1 Liquefaction Triggering Potential of Granular Soils

The liquefaction triggering potential of granular soils (sand and gravel) was evaluated using the same approach used in the MCE study. In this approach, cyclic stress ratios (CSRs) induced by the design earthquake are compared with the cyclic resistance ratios (CRRs). The CSRs were computed from the site response analysis results as presented above. The CRRs were evaluated based on the SPT $(N_1)_{60}$ values derived from the measured BPT, SPT or LPT data. The conversion of measured BPT, SPT and LPT blow counts into equivalent SPT $(N_1)_{60}$ values were presented in detail in KC (2006).

The procedure outlined in Youd et al. (2001) was used to determine the CRRs using the equivalent SPT $(N_1)_{60}$. The magnitude of the 500 year design earthquake was taken as M5.8 to determine the magnitude correction factor K_m. The correction factor for initial confining stress, K_σ is same as that used in the MCE study. Similar to the MCE study, liquefaction resistance curve corresponding to fines content (FC) of 10% was used.

Figures 23 shows the liquefaction evaluation in the foundation soils at the dam toe and Figure 24 shows the same beneath the dam crest. The earthquake induced CSRs are expressed in terms of the required $(N_1)_{60}$ to prevent liquefaction in Figures 23 and 24 for the six earthquake records. The required SPT $(N_1)_{60}$ are quite small at all locations except near the dam toe at BPT05-03 where noticeable values were obtained. However, Figures 23 and 24 show that liquefaction will not be triggered in granular soils at any of these locations under the 500 year design earthquake.

7.2 Liquefaction Triggering Potential of Silty Soils

The CSRs corresponding to the six earthquake records induced in the silt layers beneath the dam crest at BPT05-04 and BPT05-05 were very small (< 0.04). Near the dam toe, at BPT05-04 and BPT05-05, the average of the induced CSRs corresponding to the six earthquake records ranged between 0.04 to 0.09. Since the 500 year design earthquake magnitude is M5.8, less than six cycles of loading with such low CSRs is not expected to cause liquefaction in the silt layers.

8. SEISMIC STABILITY OF DAM UNDER 500 YEAR EARTHQUAKE

Since liquefaction will not be triggered in the foundation soils, there is no need to conduct flow slide analyses since none of the foundation soils will loose appreciable strength during the 1 in 500 year earthquake. However, there will be cyclic movements of the dam during an earthquake event of this magnitude. We have not predicted permanent seismic movements by calculation because we expect that these movements will be small. These movements may be permanent but will not lead to release of the reservoir, provided the freeboard is always more than 1.5 m[3].

The dam will not fail under a 500 year return period earthquake but will fail if shaken by a MCE. There is a threshold earthquake between these two events which will fail the dam. As stated earlier, safety at the 500 year level earthquake has been accepted by the Regulator for the temporary closure design and construction period. Irrespective of the outcome of this work, a threshold earthquake can occur at any time and fail the dam.

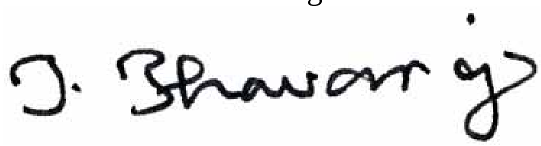
If the dam is left in place as part of the final closure scheme, it can then be made safe by either improving the seismic resistance of the foundation as described in our KC (2006) report or by substantially reducing the reservoir level which is roughly equivalent to

[3] We understand that lowering of the reservoir is constrained by the bottom elevation of the riprap on the upstream slope.

decommissioning the dam. Reductions in the reservoir level will require re-design of the spillway and siphon system together with careful consideration of the downstream stability of the Intermediate Dam with a reduced reservoir.

KLOHN CRIPPEN BERGER LTD.

Bryan D. Watts, P.Eng.
Senior Geotechnical Engineer



Dr. Thava Thavaraj, E.I.T.
Geotechnical Engineer

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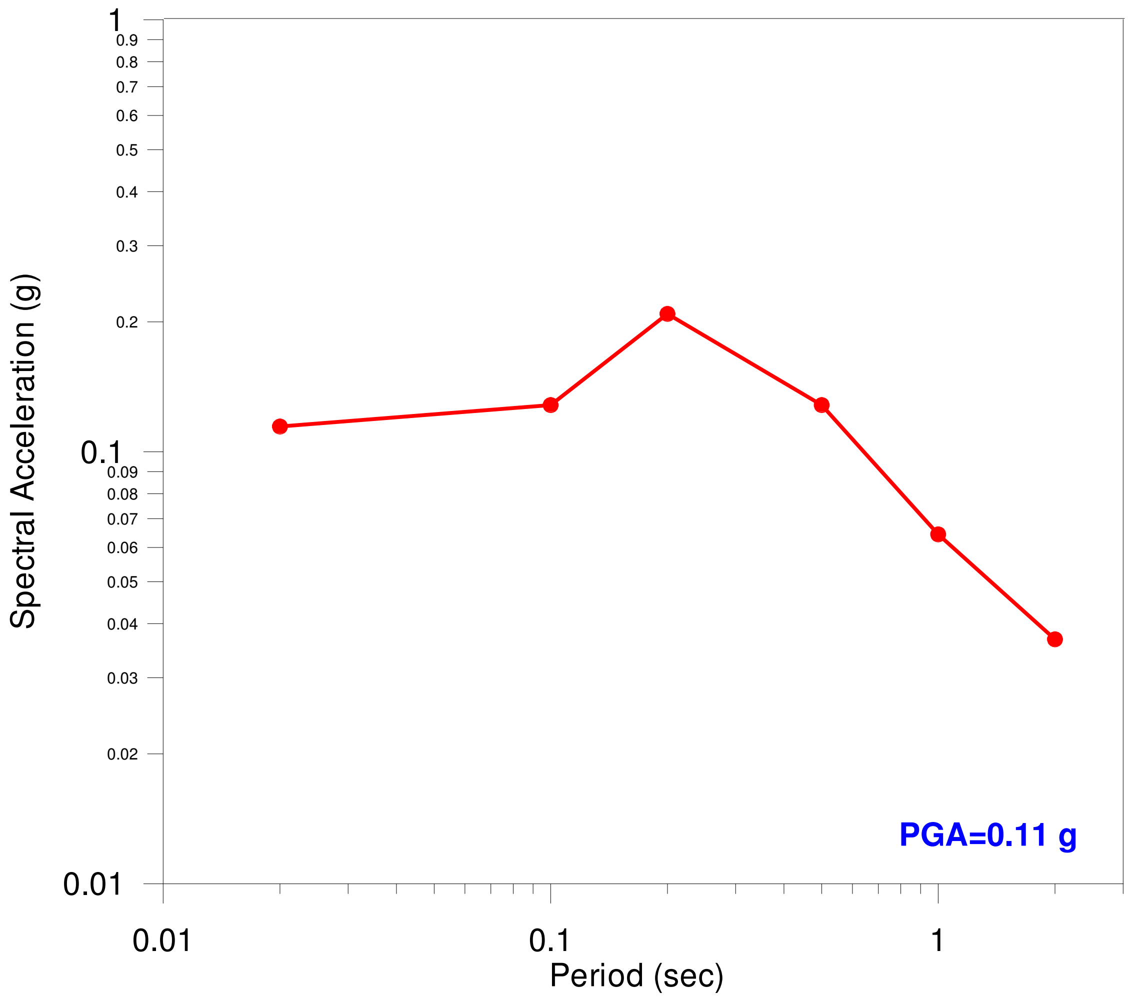
FIGURES



UNIFORM HAZARD RESPONSE SPECTRUM (UHRS) - ATKINSON (2004)

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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

SCALE

Klohn Crippen Berger

PROJECT: ROSE CREEK TAILINGS IMPOUNDMENT CROSS VALLEY DAM SEISMIC STABILITY

TITLE: MEDIAN UHRS FOR 500 YEAR RETURN PERIOD EARTHQUAKE FOR FARO FROM PROBABILISTIC ANALYSES

CLIENT: **DELOITTE & TOUCHE INC.**
ANVIL MINING RANGE COMPLEX

DATE OF ISSUE	PROJECT No.	FIGURE NO.	REV.
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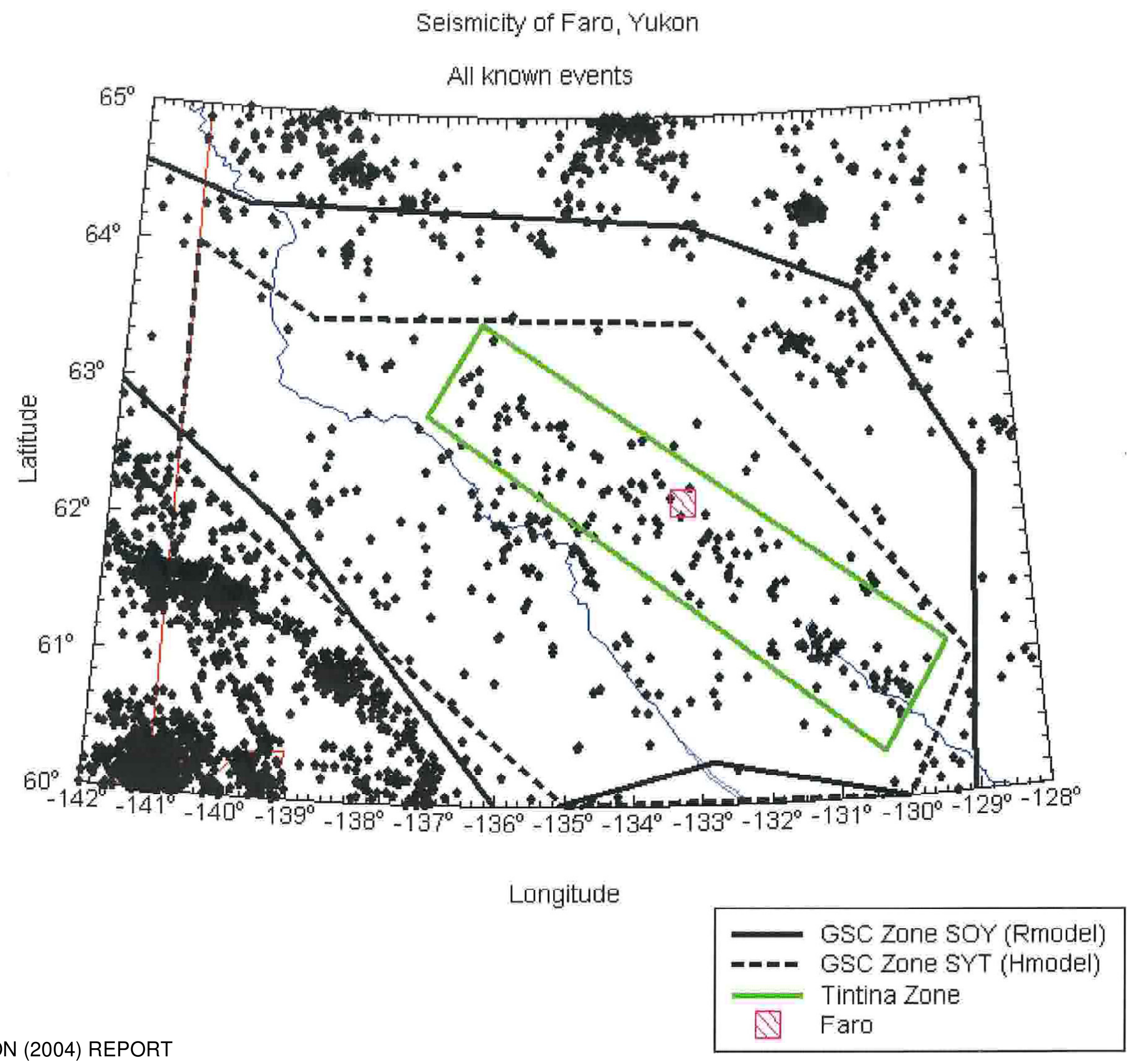
APPROVAL



NOTE:
FIGURE TAKEN FROM ATKINSON (2004) REPORT

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

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Klohn Crippen Berger

CLIENT:
DELOITTE & TOUCHE INC.
ANVIL MINING RANGE COMPLEX

PROJECT
ROSE CREEK TAILINGS IMPOUNDMENT
CROSS VALLEY DAM SEISMIC STABILITY

TITLE
SEISMICITY AROUND FARO AND THE TINTINA AND GSC'S SEISMOGENIC SOURCE ZONES

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
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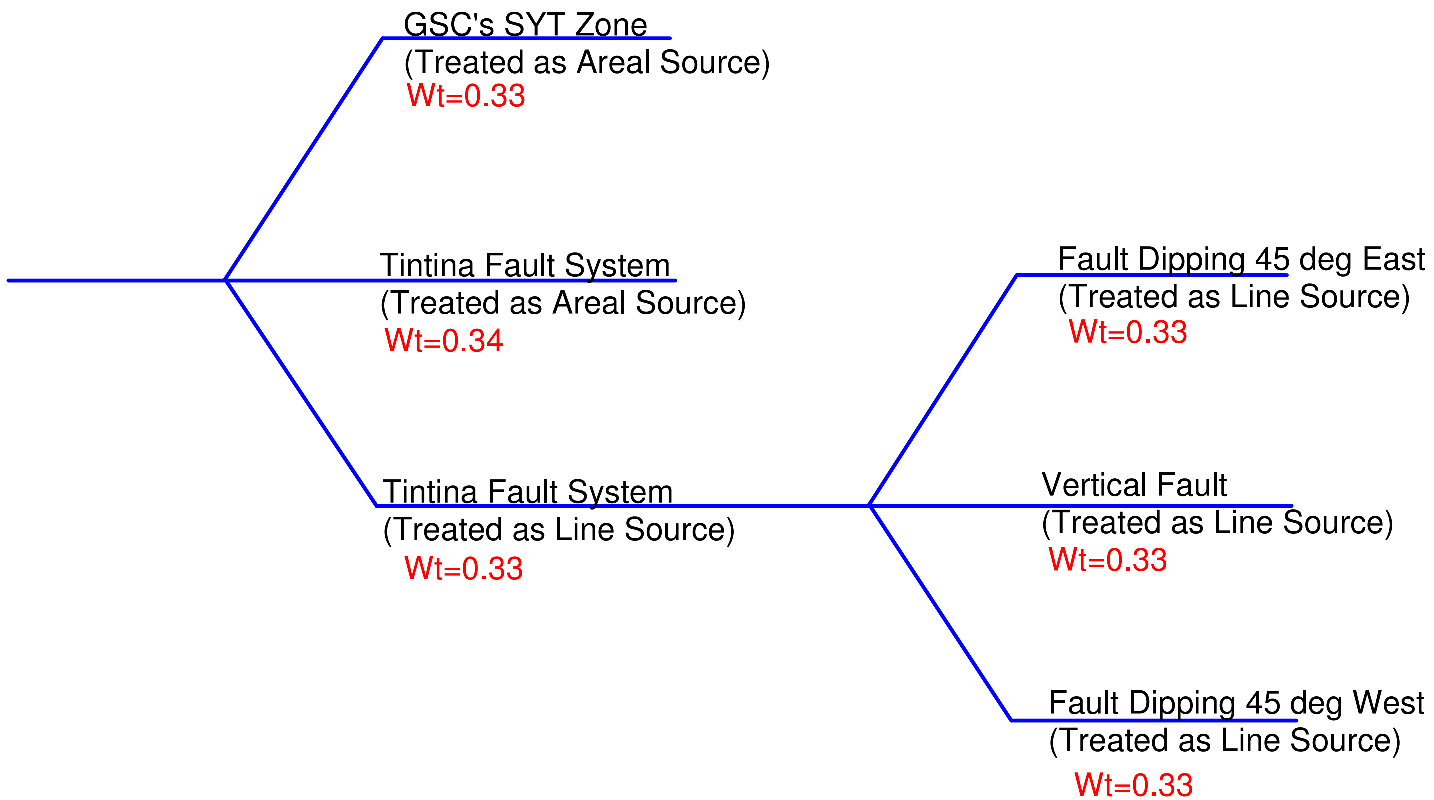
APPROVAL			



PART OF LOGIC TREE WITH ASSIGNED WEIGHTS USED BY ATKINSON(2004) TO TREAT
UNCERTAINTIES ASSOCIATED WITH TINTINA FAULT SYTEM

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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

Klohn Crippen Berger

CLIENT:
DELOITTE & TOUCHE INC.
ANVIL MINING RANGE COMPLEX

PROJECT
ROSE CREEK TAILINGS IMPOUNDMENT
CROSS VALLEY DAM SEISMIC STABILITY

TITLE
LOGIC TREE USED BY ATKINSON (2004) TO TREAT
UNCERTAINTIES ASSOCIATED WITH TINTINA FAULT SYSTEM

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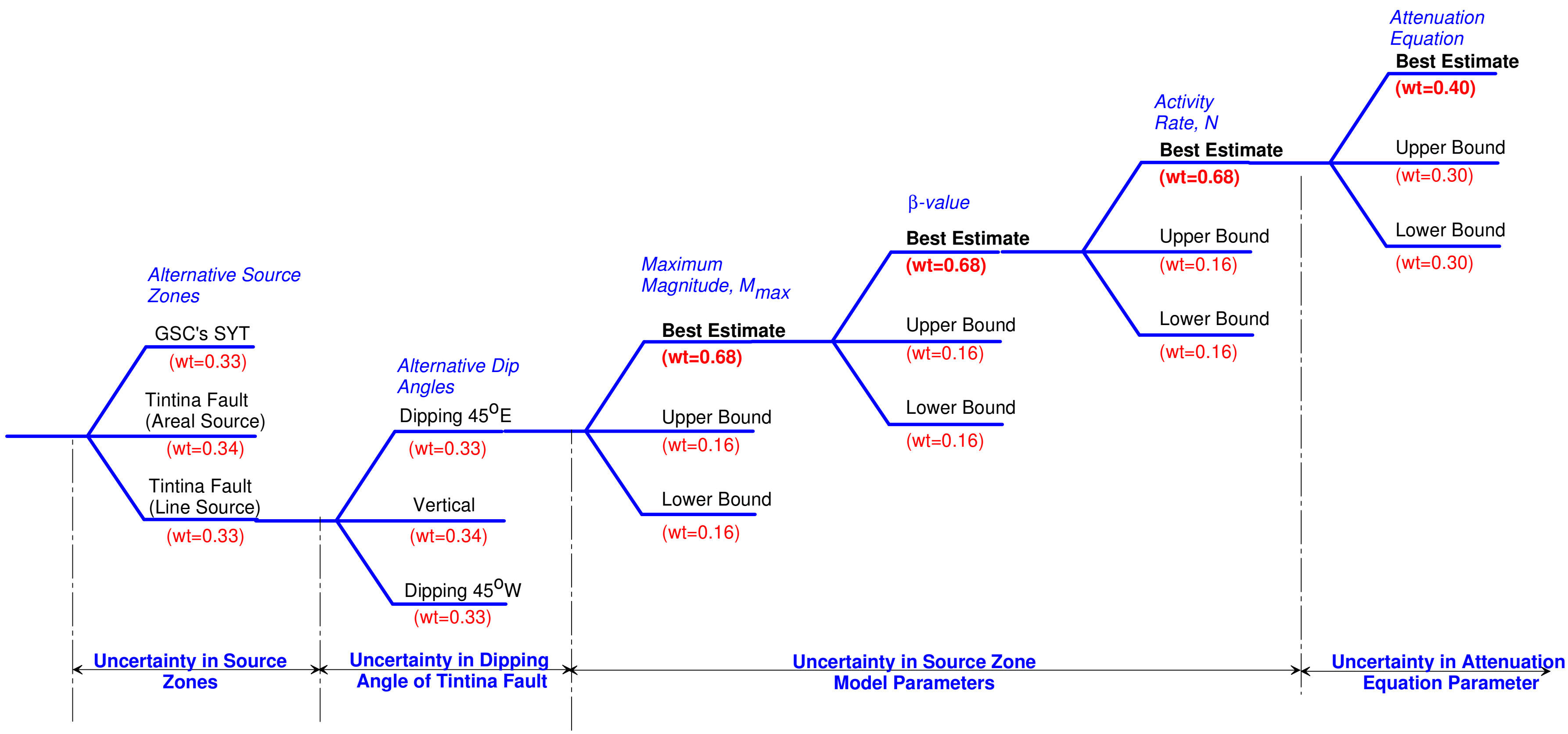

EXTENDED LOGIC TREE WITH ASSIGNED WEIGHTS USED BY ATKINSON (2004) IN THE SEISMIC HAZARD ANALYSIS FOR FARO

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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

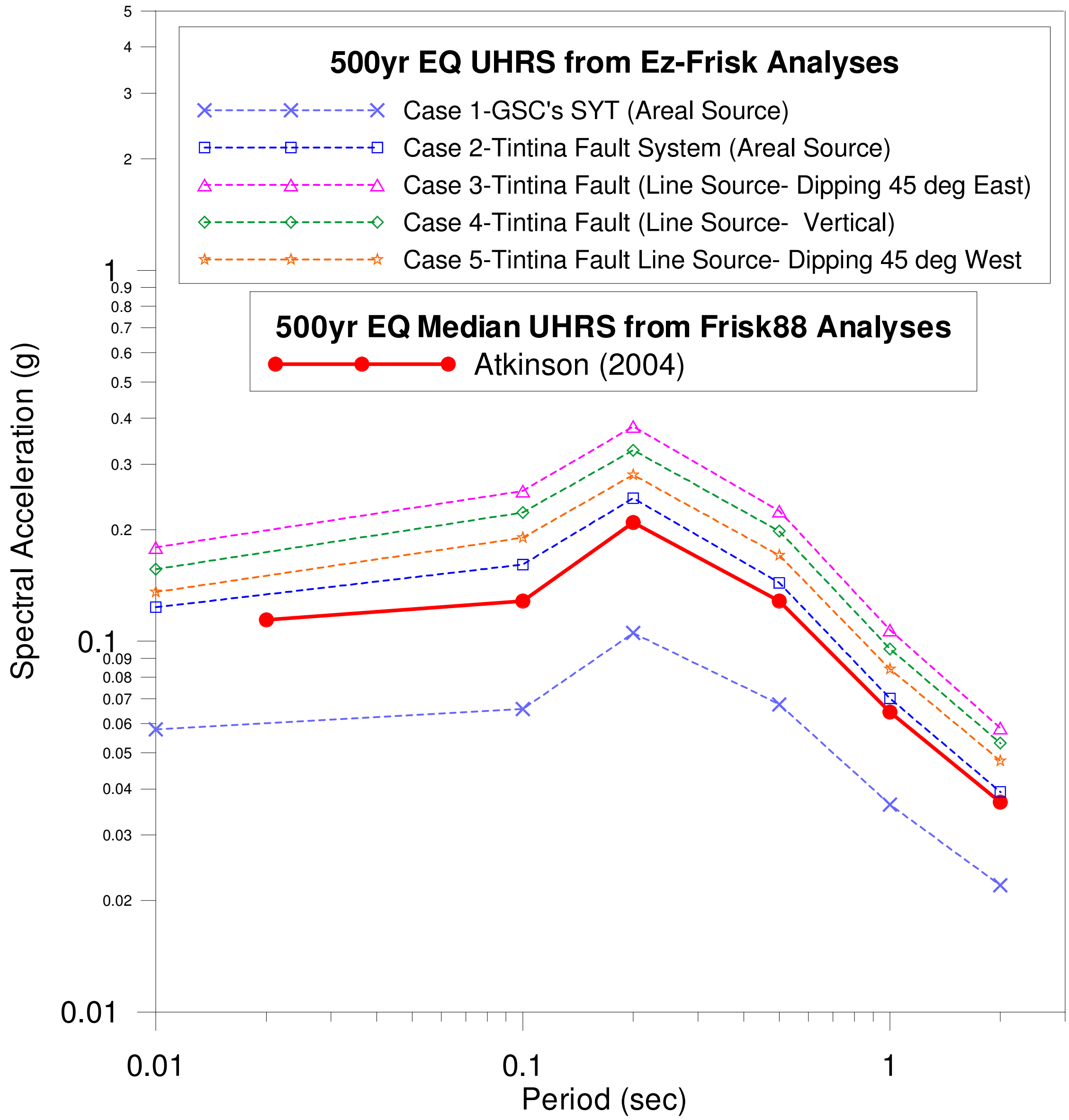
Klohn Crippen Berger

CLIENT:
DELOITTE & TOUCHE INC.
ANVIL MINING RANGE COMPLEX

PROJECT
ROSE CREEK TAILINGS IMPOUNDMENT
CROSS VALLEY DAM SEISMIC STABILITY

TITLE
LOGIC TREE USED BY ATKINSON (2004) TO TREAT UNCERTAINTIES ASSOCIATED WITH TINTINA FAULT SYSTEM

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
JANUARY 23, 2007	M09237A04 01	4	
APPROVAL			



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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

SCALE

Klohn Crippen Berger

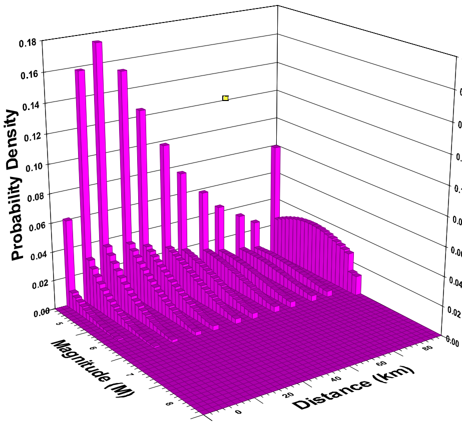
PROJECT: ROSE CREEK TAILINGS IMPOUNDMENT CROSS VALLEY DAM SEISMIC STABILITY

TITLE: SUMMARY OF EZ-FRISK SEISMIC HAZARD ANALYSES RESULTS

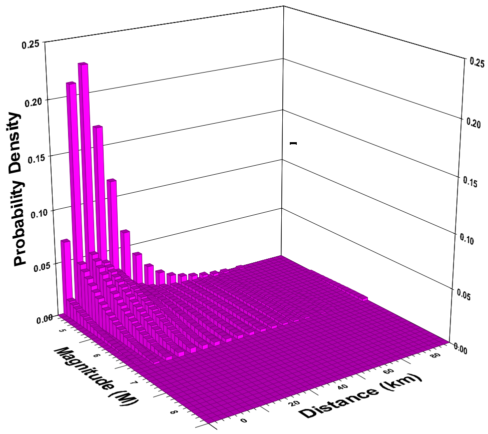
CLIENT: **DELOITTE & TOUCHE INC.** ANVIL MINING RANGE COMPLEX

DATE OF ISSUE	PROJECT No.	FIGURE NO.	REV.
JANUARY 23, 2007	M09237A04 01	5	

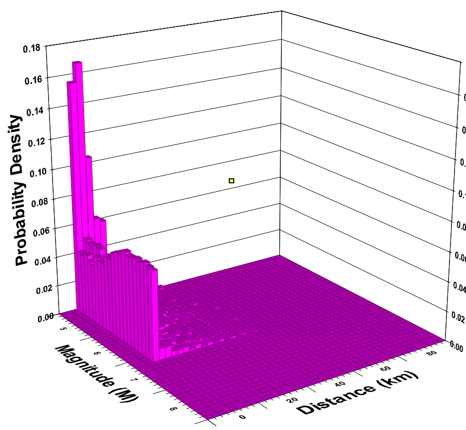
APPROVAL



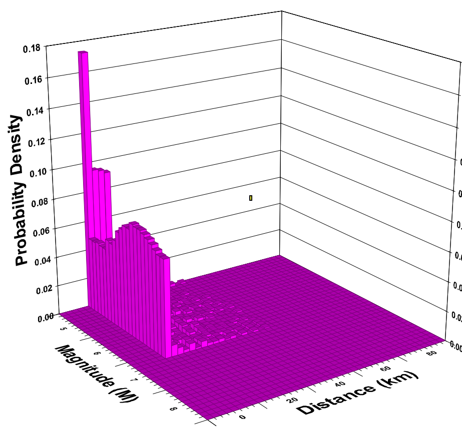
CASE 1



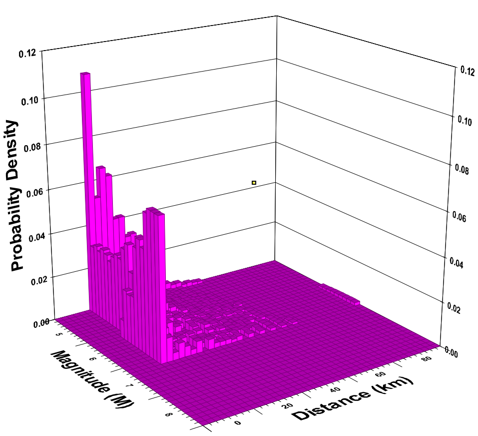
CASE 2



CASE 3



CASE 4



CASE 5

Case	Alternative Model	Source Type	PGA (g)	Mean Magnitude	Mean Distance (km)
1	GSC's SYT	Area	0.058	5.6	58
2	Tintina Fault System	Area	0.124	5.6	26
3	Tintina Faut- Dipping at 45° East	Line	0.179	5.9	16
4	Tintina Faut-Vertical	Line	0.156	5.9	21
5	Tintina Faut- Dipping at 45° West	Line	0.136	6.0	27

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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

SCALE

Klohn Crippen Berger

PROJECT
ROSE CREEK TAILINGS IMPOUNDMENT
CROSS VALLEY DAM SEISMIC STABILITY

TITLE
MAGNITUDE-DISTNACE DEAGGREGATION PLOTS
FOR CASES 1 TO 5

CLIENT:
DELOITTE & TOUCHE INC.
ANVIL MINING RANGE COMPLEX

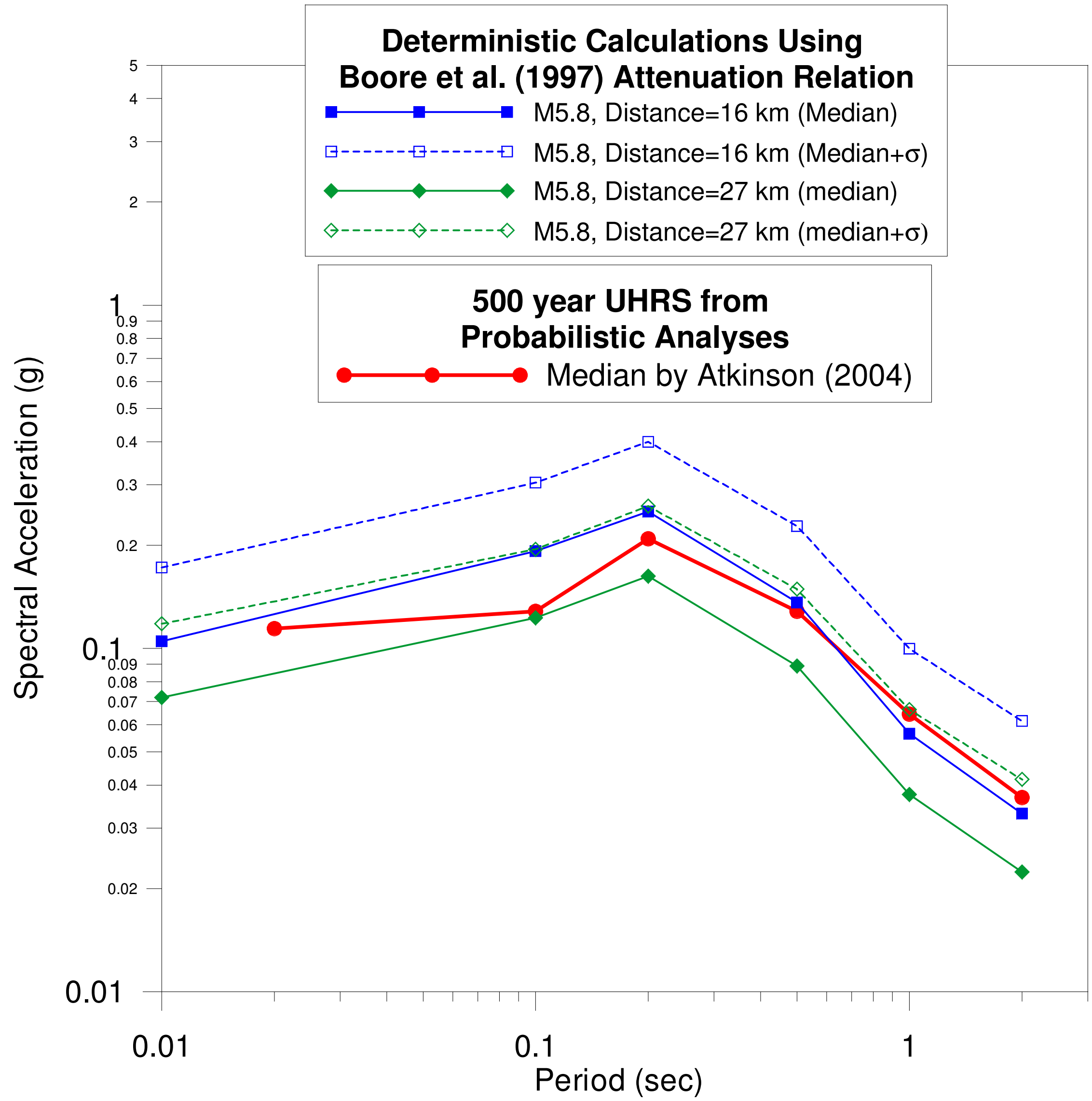
DATE OF ISSUE
JANUARY 23, 2007

APPROVAL

PROJECT No.
M09237A04 01

FIGURE NO.
6

REV.



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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

SCALE

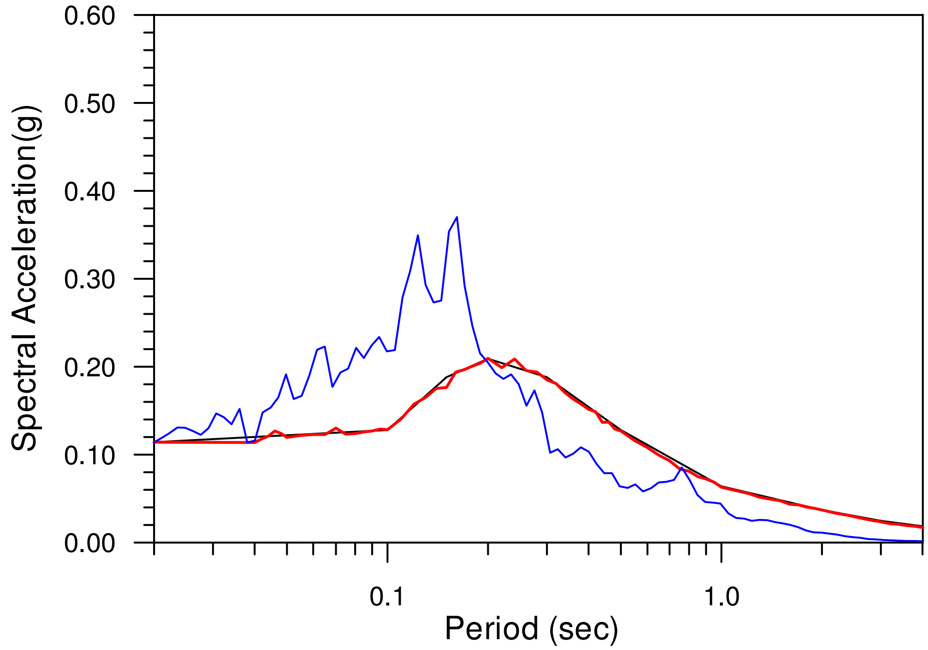
Klohn Crippen Berger

PROJECT: ROSE CREEK TAILINGS IMPOUNDMENT
CROSS VALLEY DAM SEISMIC STABILITY

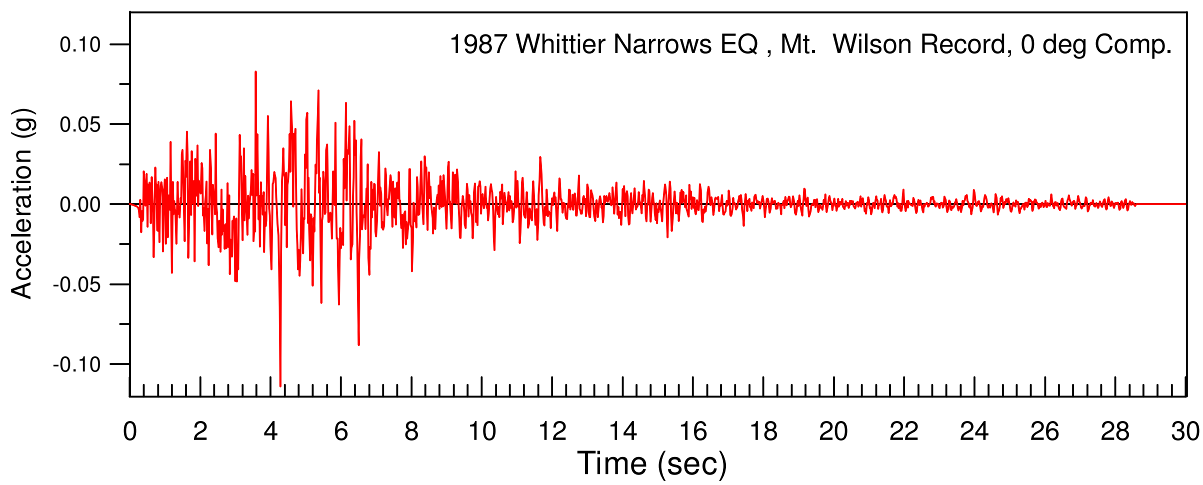
TITLE: SUMMARY OF DETERMINISTIC SEISMIC
HAZARD CALCULATION RESULTS

CLIENT:
DELOITTE & TOUCHE INC.
ANVIL MINING RANGE COMPLEX

DATE OF ISSUE	PROJECT No.	FIGURE NO.	REV.
JANUARY 23, 2007	M09237A04 01	7	
APPROVAL			



COMPARISON OF ACCELERATION RESPONSE SPECTRA



TARGET SPECTRUM MATCHED ACCELERATION TIME HISTORY

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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

SCALE

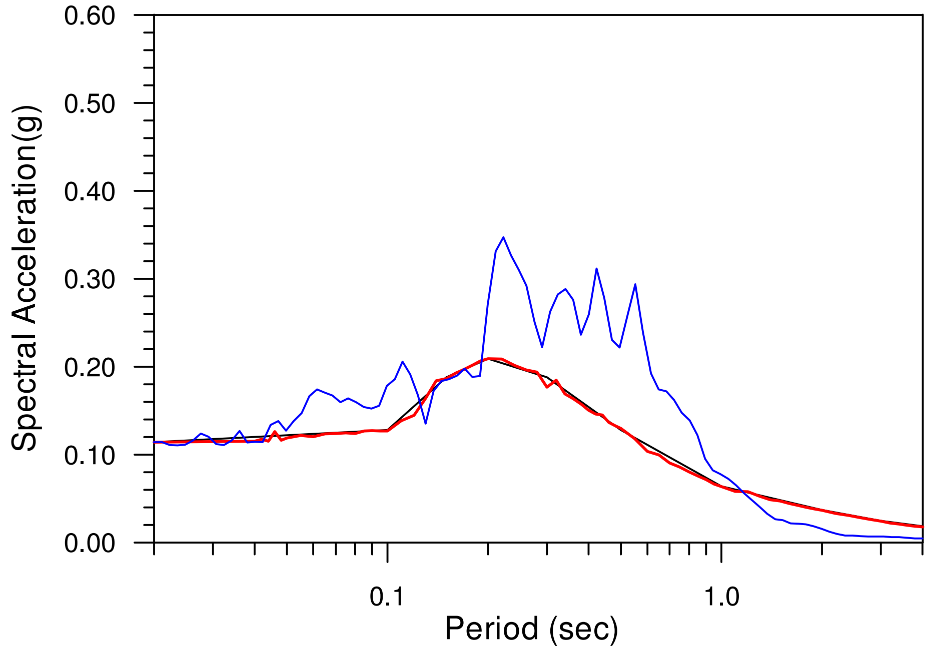
Klohn Crippen Berger

PROJECT: ROSE CREEK TAILINGS IMPOUNDMENT
CROSS VALLEY DAM SEISMIC STABILITY

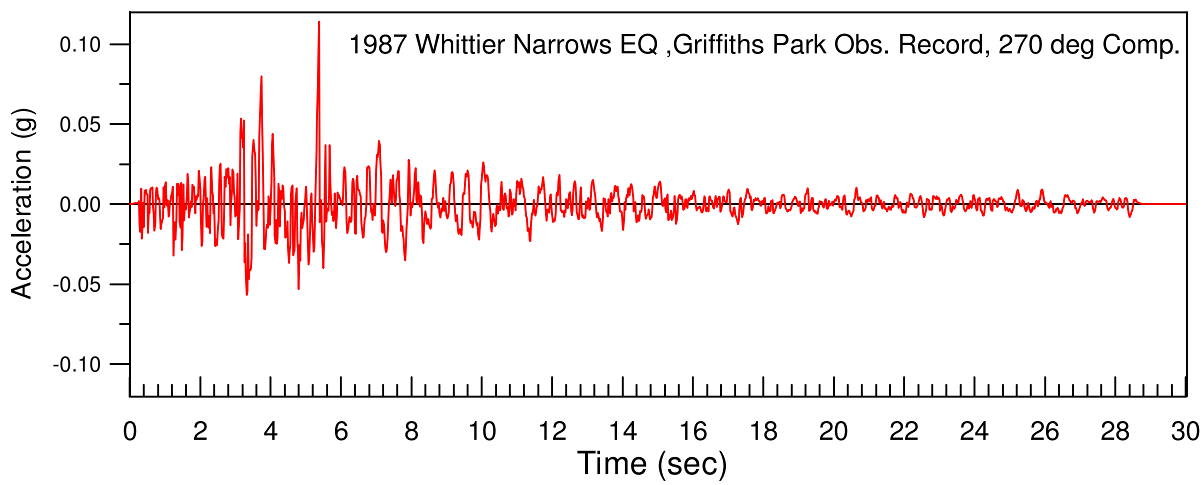
TITLE: MODIFIED TIME HISTORY 1
MATCHING THE 500 YEAR DESIGN SPECTRA

CLIENT: **DELOITTE & TOUCHE INC.**
ANVIL MINING RANGE COMPLEX

DATE OF ISSUE	PROJECT No.	FIGURE NO.	REV.
JANUARY 23, 2007	M09237A04 01	8	
APPROVAL			



COMPARISON OF ACCELERATION RESPONSE SPECTRA



TARGET SPECTRUM MATCHED ACCELERATION TIME HISTORY

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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

SCALE

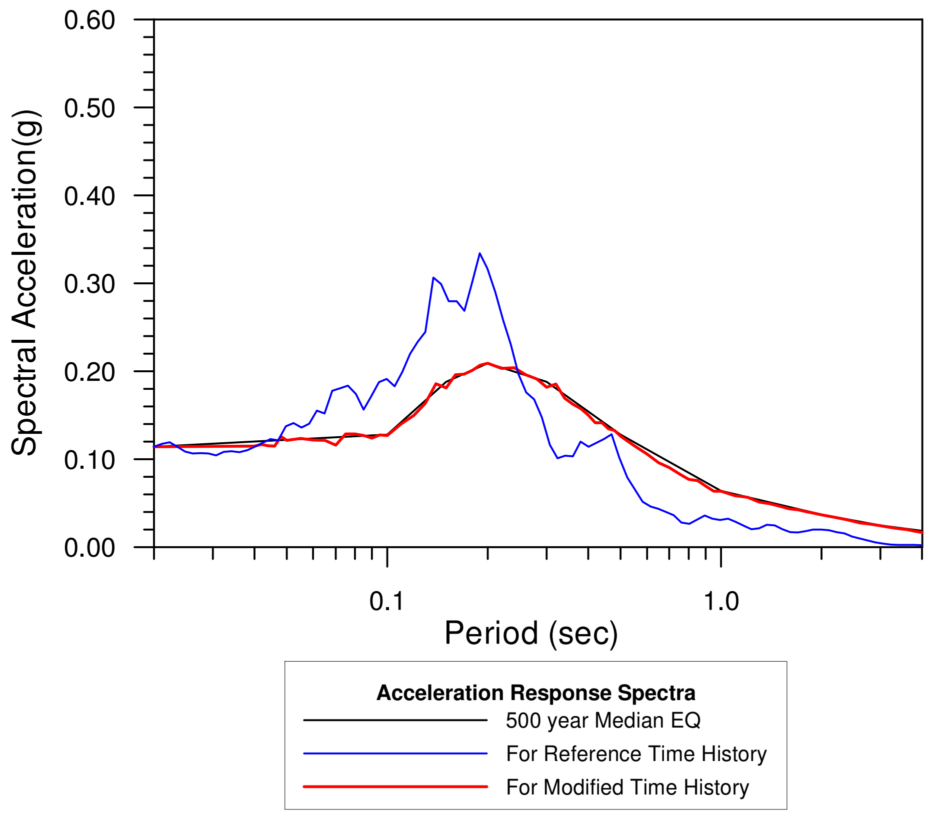
Klohn Crippen Berger

PROJECT: ROSE CREEK TAILINGS IMPOUNDMENT CROSS VALLEY DAM SEISMIC STABILITY

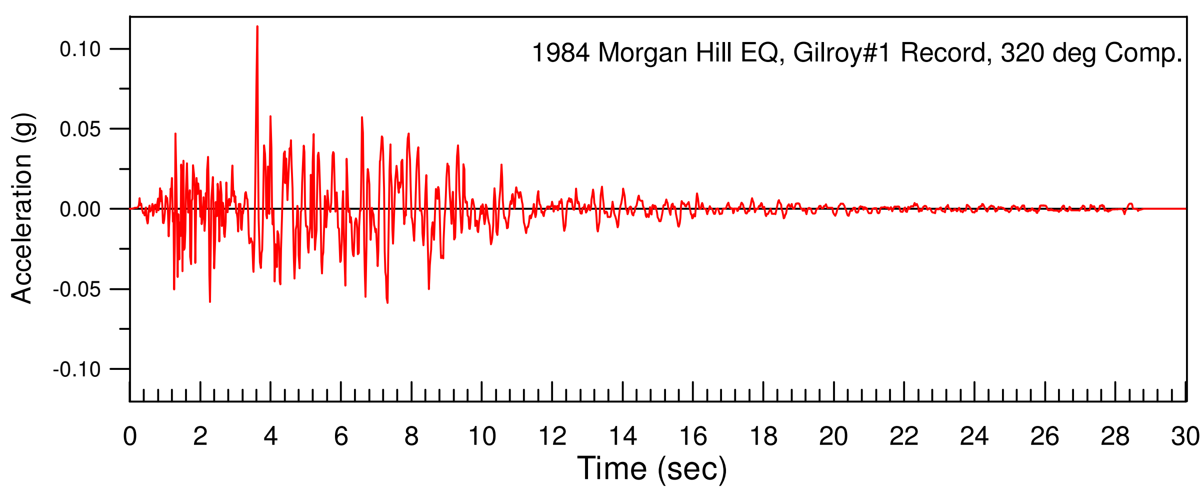
TITLE: MODIFIED TIME HISTORY 2 MATCHING THE 500 YEAR DESIGN SPECTRA

CLIENT: **DELOITTE & TOUCHE INC.** ANVIL MINING RANGE COMPLEX

DATE OF ISSUE	PROJECT No.	FIGURE NO.	REV.
JANUARY 23, 2007	M09237A04 01	9	
APPROVAL			



COMPARISON OF ACCELERATION RESPONSE SPECTRA



TARGET SPECTRUM MATCHED ACCELERATION TIME HISTORY

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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

SCALE

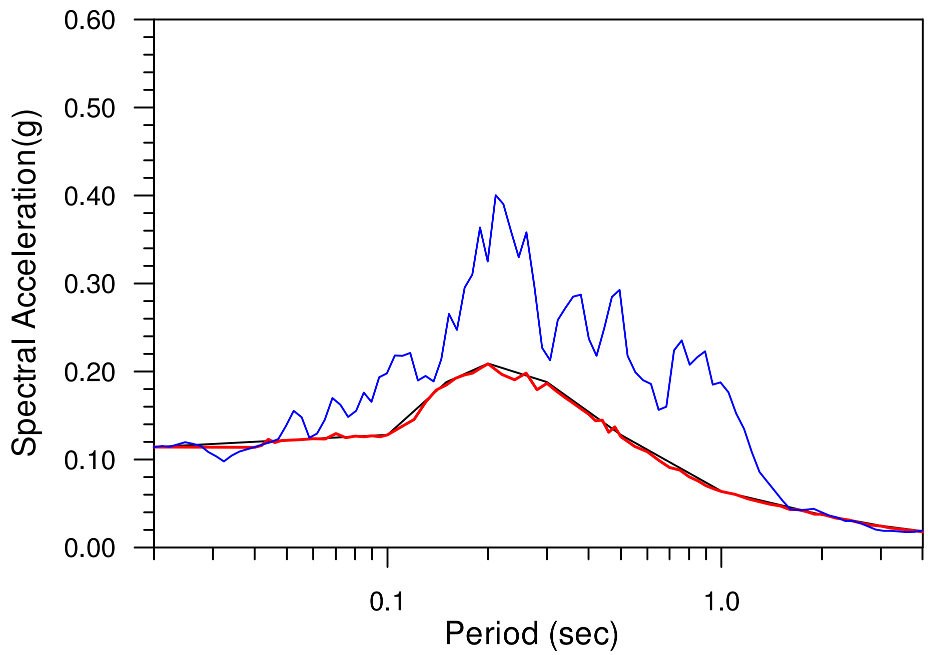
Klohn Crippen Berger

PROJECT: ROSE CREEK TAILINGS IMPOUNDMENT
CROSS VALLEY DAM SEISMIC STABILITY

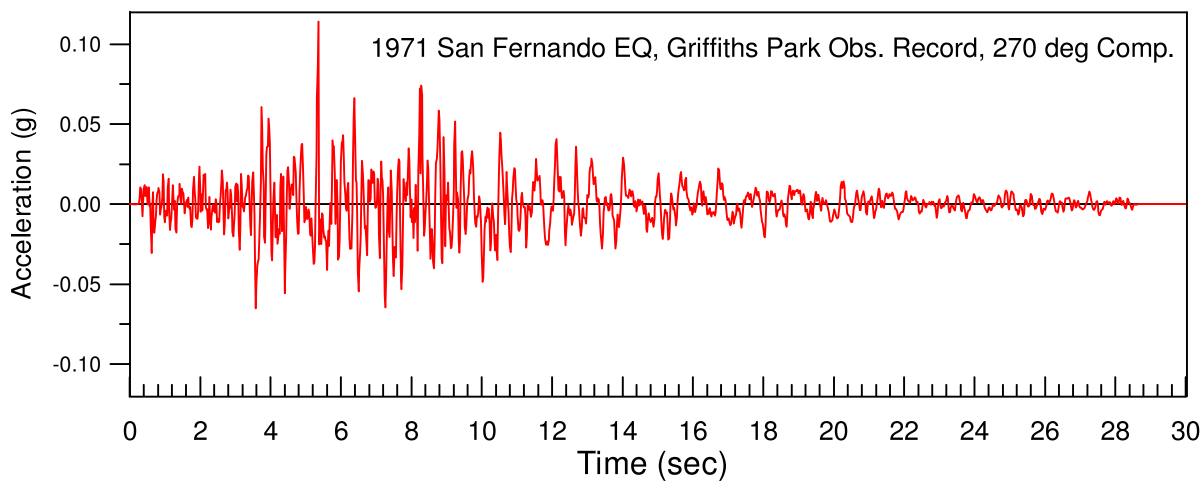
TITLE: MODIFIED TIME HISTORY 3
MATCHING THE 500 YEAR DESIGN SPECTRA

CLIENT: **DELOITTE & TOUCHE INC.**
ANVIL MINING RANGE COMPLEX

DATE OF ISSUE	PROJECT No.	FIGURE NO.	REV.
JANUARY 23, 2007	M09237A04 01	10	
APPROVAL			



COMPARISON OF ACCELERATION RESPONSE SPECTRA



TARGET SPECTRUM MATCHED ACCELERATION TIME HISTORY

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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

SCALE

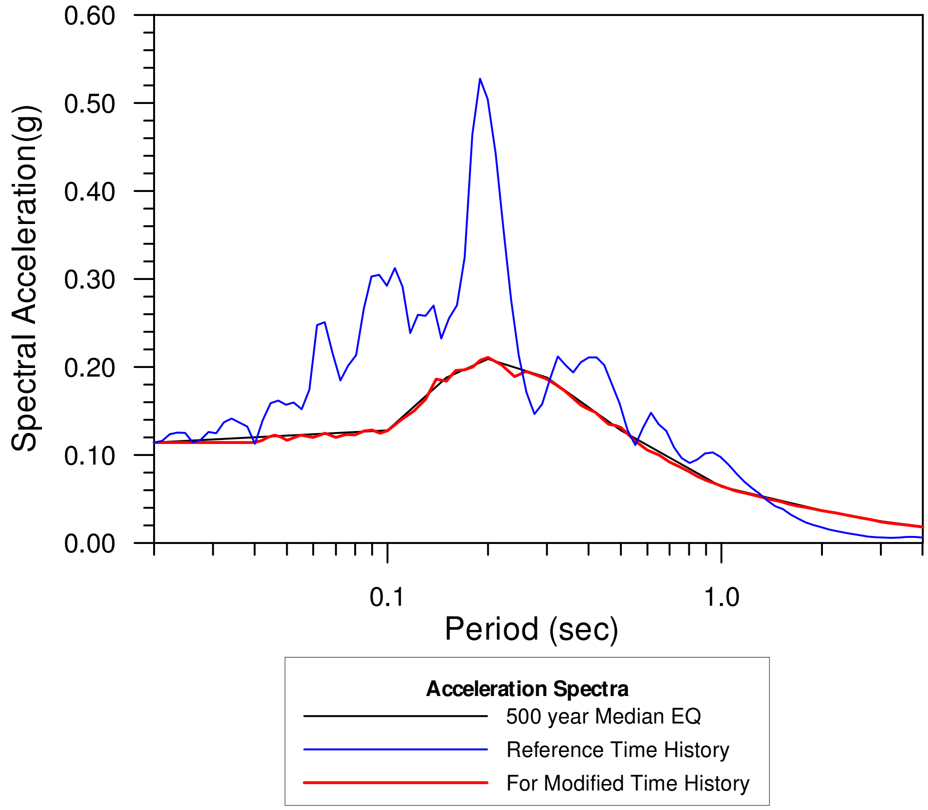
Klohn Crippen Berger

PROJECT: ROSE CREEK TAILINGS IMPOUNDMENT CROSS VALLEY DAM SEISMIC STABILITY

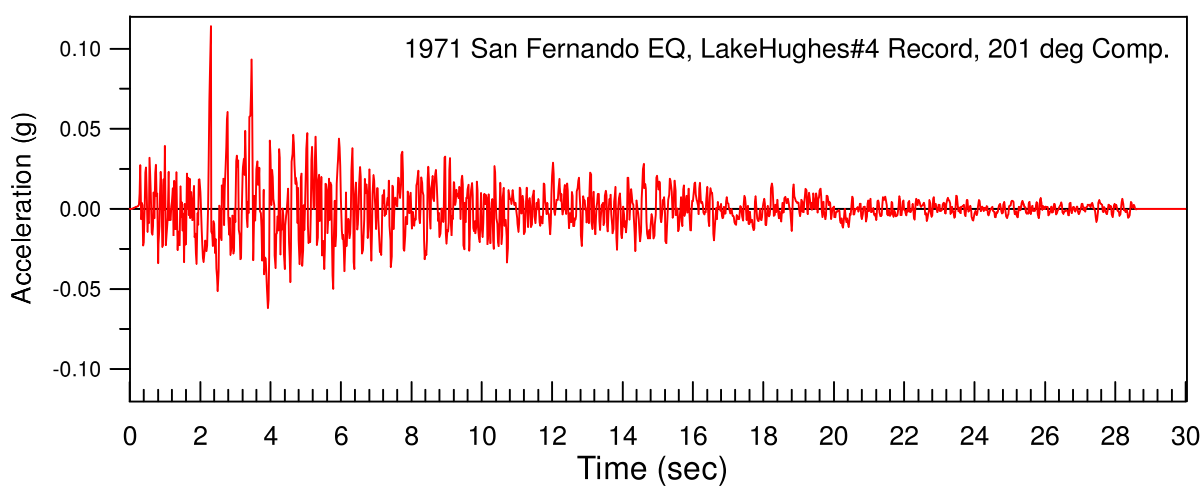
TITLE: MODIFIED TIME HISTORY 4 MATCHING THE 500 YEAR DESIGN SPECTRA

CLIENT: **DELOITTE & TOUCHE INC.** ANVIL MINING RANGE COMPLEX

DATE OF ISSUE	PROJECT No.	FIGURE NO.	REV.
JANUARY 23, 2007	M09237A04 01	11	
APPROVAL			



COMPARISON OF ACCELERATION RESPONSE SPECTRA



TARGET SPECTRUM MATCHED ACCELERATION TIME HISTORY

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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

SCALE

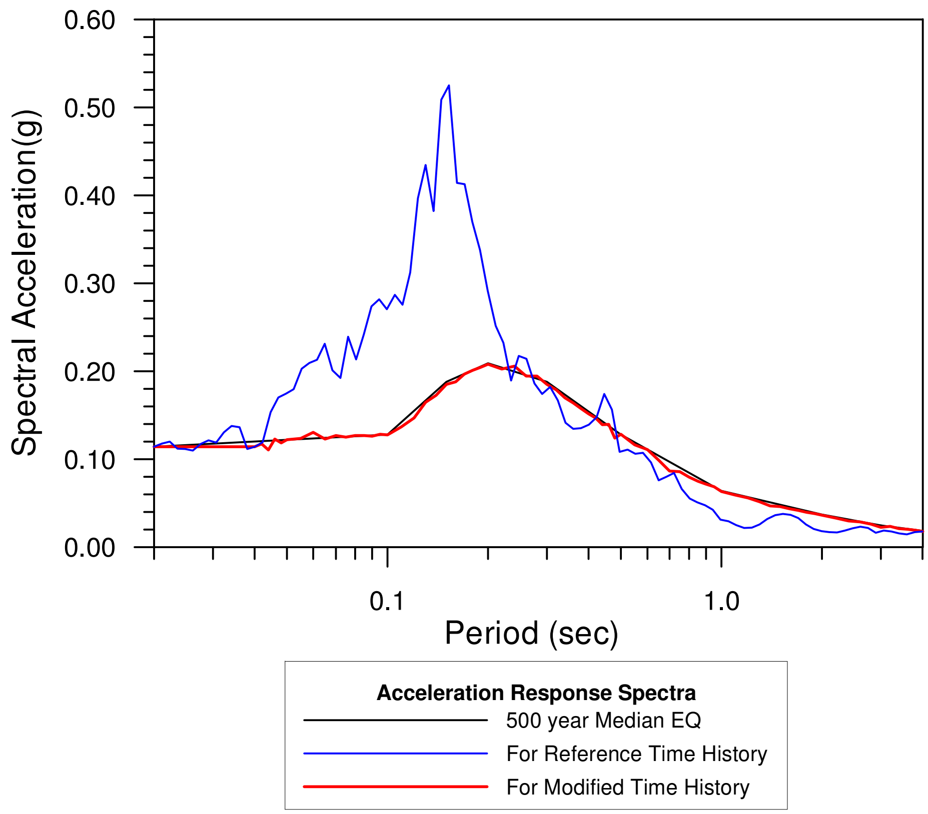
Klohn Crippen Berger

PROJECT
ROSE CREEK TAILINGS IMPOUNDMENT
CROSS VALLEY DAM SEISMIC STABILITY

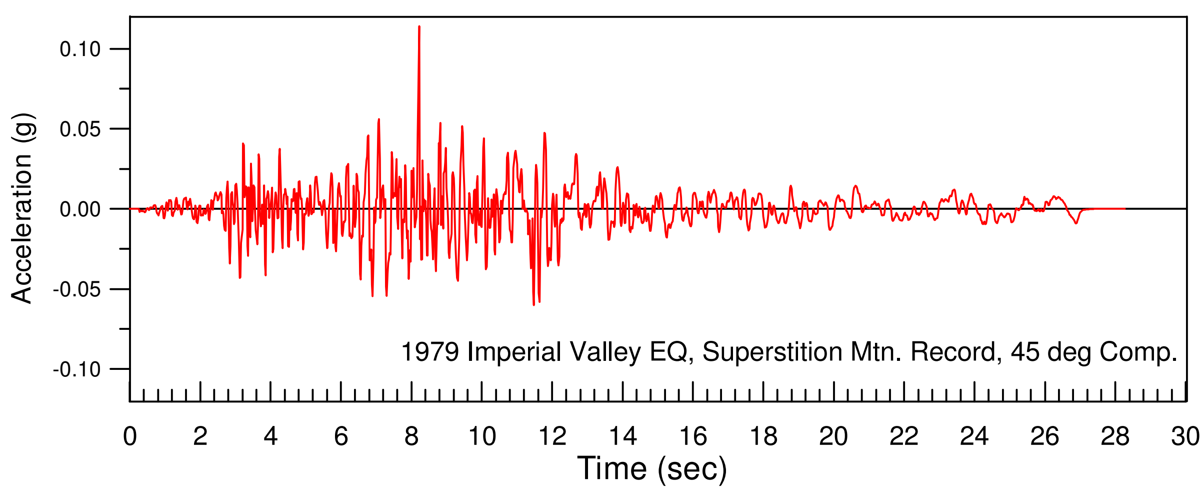
TITLE
MODIFIED TIME HISTORY 5
MATCHING THE 500 YEAR DESIGN SPECTRA

CLIENT:
DELOITTE & TOUCHE INC.
ANVIL MINING RANGE COMPLEX

DATE OF ISSUE	PROJECT No.	FIGURE NO.	REV.
JANUARY 23, 2007	M09237A04 01	12	
APPROVAL			



COMPARISON OF ACCELERATION RESPONSE SPECTRA



TARGET SPECTRUM MATCHED ACCELERATION TIME HISTORY

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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

SCALE

Klohn Crippen Berger

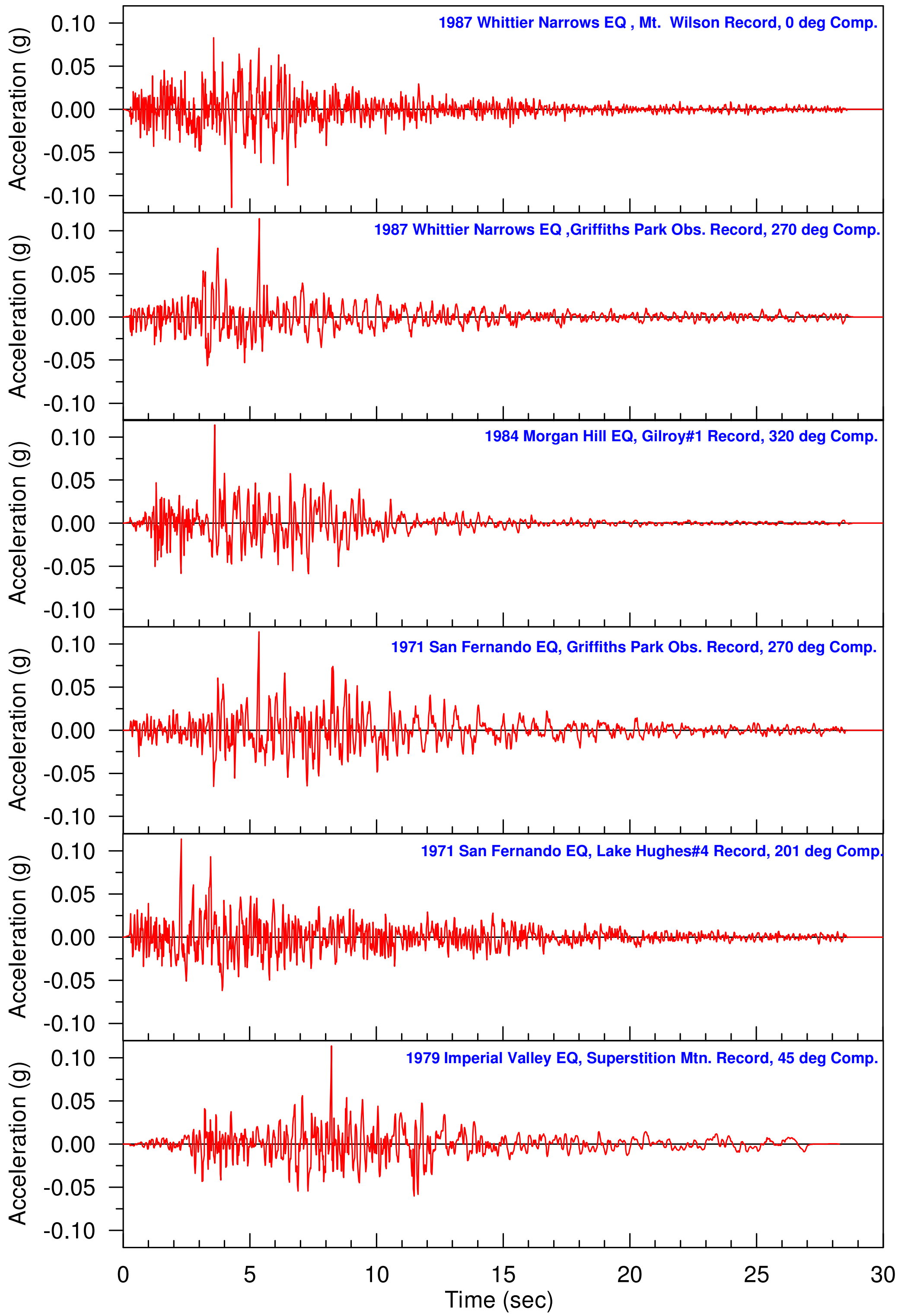
PROJECT: ROSE CREEK TAILINGS IMPOUNDMENT
CROSS VALLEY DAM SEISMIC STABILITY

TITLE: MODIFIED TIME HISTORY 6
MATCHING THE 500 YEAR DESIGN SPECTRA

CLIENT:
DELOITTE & TOUCHE INC.
ANVIL MINING RANGE COMPLEX

DATE OF ISSUE	PROJECT No.	FIGURE NO.	REV.
JANUARY 23, 2007	M09237A04 01	13	

APPROVAL



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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

SCALE

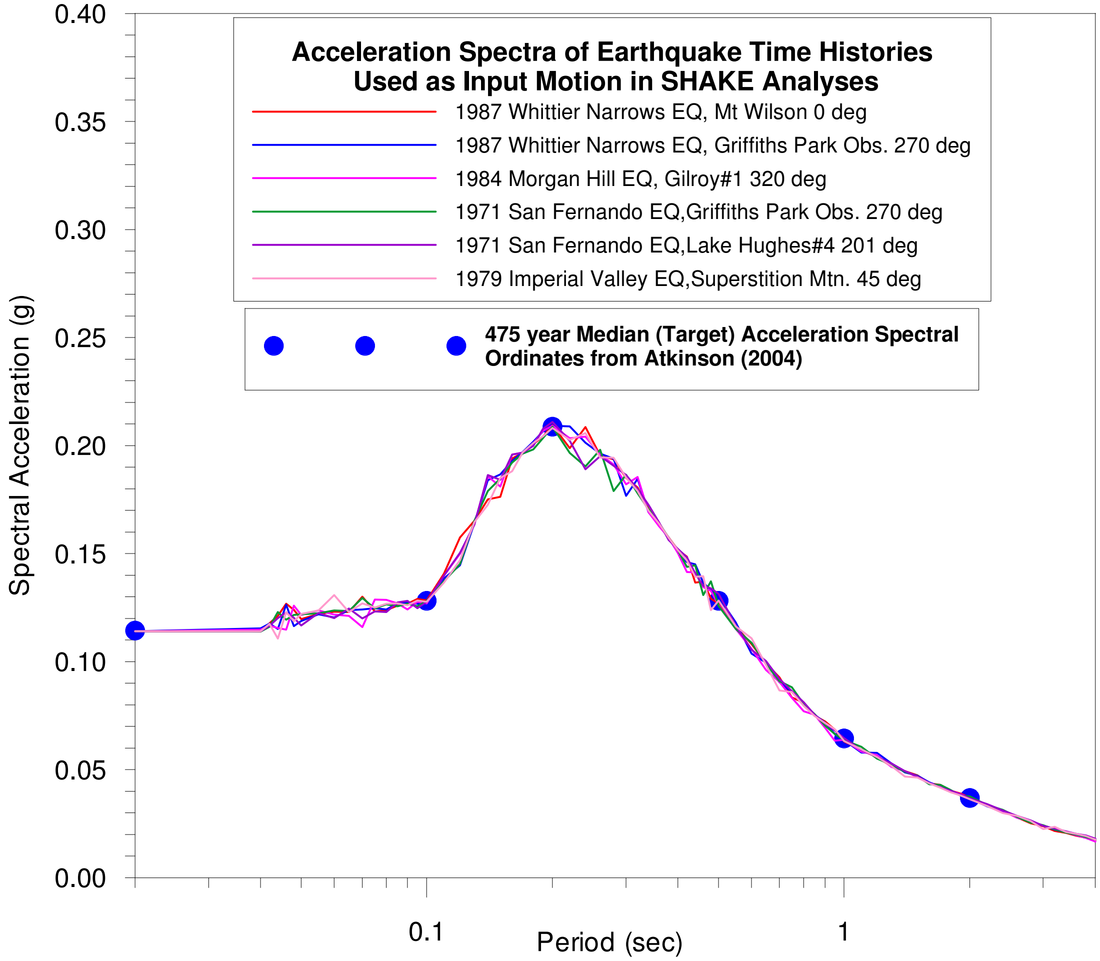
Klohn Crippen Berger

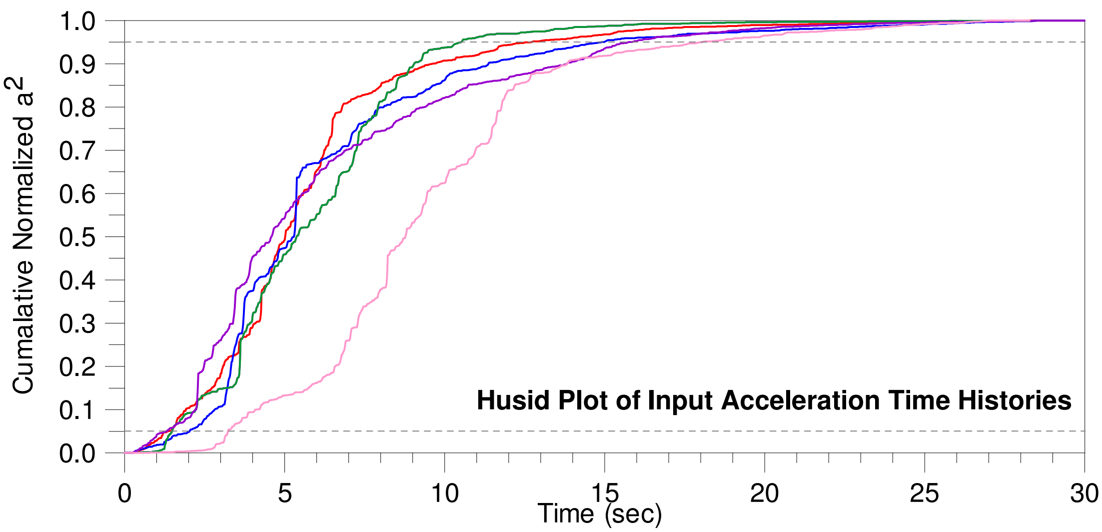
PROJECT
ROSE CREEK TAILINGS IMPOUNDMENT
CROSS VALLEY DAM SEISMIC STABILITY

TITLE
TIME HISTORIES USED AS INPUT MOTION
IN THE SITE RESPONSE ANALYSES

CLIENT:
DELOITTE & TOUCHE INC.
ANVIL MINING RANGE COMPLEX

DATE OF ISSUE	PROJECT No.	FIGURE NO.	REV.
JANUARY 23, 2007	M09237A04 01	14	
APPROVAL			





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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

SCALE

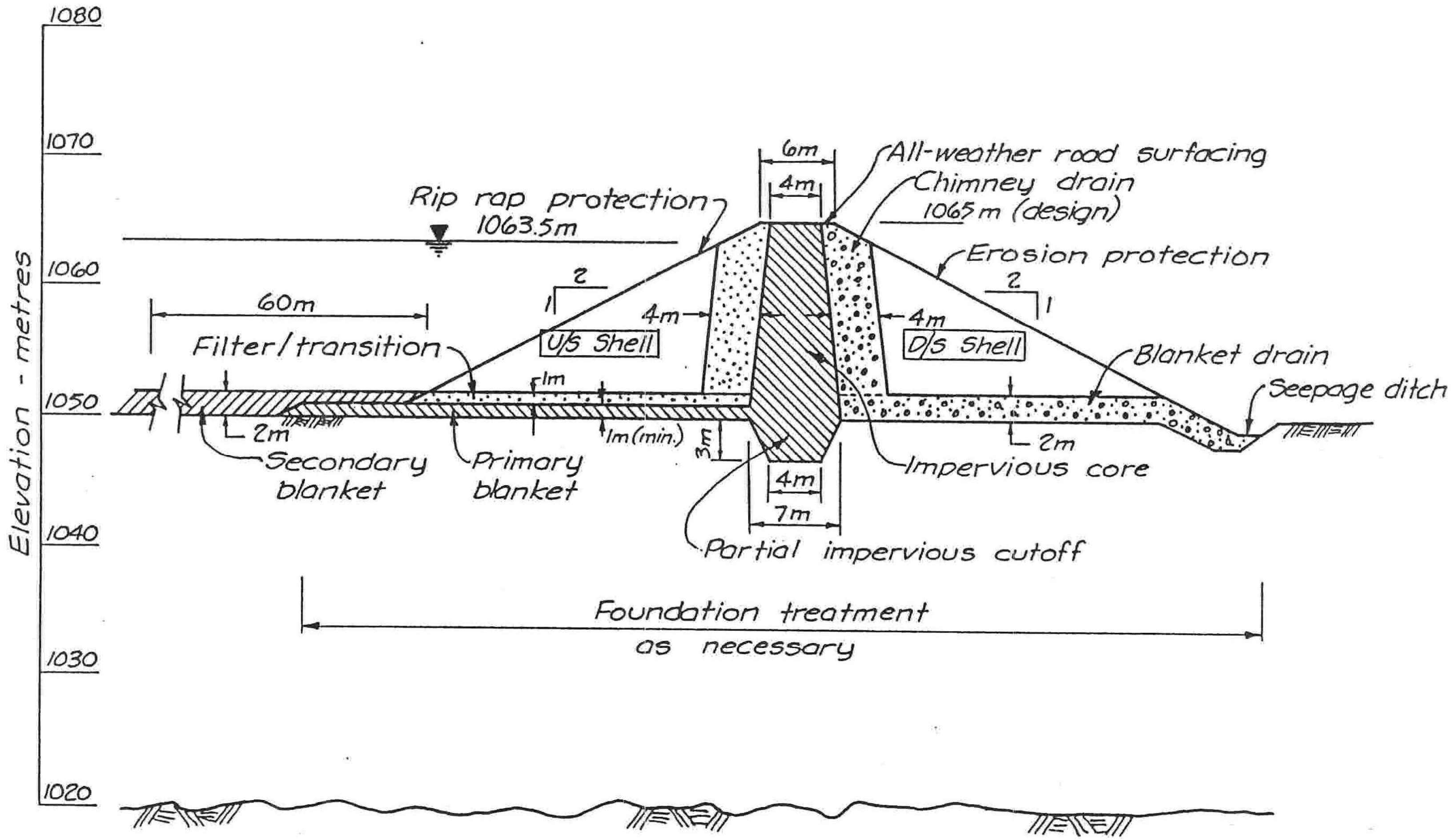
Klohn Crippen Berger

PROJECT
ROSE CREEK TAILINGS IMPOUNDMENT
CROSS VALLEY DAM SEISMIC STABILITY

TITLE
RESPONSE SPECTRA AND HUSID PLOT OF TIME HISTORIES
USED AS INPUT MOTION IN THE SITE RESPONSE ANALYSES

CLIENT:
DELOITTE & TOUCHE INC.
ANVIL MINING RANGE COMPLEX

DATE OF ISSUE	PROJECT No.	FIGURE NO.	REV.
JANUARY 23, 2007	M09237A04 01	15	
APPROVAL			



NOTE:
FIGURE SHOWING TYPICAL DESIGN SECTION OF THE CROSS VALLEY DAM
TAKEN FROM GOLDER ASSICATES REPORT TO CYPRUS ANVIL MINING DATED JUNE 1980

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

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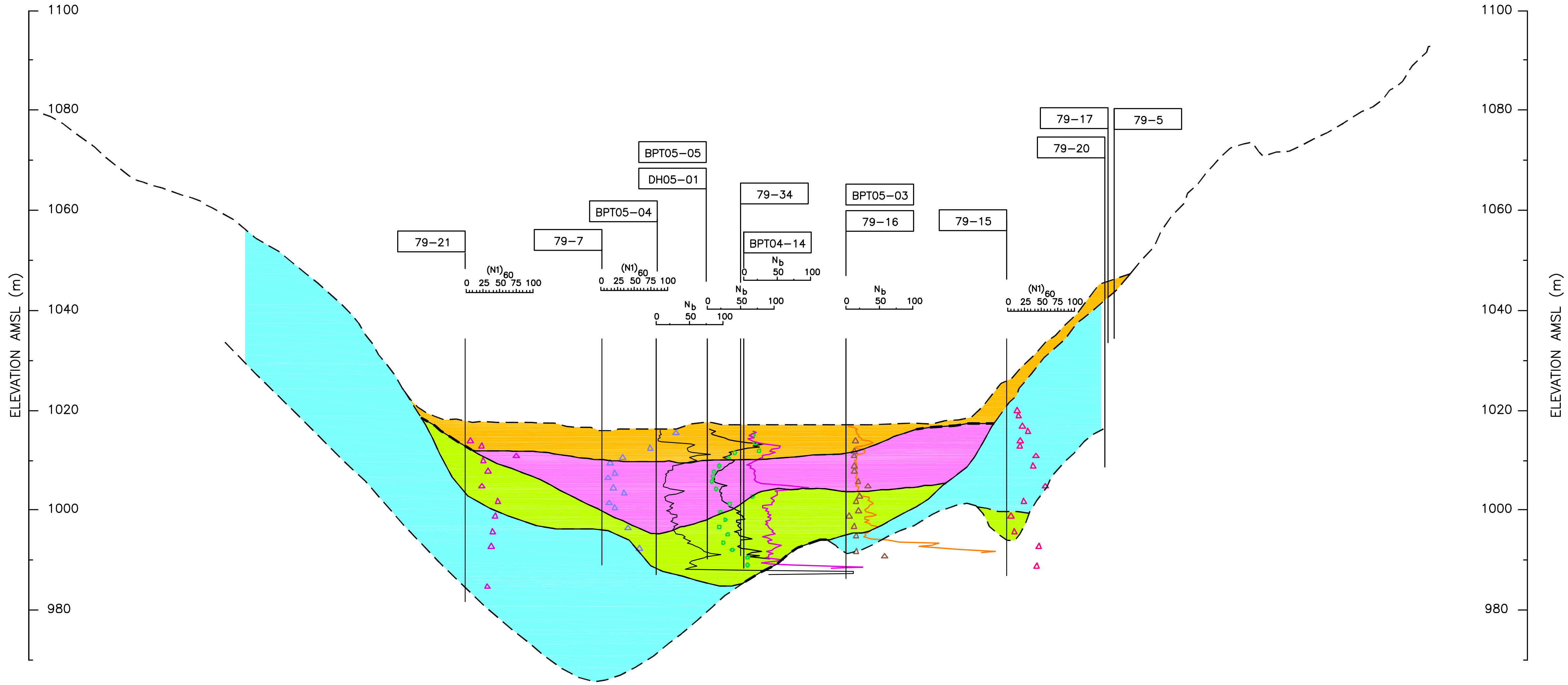
Klohn Crippen Berger

CLIENT:
DELOITTE & TOUCHE INC.
ANVIL MINING RANGE COMPLEX

PROJECT	ROSE CREEK TAILINGS IMPOUNDMENT CROSS VALLEY DAM SEISMIC STABILITY
TITLE	CROSS VALLEY DAM TYPICAL DESIGN SECTION
DATE OF ISSUE	JANUARY 23, 2007
APPROVAL	
PROJECT No.	M09237A04 01
FIGURE. No.	16
REV.	



SECTION A / 18

LEGEND

- ROSE CREEK ALLUVIUM – DENSE
- ROSE CREEK ALLUVIUM – LOOSE
- PLEISTOCENE SANDS AND GRAVELS – DENSE
- PLEISTOCENE GLACIAL TILL

NOTE:

1. SECTION IS TAKEN FROM KLOHN LEONOFF (1981) DRAWING AND UPDATED WITH KC BECKER AND DRILL HOLE INFORMATION.
2. FOUNDATION CONDITIONS ARE KNOWN ONLY AT THE TEST HOLE LOCATIONS. THE SOIL STRATIGRAPHY SHOWN BETWEEN THE TEST HOLES IS AN INTERPRETATION ONLY.
3. THE ACCURACY OF THE 79/80 TEST HOLE LOCATIONS IS NOT KNOWN.
4. N_b – MEASURED BECKER BLOW COUNTS AND $(N_1)_{60}$ – CORRECTED SPT/LPT BLOW COUNTS.

VERTICAL SCALE 0 — 50 m

HORIZONTAL SCALE 0 — 200 m

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

SCALE

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CLIENT
DELOITTE & TOUCHE INC.
ANVIL RANGE MINING COMPLEX

Klohn Crippen Berger

PROJECT
ROSE CREEK TAILINGS IMPOUNDMENT
CROSS VALLEY DAM SEISMIC STABILITY

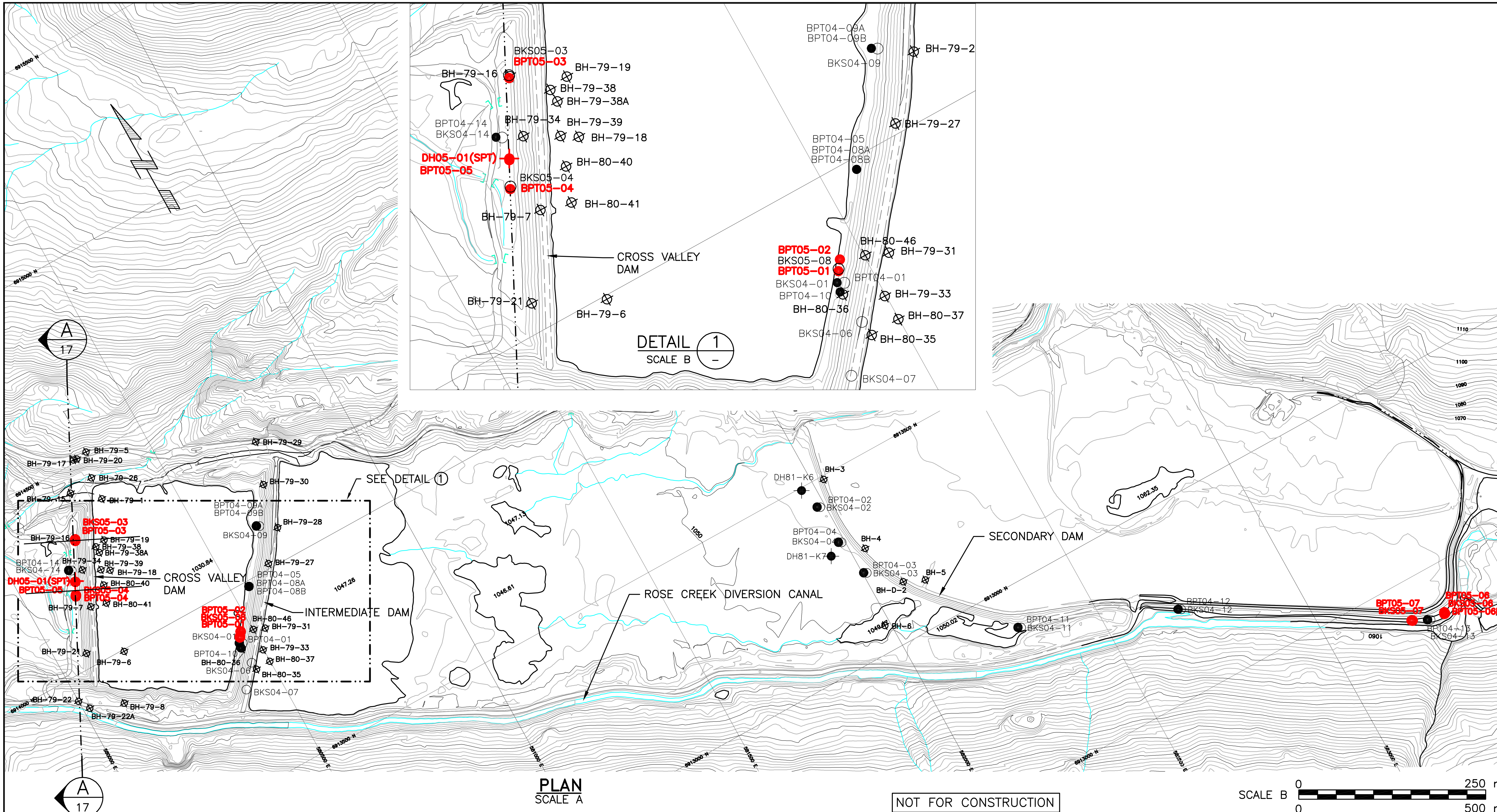
TITLE
CROSS VALLEY DAM
FOUNDATION STRATIGRAPHY

PROJECT No. M09237A04

FIG. No. 17

KCB-R-MLB

Drawing File: M:\M09237A04-A01A02 A03- Rose Creek YK Tailings Liquefaction\400 Site Work and Design Calculations\412 2006 Drawings\070122\fig17.dwg (cwong)



PLAN

SCALE A

LEGEND

BH-80-36 GOLDER TEST HOLE

BKS05-03 KLOHN CRIPPEN OPEN BECKER TEST

BPT05-04 KLOHN CRIPPEN CLOSED BECKER TEST

DH05-01 KLOHN CRIPPEN TEST HOLE

NOTES:

1. BASE PLAN TAKEN FROM 2003 FARO SITE PLAN1_Ver2000.DWG PROVIDED BY SRK.
2. CONTOUR INTERVAL IS 2m RELATIVE TO MEAN SEA LEVEL.
3. BH3 TO BH6 AND BH-D-2 LOCATIONS ARE APPROXIMATE.

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

SCALE B 0 250 m

SCALE A 0 500 m

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CLIENT
DELOITTE & TOUCHE INC.
ANVIL RANGE MINING COMPLEX

Klohn Crippen Berger

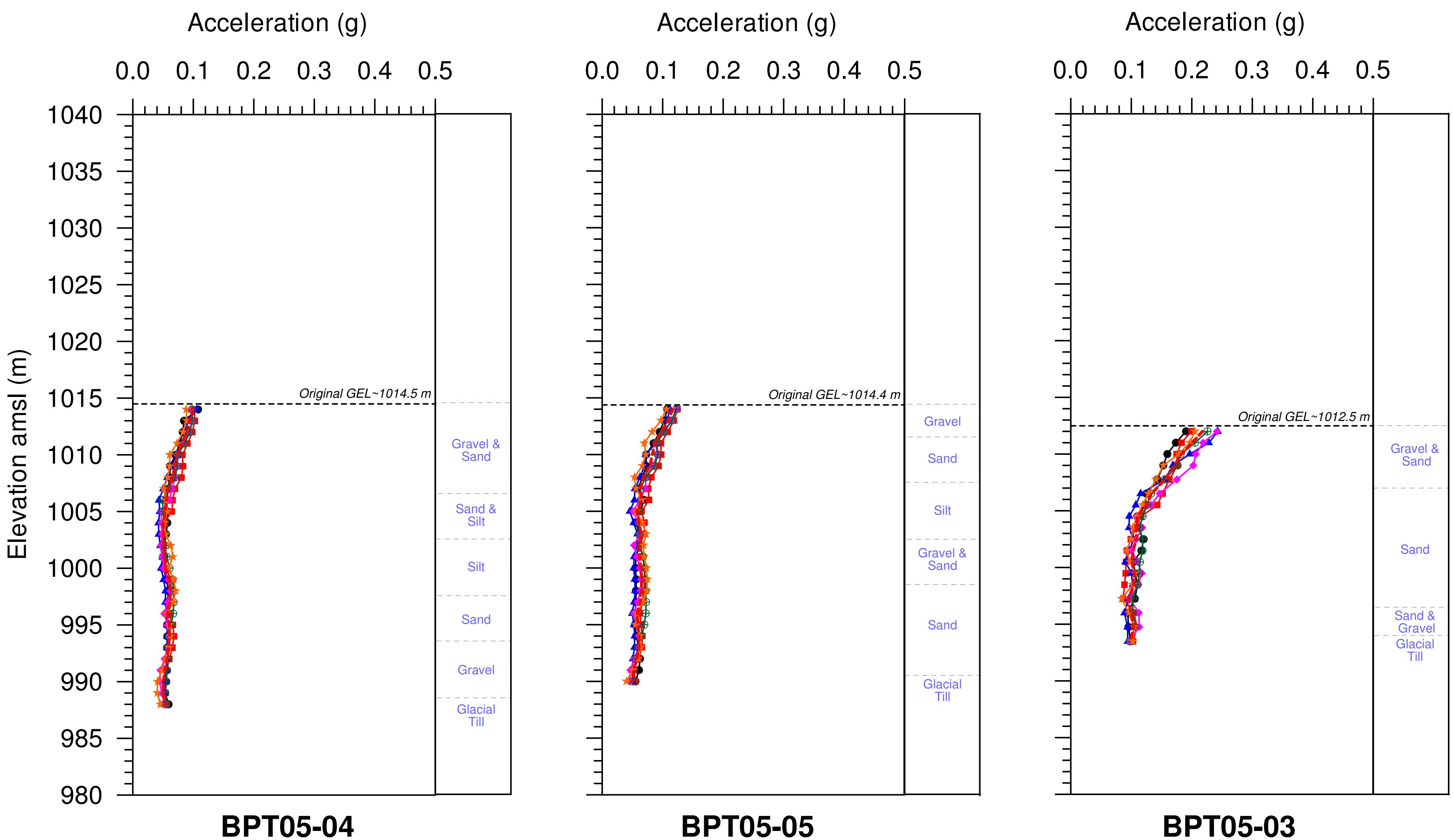
PROJECT
ROSE CREEK TAILINGS IMPOUNDMENT
CROSS VALLEY DAM SEISMIC STABILITY

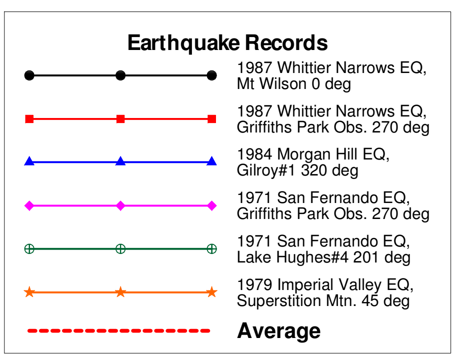
TITLE
TEST HOLE LOCATION PLAN

PROJECT No. M09237A04

FIG. No. 18

Date: 1/22/2007
Scale: 1=5(PS)
Drawing File: M:\M09237A04-A01A02 A03- Rose Creek YK Tailings Liquefaction\412 2006 Site Work and Design Calculations\412 2006 Drawings\070122\fig18.dwg (cwong)
Xrefs: TESTHOLE75, TESTHOLE





Notes:
1. Required $(N_1)_{60}$ computed from EQ induced CSR following Youd et al. (2001).
2. Required $(N_1)_{60}$ less than 1 plotted as 1 for illustration only.
3. Measured BPT blow counts converted to equivalent N_{60} using the Sy (1993) method.
4. Equivalent $(N_1)_{60}$ greater than 50 plotted as 50 for illustration only.
5. Soil layering interpreted from open Becker tests and drill hole data.

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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

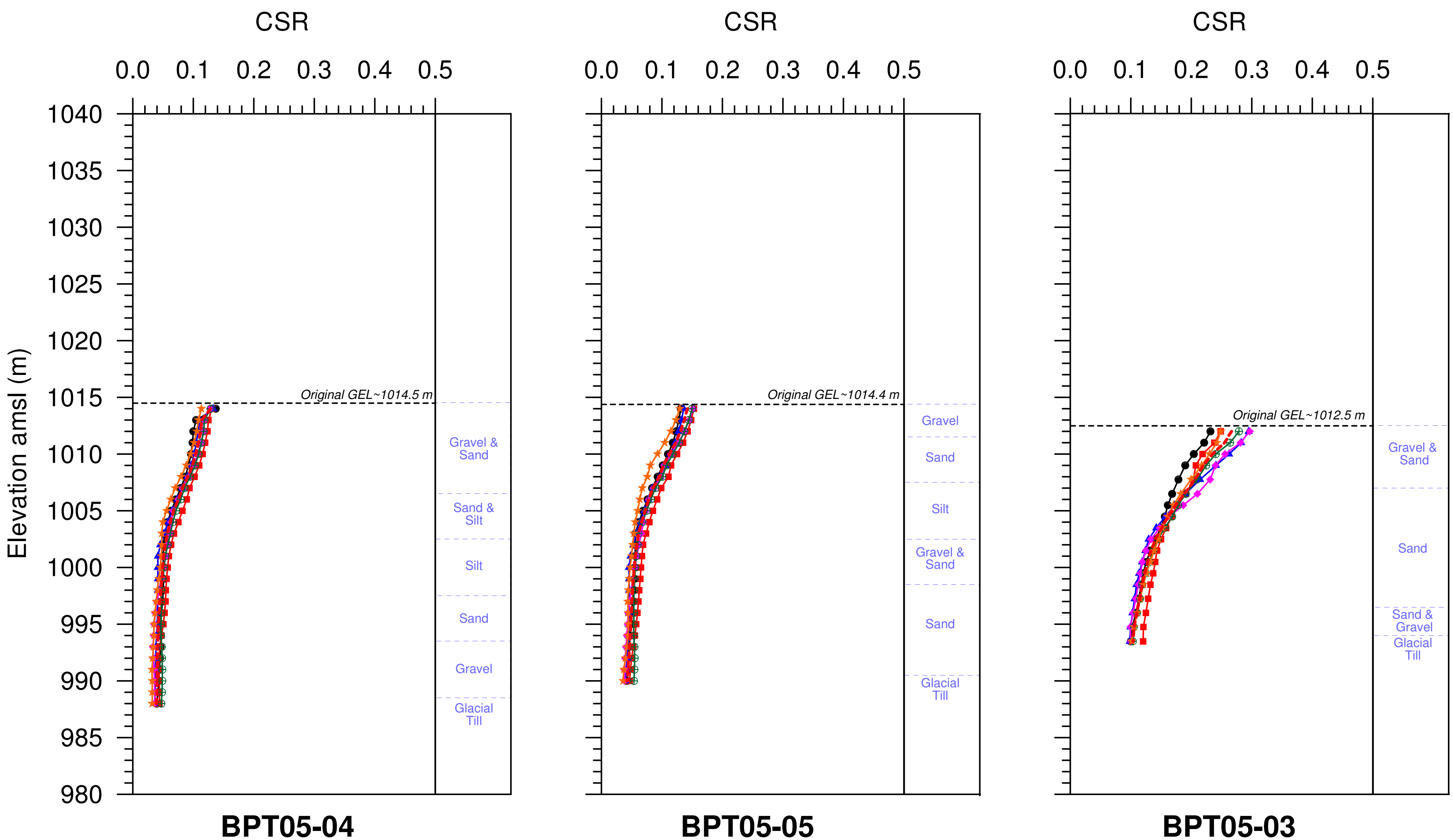
Klohn Crippen Berger

CLIENT:
DELOITTE & TOUCHE INC.
ANVIL MINING RANGE COMPLEX

PROJECT
ROSE CREEK TAILINGS IMPOUNDMENT
CROSS VALLEY DAM SEISMIC STABILITY

TITLE
PEAK ACCELERATION PROFILES AT THE CROSS VALLEY DAM TOE

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
JANUARY 23, 2007	M09237A04 01	19	
APPROVAL			



Earthquake Records

- 1987 Whittier Narrows EQ, Mt Wilson 0 deg
- 1987 Whittier Narrows EQ, Griffiths Park Obs. 270 deg
- 1984 Morgan Hill EQ, Gilroy#1 320 deg
- 1971 San Fernando EQ, Griffiths Park Obs. 270 deg
- 1971 San Fernando EQ, Lake Hughes#4 201 deg
- 1979 Imperial Valley EQ, Superstition Mtn. 45 deg
- **Average**

Notes:
1. Required $(N_1)_{60}$ computed from EQ induced CSR following Youd et al. (2001).
2. Required $(N_1)_{60}$ less than 1 plotted as 1 for illustration only.
3. Measured BPT blow counts converted to equivalent N_{60} using the Sy (1993) method.
4. Equivalent $(N_1)_{60}$ greater than 50 plotted as 50 for illustration only.
5. Soil layering interpreted from open Becker tests and drill hole data.

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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 23, 2007

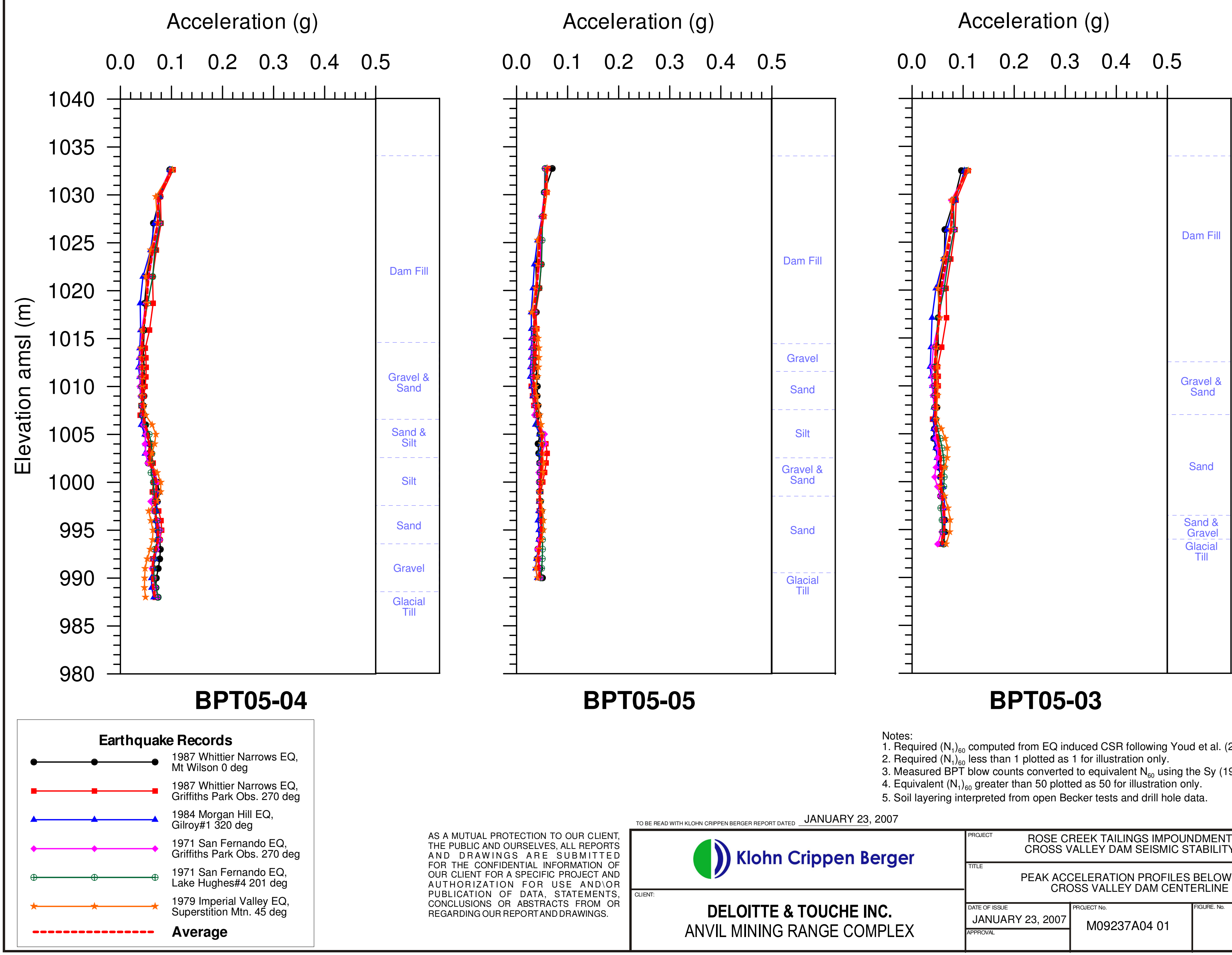
Klohn Crippen Berger

CLIENT: **DELOITTE & TOUCHE INC.** ANVIL MINING RANGE COMPLEX

PROJECT: ROSE CREEK TAILINGS IMPOUNDMENT CROSS VALLEY DAM SEISMIC STABILITY

TITLE: CYCLIC STRESS RATIO PROFILES AT THE CROSS VALLEY DAM TOE

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
JANUARY 23, 2007	M09237A04 01	20	
APPROVAL			



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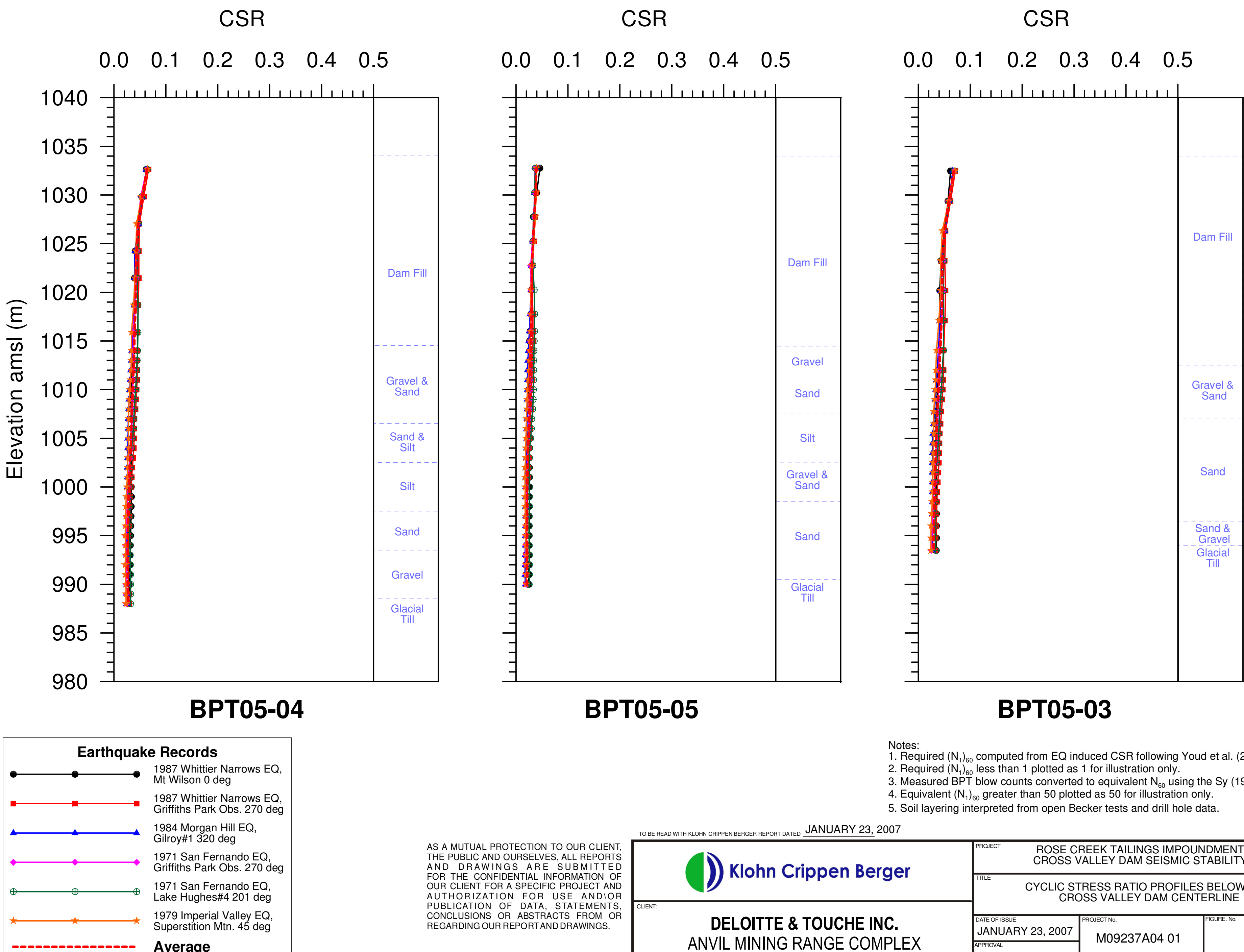
CLIENT: **DELOITTE & TOUCHE INC.**
ANVIL MINING RANGE COMPLEX

PROJECT: ROSE CREEK TAILINGS IMPOUNDMENT CROSS VALLEY DAM SEISMIC STABILITY

TITLE: PEAK ACCELERATION PROFILES BELOW THE CROSS VALLEY DAM CENTERLINE

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
JANUARY 23, 2007	M09237A04 01	21	
APPROVAL			



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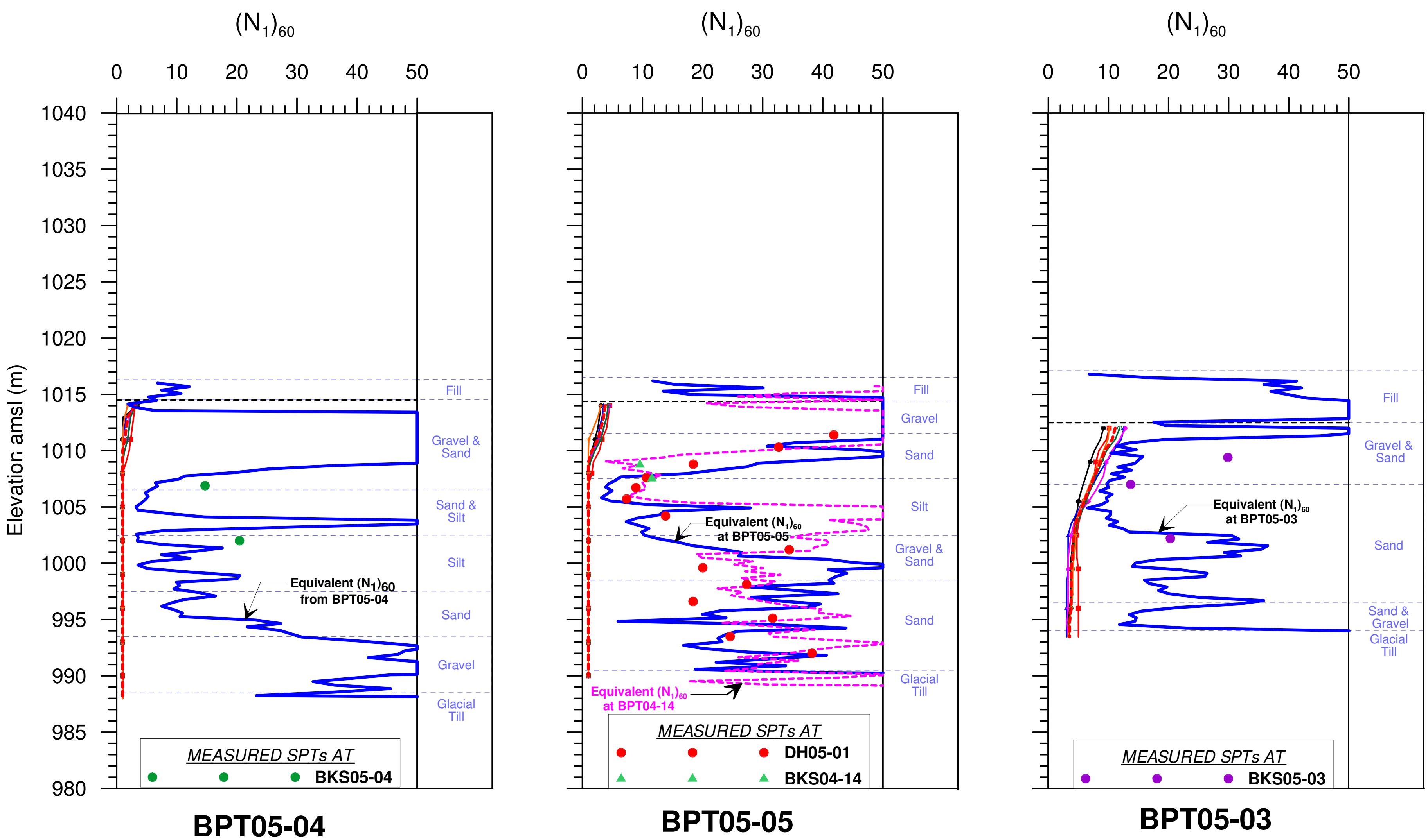
CLIENT: **DELOITTE & TOUCHE INC.**
ANVIL MINING RANGE COMPLEX

PROJECT: ROSE CREEK TAILINGS IMPOUNDMENT CROSS VALLEY DAM SEISMIC STABILITY

TITLE: CYCLIC STRESS RATIO PROFILES BELOW THE CROSS VALLEY DAM CENTERLINE

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
JANUARY 23, 2007	M09237A04 01	22	

APPROVAL



$(N_1)_{60}$ Required to Prevent Liquefaction

- 1987 Whittier Narrows EQ, Mt Wilson 0 deg
- 1987 Whittier Narrows EQ, Griffiths Park Obs. 270 deg
- 1984 Morgan Hill EQ, Gilroy#1 320 deg
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- 1971 San Fernando EQ, Lake Hughes#4 201 deg
- 1979 Imperial Valley EQ, Superstition Mtn. 45 deg
- **Average**

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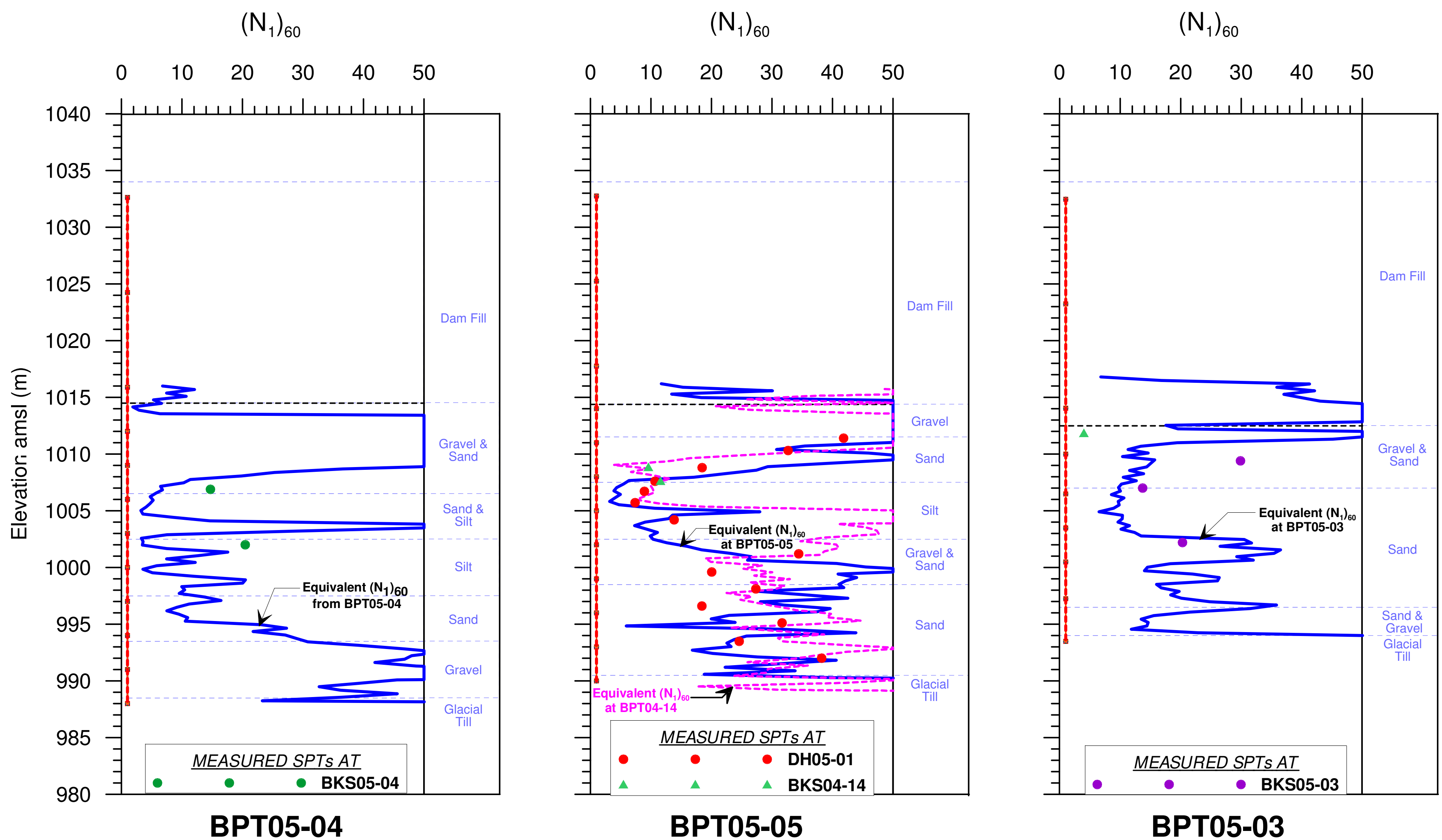
CLIENT: **DELOITTE & TOUCHE INC.**
ANVIL MINING RANGE COMPLEX

PROJECT: ROSE CREEK TAILINGS IMPOUNDMENT
CROSS VALLEY DAM SEISMIC STABILITY

TITLE: LIQUEFACTION ASSESSMENT AT THE
CROSS VALLEY DAM TOE

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
JANUARY 23, 2007	M09237A04 01	23	

APPROVAL



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Klohn Crippen Berger	PROJECT: ROSE CREEK TAILINGS IMPOUNDMENT CROSS VALLEY DAM SEISMIC STABILITY
CLIENT: **DELOITTE & TOUCHE INC.** ANVIL MINING RANGE COMPLEX	TITLE: LIQUEFACTION ASSESSMENT BELOW THE CROSS VALLEY DAM CENTERLINE

DATE OF ISSUE	PROJECT No.	FIGURE. No.	REV.
JANUARY 23, 2007	M09237A04 01	24	
APPROVAL			